Spectacle Lakes - Beldora Wetland Management Plan

November 2006

BBLAP

Government of South Australia

South Australian Murray-Darling Basin Natural Resources Management Board

This wetland management plan was written by Hugh Robertson for the Beldora landholders and other Spectacle Lakes landholders and the Berri Barmera Local Action Planning Committee. The wetland management plan was reviewed and endorsed by the SA River Murray Wetland Technical Group.

Funding was provided by the National Action Plan for Salinity and Water Quality, the National Heritage Trust, and the South Australian Murray-Darling Basin Natural Resources Management Board.

The management plan has been prepared according to the *Guidelines for developing wetland management plans for the River Murray in South Australia 2003* (DWLBC 2003) and as such fulfils obligations under the Water Allocation Plan for the River Murray Prescribed Watercourse.

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Cite as:
Robertson, H.A. (2006). *Spectacle Lakes-Beldora Wetland Management Plan*. Berri Barmera Local Action Planning Committee, Berri, SA.

Acknowledgements:
This wetland management plan has been developed with the support of a number of organisations, community groups and individuals. The contributions of the Beldora landholders (particularly Don Dalziel and Ed Cottam), Department of Environment and Heritage, South Australian Murray-Darling Basin Natural Resources Management Board, Department for Water, Land and Biodiversity Conservation and the members of the SA River Murray Wetland Technical Group are especially acknowledged.

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Cover photos:
Inundated wetland habitat in Spectacles Lakes-Beldora (Photos: H. Robertson, June 2006)

Community endorsement of the Spectacle Lakes-Beldora Wetland Management Plan

Since 1995 the Beldora landholders (Beldora Station Pty Ltd) and other landholders have been implementing management actions to conserve floodplain wetland habitat at the Spectacle Lakes and Beldora wetlands, which occur on Crown Land.

The Beldora landholder group have been working in collaboration with the Berri Barmera LAP, Department of Environment and Heritage, SA Murray-Darling Basin NRM Board and the Department for Water, Land and Biodiversity Conservation to develop this Wetland Management Plan.

We are pleased to present the Spectacle Lakes-Beldora Wetland Management Plan for accreditation and application for a long-term allocation water licence.

Don Dalziel

Chairperson - Wetlands
Beldora Station Pty Ltd

Paul Stribley

Project Manager
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Note:
This Wetland Management Plan encompasses both the floodplain and wetland areas of Spectacle Lakes-Beldora.

Within the text ‘Spectacle Lakes-Beldora refers to the wetland-floodplain complex as a whole, whereas ‘wetland’ and ‘lagoon’ only refer to the wetland areas. ‘Floodplain’ refers to the area of higher elevation inundated during flood events.

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INTRODUCTION

In 2003 a management plan was prepared for the Spectacle Lakes wetland complex (Wetland Care Australia 2003). The 2003 Plan provided an initial focus for the Beldora and Spectacle Lakes landholder group to manage the land and water resources in the wetlands.

On the 1st July 2002, the Minister for the Environment and Conservation adopted the *Water Allocation Plan for the River Murray Prescribed Watercourse.* In doing so, a water allocation of 200 GL of South Australia's entitlement flow of 1850 GL per annum was endorsed for wetlands along the River Murray. To obtain a water allocation, individual community groups are required to submit a Wetland Management Plan that meets the criteria in the *Guidelines for Developing Wetland Management Plans for the River Murray in South Australia* ('Guidelines') (DWLBC 2003).

This Spectacle Lakes-Beldora Wetland Management Plan has been upgraded to meet the criteria set out in the 'Guidelines'.

What are the environmental, social and cultural significances of Spectacle Lakes-Beldora?

Spectacle Lakes and the Beldora wetlands are adjacent to the River Murray, approximately 13 km southwest of Barmera. Spectacle Lakes and Beldora wetlands contain a number of permanent and temporary wetlands. These include the Spectacle Lakes (inlet, First Lake, End Lake), the Beldora Wetlands and temporary wetlands scattered across the floodplain.

Spectacle Lakes-Beldora represents a site of very significant ecological value, particularly due to the habitat it provides for native flora and fauna communities (SKM 2004, SKM 2006). The wetlands also have high social value to the group of landholders that manage the area. The location of Spectacle Lakes-Beldora adjacent to the River Murray suggests the wetlands would also have been significant for local indigenous communities, particularly for food and water resources.

Spectacle Lakes is identified as a wetland of national significance, being listed in the *Directory of Important Wetlands in Australia* (Environment Australia 2001). In the *Directory* Spectacle Lakes satisfied three of six criteria for 'significance', specifically:

1. *It is a good example of a wetland type occurring within a biogeographic region in Australia*

2. *It is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex.*

3. *It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail.*

Spectacle Lakes-Beldora has also been identified as a wetland of high priority for management in the *Wetlands Atlas of the South Australian Murray Valley* (Jensen *et al*. 1996) and in *River Murray Wetlands: their characteristics, significance and management* (Thompson 1986). Spectacle Lakes-Beldora is also included within Bookmark Biosphere Reserve.

Although the site is managed as annual leasehold (Crown land), since the late 1990s the floodplain and wetlands have been managed for both grazing and wetland conservation. The Beldora Station landholders first obtained an annual licence in 1995 (E. Cottam pers. comm. 2006).

Apart from the Beldora Station, other landholders at Spectacle Lakes have also been actively involved in wetland management, and this community involvement is considered valuable for the ongoing management of these wetlands.

Why does Spectacle Lakes-Beldora need a Wetland Management Plan?

There are a number of threats to the long-term sustainability of Spectacle Lakes-Beldora. For example, the lack of frequent flood events threatens the survival of trees including River Red Gums (*Eucalyptus camaldulensis*). Accumulation of salt on the wetland is also a threat to native flora and fauna, and poses a risk to water quality in the River Murray.

These issues highlight the need for a coordinated and scientifically-informed approach to the management of wetlands at Spectacle Lakes-Beldora.

The Beldora landholder group have initiated a number of management actions, including installation of regulating structures to manage water levels. Ongoing management of the water levels is considered important for wetland conservation. However, the lack of a detailed management plan limits the capacity to manage Spectacle Lakes-Beldora.

This Spectacle Lakes-Beldora Wetland Management Plan establishes clear management objectives to maintain the condition of the wetland.

MISSION STATEMENT

To maintain and increase the diversity of native flora and fauna in Spectacle Lakes and the Beldora wetlands through management of water levels and grazing in the wetland.

VISION STATEMENT

The vision for Spectacle Lakes and the Beldora wetlands is to increase diversity, regeneration and breeding of native flora and fauna, and maintain low surface water salinity levels, by manipulating water levels and the grazing regime. The vision is also to maintain continued community involvement in wetland management and monitoring.

MANAGEMENT OBJECTIVES

- Manipulate the water levels in Spectacle Lakes and the Beldora wetlands to provide habitat for native fauna, and to promote the regeneration of wetland and floodplain vegetation.
- Extend the duration of flood events in Spectacle Lakes and the Beldora wetlands (particularly in 'First Lake') by manipulating regulating structures after periods of high flows.
- Maintain low surface water salinity levels in the wetlands by monitoring the input of saline groundwater when the wetlands are dry, and investigate options to flush the wetland.
- Control the access and stocking rates of cattle in the wetlands to maintain the diversity of native plants and improve water quality.
- Control the abundance of noxious weeds and other pest plants.
- Control the abundance of pest animals, particularly introduced species of fish.
- Maintain a vibrant community group with the capacity to undertake wetland management and monitoring.
- Formalise ongoing management arrangements in Spectacle Lakes-Beldora with key stakeholders.

MANAGEMENT ACHIEVEMENTS AT SPECTACLE LAKES & BELDORA WETLANDS

1995	▪ Beldora landholder group obtained lease to manage land and wetlands including the Spectacle Lakes and Beldora Wetlands
1995-2006	▪ Ongoing pest plant control (e.g. Boxthorn removal, Gazelia spraying), including use of contractors ▪ Ongoing pest animal control (e.g. Rabbit shooting ~100s per year) ▪ Schools (incl. Cobdolga, Glossop, Stradbroke) visited wetlands (e.g. WaterWatch)
2003	▪ Regulating structures installed at Spectacle Lakes-Beldora ▪ First drying event implemented in the wetlands (regulators closed). Significant reduction in Carp abundance, increase in wetland plants and improved water clarity ▪ Initial Spectacle Lakes-Beldora Management Plan completed by Wetland Care Australia ▪ Baseline Survey of physical and ecological features of Beldora Wetlands
2003-2006	▪ Ongoing wetland monitoring by landholder group
2005	▪ Baseline Survey of physical and ecological features of Spectacle Lakes ▪ Temporary Water Licence obtained to inundate wetlands
2006	▪ Community meetings held to discuss update of the Wetland Management Plan ▪ Enviro-fund application submitted to install cattle watering sites on high land away from wetlands ▪ Temporary Water Licence obtained to inundate wetlands ▪ Closure of Beldora wetlands regulator (October 2006) due to drought conditions

