Aquatic and Littoral Vegetation of the Murray River Downstream of Lock 1, the Lower Lakes, Murray Estuary and Coorong.

A Literature Review.

Susan Gehrig and Jason Nicol

4 August 2010

SARDI Publication Number F2010/000297-1

SARDI Research Report Series No. 482

Government of South Australia

Department of Environment and Natural Resources

This Publication may be cited as:

Gehrig, S. and Nicol, J. (2010). Aquatic and littoral vegetation of the Murray River downstream of Lock 1, the Lower Lakes, Murray Estuary and Coorong. A literature review. South Australian Research and Development Institute (Aquatic Sciences), Adelaide, 65pp. SARDI Publication Number F2010/000297-1. SARDI Research Report Series No. 482.

South Australian Research and Development Institute
SARDI Aquatic Sciences
2 Hamra Avenue
West Beach SA 5024

Telephone: (08) 8207 2400
Facsimile: (08) 8207 5481
http://www.sardi.sa.gov.au

Printed in Adelaide August 2010

SARDI Publication Number F2010/000297-1
SARDI Research Report Series Number 482

Authors: Susan Gehrig and Jason Nicol

Reviewers: Chris Bice and Katherine Cheshire

Approved by: Qifeng Ye, Program Leader – Inland Waters & Catchment Ecology

Signed:

Date: 4 August 2010

Distribution: DENR, MDBA, SAMDBNRM Board, DFW, and SARDI Aquatic Sciences Library

Circulation: Public Domain

Table of Contents

List of Figures

List of Tables

List of Appendices

Acknowledgements

The authors thank Amy George, Hafiz Stewart, Chris Bice and Katherine Cheshire for comments on early drafts of this review. This review was funded by the Department of Environment and Natural Resources, through the Murray Futures (Lower Lakes) Program.

Executive Summary

This literature review summarises the available information on the aquatic and littoral vegetation communities of the Murray River downstream of Lock 1, Lakes Alexandrina and Albert, Murray Estuary and Coorong. The purpose of the review is to provide background information for:

- identification of key drivers that influence the aquatic and littoral vegetation of the system,
- determining key knowledge gaps,
- a series of risk assessments that will investigate the potential impacts of proposed management scenarios for acid sulfate soil mitigation in the Lower Lakes,
- the potential recovery of the system when freshwater flows return,
- and long-term planning,

The study region has been split into five biogeographic regions that historically had significantly different aquatic and littoral plant communities:

- the gorge (Lock 1 to Mannum),
- lower swamps (Mannum to Wellington),
- Lower Lakes (Lakes Alexandrina and Albert),
- Murray Estuary (Goolwa to Tauwitchere)
- Coorong Lagoons

The two main factors that determine the aquatic and littoral plant community in the study area are water regime (especially water depth) and salinity. Upstream of the barrages water regime is probably the most important factor (although salinity is important at a local scale) and downstream of the barrages salinity is the most important factor (although water level is important in the South Lagoon of the Coorong).

The study area has undergone significant changes since European settlement. Prior to large-scale water abstraction and river regulation there were spring floods with low water levels in summer and autumn upstream of Wellington, the Lower Lakes were predominantly fresh and Murray Estuary (which extended to Point Sturt) and Coorong had a variable salinity regime that was dependent on river flow. Large-scale abstraction for irrigated agriculture commenced in the early 1900s, which resulted in reduced river flows and saline incursions extending upstream of Point Sturt. The construction of the barrages in 1940 returned the Lower Lakes to a freshwater ecosystem but disconnected the Murray Estuary and Coorong from Lake Alexandrina. This has resulted in predominantly static water levels between Goolwa and Lock 1, a variable salinity regime in the Murray Estuary and North Lagoon of the Coorong and the South Lagoon being

predominantly hypersaline. Subsequently, the vegetation communities of each biographic region are typically characterised by species that are adapted to the prevailing environmental conditions in each region.

Despite being highly modified, a total of 353 plant and macroalgae taxa (including 132 exotics and five listed as rare in South Australia) have been recorded from the study region since 1975. The study area is important (it is an aquatic system in an otherwise dry environment) and contributes to regional and state biodiversity because a completely different suite of species is often present compared to the adjacent highland.

The River Murray downstream of Lock 1, Lower Lakes, Murray Estuary and Coorong has undergone further changes in recent years due to the combination of drought and water abstraction. Reduced inflows into the system due to river regulation, abstraction and the recent drought have resulted in a several problems, including, the longest closure of the barrages on record, the near closure of the Murray Mouth in the early 2000s which consequently requires dredging to remain open. Furthermore, low flows over Lock 1 since 2007 have resulted in the drawdown of water levels in the Lower Lakes and Murray downstream of Lock 1, which are currently below sea level. As a result the vegetation of the system has undergone significant changes. *Ruppia megacarpa*, which was common in Murray estuary and North Lagoon, has not been observed since the mid 1990s. *Ruppia tuberosa*, a highly salt tolerant species that was common in the South Lagoon early this century, has declined in abundance in the South Lagoon but colonised the North Lagoon.

Fringing wetlands in the Lower Lakes and floodplain wetlands upstream of Wellington that were historically permanent have dried completely, which has resulted in the loss of large areas of submergent (e.g. *Vallisneria spiralis, Potamogeton crispus*) and (in some cases) amphibious species (e.g. *Myriophyllum* spp.) from these habitats. Species lost from the permanent wetlands have not colonised the remnant inundated habitats (the main channel and Lower Lakes). Fringing communities have also undergone significant changes with the less desiccation tolerant species (e. g *Typha* spp. *Schoenoplectus validus*) declining in abundance; however, the more desiccation (e.g. *Phragmites australis*) and salt (e.g. *Halosarcia pergranulata, Sarcocornia quinqueflora*) tolerant fringing species have remained but are disconnected from the inundated habitats.

Nevertheless, the system has showed that it is resilient and currently has capacity for recovery. Water level rises as part of the Goolwa Channel water level management plan have resulted in recolonisation of submergents and growth of fringing species in Goolwa Channel. How long the system can remain resilient is unknown.

1. Introduction

This literature review summarises the available information on the aquatic and littoral vegetation communities of the River Murray downstream of Lock 1, Lakes Alexandrina and Albert, Murray Estuary and Coorong. The purpose of the review is to provide background information for:

- identification of key drivers that influence the aquatic and littoral vegetation of the system,
- determining key knowledge gaps,
- a series of risk assessments that will investigate the potential impacts of proposed management scenarios for acid sulfate soil mitigation in the Lower Lakes,
- the potential recovery of the system when freshwater flows return,
- and long-term planning,

The information available regarding the aquatic and littoral vegetation of the study region has been collected sporadically and there is only one long-term data set; *Ruppia tuberosa* monitoring in the South Lagoon of the Coorong that was first undertaken in 1999 (Paton 2000) and is ongoing. The majority of the information available is from targeted, short-term studies (usually 2-3 years); therefore, medium to long-term changes through time can only be compared on a qualitative basis. Nevertheless, there is a considerable amount of peer reviewed and grey literature available regarding the vegetation of the study region dating back to the mid 1970s and documented oral history accounts of the region dating back to the late 1800s (Sim and Muller 2004).

The earliest available published information was a catalogue of the submergent plants and algae of the Coorong Lagoons (Womersley 1975). In the late 1970s Brock (1979; 1981b; 1981a; 1982a; 1982b) investigated the ecology and physiology of *Ruppia* spp. the dominant submergent species in the Coorong. There were further studies of the submergent plants in the Coorong in the 1980s (Geddes and Butler 1984; Geddes 1987; Geddes and Hall 1990) and 1990s (Edyvane *et al.* 1996) and recent long-term monitoring in the South Lagoon (Paton 1996; Paton 2000; Paton 2001; Paton and Bolton 2001; Paton 2005a; Paton 2005b; Paton and Rogers 2008).

The aquatic and littoral vegetation upstream of the barrages has not been studied to the same extent as the Coorong. Qualitative one-off surveys as part of large scale biological surveys were undertaken in the mid 1980s (Pressey 1986; Thompson 1986), mid 1990s (Nichols 1998), early this century (Stewart *et al.* 2009) and as part of the South Australian Murray-Darling Basin Natural Resources Management Board commissioned wetland baseline surveys from 2004 to 2007 (Holt *et al.* 2005; Nicol *et al.* 2006; Marsland and Nicol 2007; Marsland and Nicol 2008). The aforementioned studies were one-off surveys with the aim to record species present;

however, they provide an excellent baseline with which to compare recent changes. In addition, a vegetation condition monitoring program was established in the Lower Lakes in 2008 to report on Living Murray targets (Marsland and Nicol 2009; Nicol and Marsland 2010) and monitoring was undertaken in 2008-09 in wetlands downstream of Lock 1 to investigate the impacts of low water levels (Nicol 2010), both monitoring programs are used to assess the current condition of the plant communities.

Many of the dominant species in the study area are cosmopolitan and information regarding the physiological tolerances and water regime preferences of individual species usually comes from peer reviewed scientific papers. However, quantitative information regarding the salinity tolerances is only available for 69 of the 353 recorded plant and macroalgae taxa. Furthermore, much of this information has been collected from outside of the study area and has been supplemented by expert opinion and observations.

1.1. Study Region

This review will focus on the aquatic and littoral (fringing) vegetation of the River Murray and associated wetlands (connected at historical pool level) downstream of Lock 1 (gorge and lower swamps), Lakes Alexandrina and Albert, the Murray Estuary (Goolwa to Tauwitchere) and the Coorong lagoons (Figure 1). The River Murray below Lock 1 was included in this review due to its hydrological connectivity with the Lower Lakes (upstream of the Clayton regulator). Water levels in the Lower Lakes are dependent on flows over Lock 1 and wind driven water level fluctuations (seiches) in the lakes affect water levels in the main channel and wetlands as far upstream as Lock 1. The Coorong and Murray Estuary, whilst disconnected from Lake Alexandrina by the barrages, rely on flows from the lakes to maintain a variable salinity regime.

The River Murray in South Australia has been traditionally split into five biogeographical units based primarily on geomorphology (Pressey 1986; Thompson 1986). The valley section (NSW/SA border to Lock 3) is characterised by a broad floodplain with numerous permanent and temporary wetlands (Holt et al. 2005). Downstream of Lock 3 the river enters a narrow, deep limestone trench, with steep cliffs on either side of the river (gorge section, Lock 3 to Mannum) (Pressey 1986; Thompson 1986; Jensen et al. 1996). Between Mannum and Wellington (the lower swamps), the river still flows through a narrow gorge; however, the floodplain has been extensively modified and largely converted to dairy swamps (the remnant wetlands are generally areas where levees could not be constructed) (Pressey 1986; Thompson 1986). Downstream of Wellington the river flows into a broad, shallow terminal freshwater lake system (Lakes Alexandrina and Albert, the Lower Lakes) (Pressey 1986; Thompson 1986; Jensen et al. 1996; Phillips and Muller 2006) (Figure 1). The Murray Estuary stretches from Goolwa to

Tauwitchere (Figure 1) and is separated from Lake Alexandrina by a series of five barrages that prevent saline water from entering the lake (Phillips and Muller 2006). South east of the Murray Estuary lies the Coorong (North and South Lagoons), a shallow elongate coastal lagoon system separated from the Southern Ocean by the Younghusband Peninsula (Geddes and Brock 1977; Geddes and Butler 1984; Geddes 1987; Department for Environment and Heritage 2000; Phillips and Muller 2006).

Despite the interactions and common factors that influence the plant community, there is considerable evidence that the plant communities in each region are distinct and will be treated separately throughout this review. For example, Nicol et al. (2006) reported that the wetland and floodplain plant communities were significantly different between the gorge, lower swamps and Lower Lakes wetlands. Likewise the plant community of the Coorong and Murray Estuary is very different from the community upstream of the barrages due to large differences in salinity upstream and downstream of the barrages.

1.1.1 Gorge (Lock 1 to Mannum)

Downstream of Lock 1 the River Murray flows predominately in a southerly direction constrained within a limestone gorge with steep cliffs on both sides of the river (Pressey 1986; Thompson 1986; Holt *et al.* 2005). The floodplain is generally less than 500 m wide and permanent wetlands, with continuous connection to the main channel, have developed on the floodplain as a result of stable water levels due to river regulation (Pressey 1986; Thompson 1986).

The primary factor that influences the aquatic and littoral vegetation between Lock 1 and Mannum is water regime, especially water level, which is primarily controlled by flows over Lock 1 and barrage operations. In addition, wind speed and direction can influence water levels on daily or even hourly time scales. Strong southerly winds can push water from the Lower Lakes up the main channel of the Murray River causing water levels to rise and strong northerly winds have the opposite effect. These short-term, wind driven water level fluctuations (seiches) have resulted in the fringes of permanent wetlands and the river channel being subjected to wetting and drying, which has probably increased the area of the littoral zone compared to wetlands with static water levels. Salinity also has an impact, especially in recent times, in dry wetlands where there is evidence of saline groundwater intrusions (J. Nicol pers. obs.).

1.1.2 Lower Swamps (Mannum to Wellington)

Similar to the gorge section, the River Murray between Mannum and Wellington flows in a southerly direction constrained within a limestone gorge (Pressey 1986; Thompson 1986; Holt *et al.* 2005) (Figure 1). However, in contrast to the gorge region, the floodplain has been extensively modified for irrigated agriculture (Pressey 1986; Thompson 1986; Jensen *et al.* 1996). Levee banks were constructed along the either side of the River Murray, irrigation channels dug and the floodplain levelled to flood irrigate pasture for dairy production. Jensen *et al.* (1996) reported that 93% of the floodplain between Mannum and Wellington was converted to dairy swamp with the remnant wetlands in areas where levees could not be constructed. However, in recent years, several dairy swamps have had grazing removed and rehabilitation/restoration is currently being undertaken (e.g. Piawalla Swamp).

The primary factor that influences the aquatic and littoral vegetation in the lower swamps is also water regime, especially water level, which is controlled by the same factors that influence water regime in the gorge region (flows over Lock 1, barrage operations and seiching). However, adjacent land use, historical land use, restoration activities, levee bank construction, salinity and invasive species are also important factors that influence the lower swamps plant community.

1.1.3 Lower Lakes (Lakes Alexandrina and Albert and the Lower Finniss River and Currency Creek)

Lakes Alexandrina and Albert are large shallow freshwater lakes situated at the terminus of the Murray-Darling Basin. Surface water predominantly feeds into Lake Alexandrina from the River Murray near the township of Wellington with minor inflows from tributaries (the Bremer, Angas and Finniss Rivers and Currency and Tookayerta Creeks) that drain the Eastern Mount Lofty Ranges (EMLR) along the south western edge of the Lake Alexandrina (Phillips and Muller 2006). Groundwater discharge and rainfall also contribute significant volumes to lakes Alexandrina and Albert (Phillips and Muller 2006). Lake Albert primarily receives water from Lake Alexandrina via a narrow channel (Narrung Narrows) connecting the two systems near Pt Malcolm (Figure 1); however, water exchange can be bidirectional between the lakes depending on wind direction. Lake Albert represents the final, local terminus of the River Murray, since it has no current or historical through flow connection with the Coorong. Only water from Lake Alexandrina drains into the Murray Estuary, Southern Ocean or the Coorong via a series of channels (Phillips and Muller 2006).

The primary factor that influences the plant community in the Lower Lakes is water regime particularly water level, which is influenced by inflows (predominantly the River Murray but inflows from the eastern Mt Lofty Ranges can be significant at times) and barrage operations. Since the construction of the Clayton regulator in 2009, which impounds flows from the Finniss River, Currency Creek and Tookayerta Creek, water levels between Clayton and Goolwa are higher than the remainder of Lake Alexandrina. Similarly the bank that was constructed across the Narrung Narrows in 2008 and subsequent pumping from Lake Alexandrina has meant that the water level in Lake Albert is higher than Lake Alexandrina. Nevertheless the seasonal water level fluctuations (winter/spring high water levels and summer/autumn low water levels) that occurred throughout the Lower Lakes still occur as do short-term wind driven water level fluctuations (Noye and Walsh 1976). Salinity is also an important factor, especially in Lake Albert wetlands and in areas adjacent to the barrages and Coorong in Lake Alexandrina.

1.1.4 Murray Estuary (Goolwa to Tauwitchere)

The Murray Estuary (via the Murray Mouth) is the only site where material (primarily sediment, nutrients and salt) can move from the Murray-Darling Basin into the Southern Ocean (Phillips and Muller 2006). The Murray Estuary is located between the Goolwa and Tauwitchere Barrages, which historically was considered part of the Coorong; however, for the purposes of this review it has been designated a separate region because it represent the extent of tidal influence and the area most affected by controlled barrage releases (Webster 2005a; Webster 2005b; Webster 2007).

In contrast to the other regions of the Murray River downstream of Lock 1, the primary factor influencing the vegetation within the Murray Estuary is salinity, which is dependent upon River Murray inflows and tidal incursion. Due to limited freshwater inflows to the Murray Estuary through the Murray Barrages over the past 10-15 years, increased sedimentation has resulted in the need for constant dredging of the Murray Mouth (since late 2002) to maintain a connection between the Coorong and Southern Ocean (Geddes 2005a; Phillips and Muller 2006; Brookes *et al.* 2009).

1.1.5 Coorong Lagoons

The Coorong is a shallow, elongate coastal lagoon confined by the coastal dune barrier of the Younghusband Peninsula (Figure 1). The Coorong stretches for 140 km in a south-east, north-west direction (Geddes and Butler 1984; Geddes 1987; Geddes and Hall 1990; Seaman 2003) and is comprised of two main lagoons (the North and South Lagoons) of similar size almost separated by a spit of land (Hells Gate) (Lothian and Williams 1988) (Figure 1).

Salinity is the primary factor that influences the plant community in the Coorong (Womersley 1975; Noye and Walsh 1976; Geddes and Brock 1977; Gilbertson and Foale 1977; Geddes 1987; Geddes and Hall 1990; Webster 2005a; Webster 2005b; Brookes *et al.* 2009; Lester and Fairweather 2009). Salinity in the Coorong is spatially and temporally variable. Salinity ranges from fresh near the barrages when large quantities of water are being released from Lake Alexandrina, through brackish to the salinity of seawater (35 gL^{-1} TDS) near the Murray Mouth (when the Barrages are closed), grading to hypersaline (>35-115 gL^{-1} TDS) in the southern end of the North Lagoon and the South Lagoon (e.g. Paton 1982; Geddes 1987; Lothian and Williams 1988; Seaman 2003; Phillips and Muller 2006; Paton and Rogers 2008). Water level is also an important factor in the South Lagoon where water levels fluctuate seasonally from winter/spring highs to late summer/autumn lows (Geddes 1987; Seaman 2003) and over shorter temporal scales due to the speed and direction of the wind (Noye and Walsh 1976).

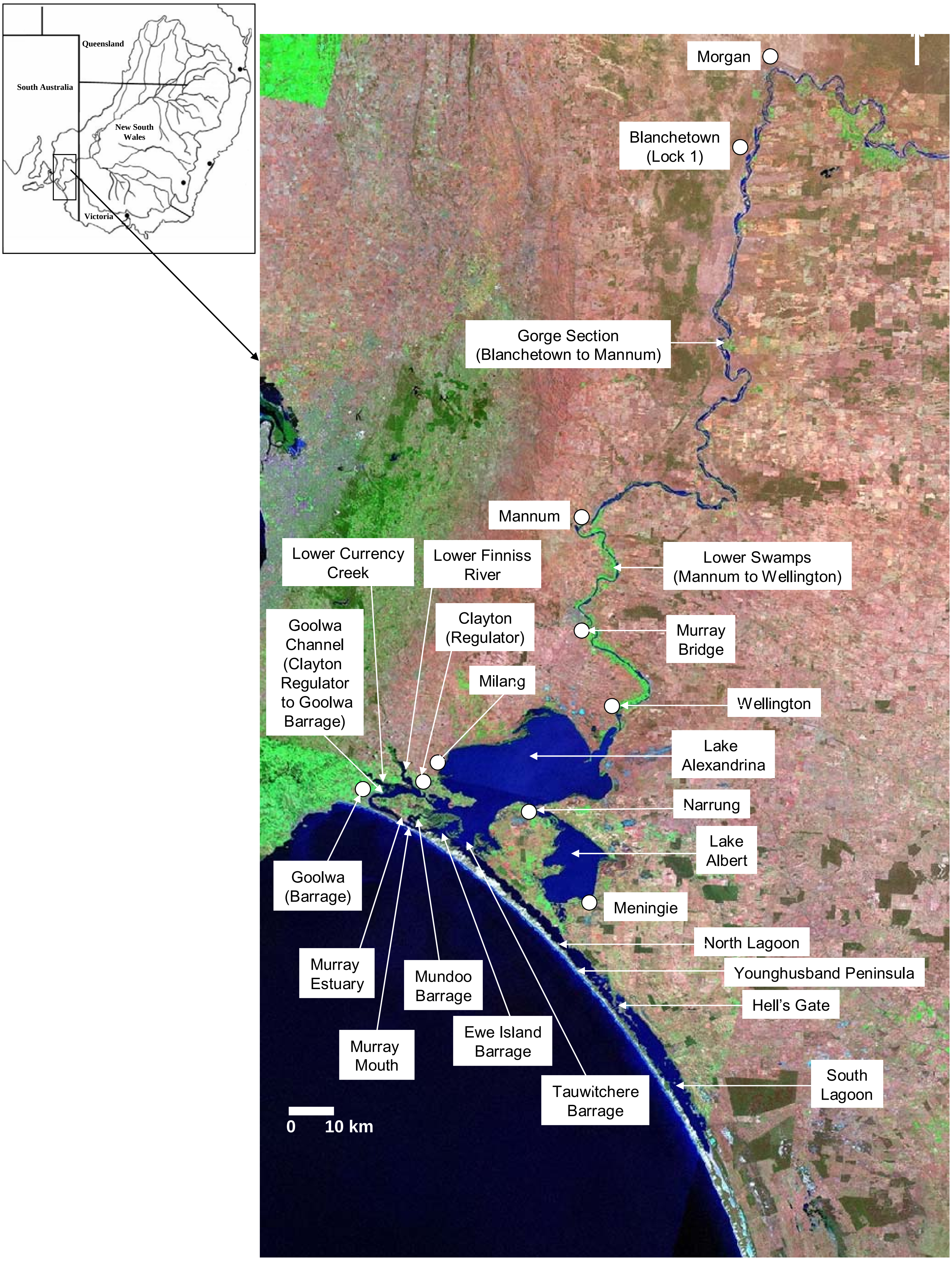

Figure 1: The River Murray from Morgan to the mouth including the Lower Lakes and Coorong Lagoons.

