Department for Environment and Heritage

Riverland Ramsar Site

Ecological Character Description

Department for Environment and Heritage

Riverland Ramsar Site

Ecological Character Description

by

Peter Newall, Lance Lloyd, Peter Gell and Keith Walker

Lloyd Environmental

Project No: LE0739

11th June 2008

Revised 13th July 2009

Contents

Cover Photo: Riverland Ramsar Site (source: Peter Newall, June 2007)

This report should be cited as follows:

Newall, P.R., Lloyd, L.N., Gell, P.A. and Walker K.F. 2009. Ecological Character Description for the Riverland Ramsar Site. Lloyd Environmental Pty Ltd Report (Project No: LE0739) to Department for Environment and Heritage, South Australia. July 2009.

Inquiries on this report can be made to:

Lance Lloyd, Director,
Lloyd Environmental Pty Ltd,
ph: 03 9884 5559, Mob: 0412 007 997,
Fax: 03 9884 7405,
lance@lloydenviro.com.au,
PO Box 3014, SYNDAL, Victoria 3149

ACKNOWLEDGEMENTS

The authors of this document thank several people provided valuable information for the project and/or comments on drafts of the document. In particular, we thank the following contributors:

- Mike Harper, Department for Environment and Heritage (South Australia);
- Tony Herbert, SA Murray-Darling Basin NRM Board;
- Nerida Sloane, Department of the Environment, Water, Heritage and the Arts;
- Anne Jensen, University of Adelaide;
- Benno Curth, Department for Environment and Heritage (South Australia);
- Felicity Smith, Department for Environment and Heritage (South Australia);
- Matt Miles, Department for Environment and Heritage (South Australia);
- Tony Sharley, Banrock Station, Hardy Wines;
- Mario Siciliano, Department for Environment and Heritage (South Australia);
- Brenton Zampatti, SA Research and Development Institute;
- Andy Close, Murray-Darling Basin Commission;
- Steve Barnett, Dept of Water and Land Biodiversity Conservation;
- Tracy Clark, ECOS Pty Ltd; and,
- DEWHA Reviewers, for detailed review which improved the final version.

This project was funded by the Department for Environment and Heritage (South Australia) with financial support from the Australian Government (Department of the Environment, Water, Heritage and the Arts).

Symbols for conceptual model diagrams courtesy of the Integration and Application Network (*ian.umces.edu/symbols*), University of Maryland Center for Environmental Science.

LIST OF ABBREVIATIONS

ANSTO	Australian Nuclear Science and Technology Organisation
AUSRIVAS	**Aus**tralian **Riv**er **A**ssessment **S**ystem
ANZECC	Australia and New Zealand Environment and Conservation Council
CAMBA	China-Australia Migratory Birds Agreement
CEPA	Community Education and Public Awareness
DEH	Department for Environment and Heritage (South Australia)
DEWHA	Department of the Environment, Water, Heritage and the Arts (Commonwealth)
ECD	Ecological Character Description
EPBC	*Environment Protection and Biodiversity Conservation Act 1999* (a Commonwealth Act)
IBRA	Interim Biogeographic Regionalisation of Australia
JAMBA	Japan-Australia Migratory Birds Agreement
NCSSA	Nature Conservation Society of South Australia
NWC	National Water Commission
RIS	Ramsar Information Sheet
ROKAMBA	Republic of Korea-Australia Migratory Birds Agreement
SAMDB NRM Board	South Australian Murray Darling Basin Natural Resource Management Board
SIGNAL	Stream Invertebrate Grade Number – Average Level

EXECUTIVE SUMMARY

This *Ecological Character Description* (ECD) has been developed following the National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands (DEWHA 2008) and contains information on the Riverland Ramsar Site (hereinafter referred to as 'the Site'). This information includes: geographic and administrative details; the Site's ecological character (including components, processes, benefits and services) at the time of Ramsar listing (1987) and currently; gaps in knowledge of the Site and issues for management; actual or potential threats; changes that have occurred since listing; site monitoring needs and triggers for management action; and communication, education and public messages to facilitate management and planning.

The Site was first listed in 1987 against the (then) criteria 1a, 1b, 1c, 3b of the Ramsar Convention. Following revision of the criteria in 1999, the Site is now listed under criteria 1-8 of the revised criteria. This ECD has been compiled between September 2007 and May 2008, 20 years after the Riverland Site was first listed, but is required to reflect conditions at the time of listing. The ECD interprets studies and reports undertaken at various times to characterise conditions at the time of listing.

This ECD was prepared subsequent to a boundary revision (dated 11 September 2007) designed to remove major non-wetland areas dominated by agriculture and add a major wetland area (Lake Woolpolool, a seasonal saline lake). The removal of the non-wetland areas does not impact on the ecological character of the Riverland Ramsar Site, whereas the inclusion of Lake Woolpolool has enhanced the waterbird and vegetation diversity of the site (RIS in prep.). The revised boundary was incorporated into a revised RIS (RIS in prep.) which has been approved by the Australian Government (11 September 2007), and the Ramsar Convention on Wetlands Secretariat has been notified. In this ECD, Lake Woolpolool is assumed to be part of the Ramsar Site, and its effective time of listing is taken as 1987.

The Site

The Riverland Ramsar Site is on the floodplain of the River Murray, between Renmark, South Australia, and the State borders with Victoria and New South Wales. As the principal river of the Murray-Darling Basin, the Murray flows 2,530 km from its source in south-eastern New South Wales to its mouth at Encounter Bay, South Australia. The Murray-Darling Basin has an area of 1.073 million km^2 (14% of mainland Australia with much of the region being flat and having aeolian and alluvial deposits of sands, silts and clays. The system is fed largely by the streams which arise in the Great Dividing Range

The River Murray has five geomorphological tracts (Mackay & Eastburn 1990) and the Site is located in the ***Mallee Trench*** tract which begins near Swan Hill, Victoria, and extends to Overland Corner, South Australia. This tract is an 850 river km plain of marine origin, crossed by the river in a well-defined incised channel.

The Site, which is 30,615 ha in size, has a boundary that follows the 1956 floodline west from the New South Wales border. It includes two major anabranch systems (Chowilla and Ral Ral Creeks) along an 80 km stretch of the River Murray, incorporating a series of creeks, channels, lagoons, billabongs, swamps and lakes.

The Site contains three generally recognised land components or 'blocks' – Murtho, Calperum, and Chowilla – defined primarily on the basis of historical ownership (see Figure 2.2). The Site blocks encompass only parts of greater land components. In particular, the Calperum and Chowilla blocks within the Site only contain fractions of the larger Calperum Station and Chowilla Reserves, respectively.

Most of the site (27,213 ha) is allocated to biodiversity conservation under Australian, State and Local Government or private ownership. Stock grazing, predominantly by sheep, is the next largest land use, allocated 3,370 ha. The Site supports a significant tourism industry that relies on the Site's inherent values. Tourism operators supply houseboat hire, nature-based boat and vehicle tours, pastoral industry tours and on-site accommodation. Recreational pursuits are centred on fishing, pleasure craft boating, bush camping, canoeing, waterfowl hunting, water-skiing and driving tours. A few commercial fishers have licenses to take Bony Herring (*Nematalosa erebi)* (a common native fish), European Carp (an exotic species) and other non-native species from the backwaters of the site.

An ECD Summary

A representation of key influences occurring at the Site is displayed below. The Riverland Ramsar Site is in a generally dry environment. Most of the water that fills the creeks and wetlands comes from remote catchments of the River Murray and its tributaries. The nature of the water regime — the magnitude, frequency, duration and seasonality of flows in the river, and the rate of rise and fall of the hydrograph — governs the ecological character of the wetland complex (Figure E1).

The Site's character is described in terms of **components** (e.g. biota; habitats; landforms), **processes** (e.g. habitat creation and flux; disturbances; energy and nutrient supply and transfer) and **benefits and services** (e.g. water supply and storage; species maintenance; fodder provision for stock and wildlife). These features are used to determine the **limits of acceptable change** to the character of the Site.

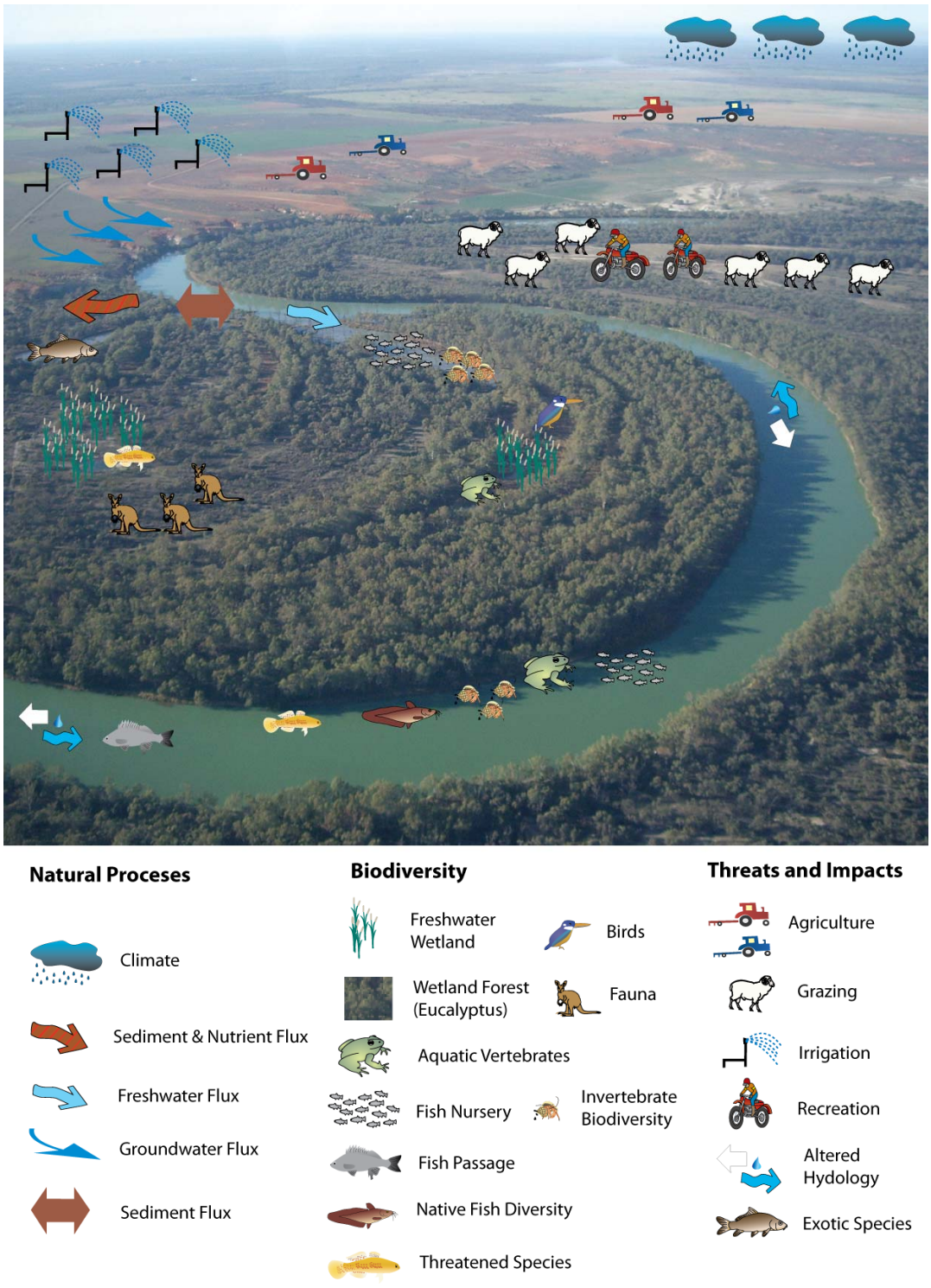


Figure E1: Riverland Ramsar Site Landscape showing components and processes.

The vegetation and habitats are influenced by the hydrology and the geomorphology of the site, with vegetation bands often delineating flooding regimes which are products of topography and elevation (Figure E2).

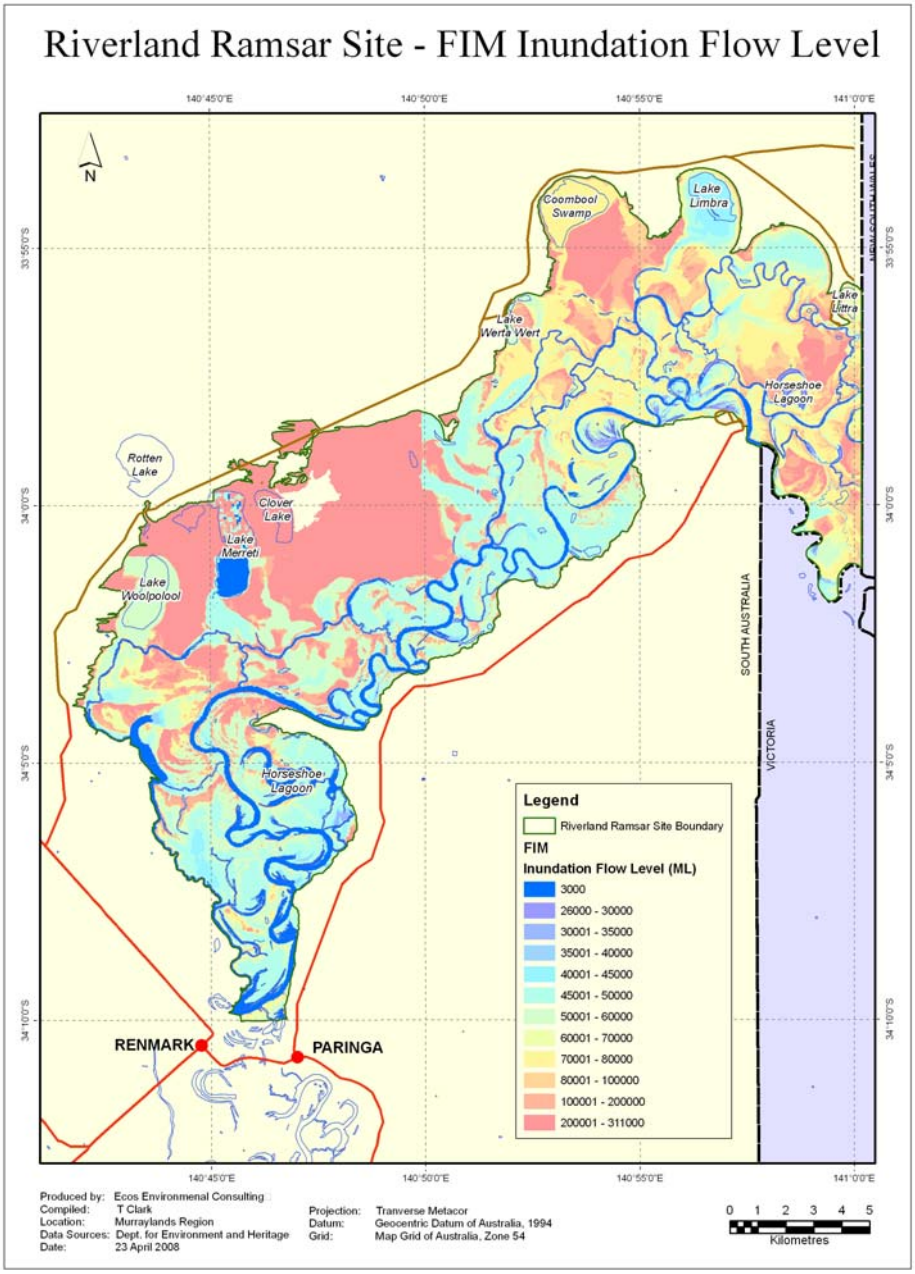


Figure E2: Flow required to inundate the Riverland Ramsar Site

Hydrology is simultaneously a component and a process. It governs the seasonality, magnitude, frequency, duration and rate of water delivery, and many biotic responses that include seed germination (including species favoured by the hydrologic regime), triggers for breeding (birds, fish, frogs), breeding success and provision of food. The season of delivery, period of inundation for ephemeral wetlands (or water level rises for permanent wetlands), fluctuations in water level and inter-annual flow variations all are influential.

Flooding is, perhaps, the most important natural process at the Site as it links the floodplain and the river. The floods replenish floodplain and lentic habitats with water and allow exchange of nutrients and biota (Figure E3).

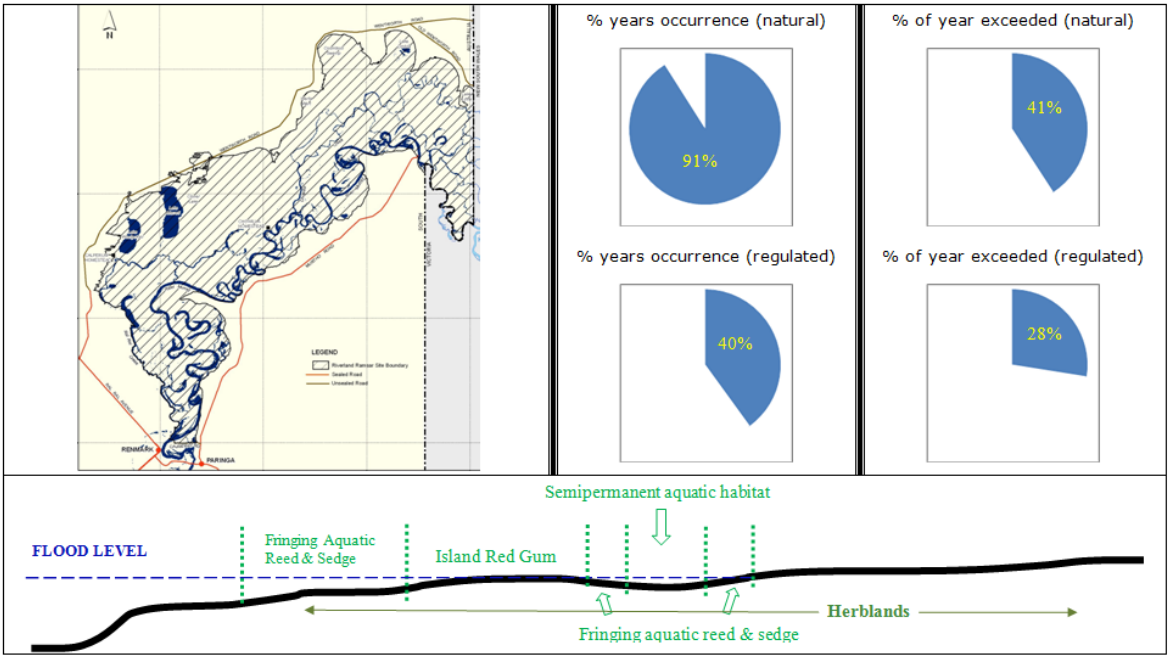


Figure E3: Conceptual model showing relationship between flood level and vegetation communities (example showing a flood of 40,000 ML day^{-1} [=40 GL day^{-1}])

Vegetation

Vegetation is a key component of the Site, contributing substantially to its ecological character and providing the habitat and landscape that form the basis of the Site's ecological services.

Vegetation of the Site encompasses a diversity of terrestrial and aquatic plant communities, from stands of *Callitris* pines on raised dunes to submerged aquatic plant meadows (in permanent wetlands). The vegetation has been surveyed on several occasions (e.g. O'Malley 1990, Margules et al. 1990, DEH 2002).

A DEH (2002) survey recognised the following wetland and floodplain vegetation communities which include arid and semi-arid hummock community: Black Box woodland; chenopod shrubland; fringing aquatic reed/sedge; herbfield, lignum shrubland, low chenopod shrubland, *Melaleuca* forest/woodland, river cooba shrubland, River Redgum woodland, River Redgum forest, river saltbush chenopod shrubland, and samphire low shrubland.

The DEH (2002) survey focuses mainly on the vegetation communities during the drier phases of the Site, although creeks and billabongs are often fringed by

Common Reed (*Phragmites australis)*, Spiny Sedge (*Cyperus gymnocaulos)* and Cumbungi (*Typha domingensis*).

There are also aquatic areas containing submergent vegetation such as Red Milfoil (*Myriophyllum verrucosum)* and Ribbonweed (*Vallisneria americana*); these areas expand during large floods (Fig E4).

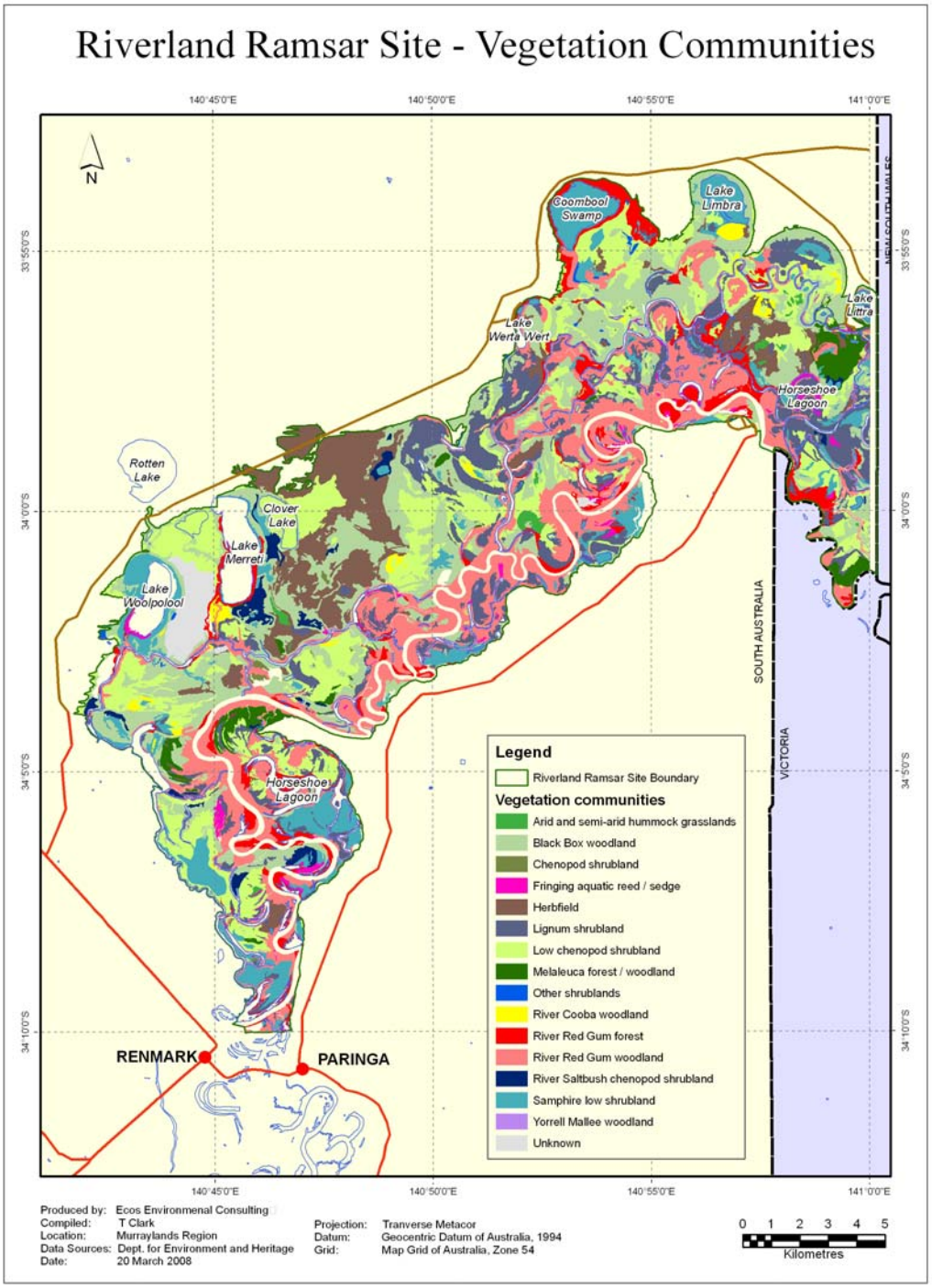


Figure E4: Vegetation Communities across the Riverland Ramsar Site.

This ECD includes two vegetation groups which were not classified above:

Fringing aquatic reed & sedge vegetation typified by Common Reed, Spiny Sedge and Cumbungi

Aquatic (permanent and semi-permanent) vegetation containing submergent vegetation such as Red Milfoil and Ribbonweed, emergent species such as Spiny sedge, Cumbungi, and Lignum, and also free-floating species such as *Azolla* spp.

The distribution of vegetation across the site is strongly determined by landform (including elevation) and hydrology. Figure E5, below, represents a diagrammatic cross-section of the landscape with the placement of the vegetation communities displays the basic relationships of hydrology, landscape and vegetation community at the Site.

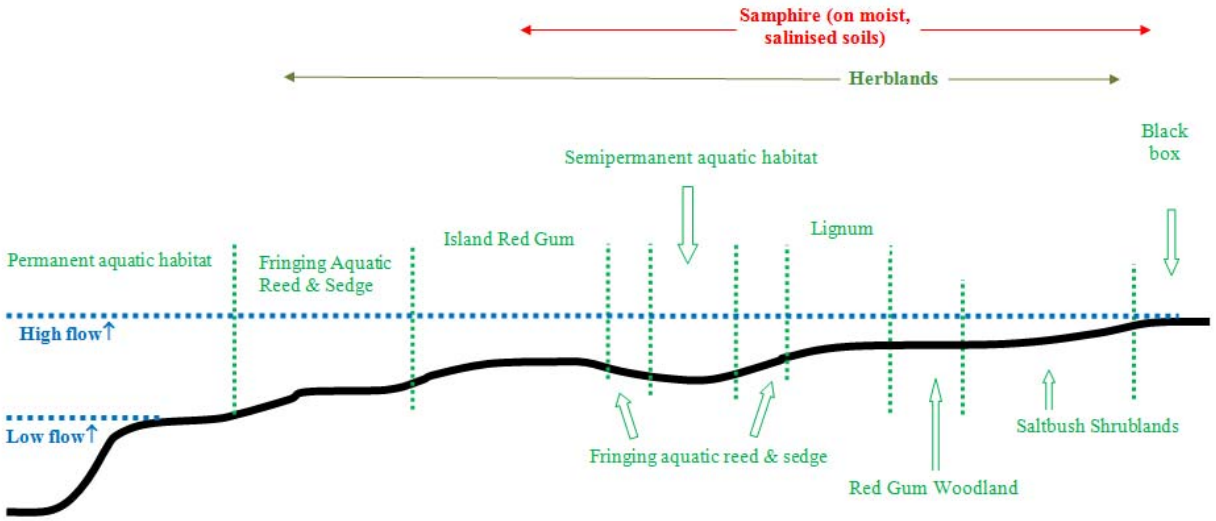


Figure E5: Vegetation community locations in relation to flood levels across the Riverland landscape

Fauna

Good information exists about the species occurrences of birds, mammals, reptiles and amphibians, fish, aquatic macroinvertebrates, molluscs and crustaceans at the Site.

Diverse **bird** assemblages include wetland, woodland, shrubland and grassland species, and species not found elsewhere in South Australia. There are 134 species recorded at Chowilla, including 30 breeding species, and Carpenter (1990) noted that 170 species had been recorded in that area. A total of 165 native bird species have been recorded across the Calperum and neighbouring Taylorville stations, including wetland, migratory and mallee-dependent species. Fifty-three species of waterbirds and two wetland raptors were recorded at Lake Woolpolool alone (Jensen

et al. 2000). The most recent RIS (in prep.) reported 179 species for the whole site, including 63 wetland-dependent species. The Site supports 13 State-listed threatened bird species, eight species listed under international agreements, and one species listed nationally as 'vulnerable' under the EPBC Act.

Twenty-five (25) species of **mammals** were recorded at Chowilla, including 17 native species. The native species included eight species of bat, three species of dasyurid (two dunnart species and a planigale), two species of kangaroo (Western Grey and the Red), a species of native mouse, the native water rat, the Short-beaked Echidna and the Brush-tailed Possum. The Feather-tailed Glider is a State-listed species, endangered in South Australia, and has been recorded within the Site. The introduced species were sheep, cattle, the rabbit, Brown Hare, feral pig, feral goat, House Mouse, and Red Fox.

Thirty-eight species of **reptiles** and nine species **amphibians** have been recorded at the Site (RIS in prep.). These include three turtle species (including the Broad-shelled Turtle *Chelodina expansa*, listed as Vulnerable in South Australia and the Murray River Turtle (*Emydura macquarii*); eighteen species of lizard, comprising nine skinks (each from a different genus), five geckoes, two goannas (including the Lace Monitor, *Varanus varius* (listed as rare in South Australia) and two species of dragons; six species of snake (including the Carpet Python, *Morelia spilota variegata*, listed as rare in South Australia); and seven species of frog (including the Southern Bell Frog, *Litoria raniformis*, listed as endangered under the EPBC Act).

The aquatic habitats on the River Murray floodplain at the Site support a diverse assemblage of **macroinvertebrates**, with a total of 96 taxa being recorded during a survey of the Chowilla block of the Site in October 1988. The main channel sites within the survey supported 27 taxa, indicating that the floodplain habitats harbour a rich faunal diversity compared to the channel, reflecting its high habitat diversity. Within the Murtho block, macroinvertebrate sampling at Woolenook, Weila and Murtho Park yielded 41, 42 and 40 taxa respectively and a detailed study of the macroinvertebrates of Clover Lake, Lake Merreti and Lake Woolpolool resulted in 86, 121 and 106 taxa being identified in the three wetlands, respectively.

Two species of freshwater mussel occur in the wetland complex. The River Mussel *Alathyria jacksoni* is typical of moderate, to fast-flowing, channels, including the River Murray channel and the larger anabranches. The Floodplain Mussel *Velesunio ambiguus* prefers slow-flowing and still-water habitats, including billabongs, backwaters and impounded areas of the main channels. The River Snail *Notopala hanleyi* was formerly common in flowing-water habitats within the Site in pre-regulation times well before listing, but has virtually disappeared in South Australia except for populations surviving in a few irrigation pipeline systems, where they are an occasional pest.

The Murray Crayfish (*Euastacus armatus)* was formerly common in flowing-water habitats within the site in pre-regulation times well before listing, but now is virtually extinct in South Australia. This may be due to river regulation causing a substantial reduction in its preferred running water habitats. The smaller Yabbie

(*Cherax destructor*) is common throughout the Site's wetlands, except in fast-flowing water.

The Site supports 16 native fish species within the Murray-Darling Basin. A recent review has highlighted that Freshwater Catfish, Murray Hardyhead, Silver Perch, Trout Cod, and Southern Pigmy Perch should be regarded as endangered in South Australia whereas Flyspecked Hardyhead and Murray Cod should be regarded as vulnerable. Significant populations of exotic fish are also present within the Riverland Ramsar Site and these species include Eastern Gambusia, European Carp and Goldfish. Redfin and other exotic species may be expected in the region but have not been recorded in published reports.

Key Actual or Potential Threats to the Site

A summary of the threats include:

- Altered flow regime;
- Climate change, particularly synergies between decreased rainfall and increased evaporation;
- Salinity;
- Very high sedimentation rates for wetlands;
- Elevated and altered groundwater regime;
- Obstructions to fish passage and desnagging;
- Grazing pressure;
- Pest flora and fauna; and,
- Human access and motorised recreation.

Altered hydrology is the major threat to the ecological character of the Site. The Site's hydrology can be separated into pre-regulation and post-regulation periods:

In pre-regulation times, the river and floodplain experienced highly variable flows. High flows were cool, turbid and fast flowing, generally occurring in spring and early summer, gradually changing at end of summer to low flows which were warm, clear and slow moving during autumn and winter. There was a marked variation between years and cease-to-flow periods occurred during droughts with some water bodies contracting to saline pools fed by saline groundwater. Local anabranches formerly flowed only during floods or high flows and floodplain inundation (and the refilling of disconnected wetlands) determined by flood magnitude, proximity to the river channel and local topography.

In post-regulation times, the river and floodplain has experienced significant changes to the seasonal nature of flow regime, including permanent base flows, leading to permanent inundation of connected wetlands, and also delay in flood initiation and a reduction in flood duration. There has been a reduction in the

frequency of small to moderate sized floods, leading to reduction in the moderate sized overbank flow events that covered large portions of the Site. There has been a reduced recharge of local groundwater ('freshwater lens') in semi-permanent wetlands, leaving insufficient water for trees. The river level has been raised by 3m, which has impacts that have led to permanent inundation of some ephemeral wetlands, saline groundwater intrusion into anabranches and floodplain, causing tree stress.

Within the post-regulation period, in the time since listing, the Site has experienced a major drought (or change of climate). This has resulted in an exacerbation of many of the impacts caused by regulation, including:

- further reduction (absence) of flooding;
- further reduction of recharge of ground water;
- exposure of sulphides which may release acid (e.g. at Tareena Billabong); and,
- greater salinity impacts due to decreased flushing of salts from the soil.

Limits of Acceptable Change - Services

Wetland of international significance (& part of Riverland Biosphere Reserve) - The short-term and long-term limits of acceptable change should both be 'no loss of any listing criteria'.

Supports populations of rare, endangered and threatened species (State & National) - Short and long term limits of acceptable change should be no loss of any rare or listed species of flora and fauna.

Provision of remnant lower River Murray floodplain habitat and species - The short term limits of acceptable change should be: no loss of any rare species of flora over any time period and no loss of any vegetation community type, excluding seasonal variations and natural annual variations. The long-term limits of acceptable change for both flora and fauna should be (a) no loss of any rare or threatened species of flora or fauna; (b) no net reduction in populations of native bird, fish, mammal, mollusc, macrocrustacean, reptile or amphibian fauna over any 10 year period; and (c) no loss of more than 20% of any vegetation type over the site as a whole within any 10 year period.

Diverse and abundant waterbirds Part 1 – Long-term limits of acceptable change should be: no loss of any rare or threatened waterbird species; and no net reduction in waterbird populations (rare, threatened or migratory) over any rolling 10 year period.

Diverse and abundant waterbirds Part 2 - Long-term limits of acceptable change should be: no loss of any rare or threatened waterbird species; and no net reduction in waterbird populations over any rolling 10 year period.

Diverse fish and invertebrate fauna - Long-term limits of acceptable change should be: no loss of any rare or threatened fish and invertebrate species; and no net reduction in fish and invertebrate populations over any rolling 10 year period.

High diversity and mosaic of both terrestrial and aquatic habitats - The short term limits of acceptable change should be no loss of any habitat type, excluding seasonal variations and natural annual variations. No further death of trees (based on CSIRO predictions for 2003) and no increase in the area of unhealthy trees should occur in any two year period. The long term limits of acceptable change should be no loss of more than 20% of any habitat type, over the site as a whole (i.e. diversity and mosaic must be maintained).

Limits of Acceptable Change – Components and Processes

The hydrological requirements for survival and recruitment of vegetation communities were used to derive the limits of acceptable change. The short term limits of acceptable change for the hydrologic regime are presented in Table E1 and long term Limits of acceptable change are presented in Table E2 below. These limits define the conditions required to support the diverse range of floodplain habitat which is a critical component of the Site's ecological character. In summary, appropriate management of the Site's hydrologic regime should form the first step in the management of the Site's ecological character.

Table E1: Required hydrologic regime: for survival (=short-term LAC))

Vegetation Community	Recurrence Interval	Duration	Timing	Magnitude	Time Between Events
Aquatic – permanent	Annual (watercourses) 1 in 2years (Billabongs and Swamps)	Permanent	Permanent	3GL/day (watercourses) 26GL/day (for Billabongs and Swamps)	0 years (watercourses) 1 Year (for Billabongs and Swamps)
Aquatic – semipermanent	1 in 2years	3-6 months	Spring/ Summer	40GL/day	1 Year
Fringing aquatic reed & sedge	1 in 2years	6 months	winter – spring/early summer	25 – 30GL/day (adjacent to channel) 45 – 60GL/day (on low relict meander plain)	1 – 2 years if well established
River Redgum forest (Flood Dependent Understorey)	1 in 3 years	4 – 7 months	winter – spring	50GL/day (for approx 1/3 of this veg comm.); 80GL/day (for approx 80% of this veg. comm.)	2 years

Vegetation Community	Recurrence Interval	Duration	Timing	Magnitude	Time Between Events
Lignum shrubland	1 in 3-10 years; more frequently in saline soils (>1.5 mS cm^{-1})	6 months (possibly as low as 3 months)	Unknown (possibly summer)	50 GL/day will reach 1/3 of community; 70 GL/day will reach 2/3)	Complete drying required between floods to enable cracking and aeration of soils
River Redgum woodland (Flood Tolerant Understorey)	1 in 3 years	4 – 7 months	winter – spring	50GL/day (for approx 1/3 of this veg comm.); 70GL/day (for approx 2/3 of this veg. comm.)	2 years
River saltbush chenopod shrubland	1 year in 30	2 – 4 months	not critical	60GL/d (for approx 1/4 of this veg comm.); 300GL/d (for majority of this veg. comm.)	Unknown (> 2 years)
Low chenopod shrubland	1 year in 30	2 – 4 months	not critical	70GL/d (for approx 1/2 of this veg comm.); 300GL/d (for majority of this veg. comm.)	Unknown (> 2 years)
Samphire low shrubland	1 in 3-10 years; more frequently in saline soils (>1.5 mS cm^{-1})	6 months (possibly as low as 3 months)	Unknown (possibly summer)	50-60 GL/day will reach 60% of community; 80 GL/day will reach 80%)	Unknown
Black Box woodland	1 year in 30	2 – 4 months	not critical	70GL/d (for approx 20% of this veg comm.); 100GL/d (for approx 40% of this veg comm.); 300GL/d (for majority of this veg. comm.)	30years

Table E2: Required hydrologic regime: for recruitment (= long-term LAC)

Vegetation Community	Recurrence Interval	Duration	Timing	Magnitude	Time Between Events
Aquatic – permanent	Annual (watercourses) 1 in 2years (Billabongs and Swamps)	Permanent	Permanent	5GL/day (watercourses) 40GL/day (for Billabongs and Swamps)	0 years (watercourses) 1 Year (for Billabongs and Swamps)
Aquatic – semipermanent	9 in 10years	Long duration, Frequently not drying out at all	Aug/Sep to Jan/Feb	40GL/day	1 Year

Vegetation Community	Recurrence Interval	Duration	Timing	Magnitude	Time Between Events
Fringing aquatic reed & sedge	1 in 1 – 2 years (nearly every year)	3 months (summer) or 6 months (winter), to enable seedlings to establish	Shallow inundation for germination, deeper water (10 – 15 cm) for seedling establishment	25 – 30GL/day (adjacent to channel) 45 – 60GL/day (on low relict meander plain)	6 - 9 months
River Redgum forest (Flood Dependent Understorey)	7 – 9 years in 10	120 days	spring	50GL/day (for approx 1/3 of this veg comm.); 80GL/day (for approx 80% of this veg. comm.)	Serial inundation 2 to 3 years in succession to optimise recruitment probability
Lignum shrubland	1 in 2-8 years; more frequently in saline soils (>1.5 mS cm^{-1})	120 days	Unknown (possibly summer)	50 GL/day will reach 1/3 of community; 70 GL/day will reach 2/3)	Complete drying required between floods to enable cracking and aeration of soils
River Redgum woodland (Flood Tolerant Understorey)	7 – 9 years in 10	120 days	spring	50GL/day (for approx 1/3 of this veg comm.); 70GL/day (for approx 2/3 of this veg. comm.)	Serial inundation 2 to 3 years in succession to optimise recruitment probability
River saltbush chenopod shrubland	1 year in 10	Long enough to saturate surface soil, with slow recession	Unknown	60GL/d (for approx 1/4 of this veg comm.); 300GL/d (for majority of this veg. comm.)	Unknown (> 2 years)
Low chenopod shrubland	1 year in 10 (2-3 years in succession every 30 years)	Long enough to saturate surface soil, with slow recession	Unknown	70GL/d (for approx 1/2 of this veg comm.); 300GL/d (for majority of this veg. comm.)	Unknown (> 2 years)
Samphire low shrubland	1 in 2-8 years; more frequently in saline soils (>1.5 mS cm^{-1})	120 days	Unknown (possibly summer)	50-60 GL/day will reach 60% of community; 80 GL/day will reach 80%)	Unknown

Vegetation Community	Recurrence Interval	Duration	Timing	Magnitude	Time Between Events
Black Box woodland	1 year in 10 (2-3 years in succession every 30 years)	Long enough to saturate surface soil, with slow recession	Unknown	70GL/d (for approx 20% of this veg comm.); 100GL/d (for approx 40% of this veg comm.); 300GL/d (for majority of this veg. comm.)	Unknown (<30years)

Changes in Ecological Character since listing

A decline in the health of the tree cover of the Site since listing represents a clear change in ecological character. The vegetation and habitat values of the Site have changed significantly due to a decrease in flood events over the past two decades. A River Redgum survey conducted in South Australia in February 2003 found that approximately 80% of the survey sites contained trees that were stressed to some degree, and 20-30% of them were severely stressed. In the area between Wentworth and Renmark (which includes the Riverland Site), more than half of all trees, including River Redgums, were stressed or dead. It is important to note that, at the time of listing, the floodplain vegetation of the Site was already experiencing significant stress, and that the continuing and increasing stress and deterioration of the site will require specific actions to maintain its ecological integrity.

A discussion of changes in vegetation and habitat values should consider not only the current condition, but also the trajectory of that condition. Assuming no intervention, the deterioration trend extends to trees currently in moderate health, which are predicted to decline further into poor health, and trees currently in poor health, which are predicted to decline further and die. Even under the more optimistic scenarios, there will be significant loss of growing trees and a commensurate decline in their role in aquatic ecology (provisions of shading, allochthonous inputs from riparian vegetation [insects, leaves, etc] and large woody debris). The current situation of only 24% of trees considered to be healthy (DEH 2003) is likely to be a threshold beyond which permanent damage to the Site occurs. Further, River RedGum and Black Box are keystone species within the Site's ecosystem and, therefore, once their populations drop to unsustainable levels the entire system will be impacted.

Knowledge Gaps

The key knowledge gaps for the Site include systematically collected data for most of the major components. The exception to this is the vegetation component, which has been surveyed in a number of studies. Natural variability is an important aspect of the components and processes that requires information. Several components (e.g. hydrology, understorey vegetation, water quality, fish, amphibians, reptiles,

crustaceans, water birds) have been monitored as part of studies assessing benefits of management actions at the Site. However, these need to be evaluated in terms of whole-of-Site monitoring, natural variation, and their use for assessing Site condition in relation to maintaining ecological character.

Data should be gathered using standard methods that allow derivation of a 'point-in-time' baseline which can be compared to future monitoring programs. Therefore the initial sampling strategy must be designed in a way that is cognisant of repeatability. The data should also be gathered using approaches and methods that allow comparison with other data sets within the site, the Murray-Darling Basin, and the rest of Australia.

Key Site Monitoring Needs

The monitoring needs of the site should focus on the limits of acceptable change for the maintenance of the Site's ecological character. The major threats and the limits of acceptable change drive the monitoring needs and prioritisations. Priorities for monitoring were established by considering the highest value components which face the highest threat. Monitoring should include:

- two yearly tree health assessment using infrared satellite data;
- five yearly on-ground vegetation surveys including tree health and wetland type and fauna surveys (fauna surveys to include both aquatic and terrestrial species);
- annual bird observer counts of waterbirds;
- five yearly on-ground waterbird survey (as part of integrated sampling vegetation and fauna surveys (fauna surveys to include both aquatic and terrestrial species);
- five yearly fish and macro-invertebrate survey; and,
- the use of AUSRIVAS and Signal scores to benchmark diversity, abundance and community health of macro-invertebrate populations (this will need to be added to the 2008 survey).

Communication, Education and Public Awareness (CEPA) Messages

The primary message that needs to be communicated to relevant stakeholders is:

"An Ecological Character Description (ECD) of the Riverland Ramsar Site at the time of listing in 1987 has been prepared. The Site is listed against 8 of the 9 Ramsar listing criteria. This site is a complex riverine wetland ecosystem which provides habitat for important and nationally threatened species. The ECD documents past and current conditions, determines approaches to assess changes in condition, and identifies potential threats to the wetland's condition. The ECD identifies appropriate management considerations for future management planning and also identifies critical information gaps for management. Without active management intervention the ecological character of the site is under threat"

The stakeholders of the Riverland Ramsar Site are numerous and the messages required for each may be different, especially as part of management planning. The stakeholders for the site have been separated into four groups, according to their role and interest in the site. Initially, however, a combined set of messages, relevant to the ECD can be used to communicate the importance of the site, why it was listed, the threats to the site and future actions required.

1. INTRODUCTION

This document is an *Ecological Character Description* (ECD) for the Riverland Ramsar Site (hereinafter referred to as 'the Site'). It contains information about:

- Geographic and administrative details;
- the Site's ecological character (including components, processes, benefits and services) at the time of Ramsar listing (1987) and currently;
- gaps in knowledge of the Site and issues for management;
- actual or potential threats;
- changes that have occurred since 1987 or are currently occurring;
- site monitoring needs and triggers for management action; and,
- communication, education and public messages to facilitate management and planning.

1.1. Purpose

Ecological Character Descriptions of Ramsar listed sites address general requirements as part of the Ramsar process, and objectives based on intrinsic social, cultural and environmental features. The objectives of this ECD are:

1. To assist in implementing Australia's obligations under the Ramsar Convention, as stated in Schedule 6 (Managing wetlands of international importance) of the *Environment Protection and Biodiversity Conservation Regulations* 2000 (Commonwealth of Australia):

   a) to describe and maintain the ecological character of declared Ramsar wetlands in Australia; and

   b) to formulate and implement planning that promotes:

      i) conservation of the wetland; and

      ii) wise and sustainable use of the wetland for the benefit of humanity in a way that is compatible with maintenance of the natural properties of the ecosystem.

2. To assist in fulfilling Australia's obligation, under the Ramsar Convention, to advise, at the earliest possible time, if the ecological character of any declared wetland in its territory has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference.

3. To supplement the description of ecological character in the Ramsar Information Sheet submitted under the Ramsar Convention for each listed wetland and, with

the Ramsar Information Sheet, form an official record of the ecological character of the Site.

4. To assist the administration of the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*, particularly:

   a) to determine whether an action has, will have or is likely to have a significant impact on a declared Ramsar wetland in contravention of sections 16 and 17B of the EPBC Act; or

   b) to assess the impacts that actions referred to the Minister under Part 7 of the EPBC Act have had, will have or are likely to have on a declared Ramsar wetland.

5. To assist any person considering taking an action that may impact on a declared Ramsar wetland to decide whether to refer the action to the Minister under Part 7 of the EPBC Act for assessment and approval.

6. To inform members of the public interested in declared Ramsar wetlands to understand and value the wetlands.

An ECD also forms the basis for understanding and managing the listed wetland site, including information required to:

- design programs for monitoring its condition,
- determine methods and approaches for assessing changes to its condition,
- identify potential threats and impacts, and evaluate risks,
- devise efficient and appropriate management plans for ongoing protection of the wetland, and
- identify critical gaps in knowledge, and a means to address these gaps.

The process for preparing an ECD should engage stakeholders, laying the foundations for alignment of goals and agreed management outcomes. The Riverland Site, with its array of significant features and potential for impacts of upstream and wider catchment actions, presents a situation where stakeholder involvement is vital.

1.2. Site Details

Introductory details are presented in Table 1.1.

The Site was first listed in 1987 against the (then) criteria 1a, 1b, 1c, 3b of the Ramsar Convention. Following revision of the criteria in 1999, the Site is now listed under criteria 1-8 of the revised convention (Refer Section 2).

Table 1.1: Introduction to the Riverland Ramsar Site

Ramsar Site	Riverland
General Location	Adjacent to the River Murray between Renmark, South Australia and the Victorian and New South Wales state borders.
Area	30,615 ha
Geographical Coordinates	North-east corner – Lat: 33° 55' 49.7" S; Long: 141° 00' 9.7" E South-east corner – Lat: 34° 01' 142"S; Long: 140° 00' 9.9" E Southern central point- Lat: 34° 09' 59.3"S; Long: 140° 46' 45.4"E
Date of Listing	1987 (Lake Woolpolool area was added in 2007)
Date Used for Description	1987
Original Description Date	March 2008 (this document is the first description), Revised May 2009.
Version Number	2
Status of Description	First description, following site visit and consultation with stakeholders
Compiler's Name	Lance Lloyd (Lloyd Environmental Pty Ltd) lance@lloydenviro.com.au Peter Newall (Consulting Aquatic Ecologist) p.newall@bigpond.com
Ramsar Information Sheet	Ramsar Information Sheet: Riverland (last updated May 2009) Ramsar sites information service, Ramsar sites database: http://ramsar.org/ris/key_ris_index.htm Ramsar Site No.: 377 Wetlands International Site Reference No: 5AU029
Management Plan	A number of catchment and local plans regulate or promote protective actions throughout and/or adjacent to the Site. A management plan is being developed for official approval.
Responsible Management Authority	Department for Environment and Heritage Regional Conservation Directorate, Murraylands Region 28 Vaughan Terrace, Berri SA 5343, Australia Ph: (61 8) 8595 2111 Director of National Parks (for Calperum Block) Department of the Environment, Water, Heritage and the Arts GPO Box 787, Canberra ACT 2601 Australia Ph: (61 2) 6274 1111

1.3. Date of Description

This ECD has been compiled between September 2007 and July 2009, approximately 20 years after the Riverland Site was first listed, but is required to reflect conditions at the time of listing. The ECD utilises studies and reports undertaken at various times, but these have been interpreted to represent conditions at the time of listing.

This ECD was prepared subsequent to a boundary revision (dated 11 September 2007) designed to:

- excise major non-wetland areas dominated by agriculture; and,
- include a major wetland area (Lake Woolpolool, a seasonal saline lake).

The removal of the non-wetland areas does not impact on the ecological character of the Riverland Ramsar Site, whereas the inclusion of Lake Woolpolool has enhanced the waterbird and vegetation diversity of the site (RIS in prep). The revised boundary was incorporated into a revised RIS (RIS in prep) which has been approved by the Australian Government (11 September 2007), and the Ramsar Convention on Wetlands Secretariat has been notified.

In this ECD, Lake Woolpolool is assumed to be part of the Ramsar Site, and its effective time of listing is taken as 1987. Further, the non-wetland agricultural area excluded as part of the boundary change is not part of the ECD.

1.4. Relevant Treaties, Legislation or Regulations

This section describes treaties, legislation and regulations relevant to the protection of the Site, although most were enacted subsequent to 1987.

1.4.1 International treaties and strategies

Ramsar Convention

The *Convention on Wetlands of International Importance especially as Waterfowl Habitat* (Ramsar, Iran, 1971), known as the Ramsar Convention, is an inter-governmental treaty dedicated to the conservation and sustainable use of wetlands (Environment Australia 2001). Australia was one of the first 18 countries to sign the Convention in 1971, and its obligations to protect and maintain the ecological character of its Ramsar sites are recognised in the Commonwealth EPBC Act, described in Section 1.4.2.

The Ramsar Secretariat maintains a *List of Wetlands of International Importance* that includes 65 Australian sites as at September 2007 (c. 7.5 million ha). Criteria to determine international importance are set out by the Ramsar Secretariat at http://www.ramsar.org/key_guide_list2006_e.htm#V. They include considerations of representative, rare or unique wetland type, the presence of vulnerable, rare or threatened species or ecological communities, diversity of particular biogeographic regions, supporting critical life stages of plant or animal species, the support of large waterbird populations, significance to native fish populations and support for 1% or more of wetland dependent organisms.

Ramsar wetlands and the EPBC Act

Under the EPBC Act, a person is required to obtain an approval for any action that has, is likely to, or will have a significant impact on a matter of National Environmental Significance, which includes the ecological character of a wetland. Actions that would affect the ecological character of wetlands include:

- areas of wetland being destroyed or substantially modified;
- a substantial and measurable change in the hydrological regime (for example, a change to ground-water, or to the volume, timing, duration and frequency of surface-water flows);
- any change that might affect the habitat or life cycle of native species dependent on the wetland;
- a substantial and measurable change in the physico-chemical status of the wetland (for example, a change in salinity, pollutants, nutrients or water temperature which may affect biodiversity, ecological integrity, social amenity or human health); and,
- an invasive species potentially harmful to the wetland community.

The EPBC Act also sets standards for managing Ramsar wetlands through the *Australian Ramsar Management Principles*, established as regulations under the Act (Environment Australia 2001).

International conventions on migratory species

Australia is a signatory to three international conventions on migratory species:

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

JAMBA and CAMBA are bilateral agreements between the governments of Japan and Australia and China and Australia, seeking to protect migratory birds in the East Asian – Australasian Flyway. The two agreements list terrestrial, water and shorebird species (most are shorebirds) that migrate between Australia and the respective countries. They require parties to protect migratory birds from 'take or trade', except under limited circumstances, to protect and conserve habitats, exchange information and build cooperative relationships. The JAMBA agreement also includes specific provisions for conservation of threatened birds (DEWHA 2009a).

ROKAMBA, signed in Feb 2006, is a bilateral agreement similar to JAMBA and CAMBA. The agreement obliges its Parties to protect bird species which regularly migrate between Australia and the Republic of Korea, and their environment. An annex to ROKAMBA contains a list of species or subspecies of birds for which there is reliable evidence of migration between the two countries.

1.4.2 Commonwealth Legislation and Policy

The principal Commonwealth environmental legislation that relates to wetland conservation is the EPBC Act. Under the Act, any actions that have, or are likely to have, a significant impact on a matter of National Environmental Significance requires approval from the Commonwealth Environment Minister.

Seven matters of national environmental significance are identified in the Act:

- World heritage properties;
- National heritage places;
- Wetlands of international importance (Ramsar wetlands);
- Threatened species and ecological communities;
- Migratory species;
- Commonwealth marine areas; and,
- Nuclear actions (including uranium mining).

The matters relevant to the Riverland Site are Ramsar listing, nationally-threatened species and ecological communities and migratory species.

EPBC Act and protection of species listed under international conventions

The species that are the subject of the agreements or conventions are listed as 'migratory species', a matter of National Environmental Significance under the EPBC Act. Any action that may affect these species requires the Commonwealth Minister for the Environment to decide whether the action will, or is likely to, have a significant impact on the listed species, and whether the action will require approval under the EPBC Act. If this approval is required, an environmental assessment is carried out. The Minister decides then whether to approve the action, and what conditions (if any) to impose.

1.4.3 State Legislation

Pertinent South Australian legislation includes the:

- Aboriginal Heritage Act 1988 – protects sites and artefacts;
- Development Act 1993 – controls development;
- Environmental Protection Act 1988 – controls pollution and waste disposal;
- Fisheries Act 1982 – protects and manages state fisheries;
- Harbors and Navigation Act 1993 – controls boat access and use;
- National Parks and Wildlife Act 1972 – protects and manages conservation sites and native flora and fauna;
- Native Vegetation Act 1991 – controls clearing of native vegetation, Heritage Agreements;
- Pastoral Land Management and Conservation Act 1989 – manages pastoral land;

- River Murray Act 2003 – promotes integrated management of river resources; and,
- Natural Resource Management Act 2005 – integrates regional natural resource management.

2. DESCRIPTION OF THE SITE

2.1 Setting

The Riverland Ramsar Site is on the floodplain of the River Murray, between Renmark, South Australia, and the state borders with Victoria and New South Wales (Figure 2.1) (RIS in prep.). As the principal river of the Murray-Darling Basin, the Murray flows 2,530 km from its source in south-eastern New South Wales to its mouth at Encounter Bay, South Australia.

The Basin has an area of 1.073 million km^2 (14% of mainland Australia), including four states and one federal territory. Much of the region is flat, with extensive aeolian and alluvial deposits of sands, silts and clays. An outcrop of folded meta-morphic rocks provides slightly-elevated relief in the north-west, and the high metamorphic and igneous rock outcrops of the Great Dividing Range from the eastern and southern borders (Murray-Darling Basin Ministerial Council 1987; RIS in prep.).

The River Murray has five geomorphological tracts (Mackay & Eastburn 1990):

The Headwaters: a tract extending about 450 river km from the source. The catchment is <2% of the Basin area, but contributes nearly 40% of the discharge.

The Riverine Plains: a flat, 800 river km tract of river and lake deposits where the River Murray flows in shallow, branching, meandering channels.

The Mallee Trench: an 850 river km plain of marine origin, crossed by the river in a well-defined, incised channel.

The Mallee Gorge: a 350 river km channel flanked by steep limestone cliffs.

The Lakes and Coorong: including the terminal lakes, Lake Alexandrina and Albert, and the Coorong. This area also is a Ramsar site.

The Riverland Ramsar Site is located in the 'Mallee Trench', which begins near Swan Hill, Victoria, and extends to Overland Corner, South Australia.

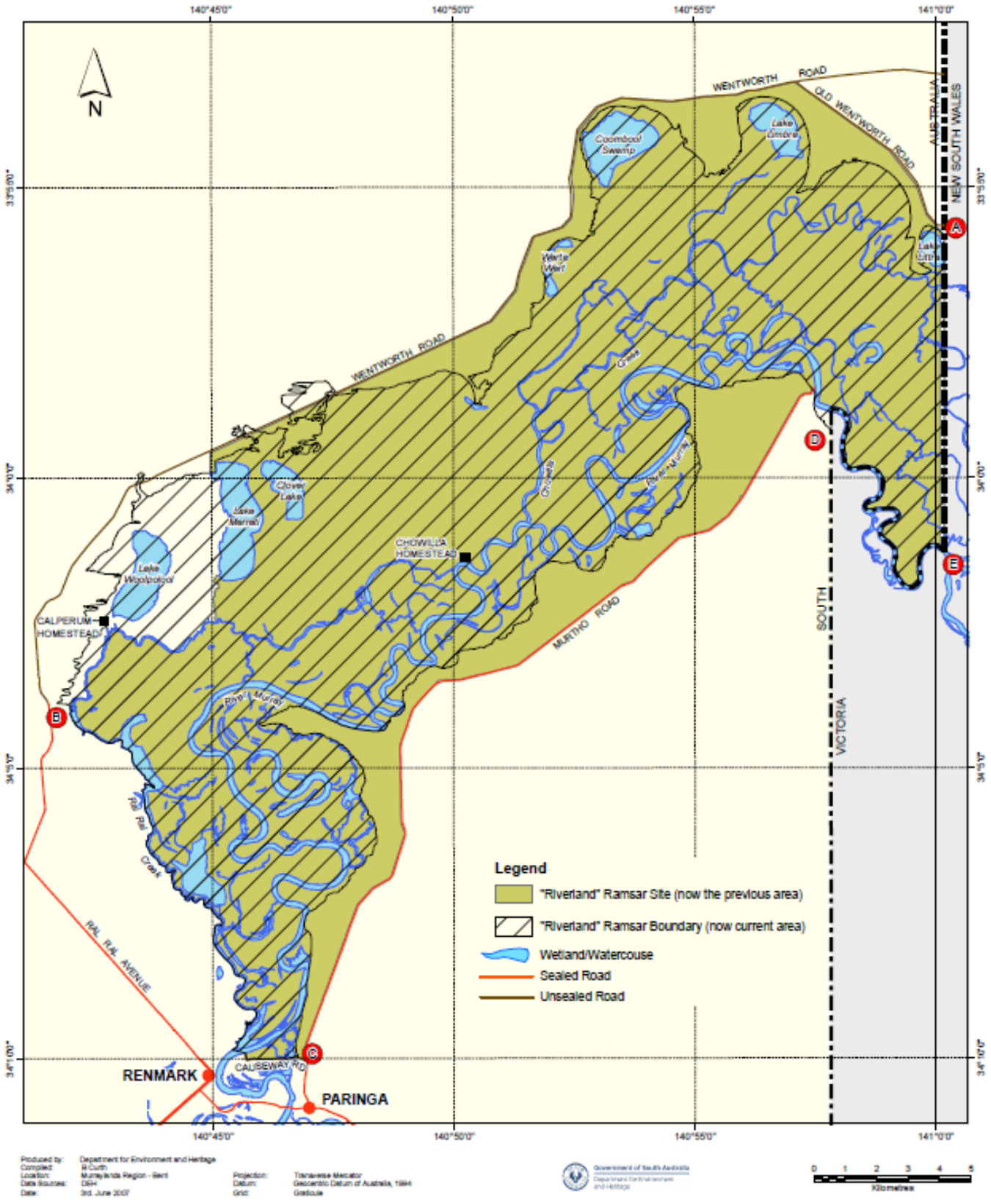


Figure 2.1: Map of Ramsar Site (with boundary change gazetted on 11/09/2007)

The Site is situated in an ancient riverine plain with alluvial fans composed of unconsolidated sediments with evidence of former stream channels. The River Murray and Murrumbidgee River and their major tributaries, the Lachlan and Goulburn Rivers, flow westwards across this plain. Vegetation consists of River Redgum and Black Box forests, Box woodlands, saltbush shrublands, extensive grasslands and swamp communities (Environment Australia 2000).

2.2 Riverland Ramsar Site

The whole of the Riverland Ramsar site is in the Riverland Biosphere Reserve (http://www.riverland.net.au/~bbwaters/page4.html). The Site contains three generally recognised land components or 'blocks' – Murtho, Calperum, and Chowilla – defined primarily on the basis of historical ownership (see Figure 2.2). The Site blocks encompass only parts of greater land components. In particular, the Calperum and Chowilla blocks within the Site only contain fractions of the larger Calperum Station and Chowilla Reserves, respectively.

2.2.1 Murtho Block

The Murtho block of the Site is the southern-most section and for the purposes of this document contains the land within the River Murray National Park (Bulyong Island) and Murtho Forest Reserve, and the adjacent sections of private land to the east, within the Site (see Figure 2.2 for a map of land tenure of the Site).

2.2.2 Calperum Block

The Calperum block is the middle portion of the Site that intersects with the Calperum Station. The vast majority (approximately 97 percent of the 245,800 ha) of the Calperum Station is outside the Riverland Ramsar Site, leaving approximately 8,500 ha within the site (Parks Australia 2005). Within this 8,500 ha, there is approximately 20 km of River Murray frontage and many more kilometres of anabranch and creek frontage, including the Ral Ral Creek Anabranch (Figure 2.3).

2.2.3 Chowilla Block

The Chowilla block of the Site intersects with most of the Chowilla Game Reserve, to the south of the Chowilla Regional Reserve. The two Chowilla reserves are run by the DEH and also form part of the much larger Riverland Biosphere Reserve. This part of the Site is also part of the Chowilla Floodplain and Lindsay-Wallpolla Living Murray Icon site.

While the different blocks are separated on the basis of human historical, rather than environmental, features, there are some habitat differences between the blocks. Within the Riverland Ramsar Site, the Chowilla block contains River Redgum forest, River Redgum woodland, Black Box woodland and chenopods shrublands, with the Murtho block more similar to the moister, low elevation parts of Chowilla block. The Calperum block contains many wetlands (some of which are permanent due to river regulation) and also dryer, slightly more elevated parts similar to areas of Chowilla.

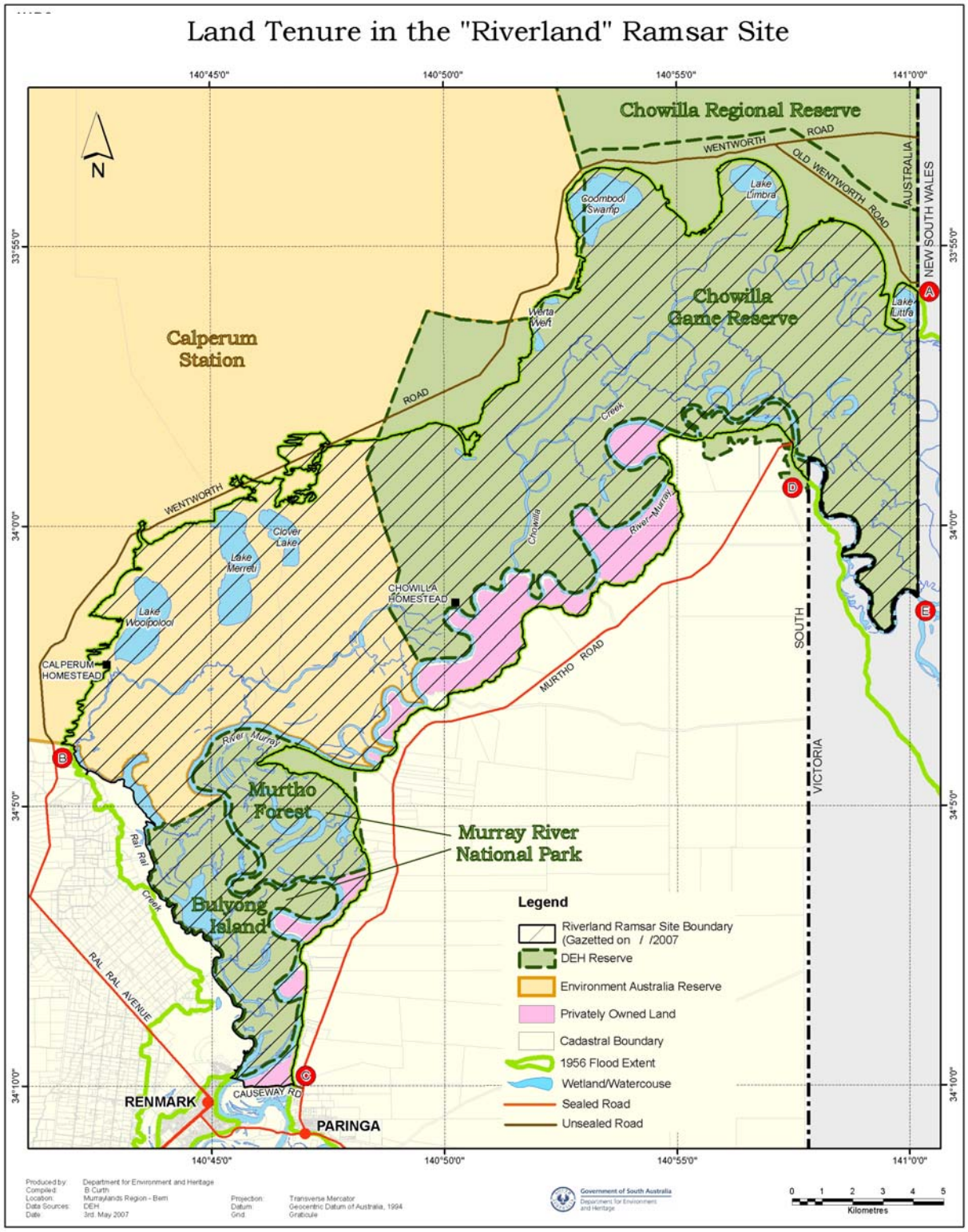


Figure 2.2: Land tenure at the Riverland Ramsar Site, shows the three main site blocks: Calperum, Chowilla and Murtho.

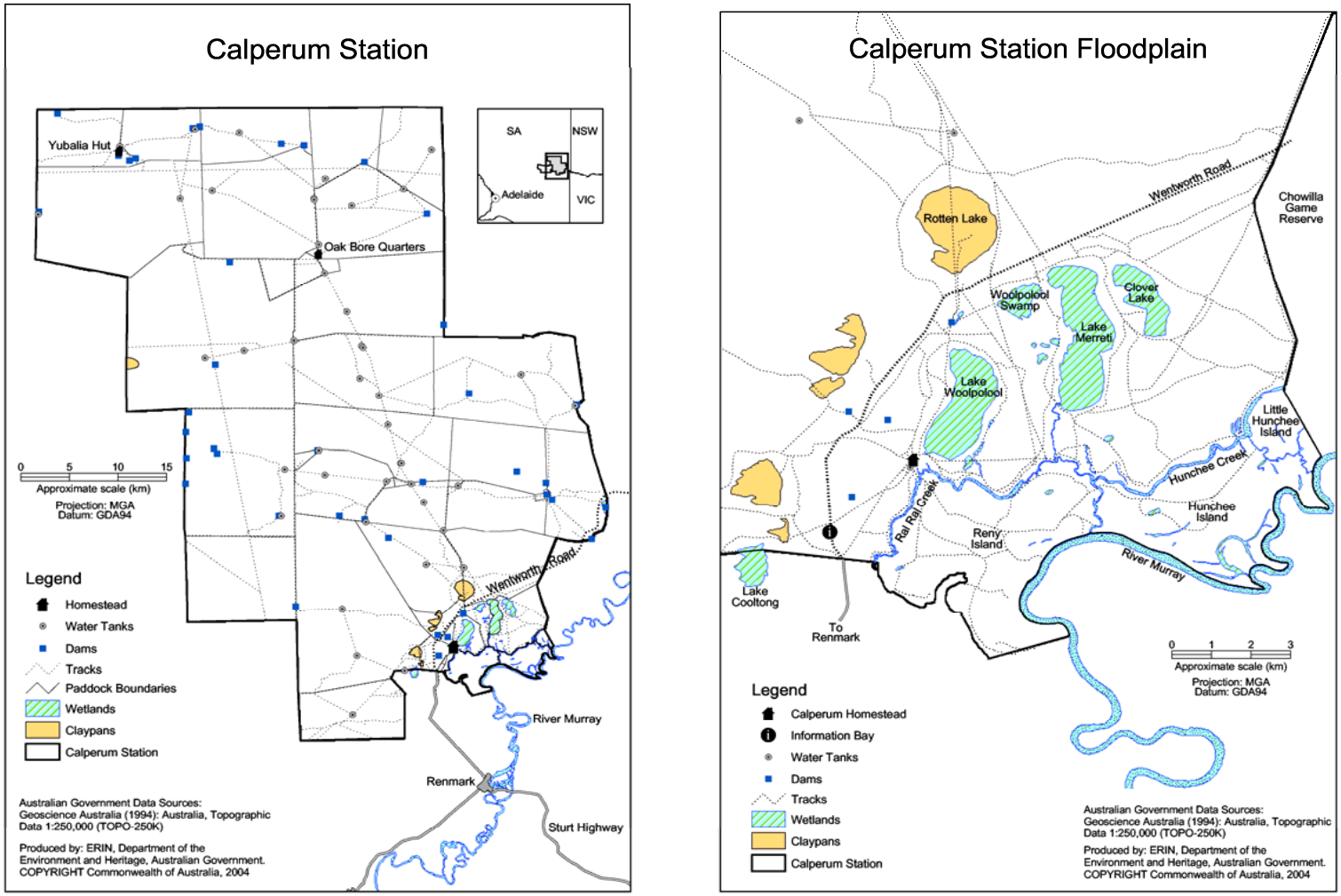


Figure 2.3: Calperum Station showing the floodplain habitat

2.3 Overview of Ramsar Site

The Site boundary follows the 1956 floodline west from the New South Wales border. It includes two major anabranch systems (Chowilla and Ral Ral Creeks) along an 80 km stretch of the River Murray, incorporating a series of creeks, channels, lagoons, billabongs, swamps and lakes. The total area is 30,615 hectares (Table 2.1, Figure 2.4).