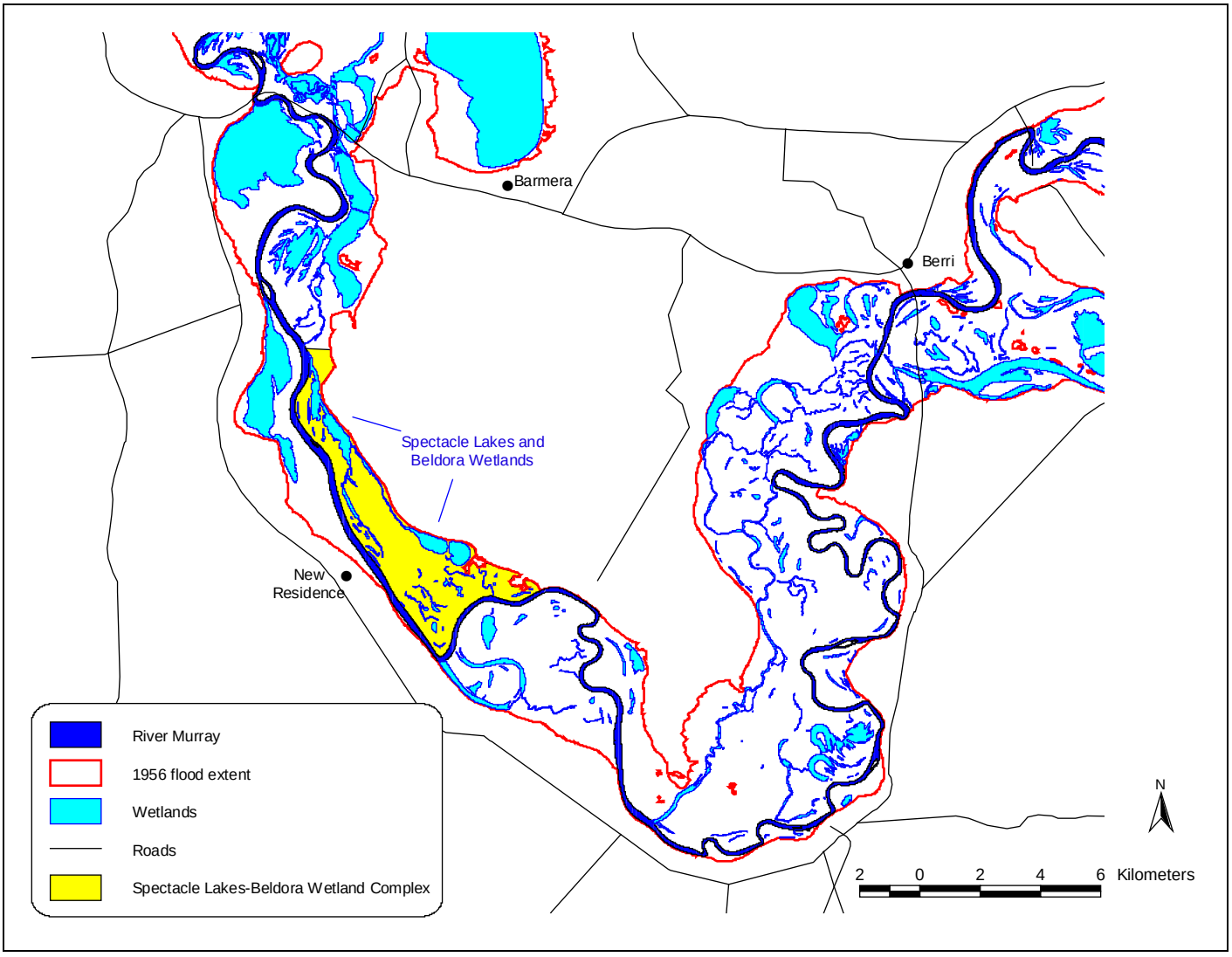
SITE DESCRIPTION

LOCATION

Spectacle Lakes-Beldora is located adjacent to the River Murray upstream of Lock/Weir 3, approximately 13 km southwest of Barmera (Map 1).

Spectacle Lakes-Beldora can be found on the 1:50,000 map sheet 'Moorook - 6929-2' at 444452 E, 6200065 N (AMG zone 54).

Spectacle Lakes and the Beldora wetlands are described in the *Wetlands Atlas of the South Australian Murray Valley* (Jensen *et al*. 1996) under atlas numbers S0187 and S0186.



Map 1. Location of Spectacle Lakes and Beldora Wetlands, near Barmera, South Australia

PHYSICAL FEATURES

Geomorphology

The Spectacle Lakes-Beldora wetland complex covers a total area of approximately 1853 ha to the east of the River Murray. This includes over 288 ha of permanent or temporary wetlands.

Five wetland areas can be defined in Spectacle Lakes-Beldora (Map 2), these are:

- Permanent wetlands connected to River Murray (108 ha): at north of wetland complex
- Spectacle Lakes inlet (26 ha)
- Beldora Wetlands (17 ha): managed wetland area to west of wetland complex
- Temporary wetlands (137 ha): at higher elevations on floodplain (incl. First Lake & End Lake)

The wetland-floodplain complex is situated in an area of natural low depression adjacent to the River Murray. The Baseline Survey of the wetlands identified the geomorphology as comprising 'lentic channel forms, scroll swales, deflation basins and miscellaneous floodplain depressions' (SKM 2004, 2006).

Soils

The soils in Spectacle Lakes-Beldora have not been comprehensively mapped. However, in general the soils within the permanent and temporary wetlands are dark, heavy clays. Soils at higher elevation on the floodplain had a high sand content (H. Robertson pers. obs. 2006).

Soil logs described at groundwater bores (SKM 2006) identified the underlying geology as from the Coonambidgal and Monoman Formation. Soil types included sand, gravely sand, clayey sand, sandy clay and firm clay. Most of the clays were grey, green and/or brown clays, which are common in floodplain wetlands along the River Murray.

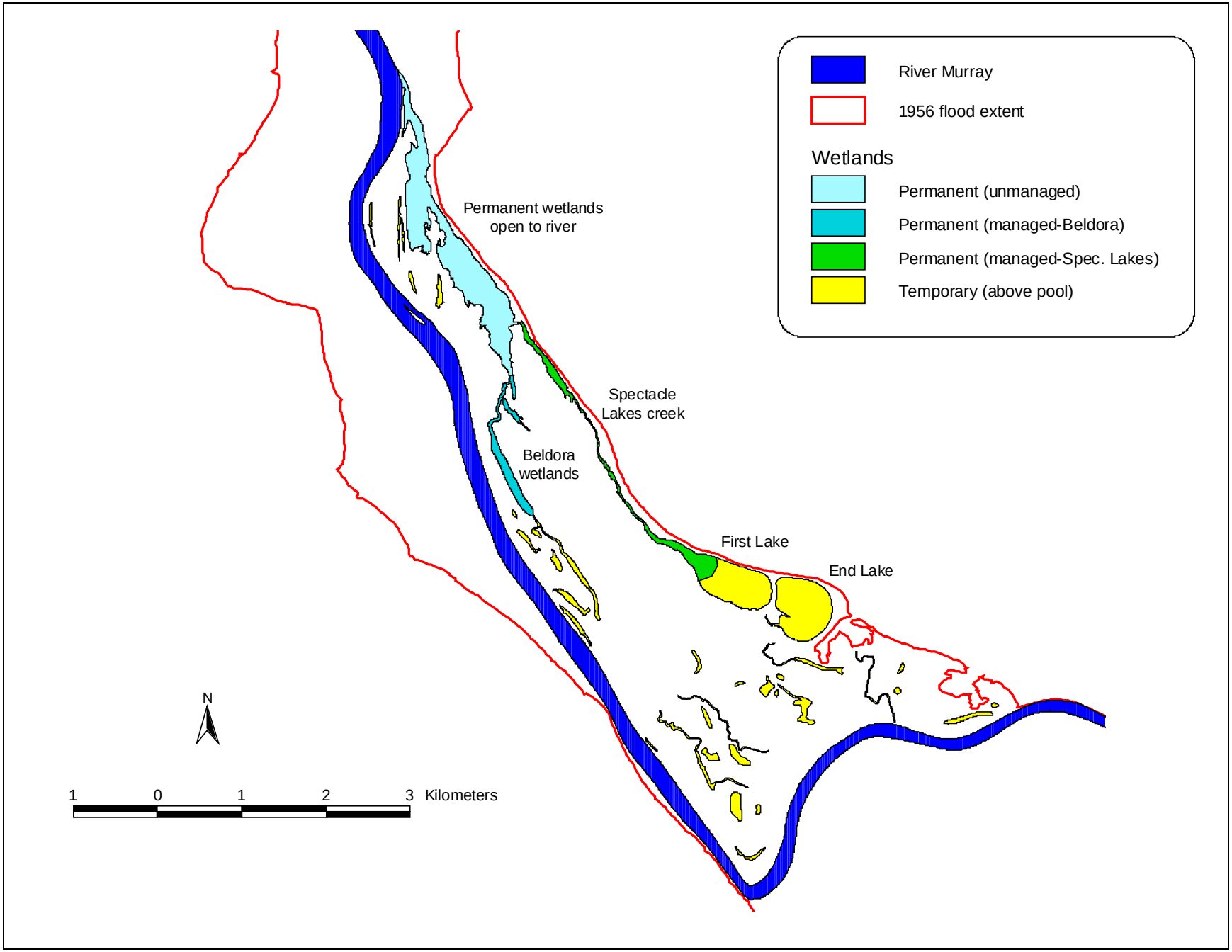
Climate

The Riverland region of South Australia experiences hot dry summers and cool winters. The climate is described as warm (persistently dry). The average maximum daily temperature for Berri is 23˚C, ranging between 31˚C in January and 15˚C in July (Table 1). The average annual rainfall is 260 mm with most falling during the winter months. Evaporation rates are highest during the warmer summer months. In no months does rainfall exceed evaporation (Bureau of Meteorology 2005).

Table 1. Monthly average temperature, rainfall and evaporation recorded at Berri.

	Month												Annual Avg.
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Temp. (max)	31.1	30.2	28.1	22.6	18.9	15.8	15.5	17.2	20.8	23.5	26.9	29.7	23.3
Temp. (min)	15.2	15.0	13.4	10.1	7.9	6.2	5.3	5.9	7.7	10.0	12.1	14.2	10.2
Rainfall (mm)	16.5	22.1	11.4	16.5	27.9	26.0	24.3	27.1	26.8	24.3	19.9	19.2	262
Evap. (mm)	324	288	260	143	97	56	52	95	134	184	271	329	2233

Source: Bureau of Meteorology (2005).



Map 2: Permanent and temporary wetlands in the Spectacle Lakes-Beldora wetland complex (incl. managed and unmanaged wetlands).

HISTORICAL & CURRENT WATER FLOWS

Wetland habitat in Spectacle Lakes-Beldora includes permanent and temporary wetlands, including:

- Spectacle Lakes (First Lake & End Lake)
- Spectacle Lakes creek (supplies water to First Lake, End Lake)
- Beldora wetlands
- Permanent wetlands connected to River Murray (at north of wetland complex)
- Temporary wetlands scattered across the floodplain (at higher elevation)

These wetlands all have different water regimes. The main source of water for the permanent wetlands is the inlet to the River Murray at the north of the wetland complex (Map 2). There are also a number of temporary inlets, which connect the wetlands to the River Murray during flood events (e.g. > 50,000 ML/day flow). The main downstream inlet to the Spectacle Lakes is a temporary channel, which begins to flow when flows in the River Murray are >40,000 ML/day.

Scope of this Wetland Management Plan

This Wetland Management Plan focuses on wetlands that can be managed using regulating structures.

Within the text, **'Spectacle Lakes'** refers to the inlet channel (First Lake and End Lake are mostly dry at pool level). '**Beldora Wetlands'** refers to the Beldora wetlands closer to the River Murray.

Historical flows

Prior to the regulation of flows in the River Murray and the construction of locks and weirs, the Spectacle Lakes and Beldora wetlands would have had an unpredictable water regime.

The volume, frequency and timing of inundation would have varied considerably depending on flows in the River Murray. Notably, prior to river regulation flows into South Australia of >52,000 ML/day occurred in >75% of years (MDBC 2005).

Spectacle Lakes-Beldora would also have been frequently dry, at times when the water level in the river dropped below the wetland (Young 2001).