1.1.6 Changes to the Natural Flow Regime

The River Murray downstream of Lock 1, Lower Lakes, Murray Estuary and Coorong have undergone significant changes since European settlement (Sim and Muller 2004; Phillips and Muller 2006; Fluin *et al.* 2007; Dick *et al.* 2010). Prior to the construction of the barrages, main channel locks and weirs and headwater storages the River Murray downstream of Lock 1 would have had a variable flow regime with spring floods and low water levels in autumn (Walker 1985; Walker 1986; Walker *et al.* 1992; Walker and Thoms 1993; Davies *et al.* 1994; Maheshwari *et al.* 1995; Walker *et al.* 1995; Puckridge *et al.* 1998; Puckridge *et al.* 2000). Downstream of Wellington the water levels were more stable because of the large area of the lakes and permanent inflows from the River Murray, which resulted in the lakes being predominantly fresh with occasional saline incursions only as far upstream as Point Sturt, during periods of low flow (Sim and Muller 2004; Fluin *et al.* 2007). The Murray Estuary and Coorong were truly estuarine systems with a variable salinity regime along the entire length of the Coorong (Fluin *et al.* 2007; Dick *et al.* 2010).

Early last century abstraction of water for irrigation commenced and the construction of Hume Dam was completed, which resulted in more frequent saline incursions that reached much further upstream (Sim and Muller 2004; Fluin *et al.* 2007). The saline incursions prompted the construction of the barrages, which were completed in 1940 and returned the Lower Lakes to a freshwater system (Sim and Muller 2004; Fluin *et al.* 2007). The construction of the barrages, coupled with regulation further upstream meant that the water level between the barrages and Lock 1 was generally static, except during periods of high flow (Walker 1985; Walker 1986; Walker *et al.* 1992; Walker and Thoms 1993; Davies *et al.* 1994; Maheshwari *et al.* 1995; Walker *et al.* 1995; Puckridge *et al.* 1998; Puckridge *et al.* 2000). The Murray Estuary and Coorong were disconnected from the lakes and the salinity gradient in the Coorong changed. The salinity in the Coorong ranged from fresh to marine in the Murray Estuary (depending on barrage outflows), brackish to hypermarine in the North Lagoon and hypermarine the South Lagoon (Geddes and Hall 1990; Dick *et al.* 2010).

Following construction of the Barrages and Lock 1, the conditions in the River Murray downstream of Lock 1, the Lower Lakes, Murray Estuary and Coorong were dependent on flow over Lock 1 and barrage operations. During the 1940s there were several years of drought and this was considered a dry decade; in the 1950s there were several large floods. The 1960s were generally dry, but there were again several large floods in the 1970s. The 1980s there characterised by a severe drought that resulted in the closure of the Murray Mouth (Geddes and Butler 1984), in the 1990s there were several large floods (the last one in 1996) and this century has been the driest period on record in the Murray-Darling Basin (DWLBC 2010). Climatic factors and high levels of abstraction have determined flow over Lock 1. This has in turn, determined the water levels in the Lower Lakes, barrage outflows and the salinity in the Murray Estuary and Coorong.

1.2. Vegetation of the River Murray Downstream of Lock 1, Lower Lakes, Murray Estuary and Coorong

A total of 353 taxa (including 132 exotics and four listed as rare in South Australia) have been recorded from the study region since 1975 (list compiled from the following studies: Womersley 1975; Paton 1982; Pressey 1986; Thompson 1986; Geddes 1987; Renfrey *et al.* 1989; Brandle *et al.* 2002; Seaman 2003; Holt *et al.* 2005; Nicol *et al.* 2006; Weedon *et al.* 2006; Marsland and Nicol 2007; Marsland and Nicol 2008; Marsland and Nicol 2009; Stewart *et al.* 2009; Marsland *et al.* 2010; Nicol 2010; Nicol and Marsland 2010) (Appendix 1).

The River Murray (and associated wetlands and floodplain), Lower Lakes, Murray Estuary and Coorong is an aquatic ecosystem in an otherwise dry environment and many of the recorded 353 plant taxa do not occur above the 1956 flood level. Therefore, the region covered in the review (albeit highly modified) contributes significantly to regional and state biodiversity because a completely different suite of species is often present compared to the surrounding land (*sensu* Pollock *et al.* 1998). In addition, the Lower Lakes is the common boundary of South Australia's three wettest bioregions; the Mt Lofty Ranges, South East and Murray and elements of the wetland flora for each region is represented in the Lower Lakes.

1.2.1 Functional Groups

Due to the large number of species and communities present, species were classified into functional groups (based on water regime preferences) outlined in Table 1. The position each group occupies in relation to flooding depth and duration is outlined in Figure 2. The functional classification was based on the classification framework devised by Brock and Casanova (1997), which was based on species from wetlands in the New England Tablelands region of New South Wales and modified to suit the River Murray downstream of Lock 1, the Lower Lakes, Murray Estuary and Coorong.

The use of a functional group approach to assess change through time and potential impacts of management strategies has several advantages compared to a species or community based approach:

- species with similar water regimes preferences are grouped together, which simplifies systems with high species richness (especially where there are large numbers of species with similar water regime preferences),
- predictions about the response of the plant community are made based on processes and does not require prior biological knowledge of the system,
- is transferrable between systems,
- robust and testable models that predict the response of a system to an intervention or natural event can be constructed, which can in turn be used as hypotheses for monitoring programs.

However there are limitations of the approach, which include:

- loss of information on species or communities (especially if there are species or communities of conservation significance or there is a pest plant problem),
- uncertainty regarding which species should be classified into which functional group,
- important factors (e.g. salinity) are often not taken into consideration (additional factors can be included; however, this can often complicate the functional classification and in systems where there is low species richness the number of groups may be greater than the number of species).

In this review, changes in ecological condition through time for each biogeographical region will be reviewed using species, community and functional approaches. The functional approach is explored because the conceptual models used in the environmental impact assessment and risk assessment will use functional groups to predict responses and impacts.

Table 1: Functional classification of plant species based on water regime preferences, modified from Brock and Casanova (1997).

Functional Group	Abbreviation	Water Regime Preference	Examples
Terrestrial dry	Tdr	Will not tolerate inundation and tolerates low soil moisture for extended periods.	*Atriplex vesicaria*, *Rhagodia spinescens, Enchylaena tomentosa*
Terrestrial damp	Tda	Will tolerate inundation for short periods (<2 weeks) but require high soil moisture throughout their life cycle.	*Centaurea calcitrapa, Chenopodium album, Fumaria bastardii*
Floodplain	F	Temporary inundation, plants germinate on newly exposed soil after flooding but not in response to rainfall.	*Epaltes australis, Centipeda minima, Lachnagrostis filiformis*
Amphibious fluctuation tolerators-emergent	AFTE	Fluctuating water levels, plants do not respond morphologically to flooding and drying and will tolerate short-term complete submergence (<2 weeks).	*Cyperus gymnocaulos, Juncus kraussii, Schoenoplectus pungens*
Amphibious fluctuation tolerators-woody	AFTW	Fluctuating water levels, plants do not respond morphologically to flooding and drying and are large perennial woody species.	*Eucalyptus camaldulensis, Melaleuca halmaturorum, Muehlenbeckia florulenta*
Amphibious fluctuation tolerators-low growing	AFTL	Fluctuating water levels, plants do not respond morphologically to flooding and drying and are generally small herbaceous species.	*Limosella australis, Crassula helmsii, Brachycome basaltica*
Amphibious fluctuation responders-plastic	AFRP	Fluctuating water levels, plants respond morphologically to flooding and drying (e.g. increasing above to below ground biomass ratios when flooded).	*Persicaria lapathifolium, Ludwigia peploides, Myriophyllum* spp.
Floating	Fl	Static or fluctuating water levels, responds to fluctuating water levels by having some or all organs floating on the water surface. Most species require permanent water to survive.	*Azolla* spp., *Lemna* spp., *Spirodella punctata*
Submergent r-selected	Sr	Temporary wetlands that hold water for longer than 4 months.	*Ruppia tuberosa, Ruppia polycarpa, Lamprothamnium papulosum*
Emergent	E	Static shallow water <1 m or permanently saturated soil.	*Typha* spp., *Phragmites australis, Schoenoplectus validus*
Submergent k-selected	Sk	Permanent water.	*Vallisneria americana, Potamogeton crispus, Ruppia megacarpa*

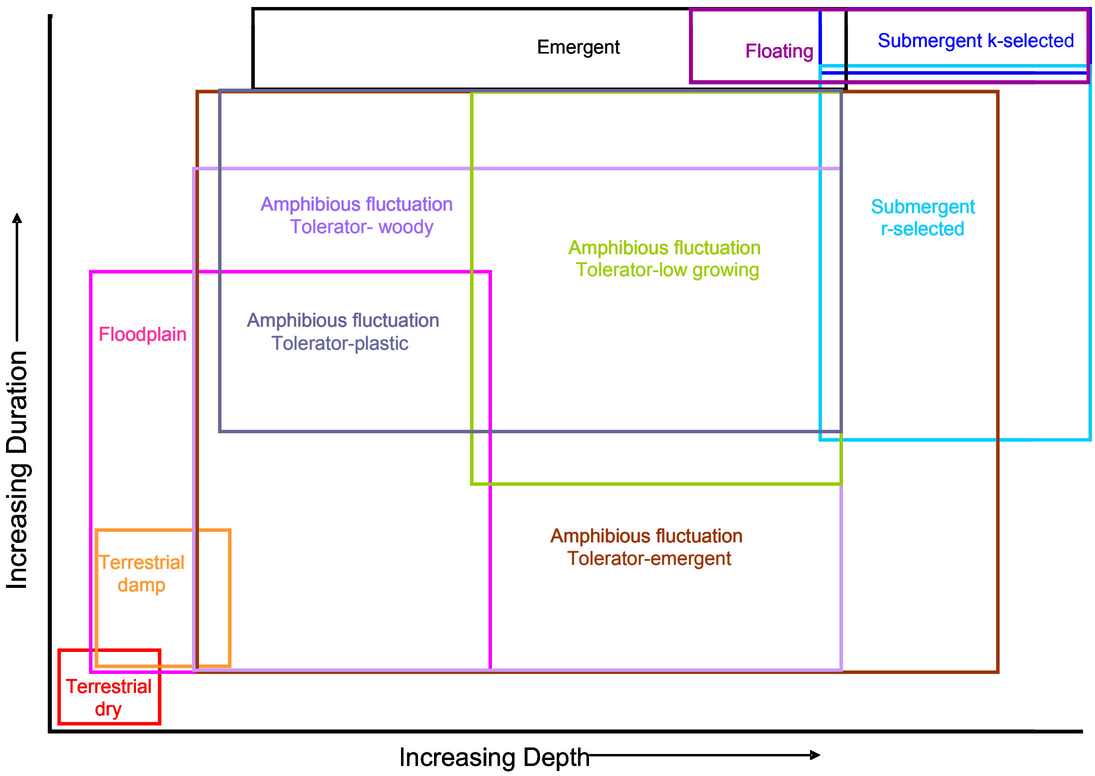

Figure 2: Plant functional groups in relation to depth and duration of flooding.

The "terrestrial dry" functional group is intolerant of flooding and taxa will persist in environments with low soil moisture (Table 1) (Brock and Casanova 1997). Taxa from this functional group often invade wetlands that have been drawn down for an extended period or floodplains where there has been a lack of flooding but are generally restricted to highlands that never flood (Brock and Casanova 1997).

Taxa in the "terrestrial damp" group will tolerate inundation for short periods and require high soil moisture to complete their life cycle (Table 1) (Brock and Casanova 1997). Taxa from this functional group are often winter annuals, perennial species that grow around the edges of permanent water bodies where there is high soil moisture or species that colonise wetlands shortly after they are drawn down and riparian zones and floodplains shortly after flood waters recede (Brock and Casanova 1997).

Taxa in the "floodplain" functional group exhibit most of the traits of terrestrial species; they are generally intolerant of long-term inundation but are restricted to areas that flood periodically (they are absent from the highlands) because they only germinate after flood waters recede or wetlands are drawn down, not in response to rainfall (Table 1) (Nicol 2004). Taxa from this functional group colonise floodplains and riparian zones after flood waters have receded and when wetlands are drawn down (Nicol 2004). Floodplain species often have flexible life history strategies, they grow whilst soil moisture is high and flower and set seed (after which most species die) in response to low soil moisture (Nicol 2004).

The "amphibious fluctuation tolerator-emergent" group consists mainly of emergent sedges and rushes that prefer high soil moisture or shallow water but require their photosynthetic parts to be emergent, although many will often tolerate short-term submergence (Table 1) (Brock and Casanova 1997). Taxa from this group are often found on the edges of permanent water bodies, in seasonal and temporary wetlands, in riparian zones and areas that frequently wet and dry.

Species in the "amphibious fluctuation tolerator-woody" group have similar water regime preferences to the amphibious fluctuation tolerator-emergent group (Figure 2) and consist of woody perennial species (Table 1) (Brock and Casanova 1997). Plants generally require high soil moisture in the root zone but there are several species (e.g. *Eucalyptus largiflorens*) that are tolerant of desiccation for extended periods (Roberts and Marston 2000). Species in this functional group are generally found on the edges of permanent water bodies, in seasonal and temporary wetlands, in riparian zones and areas that frequently wet and dry.

The "amphibious fluctuation tolerator-low growing" group have similar water regime preferences to the amphibious fluctuation tolerator-emergent and amphibious fluctuation tolerator-woody group (Figure 2); however, some species can grow totally submerged except during flowering (when there is a requirement for a dry phase) (Table 1) (Brock and Casanova 1997). Species in the this functional group are generally found on the edges of permanent water bodies, in seasonal and temporary wetlands, in riparian zones and areas that frequently wet and dry but species are usually less desiccation tolerant than species in the other amphibious tolerator groups (Figure 2).

The "amphibious fluctuation responder-plastic" group occupies a similar zone to the amphibious fluctuation tolerator-low growing group; except that they have a physical response to water level changes such as rapid shoot elongation or a change in leaf type (Brock and Casanova 1997). They can persist on damp and drying ground because of their morphological flexibility but can flower even if the site does not dry out. They occupy a slightly deeper/wet for longer area than the amphibious fluctuation tolerator-low growing group (Figure 2).

Species in the "floating" functional group float on the top of the water (often unattached to the sediment) with the majority of species requiring the presence of free water of some depth year round; although, some species can survive and complete their life cycle stranded on mud (Table 1) (Brock and Casanova 1997). Taxa in this group are usually found in permanent waterbodies, often forming large floating mats upstream of barriers (e.g. weirs), in lentic water bodies and slackwaters.

"Submergent r-selected" species colonise recently flooded areas (Table 1) and show many of the attributes of Grime's (1979) r-selected (ruderal) species, which are adapted to periodic disturbances. Many require drying to stimulate germination; they frequently complete their life cycle quickly and die off naturally. They persist via a dormant, long-lived bank of seeds, spores or asexual propagules (e.g. *Ruppia tuberosa* and *Ruppia polycarpa* turions in the soil) (Brock 1982b). They prefer habitats that are annually flooded to a depth of more than 10cm but can persist as dormant propagules for a number of years (temporary or ephemeral wetlands).

The "emergent" group consists of taxa that require permanent shallow water or a permanently saturated root zone, but require emergent leaves or stems (Table 1). They are often found on the edges of permanent waterbodies and in permanent water up to 2 m deep (depending on species) or in areas where there are shallow water tables (Roberts and Marston 2000).

"Submergent k-selected" species require permanent water greater than 10 cm deep for more than a year to either germinate or reach sufficient biomass to start reproducing (Table 1) (Roberts and Marston 2000). Species in this group show many of the attributes of Grime's (1979) k-selected (competitor) species that are adapted to stable environments and are only found in permanent water bodies. The depth of colonisation of submergent k-selected species is dependant on photosynthetic efficiency and water clarity (*sensu* Spence 1982)

Whilst water regime is the primary driver of plant community composition (e.g. Brownlow 1997; Nielsen and Chick 1997; Begg *et al.* 1998; Blanch *et al.* 1999b; Blanch *et al.* 1999a; Blanch *et al.* 2000; Casanova and Brock 2000; Capon 2003; Nicol *et al.* 2003; Capon 2007; Deegan *et al.* 2007; Boers and Zedler 2008), especially upstream of the barrages, salinity is also an important driver particularly in downstream of the barrages (Geddes and Butler 1984; Geddes 1987; Geddes and Hall 1990; Brookes *et al.* 2009; Lester and Fairweather 2009). Therefore, each taxon and community was assigned a salinity tolerance group based on values reported in the literature (if available) or field observations (Table 2).

Table 2: Functional classification based on salinity tolerance.

Salinity Tolerance Group	EC (Salinity) Range	Examples (with water regime functional group)
High	>50,000 µS.cm^{-1} (>31,250 mgl^{-1})	*Halosarcia pergranulata* (AFTE), *Sarcocornia quinqueflora* (AFTE), *Ruppia tuberosa* (Sr), *Melaleuca halmaturorum* (AFTW)
Moderate	10,000-50,000 µS.cm^{-1} (6,250-31,250 mgl^{-1})	*Phragmites australis* (E), *Eucalyptus camaldulensis* (AFTW), *Lepilaena australis* (Sr) *Juncus kraussii* (AFTE)
Low	<10,000 µS.cm^{-1} (<6,250 mgl^{-1})	*Potamogeton crispus* (Sk), *Schoenoplectus validus* (E), *Salix babylonica* (E), *Azolla filiculoides* (Fl)

The values for salinity tolerance are (where possible) absolute salinity tolerances of adult plants determined under laboratory or greenhouse conditions. If this information is unavailable inferences of the salinity tolerance of species have been made from field observations (e.g. coexistence with species of high salinity tolerance, present in areas of salt scald or high salinity water). In addition, salinity tolerance values did not take into consideration the salinity thresholds of juveniles (e.g. Marcar *et al.* 2000; Naidoo and Kift 2006), germination and recruitment (e.g. Ungar 2001; Malcolm *et al.* 2003; Greenwood and MacFarlane 2006; Robinson *et al.* 2006; Song *et al.* 2008; Wetson *et al.* 2008; Elsey-Quirk *et al.* 2009), key life history stages (e.g. flowering and seed set) (e.g. Short and Colmer 1999; Salter *et al.* 2010), interactions between salinity and other environmental factors (e.g. Clarke and Hannon 1970; Davis 1978; Stephens 1990; Naidoo and Kift 2006; Raulings *et al.* 2007; Salter *et al.* 2007; Colmer and Flowers 2008; Flowers and Colmer 2008; Salter *et al.* 2008; Song *et al.* 2009) and competition (e.g. Greenwood and MacFarlane 2009).

2. Recent Ecological Condition (2004-2007)

The plant communities present at the regional scale prior to 2007 were primarily the result of water regime (upstream of the barrages) (Holt *et al.* 2005; Nicol *et al.* 2006; Weedon *et al.* 2006; Marsland and Nicol 2007; Marsland and Nicol 2008; Marsland *et al.* 2010) and salinity (downstream of the barrages) (e.g. Geddes and Brock 1977; Paton 1982; Geddes and Butler 1984; Geddes 1987; Geddes and Hall 1990; Paton and Rogers 2008) (Appendix 2), which is driven by River Murray flows. However, local land use (e.g. urbanisation, grazing) and wave action are also important at the wetland or reach scale (e.g. Holt *et al.* 2005; Nicol *et al.* 2006; Weedon *et al.* 2006; Marsland and Nicol 2007; Marsland and Nicol 2008; Marsland *et al.* 2010).

The Murray-Darling Basin had been in extended drought during 2004-2007 with no overbank flows (the last large overbank flow was in 1996 and there was an in channel flow in 2000) with one small in-channel flow in 2005 (DWLBC 2010). During this time water levels upstream of the barrages fluctuated between 0.8 m AHD in spring and 0.5 m AHD in autumn (Figure 3). Prior to 2004 water levels generally fluctuated between 0.9 m AHD in spring 0.5 m AHD in autumn with water levels falling to 0.4 m AHD in autumn 2003 (Figure 3). In addition, flows over the barrages have been limited with small releases in September-October 2003 (Geddes 2005a) and August 2004 (Geddes 2005b) (Figure 4). The resultant low flows caused the near closure of the Murray Mouth, which has been kept open by dredging since late 2002 (Phillips and Muller 2006). This has resulted in marine (or greater) salinities in the Murray Estuary and a salinity gradient ranging from marine adjacent to Tauwitchere Barrage to hypermarine in the South Lagoon of the Coorong (Phillips and Muller 2006). The salinity in the North and South Lagoons of the Coorong has been steadily increasing through time due to the continual input of salt from the Southern Ocean via the open Murray Mouth, lack of tidal flushing south of Tauwitchere Barrage and lack of flows from the River Murray that will flush salt out of the system into the Southern Ocean (Brookes *et al.* 2009).

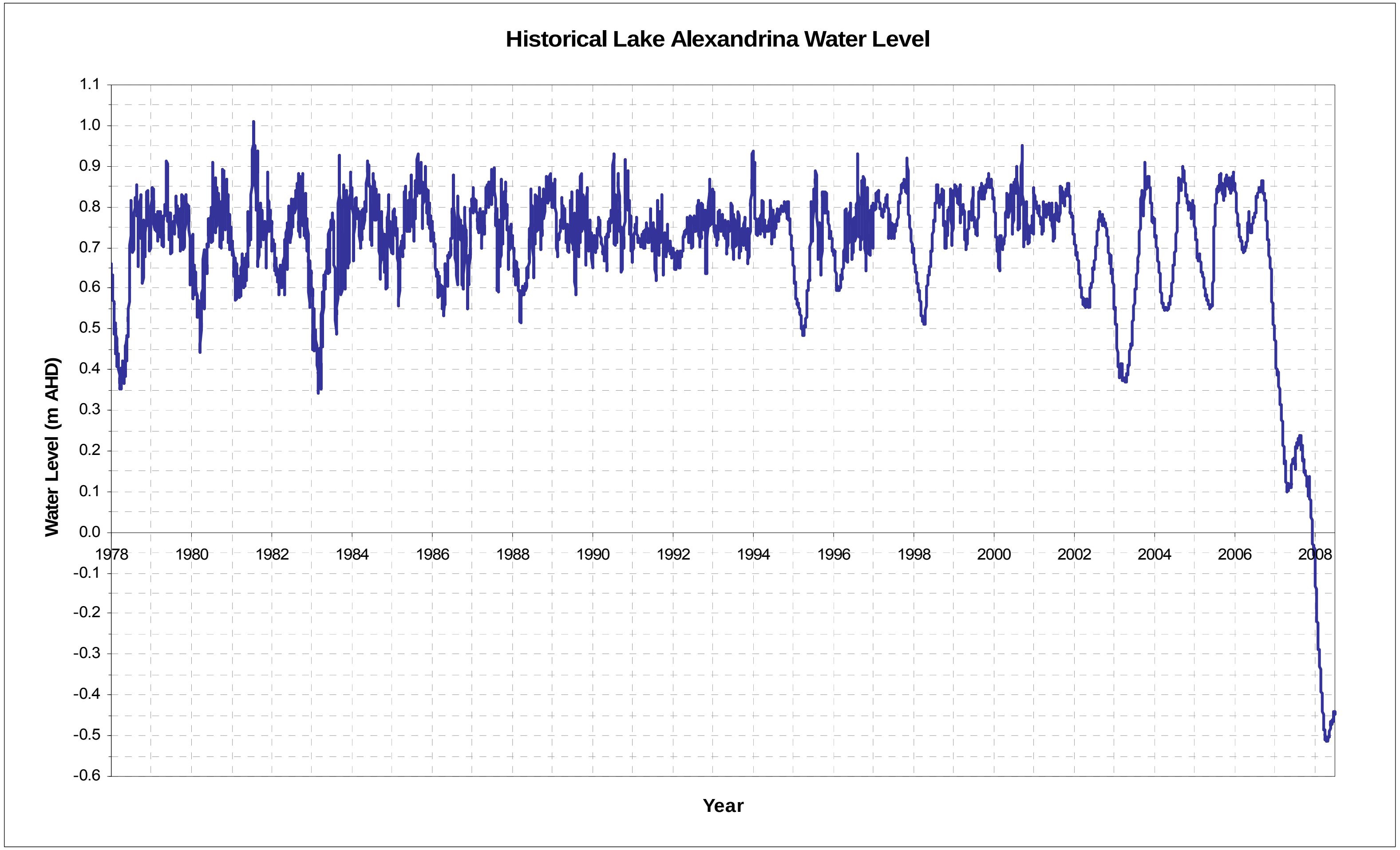

Figure 3: Water levels in the Lower Lakes (m AHD) from 1978 to 2008 (DWLBC 2010).