Before construction of locks and weirs along the lower River Murray in 1922 to 1937, the River Murray in South Australia generally experienced highly variable flows. In spring and early summer the River was generally high, cool, turbid and fast flowing, gradually changing to become low, warm, clear and slow moving towards the end of summer. During drought, the flow would cease and saline pools would form through the interception of underlying saline groundwater (Sharley & Huggan 1995).

Since weir construction, the River and the main anabranch systems flow continuously and many wetlands are permanently inundated due to the river level having risen up to 3 m in the pools impounded by weirs at Locks 5 – 6. Regional saline groundwater (30,000 to 40,000 mg/L Total Dissolved Solids) now flows into the anabranch creeks. Up to 145 tonnes of salt per day can enter the Chowilla Anabranch system following a major flood compared to the steady background level of 43 tonnes per day, which is re-established after the effects of floods have passed (Sharley & Huggan 1995). Saline ground water mounds have formed beneath irrigated areas adjacent to the Riverland wetland e.g. the Renmark and Chaffey Irrigation Areas contribute approximately 34 tonnes of salt per day to the Ral Ral Anabranch (Woodward-Clyde 1999).

River regulation has greatly modified the frequency, height and duration of flows through the Riverland Site. Except in major floods, flow to South Australia is regulated through an agreement between the Murray-Darling Basin States/Territories and the Australian Government. Under the current water sharing rules, South Australia has a minimum 'entitlement' of 1,850 GL per year, although it did not receive entitlement flows in 2006, and did not receive full entitlement in 2007 or 2008 due to drought. Entitlement flows vary monthly, depending on demand for irrigation water and range from 7,000 ML/day or more in December-January to 3,000 ML/day in May-June. Significant overbank flow at the Site requires a flow greater than 50,000 ML/day. At least 80,000 ML/day is required to inundate half the floodplain and total inundation is achieved when flows reach 150,000 ML/day.

Wetland types and depths vary throughout the Site. Representative water depths are: main river 4-8 m; anabranch creeks 1-3 m; permanent wetlands <1-2 m and temporary wetlands 1-2 m. Since the construction of Locks 5-6 the river, main anabranches and many wetlands are permanently inundated, with little water fluctuation except during floods. For many temporary wetlands the reverse is true with areas receiving water less often and for less time than they did under unregulated conditions.

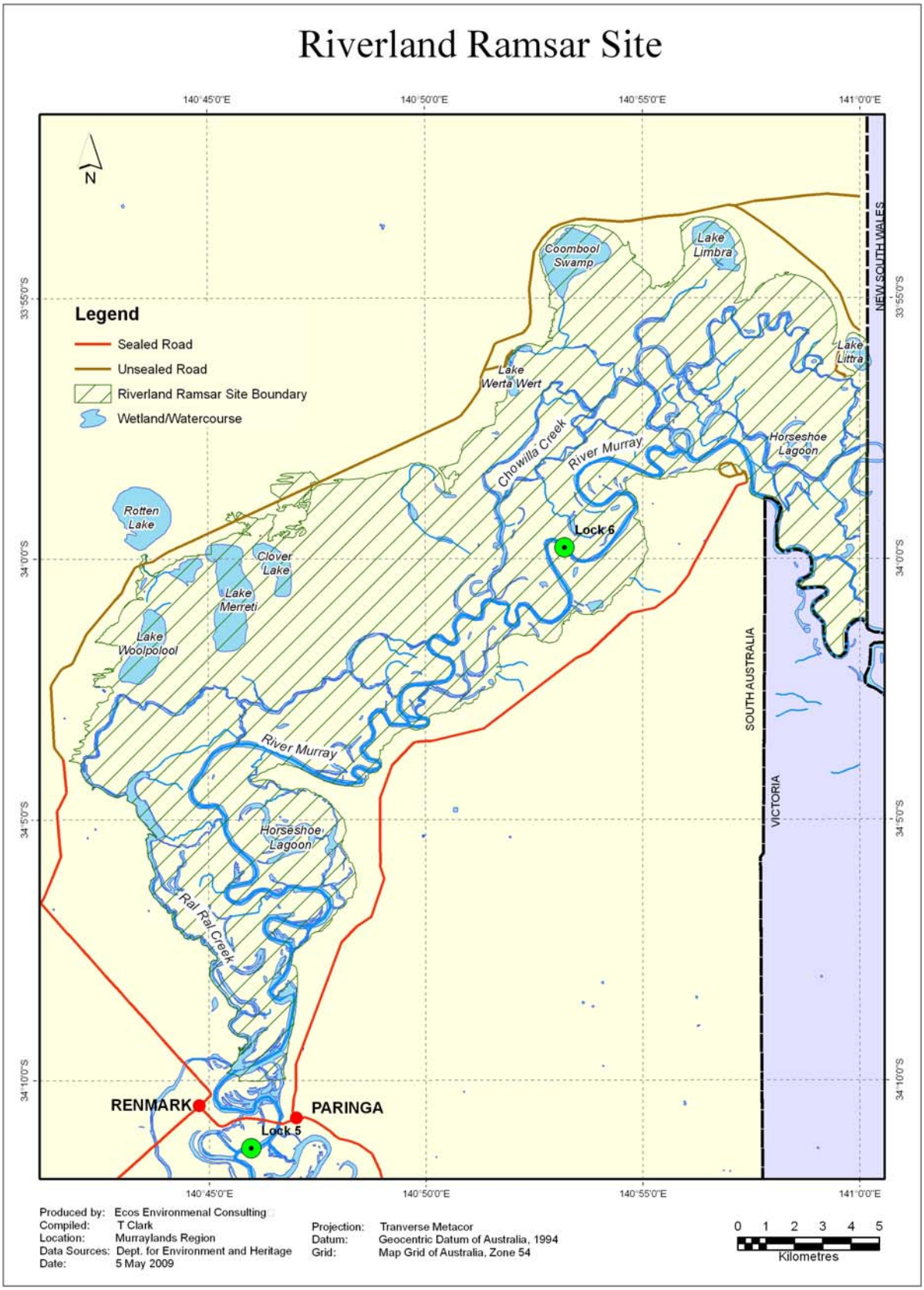


Figure 2.4: Map of major wetland sites within the Riverland Ramsar Site

In this overview section of the report, the Ramsar wetland types classification is used to identify and distinguish the types of wetland occurring in the Site. More locally-derived approaches of vegetation classification are presented in the section describing vegetation as a Site component (Section 3.2.6).

The Ramsar-defined wetland types that occur at the Site are displayed in Table 2.1, with associated landforms in the Riverland and some examples from within the Site. A map of these wetland types across the site is presented in Figure 2.5.

Table 2.1: Wetland types, areas, associated landforms and examples within the Riverland Ramsar Site

Code	Wetland Types	AREA (ha)	Associated Landforms	Examples within Riverland Ramsar Site
Xf	Freshwater, tree-dominated wetlands	4,032	scroll floodplain landform which supports River Redgum woodland	opposite Bunyip Reach and Nil Nil
M	Permanent rivers/streams/creeks	1,845	active floodplain channels	River Murray, Chowilla and Ral Ral Anabranch systems
P	Seasonal/intermittent freshwater lakes	770	(i) deflation basins; and (ii) lentic channels such as ancestral river oxbows	(i) Coombool Swamp and Lake Limbra; (ii) Punkah Island, Horseshoe Lagoon
O	Permanent freshwater lakes	535	(i) deflation basins; (ii) lentic channels such as ancestral river oxbows; and (iii) remnant channels	(i) Lake Merreti; (ii) Isle of Man; and (iii) Woolenook, Horseshoe Lagoon
Tp	Permanent freshwater marshes/pools	343	(i) scroll swales; (ii) slack water areas; (iii) discrete depositional basins; (iv) Interconnected depositional basin; (v) impounded wetlands; and (vi) miscellaneous floodplain depressions	(i) Nil Nil; (ii) Chowilla Anabranch; (iii) Pilby Creek complex; (iv) Bunyip Reach; (v) Whirlpool Corner; and (vi) Weila/Murtho Park
R	Seasonal saline/brackish lake	330	A deflation basin that was salinised in the 1950's due to land management practices	Lake Woolpolool
N	Seasonal/intermittent/irregular rivers/stream/creek	Not Available	lentic channels such as distributary channels and "crevasse" channels	Reny and Chowilla islands
Ts	Seasonal/intermittent freshwater marshes/pools on inorganic soils	Not Available	(i) discrete depositional basins; (ii) lentic channels such as remnant channels; and (iii) miscellaneous floodplain depressions	(i) Longwang Island; (ii) Brandy Bottle Waterhole; and (iii) Gum Flat

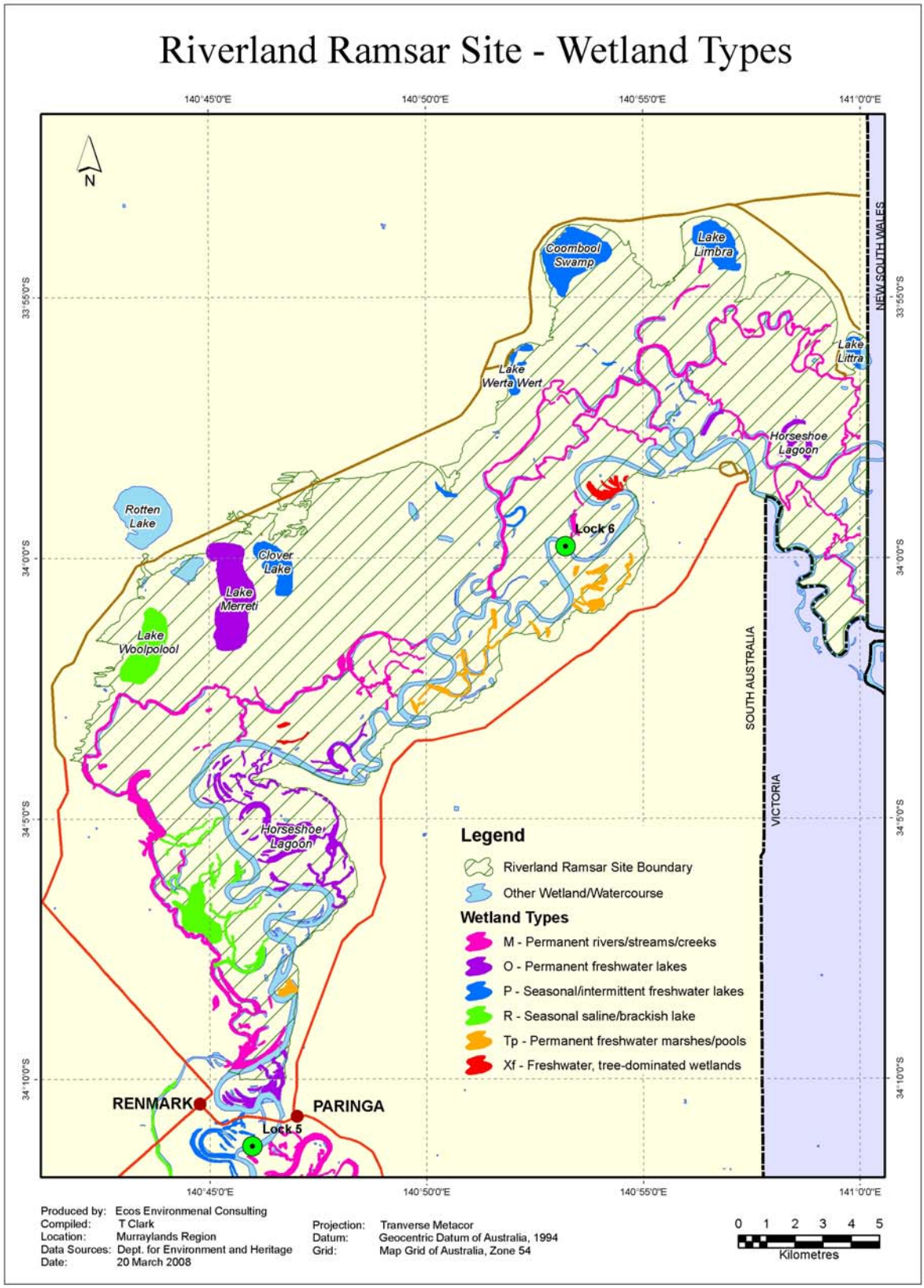


Figure 2.5: Wetland types within the Riverland Ramsar Site
(note: the main River Channel is also category M but is mapped light blue)

2.4 Ramsar Listing

The Site was originally listed in November 1987 against the (then) criteria 1(a), 1(b), 1(c), and 3(b), which states that "a wetland should be considered internationally important if:

> **1a** – It is a particularly good representative example of a natural or near-natural wetland, characteristic of the appropriate biogeographical region;
>
> **1b** – It is a particularly good representative example of a natural or near-natural wetland, common to more than one biogeographical region;
>
> **1c** – It is a particularly good representative example of a wetland, which plays a substantial hydrological, biological or ecological role in the natural functioning of a major river basin or coastal system, especially where it is located in a trans-border position
>
> **3b** – it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity".

In 1999 the Ramsar criteria were revised and, in 2006, the RIS for the Riverland Site also was revised. The Site is now listed under criteria 1 to 8 (Table 2.2).

Table 2.2: Ramsar Citeria under which the Riverland Ramsar Site is Listed

Group A: Sites containing representative, rare or unique wetland types	
Criterion 1:	A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate bioregion.
Group B: Sites of international importance for conserving biological diversity	
Criteria based on species and ecological communities	
Criterion 2:	A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.
Criterion 3:	A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.
Criterion 4:	A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
Specific criteria based on waterbirds	
Criterion 5:	A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.
Criterion 6:	A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

Specific criteria based on fish	
Criterion 7:	A wetland should be considered internationally important if 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.
Criterion 8:	A wetland should be considered internationally important if 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.

Criterion 1 (representative / rare / unique wetland type in appropriate biogeographic region)

The Site is located in the lower River Murray basin of the Murray-Darling Division (http://www.bom.gov.au/hydro/wr/basins/index.shtml). At the time of listing, the Site contained one of the only parts of the lower River Murray floodplain not used for irrigation (within the Chowilla Floodplain), preserving much of its natural character. This has led to the Chowilla Floodplain being regarded as an 'icon site' by the Murray-Darling Basin Commission, one of six such sites in the basin (http://thelivingmurray.mdbc.gov.au/iconsites).

The Site has also been noted to contain excellent regional representative examples of a major floodplain system within the the lower River Murray floodplain. As such, the Site is representative of a floodplain system within the region, and also rare in that almost all of the other examples these wetland types in the region have been impacted by irrigation.

Criterion 2 (vulnerable / endangered / critically endangered species or ecological communities)

This criterion is focused on species and communities listed at the Commonwealth level, principally through the EPBC Act.

The Site supports the following taxa, listed as Vulnerable under section 179 of the EPBC Act:

- Regent Parrot (Eastern), *Polytelis anthopeplus monarchoides*;
- Southern Bell Frog, *Litoria raniformis*;
- Murray Cod, *Maccullochella peelii peelii; and*,
- Murray Hardyhead, *Craterocephalus fluviatilis.*

The Regent Parrot (eastern) is confined to the semi-arid interior of southeastern mainland Australia. It primarily inhabits riparian or littoral River Redgum (*Eucalyptus camaldulensis*) forests or woodlands and adjacent Black Box (*E. largiflorens*) woodlands, with nearby open mallee woodland or shrubland (DEWHA 2009b). In South Australia, the key breeding population occurs in the Murray-Mallee

region, centred along the River Murray. Nesting typically occurs in River Redgum (*Eucalyptus camaldulensis*), and occasionally in Black Box (*E. largiflorens*), usually within 16 m of permanent water, or sometimes actually standing in water (DEWHA 2009b). Nest sites may sometimes occur near temporary water sources, such as ephemeral streams or seasonal billabongs, but these are usually within about 60 to 100 m of permanent water sites. These environmental conditions and tree species are provided by the Site.

The Southern Bell Frog (also known as the Growling Grass Frog) has declined dramatically across its range. Population studies have shown that Southern Bell Frog populations are positively influenced by permanent water, the extent of aquatic vegetation, extensive riparian or floodplain grasslands and the presence of other nearby Growling Grass Frog populations (Heard *et. al.* 2004). The species is dependent upon permanent freshwater lagoons for breeding. The ideal breeding habitat is the shallow part of still or slow-flowing lagoons, generally with a complex vegetation structure (DEWHA 2009b). Despite their requirement for permanent water for breeding, they also require terrestrial habitat (such as grasslands and forests), feeding mainly on terrestrial invertebrates such as beetles, termites, cockroaches, moths, butterflies and various insect larvae (DEWHA 2009b). The combined habitat requirements of permanent waters with still to slow-flowing areas and nearby forests and grasslands is provided by the Riverland Ramsar Site. Among the threats to the Southern Bell Frog, habitat loss through stock grazing and irrigation are considered major (DEWHA 2009b). Again, the Site provides some sanctuary form these impacts, making it a key refuge for this species within the region.

Murray Cod are found in a range of warm water habitats across the Murray-Darling Basin. The species is highly dependant on woody debris for habitat, using it to shelter from fast-flowing water and for spawning in lowland rivers (DEWHA 2009). Although the Riverland Ramsar Site offers substantial natural habitat in the form of deep pools and coarse woody debris, the Site also suffers from one of the major threats to the Murray Cod – altered hydrologic regime through the isntallation of locks and weirs. However, the large network of flowing anabranches within the Site provides valuable habitat for the Murray Cod, particularly as several of the anabranches are susceptible to flooding, connecting the channel to the floodplain. This attribute is relatively rare in the post-regulation River Murray and is largely restricted to this and other Ramsar sites.

The Murray Hardyhead is only known from the Murray-Darling River system and inhabits the margins of slow, lowland rivers, and lakes, billabongs and backwaters. It is found amongst aquatic plants and over gravel beds in both fresh and highly saline waters (DEWHA 2009). It has a short life history with fish typically only living for 15 months, so they do not persist in locations which do not provide the right conditions for the species. It is now found only in the lower southern part of the Basin, having suffered reductions in its distribution and abundance (Lintermans 2007). Causes of its decline are uncertain but are thought to include increasing salinisation, habitat degradation, altered flow regimes and impacts of alien species

(Lintermans 2007). The species is in dramatic decline and its presence at the Riverland Ramsar Site makes the Site a place of high importance for the species.

Criterion 3 (supports populations of plant and/or animals important for regional biodiversity)

This criterion includes species and communities listed at the State level. There are twenty-eight plant species listed at the State level under the National Parks and Wildlife Act 1972 that are found at the Site on a permanent or seasonal basis (Appendix 1.1). Twenty species are listed as rare and eight as vulnerable. The Site also contains animal species listed at the State level, including twenty-two State listed threatened species that inhabit the Site on a permanent or seasonal basis (Appendix 2.2). Fourteen of these species are listed as rare (two reptiles, twelve birds), seven as vulnerable (one reptile and six birds), and one (the Feather-tailed Glider, *Acrobates pygmaeus*) is listed as endangered.

This criterion also includes consideration of diversity within a bioregional context. As noted in the discussion for Criterion 1, the Site is located within the Murray River Drainage Division (AWRC 1975). This Drainage Division covers habitats which range from alpine meadows above the tree line, through wet montane forest, to arid lowlands in the continental interior. As described for Criterion 1 (above) the Site area overlaps with one of the only parts of the lower River Murray floodplain not used for irrigation, preserving much of its natural character. The full range of the riverine vegetation communities expected within this part of the lower River Murray floodplain is found within or near the Site (Margules et al. 1990). The Chowilla floodplain has a high diversity of both terrestrial and aquatic habitats, including fish breeding habitat and areas that support populations of breeding waterbirds (MDBC 2006). Significantly, the Chowilla floodplain contains the largest remaining area of natural River Redgum (*Eucalyptus camaldulensis)* forest in the lower River Murray (Sharley and Huggan, 1995).

Maintenance of remnant populations of endangered flora and fauna within the Site that are uncommon or extinct elsewhere in the lower River Murray has been acknowledged in numerous studies and has been attributed to unique flowing waters and habitat diversity in the Site's anabranch systems (O'Malley and Sheldon, 1990; Pierce, 1990; Sharley and Huggan, 1995; Zampatti *et al*, 2005). Recent fish investigations have provided further evidence of the Site's high conservation value (MDBC 2006). Fourteen species of freshwater fish have been recorded in sampling conducted during 2004 and 2005. The diversity of aquatic habitats within the Site's anabranch systems seems to benefit Murray Cod populations in particular, allowing different sized Murray Cod to exploit different habitats (Zampatti *et al*, 2005). Similarly, Carpenter (1990:64) noted that the Chowilla area is recognised as a site of high avian diversity and noted for the presence of species not readily found elsewhere in the State. Carpenter attributed this to regionally high habitat diversity and a relatively low level of disturbance, stating that it has "outstanding importance for bird fauna in South Australia. The woodland habitats support a high diversity of resident species, many of high conservation significance, as well as providing a corridor for bird movements interstate. The wetland habitats, particularly those

prone to extensive periodic flooding, provide important breeding habitat for large numbers of breeding waterbirds."

Criterion 4 (supports species at critical stages or provides refuge in adverse conditions)

The Riverland wetland provides critical summer or stopover habitat for eight species of migratory birds listed under the JAMBA, CAMBA and ROKAMBA agreements. These are:

- Sharp-tailed Sandpiper (*Calidris acuminate*)
- Curlew Sandpiper (*Calidris ferruginea*)
- Red-necked Stint (*Calidris ruficollis*)
- Eastern (Great) Egret (*Ardea modesta*)
- White-bellied Sea-Eagle (*Haliaeetus leucogaster*)
- Caspian Tern (*Hydroprogne caspia*)
- Glossy Ibis (*Plegadis falcinellus*)
- Greenshank (*Tringa nebularia*)

These species and their listings are presented in Appendix 2.4. The Site is also important as habitat for nomadic waterbirds during times of drought in central and eastern Australia (Appendix 2.5) and for nomadic bush-bird species during the dry southern Australian summer (November to March), (Appendix 2.6).

During a 10-day bird survey of the Chowilla floodplain in 1988, Carpenter (1990) recorded a total of 30 breeding species. Of these, there were eight species of waterbird recorded breeding during the survey:

- Little-pied Cormorant (*P. melanoleucos*)
- Black Swan (*Cygnus atratus*)
- Australian Shelduck (*Tadorna tadornoides*)
- Pacific Blackduck (*Anas superciliosa*)
- Australian Grey Teal (*Anas gracilis*)
- Maned Duck (Wood Duck)(*Chenonetta jubata*)
- Masked Lapwing (*Vanellus miles*)
- Red-capped Plover (*Charadrius ruficapillus*)

Harper (2003) monitored waterbird breeding in Lake Merreti between 1987 and 1995. He noted that 9 species of colonial waterbirds had breeding events over those years (Table 2.3).

Table 2.3: Native Colonial Waterbird Species and Breeding Evenets at Lake Merreti between 1987 – 1995.

Species	Number of Breeding events in 9 years
Strawneck ibis	6
White ibis	6
Yellow-billed spoonbill	2
Royal spoonbill	1
Darter	5
Pied cormorant	1
Little black cormorant	4
Little pied cormorant	2
Black swan	1

Criterion 5 (providing habitat that regularly supports 20,000 or more waterbirds)

At the time of listing insufficient data were available to say the Site met criterion 5 (then criterion 3a), but more recent data indicates that the site supports 20,000 or more waterbirds involving fifty-nine species on a regular basis. A draft management plan for the Site (DEH undated) states "During 2002, 20,000 or more waterbirds involving fifty-five species were estimated by Goodfellow pers. com. (2003) and Harper pers. com. (2003) to be utilising the Ramsar Riverland Wetland" (p56) and "Due to the rehabilitation of a number of wetland sites within the Riverland Wetland, the area regularly supports 20,000 or more waterbirds" (p25).

The Ramsar Guidelines (Glossary) http://ramsar.org/key_guide_list2006_e.htm#E states: regularly (Criteria 5 & 6) - as in supports regularly - a wetland regularly supports a population of a given size if: i) the requisite number of birds is known to have occurred in two thirds of the seasons for which adequate data are available, the total number of seasons being not less than three; or ii) the mean of the maxima of those seasons in which the site is internationally important, taken over at least five years, amounts to the required level (means based on three or four years may be quoted in provisional assessments only).

In establishing long-term 'use' of a site by birds, natural variability in population levels should be considered especially in relation to the ecological needs of the populations present. Thus in some situations (e.g., sites of importance as drought

or cold weather refuges or temporary wetlands in semi-arid or arid areas - which may be quite variable in extent between years), the simple arithmetical average number of birds using a site over several years may not adequately reflect the true ecological importance of the site. In these instances, a site may be of crucial importance at certain times ('ecological bottlenecks'), but hold lesser numbers at other times. In such situations, there is a need for interpretation of data from an appropriate time period in order to ensure that the importance of sites is accurately assessed.

In some instances, however, for species occurring in very remote areas or which are particularly rare, or where there are particular constraints on national capacity to undertake surveys, areas may be considered suitable on the basis of fewer counts. A difficulty with quantifying the waterbird numbers at the Riverland Ramsar Site is not only the paucity of data but also that information is generally available for individual wetlands rather than the whole-of-site. The data presented below has been used in support of this criterion. However, future monitoring will be required to confirm the validity of nomination under this criterion. Further, monitoring of sporadically-filled but nonetheless important wetlands will require consideration of the application and testing of the term ‘reglularly’. In humid areas with consistent hydrologic regimes, ‘regularly’ may be able to measured as a percent of all years that have been monitored. Whereas in arid or semi-arid regions, ‘regularly may’ be more meaningful if based on whether or not the very high numbers recur (almost predictably) whenever a major inundation event occurs (albeit with a 10-year recurrence interval).

Some reported waterbird numbers and years are:

Site	Month & Year	Total Waterbird Count	Reference
Lake Merreti	Feb 2002	>23,000	Harper Unpub. Data
Lake Merreti	May 2001	>18,500	Harper Unpub. Data
Lake Merreti	March 2001	>19,000	Harper Unpub. Data
Lake Woolpolool	Feb 2002	>4,700	Harper Unpub. Data
Lake Woolpolool	January 2000	10,025	Harper 2003
Lake Woolpolool	May 2001	8,224	Harper 2003
Lake Woolpolool	October 2002	14,674	Harper 2003
Werta Wert	December 2005	3,066	Aldridge et al. 2006
Werta Wert	February 2006	3,161	Aldridge et al. 2006
Werta Wert	April 2006	2,350	Aldridge et al. 2006
Chowilla Floodplain (selected sites)	October 1988	> 5,000	Carpenter 1990

See Appendix 2.1 for a list of waterbird species recorded using the site.

Unpublished data from Harper (presented in Appendix 2.9), displays over 23,000 birds counted at Lake Merreti one day in February 2002, over 18,500 at the same site in May 2001 and over 19,000 in March 2001. As discussed above, these high numbers are from one site within the wetland – the 'whole-of-site' numbers are likely to be much larger but are not available. The same data set displays over 8,000 birds at Lake Woolpolool in May 2001 and over 4,700 in February 2002, on the same days as the high numbers were recorded at Lake Merreti.

Criterion 6 (providing habitat that regularly supports 1% of the global population of one species of waterbird)

At the time of listing insufficient data were available to say the Site met criterion 6 (then criterion 3c), but more recent data indicates that the site supports 1% of the population of three species on a regular basis. Similar to the previous criterion, there appears to be a paucity of quantitative data for supporting this criterion for the site – particularly over long periods. Therefore, although the data presented within this ECD supports this criterion, future monitoring will be required to confirm the validity of nomination under this criterion.

The following species have been recorded at the Site in numbers representing greater than 1% of their estimated global population:

- Freckled Duck, *Stictonetta naevosa*;

- Red-necked Avocets, *Recurvirostra novaehollandiae*; and
- Red-kneed Dotterel, *Erythrogonys cinctus*.

Freckled Duck: The IUCN redlist (Birdlife International 2008) estimates a global population of 20,000 Freckled Duck, and therefore 200 individuals would represent 1% of the global population. DEH (undated) states that the highest species count for Freckled Duck on the Site between 2000 and 2003 was 620 birds, recorded on Lake Merreti (Harper pers. com. 2003, in DEH undated). The data used by DEH (undated) are provided in Appendix 2.9 and show that between October 2000 and November 2002, the number of Freckled Duck on Lake Merreti exceeded 200 on three occasions (May 2001, February 2002 and November 2002).

Red-kneed Dotterel: The IUCN redlist (Birdlife International 2008) estimates a global population of 26,000 Red-kneed Dotterel, and therefore 260 individuals would represent 1% of the global population. DEH (undated) states that the highest species count for Red-kneed Dotterel on the Site between 2000 and 2003 was 277 birds, recorded on Lake Merreti (Harper pers. com. 2003, in DEH undated). The data in Appendix 2.9 show that this was in March 2002.

Red-necked Avocet: The IUCN redlist (Birdlife International 2008) estimates a global population of 110,000 Red-necked Avocet, and therefore 1,100 individuals would represent 1% of the global population.DEH (undated) noted that the highest species count for Red-necked Avocet (*Recurvirostra novaehollandiae*) on the Site between 2000 and 2003 was 3,600 birds, recorded on Lake Merreti (Harper pers. com. 2003, in DEH undated). In the Bird Atlas (Barrett et al., 2003) Red-necked Avocets were only confirmed in every 20th report from the Riverland and were not recorded to breed in the Riverland between 1998 and 2002. However the data provided in Appendix 2.9 displays Red-necked Avocets exceeding 1,100 at Lake Merreti on four occasions between February and May 2002, and again in October 2002. Also, the number of Red-necked Avocets at Lake Woolpolool exceeded 1,600 in January 2002, was over 6,000 in October 2002 and greater than 2,500 in November 2002. In February 2005 the number reached 1000 at Lake Littra.

All three species listed above have been used to support listing under criterion 6, with the recommendation that future monitoring be undertaken to confirm this listing.

Criterion 7 (supporting a significant proportion of indigenous fish taxa, life-history stages, species interactions or populations that are representative of wetland benefits and/or values)

The Site supports 16 species of freshwater native fish species within the Murray-Darling Basin, (Table 2.4). Nine family groups are represented within the 16 species. These fish have adapted to high variability in flow and water quality. This has resulted in the Site's fish assemblage displaying a high biodisparity and five different reproductive styles.

This information is supported by studies undertaken within the Site. In the Murtho

component of the Site (SKM 2005) eight native fish species were found across four sampled sites (Templeton, Weila, Murtho Park and Woolenook Bend). Similarly, surveys of the lakes and creeks on Calperum have recorded twelve species of native fish (Parks Australia 2005) and a survey in the Chowilla region near the time of Ramsar listing of the Site (Lloyd 1990) recorded eight native fish species.

Criterion 8 (supplying an important food source, spawning ground, nursery and/or migration path for fishes, on which fish stocks depend)

Golden Perch (*Macquaria ambigua*) and Silver Perch (*Bidyanus bidyanus*) undertake extensive migrations in fresh water (Reynolds, 1983; Mackay 1990). The Chowilla Anabranch within the Site is a pathway for these fish to migrate around Lock 6, which is a barrier at low-medium flows. Murray Cod and Australian Smelt also migrate through the anabranches undertaking moderate length migrations. All fish need to move around the Site to find mates, food and habitats as well as avoid predators. The Site provides habitat for breeding and a nursery for juvenile stages of Golden Perch (*Macquaria ambigua*) and Silver Perch (*Bidyanus bidyanus)*. Floods in spring and early summer ensure abundant plankton and other organisms as food for young fish (Lloyd 1990, Zampatti 2006b). Significant numbers of larvae of Australian smelt (*Retropinna semoni*) were recorded in the anabranches of the Site by Lloyd (1990), particularly in the slow-flowing anabranches where the slow currents keep the semi-bouyant developing eggs in suspension. The presence of larval and post larval stages is evidence of the Site providing a spawning ground/nursery for this species.

Other species have also been captured as larvae within the Site's waterways, including: Flatheaded Gudgeon (*Philypnodon grandiceps*); Carp gudgeon (*Hypseleotris* spp.); Bony Herring (*Nematalosa erebi*); Unspecked Hardyhead (*Craterocephalus stercusmuscarum fulvus*, a subspecies of the Flyspecked Hardyhead); Golden Perch (*Macquaria ambigua*); Murray Cod (*Maccullochella peelii peelii*) and Crimson-spotted Rainbowfish (*Melanotaenia fluviatilis*) (Zampatti 2006b).

Table 2.4: Native fish species found within the Riverland Ramsar Site (Lloyd 1990; Pierce 1990; Harper 2003; Zampatti et al. 2006a & 2006b; RIS in prep.)

Family	Species	Common Name	Reproductive Guild*
Clupeidae	*Nematalosa erebi*	Bony Herring	D2
Retropinnidae	*Retropinna semoni*	Australian Smelt	A
Plotosidae	*Tandanus tandanus*	Freshwater Catfish[E]	C2
Melanotaeniidae	*Melanotaenia fluviatilis*	Crimson-spotted Rainbowfish	A
Atherinidae	*Craterocephalus fluviatilis*	Murray Hardyhead[E*]	A
	Craterocephalus stercusmuscarum fulvus	Flyspecked Hardyhead[V]	A
Percichthyidae	*Maccullochella peelii peelii*	Murray Cod[V*]	C2
	Maccullochella macquariensis#	Trout Cod[E]	C2
	Macquaria ambigua	Golden Perch	D1
Teraponidae	*Bidyanus bidyanus*	Silver Perch[E]	D1
Kuhliidae	*Nannoperca australis#*	Southern Pigmy Perch[E]	B
Eleotridae	*Hypseleotris klunzingeri*^	Western Carp Gudgeon	C2
	Hypseleotris sp. A^	Midgley's Carp Gudgeon	C2
	Hypseleotris sp. B^	Lake's Carp Gudgeon	C2
	Philypnodon grandiceps	Flathead Gudgeon	C2
	Philypnodon sp. 2	Dwarf Flathead Gudgeon	C2

#Not recorded in recent surveys

^Regarded as a species complex with species A and B not formally described

[E]Regarded as endangered in SA (Hammer et al. 2007)

[V] Regarded as vulnerable in SA (Hammer et al. 2007)

[*] Listed under the EPBC Act

*according to Growns (2004):

Guild	Definition
A	Adhesive, demersal eggs with no parental care
B	Low fecundity, small non-adhesive demersal eggs with short incubation times
C2	Show parental care, including nest building and protection of young with species not generally undergo a spawning migration and typically have large eggs
D1	Single spawning species with high fecundity, non-adhesive eggs with no parental care with species undergoing a spawning migration
D2	Single spawning species with high fecundity, non-adhesive eggs with no parental care and display no spawning migration

2.5 Land Use and Tenure

Land uses, managers and areas at the Site are displayed in Table 2.5. Most land (27,213 ha) is allocated to biodiversity conservation under Australian, State and Local Government or private ownership. Stock grazing, predominantly by sheep, is the next largest land use, allocated 3,370 ha.

The Site supports a significant tourism industry that relies on the Site's inherent values. Tourism operators supply houseboat hire, nature-based boat and vehicle tours, pastoral industry tours and on-site accommodation. Recreational pursuits are centered on fishing, pleasure craft boating, bush camping, canoeing, waterfowl hunting, water-skiing and driving tours.

A few commercial fishers have been issued licenses to take Bony Herring (*Nematalosa erebi)* (a common native fish), European Carp (an exotic species) and other non-native species from the backwaters of the River Murray in South Australia using gill nets. A number of sites within the Site are available for commercial harvesting of these species.

Approximately 70 domestic or irrigation pumps take water from the River Murray channel, backwaters or anabranch creeks within the Riverland. Two small irrigation-based enterprises, a vineyard (32 ha) and an irrigated pasture (37 ha) exist within the Site.

Over the last 20 years extensive research and monitoring have been undertaken throughout the Site. Efforts have focused on ecosystem and threatening processes and the interactions of management (e.g. O'Malley and Sheldon 1990; Sharley and Huggan 1995; Overton et al. 2005).

Areas of land outside the Site are supplied irrigation water by pumps located in the Site. These include the Cooltong/Chaffey Irrigation Area (1,118 ha), private diversions from Ral Ral Anabranch and the Paringa/Murtho area (4,000 ha). The dominant horticultural enterprises involve vines and orchards with small areas of vegetables and sown pastures. Dryland farming also occurs to the south of the Site and involves cereal grain crops, pastures for hay and livestock. North of the Site is the Chowilla Regional Reserve, owned by the SA Department for Environment and Heritage, and the continuation of Calperum Station, a pastoral lease owned and managed by the Australian Government for biodiversity outcomes. Privately owned or local government (Renmark-Paringa District Council) land adjoins the remainder of the Site.

Table 2.5: Land uses, land managers and land areas in the Riverland Ramsar Site.

Land Use	Land Owner / manager	Area (ha)
Murtho Forest Reserve	Primary Industries and Resources SA, South Australian Government	1,709
River Murray National Park (Bulyong Island section)	Department for Environment and Heritage, South Australian Government	2,382
Chowilla Game Reserve (part)	Department for Environment and Heritage, South Australian Government (leased to Robertson-Chowilla Pty Ltd)	14,916
Calperum Station (part)	South Australian Government Pastoral Lease – invested in Director National Parks, Australian Government DEWHA	8,500
Crown land	South Australian Government - vested in the Minister for Environment and Conservation, River Murray channel, including the 150 link (30.18 metre) wide reserve for public use along the majority of the River's southern bank that became the practice to retain after 1898	793
Local Government	District Council of Renmark-Paringa	9
Privately owned	Companies, partnerships or individual owners	2,306
TOTAL		30,615

3. ECOLOGICAL CHARACTER OF THE RIVERLAND RAMSAR SITE

This chapter describes the components, processes and benefits/services of the Site and the linkages between them. Conceptual models of the ecosystem are then presented, followed by the limits of acceptable change to the key components, processes and benefits/services of the Site.

3.1 General Description

A representation of key components and processes occurring at the Site is displayed in Figure 3.1. The Riverland Ramsar Site is in a generally dry environment. Most of the water that fills the creeks and wetlands comes from remote catchments of the River Murray and its tributaries. The nature of the water regime — the magnitude, frequency, duration and seasonality of flows in the river, and the rate of rise and fall of the hydrograph — governs the ecological character of the wetland complex (see Section 3.5).

Another facet of the Site's water regime is water retention. This is affected by flows in the River Murray, and by local landforms (geomorphology), including localised depressions; abandoned channels and billabongs; linking channels; levees; larger deflation basins; and topography and elevation of the floodplain.

These geomorphic features also affect the components, processes and benefits and services of the Site. Water delivery will influence the geomorphic attributes of the Site, and conversely these will influence water delivery (e.g. rates, courses, and pooling). The vegetation and habitats are influenced by the hydrology and the geomorphology of the Site, with vegetation bands often delineating flooding regimes and the flooding regimes being products of topography and elevation.

Figure 3.1 displays several components and processes of the Site including climate, soils, vegetation, fauna, and water quality, all of which contribute to the ecological character of the Site. The principal component and process that drives the Site and system, however, is hydrology. This includes the surface water and groundwater regime. The range of components and processes is explored in following sections. Section 3.5 brings these elements together as conceptual models.

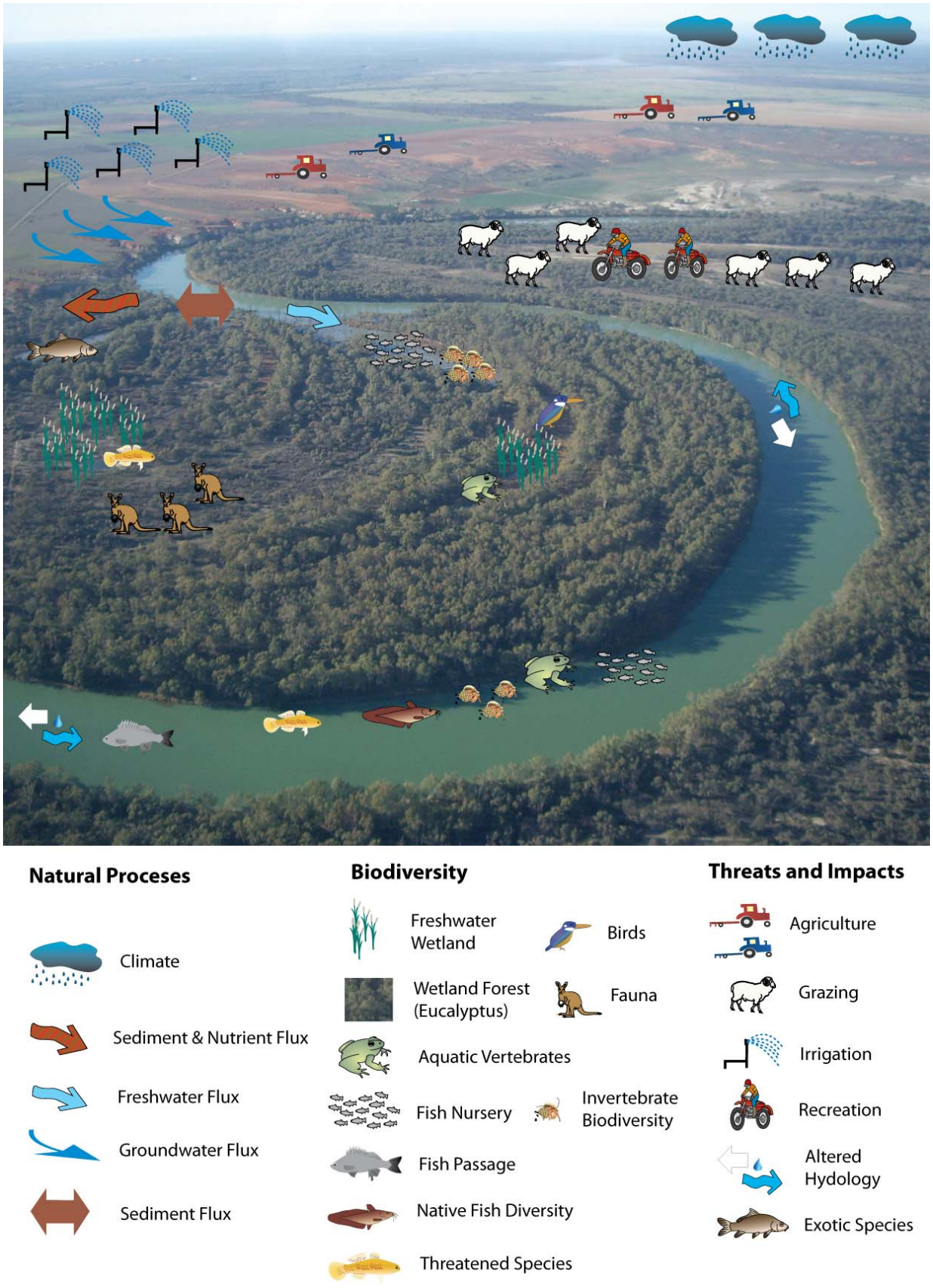


Figure 3.1: Riverland Ramsar Landscape showing components and processes

3.2 Components of the Site

The major components of the Site include:

- Climate;
- Geomorphology;
- Soils;
- Hydrology;
- Water quality;
- Vegetation & Habitat; and,
- Fauna.

Each component is discussed below.

3.2.1 Climate

The Riverland experiences features of a Mediterranean climate (temperate rainy climate with cool winters and dry, warm-to-hot summers) and also a dry subtropical climate (Steppe, climate hot) (Strahler and Strahler 1992). The Site is within the southern extension of Australia's central arid zone and temperatures can vary significantly diurnally and seasonally. At nearby Renmark (1 km from the southern Site boundary), the average summer temperature minima and maxima are 16°C and 31.6°C, respectively. In winter, the range is 5.5°C to 17°C.

Regional rainfall averages 260.5 mm per annum (data for Renmark, 1889-2002), with a poorly-defined peak in winter-spring (Figure 3.2). Annual evaporation is 1960 mm (RIS in prep.).

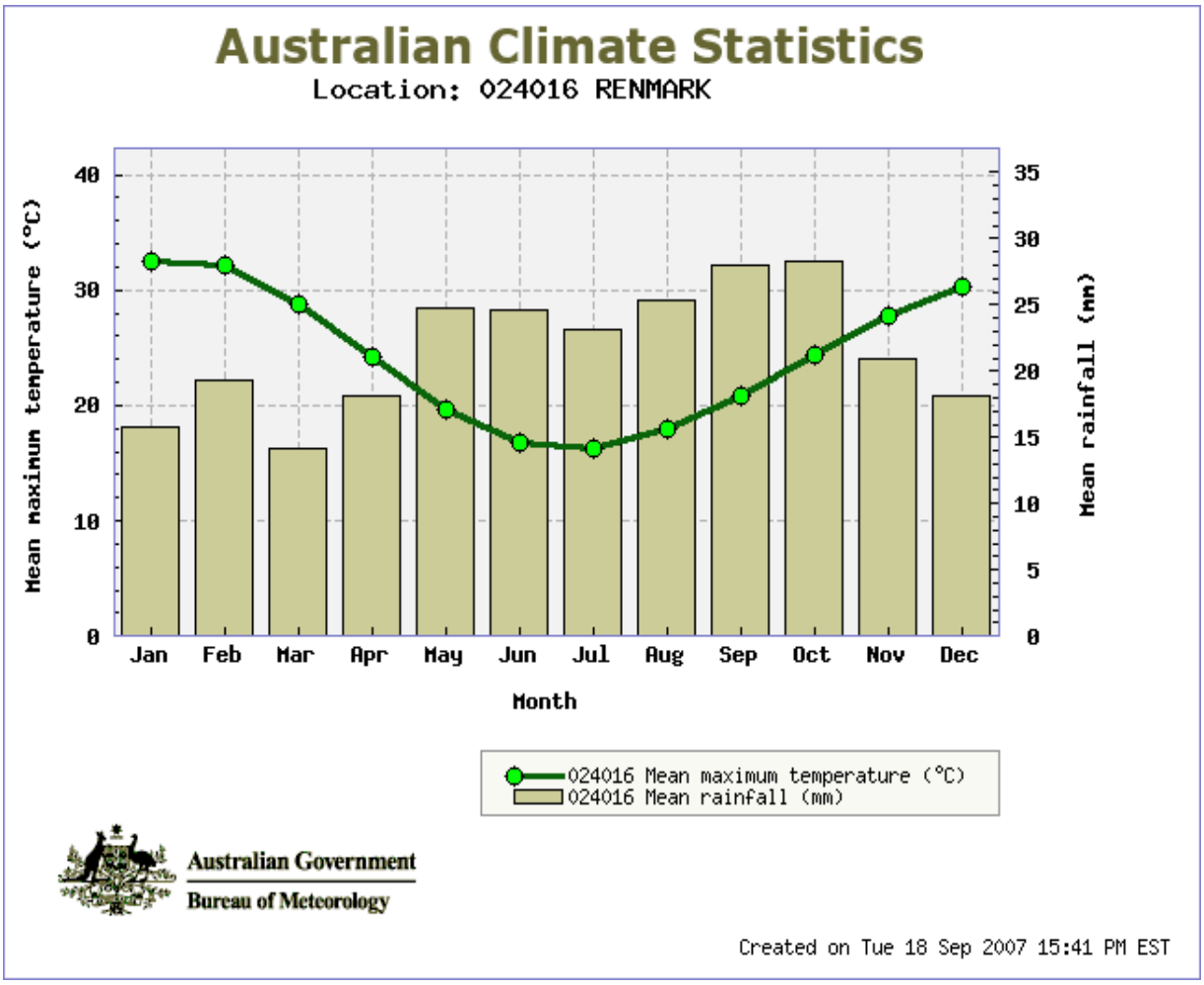


Figure 3.2: Climograph for Renmark, 1957-2007 (Temperature) and 1889-2002 (Rainfall). Source :
http ://www.bom.gov.au/climate/averages/tables/cw_024016.shtml

Rainfall is highly variable, with recorded annual extremes of 89.5 mm and 517.0 mm. The 10th and 90th percentiles for rainfall for each month are displayed in Figure 3.3. Drought occurs frequently, but there is no clear pattern in occurrence of wet and dry years (RIS in prep.). Historically, ENSO (El Niño) has an approximate 5-year return period. In general the River Murray crosses longitudes and is less susceptible to ENSO than the Darling River, which crosses latitudes. The River Murray's contribution is roughly 90 percent of the total, and it is more reliable than that of the Darling. The late 1980s (i.e. prior to and during the Site's listing) was a dry period and most of the water in the Lower River Murray was from the Darling River, stored in Lake Victoria for release during the irrigation season.

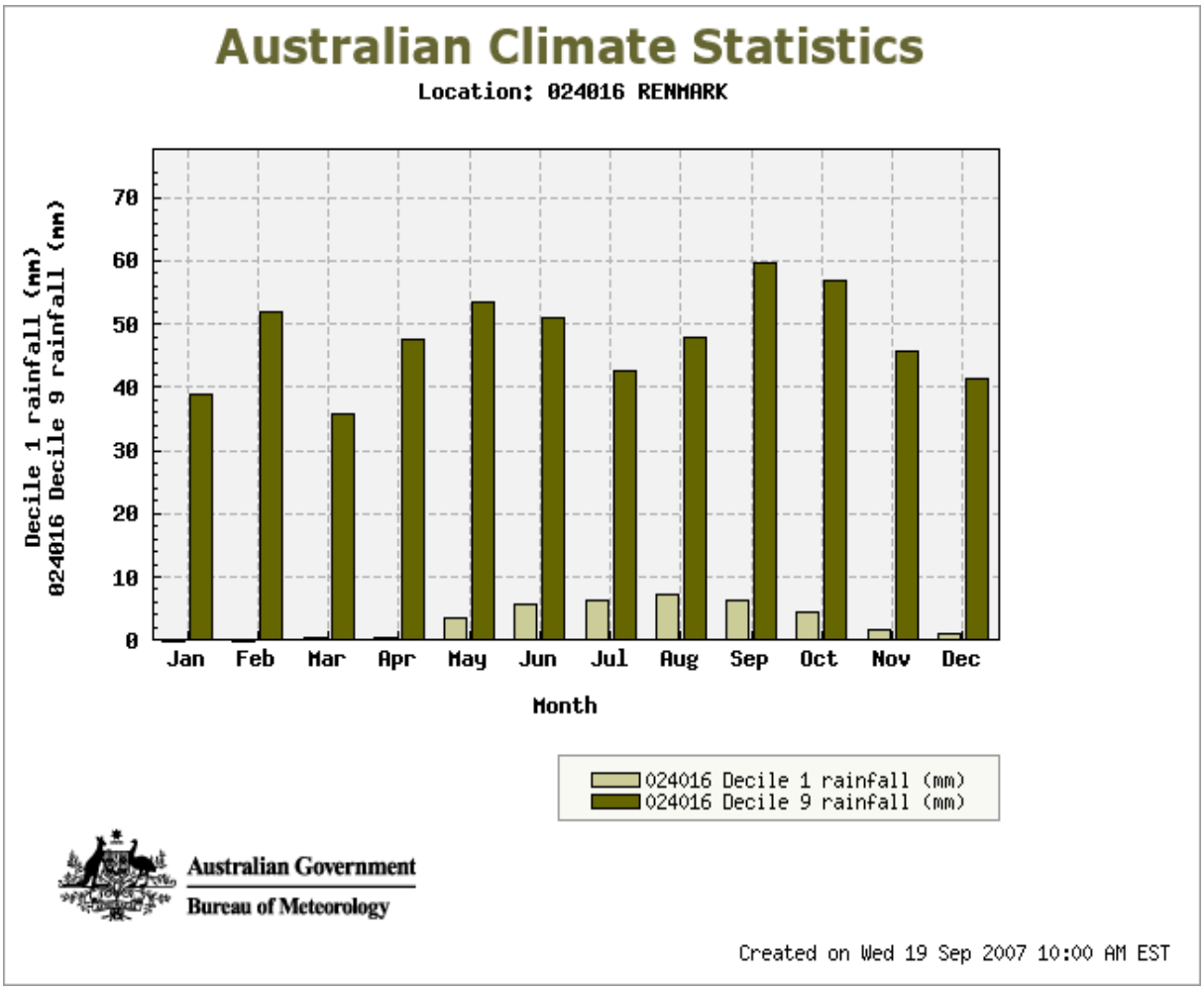


Figure 3.3: Graph of 10th percentile (Decile 1) and 90th percentile (Decile 9) for Renmark, 1889 – 2002. Source :
http ://www.bom.gov.au/climate/averages/tables/cw_024016.shtml

In the context of this ECD, the key features of climate are floods and droughts and the future impacts of climate change. Although climate change was not recognized as an issue at the time of listing (1987), it clearly warrants consideration in the following sections describing changes and threats to the Site.

3.2.2 Geomorphology

In this section, geomorphology is treated as a component (i.e. in terms of landforms) rather than a process, although both roles apply. Through differential retention of water and variations in depth, surface area and elevation, local landforms are responsible for the mosaic of habitats at the Site. They also influence the dynamics of wetting and drying phases.

This section describes wetland habitat types based on geomorphology whereas the Ramsar Convention uses wetland types that are defined by water regime, salinity and vegetation cover and a description of these wetland types is found in section 2.4.

There are six major landform-based habitat types at Chowilla (Sheldon & Lloyd 1990):

1. River channel: Large, wide channels of the River Murray
2. Anabranches: Much narrower channels with a variety of flow regimes, usually remaining connected to the main channel
3. Backwaters: Waterbodies connected to the main channel at normal pool level
4. Billabongs: Mostly still, isolated water bodies connected to the main channel only at times of flood
5. Swamps: Wetland areas with shallow basins and little free water but highly saturated soils
6. Floodplain: "Terrestrial" areas subject to occasional flooding episodes and free draining, retaining water during flood

The River Murray channel (Plate 3.1) attains depths of 5-6 metres and is wide in this stretch of the river, confined on one side by cliffs and spilling over into the floodplain on the other as it meanders across the floodplain. The waters of the main channel are characteristically turbid but well oxygenated. The river has a variety of habitat types with different substrate types (sand and clay), woody debris, deep pools and vegetated margins.

Plate 3.1: River Murray Channel (Wetland Type M) Overlooking Cliffs (Lance Lloyd, June 2007)

Anabranches (Plate 3.2) have variable depths, depending on flow in the main channel, and provide a variety of habitat types. The faster-flowing anabranches have narrow channels and are prime habitat for riverine species including Murray Cod, Murray Crayfish and River Mussels. In contrast, the slower-flowing anabranches are much wider, providing shallow, warm and slow-to-still water habitats that encourage large invertebrate and plant populations.

Anabranches have been identified as a unique habitat on the River Murray floodplain (Sheldon & Lloyd 1990, Lloyd 1990, Lloyd and Boulton 1990, Boulton and Lloyd 1991, Whiterod et al. 2004, McCarthy 2005). Anabranches are known to have specific water requirements based on the requirements of a suite of distinctive flora and fauna which depend upon these habitats. Both fast and slow flowing anabranches are present within the Riverland Ramsar Site.

Permanently flowing water provides an essential habitat component for a number of River Murray fauna. Prior to the construction of the weirs, flowing water habitat was available in both the river and the anabranches, but now only occurs in some anabranch sections. The fast flowing anabranches are generally deeply incised and subject to rapid changes in level according to river flow. They are therefore lined by a narrow zone of emergent plants. Groundwater discharge from the creeks contributes to relatively shallow and low-salinity groundwater beneath the adjacent floodplain, which promotes the growth of trees in the fringing Redgum woodland.

Fast Anabranches represent a contrasting flowing, relatively well-oxygenated aquatic habitat to the River Murray and to floodplain wetlands. The flow of water also reduces the potential for high water temperatures which can occur in shallow standing water in wetlands. Anabranches provide potential habitat for the locally extinct River Murray Crayfish (*Euastacus armatus*) which grazes on epiphytes and other organic debris and preys on aquatic invertebrates. Deep holes in the main channel and larger anabranches which have cooler water provide habitat for Murray Cod. Other species which are favoured by flowing water include the River Snail (*Notopala hanleyi*), the Freshwater Shrimp (*Macrobrachium australiense*) and River Mussel (*Alathyria jacksoni*).

Slow flowing anabranches are generally wider and shallower than fast flowing anabranches and they also tend to become dry at low river levels (Plate 3.3). These anabranches provide relatively shallow, warm and still habitat for the establishment of large aquatic invertebrate and plant communities.

Anabranches provide passage for fish between river reaches (and around locks and other barriers) and are particularly important for the migratory species Silver Perch, Golden Perch and, to some extent, Murray Cod. Flowing water provides an important breeding habitat for Australian Smelt.

Plate 3.2: Pipeclay Creek – a fast flowing anabranch of the River Murray in the Riverland Ramsar Site (Wetland Type M) (Lance Lloyd, June 2007)

Plate 3.3: A slow-flowing anabranch in the Riverland Ramsar Site during a dry phase (Wetland Type N) (Lance Lloyd, June 2007)

Backwaters (Plate 3.4) are less common, with variable depth and generally slow flow and a permanent or semi-permanent connection to the main channel (Sheldon and Lloyd, 1990). Where conditions allow, backwaters may thermally stratify, forming a cool, saline, hypoxic (oxygen deficient) bottom layer (hypolimnion).

Plate 3.4: River Murray Backwater (Wetland Type Tp) (Photo: Lance Lloyd, June 2007)

Billabongs (oxbows; Plate 3.5) are more common locally than elsewhere along the River Murray in South Australia. Disconnection from the main channel often causes billabongs to dry, allowing herbaceous vegetation to grow on the nutrient-rich sediment. This provides food for aquatic animals following inundation (Sheldon and Lloyd, 1990).

Plate 3.5: Pilby Creek Wetland, a River Murray Billabong (Wetland Type O) (Photo: Anne Jensen)

The shallow waters and gently-sloping banks of billabongs provide a habitat for aquatic macrophytes, which in turn harbour many forms of aquatic and terrestrial fauna. Water quality varies with the frequency of inundation, period of time since inundation and the extent of macrophyte growth and decay. The dry phase can be greatly extended as a result of river regulation, where flooding frequency is reduced. This is discussed in the sections on hydrology and threats.

Calperum contains a similar suite of landforms to the Chowilla block, with its most readily identified landforms being the 5 major wetland depressions - Lake Merreti, Lake Woolpolool, Clover Lake, Woolpolool Swamp and Rotten Lake - and the Ral Ral anabranch system. The five wetland depressions encompass an area of approximately 1,100 ha (Rotten Lake is not within the Site), with approximately 3,200 ha of floodplain directly associated with the depressions (Parks Australia 2005).

The landforms of the **Murtho** block contain a lower percentage of the drier floodplain areas and a relatively larger proportion of lentic channel forms, active channels, backwaters and miscellaneous floodplain depressions.

3.2.3 Soils

Soil type varies across the Site, but grey self-mulching cracking clays, brown siliceous sands and firm grey siliceous sands are dominant at the Site (Laut et al. 1977). Elevated areas typically have the sandy soils, often associated with stands of Murray Pine, *Callitris preisii*.

The Atlas of South Australia (www.atlas.sa.gov.au/go/resources/atlas-of-south-australia-1986/environment-resources/soils) identified two broad soil groups within the Site: self-mulching cracking clays; and crusty red duplex soils. The website provides the following general descriptions of the soil types:

> **Self-mulching cracking clays** occur on the alluvium of the River Murray valley. They typically have uniform fine-textured profiles with significant cracks when dry, although the cracks are not always apparent at the surface. Most of the clays are moderately fertile in their natural state. In the higher rainfall areas these soils support cereals and improved pastures. In the interior, the natural pastures on the clay soil floodplains provided fodder for the flocks of the early pastoralists.
>
> **Crusty red duplex soils** occur in arid regions, usually on tablelands and stony plains, and are often associated with red cracking clays in saucer-like depressions. A surface pavement of gravels is often partly embedded in the loamy brown surface soil. There is an abrupt boundary to the red clay subsoil. Through overgrazing, large areas have lost the sparse shrubland that once provided grazing for sheep and cattle, although ephemeral herbs may provide excellent feed following heavy rains.

Soil descriptions for the Murtho block (SKM 2005) and the Calperum block (Parks Australia 2005) indicate that the soil profiles of the site broadly consist of inter-bedded layers of sand and clay with some silt content at the surface. In general the profiles showed soils with higher clay content underlain by sandy soils.

3.2.4 Hydrology

Hydrology is simultaneously a component and a process. It governs the seasonality, magnitude, frequency, duration and rate of water delivery, and many biotic responses that include seed germination (including species favoured by the hydrologic regime), triggers for breeding (birds, fish, frogs), breeding success and provision of food. The season of delivery, period of inundation for ephemeral wetlands (or water level rises for permanent wetlands), fluctuations in water level and inter-annual flow variations all are influential.

The inundation levels at the Site are shown in Figure 3.4. These levels show the significant flow bands across the site as predicted by the Floodplain Inundation Model (FIM; Overton et al. 2006b).

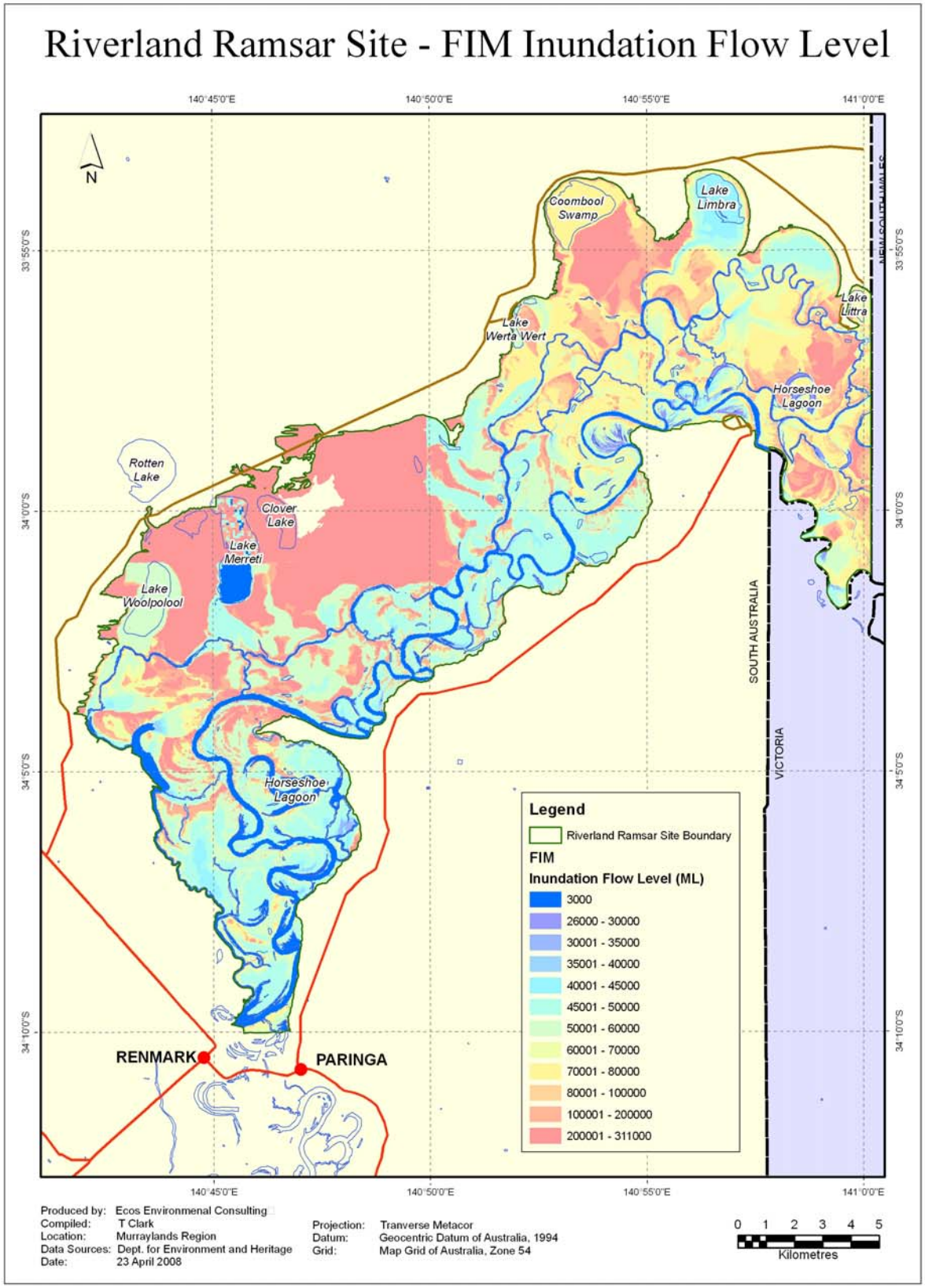


Figure 3.4: Inundation levels at the Site as predicted by the Floodplain Inundation Model (FIM; Overton et al. 2006b).

The hydrological regime is dominated by regulation of the River Murray. The impacts of regulation were evident in 1987. The River Murray's annual hydrograph (1922-2006) shows a high degree of inter-annual variability, typical of rivers in dry regions throughout the world (Figure 3.5).

An understanding of the post regulation hydrology is assisted by consideration of the pre-regulation hydrology. Prior to regulation, the River Murray experienced seasons with highly variable flows. Although there was marked variation between years, in spring and early summer the River Murray was generally high, cool, turbid and fast flowing. Towards the end of summer, flows in the River Murray gradually changed to become low, warm, clear and slow moving (MDBC 1991). During times of droughts, the flow would cease completely and the river would contract to saline pools fed by saline groundwater from the Pliocene Sands aquifer incised in the Coonambidgal and Monoman Formations (Sharley & Huggan 1995).

The demand for water from the Murray-Darling Basin has increased steadily since 1922 (when the first weir was built on the river in South Australia). The trend was interrupted in 1974-75, when there was a major flood, and again from the late 1990s to the present, when there has been a significant decline in rainfall, hence streamflow.

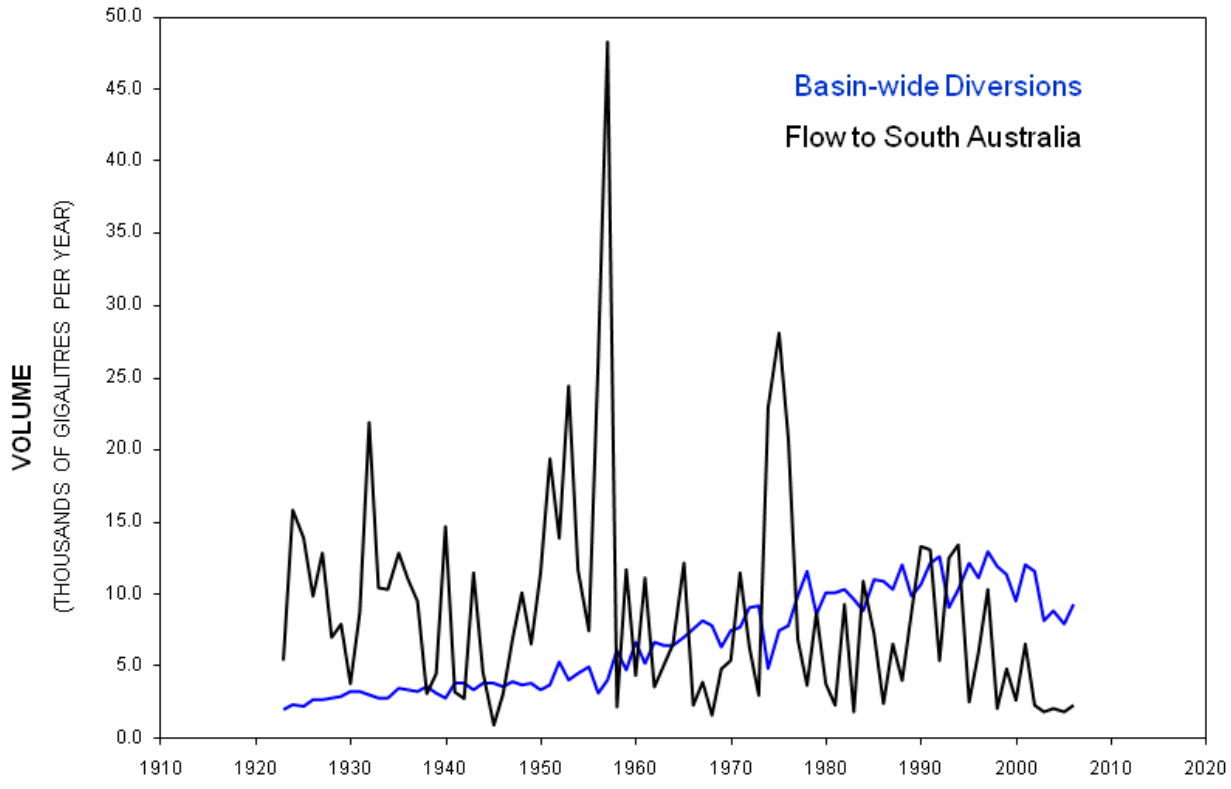


Figure 3.5: River Murray Hydrology 1922 to 2006 (Source: Murray Darling Basin Commission Flow database).