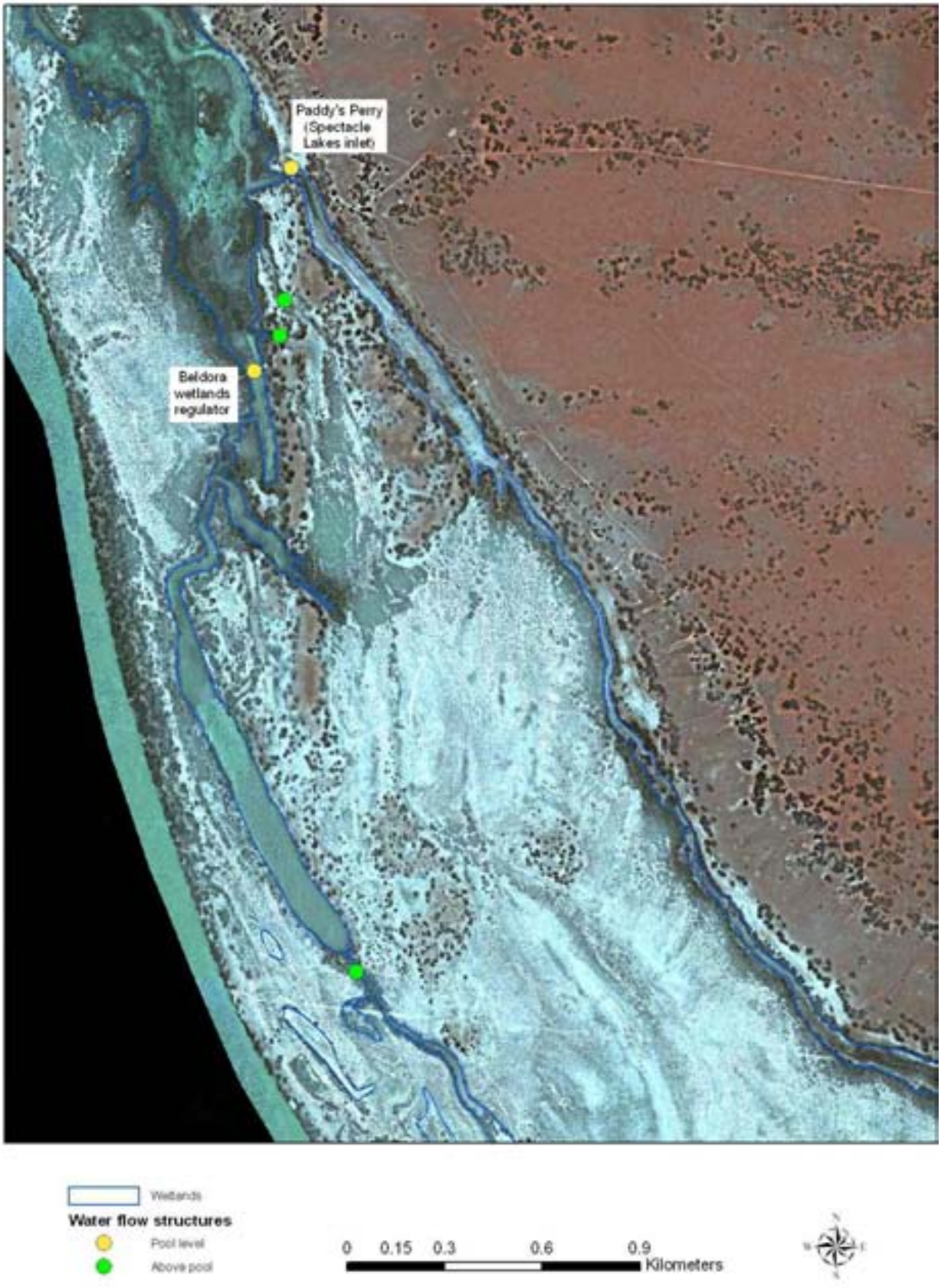
Current flows

Since river regulation and the construction of locks and weirs along the River Murray, the water regime in Spectacle Lakes-Beldora has been altered. Under current conditions flows into South Australia of >52,000 ML/d now only occur in <30% of years (MDBC 2005).

Following the construction of Lock 3 (in 1925), approximately 151 ha of the wetlands in Spectacle Lakes-Beldora were permanently connected with the River Murray at pool level (FSL 9.80 mAHD). Due to the narrowing of the river channel upstream of Lock 3, rapid changes in water levels can occur as river flows vary (M. Harper pers. comm. 2006), which affects water levels in Spectacle Lakes-Beldora.

Wetlands above pool have been predominantly dry since river regulation. In recent times (e.g. since 1993), the lack of floods has been exacerbated by drought conditions, which has resulted in the decline of floodplain habitat along the River Murray floodplain (MDBC 2003), including Spectacle Lakes-Beldora.

The last significant high river (moderate flood) occurred in the summer of 2000/2001 (Figure 1).



Map 3. Location of water flow structures in Spectacle Lakes and Beldora wetlands. Note: Above pool structures control water flow into temporary wetlands.

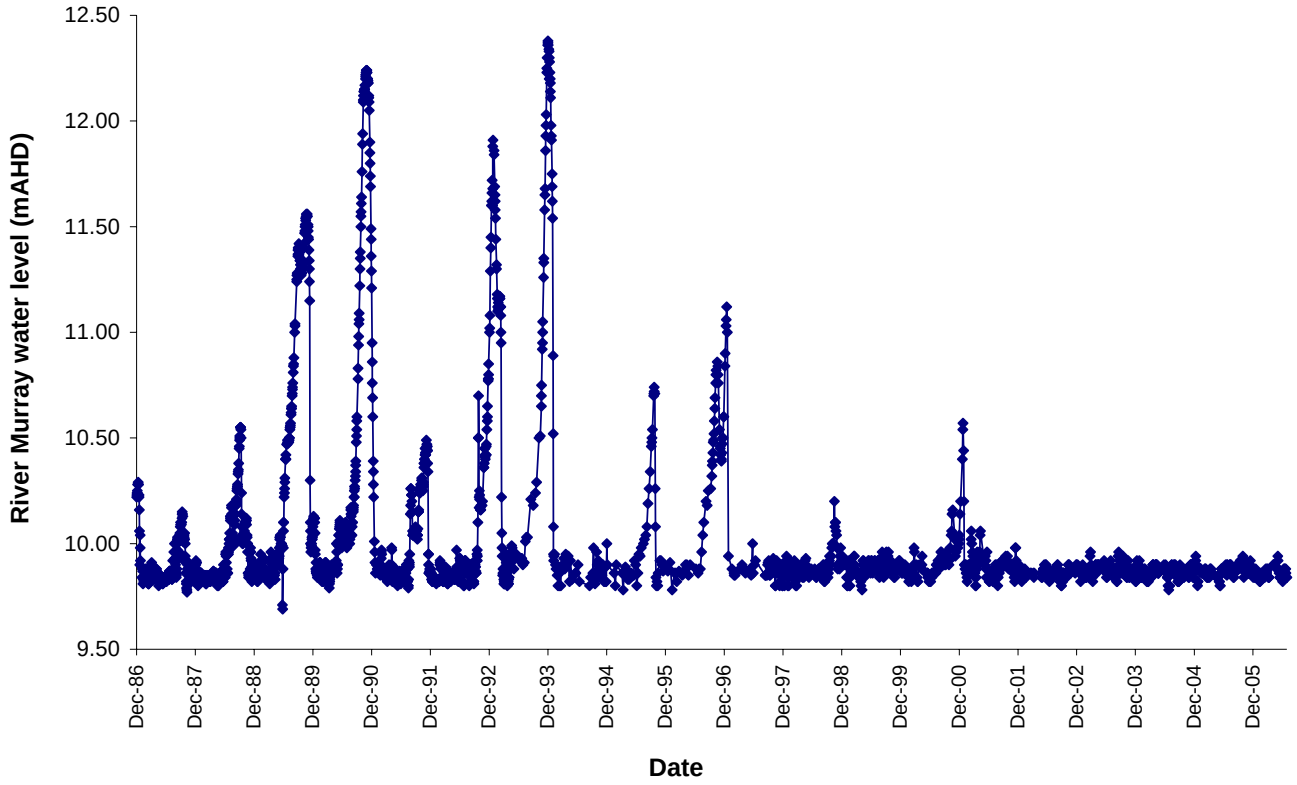


Figure 1: Water level in the River Murray (at Loveday) between 1986 and 2006 (DWLBC 2006).

During 2003, two regulating structures were installed across the inlets to the Spectacle Lakes and the Beldora wetlands (Map 3). These structures were installed to be able to reinstate wetting and drying regimes in the wetlands (see 'Water Flow Structures' for further details).

The first managed drying event occurred between 2003 and 2005. Paddy's Perry regulator was closed to dry the Spectacle Lakes. The drying event took >1 year, with the local landholders noticing a significant improvement in the wetland ecosystem (e.g. increased water clarity).

The Beldora Wetlands regulator was also closed during 2003. However, the structure was not able to completely dry the wetland due to the leakage of water through the regulator stop logs.

Currently there is limited capacity for Lock 3 weir manipulations (due to structural issues), and therefore limited capacity for weir manipulations to be used to increase water levels and area of inundation in Spectacle Lakes-Beldora.

WATER FLOW STRUCTURES

Description of water flow structures

The water level in Spectacle Lakes and Beldora Wetlands are managed by the operation of two main regulating structures (Map 3). Specifically, these structures are:

- **Spectacle Lakes regulator (Paddy's Perry)** (Figure 2): Two box culverts each 0.9 m x 1.2 m across entrance to Spectacle Lakes inlet channel.

- **Beldora Wetlands regulator** (Figure 3): Six box culverts each 0.9 m x 1.2 m across entrance to Beldora Wetlands. Structure leaks when closed, cannot be used to completely dry the wetlands.

There are three smaller structures in the Beldora wetlands, including two above pool level (Figure 4).

Figure 2. Photograph of the Spectacle Lakes regulating structure (Paddy's Perry).

Figure 3. Photograph of the Beldora Wetlands regulating structure.

Figure 4: Photographs of two of the smaller structures in the Beldora wetlands.

The location (geographic coordinates), sill level and commence to flow level for each the water flow structures is listed in Table 2.

Table 2. Geographic coordinates, sill levels and commence to flow rates (River Murray) for structures in Spectacle Lakes-Beldora.