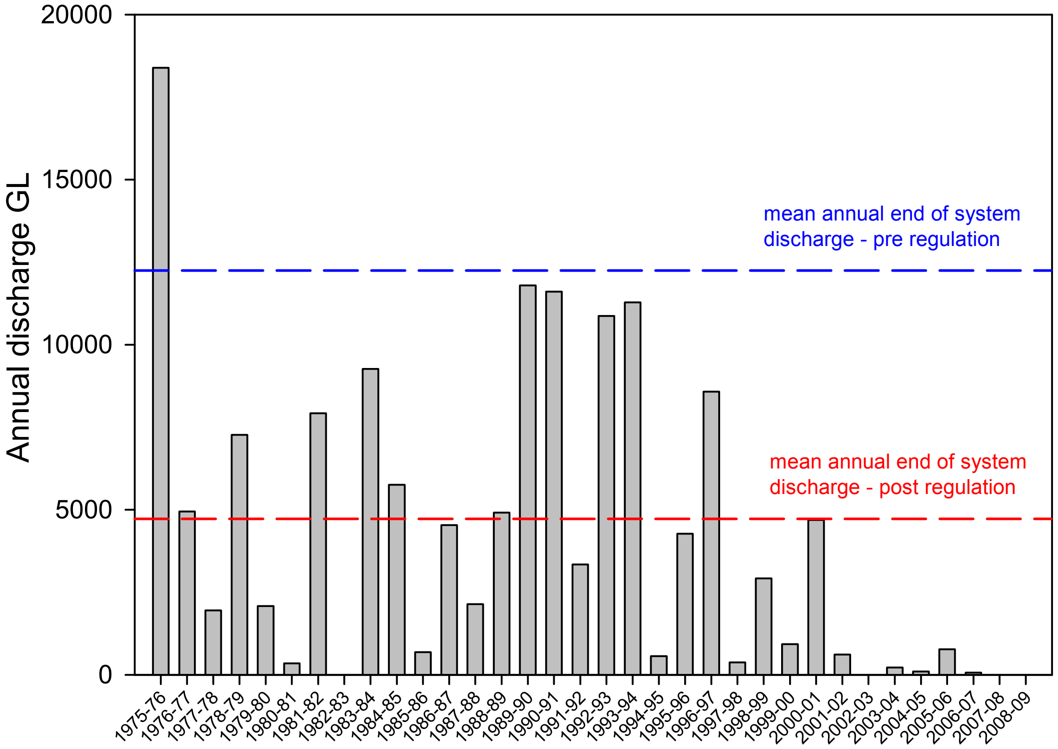

Figure 4: Annual discharge from the barrages from 1975 to 2006 (Bice 2010).

2.1. Gorge (Lock 1 to Mannum)

The aquatic and littoral plant communities between Mannum and Lock 1 between 2004 and 2007 were typical of areas with limited water level fluctuations (Walker 1985; Walker 1986; Walker *et al.* 1992; Walker and Thoms 1993; Walker *et al.* 1994; Blanch *et al.* 1999b; Blanch *et al.* 2000) (Appendix 2a).

The shallow (<1 m depth) permanently inundated areas of wetlands connected at pool level were dominated by submergent k-selected species such as *Vallisneria spiralis, Ceratophyllum demersum Potamogeton crispus* and *Potamogeton tricarinatus*, desiccation intolerant Amphibious fluctuation responder-plastic species such as *Myriophyllum verrucosum* and *Myriophyllum papulosum* and floating species such as *Azolla filiculoides* (Appendix 2a). The areas deeper than 1 m were generally devoid of vegetation with the exception of Floating species (Holt *et al.* 2005; Nicol *et al.* 2006; Weedon *et al.* 2006; Marsland and Nicol 2007; Marsland and Nicol 2008).

The wetland fringing vegetation was often dominated by dense; almost monospecific stands of Emergent species such as *Typha* spp., *Phragmites australis* and *Schoenoplectus validus*; however, there were areas with diverse Floodplain, Amphibious and Emergent herb, sedge and rush communities that included, *Juncus usitatus, Cyperus gymnocaulos, Limosella australis, Bolboschoenus caldwellii, Mimulus repens, Lycopus australis, Berula erecta, Epaltes australis, Sporobolus mitchellii, Ludwigia peploides, Persicaria lapathifolium, Lachnagrostis filiformis* and *Stemodia florulenta* (Holt *et al.* 2005; Nicol *et al.* 2006; Weedon *et al.* 2006; Marsland and Nicol 2007; Marsland and Nicol 2008) (Appendix 2a). The overstorey (if present) was *Eucalyptus camaldulensis,* with *Myoporum montanum, Acacia stenophylla* (open woodland) and *Muehlenbeckia florulenta* (often forming dense closed shrublands). The condition of *Eucalyptus camaldulensis* trees was generally good to excellent; although, the proportion of trees in moderate to poor condition was generally higher in wetlands closer to Lock 1 (Holt *et al.* 2005; Nicol *et al.* 2006; Weedon *et al.* 2006; Marsland and Nicol 2007; Marsland and Nicol 2008).

The main channel was generally devoid of submergent species except for small patches on shallow bars and benches (Marsland *et al.* 2010). In contrast the fringing vegetation was dominated by dense stands of the Emergents *Typha* spp. *Phragmites australis* and S*choenoplectus validus*, often with *Eucalyptus camaldulensis* and *Acacia stenophylla* overstorey. *Salix* spp. (willows) formed dense; almost monospecific stands in some areas especially between Mannum and Purnong (Marsland *et al.* 2010).

2.2. Lower Swamps (Mannum to Wellington)

Similar to the gorge section the aquatic and littoral plant communities between Mannum and Wellington between 2004 and 2007 were typical of areas with limited water level fluctuations (Walker 1985; Walker 1986; Walker *et al.* 1992; Walker and Thoms 1993; Walker *et al.* 1994; Blanch *et al.* 1999b; Blanch *et al.* 2000) (Appendix 2b).

Wetlands in the Lower Swamps are generally shallower that those in the gorge section and generally do not have large beds of Submergent species (Appendix 2b) or areas of open water (with the exception of Reedy Creek and Rocky Gully, which were dominated by open water and floating species and *Ruppia megacarpa* and *Potamogeton crispus* respectively) (Holt *et al.* 2005; Nicol *et al.* 2006). Lower Swamps wetlands are generally dominated by extensive stands of emergent species such as *Typha* spp. and *Phragmites australis* with high abundances of agricultural weeds and pasture species such as *Medicago* spp., *Trifolium* spp., *Lolium* spp. and *Melilotus* spp. in the littoral zone (Holt *et al.* 2005; Nicol *et al.* 2006) (Appendix 2b). Nevertheless there are small areas of diverse Floodplain, Amphibious and Emergent herb, sedge and rush communities with similar species compositions to gorge wetlands (Holt *et al.* 2005; Nicol *et al.* 2006) (Appendix 2b). The over storey was generally *Eucalyptus camaldulensis, Acacia stenophylla* (open woodlands or scattered trees) or *Muehlenbeckia florulenta* (scattered shrubs or closed shrublands) and the majority of

Eucalyptus camaldulensis trees were in either good or excellent condition (Holt *et al.* 2005; Nicol *et al.* 2006) (Appendix 2b).

Similar to the gorge section the main channel was generally devoid of Submergent species except for small patches on shallow bars and benches. The fringing vegetation between Mannum and Wellington is predominantly *Salix* spp. with small scattered patches of *Phragmites australis* and *Typha* spp. (Marsland *et al.* 2010).

2.3. Lower Lakes (Lakes Alexandrina and Albert and the Lower Finniss River and Currency Creek)

The vegetation in the Lower Lakes was also typical of systems with limited water level fluctuations (Walker 1985; Walker 1986; Walker *et al.* 1992; Walker and Thoms 1993; Walker *et al.* 1994; Blanch *et al.* 1999b; Blanch *et al.* 2000) (Appendix 2c); however, salinity (*sensu* King *et al.* 1990) and wave action (*sensu* Wilson and Keddy 1985; Foote and Kadlec 1988; Coops and Van der Velde 1996; Hudon *et al.* 2000; Doyle 2001; Hawes *et al.* 2003; Riis and Hawes 2003) were also important factors that determined the abundance and distribution of plants.

The open water areas of Lakes Alexandrina and Albert were generally devoid of plants probably due to wave action and depth (most areas that were shallow and could support submergent or amphibious species were subjected to wave action and there was insufficient light penetration in areas that are deeper than 1 m to support submergent and amphibious species). Submergent and amphibious species were generally restricted to fringing wetlands, sheltered bays, Goolwa Channel and the lower reaches of Currency Creek and the Finniss River. The areas with the greatest abundances of Submergent and Amphibious species were the wetlands and sheltered areas along the western shoreline of Lake Alexandrina and Goolwa Channel (Holt *et al.* 2005; Nicol *et al.* 2006). For example, extensive beds of *Vallisneria spiralis* were present at Milang Shores, Dunns Lagoon, Clayton Bay and in the channels on Hindmarsh Island (Holt *et al.* 2005) and *Myriophyllum* spp. was abundant near the Hindmarsh Island bridge (J. Nicol pers. obs.), in Clayton Bay, Dunns Lagoon (Holt *et al.* 2005) and Hunters Creek (Nicol *et al.* 2006). The plant communities present in wetlands along the eastern shoreline of Lake Alexandrina and around the edges of Lake Albert suggested that salinity plays a role in structuring the community. *Ruppia* spp. and *Lepilaena cylindrocarpa* were the dominant Submergent species in wetlands along the eastern shoreline of Lake Alexandrina and around Lake Albert (Holt *et al.* 2005; Nicol *et al.* 2006).

The fringing vegetation of the Lower Lakes was dominated by dense stands of *Typha* spp. and *Phragmites australis,* particularly the western shoreline of Lake Alexandrina, Goolwa Channel and lower reaches of Currency Creek and Finniss River (Seaman 2003). Nevertheless, there were areas of samphire vegetation (*Sarcocornia quinqueflora, Suaeda australis, Juncus kraussii, Halosarcia pergranulata*) and dense *Muehlenbeckia florulenta* shrublands predominantly around the edges of wetlands along the eastern shore of Lake Alexandrina, adjacent to the barrages and around Lake Albert (Seaman 2003; Holt *et al.* 2005; Nicol *et al.* 2006) (Appendix 2c).

Melaleuca halmaturorum is the dominant tree in the Lower Lakes and forms dense closed woodlands (Holliday 2004). *Melaleuca halmaturorum* woodlands are scattered around the edges of the Lower Lakes with the largest woodlands located at the mouth of Hunters Creek, on the northern shore of Hindmarsh Island, on Goat and Goose Islands near Clayton, in Salt Lagoon on the south-eastern shore of Lake Alexandrina and Kennedy Bay on the southern shore of Lake Albert. Age class information is only available for the stand at the mouth of Hunters Creek, which are predominantly older trees (>28 years) and there was no evidence of recruitment in the previous 10 years (all juveniles were planted by the local landcare group) (Nicol *et al.* 2006).

2.4. Murray Estuary (Goolwa to Tauwitchere)

The temporally variable salinity regime (low salinities during barrage outflows and marine salinities when the barrages are closed) that historically characterised the Murray Estuary (Geddes and Hall 1990) have not been present since the mid 1990s due to closure of the barrages and dredging of the Murray Mouth (Geddes 2005a; Geddes 2005b). The salinity in the Murray Estuary from 2004 to 2007 was marine for the most part with very little temporal variation (Brookes *et al.* 2009).

Historically, *Ruppia megacarpa* was the dominant submergent species in the Murray Estuary (and North Lagoon of the Coorong) because it is adapted to variable salinities ranging from fresh to 46‰ TDS (Brock 1982a; Brock 1982b). From the 1980s to the mid 1990s extensive beds of *Ruppia megacarpa* were present throughout the Murray Estuary (Geddes and Butler 1984; Geddes 1987; Edyvane *et al.* 1996). However, after the near closure of the Murray Mouth in 2001 the Murray Estuary was completely devoid of submergent species and has remained devoid of submergents to the present day, even after the controlled barrage releases in September-October 2004 and August 2005 (Geddes 2005a; Geddes 2005b; Nicol 2007). In addition, Nicol (2007) reported that there was no viable *Ruppia megacarpa* seed bank in the Murray Estuary. The population dynamics of *Ruppia megacarpa* in the Murray Estuary from the mid 1970s to 2005 are summarised in Nicol (2005)

There is little information regarding the littoral vegetation of the Murray Estuary, there are extensive areas of sandy beaches and samphire shrublands (*Halosarcia pergranulata, Suaeda australis, Sarcocornia quinqueflora*) (Phillips and Muller 2006; Stewart *et al.* 2009) (Appendix 2d). In addition there are localised areas of emergent freshwater species (*Typha* spp., *Phragmites australis*) in areas where fresh groundwater discharges along the shoreline (Phillips and Muller 2006) (Appendix 2d).

2.5. Coorong Lagoons

A salinity gradient (salinity increases south-easterly along the length of the Coorong), ranging from marine close to Tauwitchere Barrage to hypermarine throughout most of the North Lagoon and all of the South Lagoon existed from 2004 to 2007. The increasing salinities were due lack of freshwater inflows (Figure 4) and inputs of salt from the Southern Ocean and evapoconcentration along the length of the Coorong lagoons in areas where tidal flushing is absent (Webster 2005b).

Historically *Ruppia megacarpa* was the dominant submergent species in the North Lagoon and *Ruppia tuberosa* in the South Lagoon (Womersley 1975; Geddes and Brock 1977; Geddes and Butler 1984; Geddes 1987; Geddes and Hall 1990). *Ruppia megacarpa* has not been observed in the North Lagoon since the early 1990s (Geddes and Hall 1990; Edyvane *et al.* 1996). *Ruppia tuberosa* has a higher salinity tolerance than *Ruppia megacarpa* and was common in the South Lagoon until the 2000s (Womersley 1975; Geddes and Brock 1977; Geddes and Butler 1984; Geddes 1987; Geddes and Hall 1990; Leary 1993; Paton 2000; Paton 2001; Paton *et al.* 2001; Nicol 2005; Phillips and Muller 2006). Since the early 2000s the abundance of *Ruppia tuberosa* has declined and by 2007 was absent from the southern half of the South Lagoon and had began to colonise the southern end of the North Lagoon (Paton 2005a; Paton 2005b; Paton and Rogers 2008; Brookes *et al.* 2009). The population dynamics of *Ruppia megacarpa* and *Ruppia tuberosa* in the North and South Lagoons of the Coorong from the mid 1970s to 2005 are summarised in Nicol (2005).

Similar to the Murray Estuary there is little information regarding the littoral vegetation of the Coorong; however, there are extensive areas of sandy beaches and samphire shrublands (*Halosarcia pergranulata, Suaeda australis, Sarcocornia quinqueflora*) (Phillips and Muller 2006; Stewart *et al.* 2009) (Appendix 2e). In addition, there are localised areas of emergent freshwater species (*Typha* spp., *Phragmites australis*) where fresh groundwater discharges along the shoreline (Phillips and Muller 2006) (Appendix 2e).

3. Current Ecological Condition (post 2007)

Since 2007 flows over Lock 1 have not been sufficient to maintain pool level upstream of the barrages, consequently water levels have been steadily falling to unprecedented lows (Figure 3). This has exposed and desiccated large areas of lakebed, all of the fringing freshwater wetlands in the Lower Lakes, large areas of riverbank and all of the formerly permanent freshwater wetlands between Wellington and Lock 1. Exposure and subsequent oxidization of sediments that have not been exposed, in some cases, for thousands of years have resulted in the development of extensive areas of acid sulfate soils between the barrages and Lock 1 (Merry *et al.* 2003; Lamontagne *et al.* 2004; Fitzpatrick *et al.* 2009a; Fitzpatrick *et al.* 2009b). In attempts to prevent the formation or mitigate acid sulfate soils; a bank was constructed at the Narrung Narrows and a regulator constructed at Clayton (Figure 1). Water was pumped from Lake Alexandrina into Lake Albert at Narrung and the Goolwa Channel at Clayton to maintain higher water levels in Lake Albert and Goolwa Channel. In addition, flows from the Finniss River and Tookayerta and Currency Creeks will be impounded by the Clayton regulator and prevented from flowing into Lake Alexandrina to maintain water levels after pumping has ceased. The aforementioned structures have disconnected Lake Albert and Goolwa Channel from Lake Alexandrina and water levels are now held at higher levels in the associated waterbodies.

The absence of flows over the barrages (Figure 4) and continued dredging to keep the Murray Mouth open has resulted in almost constant marine salinities in the Murray Estuary and further salt inputs into the North and South Lagoons of the Coorong (Brookes *et al.* 2009).

3.1. Gorge (Lock 1 to Mannum)

Nicol (2010) undertook understorey vegetation and *Eucalyptus camaldulensis* condition surveys in six gorge wetlands between Mannum and Lock 1 (Mannum Swamps, Lake Carlet, Caurnamont, Wongulla Lagoon, Devon Downs North and Noonawirra) in spring 2008 and autumn 2009. The current condition of vegetation in the gorge section was determined by comparing information from Nicol (2010) and the River Murray Wetlands baseline surveys (Holt *et al.* 2005; Nicol *et al.* 2006; Weedon *et al.* 2006; Marsland and Nicol 2007; Marsland and Nicol 2008).

The major change in the plant community since 2007 between Lock 1 and Mannum is the complete disappearance of submergent and floating species from wetlands due to desiccation of floodplain wetlands. Extensive beds of *Vallisneria spiralis, Potamogeton crispus, Potamogeton tricarinatus, Azolla filiculoides* and the amphibious fluctuation responder-plastic species *Myriophyllum verrucosum* that were present in wetlands throughout the gorge section (Holt *et al.* 2005; Nicol *et al.* 2006; Weedon *et al.* 2006; Marsland and Nicol 2007; Marsland and Nicol 2008) (Appendix 2a) have completely disappeared and there has been no observed colonisation of these species (except *Azolla filiculoides*) in the main channel (Table 3) (Marsland *et al.* 2010; Nicol 2010). In addition to the loss of submergents, the amphibious and floodplain herb and grass communities that were present in the littoral zone (Holt *et al.* 2005; Nicol *et al.* 2006; Weedon *et al.* 2006; Marsland and Nicol 2007; Marsland and Nicol 2008), were not observed by Nicol (2010) in spring 2008 or autumn 2009 (Table 3).

The large stands of P*hragmites australis* that were present prior to 2007 along the banks of the River Murray and around the edges of wetlands (Holt *et al.* 2005; Nicol *et al.* 2006; Weedon *et al.* 2006; Marsland and Nicol 2007; Marsland and Nicol 2008; Marsland *et al.* 2010) (Appendix 2a) still remained and appeared to be in good condition and growing (Marsland *et al.* 2010; Nicol 2010). The *Typha* spp. and *Schoenoplectus validus* stands, whilst live plants were present, showed reduced extent and appeared to be in poor condition (Marsland *et al.* 2010; Nicol 2010).

Terrestrial dry species such as *Atriplex* spp., *Enchylaena tomentosa, Teucrium racemosum* and *Einadia nutans*, which were historically only present on the floodplain above historical pool level (Holt e*t al.* 2005; Nicol *et al.* 2006; Weedon et al 2006; Marsland and Nicol 2007; Marsland and Nicol 2008) had colonised the dry wetland beds (Nicol 2010). However, large numbers of healthy *Eucalyptus camaldulensis* saplings were also present on the dry wetland bed that had recruited as a result of low water levels (Nicol 2010).

Eucalyptus camaldulensis condition, despite the low water levels, was predominantly good to excellent in the surveyed wetlands prior to 2007 (Weedon *et al.* 2006; Marsland and Nicol 2007; Marsland and Nicol 2008) and in 2008-09; however, canopy density was generally lower in autumn 2009 than in spring 2008 (Nicol 2010). It is unknown whether this result was a seasonal pattern or the early stages of a decline in condition (Nicol 2010).

Table 3: Species present (and functional group) in the 2005 (Nicol *et al.* 2006; Weedon *et al.* 2006), 2006 (Marsland and Nicol 2007) and 2007 (Marsland and Nicol 2008) River Murray Wetlands Baseline Surveys not recorded in the Lock 1 Wetlands draw down monitoring (Nicol 2010) (*denotes exotic species, #denotes listed as rare in South Australia).

Species	Functional Group
Alternanthera denticulata	Floodplain
Ammania multiflora	Floodplain
Centipeda minima	Floodplain
Epaltes australis	Floodplain
Eragrostis australasica	Floodplain
Haloragis aspera	Floodplain
Lachnagrostis filiformis	Floodplain
Lythrum hyssopifolia	Floodplain
Morgania floribunda	Floodplain
Polygonum plebium	Floodplain
Psuedognaphalium luteo-album	Floodplain
Rhodanthe pygmaeum	Floodplain
Swainsona swainsonoides	Floodplain
Wahlenbergia fluminalis	Floodplain
Cyperus exaltatus	Amphibious fluctuation tolerator-emergent
Juncus usitatus	Amphibious fluctuation tolerator-emergent
Limosella australis	Amphibious fluctuation tolerator-low growing
*Cotula coronopifolia**	Amphibious fluctuation responder-plastic
Hydrocotyle verticillata	Amphibious fluctuation responder-plastic
Ludwigia peploides spp. *montevidensis*	Amphibious fluctuation responder-plastic
Marsilea drummondii	Amphibious fluctuation responder-plastic
Myriophyllum papillosum#	Amphibious fluctuation responder-plastic
Myriophyllum verrucosum	Amphibious fluctuation responder-plastic
Nymphaea sp.*	Amphibious fluctuation responder-plastic
*Ranunculus scleratus**	Amphibious fluctuation responder-plastic
Rumex bidens	Amphibious fluctuation responder-plastic
*Rumex crispus**	Amphibious fluctuation responder-plastic
Berula erecta	Emergent
Bolboschoenus caldwellii	Emergent
Eleocharis acuta	Emergent
Eleocharis sphacelata	Emergent
Schoenoplectus validus	Emergent
Triglochin procerum	Emergent
Azolla filiculoides	Floating
Lepilaena australis	Submergent r-selected
Nitella sp.	Submergent r-selected
Ceratohylloum demersum#	Submergent k-selected
Potamogeton crispus	Submergent k-selected
Potamogeton tricarinatus	Submergent k-selected
Vallisneria spiralis	Submergent k-selected

3.2. Lower Swamps (Mannum to Wellington)

No vegetation surveys of Lower Swamps wetlands have been undertaken since the 2004 (Holt e*t al.* 2005) and 2005 (Nicol *et al.* 2006) River Murray Wetlands Baseline Surveys. However, the same changes observed in the gorge section wetlands probably occurred in the Lower Swamps. Submergent and floating species would be completely absent, amphibious, emergent and terrestrial damp species would have declined in abundance and terrestrial dry species (probably predominantly agricultural weeds and pasture species) colonised the wetland beds (it is unknown whether large numbers of *Eucalyptus camaldulensis* saplings have recruited in response to the draw down or whether the stands of *Typha* spp. and *Phragmites australis* have survived).