There is some hydrological persistence in the hydrograph, in that wet and dry years often occur in sequences. For example, the decade of the 1940s was very dry, and the 1950s was very wet.

This is partly related to ENSO (El Niño has a 5-year return interval), and depends somewhat on the inflow from the Darling. The River Murray crosses 13 degrees of longitude; its headwaters are in areas dominated by winter-spring rainfall, and it is less affected by ENSO. The Darling crosses 13 degrees of latitude; its headwaters are in areas where peak flows are from erratic summer monsoonal systems, and it is more affected by ENSO.

The degree of variability means that the background variation in the hydrograph is difficult to predict, and difficult to describe statistically. In statistical terms, it could take many years to detect statistically significant trends in annual flow (and other hydrological parameters). The problem is difficult enough when the baseline (the regional climate) is stable, but this is not so for the River Murray—long-term shifts in rainfall mean that it is of dubious value to compare long-term averages. This is strikingly shown in the hydrograph. The downturn in streamflow over the last 10-15 years has few if any historical precedents, and its impact has been intensified by the high level of demand for water.

In historical terms, the flood of 1974-75 is regarded as a 1 in 10 year event, but no comparable flood has occurred now for nearly 30 years. The hydrological changes imposed by regulation at the Site affect the smaller floods to a greater degree than larger ones. Regulation has significantly changed the frequency distributions of small to moderate sized floods, particularly over-bank flows.

The local anabranches formerly flowed only during floods (MDBC 2006) or high flows. The extent of floodplain inundation, hence the refilling of disconnected wetlands, was determined by flood magnitude, proximity to the river channel and local topography.

The infrastructure that has altered the hydrology of the Site includes dams in upstream catchments, Locks 5-6 on the River Murray channel, weirs and banks across the anabranches and hydrological structures on wetland sites. Lock 6 is downstream of the Chowilla anabranch inlet and 8 km upstream of the anabranch outlet. It has raised the river level by 3 m, banking water up into the anabranch system. Several banks and weirs on the anabranches restrict the volume of water that can by-pass Lock 6.

Lock 5 is downstream of the Ral Ral anabranch outlet (Figure 2.4) and, like Lock 6, raises the river level by 3 m, backing water into the anabranch system. The elevated water levels enhance water extraction and navigation of the main channel and also minimise saline inflows from the banks and wetlands directly connected to the River (RIS in prep.).

The ecological impacts of regulation include:

- permanent inundation of some ephemeral wetlands, hence loss of a summer drying phase;
- loss of in-stream habitat diversity necessary to maintain biological diversity;
- loss of flow dependent native fauna – for example, river mussels, Murray Crayfish and river snails;
- reduced range of bank habitats;
- reduced exchange of organic material, carbon, nutrients and sediment between floodplain and river;
- barriers to fish passage;
- declines in native fish abundance –floods promote reproduction in most native species, but stable flows may favour alien species, notably European Carp;
- reduced diversity and biomass of invertebrates in annually-flooded areas;
- reduced recharge of local groundwater ('freshwater lens') in semi-permanent wetlands, leaving insufficient water for trees;
- reduced diversity of waterbirds and terrestrial native fauna;
- degradation of natural low-flow channel;
- thermal stratification creating hypoxic bottom water and favouring blue-green algae;
- raised saline groundwater levels into the root zone of floodplain vegetation, causing dieback and soil scalding; and,
- natural ecological processes disrupted by unnatural constant flow for sustained periods, unseasonable flow and increased minimum flow (MDBC 2006).

The impacts of flow regulation from upstream in the River Murray system are most evident through the reduction in the moderate sized overbank flow events that covered large portions of the Site. Table 3.1 compares flood frequency data for pre- and post-regulation conditions at the Site. It shows that the effect of flow regulation and diversions on the floodplain has been to reduce flood frequency for all flood volumes displayed. For example, under natural conditions, a flood of 80,000 ML/day (covering nearly 50% of the floodplain) happened almost every 2 years (45 years out of 100) for an average period of 3.2 months. Under regulation, it occurs once every eight years for an average 2.6 months (MDBC 2006).

Table 3.1: Flooding extent, frequency, and duration under natural and regulated conditions at the Site (Source: Sharley and Huggan 1995).

River Murray flow (ML/day)	Area inundated (ha)	% Area of Chowilla floodplain inundated	Return period (Number of times peak flows occur in 100 years)		Duration (Number of months flow is exceeded)	
			Natural	Regulated	Natural	Regulated
5,000	-	-	100	100	11.4	9.5
10,000	-	-	100	94	10.1	4.6
20,000	-	-	99	63	7.8	4.6
40,000	1,400	8.0	91	40	4.9	3.3
50,000	2,200	12.4	79	30	3.9	2.7
60,000	4,000	22.6	59	21	3.9	2.5
70,000	5,600	37.6	49	15	3.6	2.9
80,000	8,200	46.3	45	12	3.2	2.6
90,000	11,100	62.7	37	11	3.1	2.1
100,000	13,200	74.6	32	9	2.9	2.0
140,000	16,800	94.9	14	4	2.1	2.5
200,000	17,700	100	3	1	2.0	2.0
300,000	17,700	100	1	0	2.0	-

Groundwater also is a critical aspect of the Site's hydrology. Prior to flow regulation, the main channel of the River Murray intercepted and drained regional saline groundwater at the Site, with the groundwater flowing under the anabranches. This left the anabranches dry between floods (MDBC 1991).

Post-regulation, the increased elevation of the water surface created by Lock 6 has resulted in the anabranches being filled by the impounded water and has also created a back-pressure on the adjacent groundwater, with it subsequently flowing into the now inundated anabranches. This saline groundwater now reaches the River Murray downstream of Lock 6, via the anabranch system (MDBC 1991).

The back pressure on the groundwater is also leading to rising water tables on the floodplain creating salinity stress for the tree cover. Overton et al. (2006) have reported severe declines in tree health on the floodplains of the Site, and have found the primary cause to be salinisation of the floodplain soils caused by increased groundwater discharge and hence increased movement of salt up into the plant root zone. The reduced frequency and duration of medium-sized floods adds

to the pressure created on the groundwater through the elevation of the surface water. Under natural conditions, the medium-sized floods leach salt from the plant root zone and supply fresh water for transpiration. The marked reduction in these floods further exacerbates the salinity stress on the floodplain vegetation.

Areas where the groundwater has been flushed have low salinity groundwater that supports a healthy tree cover, whereas the remaining areas have a raised water table with high salinities which creates a stressed tree cover.

In a hydrogeological benchmark assessment for salt accessions to the River Murray between Wentworth and Renmark, REM (2003) assigned the Chowilla floodplain and the Murtho irrigation area as first and second priority 'hotspots' respectively, for management intervention and monitoring. The hot-spots were rated using semi-quantitative criteria based on current and future impacts, and the capacity to be able to manage the problem. Chowilla achieved the highest ranking primarily due to high (measured) salt accession to the River. Murtho received second ranking based on the potential for future salt accessions to become high.

Within Chowilla, the key process for the discharge of salt during low to medium river flow was identified as direct groundwater discharge (REM 2003). During higher river flows (when over-bank flow occurs), salt is discharged from the floodplain sediments by:

- flushing of stagnant pools of saline water;
- wash-off of salt from the floodplain surface; and/or,
- flood water recharging the floodplain aquifer and creating a groundwater pressure gradient back to the River channel. This is a major process influencing the discharge of salt from anabranch systems found in Chowilla.

Within Murtho, the presence of small groundwater mounds in the region has accelerated discharge of salt to the River and floodplain by displacing naturally saline groundwater (at 10,000 to 30,000 mg/L) from the Channel Sands aquifer to the River. Modelling has indicated that, within 50 to 100 years, the groundwater mounds could increase salt accessions to the River by more than three times the current load of 30 T/day. Much of this increase is due to historic irrigation that was less efficient than current operations (REM 2003).

Discussing limitations of the data, REM (2003) state that their findings should be considered as preliminary only and strongly recommend additional sampling for verification. However, they did note that indicators of salinity (e.g. samphire growth, salt scalding and groundwater seepage) were high in four of their delineated sub-regions, three of which (Murtho, Ral Ral, and Chowilla) are located within the Site. Sub-regions that showed greater evidence of salinity also showed higher levels of tree stress, with highly affected sub-regions showing tree stress levels often above 70 percent (REM 2003).

3.2.5 Water Quality

The main issues with water quality at the Site are turbidity, eutrophication and salinity. A water quality report published by the Murray-Darling Basin Commission in 1988 provides information on a range of water quality indicators relevant to the Site in the decade immediately before its Ramsar designation.

Turbidity in this reach of the River Murray is dominated by the effects of the Darling River, which carries large quantities of fine clays (mean particle diameter 2 µm) (Mackay 1988). Turbidity monitoring in the River Murray in 1978-1986 showed a doubling of turbidity above and below the Darling River confluence (median 23 NTU at Merbein; 46 NTU at Lock 9), with the Darling River at the confluence having a median 76 NTU (Mackay 1988). At Lock 5, near the Riverland Ramsar Site, the median turbidity over the 9-year sampling period was even higher than Lock 9, at 65 NTU, probably reflecting inputs from Lake Victoria, which at that time was used to store water from the Darling River. Water quality is highly variable in space and time and is affected by flow conditions. However, the increased turbidity values downstream of the Darling confluence were a consistent feature of the monitoring results. Some of the suspended clay settles during periods of low flow, and this may be increased by flocculation caused by high salinity.

Nutrients were also typically high in the River Murray downstream of the Darling confluence, with median total phosphorus concentrations increasing from 0.068 mgL^{-1} at Merbein, to 0.112 mgL^{-1} at Lock 9 over the sampling period. The median total phosphorus concentration at the Darling River site over the sampling period was very high at 0.310 mgL^{-1}. Similar to turbidity results, the median total phosphorus concentration showed further increases from Lock 9, reaching 0.129 mgL^{-1} at Lock 5 (Mackay 1988). A similar pattern was observed for filterable reactive phosphorus (0.010 mgL^{-1} at Merbein; 0.024 mgL^{-1} at Lock 9; 0.175 mgL^{-1} in the Darling River; and 0.027 mgL^{-1} at Lock 5).

High nutrient concentrations in the River Murray within this reach typically do not result in high phytoplankton biomass (algal blooms) due to the light reduction caused by the high turbidity. However, the potential for algal blooms remains high, and can occur when flows are low enough to allow a settling of the fine clays (Mackay 1988). An aspect of the typically high turbidity is that it favours blue-green algal species that can regulate their own buoyancy and therefore remain near the water surface. Therefore, when flows diminish and turbidity reduces, these species are available to take advantage of the improved light environment and high nutrient concentrations, and flourish, causing algal blooms. Blue-green algae (Cyanoprokaryotes) include some species which are toxic to humans, mammals and fish.

Median salinity in the reach of the River Murray at Lock 5 between 1978 and 1986 was 494 EC (Electrical Conductivity units at 25°: EC-25) (Mackay 1988). Within the South Australian section of the River Murray, much of the natural groundwater flow is towards the River and has been increased by:

- vegetation clearance (increasing accessions);

- irrigation causing groundwater mounding; and,
- groundwater displacement by weirs.

These changes have increased the accession of salt to the River.

There is a strong relationship between river flow and many measures of water quality, including salinity. In simple terms, the relationship between flow and salinity is an inverse one (i.e. increased flows result in lower salinities – although a flood after a dry spell may cause a sharp temporary increase in river salinity).

Prior to regulation the River Murray would cease to flow during droughts and salinity in the remnant pools could rise to 10,000 EC within the South Australian reaches. The effect of regulation has been to maintain flows through the drier periods, and as a result, river salinities rarely reached 1,500 EC during the sampling period, even during droughts (Mackay 1988). Although this simple inverse relationship is generally correct, the situation is more complex in practice, and salinity reduction measures such as dilution flows and revised water allocations require computer modelling for management of flows and salinity.

In a study of water quality of eight River Murray floodplain wetlands in South Australia (Suter et al. 1993) three wetlands within the Riverland site were sampled between May 1990 and February 1992. The three wetlands were Clover Lake, Lake Merreti and Lake Woolpolool. Salinity and its variability ranged between the wetlands. Total dissolved solids (TDS) in Clover Lake ranged from 3,210 mg/L at the end of a long drying phase, down to 334 mg/L one month later when floodwaters replenished water in the system. In contrast, Lake Merreti displayed a much smaller range, from a high of 532 mg/L down to 207 mg/L. Lake Woolpolool recorded the highest salinity reading for the entire study, 44,000 mg/L, after a comparatively low reading of 1,710 mg/L a few months earlier, giving it a seasonal fluctuation of 2,470% (Suter et al. 1993). Clover Lake and Lake Merreti both displayed a comparatively uniform salinity across the water bodies during each sampling event, whereas Lake Woolpolool was noted as displaying a distinct difference between the northern and southern sections due to more regular inputs of freshwater from Ral Ral Creek at the southern end of the lake.

Turbidity was highly variable in the three lakes, with each ranging an order of magnitude from maximum to minimum readings. Lake Merreti recorded the highest mean turbidity during the study (210 NTU), Lake Woolpolool the lowest of the three (40 NTU) and Clover Lake had a mean of 110 NTU (Suter et al. 1993). The authors noted that turbidity readings were generally influenced by salinity, with high salinities (exceeding 3,000 mg/L) reducing turbidity.

The above section on water quality focuses on the Site at the time of Ramsar listing. In the last decade, major reductions in rainfall across the Murray Darling Basin have led to diminished flow in the River Murray. If this weather pattern persists, water quality at the Site will alter. The effects are likely to include increased salinities and increased algal blooms.

3.2.6 Vegetation and Habitat

Vegetation is a key component of the Site, contributing substantially to its ecological character and providing the habitat and landscape that form the basis of the Site's ecological services.

Vegetation of the Site encompasses a diversity of terrestrial and aquatic plant communities, from stands of *Callitris* pines on raised dunes to permanent wetlands. The vegetation has been surveyed on several occasions (e.g. O'Malley 1990, Margules et al. 1990, DEH 2002). Variations in sampling and descriptive approaches have led to different classifications. Although some vegetation communities/classes are comparable between studies, others are not.

The DEH survey produced a comprehensive baseline for the Site (Figure 3.7). This survey recognised the following wetland and floodplain vegetation communities which include arid and semi-arid hummock community, Black Box woodland, chenopod shrubland, fringing aquatic reed/sedge, herbfield, Lignum shrubland, low chenopod shrubland, *Melaleuca* forest/woodland, River Cooba shrubland, River Redgum woodland, River Redgum forest, river saltbush chenopod shrubland, and samphire low shrubland.

O'Malley's 1990 study covered a large part of the Site and provides a description and classification of vegetation as sampled from May 1988 to January 1989 – mostly within a year of the Site being Ramsar listed. The study identified six major community types: floodplain Black Box ± River Redgum ± Lignum ± River Cooba; blackbush/hopbush sand-based communities; lakebed herbfield; River Redgum forest communities; weedy lagoon communities; and aquatic herbfield.

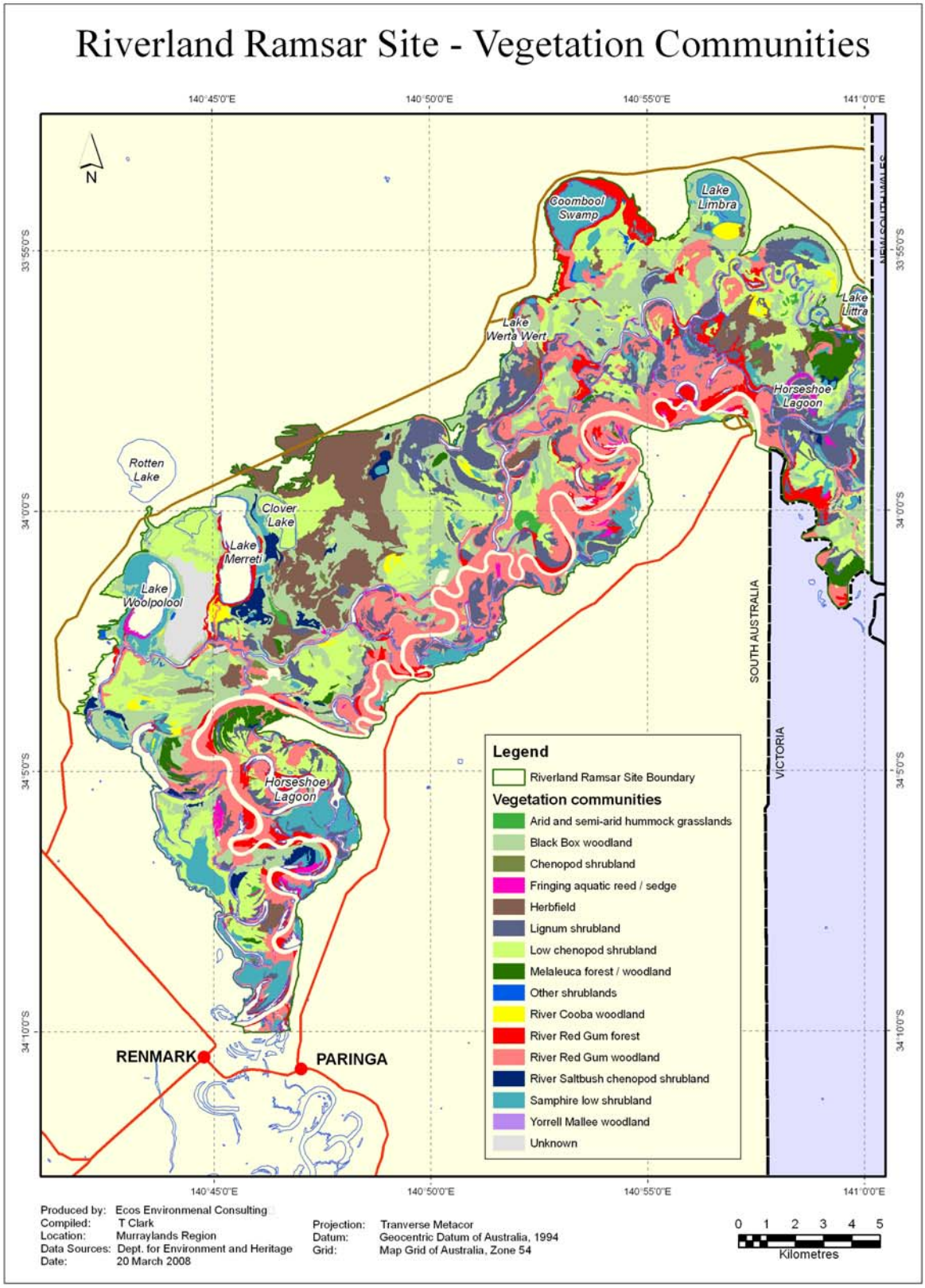


Figure 3.7: Vegetation Communitiues based on 2002 DEH Survey

The vegetation communities identified by Margules et al. (1990) and O'Malley (1990), both of which were close to the time of Ramsar listing, and the DEH (2002) survey (see Figure 3.7) are all broadly similar and the following vegetation communities are recognised:

River Redgum *Eucalyptus camaldulensis* forest / woodland over low open shrubs of Ruby Saltbush *Enchylaena tomentosa*, Nitre Goosefoot *Chenopodium nitrariaceum* or Spreading Emu-bush *Eremophila divaricata* or with forb ± sedge ± grass understorey or floating freshwater herbland (Plate 3.6). The primary distinction between the 'forest' and woodland classifications is that the River Redgum forest communities have a denser growth of trees than the woodland. The denser growth of trees is associated with greater water availability, as displayed by the distributions of the two community types in Figure 3.8. The River Redgum forest communities are typically found closer to permanent water courses and wetlands within the Site.

Plate 3.6: River Redgum (*Eucalyptus camaldulensis*) forest / woodland (Wetland Type Xf) (Photo: Anne Jensen)

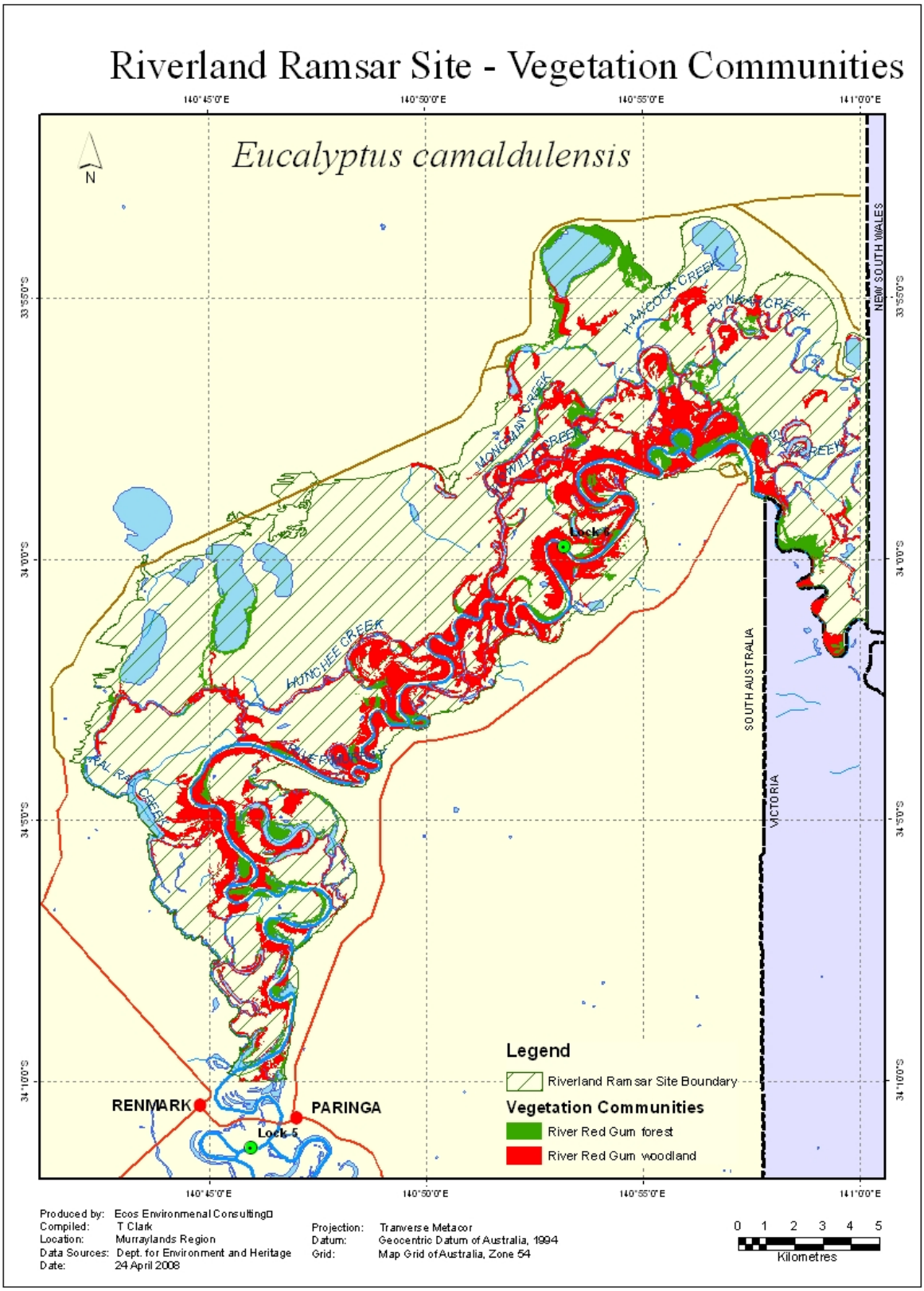


Figure 3.8: Distribution of River Redgum forest and woodland communities over the Riverland Ramsar Site, 2002.

Black Box (*Eucalyptus largiflorens)* woodland with either ephemeral forb/grass, chenopod shrubland dominated by *Atriplex* and *Sclerolaena* spp. or Pigface *Disphyma clavellatum* understorey (Plate 3.7). The Black Box woodland community is typically associated with higher elevations than the River Redgum communities, at greater distances from the watercourses and permanent wetlands (Figure 3.9).

Plate 3.7: Black Box (*Eucalyptus largiflorens*) woodland (Wetland Type Xf) (Photo: Anne Jensen)

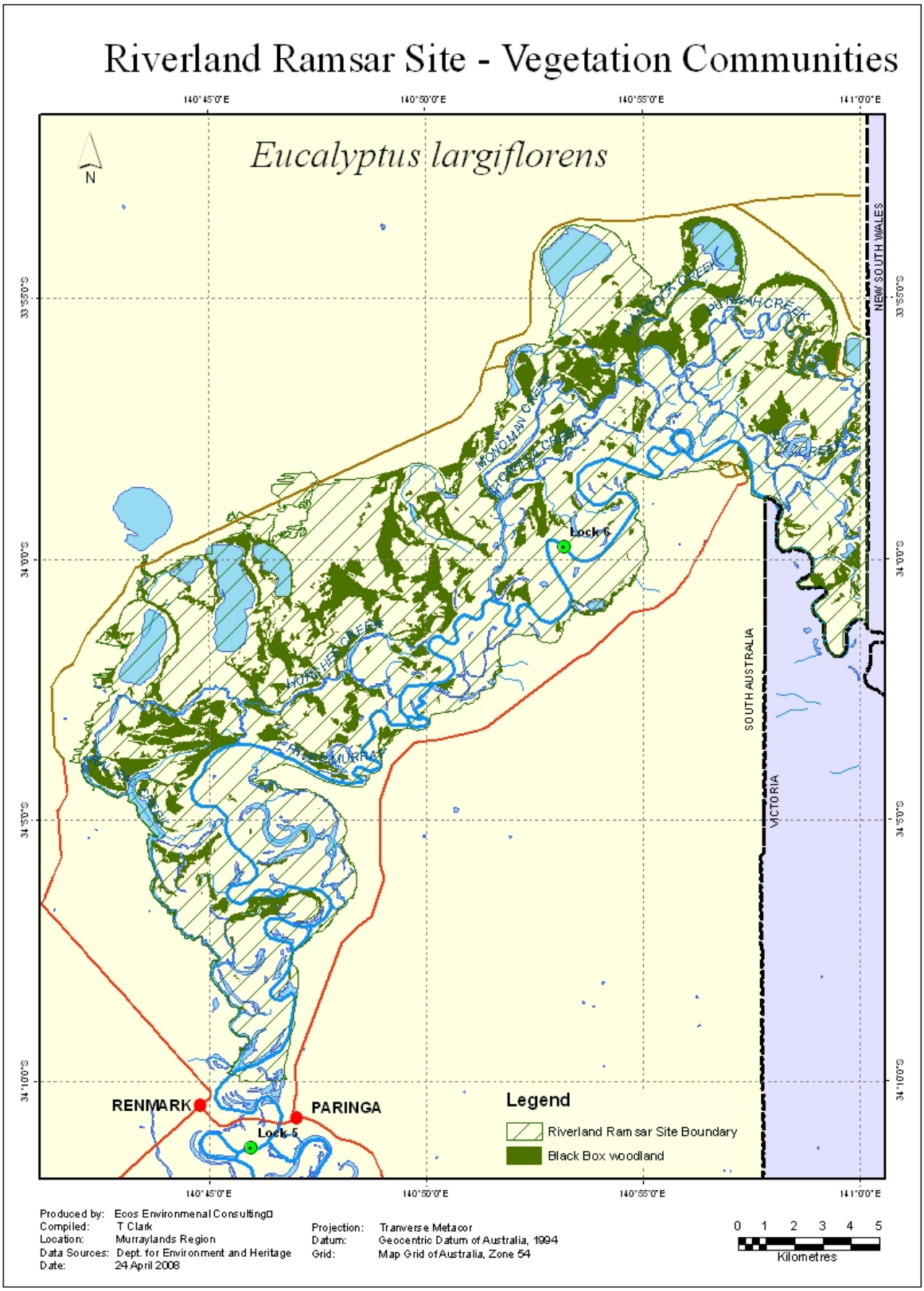


Figure 3.9: Distribution of Black Box woodland communities over the Riverland Ramsar Site, 2002.

Lignum (*Muehlenbeckia florulenta)* shrubland +/- River Redgum, Black Box and River Cooba *Acacia stenophylla* and/or an understorey of herbland or grassland (Plate 3.8). Although the lignum shrubland communities are defined and typified by the lignum shrub layer, they are occasionally associated with a sparse tree layer of River Redgum, Black Box and River Cooba. Similar to the Black Box woodland communities, the Lignum shrubland communities are typically associated with higher elevations, at greater distances from the watercourses and permanent wetlands (Figure 3.10).

Plate 3.8: Lignum (*Muehlenbeckia florulenta*) shrubland (Wetland Type R) (Photo: Anne Jensen)

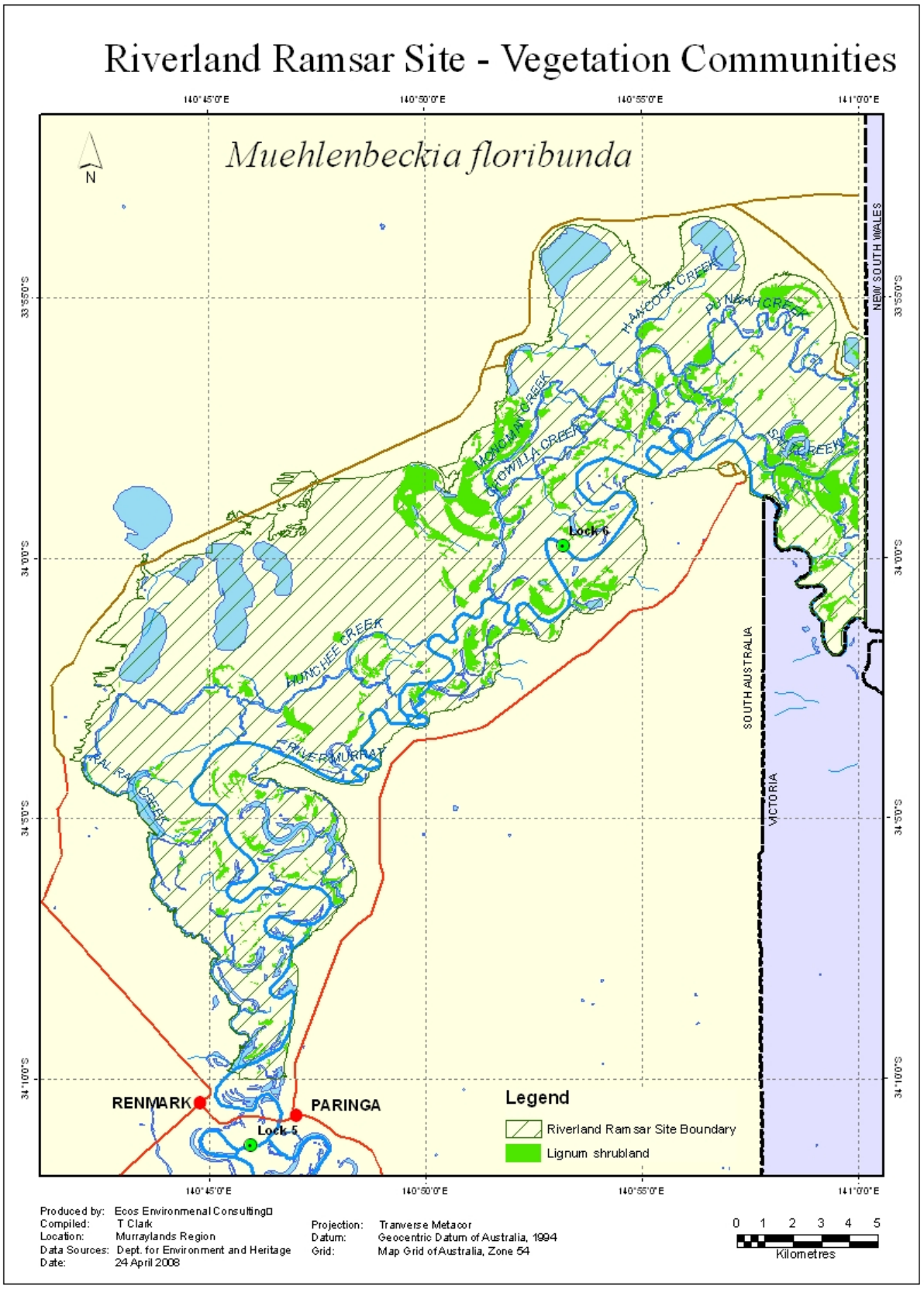


Figure 3.10: Distribution of lignum shrubland communities over the Riverland Ramsar Site, 2002.

River saltbush (*Atriplex rhagodioides)* chenopod shrubland (Plate 3.9).

Plate 3.9: River saltbush (*Atriplex rhagodioides*) chenopod shrubland (Wetland Type R) (Photo: Anne Jensen)

Low chenopod shrubland dominated by *Atriplex* and *Sclerolaena* spp. (Plate 3.10).

Plate 3.10: Low chenopod shrubland (Wetland Type R) (Photo: Mike Harper)

Samphire low shrubland dominated by *Halosarcia indica, H. pergranulata* and *Pachycornia triandra* (Plate 3.11).

Plate 3.11: Samphire low shrubland (Wetland Type R) (Photo: Anne Jensen)

Herbfield dominated by *Calocephalus sonderi, Plantago cunninghamii* and *Lepidium* spp., or grassland dominated *Bromus rubens* and *Vulpia* spp. and /or *Sporobolus mitchellii* (Plate 3.12).

Plate 3.12: Herbfield/grassland (Wetland Type Ts) (Photo: Peter Newall)

The above classification focuses mainly on the vegetation communities during the drier phases of the Site, although creeks and billabongs are often fringed by Common Reed (*Phragmites australis)*, Spiny Sedge (*Cyperus gymnocaulos)* and Cumbungi (*Typha domingensis*). There are also aquatic areas containing submergent vegetation such as Red Milfoil (*Myriophyllum verrucosum)* and Ribbonweed (*Vallisneria americana*), these areas expand during large floods. The Margules et al. (1990) classification has also been more widely used within management plans for the region and a previous RIS for the Site. This ECD identifies two more groups described but not classified by Margules et al. (1990):

Fringing aquatic reed & sedge (Plate 1.13) is typified by Common Reed (*Phragmites australis*), Spiny Sedge (*Cyperus gymnocaulos*) and Cumbungi (*Typha* spp.); and,

Aquatic (permanent and semi-permanent) (Plate 1.13) containing submergent vegetation such as Red Milfoil (*Myriophyllum* spp.) and Ribbonweed (*Vallisneria Americana)*, emergent species such as Spiny Sedge, Cumbungi, and Lignum, and also free-floating species such as *Azolla* spp.

Plate 3.13: Riparian and aquatic vegetation habitat (Wetland Type M) (Photo: Anne Jensen)

A study of the aquatic macrophyte communities within the Site (Roberts and Ludwig 1990) identified four distinct communities, two of which contained an overstorey of River Redgum (redgum + reed; redgum + sedge-rush) and two without a tree overstorey (Spiny Sedge + grass; riparian grasses). The communities were associated with different flow regimes and bank steepness measures, with 'redgum + reed' community mainly found at sites on the main river channel whereas the 'redgum + sedge-rush' community was restricted to billabongs and backwaters. 'Spiny sedge + grass' communities were restricted to backwaters and slow anabranches, whereas the 'riparian grasses' community type was limited to slow and fast flowing anabranches.

A description of vegetation within the Calperum block (Parks Australia 2005) notes "The River Murray floodplains at the southernmost portion of Calperum represent a

small but significant vegetation community, dominated by Red Rivergum *(Eucalyptus camaldulensis*), Black Box *(E. largiflorens),* River Cooba *(Acacia stenophylla)* and Lignum (*Muehlenbeckia florulenta*)". This focus on the drier vegetation units reflects the substantially greater percentage of cover by these communities. However, aquatic and semi aquatic habitats are also represented within Calperum. For example, Suter et al. (1993, in Harper 2003) noted a suite of aquatic and semi-aquatic species, including Spike Rush, Waterbuttons and Spiny Sedge.

Landform (including elevation) and hydrology are strong determinants of vegetation distribution across the site. Table 3.2 presents the key geomorphic and hydrologic features associated with the vegetation communities described above and displayed in Figure 3.11. This figure represents a diagrammatic cross-section of the landscape where the placement of the vegetation communities displays the basic relationships of hydrology, landscape and vegetation community at the Site. Table 3.2 does not represent all combinations, but does present important hydrological features, including flooding regime and duration.

Environmental flow programs often do not have defined targets, and their effects may not be measured other than by casual observations. Yet there are profound differences in the strategies needed for, say, *ad hoc* flow allocations meant to arrest the rate of mortality in River Redgums and programmed flow regimes designed to have sustained effects on entire floodplain communities.

As a rule, animals and plants require water for *survival*, more water for *growth* and still more water for *reproduction*.

Even reproduction may not be a sufficient response, if the goal is to maintain populations over the long term. For example, localized flooding may encourage seeds to germinate, but the seedlings must grow to maturity before they become potentially reproductive. In the case of River Redgums, it takes 2-3 years for the young trees to develop a sinker root that confers some independence of moisture at the soil surface. Until then, the saplings may require a second flooding, especially in the following summer, to maintain soil moisture near the surface and ensure survival. Serial floods, rather than isolated events, are associated with the major cohorts of River Redgums over the last century (Dexter 1967).

The process of *recruitment* (the accrual of potentially reproductive individuals to populations) therefore, is the key to effective management. Recruitment requires more water, delivered at critical times in the life cycle. If the target is a community, rather than individual species, the water regime may need to be diversified, in space and time, to meet the requirements of a diverse suite of organisms. From a manager's viewpoint, it may be necessary to select key species to represent different sections of the community with similar water-regime needs.

Landform, hydrology and vegetation of the Site combine to form the habitat-types. The wetland types, as presented on the RIS (in prep.), also describe the types of habitat found within the Site (Table 2.1).

Table 3.2: Vegetation communities and their associated landforms and hydrology in the Riverland Ramsar Site

Vegetation Community*		Associated landforms/landscape# (AMP = active meander plain; LRMP = low relict meander plain; HRMP = high relict meander plain)	Associated hydrologic regime‡		
			Flow (GL/day)	Recurrence interval	Duration
Aquatic	Permanent	Channels; Billabongs; swamps	5 – 40 40 – 50	1 in 2 years 1 in 2 years	Permanent
	Semi-permanent	AMP: Floodouts; backplains. LRMP: channels; swamps; backplains	50 – 60 60 – 70	1 in 2 years 1 in 3 years	Long duration,. frequently not drying out at all
Fringing aquatic reed & sedge		AMP: Floodouts; backplains. LRMP: channels; swamps; backplains	50 – 60 60 – 70	1 in 2 years 1 in 3 years	3 months (summer) or 6 months (winter), to enable seedlings to establish
Herbfield		AMP: scroll plains; floodouts. LRMP: channels; floodouts; depressions	5 – 40 50 – 60 60 – 70 70 – 80 80 – 90	1 in 2 years 1 in 2 years 1 in 3 years 1 in 4 years 1 in 4 years	Highly variable dependent upon floodplain elevation
River Redgum Forest		AMP: scroll plains.	5 – 40 40 – 50	1 in 2 years 1 in 2 years	3 months
Lignum shrubland		AMP: backplains, floodouts; LRMP: depressions; levees; scrolls; backplains; floodouts .	40 – 50 50 – 60 60 – 70 70 – 80	1 in 2 years 1 in 2 years 1 in 3 years 1 in 4 years	3 months
River Redgum woodland		AMP: scroll plains. LRMP: channel.	50 – 60 60 – 70	1 in 2 years 1 in 3 years	3 months
River Saltbush chenopod shrubland		LRMP: Lunette. HRMP: depressions. Terraces. Upland Rises	70 – 80	1 in 4 years	Long enough to saturate surface soil, with slow recession (at least 2-4

Vegetation Community*	**Associated landforms/landscape#** (AMP = active meander plain; LRMP = low relict meander plain; HRMP = high relict meander plain)	**Associated hydrologic regime‡**		
		Flow (GL/day)	Recurrence interval	Duration
				months)
Low chenopod shrubland	LRMP: Lunette. HRMP: depressions. Terraces. Upland Rises	70 – 80	1 in 4 years	Long enough to saturate surface soil, with slow recession (at least 2-4 months)
Samphire low shrubland	LRMP: Lunette. HRMP: depressions. Terraces. Upland Rises (in moist, salinised areas)	70 – 80	1 in 4 years	3 months
Black Box woodland	AMP: scroll plains; levees. LRMP: channel; levees; scrolls; lunettes. HRMP: depressions; levees; prior streams.	70 – 80 80 – 90 90 – 140	1 in 4 years 1 in 4 years 1 in 8 years	Long enough to saturate surface soil, with slow recession (at least 2-4 months)

*****Largely derived from RIS (in prep.); #Largely derived from MDBC (1991) Fact Sheet 14; ‡Largely derived from MDBC (2006) – Icon site EMP

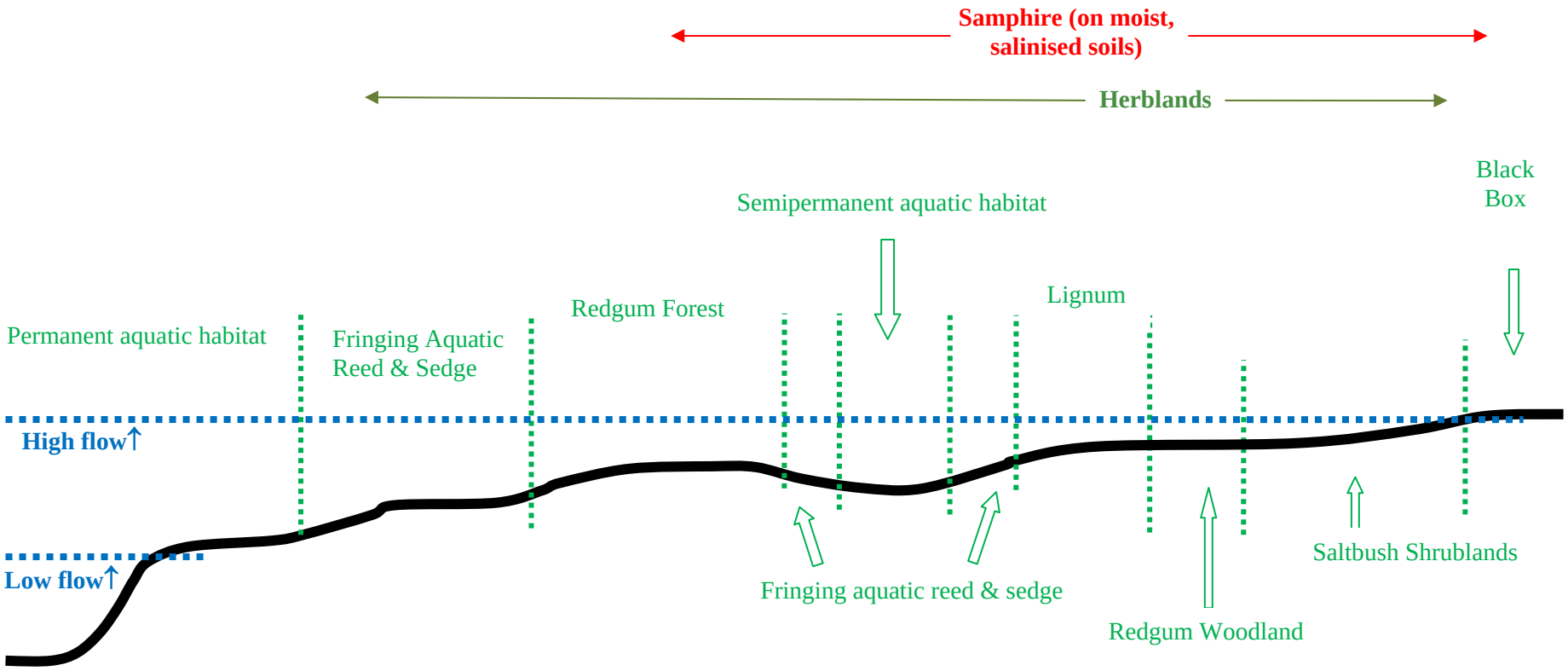


Figure 3.11: Characterisation of vegetation zones of the Site (after MDBC 1991 – Fact Sheet 6).

As is well-known, the hydrological changes imposed by regulation within the site have more to do with smaller floods than big ones. Regulation has changed the frequency distributions of small-to-moderate-sized floods, particularly over-bank flows. In ecological terms, these smaller floods promote recruitment in some sectors of the river-floodplain community and provide low-level 'bridging' recruitment in populations of longer-lived species (e.g. fish, trees).

The term recruitment here refers to the accrual of potentially reproductive individuals to populations. That is, newly germinated seedlings, or newly-spawned fish, are not recruits until they have attained maturity and are able to contribute their own progeny. As a guide, for River Redgums there needs to be substantial recruitment at least once in a decade, and for Murray Cod the interval should not be longer than about seven years.

If recruitment does not occur within these intervals, the populations will decline. As older individuals die, they will not be replaced by others and, over time, the population age profile will change.

A flood may promote reproduction among plants and animals, but for some species at least, it does not ensure recruitment. Judging from historical events, River Redgums may require a second, follow-up flood, perhaps a year after the first, to ensure that soil moisture is maintained for seedlings that have not yet developed sinker roots (and some independence from conditions at the soil surface).

3.2.7 Vegetation and Inundation Level

The dependence of plant distributions upon hydrologic regime at the Site is displayed in Figures 3.12 to 3.14, which show the distributions of three major species (River Redgum, Black Box and Lignum) across the site, in relation to floodplain inundation categories. Note that the areal coverage presented in these figures is different to the coverage presented in Figures 3.8 to 3.10, as Figures 3.8 to 3.10 display vegetation *community* coverage (e.g. River Redgum *forest*, Black Box *woodland*), whereas Figures 3.12 to 3.14 display coverage by the individuals of each species, regardless of community type. Many of the River Redgum trees are not located within River Redgum forests or woodlands. Similarly, a large percentage of the Black Box trees are not located within Black Box woodland (compare Figure 3.9 with Figure 3.13). Despite the larger area covered by the individual trees in comparison to associated vegetation communities, the distributions are generally similar.

The distribution of River Redgum across inundation flow categories within the Site (Figure 3.12) shows a very clear predominance of trees at sites inundated by flows from 45,000 to 80,000 ML day^{-1} (45 – 80 GL day^{-1}), with more than half the tree cover from this species being located in the 45 – 50 and 50 – 60 GL day^{-1} categories. This is supported by the vegetation community data presented in Table 3.3, which shows that the River Redgum forest and woodland communities similarly show a strong preference for these flow categories. Although less widely distributed than the River Redgums, Lignum shows a similar distribution pattern, peaking in

abundance at the sites inundated by flows of 45 – 50 and 50 – 60 GL day^{-1} (Figure 3.14) and the lignum shrubland community distribution shows a similar pattern (Table 3.3).

In contrast, the Black Box distribution is negligible below 50 GL day^{-1}, gradually increases with increasing inundating flow volumes and peaking at the highest category of 200 to 311 GL day^{-1}. Again, the distribution of the Black Box woodland community reflects the distributions of the Black Box trees. The distribution of River Saltbush chenopod shrubland similarly shows a strong peak in the drier areas of the Site (Table 3.3). In contrast, the distributions of permanent and semipermanent aquatic communities (Table 3.3) are generally restricted to areas that only require 3 GL day^{-1} for inundation, with a smaller peak in areas inundated flow volumes of 45 – 60 GL day^{-1} associated with the larger wetlands that retain water and soil moisture between large events.

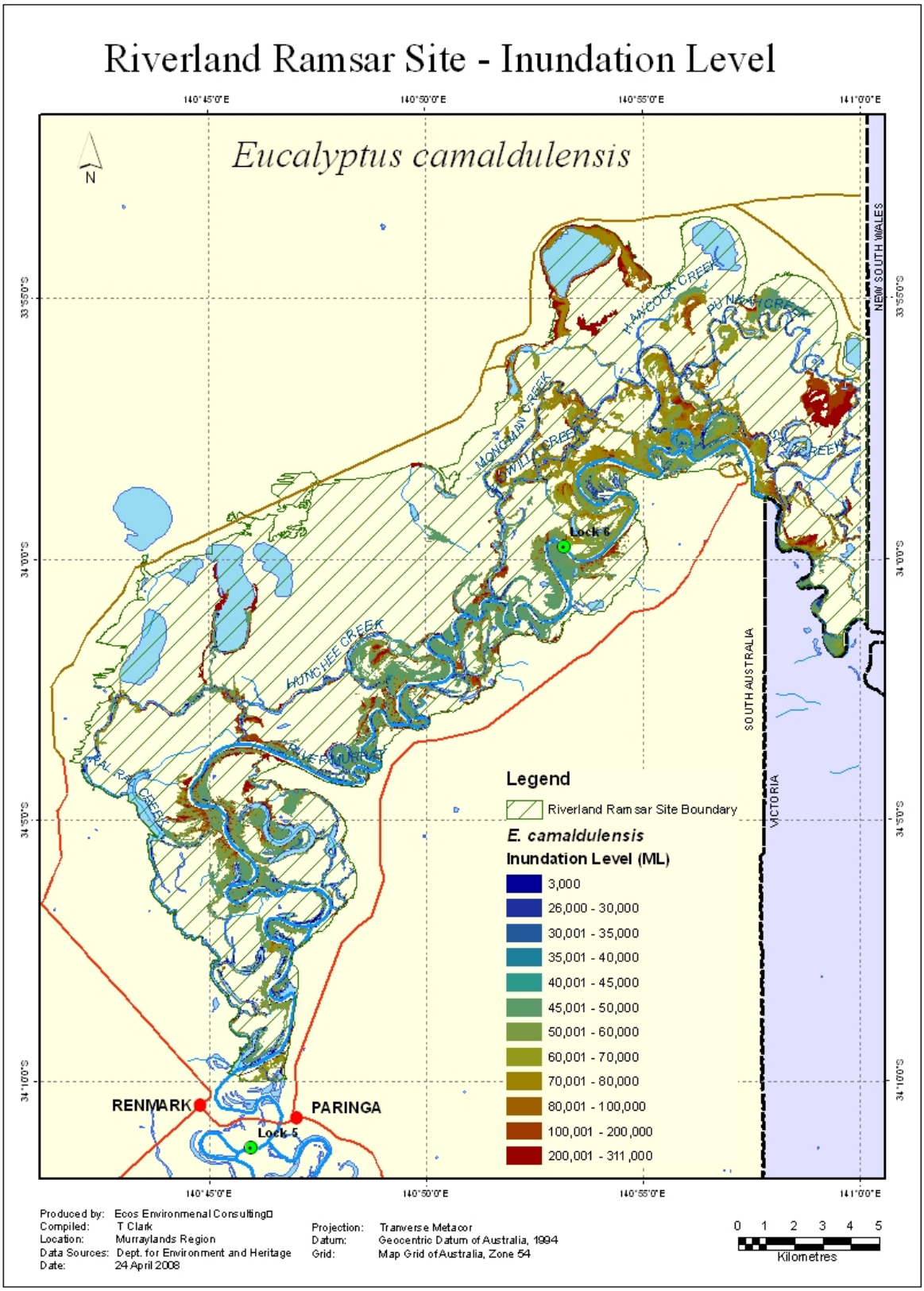


Figure 3.12: Distribution of River Redgum grouped by inundation levels over the Riverland Ramsar Site, 2002.

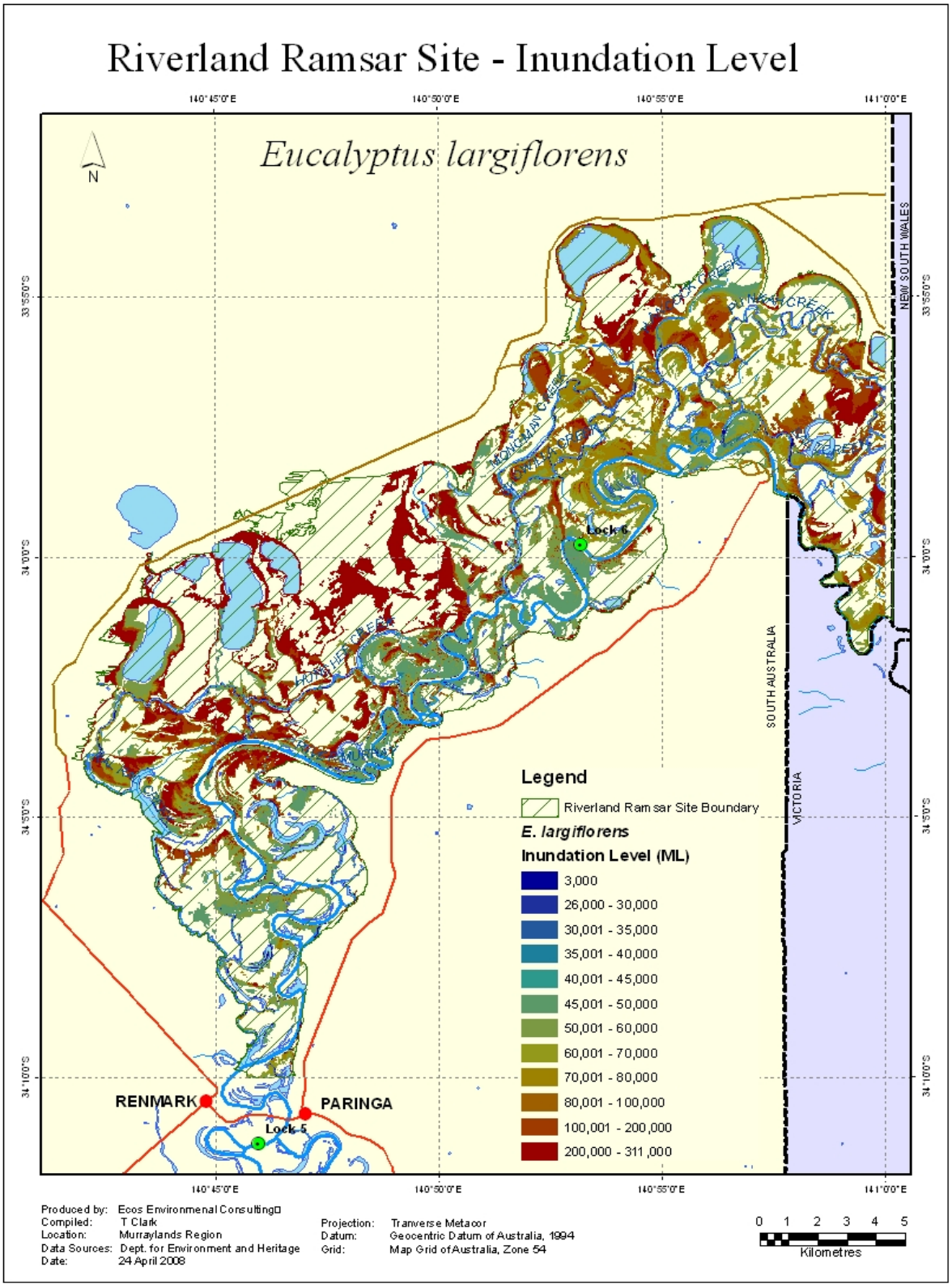


Figure 3.13: Distribution of Black Box grouped by inundation levels over the Riverland Ramsar Site, 2002.

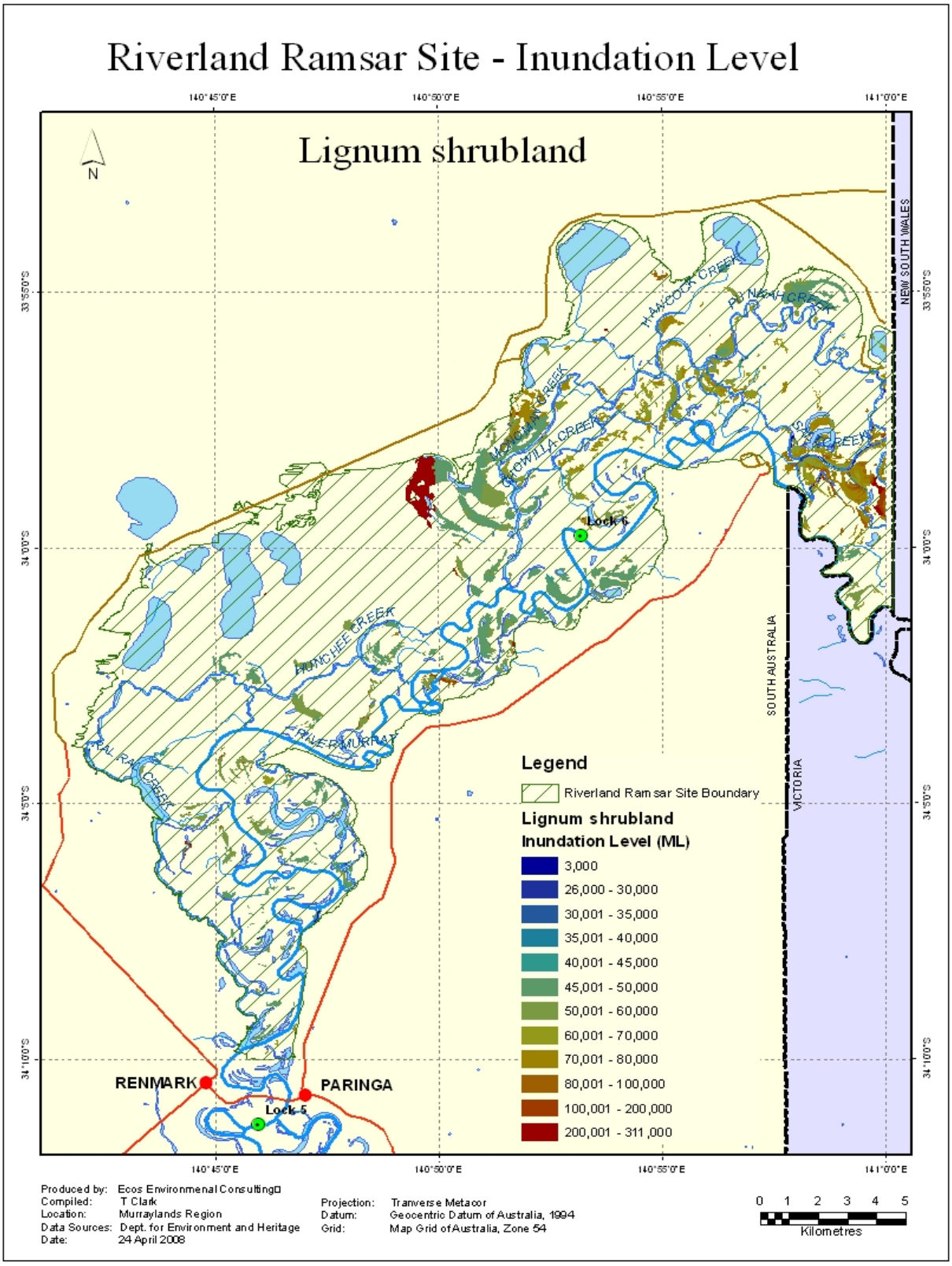


Figure 3.14: Distribution of Lignum grouped by inundation levels over the Riverland Ramsar Site, 2002.

Table 3.3: Area and degree of Vegetation community inundated under various flow ranges (from River Murray FIM)

Vegetation Community	Hectares	Gap in FIM layer	Flood inundation range (GL day^{-1}) 3	26-30	31-35	36-40	41-45	46-50	51-60	61-70	71-80	81-100	101-200	201-311
Arid and semi-arid hummock grasslands	122.33						0.1	44.4	24.4	1.2	28.5	0.5	1.0	
Black Box woodland	5838.36	0.0	0.4	0.2	0.0	0.1	0.2	5.6	10.4	4.8	9.3	10.1	22.0	36.8
Chenopod shrubland	46.27	0.0	0.0	0.0	0.0	0.0	0.0	1.3	44.8	3.8	4.7	10.8	15.0	19.5
Fringing aquatic reed / sedge	275.16	0.0	4.5	25.1	1.1	3.5	5.1	28.5	21.4	2.6	2.7	2.5	1.1	1.9
Herbfield	2322.50	0.1	0.0	0.0	0.0	0.3	0.3	5.1	13.1	3.7	8.4	1.8	1.8	65.4
Lignum shrubland	2945.32	0.0	0.6	0.5	0.1	0.3	0.9	35.2	23.2	11.8	16.7	3.3	1.8	5.7
Low chenopod shrubland	4834.11	4.4	0.1	0.1	0.0	0.0	0.7	14.1	21.9	7.8	14.0	4.4	4.4	28.0
Melaleuca forest / woodland	586.21	0.0	0.3	0.8	0.1	0.0	0.1	1.0	7.0	4.8	8.7	4.5	26.4	46.2
Other shrublands	63.62	1.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.3	2.3	2.3	3.5	90.2
River Cooba woodland	230.86	0.0	0.0	0.1	0.0	0.0	18.1	25.2	23.1	9.8	7.5	0.3	2.2	13.6
River Redgum forest	1550.21	0.0	6.1	2.6	0.8	1.2	3.3	23.4	16.1	6.9	17.0	6.4	5.4	10.6
River Redgum woodland	5305.03	0.0	3.8	2.3	0.5	0.8	2.2	24.6	25.4	10.4	13.6	4.4	7.1	4.9
River Saltbush chenopod shrubland	350.29	0.0	0.1	0.0	0.0	0.2	1.0	16.9	8.4	0.4	2.4	0.8	6.1	63.8
Samphire low shrubland	2485.17	0.0	0.4	0.7	0.7	0.8	13.1	24.5	19.5	5.5	16.8	2.7	4.5	10.7
Unknown	425.56	0.2	1.6	0.1	0.0	0.0	0.0	1.4	5.0	0.2	0.2	0.2	0.4	90.8
Yorrell Mallee woodland	0.78	11.0	0.0	0.0	0.0	0.0	0.0	1.6	0.1	0.0	0.0	0.3	1.8	85.2
Permanent and Semi-permanent aquatic communities	3254.88	0.0	57.5	3.6	0.4	0.3	0.9	7.3	13.7	2.5	2.4	3.1	3.2	5.0
Hectares per inundation category		219	2244	403	76	120	664	4940	5444	2038	3513	1487	2465	7026
% of Total Area Inudated per category		0.7	7.3	1.1	0.2	0.4	2.2	16.1	17.8	6.7	11.5	4.9	8.0	22.9

3.2.8 Fauna

While there is good information about the species occurrences of birds, mammals, reptiles and amphibians, aquatic macroinvertebrates, molluscs and crustaceans and fish there is poor if any information on the populations of these fauna through time. Some snapshots exist for some fauna but these have been undertaken during the current drought period and are unlikely to be representative of the time of listing (e.g. Harper 2003; Zampatti et al. 2006b).

Avifauna The vegetation communities and habitats described in the previous sections sustain diverse bird assemblages, including wetland, woodland, shrubland and grassland species, and species not found elsewhere in South Australia. This reflects the habitat diversity of the Site, its relatively low disturbance and its remoteness from human population centres (Carpenter 1990). The Site also provides a corridor for bird movements between regions.

Carpenter (1990) recorded 134 species at Chowilla, including 30 breeding species, and noted that 170 species had been recorded in that area. A total of 165 native bird species have been recorded across the Calperum and neighbouring Taylorville stations, including wetland, migratory and mallee-dependent species (Parks Australia, 2005), and 53 species of waterbirds and two wetland raptors were recorded at Lake Woolpolool alone (Jensen 2000; Harper 2003). The most recent RIS (in prep.) reported 179 species for the whole site, including 63 wetland-dependent species (Appendix 2.1). As noted in Section 2 of this report, the Site supports 18 State-listed threatened bird species (Appendix 2.3), eight species listed under international agreements (Appendix 2.4), and one species listed nationally as ‘vulnerable’ under the EPBC Act. A list of all bird species recorded as part of a DEH survey in 2003 is presented in Appendix 2.2

Mammals In a survey near the time of Ramsar listing (Brandle and Bird 1990), 25 species of mammals were recorded at Chowilla, including 17 native species. The native species included eight species of bat, three species of dasyurid (two dunnart species and a planigale), two species of kangaroo (Western Grey and the Red), a species of native mouse, the native water rat, the Short-beaked Echidna and the Brush-tailed Possum. The introduced species were sheep, cattle, the rabbit, brown hare, feral pig, feral goat, House Mouse and Red Fox.

A total of 25 native mammal species have been recorded across the Calperum and neighbouring Taylorville stations (although the majority of these species were from mallee not floodplain habitat) of which the Western Grey Kangaroo and Red Kangaroo are the most abundant (Parks Australia 2005). About half of these 25 species recorded are bats.

A list of all mammal species recorded as part of a DEH survey in 2003 is presented in Appendix 2.8.

Although not recorded during the 1988 Chowilla survey (Brandle and Bird 1990), the Feather-tailed Glider is a State-listed species, endangered in South Australia, and has been recorded within the Site (RIS in prep.).

Brandle and Bird's (1990) data were limited, but some conclusions could be drawn:

- the Site contains a species assemblage that is surprisingly diverse and unique to the riverine corridor of the upper River Murray in South Australia;
- the Site has not escaped the widespread, devastating changes to the Australian semi-arid and arid zones, including extinctions to almost all the medium-sized species of rodents, small macropods, bandicoots, and dasyurids;
- several habitat types are important to the mammal fauna, especially the low flood plain areas subject to frequent inundation; and,
- feral animals present particular problems for the Site's fauna, in particular, rabbits, feral goats, feral pigs and foxes either directly or indirectly contribute pressure on the native fauna.

Reptiles and Amphibians Thirty-eight species of reptiles have been recorded at the Site (RIS in prep.). These include three turtle species, lizards such as gecko, dragon, monitor and skink species and six species of snake.

Bird and Armstrong (1990) surveyed the Chowilla block of the Site in October 1988 and recorded:

- seven species of frog (including the Southern Bell Frog, *Litoria raniformis*, listed as endangered under the EPBC Act);
- eighteen species of lizard, comprising;
    - nine skinks (each from a different genus);
    - five geckoes;
    - two goannas (including the Lace Monitor, *Varanus varius*, listed as Rare in South Australia); and,
    - two species of dragons;
- one turtle (Eastern Long-necked Turtle, *Chelodina longicollis*); and,
- five snakes.

As in the mammal survey by Brandle and Bird (1990), Bird and Armstrong (1990) stated that their sampling was limited and indicative only, and cited several species of herpetofauna that were not found during the survey but had been recorded at the Site on other occasions. These included two species of turtle (the Broad Shelled Turtle *Chelodina expansa*, listed as Vulnerable in South Australia and the Murray

River Turtle *Emydura macquarii*) a gecko and the carpet python (*Morelia spilota variegata*, listed as Rare in South Australia). Additionally, there are other species that have been found in similar habitats and may occur on the Site, but have not been recorded. A survey of the site by DEH in 2003 found twenty-seven species of reptiles, and is presented in Appendix 2.7.

The RIS (in prep.) noted eight species of frog have been recorded at the site. The survey by Bird and Armstrong found seven species, which covered the list of frog species known for the Chowilla region:

- Peron's Tree Frog (*Litoria peronii*);
- Southern Bell Frog (*Litoria raniformis*);
- Eastern Sign Bearing Froglet (*Crinia parinsignifera*);
- Bull Frog (*Limnodynastes dumerilii*);
- Long-thumbed Frog (*Limnodynastes fletcheri*);
- Spotted Grass Frog (*Limnodynastes tasmaniensis*); and,
- Sudell's Frog (*Neobatrachus sudelli*).

A species of frog not found in Chowilla – the Common Eastern Froglet (*Crinia signifera*) - was recorded at Woolpolool (Harper 2003), Whirlpool Corner and also Woolenook in the Murtho block (SKM 2005). The updated RIS (in prep.) had not included the Common Eastern Froglet in its list of eight amphibians, instead noting the presence of the Painted Frog (*Neobatrachis pictus)*. Therefore, the total number of frogs recorded at the site is nine.

Aquatic Macroinvertebrates The aquatic habitats on the River Murray floodplain at the Site support a diverse assemblage of macroinvertebrates, with a total of 96 taxa being recorded during a survey of the Chowilla section of the Site in October 1988 (Lloyd and Boulton 1990). The main channel sites within the survey recorded 27 taxa, indicating that the floodplain habitats harbour a rich faunal diversity compared to the channel, reflecting its high habitat diversity.

The Lloyd and Boulton (1990) survey demonstrated that many macroinvertebrate taxa display specific habitat requirements. The functional feeding groups (e.g. predators, detritivores) also showed significant differences in habitat distributions, emphasizing the need for a broad range of habitat types within the floodplain. In particular, flow regimes and vegetation structural complexity separated many taxa and functional feeding groups (Boulton and Lloyd 1991). For example, there was little faunal overlap between billabongs and the main river channel.

