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Assessment of environmental water requirements for the proposed Basin Plan: **The Coorong, Lower Lakes and Murray Mouth**

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Murray region

Assessment of the Coorong, Lower Lakes and Murray Mouth environmental water requirements

1. Introduction

The Water Act 2007 (Cwlth) established the Murray-Darling Basin Authority (MDBA) and tasked it with the preparation of a Basin Plan to provide for the integrated management of the Basin's water resources. One of the key requirements of the Basin Plan is to establish environmentally sustainable limits on the quantities of surface water that may be taken for consumptive use, termed Sustainable Diversion Limits (SDLs). SDLs are the maximum long-term annual average volumes of water that can be taken from the Basin and they must represent an Environmentally Sustainable Level of Take (ESLT).

The method used to determine the ESLT is described in detail within *'The proposed "environmentally sustainable level of take" for surface water of the Murray-Darling Basin: Method and Outcomes,'* (MDBA 2011). A summary of the main steps undertaken to determine the ESLT is presented in Figure 1. The assessment of environmental water requirements including specification of site-specific flow indicators at a subset of hydrologic indicator sites (Step 3 of the overall ESLT method) is the focus of this document.

The work described herein is the MDBA's current understanding of the environmental water requirements of the Coorong, Lower Lakes and Murray Mouth. It is not expected that the environmental water requirements assessments will remain static, rather it is intended that they will evolve over time in response to new knowledge or implementation of environmental watering actions. Within this context, feedback is sought on the material presented within this document whether that be as part of the formal draft Basin Plan consultation phase or during the environmental watering implementation phase within the framework of the Environmental Watering Plan.

1.1. Method to determine site-specific flow indicators

Assessment of environmental water requirements for different elements of the flow regime using the hydrologic indicator site approach is one of the key lines of evidence that has informed the proposed SDLs. Effort focussed on regions and parts of the flow regime with greatest sensitivity to the scale of reduction in diversions necessary to achieve environmental objectives, an ESLT and a healthy working Basin.

Within the overall framework of the ESLT method (Figure 1) the MDBA used an iterative process to assess environmental water requirements and develop site-specific flow indicators.

The hydrologic indicator site approach uses detailed eco-hydrological assessment of environmental water requirements for a subset of the key environmental assets and key ecosystem functions across the Basin. Effort focused on high flow (freshes, bankfull flows and overbank flows) requirements reflecting the prioritisation of effort on parts of the flow regime that are most sensitive to the determination of the ESLT and SDLs. The Coorong, Lower Lakes and Murray Mouth is one of the key environmental assets where a detailed assessment of environmental water requirements was undertaken.

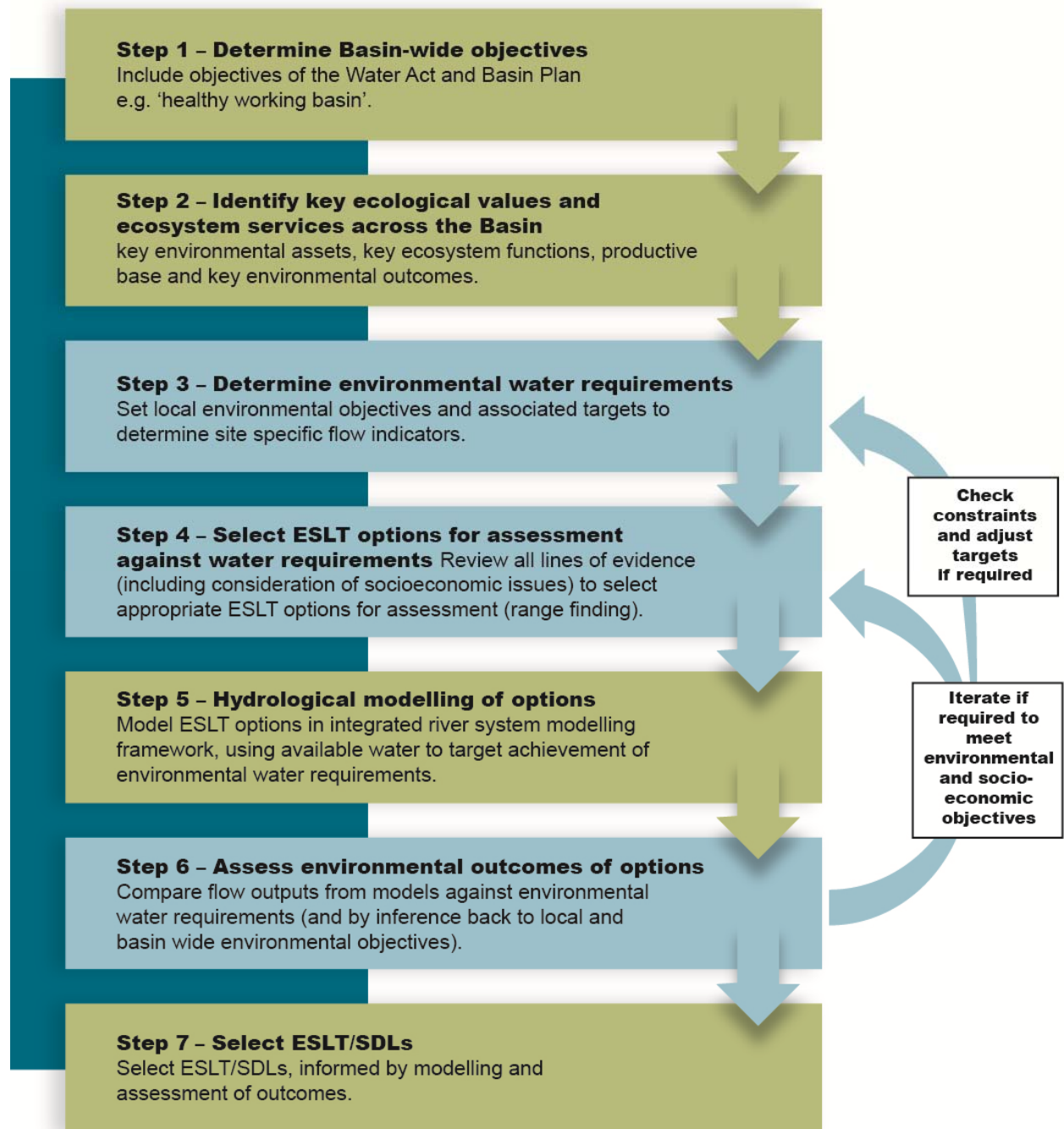


Figure 1: Outline of method used to determine an Environmentally Sustainable Level of Take (Source: MDBA 2011).

Detailed environmental water requirement assessments lead to the specification of site-specific flow indicators to achieve site-specific ecological targets. Flow indicators were expressed at a hydrologic indicator site or sites. Environmental water requirements specified at hydrologic indicator sites are intended to represent the broader environmental flow needs of river valleys or reaches and thus the needs of a broader suite of ecological assets and functions.

This report provides a description of the detailed eco-hydrological assessment of environmental water requirements for the Coorong, Lower Lakes and Murray Mouth including information supporting the development of site-specific flow indicators for the site. More information on how the site-specific flow indicators for the Coorong, Lower Lakes and Murray Mouth were used within the Basin-wide modelling process to inform the ESLT (i.e. Step 5 and 6 in Figure 1) can be found in the report *'Hydrologic modelling to inform the proposed Basin Plan: Methods and results'* (MDBA 2012).

A description of the detailed eco-hydrological assessments of environmental water requirements for other indicator sites are described in other documents in the series *'Assessment of environmental water requirements for the proposed Basin Plan'*.

1.2.Scope and purpose for setting site-specific flow indicators

The MDBA's assessment of environmental water requirements and associated site-specific flow indicators at hydrologic indicator sites has been used to inform the development of SDLs. This enables the MDBA to estimate the amount of water that will be required by the environment over the long-term to achieve a healthy working Basin through the use of hydrological models. Accordingly, site-specific flow indicators are not intended to stipulate future use of environmental water. MDBA expects that the body of work undertaken to establish these site-specific flow indicators will provide valuable input to environmental watering but this watering will be a flexible and adaptive process guided by the framework of the Environmental Watering Plan and natural eco-hydrological cues. It will be up to the managers of environmental water, such as the Commonwealth Environmental Water Holder, State Government agencies, and local communities to decide how best to use the available environmental water during any one year to achieve environmental outcomes.

2. Site location and extent

The Coorong, Lower Lakes and Murray Mouth are located at the downstream end of the Murray–Darling River system (Figure 2). The 140,500 ha hydrologic indicator site is one of Australia's most important wetland areas and includes a diverse range of freshwater, estuarine and marine habitats which supports unique plant and animal life (Department of the Environment, Water, Heritage and the Arts 2009).

The River Murray terminates in South Australia at the Southern Ocean, having passed through Lake Alexandrina, the Murray Estuary and finally, the Murray Mouth. Lake Albert is a terminal lake connected to Lake Alexandrina by a narrow channel. These two lakes are often called the Lower Lakes.

The Coorong is a shallow, brackish to hypersaline lagoon approximately 140 km long, separated from the Southern Ocean by a narrow sand dune peninsula. It can be divided into three distinct regions based on different salinity patterns — the Murray Estuary, North Lagoon and South Lagoon.

The boundary of the Coorong, Lower Lakes and Murray Mouth hydrologic indicator site is defined by the Ramsar Wetlands of Australia dataset. Spatial data used in Figure 2 is listed in Appendix A.