Structure	Location (AMG Zone 54)	Structure	Sill level * (mAHD)	Commence to flow
Spectacle Lakes (Paddy's Perry)	444884 E 6200664 N	0.9 x 1.2 m box culverts (2)	9.43	Flows below pool level
Beldora Wetland (BW) Regulator	444765 E 6200066 N	0.9 x 1.2 m box culverts (6)	9.41	Flows below pool level
Eastern Inlet (BW)	444861 E 6200284 N	0.45 diameter pipe (with gate)	above pool	Unknown
Eastern Inlet No. 2 (BW)	444846 E 6200175 N	0.45 diameter pipe (with gate)	above pool	Unknown
Southern Inlet (BW)	445080 E 6198218 N	15 cm diameter pipe	above pool	Unknown (silted up?)
Downstream channel	na	Temporary inlet	above pool	> 40,000 ML/day flow

***** Normal lock/weir 3 pool level is 9.8 m AHD.

Management of existing structures

Under current conditions the Spectacle Lakes and Beldora Wetlands are managed independently from each other. The Paddy's Perry regulator controls the water levels in Spectacle Lakes, while the Beldora Wetlands regulator controls the water level in that wetland.

Ongoing fluctuation of the water levels in Spectacle Lakes and Beldora Wetlands is recommended, to increase the diversity of wetland habitat (particularly native plants), and provide habitat for native birds, fish, frogs and other fauna.

The maximum water level that can be held in Spectacle Lakes is approximately 10.6 mAHD (top of the Paddy's Perry regulator), the maximum water level that can be held in the Beldora Wetlands is 10.4 mAHD.

During flood events the water level will rise above the regulating structures.

Proposed upgrades to Beldora Wetlands regulator

The Beldora Wetlands regulator was installed during 2003. However, when the regulator was closed to dry the wetland in 2003 there was only a small drawdown in the water level, as water leaked through the regulator stop logs (D. Dalziel & E. Cottam pers. comm. 2006).

Stop logs on the Spectacle Lakes regulator also need to be replaced because of leakage. This is because some of the Red Gum logs are difficult to insert and as fittings have deteriorated.

An upgrade of the stop logs/boards on both regulators is recommended. A sluice gate type culvert or a single sheet of aluminium may work best (reduced likelihood of water leakage).

FLOOD INUNDATION MODEL

The River Murray Flood Inundation Model (Overton *et al*. 1999) presents hypothetical scenarios of where water would flow in a wetland under different river flow rates. The output from the model can assist management decisions when assessing in-coming River flows, or with manipulating water flow using flow control structures.

The following diagrams show the extent of inundation in Spectacle Lakes-Beldora (Figure 5). At 10,000 ML/day flow in the River Murray the permanent wetlands are inundated, but First Lake and End Lake (Spectacle Lakes) are dry. At 25,000 ML/day both First Lake and End Lake are inundated. Once the river flows reach 100,000 ML/day, the wetland and most of the surrounding floodplain is connected to the river channel (over bank flooding is occurring).

However, the Flood Inundation Model does not capture the inundation of all the inlets. For example, the downstream inlet to Spectacle Lakes is inundated when river flows exceed 40,000 ML/day. This limitation is due to the small size of the channels and the large scale of the computer model.

WETLAND VOLUME

Information on the surface area, maximum water depth, and volume of inundation are required to determine the environmental water requirements of the Spectacle Lakes and Beldora wetlands.

Table 3 lists the area, depth and volume of inundation for Spectacle Lakes-Beldora, based on results from the River Murray Wetlands Baseline Survey (SKM 2004, 2006).

Approximately 210 ML of water is required to fill Spectacle Lakes to normal pool level (9.80 mAHD), while approximately 155 ML is required to inundate the Beldora wetlands to pool level (Table 3).

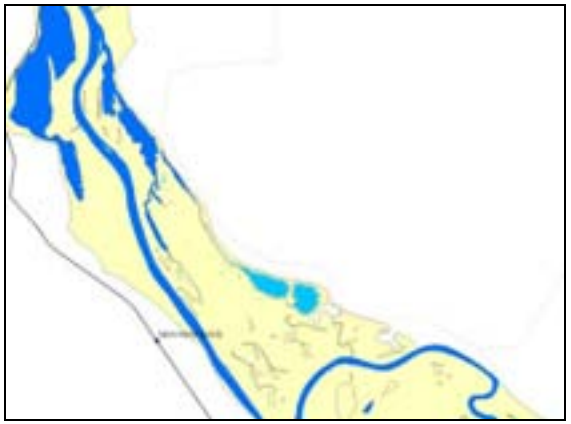
Table 3. Surface area, maximum depth and volume of inundation for different water levels.

Water Level (mAHD)	Spectacle Lakes			Beldora Wetlands		
	Area (ha)	Depth (m)	Vol. (ML)	Area (ha)	Depth (m)	Vol. (ML)
8.8	0.1	0.06	0.5	0.2	0.1	0.1
9.1	7	0.36	7	6	0.4	12
9.3	13	0.56	39	10	0.6	40
9.6	20	0.86	120	15	0.9	105
9.8	26	1.06	208	17	1.1	155

Source: Based on information in Baseline Survey (SKM 2004, 2006), although further geospatial analysis was required.

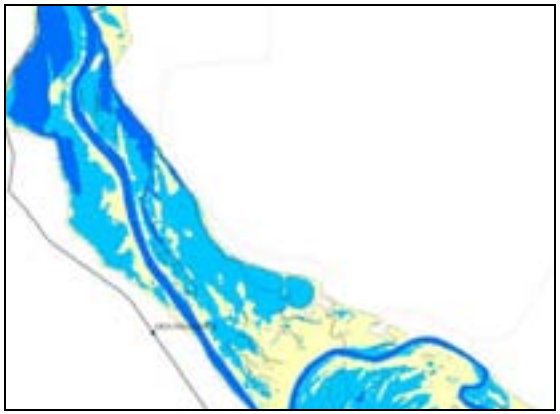
Notes:
- 'End Lake' is not included in the Spectacle Lakes calculation (since not inundated at pool level)
- River Murray normal pool level at Lock/Weir 3 is 9.8 mAHD
- Wetland bed in Spectacle Lakes approximately 8.7 mAHD; in Beldora wetlands approximately 8.7 mAHD
- Commence to flow level for Spectacle Lakes is 9.43 mAHD; for Beldora wetlands is 9.41 mAHD

10,000 ML/day flow

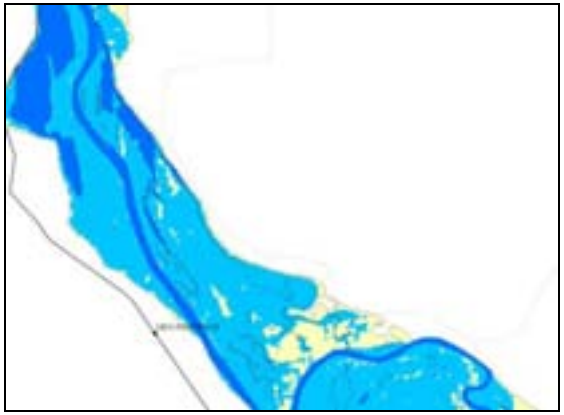


25,000 ML/day flow

50,000 ML/day flow



75,000 ML/day flow



100,000 ML/day flow

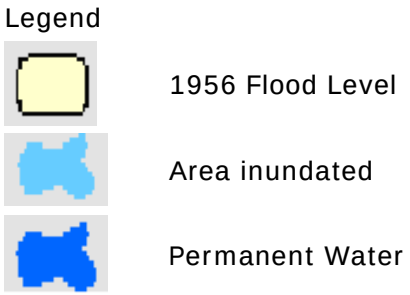


Figure 5. River Murray Flood Inundation Model for Spectacle Lakes-Beldora, showing area of wetland inundation under different flow rates.

GROUNDWATER

Groundwater effects surface water hydrology and soil and water salinity in many wetlands along the River Murray.

Changes in land use and river regulation have had a significant impact on groundwater hydrology. For example, the construction of Lock/Weir 3 and the subsequent creation of permanent weir pools have elevated regional groundwater levels, which has resulted in the salinisation of some wetlands.

Groundwater at Spectacle Lakes-Beldora was studied in River Murray Wetlands Baseline Survey (SKM 2004, 2006). Groundwater has also been monitored by the Beldora landholder group (2003-2006).

Groundwater hydrology

Detailed information on the depth to groundwater was recorded from eight piezometers during 2004, and from five piezometers during 2005 (SKM 2004, 2006). Each piezometer was monitored on four occasions during this period.

Refer to Appendix 1 for the monitoring results. Refer to Appendix 2 for the location of the piezometers.

Groundwater elevations in the 13 piezometers ranged from 7.88 mAHD to 10.46 mAHD during the two Baseline Surveys, compared to the weir pool level of 9.8-9.9 mAHD (Appendix 1). The weir pool level appears to have a significant control of groundwater levels on the floodplain, with there being a groundwater gradient from the river into the wetland (SKM 2004, 2006). There is also a groundwater flow gradient from the highland towards the floodplain (Appendix 2). Salt accumulation on the floodplain is likely to occur due the evapoconcentration of groundwater.

The depth of the groundwater below ground level (bgl) ranged from 0.57 to 4.64 m bgl (Appendix 1). Shallow groundwater levels (between 1 m and 5m bgl) create the potential for significant hydraulic interaction between surface water and groundwater (SKM 2006).

Maintaining a low level of saline groundwater input into Spectacle Lakes and Beldora wetlands is a high priority to maintain low salinity levels in the wetland, which provides excellent freshwater habitat for native flora and fauna, including wetland plants, fish and macroinvertebrates. This may require regularly inundating the wetlands to reduce the upward pressure of groundwater (Steggles and Tucker 2003). It is also important to promote natural (and possibly managed) flood events in low-lying areas of the floodplain as a mechanism to flush salt that has accumulated due to evapoconcentration.

Groundwater management

The wetland bed is less than 9.0 m AHD, while observed groundwater levels ranged between 7.88 mAHD and 10.46 mAHD. This suggests the potential for significant interactions between surface water and groundwater. During drying events it is likely that evaporation creates groundwater flow towards into low lying areas of the wetlands, which can result in deposition of salt at and near the soil surface. This process may contribute to rising salinity levels within the wetland, particularly at lower wetland levels.

It is therefore recommended to continue carefully monitor the groundwater levels (and groundwater intrusion) during drying events.

Prolonged drying events may not be suitable for the wetland due the possibility of increased soil and water salinity levels.

Groundwater salinity

Groundwater salinity was recorded from eight piezometers during the two Baseline Survey surveys (Appendix 1). Salinity levels ranged from 10,340 to 59,400 µS/cm during 2004-2005. There was some seasonal variation in groundwater salinity, which seemed related to the high river flows during this period (e.g. October 2005).

The high groundwater salinity measured across the site is probably the result of concentration of salts by evaporative discharge from the watertable (SKM 2006).