Within the Murtho block, macroinvertebrate sampling at Woolenook, Weila and Murtho Park yielded 41, 42 and 40 taxa, respectively (SKM 2005). A detailed study of the macroinvertebrates of Clover Lake, Lake Merreti and Lake Woolpolool (Suter et al. 1993) resulted in 86, 121 and 106 taxa being identified in the three wetlands,

respectively. The study by Suter et al. (1993) examined eight wetlands in the South Australian floodplain of the River Murray and noted that all wetlands in the study had high species richness, although the 86 taxa at Clover Lake was the equal lowest richness of the eight wetlands. The lower number of taxa at Clover Lake was related to a trend of increasing richness at permanently inundated wetlands and at low salinity wetlands (Suter et al. 1993).

As the fauna of the floodplain is the most diverse and the floodplain habitat is potentially the most threatened by alteration of the flooding regime, the wetland macroinvertebrate fauna is particularly vulnerable to the effects of river regulation.

Molluscs & Macrocrustaceans Two species of freshwater mussel occur in the wetland complex. The river mussel *Alathyria jacksoni* is typical of moderate- to fast-flowing channels, including the River Murray channel and the larger anabranches. The floodplain mussel *Velesunio ambiguus* prefers slow-flowing and still-water habitats, including billabongs, backwaters and impounded areas of the main channels.

The river snail *Notopala hanleyi* was formerly common in flowing-water habitats within the site prior to listing in pre-regulation times, but has virtually disappeared in South Australia except for populations surviving in a few irrigation pipeline systems, where they are an occasional pest. In the last 10-15 years (pre-2007) efforts have been made to establish snail populations in some regional wetlands. The species is declared endangered in New South Wales.

The Murray crayfish *Euastacus armatus* was formerly common in flowing-water habitats within the site prior to listing in pre-regulation times, but now is virtually extinct in South Australia. This may be due to river regulation causing a substantial reduction in its preferred running water habitats. The smaller yabbie (*Cherax destructor*) is common throughout the Site's wetlands, except in fast-flowing water.

Atkins and Musgrove (1990) indicated that the freshwater shrimp (*Macrobrachium australiense*) occurs in a range of lotic habitats within the Site.

Fish As noted in Section 2.2 of this report, the Site supports 16 native fish species within the Murray-Darling Basin (Table 3.4). In the Murtho block of the Site (SKM 2005) eight native fish species were found across four sampled sites (Templeton, Weila, Murtho Park and Woolenook Bend). In the Calperum block twelve native fish species have been recorded (Parks Australia 2005).

In a survey within the Chowilla block in 1988, Lloyd (1990) collected eleven species of fish, three of which were exotic. Lloyd noted that the species caught were those known to be common in the area, and that the brief sampling event was unlikely to find locally rare species. The study revealed that, although similar to fish faunal assemblages at other sites on the River Murray, the fish at the Site displayed clear habitat differentiation, due to the extensive development of floodplain macrohabitats at the Site (Lloyd 1990). This supports the suggestion that maintenance of the Site's fish diversity is dependent upon maintenance of habitat diversity.

In surveys conducted in 2005 and 2006, Zampatti et al. (2006a and 2006b) reported 13 species of fish (which included 3 exotic species). These studies showed that fish larvae for most native fish were present for much longer periods during the year in which a spring flow event was observed. The same studies showed significant associations between fish numbers with particular habitats such as large woody debris, emergent and riparian vegetation for the larger bodied fish (Callop and Silver Perch) and Australian Smelt. Bony Herring and Murray Rainbowfish were positively correlated with open water (near vegetation beds) and the gudgeon species associated with submerged or floating-leaved vegetation.

Although there are no fish species listed under the National Parks and Wildlife Act (1972), a recent review has highlighted that Freshwater Catfish, Murray Hardyhead, Silver Perch, Trout Cod and Southern Pigmy Perch should be regarded as endangered in SA whereas Flyspecked Hardyhead and Murray Cod should be regarded as vulnerable (Hammer et al 2007).

Significant populations of exotic fish are also present within the Riverland Ramsar Site and these species include Eastern Gambusia, European Carp and Golfish. Redfin and other exotic species maybe expected in the region but have not been recorded in published reports.

Findings of the Site's Faunal Studies The information available for the Riverland Site at the time of Ramsar listing reveals a diverse fauna. The studies undertaken for the NCSSA report (O'Malley and Sheldon 1990) strongly suggest that the basis of the faunal diversity is the habitat diversity and that this is dependent upon a water regime that includes natural flow variations including regular flooding and drying sequences.

3.2.9 Critical components of the Site

Each of the components described in the sections above contribute to the status of the ecological character of the Site. However, the role of the vegetation in providing the habitat template, and the influence of the hydrologic regime upon the vegetation structure and dynamics, highlight the vegetation and hydrology as the primary critical components of the Site. Accordingly, these components and their interactions are the focus of the conceptual models later in this document (Section 3.5).

3.3 Processes of the Site

Ecosystem processes are "the changes or reactions which occur naturally within wetland systems. They may be physical, chemical or biological" in nature (Ramsar Convention 1996 Resolution, in DEWHA 2008). They include all those processes that occur between organisms, and within and between populations and communities, including interactions with the non-living environment, which results in existing ecosystems and brings about changes in ecosystems over time (Australian Heritage Commission 2002, in DEWHA 2008).

The key ecosystem process that occurs within the Riverland Site is hydrological: the inundation and replenishment of various forms of wetland habitat. This process is essentially the driver of the Site's ecological character, maintaining connectivity and enabling a range of subsequent processes, including:

- Vegetation growth, providing a mosaic of habitat types for fauna;
- Survival, growth, reproduction, and recruitment of a range of biological communities; of particular importance are:
    - River Redgum forests/woodlands;
    - Black Box woodlands;
    - Lignum, chenopod and samphire shrublands;
    - Herbfields;
    - Billabongs, anabranches and basins;
- Freshwater recharge of saline groundwater systems, including freshwater lenses under temporary wetlands;
- Storage and diversion of high flow waters, providing water supplies for humans, stock and wildlife;
- Flushing of salt from floodplain soils, reducing salinity impacts;
- Energy and nutrient processing, providing a base for ecosystems;
- Deposition of fine sediments and nutrients, enhancing water quality of the main channel;
- Breeding and recruitment of the broad range of life forms at the Site; and,
- Dispersal of flora and fauna.

The influence of higher flood waters can also result in the formation and erosion of geomorphic features, ranging from the formation of natural levees, to the filling of depressions with sediment deposits.

The ecological processes listed above are summarised in Tables 3.4 and 3.5. Section 3.5 also provides conceptual models of these processes and interactions at the Site. The pre- and post-regulation hydrologic regime at the Site has been described in Section 3.2.4 of the report, as have the ecological impacts of river regulation.

3.4 Benefits and Services of the Site

Benefits and services of Ramsar listed sites include:

- benefits to humans derived from the site; and,
- non-anthropocentric ecosystem services derived from the site (DEWHA 2008).

Benefits to humans derived from the Site include:

- Cultural heritage (indigenous and European);
- Tourism/recreation;
- Drinking water for livestock;
- Water for irrigated agriculture;
- Livestock fodder;
- Flood retardation;
- Pollutant reduction, including nutrient inputs to the River Murray;
- Sediment trapping;
- Educational and scientific values, including studies on groundwater; and,
- Greenhouse gas offset.

The non-anthropocentric ecosystem services provided by the Site include:

- Wetlands of International Significance;
- Unique occurrence of wetlands in the normally semi-dry lower River Murray floodplain environment;
- Part of the Riverland Biosphere Reserve;
- One of the only parts of the lower River Murray floodplain not irrigated, retaining much of its natural character; hence natural heritage;
- A highly diverse mosaic of both terrestrial and aquatic habitats; probably the highest biodiversity of any site along the Lower River Murray;
- Supports populations of rare, endangered and nationally threatened species;
- Supports populations of rare, endangered and threatened species and communities in South Australia;
- The site has:
    - 28 plant species of state significance;
    - 4 animal species of national significance;

- ❖ Southern Bell Frog (*Litoria raniformis*);
- ❖ Regent Parrot (*Polytelis anthopeplus monarchoides*);
- ❖ Murray Cod (*Maccullochella peelii peelii*);
- ❖ Murray Hardyhead (*Craterocephalus fluviatilis*);

- 23 animal species of state significance;

- o Diverse and abundant waterbirds;
- o Diverse fish fauna (including nationally significant species); and,
- o Diverse invertebrate fauna.

The benefits to humans are displayed in Table 3.4 and the ecosystem services provided by the site are shown in Table 3.5. Both tables present the primary processes contributing to the services and the key components at the source of those processes.

Table 3.4: Benefits provided by the Riverland Ramsar Site with relevant processes and components

Benefits provided	Ecological Processes Creating / Supporting the Service	Key Components
Cultural heritage (indigenous and European)	Maintenance of current landform integrity to meet cultural and spiritual values	Geomorphology
	Maintenance of habitat quality and integrity to meet cultural and spiritual values	Hydrology, Water Quality
	Maintenance of ecosystem, biotic communities, and species populations to meet cultural and spiritual values	Hydrology, Water Quality, Vegetation & Habitat
	Preservation of artefacts, including: middens; burial sites; scarred trees; and campsites	Geomorphology
Tourism/recreation	Provision of water regime to meet tourism/recreation needs, including: boating; house-boating; fishing; camping; and aesthetic enjoyment	Hydrology
	Provision of water quality to meet tourism/recreation needs, including: boating; house-boating; fishing; camping; and aesthetic enjoyment	Water Quality
	Maintenance of biotic communities and species populations to meet tourism/recreation needs for fishing, birdwatching, and waterfowl hunting.	Hydrology, Water Quality, Vegetation & Habitat
Drinking water and fodder for livestock	Provision of water to meet stock watering requirements	Hydrology
	Provision of water to sustain plants for stock fodder	Hydrology
	Maintenance of water quality to meet stock watering requirements, including acceptable salinities and algal concentrations	Water Quality

Benefits provided	Ecological Processes Creating / Supporting the Service	Key Components
Water for irrigated agriculture	Provision of water to meet irrigation water quantity requirements	Hydrology
	Provision of water to meet irrigation water quality requirements, particularly of salinity	Water Quality
Flood retardation	Maintenance of depressions and other landforms that capture and retard overbank flows	Geomorphology
	Maintenance of vegetation cover that contributes to surface roughness and impedes flood flows	Hydrology, Vegetation & Habitat
Pollutant reduction, including nutrient inputs to the River Murray	Maintenance of depressions and other landforms that capture and retard overbank flows, enabling trapping of nutrients and organics in swamps and billabongs	Geomorphology
	Maintenance of vegetation for uptake of nutrients and organics in swamps and billabongs	Hydrology, Vegetation & Habitat
Sediment trapping	Maintenance of depressions and other landforms that capture and retard overbank flows, promoting sediment deposition	Geomorphology
	Maintenance of vegetation cover that contributes to surface roughness and impedes flood flows, promoting sediment deposition	Hydrology, Vegetation & Habitat
Educational and scientific values, including studies on groundwater	Maintenance of current landform quality and integrity to meet scientific and educational study requirements	Geomorphology
	Maintenance of habitat quality and integrity to meet scientific and educational study requirements	Hydrology, Water Quality
	Maintenance of ecosystem, biotic communities, and species populations to meet scientific and educational study requirements	Hydrology, Water Quality, Vegetation & Habitat

Human benefits from the Site include indigenous and European **cultural heritage**. The Riverland has a rich Aboriginal history of some 12,000 years and nearly 180 years of European occupation. Numerous Aboriginal and European heritage sites are located throughout the Ramsar Site.

The Maraura, Ngintait and Erawirung Aboriginal peoples occupied the area. Burnt clay and "middens" of mussel shells mark old campsites. There are also burial sites, scarred trees and isolated artefacts. The people made baskets and nets to catch fish and waterfowl and possums, kangaroos, mussels, yabbies and turtles were also eaten. They made canoes from the bark of River Redgum trees and used possum skins as cloaks. Plants like Cumbungi (*Typha* spp.) produced edible tubers and seeds that were ground into flour.

The first pastoral lease over the region north of the river, known as Chowilla Station, was issued in 1851. In 1864, the lease was assumed by the Robertson family, forebears of the present day lessees. The first owner of the area south of the river between Renmark and the Victorian border was E.M. Bagot. In 1887, the Government set aside 30,000 acres (= 12,141 ha) at the downstream end of Chowilla, then known as Bookmark, for an irrigation area. The town of Renmark was laid out on this land in 1886. The Robertson partnership was dissolved in 1896 and the Chowilla/Bookmark property was split to create Chowilla and Calperum Stations.

In 1871, "Littra House" was built near the NSW border on the northern side of the river to house the Stock Inspector, whose job was to prevent entry of the sheep disease Scabby Mouth into South Australia. The house later became a Customs House, and remains today as a ruin. On the south side of the river a Customs House was established at Border Cliffs in 1884, adjacent to the Victorian border, to monitor river trade between States. The house remains, although modified, and is still occupied.

In the 1880s, Longwang Island, and part of Bulyong Island on the Ral Ral Anabranch, became a community commonage for the settlement of Renmark. At the end of World War I, the commonage was leased to the Returned Servicemens League for horse agistment. In 1967, an evaporation basin was established on Bulyong Island to receive drainage water from local irrigation areas, but this was decommissioned in 1989, after a flood breached the embankment. The islands now are part of the River Murray National Park.

From May 1942 to May 1945, there was a Prisoner of War wood-cutting camp at Woolenook Bend in the Murtho Forest Reserve. Black Box densities were reduced to 1-2 trees per acre (PIRSA 1997), but these trees have a remarkable capacity to re-sprout. Many of the trees harvested during this period remain alive, and can be identified by multiple stems and scarred trunks. The timber was used for fences, buildings and vineyard trellises, and as fuel for irrigation pumps, electricity generators, domestic needs and steamboats.

Other human benefits of the Site include its economic contribution to the region. The water in this section of the River Murray has been the catalyst for the region's economic development. This ranges from early development of the pastoral industry through provision of **water and fodder for livestock**, through the riverboat trade

during the late 1800s, to the **irrigation** industry of the present day. In addition to other forms of industry, the Site has been a major contributor to the region's **tourism and recreation** values. Recreational fishing of native and introduced fish along the River Murray and backwaters within the Site is a long-established use of the Site. The area provides a range of tourist activities such as bush camping, fishing, boating, house boating and accommodation in shearers' quarters. It is reputedly the most valuable area in South Australia for the canoeing component of outdoor educational programs for secondary schools, tertiary educational classes and youth agencies.

The Site has also been the focus of significant **environmental scientific research**, particularly over the last two decades. Key programs have included the *Chowilla Floodplain Integrated Natural Resource Management Program* in the early 1990's, the *Riverland Biosphere Reserve Program*, and more recent activities associated with Chowilla being declared an *Icon Site* and *Significant Ecological Asset* under the Murray-Darling Basin Commission's program, *The Living Murray*.

Channel maintenance and water quality maintenance for the River Murray, **flood retardation** and **floodwater storage** for use in salt dilution are important ecosystem services. The Site is likely to reduce the input of sediment to the River Murray through **sediment trapping** within aquatic-vegetated backwaters adjacent to the main river channel. Similarly, these communities **trap pollutants** including nutrients, reducing the risk of eutrophication and algal blooms further downstream.

Within the Site there are also large, often dry wetlands such as Coombool Swamp and Lakes Limbra and Littra that retain large volumes of flood water. This slows the rate at which floodwaters rise, thereby reducing flood peaks. Similarly, Lake Merreti stores floodwaters which, through agreement with local irrigators and water managers, are released to dilute high-salinity flows in Ral Ral Creek following the flood recession.

Table 3.5: Ecosystem services provided by the Riverland Ramsar Site with relevant processes and components

Ecosystem Services	Ecological Processes Creating / Supporting the Service	Key Components
Wetlands of International Significance Incorporated into the Riverland Biosphere Reserve	Provision of water volumes for ecosystem requirements (including groundwater replenishment & salt flushing)	Hydrology
	Water delivery regime supporting wetland mosaic/diversity	Hydrology
	Maintenance of landform variation	Geomorphology
	Providing aquatic habitat medium to meet species requirements, including salinity, nutrients, and algal concentrations	Water Quality
Unique occurrence of wetlands in the normally semi-dry lower River Murray floodplain environment	Water delivery regime, including variations in flooding magnitude, frequency, duration, seasonality	Hydrology
	Landform processes creating depressions, basins, channels for water retention	Geomorphology
Provision of remnant lower River Murray floodplain habitat and species (not impacted by human irrigation)	Hydrologic regime, including variations in flooding magnitude, frequency, duration, seasonality	Hydrology
	Landform processes creating depressions, basins, and channels for water retention	Geomorphology
	Growth and establishment of plant species and communities	Vegetation and Habitat
High diversity and mosaic of both terrestrial and aquatic habitats	Maintenance of landform variation	Geomorphology
	Water delivery regime supporting wetland mosaic/diversity (including flood-recurrence variations, contributing to vegetation bandings)	Hydrology
	Provision of nutrients and growth surfaces	Substrate

Ecosystem Services	Ecological Processes Creating / Supporting the Service	Key Components
Supports populations of rare, endangered and threatened species (State & National)	Provision of required physical, chemical and biotic environment	Vegetation and Habitat
Diverse and abundant waterbirds	Provision of water volumes for ecosystem requirements	Hydrology
	Water delivery regime supporting wetland mosaic/diversity	Hydrology
	Provision of shelter	Vegetation and Habitat
	Provision of required physical, chemical and biotic environment	Vegetation and Habitat
Diverse fish and invertebrate fauna	Provision of water volumes for ecosystem requirements	Hydrology
	Water delivery regime supporting wetland mosaic/diversity	Hydrology
	Provision of shelter	Vegetation and Habitat
	Provision of required physical, chemical and biotic environment	Vegetation and Habitat
	Providing aquatic habitat medium to meet species requirements	Water Quality

3.5 Conceptual Models of the Site

Conceptual models draw on scientific information to describe the processes that govern ecosystem health. An ecosystem is 'healthy' when its character (its native flora and fauna, for example) is sustained over time, notwithstanding disturbances due to human activities or events like droughts and floods. In these circumstances, the ecosystem is resilient enough to withstand disturbances, maintain processes and supply resources. Its resilience depends, of course, on the degree and nature of exploitation or change. A model can describe a 'healthy' ecosystem that meets the management objective and can also include known impacts and show how they reduce health or biodiversity.

Conceptual models are "a generalised description or representation of the structure and function of a complex system". They are constructed from a series of hypotheses that:

- represent processes known to degrade ecosystems;
- identify processes which can be managed to restore ecosystem function; and,
- inform scientific investigation and monitor management actions.

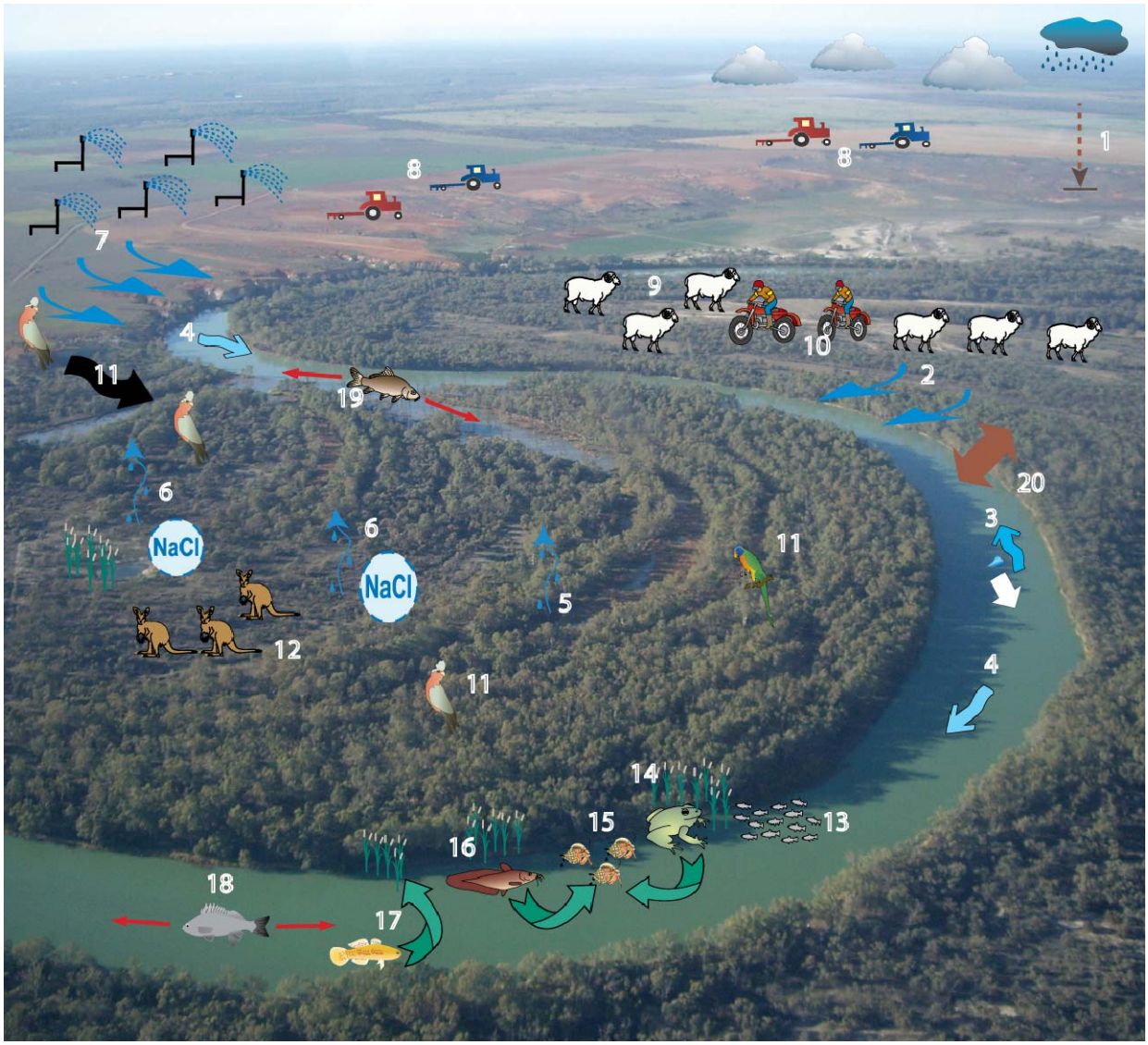
3.5.1 Landscape conceptual models

The landscape models below build upon Figure 3.1 (presented at the start of Section 3) and show key components and processes, and their interactions, of the Riverland Site at a landscape scale under two sets of conditions:

- **Low water levels** with the water mainly confined to within the river channel; and (Figure 3.15); and,
- **Flood conditions** when water spills through the anabranches and across the floodplain and wetlands (Figure 3.16).

Low Water Conditions

Under low water conditions (Figure 3.15) water is retained mainly within the main channel and the rainfall (1) is not sufficient to maintain the wetlands on the floodplain. During this time, evaporation and salt concentration (5 & 6) become important processes. Some aquatic flora and fauna lay dessicant resistant eggs or seeds to hatch or germinate on the next flood. Groundwater inflows occur along the river channel and floodplain in this reach from natural sources (2) and as a result to perched water tables from local irrigation (7). Freshwater flows (4) occur from the remote, wetter catchments upstream and are altered by river regulation (3) resulting from upstream weirs and storages as well as weirs and river abstraction in this reach. Local impacts are also evident through land cleareance and soil disturbance from irrigation (7), dryland agriculture (8), grazing (9) and recreation activities (10).



Natural Proceses

Climate

Evaporation and Salt Concentration

Freshwater Flow

Groundwater Flux

Sediment Flux

Precipitation & Run-off

Biodiversity

Wetland Vegetation

Wetland Forest (Eucalyptus)

Aquatic Vertebrates

Fish Nursery

Fish Passage

Native Fish Diversity

Threatened Species

Bush Birds

Terrestrial Fauna

Invertebrate Fauna

Threats and Impacts

Agriculture

Grazing

Irrigation

Recreation

Altered Hydology

Exotic Species

Figure 3.15: Riverland Ramsar Landscape under low water levels (numbers in text refer to this diagram)

In the dry phase, the floodplain becomes a haven for bush birds (11) and terrestrial fauna (12), which move onto the floodplain and are able to exploit the abundant resources of the drying floodplain. The river channel is the main aquatic habitat during this period with with fish larvae (13), reptiles and frogs (14), macroinvertebrates (15) and fish (16) depending upon this vital habitat which includes riparian reeds, macrophtes and woody debris making up the majority of habitat. Fish, reptiles, and frogs all depend upon macroinvertebrate populations in the river at this time. Threatened species (17) also depend upon riparian and other habitat. The lack of high flows mean that fish undergo short, local movements both up- and down-stream (18).

Flood Conditions

Under flood conditions (Figure 3.16) water spills out of the main channel and the local rainfall (1) assists in maintaining the wetlands on the floodplain. Groundwater inflows occur along the river channel and floodplain in this reach from natural sources (2) and as a result to perched water tables from local irrigation (14). Freshwater flows (4) increases from upstream sources, however these are still altered by river regulation (3) resulting from upstream weirs and storages as well as weirs and river abstraction in this reach but flood waters inundated wetlands and the floodplain (5). Local impacts from land cleareance and soil disturbance from irrigation (14), dryland agriculture (15), grazing (16) and recreation activities (17) still occur as well as sediment fluxes from local run-off (18) from cleared or grazed lands.

As the floodplain is inundated, bush birds and terrestrial fauna (13) move from the floodplain but some species are still able to exploit the floodplain. As flows increase migratory fish make short and long upstream migrations to find additional habitat and breeding (7), native and exotic fish colonise floodplain wetlands as connections are made between the River and floodplain habitats with increasing water levels (8). As wetlands are inundated aquatic vegetation expands and creates aquatic habitat (6) including for threatened species which colonise these habitats (8). Some aquatic flora and fauna which have laid dessicant resistant eggs or seeds hatch or germinate. Fauna also colonise the inundated floodplain habitats to breed and proliferate (9), fish spawning producing larvae (10) which eventually move back to the main channel (11) as they grow. The reptiles, frogs, macroinvertebrates and fish (10) inhabiting the river channel are triggered to move onto the floodplain as water levels rise to expoit the abundant food resources, these populations increase and their condition improves before they migrate back to the main channel as water levels fall (12).

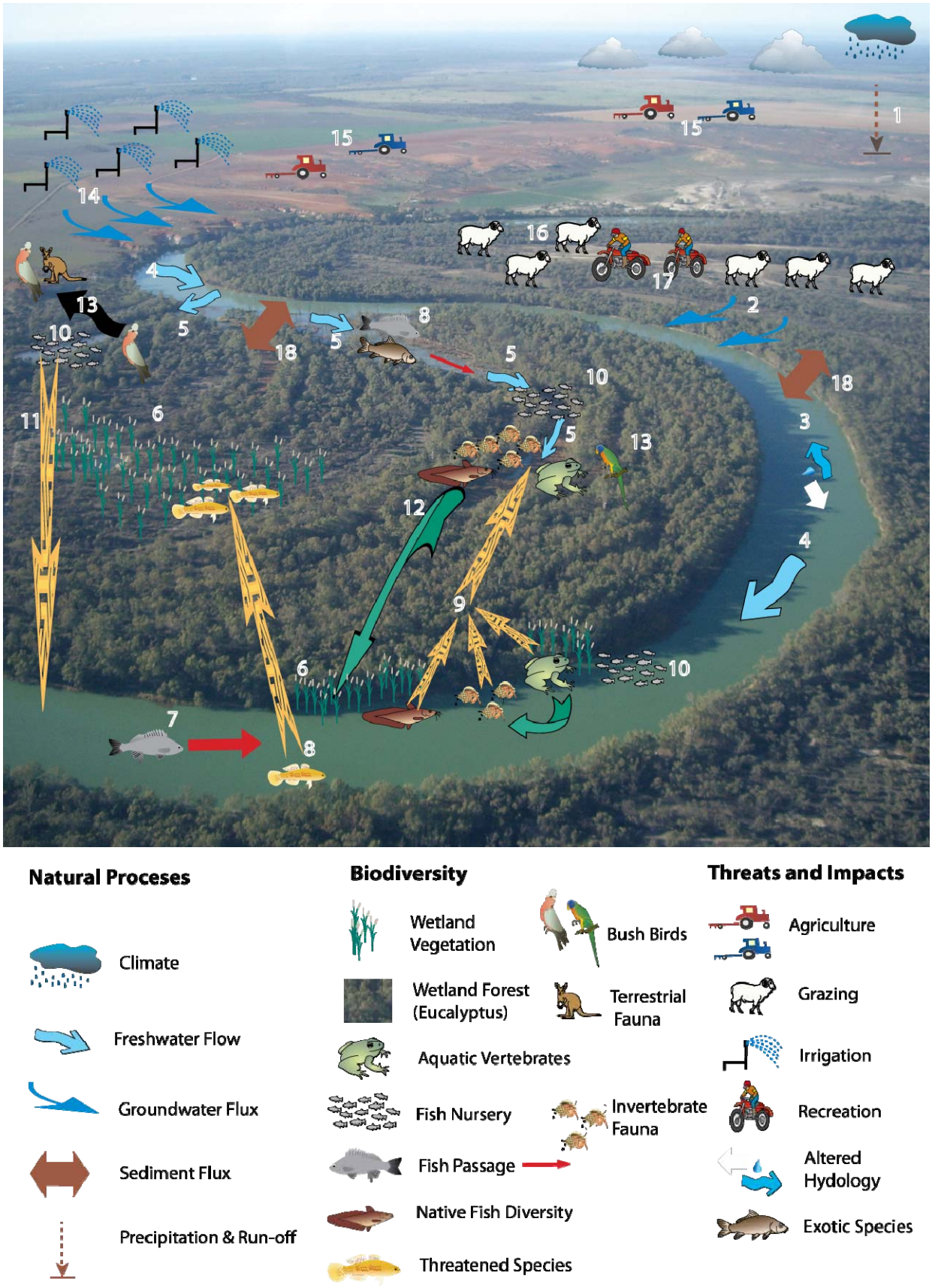


Figure 3.16: Riverland Ramsar Landscape under flood conditions (numbers in text refer to this diagram)

3.5.2 Flood levels and vegetation communities

Complementary models (Figure 3.17) represent interactions between vegetation and flooding regimes, presented as duration, frequency and extent. The visual aids for the model include:

i. floodplain cross-sections incorporating landforms, vegetation and flood levels;

ii. inundation maps for discharges that correspond with the cross-sections; and

iii. pie charts displaying duration and recurrence intervals for the specific discharges. All hydrological data used in the pie charts for Figure 3.17 were sourced from Sharley and Huggan (1995).

The following caveats apply:

- The vegetation bands are based on generalisations from the literature and personal observations. The presence of a plant community at one point in the landscape does not preclude it from occurring elsewhere. For example, lignum shrubland is shown at a lower elevation than River Redgum woodland vegetation, yet there are many places where lignum occurs as an understorey to River Redgum;

- The hydrological information presented in Figure 3.17 for 'regulated' conditions refers to modelled outputs based on data gathered since regulation and up to 1995 (and therefore approximates conditions up to the time of listing of the Site in 1987). Since then, the regional climate has been comparatively dry, with less rainfall and higher evaporation.

Figure 3.17(a) displays the flood extent at flows of 5,000 ML day^{-1}. This level of discharge maintains the water in the main channel, anabranches and creek systems without causing overbank flow. Accordingly, as displayed on the cross-section of Figure 3.17 (a), this rate of flow inundates the permanent aquatic vegetation associated with these systems. This includes habitats with River Redgum as riparian overstorey and also the habitats dominated by submerged, emergent and free-floating aquatic macrophytes. Permanent aquatic habitats disconnected from the main channel, such as billabongs and relict channels, would not be replenished from flows of this magnitude.

The permanent aquatic habitats (Plates 3.1) are significant for conservation, particularly the anabranches (Plates 3.2) which are rare on the River Murray in South Australia and resemble the channel of the River Murray prior to regulation (Sheldon and Lloyd 1990). The diversity of aquatic habitats is rated as high by Sheldon and Lloyd (1990) and is reflected in the variety of physical environments present. The anabranch creeks are important breeding areas for native fish species and refugia for declining aquatic species.

Flows of 5,000 ML day^{-1} would be exceeded 11.4 months of the year under natural (unregulated) conditions and, under regulation, are exceeded for 9.5 months of the year (Sharley and Huggan 1995). This flow was exceeded every year (displayed as 100% of years) under natural conditions and was also exceeded every year at the time of Ramsar listing [described as 'regulated' in Figure 3.17 (a) and in the paragraphs below].

As discharge increases to 40,000 ML day^{-1} [Figure 3.17 (b)], water breaches the banks of the channels and anabranches, reaching areas occupied by the fringing reed and sedge, flows into the semi-permanent aquatic habitats, and replenishes permanent aquatic habitats such as billabongs and relict channels (Plates 3.2 – 3.5). Areas of 'island' River Redgum forest are inundated by this level of discharge and some areas of herbland and samphire shrublands are also inundated [refer also to Figure 3.17 (d)]. These wetlands in the floodplain provide seasonal habitat for migratory birds listed under international agreements such as JAMBA, CAMBA and ROKAMBA.

As displayed in Figure 3.17 (b), flows of 40,000 ML day^{-1} would be exceeded for over one-third of the year (nearly five months) under natural conditions but under regulation are exceeded approximately one-quarter of the year (just over three months) (Sharley and Huggan 1995). The decreased duration is due to the highly regulated flow in the River Murray, controlled by the dams and weirs upstream of the site. This flow was exceeded in just over 90% of years under natural (unregulated) conditions and, under regulation, is exceeded for 40% of the years.

Discharges of 60,000 ML day^{-1} [Figure 3.17 (c)] occurred approximately 59% of years under natural conditions and, under regulation, occur approximately 21% of years. On average, flows of this magnitude would have been exceeded four months of each year, and under regulation are exceeded two and one-half months of each year. At this level of discharge, the Lignum Shrublands are inundated, as are more zones of Herbland and Samphire Shrubland [refer also to Figure 3.17 (d)].

Discharges of 80,000 ML day^{-1} [Figure 3.17 (d)] inundate the River Redgum Woodlands and reach the Saltbush (chenopod) Shrublands. Under natural conditions, this level of discharge occurred in 45% of years and was exceeded, on average, for just more than three months every year. Under regulation, these flows have markedly reduced, occurring on average 12% of years and are exceeded for an average of 2.6 months per year.

At discharges of 100,000 ML day^{-1} [Figure 3.17 (e)] the Black Box woodland is inundated. Pre-regulation, these flows occurred just over 30% of years and now occur in less than 10% of years. Under natural conditions this level of flooding occurs for an average of nearly three months per year, whereas under regulation flooding occurs for an average of two months per year.

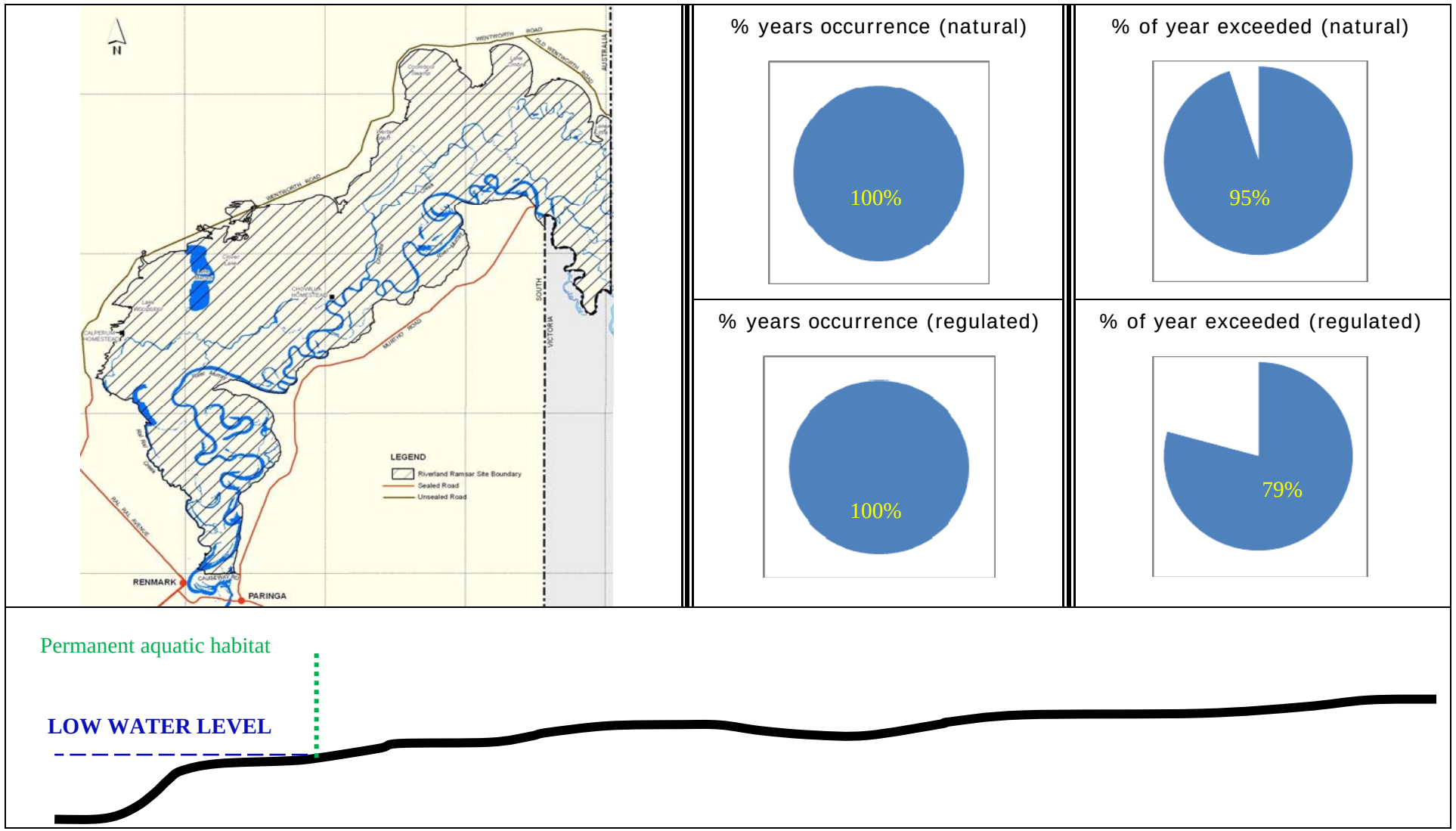


Figure 3.17 (a) Hydrological Conceptual Model 5,000 ML day-1 (= 5 GL day-1)

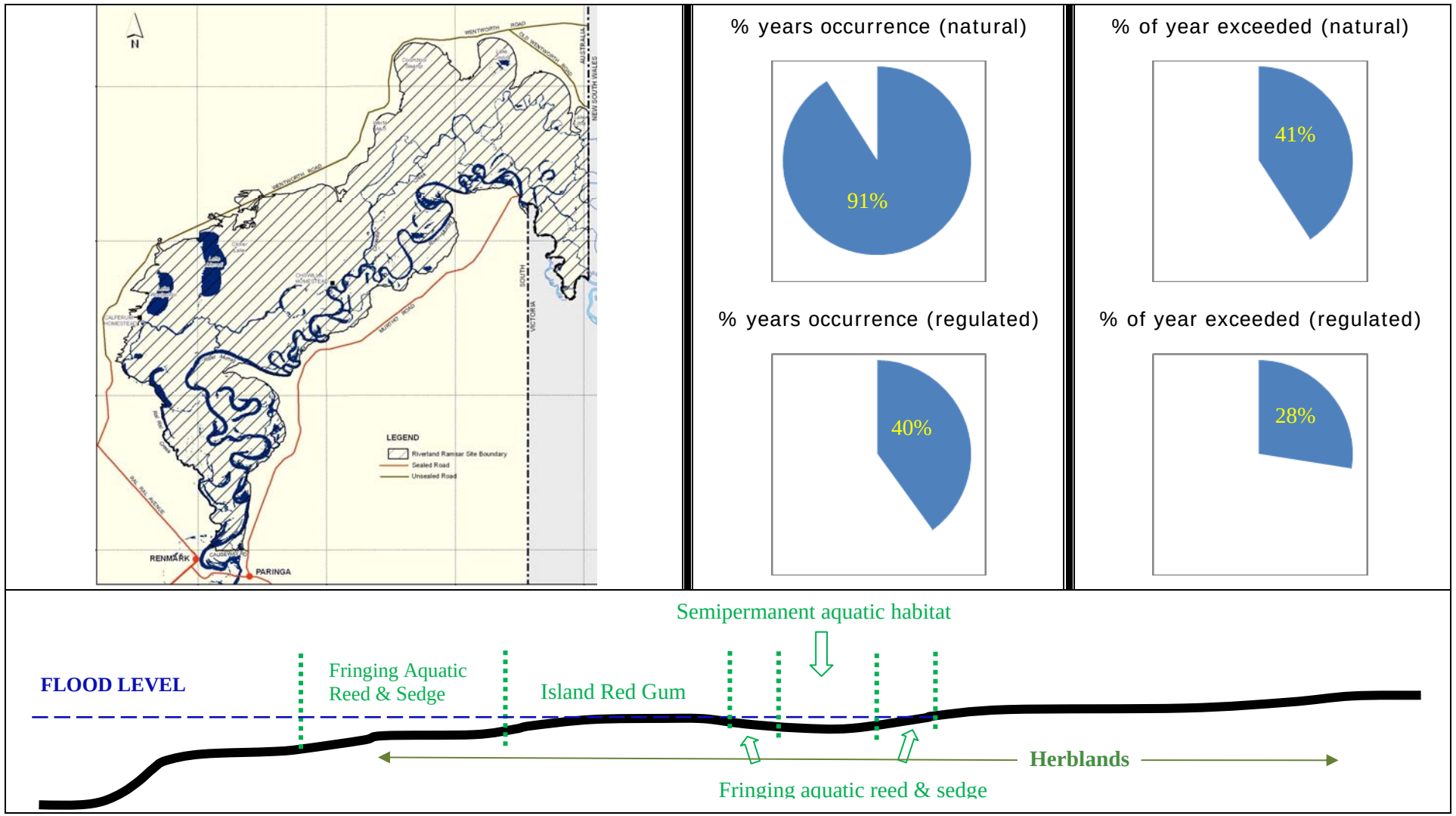


Figure 3.17 (b) Hydrological Conceptual Model 40,000 ML day-1 (=40 GL day-1)

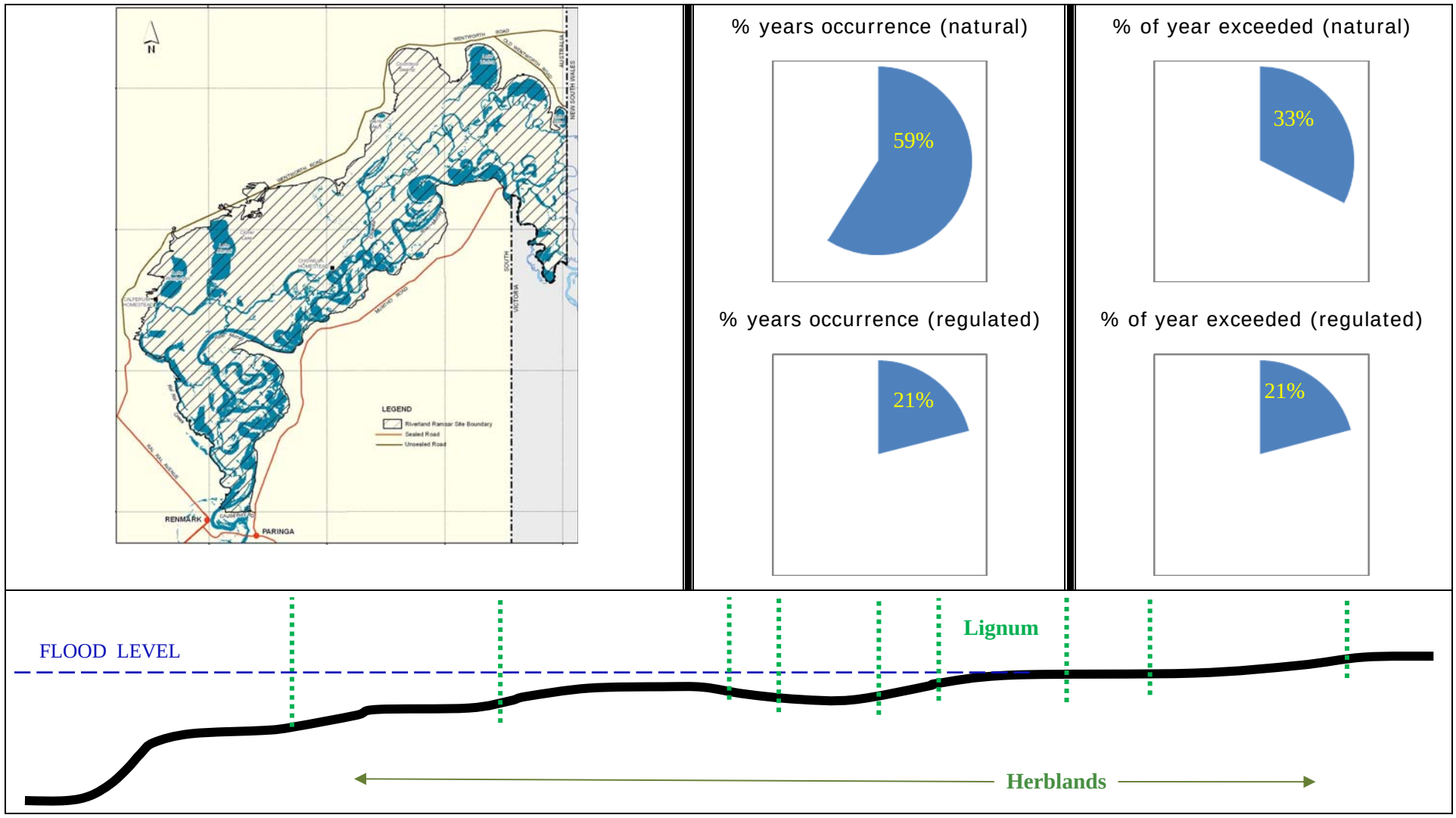


Figure 3.17 (c) Hydrological Conceptual Model 60,000 ML day-1 (=60 GL day-1)

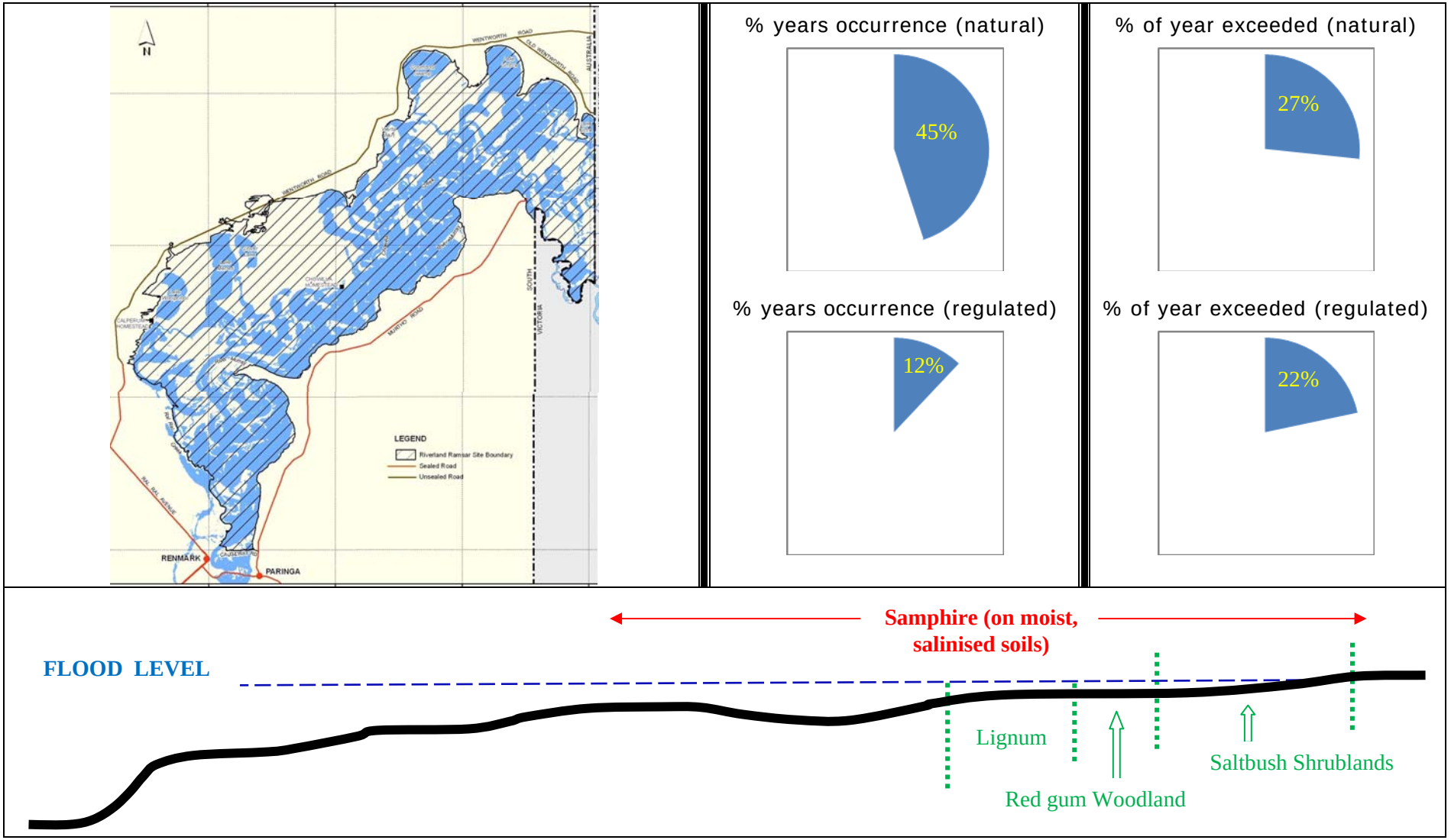


Figure 3.17 (d) Hydrological Conceptual Model 80,000 ML day-1 (=80 GL day-1)

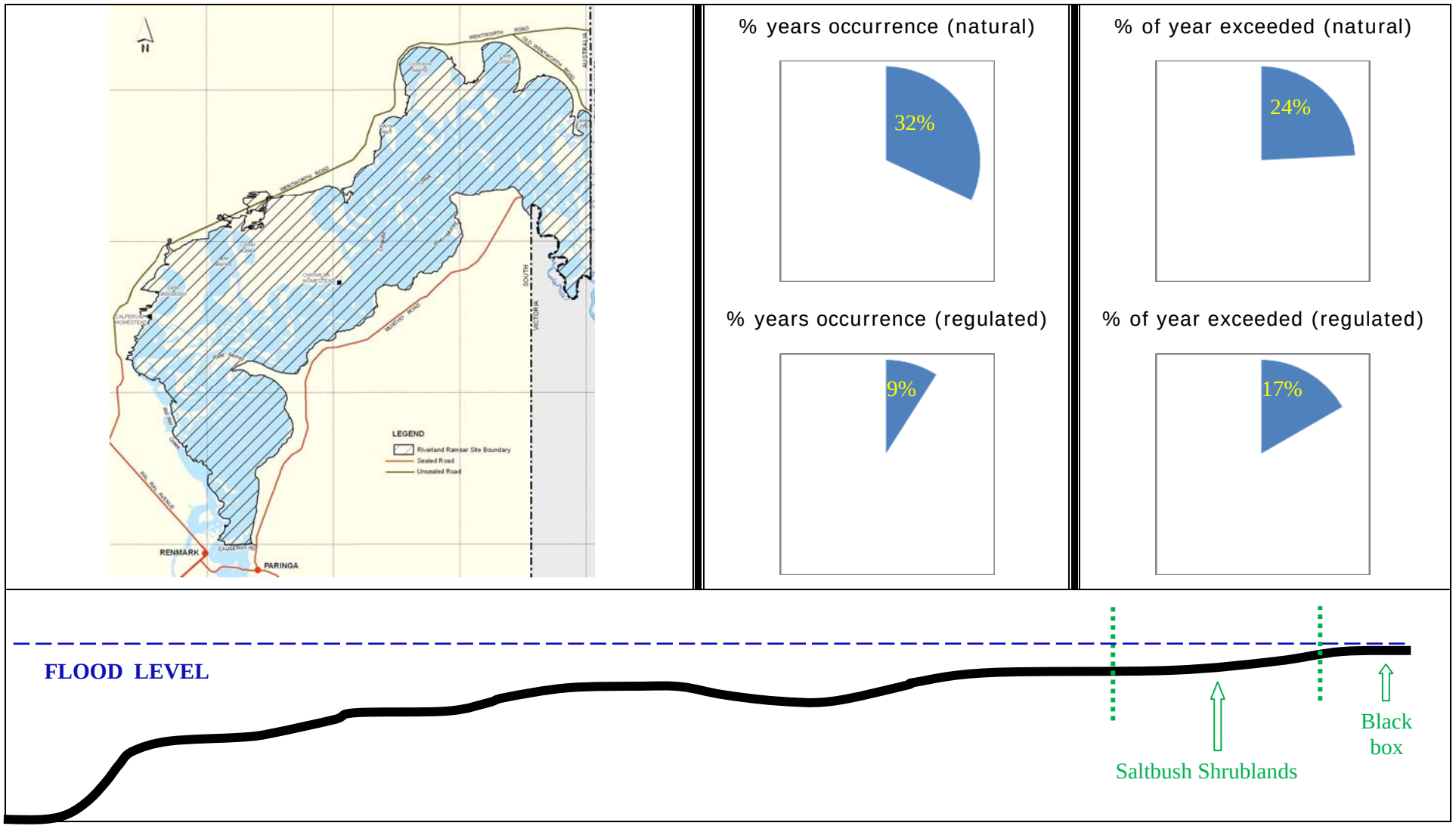


Figure 3.17 (e) Hydrological Conceptual Model 100,000 ML day-1 (=100 GL day-1)

3.5.3 Biological processes

Flooding is, perhaps, the most important natural process at the Site as it links the floodplain and the river (Lloyd et al. 1994). The floods replenish floodplain and lentic habitats with water and allow exchange of nutrients and biota. Flooding provides a period of relative stability (Odum 1969) that results in a period of "predictable" sequence of changes to the environment which can be exploited by many floodplain organisms. For example, flooding boosts invertebrate production, promotes interactions between wetland biota, triggers breeding activity in birds and fish, creates nursery habitat for fish, initiates River Redgum regeneration and growth, and creates extensive areas for aquatic plant colonisation (Lloyd et al. 1991).

The initial inflow of water on to the floodplain triggers these events. Low to higher areas are inundated sequentially until the peak of the flood has passed; nutrients, sediment and biota are contributed to the floodplain during this phase. Water levels recede rapidly at first, until natural sill heights are reached; they then decrease slowly from evaporation or seepage to groundwater (Lloyd et al. 1994).

During flood recession and droughts, river flows decrease and the water level drops, isolating the floodplain further and creating isolated wetlands and pools in anabranches. The isolation and concentration of biota into pools may result in higher mortalities from physiological stress (including oxygen deficits, temperature extremes and physico-chemical changes), increased predation (because predators have increased access to small species) and competition (because large numbers of aquatic animals become concentrated in pools). This is evident in the complete absence of a year class of the River Mussel, *Alathyria jacksoni* in the Mallee Plains zone of the River Murray, corresponding to the 1967-8 drought (Walker 1990).

Flooding drives many of the biological processes of floodplain wetlands. Plants and invertebrates re-colonise the floodplain at downstream areas during floods, either through passive distribution or active production of larvae or propagules. Floodplain wetlands rely upon the interactions between the river and its floodplain. These links are reinforced when the aquatic habitats are replenished with water, allowing exchange of nutrients and biota (Walker 1986; Boulton and Lloyd 1991, 1992).

Many plants require flooding to grow, flower, set seed or germinate. River Redgums at the Site flower and set seed in response to flooding; germinating and the seedlings rapidly grow in the moist floodplain soils. The survival of the seedlings (recruitment) - the most critical phase – is enhanced by mild summers following flooding, and by shallow flooding in subsequent years (Dexter 1967). While perennial hydrophytes sprout from buried rhizomes, annuals are dependent on seed-banks or propagule stores in the soil to re-establish after a dry spell. Some may respond in the first weeks of flooding; others may require several weeks before germinating (Casanova & Brock 1990, Ward 1992; Lloyd et al. 1994).

Flooding is also important to fish as it triggers spawning activity and creates nursery habitat for young fish (Geddes & Puckridge 1989; Gehrke 1990, 1991, 1992;

Puckridge & Walker 1990, Boulton & Lloyd 1992; Lloyd et al. 1994). The rapidity of invertebrate emergence from the sediments produces a valuable food resource suitable for juvenile and post-larval fish (e.g. Golden Perch; Arumugam & Geddes 1987) and waterfowl (Braithwaite 1975, Briggs & Maher 1983, Briggs & Maher 1985, Maher & Carpenter 1984, Crome 1986, Crome & Carpenter 1988).

From studies of wetland sediment samples from the Site, invertebrates emerge from resting stages in the floodplain sediment during the first week of reflooding are small enough to be prey for juvenile fish (Boulton & Lloyd 1992). Callop, Silver Perch and carp gudgeons all first feed at about 5-6 days of age, whereas Murray Cod and catfish undertake first feeding at about 20 days (Lake 1967). This timing matches the peaks of emergence of invertebrates from sediments (Boulton & Lloyd 1992).

During flooding, fish may undertake a range of significant movements. Long migrations of Golden and Silver Perch have been observed during floods (Reynolds 1983, Mallen-Cooper 1989), presumably as part of their spawning behaviour. Shorter movements for breeding, feeding or habitat selection occur during all flows (Lloyd et al. 1991; Mallen-Cooper 1989).

3.5.4 Physico-chemical processes

The pre-regulation River Murray, like other floodplain rivers, was characterised by large variations in flow within and between years (Walker 1986). Under a natural regime, the incoming flood water alters the environment of floodplain habitats as the flow rate increases, supplying water with low salinity, high turbidity, variable temperatures and low oxygen levels. The floodwaters spread over the floodplain, re-connecting the river to isolated backwaters and billabongs and each other. Subsequent flooding of the floodplain wetlands results in further physico-chemical changes.

Nutrients and other chemicals are released from sediments and organic detritus, and through re-colonisation by aquatic organisms. Also, the process of flooding can cause an initial pulse of available nitrogen as nitrates which is then lost as nitrogen gas.

Key nutrient-cycling processes may also be affected indirectly by flooding and drying, through sediment waterlogging and desiccation cycles. It has been demonstrated that nutrient pulses were experienced about four days after floodplain sediments were inundated. Ion concentrations, as well as pH and turbidity, were inversely correlated to water level (Briggs et al. 1985). Concentrations of organic carbon were positively correlated to leaf-fall from River Redgum, phytoplankton productivity and biomass of aquatic plants. Dissolved organic carbon was negatively correlated to water level (Briggs et al. 1993).

Flooding flushes water of low pH, low oxygen concentration and high tannin content from pools on the floodplain into the main river stem (Morison 1989). Although this may be a strong chemical signal of flooding to fish in the river, the dissolved

polyphenolic compounds in blackwater are known to be toxic to native fish fry and other animals (Lloyd et al. 1994). These compounds, derived from the decomposition of tannins and lignin from vascular plant material, play other central roles in the wetland ecosystem. They contribute to, and in some cases dominate, the pool of dissolved organic carbon (DOC).

During drought, increases in salinity and temperature (at least in shallow waters), decreases in oxygen concentration and other changes in physico-chemistry, are further stressors for the animals and plants. These changes are a signal to many organisms to avoid drought by setting seed or laying resistant eggs that germinate or hatch in subsequent floods (Casanova & Brock 1990, Brock 1991; Boulton & Lloyd 1992).

3.5.5 Groundwater processes

Relatively fresh groundwater has been shown to be an important source of water for River Redgums on the floodplains of the Site and along the lower River Murray in South Australia (Thorburn & Walker 1993; Thorburn et al., 1992). Upstream of structures such as weirs or locks, groundwater under the floodplain can be raised by as much as two metres. This can have an adverse effect on deep-rooted plant species where the groundwater is saline. These conditions can result in widespread decline in woodland species, especially when combined with reduced flushing from river regulation (Jolly et al. 1992). Locally elevated groundwater can also change the water regime of nearby floodplain wetlands and streams from wet-dry to permanently wet (Lloyd et al. 1994).

Regular floods are important to the groundwater, as they recharge soil water and also flush salts that have accumulated through dry periods (Jolly *et al*., 1993; Overton and Jolly, 2004). The build-up of salts in the soils and around tree roots can stress and even kill trees. Salinisation of floodplain soils is a major factor in the declining health of floodplain trees and, in many areas, it has caused extensive vegetation death (Holland et al. 2006). Dieback is evident on the floodplains of the Site and throughout the lower River Murray in South Australia, which is a function of the combined effects of rising saline groundwater and river regulation. Flushing of salt from floodplain soils now occurs less due to reduced flood frequency (MDBC, 2003). This mechanism is shown in Figure 3.18.

The impacts of river regulation on groundwater process are exacerbated by the effects of the current drought. The lack of medium-large to large floods since prior to listing of the Site has allowed salt accumulation to proceed without significant mitigation and also intensified the water stress being felt by many of the vegetation communities through the reduction of small to medium floods.

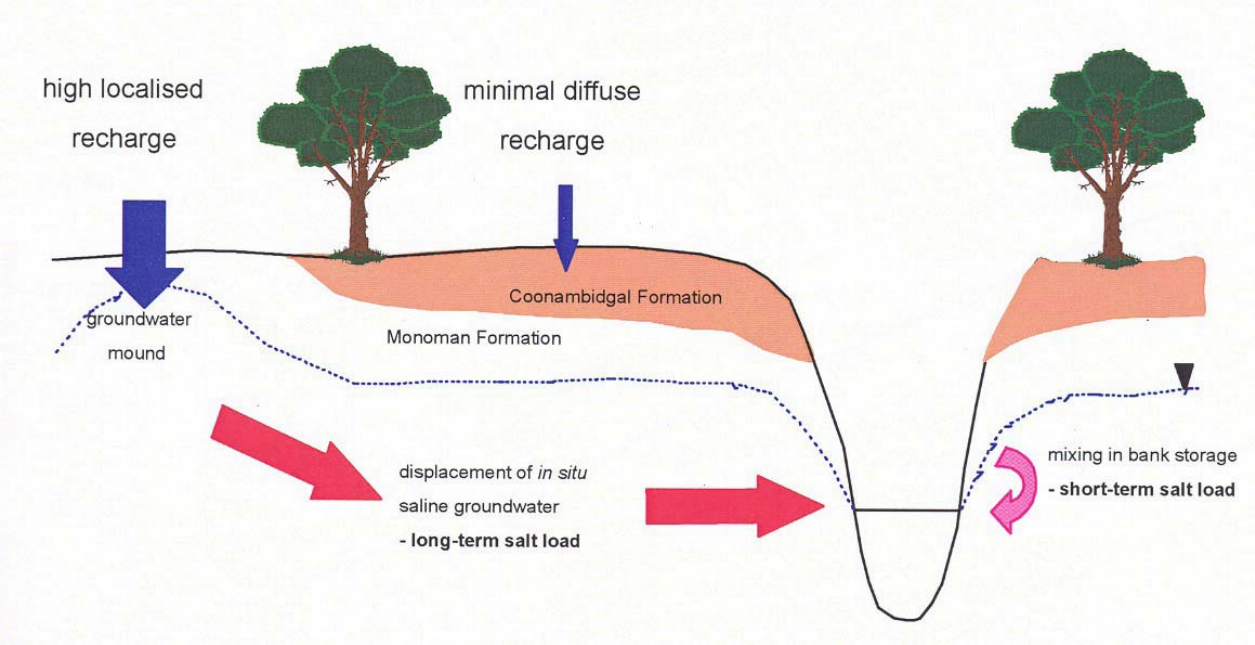


Figure 3.18: Mechanisms that lead to the accession of saline groundwater to floodplain streams, following major floods *Source:* Overton and Jolly, 2004

3.6 Key Actual or Potential Threats to the Site

Hydrology is the driving process for the ecological character of the Site. As detailed in section 3.2.4 of this document, the Site's hydrology can be separated into pre-regulation and post-regulation periods. Hydrological characteristics of these periods comprise:

Pre-regulation:

- seasons with highly variable flows;
- high flows, cool, turbid and fast flowing water in spring and early summer;
- gradual change at end of summer to low flows, warm, clear and slow moving water during autumn and winter;
- marked variation between years;
- cease-to-flow during droughts - contracting to saline pools fed by saline groundwater;
- local anabranches formerly flowed only during floods or high flows; and,
- floodplain inundation (and the refilling of disconnected wetlands) determined by flood magnitude, proximity to the river channel and local topography.

Post-regulation:

- significant changes to the seasonal nature of flow regime, including permanent base flows, leading to permanent inundation of connected wetlands, and also delay in flood initiation and a reduction in flood duration;

- o significant change (reduction) in the frequency of small to moderate sized floods, leading to reduction in the moderate sized overbank flow events that covered large portions of the Site;
- o reduced recharge of local groundwater ('freshwater lens') in semi-permanent wetlands, leaving insufficient water for trees;and,
- o river level raised by 3 m. Impacts include:
    - banking water up into the anabranch system, leading to permanent inundation of some ephemeral wetlands, hence loss of a summer drying phase;
    - a back-pressure on the adjacent groundwater, with saline groundwater consequently flowing into the now inundated anabranches and reaching the River Murray downstream of Lock 6, via the anabranch system; and,
    - back pressure on the groundwater, leading to rising water tables on the floodplain creating salinity stress for the tree cover.

Figure 3.19 displays the influences of regulation on the Site's hydrology, with a marked reduction in the occurrence of higher flows that occurred under a natural (pre-regulation) regime (red lines) compared with the current (post-regulation) regime (blue lines). For example, the probability of a flood exceeding 60 GL/day between 1966 and 1986 with no regulation was 20% (solid red line, Figure 3.19). With regulation, the probability of a similar flow in the same time period dropped to less than 10% (solid blue line, Figure 3.19). The drop in frequency of floods in the range of 5 – 100 GL/day is clearly displayed on the exceedance curve. Although less obvious, the reduction in probability of the larger floods (greater than 100 GL/day) is also significant, as these rare flows are important for large areas of Black Box woodland and chenopod shrubland communities.

Post-listing:

Within the post-regulation period, in the time since listing, the Site has experienced a change of climate, with an extended dry period at the Site and within the Murray-Darling catchment. This has resulted in an exacerbation of many of the impacts caused by regulation, including:

- o further reduction (absence) of flooding;
- o further reduction of recharge of ground water; and
- o greater salinity impacts due to decreased flushing of salts from the soil.

As well as displaying the impacts of regulation, Figure 3.19 also displays changes to the hydrology of the site since the time of listing. The dashed lines in Figure 3.19 show the 1987 to 2007 flow exceedance probabilities, compared with the 1966 to 1986 probabilities. The reduced flows are a function of a drier climate and also increased water extraction upstream. Note that increased water extraction is also a function of a drier climate. Figure 3.19 displays the extent to which the drier climate and increased extractions have exacerbated the impacts of regulation on the post-

listing hydrology of the Site, with the dashed blue line showing a large difference from the solid red line. For example the 1 in 5 year flood (i.e. 20 percent probability) has dropped from 60 GL/day in the pre-regulation, prelisting period, to 20 GL/day with regulation impacts and the post-listing climate.

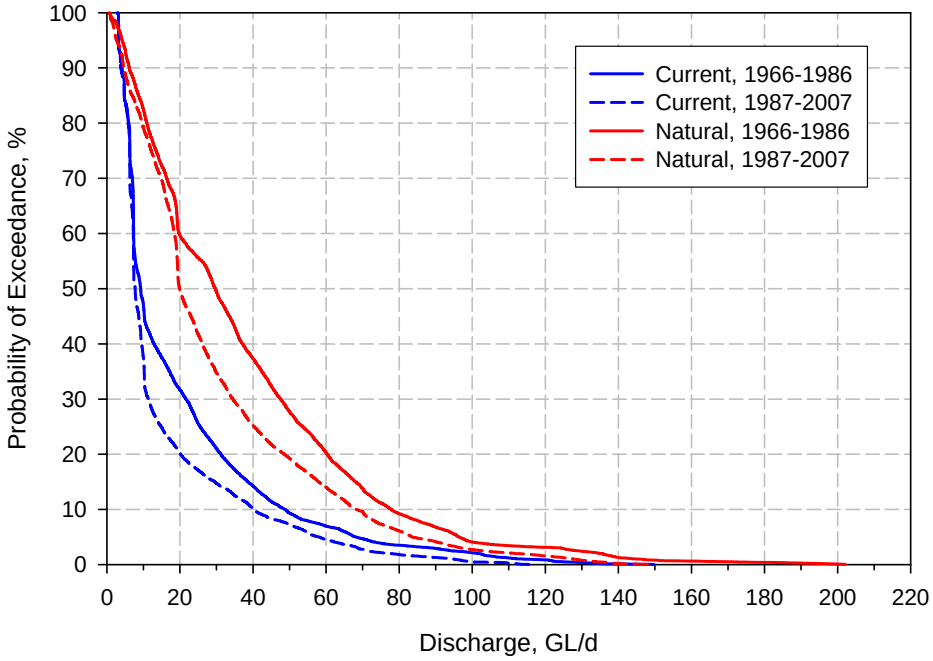


Figure 3.19: Flow exceedance curves for the Site, displaying modelled flows under natural and "current" (= post-regulation) conditions, for the 20 years before listing and 20 years after listing.