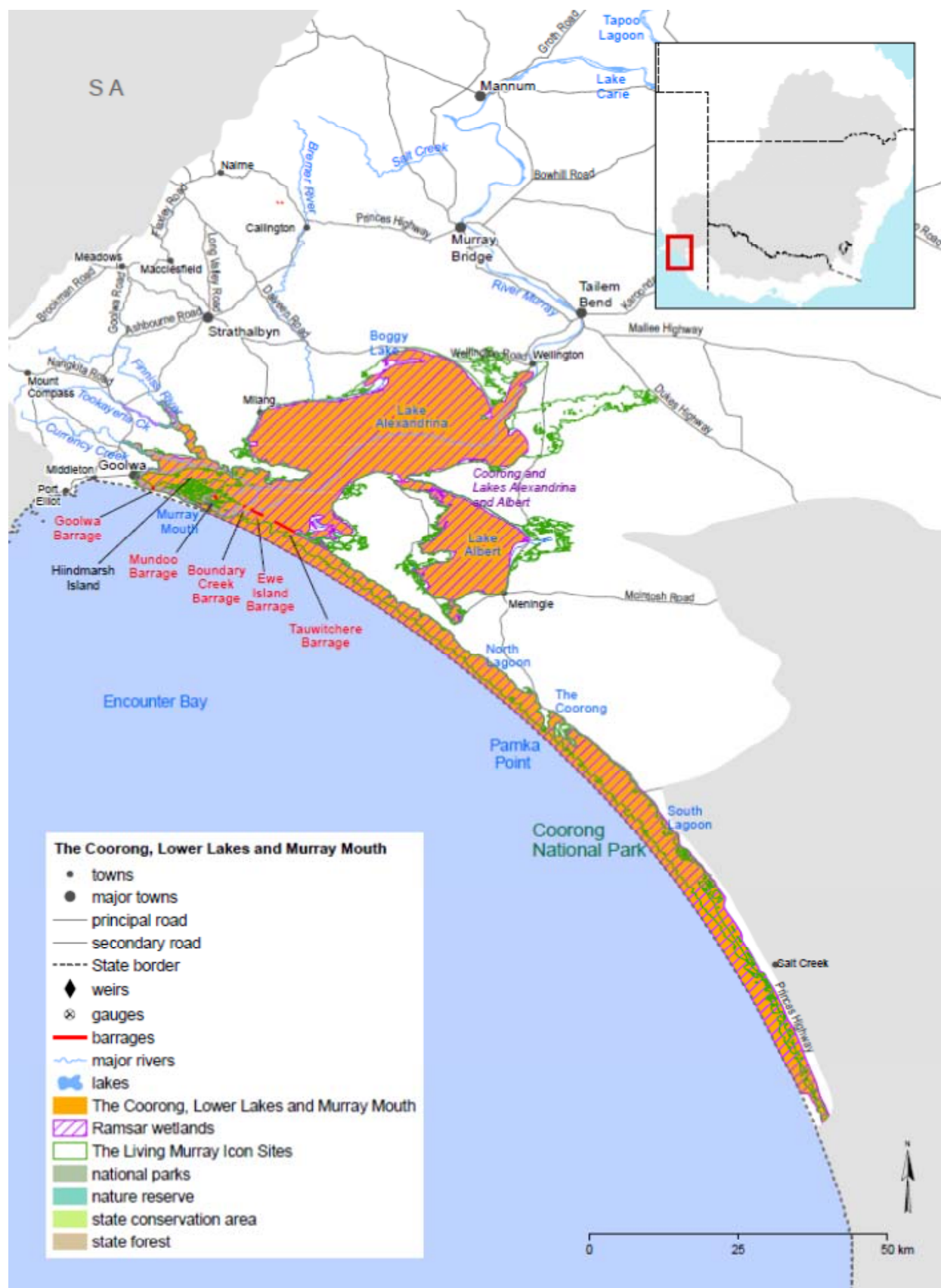


Figure 2 Location and extent of the Coorong, Lower Lakes and Murray Mouth hydrologic indicator site. Flow indicators are specified at the barrages.

3. Ecological Values

The Coorong, Lower Lakes and Murray Mouth hydrologic indicator site is listed under the Ramsar Convention (Convention on Wetlands of International Importance) and is also an icon site under The Living Murray program.

The site supports important species that are listed in international agreements and species listed as vulnerable and/or endangered under State and/or Commonwealth threatened species legislation. Appendix B provides a summary of the conservationally significant species recorded at the site.

The ecological values of the site are reflected in MDBA's assessment against the criteria used to identify key environmental assets within the Basin. The MDBA established five criteria to identify assets based on international agreements and broad alignment with the National Framework and Guidance for Describing the Ecological Character of Australian Ramsar Wetlands (Department of the Environment, Water, Heritage and the Arts 2008) and the draft criteria for identifying High Conservation Value Aquatic Ecosystems (SKM 2007).

Based on the ecological values identified at the Coorong, Lower Lakes and Murray Mouth, the site meets all five criteria for determining a key environmental asset (Table 1).

Table 1 Assessment of the Coorong, Lower Lakes and Murray Mouth against MDBA key environmental asset criteria.

Criterion	Ecological values that support the criterion
1. The water-dependent ecosystem is formally recognised in international agreements or, with environmental watering, is capable of supporting species listed in those agreements	Approximately 140,500 ha of the Coorong and Lakes Alexandrina and Albert were listed under the Convention on Wetlands of International Importance (the Ramsar Convention) in 1985. The Coorong, Lake Alexandrina and Lake Albert site meets eight of the nine nominating criteria for Ramsar listings (Phillips & Muller 2006). Species listed in the Japan–Australia, China–Australia and/or Republic of Korea–Australia migratory bird agreements have been recorded at, and are supported by, the site. Species listed in international agreements that have been recorded at the site are in Appendix B.
2. The water-dependent ecosystem is natural or near-natural, rare or unique	The site consists of a unique mosaic of 23 Ramsar wetland types which include intertidal mud, sand or salt flats, coastal brackish/saline lagoons, permanent freshwater lakes, permanent freshwater marshes/pools, shrub-dominated wetlands, and water storage areas (Phillips & Muller 2006). The site is unique in its wide representation of wetland types within the bioregion. The site includes the only estuarine system in the Murray–Darling Basin.
3. The water-dependent ecosystem provides vital habitat	<p>A large number of fish and bird species are supported by this site during critical stages of their life cycles. Of the 49 species of native fish recorded, 20 species utilise the site at critical stages of their life cycle. This includes seven fish species, such as common galaxias and estuary perch, which move between fresh, estuarine and marine waters at various stages of their life to breed (Phillips & Muller 2006).</p> <p>A total of 77 bird species have been recorded at the site, most being waterbirds (Phillips & Muller 2006). The site is important as waterbird habitat at a global, national and state scale. Forty-nine species of birds, including 25 species listed under international migratory agreements, rely on the wetland at critical life stages, such as migration stop-over, for breeding habitat or as refuge during droughts.</p>

Criterion	Ecological values that support the criterion
	This site is considered significant because of the diversity of its fish species and the diversity of their form, structure and breeding styles, including their migration habits between fresh, estuarine and marine waters (Phillips & Muller 2006).
4. Water-dependent ecosystem that supports Commonwealth, state or territory listed threatened species or communities	The site supports critically endangered, endangered, threatened and vulnerable species and ecological communities. Species and communities listed as threatened under both Commonwealth and state legislation that have been recorded at the site are in Appendix B.
5. The water-dependent ecosystem supports, or with environmental watering, is capable of supporting significant biodiversity	<p>The site is one of Australia's iconic wetlands and a biodiversity hot spot, supporting many threatened species. It also supports extensive and diverse waterbird, fish and plant assemblages, which are reliant on its complex mosaic of wetland types (Phillips & Muller 2006).</p> <p>The Department of Sustainability, Environment, Water, Population and Communities identified the Coorong as part of one of 15 national biodiversity hot spots. The biodiversity hotspot covers an area of South Australia's south-east and Victoria's south-west.</p> <p>A significant number of waterbirds use this Ramsar site, at times reaching 200,000 to 400,000 individuals — far in excess of the 20,000 or more waterbirds required to meet the Ramsar criteria (Phillips & Muller 2006). A number of species that frequent this site regularly occur in abundances greater than 1,000 individuals. Sixteen species of waterbirds have been recorded in numbers greater than 1% of the global population, including the Cape Barren goose (<i>Cereopsis novaehollandiae</i>), curlew sandpiper (<i>Calidris ferruginea</i>), red-necked avocet (<i>Recurvirostra novaehollandiae</i>) and fairy tern (<i>Sterna nereis</i>) (Phillips & Muller 2006).</p> <p>The site also supports the <i>Gahnia</i> sedgelands, swamps of the Fleurieu Peninsula, and several species of note contribute to the site's biological diversity, including the Murray hardyhead (<i>Craterocephalus fluviatilis</i>), Yarra pygmy perch (<i>Nannoperca obscura</i>), southern bell frog (<i>Litoria raniformis</i>), Australasian bittern (<i>Botaurus poiciloptilus</i>) and hooded plover (<i>Thinornis rubricollis rubricollis</i>) (Phillips & Muller 2006).</p>

4. Hydrology

The hydrology of the Coorong, Lower Lakes and the Murray Mouth is a complex, spatially and temporally variable interaction of inflows from the River Murray, other surface water and groundwater sources, and the Southern Ocean.

The Lower Lakes are large, freshwater lakes physically separated from the Murray Mouth and the Coorong by a network of manmade barrages and a series of islands. Water levels in the Lower Lakes fluctuate seasonally: they are generally higher in winter and lower in summer because of River Murray and tributary inflows and climatic factors such as wind, tides and evaporation (Phillips & Muller 2006).

In addition to River Murray inflows, tributaries from the Eastern Mount Lofty Ranges contribute to the lake inflows. The Eastern Mount Lofty Ranges region has estimated surface-water availability of 120 GL/y, representing 0.5% of total run-off from Murray–Darling Basin (CSIRO 2007). Inflows to the Lower Lakes are likely to be slightly less after losses and consumptive uses.