Similarly no vegetation surveys of the River Murray main channel have been undertaken since 2007; however, Marsland *et al.* (2010) undertook habitat assessments during electrofishing surveys in autumn 2008 that involved recording percentage cover of all plant species in an electrofishing shot (*sensu* Zampatti *et al.* 2006a; Zampatti *et al.* 2006b). No submergent or amphibious species were recorded between Mannum and Wellington in the main channel and the littoral plant community was predominantly *Salix* spp. with localised patches of *Typha* spp. and *Phragmites australis* (Marsland *et al.* 2010).

3.3. Lower Lakes (Lakes Alexandrina and Albert and the Lower Finniss River and Currency Creek)

Marsland and Nicol (2009) and Nicol and Marsland (2010) undertook vegetation surveys in spring 2008, autumn 2009 and spring 2009 as part of the vegetation condition monitoring for the Lower Lakes for the Living Murray Initiative. In addition, Marsland and Nicol (2009) determined the age class structure for *Melaleuca halmaturorum* stands at Goat Island, Hunters Creek, Hindmarsh Island, Salt Lagoon and Kennedy Bay. The current condition of the vegetation in the Lower Lakes and how it has changed in recent years was determined by comparing data from the aforementioned studies with the 2004 (Holt *et al.* 2005) and 2005 (Nicol *et al.* 2006) River Murray Wetlands baseline surveys.

Similar to the gorge and lower swamps the major change in the vegetation community Lake Alexandrina upstream of the Clayton regulator and Lake Albert is the loss of submergent species and colonisation of terrestrial dry (e.g. *Pennisetum clandestinum, Enchylaena tomentosa, Einadia nutans*) and salt tolerant taxa (e.g. *Sarcocornia quinqueflora*, *Cotula coronopifolia, Eragrostis curvula*) due to the desiccation and (in some cases) salinisation of the fringing wetlands or sheltered areas (Table 4) (Marsland and Nicol 2009). Submergent species were not observed in the inundated areas of Lake Alexandrina or Lake Albert (Marsland and Nicol 2009). However, downstream of the

Clayton regulator where water levels are higher (DWLBC 2010) and the fringing habitats are inundated, *Ruppia* spp., *Potamogeton pectinatus*, *Potamogeton crispus, Ceratophyllum demersum* and *Myriophyllum* spp. have been observed (J. Nicol pers. obs.).

The extensive *Phragmites australis* stands and *Muehlenbeckia florulenta* and samphire shrublands that were present around the edges of Lake Alexandrina and Lake Albert are still present and in many areas have expanded their distribution down the elevation to colonise areas of dry lakebed (Marsland and Nicol 2009). *Typha* spp. and *Schoenoplectus validus* stands, whilst live plants were present, showed reduced extent and appeared to be in poor condition (Marsland and Nicol 2009). Downstream of the Clayton regulator the stands of Emergent species (*Typha* spp. and *Phragmites australis*) were growing and appeared to be in excellent condition (J. Nicol pers. obs.) despite surface water conductivity in excess of 15,000 EC (DWLBC 2010).

The area of *Melaleuca halmaturorum* stands did not change significantly between 2003 and 2008 and recruitment was observed in Dunns Lagoon, Kennedy Bay, Goose Island and Salt Lagoon (Marsland and Nicol 2009). The recruitment observed in Dunns Lagoon and Kennedy Bay was due to low water levels (*sensu* Nicol and Ganf 2000), on Goose Island juveniles were only observed in areas that had been mowed and in Salt Lagoon in an area that had been burned in summer 2007-08 (Marsland and Nicol 2009). No juveniles were recorded at Hunters Creek and Hindmarsh Island and the stands were dominated by old trees (Marsland and Nicol 2009).

Table 4: Species present (and functional group) in the 2004 (Holt *et al.* 2005) and 2005 (Nicol *et al.* 2006) River Murray Wetlands baseline surveys that were not recorded in the 2008-09 Living Vegetation Murray condition monitoring surveys for the Lower Lakes (Marsland and Nicol 2009) (*denotes exotic species).

Species	Functional Group
Puccinella stricta var. perlaxa	Terrestrial damp
Puccinella stricta var. stricta	Terrestrial damp
Euphorbia drummondii	Floodplain
Lythrum hyssopifolia	Floodplain
Crassula helmsii	Amphibious fluctuation tolerator-low growing
Lilaeopsis polyantha	Amphibious fluctuation tolerator-low growing
Mimulus repens	Amphibious fluctuation tolerator-low growing
Triglochin hexagonum	Amphibious fluctuation tolerator-low growing
Centella asiatica	Amphibious fluctuation responder-plastic
Cotula vulgaris var. australasica	Amphibious fluctuation responder-plastic
Hydrocotyle verticillata	Amphibious fluctuation responder-plastic
Ludwigia peploides ssp. *montevidensis*	Amphibious fluctuation responder-plastic
Myriophyllum caput-medusae	Amphibious fluctuation responder-plastic
Myriophyllum salsugineum	Amphibious fluctuation responder-plastic
Myriophyllum simulans	Amphibious fluctuation responder-plastic
Ranunculus amphitrichus	Amphibious fluctuation responder-plastic
Rumex bidens	Amphibious fluctuation responder-plastic
Bolboschoenus caldwellii	Emergent
Eleocharis acuta	Emergent
Azolla filiculoides	Floating
Azolla pinnata	Floating
Lemna disperma	Floating
Spirodela punctata	Floating
*Batrachium trichophyllum**	Submergent r-selected
Lepilaena australis	Submergent r-selected
Lepilaena cylindrocarpa	Submergent r-selected
Ruppia polycarpa	Submergent r-selected
Ruppia tuberosa	Submergent r-selected
Potamogeton pectinatus	Submergent k-selected
Ruppia megacarpa	Submergent k-selected
Vallisneria spiralis	Submergent k-selected

3.4. Murray Estuary (Goolwa to Tauwitchere)

There has been no significant change in the submergent community of the Murray Estuary since 2007. The salinity has remained at or close to marine salinity (due to the continual dredging of the Murray Mouth) and there has been no recruitment of marine plants (Brookes *et al.* 2009). The littoral vegetation also probably has not changed significantly; however, no studies relating to the littoral vegetation of the Murray Estuary have been published in recent years.

3.5. Coorong Lagoons

The major change in the submergent vegetation in the Coorong has been the disappearance of *Ruppia tuberosa* from all but the northern quarter of the South Lagoon and expansion in distribution and abundance in the North Lagoon (Brookes *et al.* 2009). No studies relating to the littoral vegetation of the Coorong have been published in recent years; although, the increase in surface water salinity since 2007 has probably extirpated some of the less salt tolerant halophytes (e.g. *Juncus kraussii* (Naidoo and Kift 2006) and may have reduced germination, juvenile survival and seed production in other halophytes (*sensu* Bornman *et al.* 2002; Malcolm *et al.* 2003; Bornman *et al.* 2008; Flowers and Colmer 2008; Song *et al.* 2008).

4. Conclusions

The current drought coupled with river regulation and abstraction have meant the plant communities in the River Murray downstream of Lock 1, the Lower Lakes, Murray Estuary and Coorong have undergone significant changes and continue to change. Upstream of the barrages Submergent and many Amphibious species have been lost from areas where they were historically abundant (except Goolwa Channel) and have not colonised the remnant inundated habitats (Marsland and Nicol 2009; Marsland *et al.* 2010; Nicol 2010), which has significant consequences for regional biodiversity. Terrestrial and salt tolerant species that were restricted to the floodplain and highland have colonised areas that were previously permanently inundated (Marsland and Nicol 2009, Nicol and Marsland 2010; Nicol 2010). *Phragmites australis* stands, *Muehlenbeckia florulenta* shrublands, samphire shrublands, *Melaleuca halmaturorum* woodlands and *Eucalyptus camaldulensis* woodlands were (at the time of writing) generally in good condition, actively growing, flowering and in some cases colonising areas of dry wetland (Marsland and Nicol 2009; Nicol 2010). The less desiccation tolerant fringing species (*Typha* spp. *Bolboschoenus* spp. and *Schoenoplectus validus*) (Roberts and Marston 2000) were generally present but in poorer condition (Marsland and Nicol 2009; Nicol 2010). Despite the good condition of much of the fringing vegetation it is unknown how long these communities will remain in good condition, what processes maintain these communities in the absence of surface water (i.e. groundwater) and whether they play the same role in the ecosystem as hydrologically connected communities.

Despite desiccation, acidification and increased salinity, the plant community in Lower Lakes appears to be resilient. Fringing habitats in Goolwa Channel that had been colonised by terrestrial and salt tolerant species in autumn 2009 (Marsland and Nicol 2009; Nicol and Marsland 2010) were inundated in spring 2009 with water that had a conductivity of 10,000 EC (J. Nicol unpublished data). In January 2010 Submergent (e.g. *Ceratophyllum demersum*) and Amphibious (*Myriophyllum* spp.) freshwater species had colonised the fringing habitats and *Typha* spp. and *Phragmites australis* stands were actively growing and appeared to be very healthy despite a surface water conductivity of 15,000 EC (J. Nicol pers. obs.). The surface water salinity at the time of writing exceeds the upper salinity thresholds for *Typha domingensis* and *Ceratophyllum* *demersum* (Hart *et al.* 1991; Bailey *et al.* 2002), which are both abundant and appear to be in good condition in Goolwa Channel (J. Nicol pers. obs.). It is unknown whether the Lower Lakes populations of these species have higher salinity thresholds or whether they are using a fresher water source such as groundwater.

Downstream of the barrages in the Murray Estuary there has been very little if any change in the plant community which is probably due to constant marine salinity (Brookes *et al.* 2009). The system appears to have reached a stable state but whether the submergent plant community observed in the 1980s and 1900s (Geddes and Butler 1984; Geddes and Hall 1990; Edyvane *et al.* 1996) will return if a variable salinity regime is reinstated, is unknown.

In contrast to the Murray Estuary the Submergent plant communities in the North and South Lagoons of the Coorong are in a state of change. There has been a significant decline in the distribution and abundance of *Ruppia tuberosa* in the South Lagoon but an increase in the North Lagoon, which is probably due to increases in salinity (Womersley 1975; Geddes and Brock 1977; Paton 1982; Geddes and Hall 1990; Paton 1996; Paton 2000; Paton 2001; Paton *et al.* 2001; Paton and Bolton 2001; Paton 2002; Paton 2003; Nicol 2005; Paton 2005a; Paton 2005b; Paton and Rogers 2008; Brookes *et al.* 2009). To restore *Ruppia tuberosa* populations in the South Lagoon, significant engineering works and pumping may be required (in addition to barrage outflows) to reduce the salinity in the South Lagoon to enable *Ruppia tuberosa* to recolonise (Brookes *et al.* 2009).

4.1. Knowledge Gaps

The current conditions in the River Murray downstream of Lock 1, Lower Lakes, Murray Estuary and Coorong brought about by the combination of drought and over allocation have never been encountered and there is little information available regarding the response of plant communities to similar conditions.

Key knowledge gaps include:

- Impact of acid and heavy metals on propagule survival.
- Impact of acid and heavy metals on germination, recruitment and colonisation of aquatic plants.
- Mechanisms of recovery (i.e. how important is the resident propagule bank versus other mechanisms such as hydrochory, zoochory).
- Impacts of acid sulfate soil remediation (e.g. liming, bioremediation) on aquatic plant recruitment.

- Potential for regeneration from the resident propagule bank in the Lower Lakes upstream of the Clayton regulator and River Murray wetlands between Wellington and Lock 1.
- Differences in ecosystem services provided by disconnected (but otherwise in good condition) habitats (e.g. samphire shrublands, *Muehlenbeckia florulenta* shrublands, reed beds), compared with the same habitats that are hydrologically connected to a water body.
- Salinity thresholds for key life history stages (e.g. flowering and seed set, juvenile growth and survival, germination) for halophytes to determine freshwater requirements.
- Age structure of hydrologically disconnected samphire communities.
- Medium to long-term persistence of hydrologically disconnected fringing communities.
- Processes that influence the condition of fringing communities.
- Identification of important fish, bird and macroinvertebrate habitat.
- Salinity tolerances of the local populations of key macrophytes such as *Typha* spp., *Ceratophyllum demersum, Myriophyllum* spp., *Phragmites australis* and *Potamogeton* spp.
- What is the capacity for the system to recover, how long will the system remain resilient and what factors compromise or enhance resilience.
- Impacts (e.g. relative growth rate, seed production, turion production) of sub-lethal salinities on *Ruppia megacarpa* and *Ruppia tuberosa*.
- Freshwater requirements to maintain *Ruppia megacarpa* populations.

5. References

Aston, H.I. (1973). 'Aquatic Plants of Australia.' (Melbourne University Press: Melbourne)

Bailey, P., Boon, P. and Morris, K. (2002). 'Salt sensitivity database.' Land and Water Australia.

Begg, C.S., Archibold, O.W. and Delanoy, L. (1998). Preliminary investigation into the effects of water-level control on seedling recruitment in riparian Cottonwoods, *Populus deltoides,* on the South Saskatchewan River. *Canadian Field-Naturalist.* **112**: 684-693.

Bice , C. (2010). Literature review on the ecology of fishes of the Lower Murray, Lower Lakes, and Coorong. South Australian Research and Development Institute (Aquatic Sciences), SARDI Aquatic Sciences Publication Number F2010/000031-1, Adelaide.

Blanch, S.J., Ganf, G.G. and Walker, K.F. (1999a). Growth and resource allocation in response to flooding in the emergent sedge *Bolboschoenus medianus*. *Aquatic Botany* **63**: 145-160.

Blanch, S.J., Ganf, G.G. and Walker, K.F. (1999b). Tolerance of riverine plants to flooding and exposure by water regime. *Regulated Rivers: Research and Management* **15**: 43-62.

Blanch, S.J., Walker, K.F. and Ganf, G.G. (2000). Water regimes and littoral plants in four weir pools of the River Murray, Australia. *Regulated Rivers-Research & Management* **16**: 445-456.

Boers, A.M. and Zedler, J.B. (2008). Stabilized water levels and *Typha* invasiveness. *Wetlands* **28**: 676-685.

Bornman, T.G., Adams, J.B. and Bate, G.C. (2002). Freshwater requirements of a semi-arid supratidal and floodplain salt marsh. *Estuaries* **25**: 1394-1405.

Bornman, T.G., Adams, J.B. and Bate, G.C. (2008). Environmental factors controlling the vegetation zonation patterns and distribution of vegetation types in the Olifants Estuary, South Africa. *South African Journal of Botany* **74**: 685-695.

Brandle, R., Hammer, M., Wedderburn, S., Seaman, R., Noye, R. and Queale, L. (2002). 'A biological survey of the Murray Mouth Reserves, South Australia March 2002.' Department for Environment and Heritage, Adelaide.

Brock, M.A. (1979). The ecology of salt lake hydrophytes. Ph.D. thesis, The University of Adelaide.

Brock, M.A. (1981a). Accumulation of proline in a submerged aquatic halophyte, *Ruppia* L. *Oecologia* **51**: 217-219.

Brock, M.A. (1981b). The ecology of halophytes in the south-east of South Australia. *Hydrobiologia* **81**: 23-32.

Brock, M.A. (1982a). Biology of the salinity tolerant genus *Ruppia* L. in saline lakes in South Australia I. Morphological variation within and between species and ecophysiology. *Aquatic Botany* **13**: 219-248.

Brock, M.A. (1982b). Biology of the salinity tolerant genus *Ruppia* L. in saline lakes in South Australia II. Population ecology and reproductive biology. *Aquatic Botany* **13**: 249-268.

Brock, M.A. and Casanova, M.T. (1997). Plant life at the edge of wetlands: ecological responses to wetting and drying patterns. In 'Frontiers in Ecology: Building the Links'. (Eds Klomp, N. and Lunt, I.) pp. 181-192. (Elsevier Science: Oxford).

Brookes, J.D., Lamontagne, S., Aldridge, K.T., S., B., Bissett, A., Bucater, L., Cheshire, A.C., Cook, P.L.M., Deegan, B.M., Dittmann, S., Fairweather, P.G., Fernandes, M.B., Ford, P.W., Geddes, M.C., Gillanders, B.M., Grigg, N.J., Haese, R.R., Krull, E., Langley, R.A., Lester, R.E., Loo, M., Munro, A.R., Noell, C.J., Nayar, S., Paton, D.C., Revill, A.T., Rogers, D.J., Rolston, A., S.K., S., Short, D.A., Tanner, J.E., Webster, I.T., Wellman, N.R. and Ye, Q. (2009). 'An Ecosystem Assessment Framework to Guide Management of the Coorong. Final Report of the CLLAMMecology Research Cluster.' CSIRO: Water for a Healthy Country National Research Flagship, Canberra.

Brownlow, M.D. (1997). Water Regime and the Aquatic Vegetation of Bool Lagoon, South Australia. PhD thesis, The University of Adelaide.

Capon, S.J. (2003). Plant community responses to wetting and drying in a large arid floodplain. *River Research and Applications* **19**: 509-520.

Capon, S.J. (2007). Effects of flooding on seedling emergence from the soil seed bank of a large desert floodplain. *Wetlands* **27**: 904-914.

Casanova, M.T. and Brock, M.A. (2000). How do depth, duration and frequency of flooding influence the establishment of wetland plant communities? *Plant Ecology* **147**: 237-250.

Clarke, L.D. and Hannon, N.J. (1970). The mangrove swamp and salt marsh communities of the Sydney District: III. Plant growth in relation to salinity and waterlogging. *Journal of Ecology* **58**: 351-369.

Colmer, T.D. and Flowers, T.J. (2008). Flooding tolerance in halophytes. *New Phytologist* **179**: 964-974.

Coops, H. and Van der Velde, G. (1996). Effects of waves on helophyte stands: mechanical characteristics of stems of *Phragmites australis* and *Scirpus lacustris*. *Aquatic Botany* **53**: 175-185.

Cremer, K. (2000). Willow management for Australian rivers. *Natural Resource Management, The Journal of the Australian Association of Natural Resource Management* **Special Issue**: 1-22.

Cremer, K.W. (1995). 'Willow Identification for River Management in Australia.' CSIRO Division of Forestry, 3, Canberra.

Cunningham, G.M., Mulham, W.E., Milthorpe, P.L. and Leigh, J.H. (1981). 'Plants of Western New South Wales.' (New South Wales Government Printing Office: Sydney)

Davies, B.R., Thoms, M.C., Walker, K.F., O'Keeffe, J.H. and Gore, J.A. (1994). Dryland rivers: Their ecology, consevation and management. In 'The Rivers Handbook. Hydological and Ecological Principles'. (Eds Callow, P. and Petts, G.E.) pp. 484-511. (Blackwell Scientific: Oxford).

Davis, J.S. (1978). Biological communities of a nutrient enriched salina. *Aquatic Botany* **4**: 23-42.

Deegan, B.M., White, S.D. and Ganf, G.G. (2007). The influence of water level fluctuations on the growth of four emergent macrophyte species. *Aquatic Botany* **86**: 309-315.

Dick, J., Haynes, D., Tibby, J., Garcia, A. and Gell, P. (2010). A history of aquatic plants in the Ramsar-listed Coorong wetland, South Australia *Journal of Paleolimnology*.

Doyle, R.D. (2001). Effects of waves on the early growth of *Vallisneria americana*. *Freshwater Biology* **46**: 389-397.

Edyvane, K.S., Carvalho, P., Evans, K., Fotheringham, D., Kinloch, M. and McGlennon, D. (1996). 'Biological resource assessment of the Murray Mouth Estuary.' South Australian Research and Development Institute Aquatic Sciences, Adelaide.

Elsey-Quirk, T., Middleton, B.A. and Proffitt, C.E. (2009). Seed flotation and germination of salt marsh plants: The effects of stratification, salinity, and/or inundation regime. *Aquatic Botany* **91**: 40-46.

Fitzpatrick, R., Grealish, G., Shand, P., Marvanek, S., Thomas, B., Creeper, N., Merry, R. and Raven, M. (2009a). 'Preliminary assessment of acid sulfate soil materials in Currency Creek, Finniss River, Tookayerta Creek and Black Swamp region, South Australia.' CSIRO Land and Water, Adelaide.

Fitzpatrick, R.W., Grealish, G., Shand, P., Simpson, S.L., Merry, R.H. and Raven, M.D. (2009b). 'Acid sulfate soil assessment in Finniss River, Currency Creek, Black Swamp and Goolwa Channel, South Australia.' CSIRO Land and Water, 26/09, Adelaide.

Flowers, T.J. and Colmer, T.D. (2008). Salinity tolerance in halophytes. *New Phytologist* **179**: 945-963.

Fluin, J., Gell, P., Haynes, D., Tibby, J. and Hancock, G. (2007). Palaeolimnological evidence for the independent evolution of neighbouring terminal lakes, the Murray Darling Basin, Australia. *Hydrobiologia* **591**: 117-134.

Foote, A.L. and Kadlec, J.A. (1988). Effects of wave energy on plant establishemnt in shallow lacustrine wetlands. *Journal of Freshwater Ecology* **4**: 523-532.

Garcia-de-Lomas, J., Hernandez, I. and Sanchez-García, I. (2009). Incipient invasion of *Galenia secunda* Sond. (Aizoaceae) in Southern Spain. *Biological Invasions* **11**: 467-472.

Geddes, M.C. (1987). Changes in salinity and in the distribution of macrophytes, macrobenthos and fish in the Coorong lagoons, South Australia, following a period of River Murray flow. *Transactions of the Royal Society of South Australia* **111**: 173-181.

Geddes, M.C. (2005a). 'Ecological outcomes for the Murray Mouth and Coorong from the managed barrage release of September-October 2003.' South Australian Research and Development Institute (Aquatic Sciences), SARDI Aquatic Sciences Publication No. RD03/0199-2

Geddes, M.C. (2005b). 'Ecological outcomes from the small barrage outflow of August 2004.' South Australian Research and Development Institute (Aquatic Sciences), SARDI Aquatic Sciences Publication Number RD05/0018-1. SARDI Research Report Series Number 116, Adelaide.