The freshest groundwater was adjacent to the Beldora wetlands, suggesting input of fresher river water (SKM 2004).

Surface water salinity in Spectacle Lakes-Beldora is moderately low (ranging from 602 µS/cm in Spectacle Lakes to a maximum of 2530 µS/cm in Beldora Wetlands). This indicates that mixing of groundwater may be occurring (particularly in Beldora Wetlands), but that input of river water is maintaining salinity levels within the range for most wetland biota.

Salinity or Electrical Conductivity (EC)?

Electrical conductivity or EC is a measurement used to *estimate* the concentration of salt (or salinity), which is frequently used in wetland monitoring in Australia.

EC is usually measured in µS/cm (micro Siemens/cm). A measurement of 5,000 µS/cm = 5,000 EC

Seawater is approximately 45,000 EC. River Murray water (at Berri) is approximately 250 EC

1000 EC is equivalent to a salt concentration (total dissolved salts) of approximately 670 mg/l

WATER QUALITY

Surface water quality was monitored on a number of occasions during the Baseline Surveys (SKM 2004, SKM 2006). Water quality has also been monitored during community monitoring between 2003 and 2006 (B. Turner pers. comm. 2006).

Table 4 lists the water quality results from the Baseline Surveys.

Table 4. Surface water quality in Spectacle Lakes-Beldora during the Baseline Survey

Water quality parameter		Spectacle Lakes*			Beldora Wetlands**			
		5/4/05	23/8/05	5/4/05	17/11/03	3/2/04	28/2/04	23/6/04
Salinity (EC) (µS/cm)	*Min.*	678	602	657	990	811	2530	2220
	Max.	761	652	744	2040	2760	2930	2280
	Mean	710 ± 19	630 ± 11	709 ± 18	1310 ± 246	1986 ± 430	2795 ± 90	2244 ± 14
Dissolved Oxygen (mg/L)	*Min.*	3.5	1.2	1.3	7.4	8.5	11.8	8.7
	Max.	5.0	7.4	5.4	16.4	10.5	13.9	9.8
	Mean	4.1 ± 0.3	4.4 ±1.3	3.3 ± 0.9	12.7 ± 1.9	9.7 ± 0.4	13.1 ± 0.5	9.1 ± 0.2
pH	*Min.*	6.8	6.4	6.5	7.5	8.2	9.8	8.0
	Max.	7.0	7.3	7.3	9.0	9.0	10.0	8.5
	Mean	6.9 ± 0.1	6.7 ± 0.2	6.9 ± 0.2	8.3 ±	8.7 ±	9.9 ±	8.3 ±
Turbidity (NTU)	*Min.*	1	5	11	46	96	50	106
	Max.	49	101	155	760	185	229	296
	Mean	16 ± 11	41 ± 21	59 ± 34	242 ± 173	141 ± 16	130 ± 37	165 ± 44
Temp. (°C)	*Min.*	14.9	9.5	17.1	14.5	21.5	24.7	13.0
	Max.	16.7	12.3	19.3	20.9	22.8	27.6	13.9
	Mean	15.7 ± 0.4	11.0 ± 0.6	18. 1 ± 0.5	17.8 ± 1.5	22.1 ± 0.2	26.1 ± 0.6	13.6 ± 0.2

Source:
* River Murray Wetlands Baseline Survey (SKM 2006)
** River Murray Wetlands Baseline Survey (SKM 2004)

Salinity (Electrical conductivity)

Surface water salinity levels ranging from 602 µS/cm to 761 µS/cm (EC) were recorded in Spectacle Lakes during the Baseline Survey. Salinity in the Beldora Wetlands ranged from 811 µS/cm to 2930µS/cm.

Salinity levels in Spectacle Lakes are relatively low, and within the trigger levels set by ANZECC (2000) for water quality in South Central Australia wetlands (300-1,000 µS/cm). The salinity levels in Beldora wetlands are greater than in Spectacle Lakes (often greater than 2000 µS/cm). This may be due to the groundwater gradient from the River Murray towards the wetland (input of moderately saline groundwater) (SKM 2004).

Lack of flushing flows through the wetland, combined with potential input saline groundwater has led to salt accumulation on some parts of the floodplain (H. Robertson pers. obs. 2006).

Salinity management

Salinity is a key factor in deciding how to manage the water regime in Spectacle Lakes-Beldora.

Higher salinity levels occur when the water level is decreasing and salts accumulate through evaporation. Lower salinity levels occur when the water level is increasing and salts are diluted. When the wetland is drying, there is also a reduction in hydrological pressure, and a greater potential for saline groundwater seepage to affect the system (Steggles and Tucker 2003).

Notably, the salinity in Spectacle Lakes did not show an increase following the drying event between 2003 and 2005. This supports the future aim of management to implement wetting and drying cycles in Spectacles Lakes. Implementation of wetting and drying cycles in Beldora Wetlands will need to be more carefully monitored, because of the higher salinity levels in that system.

Potential salinity impacts to the River Murray resulting from wetland management also need to be considered (refer 'Flood Events'). However, salinity impacts to the River Murray had not been assessed at Spectacle Lakes-Beldora due to no suitable method being in existence (as of June 2006).

Dissolved oxygen

Dissolved oxygen concentrations ranging from 1.2 to 7.4 mg/L were recorded in Spectacle Lakes during the Baseline Survey (Table 4). Oxygen levels in Beldora Wetlands ranged from 7.4 to 16.4 mg/L.

Low levels of oxygen (e.g. <3 mg/L) can be harmful or kill aquatic organisms, including freshwater fish. The low oxygen levels in Spectacle Lakes (<4 mg/l) may be due to the abundance of decomposing organic matter following a drying event and because measurements were taken in the early morning. Low dissolved oxygen is unlikely to be a critical water quality issue in the long-term (SKM 2006).

It is recommended to include dissolved oxygen as a parameter in future water quality monitoring, particularly following the re-wetting of the wetland (SKM 2006).

pH

Moderate to high alkaline pH levels ranging from 6.4 to 10.0 were recorded across Spectacle Lakes and the Beldora Wetlands during the Baseline Survey. However, pH was generally within trigger levels defined by ANZECC (2000) for lowland rivers in south central Australia (maximum pH 9).

The high (basic) pH levels may have resulted from the buffering capacity of limestone in the sediments, or alternatively, due to the primary productivity (photosynthesis and removal of carbon dioxide) of the aquatic plants in the wetlands (SKM 2006).

Turbidity

Turbidity is an estimate of the 'cloudiness' or 'muddiness' of the water, with higher turbidity levels relating to more 'turbid' water. High levels of turbidity can suppress the growth of aquatic plants by limiting penetration of underwater light. High levels of suspended solids (a factor causing turbidity) can also impact on algae, biofilms and on aquatic fauna.

Turbidity levels ranged from 1 NTU to 155 NTU (Spectacle Lakes) and from 46 NTU to 760 NTU (Beldora Wetlands) during the Baseline Survey (Table 4). The maximum turbidity levels exceeded the trigger levels set by ANZECC (2000) for wetlands in south central Australia (1-100 NTU).

Low turbidity levels in the Spectacle Lakes may have resulted from the consolidation of the wetland soils during the drying event (SKM 2006). The high abundance of aquatic plants may also have stabilised the sediment (H. Robertson pers. obs. 2006). In the Beldora Wetlands, the shallow water

level (SKM 2004) and lack of aquatic plants may have elevated the turbidity levels, due to the impact of wind on resuspending sediments in the water column.

Reduction in Carp numbers is also likely to have improved turbidity levels in Spectacle Lakes (following the drying event). Carp disturb wetland soils and remove aquatic vegetation, leading to increased turbidity. Plans to dry Beldora Wetlands may show similar results to Spectacle Lakes in future.

Nutrients

The concentration of nutrients in the surface water was measured in Spectacle Lakes during the 2005 Baseline Survey (SKM 2006). Table 5 provides a summary of the water samples analyses.

Table 5. Surface water nutrient levels in Spectacle Lakes during the 2005 Baseline Survey.

Parameter		Spectacle Lakes**			
		5/4/05	23/8/05	18/10/05	**Overall mean**
Nitrate/ Nitrite (NOx) (µgN/L)	*Min.*	7	8	15	**7**
	Max.	8	36	21	**36**
	Mean	8 ±1	22 ± 14	18 ± 3	**16 ± 5**
Total Nitrogen (µgN/L)	*Min.*	990	950	950	**950**
	Max.	1790	1000	985	**1790**
	Mean	1390 ± 400	975 ± 25	968 ± 18	**1111 ± 136**
Filterable Reactive Phosphorus (µgP/L)	*Min.*	10	7	6	**6**
	Max.	33	7	18	**33**
	Mean	22 ±12	7 ± 0	12 ± 6	**14 ± 4**
Total Phosphorus (µgP/L)	*Min.*	78	86	67	**67**
	Max.	155	100	100	**155**
	Mean	117 ± 39	93 ± 7	84 ± 17	**98 ± 13**
Dissolved Organic Carbon (mgC/L)	*Min.*		5.0	5.0	**5.0**
	Max.	na	7.8	12.0	**12.0**
	Mean		6.4 ± 1.4	8.5 ± 3.5	**7.4 ± 1.7**

Source:
** River Murray Wetlands Baseline Survey (SKM 2006)

The concentration of nutrients in Spectacle Lakes-Beldora may also be affected by the history of cattle grazing on the floodplain. High levels of nutrients (e.g. nitrogen, phosphorus) can affect water quality and alter the wetland ecosystem (e.g. lead to algal blooms).

Total Nitrogen and Nitrate/Nitrite concentrations in the surface water during the Baseline Survey (SKM 2006) were at or below the trigger levels for lowland rivers, and freshwater lakes and reservoirs in south central Australia (ANZECC 2000).

Total Phosphorus and most FRP (Filterable Reactive Phosphorus) concentrations were also below the trigger levels for south central Australia (ANZECC 2000). Total Phosphorus levels did exceed the trigger levels for the region, but these readings are not unusual in productive wetlands. These phosphorus readings were not considered a management concern (SKM 2006).

Interestingly, the lowest Nitrogen levels were recorded near Paddy's Perry, while the highest levels of Nitrogen and FRP were recorded in First Lake (SKM 2006). See the Baseline Survey report (SKM 2006) for further discussion of nutrient levels and other water quality parameters.

ECOLOGICAL FEATURES

The ecological features of Spectacle Lakes-Beldora were recorded as part of the Baseline Survey (SKM 2004, 2006). This included information on the vegetation, fish, birds, frogs and macroinvertebrates.