Lake Alexandrina is broad and shallow with complex and extensive fringing vegetation and an array of sand and mud islands. Lake Albert, which is also shallow but typically more saline, lies south-east of Lake

Alexandrina. The Narrung Narrows, a channel between Point Malcolm and Narrung Peninsula, connects the two lakes. The channel was disconnected during recent drought but has since been reconnected.

Salinity in Lake Alexandrina is primarily controlled by flow through the barrages (Heneker 2009). As a terminal wetland with a narrow connection with Lake Alexandrina, flow into and out of Lake Albert is controlled by the water level in Lake Alexandrina, which in turn is affected by inflows, wind and evaporation. Water levels and water quality, specifically salinity levels, in Lake Albert cannot be managed independently of those in Lake Alexandrina (Heneker 2009).

The Coorong is a body of water about 140 km long, separated from the Southern Ocean by a narrow coastal dune system. It is divided into three sections: the Murray Estuary (including the Murray Mouth), North Lagoon and South Lagoon.

The Murray Estuary's location ranges between Goolwa Barrage and Pelican Point, and covers the Goolwa, Coorong and Mundoo channels. Salinity levels fluctuate with flows over the barrages and other factors, including the openness of the Murray Mouth, which connects the Coorong and the Southern Ocean (MDBC 2006). Under without development conditions, River Murray flows would have kept the Murray Mouth open all the time, but river regulation and water extraction have combined to reduce these flows to a point where they can often no longer do this. The Murray Mouth closed for the first time in 1981 (Phillips & Muller 2006) and dredging has been undertaken periodically since then to keep it open.

North Lagoon extends from Pelican Point to Parnka Point, and has salinity conditions similar to that of the Murray Mouth, with the salinity gradient increasing southwards along the lagoon.

South of Parnka Point, South Lagoon extends past Salt Creek, where it becomes a series of hypersaline lagoons (MDBC 2006). Before European settlement, South Lagoon received, in addition to flows from the River Murray, inflows from the south-east of South Australia and western Victoria, via a series of flat, inter-dunal wetlands and watercourses. Much of this area has been cleared and drained for agriculture, and natural flow paths have been interrupted. Some flows have been re-established via the Upper South East Drainage Scheme, with flows entering South Lagoon at Salt Creek (Phillips & Muller 2006). No detailed assessments have been made of pre-European flows into South Lagoon, but it is likely they followed rainfall patterns and varied annually and seasonally.

Recent assessments by the South Australian Government (Way & Heneker 2007; SA Department of Water, Land and Biodiversity Conservation 2009a) indicate it may be feasible to reinstate inflows of between 35 and 60 GL/y on average from the south east. Lester et al. (2009) assessed the impact of a range of different management scenarios on the hydrodynamics and ecosystem state in the Coorong, including increased inflows from the Upper South East Drainage Scheme. While the assessment showed some benefits from the scheme's inflows, it revealed that contributions are small compared to River Murray inflows, which are the main driver in maintaining healthy ecosystems in the Coorong (Lester et al. 2009).

The salinity of the Coorong generally increases with distance from the Murray Mouth, but varies over time, mainly in response to freshwater inflows over the barrages (MDBC 2006). Saline waters of the Coorong lagoons and Murray Mouth are prevented from entering the Lower Lakes and River Murray by the barrages built in the 1930s (MDBC 2006; Phillips & Muller 2006). The salinity variation, representing estuarine, marine and hypersaline conditions, supports different ecological communities (Brookes et al. 2009).

The magnitude and timing of River Murray inflows to the region have changed significantly since European settlement, with water consumption across the Basin reducing average annual flow at the Murray Mouth by 61% (CSIRO 2008). MDBA modelling during development of the Basin Plan further demonstrates the impact of water resource development on flows through the barrages, particularly during dry times (Table 2). The lowest rolling three-year average flow was the period between 2006–07 and 2008–09 for both without development and baseline (current development) conditions. This rolling three-year average has reduced by 96% under baseline conditions, compared to without development conditions for the same period (Table 2).

This data analysis is supported by Brookes et al. (2009), who report that water resource development, combined with a regional drought, resulted in especially low inflows to the Coorong from the Lower Lakes barrages between 2002 and 2009. This has resulted in siltation of the Murray Mouth channel and the hypersalinisation of South Lagoon, where salinities in excess of four times seawater have been recorded (Brookes et al. 2009).

Reduced river flows and an associated increased likelihood of Murray Mouth closure threaten the ecological function of the Coorong through the tendency for higher salinities in the system, changes to the water level regime, and blockage of fish migration pathways (Brookes et al. 2009). Phillips and Muller (2006) note that changes to the flow regime have resulted in significant adverse changes to the ecological character of the region since its listing as a Ramsar wetland in 1985.

Table 2 Modelled barrage without development and baseline flows (1895–2009) for the Coorong, Lower Lakes and Murray Mouth (Source: MDBA analysis).

Modelled barrage flows	Without development	Baseline (current development)
Average annual	12,500 GL	5,100 GL
Wettest five years	49,000 GL (1956–57) 36,400 GL (1917–18) 34,700 GL (1955–56) 29,400 GL (1974–75) 27,700 GL (1952–53)	42,600 GL (1956–57) 28,300 GL (1917–18) 24,800 GL (1955–56) 23,000 GL (1974–75) 18,100 GL (1975–76)
Driest five years	400 GL (2006–07) 1,800 GL (1914–15) 1,800 GL (1982–83) 2,400 GL (1902–03) 2,800 GL (2008–09)	0 GL (2008–09) 50 GL (2007–08) 60 GL (1902–03) 80 GL (1914–15) 240 GL (1944–45)
Lowest three-year rolling average	2,500 GL (2006–07 to 2008–09)	100 GL (2006–07 to 2008–09)

5. Determining the site-specific flow indicators

5.1. Setting site-specific ecological targets

The objective setting framework used to determine the ESLT is outlined in the report ‘The proposed “environmentally sustainable level of take” for surface water of the Murray-Darling Basin: Method and Outcomes’ (MDBA 2011). In summary, the MDBA developed a set of Basin-wide environmental objectives and ecological targets, which were then applied at a finer scale to develop site-specific objectives for individual key environmental assets. Using these site-specific objectives, ecological targets that relate specifically to the Coorong, Lower Lakes and Murray Mouth were developed (Table 3). Information underpinning site-specific ecological targets is shown in Table 3.

Table 3 Site-specific ecological targets for the Coorong, Lower Lakes and Murray Mouth

Targets	Justification of targets
<p>Maintain a range of healthy estuarine, marine and hypersaline conditions in the Coorong, including healthy populations of keystone species such as <i>Ruppia tuberosa</i> in South Lagoon and <i>Ruppia megacarpa</i> in North Lagoon.</p> <p>Provide sufficient flows to enable export of salt and nutrients from the Basin through an open Murray Mouth.</p> <p>Provide a variable lake level regime to support a healthy and diverse riparian vegetation community and avoid acidification.</p>	<p>Ecological values of the site are described in Table 2.</p> <p>For the purpose of determining environmental water requirements, the site has been broken into a number of parts, reflecting differences in ecological character. These parts are:</p> <ul style="list-style-type: none"> • Coorong South Lagoon; • Coorong North Lagoon; • Lakes Alexandrina and Albert; and • Murray Mouth. <p>Salinity is a major determinant of the ecological character of the Coorong (Phillips & Muller 2006). With River Murray inflows having a dominant role in influencing salinity, it also serves as a useful indicator for the purpose of informing the Basin Plan. <i>Ruppia tuberosa</i> and <i>Ruppia megacarpa</i> are recognised as keystone species in the Coorong. <i>Ruppia</i> provide habitat and food resources for a range of species, including waterbirds. Providing appropriate conditions for these plants is expected to provide appropriate conditions for the broader Coorong ecosystem.</p> <p>Water flow out of the Murray Mouth is important to export salt from the river system. Tidal exchange through the Murray Mouth is also recognised as being important in maintaining a healthy ecosystem in the Coorong.</p> <p>Salinity and water level are key determinants of the ecology of Lakes Alexandrina and Albert. Evidence suggests that prior to European settlement the lakes were predominantly freshwater with a seasonally variable water level (Phillips & Muller 2006). Barrages were constructed in the 1930s to maintain the lakes as a freshwater system in the face of increasing water extractions and reducing flows in the River Murray. Continued operation of the barrages together with additional flows for the Coorong and salt export targets will maintain the lakes as predominantly freshwater, and therefore no targets have been specified. Targets are specified to provide a variable lake level regime to water-fringing vegetation communities and avoid acidification from acid sulfate soils.</p>

Site-specific ecological targets formed the basis of an assessment of environmental water requirements and the subsequent determination of site-specific flow indicators for the Coorong, Lower Lakes and Murray Mouth, as described below.

5.2. Information used to determine site-specific flow indicators

Environmental water requirements for each site-specific ecological target, expressed as site-specific flow indicators, are discussed separately below and are summarised in Table 4.

5.2.1. Coorong

The site-specific ecological target for the Coorong is '*maintain a range of healthy estuarine, marine and hypersaline conditions in the Coorong, including healthy populations of keystone species such as *Ruppia tuberosa* in South Lagoon and *Ruppia megacarpa* in North Lagoon*'

The environmental water requirements of the Coorong have been estimated based on analysis of the needs of *Ruppia tuberosa* and *R. megacarpa*, also known as tuberous tassel and large-fruit tassel respectively. These are keystone aquatic plant species underpinning the ecology of the Coorong and can serve as indicators of the overall health of the ecosystem.