The frequency, season, magnitude, duration and rate of rise and fall of high flow events have powerful influences on the many aspects of the biota, including growth, survival, reproduction and recruitment (the replenishment of individuals, to a stage capable of reproducing, across a species).

The hydrological needs vary between species and, within a species, vary between life cycle stages. For example, ibis require floodplain inundation for nest protection from predators. The requirement may be a particular depth (e.g. 0.5 m) for a particular time period (e.g. 3 months). During this time any marked increase or decrease in water may lead to large-scale recruitment failure. However, large-scale recruitment may not be necessary every year, and variations between years may not harm the overall status of the species. Other species (e.g. some aquatic macrophytes) require continual small-scale inundation whereas some tree species, such as Black Box, may require major flooding every twenty years.

Within this context the regulated, altered flow regime is an existing threat due to it creating unnatural, permanent or near-permanent flooding of the anabranches and

creeks of the site, and also a reduction in frequency and duration of medium floods that cover much of the site.

The Site's floodplain and wetlands have been degraded by rising saline groundwater and significant reduction in the frequency and inundation period of flood events.

Processes lost from the reduced floods include flushing of soil salts and the replenishment of freshwater lenses overlying the saline groundwaters. This degradation has been exacerbated by grazing pressures (by native and domestic animals) as well as the proliferation of pests and weeds.

Changing climate is a potential threat to the Site through the impact of reduced rainfall and increased evaporation. This poses a very high threat to the ecological character of the Site. If the current 'prolonged drought' in most parts of the Murray-Darling Basin is, in fact, the beginning of a new climatic regime, the impacts will be major for the Site with severely constrained options for water delivery regimes.

Salinity is an actual and potential threat, with its impacts occurring through many potential pathways. The current drought conditions within the Murray-Darling Basin have led to lower groundwater tables and consequently reduced saline discharges from waterways (e.g. Barr Creek) into the main channel of the River Murray. A return to higher rainfalls could increase the risk of increased salt contributions from higher in the catchment. Salinity threats also occur through the groundwater at or near the site, with altered flow regimes causing back-pressure on the saline groundwater and its flow into the anabranches. Similarly, the altered flow regimes and accompanied reduction in flooding in some depressions cause a loss of local freshwater lenses over saline aquifers. These issues will need to be considered and discussed in management plans for the Site. As noted earlier (Section 3.2.4), river regulation has also reduced the frequency and duration of the floods that leach salt from the plant root zone (Overton et al. 2006a). This reduction in flushing exacerbates the impacts of salt deposition from the rising saline groundwaters and has led to a severe decline in the health of riparian vegetation communities on the floodplains of the Site (Overton et al. 2006a). In this way, the reduction in flooding created by regulation of the river not only starves the floodplain trees of water for function and growth, but also creates a level of soil salinity that makes it more difficult for the plant roots to extract water from the soil, due to osmotic pressures, and is potentially toxic to the trees (Overton et al. 2006a). The extent of change since listing, and the predictions for future changes resulting from this threat, are more fully discussed in section 4.

Sedimentation at the site has been noted as increasing markedly. The natural pre-European settlement sedimentation rate for Chowilla wetlands was likely to be in the order of < 1mm/year. At Tareena Billabong, on the NSW part of the lower River Murray floodplain, this increased to 20 mm year early in European settlement and reduced thereafter (Gell et al., 2005). Post-regulation sedimentation rates (as reported by analyses by ANSTO) in Ral Ral Creek are 10 mm/year. This poses a genuine threat of filling in some parts of the wetland, turning it into terrestrial

habitat. This issue should be addressed in the management plans for the Site, although controlling the causes may require off-site management.

Obstruction to fish passage is an important threat as this site provides a “natural fishway” around Lock 6, so further structures constructed across floodplain channels may prevent regional and local fish movement. These structures impact on fish populations by preventing fish moving to find mates or food and prevents access new habitats. Some species must swim upstream to breed and barriers may cause these species to re-absorb eggs.

Obstructions to fish passage, grazing pressure, pest flora and fauna, and human recreational impacts to the Site are common problems to many areas of conservation significance and should also be addressed within management plans for the Site.

The major threats can therefore be listed as:

- Altered flow regime;
- Climate change, particularly synergies between decreased rainfall and increased evaporation;
- Salinity;
- Very high sedimentation rates for wetlands;
- Elevated and altered groundwater regime;
- Obstructions to fish passage and desnagging;
- Grazing pressure;
- Pest flora and fauna; and,
- Human access and motorised recreation.

Whilst recognising the importance of all the threats listed above, the three most serious threats and their impacts on components, processes or services of the Site are presented in Table 3.6. The rationale for highlighting these three threats is provided in the paragraphs above, and the implications for monitoring needs is presented in Table 3.7.

Table 3.6 Key threats to the Riverland Ramsar Site

Actual or likely threat or threatening activities	Potential impact(s) to wetland components, processes and/or services	Likelihood	Timing of threat
Altered flow regime	• significant changes to the seasonal nature of flow regime • permanent, artificial inundation of connected wetlands • delay in flood initiation • reduction in flood duration • reduction in the frequency of small to moderate sized floods • reduction in the moderate sized overbank flow events that cover large portions of the Site • reduced recharge of local groundwater, leaving insufficient water for trees • river level raised by 3 m	Certain - occurring	Immediate
Changed Climate	• further reduction (absence) of flooding • further reduction of recharge of ground water • greater salinity impacts due to decreased flushing of salts from the soil	Currently occurring	Immediate
Salinity	• severe decline in the health of riparian vegetation communities on the floodplains of the Site • combining with altered flow regimes and changed climate to increase stress and death of floodplain vegetation	Currently occurring	Immediate

3.7 Limits of Acceptable Change

Limits of acceptable change are defined as “the range of variation in the components, processes and benefits/services that can occur without causing a change in the ecological character of the site” (DEWHA 2008). Identification of these limits will assist management of the Site, by defining ‘ecological boundaries’ that cannot be crossed without impacting on its ecological character.

Limits of acceptable change in this document were based on key ecosystem services (Table 3.7) and key components and processes that support these services (vegetation and hydrology, Table 3.8). If the hydrological limits provided for maintenance of the vegetation communities (Table 3.8) are met, then it is likely that the limits for ecosystem services (Table 3.7) will also be met. Limits of

acceptable change for water quality are not set, apart from salinity, because they do not strongly affect the ecological character of the Site independent of other factors.

Assessments were constrained by:

- limited knowledge for some components that contribute to the ecological character;
- knowledge gaps in relation to the natural variability of these components; and,
- the need to accommodate the altered flow regime to the Site and its future influence.

Despite these issues, **interim** limits of acceptable change need to be defined based on available data, knowledge and information. These limits can be refined as more data are obtained.

Table 3.7 displays the major ecological services of the site. The table also describes the major threats, the baseline information requirements, and **interim** limits of acceptable change to these services, beyond which the ecological character is changed. The limits provided in Table 3.7, based on ecological services, are high-level 'endpoints' for acceptable change of the Site. These are important for assessing changes to, and status of, the Site's ecological character. However, they must be supported by quantitative limits assigned to the major processes and the key components (Table 3.8) that underlie the ecological services.

The controlling influence of hydrologic regime on the Site's ecological character has been a major theme of this document. Informed management of the hydrologic regime forms the basis of future management of the Site as a whole. The magnitude, frequency, seasonal timing and duration of inundating flows controls the vegetation, salinity, habitat, breeding requirements and, ultimately, the form and function of all benefits and services of the Site. Therefore, the limits of acceptable change for the hydrologic regime, presented in Table 3.8, define the conditions required to support the Site's ecological character. In summary, appropriate management of the Site's hydrologic regime should form the first step in the management of the Site's ecological character.

The limits of acceptable change to ecosystem services, presented in Table 3.7, are primarily for 'endpoints' of the Site's management, whereas the limits of acceptable change for hydrology (Table 3.8) are for the processes that control these endpoints.

Table 3.7: Limits of acceptable change for key ecosystem services of the Riverland Ramsar Site

Ecosystem service	Threats to ecosystem services	Baseline information requirements	Interim limits of acceptable change
Wetland of international significance (& part of Riverland Biosphere Reserve) The Site is listed against the first eight of the Ramsar criteria: 1. representative, rare, or unique example of a wetland type within a bioregion 2. supports vulnerable, endangered, or critically endangered species or threatened ecological communities. 3. supports species important for maintaining the biological diversity of a bioregion. 4. supports species at a critical stage in their life cycles, or provides refuge 5. regularly supports 20,000 or more waterbirds. 6. regularly supports 1% of the individuals in a population of one species or subspecies of waterbird. 7. supports indigenous fish, contributing to global biological diversity. 8. important source of food/habitat/migration path, depended upon by fishes.	Overall, the major direct threat to the status of the Riverland Site and the subjects of its listing criteria is the altered hydrologic regime due to river regulation. Threats that contribute to or augment the effects of altered hydrology include: • climate change; • soil salinity; • groundwater salinity and rising water tables • sedimentation; • fish barriers; and • grazing; • weeds and vermin.	The baseline condition of many components of the site is poorly quantified, including quantitative measures of several of the listing criteria. In particular, the population numbers (and their natural fluctuation) of listed species have not been documented. Similarly, many pre-listing studies of the fish and water birds at the site were mainly focused on species lists rather than quantitative assessment. More recently, quantitative studies of fish and waterbirds at the site have been undertaken, although during a prolonged drought, which was not occuring at the time of listing. Baseline information requirements therefore include: documentation of population numbers of listed species and their natural distributions; and quantitative assessments of bird and fish fauna across the site, including seasonal fluctuations.	At a high level, the baseline condition of the site for this service can be described as 'meeting the first eight listing criteria'. The **short-term and long-term limits** of acceptable change should both be 'no loss of any listing criteria'. These listing criteria comprise most of the other ecological services identified for the Site, and are presented in the rows below.

Ecosystem service	Threats to ecosystem services	Baseline information requirements	Interim limits of acceptable change
Contains representative and rare, example of a wetland type within the Murray River Drainage Division (includes Ramsar Criterion1: contains a representative, rare, or unique example of a wetland type within a bioregion). The Site is representative of a floodplain system within the region, and also rare in that almost all of the other examples these wetland types in the region have been impacted by irrigation.	Similar to the previous ecosystem service, altered hydrology is the major threat to the wetland types of the site. The key aspects include changes to timing (season), quantities and delivery rates of flows, as well as recurrence intervals and period (length) of inundation. Stresses to the wetland types include the effects on salinity and groundwater, as well as the potential shift in key plant species with changes in the hydrology salinity status.	Baseline information requirements would include data on the health, extent, floristic composition and spatial variability of each identified wetland type within the Site. A broad vegetation survey of the site has been undertaken. The data gathered should be examined for their suitability in contributing to the requirements listed above, and information gaps identified.	The limits of acceptable change are based on a precautionary approach to maintenance of the sites mosaic of wetland types. The **short term limits** of acceptable change should be: no loss of more than 10% of any wetland type over the site as a whole, within any 2-year period. The **long-term limits** of acceptable change should be no loss of more than 20% of any wetland type over the site as a whole, within any 10-year period.
Supports populations of rare, endangered and threatened species (State & National) (includes Ramsar Criterion 2: Supports vulnerable, endangered, or critically endangered species or threatened ecological communities). Four nationally-listed and twenty-two state-listed faunal species have been found at the Site. Approximately half of these species are directly dependent on aquatic habitat, with the remainder dependent on the adjacent shrublands and woodlands. Twenty eight state-listed floral species have	The largest threat to baseline conditions in terms of listed species is again altered hydrologic regime from river regulation, particularly for species dependent on aquatic habitats. For many of the species not directly dependent on aquatic habitats, climate change and increasing soil and water salinity are also major threats. Limits of acceptable change for the hydrologic regime (refer to Table 3.8) have been developed to provide watering requirements designed to manage these threats.	The population numbers (and their natural fluctuation) of listed faunal species have not been documented. Similarly, many pre-listing studies of water birds and other animals at the site were mainly focused on species lists rather than quantitative assessment. More recently, quantitative studies of fish and waterbirds at the site have been undertaken, although these represent the Site during a prolonged drought, which was not being experienced at the time of listing.	The condition at the time of listing for many threatened species, particularly faunal species, is unknown (in terms of population numbers, trends, ranges) and requires further assessment. There are more data available for the listed species of flora, through vegetation surveys. There are qualitative data from 2002 (vegetation) and 2003 (fauna) available for the listed species*. The

Ecosystem service	Threats to ecosystem services	Baseline information requirements	Interim limits of acceptable change
also been recorded at the Site.		Baseline information requirements therefore include: documentation of population numbers of listed species and their natural distributions; and quantitative assessments of bird and fish fauna across the site, including seasonal fluctuations. Vegetation survey data needs to be interrogated to ensure that there is sufficient information to enable baseline description and future monitoring of distributions and abundances of listed floral species.	limits of acceptable change will need to be based on quantitatively surveyed numbers of each listed species. Surveys should be undertaken as soon as possible and repeated within 2 to 5 years (see monitoring needs, Section 6 of this document). These surveys can be to define the level of variation. **Short term** and **Long term limits** of acceptable change should be no loss of any listed species of flora and fauna.
<u>Provision of remnant lower River Murray floodplain habitat and species</u> (includes Ramsar Criterion 3: Supports species important for maintaining the biological diversity of a bioregion) Bioregional diversity is maintained through the provision of the mosaic and range of wetland types, which support the species assemblages associated with those habitats. Noted elements of the bioregional diversity within the Site include representative, rare and/or	Similar to the previous ecosystem service, the largest threat to the biological diversity of the Site lies in the altered hydrologic regime through river regulation. The biota of the Site has developed with, and adapted to, the pre-regulatory hydrologic regime, relying upon the variety of flooding events that occurred under natural conditions. The loss of this natural variability threatens the Site's biodiversity. Also similar to the previously described service, climate change	Baseline information requirements include: documentation of population numbers of listed species and their natural distributions; and quantitative assessments of mammals, reptiles, amphibians, aquatic macroinvertebrates, molluscs, and macrocrustaceans, across the site, including seasonal fluctuations. The appropriate surveys should be undertaken in conjunction with the bird and fish fauna surveys and	<u>Fauna</u>: The pre-listing condition and diversity of the faunal groups is unknown, in terms of complete species lists, distributions and abundances. The **short term limits** of acceptable change should be no loss of recorded species and should be derived from the qualitative 2003 baseline information*. A quantitative survey should be undertaken as soon as

Ecosystem service	Threats to ecosystem services	Baseline information requirements	Interim limits of acceptable change
threatened species of flora and fauna (including species of birds, mammals, reptiles, amphibians, aquatic macroinvertebrates, molluscs, macrocrustaceans and fish).	is another major threat to the Site's biodiversity, with the potential to compound the impacts of the altered hydrologic regime, as well as create long-term, near-drought conditions. Salinity increases in groundwater or surface waters can have a significant impact on the riparian and floodplain trees and therefore the whole structure of the ecosystem as well as direct impacts upon wetlands. That said, saline wetlands provide habitat for the vulnerable Murray Hardyhead. Weed invasions, introduced animals, and overgrazing by stock, native and feral animals all threaten native species and communities. Most weed species at the Site are associated with pastoral activities, with grasses and daisies being the most commonly recorded taxa. Several pest plant species can impact or displace native plants, thereby threatening the Site's biodiversity. Similarly, the impacts of overgrazing can reduce the regenerative capacity of a vegetation community or population, causing changes to the	the listed species surveys (discussed above).	possible and repeated 5-yearly. The changes can be used to define the level of variation, which could be used in future limits of acceptable change. Flora The baseline condition for flora is better established, with a several vegetation surveys of the Site having been undertaken. The **short term limits** of acceptable change should be: no loss of any rare species of flora over any time period and no loss of any vegetation community type, excluding seasonal variations and natural annual variations. Tree health data recorded in 2003 and work undertaken by CSIRO (CSIRO 2005) show tree health cannot decline further than the 2003 conditions, without causing significant changes to the site's ecological character (refer section 4). This was based on an estimated 24% of tree (River Redgum, Black

Ecosystem service	Threats to ecosystem services	Baseline information requirements	Interim limits of acceptable change
	Site's flora and vegetation structure. Feral animals can also pose threats to the faunal biodiversity of the Site, with species of reptiles, mammals and birds at risk of predation from cats and foxes.		Box and Coobah) cover being healthy. Flora and Fauna The **long-term limits** of acceptable change should be: • no loss of any rare or threatened species of flora or fauna • no net reduction in populations of native bird, fish, mammal, mollusc, macrocrustacean, reptile or amphibian fauna over any 10 year period (currently a knowledge gap); • no loss of more than 20% of any vegetation type over the site as a whole within any 10 year period (see Table 3.3); and, • no deterioration beyond the 2003 condition of tree health (CSIRO 2005).
Diverse and abundant waterbirds Part 1 (includes Ramsar Criterion 4: Supports species at a critical stage	The altered flow regime due to river regulation threatens many of the species that rely on natural	The information requirements for this Ecosystem Service would be covered by	Apart from presence data and some estimates of population sizes at specific

Ecosystem service	Threats to ecosystem services	Baseline information requirements	Interim limits of acceptable change
in their life cycles, or provides refuge) The site provides critical summer or stopover habitat for migratory birds listed under international agreements. It also provides habitat for nomadic waterbirds during regional drought and for nomadic bush-bird species during the dry summer.	flow regimes for breeding. This has been discussed earlier in the Table, whereby specific needs in relation to timing, magnitude and areal extent of flooding are impacted by the artificial flow regime of the site. Another major threat to this ecosystem service is climate change, with water shortages through reduced precipitation across the basin and increased evaporation. Increased salinity of water also poses a significant threat to this ecosystem service, with habitat provision and drinking water likely to be impacted if groundwater salinities increase and/or saline water tables rise. However, the saline Lake Woolpolool harbours species not found in freshwater areas of the site.	undertaking the surveys described in the table cells above.	locations, much of the pre-listing condition for these species across the Site is not well known. **Short term limits** of acceptable change should be derived from future quantitative surveys. A quantitative survey should be undertaken in the near future and repeated at 5-yearly intervals. Changes would be used to define the level of variation, which could be used in future limits of acceptable change. **Long-term limits** of acceptable change should be: • no net reduction in waterbird breeding numbers over any rolling 10 year period (currently a knowledge gap); and • no net reduction in waterbird populations (particularly migratory) over any rolling 10 year period (currently a knowledge gap).

Ecosystem service	Threats to ecosystem services	Baseline information requirements	Interim limits of acceptable change
Diverse and abundant waterbirds Part 2 (includes Ramsar criteria 5 & 6: Regularly supports 20,000 or more waterbirds AND Regularly supports 1% of the individuals in a population of one species or subspecies of waterbird). The site has regularly been recorded with more than 20,000 individuals of waterbird, including numbers of Freckled Duck, Red-necked Avocet and Red-kneed Dotterel that exceed 1% of their estimated global populations	Altered flow regime due to river regulation and climate change both present the greatest potential impacts to the numbers of waterbirds and the populations of individual species, for reasons discussed above Inappropriate management of individual wetland is also a threat. For instance, ad hoc management of sites which allow inundation for too long or too short a period can affect fish, waterbirds and vegetation.	The information requirements for this Ecosystem Service would be covered by undertaking the surveys described in the table cells above.	**Short term limits** of acceptable change should be derived from future quantitative surveys. A quantitative survey should be undertaken in the near future and repeated at 5-yearly intervals. Changes would be used to define the level of variation, which could be used in future limits of acceptable change. **Long-term limits** of acceptable change should be: • no reduction in number of years with >20,000 waterbirds (currently a knowledge gap); and • The site continues to support >200 Freckled Duck, >260 Red-kneed Dotterel and >1100 Red-necked Avocet across the whole site at same frequency as present (currently a knowledge gap).
Diverse fish and invertebrate fauna (includes Ramsar criteria 7 & 8:	Altered flow regime due to river regulation and climate change	The information requirements for this Ecosystem Service	Similar to much of the fauna at the Site, there is

Ecosystem service	Threats to ecosystem services	Baseline information requirements	Interim limits of acceptable change
Supports indigenous fish, contributing to global biological diversity AND Provides an important source of food/habitat/migration path, depended upon by fishes). The site supports 14 species of native fish and approximately 100 taxa of invertebrates, with the floodplain wetlands supporting a more diverse macroinvertebrate fauna than the main channel.	present the greatest potential impacts to the fish fauna of the Site including: loss/reduction of habitat through decreased flows; loss/reduction of spawning triggers and spawning habitats; and loss of floodplain connectivity with the channels. Other threats include: • Water quality – increased salinity and turbidity and eutrophication have been recorded in the Lower River Murray, with impacts on the fish and invertebrate fauna • Desnagging – removal of coarse woody debris reduces the quantity and diversity of habitat, with impacts on the number and diversity of faunal species • Riverbank stability – altered flow regimes, impacts on riparian vegetation and salinity can all contribute to decreased riverbank stability, reducing habitat for fish and invertebrates • Introduced animals – in particular, European Carp and Eastern Gambusia threaten native fish and invertebrates.	would be covered by undertaking the surveys described in the table cells above.	currently insufficient information available for quantitative limits of acceptable change. **Short term limits** of acceptable change should be should be derived from comparing data from the 2005/06 baseline information (from Zampatti et al. 2006a & 2006b) and a future survey. The changes would be used to define the level of variation, which should not be exceeded in any 2 year period. **Long-term limits** of acceptable change should be: • no loss of any rare or threatened fish and invertebrate species; and • no net reduction in fish and invertebrate populations over any rolling 10 year period.

Ecosystem service	Threats to ecosystem services	Baseline information requirements	Interim limits of acceptable change
	European Carp uproot aquatic macrophytes, increasing turbidity, and may compete for food and habitat. Eastern Gambusia also compete for food and habitat, prey on eggs and young of native fish species, and also have adverse effects on aquatic macroinvertebrates and frogs. • Barriers prevent movements of fish		
<u>High diversity and mosaic of both terrestrial and aquatic habitats</u> The range of classifications of the Site's aquatic and terrestrial habitats has displayed a high diversity for both environments, particularly within the context of the region.	Similar to previous ecosystem services, the largest threat to the biological diversity of the Site lies in the altered hydrologic regime due to river regulation. The habitats of the Site have developed with the pre-regulatory hydrologic regime, relying upon the variety of flooding events that occurred under natural conditions. The loss of this natural variability threatens the Site's habitat diversity. Also similar to previously described services, climate change is a major threat to the Site's habitat diversity, with the potential to compound the impacts of the altered hydrologic regime, as well as create long-term, near-	Although the vegetation of the Site has been surveyed, a detailed examination of the survey data is required to ensure the data is categorised in a form that enables ready assessment of changes in vegetation character and habitat provision. For example, every part of the site could be categorised in terms of Ramsar Wetland Types, with accurate measures of area covered by each wetland type documented.	Baseline condition for habitat diversity can be defined using vegetation surveys undertaken at the Site as a basis (refer Table 3.3, this document). This should be supplemented by future surveys of the Site, as required. The **short term limits** of acceptable change should be no loss of any habitat type, excluding seasonal variations and natural annual variations. No further death of trees and no increase in the area of unhealthy trees should occur in any two year period.

Ecosystem service	Threats to ecosystem services	Baseline information requirements	Interim limits of acceptable change
	drought conditions. Soil salinity, groundwater salinity and rising saline water tables threaten the structure of the River Redgum and Black Box forests and woodlands as further trees die, which will have impacts on lack of riparian shading and woody debris provision to the aquatic habitats.		The **long term limits** of acceptable change should be no loss of more than 20% of any habitat type, over the site as a whole (i.e. diversity and mosaic must be maintained)

*Baseline information on the presence of flora and fauna species at the site can be found at the DEH website (www.deh.sa.gov.au)

As discussed in Section 3.3 the major process driving the Site's ecological character is hydrology. The influence of hydrology is through the magnitude, frequency, duration of floods and droughts, rates of rise and fall of water levels and seasonal timing of water delivery to the site, and also through depth and salinity of groundwater. Similarly, the vegetation communities are a key component defining the Site's ecological character, providing the habitat and landscape that form the basis of the ecological services (Section 3.2.6). The distribution, growth and health of plant communities are strongly determined by the hydrology of the system.

Therefore, limits of acceptable change must be presented for the vegetation and for the major processes that determine status and viability (water delivery and groundwater salinity). Table 3.8 displays the communities, their hydrological requirements and salinity tolerances. Hydrological requirements for each community vary according to the ecological function being supported. For example, the water delivery requirement for promoting *survival* of individuals within the Black Box community will be different to the water delivery requirement for promoting *recruitment* within the Black Box community.

In this document, "survival" and "recruitment" are defined as:

- survival: maintaining the life of an individual or species' population
- recruitment: the establishment and growth to reproductive maturity of offspring at a spatial scale sufficient to sustain the population

The survival and recruitment requirements for the Riverland Ramsar Site are both presented within Table 3.8.

In normal circumstances, recruitment requirements should form the boundaries for limits of acceptable change, as recruitment is necessary to sustain the community and hence preserve ecological character. However, within the context of current drought conditions and limited water allocations, hydrologic requirements for survival must also be considered. Information in Table 3.8 is derived from a variety of sources, including existing literature (especially Roberts and Marston 2000), personal knowledge of the authors, and expert input from Mike Harper (DEH, Berri). The discharge magnitudes (GL day-1) are specific to the Site. They represent the volumes of water required to inundate the vegetation community at the Site and are based on information presented in Section 3.2.7 of this document.

The entries in the column 'Required hydrologic regime: for survival (= short-term limit for acceptable change)' in Table 3.8 represent the absolute limit of acceptable change in the short-term. Without meeting these minimum requirements, there is an unacceptable likelihood of major loss of the corresponding vegetation community. Longer-term limits of acceptable change (third column of Table 3.8) focus on the hydrologic requirements for the longer-

term sustainability of each vegetation community, through provision of a hydrologic regime that enables recruitment.

Two features of the information provided in Table 3.8 need further clarification. These are: the interaction between salinity impacts and water delivery requirements; and the benefits of 'serial' flooding. The water delivery requirements for each community's ecological functioning are often derived independently of salinity regime. However, in some situations the root zone salinity at a site will alter the water delivery requirements for survival of a vegetation community. For example, it is now known that Black Box communities require more frequent flooding or other sources of fresh water once the root zone salinity reaches 40,000 EC (40,000 µS cm^{-1}) (Holland et al. 2006). In Table 3.8, we have allocated root zone salinity tolerances based on available literature and personal observation of the site. Many of the entries were based on Bailey and Boon (2002) 'Upper Salinity Levels'. As the data used in the Bailey and Boon data base were compiled from measured EC conditions at which individual species have been observed, there is a reasonable potential for overestimating tolerances. For example, if a species is observed at an EC of 5000, this does not necessarily mean that the species can reproduce or recruit at that salinity. It only means that an individual of that species can exist for an unknown period of time under those conditions. As a conservative precaution, we have taken the upper level data from Bailey and Boon (2002) and multiplied it by one quarter to derive our salinity estimates in Table 3.8. For the permanent and semi-permanent aquatic communities, and also the fringing reed and sedge communities, we have provided EC tolerances for ambient surface water rather than root zone salinities.

Serial flooding is used here to describe flooding at a location that occurs two or three times in succession. Studies have documented the benefits of serial flooding for a range of biota, including frogs (Mike Harper, pers. comm.) and fish (Lloyd et al. 1991; Lloyd et al. 1994), Black Box and River Redgum (George et al. 2005; Jensen et al. in press). Within stressed vegetation communities, an initial flood promotes the health of the individuals within a population, which leads to greater seed production. River Redgum and Black Box trees (and many other species of *Eucalyptus*) typically hold their seed banks within the canopy for a year or more prior to release. A second flood will promote germination, and a third flood will increase soil moisture and aid survival of seedlings that have not developed a sinker root (which provides some independence of surface soil conditions). Therefore (for example), a recommendation of 'one flood every seven or eight years' may be better applied as 'three floods, approximately one year apart, every 20 years' in a situation where the recruitment of dominant or key taxa will be markedly improved by serial flooding. However, this approach will also need to consider the full suite of biota associated with the site. Species with a short life cycle (e.g. some small fish) clearly need more opportunities to reproduce and recruit than once in 20 years.

Table 3.8: Limits of acceptable change for key components and processes of the Riverland Ramsar Site (refer Table 3.2 for further information on natural associated hydrologic regime for each vegetation community)

Vegetation Community (as defined with hydrologic regime in Table 3.2)	**Required hydrologic regime: for survival (=short-term limit for acceptable change)**	**Required hydrologic regime: for recruitment (= long-term limit for acceptable change)**	**Root zone salinity tolerances‡ (EC = µS.cm^{-1}) †**
Aquatic – permanent Key species: • *Vallisneria americana* • *Potamogeton crispus* • *Myriophyllum* spp.	Required recurrence interval • annual (watercourses) • 1 in 2 years (swamps, billabongs) Duration • permanent Timing (season) • permanent Magnitude (GL/day) • 3 for channels • > 26 for billabongs and swamps Maximum time between events • 0 for channels • 1 year for billabongs and swamps **Percent of Community maintained by this regime: 62% (combined with semi-permanent aquatic community)**	Required recurrence interval • annual (watercourses) • 1 in 2 years (swamps, billabongs) Duration • permanent Timing (season) • permanent Magnitude (GL/day) • 5 for channels • up to 40 for some billabongs and swamps Maximum time between events • 0 for channels • 1 year for billabongs and swamps	1,500 EC (1000 mg/L) (surface water) (James and Hart 1993; Nielsen et al. 2003)

Vegetation Community (as defined with hydrologic regime in Table 3.2)	**Required hydrologic regime: for survival (=short-term limit for acceptable change)**	**Required hydrologic regime: for recruitment (= long-term limit for acceptable change)**	**Root zone salinity tolerances‡ (EC = $\mu S.cm^{-1}$) †**
Aquatic – semipermanent Key species: • *Marsilea drummondi*	Required recurrence interval • 1 in 2 years Duration • 3 – 6 months Timing (season) • Spring/Summer Magnitude (GL/day) • 40 Maximum time between events • 1 year **Percent of Community maintained by this regime: 62% (combined with Permanent aquatic)**	Required recurrence interval • 9 years in 10 Duration • Long duration, Frequently not drying out at all Timing (season) • Aug/Sep to Jan/Feb Magnitude (GL/day) • 40 Maximum time between events • 1 year	1,500 EC (1000 mg/L) (surface water) (James and Hart 1993; Nielsen et al. 2003)

Vegetation Community (as defined with hydrologic regime in Table 3.2)	**Required hydrologic regime: for survival (=short-term limit for acceptable change)**	**Required hydrologic regime: for recruitment (= long-term limit for acceptable change)**	**Root zone salinity tolerances‡ (EC = $\mu S.cm^{-1}$) †**
Fringing aquatic reed & sedge Key species: • *Typha domingensis* • *Typha orientalis* • *Phragmites australis* • *Cyperus gymnocaulos* • *Bolboschoenus caldwellii,* • *Bolboschoenus medianus*	Required recurrence interval • 1 in 2 years Duration • 6 months Timing (season) • winter – spring/early summer Magnitude (GL/day) • 25 – 30 (adjacent to channel) • 45 – 60 (on low relict meander plain) Maximum time between events • 1 – 2 years if well established **Percent of Community maintained by this regime: 89%**	Required recurrence interval • 1 in 1 – 2 years (nearly every year) Duration • 3 months (summer) or 6 months (winter), to enable seedlings to establish Timing (season) • shallow inundation for germination, deeper water (10 – 15 cm) for seedling establishment Magnitude (GL/day) • 25 – 30 (adjacent to channel) • 45 – 60 (on low relict meander plain) Maximum time between events • 6 – 9 months	1,500 EC (1000 mg/L) (surface water) (James and Hart 1993; Nielsen et al. 2003)

Vegetation Community (as defined with hydrologic regime in Table 3.2)	**Required hydrologic regime: for survival (=short-term limit for acceptable change)**	**Required hydrologic regime: for recruitment (= long-term limit for acceptable change)**	**Root zone salinity tolerances‡ (EC = $\mu S.cm^{-1}$) †**
River Redgum forest (flood dependent understorey) Key understorey species: • *Muehlenbeckia florulenta*	Required recurrence interval • 1 in 3 years; no more than 24 months without flooding Duration • 4 – 7 months on average, no more than 24 months continuous flooding Timing (season) • winter - spring Magnitude (GL/day) • 50 (for approx 1/3 of this veg comm.); 80 (for approx 80% of this veg. comm.) Maximum time between events • 2 years **Percent of Community maintained by this regime: 38% (50 GL/day); 78% (80 GL/day)**	Required recurrence interval • 7-9 years in 10 Duration • 120 days Timing (season) • spring Magnitude (GL/day) • 50 (for approx 1/3 of this veg comm.); 80 (for approx 80% of this veg. comm.) Maximum time between events • serial inundation 2 to 3 years in succession to optimise recruitment probability	1830 EC (1100 mg/L) (based on 25% of Upper Salinity Level from Bailey and Boon 2002)

Vegetation Community (as defined with hydrologic regime in Table 3.2)	**Required hydrologic regime: for survival (=short-term limit for acceptable change)**	**Required hydrologic regime: for recruitment (= long-term limit for acceptable change)**	**Root zone salinity tolerances‡ (EC = µS.cm^{-1}) †**
Lignum shrubland Key species: • *Muehlenbeckia florulenta*	Required recurrence interval • 1 in 3 - 10 years; more frequently in saline soils (>1.5 mS cm^{-1}) Duration • minimum 6 months (possibly as low as 3 months) Timing (season) • unknown. Possible that season may be critical, with summer floods lasting long enough to wet soil profile Magnitude (GL/day) • 50 GL/day will reach 1/3 of community; 70 GL/day will reach 2/3) Maximum time between events • unknown. Complete drying required between floods to enable cracking and aeration of soils. **Percent of Community maintained by this regime: 37% (50 GL/day); 73% (70 GL/day)**	Required recurrence interval • 1 in 2-8 years; more frequently in saline soils (>1.5 mS cm^{-1}) Duration • 120 days Timing (season) • unknown. Possible that season may be critical, with summer floods lasting long enough to wet soil profile Magnitude (GL/day) • 50 GL/day will reach 1/3 of community; 70 GL/day will reach 2/3) Maximum time between events • unknown. Complete drying required between floods to enable cracking and aeration of soils.	1830 EC (1100 mg/L) (based on 25% of Upper Salinity Level from Bailey and Boon 2002)

Vegetation Community (as defined with hydrologic regime in Table 3.2)	**Required hydrologic regime: for survival (=short-term limit for acceptable change)**	**Required hydrologic regime: for recruitment (= long-term limit for acceptable change)**	**Root zone salinity tolerances‡ (EC = $\mu S.cm^{-1}$) †**
River Redgum woodland (flood tolerant understorey) Key understorey species: • *Muehlenbeckia florulenta* • *Myoporum platycarpum* • *Sporobolus mitchellii* • *Paspalum vaginatum*	Required recurrence interval • 1 in 3 years; no more than 24 months without flooding Duration • 4 – 7 months on average, no more than 24 months continuous flooding Timing (season) • winter - spring Magnitude (GL/day) • 50 (for approx 1/3 of this veg comm.); 70 (for approx 2/3 of this veg. comm.) Maximum time between events • 2 years **Percent of Community maintained by this regime: 34% (50 GL/day); 70% (70 GL/day)**	Required recurrence interval • 7-9 years in 10 Duration • 120 days Timing (season) • spring Magnitude (GL/day) • 50 (for approx 1/3 of this veg comm.); 70 (for approx 2/3 of this veg. comm.) Maximum time between events • serial inundation 2 to 3 years in succession to optimise recruitment probability	1830 EC (1100 mg/L) (based on 25% of Upper Salinity Level for *Muehlenbeckia florulenta* from Bailey and Boon 2002)

Vegetation Community (as defined with hydrologic regime in Table 3.2)	**Required hydrologic regime: for survival (=short-term limit for acceptable change)**	**Required hydrologic regime: for recruitment (= long-term limit for acceptable change)**	**Root zone salinity tolerances‡ (EC = µS.cm^{-1}) †**
River saltbush chenopod shrubland Key species: • *Atriplex rhagodioides* • *Atriplex nummularia*	Required recurrence interval • 1 year in 30 Duration • 2 – 4 months Timing (season) • possibly not critical Magnitude (GL/day) • 60 (for approx 1/4 of this veg comm.); 300 (for majority of this veg. comm.) Maximum time between events • unknown **Percent of Community maintained by this regime: 27% (60 GL/day); ~100% (300 GL/day)**	Required recurrence interval* • 1 year in 10 (2-3 years in succession every 30 years) Duration • long enough to saturate surface soil, with slow recession Timing (season) • unknown Magnitude (GL/day) • 60 (for approx 1/4 of this veg comm.); 300 (for majority of this veg. comm.) Maximum time between events • unknown	Up to 23,000 (Norman 2007)

Vegetation Community (as defined with hydrologic regime in Table 3.2)	**Required hydrologic regime: for survival (=short-term limit for acceptable change)**	**Required hydrologic regime: for recruitment (= long-term limit for acceptable change)**	**Root zone salinity tolerances‡ (EC = $\mu S.cm^{-1}$) †**
Low chenopod shrubland Key species: • *Disphyma clavellatum* • *Disphyma crassifolium* • *Enchylaena tomentosa* • *Maireana schistocarpa*	Required recurrence interval • 1 year in 30 Duration • 2 – 4 months Timing (season) • possibly not critical Magnitude (GL/day) • 70 (for approx 1/2 of this veg comm.); 300 (for most of this veg. comm.) Maximum time between events • unknown **Percent of Community maintained by this regime: 49% (70 GL/day); ~100% (300 GL/day)**	Required recurrence interval* • 1 year in 10 (2-3 years in succession every 30 years) Duration • long enough to saturate surface soil, with slow recession Timing (season) • unknown Magnitude (GL/day) • 70 (for approx 1/2 of this veg comm.); 300 (for most of this veg. comm.) Maximum time between events • unknown	Soil ECe = 20 dS/m (recruitment) and 30 dS/m (survival)

Vegetation Community (as defined with hydrologic regime in Table 3.2)	**Required hydrologic regime: for survival (=short-term limit for acceptable change)**	**Required hydrologic regime: for recruitment (= long-term limit for acceptable change)**	**Root zone salinity tolerances‡ (EC = $\mu S.cm^{-1}$) †**
Samphire low shrubland Key species: • *Halosarcia pergranulata* • *Sarcocornia quinqueflora*	Required recurrence interval • 1 in 3 - 10 years; more frequently in saline soils (>1.5 mS cm^{-1}) Duration • minimum 6 months (possibly as low as 3 months) Timing (season) • unknown. Possible that season may be critical, with summer floods lasting long enough to wet soil profile Magnitude (GL/day) • 50 – 60 (for approx 60% of this veg comm.); 80 (for 80% of this veg. comm.) Maximum time between events • unknown **Percent of Community maintained by this regime: 60% (60 GL/day); ~82% (80 GL/day)**	Required recurrence interval • 1 in 2-8 years; more frequently in saline soils (>1.5 mS cm^{-1}) Duration • 120 days Timing (season) • unknown. Possible that season may be critical, with summer floods lasting long enough to wet soil profile Magnitude (GL/day) • 50 - 60 (for approx 60% of this veg comm.); 80 (for 80% of this veg. comm.) Maximum time between events • unknown	Soil ECe = 20 dS/m (recruitment) and 30 dS/m (survival)

Vegetation Community (as defined with hydrologic regime in Table 3.2)	**Required hydrologic regime: for survival (=short-term limit for acceptable change)**	**Required hydrologic regime: for recruitment (= long-term limit for acceptable change)**	**Root zone salinity tolerances‡ (EC = µS.cm^{-1}) †**
Black Box woodland Key understorey species: • *Atriplex rhagodioides* • *Atriplex nummularia*	Required recurrence interval • 1 year in 30 Duration • 2 – 4 months Timing (season) • possibly not critical Magnitude (GL/day) • 70 (for approx 20% of this veg comm.); 100 (for 40% of this veg. comm.); 300 (for almost all of this veg. comm.) Maximum time between events • 30 years **Percent of Community maintained by this regime: 22% (70 GL/day); 41% (100 GL/day); ~100% (300 GL/day)**	Required recurrence interval* • 1 year in 10 (2-3 years in succession every 30 years) Duration • long enough to saturate surface soil, with slow recession Timing (season) • unknown Magnitude (GL/day) • 70 (for approx 20% of this veg comm.); 100 (for 40% of this veg. comm.); 300 (for almost all of this veg. comm.) Maximum time between events • unknown	40,000 maximum (<40 dSm^{-1}, Holland et al. 2006)

*required recurrence interval should be subject to adaptive management to achieve rapid succession flooding

‡, The salinity estimates in this Table have been derived from upper level data in Bailey and Boon (2002) and multiplied by one quarter as a conservative approach

† For aquatic communities (i.e. the permanent and semi-permanent aquatic communities, and also the fringing reed and sedge communities), EC tolerances are provided for ambient surface water rather than root zone salinities

4. CHANGES IN ECOLOGICAL CHARACTER SINCE LISTING

The change in hydrology since listing has exacerbated the impacts of regulation and been obvious at the site with a significant reduction in the flooding frequency of all floods under 100 GL/d, but the most significant reduction in medium sized floods in the 10,000 ML/d - 30,000 ML/d range. This would have biggest impact on semi-permanent vegetation and billabongs and fringing aquatic vegetation when compared to pre-1987 period. Nonetheless, as there has been one large event (over 100GL/d) post-listing, compared to the 20 year prior to listing (when there was 3 events over 100GL/d), the floodplain condition has also declined in this period.

A decline in the health of the tree cover of the Site since listing represents a clear change in ecological character, though it still meets the nomination criteria. The vegetation and habitat values of the Site have changed significantly due to a decrease in flood events over the past two decades (DLWBC undated.). A River Redgum survey conducted in South Australia in February 2003 found that approximately 80% of the survey sites contained trees that were stressed to some degree, and 20-30% of them were severely stressed (MBDC 2003). In the area between Wentworth and Renmark (which includes the Riverland Site), more than half of all trees, including River Redgums, were stressed or dead (MDBC 2003). These findings are supported by Overton et al. (2006a), who estimated that 65% of the area of the Chowilla floodplain trees are affected by soil salinisation, compared with 40% in 1993. It is important to note that, at the time of listing, the floodplain vegetation of the Site was already experiencing significant stress, and that the continuing and increasing stress and deterioration of the site will require specific actions to maintain its ecological integrity.

Although River Redgums are justifiably recognised as iconic species and the dominant species of distinct community types, other species and vegetation communities are also being severely impacted by changes to the hydrologic regime. A survey of tree health across the Site undertaken in 2002 (DEH 2003) gave results that found approximately 43% of the area covered by River Redgum to be unhealthy or dead (Figure 4.1). The survey also found that nearly 82% of the area covered by Black Box was unhealthy or dead. Black Box communities cover a very large percentage of the site (Figure 4.2) and this very high percentage of stressed or dead vegetation indicates that the ecological character of the site is under threat across a broad range of habitats and community types (Figure 4.4). Six percent of the Black Box trees were dead in 2002 whereas only 1% of the River Redgums were dead at the same time (DEH 2003).

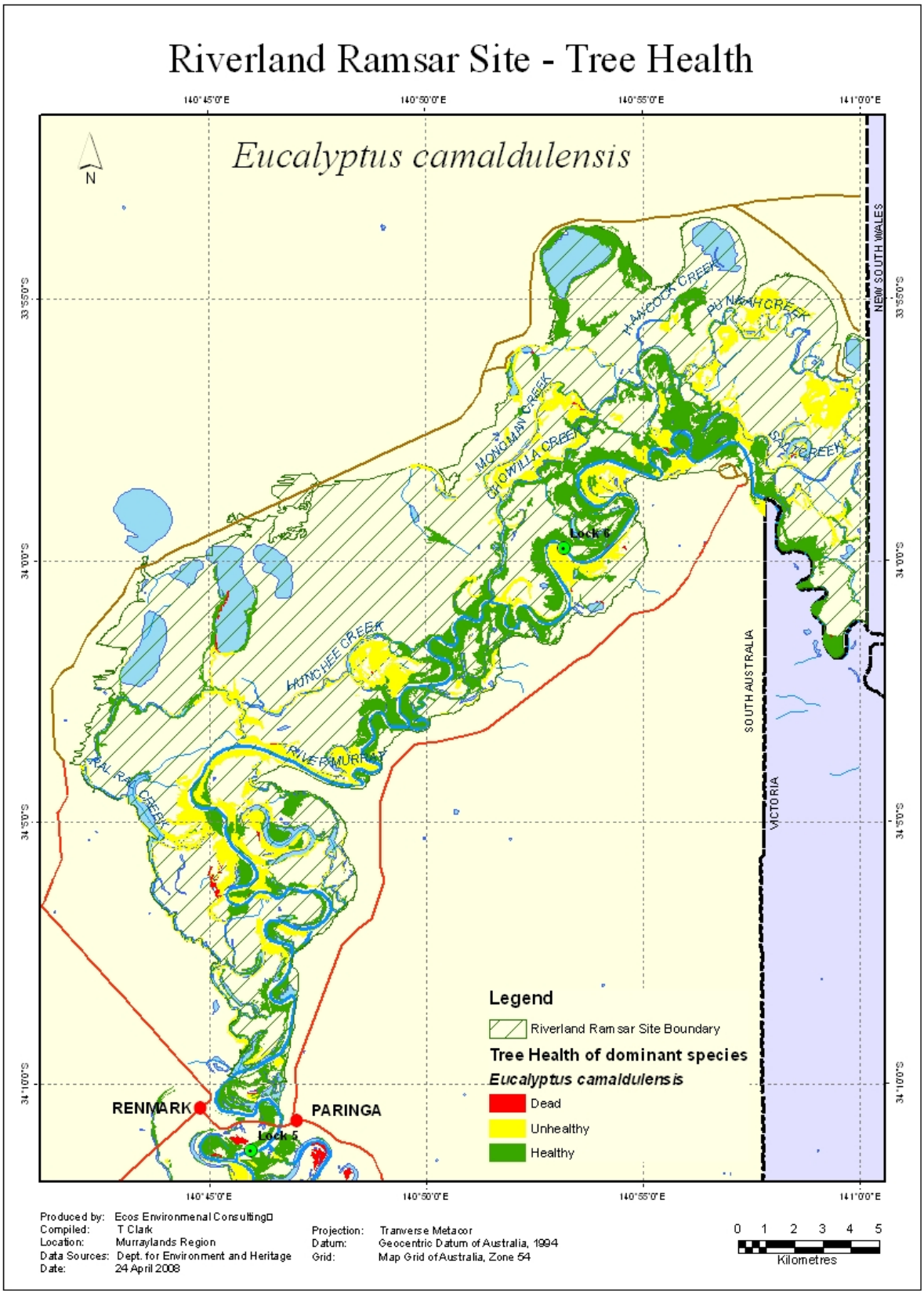


Figure 4.1 Tree health of River Redgum, Riverland Ramsar Site, 2002

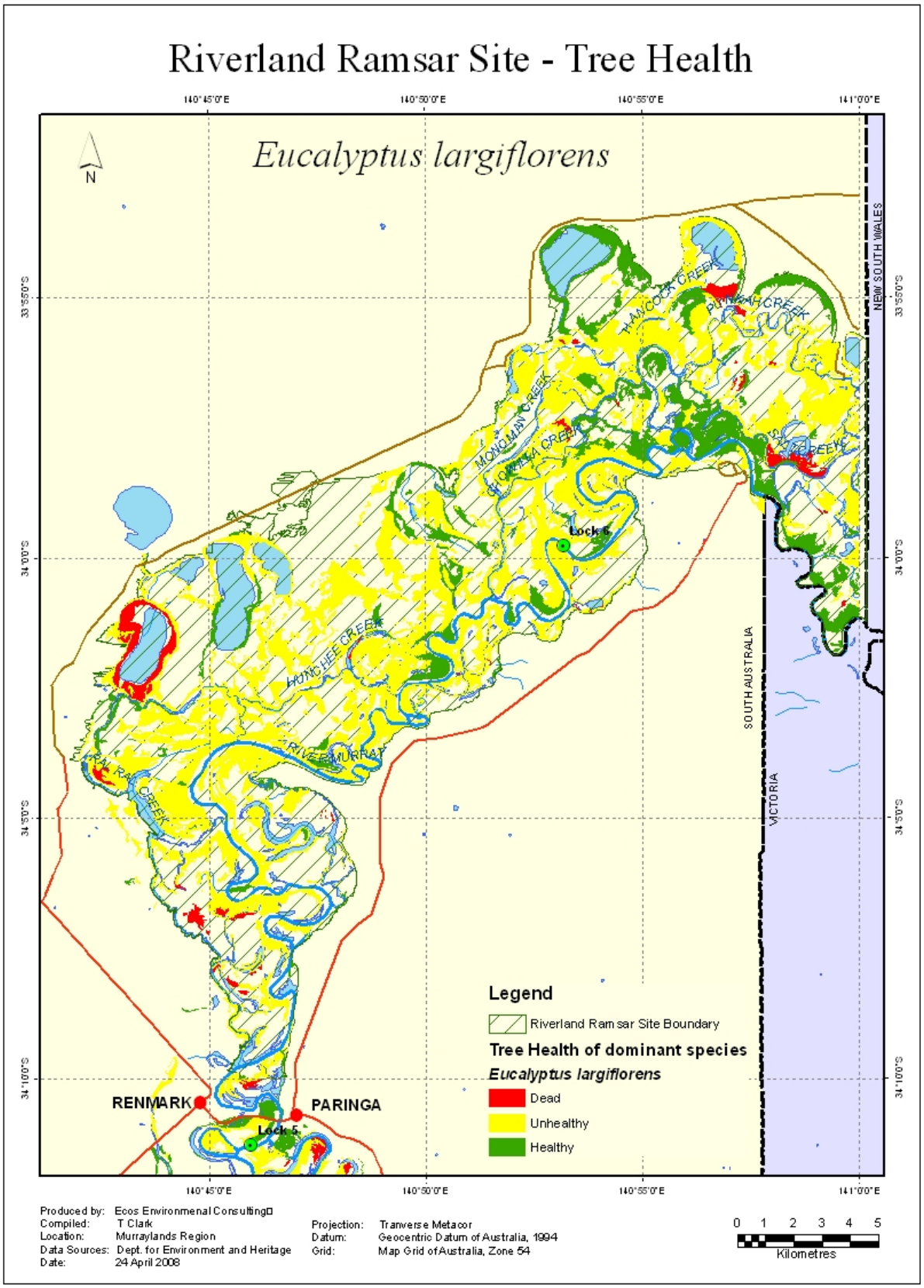


Figure 4.2 Tree health of Black Box, Riverland Ramsar Site, 2002

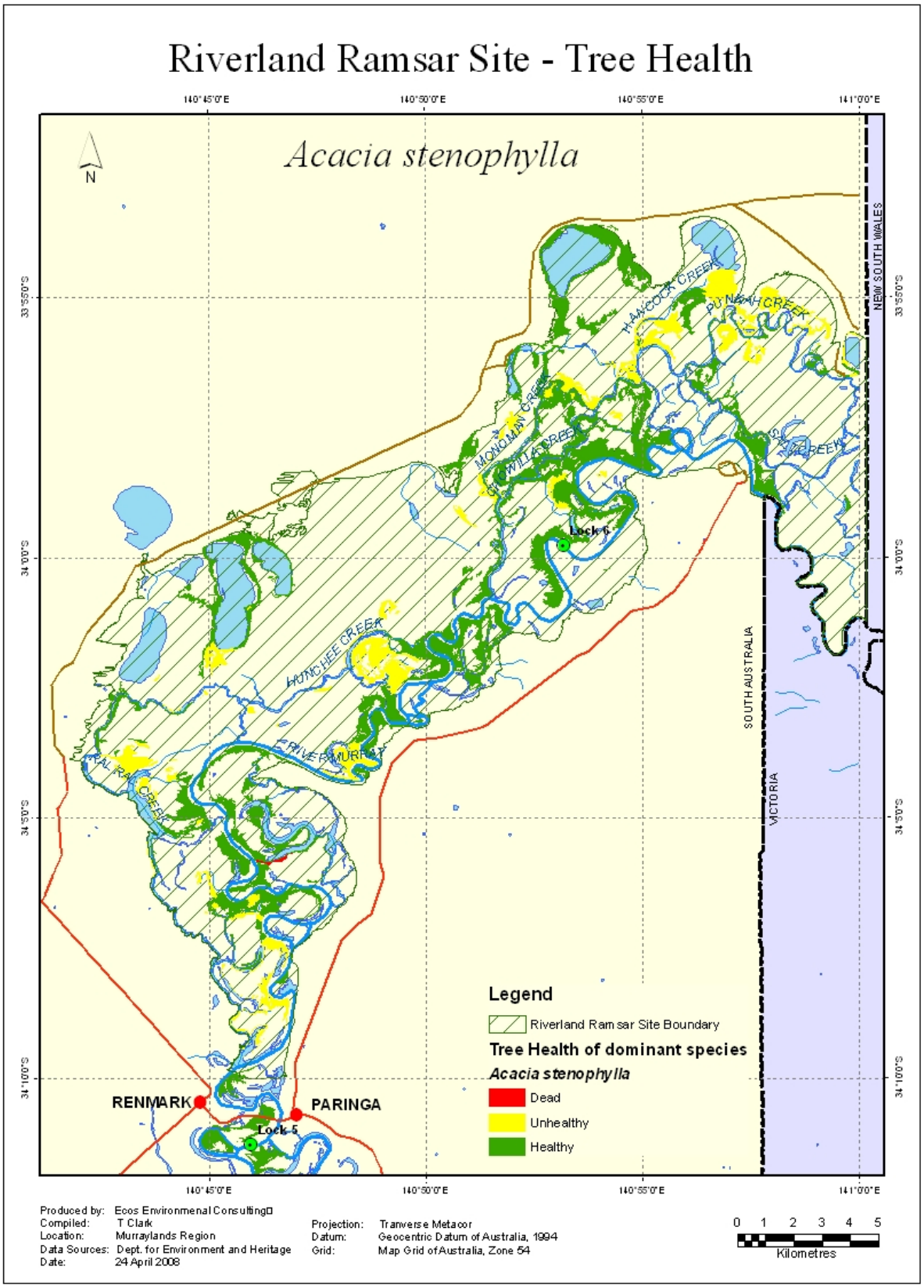


Figure 4.3 Tree health of River Cooba, Riverland Ramsar Site, 2002

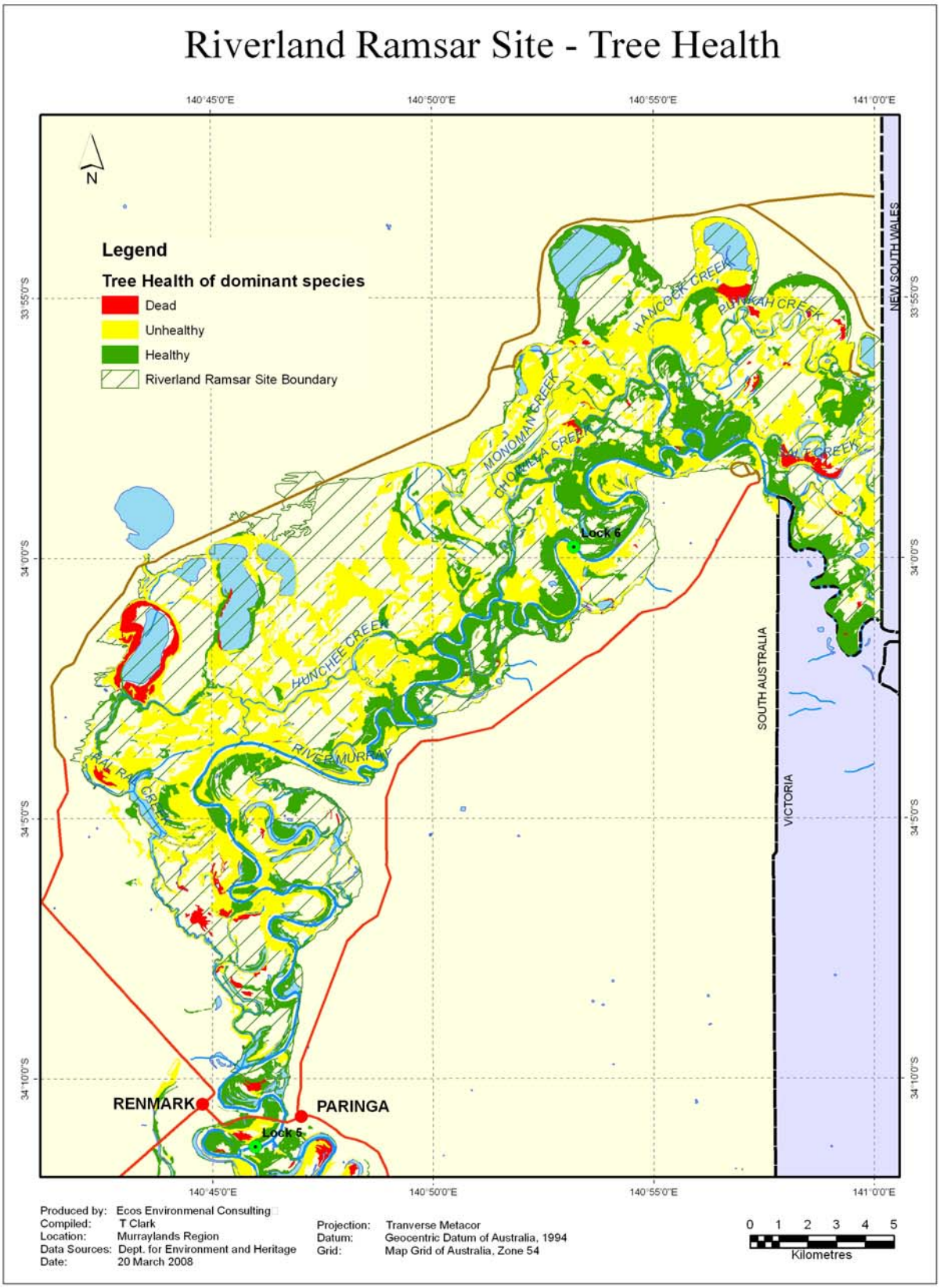


Figure 4.4 Tree health (River Redgum, Black Box and River Cooba combined) in the Riverland Ramsar Site, 2002

The changes at the Site reflect a regional decline in vegetation health on the floodplain of the lower River Murray. A vegetation survey at 100 sites along 1,450 km of the River Murray from Pericoota State Forest, Victoria to Mannum, SA was undertaken in 2002 and repeated in 2004. In 2002, 51.5% of all (River Redgum) trees surveyed were considered stressed, compared to 75.5% in 2004 (DWLBC 2005, in MDBC 2006). The results of this study are important to the Riverland Ramsar Site as they show a significant decline in tree health over a short period of time, in a large region that includes the Riverland. The DEH survey in 2002 indicates that only 43% of the River Redgum trees were stressed, indicating that the Riverland Ramsar Site might be faring better than trees along the whole reach.

A discussion of changes in vegetation and habitat values should consider, not only the current condition, but also the trajectory of that condition. Output from CSIRO (2005) described 54% of trees (River Redgum, Black Box and Coobah) in the Chowilla section of the site as being in good condition in 1993. By 2003 this number had fallen to 35% and to 24% in 2006 (Muller and Goode undated). In the absence of any management intervention, it is predicted to fall to 19% by 2035. Assuming no intervention, this deterioration trend extends to trees currently in moderate health, which are predicted to decline further into poor health, and trees currently in poor health, which are predicted to decline further and die (CSIRO 2005).

The CSIRO data is challenged by the DEH survey undertaken in 2002 (Figure 4.4) which indicates that, of all trees (River Redgum, Black Box, Coobah, Tea Tree), some 57% were considered to be healthy (which is higher than the 1993 level and much higher to the 2003 CSIRO estimate). Nonetheless, if the average annual rate of decline of 2% (since 1993) is applied to the DEH data there would still be significant loss of growing trees and decline in their role in aquatic ecosystem health (provisions of shading, allochthonous inputs from riparian vegetation [insects, leaves, etc] and large woody debris).

In 2005, it was estimated (by CSIRO 2005) that 31% of all trees are dead (as compared to 5% in the DEH Survey). By 2035, this figure is predicted to rise to 47%. The current situation (measured in 2003) of only 24% of trees considered to be healthy is likely to be a threshold beyond which permanent damage to the Site occurs. Further, River Redgum and Black Box are keystone species within the Site's ecosystem and therefore, once their populations drop to unsustainable levels, the entire system will be impacted (Muller and Goode undated).

The CSIRO (2005) predictions were modelled on the flow conditions experienced during the last 15 years (up to 2005) which were repeated to provide a 30-year outlook. This method of modelling raises the issue of another change in ecological character – changes to the climate component. Although climate change within the site cannot be confirmed in the sense of its trajectory, it is apparent that the climatic conditions in the 20 years since listing have been harsher than the period leading up to listing of the Site: "Particularly low flows have occurred in all years since 2000 as a result of an extended drought and demands for consumptive water use, which were higher than in any previous drought. This drought is one of the

most serious on record to affect the Murray-Darling Basin over the last 100 years" (MDBC 2006).

The CSIRO (2005) predictions are also supported by Overton et al. (2006a), who note that under a "do-nothing" scenario, the proportion of trees in good condition would drop to 32% by 2033 (assuming similar conditions to the last 15 years) and that "If a drought period occurs, such as in the last 5 years, the decline in vegetation will be dramatic."

The effects of management attempts to improve the vegetation, such as lowering of groundwater and increased enhancing the flow regime to increase salt flushing of the soil, will take many years to achieve results (Overton et al. 2006a).

Changes to climate magnify the impacts of altered flow regime, particularly to reduction in medium and high flow events. Although control of climate is beyond local management, a management plan for the Site should consider processes to mitigate these impacts.

Management of individual sites, via the construction of structures which allow wetlands to have natural wetting and drying cycles, and via wetland water trials in 2004-2006, have allowed individual sites to recover significantly (Aldridge et al. 2006; Nicol and Weedon 2006).

There was a dramatic increase in diversity and abundance of many plants and animals when wetting and drying trials were undertaken at Lake Merreti, noted particularly for the significant increase in waterbird numbers (Steggles and Tucker 2003). In the summer of 1994, Lake Merreti was completely dried for the first time since the 1950s. The inflow channels were also fitted with carp screens to prevent large carp entering the Lake. Since then management of lake has resulted in a change from a permanently inundated wetland to a semi-permanently, inundated wetland. Bird surveys have indicated that lake management has resulted in significantly higher diversity of birds, increased area of submerged vegetation and a far greater diversity in native fish (Steggles and Tucker 2003). Previous permanent inundation had led to loss of mature long-lived vegetation (including River Redgum and lignum stands), but now, post-management, the site supports a healthy growth of submerged plants and River Redgums and an expanded littoral zone. This vegetation however, is sensitive to disturbance from multiple fluctuations and salinisation (Steggles and Tucker 2003). Similar results were noted when Lake Woolpolool was allowed to flood in 2001 (Harper 2003).

The watering trials in 2004 – 2006 showed significant improvements in the condition of trees at many River Redgum sites and at least one Black Box site (Aldridge et al. 2006). The change in the understory of wetlands that were watered changed from terrestrial species to wetland plants was, while not uniform, significant (Nicol and Weedon 2006). The permanence of these changes was not studied but if these plants mature to set seed, then the seedbank will be renewed to await the next watering event (natural or induced). The aquatic fauna that also colonised these wetlands after watering included fish, frogs, turtles, crustaceans and water birds (Aldridge et al. 2006).

In summary, the obvious decline in the health of the tree cover of the Site since listing represents a clear change in ecological character, though it still meets the nomination criteria. At the time of listing some dead trees were present but surveys of tree health across the Site undertaken in 2002 (DEH 2003) gave results that found approximately 43% of the area covered by River Redgum to be unhealthy or dead. The survey also found that nearly 82% of the area covered by Black Box was unhealthy or dead. Individual areas within the site have responded positively to management actions such as active wetland watering

5. KNOWLEDGE GAPS

The key knowledge gaps for the Site include systematically collected data, for most of the major components, across the Site. The exception to this is the vegetation component, which has been surveyed for a number of studies (refer Section 3.6).

Natural variability is an important aspect of the components and processes that requires information. Several components (e.g. hydrology, understorey vegetation, water quality, fish, amphibians, reptiles, crustaceans, water birds) have been monitored as part of studies assessing benefits of management actions at the Site (e.g. Aldridge et al. 2006; CSIRO 2005, Nicol and Weedon 2006). However, these need to be evaluated in terms of whole-of-Site monitoring, natural variation, and their use for assessing Site condition in relation to Ramsar criteria.

Data should be gathered using standard methods that allow derivation of a 'point-in-time' baseline which can be compared to future monitoring programs. Therefore the initial sampling strategy must be designed in a way that is cognisant of repeatability (see section 6, below). The data should also be gathered using approaches and methods that allow comparison with other data sets within the site, the Murray-Darling Basin, and the rest of Australia.

Examples of the types of data required are presented in Table 5.1.

Table 5.1: Knowledge gaps for the Riverland Ramsar site

Component	Identified Knowledge Gaps	Recommended Data collection or other action to address the gap.	Priority
Vegetation	Changes across whole site since listing	5-yearly update of collated vegetation map of site	Very high
Climate	Estimate of climatic change for region, particularly in relation to delivery of rainfall and evaporation	5-yearly update of climatic extremes (95^{th} percentiles, 99^{th} percentiles), and also quartiles and averages (medians)	High
Hydrology	Inundation records for each wetland; this includes areal coverage and depths over time	Remote sensing or aerial photos of wetland extent over time, followed-up with ground truthing & depth measurements	High
	Rates of flows filling wetlands	Gauge installation/augmentation	Medium
	Contributions from groundwater are not yet quantified (although relationships often established)	Monitor groundwater levels	Low
Geomorphology	Map of landforms across site, with descriptions and ongoing geomorphic processes, especially	Geomorphic mapping of site, incorporating information from aerial photographs and including cross-sections. Strong focus on areas of	Medium - Low

Component	Identified Knowledge Gaps	Recommended Data collection or other action to address the gap.	Priority
	sedimentation rates in basins/depressions	active deposition and rates of infilling	
	Sediment deposition rates	Sediment volume measurement and calculations	Medium - Low
Water Quality	Baseline water quality data for the wetland systems	Monthly monitoring program for at least 2 years, including inputs from discharge drains and other identifiable sources	High
	Quantitative spatial and temporal changes in salinity across the Site, particularly in relation to flow regimes	Flow-event sampling for wetland systems	Medium
Fauna	Changes to faunal distributions across whole site since listing	5-yearly update of collated fauna database of site using systematic faunal surveys across site, including but not limited to: fish; mammals; birds; aquatic macroinvertebrates and amphibians.	High
	Extensive map of rare faunal species across site	Location map of vulnerable, rare or threatened species with information on habitat preferences and tolerances	High
Habitat	Map of habitats across site, with particular reference to vulnerable, rare or threatened species' requirements	Prepare habitat map based on vegetation and geomorphic maps, aerial photographs and using habitat preferences and requirements of identified species.	High
Soil salinity	Map of substrate across site with salinity categories	Survey of substrate, with representation of areas with high stock access. Measurement criteria to include colour, texture & structure, as well as measures of impacts	Medium

In addition to the components and processes identified above, the following issues and management actions were identified as knowledge gaps:

- *Environmental water allocations for the Site*: changes in response to climate change;
- *On-site management and ground works for water movement within the Site*: there appears to be more than one set of ground works being undertaken at the site, with different management agencies not necessarily aware of the goals or actions being undertaken by other agencies The Environmental

Manager of the SAMDB NRM Board controls the allocations of all water for environmental watering and wetland management; and,

- *A single, central management plan*: there are several management plans for individual components of, or areas within, the Site. These need to be collated into a cohesive Riverland Ramsar Site Management Plan with goals and actions known and accepted by all relevant resource managers.

6. KEY SITE MONITORING NEEDS

The monitoring needs of the site should focus on the limits of acceptable change for the maintenance of the Site's ecological character. The major threats have been discussed in Section 3.6 and the limits of acceptable change in Section 3.7. These are presented in Table 6.1, with associated monitoring needs and prioritisations.

Priorities for monitoring were established by considering the highest value components which face the highest threat.

Table 6.1: Key monitoring needs for the Riverland Ramsar site.