Geddes, M.C. and Brock, M.A. (1977). Limnology of some lagoons in the southern Coorong. In 'The Southern Coorong and Lower Younghusband Peninsula of South Australia'. (Eds Gilbertson, D.D. and Foale, M.R.) pp. 47-54. (Nature Conservation Society of South Australia Inc.: Adelaide).

Geddes, M.C. and Butler, A.J. (1984). Physiochemical and biological studies on the Coorong lagoons, South Australia, and the effect of salinity on the distribution of macrobenthos. *Transactions of the Royal Society of South Australia* **108**: 51-62.

Geddes, M.C. and Hall, D. (1990). The Murray Mouth and Coorong. In 'The Murray'. (Eds Mackay, N. and Eastburn, D.) pp. 200-213. (Murray Darling Basin Commission: Canberra)

Gilbertson, D.D. and Foale, M.R. (1977). 'The Coorong and lower Younghusband Peninsula of South Australia.' nature Conservation Society of South Australia, Adelaide.

Greenwood, M.E. (2008). Predicting the effects of salinity on three dominant macrophytes: An anticipatory approach to the restoration of degraded coastal wetlands in NSW, Australia Ph.D. thesis, University of Newcastle.

Greenwood, M.E. and MacFarlane, G.R. (2006). Effects of salinity and temperature on the germination of *Phragmites australis, Juncus kraussii,* and *Juncus acutus*: implications for estuarine restoration initiatives. *Wetlands* **26**: 854-861.

Greenwood, M.E. and MacFarlane, G.R. (2009). Effects of salinity on competitive interactions between two *Juncus* species. *Aquatic Botany* **90**: 23-29.

Grime, J.P. (1979). 'Plant Stategies and Vegetation Processes.' (John Wiley and Sons Ltd: Chichester).

Hart, B.T., Bailey, P., Edwards, R., Hortle, K.G., James, K., McMahon, A., Meredith, C. and Swadling, K. (1991). A review of the salt sensitivity of the Australian freshwater biota. *Hydrobiologia* **210**: 150-144.

Hawes, I., Riis, T., Sutherland, D. and Flanagan, M. (2003). Physical constraints to aquatic plant growth in New Zealand lakes. *Journal of Aquatic Plant Management* **41**: 44-52.

Heritage, S.A.D.f.E.a. (2000). 'Coorong, and Lakes Alexandrina and Albert Ramsar management plan.' Department of Environment and Heritage, Adelaide.

Holliday, I. (2004). 'Melaleucas: a Field and Garden Guide.' (Reed New Holland: Sydeny).

Holt, M., Swingler, K., O'Donnell, E., Shirley, M., Lake, M., Conallin, A., Meredith, S., Ho, S., Prider, J., Poulsen, D., Richardson, S. and Cooling, M. (2005). 'River Murray Wetlands Baseline Survey.' River Murray Catchment Water Management Board, Berri.

Hudon, C., Lalonde, S. and Gagnon, P. (2000). Ranking the effects of site exposure, plant growth form, water depth, and transparency on aquatic plant biomass. *Canadian Journal of Fisheries & Aquatic Sciences* **57**: 31-42.

Jensen, A., Paton, P., Mowbray, T., Simpson, D., Kinnear, S. and Nichols, S. (1996). 'Wetlands atlas of the South Australian Murray Valley.' South Australian Department of Environment and Natural Resources, Adelaide.

Jessop, J., Dashorst, G.R.M. and James, F.R. (2006). 'Grasses of South Australia. An illustrated guide to the native and naturalised species.' (Wakefield Press: Adelaide)

Jessop, J.P. and Tolken, H.R. (1986). 'The Flora of South Australia.' (Government of South Australia Printer: Adelaide).

Kennedy, S.A., Ganf, G.G. and Walker, K.F. (2003). Does salinity influence the distribution of exotic willows (*Salix* spp.) along the Lower River Murray? *Marine and Freshwater Research* **54**: 825-831.

Khan, M.A. and Weber, D.J. (2006). 'Ecophysiology of High Salinity Tolerant Plants.' (Springer).

King, W., Wilson, J.B. and Sykes, M.T. (1990). A vegetation zonation from saltmarsh to riverbank in New Zealand. *Journal of Vegetation Science* **1**: 411-418.

Lamontagne, S., Hicks, W.S., Fitzpatrick, R.W. and Rogers, S. (2004). 'Survey and description of sulfidic materials in wetlands of the Lower River Murray floodplains: Implications for floodplain salinity management.' CSIRO Land and Water and Cooperative Research Centre for Landscape Environments and Mineral Exploration, 28/04, Adelaide.

Leary, D.E. (1993). '*Ruppia tuberosa* in the South Lagoon of the Coorong. A preliminary commentary.' The University of Adelaide, Adelaide.

Lee, G., Carrow, R.N. and Duncan, R.R. (2005). Criteria for assessing salinity tolerance of the halophytic turfgrass seashore *Paspalum*. *Crop Science* **45**: 251-258.

Lester, R.E. and Fairweather, P.G. (2009). Modelling future conditions in the degraded semi-arid estuary of Australia's largest river using ecosystem states. *Estuarine, Coastal and Shelf Science* **85**: 1-11.

Lothian, J.A. and Williams, W.D. (1988). Wetland conservation in South Australia. In 'The Conservation of Australian Wetlands'. (Eds McComb, A.J. and Lake, P.S.) pp. 147-166. (Surrey Beatty and Sons Pty Ltd: Chipping Norton NSW).

Maheshwari, B.L., Walker, K.F. and McMahon, T.A. (1995). Effects of regulation on the flow regime of the River Murray, Australia. *Regulated Rivers Research and Management* **10**: 15-38.

Malcolm, C.V., Lindley, V.A., O'Leary, J.W., Runciman, H.V. and Barrett-Lennard, E.G. (2003). Halophyte and glycophyte salt tolerance at germination and the establishment of halophyte shrubs in saline environments. *Plant and Soil* **253**: 171-185.

Marcar, N., Crawford, D., Leppert, P., Jovnic, T., Floyd, R. and Farrow, R. (1995). 'Trees for saltland: a guide to selecting native species.' (CSIRO Australia, Division of Forestry: Canberra)

Marcar, N.E., Hossain, A., Crawford, D.F. and Nicholson, A.T. (2000). Evaluation of tree establishment treatments on saline seeps near Wellington and Young in New South Wales. *Australian Journal of Experimental Agriculture* **40**: 99-106.

Marsland, K. and Nicol, J. (2007). '2006 River Murray Wetlands Baseline Survey. Vegetation Component. .' South Australian Research and Development Institute (Aquatic Sciences), SARDI Publication Number RD04/0245-4, Adelaide.

Marsland, K., Nicol, J. and McNeil, D. (2010). 'Fish habitat in the Lower River Murray: an analysis of the nature, extent and the associated fish assemblages.' South Australian Research and Development Institute (Aquatic Sciences), F2007/000973-2, Adelaide.

Marsland, K.B. and Nicol, J.M. (2008). '2007 River Murray Wetlands Baseline Survey. Vegetation Component.' South Australian Research and Development Institute (Aquatic Sciences), SARDI Publication Number F2008/000058, Adelaide.

Marsland, K.B. and Nicol, J.M. (2009). 'Lower Lakes vegetation condition monitoring-2008/09.' South Australian Research and Development Institute (Aquatic Sciences), F2009/000370-1, Adelaide.

Merry, R.H., Fitzpatrick, R.W., Barnett , E.J., Davies, P.J., Fotheringham, D.G., Thomas, B.P. and Hicks, W.S. (2003). 'South Australian inventory of acid sulfate soil risk (atlas).' CSIRO Land and Water, Adelaide.

Naidoo, G. and Kift, J. (2006). Responses of the saltmarsh rush *Juncus kraussii* to salinity and waterlogging. *Aquatic Botany* **84**: 217-225.

Nichols, S.L. (1998). 'Riverine local action planning associations: wetlands management study.' Wetland Care Australia, Berri.

Nicol, J. (2005). 'The ecology of *Ruppia* spp. in South Australia, with reference to the Coorong. A literature review.' South Australian Research and Development Institute (Aquatic Sciences), SARDI Aquatic Sciences Publication No. RD 04/0247-2
SARDI Research Report Series No. 88, Adelaide.

Nicol, J.M. (2004). Vegetation Dynamics of the Menindee Lakes with Reference to the Seed Bank. PhD thesis, The University of Adelaide.

Nicol, J.M. (2007). 'Impact of Barrage Releases on the Population Dynamics of *Ruppia megacarpa* in the Murray Estuary and North Lagoon of the Coorong. Progress Report 2006/07. .' South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Nicol, J.M. (2010). 'Vegetation monitoring of River Murray Wetlands downstream of Lock 1.' South Australian Research and Development Institute (Aquatic Sciences), F2009/000416-1, Adelaide.

Nicol, J.M. and Ganf, G.G. (2000). Water regimes, seedling recruitment and establishment in three wetland plant species. *Marine and Freshwater Research* **51**: 305-309.

Nicol, J.M., Ganf, G.G. and Pelton, G.A. (2003). Seed banks of a southern Australian wetland: the influence of water regime on final species composition. *Plant Ecology* **168**: 191-205.

Nicol, J.M. and Marsland, K.B. (2010). 'Vegetation monitoring in the Lower Finniss River, Currency Creek and Tookayerta Creek.' South Australian Research and Development Institute (Aquatic Sciences), F2009/000674-1, Adelaide.

Nicol, J.M., Weedon, J.T. and Doonan, A. (2006). Vegetation Surveys. In 'River Murray Wetlands Baseline Survey – 2005'. (Eds Simpson, D., Holt, M., Champion, T., Horan, A. and Shirley, M.). (South Australian Murray Darling Basin Natural Resources Management Board: Berri).

Nielsen, D.L. and Chick, A.J. (1997). Flood-mediated changes in aquatic macrophyte community structure. *Marine and Freshwater Research* **48**: 153-157.

Noye, B.J. and Walsh, P.J. (1976). Wind-induced water level ocsillations in shallow lagoons. *Australian Journal of Marine and Freshwater Research* **27**: 417-430.

Orchard, A.E. (1985). *Myriophyllum* (Haloragaceae) in Australasia. 2. The Australian Species. *Brunonia* **8**: 173-291.

Paton, D.C. (1996). Management of biotic resources in the Coorong. *Xanthopus* **15**: 8-10.

Paton, D.C. (2000). 'Monitoring aquatic resources in the southern Coorong in winter 1999.' Department of Environment and Heritage, Mount Gambier.

Paton, D.C. (2001). 'Monitoring biotic resources in the Coorong, January 2001.' The University of Adelaide, Adelaide.

Paton, D.C. (2002). 'Conserving the Coorong. 2002 annual report to Earthwatch.' The University of Adelaide, Adelaide.

Paton, D.C. (2003). 'Conserving the Coorong. 2003 annual report to Earthwatch.' The University of Adelaide, Adelaide.

Paton, D.C. (2005a). '2005 winter monitoring of the southern Coorong.' The University of Adelaide and South Australian Department of Water, Land and Biodiversity Conservation, Adelaide.

Paton, D.C. (2005b). 'Monitoring of biotic systems in the Coorong region 2004-2005.' The University of Adelaide, Adelaide.

Paton, D.C., Bailey, C., Hill, B., Lewis, T. and Ziembicki, M. (2001). 'Study of the link between migratory bird numbers in the Coorong region, the composition of their mudflat habitat and the available food supply.' Murray Darling Basin Commission, Canberra.

Paton, D.C. and Bolton, J. (2001). 'Monitoring aquatic resources in the southern Coorong in winter 2000.' The University of Adelaide, Adelaide.

Paton, D.C. and Rogers, D.J. (2008). '2007 winter monitoring of the southern Coorong.' School of Earth and Environmental Sciences, The University of Adelaide, Adelaide.

Paton, P. (1982). 'Biota of the Coorong. A study for the Cardwell Buckingham Committee.' Department of Environment and Planning, S.A.D.E.P. 55, Adelaide.

Pessarakli, P. and Pessarakli, M. (2007). 'Handbook of turfgrass management and physiology.' (CRC Press).

Phillips, B. and Muller, K. (2006). 'Ecological character of the Coorong, Lakes Alexandrina and Albert Wetland of International Importance.' Department for Environment and Heritage, Adelaide.

Pollock, M.M., Naiman, R.J. and Hanley, T.A. (1998). Plant species richness in riparian wetlands - a test of biodiversity theory. *Ecology* **79**: 94-105.

Pressey, R.L. (1986). 'Wetlands of the River Murray.' River Murray Commission, Canberra.

Puckridge, J.T., Sheldon, F., Walker, K.F. and Boulton, A.J. (1998). Flow variability and the ecology of large rivers. *Marine and Freshwater Research* **49**: 55-72.

Puckridge, J.T., Walker, K.F. and Costelloe, J.F. (2000). Hydrological persistence and the ecology of dryland rivers. *Regulated Rivers-Research & Management* **16**: 385-402.

Raulings, E., Boon, P., Bailey, P., Roache, M., Morris, K. and Robinson, R. (2007). Rehabilitation of Swamp Paperbark (*Melaleuca ericifolia*) wetlands in south-eastern Australia: effects of hydrology, microtopography, plant age and planting technique on the success of community-based revegetation trials. *Wetlands Ecology and Management* **15**: 175-188.

Renfrey, A.P.C., Rea, N. and Ganf, G.G. (1989). 'The aquatic flora of Hindmarsh Island, South Australia.' Department of Environment and Planning, Adelaide.

Riis, T. and Hawes, I. (2003). Effect of wave exposure on vegetation abundance, richness and depth distribution of shallow water plants in a New Zealand lake. *Freshwater Biology* **48**: 75-87.

Roberts, J. and Marston, F. (2000). 'Water Regime of Wetland and Floodplain Plants in the Murray-Darling Basin.' CSIRO Land and Water, 30-00, Canberra.

Robinson, R.W., Boon, P.I. and Bailey, P. (2006). Germination characteristics of *Melaleuca ericifolia* Sm. (swamp paperbark) and their implications for the rehabilitation of coastal wetlands. *Marine and Freshwater Research* **57**: 703-711.

Salter, J., Morris, K., Bailey, P.C.E. and Boon, P.I. (2007). Interactive effects of salinity and water depth on the growth of *Melaleuca ericifolia* Sm. (Swamp paperbark) seedlings. *Aquatic Botany* **86**: 213-222.

Salter, J., Morris, K. and Boon, P.I. (2008). Does salinity reduce the tolerance of two contrasting wetland plants, the submerged monocot *Vallisneria australis* and the woody shrub *Melaleuca ericifolia*, to wetting and drying? *Marine and Freshwater Research* **59**: 291-303.

Salter, J., Morris, K., Read, J. and Boon, P. (2010). Impact of long-term, saline flooding on condition and reproduction of the clonal wetland tree, *Melaleuca ericifolia* (Myrtaceae). *Plant Ecology* **206**: 41-57.

Seaman, R.L. (2003). 'Coorong and Lower Lakes Ramsar habitat mapping program.' South Australian Department for Environment and Heritage, Adelaide.

Short, D.C. and Colmer, T.D. (1999). Salt tolerance in the halophyte *Halosarcia pergranulata* subsp. *pergranulata*. *Annals of Botany* **83**: 207-213.

Sim, T. and Muller, K. (2004). 'A fresh history of the lakes: Wellington to the Murray Mouth 1800s to 1935.' River Murray Catchment Water Management Board, Strathalbyn.

Song, J., Fan, H., Zhao, Y., Jia, Y., Du, X. and Wang, B. (2008). Effect of salinity on germination, seedling emergence, seedling growth and ion accumulation of a euhalophyte *Suaeda salsa* in an intertidal zone and on saline inland. *Aquatic Botany* **88**: 331-337.

Song, J., Shi, G., Xing, S., Yin, C., Fan, H. and Wang, B. (2009). Ecophysiological responses of the euhalophyte *Suaeda salsa* to the interactive effects of salinity and nitrate availability. *Aquatic Botany* **91**: 311-317.

Spence, D.H.N. (1982). The zonation of plants in freshwater lakes. *Advances in Ecological Research* **12**: 37-125.

Stephens, D.W. (1990). Changes in lake levels, salinity and the biological community of great Salt Lake (Utah, USA) 1847-1987. *Hydrobiologia* **197**: 139-149.

Stewart, H.J., Brandle, R., Foulkes, J.N., Tsymbal, V. and Madden, C. (2009). 'Impacts of salinity on the fauna of the Murray River Valley Floodplain 2002-2004.' Department for Environment and Heritage, Adelaide.

Stutzenbaker, C.D. (1996). 'Aquatic and Wetland Plants of the Western Gulf Coast.' (University of Texas Press).

Thompson, M.B. (1986). 'River Murray Wetlands, their characteristics, significance and management.' Department for Environment and Planning and Nature Conservation Society of South Australia, Adelaide.

Ungar, I.A. (2001). Seed banks and seed population dynamics of halophytes. *Wetlands Ecology and Management* **9**: 499-510.

Walker, K.F. (1985). A review of the ecological effects of river regulation in Australia. *Hydrobiologia* **125**: 111-129.

Walker, K.F. (1986). The Murray-Darling River system. In 'The Ecology of River Systems'. (Eds Davies, B.R. and Walker, K.F.). (Dr W. Junk Publishers: Dordrecht, The Netherlands).

Walker, K.F., Boulton, A.J., Thoms, M.C. and Sheldon, F. (1994). Effects of water-level changes induced by weirs on the distribution of littoral plants along the River Murray, South Australia. *Australian Journal of Marine and Freshwater Research* **45**: 1421-1438.

Walker, K.F., Sheldon, F. and Puckridge, J.T. (1995). A perspective on dryland river ecosystems. *Regulated Rivers Research and Management* **11**: 85-104.

Walker, K.F. and Thoms, M.C. (1993). Environmental effects of flow regulation on the lower River Murray, Australia. *Regulated Rivers: Research and Management* **8**: 103-119.

Walker, K.F., Thoms, M.C. and Sheldon, F. (1992). Effects of weirs on the littoral environment on the River Murray, South Australia. In 'River Conservation and Management'. (Eds Boon, P.J., Calow, P.A. and Petts, G.E.) pp. 270-293. (Wiley: Chichester).

Wardle, P. (1991). 'Vegetation of New Zealand.' (Cambridge University Press).

Webster, I.T. (2005a). 'An overview of the hydrodynamics of the Coorong and Murray Mouth.' CSIRO: Water for a Healthy Country National Research Flagship, Adelaide.

Webster, I.T. (2005b). 'An overview of the hydrodynamics of the Coorong and Murray Mouth Water levels and salinity – key ecological drivers.' CSIRO, Adelaide.

Webster, I.T. (2007). 'Hydrodynamic modelling of the Coorong.' CSIRO, Adelaide.

Weedon, J.T., Nicol, J.M. and Doonan, A. (2006). 'Mannum Swamps Baseline Vegetation Survey. Final Technical Report to the Mid Murray Local Action Planning Association.' South Australian Research and Development Institute (Aquatic Sciences), SARDI Publication Number RD04/0245-2, Adelaide.

Wetson, A.M., Cassaniti, C. and Flowers, T.J. (2008). Do conditions during dormancy influence germination of *Suaeda maritima*? *Annals of Botany* **101**: 1319-1327

Whitcraft, C., Talley, D., Crooks, J., Boland, J. and Gaskin, J. (2007). Invasion of tamarisk (*Tamarix* spp.) in a southern California salt marsh. *Biological Invasions* **9**: 875-879.

Wilson, S.D. and Keddy, P.A. (1985). The shoreline distribution of *Juncus peliocarpus* along a gradient of exposeure to waves: an experimental study. *Aquatic Botany* **21**: 277-284.

Womersley, H.B.S. (1975). Plant life in the Coorong Lagoons. In 'The Coorong'. (Ed. Noye, J.). (Department of Adult Education, The University of Adelaide: Adelaide).

Zampatti, B., Leigh, S., Nicol, J. and Weedon, J. (2006a). '2006 progress report for the Chowilla fish and aquatic macrophyte project.' SARDI Aquatic Sciences, Adelaide.

Zampatti, B., Nicol, J., Leigh, S. and Bice, C. (2006b). '2005 progress report for the Chowilla fish and aquatic macrophyte project.' SARDI Aquatic Sciences, Adelaide.

Zedler, J.B. (2001). 'Handbook for restoring tidal wetlands.' (CRC Press).

6. Appendices

Appendix 1: Plant species list (Womersley 1975; Paton 1982; Pressey 1986; Thompson 1986; Geddes 1987; Renfrey *et al.* 1989; Brandle *et al.* 2002; Seaman 2003; Holt *et al.* 2005; Nicol *et al.* 2006; Weedon *et al.* 2006; Marsland and Nicol 2007; Marsland and Nicol 2008; Marsland and Nicol 2009; Stewart *et al.* 2009; Marsland *et al.* 2010; Nicol 2010; Nicol and Marsland 2010) of the River Murray downstream of Lock 1, the Lower Lakes, Murray Estuary and Coorong with functional classification (*sensu* Brock and Casanova 1997), salinity tolerance or salinity tolerance group (if known) and regions where species were recorded (*denotes exotic species, # denotes listed as rare in South Australia).