*South Lagoon — *Ruppia tuberosa**

A number of scientific studies have assessed salinity preferences and tolerances for both *R. tuberosa* and *R. megacarpa* (Brock 1982; Brock 1985; Geddes 1987; Nicol 2005; Nicol 2007; Rogers & Paton 2009; Overton et al. 2009). These studies have shown that while there are clear thresholds and preferences, they vary between wetland systems. Consequently, studies specific to the Coorong have been used to define environmental water requirements for the proposed Basin Plan.

Salinity is not the only determinant of the distribution of *Ruppia* species. Turbidity and water depth are also significant factors (Carruthers et al. 1999). Overton et al. (2009) identified that the distribution of *R. tuberosa* in South Lagoon is linked to both salinity and water level. Lester and Fairweather (2009) similarly identified that water level is a significant determinant of the health of the ecosystem in South Lagoon. Water level is thought to be important because it impacts on *R. tuberosa* habitat (mudflats). Low water levels expose the mudflats and *R. tuberosa* plants, causing death over large areas (Paton 2010). Based on these findings, salinity and water level have been assessed to determine the environmental water requirements for South Lagoon.

Overton et al. (2009) found that *R. tuberosa* distribution in South Lagoon correlates most strongly with average salinity of about 70,000–80,000 mg/L (note that salinity of seawater is about 35,000 mg/L). The authors analysed mapping of *R. tuberosa* distribution between 1998 and 2008. This period was characterised by drier and more saline conditions than the historical average and at the end of this period there was a decline in condition attributed to elevated salinity. Therefore, it is possible that the salinity preferences of *R. tuberosa* are over-estimated. Modelled long-term average salinity in South Lagoon under baseline conditions is about 60,000 mg/L. Given the decline in condition that has been observed at the site, and the close link with increases in salinity, it is proposed that 60,000 mg/L is adopted as a long-term average salinity indicator. A lower target would likely have ecological benefits, but there is insufficient information available to make a more specific recommendation at this time.

Salinity in the Coorong varies seasonally with changes in inflows and tidal patterns. Overton et al. (2009) found that *R. tuberosa* distribution is related not only to average salinities, but also seasonal salinity peaks. *R. tuberosa* presence was greatest with peak salinity of about 100,000 mg/L, and presence of *R. tuberosa* declined by about 50% when maximum salinity exceeded about 130,000 mg/L (Overton et al. 2009). Freebairn (1999) found that active growth of *R. tuberosa* has only been reported in water up to 108,000 mg/L, and an upper threshold of about 100,000 mg/L for *R. tuberosa* has been suggested by scientists working in this area (Dr J Nicol [South Australian Research and Development Institute] 2010, pers. comm., 7 June).

These studies and observation indicate that *R. tuberosa*:

- prefers peak salinities less than 100,000 mg/L;
- may tolerate temporary increases above 100,000 mg/L, with plants becoming dormant and some decline in abundance and cover; and
- suffers the likelihood of significant decline at salinities above 130,000 mg/L.

Drawing upon this information MDBA proposes a maximum salinity indicator of less than 100,000 mg/L in 95% of years, and less than 130,000 mg/L in 100% of years.

In terms of water level, Overton et al. (2009) found *R. tuberosa* distribution in South Lagoon correlates most strongly with average annual water level of about 0.27 m Australian Height Datum (AHD), with the relationship with *R. tuberosa* presence being weaker than for salinity. Lester and Fairweather (2009) determined water levels above 0.37 m AHD provided the healthiest ecosystem state, while water levels less than –0.09 m AHD provided degraded ecosystem states in the South Lagoon. Healthy ecosystem states are important for resilience, such as for building the *Ruppia* population and seed bank, while degraded ecosystem states should be avoided.

Relationships between barrage flows and salinity and water levels are required to estimate flows to achieve these salinity and water level outcomes. Overton et al. (2009) identified correlations between flow over Tauwitchere and Ewe Island Barrages, and both salinity and water level in South Lagoon. Measured data for the period 1999–2007 were used to develop these correlations.

MDBA has explored the same correlations using 114 years of modelled data. The results are consistent with Overton et al. (2009), but provide a longer period of analysis and a more diverse range of conditions. The relationship between total barrage flow and salinity is shown in Figures 3 and 4. Figure 3 shows the relationship between average salinity in a given year to the rolling average flow over the previous three years (average salinity was found to be most closely related to the rolling three-year average).

This shows that achieving an average salinity of 60,000 mg/L requires a rolling three-year average barrage flow of between about 2,000 and 5,000 GL/y. Modelled long-term average barrage flow under current arrangements is about 5,100 GL/y. This is proposed as a minimum long-term average flow. Greater flow will reduce salinity and likely improve conditions for *R. tuberosa*, but there is insufficient information to make a more specific recommendation. Increases in long-term average flow may be required for other key environmental assets and key ecosystem functions across the Basin, and any such increase will be of benefit to *R. tuberosa* in South Lagoon (and other targets at the site).

Figure 4 shows the relationship between maximum salinity in a given year to the rolling average flow over the previous three years. Once again, a three-year rolling average was found to provide the best

relationship. This shows that to maintain salinity of less than 100,000 mg/L requires a rolling three-year average barrage flow of about 2,000 GL/y, and maintaining salinity of less than 130,000 mg/L requires a rolling three-year average barrage flow of about 1,000 GL/y.

Therefore the recommended flows to maintain suitable salinity conditions for *R. tuberosa* in South Lagoon are:

- long-term average barrage flow at least 5,100 GL/y;
- three-year rolling average barrage flow greater than 2,000 GL/y in 95% of years; and
- three-year rolling average barrage flow greater than 1,000 GL/y in 100% of years.

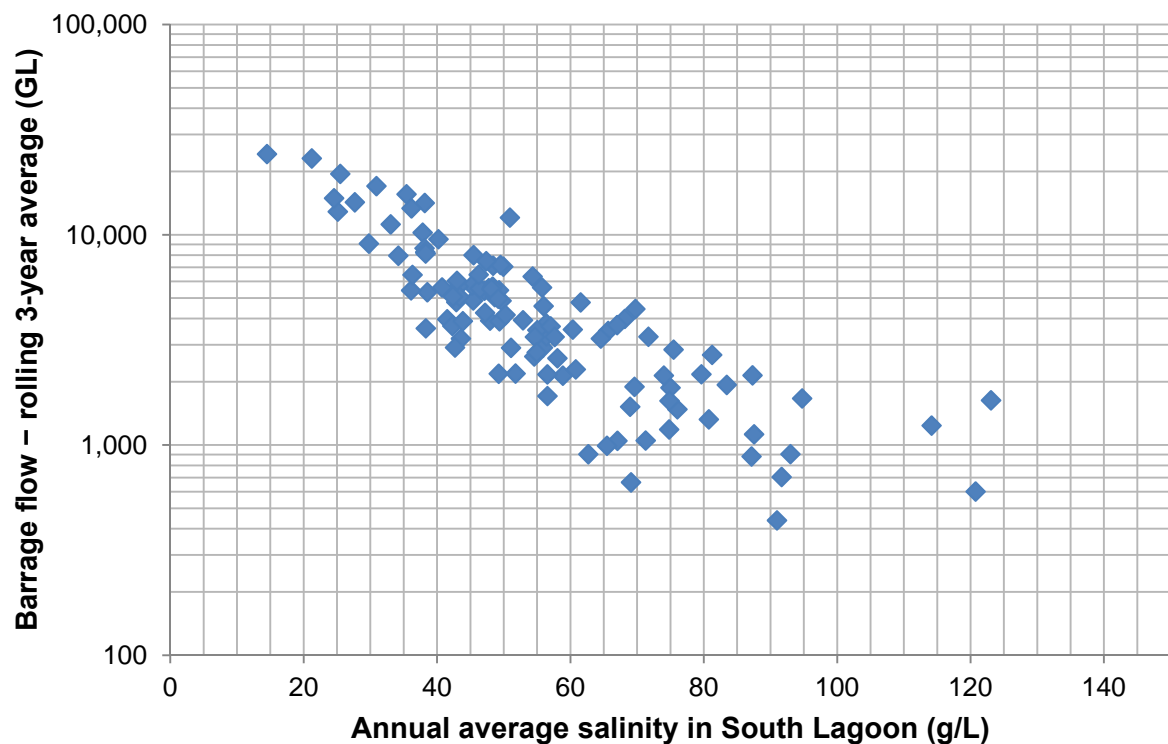


Figure 3 Relationship between barrage flow and average salinity for South Lagoon.