Baseline condition & interim limits of acceptable change	Key Indicator(s)	Monitoring needs (type & frequency)	Priority
<u>Wetland of international significance (& part of Riverland Biosphere Reserve)</u> At a high level, the baseline condition of the site for this service can be described 'meeting the first eight listing criteria'. The **short-term and long-term limits** of acceptable change should both be 'no loss of any listing criteria'. These listing criteria comprise most of the other ecological services identified for the Site, and are presented in the rows below.	The key indicators are the listing criteria. These are discussed in the rows below	See below	N/A
<u>Representative/rare/unique wetland type in appropriate biogeographic region</u> The most readily assessable indicator of each wetland type is areal extent. The vegetation of the Site has been surveyed and documented and may provide a basis for defining extent of each wetland type. Similarly, tree health for several species has been recorded for parts of the site. The **short term limits** of acceptable change should be: no loss of more than 10% of any wetland type over the site as a whole, within any 2-year period. The **long-term limits** of acceptable change should be no loss of more than 20% of any wetland type over the site as a whole, within any 10-year period. The term "as a whole" acknowledges that spatial and temporal changes to vegetation occur in relation to natural variability of hydrological regime over multi-year cycles. However, the diversity and constituents of the wetland mosaic must be maintained.	Tree health Wetland diversity Extent of Wetland Type	2 yearly tree health assessment using infrared satellite data 5 yearly on-ground vegetation surveys including tree health and wetland type and extent	Very High
<u>Supports populations of rare, endangered and threatened species (State & National)</u> The condition at the time of listing for many threatened species, particularly faunal, is unknown (in terms of population numbers, trends, ranges) and require further assessment. There are more data	Populations of rare, endangered or threatened species	5 yearly on-ground vegetation and fauna surveys	High

Baseline condition & interim limits of acceptable change	Key Indicator(s)	Monitoring needs (type & frequency)	Priority
available for the listed species of flora, through vegetation surveys. The limits of acceptable change should be based on species surveyed in 2002 (vegetation) and 2003 (fauna). Quantitative surveys should be undertaken in in the near future and repeated 5-yearly. The changes between surveys should be used to define the level of variation. **Short term** and **Long term limits** of acceptable change should be no loss of any listed species of flora and fauna.			
<u>Provision of remnant lower River Murray floodplain habitat to support regional biodiversity</u> <u>Fauna</u>: The pre-listing condition of the faunal groups is unknown, in terms of complete species lists, distributions and abundances. The **short term limits** of acceptable change should be derived from the qualitative 2003 baseline information. Quantitative surveys should be undertaken in in the near future and repeated 5-yearly. The changes between surveys should be used to define the level of variation. <u>Flora</u> The baseline condition for flora is better established, with a several vegetation surveys of the Site having been undertaken. The **short term limits** of acceptable change should be: no loss of any rare species of flora over any time period and no loss of any vegetation community type, excluding seasonal variations and natural annual variations. Tree health data recorded in 2003 and work undertaken by CSIRO show tree health should not further decline than current levels, unless significant changes to the site's ecological character. Flora and Fauna The **long-term limits** of acceptable change should be: o no loss of any rare or threatened species of flora or fauna o no net reduction in populations of bird, fish, mammal, mollusc, macrocrustacean or amphibian fauna over any 10 year period; and o no loss of more than 20% of any vegetation type over the site as a whole within any ten year period.	Tree health Populations of rare, endangered or threatened species	2 yearly tree health assessment using infrared satellite data 5 yearly on-ground vegetation and fauna surveys (fauna surveys to include both aquatic and terrestrial species)	Very High

Baseline condition & interim limits of acceptable change	Key Indicator(s)	Monitoring needs (type & frequency)	Priority
<u>Diverse and abundant waterbirds</u> Apart from presence data and some estimates of population sizes, much of the pre-listing condition for these species is not well known. **Short term limits** of acceptable change should be derived from the 2003 baseline information. Quantitative surveys should be undertaken in in the near future and repeated 5-yearly. The changes between surveys should be used to define the level of variation. **Long-term limits** of acceptable change should be: o no loss of any rare or threatened species; and o no net reduction in populations over any rolling 10 year period.	Population levels of waterbirds Species diversity of waterbirds	Annual bird observer counts of waterbirds 5 yearly on-ground waterbird (as part of integrated sampling vegetation and fauna surveys (fauna surveys to include both aquatic and terrestrial species)	High
<u>Diverse fish and invertebrate fauna</u> **Short term limits** of acceptable change should be derived from the 2005/06 SARDI Survey. This survey should be repeated in 2008 and the changes would be used to define the level of variation, which should be exceeded in any 5 year period. **Long-term limits** of acceptable change should be: o no loss of any rare or threatened species; and o no net reduction in populations over any rolling 10 year period.	Fish and macro-invertebrate abundance and diversity	Five yearly fish and macro-invertebrate survey Use AUSRIVAS and SIGNAL scores to benchmark diversity, abundance and community health of macro-invertebrate populations (this will need to be added to future surveys)	High for Fish Medium for macro-invertebrate
<u>High diversity and mosaic of both terrestrial and aquatic habitats</u> Baseline condition for habitat diversity can be defined using vegetation surveys undertaken at the Site. This should be supplemented by future surveys of the Site, as required. The **short term limits** of acceptable change should be no loss of any habitat type, excluding seasonal variations and natural annual variations. No further death of trees and no increase in the area of unhealthy trees should occur in any two year period. The **long term limits** of acceptable change should be no loss of more than 20% of any habitat type, over the site as a whole (i.e. vegetation communities may migrate, but diversity & mosaic must be maintained)	Tree health Wetland diversity	Met in above monitoring actions	Medium-High

7. COMMUNICATION, EDUCATION AND PUBLIC AWARENESS (CEPA) MESSAGES

The primary message that needs to be communicated to relevant stakeholders is:

"An ECD which reflects the ecological character of the Riverland Ramsar Site at the time of listing in 1987 is complete. The Site is listed against Criteria 1 – 8:

- *Criterion 1 (representative/rare/unique wetland type in appropriate biogeographic region);*
- *Criterion 2 (vulnerable/endangered/critically endangered species or ecological communities);*
- *Criterion 3 (supports populations of plant and/or animals important for regional biodiversity);*
- *Criterion 4 (supports species at critical stages or provides refuge in adverse conditions);*
- *Criterion 5 (providing habitat that regularly supports 20,000 or more waterbirds);*
- *Criterion 6 (providing habitat that regularly supports 1% of the global population of at least one species of waterbird);*
- *Criterion 7 (supporting a significant proportion of indigenous fish taxa, life-history stages, species interactions or populations that are representative of wetland benefits and/or values); and,*
- *Criterion 8 (supplying an important food source, spawning ground, nursery and/or migration path for fishes, on which fish stocks depend).*

This site is a complex, riverine wetland ecosystem which provides habitat for important and nationally threatened species. The ECD documents past and current conditions, determines approaches to assess changes in condition, and identifies potential threats to the wetland's character. The ECD also identifies appropriate management considerations for future management planning and critical information gaps for management. Without active management intervention the ecological character of the site is under threat.

The stakeholders of the Riverland Ramsar Site are numerous and the messages required for each may be different, especially as part of management planning. We have separated the stakeholders for the site into four groups, according to their role and interest in the site (Table 7.1). Initially, however, a combined set of messages relevant to the ECD can be used to communicate the importance of the site, why it was listed, the threats to the site and future actions required. The combined, key

communication and public education messages for the Riverland Ramsar Site are displayed in Table 7.2.

Table 7.1: Stakeholder groups for the Riverland Ramsar Site

Stakeholder Group	Stakeholders
Managers	Department of Environment and Heritage (SA) Department of Environment, Water, Heritage and the Arts (Commonwealth) Murray-Darling Basin Commission River Murray Water Landholders
Regulators	SA Murray Darling Basin NRM Board Dept of Land Water Biodiversity Conservation (SA) Environmental Protection Authority (SA) Department of Environment and Heritage Department of Environment, Water, Heritage and the Arts (for the EPBC Act)
Advisors and Funders	Australian Government – Dept of Agrivulture, Fisheries and Forestry and Department of Environment, Water, Heritage and the Arts Murray-Darling Basin Commission Consultants and Contractors Universities and Researchers: • Biosphere Reserve • Commonwealth Scientific and Industrial Research Organisation. • Murray Darling Freshwater Research Centre
Broader Community	Landholders Tourism industry Birds Australia (South Australia) General Public

Table 7.2: Key communications and public education messages for the Riverland Ramsar Site

Message No.	Simple Message	Detailed Message
1	The Riverland Ramsar Site is an internationally important wetland	The Riverland Ramsar Site is an internationally important wetland, and is now listed under criteria 1, to 8: 1. As it contains excellent regional representative examples of a major floodplain system within the Murray Scroll Belt Subregion of the Riverina Bioregion of the Murray-Darling Basin. 2. The Site supports the following taxa, listed as Vulnerable (EPBC Act 1999), including: Regent Parrot (Eastern) (*Polytelis anthopeplus monarchoides*); Southern Bell Frog (*Litoria raniformis*); Murray Cod (*Maccullochella peelii peelii*); Murray Hardyhead (*Craterocephalus fluviatilis*). 3. The wetlands supports twenty-eight plant species listed at the State level (NPWS Act 1972) that are found at the Site on a permanent or seasonal basis (Appendix 1.1). Twenty species are listed as rare and eight as vulnerable. 4. The Riverland wetland provides critical summer or stopover habitat for eight species of migratory birds listed under the JAMBA, CAMBA and ROKAMBA agreements. 5. The Site regularly supports 20,000 or more waterbirds involving fifty-nine species. 6. Freckled Duck (*Stictonetta naevosa*), Red-necked Avocet (*Recurvirostra novaehollandiae*) and Red-kneed Dotterel (*Erythrogonys cinctus*) have been recorded at the Site in numbers representing greater than 1% of their estimated global population. 7. The Site supports 16 species of freshwater native fish species (nine families) within the Murray-Darling Basin. The Site's fish assemblage displaying a high biodisparity and five different reproductive styles. 8. The Site also provides habitat for breeding and a nursery for juvenile stages of Golden Perch (*Macquaria ambigua*), Silver Perch (*Bidyanus bidyanus)* and many other fish. Floods in spring and early summer ensure abundant plankton and other organisms as food for young fish.

Message No.	Simple Message	Detailed Message
2	The Site is a zone of high biodiversity	The site is a zone of high biodiversity. The area contains a variety of aquatic and terrestrial habitats including the following vegetation communities: River Redgum forest/woodland, Black Box, Lignum, River Saltbush chenopod shrubland, low chenopod shrubland, samphire low shrubland, herbfield, grassland, fringing aquatic reed & sedge, and true aquatic habitats such as channels, billabongs, backwaters and depressions. The large area of intermittent shallow water allows the site to be a good feeding area for waterbirds. The area provides nesting habitat for many species of waterbirds (and also bushland species) within the River Redgum, Black Box woodlands and wetlands. These include: Strawneck Ibis, White Ibis, Yellow-billed Spoonbill, Royal Spoonbill, Darter, Pied Cormorant, Little Black Cormorant, Little Pied Cormorant, and Black Swan. A number of migratory birds have been recorded from the site, including species listed on the China - Australia Migratory Bird Agreement (CAMBA) and the Japan - Australia Migratory Bird Agreement (JAMBA). The floodplain wetlands also support a rich variety of invertebrate fauna.
3	The site contains many national and State threatened species	The site contains many national and State threatened species. These include the following taxa, listed as Vulnerable under section 179 of the *EPBC Act* 1999: o Regent Parrot (Eastern) (*Polytelis anthopeplus monarchoides*); o Southern Bell Frog (*Litoria raniformis*); o Murray Cod (*Maccullochella peelii peelii*) o Murray hardyhead (*Craterocephalus fluviatilis*) The following significant plant species are listed at the State level under the National Parks and Wildlife Act 1972 and inhabit the Site on a permanent or seasonal basis: o Dainty Maiden-hair *Adiantum capillus-veneris* (Vulnerable) o Swamp Daisy *Brachycome basaltica* var*. gracilis* (Rare) o Black-fruit Daisy *Brachycome melanocarpa* (Vulnerable) o Coast Daisy *Brachycome parvula* var*. lissocarpa* (Rare) o Matted Water Starwort *Callitriche sonderi* (Rare) o Water Starwort *Callitriche umbonata* (Vulnerable)

Message No.	Simple Message	Detailed Message
		o Pale Beauty-heads *Calocephalus sonderi* (Rare) o Tufted Burr-daisy *Calotis scapigera* (Rare) o Purple Crassula *Crassula peduncularis* (Rare) o Pale Flax-lily *Dianella porracea* (Vulnerable) o Small-flower Beetle-grass *Diplachne parviflora* (Rare) o Waterwort *Elatine gratioloides* (Rare) o Barren Cane-grass *Eragrostis infecunda* (Rare) o Purple Love-grass *Eragrostis lacunaria* (Rare) o Pale-fruit Cherry *Exocarpos strictus* (Rare) o Sea-Heath *Frankenia cupularis* (Rare) o Hooked Needlewood *Hakea tephrosperma* (Rare) o Nutty Club-rush *Isolepis variega* (Vulnerable) o Slender Fissure-plant *Maireana pentagona* (Rare) o Creeping Boobialla *Myoporum parvifolium* (Rare) o Upright Milfoil *Myriophyllum crispatum* (Vulnerable) o Robust Milfoil *Myriophyllum papillosum* (Rare) o Wavy Marshwort *Nymphoides crenata* (Rare) o Australian Broomrape *Orobanche cernua* var. *australiana* (Vulnerable) o Squat Picris *Picris squarrosa* (Rare) o Jagged Bitter-cress *Rorippa laciniata* (Rare) o Behr's Swainsona-pea *Swainsona behriana* (Vulnerable) o *Zannichellia palustris* (Rare) The Site's fauna is similarly diverse and includes the following State listed threatened species that inhabit the Site on a permanent or seasonal basis: o Feather-tailed Glider *Acrobates pygmaeus* (Endangered)

Message No.	Simple Message	Detailed Message
		o Broad-shell Turtle *Chelodina expansa* (Vulnerable) o Carpet Python *Morelia spilota variegata* (Rare) o Lace Monitor *Varanus varius* (Rare) o Great Crested Grebe *Podiceps cristatus* (Rare) o Australian Bittern *Botaurus poiciloptilus* (Vulnerable) o Musk Duck *Biziura lobata* (Rare) o Blue-billed Duck *Oxyura australis* (Rare) o Australasian Shoveler *Anas rhynchotis* (Rare) o Freckled Duck *Stictonetta naevosa* (Vulnerable) o Intermediate Egret *Ardea intermedia* (Rare) o Glossy Ibis *Plegadis falcinellus* (Rare) o Bush Stone-curlew *Burhinus grallarius* (Vulnerable) o Square-tailed Kite *Lophoictinia isura* (Vulnerable) o Peregrine Falcon *Falco peregrinus* (Rare) o White-bellied Sea-Eagle *Haliaeetus leucogaster* (Vulnerable) o Major Mitchell's Cockatoo *Cacatua leadbeateri* (Vulnerable)
4	The site provides many important services and benefits to the region	The site provides many important services and benefits to the region, which include: o Wetlands of International Significance; o Unique occurrence of wetlands in the normally semi-dry lower River Murray floodplain environment; o Part of the Riverland Biosphere Reserve; o One of the only parts of the lower River Murray floodplain not receiving irrigation, retaining much of its natural character and hence, natural heritage; o High diversity and mosaic of both terrestrial and aquatic habitats; probably the highest biodiversity of any site along the Lower River Murray

Message No.	Simple Message	Detailed Message
		o Supports populations of rare, endangered and nationally threatened species; o Supports populations of rare, endangered and threatened species and communities in South Australia and New South Wales Chowilla floodplain has: o 28 plant species of state significance; o 4 animal species of national significance o 23 animal species of state significance; o Diverse and abundant waterbirds; o Diverse fish fauna (including nationally significant species); and, o Diverse invertebrate fauna Benefits to humans derived from the Site include: o Cultural heritage (indigenous and European) o Tourism/recreation o Drinking water for livestock o Water for irrigated agriculture o Livestock fodder o Flood retardation o Pollutant reduction, including nutrient inputs to the River Murray o Sediment trapping o Educational and scientific values, including studies on groundwaters o greenhouse gas offset
5	Understanding the ecology of the site will enhance future management of the site	Understanding the ecology of the site will enhance future management of the site. The ECD provides a complete description of the wetland's character at the time of listing, the changes since listing, the threats likely to cause changes in the wetland's ecological character (including the ecological benefits the site provides), the key knowledge gaps of the site's ecology and functioning, monitoring requirements and triggers for management actions.

Message No.	Simple Message	Detailed Message
6	Past and present management practices provide some threats to the site's values such as human use, alterations to the hydrologic regime, grazing, vegetation clearance and introduction of pest plants and animals.	Past and present management practices within and beyond the Sites provide some threats to the site's values. The major threats to the Site include: o Climate change, particularly synergies between decreased rainfall and increased evaporation; o Altered flow regime; o Salinity; o Very high sedimentation rates for wetlands; o Elevated and altered groundwater regime; o Obstructions to fish passage; o Grazing pressure; o Pest flora and fauna; and o Human access and motorised recreation
7	The ECD project has summarised the available information on the site which describes its ecological character	The ECD project has: o collated all the available information on the site; o provided a description of the site, its biodiversity and its functions; o brought stakeholders together in the management of the site; o discovered that despite its regional significance and international listing, the site has gaps in the information required for its management and protection indicating more research and monitoring is required
8	Landholders, managers and users should promote the wise use of wetlands.	Landholders, managers and users should promote the wise use of wetlands: o The wise use of wetlands is a key concept of the Ramsar Convention on Wetlands and is defined as the 'sustainable utilisation for the benefit of humankind in a way compatible with the maintenance of the natural properties of the ecosystem'

8. GLOSSARY

Adverse conditions	ecological conditions unusually hostile to the survival of plant or animal species, such as occur during severe weather like prolonged drought, flooding, cold, etc (Ramsar Convention 2005b).
Assessment	the identification of the status of, and threats to, wetlands as a basis for the collection of more specific information through monitoring activities (as defined by Ramsar Convention 2002a, Resolution VIII.6).
Baseline	condition at a starting point. For Ramsar wetlands it will usually be the time of listing of a Ramsar site (Lambert and Elix 2006).
Benchmark	a standard or point of reference (ANZECC and ARMCANZ 2000b). a pre-determined state (based on the values which are sought to be protected) to be achieved or maintained (Lambert and Elix 2006).
Benefits	benefits/services are defined in accordance with the Millennium Ecosystem Assessment definition of ecosystem services as "the benefits that people receive from ecosystems (Ramsar Convention 2005a, Resolution IX.1 Annex A). See also "Ecosystem Services".
Biogeographic region (also 'bioregion')	a scientifically rigorous determination of regions as established using biological and physical parameters such as climate, soil type, vegetation cover, etc (Ramsar Convention 2005b).
Biological diversity	the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species (genetic diversity), between species (species diversity), of ecosystems (ecosystem diversity), and of ecological processes. This definition is largely based on the one contained in Article 2 of the Convention on Biological Diversity (Ramsar Convention 2005b).
Catchment	the total area draining into a river, reservoir, or other body of water (ANZECC and ARMCANZ 2000a).
Change in ecological character	is defined as the human-induced adverse alteration of any ecosystem component, process, and/or ecosystem benefit/service (Ramsar Convention 2005a, Resolution IX.1 Annex A).
Community	an assemblage of organisms characterised by a distinctive combination of species occupying a common environment and interacting with one another (ANZECC and ARMCANZ 2000a).
Community Composition	all the types of taxa present in a community (ANZECC and ARMCANZ 2000a).
Conceptual model	wetland conceptual models express ideas about components and processes deemed important for wetland ecosystems (Manlet et al. 2000; Gross 2003)
Contracting Parties	are countries that are Member States to the Ramsar Convention on Wetlands; 154 as at March 2007. Membership in the Convention is open to all states that are members of the United Nations, one of the UN specialized agencies, or the International Atomic Energy Agency, or is a Party to the Statute of the International Court of Justice [http://www.ramsar.org/key_cp_e.htm].
Critical stage	meaning stage of the life cycle of wetland-dependent species. Critical stages being those activities (breeding, migration stopovers, moulting etc.) which if interrupted or prevented from occurring may threaten long-term conservation of the species. (Ramsar Convention 2005b).

Ecological character	is the combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time. Within this context, ecosystem benefits are defined in accordance with the variety of benefits to people (Ecosystem Services). (Millennium definition of ecosystem services as "the benefits that people receive from ecosystems" (Ramsar Convention 2005a, Resolution IX.1 Annex A). The phrase "at a given point in time" refers to Resolution VI.1 paragraph 2.1, which states that "It is essential that the ecological character of a site be described by the Contracting Party concerned **at the time of designation for the Ramsar List**, by completion of the Information Sheet on Ramsar Wetlands (as adopted by Recommendation IV. 7).
Ecological communities	any naturally occurring group of species inhabiting a common environment, interacting with each other especially through food relationships and relatively independent of other groups. Ecological communities may be of varying sizes, and larger ones may contain smaller ones (Ramsar Convention 2005b).
Ecosystems	the complex of living communities (including human communities) and non-living environment (Ecosystem Components) interacting (through Ecological Processes) as a functional unit which provides inter alia a variety of benefits to people (Ecosystem Services). (Millennium Ecosystem Assessment 2005).
Ecosystem components	include the physical, chemical and biological parts of a wetland (from large scale to very small scale, e.g. habitat, species and genes) (Millennium Ecosystem Assessment 2005).
Ecosystem processes	are the dynamic forces within an ecosystem. They include all those processes that occur between organisms and within and between populations and communities, including interactions with the non-living environment that result in existing ecosystems and bring about changes in ecosystems over time (Australian Heritage Commission 2002). They may be physical, chemical or biological.
Ecosystem services	are the benefits that people receive or obtain from an ecosystem. The components of ecosystem services are provisioning (e.g. food & water), regulating (e.g. flood control), cultural (e.g. spiritual, recreational), and supporting (e.g nutrient cycling, ecological value). (Millennium Ecosystem Assessment 2005). See also "Benefits".
Fluvial geomorphology	the study of water-shaped landforms (Gordon *et al*. 1999)
Indicator species	species whose status provides information on the overall condition of the ecosystem and of other species in that ecosystem; taxa that are sensitive to environmental conditions and which can therefore be used to assess environmental quality (Ramsar Convention 2005b).
Indigenous species	a species that originates and occurs naturally in a particular country (Ramsar Convention 2005b).
Introduced (non-native) species	a species that does not originate or occur naturally in a particular country (Ramsar Convention 2005b).
Limits of Acceptable Change	the variation that is considered acceptable in a particular component or process of the ecological character of the wetland without indicating change in ecological character which may lead to a reduction or loss of the criteria for which the site was Ramsar listed' (modified from definition adopted by Phillips 2006).
List of Wetlands of International Importance ("the Ramsar List")	the list of wetlands which have been designated by the Ramsar Contracting Party in which they reside as internationally important, according to one or more of the criteria that have been adopted by the Conference of the Parties [http://www.ramsar.org/about/about_glossary.htm].
Monitoring	the collection of specific information for management purposes in response to hypotheses derived from assessment activities, and the use of these monitoring results for implementing management (Ramsar Convention 2002a, Resolution VIII.6).

Ramsar	city in Iran, on the shores of the Caspian Sea, where the Convention on Wetlands was signed on 2 February 1971; thus the Convention's short title, "Ramsar Convention on Wetlands" [http://www.ramsar.org/about/about_glossary.htm].
Ramsar Criteria	Criteria for Identifying Wetlands of International Importance, used by Contracting Parties and advisory bodies to identify wetlands as qualifying for the Ramsar List on the basis of representativeness or uniqueness or of biodiversity values. http://www.ramsar.org/about/about_glossary.htm
Ramsar Convention	*Convention on Wetlands of International Importance especially as Waterfowl Habitat*. Ramsar (Iran), 2 February 1971. UN Treaty Series No. 14583. As amended by the Paris Protocol, 3 December 1982, and Regina Amendments, 28 May 1987. The abbreviated names "Convention on Wetlands (Ramsar, Iran, 1971)" or "Ramsar Convention" are more commonly used [http://www.ramsar.org/index_very_key_docs.htm].
Ramsar Information Sheet (RIS)	the form upon which Contracting Parties record relevant data on proposed Wetlands of International Importance for inclusion in the Ramsar Database; covers identifying details like geographical coordinates and surface area, criteria for inclusion in the Ramsar List and wetland types present, hydrological, ecological, and socioeconomic issues among others, ownership and jurisdictions, and conservation measures taken and needed (http://www.ramsar.org/about/about_glossary.htm).
Ramsar List	the List of Wetlands of International Importance [http://www.ramsar.org/about/about_glossary.htm].
Ramsar Sites	wetlands designated by the Contracting Parties for inclusion in the List of Wetlands of International Importance because they meet one or more of the Ramsar Criteria [http://www.ramsar.org/about/about_glossary.htm].
Ramsar Sites Database	repository of ecological, biological, socio-economic, and political data and maps with boundaries on all Ramsar sites, maintained by Wetlands International in Wageningen, the Netherlands, under contract to the Convention [http://www.ramsar.org/about/about_glossary.htm].
Taxa, Taxon	A general name for a taxonomic group whatever level e.g. species or genus of any biota.
Wetlands	are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres (Ramsar Convention 1987).
Wetland Assessment	the identification of the status of, and threats to, wetlands as a basis for the collection of more specific information through monitoring activities (Finlayson *et al*. 2001; Ramsar Convention 2002a).
Wetland Ecological Risk Assessment	a quantitative or qualitative evaluation of the actual or potential adverse effects of stressors on a wetland ecosystem (US EPA 1989)
Wetland types	as defined by the Ramsar Convention's wetland classification system [http://www.ramsar.org/ris/key_ris.htm#type].
Wise use of wetlands	is the maintenance of their ecological character, achieved through the implementation of ecosystem approaches[1], within the context of sustainable development[2]" (Ramsar Convention 2005a Resolution IX.1 Annex A). 1. Including *inter alia* the Convention on Biological Diversity's "Ecosystem Approach" (CBD COP5 Decision V/6) and that applied by HELCOM and OSPAR (Declaration of the First Joint Ministerial Meeting of the Helsinki and OSPAR Commissions, Bremen, 25-26 June 2003). 2. The phrase "in the context of sustainable development" is intended to recognize that whilst some wetland development is inevitable and that many developments have important benefits to society, developments can be facilitated in sustainable ways by approaches elaborated under the Convention, and it is not appropriate to imply that 'development' is an objective for every wetland.

9. REFERENCES

Aldridge, K., Deegan, B., Burch, M. and Brookes, J. 2006. Ecological response to watering projects on Chowilla Floodplain, 2004-2006. Report to the Department of Water, Land and Biodiversity Conservation, Adelaide, S.A.

Atkins, B. & Musgrove, R. 1990. Macrocustraceans. In: Chowilla Floodplain Biological Study. Nature Conservation Society of S.A., Adelaide, SA.

Australian Heritage Commission. 2002. Australian Natural Heritage Charter for conservation of places of natural heritage significance. Second Edition. Australian Heritage Commission. Canberra.
http://www.ahc.gov.au/publications/anhc/parta.html

AWRC. 1975. Review of Australia's Water Resources 1975, Map 5, Australian Water Resources Council, Commonwealth of Australia, Canberra.

Bailey, P. and Boon, P. 2002. Contaminants fact sheet and salt sensitivity database. Land and Water Resources Research and Development Corporation, Canberra.

Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R. (2003). The New Atlas of Australian Birds. Birds Australia, Hawthorn East.

Bird, P. and Armstrong, G. 1990. Reptiles and amphibians. In O'Malley, C. & F. Sheldon. Chowilla Floodplain Biological Study. Nature Conservation Society of South Australia, Adelaide, SA.

BirdLife International 2008. 2008 IUCN Red List of Threatened Species.

Boulton, A.J. & L.N. Lloyd. 1991. Aquatic macroinvertebrate assemblages in floodplain habitats of the lower River Murray. Regulated Rivers, 6: 183-201.

Boulton, A.J. & L.N. Lloyd, 1992. Flooding frequency and invertebrate assemblages emerging from floodplain sediments at Chowilla, lower River Murray, SA. Regulated Rivers 7: 137-151.

Braithwaite, L.W. 1975. Managing waterfowl in Australia. In: Managing Aquatic Ecosystems. Nix, H.A. and Elliot, M.A. (Eds) Proc. Ecol. Soc. of Aust. 8:107-128.

Brandle, R. & P. Bird. 1990. Avifauna. In: O'Malley, C. & F. Sheldon. Chowilla Floodplain Biological Study. Nature Conservation Society of South Australia, Adelaide, SA.

Briggs, S,V. & M.T, Maher. 1983. Litter fall and leaf decomposition in a river Redgum (Eucalyptus camaldulensis) swamp. Australian Journal of Botany, 31: 307-316.

Briggs, S.V. & M.T. Maher. 1985. Linmological studies of waterfowl habitat in south-western New South Wales - Aquatic plant productivity. Australian Journal of Marine and Freshwater Research, 36: 707-715.

Briggs, S.V., M.T. Maher & S.M. Carpenter. 1985. Linmological studies of waterfowl habitat in south-western New South Wales. 1. Water Chemistry. Australian Journal of Marine and Freshwater Research, 36: 59-67.

Briggs, S.V., M.T. Maher & DJ. Tongway. 1993. Dissolved and particulate organic carbon in two wetlands in southwestern New South Wales, Australia. Hydrobiologia, 264 (1): 13-19,

Brock, M.A. 1991. Mechanisms for maintaining persistent populations of Myriophyllum varifolium 1. Hooker in a fluctuating shallow Australian lake. Aquatic Botany, 39: 211-219.

Carpenter, G. 1990. Avifauna. In: O'Malley, C. & F. Sheldon. Chowilla Floodplain Biological Study. Nature Conservation Society of South Australia, Adelaide, SA.

Casanova, M.T. & M.A. Brock. 1990. Charophyte germination and establishment from the seedbank of an Australian temporary lake. Aquatic Botany, 36: 247-254.

Crome, F.H.J. 1986. Australian waterfowl do not necessarily breed on a rising water level. Australian Journal of Wildlife Research, 13: 461-80.

Crome, F.H.J. & S.M. Carpenter. 1988. Plankton community cycling and recovery after drought -dynamics in a basin on a floodplain. Hydrobiologia, 164: 193-211.

CSIRO. 2005. Flood Extent, Groundwater Recharge and Vegetation Response from the Operation of a Potential weir in Chowilla Creek, South Australia. CSIRO Land and Water.

DEH. 2002. The South Australian River Murray Floodplain Vegetation and Fauna Survey (Oct-Nov 2002). Department for Environment and Heritage, South Australia.

DEH. undated. Riverland Ramsar Site: A Plan for Wise Use (draft plan in preparation). Department for Environment and Heritage, South Australia.

DEH 2003. A Review of Chowilla Regional Reserve 1993-2003. Department for Environment and Heritage, Adelaide, South Australia.

DEWHA 2008. *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands.* Module 2 of the National Guidelines for Ramsar Wetlands—Implementing the Ramsar Convention in Australia. Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra.

DEWHA. 2009a. http://www.environment.gov.au/biodiversity/migratory/waterbirds/bilateral.html#conservation

DEWHA. 2009b. http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

Dexter, B.D. 1967. Flooding and Regeneration of River Redgum, Eucalyptus camaldulensis, Dehn. Bulletin No. 20. Forests Commission of Victoria, Melbourne.

DWLBC n.d. Chowilla Integrated Natural Resource Management Project. Department of Water, Land and Biodiversity Conservation, South Australia. Undated report.

DWLBC, 2005. Survey of River Redgum and Black Box Health along the River Murray in New South Wales, Victoria and South Australia – 2004. Department of Water, Land and Biodiversity Conservation.

Environment Australia. 2000. Revision of the Interim Biogeographic Regionalisation for Australia (IBRA) and Development of Version 5.1 - Summary Report. Department of Environment Water and Resources, Canberra.

Environment Australia 2001, A Directory of Important Wetlands in Australia. Third Edition, Environment Australia, Canberra.

Environment Australia. 2009. http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html

Gell, P., S., Bulpin, P. Wallbrink, S. Bickford, & G. Hancock. 2005. Tareena Billabong – A palaeolimnological history of an everchanging wetland, Chowilla Floodplain, lower Murray-Darling Basin. Marine and Freshwater Research, 56: 441-456.

Geddes, M.E. & IT. Puckridge. 1989. Survival and growth of larval and juvenile native fish: the importance of the floodplain. In: Lawrence, R (Ed.). Proceedings of the Native Fish Management Workshop. Murray-Darling Basin Commission. Canberra.

Gehrke. P.E. 1990. Spatial and temporal dispersion patterns of golden perch. Macquaria ambigua, larvae in an artificial floodplain environment. Journal of Fish Biology, 37: 225-236.

Gehrke. P.C. 1991. Avoidance of inundated floodplain habitat by larvae of golden perch (Macquaria ambigua Richardson): influence of water quality or food distribution? Australian Journal of Marine and Freshwater Research, 42(6): 707-719.

Gehrke, P.C. 1992. Diel abundance. migration and feeding of fish larvae in a floodplain billabong. Journal of Fish Biology, 40:(5): 695–707.

George, A., K. Walker, K. & M. Lewis, 2005. Population status of eucalypt trees on the River Murray floodplain, South Australia. River Research and Applications, 21:271–282.

Growns, I. 2004. A numerical classification of reproductive guilds of the freshwater fishes of south-eastern Australia and their application to river management. Fisheries Management and Ecology, 11, 369–377.

Hammer, M., S. Wedderburn, & J. van Weenen. 2007. Action Plan for South Australian Freshwater Fishes: 2007-2012. Native Fish Australia (SA) Inc., Adelaide.

Harper, M. 2003. Management and Restoration Plan: Lake Woolpolool. Australian Landscape Trust, Renmark.

Heard, G., Robertson, P. & Scroggie, M. 2004. The Ecology and conservation status of the Growling Grass Frog (Litoria raniformis) within Merri Creek corridor. Second

Report: Additional field survey and site monitoring. Wildlife Profiles Report to DSE and Yarra Valley Water.

Holland, K.L., S.D. Tyerman, L.J. Mensforth, & G.R. Walker. 2006. Tree water sources over shallow, saline groundwater in the lower River Murray, south-eastern Australia: implications for groundwater recharge mechanisms. Australian Journal of Botany, 54:193–205.

James, K & B. Hart, 1993. Effect of salinity on four freshwater macrophytes. Australian Journal of Marine and Freshwater Research, 44**:** 769-77.

Jensen, A., S. Nichols, J. Nicol, 2000. Lake Woolpolool Management Plan (Lake Merreti Complex). For the Renmark to Border Local Action Planning Association and Bookmark Biosphere Reserve (BBT Services Pty Ltd). Wetland Care Australia, Berri.

Jensen, A., K. Walker, & D. Paton. in press. The role of seedbanks in restoration of floodplain woodlands. River Research and Applications.

Jolly, I.D., Hollingsworth, I.D. & G.R. Walker. 1992. The cause of Black Box decline anabranch region, South Australia an approaches. Paper presented at National Vegetation and Water Management.

Jolly, I.D., Walker, G.R. and Thorburn, P.J. 1993. Salt accumulation in semiarid floodplain soils with implications for forest health. Journal of Hydrology **150**, 589–614. doi: 10.1016/0022-1694(93)90127-U

Lake, J.S. 1967. Rearing experiments with five species of Australian freshwater fishes. II Morphogenesis and Ontogeny. Australian Journal of Marine and Freshwater Research, 18: 155-73.

Laut, P., Heyligers, P.C., Keig, G., Loffler, E., Margules, C., Scott, R.M. and M.E. Sullivan. 1977. *Environments of South Australia: Province 2 Murray Mallee*. CSIRO, Canberra.

Lintermans, M. 2007. Fishes of the Murray-Darling Basin: An Introductory Guide. MDBC Publication No. 10/07. Murray-Darling Basin Commission, Canberra.

Lloyd, L.N. 1990. Fish Communities. In: O'Malley, C. & F. Sheldon. Chowilla Floodplain Biological Study. Nature Conservation Society of South Australia, Adelaide, SA.

Lloyd, L.N. & A.J. Boulton. 1990. Aquatic Macroinvertebrates. In: O'Malley, C. & F. Sheldon. Chowilla Floodplain Biological Study. Nature Conservation Society of South Australia, Adelaide, SA.

Lloyd, L.N., J.T. Puckridge & K.F. Walker. 1991. The significance of fish populations in the Murray-Darling system and their requirements for survival. In: Dendy, T. & M. Coombe (Eds). Conservation in Management of the River Murray System. Dept of Envt & Planning, Adelaide, S.A.

Lloyd, L.N., B.P. Atkins, P.I. Boon, J. Roberts & T. Jacobs. 1994. Natural Processes in floodplain ecosystems. In: Proceedings of the Murray-Darling Basin Floodplain Wetlands Management Workshop. MDBC, Canberra.

McCarthy, B. 2005. Distribution of the Murray Crayfish (*Euastacus armatus*) in the Mallee Region of the River Murray. Report to the Mallee Catchment Management Authority and the Murray-Darling Freshwater Research Centre. Technical report 2/2005, Murray-Darling Freshwater Research Centre, Mildura.

Mackay, N. 1990. Understanding the Murray. In Mackay, N. and Eastburn, D. (Eds.). The Murray. Murray Darling Basin Commission, Canberra, Australia

Mackay, N. and Eastburn, D., (1990) The Murray. Murray Darling Basin Commission, Canberra, Australia.

Mackay, N., Hillman, T. and Rolls, J. 1988. Water Quality of the River Murray, Review of Monitoring 1978 – 1986. Murray Darling Basin Commission, Canberra.

Maher, M. & Carpenter, S.M. 1984. Benthic studies of waterfowl breeding habitat in south-western New South Wales. II. Chironomid populations. Aust. J. Mar. Freshwater. Res. 35(1): 97-110.

Mallen-Cooper. M. 1989. Fish passage in the Murray- Darling Basin. In: Lawrence, B. (Ed.). Proceedings of the Native Fish Management Workshop. Murray-Darling Basin Commission. Canberra.

Margules & Partners, P. Smith, J. Smith, & Department of Conservation, Forests & Lands Victoria, 1990. Riparian Vegetation of the River Murray, Murray-Darling Basin Commission, Canberra, ACT.

MDBC. 1991 Chowilla Resource Management Plan, Community Consultation Program. Prepared by the Murray-Darling Basin Commission's Chowilla Working Group in consultation with the Chowilla Reference Group. Murray-Darling Basin Commission, Canberra.

MDBC, 2003. Preliminary Investigations into Observed River Redgum Decline along the River Murray below Euston Technical Report 03/03. March 2003. Murray-Darling Basin Commission, Canberra.

MDBC. 2006. The Chowilla Floodplain and Lindsay-Wallpolla Islands Icon Site: Environmental Management Plan 2006–2007. MDBC Publication No. 33/06. Murray-Darling Basin Commission, Canberra.

Morison, A.K. 1989a. Fish. In: Barmah Forest - Dying for a Drink. Proceedings of a workshop on Barmah Forest, Nathalia, Victoria.

Muller, K. and Goode, J. Undated. Status report on the current health of the Chowilla site. Unpublished report to SA MDB NRM Board.

Murray-Darling Basin Ministerial Council 1987. Murray-Darling Basin Environmental Resources Study. Murray-Darling Basin Commission, Canberra.

Nicol, J. and Weedon, J. 2006. Understorey vegetation monitoring of the Chowilla River Redgum watering trials. SARDI RD Publication, Adelaide, S.A.

Nielsen, D., M. Brock, G. Rees, & D. Baldwin. 2003. Effects of increasing salinity on freshwater ecosystems in Australia. Australian Journal of Botany, 51: 655-665.

Norman, H. 2007. Saltbush - use it or lose it. CRC Salinity Factsheet 11-2007.

Odum. E.P. 1969. The strategy of ecosystem development. Science 164: 262-270.

O'Malley, C. 1990. Floodplain vegetation. In O'Malley, C. & F. Sheldon. Chowilla Floodplain Biological Study. Nature Conservation Society of South Australia, Adelaide, SA.

O'Malley, C. & F. Sheldon. 1990. Chowilla Floodplain Biological Study. Nature Conservation Society of South Australia, Adelaide, SA.

Overton, I.C. and Jolly, I.D. (2004). 'Integrated Studies of Floodplain Vegetation Health, Saline Groundwater and Flooding on the Chowilla Floodplain South Australia'. CSIRO Land and Water Technical Report 20/04.

Overton, I. C., I.D. Jolly, P.G. Slavich, M.M. Lewis, & G.R. Walker. 2006a. Modelling vegetation health from the interaction of saline groundwater and flooding on the Chowilla floodplain, South Australia. Australian Journal of Botany, 54: 207–220

Overton, I.C., K. McEwan, & J.R. Sherrah, 2006b. The River Murray. Floodplain Inundation Model – Hume Dam to Lower Lakes. CSIRO Water for a Healthy Country Technical Report 2006. CSIRO: Canberra.

Overton, I.C., J.C. Rutherford, & I.D. Jolly. 2005. Flood Extent, Groundwater Recharge and Vegetation Response from the Operation of a Potential Weir in Chowilla Creek, South Australia. Report to the South Australian Department of Water, Land and Biodiversity Conservation. CSIRO Land and Water Client Report, Commercial-in-Confidence.

Parks Australia. 2005. Calperum and Taylorville Stations Management Plan (Draft). Parks Australia, Australian Government Department of the Environment and Heritage January 2005.

PIRSA. 1997. Murtho Forest Reserve Management Plan, South Australian Department of Primary Industries, Adelaide, South Australia.

Puckridge, J.T. & K.F. Walker. 1990. Reproductive biology and larval development of a gizzard shad, *Nematalosa erebi* (Gunther) (Dorosomatinae: Teleostei), in the River Murray, South Australia. Australian Journal of Marine and Freshwater Research, 41: 695-712.

Pierce, B. E. 1990. Chowilla Fisheries Investigations. Murray Darling Basin Commission

Ramsar Convention. 1996. Resolution VI.1. Annex to Resolution VI.1. Working Definitions, Guidelines for Describing and Maintaining Ecological Character of Listed

Sites, and Guidelines for Operation on the Montreux Record. http://www.ramsar.org/res/key_res_vi.1.htm

RIS. (in prep.). Ramsar Information Information Sheet. Department of Environment and Heritage, Adelaide, SA. August 2007.

REM. 2003. Hydrogeological Benchmark Assessment for the River Murray Between Wentworth and Renmark. Final Report - Work Program. Report to the Mallee CMA.

Reynolds, L.F. 1983. Migration patterns of five fish species in the Murray-Darling River system. Australian Journal of Marine and Freshwater Research, 34(6): 857 – 871.

Roberts, J. and Ludwig, J. 1990. Aquatic Macrophyte Communities. In O'Malley, C. & F. Sheldon. Chowilla Floodplain Biological Study. Nature Conservation Society of South Australia, Adelaide, SA.

Roberts, J. & F. Marston. 2000. Water regime of wetland and floodplain plants in the Murray-Darling Basin - a source book of ecological knowledge. CSIRO Land & Water Technical Report 30/00.

Sharley, T. and Huggan, C. 1995. Chowilla Resource Management Plan - Final Report. Murray-Darling Basin Commission, ACT.

Sheldon, F. & L.N. Lloyd. 1990. Physical Limnology and Aquatic Habitats. In: Chowilla Floodplain Biological Study. Nature Conservation Society of S.A., Adelaide, S.A.

SKM. 2005. River Murray Wetlands Baseline Survey 2005.

Steggels, T. & P. Tucker. 2003. The Management of Lake Merreti: Using Past Experiences to Guide Future Projects. Australian Landscape Trust, May 2003.

Strahler A.H. and Strahler, A.N. 1992. Modern Physical Geography. John Wiley and Sons 4th Ed. New York.

Suter, P.J., P.M. Goonan, J.A. Beer, & T.B. Thompson. 1993. A Biological and Physico-Chemical Monitoring Study of Wetlands from the River Murray Floodplain in South Australia. Australian Centre for Water Quality Research, Report No. 7/93

Thornburn, P.J. & G.R. Walker. 1993. The source of water transpired by Eucalyptus camaldulensis: soil, groundwater or streams? In Ehleringet, J.R., A.E., Hall, L.P. Ting, & G.D. Farquar, (Eds.). Perspectives on plant carbon and water relations from stable isotopes. Academic Press Inc., New York.

Thornburn, P.J., G.R. Walker, G.R. & T.J. Hatton. 1992. Are Redgums taking water from soil, groundwater or streams? Paper presented at National Conference on Vegetation and Water. Adelaide, March 1992.

Walker, K.F. 1986. A review of the ecological effects of river regulation in Australia. Hydrobiologia, 125: 111-129.

Walker, K.F. 1990. Mussels. In Mackay, N. and Eastburn, D. (Eds.). The Murray. Murray Darling Basin Commission, Canberra, Australia

Ward, K.A. 1992. Investigation of the flood requirements of the moira grass plains in Barmah Forest, Victoria. Integrated Watering Strategy Report 1. Floodplain Ecology Group, Dept of Conservation and Environment, Shepparton.

Whiterod, N., Meredith, S. and Sharpe, C. 2004. Predicting the outcomes of future flooding events on Lindsay and Wallpolla Islands: current conditions and microcosm experiments. Technical Report 9/2004. Murray-Darling Freshwater Research Centre, Mildura.

Woodward-Clyde. 1999. Impacts of Irrigation on Floodplain Health and Implications for Future Management Options. Prepared for the Renmark to the Border Local Action Planning Association Incorporated.

Zampatti, B., J. Nichol, S. Leigh, S. & C. Bice. 2006a. 2005 Progress Report for the Chowilla Fish and Aquatic Macrophyte Project. SARDI Aquatic Sciences, Inland Waters Program, February, 2006

Zampatti, B., S. Leigh, J. Nicol, J. Weedon. 2006b. Progress Report for the Chowilla Fish and Aquatic Macrophyte Project. SARDI Aquatic Sciences, Inland Waters Program, November, 2006.

10. APPENDICES

10.1 Appendix 1: Flora of the Riverland Ramsar Site

10.1.1 List of dominant plant species for major vegetation communities found at the Site

Plant Species	Indigenous (Y = yes; N = no)
Acacia nyssophylla	Y
Acacia stenophylla	Y
Actinobole uliginosum	Y
Agrostis avenacea var. *avenacea*	Y
Alectryon oleifolius ssp. *canescens*	Y
Alternanthera denticulata	Y
Amphibromus nervosus	Y
Amyema miquelii	Y
Anagallis arvensis	N
Angianthus tomentosus	Y
Arctotheca calendula	N
Aristida contorta	Y
Asperula gemella	Y
Aster subulatus	N
Atriplex eardleyae	Y
Atriplex holocarpa	Y
Atriplex leptocarpa	Y
Atriplex limbata	Y
Atriplex lindleyi	Y
Atriplex lindleyi ssp. *lindleyi*	Y
Atriplex pseudocampanulata	Y
Atriplex rhagodioides	Y
Atriplex semibaccata	Y
Atriplex stipitata	Y
Atriplex suberecta	Y
Atriplex velutinella	Y
Austrodanthonia caespitosa	Y

Plant Species	Indigenous (Y = yes; N = no)
Austrodanthonia setacea	Y
Austrostipa nitida	Y
Austrostipa scabra ssp. *falcata*	Y
Azolla filiculoides	Y
Bolboschoenus caldwellii	Y
Bolboschoenus medianus	Y
Brachyscome basaltica var. *gracilis*	Y
Brachyscome ciliaris var. *ciliaris*	Y
Brachyscome ciliaris var. *lanuginosa*	Y
Brachyscome dentate	Y
Brachyscome lineariloba	Y
Brassica tournefortii	N
Bromus arenarius	Y
Bromus rubens	N
Bulbine semibarbata	Y
Calandrinia eremaea	Y
Callitris gracilis	Y
Calocephalus sonderi	Y
Calotis cuneifolia	Y
Calotis hispidula	Y
Calotis scapigera	Y
Carduus tenuiflorus	N
Carthamus lanatus	N
Centaurea melitensis	N
Centipeda crateriformis ssp. *crateriformis*	Y
Centipeda cunninghamii	Y
Centipeda minima ssp. *minima*	Y
Centipeda thespidioides	Y
Chamaesyce drummondii	Y
Chenopodium curvispicatum	Y
Chenopodium desertorum ssp. *desertorum*	Y
Chenopodium nitrariaceum	Y
Chrysocephalum apiculatum	Y
Cirsium vulgare	N

Plant Species	Indigenous (Y = yes; N = no)
Convolvulus remotus	Y
Conyza albida	N
Conyza bonariensis	N
Cotula australis	Y
Cotula bipinnata	N
Cotula coronopifolia	N
Craspedia glauca	Y
Crassula colorata var. *acuminata*	Y
Crassula helmsii	Y
Crassula peduncularis	Y
Crassula sieberiana ssp. *tetramera*	Y
Cressa australis	Y
Crinum flaccidum	Y
Cuscuta campestris	N
Cynodon dactylon	N
Cyperus gymnocaulos	Y
Damasonium minus	Y
Daucus glochidiatus	Y
Dianella porracea	Y
Disphyma crassifolium ssp. *clavellatum*	Y
Dissocarpus paradoxus	Y
Dittrichia graveolens	N
Dodonaea viscosa ssp. *angustissima*	Y
Echium plantagineum	N
Eclipta platyglossa	Y
Einadia nutans ssp. *nutans*	Y
Eleocharis acuta	Y
Emex australis	N
Enchylaena tomentosa var. *tomentosa*	Y
Enteropogon acicularis	Y
Epaltes australis	Y
Eragrostis australasica	Y
Eragrostis dielsii var. *dielsii*	Y
Eragrostis elongate	Y

Plant Species	Indigenous (Y = yes; N = no)
Eragrostis lacunaria	Y
Eremophila bignoniiflora	Y
Eremophila divaricata ssp. *divaricata*	Y
Eriochiton sclerolaenoides	Y
Erodium cicutarium	N
Erodium crinitum	Y
Eucalyptus camaldulensis var. *camaldulensis*	Y
Eucalyptus gracilis	Y
Eucalyptus largiflorens	Y
Eucalyptus porosa	Y
Euchiton sphaericus	Y
Exocarpos aphyllus	Y
Exocarpos strictus	Y
Fimbristylis velata	Y
Frankenia cupularis	Y
Frankenia pauciflora var. *gunnii*	Y
Frankenia serpyllifolia	Y
Galenia secunda	N
Gamochaeta spicata	N
Glycyrrhiza acanthocarpa	Y
Gnephosis tenuissima	Y
Goodenia fascicularis	Y
Gypsophila tubulosa	N
Hakea leucoptera ssp. *leucoptera*	Y
Haloragis aspera	Y
Halosarcia sp.	Y
Hedypnois rhagadioloides	N
Helichrysum sp.	Y
Heliotropium curassavicum	N
Heliotropium supinum	N
Helminthotheca echioides	N
Herniaria cinerea	N
Hordeum glaucum	N
Hordeum leporinum	N

Plant Species	Indigenous (Y = yes; N = no)
Hordeum marinum	N
Hornungia procumbens	N
Hypochaeris glabra	N
Isoetopsis graminifolia	Y
Isolepis platycarpa	Y
Juncus aridicola	Y
Juncus aridicola	Y
Juncus pauciflorus	Y
Juncus usitatus	Y
Lachnagrostis billardierei ssp. *billardierei*	Y
Lactuca serriola	N
Lamarckia aurea	N
Lavatera sp.	Y
Lepidium africanum	N
Lepidium fasciculatum	Y
Lepidium papillosum	Y
Lepidium pseudohyssopifolium	Y
Limonium lobatum	N
Loranthaceae sp.	Y
Ludwigia peploides ssp. *montevidensis*	N
Lycium ferocissimum	N
Lysiana exocarpi ssp. *exocarpi*	Y
Maireana appressa	Y
Maireana brevifolia	Y
Maireana ciliate	Y
Maireana georgei	Y
Maireana pentagona	Y
Maireana pentatropis	Y
Maireana pyramidata	Y
Maireana radiate	Y
Maireana sp.	Y
Maireana turbinata	Y
Malacocera tricornis	Y
Marrubium vulgare	N

Plant Species	Indigenous (Y = yes; N = no)
Marsilea drummondii	Y
Medicago minima var. *minima*	N
Medicago polymorpha var. *polymorpha*	N
Medicago truncatula	N
Melaleuca lanceolata ssp. *lanceolata*	Y
Melilotus indicus	N
Mentha australis	Y
Mesembryanthemum crystallinum	N
Mesembryanthemum nodiflorum	N
Mimulus repens	Y
Muehlenbeckia florulenta	Y
Muehlenbeckia horrida ssp. *horrida*	Y
Myoporum montanum	Y
Myoporum parvifolium	Y
Myosurus minimus var. *australis*	Y
Myriophyllum crispatum	Y
Myriophyllum papillosum	Y
Myriophyllum verrucosum	Y
Neatostema apulum	N
Nicotiana goodspeedii	Y
Nicotiana velutina	Y
Nitraria billardierei	Y
Olearia pimeleoides ssp. *pimeleoides*	Y
Omphalolappula concava	Y
Onopordum acaulon	N
Osteocarpum acropterum var. *acropterum*	Y
Oxalis perennans	Y
Paspalum vaginatum	N
Pentaschistis airoides	N
Persicaria decipiens	Y
Persicaria lapathifolia	Y
Phragmites australis	Y
Phyla canescens	N
Phyllanthus lacunarius	Y

Plant Species	Indigenous (Y = yes; N = no)
Picris squarrosa	Y
Pimelea microcephala ssp. *microcephala*	Y
Pimelea trichostachya	Y
Pittosporum angustifolium	Y
Plagiobothrys plurisepaleus	Y
Plantago cunninghamii	Y
Poa fordeana	Y
Pogonolepis muelleriana	Y
Polycalymma stuartii	Y
Polygonum plebeium	Y
Polypogon monspeliensis	N
Pratia concolor	Y
Pseudognaphalium luteoalbum	Y
Psilocaulon granulicaule	N
Pycnosorus pleiocephalus	Y
Ranunculus pentandrus var. *platycarpus*	Y
Reichardia tingitana	N
Rhagodia spinescens	Y
Rhagodia ulicina	Y
Rhodanthe corymbiflora	Y
Rhodanthe floribunda	Y
Rhodanthe moschate	Y
Rhodanthe polygalifolia	Y
Rhodanthe pygmaea	Y
Rorippa eustylis	Y
Rostraria cristata	N
Rostraria pumila	N
Rumex bidens	Y
Rumex tenax	Y
Salix babylonica	N
Salsola tragus	Y
Sarcocornia quinqueflora	Y
Sarcozona praecox	Y
Schismus barbatus	N

Plant Species	Indigenous (Y = yes; N = no)
Schoenoplectus pungens	Y
Schoenoplectus validus	Y
Scleroblitum atriplicinum	Y
Sclerolaena brachyptera	Y
Sclerolaena decurrens	Y
Sclerolaena diacantha	Y
Sclerolaena divaricata	Y
Sclerolaena muricata var. *muricata*	Y
Sclerolaena muricata var. *semiglabra*	Y
Sclerolaena obliquicuspis	Y
Sclerolaena stelligera	Y
Sclerolaena tricuspis	Y
Senecio cunninghamii var. *cunninghamii*	Y
Senecio glossanthus	Y
Senecio pinnatifolius	Y
Senecio quadridentatus	Y
Senecio runcinifolius	Y
Senna artemisioides ssp. *petiolaris*	Y
Setaria jubiflora	Y
Sida ammophila	Y
Silene apetala	N
Sisymbrium erysimoides	N
Sisymbrium irio	N
Solanum esuriale	Y
Solanum lacunarium	Y
Solanum nigrum	N
Sonchus asper ssp. *glaucescens*	N
Sonchus oleraceus	N
Sonchus tenerrimus	N
Spergularia diandra	N
Spergularia marina	N
Spergularia rubra	N
Spirodela punctata	Y
Sporobolus mitchellii	Y

Plant Species	Indigenous (Y = yes; N = no)
Sporobolus virginicus	Y
Stemodia florulenta	Y
Suaeda australis	Y
Swainsona microphylla	Y
Swainsona microphylla ssp. *minima*	Y
Swainsona phacoides	Y
Tecticornia indica ssp. *leiostachya*	Y
Tecticornia pergranulata	Y
Tecticornia pergranulata ssp. *divaricata*	Y
Tecticornia pergranulata ssp. *pergranulata*	Y
Tecticornia triandra	Y
Tetragonia eremaea	Y
Tetragonia tetragonioides	Y
Teucrium racemosum	Y
Teucrium sessiliflorum	Y
Threlkeldia diffusa	Y
Thysanotus sp.	Y
Trichanthodium skirrophorum	Y
Triglochin calcitrapum	Y
Triptilodiscus pygmaeus	Y
Typha domingensis	Y
Urospermum picroides	N
Vallisneria americana var. *americana*	Y
Verbena officinalis	N
Veronica peregrina ssp. *xalapensis*	N
Vittadinia australasica var. *australasica*	Y
Vittadinia cervicularis var. *cervicularis*	Y
Vittadinia cuneata	Y
Vittadinia cuneata var. *cuneata forma cuneata*	Y
Vittadinia dissecta var. *hirta*	Y
Vulpia muralis	N
Vulpia myuros forma myuros	N
Wahlenbergia fluminalis	Y
Wahlenbergia tumidifructa	Y

Plant Species	Indigenous (Y = yes; N = no)
Waitzia acuminata var. *acuminata*	Y
Wilsonia rotundifolia	Y
Xanthium occidentale	N
Xanthium spinosum	N
Zaluzianskya divaricata	N
Zygophyllum ammophilum	Y
Zygophyllum eremaeum	Y
Zygophyllum glaucum	Y
Zygophyllum iodocarpum	Y

10.1.2 Appendix 1.1: Plant species listed at the State level under the National Parks and Wildlife Act 1972 known to be present at the Site on a permanent or seasonal basis:

- *Adiantum capillus-veneris*, Dainty Maiden-hair (Vulnerable)
- *Brachycome basaltica* var. *gracilis*, Swamp Daisy (Rare)
- *Brachycome melanocarpa*, Black-fruit Daisy (Vulnerable)
- *Brachycome parvula* var. *lissocarpa*, Coast Daisy (Rare)
- *Callitriche sonderi*, Matted Water Starwort (Rare)
- *Callitriche umbonata*, Water Starwort (Vulnerable)
- *Calocephalus sonderi*, Pale Beauty-heads (Rare)
- *Calotis scapigera*, Tufted Burr-daisy (Rare)
- *Crassula peduncularis*, Purple Crassula (Rare)
- *Dianella porracea*, Pale Flax-lily (Vulnerable)
- *Diplachne parviflora*, Small-flower Beetle-grass (Rare)
- *Elatine gratioloides*, Waterwort (Rare)
- *Eragrostis infecunda*, Barren Cane-grass (Rare)
- *Eragrostis lacunaria*, Purple Love-grass (Rare)
- *Exocarpos strictus*, Pale-fruit Cherry (Rare)
- *Frankenia cupularis*, Sea-Heath (Rare)
- *Hakea tephrosperma*, Hooked Needlewood (Rare)

- *Isolepis producta*, Nutty Club-rush (Vulnerable)
- *Maireana pentagona*, Slender Fissure-plant (Rare)
- *Myoporum parvifolium*, Creeping Boobialla (Rare)
- *Myriophyllum crispatum*, Upright Milfoil (Vulnerable)
- *Myriophyllum papillosum*, Robust Milfoil (Rare)
- *Nymphoides crenata*, Wavy Marshwort (Rare)
- *Orobanche cernua* var. *australiana*, Australian Broomrape (Vulnerable)
- *Picris squarrosa*, Squat Picris (Rare)
- *Rorippa laciniata*, Jagged Bitter-cress (Rare)
- *Swainsona behriana*, Behr's Swainsona-pea (Vulnerable)
- *Zannichellia palustris* (Rare)

10.2 Appendix 2: Fauna of the Riverland Ramsar Site

10.2.1 Appendix 2.1: List of waterbird / wader species recorded utilising the Riverland Ramsar Wetland (RIS in prep.).

Hoary-headed Grebe (*Poliocephalus poliocephalus*)

Australian Grebe (*Tachybaptus novaehollandiae)*

Great Crested Grebe (*Podiceps cristatus)*

Australian Pelican (*Pelecanus conspicillatus*)

Great Cormorant (*Phalacrocorax carbo*)

Little Black Cormorant (*P. sulcirostris*)

Pied Cormorant (P*. varius*)

Little Pied Cormorant (P*. melanoleucos*)

Australian Darter (*Anhinga novaehollandiae*)

White-necked Heron (*Ardea pacifica*)

Great (Large) Egret (A*. Alba*)

Intermediate Egret (*A. intermedia*)

White-faced Heron (*A. novaehollandiae*)

Little Egret (A*. garzetta*)

Cattle Egret (A*. ibis*)

Australian Bittern (*Botaurus poiciloptilus*)

Rufous Night-Heron (*Nycticorax caledonicus*)

Australian Ibis (*Threskiornis molucca*)

Hardhead (*Aythya australis*)

Australian Wood Duck (*Chenonetta jubata*)

Blue-billed Duck (*Oxyura australis*)

Musk Duck (*Biziura lobata*)

White-bellied Sea-Eagle (*Haliaeetus leucogaster*)

Swamp Harrier (*Circus approximans*)

Buff-banded Rail (*Rallus philippensis*)

Australian Spotted Crake (*P. fluminea*)

Dusky Moorhen (*Gallinula tenebrosa*)

Black-tailed Native-hen (*G. ventralis*)

Purple Swamphen (*Porphyrio porphyrio*)

Eurasian Coot (*Fulica atra*)

Black-winged Stilt (*Himantopus himantopus*)

Banded Stilt (*Cladorhynchus leucocephalus*)

Red-necked Avocet (*Recurvirostra novaehollandiae*)

Masked Lapwing (*Vanellus miles*)

Straw-necked Ibis (*Threskiornis spinicollis*)

Glossy Ibis (*Plegadis falcinellus*)

Royal Spoonbill (*Platalea regia*)

Yellow-billed Spoonbill (P*. Flavipes*)

Black Swan (*Cygnus atratus*)

Freckled Duck (*Stictonetta naevosa*)

Australian Shelduck (*Tadorna tadornoides*)

Pink-eared Duck (*Malacorhynchus membranaceus*)

Grey Teal (*Anas gracilis*)

Chestnut Teal (A*. castanea*)

Pacific Black Duck (*A. superciliosa*)

Australasian Shoveler (A*. rhynchotis*)

Red-capped Plover (*Charadrius ruficapillus*)

Black-fronted Plover (*C. melanops*)

Red-kneed Dotterel (C*. cinctus*)

Common Greenshank (*Tringa nebularia*)

Sharp-tailed Sandpiper (*Calidris acuminata*)

Red-necked Stint (*C. ruficollis*)

Curlew Sandpiper (C*. ferruginea*)

Silver Gull (*Larus novaehollandiae*)

Whiskered Tern (*Chlidonias hybridus*)

Gull-billed Tern (*Gelochelidon nilotica*)

Caspian Tern (*Hydroprogne caspia*)

Clamorous Reed Warbler (*Acrocephalus stentoreus*)

Golden-headed (*Cisticola Cisticola exilis*)

10.2.2 Appendix 2.2: List of all bird species found at the Site during a 2003 survey by DEH (2002) (* = introduced species)

- **Passer domesticus* House Sparrow
- **Sturnus vulgaris* Common Starling
- *Acanthagenys rufogularis* Spiny-cheeked Honeyeater
- *Acanthiza chrysorrhoa* Yellow-rumped Thornbill
- *Acanthiza nana* Yellow Thornbill
- *Acanthiza uropygialis* Chestnut-rumped Thornbill
- *Accipiter cirrhocephalus* Collared Sparrowhawk
- *Accipiter fasciatus* Brown Goshawk
- *Accipiter novaehollandiae* Grey Goshawk
- *Acrocephalus australis* Australian Reed Warbler, (Clamorous Reed-Warbler)
- *Aegotheles cristatus* Australian Owlet-nightjar
- *Anas gracilis* Grey Teal
- *Anas rhynchotis* Australasian Shoveler
- *Anas superciliosa* Pacific Black Duck
- *Anhinga melanogaster* Darter
- *Anthochaera carunculata* Red Wattlebird
- *Anthus novaeseelandiae* Richard's Pipit
- *Aphelocephala leucopsis* Southern Whiteface
- *Aquila audax* Wedge-tailed Eagle
- *Ardea modesta* Eastern (Great) Egret
- *Artamus cinereus* Black-faced Woodswallow
- *Artamus personatus* Masked Woodswallow
- *Artamus superciliosus* White-browed Woodswallow
- *Barnardius zonarius* Australian Ringneck, (Ring-necked Parrot)
- *Burhinus grallarius* Bush Stone-curlew
- *Cacatua galerita* Sulphur-crested Cockatoo
- *Cacatua leadbeateri* Major Mitchell's Cockatoo
- *Cacatua roseicapilla* Galah

- *Cacatua sanguine* Little Corella
- *Calidris acuminate* Sharp-tailed Sandpiper
- *Charadrius ruficapillus* Red-capped Plover
- *Chenonetta jubata* Australian Wood Duck, (Maned Duck)
- *Chrysococcyx basalis* Horsfield's Bronze-cuckoo
- *Chrysococcyx osculans* Black-eared Cuckoo
- *Cincloramphus mathewsi* Rufous Songlark
- *Circus approximans* Swamp Harrier
- *Climacteris picumnus* Brown Treecreeper
- *Colluricincla harmonica* Grey Shrike-thrush
- *Coracina novaehollandiae* Black-faced Cuckoo-shrike
- *Corcorax melanorhamphos* White-winged Chough
- *Corvus bennetti* Little Crow
- *Corvus coronoides* Australian Raven
- *Corvus mellori* Little Raven
- *Cracticus nigrogularis* Pied Butcherbird
- *Cracticus torquatus* Grey Butcherbird
- *Cygnus atratus* Black Swan
- *Dacelo novaeguineae* Laughing Kookaburra
- *Daphoenositta chrysoptera* Varied Sittella
- *Dicaeum hirundinaceum* Mistletoebird
- *Dromaius novaehollandiae* Emu
- *Egretta novaehollandiae* White-faced Heron
- *Elseyornis melanops*Black-fronted Dotterel
- *Entomyzon cyanotis* Blue-faced Honeyeater
- *Epthianura albifrons* White-fronted Chat
- *Erythrogonys cinctus* Red-kneed Dotterel
- *Eurostopodus argus* Spotted Nightjar
- *Falco berigora* Brown Falcon
- *Falco cenchroides* Nankeen Kestrel
- *Falco longipennis* Australian Hobby
- *Falco peregrinus* Peregrine Falcon

- *Fulica atra* Eurasian Coot
- *Geopelia cuneata* Diamond Dove
- *Geopelia placida* Peaceful Dove
- *Grallina cyanoleuca* Magpie-lark
- *Gymnorhina tibicen* Australian Magpie
- *Haliastur sphenurus* Whistling Kite
- *Hieraaetus morphnoides* Little Eagle
- *Himantopus himantopus* Black-winged Stilt
- *Hirundo neoxena* Welcome Swallow
- *Lalage tricolor* White-winged Triller
- *Lichenostomus penicillatus* White-plumed Honeyeater
- *Lichenostomus virescens* Singing Honeyeater
- *Malurus cyaneus* Superb Fairy-wren
- *Malurus lamberti* Variegated Fairy-wren
- *Malurus leucopterus* White-winged Fairy-wren
- *Malurus splendens* Splendid Fairy-wren
- *Manorina flavigula* Yellow-throated Miner
- *Manorina melanocephala* Noisy Miner
- *Megalurus gramineus* Little Grassbird
- *Melanodryas cucullata* Hooded Robin
- *Melithreptus brevirostris* Brown-headed Honeyeater
- *Melopsittacus undulatus* Budgerigar
- *Merops ornatus* Rainbow Bee-eater
- *Milvus migrans* Black Kite
- *Myiagra inquieta* Restless Flycatcher
- *Ninox novaeseelandiae* Southern Boobook
- *Northiella haematogaster* Blue Bonnet
- *Nycticorax caledonicus* Nankeen Night Heron
- *Ocyphaps lophotes* Crested Pigeon
- *Pachycephala inornata* Gilbert's Whistler
- *Pachycephala rufiventris* Rufous Whistler
- *Pardalotus striatus* Striated Pardalote

- *Pelecanus conspicillatus* Australian Pelican
- *Petrochelidon ariel* Fairy Martin
- *Petrochelidon nigricans* Tree Martin
- *Petroica goodenovii* Red-capped Robin
- *Phalacrocorax carbo* Great Cormorant
- *Phalacrocorax melanoleucos* Little Pied Cormorant
- *Phalacrocorax sulcirostris* Little Black Cormorant
- *Phalacrocorax varius* Pied Cormorant
- *Phaps chalcoptera* Common Bronzewing
- *Philemon citreogularis* Little Friarbird
- *Phylidonyris albifrons* White-fronted Honeyeater
- *Platalea flavipes* Yellow-billed Spoonbill
- *Platycercus elegans* Crimson Rosella
- *Plectorhyncha lanceolata* Striped Honeyeater
- *Podargus strigoides* Tawny Frogmouth
- *Poliocephalus poliocephalus* Hoary-headed Grebe
- *Polytelis anthopeplus* Regent Parrot
- *Pomatostomus ruficeps* Chestnut-crowned Babbler
- *Pomatostomus superciliosus* White-browed Babbler
- *Porphyrio porphyrio* Purple Swamphen
- *Psephotus haematonotus* Red-rumped Parrot
- *Psephotus varius* Mulga Parrot
- *Psophodes cristatus* Chirruping Wedgebill
- *Pyrrholaemus brunneus* Redthroat
- *Recurvirostra novaehollandiae* Red-necked Avocet
- *Rhipidura albiscapa* Grey Fantail
- *Rhipidura leucophrys* Willie Wagtail
- *Smicrornis brevirostris* Weebill
- *Sterna caspia* Caspian Tern
- *Struthidea cinerea* Apostlebird
- *Tachybaptus novaehollandiae* Australasian Grebe, (Little Grebe)
- *Tadorna tadornoides* Australian Shelduck