Species	Functional Group	Salinity Tolerance	Gorge	Lower Swamps	Lower Lakes	Murray Estuary	Coorong	References
Acacia stenophylla	Amphibious fluctuation tolerator-woody	Moderate	*					(Marcar *et al.* 2000)
*Agapanthus praecox**	Terrestrial dry	Unknown			*			
Alternanthera denticulata	Floodplain	Unknown	*					
Ammania multiflora	Floodplain	Unknown	*					
Amyema melaleucae	NA: Mistletoe	Unknown			*	*	*	
Amyema preissii	NA: Mistletoe	Unknown	*					
*Apium graveolens**	Terrestrial damp	Unknown	*	*				
Apium prostratum ssp. *prostratum*	Terrestrial damp	Unknown	*					
*Arctotheca calendula**	Terrestrial dry	Unknown	*	*	*			
Asperula gemella	Terrestrial damp	Unknown	*	*				
*Asphodelus fistulosus**	Terrestrial dry	Unknown	*	*				
*Aster subulatus**	Terrestrial damp	Moderate-at least 18,000 mgl^{-1}	*	*	*			(Bailey *et al.* 2002)
Atriplex cinerea	Terrestrial dry	Unknown			*			
Atriplex leptocarpa	Terrestrial dry	Unknown	*					
Atriplex lindleyi ssp. *lindleyi*	Terrestrial dry	Unknown	*					
Atriplex nummularia	Terrestrial dry	Moderate	*	*				(Jessop and Tolken 1986)
Atriplex paludosa	Amphibious fluctuation tolerator-emergent	High	*		*	*	*	(Jessop and Tolken 1986)
Atriplex paludosa ssp. *cordata*	Amphibious fluctuation tolerator-emergent	High			*			(Jessop and Tolken 1986)
Atriplex paludosa ssp. *paludosa*	Amphibious fluctuation tolerator-emergent	High			*			(Jessop and Tolken 1986)
*Atriplex prostrata**	Terrestrial damp	Moderate-30,000 mgl^{-1}	*	*	*			(Wardle 1991)
Atriplex semibaccata	Terrestrial dry	Unknown	*	*	*			
Atriplex stipitata	Terrestrial dry	Unknown	*	*	*			
Atriplex suberecta	Floodplain	Unknown	*	*				
Atriplex vesicaria	Terrestrial dry	Unknown	*					
Austrostipa puberula	Terrestrial dry	Unknown			*			
Austrostipa stipoides	Terrestrial dry	Unknown		*	*			
*Avena barbata**	Terrestrial dry	Unknown	*	*	*			
Azolla filiculoides	Floating	Low-4,400 mgl^{-1}	*	*	*			(Bailey *et al.* 2002)
Azolla pinnata	Floating	Low-1,100 mgl^{-1}	*	*	*			(Bailey *et al.* 2002)
*Batrachium trichophyllum**	Submergent r-selected	Unknown			*			
*Berula erecta**	Emergent	Unknown	*	*	*			
Bolboschoenus caldwellii	Emergent	Moderate-25,000 mgl^{-1}	*	*	*	*		(Bailey *et al.* 2002)
Bolboschoenus medianus	Emergent	Moderate-28,000 mgl^{-1}		*	*	*		(Bailey *et al.* 2002)
Brachycome linearilobia	Floodplain	Unknown	*					
Brachycome basaltica	Floodplain	Unknown	*					
*Brassica rapa**	Terrestrial dry	Unknown	*	*	*			
*Brassica tournifortii**	Terrestrial dry	Unknown	*	*	*			
Briza minor	Terrestrial dry	Unknown		*	*			
*Bromus catharticus**	Terrestrial dry	Unknown	*	*	*			
*Bromus diandrus**	Terrestrial dry	Unknown	*	*	*			
Bromus hordeaceus ssp. *hordeaceus*	Terrestrial dry	Unknown	*	*	*			
*Bromus hordeaceus**	Terrestrial dry	Unknown	*	*	*			
*Bromus molliformis**	Terrestrial dry	Unknown	*	*				
*Bromus rubens**	Terrestrial dry	Unknown	*	*				

Species	Functional Group	Salinity Tolerance	Gorge	Lower Swamps	Lower Lakes	Murray Estuary	Coorong	References
Bromus uniloides*	Terrestrial dry	Unknown	*		*			
Bupleurum semicompositum*	Terrestrial damp	Unknown	*					
Callistemon brachyandrus#	Amphibious fluctuation tolerator-woody	Unknown	*					
Calotis hispidula	Floodplain	Unknown	*					
Calystegia sepium	Amphibious fluctuation tolerator-emergent	Moderate-10,000 mgl^{-1}	*	*	*			(Stutzenbaker 1996)
Carex apressa	Amphibious fluctuation tolerator-emergent	Unknown	*	*	*			
Carex fasicularis	Amphibious fluctuation tolerator-emergent	Unknown		*	*			
Carpobrotus rossii	Terrestrial dry	High	*	*	*	*	*	(Jessop and Tolken 1986)
Carrichtera annua*	Terrestrial dry	Unknown	*	*				
Centaurea calcitrapa*	Terrestrial damp	Unknown	*	*	*			
Centaurium tenuiflorum*	Terrestrial damp	Unknown	*	*	*			
Centella asiatica	Amphibious fluctuation responder-plastic	Low-3,500 mgl^{-1}		*	*			(Stutzenbaker 1996)
Centipeda minima	Floodplain	Unknown	*					
Ceratophyllum demersum#	Submergent k-selected	Moderate-at least 8,000 mgl^{-1}	*	*	*			J. Nicol pers. obs.
Chenopodium album*	Terrestrial damp	Unknown	*	*	*			
Chenopodium curvispicatum	Terrestrial dry	Unknown		*				
Chenopodium glaucum*	Terrestrial damp	Unknown	*	*	*			
Chenopodium pumilio	Floodplain	Unknown	*	*				
Chloris tuncata	Terrestrial dry	Unknown	*	*	*			
Cirsium vulgare*	Terrestrial damp	Unknown	*	*	*			
Cladium procerum	Amphibious fluctuation tolerator-emergent	Moderate			*			(Jessop and Tolken 1986)
Clematis microphylla var. microphylla	Terrestrial dry	Unknown			*			
Convolvulus arvensis*	Terrestrial damp	Unknown		*				
Convolvulus erubescens	Terrestrial damp	Unknown			*			
Conyza bonariensis*	Terrestrial damp	Unknown	*	*	*			
Cotula bipinnata*	Amphibious fluctuation responder-plastic	Unknown	*	*	*			
Cotula coronopifolia*	Amphibious fluctuation responder-plastic	High-36,000 mgl^{-1}	*	*	*			(Bailey et al. 2002)
Cotula vulgaris var. australasica	Amphibious fluctuation responder-plastic	High	*	*	*			J. Nicol pers. obs.
Craspedia uniflora	Terrestrial dry	Unknown	*					
Crassula colorata var. acuminata	Amphibious fluctuation tolerator-low growing	Unknown	*					
Crassula helmsii	Amphibious fluctuation tolerator-low growing	Moderate-10,000 mgl^{-1}	*	*	*			
Cressa cretica	Amphibious fluctuation tolerator-emergent	High	*					(Jessop and Tolken 1986)
Critesion marinum*	Terrestrial dry	High	*	*	*	*		http://www.dpi.vic.gov.au/DPI/Vro/vrosite.nsf/pages/water_sss_sea_barley
Cucumis myriocarpus*	Terrestrial dry	Unknown	*					
Cynodon dactylon*	Terrestrial dry	High-35,000 mgl^{-1}	*	*	*			
Cyperus exaltatus	Amphibious fluctuation tolerator-emergent	Unknown	*	*	*			
Cyperus gunnii ssp. gunnii	Amphibious fluctuation tolerator-emergent	Unknown			*			
Cyperus gymnocaulos	Amphibious fluctuation tolerator-emergent	Moderate-25,000 mgl^{-1}	*	*	*			Bailey et al. 1992
Danthonia caespitosa	Terrestrial dry	Unknown	*					
Dianella brevicaulis	Terrestrial dry	Unknown			*			
Dianella revoluta	Terrestrial dry	Unknown		*				
Disphyma crassifolium ssp. clavellatum	Terrestrial dry	High			*	*	*	(Jessop and Tolken 1986), J. Nicol pers. obs.
Distichlis distichophylla	Terrestrial damp	High	*	*	*	*		(Jessop and Tolken 1986), J. Nicol pers. obs.
Dittrichia graveolens*	Terrestrial damp	Unknown	*					
Dodonaea attenuata	Terrestrial dry	Unknown	*					
Echinochloa crus-galli*	Terrestrial damp	Unknown	*					
Echium plantagineum*	Terrestrial dry	Unknown	*	*				
Eclipta platyglossa	Terrestrial damp	Unknown	*					
Ehrharta longiflora*	Terrestrial damp	Unknown	*	*	*			
Einadia nutans ssp. nutans	Terrestrial dry	Unknown	*	*				
Eleocharis acuta	Emergent	Moderate-at least 7,000 mgl^{-1}	*	*	*			
Eleocharis gracilis	Emergent	Unknown	*	*	*			
Eleocharis sphacelata	Emergent	Low	*	*	*			J. Nicol pers. obs.
Enchylaena tomentosa var. tomentosa	Terrestrial dry	Moderate	*	*	*			(Jessop and Tolken 1986)
Epaltes australis	Floodplain	Unknown	*	*				

Species	Functional Group	Salinity Tolerance	Gorge	Lower Swamps	Lower Lakes	Murray Estuary	Coorong	References
Epaltes cunninghamii	Floodplain	Unknown	*	*	*			
Epilobium pallidiflorum	Terrestrial damp	Unknown	*	*	*			
Eragrostis australasica	Floodplain	Unknown	*	*				
*Eragrostis curvula**	Terrestrial damp	High	*	*	*	*		(Jessop *et al.* 2006), J. Nicol pers. obs.
Eragrostis dielsii	Floodplain	Unknown	*	*	*			
Eragrostis lacunaria	Floodplain	Unknown	*					
Eremophila divaricata	Terrestrial dry	Unknown	*					
Eremophila scoparia#	Terrestrial dry	Unknown	*					
Eucalyptus camaldulensis var. camaldulensis	Amphibious fluctuation tolerator-woody	Moderate-20,000 EC	*	*				Bailey *et al.* 1992
Eucalyptus largiflorens	Amphibious fluctuation tolerator-woody	Moderate-40,000 EC	*	*				Bailey *et al.* 1992
Euphorbia drummondii	Floodplain	Unknown	*	*	*			
Euphorbia tannensis	Terrestrial dry	High	*					J. Nicol pers. obs.
*Euphorbia terracina**	Terrestrial dry	High	*	*	*			J. Nicol pers. obs.
Festuca arundinacea	Terrestrial damp	Moderate		*	*			J. Nicol pers. obs.
*Foeniculum vulgare**	Terrestrial damp	Low	*	*	*			(Cunningham *et al.* 1981)
Frankenia pauciflora var. *gunnii*	Terrestrial dry	High	*	*	*			(Cunningham *et al.* 1981)
Frankenia serpyllifolia	Terrestrial dry	High			*	*		(Cunningham *et al.* 1981)
*Fraxinus rotundifolia ssp. rotundifolia**	Terrestrial dry	Low	*					(Cunningham *et al.* 1981)
*Fumaria bastardii**	Terrestrial damp	Low	*	*	*			(Cunningham *et al.* 1981)
Fumaria capreolata ssp. *capreolata**	Terrestrial damp	Low		*				(Cunningham *et al.* 1981)
Gahnia filum	Amphibious fluctuation tolerator-emergent	High		*	*			(Jessop and Tolken 1986)
*Galenia secunda**	Terrestrial dry	High	*	*	*			(Garcia-de-Lomas *et al.* 2009)
Gazania linearis	Terrestrial dry	High	*					J. Nicol pers. obs.
Glyceria australis	Emergent	Unknown			*			
Haloragis aspera	Floodplain	Unknown	*					
Halosarcia pergranulata ssp. *pergranulata*	Amphibious fluctuation tolerator-emergent	High-46,750 mgl^{-1}	*	*	*	*	*	(Short and Colmer 1999)
Helichrysum scorpoides	Terrestrial dry	Unknown	*					
*Heliotropium curassavicum**	Floodplain	High	*	*				(Cunningham *et al.* 1981)
*Heliotropium europaeum**	Floodplain	Unknown	*					
Hemichroa pentandra	Amphibious fluctuation tolerator-emergent	High			*	*		(Brandle *et al.* 2002)
*Holcus lanatus**	Terrestrial damp	Unknown		*	*			
Hydrocotyle verticillata	Amphibious fluctuation responder-plastic	Unknown	*	*	*			
*Hypochoeris glabra**	Terrestrial dry	Unknown	*	*	*			
*Hypochoeris radicata**	Terrestrial dry	Unknown	*	*	*			
*Ipomoea indica**	Terrestrial damp	Unknown	*	*	*			
Isachne globosa	Amphibious fluctuation tolerator-emergent	Unknown			*			
Isolepis cernua	Amphibious fluctuation tolerator-low growing	Moderate-30,000 mgl^{-1}			*			(Wardle 1991)
Isolepis fluitans	Amphibious fluctuation tolerator-low growing	Unknown		*				
Isolepis inundata	Amphibious fluctuation tolerator-low growing	Unknown	*	*	*			
Isolepis hookeriana	Amphibious fluctuation tolerator-low growing	Unknown	*					
Isolepis nodosa	Amphibious fluctuation tolerator-emergent	High		*	*	*	*	(Jessop and Tolken 1986), J. Nicol per. obs.
*Juncus acutus**	Amphibious fluctuation tolerator-emergent	High-at least 40,000 mgl^{-1}		*	*	*		(Greenwood 2008; Greenwood and MacFarlane 2009)
Juncus aridicola	Amphibious fluctuation tolerator-emergent	Unknown	*	*				
*Juncus articulatus**	Amphibious fluctuation tolerator-emergent	Unknown		*				
Juncus caespiticius	Amphibious fluctuation tolerator-emergent	Unknown			*			
Juncus kraussii	Amphibious fluctuation tolerator-emergent	Moderate-28,000 mgl^{-1}	*	*	*	*	*	(Clarke and Hannon 1970; Naidoo and Kift 2006)
Juncus pallidus	Amphibious fluctuation tolerator-emergent	High	*	*	*			(Jessop and Tolken 1986)
Juncus pauciflorus	Amphibious fluctuation tolerator-emergent	Unknown			*			
Juncus sarophorus	Amphibious fluctuation tolerator-emergent	Unknown			*			
Juncus usitatus	Amphibious fluctuation tolerator-emergent	Moderate						http://www.anbg.gov.au/cpbr/WfHC/Juncus-usitatus/index.html
Lachnagrostis filiformis	Floodplain	Unknown	*	*	*			
*Lactuca saligna**	Terrestrial dry	Unknown	*	*	*			
*Lactuca serriola**	Terrestrial dry	Unknown	*	*	*			
*Lagunaria patersonii**	Terrestrial dry	Unknown			*			
*Lagurus ovatus**	Terrestrial dry	Unknown		*	*	*		

Species	Functional Group	Salinity Tolerance	Gorge	Lower Swamps	Lower Lakes	Murray Estuary	Coorong	References
*Lamarckia aurea**	Terrestrial dry	Unknown	*					
Lamprothamnium papulosum	Submergent r-selected	High-210,000 mgl^{-1}			*	*	*	Bailey *et al.* 1992
Lawrencia squamata	Amphibious fluctuation tolerator-emergent	High			*	*	*	(Jessop and Tolken 1986)
Lemna disperma	Floating	Unknown	*	*	*			
Lemna minor	Floating	Moderate-10,000 mgl^{-1}	*	*	*			Bailey *et al.* 1992
*Lepidium africanum**	Terrestrial dry	Unknown	*					
*Lepidium bonariensis**	Terrestrial dry	Unknown	*		*			
Lepilaena australis	Submergent r-selected	Moderate-11,000 mgl^{-1}	*	*	*			Bailey *et al.* 1992
Lepilaena cylindrocarpa	Submergent r-selected	High-103,000 mgl^{-1}			*			Bailey *et al.* 1992
Leptospermum continentale	Terrestrial dry	Unknown	*	*	*			
Lilaeopsis polyantha	Amphibious fluctuation tolerator-low growing	Moderate			*			(Jessop and Tolken 1986)
*Limonium binervosum**	Amphibious fluctuation tolerator-low growing	High				*	*	(Brandle *et al.* 2002)
Limosella australis	Amphibious fluctuation tolerator-low growing	Unknown	*					
*Lolium rigidum**	Terrestrial dry	Moderate	*	*	*			(Jessop *et al.* 2006)
Lomandra leucocephala ssp. *robusta*	Terrestrial dry	Unknown	*					
Ludwigia peploides ssp. *montevidensis*	Amphibious fluctuation responder-plastic	Unknown	*	*	*			
*Lupinus cosentinii**	Terrestrial dry	Unknown	*	*				
*Lycium ferocissimum**	Terrestrial dry	High	*	*	*			Cunningham *et al.* 1981
Lycopus australis	Amphibious fluctuation tolerator-emergent	Unknown	*	*	*			
Lysiana exocarpi ssp. *exocarpi*	NA: Mistletoe	Unknown	*					
Lythrum hyssopifolia	Amphibious fluctuation tolerator-emergent	Unknown	*	*	*			
Lythrum salicaria	Amphibious fluctuation tolerator-emergent	Unknown	*	*	*			
Maireana brevifolia	Terrestrial dry	Unknown	*					
Maireana enchylaenoides	Terrestrial dry	Unknown	*					
Maireana macrocarpa	Terrestrial dry	Unknown	*					
Maireana microcarpa	Terrestrial dry	Unknown	*	*	*			
Maireana oppositfolia	Terrestrial dry	Unknown			*	*	*	
*Malva parviflora**	Terrestrial dry	Moderate	*	*	*			(Jessop and Tolken 1986)
*Marrubium vulgare**	Terrestrial dry	Moderate	*	*	*			(Jessop and Tolken 1986)
Marsilea drummondii	Amphibious fluctuation responder-plastic	Low-300 mgl^{-1}	*	*	*			(Aston 1973)
Medicago polymorpha var. *polymorpha**	Terrestrial dry	Unknown	*	*	*			
*Medicago truncatula**	Terrestrial dry	Unknown	*	*	*			
Melaleuca halmaturorum ssp. *halmaturorum*	Amphibious fluctuation tolerator-woody	High-44,000 mgl^{-1}		*	*	*	*	(Marcar *et al.* 1995)
*Melilotus alba**	Terrestrial dry	Unknown	*	*				
*Melilotus indica**	Terrestrial dry	Moderate-15,000 mgl^{-1}	*	*	*	*		(Khan and Weber 2006)
Mentha australis	Amphibious fluctuation tolerator-emergent	Unknown	*	*	*			
*Mentha piperita**	Amphibious fluctuation tolerator-emergent	Unknown	*	*	*			
*Mesembryanthemum crystallinum**	Floodplain	High	*	*				Cunningham *et al.* 1981
*Mesembryanthemum nodiflorum**	Floodplain	High	*					Cunningham *et al.* 1981
Mimulus repens	Amphibious fluctuation tolerator-low growing	Moderate-20,000 mgl^{-1}	*	*	*			(Wardle 1991)
Mollugo cerviana	Floodplain	Unknown	*					
Muehlenbeckia florulenta	Amphibious fluctuation tolerator-woody	Moderate	*	*	*			Cunningham *et al.* 1981
Muehlenbeckia gunnii	Amphibious fluctuation tolerator-woody	Moderate			*			Cunningham *et al.* 1981
Muehlenbeckia horrida	Amphibious fluctuation tolerator-woody	Moderate	*					Cunningham *et al.* 1981
Myoporum insulare	Terrestrial dry	High			*	*	*	Cunningham *et al.* 1981
Myoporum montanum	Terrestrial dry	Unknown	*	*	*			
Myoporum parvifolium	Terrestrial dry	Unknown	*	*	*			
Myriocephalus stuartii	Floodplain	Unknown	*					
Myriophyllum caput-medusae	Amphibious fluctuation responder-plastic	Moderate-at least 10,000 EC		*	*			J. Nicol unpublished data
Myriophyllum crispatum	Amphibious fluctuation responder-plastic	Low	*					(Orchard 1985)
Myriophyllum papulosum#	Amphibious fluctuation responder-plastic	Low	*					(Orchard 1985)
Myriophyllum salsugineum	Amphibious fluctuation responder-plastic	Moderate-at least 15,000 EC		*	*			J. Nicol unpublished data
Myriophyllum simulans	Amphibious fluctuation responder-plastic	Low		*				(Orchard 1985)
Myriophyllum verrucosum	Amphibious fluctuation responder-plastic	Low	*					(Orchard 1985)
*Myrsiphyllum asparagoides**	Terrestrial dry	Unknown	*	*				

Species	Functional Group	Salinity Tolerance	Gorge	Lower Swamps	Lower Lakes	Murray Estuary	Coorong	References
*Nicotiana glauca**	Terrestrial dry	Unknown	*					
Nicotiana goodspeedii	Terrestrial dry	Unknown	*					
Nitella sp.	Submergent r-selected	Unknown	*					
Nymphaea sp.*	Amphibious fluctuation responder-plastic	Unknown	*					
Olea europaea ssp. *europaea**	Terrestrial dry	Moderate	*					(Jessop and Tolken 1986)
*Onopordum acanthium**	Terrestrial damp	Unknown	*	*	*			
Opuntia sp.*	Terrestrial dry	Unknown	*					
Osteocarpum acropterum var. *acropterum*	Terrestrial dry	Moderate	*					Cunningham *et al.* 1981
*Oxalis pes-caprae**	Terrestrial dry	Unknown	*	*	*			
Pachycornia arbuscula	Terrestrial dry	High			*			Cunningham *et al.* 1981
Pachycornia triandra	Terrestrial dry	High	*					Cunningham *et al.* 1981
*Parapholis incurva**	Terrestrial damp	Moderate-31,000 mgl^{-1}	*	*	*	*		(Zedler 2001)
Paspalidium jubiflorum	Terrestrial damp	Unknown	*					
*Paspalum dilatatum**	Terrestrial damp	Low		*	*			http://www.fao.org/ag/AGP/AGPC/doc/GBASE/DATA/PF000288.HTM
*Paspalum distichum**	Terrestrial damp	Moderate-14,000 mgl^{-1}	*	*	*			http://www.fao.org/ag/AGP/AGPC/doc/GBASE/DATA/Pf000289.HTM
*Paspalum vaginatum**	Terrestrial damp	High-35,000 mgl^{-1}	*	*	*	*		(Lee *et al.* 2005)
*Pennisetum clandestinum**	Terrestrial dry	Moderate-13,000 mgl^{-1}	*	*	*			(Pessarakli and Pessarakli 2007)
Persicaria decipiens	Amphibious fluctuation responder-plastic	Unknown	*	*	*			
Persicaria lapathifolium	Amphibious fluctuation responder-plastic	Unknown	*	*	*			
*Phalaris arundinacea**	Amphibious fluctuation tolerator-emergent	Unknown		*	*			
*Phalaris minor**	Amphibious fluctuation tolerator-emergent	Unknown		*				
*Phalaris paradoxa**	Amphibious fluctuation tolerator-emergent	Unknown	*					
Phragmites australis	Emergent	Moderate-22,500 mgl^{-1}	*	*	*	*	*	Bailey *et al.* 1992
*Phyla canescens**	Amphibious fluctuation tolerator-low growing	High	*	*	*			Cunningham *et al.* 1981
Picris angustifolia	Terrestrial dry	Unknown	*	*				
Picris hieracoides var. *hieracoides**	Terrestrial dry	Unknown	*					
Pimelea glauca	Terrestrial dry	Unknown	*					
Plantago coronopus ssp. *coronopus**	Terrestrial dry	High-32,000 mgl^{-1}	*	*	*	*	*	(Wardle 1991)
Plantago cunninghamii	Terrestrial dry	Unknown	*					
*Plantago lanceolata**	Terrestrial dry	Unknown	*					
*Plantago major**	Terrestrial dry	Unknown	*	*				
Plantago turrifera	Floodplain	Unknown		*				
*Poa annua**	Terrestrial damp	Low-1,250 mgl^{-1}		*	*			(Pessarakli and Pessarakli 2007)
Poa labillardieri var. *labillardieri*	Terrestrial damp	Unknown			*			
Poa poiformis	Terrestrial damp	Unknown			*	*		
*Polygonum aviculare**	Terrestrial dry	Unknown	*	*	*			
Polygonum plebium	Floodplain	Unknown	*					
*Polypogon maritimus**	Amphibious fluctuation tolerator-emergent	High			*	*		(Brandle *et al.* 2002)
*Polypogon monspeliensis**	Amphibious fluctuation tolerator-emergent	High-35,000 mgl^{-1}	*	*	*			(Wardle 1991)
*Polypogon viridis**	Amphibious fluctuation tolerator-emergent	Moderate			*			(Brandle *et al.* 2002)
Potamogeton crispus	Submergent k-selected	Low	*	*	*			(Jessop and Tolken 1986)
Potamogeton pectinatus	Submergent k-selected	Moderate-10,000 mgl^{-1}			*			Bailey *et al.* 1992
Potamogeton tricarinatus	Submergent k-selected	Low	*					(Jessop and Tolken 1986)
Psuedognaphalium luteo-album	Floodplain	Unknown	*	*	*			
*Puccinellia distans**	Terrestrial damp	Moderate- at least 15,000 mgl^{-1}			*			(Khan and Weber 2006)
Puccinellia fasciculata	Terrestrial damp	Unknown			*			
Puccinellia stricta var. *perlaxa*	Terrestrial damp	Moderate-30,000 mgl^{-1}			*			(Wardle 1991)
Puccinellia stricta var. *stricta*	Terrestrial damp	Moderate-30,000 mgl^{-1}			*			(Wardle 1991)
Ranunculus amphitrichus	Amphibious fluctuation responder-plastic	Unknown		*	*			
*Ranunculus scleratus**	Amphibious fluctuation responder-plastic	Unknown	*					
*Ranunculus trilobus**	Amphibious fluctuation responder-plastic	Unknown			*			
*Reichardia tingitana**	Terrestrial dry	Unknown	*	*	*			
Rhagodia candolleana ssp. *candolleana*	Terrestrial dry	Unknown			*			
Rhagodia parabolica	Terrestrial dry	Unknown	*	*	*			