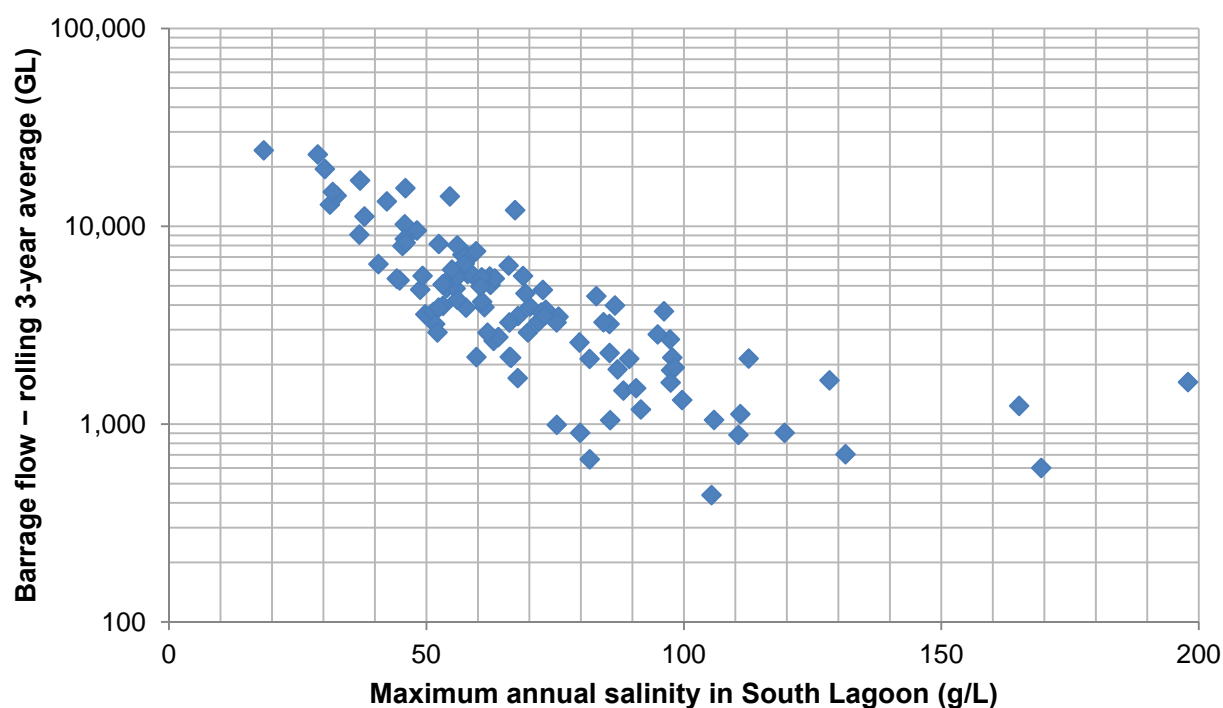


Figure 4 Relationship between barrage flow and maximum salinity for South Lagoon.

There is also anecdotal evidence to suggest that large flow events are required to overcome the progressive increases in South Lagoon salinity that occur during extended dry periods. This gradual increase may not be prevented through provision of minimum barrage flows alone, however there have been no specific studies that quantify the requirement. Accordingly, in the absence of further information, maintenance of at least the current frequency of high flows is recommended. This may well represent a minimum requirement. The increase in long-term average flow and high flows that will result from providing water to upstream key environmental assets and key ecosystem functions across the Basin would be likely to provide additional benefits to the South Lagoon (and entire Coorong, Lower Lakes and Murray Mouth site) that are not quantified.

The relationship between barrage flow and water level in South Lagoon is shown in Figure 5. Water level was found to be most closely correlated with barrage flow in the same year, rather than a rolling average as for salinity. The relationship between barrage flow and water level is weaker, particularly for periods of low flow when other factors such as wind and tidal behaviour are likely to be more influential.

For this reason water level is not used as a primary determinant, but checks for consistency have been made with flows estimated for salinity. The flows proposed based on salinity requirements for *R. tuberosa* will avoid very low water levels associated with degraded ecosystem states (less than -0.09 m AHD) and provide water levels in the range of healthy ecosystem states (>0.37 m AHD) in many years.

Figure 5 also indicates that high flows (>5,100 GL/y) may be important in achieving high water levels and associated healthy ecosystem states. There is insufficient scientific information to make specific recommendations regarding the frequency at which these high-flows are required, and in the absence of further information maintenance of at least the current frequency of high flows is recommended.

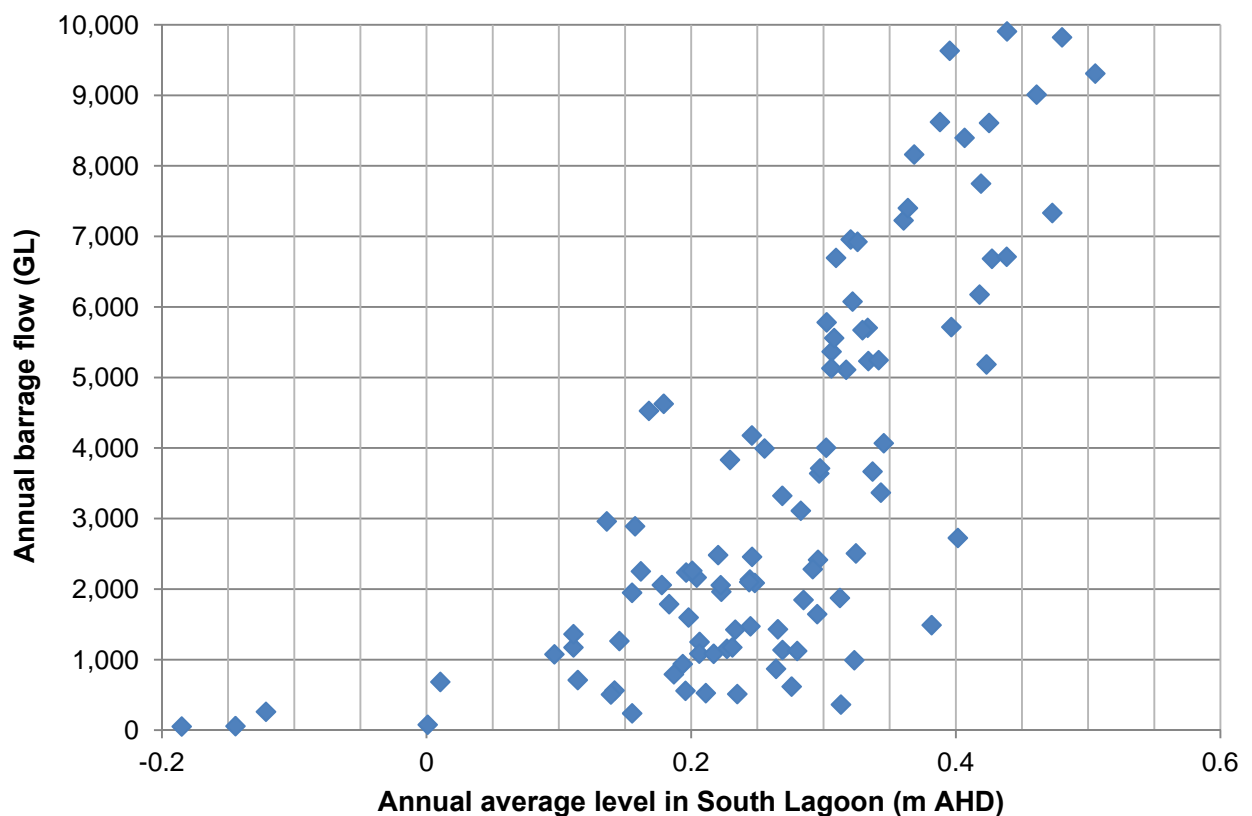


Figure 5 Relationship between barrage flow and water level for South Lagoon

North Lagoon – Ruppia megacarpa

Relative to *R. tuberosa*, less is known regarding the salinity preferences of *R. megacarpa* in the Coorong. Some information is available regarding thresholds of salinity tolerance. Brock (1982) identifies *R. megacarpa* as having an upper threshold of about 46,000 mg/L.

Brock (1982) also identified that salinity has an impact on germination of *R. megacarpa*. Maximum seed germination occurred in freshwater. Seed germination reduced by about 93% at a salinity of 19,000 mg/L, and no germination occurred at a salinity of 42,000 mg/L. Periods of low salinity (i.e. lower than seawater) are therefore likely to be important for recruitment of *R. megacarpa*.

Relationships between barrage flow and average and maximum salinity in North Lagoon are shown in Figures 6 and 7. The minimum flow of 1,000 to 2,000 GL/y is consistent with a maximum salinity of about 40 to 50 g/L (i.e. 40,000 to 50,000 mg/L), and the long-term average flow of 5,100 GL/y will provide average salinities in the range 15 to 25 g/L (i.e. 15,000 to 25,000 mg/L). High-flow years will provide lower salinities and may be important for recruitment of *Ruppia* species. The flows proposed for South Lagoon are therefore considered appropriate for North Lagoon.

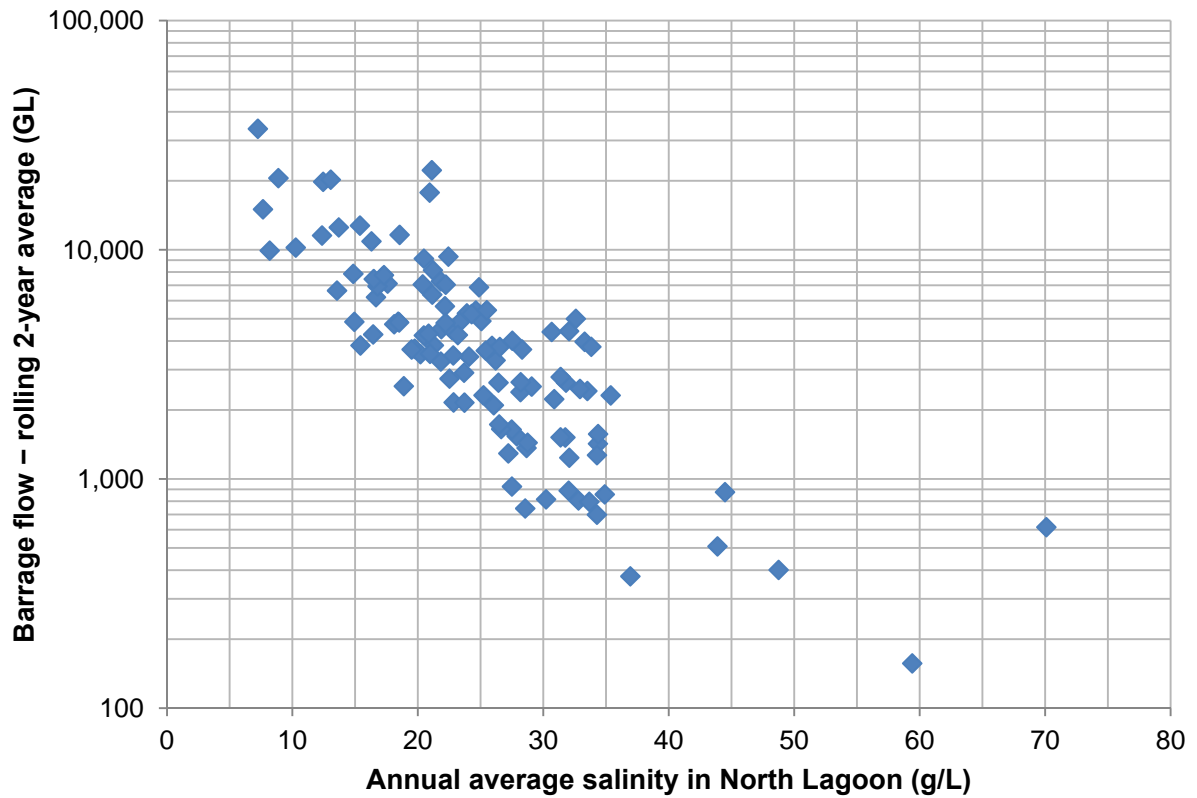


Figure 6 Relationship between barrage flow and average salinity for North Lagoon.