Vegetation

Vegetation mapping

A large number of different vegetation communities (>15) were identified in Spectacle Lakes and Beldora Wetlands during the Baseline Survey, these include:

- River Red Gum (*Eucalyptus camaldulensis*) open forest
- River Red Gum woodland (regenerating)
- River Red Gum) / Black Box (*Eucalyptus largiflorens*) woodland
- Black Box woodland
- Black Box open forest
- Samphire (*Halosarcia* sp.) shrubland
- Lignum (*Muehlenbeckia florulenta*) shrubland
- Sea-heath (*Frankenia* sp.) shrubland
- Couch (*Sporobolus* sp.) grassland
- Beardgrass (*Polypogon monspiliensis*) grassland
- Water Primrose (*Ludwiga peploides*) herbland
- Ribbonweed (*Vallisneria spiralis*) submerged herbland
- Cumbungi (*Typha* sp.) sedgeland
- Spiny Sedge (*Cyperus gymnocaulos*) sedgeland
- Club-rush (*Schoenoplectus* sp.) sedgeland

A number of smaller-scale vegetation associations were also identified during the Baseline Survey. Refer to Appendix 3 for a map of the vegetation communities in Spectacle Lakes-Beldora.

Detailed plant surveys were also undertaken during the Baseline Survey. Refer to Appendix 4 for a list of the plant species recorded in the surveys.

Figure 6 provides photographs of some of the vegetation communities in Spectacle Lakes-Beldora.

Description of vegetation communities

Floodplain vegetation at Spectacle Lakes-Beldora is dominated by tree and shrub species including Black Box (*Eucalyptus largiflorens*), River Red Gum (*Eucalyptus camaldulensis*), Lignum (*Muehlenbeckia florulenta*), Samphire (*Halosarcia* spp.) and Saltbush (*Atriplex* spp.). The dominance of Samphire on some areas of the floodplain suggests high soil salinity in these areas (Cunningham *et al*. 1992).

The condition of River Red Gums adjacent to the Spectacle Lakes inlet and around First Lake was generally good to excellent, but only a few River Red Gums were growing around the End Lake (SKM 2006). River Red Gums on the floodplain between the river and Spectacle Lakes ranged from poor to excellent condition (SKM 2004).

The condition of Black Box adjacent to the Spectacle Lakes inlet and First Lake ranged from good to excellent (SKM 2006). Black Box on the floodplain between the river and Spectacle Lakes ranged from moderate to excellent condition (SKM 2004).

It is recommended to investigate options to pump water into temporary wetlands and onto the floodplain to maintain the condition of trees away from the permanent wetlands.

Wetland habitat dominated by Azolla (*Azolla* sp), Cumbungi (*Typha* sp.) and River Red Gum (*E. camaldulensis*) along Spectacle Lakes creek.

Wetland habitat dominated by Water milfoil (*Myriophyllum* sp.), Water Primrose (*Ludwiga peploides* ssp. *montevidensis*), rushes (*Juncus* sp.) and River Red Gum (*E. camaldulensis*).

River Red Gum (*E. camaldulensis*) thicket along Spectacle Lakes creek (near First Lake).

Nardoo (*Marsilea* sp.) in shallow water.

Figure 6. Photographs of vegetation communities in Spectacle Lakes-Beldora.

Wetland vegetation is very diverse in Spectacle Lakes-Beldora. A number of emergent, floating and submerged aquatic plants occur in the wetlands including: Ribbonweed (*Vallisneria spiralis*), Water Primrose (*Ludwiga peploides*), Cumbungi (*Typha* sp.), Rush (*Juncus usitatus*), Common Spike-sedge (*Eleocharis acuta*), River Club-rush (*Schoenoplectus validus*), Nitella (*Nitella* sp.), Water milfoil (*Myriophyllum* sp.), Nardoo (*Marsilea* sp.) and other wetland plants.

A large number of River Red Gum trees have regenerated at the end of the Spectacle Lakes inlet near First Lake. This area has had grazing removed. Following the manipulation of the water level (drying event) and the removal of grazing a dense stand (thicket) of River Red Gums has established (D. Dalziel and E. Cottam pers. comm. 2006; SKM 2006). While the increase in River Red Gum recruits is evidence of the positive effect of water level manipulation the thicket may exclude the regeneration of other native plants. River Red Gums also germinated in grazed area following the drying event and many seedlings are still present.

The grazed area supported a larger number of native species than the ungrazed area, and in the ungrazed region the introduced grass *Polypogon monspiliensis* is dominant (SKM 2006). While the removal of grazing may reduce pugging and increase the recruitment of River Red Gum, this may also allow introduced plant species to increase in abundance. However, further assessment is required.

The Baseline Survey noted that Spectacle Lakes-Beldora would be an excellent site for a grazing trial, to see the effect grazing has on control of weed species (SKM 2006).

While the lack of flood events is likely to have reduced the extent of wetland vegetation, Spectacle Lakes-Beldora still supports a very diverse wetland plant community. Increased environmental flows to the temporary wetland areas should promote the establishment of more native wetland plants.

High abundance of Cumbungi (*Typha* sp.), particularly around edge of the Beldora Wetlands, may reduce the diversity of native wetland plants in the future. The extent of Cumbungi following future wetting and drying events should be monitored. The abundance of Cumbungi in the inlet to Spectacle Lakes (near Paddy's Perry) also needs to be monitored, as high abundance may restrict the flow of water and fish passage.

Three species of conservation significance have been recorded in Spectacle Lakes-Beldora: *Sclerolaena stelligera* and *Myriophyllum simulans* (both 'uncertain' conservation status in South Australia), and *Myriophyllum papillosum* ('rare' in South Australia) (SKM 2004).

Introduced pest plants also occur in Spectacle Lakes-Beldora, which may need to be controlled. Some of the introduced plants observed include: African Boxthorn (*Lycium ferocissimum*), Canary Grass (*Phalaris minor*), Annual Beardgrass (*Polypogon monspiliensis*), Noogoora Burr (*Xanthium occidentale*) and Common Sow-thistle (*Sonchus oleraceus*). Many of these introduced species are classified as terrestrial plants and would not tolerate inundation if a flood event occurred.

Since 1995, the Beldora and Spectacle Lakes landholders have undertaken pest plant control, including spraying and physical removal of weeds (e.g. African Boxthorn). The Beldora landholders group is committed to maintain complete eradication of Boxthorn from the site (pers. comm. 2006).

Vegetation management

Maintaining the diversity of plant species and wetland habitats is important for future wetland management at Spectacle Lakes-Beldora.

Management of the regulation structures enables the water levels to be manipulated, and promote the growth and regeneration of emergent, submerged and floating aquatic plants.

The current hydrological regime (wetting and drying) appears appropriate because there are a large number of native wetland plants in high abundance (SKM 2006). Grazing appears to be increasing the diversity of wetland plants in some regions, and limiting the abundance of pest plants. Maintaining high clarity (low turbidity) of the water column, as occurred following the previous drying event is important for the conservation of wetland plants in the ecosystem.

Ongoing monitoring of vegetation condition, including tree health is important to observe the response of wetland vegetation to different wetting and drying regimes.

Fauna

Refer to Appendix 6 for a list of fauna species recorded in Spectacle Lakes-Beldora.

Birds

More than 130 native bird species have been recorded in Spectacle Lakes-Beldora from the Baseline Survey and from other surveys (D & B Dalziel pers. comm. 2006), including a number of significant species (Appendix 6).

Bird surveys were conducted at four sites during the 2003/2004 Baseline Survey (SKM 2004) and at four sites during 2005 (SKM 2006). These sites included a range of different habitat types in and adjacent to the wetlands.

A total of 25 species of waterbirds (268 individuals) were observed in Beldora Wetlands during the 2003/04 survey. Grey Teal and Australian Pelican were the most abundant. Species that were observed foraging in the wetlands included: Red-kneed Dotteral, Australian White Ibis, Yellow-billed Spoonbill, Caspian Tern, Grey Teal, Australian Pelican, Purple Swamphen, Black-fronted Dotteral, Dusky Moorhen, White-faced Heron and Great Egret (SKM 2004).

A total of 25 species of waterbirds (332 individuals) were observed in Spectacle Lakes during the 2005 survey. Black-winged Stilt, Grey Teal and Eurasian Coot were the most abundant.
Regent Parrot has also been recorded in Spectacle Lakes-Beldora, which is a listed as 'vulnerable' in both South Australia and nationally. A Recovery Plan for Regent Parrot is currently being implemented in the Riverland, South Australia (Schultz 2005).

The Beldora landholders have also observed Freckled Duck, Musk Duck and Peregrine Falcon, which are listed as rare or vulnerable in South Australia (D. Dalziel pers. comm. 2006).

A number of migratory bird species have also been observed, which are listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Appendix 6).

Bird management

The diversity of habitats needs to be maintained to ensure the wetland bird species diversity does not decline. This includes maintaining areas of open water and areas dominated by wetland plants.

Ongoing manipulation of the water levels in Spectacle Lakes-Beldora is considered important for wetland bird conservation. Fluctuation of the water levels aims to increase the diversity and abundance of wetland plants, providing habitat and food resources for ducks, rails, egrets, spoonbills, grebes, cormorants, ibis, and other wetland birds.

It is recommended not to dry both Spectacle Lakes and the Beldora Wetlands at the same time. Keeping one part of the wetland complex inundated provides a refuge for the waterbirds.

Future bird surveys will be conducted during autumn and spring months to record signs of breeding and important bird refuges.

Fish

Fish surveys were undertaken during the Baseline Survey on two occasions during 2003/2004 (SKM 2004) and on two occasions during 2005 (SKM 2006). A variety of gear types was used including: bait traps, fyke nets, seine nets, gill nets and electro-fishing.

A total of nine species (6 native and 3 introduced) and 9901 individuals were collected from the Beldora Wetlands during the 2003/04 survey (SKM 2004). Native Carp Gudgeon were the most abundant (8719 individuals) followed by Gambusia (1033) and Carp (38). A total of seven species (4 native and 3 introduced) and 887 individuals were collected from the Spectacle Lakes (inlet and First Lake) during the 2005 survey (SKM 2006).

A fish survey was also undertaken in winter 2006. The most abundant species recorded were Carp Gudgeon, Bony Bream, Australian Smelt and Gambusia (B. Turner pers. comm. 2006).

While Spectacle Lakes-Beldora has a diverse assemblage of native fish, no species of conservation significance were recorded during the surveys.

The presence of adult and juvenile carp suggests that they may be recruiting in the wetland. Notably, during the 2003-2005 drying event approximately 350 dead Carp were observed on the wetland bed. Future drying events and/or carp separation cages may be used to control carp numbers.

Fish management

Spectacle Lakes-Beldora provides excellent habitat for small-bodied native fishes and has good water quality (SKM 2006). The diversity of wetland plants and habitats, including areas of open water support at least 6 species of native freshwater fish.