- *Threskiornis molucca* Australian White Ibis
- *Threskiornis spinicollis* Straw-necked Ibis
- *Todiramphus pyrrhopygia* Red-backed Kingfisher
- *Todiramphus sanctus* Sacred Kingfisher
- *Tribonix mortierii* Black-tailed Native-hen
- *Vanellus miles* Masked Lapwing
- *Vanellus tricolor* Banded Lapwing
- *Zosterops lateralis* Silvereye

10.2.3 Appendix 2.3: Fauna species listed at the State level under the National Parks and Wildlife Act 1972 known to be present at the Site on a permanent or seasonal basis:

Mammals

- *Acrobates pygmaeus*, Feather-tailed Glider (Endangered)

Reptiles

- *Chelodina expansa*, Broad-shell Turtle (Vulnerable)
- *Morelia spilota variegata*, Carpet Python (Rare)
- *Varanus varius*, Lace Monitor (Rare)

Birds

- *Anas rhynchotis,* Australasian Shoveler (Rare)
- *Ardea intermedia,* Intermediate Egret (Rare)
- *Biziura lobata,* Musk Duck (Rare)
- *Botaurus poiciloptilus,* Australian Bittern (Vulnerable)
- *Burhinus grallarius,* Bush Stone-curlew (Vulnerable)
- *Cacatua leadbeateri,* Major Mitchell's Cockatoo (Vulnerable)
- *Cisticola exilis,* Golden-headed Cisticola (Rare)
- *Entomyzon cyanotis,* Blue-faced Honeyeater (Rare)
- *Falco peregrines,* Peregrine Falcon (Rare)
- *Haliaeetus leucogaster,* White-bellied Sea-Eagle (Vulnerable)
- *Lophoictinia isura,* Square-tailed Kite (Vulnerable)
- *Oxyura australis,* Blue Billed Duck (Rare)
- *Philemon citreogularis,* Little Friarbird (Rare)
- *Plectorhyncha lanceolata,* Striped Honeyeater (Rare)
- *Plegadis falcinellus,* Glossy Ibis (Rare)
- *Podiceps cristatus*, Great Crested Grebe (Rare)
- *Pyrrholaemus brunneus,* Redthroat (Rare)
- *Stictonetta naevosa,* Freckled Duck (Vulnerable)

10.2.4 Appendix 2.4: Species recorded at the Site and listed under international migratory agreements include:

- *Ardea modesta*, Great (Eastern) Egret (JAMBA, CAMBA)
- *Calidris acuminata*, Sharp-tailed Sandpiper (JAMBA, CAMBA, ROKAMBA)
- *Calidris ferruginea*, Curlew Sandpiper (JAMBA, CAMBA, ROKAMBA)
- *Calidris ruficollis*, Red-necked Stint (JAMBA, CAMBA, ROKAMBA)
- *Haliaeetus leucogaster*, White-bellied Sea-Eagle (CAMBA)
- *Hydroprogne caspia*, Caspian Tern (CAMBA)
- *Plegadis falcinellus*, Glossy Ibis (CAMBA)
- *Tringa nebularia*, Greenshank (JAMBA, CAMBA,ROKAMBA)

10.2.5 Appendix 2.5: Nomadic waterbird species known to use the Site in times of drought

- *Anas gracilis*, Grey Teal
- *Anas rhynchotis*, Australasian Shoveler
- *Aythya australis*, Hardhead,
- *Charadrius ruficapillus*, Red-caped Plover
- *Chlidonias hybridus*, Whiskered Tern,
- *Cladorhynchus leucocephalus*, Banded Stilt
- *Fulica atra*, Eurasian Coot
- *Himantopus himantopus*, Black-winged Stilt
- *Hydroprogne caspia*, Caspian Tern
- *Malacorhynchus membranaceus*, Pink-eared Duck
- *Platalea flavipes*, Yellow-billed Spoonbill
- *Poliocephalus* p*oliocephalus*, Hoary-headed Grebe
- *Recurvirostra novaehollandiae*, Red-necked Avocet
- *Stictonetta naevosa*, Freckled Duck
- *Tribonix mortierii*, Black-tailed Native-hen

10.2.6 Appendix 2.6: Nomadic bush-bird species that use the Site during the dry southern Australian summer period

- *Artamus cinereus,* Black-faced Wood Swallow
- *Artamus leucorhynchus,* White-breasted Wood Swallow
- *Chrysococcyx basalis,* Horsfield's Bronze Cuckoo
- *Chrysococcyx osculans,* Black-eared Cuckoo
- *Cuculus pallidus,* Pallid Cuckoo
- *Cuculus pyrrophanus,* Fan-tailed Cuckoo
- *Halcyon pyrrhopygia,* Red-backed Kingfisher
- *Lalage sueurii,* White-winged Triller
- *Melopsittacus undulates,* Budgerigar
- *Nymphicus hollandicus,* Cockatiel

10.2.7 Appendix 2.7: List of Reptiles found at the Site during a 2003 survey by DEH (2002)

- *Chelodina longicollis* Common Long-necked Tortoise
- *Christinus marmoratus* Marbled Gecko
- *Cryptoblepharus cf carnabyi* Desert Wall skink
- *Ctenophorus pictus* Painted Dragon
- *Ctenotus olympicus* Saltbush Ctenotus
- *Ctenotus regius Eastern* Desert Ctenotus
- *Ctenotus schomburgkii* Sandplain Ctenotus
- *Diplodactylus tessellatus* Tessellated Gecko
- *Diplodactylus vittatus* Eastern Stone Gecko
- *Egernia striolata* Eastern Tree Skink
- *Emydura macquarii* Macquarie Tortoise
- *Eremiascincus richardsonii* Broad-banded Sandswimmer
- *Eulamprus quoyii* Eastern Water Skink
- *Gehyra variegata* Tree Dtella
- *Heteronotia binoei* Bynoe's Gecko
- *Lerista punctatovittata* Spotted Slider
- *Lucasium damaeum* Beaded Gecko
- *Menetia greyii* Dwarf Skink
- *Morethia adelaidensis* Adelaide Snake-eye
- *Notechis scutatus* Eastern Tiger Snake
- *Pogona vitticeps* Central Bearded Dragon
- *Pseudonaja textilis* Eastern Brown Snake
- *Ramphotyphlops bituberculatus* Rough-nosed Blind Snake
- *Rhynchoedura ornate* Beaked Gecko
- *Tiliqua rugosa* Sleepy Lizard
- *Varanus gouldii* Sand Goanna
- *Varanus varius* Tree Goanna

10.2.8 Appendix 2.8: List of Mammals found at the Site during a 2003 survey by DEH (2002) (* = introduced species)

- **Felis catus* Cat
- **Lepus capensis* Brown Hare
- **Mus musculus* House Mouse
- **Oryctolagus cuniculus* Rabbit
- **Ovis aries* Sheep
- **Sus scrofa* Pig
- **Vulpes vulpes* Fox
- *Cercartetus concinnus* Western Pygmy-possum
- *Hydromys chrysogaster* Water-rat
- *Macropus fuliginosus* Western Grey Kangaroo
- *Macropus rufus* Red Kangaroo
- *Mormopterus spp. (species complex) (NC)* Southern Freetail-bats
- *Planigale gilesi* Giles' Planigale
- *Pseudomys bolami* Bolam's Mouse
- *Sminthopsis crassicaudata* Fat-tailed Dunnart
- *Sminthopsis murina* Common Dunnart
- *Tachyglossus aculeatus* Short-beaked Echidna
- *Trichosurus vulpecular* Common Brushtail Possum

10.2.9 Appendix 2.9: Bird species and numbers recorded on the site (M. Harper, unpublished data)

Bird species and numbers recorded at Lake Merreti in 2000 and 2001

Species \ Date	30/10/2000	15/12/2000	16/1/2001	6/2/2001	6/3/2001	3/4/2001	2/5/2001	1/6/2001	13/7/2001	5/9/2001	5/10/2001	2/11/2001	4/12/2001
Hoary-headed Grebe *Poliocephalus poliocephalus*	50	300	2000	770	320		100		135	100	24	6	310
Great Crested Grebe *Podiceps cristatus*		6											
Australian Pelican *Pelecanus conspicillatus*		50	200	200	550	132	140	1200	22	145	31	19	40
Great Cormorant *Phalacrocorax carbo*		150		40	25	2	36		2	25	9		
Little Black Cormorant *Phalacrocorax sulcirostris*	30	40	40	30	46			14			92	26	
Pied Cormorant *Phalacrocorax varius*													
Little Pied Cormorant *Phalacrocorax melanoleucos*	8	30	40	230	112	215	364	232	40	53	294	118	18
Australian Darter *Anhinga novaehollandiae*		20				4	3					1	
White-necked Heron *Ardea pacifica*						12	18	1	2	15			
Great (Large) Egret *Egretta alba*	6	5		2	31	82	116	204	10	19	5		1
Intermediate Egret *Egretta intermedia*										1			

Species \ Date	30/10/2000	15/12/2000	16/1/2001	6/2/2001	6/3/2001	3/4/2001	2/5/2001	1/6/2001	13/7/2001	5/9/2001	5/10/2001	2/11/2001	4/12/2001
White-faced Heron *Egretta novaehollandiae*					28	49	48	4	2	36	8	12	12
Little Egret *Egretta garzetta*											1		1
Rufous Night-Heron *Nycticorax calendonicus*													
Australian Ibis *Threskiornis molucca*	40	30	30	50	28	119	63	15	2	41	6	1	
Straw-necked Ibis *Carphibis spinicollis*	20			230			7			24			
Glossy Ibis *Plegadis falcinellus*			10	16	15								
Royal Spoonbill *Platalea regia*							3	3					
Yellow-billed Spoonbill *Platalea flavipes*	5	10	25	2	15		77	118	30	145	76	15	38
Black Swan *Cygnus atratus*	100	20	10	50	580	590	810	674	730	115	164	145	78
Freckled Duck *Stictonetta naevosa*	12		24				256	40		23	69	2	90
Australian Shelduck *Tadorna tadornoides*		30		15	74	120	144	80	70	160	235	547	295
Pink-eared Duck *Malacorhynchos membranaceus*	300	40		40	400	1050	500	600	1250	1800	450	890	720
Grey Teal *Anas gracilis*	400	350	400	2000	4000	7140	9400	5500	3660	3640	5110	6875	4600
Chestnut Teal *Anas castanea*							2	2			4		
Pacific Black Duck *Anas superciliosa*	40	50	50	100	180	155	200	320	420	184	60	160	110

Date / Species	30/10/2000	15/12/2000	16/1/2001	6/2/2001	6/3/2001	3/4/2001	2/5/2001	1/6/2001	13/7/2001	5/9/2001	5/10/2001	2/11/2001	4/12/2001
Australasian Shoveler *Anas rhynchotis*			30	20	80	80	105	300	40	20	46	2	65
Hardhead *Aythya australis*	500	3000	2000	400		20	30			46	140	4	150
Australian Wood Duck *Chenonetta jubata*			5	50	410	380	400	300	80	26	20	46	8
Musk Duck *Biziura lobata*			1										
White-bellied Sea-Eagle *Haliaeetus leucogaster*						1	2	1	2	1		2	
Swamp Harrier *Circus approximans*		2		2				1		1			
Australian Spotted Crake *Porzana fluminea*													
Black-tailed Native-hen *Tribonix mortierii*				25		3		15		430	540	720	610
Purple Swamphen *Porphyrio porphyrio*	30	30											
Eurasian Coot *Fulica atra*	100	400	400	600	1800	3650	5200	4800	4800	3230	3925	4700	3120
Black-winged Stilt *Himantopus himantopus*				40	95	284	142	60	65	80	5	116	60
Banded Stilt *Cladorhynchus leucocephalus*													2
Red-necked Avocet *Recurvirostra novaehollandiae*					2	11	19	120	290	620	9	8	14
Masked Lapwing *Vanellus miles*			30	15	65	56	67	35	52	27	43	48	25

Species \ Date	30/10/2000	15/12/2000	16/1/2001	6/2/2001	6/3/2001	3/4/2001	2/5/2001	1/6/2001	13/7/2001	5/9/2001	5/10/2001	2/11/2001	4/12/2001
Common Greenshank *Tringa nebularia*													
Red-capped Plover *Charadrius ruficapillus*						40	25	80	80		6		
Black-fronted Plover *Charadrius melanops*								40					6
Red-kneed Dotterel *Erythrogonys cinctus*			20		17	10	2	40	26	22	55	38	114
Red-necked Stint *Calidris ruficollis*							12						
Sharp-tailed Sandpiper *Calidris acuminata*			10		7	6				120			10
Silver Gull L. novaehollandiae		50	50	40	15	90	233	115	5	135	86	14	7
Whiskered Tern *Childonias hybridus*										17	142	40	52
Gull-billed Tern *Gelochelidon nilotica*												1	
Caspian Tern *Hydroprogne caspia*		5	5		32	20	30	76	4	24	22	5	3
Cattle Egret *Ardeola ibis*										1			
Bar-tailed Godwit *Limosa lapponica*													
Sum: Total Birds Counted	1641	4618	5380	4967	8927	14321	18554	14990	11819	11326	11677	14561	10559

Species and numbers recorded at Lake Merreti in 2002

Species \ Date	3/1/2002	1/2/2002	4/3/2002	2/4/2002	6/5/2002	3/6/2002	1/7/2002	1/8/2002	1/9/2002	6/10/2002	6/11/2002
Hoary-headed Grebe *Poliocephalus poliocephalus*	317	214	288	15	56	110	165	70	148	185	60
Great Crested Grebe *Podiceps cristatus*											
Australian Pelican *Pelecanus conspicillatus*	144	430	190	32	18	4	9	3	3	7	15
Great Cormorant *Phalacrocorax carbo*	6	11					1	4	11		
Little Black Cormorant *Phalacrocorax sulcirostris*	5	28						1			
Pied Cormorant *Phalacrocorax varius*			6						20		
Little Pied Cormorant *Phalacrocorax melanoleucos*	55	92	8	18	10	5		20	20		2
Australian Darter *Anhinga novaehollandiae*		3									
White-necked Heron *Ardea pacifica*		1	2	2							
Great (Large) Egret *Egretta alba*	2	8	4	2							1
Intermediate Egret *Egretta intermedia*											
White-faced Heron *Egretta novaehollandiae*	5	7	2	3		2					
Little Egret *Egretta garzetta*	1										

Date / Species	3/1/2002	1/2/2002	4/3/2002	2/4/2002	6/5/2002	3/6/2002	1/7/2002	1/8/2002	1/9/2002	6/10/2002	6/11/2002
Rufous Night-Heron *Nycticorax calendonicus*	2		1		1		1				
Australian Ibis *Threskiornis molucca*	11	48	28	160	4			4	7	1	4
Straw-necked Ibis *Carphibis spinicollis*				2					2		
Glossy Ibis *Plegadis falcinellus*											
Royal Spoonbill *Platalea regia*				1							
Yellow-billed Spoonbill *Platalea flavipes*	85	237	261	267	42	12	16	18	17	10	13
Black Swan *Cygnus atratus*	426	708	446	580	350	80	70	28	42	23	8
Freckled Duck *Stictonetta naevosa*	79	620	120	160	58	20	26	22	102	136	202
Australian Shelduck *Tadorna tadornoides*	356	846	260	90	32	24	40	32	14 (4)		24
Pink-eared Duck *Malacorhynchos membranaceus*	2700	1376	1970	4500	2850	4600	3500	2700	2800	1000	450
Grey Teal *A. gracilis*	7500	8900	7500	6000	3140	2700	2510	2200	3600	1470	750
Chestnut Teal A. castanea											
Pacific Black Duck *A. superciliosa*	200	96	92	140	90	100	224	100	110	112	280
Australasian Shoveler *A. rhynchotis*	120	730	282	180	210	70	343	240	348	286	62
Hardhead *Aythya australis*	45				2		12	35	128	225	182
Australian Wood Duck *Chenonetta jubata*		7				10	8	6			

Date / Species	3/1/2002	1/2/2002	4/3/2002	2/4/2002	6/5/2002	3/6/2002	1/7/2002	1/8/2002	1/9/2002	6/10/2002	6/11/2002
Musk Duck *Biziura lobata*								1	2		
White-bellied Sea-Eagle *Haliaeetus leucogaster*			1			1		1		1	
Swamp Harrier *Circus approximans*	1	1	1	1		1	2	2	2		1
Australian Spotted Crake *P. fluminea*			2								
Black-tailed Native-hen *G. ventralis*	480	600	320	260	280	150	440	100	48	104	110
Purple Swamphen *Porphyrio porphyrio*											
Eurasian Coot *Fulica atra*	4500	5400	3400	1500	180	280		240	750	236	40
Black-winged Stilt *Himantopus himantopus*	46	295	268	156	80	90	120	70	65		96
Banded Stilt *Cladorhynchus leucocephalus*							2				
Red-necked Avocet *Recurvirostra novaehollandiae*	660	2326	3600	2500	1570	620	518	420	180	2870	560
Masked Lapwing *Vanellus miles*	25	30	70	64	18	24	6	15	12	28	22
Common Greenshank *Tringa nebularia*			2							2	
Red-capped Plover *C. ruficapillus*			53		3		70				
Black-fronted Plover *C. melanops*		8	6		34	6	8	14	4	2	
Red-kneed Dotterel *E. cinctus*	115	165	277	85	50	14	22	6	2	16	14

Date / Species	3/1/2002	1/2/2002	4/3/2002	2/4/2002	6/5/2002	3/6/2002	1/7/2002	1/8/2002	1/9/2002	6/10/2002	6/11/2002
Red-necked Stint *Calidris ruficollis*			2		16						
Sharp-tailed Sandpiper *C. acuminata*	40		20	45						2	26
Silver Gull *L. novaehollandiae*	2	56	11	54	8	3	2	4	3		
Whiskered Tern *Childonias hybridus*	36	17							12	30	156
Gull-billed Tern *Gelochelidon nilotica*											
Caspian Tern *Hydroprogne caspia*		6	4	8	3	3	12	9	32		
Cattle Egret *Ardeola ibis*											
Bar-tailed Godwit *Limosa lapponica*										1	
Sum: Total Birds Counted	17964	23266	19497	16825	9105	8929	8127	6365	8470	6747	3078

Species and numbers recorded at Lake Woolpolool in 2000 and 2001

Species \ Date	3/11/2000	15/12/2000	10/1/2001	6/2/2001	6/3/2001	3/4/2001	2/5/2001	1/6/2001	13/7/01	5/9/2001	5/10/2001	2/11/2001	4/12/2001
Australian Grebe *Tachybaptus novaehollandiae*												1	
Hoary-headed Grebe *Poliocephalus poliocephalus*	17	10	50	240							16		20
Australian Pelican *Pelecanus conspicillatus*	1	63	35	4		540	34					1	
Great Cormorant *P. carbo*		35	35	18	38	42				2	1		
Little Black Cormorant *P. sulcirostris*						25		2					
Little Pied Cormorant *P. melanoleucos*			5		88								16
White-necked Heron *Ardea pacifica*					1	15	1	7					
Great (Large) Egret *Egretta alba*		32	20			103			1	1			
White-faced Heron *E. novaehollandiae*		7	2	7	27	45	24	7		2			4
Little Egret *E. garzetta*												1	
Australian Bittern *Botaurus poiciloptilus*								1					
Australian Ibis *T. molucca*	1	65	18	4	5	17	20					11	28
Straw-necked Ibis *Carphibis spinicollis*						7							
Glossy Ibis *Plegadis falcinellus*				3									6

Species \ Date	3/11/2000	15/12/2000	10/1/2001	6/2/2001	6/3/2001	3/4/2001	2/5/2001	1/6/2001	13/7/01	5/9/2001	5/10/2001	2/11/2001	4/12/2001
Royal Spoonbill *Platalea regia*									1				
Yellow-billed Spoonbill *P. flavipes*		44	6			22	32		11		2	4	60
Black Swan *Cygnus atratus*	160	280	460	650	600	806	750	677	48	57	238	250	160
Freckled Duck *Stictonetta naevosa*				20									
Australian Shelduck *Tadorna tadornoides*	26	75	85	95	40	90	46	2		8	38	8	
Pink-eared Duck *Malacorhynchos membranaceus*	10	500	140	110			10						30
Grey Teal *A. gracilis*	385	230	370	1800	1020	4000	6500	3800	5000	2150	2530	3730	4500
Chestnut Teal *A. castanea*	4			2	4	10	4						
Pacific Black Duck *A. superciliosa*	16		10	32	26	68	300	60			11	3	2
Australasian Shoveler *A. rhynchotis*		6	4	100	110	100	200	54	20		210	6	25
Hardhead *Aythya australis*	600	32	150	550	46		86				10		20
Australian Wood Duck *Chenonetta jubata*			15	30	50	30	5	15				10	
Blue-billed Duck *Oxyura australis*				6									
Swamp Harrier *Circus approximans*			2	2	2	1		1	1	2	1	2	2
Buff-banded Rail *Rallus philippensis*					1					1		3	

Species \ Date	3/11/2000	15/12/2000	10/1/2001	6/2/2001	6/3/2001	3/4/2001	2/5/2001	1/6/2001	13/7/01	5/9/2001	5/10/2001	2/11/2001	4/12/2001
Australian Spotted Crake *P. fluminea*							8						32
Black-tailed Native-hen *G. ventralis*													60
Purple Swamphen *Porphyrio porphyrio*			6	5	10	10	4	5	4	4	2	6	5
Eurasian Coot *Fulica atra*		240	820	800	940	15	2	1250	500		300	1600	2550
Black-winged Stilt *Himantopus himantopus*		90	130	120	74	62	164	42	10	3	7	20	120
Banded Stilt *Cladorhynchus leucocephalus*		60	20		23							80	60
Red-necked Avocet *Recurvirostra novaehollandiae*		15	10								141	420	390
Masked Lapwing *Vanellus miles*	2		10		4	4	10			6	10		4
Common Greenshank *Tringa nebularia*						2	2						1
Red-capped Plover *C. ruficapillus*								15					10
Black-fronted Plover *C. melanops*													2
Red-kneed Dotterel *E. cinctus*											5	40	8
Red-necked Stint *Calidris ruficollis*								25					
Sharp-tailed Sandpiper *C. acuminata*				2			3				1	17	11

Date / Species	3/11/2000	15/12/2000	10/1/2001	6/2/2001	6/3/2001	3/4/2001	2/5/2001	1/6/2001	13/7/01	5/9/2001	5/10/2001	2/11/2001	4/12/2001
Curlew Sandpiper *C. ferruginea*													
Silver Gull *L. novaehollandiae*	10	95	265	150	145	324	19				44	42	25
Whiskered Tern *Childonias hybridus*	2										38		68
Caspian Tern *Hydroprogne caspia*			8	12	6	12					8	35	
Sum: Total Birds Counted	1234	1879	2676	4762	3260	6350	8224	5963	5596	2236	3613	6290	8219

Species and numbers recorded at Lake Woolpolool in 2002

Species \ Date	3/1/2002	1/2/2002	4/3/2002 Dry	2/4/2002 Dry	6/5/2002 Dry	3/6/2002 Dry	1/7/2002 Dry	1/8/2002	1/9/2002	6/10/2002	6/11/2002
Australian Grebe *Tachybaptus novaehollandiae*											
Hoary-headed Grebe *Poliocephalus poliocephalus*											53
Australian Pelican *Pelecanus conspicillatus*											11
Great Cormorant *P. carbo*											
Little Black Cormorant *P. sulcirostris*											
Little Pied Cormorant *P. melanoleucos*											
White-necked Heron *Ardea pacifica*											
Great (Large) Egret *Egretta alba*											
White-faced Heron *E. novaehollandiae*	4	2								3	2
Little Egret *E. garzetta*											
Australian Bittern *Botaurus poiciloptilus*											
Australian Ibis *T. molucca*	23	4						1		2	1
Straw-necked Ibis *Carphibis spinicollis*											
Glossy Ibis *Plegadis falcinellus*											
Royal Spoonbill *Platalea regia*											1
Yellow-billed Spoonbill *P. flavipes*	35									6	7
Black Swan *Cygnus atratus*	11	4						130	100	37	173
Freckled Duck *Stictonetta naevosa*											32

Species \ Date	3/1/2002	1/2/2002	4/3/2002 Dry	2/4/2002 Dry	6/5/2002 Dry	3/6/2002 Dry	1/7/2002 Dry	1/8/2002	1/9/2002	6/10/2002	6/11/2002
Australian Shelduck *Tadorna tadornoides*		130						40	30 (4)	50 (4)	62
Pink-eared Duck *Malacorhynchos membranaceus*	800								24	1250	4200
Grey Teal *A. gracilis*	6500	4000						1040	1700	5170	2100
Chestnut Teal *A. castanea*											
Pacific Black Duck *A. superciliosa*	20							8	10		4
Australasian Shoveler *A. rhynchotis*	6								240	165	162
Hardhead *Aythya australis*										6	8
Australian Wood Duck *Chenonetta jubata*											7
Blue-billed Duck *Oxyura australis*											
Swamp Harrier *Circus approximans*	2	2						1	2	2	2
Buff-banded Rail *Rallus philippensis*											
Australian Spotted Crake *P. fluminea*		15								3	
Black-tailed Native-hen *G. ventralis*		80								30	
Purple Swamphen *Porphyrio porphyrio*	4	6								6	4
Eurasian Coot *Fulica atra*	550										500
Black-winged Stilt *Himantopus himantopus*	90	7						22	280	225	80
Banded Stilt *Cladorhynchus leucocephalus*									54	210	
Red-necked Avocet *Recurvirostra novaehollandiae*	1680								840	6220	2550

Species \ Date	3/1/2002	1/2/2002	4/3/2002 Dry	2/4/2002 Dry	6/5/2002 Dry	3/6/2002 Dry	1/7/2002 Dry	1/8/2002	1/9/2002	6/10/2002	6/11/2002
Masked Lapwing *Vanellus miles*	9	4						26	24	2	8
Common Greenshank *Tringa nebularia*	4	3							2	2	
Red-capped Plover *C. ruficapillus*								25		350	
Black-fronted Plover *C. melanops*									4	2	
Red-kneed Dotterel *E. cinctus*	15									4	
Red-necked Stint *Calidris ruficollis*										14	
Sharp-tailed Sandpiper *C. acuminata*	115	500								800	90
Curlew Sandpiper *C. ferruginea*										7	
Silver Gull *L. novaehollandiae*	10								6	4	
Whiskered Tern *Childonias hybridus*	140								25	100	
Caspian Tern *Hydroprogne caspia*	9							46	48		30
Sum: Total Birds Counted	10027	4757						1339	3359	14620	10087

Bird species and numbers recorded at Coppermine Waterhole in 2006 and 2007

Species \ Date	1/3/2006	11/29/2006	12/18/2006	1/25/2007	2/23/2007	3/28/2007	4/24/2007	5/31/2007	6/27/2007	7/27/2007	8/23/2007
Australian Grebe *Tachybaptus novaehollandiae*	37		28	16	14	78	40	39	4	6	
Hoary-headed Grebe *Poliocephalus poliocephalus*	70		66	19	75	222	282	250	80	47	87
Great Crested Grebe *Podiceps cristatus*					1						
Australian Pelican *Pelecanus conspicillatus*			28	4	1	2	60	7	2	1	1
Great Cormorant *P. carbo*		1	8	1	2			10			
Little Black Cormorant *P. sulcirostris*						4					
Little Pied Cormorant *P. melanoleucos*		3	33	7	2	4	3	2			
Australian Darter *Anhinga novaehollandiae*				1			1				
White-necked Heron *Ardea pacifica*	2	7								1	1
Great (Large) Egret *Egretta alba*	1	10		7	1			1	1		
White-faced Heron *E. novaehollandiae*		14	41	14	5	8	4	2	4	2	3
Australian Ibis *T. molucca*		8	17	4		1	2	5	1	1	
Straw-necked Ibis *Carphibis spinicollis*			62	4	3				1	1	
Glossy Ibis *Plegadis falcinellus*		1	3								
Royal Spoonbill *Platalea regia*		4	10				1				
Yellow-billed Spoonbill *P. flavipes*			8	8			3	22	15	3	5
Black Swan *Cygnus atratus*	7	8	10	2	7	24	77	33	29	17	5
Freckled Duck *Stictonetta naevosa*		2	4	1							
Australian Shelduck *Tadorna tadornoides*		15							2	2	

Species \ Date	1/3/2006	11/29/2006	12/18/2006	1/25/2007	2/23/2007	3/28/2007	4/24/2007	5/31/2007	6/27/2007	7/27/2007	8/23/2007
Pink-eared Duck *Malacorhynchos membranaceus*		38	846	64	23	6	2				6
Grey Teal *A. gracilis*	530	2704	5330	174	310	280	460	4	4	44	92
Chestnut Teal *A. castanea*							4				
Pacific Black Duck *A. superciliosa*	20	32	56	44	75	123	204	12	26	33	40
Australasian Shoveler *A. rhynchotis*	8	2	21	8	41	63	75	10	4	8	
Hardhead *Aythya australis*	60	18	345	35	7	4		8	7	91	180
Australian Wood Duck *Chenonetta jubata*	22	57	98	35	86	105	104	2			
Musk Duck *Biziura lobata*						1	2	1			
Swamp Harrier *Circus approximans*		1	1				1				
Australian Spotted Crake *P. fluminea*				1							
Black-tailed Native-hen *G. ventralis*		79	40								
Eurasian Coot *Fulica atra*	400	11	63	98	123	80	84	114	12	2	
Black-winged Stilt *Himantopus himantopus*		87			48	16		3			
Red-necked Avocet *Recurvirostra novaehollandiae*		24									
Masked Lapwing *Vanellus miles*		21	22	6	18	13	5	6	5	2	3
Common Greenshank *Tringa nebularia*					9	2					
Black-fronted Plover *C. melanops*		4	4	4	2	2			2		
Red-kneed Dotterel *E. cinctus*										2	
Sharp-tailed Sandpiper *C. acuminata*			10								
Silver Gull *L. novaehollandiae*		23									

Species \ Date	1/3/2006	11/29/2006	12/18/2006	1/25/2007	2/23/2007	3/28/2007	4/24/2007	5/31/2007	6/27/2007	7/27/2007	8/23/2007
Whiskered Tern *Childonias hybridus*			5								
Caspian Tern *Hydroprogne caspia*		6			2	7					
Emu *Dromaius novaehollandiae*			56								
Sum: Total Birds Counted	1157	3180	7215	557	855	1045	1414	531	199	263	423

Bird species and numbers recorded at Lake Littra in 1989 - 2004

Species \ Date	10/29/1989	7/22/1990	1/7/1993	10/11/1995	3/12/1996	9/28/2004	10/14/2004	11/16/2004
Australian Grebe *Tachybaptus nuovaehollandiae*								
Hoary -Headed Grebe *Poliocephalus poliocephalus*	5							
Australian Pelican *Pelecanus conspicillatus*				8	320			
Great Cormorant *P. carbo*								
Little Black Cormorant *P. sulcirostris*								
Pied Cormorant *P. varius*								
White-necked Heron *Ardea pacifica*						3		
Great (Large) Egret *Egretta alba*				2			5	
White-faced Heron *E. novaehollandiae*		2				4	10	
Australian Ibis *T. molucca*	5		20	3				
Straw-necked Ibis *Carphibis spinicollis*								
Royal Spoonbill *Platalea regia*							2	
Yellow-billed Spoonbill *P. flavipes*		3			40	1	23	3
Black Swan *Cygnus atratus*	2	2		4		6	15	6
Freckled Duck *Stictonetta naevosa*								
Australian Shelduck *Tadorna tadornoides*		25		2	80	24	10	
Pink-eared Duck *Malacorhynchos membranaceus*	8			10			10	12
Grey Teal *A. gracilis*	15	85		60	350	1300	740	160
Pacific Black Duck *A. superciliosa*		4		20		4	2	
Australasian Shoveler *A. rhynchotis*								
Hardhead *Aythya australis*	3			12				
Australian Wood Duck *Chenonetta jubata*	2							

Species \ Date	10/29/1989	7/22/1990	1/7/1993	10/11/1995	3/12/1996	9/28/2004	10/14/2004	11/16/2004
Swamp Harrier *Circus approximans*								
Spotless Crake *Porzana tabuensis*								
Black-tailed Native-hen *G. ventralis*						50	120	125
Purple Swamphen *Porphyrio porphyrio*								
Eurasian Coot *Fulica atra*	10			50				
Black-winged Stilt *Himantopus himantopus*					30	39	95	
Red-necked Avocet *Recurvirostra novaehollandiae*					180	60	180	180
Masked Lapwing *Vanellus miles*		10				7	23	4
Common Greenshank *Tringa nebularia*								
Red-capped Plover *C. ruficapillus*								
Black-fronted Plover *C. melanops*		2					2	2
Red-kneed Dotterel *E. cinctus*							25	130
Sharp-tailed Sandpiper *C. acuminata*								10
Silver Gull *Larus novaehollandiae*						2		
Whiskered Tern *Childonias hybridus*						1		
Caspian Tern *Hydroprogne caspia*							1	
Sum: Total Birds Counted	50	133	20	171	1000	1501	1263	632

Bird species and numbers recorded at Lake Littra in 2005 & 2006

Species \ Date	1/13/2005	2/8/2005	1/10/2006	2/16/2006	3/22/2006	4/26/2006	5/22/2006	6/26/2006	7/24/2006
Australian Grebe *Tachybaptus nuovaehollandiae*				23					
Hoary -Headed Grebe *Poliocephalus poliocephalus*	330		80	840	500	20	2		
Australian Pelican *Pelecanus conspicillatus*			4				6		
Great Cormorant *P. carbo*				24					
Little Black Cormorant *P. sulcirostris*				4	10				
Pied Cormorant *P. varius*				1					
White-necked Heron *Ardea pacifica*			2						
Great (Large) Egret *Egretta alba*									
White-faced Heron *E. novaehollandiae*		3	21	14	8		1	6	4
Australian Ibis *T. molucca*			10		1		1	3	3
Straw-necked Ibis *Carphibis spinicollis*			300						
Royal Spoonbill *Platalea regia*			1						
Yellow-billed Spoonbill *P. flavipes*							14	6	14
Black Swan *Cygnus atratus*			4	9	37	45	31	23	26
Freckled Duck *Stictonetta naevosa*				73	2	16			
Australian Shelduck *Tadorna tadornoides*			45			2			2
Pink-eared Duck *Malacorhynchos membranaceus*	12	80	350	90	15	190	300		10
Grey Teal *A. gracilis*	1200	1900	2400	1600	560	2000	150	110	400
Pacific Black Duck *A. superciliosa*			120	45	6	16			10
Australasian Shoveler *A. rhynchotis*	9	50	45	50	58	86	50		27
Hardhead *Aythya australis*	20		1010	360	22				6
Australian Wood Duck *Chenonetta jubata*									12

Species / Date	1/13/2005	2/8/2005	1/10/2006	2/16/2006	3/22/2006	4/26/2006	5/22/2006	6/26/2006	7/24/2006
Swamp Harrier *Circus approximans*	1			1	1			1	
Spotless Crake *Porzana tabuensis*			2						
Black-tailed Native-hen *G. ventralis*	54	135	165	30		12	16	23	14
Purple Swamphen *Porphyrio porphyrio*				1	3				
Eurasian Coot *Fulica atra*			1350	450	750	143			
Black-winged Stilt *Himantopus himantopus*	40	126	165	100			7	40	45
Red-necked Avocet *Recurvirostra novaehollandiae*	500	1000	520	10	18		3	160	150
Masked Lapwing *Vanellus miles*	6	24	31	12	6		4	10	10
Common Greenshank *Tringa nebularia*	1	2							
Red-capped Plover *C. ruficapillus*								2	
Black-fronted Plover *C. melanops*	2	26	2	2		2		12	2
Red-kneed Dotterel *E. cinctus*	148	120	135	11	6	6	12	26	24
Sharp-tailed Sandpiper *C. acuminata*	1	8							
Silver Gull *Larus novaehollandiae*	2		4						7
Whiskered Tern *Childonias hybridus*									
Caspian Tern *Hydroprogne caspia*			1						
Sum: Total Birds Counted	2326	3474	6767	3750	2003	2538	597	422	766

Bird species and numbers recorded at Pilby Lagoon between April 1998 & August 2003

Species \ Date	4/3/1998	4/16/2003	4/28/2003	5/5/2003	5/21/2003	6/3/2003	6/19/2003	7/4/2003	8/4/2003	8/27/2003
Australasian Grebe *Tachybaptus novaehollandiae*								2		2
Hoary -Headed Grebe *Poliocephalus poliocephalus*	6			2	2	6	15	12	22	33
Australian Pelican *Pelecanus conspicillatus*										
Great Cormorant *P. carbo*	2									
Little Black Cormorant *P. sulcirostris*	4									
Little Pied Cormorant *P. melanoleucos*	10		1					1	1	
Australian Darter *Anhinga melanogaster*	4									
White-necked Heron *Ardea pacifica*										
Great (Large) Egret *Egretta alba*										
Intermediate Egret *E. intermedia*										
White-faced Heron *A. novaehollandiae*										
Australian Ibis *T. molucca*	3									
Straw-necked Ibis *Carphibis spinicollis*										
Royal Spoonbill *Platalea regia*										
Yellow-billed Spoonbill *P. flavipes*								1		
Black Swan *Cygnus atratus*	15							3		
Freckled Duck *Stictonetta naevosa*										
Australian Shelduck *Tadorna tadornoides*			4	4	4	4				6
Pink-eared Duck *Malacorhynchos membranaceus*										
Grey Teal *A. gracilis*	180	40	38	110	154	180	154	40	25	97
Pacific Black Duck *A. superciliosa*	120	12	18	27	26	32	2	2	4	4
Australasian Shoveler *A. rhynchotis*				4	4	6	1			5

Species / Date	4/3/1998	4/16/2003	4/28/2003	5/5/2003	5/21/2003	6/3/2003	6/19/2003	7/4/2003	8/4/2003	8/27/2003
Hardhead *Aythya australis*	20			1	17	48	13	7	11	14
Australian Wood Duck *Chenonetta jubata*										
White-bellied Sea-Eagle *Haliaeetus leucogaster*										
Swamp Harrier *Circus approximans*										
Black-tailed Native-hen *G. ventralis*										
Purple Swamphen *Porphyrio porphyrio*										
Eurasian Coot *Fulica atra*			41			10		9		
Black-winged Stilt *Himantopus himantopus*										
Masked Lapwing *Vanellus miles*		2								
Black-fronted Plover *C. melanops*						2			2	
Silver Gull *L. novaehollandiae*										
Whiskered Tern *Childonias hybridus*										
Sum: Total Birds Counted	364	54	102	148	207	288	185	77	65	161

Bird species and numbers recorded at Pilby Lagoon between Sept. 2003 & August 2004

Species \ Date	9/23/2003	10/30/2003	12/8/2003	1/12/2004	3/3/2004	3/10/2004	4/7/2004	5/21/2004	8/10/2004	8/26/2004
Australasian Grebe *Tachybaptus novaehollandiae*	2						2		7	10
Hoary -Headed Grebe *Poliocephalus poliocephalus*	4	4	10	22	7	6	2		5	
Australian Pelican *Pelecanus conspicillatus*			3	11	1	1		1	2	
Great Cormorant *P. carbo*			1		2	2			1	12
Little Black Cormorant *P. sulcirostris*			6	14	5	2				
Little Pied Cormorant *P. melanoleucos*	4	5	5	20	17		11	2	6	3
Australian Darter *Anhinga melanogaster*	1	1	1	2		4	1	2	1	1
White-necked Heron *Ardea pacifica*				1	1				2	
Great (Large) Egret *Egretta alba*		1	1	1	1					1
Intermediate Egret *E. intermedia*										
White-faced Heron *A. novaehollandiae*			2							2
Australian Ibis *T. molucca*	1		5	4	10	8	1		1	3
Straw-necked Ibis *Carphibis spinicollis*										
Royal Spoonbill *Platalea regia*										
Yellow-billed Spoonbill *P. flavipes*			1							
Black Swan *Cygnus atratus*	2				15	40	37	7	2	6
Freckled Duck *Stictonetta naevosa*										
Australian Shelduck *Tadorna tadornoides*							7		2	8
Pink-eared Duck *Malacorhynchos membranaceus*										
Grey Teal *A. gracilis*	55	45	120	37	76	41	69	80	21	25
Pacific Black Duck *A. superciliosa*	10	13	14	6	4	2	6	13	16	24

Species / Date	9/23/2003	10/30/2003	12/8/2003	1/12/2004	3/3/2004	3/10/2004	4/7/2004	5/21/2004	8/10/2004	8/26/2004
Australasian Shoveler *A. rhynchotis*										
Hardhead *Aythya australis*			15	3		1	2			8
Australian Wood Duck *Chenonetta jubata*		2								
White-bellied Sea-Eagle *Haliaeetus leucogaster*						1			1	
Swamp Harrier *Circus approximans*		1								
Black-tailed Native-hen *G. ventralis*				3						
Purple Swamphen *Porphyrio porphyrio*				1	1					
Eurasian Coot *Fulica atra*	4	10	10	132	38	42	55	52	16	
Black-winged Stilt *Himantopus himantopus*										
Masked Lapwing *Vanellus miles*										
Black-fronted Plover *C. melanops*	2					2	2			
Silver Gull *L. novaehollandiae*										
Whiskered Tern *Childonias hybridus*										
Sum: Total Birds Counted	85	82	194	257	178	152	195	157	83	103

Bird species and numbers recorded at Pilby Lagoon between Sept. 2004 & Nov. 2005

Species \ Date	9/28/2004	14/1/2/04	2/22/2005	4/19/2005	5/11/2005	6/30/2005	8/5/2005	9/13/2005	10/26/2005	11/23/2005
Australasian Grebe *Tachybaptus novaehollandiae*	10	4	13		10	45	55	14		
Hoary -Headed Grebe *Poliocephalus poliocephalus*			10	40	80	58	40	18		
Australian Pelican *Pelecanus conspicillatus*	12	22	29	1	11	30	13	8	2	3
Great Cormorant *P. carbo*	2	4	8	1	2	14	2	6		1
Little Black Cormorant *P. sulcirostris*	19	32	24	6	2	3	6	18	47	21
Little Pied Cormorant *P. melanoleucos*	27	22	4	8	6	20	3	14	6	
Australian Darter *Anhinga melanogaster*	3	3	3	4	3	10	4	5	2	2
White-necked Heron *Ardea pacifica*										
Great (Large) Egret *Egretta alba*	1					2	1			
Intermediate Egret *E. intermedia*										
White-faced Heron *A. novaehollandiae*			2		1	2	1			1
Australian Ibis *T. molucca*	5	9		1	3	6	2	1		1
Straw-necked Ibis *Carphibis spinicollis*										
Royal Spoonbill *Platalea regia*	1									
Yellow-billed Spoonbill *P. flavipes*	1	1			2	10	10	1		
Black Swan *Cygnus atratus*	2	4	6	2	5	13	8	4	6	2
Freckled Duck *Stictonetta naevosa*					4					
Australian Shelduck *Tadorna tadornoides*	4				4			2		
Pink-eared Duck *Malacorhynchos membranaceus*				4	50	140				
Grey Teal *A. gracilis*	27	70	32	228	240	135	28	110	10	51
Pacific Black Duck *A. superciliosa*	13	34	4	2	20	8	40	26		12
Australasian Shoveler *A. rhynchotis*				2	28	55				

Species / Date	9/28/2004	14/1/2/04	2/22/2005	4/19/2005	5/11/2005	6/30/2005	8/5/2005	9/13/2005	10/26/2005	11/23/2005
Hardhead *Aythya australis*	14	6	2	5	35	24	50	35	4	4
Australian Wood Duck *Chenonetta jubata*										
White-bellied Sea-Eagle *Haliaeetus leucogaster*										1
Swamp Harrier *Circus approximans*		1					1			
Black-tailed Native-hen *G. ventralis*										
Purple Swamphen *Porphyrio porphyrio*	1		2	1	2		5	7		3
Eurasian Coot *Fulica atra*	12	100	122	95	230	300	350	420	350	360
Black-winged Stilt *Himantopus himantopus*										
Masked Lapwing *Vanellus miles*			2							
Black-fronted Plover *C. melanops*			2							
Silver Gull *L. novaehollandiae*										
Whiskered Tern *Childonias hybridus*										
Sum: Total Birds Counted	154	312	265	400	738	875	619	689	427	462

Bird species and numbers recorded at Pilby Lagoon between Dec. 2005 & Apr. 2007

Species \ Date	12/21/2005	1/23/2006	9/28/2006	10/30/2003	11/27/2006	12/18/2006	1/25/2007	2/23/2007	3/28/2007	4/24/2007
Australasian Grebe *Tachybaptus novaehollandiae*			2	2						
Hoary -Headed Grebe *Poliocephalus poliocephalus*				2						
Australian Pelican *Pelecanus conspicillatus*	19		2		3	5	6	4	40	8
Great Cormorant *P. carbo*	2	4				8				
Little Black Cormorant *P. sulcirostris*	16	90	4	2	6	47	47	52		
Little Pied Cormorant *P. melanoleucos*	2		8	22	14	38	9	6		
Australian Darter *Anhinga melanogaster*	3	6	1	2	4	5	2			
White-necked Heron *Ardea pacifica*										
Great (Large) Egret *Egretta alba*		4				15	3	3		2
Intermediate Egret *E. intermedia*						1				
White-faced Heron *A. novaehollandiae*		7	2			1	2	7	6	8
Australian Ibis *T. molucca*		18	3			5	12	2		
Straw-necked Ibis *Carphibis spinicollis*		3							1	
Royal Spoonbill *Platalea regia*								1		
Yellow-billed Spoonbill *P. flavipes*		21						1		2
Black Swan *Cygnus atratus*		5	6				2	2	2	
Freckled Duck *Stictonetta naevosa*										
Australian Shelduck *Tadorna tadornoides*			8					2	3	2
Pink-eared Duck *Malacorhynchos membranaceus*		8		4	2	4				
Grey Teal *A. gracilis*	206	70	50	121	62	10	20	260	260	25
Pacific Black Duck *A. superciliosa*	43	16	14	2	6	7	20	70	31	38
Australasian Shoveler *A. rhynchotis*			4	10	23		2	4	2	

Species / Date	12/21/2005	1/23/2006	9/28/2006	10/30/2003	11/27/2006	12/18/2006	1/25/2007	2/23/2007	3/28/2007	4/24/2007
Hardhead *Aythya australis*	2	2		42	2					
Australian Wood Duck *Chenonetta jubata*										
White-bellied Sea-Eagle *Haliaeetus leucogaster*				1						
Swamp Harrier *Circus approximans*										
Black-tailed Native-hen *G. ventralis*										
Purple Swamphen *Porphyrio porphyrio*	2	2	2	2	3	3				
Eurasian Coot *Fulica atra*	280	80	10	66	36	16	10	33		
Black-winged Stilt *Himantopus himantopus*		1							3	
Masked Lapwing *Vanellus miles*		4						12	12	2
Black-fronted Plover *C. melanops*								6	13	85
Silver Gull *L. novaehollandiae*									16	
Whiskered Tern *Childonias hybridus*		3								
Sum: Total Birds Counted	575	344	116	278	161	165	135	465	389	172

Bird species and numbers recorded at Lake Werta Wert between Sept. 2004 & Dec. 2005

Species \ Date	9/28/2004	10/14/2004	11/16/2004	12/13/2004	1/13/2005	2/8/2005	4/5/2005	12/21/2005
Australian Grebe *Tachybaptus novaehollandiae*	6	6	14	2	3	2		
Hoary -Headed Grebe *Poliocephalus poliocephalus*	32	81	82	43	25	40		565
Great Crested Grebe *Podiceps cristatus*								2
Australian Pelican *Pelecanus conspicillatus*					6	80		
Great Cormorant *P. carbo*								
Little Pied Cormorant *P. melanoleucos*		1		1			1	
Australian Darter *Anhinga novaehollandiae*				1	1	1		
Great (Large) Egret *Egretta alba*					1			
White-faced Heron *E. novaehollandiae*				2	6	2		4
Australian Ibis *T. molucca*						1		
Straw-necked Ibis *Carphibis spinicollis*							1	
Yellow-billed Spoonbill *P. flavipes*			3			5	13	
Black Swan *Cygnus atratus*	4			2	3			
Freckled Duck *Stictonetta naevosa*		5	28	28				6
Australian Shelduck *Tadorna tadornoides*								
Pink-eared Duck *Malacorhynchos membranaceus*	4	140	30	177	36	46	50	500
Grey Teal *A. gracilis*	248	118	330	310	860	880	320	1080
Chestnut Teal *A. castanea*								
Pacific Black Duck *A. superciliosa*	4	2	10	8	18	5	6	15
Australasian Shoveler *A. rhynchotis*				2	32	24	7	
Hardhead *Aythya australis*	22	38	20	115	2	23		660
Australian Wood Duck *Chenonetta jubata*	54	16	15	6	180	80	14	55

Species \ Date	9/28/2004	10/14/2004	11/16/2004	12/13/2004	1/13/2005	2/8/2005	4/5/2005	12/21/2005
Blue-billed Duck *Oxyura australis*								
Musk Duck *Biziura lobata*	1	1	1	1				
Dusky Moorhen *Gallinura tenebrosa*								
Black-tailed Native-hen *G. ventralis*		20	14		63			
Purple Swamphen *Porphyrio porphyrio*				1				
Eurasian Coot *Fulica atra*	17	60	50	170	2	12		176
Black-winged Stilt *Himantopus himantopus*				3	33	23	13	1
Red-necked Avocet *Recurvirostra novaehollandiae*						18		
Masked Lapwing *Vanellus miles*	4	8	6	15	8	7	5	2
Red-capped Plover *C. ruficapillus*					2			
Black-fronted Plover *C. melanops*		6	6	5	4		2	
Red-kneed Dotterel *Erythrogonys cinctus*	4	2	12	2	8	40	6	
Sum: Total Birds Counted	400	504	621	894	1293	1289	438	3066

Bird species and numbers recorded at Lake Werta Wert between Jan. 2006 & Feb. 2008

Species \ Date	1/23/2006	2/16/2006	3/22/2006	4/26/2006	5/22/2006	6/26/2006	7/24/2006	8/29/2006	2/19/2008
Australian Grebe *Tachybaptus nuovaehollandiae*									16
Hoary -Headed Grebe *Poliocephalus poliocephalus*	360	405	310	152	28				62
Great Crested Grebe *Podiceps cristatus*									
Australian Pelican *Pelecanus conspicillatus*		6	40		5	1			
Great Cormorant *P. carbo*		1							
Little Pied Cormorant *P. melanoleucos*					2	1	4		
Australian Darter *Anhinga novaehollandiae*		2			2				
Great (Large) Egret *Egretta alba*		1							
White-faced Heron *E. novaehollandiae*	2	2							
Australian Ibis *T. molucca*	1	1	2						
Straw-necked Ibis *Carphibis spinicollis*									
Yellow-billed Spoonbill *P. flavipes*		22	4	4	7	3	6	5	1
Black Swan *Cygnus atratus*	6	13	14	4			2	3	
Freckled Duck *Stictonetta naevosa*	84	122	30	32	10				
Australian Shelduck *Tadorna tadornoides*							2		2
Pink-eared Duck *Malacorhynchos membranaceus*	214	970	145	420	625	28			1
Grey Teal *A. gracilis*	650	1330	1550	1440	330	180	712	400	24
Chestnut Teal *A. castanea*							2		
Pacific Black Duck *A. superciliosa*	30	15	12	8			15	2	3
Australasian Shoveler *A. rhynchotis*	10	16	18	100	32	8	16		12
Hardhead *Aythya australis*	240	60	6						
Australian Wood Duck *Chenonetta jubata*	22	125	320	132	28	2	14	14	7

Species \ Date	1/23/2006	2/16/2006	3/22/2006	4/26/2006	5/22/2006	6/26/2006	7/24/2006	8/29/2006	2/19/2008
Blue-billed Duck *Oxyura australis*		10							
Musk Duck *Biziura lobata*									
Dusky Moorhen *Gallinura tenebrosa*			1						
Black-tailed Native-hen *G. ventralis*									
Purple Swamphen *Porphyrio porphyrio*									
Eurasian Coot *Fulica atra*	76	37	8	6	4				14
Black-winged Stilt *Himantopus himantopus*		10		21	30	23	30	2	
Red-necked Avocet *Recurvirostra novaehollandiae*			30	3	14	96	122	15	
Masked Lapwing *Vanellus miles*	2	2	13	8	11	14	2	2	4
Red-capped Plover *C. ruficapillus*						8			
Black-fronted Plover *C. melanops*	5	11	15	20	5	55	7	9	
Red-kneed Dotterel *Erythrogonys cinctus*					65	70	2		
Sum: Total Birds Counted	1702	3161	2518	2350	1198	489	936	452	146

10.3 Appendix 3: The Consultants

Peter Newall, Independent Consulting Aquatic Ecologist

Peter Newall has over 20 years experience in studying, monitoring and assessing the physical, chemical and biological condition of water bodies and their catchments. He holds a B.Sc. Honours degree in Botany/Physical Geography (wetland ecology), a M.Env.Sci. degree in stream ecology and a PhD. on fish distributions across aquatic ecoregions. His work has included: examining the ecological condition of a broad range of aquatic ecosystems; developing systems for the use of biological indicators in ecosystem assessment and management; derivation of condition targets/objectives for natural resources; and developing river management policies for the care and protection of rivers.

Peter has been involved in developing water quality guidelines and objectives for aquatic ecosystem health, deriving biological regions for the assessment of stream condition across Victoria, developing the EPA (Victoria) protocol for the monitoring of licensed discharges to streams across Victoria, and furthering the development of biological indicators of stream condition. His work in these areas has been incorporated into the Victorian State Environment Protection Policy (Waters of Victoria) and its supporting documents.

Other studies he has undertaken include assessing catchment and land use management impacts upon receiving waterways; ecological risk assessments of streams; environmental assessment of streams and catchments; and character descriptions of wetlands.

Peter was a member or the CRC for Freshwater Ecology for five years, and has also worked in Environmental Auditing with EPA and as a consultant, particularly in natural resource auditing, focusing on waterway and catchment auditing.

Lance Lloyd, Principal Ecologist, Lloyd Environmental Pty Ltd

Principal Ecologist, Lance Lloyd, BSc, MSc. MAIBiol., provides high level strategic advice and services to industry and Government across Australia. He has 27 years experience in environmental consulting, research and management. His key expertise developed over this time is in relating the ecology of aquatic systems to the needs of management issues. The majority of his work during his professional life, since 1979, has been in the ecology of aquatic and floodplain ecosystems and water regimes in flowing & lentic waters and their management. His M.Sc. studies and some of his major research projects and several published papers focused upon the central role of environmental water management to the ecology and biological requirements of fish, invertebrates and plants.

Lance also led a project to develop a wetlands inventory on Commonwealth Lands as a contribution to the "Directory of Important Wetlands in Australia (3rd Edition)". In 2003, Lance led an expert team to review the Environmental Water Requirements for Internationally significant Wetlands Framework where he undertook detailed studies on the Wyndgate Wetlands which are part of Coorong and Lakes Alexandrina

and Albert Ramsar Site. He has contributed significantly to the MDBC Floodplain Wetlands Management Strategy. He was the lead author of the paper entitled "Natural Processes in Floodplain Ecosystems" which synthesised the current knowledge of floodplain wetland ecosystems and was produced as part of the MDBC Floodplain Wetlands Management Strategy.

Lance was a co-author of the FLOWs methodology for Victorian Streams and Rivers and is currently leading a project to develop, pilot and refine a draft FLOWs methodology for the estuary ecosystems of Victoria. He was a key member of the team which developed the wetlands R&D requirements for Land & Water Australia in 1998, which included a specific review of water regime management and its research requirements.

Further, he was a board member of the Fisheries Co-management Council of Victoria (an advisory group to the Victorian Minister of Agriculture) in 2002 -2005. On the FCC he was responsible for the Estuaries, Bays and Inlets Fisheries. He led a process to develop a 10 year Vision for the Fisheries Industry in the region. He also served on the Victorian Fisheries Research Advisory Board for the Fisheries R&D Corporation. He currently chairs the Translocation Evaluation Panel for the Victorian Government which evaluates risks from fish translocations in Victoria.

In addition to the Riverland Ramsar site ECD, Lance is also leading the Ecological Character Description Project for the Tasmanian Government on the Floodplain Lower Ringarooma Ramsar Site. He was a key team members of the Gippsland Lakes and Corner Inlet Ecological Character Description Projects.

Prof. Peter Gell, Wetland Palaeolimnology and Avifauna Specialist

Peter is a limnologist and palaeoecologist with 22 years experience in environmental consulting. He is sole chief investigator on an Australian Research Council Linkage grant examining the long term ecological history of lower River Murray Wetlands in association with the River Murray Natural Resource Management Board and chief investigator on an ARC Linkage grant with Department of Water land & Biodiversity Conservation on the long term ecological character of The Coorong. He was part of the team that reviewed the Ecological character of The Coorong for the Department of Environment and Heritage. He has undertaken major projects examining the ecological character of Lake Bonney (SE) and South Australian estuaries for the EPA of SA. He is convener of the ARC network Ozpacs that integrates short term palaeoecological studies Australia-wide to provide a long term state of the environment report for the continent. He is co-chair of the Salinity, Climate and Salinisation working group within the International Geosphere-Biosphere Project Past Global Changes project Limpacs that examines the impact of climate and people on lake ecosystems worldwide. He is a member of the eWater CRC's research project team 'Multiple Drivers of River Ecosystems'. He has been monitoring the waterbirds of Lake Cowal NSW for 15 years and has examined the long term history of over 30 MDB wetlands using fossil bioindicators in sediments. He has produced over 65 publications and 60 industry reports.

A. Prof. Keith Walker, Expert Ecologist on the River Murray System

Associate Professor Keith Walker is a lecturer at the Dept of Environmental Biology in the University of Adelaide and is an internationally recognised expert on river ecology and the impacts of flow regulation with over thirty years experience in research, university education and consultancies. He has undertaken more than 40 significant consultancies, conducted over 40 research projects for the Australian and State Governments and research funding bodies and published over 200 scientific papers. His work has focussed on the rivers of the Murray-Darling Basin, on fish, aquatic plants, macroinvertebrates and mussels in particular. He is currently a member of the Living Murray Scientific Reference Panel and the Independent Sustainable Rivers Audit Group for the MDBC. In the later role, he has overseen the development of an independent audit and assessment program for the rivers of the Murray-Darling Basin.

10.4 Appendix 4: Methodology to Develop the ECD

Completion of the ECD comprised eight major tasks:

1. Project Inception and site visit
2. Literature and Information Review
3. Content of the ECD
4. Preparation of 1st Draft ECD for review by DEWHA
5. Preparation of revised RIS, using the ECD
6. Revision of 1st Draft ECD (with DEWHA comments)
7. Presentation of 2nd Draft ECD to stakeholders in a workshop format, seeking comments/feedback
8. Finalisation of ECD, incorporating stakeholder comments

Client-consultant partnership was an important component of the process to ensure alignment of goals and common understanding of approaches. This included client-consultant meetings to ensure a high level of communication. The team also conducted interviews and informal discussions with relevant stakeholders and resource managers, to further develop our understanding of the site. The structured workshop (Task 7) assisted with crystallising our understanding of the site and developing the conceptual model for the wetland.

The tasks outlined above are described in the following sections.

Task 1: Project Inception and Site Inspection

The project commenced with an inception meeting with the Client Project Manager and the Consultants' project manager. This meeting was to:

- **Confirm** project objectives, and outputs sought;
- **Discuss and finalise** timeframes and key dates for delivery of project outputs**;** and,
- **Confirm** existing information sources and **obtain** relevant reports, information, and data from the client.

This component was vital for ensuring alignment of objectives and discussion of approaches. The inception meeting was also used as a springboard for making contacts, obtaining details of key stakeholders and pursuing reference documents.

Site Inspection: Following the inception meeting a site inspection was undertaken to view the key areas and habitats of the Riverland Ramsar site. The site inspection was led by the client Project Manager, who had extensive experience managing the Site. A small plane was also chartered to fly over the Ramsar site, providing greater spatial perspective of the site.

Task 2: Literature and Information Review

The literature review initially focussed on the condition of the Ramsar site at the time of Ramsar listing. Information on changes to condition since listing was subsequently reviewed and documented. Information reviewed included documents prepared prior to and during the listing process, as well as through perusal of subsequent reports and studies on the condition of the wetland.

Collate/summarise information from inception meeting and Stakeholders: At the inception meeting relevant available documents held by the client were requested, as well as contact details of stakeholders and their relevant roles in relation to the Ramsar Site. Subsequent to the inception meeting contact was made with relevant stakeholders as part of document searching/gathering. The collated and summarised information enabled an assessment of information gaps and needs.

Information and data search and review: Using the approaches and structures identified at the inception meeting and the collated information, information needs were prioritised and the most likely sources (people and documents) were identified. The data search and summary was a key component of the project and was allocated a substantial amount of time. An "information log" was developed to document the reports and information resources available to the project. The "information log" was used during the course of the project to inform stakeholders which documents the project team possessed and which ones were missing for the project. The "information log" will be continually updated throughout the project. A significant component of this included interviews and discussions with key stakeholders.

Literature Summary: The information and data obtained was summarised to facilitate review of knowledge status and gaps, and was used as an important basis for the production of the ECD. The literature summary was structured to enable ready assessment against ECD requirements.

Discussions with DEH and Government Agencies: Discussion with the client and key Government stakeholders was a regular and vital part of the project, both in the collection of information and also in the compilation of the literature summary. Regular feedback maximised the opportunity to uncover all relevant information.

Task 3: Content of the ECD

A scientific panel was convened and focussed on identifying:

- key ecological components and processes in the Riverland Ramsar site;
- the benefits and services that characterise the site;
- key actual or potential threats to the site;
- knowledge gaps;
- monitoring needs; and,
- an appropriate preliminary conceptual model of the system.

The Panel workshop consisted of the project team (Dr Peter Newall, Lance Lloyd, Dr Peter Gell and Assoc. Prof. Keith Walker) who have substantial knowledge of the River Murray and its associated wetlands, covering a broad range of environmental/ecological disciplines.

Task 4: Preparation of a Draft ECD for review by DEWR

A Draft of the ECD was prepared from the information gathered through the literature review, Scientific Panel and through liaison with the client. The draft was provided to the client manager, for distribution to relevant staff within DEWR.

The Draft ECD generally followed the draft national framework, which includes:

- Executive Summary
- Acknowledgements
- Table of Contents
- List of Abbreviations
- **Introduction**, including site details, purpose of the ECD, legislative context
- **Detailed Description of the Site**, including overview of the site; ECD context; Ramsar/DIWA criteria; geographic and ecosystem description
- **Description of Ecological Character of the Site**, focusing on components, processes & benefits/services; conceptual model of site & system, quantified limits of change. Consideration will need to include biological, physical and chemical aspects of wetland condition and processes
- **Key Actual or Potential Threats or Risks to the Site**, to aid identification of potential changes and their importance
- **Knowledge Gaps** (and suggested approaches for addressing them)
- **Changes in Ecological Character** (if appropriate), including whether changes have occurred since listing
- **Key Site Monitoring Needs**, identified from conceptual model, and covering knowledge gaps, assessing trends/changes and relevant triggers, monitoring management outcomes
- **Triggers for Management Action**, to be quantitative and place high importance on identified risks/threats
- **Communication, Education and Public Awareness (CEPA) Messages**, summarising key ecological messages that will facilitate management planning and action
- Glossary
- References; and,
- Appendices.

The 'Executive Summary' to 'List of Abbreviations' and 'Glossary' to 'Appendices' were not completed at this draft stage.

Describing the Components, Processes and Benefits/Services: The development of ecological character required a description of the ecosystem components, processes and benefits/services that characterise the Ramsar site. An important requirement within this task was the need to document the condition of the site at the time of its designation for the Ramsar list as well as current condition. This included assessments of trends in the condition of relevant components, processes and services and past and current changes in its character.

Development of Conceptual Models: Conceptual models were developed to represent the ecological processes and components of the Ramsar Site in a simplified way, to will assist in describing the ecological character of the site.

Conceptual models draw on existing scientific information to describe the critical processes that contribute to (or limit) wetland or ecosystem health. A model can describe a 'healthy' ecosystem that meets the management objective and can include known impacts and show how they reduce health or biodiversity.

Conceptual models are defined as "a generalised description or representation of the structure and function of a complex system". In order to develop a conceptual model, the following steps were undertaken:

- define the purpose of the conceptual model
- specify the system boundaries
- identify individual model components
- describe relationships between components
- "build" the conceptual model

Prepare Draft ECD: The ecological character was described in accordance with the Draft National Framework. This required a description of the ecosystem components, processes and benefits/services that characterise the wetland as well as the conceptual model of the ecological functioning of the wetland system (described above).

Beyond the description of the wetland site, knowledge gaps were identified and recommendations made accordingly, including the development of monitoring recommendations. As well as filling of knowledge gaps, monitoring recommendations considered information required for assessment of trends, triggers for management action (including assessments of threats/risks), and feedback on management actions.

Task 5: Preparation of revised RIS, using the ECD

The preparation of the revised RIS used the existing RIS as a basis and incorporated changes to the site boundaries as well as any relevant changes to the ecology of the site since the preparation of the previous RIS. Much of the work undertaken as part of the Literature Review and also stakeholder discussion and team-member knowledge of the site fed into this task.

Task 6: Revision of 1st Draft ECD (DEWHA comments)

The project team collated the comments provided by DEWR and incorporated those comments into a revision of the draft ECD, producing a 2nd Draft ECD for Key Stakeholder review. The 2nd draft ECD was circulated to the Key Stakeholders approximately 2 weeks prior to the presentation & workshop (Task 7).

Task 7: Presentation of 2nd Draft ECD to stakeholders in a workshop format, seeking comments/feedback

The purpose of the presentation was to field feedback from the client, Steering Committee and other key stakeholders in a face-to-face situation. The goal was to encapsulate the key comments in a workshop environment after the presentation and seek agreement/consensus on those comments. Feedback received from the presentation/workshop was documented and circulated to ensure completeness and alignment of understandings prior to preparation of the final draft of the ECD.

Task 8: Finalisation of ECD.

The ECD was finalised, incorporating the stakeholder comments following the workshop and subsequent feedback.

10.5 Appendix 5: Ramsar Information Sheet for the Riverland Ramsar Site

Appendix 5

Information Sheet on Ramsar Wetlands (RIS) – 2009-2012 version

1. Name and address of the compiler of this form:
Mr. Mike Harper, Department for Environment and Heritage, Murraylands Region, PO Box 231, Berri, South Australia, 5343.
Updated by Peter Newall and Lance Lloyd, Lloyd Environmental Pty Ltd, PO Box 3014, Syndal, Vic, 3149.

FOR OFFICE USE ONLY.
DD MM YY
Designation date | Site Reference Number

2. Date this sheet was completed/updated:
13 July 2009

3. Country:
Australia

4. Name of the Ramsar site:
The precise name of the designated site in one of the three official languages (English, French or Spanish) of the Convention. Alternative names, including in local language(s), should be given in parentheses after the precise name.
"Riverland" South Australia

5. Designation of new Ramsar site or update of existing site:

This RIS is for (tick one box only)**:**
a) Designation of a new Ramsar site ❑; or
b) Updated information on an existing Ramsar site ☑

6. For RIS updates only, changes to the site since its designation or earlier update:

a) Site boundary and area

The Ramsar site boundary and site area are unchanged: ❑
or
If the site boundary has changed:
i) the boundary has been delineated more accurately ☑;; or
ii) the boundary has been extended ❑; or
iii) the boundary has been restricted** ☑

and/or

If the site area has changed:
i) the area has been measured more accurately ❑; or
ii) the area has been extended ❑; or
iii) the area has been reduced** ☑ (The previous area of 34,618 was an approximate area)

** **Important note**: If the boundary and/or area of the designated site is being restricted/reduced, the Contracting Party should have followed the procedures established by the Conference of the Parties in the Annex to COP9 Resolution IX.6 and provided a report in line with paragraph 28 of that Annex, prior to the submission of an updated RIS.

b) Describe briefly any major changes to the ecological character of the Ramsar site, including in the application of the Criteria, since the previous RIS for the site:

The Riverland Ramsar site was established in 1987 and an updated RIS was developed in 1998. This is a further update of an RIS (in prep) to register the site's increased Ramsar criterion and ecological knowledge and describe a site boundary and area change. The original Ramsar area was 34,618 and has been reduced by 4003 hectares to 30,615 through the removal of major non-wetland areas dominated by

agriculture. However, the boundary change has resulted in a 2,347 hectare increase of wetland area. The major change in ecological character resulting from the boundary changes is this increase in wetland area by including Lake Woolpoolool, a seasonal brackish lake. This increases waterbird and vegetation diversity of the site. The removal of major non-wetland areas has no impact on the ecological character of the Riverland Ramsar site. The Criteria description has significantly changed since the previous RIS and now includes eight out of the nine Criteria, due to a significant increase in knowledge of the site. Refer Appendix I for map of boundary changes.