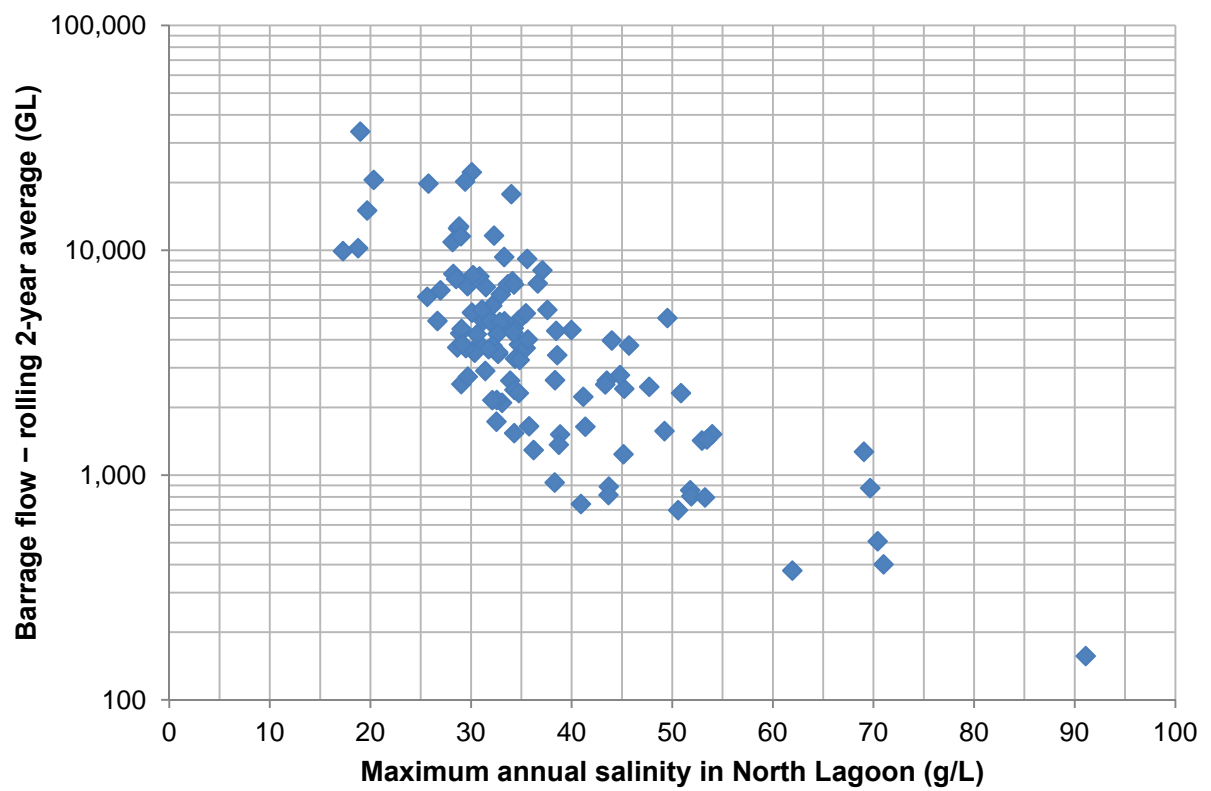


Figure 7 Relationship between barrage flow and maximum salinity for North Lagoon.

Issues relevant to both Coorong lagoons

While the figures above show that there is a relationship between barrage flow and salinity, there is some spread in the data and therefore uncertainty in the recommended flows to achieve the salinity targets in the North and South Lagoons. The flow indicators are therefore intended to serve as an indication of the flows needed to achieve the desired salinities, but the primary point of assessment will be salinity outputs from the hydrodynamic modelling. Refinements can then be made to the flow indicators if required.

Research (e.g. Lester & Fairweather 2009) has demonstrated that the health of the Coorong is sensitive to closure of the Murray Mouth and it is very unlikely that the Coorong would support predominantly healthy ecosystem states without functional connectivity to the southern ocean.

Regional management objectives (e.g. MDBC 2006; Phillips & Muller 2006) include having a permanently open Murray Mouth, although the objectives do not describe the extent to which the mouth should be open (i.e. depth and width of the mouth, and the proportion of time these are achieved over the year). The width, depth and location of the mouth is also dependent on a range of factors including Murray flows, tidal and storm activity, and antecedent conditions. In addition, management intervention by dredging was used between 2002 and 2010 to maintain an open Murray Mouth.

Notwithstanding these issues minimum flows of 1,000 to 2,000 GL/y are often cited as being required to keep the mouth open (eg Phillips & Muller 2006). Consequently it is expected that the flow regime specified to meet targets for the Coorong, Lower Lakes and Murray Mouth hydrologic indicator site will be sufficient to maintain an open Murray Mouth for a high proportion of time, and thus support healthy ecosystem states within the Coorong and maintain its ecological character. Accordingly, the MDBA has not set a specific target for Murray Mouth openness although all Basin Plan scenarios are assessed to determine the outcomes for Murray Mouth opening.

5.2.2. Salt Export

The site-specific ecological target for salt export is to *“provide sufficient flows to enable export of salt and nutrients from the Basin through an open Murray Mouth”*.

The proposed Basin Plan has a salt export target to the Southern Ocean of a minimum of 2 million t/y. The target is based on the salt export target of 1.8 million t/y at Morgan (with a 10% allowance for further salt intrusion between Morgan and the barrages), which was previously developed under the Basin Salinity Management Strategy. The Basin Salinity Management Strategy target is based on actual discharge of salt from the Basin (to Morgan) over the period between 1975 and 2000.

The actual amount of salt discharged from the Basin depends on the volume of flow through the Murray Mouth and the salinity of that flow. In very dry years, even under natural conditions, salt export would be less than 2 million t/y. Conversely, in wet years, salt export would be significantly greater than the target amount. The target is therefore most appropriately considered as a long term average, and the proposed Basin Plan therefore proposes reporting salt export on a rolling 10 year average basis.

With the volume of flow required to export the required amount of salt dependant on the salinity of water in the River Murray, and salinity varying over time in response to a range of factors, the MDBA has chosen not to set a specific flow indicator to achieve salt export. The hydrologic models include the capacity to model salt export and this will be used as a mechanism to assess the achievement of this

target. Delivery of flows for the Coorong, as described above, as well as flows to other indicator sites upstream, will assist in achieving the salt export target.

5.2.3. Lake Levels

The site-specific ecological target for lake levels is to *“provide a variable lake level regime to support a healthy and diverse riparian vegetation community and avoid acidification”*.

Water levels and water level variability in Lakes Alexandrina and Albert are a primary determinant of the ecological character of the lakes and associated fringing riparian vegetation, with particular influence on the extent and patterns of submerged and emergent aquatic plants (Phillips & Muller 2006). Water levels in the lakes were naturally variable, and variable water levels promote diverse and healthy aquatic and riparian plant communities. Historically the barrages have been operated to maintain lake levels mostly between about 0.6 and 0.8 m (AHD), which is considered to be less variable than under without development conditions.

Experience from the recent drought has highlighted the significant risk of acid sulfate soils, which contain iron sulfide minerals, resulting from low lake levels. Exposure of the soils to oxygen can lead to the formation of sulfuric acid and the release of contaminants. This process can create very low pH, contaminate soil and water and lead to the deoxygenation of water bodies. It is a significant issue for ecology, consumptive use of water and public health (Fitzpatrick et al. 2008). An estimated 85% of the sediments of the Lower Lakes have the ability to generate acid upon air exposure with the severity depending on soil type (SA Department of Environment and Heritage 2010). The most severe examples of acid sulfate soils are found in the clay-rich sediments in the middle of Lakes Alexandrina and Albert (SA Department of Environment and Heritage 2010).

Considerable efforts to assess the risk of acid sulfate soil in the Lower Lakes have identified acidification trigger levels and indicate that water levels of –0.75 m AHD in Lake Albert and –1.75 m AHD in Lake Alexandrina are the levels below which broad-scale acidification is likely to occur (SA Department of Environment and Heritage 2010). Localised acid sulfate soil hot spots are likely to exist above these trigger levels, which could have significant adverse impacts i.e. between 0 m and –0.75 m AHD in Lake Albert and 0 m and –1.75 m AHD in Lake Alexandrina (SA Department of Environment and Heritage 2010). To manage acidification risks in lakes Alexandrina and Albert the MDBA has adopted a minimum lake level indicator of 0 m AHD.

Lake levels are determined by inflows from the River Murray and other tributaries, as well as barrage operations. Provision of barrage flows required to achieve Coorong targets will necessitate lake levels at or above sea level, except perhaps for short periods during severe drought. Therefore, it is considered that lake levels are not a primary driver for determining environmental water requirements, and no specific flow requirement is set to achieve the lake level indicator. Basin Plan hydrological modelling will test the achievement of this lake level indicator and the validity of the assumption.