Species	Functional Group	Salinity Tolerance	Gorge	Lower Swamps	Lower Lakes	Murray Estuary	Coorong	References
Rhodanthe pygmaeum	Terrestrial dry	Unknown	*					
Rorippa eusylis	Floodplain	Unknown	*					
Rorippa islandica	Floodplain	Unknown	*					
*Rorippa nasturtium-aquaticum**	Emergent	Unknown	*	*	*			
*Rorippa palustris**	Floodplain	Unknown	*	*	*			
*Rostraria cristata**	Terrestrial dry	Unknown	*					
*Rubus ulmifolius**	Amphibious fluctuation tolerator-emergent	Unknown			*			
Rumex bidens	Amphibious fluctuation responder-plastic	Unknown	*	*	*			
*Rumex conglomeratus**	Amphibious fluctuation responder-plastic	Unknown		*	*			
*Rumex crispus**	Amphibious fluctuation responder-plastic	Unknown	*					
*Rumex pulcher ssp. pulcher**	Amphibious fluctuation responder-plastic	Unknown		*				
Ruppia megacarpa	Submergent k-selected	High-63,000 mgl^{-1}		*	*	*	*	(Brock 1979; Brock 1981b; Brock 1981a)
Ruppia polycarpa	Submergent r-selected	High-125,000 mgl^{-1}			*			(Brock 1979; Brock 1981b; Brock 1981a)
Ruppia tuberosa	Submergent r-selected	High- 230,000 mgl^{-1}		*	*		*	(Brock 1979; Brock 1981b; Brock 1981a)
*Sagina apetala**	Terrestrial damp	Unknown	*					
*Sagina maritima**	Terrestrial damp	High				*	*	(Brandle *et al.* 2002)
*Salix babylonica**	Emergent	Low-4,300 mgl^{-1}	*	*	*			(Kennedy *et al.* 2003)
*Salix fragilis**	Emergent	Low		*				(Cremer 1995; Cremer 2000)
Salix matsudana "Tortuosa"*	Emergent	Low	*					(Cremer 1995; Cremer 2000)
*Salix nigrum**	Emergent	Low		*				(Cremer 1995; Cremer 2000)
Salsola kali var. *kali*	Terrestrial dry	High	*					Cunningham *et al.* 1981
Samolus repens	Terrestrial damp	High-40,000 mgl^{-1}		*	*	*	*	(Wardle 1991)
Sarcocornia blackiana	Amphibious fluctuation tolerator-emergent	High			*	*	*	(Brandle *et al.* 2002)
Sarcocornia quinqueflora	Amphibious fluctuation tolerator-emergent	High-53,000 mgl^{-1}	*	*	*	*	*	(Wardle 1991)
*Schinus molle**	Terrestrial dry	Unknown	*					
*Schismus barbatus**	Terrestrial dry	Unknown	*					
Schoenoplectus pungens	Amphibious fluctuation tolerator-emergent	High-39,000 mgl^{-1}	*	*	*	*	*	(Wardle 1991)
Schoenoplectus validus	Emergent	Low- 700 mgl^{-1}	*	*	*			Bailey *et al.* 1992
Scleroblitum atriplicinum	Floodplain	Unknown	*	*	*			
Sclerolaena blackiana	Terrestrial dry	Unknown	*	*	*			
Sclerolaena brachyptera	Terrestrial dry	High	*					Cunningham *et al.* 1981
Sclerolaena diacantha	Terrestrial dry	Unknown	*					
Sclerolaena divaricata	Terrestrial dry	Unknown	*	*	*			
Sclerolaena muricata var. muricata	Terrestrial dry	Unknown	*					
Sclerolaena muricata var. *villosa*	Terrestrial dry	Unknown	*	*	*			
Sclerolaena tricuspis	Terrestrial dry	Unknown	*					
Sclerostegia arbuscula	Amphibious fluctuation tolerator-emergent	High	*	*	*	*	*	(Brandle *et al.* 2002)
Senecio cunninghamii	Floodplain	Unknown	*					
Senecio glossanthus	Terrestrial dry	Unknown			*			
Senecio lautus	Terrestrial dry	Unknown	*	*	*			
Senecio pterophorus var. *pterophorus**	Terrestrial dry	Unknown	*	*	*			
Senecio runcinifolius	Floodplain	Unknown	*	*	*			
Senna artemisiodes ssp. *filiofolia*	Terrestrial dry	Unknown	*					
*Silene apetala**	Terrestrial dry	Unknown	*					
*Sinapis alba**	Terrestrial dry	Unknown	*	*	*			
*Sisymbrium erysimoides**	Terrestrial dry	Unknown	*					
*Sisymbrium irio**	Terrestrial dry	Unknown	*					
*Solanum nigrum**	Terrestrial damp	Unknown	*	*				
Sonchus asper ssp. *glaucescens**	Terrestrial damp	Unknown	*	*	*			
Sonchus hydrophilus	Terrestrial damp	Unknown	*	*	*			
*Sonchus oleraceus**	Terrestrial damp	Unknown	*	*	*	*		
*Spergularia marina**	Terrestrial damp	High	*	*	*	*		Cunningham *et al.* 1981
Spirodela punctata	Floating	Unknown	*	*	*			
Sporobolus virginicus	Terrestrial damp	High			*	*		(Brandle *et al.* 2002)
Sporobolus mitchellii	Floodplain	High	*					J. Nicol pers. obs.

Species	Functional Group	Salinity Tolerance	Gorge	Lower Swamps	Lower Lakes	Murray Estuary	Coorong	References
Stemodia florulenta	Floodplain	Unknown	*					
Stipa drummondii	Terrestrial dry	Unknown	*					
Stipa nitida	Terrestrial dry	Unknown	*					
Stipa stipoides	Terrestrial dry	High				*	*	(Brandle *et al.* 2002)
Suaeda australis	Amphibious fluctuation tolerator-emergent	High-35,000 mgl^{-1}	*	*	*	*	*	(Clarke and Hannon 1970)
Swainsona greyana	Floodplain	Unknown	*					
Swainsona swainsonoides	Floodplain	Unknown	*					
*Tamarix aphylla**	Terrestrial dry	High	*		*			(Whitcraft *et al.* 2007)
Tecticornia indica ssp. *leiostachya*	Amphibious fluctuation tolerator-emergent	High	*	*	*	*	*	Cunningham *et al.* 1981
Tetragonia eremaea	Terrestrial dry	High	*					Cunningham *et al.* 1981
Tetragonia implexicoma	Terrestrial dry	High			*	*		Cunningham *et al.* 1981
Tetragonia tetragonoides	Terrestrial dry	High	*	*				Cunningham *et al.* 1981
Teucrium racemosum	Terrestrial dry	Unknown	*					
Threlkeldia diffusa	Amphibious fluctuation tolerator-emergent	High	*	*	*	*		(Brandle *et al.* 2002)
Trachymene cyanopetula	Floodplain	Unknown	*					
*Trifolium arvense var. arvense**	Terrestrial dry	Unknown	*					
*Trifolium repens**	Terrestrial dry	Unknown	*	*	*			
Triglochin hexagonum	Amphibious fluctuation tolerator-low growing	Unknown			*			
Triglochin procerum	Emergent	Moderate-10,000 mgl^{-1}	*	*	*			Bailey *et al.* 1992
Triglochin striatum	Amphibious fluctuation tolerator-low growing	High-40,000 mgl^{-1}	*	*	*	*	*	(Clarke and Hannon 1970; Wardle 1991)
Typha domingensis	Emergent	Moderate-at least 13,000 EC	*	*	*			J. Nicol pers. obs.
Typha orientalis	Emergent	Moderate-at least 13,000 EC	*	*	*			J. Nicol pers. obs.
Urtica incisa	Terrestrial damp	Unknown	*	*	*			
*Urtica urens**	Terrestrial damp	Unknown	*	*	*			
Vallisneria spiralis	Submergent k-selected	Moderate 13,320 mgl^{-1}	*	*	*			
*Verbascum virgatum**	Terrestrial dry	Unknown		*				
*Vicia sativa**	Terrestrial dry	Unknown	*	*	*			
Viminaria juncea	Amphibious fluctuation tolerator-woody	Unknown			*			
Vittadinia cuneata var. cuneata	Terrestrial dry	Unknown	*					
Vittadinia gracilis	Terrestrial dry	Unknown	*					
*Vulpia fasciculata**	Terrestrial damp	High	*	*	*	*		(Brandle *et al.* 2002)
*Vulpia myuros**	Terrestrial dry	Unknown	*					
Wahlenbergia fluminalis	Floodplain	Unknown	*					
Wilsonia rotundifolia	Terrestrial damp	Moderate	*	*	*	*		Cunningham et al. 1981
*Xanthium occidentale**	Floodplain	Unknown	*					
*Xanthium occidentale**	Floodplain	Unknown	*					

Appendix 2: List of dominant plant communities in a. the gorge, b. lower swamps, c. Lower Lakes, d. Murray Estuary and e. Coorong Lagoons (Brandle *et al.* 2002; Holt *et al.* 2005; Nicol *et al.* 2006; Marsland and Nicol 2007; Marsland and Nicol 2008; Stewart *et al.* 2009; Marsland *et al.* 2010).

a.

Vegetation Community	Dominant Species	Functional Group	Salinity Tolerance

Vegetation Community	Dominant Species	Functional Group	Salinity Tolerance
Austral Seablite Low Shrubland over Creeping Brookweed	*Suaeda australis, Samolus repens*	Terrestrial damp	High
Black-seed Samphire Low Shrubland	*Tecticornia pergranulata* ssp. *pergranulata*	Amphibious fluctuation tolerator-emergent	High
Brown-head Samphire Low Shrubland +/- emergent Lignum	*Tecticornia indica* ssp. *leiostachya*	Amphibious fluctuation tolerator-emergent	High
Shrubby Samphire Low Shrubland	*Pachycornia arbuscula*	Terrestrial dry	High
Common Reed Tussock Grassland +/- Lignum and River Red Gum	*Phragmites australis*	Emergent	Moderate
Narrow-leaf Bulrush Sedgeland +/- Common Reed +/- River Club-rush and emergent River Red Gum	*Typha domingensis*	Emergent	Low
Poorly defined floristic association unified by introduced species, in particular, the grass Salt-water Couch	*Paspalum vaginatum*	Terrestrial damp	Moderate
Broad-leaf Bulrush Tussock Grassland +/- River Club-rush	*Typha orientalis, Schoenoplectus validus*	Emergent	Low
River Club-rush Sedgeland +/- emergent River Red Gum	*Schoenoplectus validus*	Emergent	Low
Salt Club-rush Sedgeland	*Bolboschoenus caldwellii*	Emergent	Moderate
Lignum Tall Shrubland	*Muehlenbeckia florulenta*	Amphibious fluctuation tolerator-woody	Moderate
River Box / River Red Gum +/- River Coobah Open Woodland over dense Lignum	*Muehlenbeckia florulenta, Einadia nutans* ssp. *nutans, Enchylaena tomentosa* var. *tomentosa*	Amphibious fluctuation tolerator-woody/Terrestrial dry	Moderate
Lignum Tall Shrubland over Black-seed Samphire/Ruby Saltbush	*Muehlenbeckia florulenta, Tecticornia pergranulata* ssp. *pergranulata, Enchylaena tomentosa* var. *tomentosa*	Amphibious fluctuation tolerator-woody/Amphibious fluctuation tolerator-emergent/Terrestrial dry	Moderate
River Red Gum Open Forest over Common Reed +/-Lignum	*Phragmites australis, Eucalyptus camaldulensis* var. *camaldulensis, Muehlenbeckia florulenta, Cyperus gymnocaulos*	Emergent/Amphibious fluctuation tolerator-woody/Amphibious fluctuation tolerator-emergent	Moderate
River Red Gum Open Forest over Lignum/Spiny Flat-sedge+/-Warrego Summer-grass	*Eucalyptus camaldulensis* var. *camaldulensis, Muehlenbeckia florulenta, Cyperus gymnocaulos*	Amphibious fluctuation tolerator-woody/Amphibious fluctuation tolerator-emergent	Moderate
River Red Gum and River Box Woodland over Spiny Flat-sedge/Shrubby Groundsel	*Eucalyptus camaldulensis* var. *camaldulensis, Cyperus gymnocaulos, Eucalyptus largiflorens*	Amphibious fluctuation tolerator-woody/Amphibious fluctuation tolerator-emergent	Moderate
River Red Gum Woodland over Common Spike-rush/Spiny Flat-sedge/Common Blown-grass	*Lachnagrostis filiformis, Eleocharis acuta, Cyperus gymnocaulos, Paspalum distichum Eucalyptus camaldulensis* var. *camaldulensis*	Floodplain/Emergent/Amphibious fluctuation tolerator-woody/Amphibious fluctuation tolerator-emergent	Moderate
River Box Woodland over Ruby Saltbush	*Eucalyptus largiflorens, Enchylaena tomentosa* var. *tomentosa, Einadia nutans* ssp. *nutans*	Amphibious fluctuation tolerator-woody/Terrestrial dry	Moderate
River Box Open Woodland over Spreading Emubush and Ruby Saltbush	*Eremophila divaricata ssp. divaricata, Salsola kali, Einadia nutans* ssp. *nutans, Enchylaena tomentosa* var. *tomentosa*	Terrestrial dry	Moderate
River Coobah Open Woodland over Ruby Saltbush+/- Short-leaf Bluebush Low Shrubland	*Enchylaena tomentosa* var. *tomentosa*	Terrestrial dry	Moderate
Rat-tail Couch Tussock Grassland +/- Chenopods and Sedges	*Sporobolus mitchellii, Muehlenbeckia florulenta*	Floodplain/Amphibious fluctuation tolerator-woody	Moderate
Eucalyptus camaldulensis/Eucalyptus largiflorens over *Myoporum montanum*	*Eucalyptus camaldulensis, Eucalyptus largiflorens, Myoporum montanum*	Amphibious fluctuation tolerator-woody/Terrestrial dry	Moderate
Eucalyptus camaldulensis over *Muehlenbeckia florulenta* with *Phragmites australis+/- Typha domingensis+/-Schoenoplectus validus*	*Eucalyptus camaldulensis, Muehlenbeckia florulenta, Phragmites australis*	Amphibious fluctuation tolerator-woody/Emergent	Moderate
Eucalyptus camaldulensis over *Myoporum montanum +/- Typha* sp. +/- *Phragmites australis*	*Eucalyptus camaldulensis, Myoporum montanum*	Amphibious fluctuation tolerator-woody/Terrestrial dry	Moderate
Halosarcia pergranulata ssp. *pergranulata* shrubland	*Halosarcia pergranulata* ssp. *pergranulata*	Amphibious fluctuation tolerator-emergent	High
Phragmites australis/Typha domingensis/Schoenoplectus validus sedgeland	*Phragmites australis, Typha domingensis, Schoenoplectus validus*	Emergent	Low
Phragmites australis grassland	*Phragmites australis*	Emergent	Moderate
Eucalyptus camaldulensis over *Phragmites australis +/- Schoenoplectus validus +/- Typha* sp.	*Eucalyptus camaldulensis, Phragmites australis*	Amphibious fluctuation tolerator-woody/Emergent	Moderate
Eucalyptus camaldulensis over *Myoporum montanum +/- Typha* sp. +/- *Phragmites australis*	*Eucalyptus camaldulensis, Myoporum montanum*	Amphibious fluctuation tolerator-woody/Terrestrial dry	Moderate
Eucalyptus largiflorens / Eucalyptus camaldulensis woodland	*Eucalyptus largiflorens, Eucalyptus camaldulensis*	Amphibious fluctuation tolerator-woody	Moderate
Salix babylonica woodland	*Salix babylonica*	Emergent	Low
Eucalyptus camaldulensis/Salix babylonica woodland	*Eucalyptus camaldulensis, Salix babylonica*	Amphibious fluctuation tolerator-woody/Emergent	Low
Eucalyptus camaldulensis over *Acacia stenophylla +/- Muehlenbeckia florulenta*	*Eucalyptus camaldulensis, Acacia stenophylla*	Amphibious fluctuation tolerator-woody	Moderate
Acacia stenophylla over *Muehlenbeckia florulenta*	*Acacia stenophylla, Muehlenbeckia florulenta*	Amphibious fluctuation tolerator-woody	Moderate
Eucalyptus largiflorens woodland over *Muehlenbeckia florulenta +/- Enchylaena tomentosa*	*Eucalyptus largiflorens, Muehlenbeckia florulenta*	Amphibious fluctuation tolerator-woody	Moderate
Juncus sp. sedgeland	*Juncus* sp.	Amphibious fluctuation tolerator-emergent	Moderate
Eucalyptus camaldulensis/Eucalyptus largiflorens over *Cyperus gymnocaulos/Paspalum dilatatum*	*Eucalyptus camaldulensis, Eucalyptus largiflorens, Cyperus gymnocaulos, Paspalum dilatatum*	Amphibious fluctuation tolerator-woody/Amphibious fluctuation tolerator-emergent/Terrestrial damp	Moderate
Eucalyptus camaldulensis over *Muehlenbeckia florulenta*	*Eucalyptus camaldulensis, Muehlenbeckia florulenta*	Amphibious fluctuation tolerator-woody	Moderate
Eucalyptus largiflorens woodland	*Eucalyptus largiflorens*	Amphibious fluctuation tolerator-woody	Moderate
Typha sp./*Schoenoplectus validus* sedgeland	*Typha* sp., *Schoenoplectus validus*	Emergent	Low
Triglochin procerum herbland	*Triglochin procerum*	Emergent	Low
Typha sp. sedgeland	*Typha* sp.	Emergent	Low
Vallisneria spiralis submerged herbland	*Vallisneria spiralis*	Submergent k-selected	Low
Schoenoplectus validus sedgeland	*Schoenoplectus validus*	Emergent	Low
Eucalyptus camaldulensis var. *camaldulensis/Salix babylonica* woodland+/- *Phragmites australis*	*Eucalyptus camaldulensis* var. *camaldulensis, Salix babylonica*	Amphibious fluctuation tolerator-woody/Emergent	Low

Vegetation Community	Dominant Species	Functional Group	Salinity Tolerance
Phragmites australis grassland +/- *Schoenoplectus validus*	*Phragmites australis*	Emergent	Moderate
Typha sp./*Phragmites australis/Schoenoplectus validus* sedgeland	*Typha* sp., *Phragmites australis, Schoenoplectus validus*	Emergent	Low
Triglochin procerum, Eleocharis acuta sedgeland	*Triglochin procerum, Eleocharis acuta*	Emergent	Low
Halosarcia pergranulata ssp. *pergranulata* shrubland	*Halosarcia pergranulata* ssp. *pergranulata*	Amphibious fluctuation tolerator-emergent	High
Myriophyllum verrucosum herbland	*Myriophyllum verrucosum*	Amphibious fluctuation responder-plastic	Low
Cyperus gymnocaulos/Eleocharis acuta sedgeland	*Cyperus gymnocaulos, Eleocharis acuta*	Amphibious fluctuation tolerator-emergent/Emergent	Moderate
Eucalyptus camaldulensis var. *camaldulensis* +/- *Paspalum distichum, Muehlenbeckia florulenta* and *Senecio* sp.	*Eucalyptus camaldulensis* var. *camaldulensis*	Amphibious fluctuation tolerator-woody	Moderate
Eucalyptus camaldulensis var. *camaldulensis* +/- *Muehlenbeckia florulenta, Carrichtera annua* and *Cyperus gymnocaulos*	*Eucalyptus camaldulensis* var. *camaldulensis*	Amphibious fluctuation tolerator-woody	Moderate
Muehlenbeckia florulenta shrubland	*Muehlenbeckia florulenta*	Amphibious fluctuation tolerator-woody	Moderate
Vallisneria spiralis/Nymphaea sp. herbland	*Vallisneria spiralis, Nymphaea* sp.	Submergent k-selected/Emergent	Low
Eucalyptus camaldulensis var. *camaldulensis* woodland	*Eucalyptus camaldulensis* var. *camaldulensis*	Amphibious fluctuation tolerator-woody	Moderate
Phragmites australis/Eleocharis sphacelata sedgeland	*Phragmites australis, Eleocharis sphacelata*	Emergent	Low
Phragmites australis/Schoenoplectus validus sedgeland	*Phragmites australis, Schoenoplectus validus*	Emergent	Low
Diverse riparian herbland	*Alternanthera denticulata, Aster subulatus, Cyperus gymnocaulos, Eleocharis acuta, Hydrocotyle verticillata, Juncus usitatus, Rumex bidens, Triglochin procerum*	Floodplain/Terrestrial damp/Amphibious fluctuation tolerator-emergent/Emergent/Amphibious fluctuation responder-plastic	Low
Chenopod shrubland	*Atriplex prostrata, Atriplex semibaccata, Enchylaena tomentosa, Muehlenbeckia florulenta, Sporobolus mitchelli*	Floodplain/Terrestrial damp/Terrestrial dry/Amphibious fluctuation tolerator-woody	Moderate
Sporobolus mitchellii grassland	*Sporobolus mitchellii*	Floodplain	Moderate
Eleocharis acuta sedgeland	*Eleocharis acuta*	Emergent	Moderate
Juncus usitatus sedgeland	*Juncus usitatus, Cyperus gymnocaulos*	Amphibious fluctuation tolerator-emergent	Moderate
Juncus usitatus/Limosella australis sedgeland	*Juncus usitatus/Limosella australis*	Amphibious fluctuation responder-emergent/Amphibious fluctuation tolerator-low growing	Moderate
Persicaria lapathifolium herbland	*Persicaria lapathifolium/Mimulus repens*	Amphibious fluctuation responder-plastic/Amphibious fluctuation tolerator-low growing	Low
Heliotropium europaeum herbland	*Heliotropium europaeum*	Floodplain	Moderate

b.