A decline in the health of the tree cover of the Site since listing represents a clear change in ecological character. The vegetation and habitat values of the Site have changed significantly due to a decrease in flood events over the past two decades (DWLBC undated.). At the time of listing, the floodplain vegetation of the Site was already experiencing significant stress. The continuing and increasing stress and deterioration of the site will require specific actions to maintain its ecological integrity.

A change in hydrology since listing has been obvious at the site with a significant reduction in the flooding frequency of all floods under 100 GL/d, the most significant reduction being medium sized floods in the 10 GL/d - 30 GL/d range. This would have most impact on semi-permanent vegetation and billabongs and fringing aquatic vegetation when compared to pre-1987 period. Further, as there has been one large event (over 100GL/d) post-listing, compared to the 20 years prior to listing (when there was 3 events over 100GL/d), the floodplain condition has also declined in this period.

---

7. Map of site:

Refer to Annex III of the *Explanatory Note and Guidelines*, for detailed guidance on provision of suitable maps, including digital maps.

a) A map of the site, with clearly delineated boundaries, is included as:

i**) a hard copy** (required for inclusion of site in the Ramsar List): ☑;

ii**) an electronic format** (e.g. a JPEG or ArcView image) ☑; (Refer Appendix II for map of the site).

iii) **a GIS file providing geo-referenced site boundary vectors and attribute tables** ☑.

b) Describe briefly the type of boundary delineation applied:

e.g. the boundary is the same as an existing protected area (nature reserve, national park, etc.), or follows a catchment boundary, or follows a geopolitical boundary such as a local government jurisdiction, follows physical boundaries such as roads, follows the shoreline of a waterbody, etc.

The site boundary follows the 1956 flood line west from the NSW border through to the western side of Ral Ral creek. It follows the western bank of the Ral Ral Creek to the junction of the River Murray. The boundary crosses the River Murray to Causeway Road and follows the northern edge of the road. The boundary then follows the 1956 flood line east to the Victorian border. It then follows the Victorian border north to the River Murray where it follows the southern bank of the river east where it meets the New South Wales border.

---

8. Geographical coordinates (latitude/longitude, in degrees and minutes):

Provide the coordinates of the approximate centre of the site and/or the limits of the site. If the site is composed of more than one separate area, provide coordinates for each of these areas.

Coordinates for the approximate centre of the Ramsar site: Latitude: 34° 02' South; Longitude 140° 50' East. Coordinates for the:

North-east corner - Latitude: 33° 55' 49.7" South; Longitude 141° 00' 9.7" East

South-east corner - Latitude: 34° 01' 142"South; Longitude 140° 00' 9.9" East

Southern central point- Latitude: 34° 09' 59.3"South; Longitude 140° 46' 45.4"East

---

9. General location:

Include in which part of the country and which large administrative region(s) the site lies and the location of the nearest large town.

Located within the South Australian section of the Murray Darling Basin , along the River Murray between Renmark and the Victorian and New South Wales border.

10. Elevation: (in metres: average and/or maximum & minimum)
The elevation ranges from 15 to 20 m above sea level.

11. Area: (in hectares)
The total area of the site is 30,615 hectares.

12. General overview of the site:
Provide a short paragraph giving a summary description of the principal ecological characteristics and importance of the wetland.

The wetland area encompasses two major anabranch systems along an 80km section of the River Murray. This section incorporates a series of creeks, channels, lagoons, billabongs, swamps and lakes. Between the water-bodies, extensive areas of low-lying floodplain are flooded during high river levels and some areas retain water temporarily.

The floodplain contains 11 of the 12 vegetation communities within the Riverina Biogeographical Region (Environment Australia 2000) and provides habitat for nationally threatened species such as Regent Parrot (Eastern) (*Polytelis anthopeplus monarchoides,)* Southern Bell Frog (*Litoria raniformis*), Murray Cod *(Maccullochella peeli peeli)* and Murray hardyhead *(Craterocephalus fluviatilis)*. The wetland is important habitat for a large number of migratory and nomadic birds and state threatened species and the wetland's native fish populations display a high degree of biodisparity.

13. Ramsar Criteria:
Tick the box under each Criterion applied to the designation of the Ramsar site. See Annex II of the *Explanatory Notes and Guidelines* for the Criteria and guidelines for their application (adopted by Resolution VII.11). All Criteria which apply should be ticked.

1	2	3	4	5	6	7	8	9
✓	✓	✓	✓	✓	✓	✓	✓	

14. Justification for the application of each Criterion listed in 13 above:
Provide justification for each Criterion in turn, clearly identifying to which Criterion the justification applies (see Annex II for guidance on acceptable forms of justification).

Criterion 1 Containing a representative example of a near-natural wetland type found within the Riverina biogeographical region.

The Site is located in the Lower River Murray of the Murray-Darling Drainage Division (AWRC 1975). At the time of listing, the Site contained one of the only parts of the lower Murray floodplain not used for irrigation (within the Chowilla Floodplain), preserving much of its natural character. This part of the Site is designated as an Icon Site by the Murray-Darling Basin Authority, one of six such sites in the basin. The Site is representative of a floodplain system within the region, and also rare in that almost all of the other examples of these wetland types in the region have been impacted by irrigation.

Criterion 2 Providing habitat for listed threatened species.

The Riverland Ramsar site supports the following Nationally threatened species defined under section 179 of the Australian "*Environment Protection and Biodiversity Conservation Act* 1999". They are listed as Vulnerable:

- Regent Parrot (Eastern) (*Polytelis anthopeplus monarchoides)* Recorded by Smith (1992 & 2001).
- Southern Bell Frog (*Litoria raniformis)* Recorded by O'Malley& Sheldon (1990) Australian Landscape Trust (2002) and Harper (*pers.comm.*)
- *Murray Cod (Maccullochella peeli peeli)* Regularly caught by professional fishers Pierce (1997).
- Murray hardyhead *(Craterocephalus fluviatilis)* Recorded by Nichols and Gilligan (2004).

The Site provides the physical and biological habitat requirements for these species, and sanctuary from a range on human impacts that occur in similar landscapes outside the Site

Criterion 3 Supporting populations of plant and animal species important for maintaining the biological diversity of the Riverina biogeographical region.

Flora The Site supports twenty-eight plant species on a permanent or seasonal basis, listed at the State level under the National Parks and Wildlife Act 1972 (Appendix VII). Twenty species are listed as rare and eight as vulnerable.

Fauna In addition to the fish species listed at the National level, there are four fish species listed as endangered and one as vulnerable in South Australia (Appendix IV). The Site also contains other animal species listed at the State level, including twenty-two State listed threatened species that inhabit the Site on a permanent or seasonal basis (Appendix VIII). Fourteen of these species are listed as rare (two reptiles, seven birds), seven as vulnerable (one reptile and six birds), and one (the Feather-tailed Glider, *Acrobates pygmaeus*) is listed as endangered.

Maintenance of remnant populations of endangered flora and fauna within the Site that are uncommon or extinct elsewhere in the lower Murray has been acknowledged in numerous studies and has been attributed to unique flowing waters and habitat diversity in the Site's anabranch systems (O'Malley and Sheldon, 1990; Pierce, 1990; Sharley and Huggan, 1995; Zampatti et al, 2006a). The Riverland Ramsar Site contains a broad range of biological diversity occurring in the region (including habitat types) and supports elements of biological diversity that are rare and particularly characteristic of the region. The site contains a full range of the region's lowland riverine vegetation communities (Margules et al.1990).

Criterion 4 Providing habitat for animal species at a critical stage in their life cycles and provides refuge during adverse conditions.

The Riverland wetland provides critical summer or stopover habitat for at least 8 species of migratory birds listed under the following agreements: Agreement between the Government of Australia and the Government of the Japan, (JAMBA) People's Republic of China (CAMBA) and Republic of Korea (ROKAMBA) for the protection of Migratory Birds in Danger of extinction and their Environment (refer to Appendix III A for list of relevant species).

During a 10-day bird survey of the Chowilla floodplain in 1988, Carpenter (1990) recorded a total of 30 breeding species. Of these breeding species, eight were species of waterbird (Appendix III E). The site is also habitat for nomadic waterbirds during times of drought in central and eastern Australian when the areas wetlands dry (refer to Appendix III B for list of relevant species) and also habitat for nomadic bush-bird species during the dry southern Australian summer period (November to March) (also refer to Appendix III C for a list of these species).

Criterion 5 Providing habitat that regularly supports 20,000 or more waterbirds.

Due to the rehabilitation of a number of wetland sites within the Riverland Ramsar site, the area regularly supports 20,000 or more waterbirds involving fifty-nine species (see Appendix III for list of species). Over 23,000 birds were counted at Lake Merreti one day in February 2002, over 18,500 at the same site in May 2001 and over 19,000 in March 2007 (Harper, unpublished data). These high numbers are from one site within the wetland – 'whole-of-site' numbers would be much larger but have not been gathered. The same data set displays over 8,000 birds at Lake Woolpolool in May 2001 and over 4,700 in February 2002, on the same days as high numbers were recorded at Lake Merreti.

Criterion 6 Providing habitat that regularly supports 1% of the global population of one species of waterbirds.

Freckled Duck (*Stictonetta naevosa*), Red-necked Avocets (*Recurvirostra novaehollandiae*) and Red-kneed Dotterel, (*Erythrogonys cinctus*) have been recorded at the Site in numbers representing greater than 1% of their estimated global population. The IUCN redlist (Birdlife International 2008) estimates a global population of 20,000 Freckled Duck, 26,000 Red-kneed Dotterel and 110,000 Red-necked Avocet, therefore requiring 200, 260 and 1,100 individuals for each species respectively to represent 1% of the global population. Unpublished data from Harper (pers. comm.) show that between October 2000 and November 2002, the number of Freckled Duck on Lake Merreti exceeded 200 on three occasions (May 2001, February 2002 and November 2002), with a highest number of 620 birds. The same unpublished

data show Red-necked Avocets exceeding 1,100 at Lake Merreti on four occasions between February and May 2002, and again in October 2002; and 277 Red-kneed Dotterel at the Site in March 2002. At a different part of the Site -Lake Woolpolool - the number of Red-necked Avocets exceeded 1,600 in January 2002, was over 6,000 in October 2002 and greater than 2,500 in November 2002. In February 2005 the number reached 1000 at Lake Littra.

Criterion* 7 *Supporting a significant proportion of indigenous fish species or families and life-history stages that are representative of wetland benefits and/or values and thereby contributes to global biodiversity.

The Site supports 16 species of freshwater native fish species within the Murray-Darling Basin, (Appendix IV). These fish have adapted to high variability in flow and water quality resulting in the Site's fish assemblage displaying a high biodisparity and five different reproductive styles. Studies undertaken within different parts of the Site found eight native fish species across four sampled sites in the Murtho Block (Templeton, Weila, Murtho Park and Woolenook Bend) (SKM 2005). Similarly, surveys of the lakes and creeks on Calperum have recorded twelve species of native fish (Parks Australia 2005) and a survey in the Chowilla region near the time of Ramsar listing of the Site (Lloyd 1990) recorded eight native fish species.

Criterion 8 Supplying an important source of food for fishes, spawning ground, nursery and migration path on which fish stocks, either within the wetland or elsewhere, depend.

Two of the site's fish species, the Golden Perch (*Macquaria ambigua)* and Silver Perch (*Bidyanus bidyanus)* are potamodromous i.e. truly migratory fish whose migrations occur wholly within fresh water (Mackay 1990). The Chowilla Anabranch within the Riverland wetland is an important pathway for these fish to migrate around Lock 6, a fish barrier during low to medium flows. The site also provides fish breeding and nursery habitats in warm shallow floodwaters overlaying the extensive floodplain and wetlands during spring and early summer flood events. As the floodwaters spread over previously dry ground there is an abundant production of plankton and subsequent proliferation of larger food organisms, all of which contribute to the diet of young fish.

Significant numbers of larvae of Australian smelt (*Retropinna semoni*) were recorded in the anabranches of the Site by Lloyd (1990), particularly in the slow-flowing anabranches where the slow currents keep the semi-bouyant developing eggs in suspension. The presence of larval and post larval stages is evidence of the Site providing a spawning ground/nursery for this species. Other species have also been captured as larvae within the Site's waterways, including: Flatheaded Gudgeon (*Philypnodon grandiceps*); Carp gudgeon (*Hypseleotris* spp.); Bony Herring (*Nematalosa erebi*); Unspecked Hardyhead (*Craterocephalus stercusmuscarum fulvus*, a subspecies of the Flyspecked Hardyhead); Golden Perch (*Macquaria ambigua*); Murray Cod (*Maccullochella peelii peelii*) and Crimson-spotted Rainbowfish (*Melanotaenia fluviatilis*) (Zampatti 2006b)

---

15. Biogeography (required when Criteria 1 and/or 3 and /or certain applications of Criterion 2 are applied to the designation):

Name the relevant biogeographic region that includes the Ramsar site, and identify the biogeographic regionalisation system that has been applied.

a) biogeographic region: The Site is situated within Basin 26 – Lower Murray River – of Division IV: Murray-Darling Division.

b) biogeographic regionalisation scheme (include reference citation): Australian Drainage Divisions (DEWHA 2007)

---

16. Physical features of the site:

Describe, as appropriate, the geology, geomorphology; origins - natural or artificial; hydrology; soil type; water quality; water depth, water permanence; fluctuations in water level; tidal variations; downstream area; general climate, etc.

The site has a temperate climate with cool winters and warm to hot summers. Diurnal and seasonal temperature variations can be significant as the area is considered to be within the southern extension of Australia's central arid zone. Average summer maximum temperature is 31.6°Celsius and minimum 16°

Celsius. In winter months these fall to 17° Celsius and 5.5° Celsius, respectively. Annual rainfall is low and irregular, averaging 260mm per annum, with a slight winter and spring predominance. Drought occurs frequently but there is no clear pattern in occurrence of good years and drought (Sharley & Huggan 1995). Average annual evaporation is 1960mm.

The site is of natural origin and is located on a very wide (up to 10 km) section of an incised ancestral floodplain and comprises active meander plain, low relict meander plain, high relict meander plain and terrace with the upland rise and near-vertical cliffs bordering the floodplain (Hollingsworth *et al.* 1990).

Soil type changes greatly over the landscape with neutral and alkaline grey self-mulching cracking clays, neutral brown siliceous sands and neutral firm grey siliceous sands dominating the ancestral floodplain. (Laut *et al.*1977). Sediment type ranges from deep poorly drained self-mulching cracking clays to deep well drained sands and calcareous earths (Laut *et al.*1977). There is significant variation in organic content in the wetland sediments that reflects the degree of wetland formation (Thomson 1975).

Hydrology is a major component/process of the site. Before construction of weirs in 1922 to 1937, the site experienced highly variable flows. In spring and early summer the river was generally high, cool, turbid and fast flowing, gradually changing to become low, warm, clear and slow moving towards the end of summer. During drought, the flow would cease and saline pools would form through the interception of underlying saline groundwater (Sharley & Huggan 1995). Since weir construction, flow is regulated, except in major floods. The river and the main anabranch systems in the site now flow continuously and many wetlands are artificially permanently inundated due to the river level having risen up to 3 m in the pools impounded by weirs. Regional saline groundwater (30,000 to 40,000 mg/L Total Dissolved Solids) now flows into the anabranch creeks. Saline ground water mounds have formed beneath irrigated areas adjacent to the Riverland wetland (Woodward-Clyde 1999). Significant overbank flow at the Site requires a flow greater than 50,000ML/day. At least 80,000 ML/day is required to inundate half the floodplain and total inundation is achieved when flows reach 150,000ML/day.

Water Quality is variable across the site and through time. It is affected by periods of low and high flows, saline groundwater inflows and as a result of a drying event (Thompson 1986; Wetlands Working Party 1989; Suter et al. 1993). Salinity can vary by an order of magnitude within a waterbody [e.g. Lake Woolpoolool: 1,710-44,000 mg/L (Suter et al. 1993)] but is lower and more consistent within the areas permanently inundated by locks and weirs [e.g. River channel Lock 5: 215-452 mg/L, (Crabb 1997)]. Similarly, total phosphorus and turbidity measures range widely through time and space within the site, whereas pH is typically mildly to strongly alkaline (Crabb 1997; Suter et al. 1993; Tucker 2003).

Water depth can vary greatly within the site, contributing to a range of different wetland types. Examples of water depth ranges are; main river 4-8m, anabranch creeks 1-3m, permanent wetlands <1-2m and temporary wetlands 1-2m. The main anabranch systems and associated wetland systems that are now permanently inundated by regulating structures experience little fluctuation in water depth throughout the year, except during flood periods. For many temporary wetlands the reverse is true with areas receiving water less often and for shorter durations. Flooding which can occur during spring and early summer will inundate the site to varying degrees, depending on the quantity of floodwater. Generally the floodplain will begin to become significantly inundated once general over the bank flows occur at approximately 50,000ML/day flow into the site. These flows now only occur on an average once in 10 to 12 years.

17. Physical features of the catchment area:
Describe the surface area, general geology and geomorphological features, general soil types, and climate (including climate type).

The Murray-Darling Basin occurs within five states of Australia and has a surface area of 1.06 million square kilometres (14% of Australia). It covers 14 degrees of latitude (24 to 38 degrees South). The River Murray is 2,530km long from its source in the Australian Alps to its mouth. The Riverland site is located near the lower end of the basin, approximately 568Km from the river mouth. Much of the Basin is flat, with highlands occurring the east and south where metamorphic and igneous rocks outcrop, providing the greatest relief in the basin. Sandstones and other sedimentary rocks also outcrop in the Basin (Murray-Darling Basin Ministerial Council 1987).

The Murray has five geomorphological tracts (Mackay & Eastburn 1990): ***The Headwaters***: extending about 450 river km from the source. This tract is <2% of the Basin area, but contributes nearly 40% of the discharge. ***The Riverine Plains***: a flat, 800 river km tract of river and lake deposits where the Murray flows in shallow, branching, meandering channels. ***The Mallee Trench***: a 850 river km plain of marine origin, crossed by the river in a well-defined incised channel. ***The Mallee Gorge***: a 350 river km channel flanked by steep limestone cliffs. ***The Lakes and Coorong***: including the terminal lakes, Lake Alexandrina and Albert, and the Coorong. This area also is a Ramsar site. The Riverland Ramsar Site is located within the Mallee Trench.

Soil types range from acid leached soils in the east to skeletal soils and desert loams in the northwest and red-brown earths and other highly calcareous soils in the southwest. On the westerly draining plains of the Basin's northern rivers there are extensive areas of fertile black cracking clay soils. In contrast, the plains of the Basin's southern rivers have poorer grey and brown clay soils. These alluvial plains occupy one-third of the Basin (Murray-Darling Basin Ministerial Council 1987).

Agriculture is the dominant economic activity in the Basin, which is Australia's most important agriculture region. Most of the basin's area is devoted to pastoral and dryland farming (sheep, cattle and grain crops). However there are parts of the Basin where irrigation dominates the landscape and involves the growing of pasture, fodder and grain crops, cotton, and horticulture crops. Almost 75% of Australia's irrigated crops occur in the Murray-Darling Basin. Forestry, mining and electricity generation are also significant economic activities within the Basin.

Rainfall varies from over 1400mm per annum in the highlands to below 300mm in the west and northwest. Annual variability of rainfall increases inland. Virtually the entire Basin experiences droughts and floods from time to time. Temperatures range from average summer maxima of over 30° C in the northwest, to winter maxima averaging less than 0° C in alpine areas. Except in alpine areas, potential evaporation far exceeds rainfall (Murray-Darling Basin Ministerial Council 1987).

18. Hydrological values:
Describe the functions and values of the wetland in groundwater recharge, flood control, sediment trapping, shoreline stabilization, etc.

The aquatic vegetated backwaters adjacent to the main River Murray channel can trap sediments, and their complex food chains trap nutrients, thus reducing the risk of toxic blue-green algae blooms further downstream. Large dry wetlands such as Coombool Swamp and Lakes Limbra and Littra within the Riverland Ramsar site are able to absorb large volumes of water during periods of floods. They slow the rate at which floodwaters rise and cause lower flood peaks than if water was confined to the main channel. Floodwater is stored in Lake Merreti and is released to dilute flows down Ral Ral Creek, once salinity levels become elevated after floods recede.

19. Wetland Types

a) presence:

Circle or underline the applicable codes for the wetland types of the Ramsar "Classification System for Wetland Type" present in the Ramsar site. Descriptions of each wetland type code are provided in Annex I of the *Explanatory Notes & Guidelines*.

Marine/coastal: A • B • C • D • E • F • G • H • I • J • K • Zk(a)

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

Human-made: 1 • 2 • 3 • 4 • 5 • 6 • 7 • 8 • 9 • Zk(c)

b) dominance:

List the wetland types identified in a) above in order of their dominance (by area) in the Ramsar site, starting with the wetland type with the largest area.

Xf, M, P, O, Tp, R, N and Ts

20. General ecological features:

Provide further description, as appropriate, of the main habitats, vegetation types, plant and animal communities present in the Ramsar site, and the ecosystem services of the site and the benefits derived from them.

The Riverland Ramsar site has a rich diversity of terrestrial and aquatic habitats. Terrestrial habitats include forest, woodland, shrubland, herbfield and grassland areas. On the floodplain these habitats can intermittently become aquatic systems for varying degrees of time depending on the size and length of a flood event and the elevation of the particular habitat. The truly aquatic habitats range from deep to shallow open freshwater areas, saline shallow open water to shallow and deep freshwater marshes. Major vegetation types within the site are: River Red Gum (*Eucalyptus camaldulensis*) forest and woodland; Black Box (*Eucalyptus largiflorens)* woodland; Lignum (*Muehlenbeckia florulenta)* shrubland; River Saltbush (*Atriplex rhagodioides)* chenopod shrubland; Low chenopod shrubland (dominated by *Atriplex* spp. and *Sclerolaena* spp.); Samphire (e.g. *Halosarcia* spp.) low shrubland; and Herbfield (with a wide variety of species).

Native animal species recorded within the site have included one hundred and seventy-nine species of birds (of which sixty-three species are wetland dependant - see Appendix III), sixteen species of fish, thirty-eight reptile species, nineteen native mammal species, all eight frog species known to inhabit the River Murray floodplain within the region.

During periods of medium to large flood events, colonial waterbirds nest on both Lake Merriti and Lake Littra. Lake Merriti has the largest colonies and in a year when there is a large flood, can number over 1,000 nests of up to six breeding species. The dominant species are Australian Ibis (*Threskiornis molucca)* and Straw-necked Ibis (*Threskiornis spinicollis*). Both Ibis species also breed at Lake Woolpoolool when inundated.

Ecosystem services include: *Wetland products* (drinking water for humans and livestock, water for irrigated agriculture and livestock fodder); *Regulating services* (flood retardation, sediment and nutrient deposition and replenishment of groundwater); *Cultural services* [aesthetic values, cultural heritage, sense of place (cultural significance), educational values, recreational fishing and hunting, water sports and activities, camping and touring and nature observation and commercial based ecotourism]; and *Supporting services* (maintaining bioregional biodiversity, supporting an abundance of particular species, supporting a significant proportions of particular species populations, being representative of a bioregion, supporting threaten species and being important as habitat for animal taxa as a refuge during adverse conditions).

21. Noteworthy flora:

Provide additional information on particular species and why they are noteworthy (expanding as necessary on information provided in 14, Justification for the application of the Criteria) indicating, e.g., which species/communities are unique, rare, endangered or biogeographically important, etc. *Do not include here taxonomic lists of species present – these may be supplied as supplementary information to the RIS*.

Twenty-eight significant plant species are listed at the State level under the *National Parks and Wildlife Act* 1972 and inhabit the site on a permanent or seasonal basis. These are listed in Appendix VII.

22. Noteworthy fauna:

Provide additional information on particular species and why they are noteworthy (expanding as necessary on information provided in 14. Justification for the application of the Criteria) indicating, e.g., which species/communities are unique, rare, endangered or biogeographically important, etc., including count data. *Do not include here taxonomic lists of species present – these may be supplied as supplementary information to the RIS*.

The Riverland wetland supports the following nationally threatened species defined under section 179 of the Australian "*Environment Protection and Biodiversity Conservation Act* 1999":

- Regent Parrot (Eastern) (*Polytelis anthopeplus monarchoides)* listed as Vulnerable
- Southern Bell Frog (*Litoria raniformis)* listed as Vulnerable
- *Murray Cod (Maccullochella peeli)* listed as Vulnerable
- Murray hardyhead *(Craterocephalus fluviatilis)* listed as Vulnerable.

Significant fauna species listed at a State level and inhabiting the site on a permanent or seasonal basis are displayed in Appendix VIII.

23. Social and cultural values:

a) Describe if the site has any general social and/or cultural values e.g., fisheries production, forestry, religious importance, archaeological sites, social relations with the wetland, etc. Distinguish between historical/archaeological/religious significance and current socio-economic values:

Socio-economic values include: recreational fishing of both native and introduced fish along the River Murray and backwaters within the Riverland Ramsar site; tourism and recreational activities such as bush camping, fishing, boating, house boating and accommodation in shearers quarters; high values as a site for the canoeing component of outdoor educational programs for secondary schools, tertiary educational classes and youth agencies. The water resource flowing down this section of the River Murray has been the catalyst for the region's economic development, including the pastoral industry, riverboat trade during the 1880's, and the high tech irrigation industry of the present day.

Significant environmental scientific research has been undertaken within the site, including the Chowilla floodplain integrated natural resource management program in the early 1990's and more recently through the Riverland Biosphere Reserve program. The Chowilla block is part of the Chowilla Floodplain and Lindsay-Wallpolla Islands Icon Site under Murray Darling Basin Authority's program 'The Living Murray'.

The Riverland has a rich Aboriginal history of some 12,000 years and nearly 180 years of European occupation. Numerous Aboriginal and European heritage sites are located throughout the Ramsar Site. The Maraura, Ngintait and Erawirung Aboriginal peoples occupied the area prior to European settlement.

b) Is the site considered of international importance for holding, in addition to relevant ecological values, examples of significant cultural values, whether material or non-material, linked to its origin, conservation and/or ecological functioning?

If Yes, tick the box ☑ and describe this importance under one or more of the following categories:

i) sites which provide a model of wetland wise use, demonstrating the application of traditional knowledge and methods of management and use that maintain the ecological character of the wetland:

ii) sites which have exceptional cultural traditions or records of former civilizations that have influenced the ecological character of the wetland:

iii) sites where the ecological character of the wetland depends on the interaction with local communities or indigenous peoples:

iv) sites where relevant non-material values such as sacred sites are present and their existence is strongly linked with the maintenance of the ecological character of the wetland:

Refer to section 23a above

24. Land tenure/ownership:
a) within the Ramsar site:

- Murtho Forest Reserve 1,709 hectares, South Australian Government – Primary Industries and Resources SA.
- River Murray National Park (Bulyong Island section) 2,382 hectares, South Australian Government – Department for Environment and Heritage.
- Part Chowilla Game Reserve 14,916 hectares, South Australian Government – Department for Environment and Heritage and leased to Robertson-Chowilla Pty Ltd.
- Part Calperum Station 8,500 hectares, South Australian Government Pastoral Lease - invested in Director National Parks, Australian Government Department of the Environment and Water Resources.
- Crown land, South Australian Government - vested in the Minister for Environment and Conservation, River Murray channel (793ha) and the 150 link wide reserve for public use along the majority of the River's southern bank that became the practice to retain after 1898.
- Local Government 9 hectares – District Council of Renmark Paringa
- Privately owned land, 2,306 hectares involving a number of companies, partnerships or individual owners.

b) in the surrounding area:

To the north is Chowilla Regional Reserve owned by the South Australian Government - Department for Environment and Heritage and the continuation of Calperum Station a pastoral lease owned by the Australian Government. Privately owned or local government (Renmark Paringa District Council) land adjoins the remainder of Ramsar site.

25. Current land (including water) use:
a) within the Ramsar site:

The dominant land use of the Riverland Ramsar site is biodiversity conservation (27,213ha), under Australian, State and Local Government or private ownership. Stock grazing, predominantly sheep, is the next largest land use within the Ramsar site and involves an area of 3,370 hectares. Approximately 70 domestic or irrigation pumps take water from the main channel, backwaters or anabranch creeks within the Riverland wetland. Two small irrigation based enterprises exist within the Ramsar site.

A limited number of commercial fishers have been issued a license to take non-native species and Bony Bream (*Nematalosa erebi)* (a common native fish) from the river system. Visitor recreational pursuits are dominantly centered on water-based activities such as fishing, pleasure craft boating, bush camping, canoeing, waterfowl hunting, water-skiing and driving tours.

b) in the surroundings/catchment:

Irrigation pumps located within the Ramsar site supply water to the Cooltong/Chaffey Irrigation Area (1,118 ha), private irrigators from the Ral Ral Anabranch and the Paringa/Murtho area (4,000ha) to irrigated adjacent crops. The dominant horticulture enterprises involve vines and orchards with small areas of vegetables and sown pastures. Dryland farming also occurs to the south of the site and involves cereal grain crops, pastures for hay and livestock. To the north lies Chowilla Regional Reserve that supports a commercial pastoral operation and the remainder of Calperum Station that is managed for biodiversity outcomes.

---

26. 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:

Key factors adversely affecting the site include:

- Alteration to the natural hydrological regime (as described in Section 16, above). Ecological impacts include loss of habitats, barriers to fish passage, loss of species requirements for reproduction and regeneration, degradation of natural low flow channel shape, and thermal stratification that develops anoxic bottom water that favours cyanobacteria. Artificially high water levels have also raised saline ground water levels into the root zone of floodplain vegetation, causing dieback and soil scalding.
- Reduced water quality, particularly higher turbidities during receipt of waters from Menindee Lakes.
- Increased salinity, leading to extensive vegetation death in many areas. Causes include weirs, land clearance and irrigation.
- Introduced fish – Common Carp (*Cyprinus carpio)* and Eastern Gambusia (*Gambusia holbrooki)* impacting on water quality and competing with/preying on native species (frog, fish and invertebrate).
- De-snagging – removal of coarse woody debris (mostly fallen River Red Gums, *Eucalyptus camaldulensis*) leading to massive loss of habitat. This is not a current activity, but was extensive in the past.
- Excessive grazing pressure by domestic stock, feral herbivores and abundant native animals reducing regeneration of native vegetation, destroying habitat value and decreasing river bank stability.
- Weeds - A floodplain vegetation survey conducted in part of the site during 1988 and 1989 revealed that 22% of the 307 species of vascular plants were introduced (O'Malley & Sheldon 1990). More than half of the species corresponded to localities that had been exposed to intensive pastoral activities. The list included the following species of significant environmental and/or economic concern African Boxthorn (*Lycium ferocissimum*), Bathurst Burr (*Xanthium spinosum)*, California Burr (*Xanthium californicum),* Golden Dodder *(Cuscuta campestris),* Prickly Pear *(Opuntia spp.),* Willows (*Salix sp.*) and Poison Buttercup (*Ranunculus scleratus*).
- Introduced animals - a significant number of introduced animals, bird and fish species inhabit the Riverland wetland. In particular, predation by foxes (*Vulpes vulpes*) and cats (*Felis catus*) pose significant risk to threatened species such as Broad-shell Tortoise (*Chelodina expansa*), Carpet Python (*Morelia spilota variegata*), and Bush Stone-curlew(*Burhinus grallarius*).
- Unsustainable recreational use. Issues include waste disposal; destruction of vegetation and soil compaction through the establishment of camping sites and excessive firewood removal; vehicle track proliferation; uncontrolled pets; disturbance to colonial nesting waterbirds from boating; and river and creek bank erosion and sedimentation from wave wash and indiscriminate boat mooring

b) in the surrounding area:

An environmental audit of the rivers within the Murray-Darling Basin (Norris *et.al.*2001) rated the river zone in which the Riverland Ramsar site is located as being poor, very poor or extremely poor for 10 out of 11 biotic/environmental features ('in-stream salinity was the only feature that rated as 'good'). Impacts from the surrounding area and up-catchment include changes to hydrology, decreasing water quality and habitat degradation. The Sustainable Rivers Audit Report indicates that the Lower Murray reach of the Murray-Darling Basin in which the Riverland Ramsar Site is located was of poor condition for all three factors examined (Fish, Hydrology and Macroinvertebrates) during surveys in 2004-2007 (Davies et al. 2008).

---

27. Conservation measures taken:

a) List national and/or international category and legal status of protected areas, including boundary relationships with the Ramsar site:

In particular, if the site is partly or wholly a World Heritage Site and/or a UNESCO Biosphere Reserve, please give the names of the site under these designations.

A significant proportion of the Riverland Ramsar site is under some type of government legal protection. The areas are as follows;

- The whole of the Riverland Ramsar site is incorporated into the Riverland Biosphere Reserve,
- Murtho Forest Reserve (1,709 hectares)
- River Murray National Park (Bulyong Island section) (2,382 hectares)
- Part Chowilla Game Reserve (14,916 hectares)
- Part Calperum Station 8,500 hectares invested in the Director National Parks and managed by the Australian landscape Trust under contract to implement UNESCO's Man and Biosphere program objectives.
- Native Vegetation Heritage Agreement 90 hectares, privately owned land under State Government Native Vegetation Act Agreement.

b) If appropriate, list the IUCN (1994) protected areas category/ies which apply to the site (tick the box or boxes as appropriate):

Ia ❑;Ib ❑; II ☑; III ❑; IV ☑; V ❑; VI ☑

c) Does an officially approved management plan exist; and is it being implemented?:

No, however a draft plan is being developed. Most of the area is under individual management plans for the categories listed in Section 27(a), above.

d) Describe any other current management practices:

Plans of Management - A number of catchment and local plans regulate or promote protective actions throughout and/or adjacent to the site. They are;

- Water Allocation Plan for the River Murray Prescribed Watercourse, 2002
- Integrated Natural Resource Management Plan for the South Australian Murray-Darling Basin, 2003 (Integrated Natural Resource Management Group for the SA Murray Darling Basin Inc.).
- Biodiversity Plan for the South Australian Murray-Darling Basin, 2001 (Department for Environment and Heritage).
- Renmark to the Border Local Action Plan, 1999 (Renmark to the Border Local Action Planning Association Incorporated).
- Murtho Land and Water Management Plan, 1999, Ral Ral Land and Water Management Plan, 1999 and Merreti Land and Water Management Plan, 1999 (Renmark to the Border Local Action Planning Association Incorporated).

A number of wetland site plans and guidelines have been developed. They are;

- Chowilla Regional Reserve and Game Reserve Management Plan, 1995.
- Murray River National Park Management Plan, 1994.
- Chowilla Resource Management Plan, 1995.
- Lakes Woolpoolool and Merreti Wetland Complex Habitat Management Plan, 2002.
- Management and Restoration Plan – Lake Woolpoolool, 2003.
- Lake Merreti - Hydrological Management Guidelines, 2002.
- Wetland Management Plans for Lakes Littra and Limbra, Werta Wert Lagoons, Slaney and Pipeclay Billabong and the Pibly Complex, 2006.
- Chowilla Floodplain Living Murray Asset Plan 6.3, 2006

Community Participation - The following community groups are involved in either the management of a particular site or issues within the Riverland Ramsar site:

- South Australian Murray-Darling Natural Resources Management Board – responsible for integrated natural resource management at a regional level, has a range of responsibilities and powers under the *Natural Resources Management Act* 2005.
- Renmark to the Border Local Action Planning Association Inc. – promotes community on ground action through the development and implementation of local Land and Water Management Plans
- National Parks and Wildlife Murraylands Consultative Committee – provides management advice to the Department for Environment and Heritage regarding Chowilla Game Reserve and the Murray River National Park.
- Friends of Riverland Parks – assist Department for Environment and Heritage staff in the management of Chowilla Game Reserve and the Murray River National Park.
- The Field and Game Association of South Australia - Renmark and Berri Branch manage under lease a section of Murtho Forest Reserve as a game reserve.
- Woolenook Wetlands Association - undertake environmental management and restoration actions within the Woolenook Bend wetland complex.
- Whirlpool Corner Wetland Group - undertake environmental management and restoration actions on the Whirlpool Corner wetland and adjacent floodplain.
- Templeton Wetland group - undertake environmental management and restoration actions on the Templeton Wetland and adjacent floodplain
- Pilby Lagoon Committee – assists the Department for Environment and Heritage in the management of Pilby Lagoon wetland.
- Community Land Management Inc. – assists Australian Landscape Trust in the management of biodiversity on Calperum Station.

The Living Murray - In 2002, the Murray Darling Basin Ministerial Council established The Living Murray Initiative in response to concerns about the environmental and economic health of the River Murray system. The initiative involves a number of collective actions to return the system to a healthy working river. In 2003 a decision was made to commit $500m to the First Step of The Living Murray Initiative, that is, to recover 500GL of water over five years (from 2004) to improve environmental flows at six Icon Sites along the River Murray. The six sites that will benefit from the First Step are the Barmah-Millewa Forests, Gunbower-Pericoota Forests, Hattah Lakes, Chowilla Floodplain and Lindsay-Wallpolla Islands, the Murray Mouth (including the Coorong and the Lower Lakes) and the River Murray Channel.

The Chowilla Floodplain and Lindsay-Wallpolla Islands Icon Site has limited chance of achieving the MDBMC objectives without intervention. Through mechanisms such as weir pool manipulation, modification of existing flow control structures, the installation of new flow control structures, groundwater management schemes, wetland management including watering initiatives, land management, the recovery of 500GL/year, and by maximising water releases from local storages; it is anticipated that significant ecological benefits to the Chowilla Floodplain and Lindsay-Wallpolla Islands Icon Site will be delivered. This will help preserve the significant environmental, social and cultural heritage values of the site.

28. Conservation measures proposed but not yet implemented:
e.g. management plan in preparation; official proposal as a legally protected area, etc.

As indicated in section 27 a number of governmental endorsed management plans have been developed for sites and/or cover management issues within the Ramsar site. A management plan for the Riverland Ramsar wetland that integrates existing plans, government policies and strategies is presently being developed by the South Australian Department for Environment and Heritage in conjunction with a Community Steering Group.

29. Current scientific research and facilities:
e.g., details of current research projects, including biodiversity monitoring; existence of a field research station, etc.

A number of research institutions, Universities, government agencies, private organisations and community groups are currently undertaking the following research and monitoring activities;

- Environmental flow enhancement,
- Saline groundwater distribution and impacts on river salinity and floodplain vegetation health,
- Hydrological management of wetlands and ecosystem response,
- Total grazing impacts on floodplain vegetation communities,
- Threatened species natural history and distribution,
- Floodplain biological surveys,
- Cultural heritage surveys
- Species ecology, and
- Surface and ground water quality.

30. Current communications, education and public awareness (CEPA) activities related to or benefiting the site:
e.g. visitors' centre, observation hides and nature trails, information booklets, facilities for school visits, etc.

The majority of environmental education activities within the Riverland Ramsar site are centered on Calperum Station and Chowilla Game Reserve. However students from local and non-local educational institutions also utilise other sites within the Riverland wetland as an outside classroom especially for Water Watch and other related activities.

Calperum Station has accommodation facilities and conducts programs, including camps, aimed at students from primary school to university. The site is also a focal point for the annual state frog census survey that attracts over 150 local students and parents. Calperum has a major information bay that describes the properties programs and partnerships, the Man and Biosphere Reserve program, and the mallee and floodplain ecosystems. A booklet has been published which describes the properties history, ecology and management programs.

Chowilla Game Reserve focuses on visitor education due to the high recreational use of the Reserve. Two information bays have been established at visitor focal points and are designed to inform visitors and encourage them to utilise the area in a sustainable manner. At the Border Cliffs Customs House the Game Reserve offers a 4km self guided wetland walking trail and board walk that provides visitors with an insight into the natural environment. A booklet has also been published on the history of the Border Cliffs Customs House. Following the Chowilla Anabranch for 25 kilometres is the Old Coach Road self guided vehicle trail that informs visitors of past and present human occupation and management and aspects of the natural environment.

31. Current recreation and tourism:
State if the wetland is used for recreation/tourism; indicate type(s) and their frequency/intensity.

Recreation - The Riverland wetland contains many features of interest to visitors and locals especially along the River Murray and adjacent anabranch systems. The main activities pursued are; fishing both fin-fish and crustaceans, house boating, bush camping, canoeing, waterfowl hunting, general boating, water-skiing and driving tours. There are six public boat ramps located within the wetland, and significant numbers of boats travel the Riverland Ramsar site section of the River Murray.

Tourism - The site supports a significant tourism industry that relies on the Wetland's values for survival. Three houseboat marinas are located within the Ramsar site, one with 33 sites on the downstream end of the Ral Ral Anabranch, and two sites on the River Murray. The total number of houseboats utilising the Ramsar site on a regular basis from marinas located in or adjacent to the wetland is over 80. A paddle streamer "Industry" licensed to carry 70 people and operated by the local community conducts tours along the River Murray within the Riverland wetland.

32. Jurisdiction:
Include territorial, e.g. state/region, and functional/sectoral, e.g. Dept of Agriculture/Dept. of Environment, etc.

Commonwealth Government; Murray Darling Basin Authority
Dept of Environment, Water, Heritage and the Arts
South Australian Government; The Department of Water, Land and Biodiversity Conservation
Department for Environment and Heritage
Primary Industries & Resources SA
South Australian Murray Darling Basin Natural Resources Management Board
Renmark Paringa Council

33. Management authority:
Provide the name and address of the local office(s) of the agency(ies) or organisation(s) directly responsible for managing the wetland. Wherever possible provide also the title and/or name of the person or persons in this office with responsibility for the wetland.

At present there is no single management authority, however the following Government department has taken on a coordination role:

Department for Environment and Heritage
Regional Conservation Directorate
Murraylands Region
PO Box 231Berri, South Australia, 5343
Australia
Telephone Number 08 8595 2222
Contact Person: Mr. Mike Harper, Wetland Officer

34. Bibliographical references:
Scientific/technical references only. If biogeographic regionalisation scheme applied (see 15 above), list full reference citation for the scheme.

Australian Landscape Trust, (2002) Calperum & Taylorville Stations 2001-2002 Research and Monitoring Report, Renmark.

AWRC. 1975. Review of Australia's Water Resources 1975, Map 5, Australian Water Resources Council, Commonwealth of Australia, Canberra.

BirdLife International 2008. 2008 IUCN Red List of Threatened Species.

Carpenter, G. 1990. Avifauna. In: O'Malley, C. & F. Sheldon. Chowilla Floodplain Biological Study. Nature Conservation Society of South Australia, Adelaide, SA.

Crabb P., (1997), *Murray-Darling Basin Resources*. Murray-Darling Basin Commission, Canberra

Davies PE, JH Harris, TJ Hillman and KF Walker 2008. SRA Report 1: A Report on the Ecological Health of Rivers in the Murray–Darling Basin, 2004–2007. Prepared by the Independent Sustainable Rivers Audit Group for the Murray– Darling Basin Ministerial Council.

DEWHA (2007) Australian Natural Resources Atlas. http://www.anra.gov.au/topics/water/overview/index.html#river

Department of Water, Land and Biodiversity Conservation (undated). Chowilla Integrated Natural Resource Management Project. Department of Water, Land and Biodiversity Conservation, South Australia. Undated report.

Environment Australia, (2000) *Revision of the Interim Biogeographic Regionalisation for Australia (IBRA) and Development of Version 5.1*

Growns, I. (2004) A numerical classification of reproductive guilds of the freshwater fishes of south-eastern Australia and their application to river management. Fisheries Management and *Ecology*, 11, 369–377.

Harper M. J., (Personal Communication),. Department for Environment and Heritage, Berri, South Australia.

Hollingsworth I.D., Meissner A.P. & Davies G., (1990) *A reconnaissance Soil survey of the Chowilla Anabranch System of the River Murray in SA and NSW*., Prepared for the Murray-Darling basin Commission by the South Australian Department of Agriculture, Adelaide.

Lloyd, L.N. 1990. Fish Communities. In: O'Malley, C. & F. Sheldon. Chowilla Floodplain Biological Study. Nature Conservation Society of South Australia, Adelaide, SA.

Laut P., Heyligers P.C., Keig G., Loffler E., Margules C., Scott R.M. and Sullivan M.E., (1977). *Environments of South Australia: Province 2 Murray Mallee*. CSIRO, Canberra.

Mackay, N. (1990). Understanding the Murray. In Mackay, N. and Eastburn, D. (Eds.). *The Murray*. Murray Darling Basin Commission, Canberra, Australia

Mackay N. and Eastburn D., (1990) *The Murray. Murray Darling Basin Commission,* Canberra, Australia

Margules and Partners PTY LTD, P and J Smith Ecological Consultants and Department of Conservation Forests and Lands Victoria, (1990) *River Murray Riparian Vegetation Study*

Murray-Darling Basin Ministerial Council, (1987*) Murray-Darling Basin Environmental Resources Study*. Murray-Darling Basin Commission, Canberra

Nichols, S. and Gilligan, D. (2004) What about the fish? Improving fish passage through wetland flow control structures in the lower River Murray. Australian Landscape Trust and New South Wales Fisheries.

Norris R. H., Liston P., Davies N., Coysh J., Dyer F., Linke S., Prosser I. & Young B., (2001) *Snapshot of the Murray-Darling Basin River Condition*. Report to the Murray-Darling Basin Commission

O'Malley C., Sheldon F., (1990) *Chowilla Floodplain Biological Study*. Nature Conservation Society of South Australia Inc

Parks Australia. 2005. Calperum and Taylorville Stations Management Plan (Draft). Parks Australia, Australian Government Department of the Environment and Heritage January 2005.

Pierce, B. E. 1990. Chowilla Fisheries Investigations. Murray Darling Basin Commission

Pierce B. E., (1997) *The Fish Factory*, Southern Fisheries Autumn 1997

Sharley T. and Huggan C., (1995) *Chowilla Resource Management Plan- Final Report*. Prepared by the Murray-Darling Basin Commission's Chowilla Working group in consultation with the Chowilla Reference Group.

SKM. 2005. River Murray Wetlands Baseline Survey 2005.

Smith, K., (1992). *The Regent Parrot in South Australia – Survey of breeding distribution & photographic index of nesting sites.*

Smith K. W., (2001) *Regent Parrot Nest Survey 2000 – A report on regent parrot nesting and monitoring in the South Australian Riverland.*

Suter P.J., Goonan P.M., Beer J.A. and Thompson T.B., (1993) *A Biological and Physico-Chemical Monitoring Study of Wetlands from the River Murray Floodplain in South Australia.* Australian centre for Water Quality Research. Report No. 7/93

Thomson R.M., (1975) *Geomorphology of the Murray Valley in South Australia.* M.A. thesis, University of Adelaide.

Thompson M.B., (1986) *River Murray Wetlands, Their Characteristics, Significance and Management. Report on a study of wetlands along the South Australian section of the River Murray (including Lower lakes and Coorong).* University of Adelaide.

Tucker P. (2003) Pilby Wetland Hydrological Guidelines. Australian Landscape Trust.

Wetlands Working Party, (1988) Enhancing Wetlands. South Australian River Murray Wetlands Working Party Report.

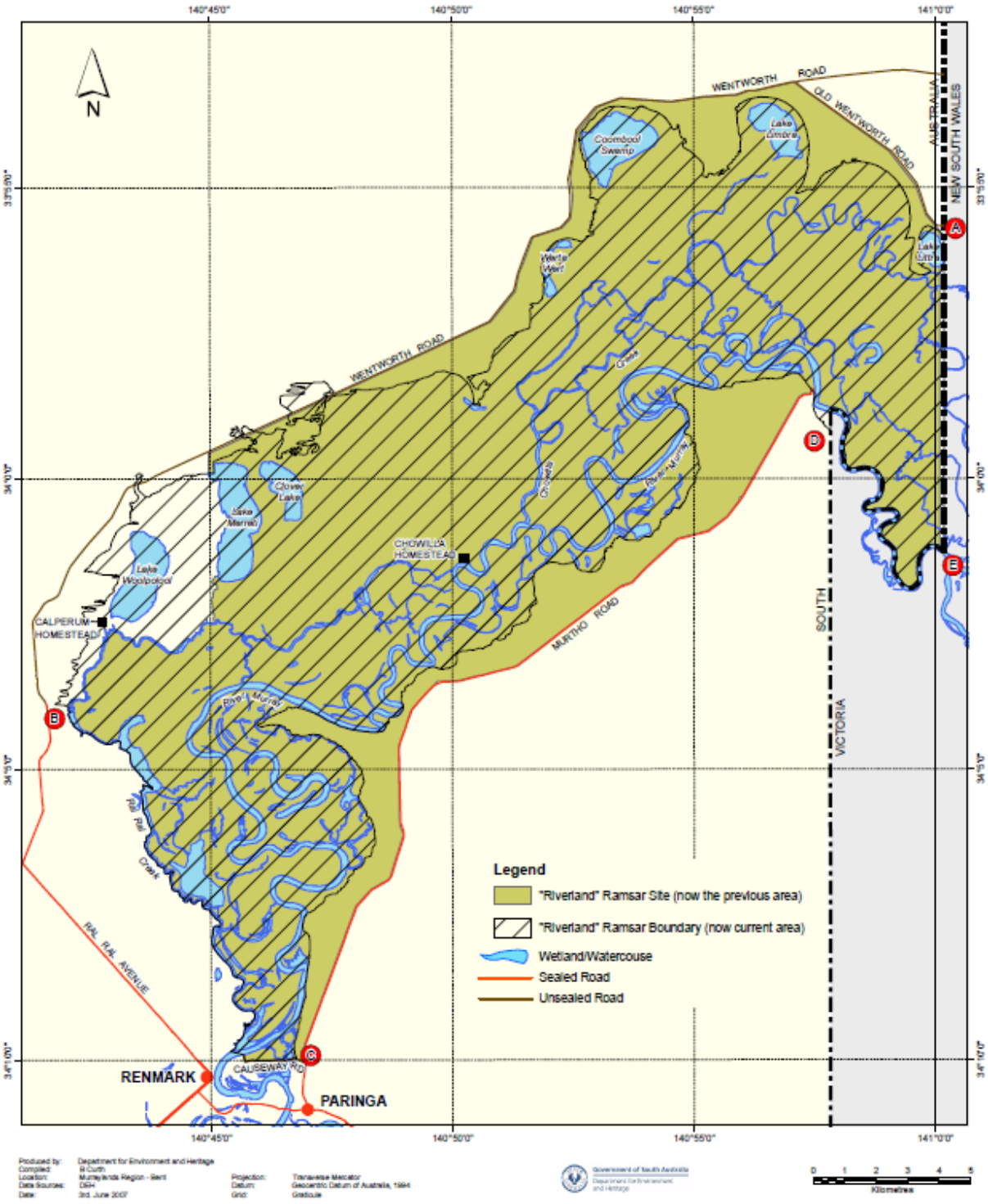
Woodward-Clyde, (1999) *Impacts of Irrigation on Floodplain Health and Implication's for Future Management Options*, Prepared for the Renmark to the Border Local Action Planning Association Incorporated.

Zampatti, B., J. Nichol, S. Leigh, S. & C. Bice. 2006a. 2005 Progress Report for the Chowilla Fish and Aquatic Macrophyte Project. SARDI Aquatic Sciences, Inland Waters Program, February, 2006

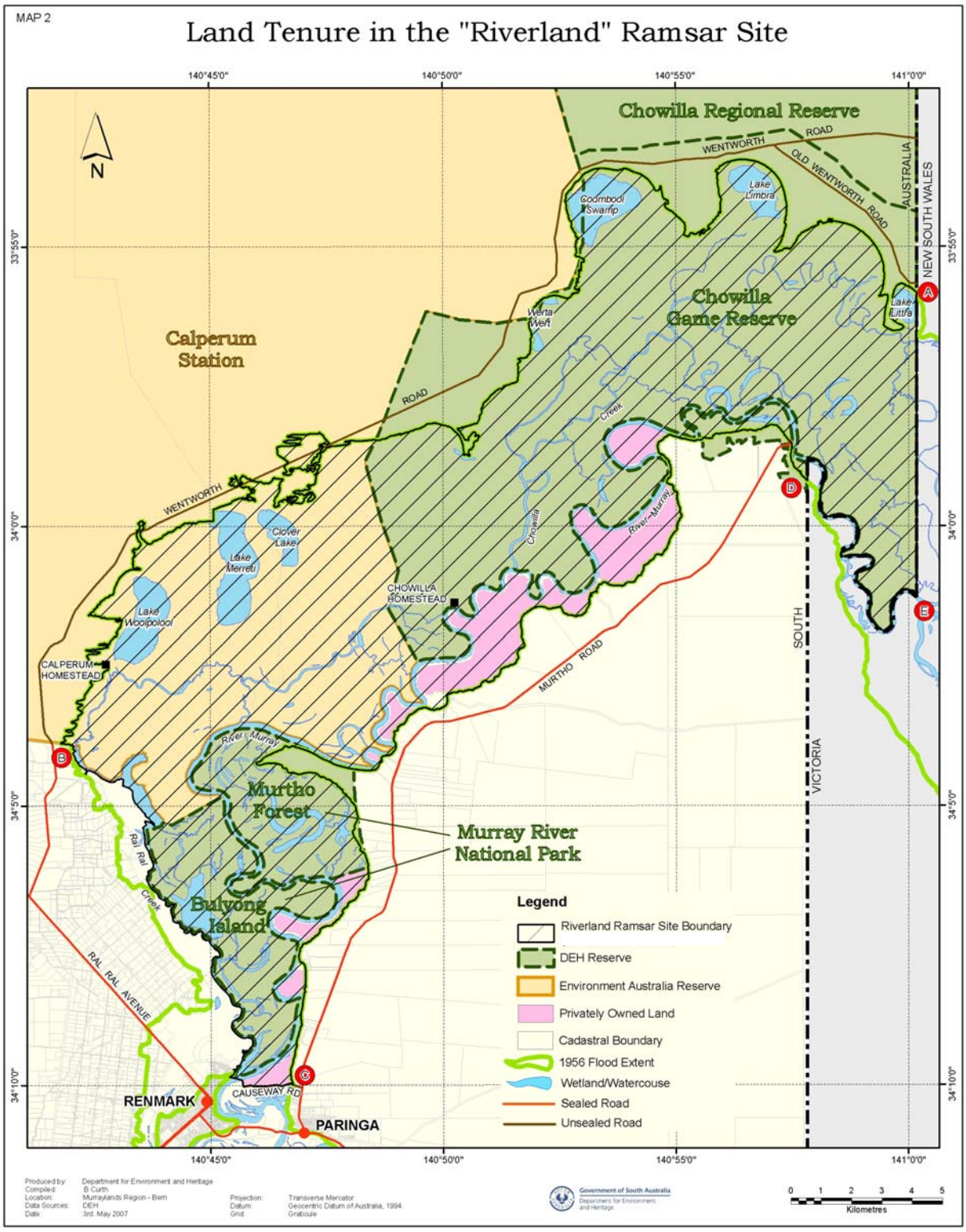
Zampatti, B., S. Leigh, J. Nicol, J. Weedon. 2006b. Progress Report for the Chowilla Fish and Aquatic Macrophyte Project. SARDI Aquatic Sciences, Inland Waters Program, November, 2006.

Please return to: **Ramsar Convention Secretariat, Rue Mauverney 28, CH-1196 Gland, Switzerland**
Telephone**: +41 22 999 0170** • Fax: **+41 22 999 0169** • e-mail: **ramsar@ramsar.org**

Appendix I: Map of boundary changes to the Riverland Ramsar Site



Appendix II: Map of Riverland Ramsar Site



Appendix III: **Birds recorded utilising the Riverland Ramsar Wetland**

A. Birds listed under international migratory agreements recorded in the Riverland Ramsar Site:

Eastern Great Egret (*Ardea modesta)* (JAMBA, CAMBA)
Glossy Ibis (*Plegadis falcinellus)* (CAMBA)
White-bellied Sea-Eagle (*Haliaeetus leucogaster)* (CAMBA)
Red-necked Stint (*Calidris ruficollis)* (JAMBA, CAMBA, ROKAMBA)
Sharp-tailed Sandpiper (*Calidris acuminata)* (JAMBA, CAMBA, ROKAMBA)
Curlew Sandpiper (*Calidris ferruginea)* (JAMBA, CAMBA, ROKAMBA)
Greenshank (*Tringa nebularia)* (JAMBA, CAMBA,ROKAMBA)
Caspian Tern (*Hydroprogne caspia)* (CAMBA)

B. Waterbirds that rely upon the Riverland Ramsar Site during times of drought in central and eastern Australia:

Hoary-headed Grebe (*Poliocephalus* p*oliocephalus)*
Yellow-billed Spoonbill (*Platalea flavipes)*
Freckled Duck (*Stictonetta naevosa)*
Pink-eared Duck (*Malacorhynchus membranaceus)*
Grey Teal (*Anas gracilis)*
Australasian Shoveler (*Anas rhynchotis)*
Hardhead (*Aythya australis)*
Black-tailed Native-hen (*Tribonyx ventralis)*
Eurasian Coot (*Fulica atra)*
Banded Stilt (*Cladorhynchus leucocephalus*)
Black-winged Stilt (*Himantopus himantopus)*
Red-necked Avocet (*Recurvirostra novaehollandiae)*
Red-caped Plover (*Charadrius ruficapillus)*
Whiskered Tern (*Chlidonias hybridus)*
Caspian Tern *(Hydroprogne caspia)*

C. Nomadic bush-bird species that use the Riverland Ramsar Site during the dry southern Australian summer period:

Cockatiel (*Nymphicus hollandicus)*
Budgerigar (*Melopsittacus undulatus)*
Pallid Cuckoo (*Cuculus pallidus)*
Fan-tailed Cuckoo (*Cuculus pyrrophanus)*
Black-eared Cuckoo (*Chrysococcyx osculans)*
Horsfield's Bronze Cuckoo (*Chrysococcyx basalis)*
Red-backed Kingfisher (*Halcyon pyrrhopygia)*
Whited-breasted Wood Swallow (*Artamus leucorhynchus)*
Black-faced Wood Swallow (*Artamus cinereus)*
White-winged Triller (*Lalage sueurii)*

D. Wetland dependent birds recorded utilising the Riverland Ramsar Site

Hoary-headed Grebe (*Poliocephalus poliocephalus*)
Australian Grebe (*Tachybaptus novaehollandiae)*
Great Crested Grebe (*Podiceps cristatus)*
Australian Pelican (*Pelecanus conspicillatus*)
Great Cormorant (*Phalacrocorax carbo*)
Little Black Cormorant (*Phalacrocorax sulcirostris*)
Pied Cormorant (*Phalacrocorax varius*)
Little Pied Cormorant (*Phalacrocorax melanoleucos*)
Australian Darter (*Anhinga novaehollandiae*)
White-necked Heron (*Ardea pacifica*)
Eastern Great Egret (*Ardea modesta*)
Intermediate Egret (*Ardea intermedia*)
White-faced Heron (*Egretta novaehollandiae*)
Little Egret (*Egretta garzetta*)
Cattle Egret (*Ardea ibis*)
Australian Bittern (*Botaurus poiciloptilus*)
Nankeen Night-Heron (*Nycticorax caledonicus*)
Australian White Ibis (*Threskiornis molucca*)
Straw-necked Ibis (*Threskiornis spinicollis*)
Glossy Ibis (*Plegadis falcinellus*)
Royal Spoonbill (*Platalea regia*)
Yellow-billed Spoonbill (*Platalea flavipes*)
Black Swan (*Cygnus atratus*)
Freckled Duck (*Stictonetta naevosa*)
Australian Shelduck (*Tadorna tadornoides*)
Pink-eared Duck (*Malacorhynchus membranaceus*)
Grey Teal (*Anas gracilis*)
Chestnut Teal (*Anas castanea*)
Pacific Black Duck (*Anas superciliosa*)
Australasian Shoveler (*Anas rhynchotis*)
Hardhead (*Aythya australis*)
Australian Wood Duck (*Chenonetta jubata*)
Blue-billed Duck (*Oxyura australis*)
Musk Duck (*Biziura lobata*)
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)
Swamp Harrier (*Circus approximans*)
Buff-banded Rail *(Gallirallus philippensis*)
Australian Spotted Crake (*Porzana fluminea*)
Dusky Moorhen (*Gallinula tenebrosa*)
Black-tailed Native-hen (*Tribonyx ventralis*)
Purple Swamphen (*Porphyrio porphyrio*)
Eurasian Coot (*Fulica atra*)
Black-winged Stilt (*Himantopus himantopus*)
Banded Stilt (*Cladorhynchus leucocephalus*)
Red-necked Avocet (*Recurvirostra novaehollandiae*)
Masked Lapwing (*Vanellus miles*)
Red-capped Plover (*Charadrius ruficapillus*)
Black-fronted Dotterel (*Elseyornis melanops*)
Red-kneed Dotterel (*Erythrogonys cinctus*)
Common Greenshank (*Tringa nebularia*)
Sharp-tailed Sandpiper (*Calidris acuminata*)
Red-necked Stint (*Calidris ruficollis*)
Curlew Sandpiper (*Calidris ferruginea*)
Silver Gull (*Chroicocephalus novaehollandiae*)
Whiskered Tern (*Chlidonias hybrida*)
Gull-billed Tern (*Gelochelidon nilotica*)
Caspian Tern (*Hydroprogne caspia*)
Australian Reed-Warbler (*Acrocephalus australis*)
Golden-headed Cisticola (*Cisticola exilis*)

E. Waterbirds recorded breeding at the Riverland Ramsar Site

- Little-pied Cormorant (*Phalacrocorax. melanoleucos*)
- Black Swan (*Cygnus atratus*)
- Australian Shelduck (*Tadorna tadornoides*)
- Pacific Black Duck (*Anas superciliosa*)
- Australian Grey Teal (*Anas gracilis*)
- Australian Wood Duck (*Chenonetta jubata*)
- Masked Lapwing (*Vanellus miles*)
- Red-capped Plover (*Charadrius ruficapillus*)

Appendix IV: Indigenous fish species found within the Riverland Ramsar site (Lloyd 1990; Pierce 1990; Harper 2003; Zampatti et al. 2005 & 2006)

Family	**Species**	**Common Name**	**Reproductive Guild***
Clupeidae	*Nematalosa erebi*	Bony Herring	D2
Retropinnidae	*Retropinna semoni*	Australian Smelt	A
Plotosidae	*Tandanus tandanus*	Freshwater Catfish[E]	C2
Melanotaeniidae	*Melanotaenia fluviatilis*	Crimson-spotted Rainbowfish	A
Atherinidae	*Craterocephalus fluviatilis*	Murray Hardyhead[E*]	A
	Craterocephalus stercusmuscarum fulvus	Flyspecked Hardyhead[V]	A
Percichthyidae	*Maccullochella peelii peelii*	Murray Cod[V*]	C2
	Maccullochella macquariensis#	Trout Cod[E]	C2
	Macquaria ambigua	Golden Perch	D1
Teraponidae	*Bidyanus bidyanus*	Silver Perch[E]	D1
Kuhliidae	*Nannoperca australis#*	Southern Pigmy Perch[E]	B
Eleotridae	*Hypseleotris klunzingeri*^	Western Carp Gudgeon	C2
	Hypseleotris sp. A^	Midgley's Carp Gudgeon	C2
	Hypseleotris sp. B^	Lake's Carp Gudgeon	C2
	Philypnodon grandiceps	Flathead Gudgeon	C2
	Philypnodon sp. 2	Dwarf Flathead Gudgeon	C2

#Not recorded in recent surveys

^Regarded as a species complex with species A and B not formally described

[E]Regarded as endangered in SA

[V] Regarded as vulnerable in SA

[*] Listed under the EPBC Act

*according to Growns (2004):

Guild	Definition
A	Adhesive, demersal eggs with no parental care
B	Low fecundity, small non-adhesive demersal eggs with short incubation times
C2	Show parental care, including nest building and protection of young with species not generally undergo a spawning migration and have large eggs
D1	Single spawning species with high fecundity, non-adhesive eggs with no parental care with species undergoing a spawning migration
D2	Single spawning species with high fecundity, non-adhesive eggs with no parental care and display no spawning migration

Appendix V: Key species major of vegetation communities at the Riverland Ramsar Site

River Red Gum *Eucalyptus camaldulensis* forest/woodland over low open shrubs of Ruby Saltbush *Enchylaena tomentosa*, Nitre Goosefoot *Chenopodium nitrariaceum* or Spreading Emu-bush *Eremophila divaricata* or with forb +/- sedge +/- grass understorey or floating freshwater aquatic herbland. .

Black Box (*Eucalyptus largiflorens)* woodland with either ephemeral forb/grass, chenopod shrubland dominated by *Atriplex* and *Sclerolaena* spp. or Pigface *Disphyma clavellatum* understorey.

Lignum (*Muehlenbeckia florulenta)* shrubland +/- River Red Gum, Black Box and River Cooba *Acacia stenophylla* and/or a understorey of herbland or grassland.

River Saltbush (*Atriplex rhagodioides)* chenopod shrubland.

Low chenopod shrubland dominated by *Atriplex* and *Sclerolaena* spp.

Samphire low shrubland dominated by *Halosarcia indica, H. pergranulata* and *Pachycornia triandra*

Herbfield dominated by *Calocephalus sonderi, Plantago cunninghamii* and *Lepidium* spp., or grassland dominated *Bromus rubens* and *Vulpia* spp. and /or *Sporobolus mitchellii*

Permanently inundated wetlands such as creeks and billabongs are often fringed by; Common Reed (*Phragmites australis),* Spiny Sedge (*Cyperus gymnocaulos)* and Cumbungi (*Typha domingensis).* The aquatic areas themselves contain submergent vegetation such as Red Milfoil (*Myriphyllum verrucosum)* and Ribbonweed (*Vallisneria americana).*

Appendix VI: Frog species recorded in the Riverland Ramsar Site

- Peron's Tree Frog (*Litoria peroni*)*;*
- Southern Bell Frog (*Litoria raniformis);*
- Eastern Sign-bearing Froglet (*Crinia parinsignifera*)*;*
- Eastern Banjo Frog (*Limnodynastes dumerilli*)*;*
- Long-thumbed Frog (*Limnodynastes fletcheri*)*;*
- Spotted Grass Frog (*Limnodynastes tasmaniensis*)*;*
- Painted Frog (*Neobatrachis pictus*)*;* and
- Burrowing Frog (*Neobatrachis sudelli*).

Appendix VII: Significant plant species listed at the State level under the *National Parks and Wildlife Act* 1972 and recorded in the Riverland Ramsar Site (R = Rare, V = Vulnerable)

- Dainty Maiden-hair *Adiantum capillus-veneris* V
- Swamp Daisy *Brachycome basaltica var. gracilis* R
- Black-fruit Daisy *Brachycome melanocarpa* V
- Coast Daisy *Brachycome parvula var. lissocarpa* R
- Matted Water Starwort *Callitriche sonderi* R
- Water Starwort *Callitriche umbonata* V
- Pale Beauty-heads *Calocephalus sonderi* R
- Tufted Burr-daisy *Calotis scapigera* R
- Purple Crassula *Crassula peduncularis* R
- Pale Flax-lily *Dianella porracea* V
- Small-flower Beetle-grass *Diplachne parviflora* R
- Waterwort *Elatine gratioloides* R
- Barren Cane-grass *Eragrostis infecunda* R
- Purple Love-grass *Eragrostis lacunaria* R
- Pale-fruit Cherry *Exocarpos strictus* R
- Sea-Heath Frankenia cupularis R
- Hooked Needlewood *Hakea tephrosperma* R
- Nutty Club-rush *Isolepis product* V
- Slender Fissure-plant *Maireana pentagona* R
- Creeping Boobialla *Myoporum parvifolium* R
- Upright Milfoil *Myriophyllum crispatum* V
- Robust Milfoil *Myriophyllum papillosum* R
- Wavy Marshwort *Nymphoides crenata* R
- Australian Broomrape *Orobanche cernua var. australiana* V
- Squat Picris *Picris squarrosa* R
- Jagged Bitter-cress *Rorippa laciniata* R
- Behr's Swainsona-pea *Swainsona behriana* V
- *Zannichellia palustris* R

Appendix VIII: significant fauna species listed at a State level that inhabit the Riverland Ramsar Site on a permanent or seasonal basis

Mammal Species	**Conservation Status**
Feather tailed Glider *Acrobates pygmaeus*	E

Reptile Species	**Conservation Status**
Broad-shell Tortoise *Chelodina expansa*	V
Carpet Python *Morelia spilota variegata*	R
Lace Monitor *Varanus varius*	R

Bird Species	**Conservation Status**
Great Crested Grebe *Podiceps cristatus*	R
Australian Bittern *Botaurus poiciloptilus*	V
Musk Duck *Biziura lobata*,	R
Blue Billed Duck *Oxyura australis*	R
Australasian Shoveler *Anas rhynchotis*	R
Freckled Duck *Stictonetta naevosa*	V
Intermediate Egret *Ardea intermedia*	R
Glossy Ibis *Plegadis falcinellus*	R
Bush Stone-curlew *Burhinus grallarius*	V
Square-tailed Kite *Lophoictinia isura*	V
Peregrine Falcon *Falco peregrinus*	R
White-bellied Sea-Eagle *Haliaeetus leucogaster*	V
Major Mitchell's Cockatoo *Cacatua leadbeateri*	V
Redthroat *Pyrrholaemus brunneus*	R
Blue-faced Honeyeater *Entomyzon cyanotis*	R
Little Friarbird *Philemon citreogularis*	R
Striped Honeyeater *Plectorhyncha lanceolata*	R
Golden-headed Cisticola *Cisticola exilis*	R

Conservation Status Codes - E = Endangered, R = Rare and V = Vulnerable