Determination of a more detailed lake level regime and associated barrage operating strategy to enhance the values of the lakes is considered beyond the scope of the proposed Basin Plan, and is an issue best addressed through the Environmental Water Plan process with state government and local community input.

During initial consultation on the draft Basin Plan the MDBA received feedback on the emerging issues surrounding acid sulfate soils and water levels downstream of Lock 1. While the modelling that the

MDBA undertakes can assess the capacity to maintain minimum water levels in this reach of the River Murray to minimise acidification risks, a minimum river level indicator had not been explored by the MDBA in developing the draft Basin Plan. This is likely to be a matter for further consideration.

5.3. Proposed flow indicators

Table 4 provides a summary of the flow indicators adopted for the proposed Basin Plan based on a review of science and information contained in Section 5.2, checked against an analysis of modelled without development and baseline flow data.

The MDBA has reviewed work undertaken by the South Australian Government and acknowledges that the indicators proposed by the MDBA are different to those proposed by the South Australian Government. These differences occur because the ecological objectives differ (e.g. South Australia has an objective for Lake Alexandrina salinity) and this difference in objectives has also lead to a different approach to assessing environmental water requirements (i.e. South Australia uses Lake Alexandrina salinity as the primary objective for determining environmental water requirements).

6. Flow Delivery Constraints

Basin-wide environmental objectives have been developed within the context of being deliverable in a working river system that contains public and private storages and developed floodplains. These constraints typically limit the delivery of some high flow events for the watering of floodplain communities. Whilst high flow events provide benefits to the Coorong, Lower Lakes and Murray Mouth, the salinity, flow and water level indicators set out in this report can mostly be achieved through the delivery of regulated or in-channel flows. Consequently flow delivery constraints are not considered to be a significant issue in the achievement of ecological targets for this site.

7. Summary and conclusion

The Coorong, Lower Lakes, and Murray Mouth is a key environmental asset within the Basin and is an important site for the determination of the environmental water requirements of the Basin. MDBA has undertaken a detailed eco-hydrological assessment of Coorong, Lower Lakes, and Murray Mouth environmental water requirements. Specified flow indicators are indicative of a long-term flow regime required to enable the achievement of site-specific ecological targets at the Coorong, Lower Lakes, and Murray Mouth, and for the broader river valley and reach. Along with other site-specific flow indicators developed across the Basin at other hydrologic indicator sites, these environmental flow requirements were integrated within hydrological models to inform the ESLT. This process including consideration of a range of constraints such as those outlined in Section 6 is described in further detail within the companion report on the modelling process *'Hydrologic modelling to inform the proposed Basin Plan: Methods and results'* (MDBA 2012).

The flow indicators in this report are used to assess potential Basin Plan scenarios. MDBA (2012) summarises how the proposed draft Basin Plan released in November 2011 performs against flow indicators for Coorong, Lower Lakes, and Murray Mouth.

Table 4 Site-specific ecological targets and associated flow indicators for the Coorong, Lower Lakes and Murray Mouth

Site-specific ecological targets	Required characteristics	Site-specific flow indicators	Results under modelled without development conditions	Results under modelled baseline conditions
Maintain a range of healthy estuarine, marine and hypersaline conditions in the Coorong, including healthy populations of keystone species such as <i>Ruppia tuberosa</i> in South Lagoon and <i>Ruppia megacarpa</i> in North Lagoon	South Lagoon salinity average long-term salinity <60,000 mg/L. maximum salinity <100,000 mg/L in 95% of years. maximum salinity <130,000 mg/L in 100% of years.	Barrage flow Long-term average at least 5,100 GL/y. Rolling 3-year average >2,000 GL/y in 95% of years. Rolling 3-year average >1,000 GL/y in 100% of years. Maintain at least the proportion of years with high flows (5,100–10,000 GL/y) that is experienced under baseline conditions.	12,500 GL/y 100% of years 100% of years Flows >5,100 GL/y: 89% of years	5,100 GL/y 79% of years 91% of years Flows >5,100 GL/y: 36% of years
	North Lagoon salinity average annual salinity <20,000 mg/L in a proportion of years maximum salinity <50,000 mg/L	Same as above	Same as above	Same as above
Provide sufficient flows to enable export of salt and nutrients from the Basin through an open Murray Mouth	Salt export 2 million tonnes per year, reported on a rolling 10 year average basis.	NA	NA	NA
Provide a variable lake level regime to support a healthy and diverse riparian vegetation community and avoid acidification	Lake levels Lakes Albert and Alexandrina water levels >0 m AHD.	None additional to those above. Modelling will test the assertion that delivery of above flows will provide appropriate lake levels.	N/A	N/A

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Appendix A

Data used in producing hydrologic indicator site maps

Data	Dataset name	Source ^a
Basin Plan regions	Draft Basin Plan Areas 25 May 2010	Murray–Darling Basin Authority (2010)
Dam walls/barrages	GEODATA TOPO 250K Series 3 Topographic Data	Geoscience Australia 2006
Gauges	100120 Master AWRC Gauges	
Icon sites	Living Murray Indicative Icon Site Boundaries	Murray–Darling Basin Commission (2007)
Irrigation areas	Combined Irrigation Areas of Australia Dataset	Bureau of Rural Sciences (2008)
Lakes	GEODATA TOPO 250K Series 3 Topographic Data	Geoscience Australia (2006)
Maximum wetland extents	Wetlands GIS of the Murray–Darling Basin Series 2.0 (Kingsford)	Murray–Darling Basin Commission (1993)
National parks/nature reserves	Digital Cadastral Database	New South Wales Department of Lands (2007)
National parks/nature reserves	Collaborative Australian Protected Areas Database — CAPAD 2004	Department of the Environment, Water, Heritage and the Arts (2004)
Nationally important wetlands	Directory of Important Wetlands in Australia Spatial Database	Department of the Environment, Water, Heritage and the Arts (2001)
Ocean and landmass	GEODATA TOPO 250K Series 3 Topographic Data	Geoscience Australia (2006)
Ramsar sites	Ramsar wetlands in Australia	Department of the Environment, Water, Heritage and the Arts (2009)
Rivers	Surface Hydrology (AUSHYDRO version 1-6)	Geoscience Australia (2010)
Roads	GEODATA TOPO 250K Series 3 Topographic Data	Geoscience Australia (2006)
State border	GEODATA TOPO 250K Series 3 Topographic Data	Geoscience Australia (2006)
State forests	Digital Cadastral Database	New South Wales Department of Lands (2007)
Towns	GEODATA TOPO 250K Series 3 Topographic Data	Geoscience Australia (2006)
Weirs	Murray–Darling Basin Weir Information System	Murray–Darling Basin Commission (2001)
Weirs 2	River Murray Water Main Structures	Murray–Darling Basin Authority (2008)

^a Agency listed is custodian of relevant dataset; year reflects currency of the data layer.

Appendix B

Species relevant to criteria 1 and 4: The Coorong, Lower Lakes and Murray Mouth

Species	Recognised in international agreement(s) ¹	<i>Environment Protection and Biodiversity Conservation Act 1999</i> (Cwlth)	<i>National Parks and Wildlife Act 1972</i> (SA) ²	<i>Fisheries Management Act 2007</i> (SA)
Amphibians and reptiles				
Brown toadlet (<i>Pseudophryne bibronii</i>) ⁷			R	
Golden bell frog (<i>Litoria raniformis</i>) ^{3, 7}		V	V	
Heath goanna (<i>Varanus rosenbergi</i>) ⁷			V	
Marbled toadlet (<i>Pseudophryne semimarmorata</i>) ⁷			V	
Birds				
Australasian bittern (<i>Botaurus poiciloptilus</i>) ^{3, 7}			V	
Australasian shoveler (<i>Anas rhynchos</i>) ⁷			R	
Australian bustard (<i>Ardeotis australis</i>) ⁷			V	
Banded stilt (<i>Cladorhynchus leucocephalus</i>) ⁷			V	
Bar-tailed godwit (<i>Limosa lapponica</i>) ^{3, 7}	✓		R	
Beautiful firetail (<i>Stagonopleura bella</i>) ⁷			R	
Black-tailed godwit (<i>Limosa limosa</i>) ^{3, 7}	✓		R	
Blue bonnet (<i>Northiella haematogaster</i>) ⁷			ssp	
Blue-billed duck (<i>Oxyura australis</i>) ⁷			R	
Blue-winged parrot (<i>Neophema chrysostoma</i>) ⁷			V	
Brown quail (<i>Coturnix ypsilophora</i>) ⁷			V	
Bush stone-curlew (<i>Burhinus grallarius</i>) ⁷			R	
Cape Barren goose (<i>Cereopsis novaehollandiae</i>) ^{3, 7}			R	
Caspian tern (<i>Sterna caspia</i>) ³	✓			
Cattle egret (<i>Ardea ibis</i>) ⁷			R	
Common greenshank (<i>Tringa nebularia</i>) ³	✓			
Common sandpiper (<i>Tringa hypoleucos</i>) ^{3, 7}	✓		R	
Common tern (<i>Sterna hirundo</i>) ⁷			R	
Curlew sandpiper (<i>Calidris ferruginea</i>) ³	✓			
Darter (<i>Anhinga novaehollandiae</i>) ⁷			R	
Diamond firetail (<i>Stagonopleura guttata</i>) ⁷			V	
Eastern curlew (<i>Numenius madagascariensis</i>) ^{3, 7}	✓		V	
Eastern great egret (<i>Ardea alba</i>) ³	✓			
Eastern reef egret (<i>Egretta sacra</i>) ⁷			R	
Elegant parrot (<i>Neophema elegans</i>) ⁷			R	
Fairy tern (<i>Sterna nereis</i>) ^{3, 7}			E	