Drying Spectacle Lakes and the Beldora Wetlands is recommended every few years to reduce the abundance of adult Carp in the wetlands. It is not recommended to dry Spectacle Lakes and Beldora Wetlands at the same time, as the wetlands are likely to provide important refuges for native fish.

Ongoing monitoring is important, to identify the fish populations using different parts of the wetlands and to investigate whether the regulating structures inhibit fish passage. It has been identified that the carp screens, stop logs and closed-top box culvert may deter fish passage for some species (SKM 2006). It was also suggested that this wetland could be considered for trialling carp separation cages.

Frogs

Frogs surveys were undertaken as on four occasions during 2003/2004 (SKM 2004) and on five occasions during 2005 (SKM 2006).

Seven frog species were recorded during the 2003/04 survey, these included: Eastern Sign-bearing Froglet, Spotted Grass Frog, Common Eastern Froglet, Peron's Tree Frog, Sudell's Frog, Long-thumbed Frog and the Southern Bell Frog.

Six frog species were recorded during the 2005 survey, with the Eastern Banjo Frog being the only species not previously recorded. The most common species during these surveys was the Eastern Sign-bearing Froglet.

The Southern Bell Frog is listed as vulnerable both in South Australia and nationally (under the EPBC Act). Southern Bell Frog is usually found in permanent lagoons, particularly those with emergent vegetation (Robinson 1995). A Recovery Plan for Southern Bell Frog is currently being implemented along the River Murray in South Australia (Schultz 2005).

Frog management

Overall, the diversity of frog species at Spectacle Lakes-Beldora was high relative to other wetlands in the region. This may be due to the diversity of fringing wetland vegetation and good water quality (SKM 2004, 2006)

The filling event in 2005 had a positive effect on the number of frogs calling in Spectacle Lakes, and this type of management should be repeated in the future (SKM 2006).

Future surveys will help to determine the importance of different habitats within the wetland as refuges for frogs, and to monitor the impact of the wetland management on frog populations.

Macroinvertebrates

Macroinvertebrates samples were taken on two occasions during 2003/2004 (SKM 2004) and on two occasions during 2005 (SKM 2006) in Spectacle Lakes-Beldora.

A total of 44 taxa (>14,000 individuals) were collected from the Beldora Wetlands during the 2003/04 survey. Insects were the most dominant group (85% of individuals), followed by the segmented worms (Oligochaetes). The most abundant taxa were the Corixidae (true bugs), Ceratopogonidae (biting midges) and Chironominae (non-biting midges).

A total of 47 taxa (>6,000 individuals) were collected from the Spectacle Lakes during the 2005 survey. Insects were again the most dominant group (80% of individuals), with the most abundant insect taxa being the Chironomidae (non-biting midges). The number of taxa in recorded was considered higher than most other wetlands in this region (SKM 2006).

Macroinvertebrate management

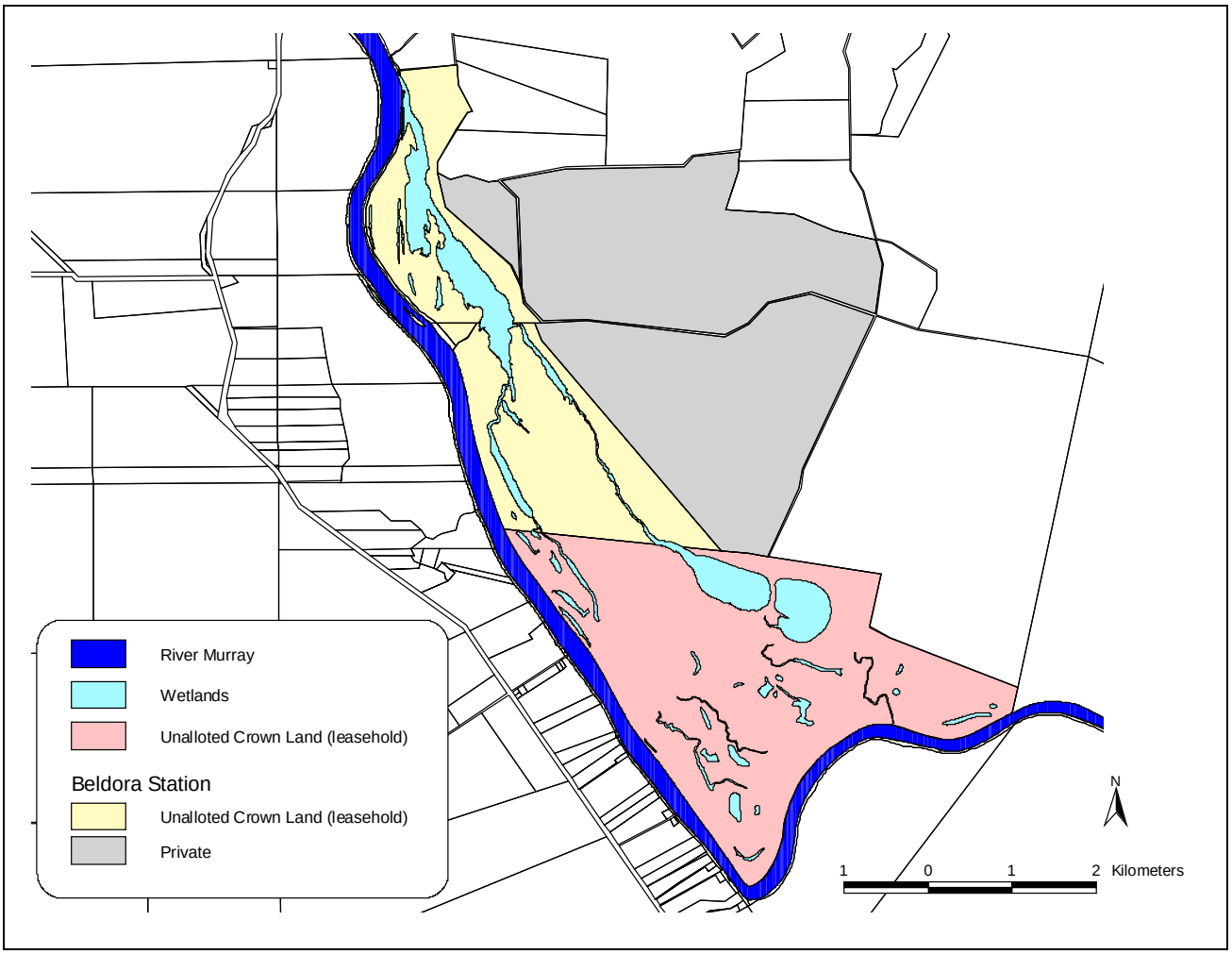
Overall, the wetlands contain a very high diversity of macroinvertebrate taxa, which can probably be attributed to the diverse in-stream habitat of aquatic plants and woody debris (SKM 2004, SKM 2006).

It is recommended to undertake macroinvertebrate surveys in Spectacle Lakes and the Beldora wetlands after future filling events, to see how macroinvertebrates responds to wetland management.

LAND TENURE, JURISDICTION AND MANAGEMENT ARRANGEMENTS

Land tenure

Spectacle Lakes-Beldora occurs on both private land and Crown land. The Crown land areas are currently administered as annual leasehold land, which is leased to two different landholders (Map 4).



Map 4. Land tenure at Spectacle Lakes-Beldora

Jurisdiction authority and management arrangements

Department of Environment and Heritage (under Minister for Environment and Conservation) have overall jurisdictional authority for Crown land in the Spectacle Lakes and Beldora Wetlands. Therefore, all significant management decisions need to be made in consultation with DEH.

The two annual leaseholders as occupants of the land also have management responsibility. The primary management activity on the leasehold land is wetland conservation, with some cattle grazing.

Wetland management at Spectacle Lakes-Beldora is undertaken by the Beldora Station landholders with assistance from the SA Murray-Darling Basin NRM Board and the Berri Barmera LAP.

THREATS TO THE WETLAND

Identifying threats to the wetland is an important component in informing wetland managers of problems and ensuring management actions themselves do not pose a threat to wetland rehabilitation.

A number of threatening processes to the values of the Spectacle Lakes and the Beldora wetlands have been identified. These include **biological threats** such as weed infestations, **physical threats** such as salinisation of the wetland, and **management-related threats**.

Some of the major threats to the values of Spectacle Lakes-Beldora include increased surface water salinity leading to the decline in native flora and fauna, and high abundance of pest animals and pest plants.

Table 6 lists the specific threats to Spectacle Lakes-Beldora, identifies their cause and potential impact, and describes some of the steps that have been taken or are to be taken to minimise their impact.

High abundance of Cumbungi (*Typha* sp.), Beldora wetlands (2004).

Stressed River Red Gum (*Eucalyptus camaldulensis*) (2004).

Table 6. Physical, biological and management-related threats to the values of the Spectacle Lakes and the Beldora wetlands.