Vegetation Community	Dominant Species	Functional Group	Salinity Tolerance
Austral Seablite Low Shrubland over Creeping Brookweed	*Suaeda australis, Samolus repens*	Terrestrial damp	Moderate
Black-seed Samphire Low Shrubland	*Tecticornia pergranulata* ssp. *pergranulata*	Amphibious fluctuation tolerator-emergent	High
Brown-head Samphire Low Shrubland +/- emergent Lignum	*Tecticornia indica* ssp. *leiostachya*	Amphibious fluctuation tolerator-emergent	High
Common Reed Tussock Grassland +/- Lignum and River Red Gum	*Phragmites australis*	Emergent	Moderate
Narrow-leaf Bulrush Sedgeland +/- Common Reed +/- River Club-rush and emergent River Red Gum	*Typha domingensis*	Emergent	Low
Poorly defined floristic association unified by introduced species, in particular, the grass Salt-water Couch	*Paspalum vaginatum*	Terrestrial damp	Moderate
Broad-leaf Bulrush Tussock Grassland +/- River Club-rush	*Typha orientalis, Schoenoplectus validus*	Emergent	Low
River Club-rush Sedgeland +/- emergent River Red Gum	*Schoenoplectus validus*	Emergent	Low
Salt Club-rush Sedgeland	*Bolboschoenus caldwellii*	Emergent	Moderate
Lignum Tall Shrubland	*Muehlenbeckia florulenta*	Amphibious fluctuation tolerator-woody	Moderate
Lignum Tall Shrubland over Black-seed Samphire/Ruby Saltbush	*Muehlenbeckia florulenta, Tecticornia pergranulata* ssp. *pergranulata, Enchylaena tomentosa* var. *tomentosa*	Amphibious fluctuation tolerator-woody/Amphibious fluctuation tolerator-emergent/Terrestrial dry	Moderate
River Red Gum Open Forest over Common Reed +/-Lignum	*Phragmites australis, Eucalyptus camaldulensis* var. *camaldulensis, Muehlenbeckia florulenta, Cyperus gymnocaulos*	Emergent/Amphibious fluctuation tolerator-woody/Amphibious fluctuation tolerator-emergent	Moderate
River Red Gum Open Forest over Lignum/Spiny Flat-sedge+/-Warrego Summer-grass	*Eucalyptus camaldulensis* var. *camaldulensis, Muehlenbeckia florulenta, Cyperus gymnocaulos*	Amphibious fluctuation tolerator-woody/Amphibious fluctuation tolerator-emergent	Moderate
River Red Gum Woodland over Common Spike-rush/Spiny Flat-sedge/Common Blown-grass	*Lachnagrostis filiformis, Eleocharis acuta, Cyperus gymnocaulos, Paspalum distichum Eucalyptus camaldulensis* var. *camaldulensis*	Floodplain/Amphibious fluctuation tolerator-woody/Emergent/Amphibious fluctuation tolerator-emergent	Moderate
River Box Woodland over Ruby Saltbush	*Eucalyptus largiflorens, Enchylaena tomentosa* var. *tomentosa, Einadia nutans* ssp. *nutans*	Amphibious fluctuation tolerator-woody/Terrestrial dry	Moderate
Eucalyptus camaldulensis/Salix spp. woodland	*Eucalyptus camaldulensis, Salix* spp.	Amphibious fluctuation tolerator-woody/Emergent	Low
Eucalyptus camaldulensis over *Enchylaena tomentosa* +/- *Muehlenbeckia florulenta*	*Eucalyptus camaldulensis, Enchylaena tomentosa*	Amphibious fluctuation tolerator-woody/Terrestrial dry	Moderate
Phragmites australis/Ehrharta longifolia grassland over *Mesembryanthemum nodiflorum*	*Phragmites australis, Ehrharta longifolia, Mesembryanthemum nodiflorum*	Emergent/Terrestrial dry	Moderate
Phragmites australis/Typha domingensis/Schoenoplectus validus sedgeland	*Phragmites australis, Typha domingensis, Schoenoplectus validus*	Emergent	Low
Salix spp. woodland over *Phragmites australis*	*Salix* spp., *Phragmites australis*	Emergent	Low
Typha sp./*Bolboschoenus medianus sedgeland*	*Typha* sp., *Bolboschoenus medianus*	Emergent	Low
Typha sp. sedgeland	*Typha* sp.	Emergent	Low

Vegetation Community	Dominant Species	Functional Group	Salinity Tolerance
Muehlenbeckia florulenta shrubland	*Muehlenbeckia florulenta*	Amphibious fluctuation tolerator-woody	Moderate
Phragmites australis grassland	*Phragmites australis*	Emergent	Moderate
Schoenoplectus validus/Phragmites australis/Eleocharis sphacelata sedgeland	*Schoenoplectus validus, Phragmites australis, Eleocharis sphacelata*	Emergent	Low
Schoenoplectus validus sedgeland	*Schoenoplectus validus*	Emergent	Low
Typha sp./*Schoenoplectus validus* sedgeland	*Typha* sp., *Schoenoplectus validus*	Emergent	Low
Eleocharis acuta/Triglochin procerum sedgeland over *Berula erecta*	*Eleocharis acuta, Triglochin procerum, Berula erecta*	Emergent	Low
Eleocharis sphacelata sedgeland over *Triglochin procerum/Persicaria decipiens*	*Eleocharis sphacelata, Triglochin procerum, Persicaria decipiens*	Emergent/Amphibious fluctuation responder-plastic	Low
Halosarcia pergranulata ssp. *pergranulata* shrubland	*Halosarcia pergranulata* ssp. *pergranulata*	Amphibious fluctuation tolerator-emergent	High
Muehlenbeckia florulenta shrubland over *Enchylaena tomentosa*	*Muehlenbeckia florulenta, Enchylaena tomentosa*	Amphibious fluctuation tolerator-woody/Terrestrial dry	Moderate
Typha sp. sedgeland over *Triglochin procerum*	*Typha* sp., *Triglochin procerum*	Emergent	Low
Suaeda australis shrubland	*Suaeda australis*	Terrestrial damp	High
Chenopodium glaucum herbland	*Chenopodium glaucum*	Terrestrial damp	Unknown
Salix babylonica woodland	*Salix babylonica*	Emergent	Low
Bolboschoenus caldwellii sedgeland	*Bolboschoenus caldwellii*	Emergent	Moderate
Agrostis avenacea grassland	*Agrostis avenacea*	Floodplain	Unknown
Lolium sp./*Avena barbata/Halosarcia pergranulata* ssp. *pergranulata* grassland/shrubland	*Lolium* sp., *Avena barbata, Halosarcia pergranulata* ssp. *pergranulata*	Terrestrial dry/Amphibious fluctuation tolerator-emergent	Moderate
Eleocharis acuta sedgeland	*Eleocharis acuta*	Emergent	Moderate
Paspalum distichum grassland	*Paspalum distichum*	Terrestrial damp	Moderate
Vallisneria spiralis submerged herbland	*Vallisneria spiralis*	Submergent k-selected	Low
Triglochin procerum herbland	*Triglochin procerum, Berula erecta, Eleocharis acuta*	Emergent	Low
Typha sp./*Phragmites australis* sedgeland	*Typha* sp., *Phragmites australis* sedgeland	Emergent	Low
Eucalyptus camaldulensis var. *camaldulensis* woodland (planted) +/- *Eleocharis acuta, Paspalum distichum, Phragmites australis* and *Berula erecta*	*Eucalyptus camaldulensis* var. *camaldulensis*	Amphibious fluctuation tolerator-woody	Moderate
Salix ?nigrum woodland over *Triglochin procerum*	*Salix ?nigrum, Triglochin procerum*	Emergent	Low
Diverse herbland including *Triglochin procerum, Hydrocotyle verticillata, Berula erecta*	*Triglochin procerum, Hydrocotyle verticillata, Berula erecta*	Emergent	Low
Pennisetum clandestinum grassland	*Pennisetum clandestinum*	Terrestrial dry	Moderate
Paspalum distichum grassland	*Paspalum distichum*	Terrestrial damp	Moderate
Ruppia megacarpa submerged herbland	*Ruppia megacarpa*	Submergent k-selected	High
Phragmites australis/Bolboschoenus caldwellii sedgeland	*Phragmites australis, Bolboschoenus caldwellii*	Emergent	Moderate

c.

Vegetation Community	Dominant Species	Functional Group	Salinity Tolerance
Salt Bluebush/ Marsh Saltbush Low Shrubland +/- Swamp Paper-bark	*Maireana oppositfolia, Plantago coronopus* ssp. *coronopus,*	Terrestrial dry	Moderate
Beaded Samphire Low Shrubland +/- Lignum	*Sarcocornia quinqueflora, Samolus repens*	Amphibious fluctuation tolerator-emergent/Terrestrial damp	High
Lignum Closed Shrubland with Common Reed	*Muehlenbeckia florulenta, Phragmites australis*	Amphibious fluctuation tolerator-woody/Emergent	Moderate
Narrow-leaf Bulrush +/- Common Reed Reedland	*Aster subulatus, Berula erecta, Typha domingensis, Phragmites australis*	Emergent/Terrestrial damp	Moderate
Beaded Samphire Low Shrubland over Austral Seablite	*Sarcocornia quinqueflora, Suaeda australis*	Amphibious fluctuation tolerator-emergent/Terrestrial damp	High
Austral Seablite Low Shrubland over Creeping Brookweed	*Suaeda australis, Samolus repens*	Terrestrial damp	High
Sea Rush Sedgeland over Creeping Brookweed	*Juncus kraussii, Samolus repens*	Amphibious fluctuation tolerator-emergent/Terrestrial damp	Moderate
Swamp Paper-bark Low Closed Forest over Sea Rush	*Melaleuca halmaturorum* ssp. *halmaturorum, Juncus kraussii, Muehlenbeckia florulenta*	Amphibious fluctuation tolerator-woody	Moderate
Black-seed Samphire Low Shrubland	*Tecticornia pergranulata* ssp. *pergranulata*	Amphibious fluctuation tolerator-emergent	High
Brown-head Samphire Low Shrubland +/- emergent Lignum	*Tecticornia indica* ssp. *leiostachya*	Amphibious fluctuation tolerator-emergent	High
Shrubby Samphire Low Shrubland	*Pachycornia arbuscula*	Terrestrial dry	High
Common Reed Tussock Grassland +/- Lignum and River Red Gum	*Phragmites australis*	Emergent	Moderate
Narrow-leaf Bulrush Sedgeland +/- Common Reed +/- River Club-rush and emergent River Red Gum	*Typha domingensis*	Emergent	Moderate
Poorly defined floristic association unified by introduced species, in particular, the grass Salt-water Couch	*Paspalum vaginatum*	Terrestrial damp	Moderate
Broad-leaf Bulrush Tussock Grassland +/- River Club-rush	*Typha orientalis, Schoenoplectus validus*	Emergent	Low
River Club-rush Sedgeland +/- emergent River Red Gum	*Schoenoplectus validus*	Emergent	Low
Salt Club-rush Sedgeland	*Bolboschoenus caldwellii*	Emergent	Moderate
Lignum Tall Shrubland	*Muehlenbeckia florulenta*	Amphibious fluctuation tolerator-woody	Moderate
Gahnia filum sedgeland over +/- *Cynodon dactylon*	*Gahnia filum*	Amphibious fluctuation tolerator-emergent	High
Halosarcia pergranulata ssp. *pergranulata* shrubland	*Halosarcia pergranulata ssp. pergranulata*	Amphibious fluctuation tolerator-emergent	High
Melaleuca halmaturorum low woodland	*Melaleuca halmaturorum*	Amphibious fluctuation tolerator-woody	High

Vegetation Community	Dominant Species	Functional Group	Salinity Tolerance
Phragmites australis sedgeland with emergent willow	*Phragmites australis, Salix babylonica*	Emergent	Low
Suaeda australis shrubland	*Suaeda australis*	Terrestrial damp	High
Salix babylonica woodland over *Phragmites australis*	*Salix babylonica, Phragmites australis*	Emergent	Low
Schoenoplectus validus sedgeland	*Schoenoplectus validus*	Emergent	Low
Typha sp./ *Phragmites australis* sedgeland	*Typha* sp., *Phragmites australis*	Emergent	Low
Typha sp. / *Schoenoplectus validus* sedgeland	*Typha* sp., *Schoenoplectus validus*	Emergent	Low
Typha sp. sedgeland	*Typha* sp.	Emergent	Low
Schoenoplectus pungens sedgeland	*Schoenoplectus pungens*	Emergent	High
Bolboschoenus caldwellii sedgeland	*Bolboschoenus caldwellii*	Emergent	Moderate
Juncus kraussii sedgeland	*Juncus kraussii*	Amphibious fluctuation tolerator-emergent	Moderate
Critesion marinum / Lolium perenne grassland	*Critesion marinum, Lolium perenne*	Terrestrial dry	Moderate
Eleocharis acuta / Bolboschoenus caldwellii sedgeland	*Eleocharis acuta, Bolboschoenus caldwellii*	Emergent	Low
Halosarcia pergranulata ssp. *pergranulata /Sarcocornia quinqueflora* shrubland over *Triglochin striatum/ Ruppia polycarpa*	*Halosarcia pergranulata* ssp. *pergranulata, Sarcocornia quinqueflora, Triglochin striatum, Ruppia polycarpa*	Amphibious fluctuation tolerator-emergent/Amphibious fluctuation tolerator-low growing/Submergent r-selected	High
Lepilaena cylindrocarpa / Nitella herbland	*Lepilaena cylindrocarpa, Nitella* sp.	Submergent r-selected	High
Myriophyllum caput-medusae herbland	*Myriophyllum caput-medusae*	Amphibious fluctuation responder-plastic	Moderate
Pennisetum clandestinum +/- Paspalum vaginatum	*Pennisetum clandestinum*	Terrestrial damp	Moderate
Pennisetum clandestinum grassland	*Pennisetum clandestinum*	Terrestrial dry	Moderate
Ruppia polycarpa submerged herbland	*Ruppia polycarpa*	Submergent r-selected	High
Triglochin procerum herbland	*Triglochin procerum*	Emergent	Moderate
Frankenia pauciflora var. gunnii shrubland over *Cotula coronopifolia*	*Frankenia pauciflora var. gunnii, Cotula coronopifolia*	Amphibious fluctuation responder-plastic	High
Lycium ferocissimum shrubland	*Lycium ferocissimum*	Terrestrial dry	High
Paspalum vaginatum grassland	*Paspalum vaginatum*	Terrestrial damp	Moderate
Schoenoplectus pungens sedgeland	*Schoenoplectus pungens*	Amphibious fluctuation tolerator-emergent	High
Typha sp./*Schoenoplectus validus* sedgeland	*Typha* sp., *Schoenoplectus validus*	Emergent	Low
Eleocharis acuta sedgeland over *Paspalum vaginatum*	*Eleocharis acuta, Paspalum vaginatum*	Emergent/Terrestrial damp	Moderate
Muehlenbeckia florulenta shrubland	*Muehlenbeckia florulenta*	Amphibious fluctuation tolerator-woody	Moderate
Sarcocornia quinqueflora shrubland	*Sarcocornia quinqueflora*	Amphibious fluctuation tolerator-emergent	High
Typha sp./*Phragmites australis* sedgeland	*Typha* sp., *Phragmites australis*	Emergent	Moderate
Muehlenbeckia florulenta shrubland over *Halosarcia pergranulata* ssp. *pergranulata+/- Atriplex leptocarpa*	*Muehlenbeckia florulenta, Halosarcia pergranulata* ssp. *pergranulata*	Amphibious fluctuation tolerator-woody/Amphibious fluctuation tolerator-emergent	Moderate
Muehlenbeckia florulenta shrubland over *Phragmites australis*	*Muehlenbeckia florulenta, Phragmites australis*	Amphibious fluctuation tolerator-woody/Emergent	Moderate
Suaeda australis shrubland	*Suaeda australis*	Amphibious fluctuation tolerator-emergent	High
Paspalum distichum grassland	*Paspalum distichum*	Terrestrial damp	Moderate
Typha domingensis sedgeland	*Typha domingensis*	Emergent	Low
Bolboschoenus caldwellii/Juncus kraussii sedgeland	*Bolboschoenus caldwellii, Juncus kraussii*	Emergent/Amphibious fluctuation tolerator-emergent	Moderate
Typha sp./*Bolboschoenus caldwellii* sedgeland	*Typha* sp., *Bolboschoenus caldwellii*	Emergent	Moderate
Suaeda australis/Sarcocornia quinqueflora shrubland	*Suaeda australis, Sarcocornia quinqueflora*	Amphibious fluctuation tolerator-emergent/Terrestrial damp	High
Paspalum distichum grassland	*Paspalum distichum*	Terrestrial damp	Moderate
Ruppia megacarpa submerged herbland	*Ruppia megacarpa*	Submergent k-selected	High
Myriophyllum salsugineum herbland	*Myriophyllum salsugineum*	Amphibious fluctuation responder-plastic	Moderate
Typha sp. over *Paspalum distichum/Bolboschoenus caldwellii*	*Typha sp., Paspalum distichum, Bolboschoenus caldwellii*	Emergent/Terrestrial damp	Moderate
Bolboschoenus caldwellii sedgeland over *Halosarcia pergranulata* ssp. *pergranulata*	*Bolboschoenus caldwellii, Halosarcia pergranulata* ssp. *pergranulata*	Emergent/Amphibious fluctuation tolerator-emergent	Moderate
Halosarcia pergranulata ssp. *pergranulata/Triglochin striatum* shrubland/herbland	*Halosarcia pergranulata* ssp. *pergranulata, Triglochin striatum*	Amphibious fluctuation tolerator-emergent/Amphibious fluctuation tolerator-low growing	High
Paspalum distichum grassland +/- *Ruppia polycarpa*	*Paspalum distichum*	Submergent r-selected/Terrestrial damp	Moderate
Bolboschoenus caldwellii sedgeland +/- *Ruppia polycarpa, Batrachium trichophyllum, Cotula coronopifolia*	*Bolboschoenus caldwellii*	Emergent	Moderate
Paspalum distichum grassland +/- *Eleocharis acuta*	*Paspalum distichum*	Terrestrial damp	Moderate
Ruppia tuberosa submerged herbland	*Ruppia tuberosa*	Submergent r-selected	High
Cotula coronopifolia herbland	*Cotula coronopifolia*	Amphibious fluctuation responder-plastic	High
Eleocharis acuta sedgeland	*Eleocharis acuta*	Emergent	Moderate
Vallisneria spiralis submerged herbland	*Vallisneria spiralis*	Submergent k-selected	Low
Cyperus gymnocaulos sedgeland	*Cyperus gymnocaulos*	Amphibious fluctuation tolerator-emergent	Moderate
Phragmites australis grassland	*Phragmites australis*	Emergent	Moderate

d.

Vegetation Community	Dominant Species	Functional Group	Salinity Tolerance
Thick-head Samphire/Marsh Saltbush +/- Shrubby Samphire Low Shrubland	*Frankenia pauciflora, Sarcocornia blackiana, Atriplex paludosa, Samolus repens, Suaeda australis*	Amphibious fluctuation tolerator-emergent/Terrestrial damp	High
Salt Bluebush/ Marsh Saltbush Low Shrubland +/- Swamp Paper-bark	*Maireana oppositfolia, Plantago coronopus* ssp. *coronopus,*	Terrestrial dry	High
Beaded Samphire Low Shrubland +/- Lignum	*Sarcocornia quinqueflora, Samolus repens*	Amphibious fluctuation tolerator-emergent/Terrestrial damp	High
Swamp Paper-bark Low Woodland over Sea Rush +/- Salt Club-rush Sedges and Beaded Samphire/ Austral Seablite low shrubs	*Melaleuca halmaturorum* ssp. *halmaturorum, Juncus kraussii*	Amphibious fluctuation tolerator-woody/Amphibious fluctuation tolerator-emergent	High
Lignum Closed Shrubland with Common Reed	*Muehlenbeckia florulenta, Phragmites australis*	Amphibious fluctuation tolerator-woody/Emergent	Moderate
Beaded Samphire Low Shrubland over Austral Seablite	*Sarcocornia quinqueflora, Suaeda australis*	Terrestrial damp	High
Austral Seablite Low Shrubland over Creeping Brookweed	*Suaeda australis, Samolus repens*	Terrestrial damp	High
Sea Rush Sedgeland over Creeping Brookweed	*Juncus kraussii, Samolus repens*	Amphibious fluctuation tolerator-emergent/Terrestrial damp	High
Swamp Paper-bark Low Closed Forest over Sea Rush	*Melaleuca halmaturorum* ssp. *halmaturorum, Juncus kraussii, Muehlenbeckia florulenta*	Amphibious fluctuation tolerator-woody/Amphibious fluctuation tolerator-emergent	High
Black-seed Samphire Low Shrubland	*Tecticornia pergranulata* ssp. *pergranulata*	Amphibious fluctuation tolerator-emergent	High
Brown-head Samphire Low Shrubland +/- emergent Lignum	*Tecticornia indica* ssp. *leiostachya*	Amphibious fluctuation tolerator-emergent	High
Shrubby Samphire Low Shrubland	*Pachycornia arbuscula*	Terrestrial dry	High
Poorly defined floristic association unified by introduced species, in particular, the grass Salt-water Couch	*Paspalum vaginatum*	Terrestrial damp	High
Salt Club-rush Sedgeland	*Bolboschoenus caldwellii*	Emergent	Moderate
Schoenoplectus pungens sedgeland	*Schoenoplectus pungens*	Amphibious fluctuation tolerator-emergent	High
Bolboschoenus caldwellii/Juncus kraussii sedgeland	*Bolboschoenus caldwellii, Juncus kraussii*	Amphibious fluctuation tolerator-emergent/Emergent	Moderate
Suaeda australis/Sarcocornia quinqueflora shrubland	*Suaeda australis, Sarcocornia quinqueflora*	Amphibious fluctuation tolerator-emergent/Terrestrial damp	High
Ruppia megacarpa submerged herbland	*Ruppia megacarpa*	Submergent k-selected	High
Ruppia tuberosa submerged herbland	*Ruppia tuberosa*	Submergent r-selected	High

e.

Vegetation Community	Dominant Species	Functional Group	Salinity Tolerance
Thick-head Samphire/Marsh Saltbush +/- Shrubby Samphire Low Shrubland	*Frankenia pauciflora, Sarcocornia blackiana, Atriplex paludosa, Samolus repens, Suaeda australis, Limonium binervosum*	Amphibious fluctuation tolerator-emergent/Terrestrial damp	High
Salt Bluebush/ Marsh Saltbush Low Shrubland +/- Swamp Paper-bark	*Maireana oppositfolia, Plantago coronopus* ssp. *coronopus,*	Terrestrial dry	High
Beaded Samphire Low Shrubland over Austral Seablite	*Sarcocornia quinqueflora, Suaeda australis*	Amphibious fluctuation tolerator-emergent/Terrestrial damp	High
Black-seed Samphire Low Shrubland	*Tecticornia pergranulata* ssp. *pergranulata*	Amphibious fluctuation tolerator-emergent	High
Ruppia tuberosa submerged herbland	*Ruppia tuberosa*	Submergent r-selected	High