Species	Recognised in international agreement(s) ¹	Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)	National Parks and Wildlife Act 1972 (SA) ²	Fisheries Management Act 2007 (SA)
Flame robin (<i>Petroica phoenicea</i>) ⁷			V	
Flesh-footed shearwater (<i>Ardenna carneipes</i>) ⁷			R	
Freckled duck (<i>Stictonetta naevosa</i>) ⁷			V	
Glossy ibis (<i>Plegadis falcinellus</i>) ^{3, 7}	✓		R	
Great crested grebe (<i>Podiceps cristatus</i>) ^{3, 7}			R	
Great knot (<i>Calidris tenuirostris</i>) ^{3, 7}	✓		R	
Greater sand plover (<i>Charadrius leschenaultii</i>) ⁷			R	
Grey currawong (<i>Strepera versicolor</i>) ⁷			ssp	
Grey falcon (<i>Falco hypoleucos</i>) ⁷			R	
Grey plover (<i>Pluvialis squatarola</i>) ³	✓			
Grey-tailed tattler (<i>Tringa brevipes</i>) ^{3, 7}	✓		R	
Hooded plover (<i>Thinornis rubricollis</i>) ^{3, 7}			V	
Intermediate egret (<i>Ardea intermedia</i>) ⁷			R	
Jacky winter (<i>Microeca fascians</i>) ⁷			ssp	
Latham's snipe (<i>Gallinago hardwickii</i>) ^{3, 7}	✓		R	
Lesser sand plover (<i>Charadrius mongolus</i>) ⁷			R	
Lewin's rail (<i>Rallus pectoralis</i>) ^{3, 7}			V	
Little egret (<i>Egretta garzetta</i>) ⁷			R	
Little tern (<i>Sternula albifrons</i>) ^{3, 7}	✓		E	
Long-toed stint (<i>Calidris subminuta</i>) ⁷			R	
Malleefowl (<i>Leipoa ocellata</i>) ⁷			V	
Marsh sandpiper (<i>Tringa stagnatilis</i>) ³	✓			
Mount Lofty Ranges southern emu-wren (<i>Stipiturus malachurus intermedius</i>) ³			E	
Musk duck (<i>Biziura lobata</i>) ^{3, 7}			R	
Orange-bellied parrot (<i>Neophema chrysogaster</i>) ^{3, 7}			E	
Oriental reed-warbler (<i>Acrocephalus orientalis</i>) ³	✓			
Pacific golden plover (<i>Pluvialis fulva</i>) ^{3, 7}	✓		R	
Painted button-quail (<i>Turnix varius</i>) ⁷			R	
Pectoral sandpiper (<i>Calidris melanotos</i>) ^{3, 7}	✓		R	
Peregrine falcon (<i>Falco peregrinus</i>) ⁷			R	
Pied oystercatcher (<i>Haematopus longirostris</i>) ⁷			R	
Purple-gaped honeyeater (<i>Lichenostomus cratitius</i>) ⁷			ssp	
Red knot (<i>Calidris tenuirostris</i>) ³	✓			
Red-necked phalarope (<i>Phalaropus lobatus</i>) ³	✓			
Red-necked stint (<i>Calidris ruficollis</i>) ³	✓			

Species	Recognised in international agreement(s) ¹	Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)	National Parks and Wildlife Act 1972 (SA) ²	Fisheries Management Act 2007 (SA)
Restless flycatcher (<i>Myiagra inquieta</i>) ⁷			R	
Rock parrot (<i>Neophema petrophila</i>) ⁷			R	
Ruddy turnstone (<i>Arenaria interpres</i>) ^{3, 7}	✓		R	
Ruff (<i>Philomachus pugnax</i>) ^{3, 7}	✓		R	
Rufous bristlebird (<i>Dasyornis broadbentii</i>) ⁷			ssp	
Sanderling (<i>Calidris alba</i>) ^{3, 7}	✓		R	
Scarlet robin (<i>Petroica boodang</i>) ⁷			ssp	
Sharp-tailed sandpiper (<i>Calidris acuminata</i>) ³	✓			
Shy heathwren (shy hylacola) (<i>Calamanthus cautus</i>) ⁷			R	
Sooty oystercatcher (<i>Haematopus fuliginosus</i>) ⁷			R	
Southern emu-wren (south east ssp) (<i>Stipiturus malachurus polionotum</i>) ⁷			R	
Spotless crake (<i>Porzana tabuensis</i>) ⁷			R	
Terek sandpiper (<i>Xenus cinereus</i>) ^{3, 7}	✓		R	
Wandering tattler (<i>Tringa incana</i>) ³	✓			
Whimbrel (<i>Numenius phaeopus</i>) ⁷			R	
White-bellied sea-eagle (<i>Haliaeetus leucogaster</i>) ⁷			E	
Wood sandpiper (<i>Tringa glareola</i>) ⁷			R	
Yellow chat (<i>Epthianura crocea</i>) ⁷			E	
Yellow-tailed black-cockatoo (<i>Calyptorhynchus funereus</i>) ⁷			V	
Fish				
Congolli (<i>Pseudaphritis urvilli</i>) ^{3, 5, 6}			VU	
Estuary perch (<i>Macquaria colonorum</i>) ^{3, 6}			EN	
Murray cod (<i>Maccullochella peelii peelii</i>) ^{3, 5, 6}		V	EN	
Murray hardyhead (<i>Craterocephalus fluvialilis</i>) ^{3, 5, 6}		V	CE	
Barred galaxias (<i>galaxias fuscus</i>) ^{5, 6}		E		
Short-headed lamprey (<i>Mordacia mordax</i>) ⁶			EN	
Southern pygmy perch (<i>Nannoperca australis</i>) ^{3, 6}			EN	P
Yarra pygmy perch (<i>Nannoperca obscura</i>) ^{3, 5, 6}		V	CE	P
Mammals				
Swamp rat (<i>Rattus lutreolus</i>) ⁷			R	
Common wombat (<i>Vombatus ursinus</i>) ⁷			R	
Yellow-bellied sheath-tail bat (<i>Saccolaimus flaviventris</i>) ⁷			R	
Plants				
<i>Atriplex australasica</i> ⁷			R	

Species	Recognised in international agreement(s) ¹	Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)	National Parks and Wildlife Act 1972 (SA) ²	Fisheries Management Act 2007 (SA)
<i>Austrostipa tenuifolia</i> ⁷			R	
Blunt greenhood (<i>Pterostylis curta</i>) ⁷			R	
Coloured spider-orchid (<i>Caladenia colorata</i>) ⁷			E	
Creeping boobialla (<i>Myoporum parvifolium</i>) ⁷			R	
Dune fanflower (<i>Scaevola calendulacea</i>) ^{3, 7}		V	V	
Dune helmet-orchid (<i>Corybas expansus</i>) ⁷			V	
Fat-leaved wattle (<i>Acacia pinguifolia</i>) ^{4, 7}			E	
Hornwort (<i>Ceratophyllum demersum</i>) ⁷			R	
Kangaroo Island pomaderris (<i>Pomaderris halmaturina halmaturina</i>) ⁷			V	
Leafy twig-rush (<i>Cladium procerum</i>) ⁷			R	
Little dip spider-orchid (<i>Caladenia richardsiorum</i>) ⁷			E	
Mallee bitter-pea (<i>Daviesia benthamii humilis</i>) ⁷			R	
Metallic sun-orchid (<i>Thelymitra epipactoides</i>) ^{3, 7}		E	E	
Narrow-leaf wax-flower (<i>Philothea angustifolia angustifolia</i>) ⁷			R	
Native broom (<i>Viminaria juncea</i>) ⁷			R	
Osborn's eyebright (<i>Euphrosia collina osbornii</i>) ⁴			E	
Pink gum (<i>Eucalyptus fasciculosa</i>) ⁷			R	
Resin wattle (<i>Acacia rheticarpa</i>) ⁷			V	
Ruddy ground-fern (<i>Hypolepis rugosula</i>) ⁷			R	
Sandhill greenhood (<i>Pterostylis arenicola</i>) ^{3, 7}		V	V	
Scaly poa (<i>Poa fax</i>) ⁷			R	
Scarlet grevillea (<i>Grevillea treueriana</i>) ³		V	V	
Silver daisy-bush (<i>Olearia pannosa ssp. pannosa</i>) ^{3, 7}		V	V	
Sticky daisy-bush (<i>Olearia passerinoides glutescens</i>) ⁷			R	
Tall blown-grass (<i>Lachnagrostis robusta</i>) ⁷			R	
Velvet daisy-bush (<i>Olearia pannosa cardiophylla</i>) ⁷			R	
White correa (<i>Correa alba</i> var. <i>pannosa</i>) ⁷			R	
White purslane (<i>Neopaxia australasica</i>) ⁷			R	
Yellow swainson-pea (<i>Swainsona pyrophila</i>) ³		V	R	
Communities				
Gahnia sedgeland ecosystem ³				
Swamps of the Fleurieu Peninsula ³				

CE = critically endangered E = endangered P = protected R = rare SSP = threatened at the sub-specific level² V = vulnerable

- 1 Japan–Australia Migratory Bird Agreement, China–Australia Migratory Bird Agreement, or Republic of Korea–Australia Migratory Bird Agreement
- 2 ssp = Threatened status applies at the subspecific level. The Biological Databases of South Australian records are at species level; for completeness these records are retained but expert interpretation is required for this record to resolve subspecific taxonomy.
- 3 Phillips & Muller (2006)
- 4 SA Department of Water, Land and Biodiversity Conservation (2009b)
- 5 Wedderburn & Hammer (2003)
- 6 SA Department of Environment and Heritage (n.d.)
- 7 SA Department of Environment and Heritage (2009)