THREATS			CAUSE	IMPACT	RESPONSE TO REDUCE THREAT
Physical	Actual	**Altered water regime**	▪ Construction of locks and weirs along the River Murray. ▪ Reduced frequency and duration of flood events.	▪ Wetlands permanently inundated for most of the past 70 years due to the high water level (pool level) maintained in the River Murray. ▪ Altered water regime, including lack of flood events, has resulted in the decline of native flora and fauna communities, and contributed to the accumulation of salt on the floodplain.	▪ Develop and implement a wetland operational plan (wetting and drying regime) to mimic the 'natural' water regime that would have occurred in the past, which also aims to limit the impact of high salinity in the wetland. ▪ Investigate options to increase frequency of flood events in Spectacle Lakes-Beldora (e.g. weir manipulations, water pumping).
	Potential	**Decline in surface water quality (and soils) due to increased salinity**	▪ Elevated groundwater table under Spectacle Lakes-Beldora due to changed land uses in the region. ▪ Reduced frequency and duration of flood events.	▪ Increased surface water salinity levels in the wetlands. ▪ Increased accumulation of salts on the floodplain (soils, salt crusts). ▪ Reduced diversity of native wetland flora and fauna due to high salt levels.	▪ Develop and implement a wetland operational plan (wetting and drying regime) to mimic the 'natural' water regime that would have occurred in the past, which also aims to limit the impact of high salinity in the wetland. ▪ Investigate options to increase frequency of flood events in Spectacle Lakes-Beldora (e.g. weir manipulations, water pumping).
Biological	Actual	**Increased abundance of pest plants**	▪ Establishment of introduced weed species and other pest plants on the floodplain and in the wetlands.	▪ A number of introduced pest plants including African Boxthorn (*Lycium ferocissimum*), Noogoora Burr (*Xanthium occidentale*) and Lippia (*Phyla canescens*) have been observed in Spectacle Lakes-Beldora. Further invasion of these species and other introduced pest plants impacts on native vegetation. ▪ Lack of variation in water levels allows Cumbungi (*Typha* spp.) and Common Reed (*Phragmites australis*) to dominate some areas of the wetland and restricts the establishment of other native wetland plants.	▪ Control the abundance of African Boxthorn and other pest plants by physical removal and other control options. ▪ Monitor the spread of Common Reed and Cumbungi in Spectacle Lakes-Beldora. If required, investigate options to reduce abundance (e.g. dredging, cutting).
	Actual	**Increased abundance of pest animals**	▪ Invasion and establishment of aquatic and terrestrial pest animals.	▪ High rabbit abundance impacts on native vegetation, particularly on the recruitment of native trees, grasses and herbs on the floodplain. ▪ High abundance of Carp (*Cyprinus carpio*) can impact on water quality and the regeneration of wetland plants.	▪ Monitor rabbit abundance in Spectacle Lakes-Beldora. ▪ Undertake drying events every few years to reduce the abundance of adult Carp in the wetlands.
	Potential	**Establishment of thickets of River Red Gum**	▪ Removal of cattle grazing from the wetland.	▪ Following the removal of cattle from the southern end of Spectacle Lakes a thicket of River Red Gum regenerated. This is considered to be a threat to the regeneration and growth of other native wetland plants.	▪ Manage sustainable cattle stocking rates in the wetlands. ▪ Need to investigate the impact of grazing, and removal of grazing on the diversity, growth and regeneration of River Red Gum and other wetland plants.
Management	Potential	**Decline in condition of habitat caused by vehicles, and other recreation related activities**	▪ Spectacle Lakes-Beldora is currently managed as annual leasehold property, and is not currently accessible to public. If public were able to access the floodplain, excessive vehicle use, and other activities may threaten the ecosystem.	▪ Excessive vehicle use leads to degradation of native vegetation, contributes to soil erosion, and prevents regeneration of plants.	▪ Continue to manage Spectacle Lakes-Beldora as annual leasehold land. ▪ Rationalise the network of tracks (e.g. block superfluous tracks and revegetate with floodplain species).
	Potential	**Lack of continued community involvement in management of Spectacle Lakes-Beldora.**	▪ Lack of a community involvement in the management and monitoring of the Spectacle Lakes and Beldora wetlands.	▪ No community ownership of wetland management at Spectacle Lakes-Beldora. ▪ Reduced monitoring of the response of Spectacle Lakes-Beldora to management.	▪ Maintain the Spectacle Lakes-Beldora wetland group, which has capacity to undertake wetland management and wetland monitoring. ▪ Undertake capacity building activities to support the long-term management of Spectacle Lakes-Beldora by local community.

MANAGEMENT OBJECTIVES

The management objectives for Spectacle Lakes-Beldora were previously listed on page 7. These objectives have been developed through consultation with the Beldora landholder group, Department of Environment and Heritage, and other stakeholders and summarised below:

- Manipulate water levels to provide habitat for native fauna, and to promote the regeneration of wetland and floodplain vegetation.
- Extend the duration of flood events in Spectacle Lakes and the Beldora wetlands (particularly in 'First Lake') by manipulating regulating structures after periods of high flows.
- Maintain low surface water salinity levels by monitoring the input of saline groundwater, and investigating options to flush the wetland.
- Control cattle access to the wetlands and cattle stocking rates.
- Control abundance of noxious weeds and other pest plants.
- Control abundance of pest animals, particularly introduced species of fish.
- Maintain community group with the capacity to undertake wetland management and monitoring.
- Formalise management arrangements with key stakeholders.

Table 7 lists the specific management objectives for Spectacle Lakes-Beldora, and describes the management actions, resources and management priority to address these objectives. Table 7 also outlines a timetable for implementing the management actions in Spectacle Lakes-Beldora.

The objectives will be reviewed and updated in June 2010 (or as required).

Future management objectives for Spectacle Lakes-Beldora will be guided by an adaptive management approach ('learning by doing'). The ongoing monitoring program will also provide results to inform future management decisions.

Table 7. Management objectives for Spectacle Lakes-Beldora, including specific management aims, management actions and priorities.

MANAGEMENT OBJECTIVES	SPECIFIC MANAGEMENT AIMS	ACTIONS / ACTIVITIES	RESOURCES	TIMETABLE	PRIORITY
Manipulate the water levels in Spectacle Lakes and the Beldora wetlands to provide habitat for native fauna, and to promote the regeneration of wetland and floodplain vegetation.	▪ Implement a drying event (duration >1 year) in Spectacle Lakes between July 2006 and July 2010. ▪ Implement two drawdown events (duration >1/2 year) in Beldora Wetland between July 2006 and July 2010. ▪ Maintain the abundance and diversity of wetland birds. Including at least 500 individual wetland birds during the wetting cycle, and 2 threatened species. ▪ Maintain populations of at least 5 species of frog, with an aim of increasing the abundance of frogs. ▪ Maintain populations of at least 3 species of native fish, with an aim of increasing the abundance of fish. ▪ Observe no decline in tree health of River Red Gum and Black Box and River Cooba over the next 5 years. ▪ Maintain the diversity and extent of wetland plants in Spectacle Lakes and Beldora Wetlands.	▪ Implement Wetland Operational Plan. ▪ Investigate options to increase frequency of flood events in Spectacle Lakes-Beldora (weir manipulations, pumping). ▪ Replace the stop logs in the regulating structures to reduce the leakage of water during drying events. ▪ Monitor the abundance of native fauna at different times of the year in response to wetland management. ▪ Monitor the change in wetland and floodplain vegetation in response to wetland management.	▪ Require a valid water licence to receive a River Murray water allocation. ▪ Technical expertise to support monitoring program.	▪ See Wetland Operational Plan and Monitoring Program for further details. ▪ Replace stop logs by December 2006.	**HIGH**
Extend the duration of flood events in Spectacle Lakes and the Beldora wetlands (particularly in 'First Lake') by manipulating regulating structures after periods of high flows.	▪ Close Paddy's Perry regulator after flood peak has passed to extend duration of inundation in temporary wetlands, particularly to extend inundation in First Lake. ▪ Investigate options to reduce barriers to flow between First Lake and End Lake by June 2007.	▪ Monitor the change in water levels at the regulating structures and extent of inundation in First Lake and temporary wetlands. ▪ Close structures to increase flood duration in consultation of Wetland Officers. ▪ Seek funding to survey the presence of barriers to flow between First Lake and End Lake. Minor earthworks may be required if barriers to flow are identified.	▪ Technical expert (surveyor) to identify the presence of barriers to flow.	▪ Close structures as required. ▪ Survey inlet between First Lake and End Lake by June 2007.	**MEDIUM**
Maintain low surface water salinity levels in the wetlands by monitoring the input of saline groundwater when the wetlands are dry, and investigating options to flush the wetland.	▪ Observe surface water salinity levels < 1000 µS/cm (EC) for at least 70% of the duration of the wetting cycle in Spectacle Lakes. ▪ Observe surface water salinity levels < 2000 µS/cm (EC) for at least 70% of the duration of the wetting cycle in Beldora Wetlands.	▪ Implement Wetland Operational Plan. ▪ Investigate options to increase frequency of flood events in Spectacle Lakes-Beldora (weir manipulations, pumping). ▪ Monitor change in surface water and groundwater salinity in response to management (e.g. monitor input of saline groundwater when the wetlands are dry).	▪ Require a valid water licence to receive a River Murray water allocation. ▪ Technical expertise to support monitoring program.	▪ See Wetland Operational Plan and Monitoring Program for further details.	**HIGH**
Manage cattle access to the wetlands and cattle stocking rates to promote biodiversity.	▪ Maintain sustainable stocking rates of cattle. ▪ Investigate options to construct remote watering sites on the highland by June 2007. ▪ Investigate options for research institutions to study the effect of cattle grazing, removal of cattle, on the wetlands by December 2007.	▪ Monitor the number of cattle accessing the floodplain. ▪ Discuss watering site options with relevant contractors and government departments. ▪ Approach research institutions about research projects at Spectacle Lakes.		▪ Cattle management is ongoing. ▪ Discuss watering site options by June 2007. ▪ Investigate research options by Dec 2007.	**HIGH**
Control the abundance of noxious weeds and other pest plants.	▪ Control the populations of African Boxthorn, and other pest plants, over 5 years and observe no increase in the abundance of pest plants.	▪ Monitor the distribution and abundance of pest plants in Spectacle Lakes-Beldora (in conjunction with SAMDB NRMB). ▪ Implement control programs for pest plant populations as necessary (e.g. spraying of African Boxthorn). ▪ Map the extent of Cumbungi and Common Reed in the wetland,	▪ Technical expertise to map pest plants distribution. ▪ SAMDB NRMB to assist.	▪ See Monitoring Program for further details.	**MEDIUM**
Control the abundance of pest animals, particularly introduced species of fish.	▪ Undertake fish monitoring at least 1 x/year to record the abundance of Carp and other introduced fish. ▪ Implement a drying event (duration >1 year) in Spectacle Lakes between July 2006 and July 2010, which aims to reduce the abundance of adult Carp.	▪ Monitor the distribution and abundance of pest animals in Spectacle Lakes-Beldora, particularly fish surveys (in conjunction with SAMDB NRMB). ▪ Implement Wetland Operational Plan.	▪ Technical expertise to survey pest animal populations. ▪ SAMDB NRMB to assist.	▪ See Monitoring Program for further details.	**MEDIUM**
Maintain a vibrant community group with the capacity to undertake wetland management and monitoring.	▪ Maintain the involvement of Spectacle Lakes-Beldora wetland group over the next 5 years. ▪ Organise a least 4 wetland monitoring days per year with the Spectacle Lakes-Beldora wetland group.	▪ Hold regular meetings and monitoring days with the Spectacle Lakes-Beldora wetland group.		▪ See Monitoring Program for further details.	**HIGH**
Formalise ongoing management arrangements in Spectacle Lakes-Beldora with key stakeholders.	▪ Organise meetings to discuss wetland management with the Spectacle Lakes-Beldora wetland group, DEH and other key stakeholders annually (if required).	▪ Circulate the Wetland Management Plan to key stakeholders, and organise annual meetings (if required). ▪ On occasion invite staff from government departments to meetings.		▪ 1st meeting by June 2007	**HIGH**

WETLAND OPERATIONAL PLAN (WATER REGIME)

The wetland operation plan outlines the management of the water regime in Spectacle Lakes and the Beldora wetlands, based on the management objectives outlined in Table 7.

The water regime in the Spectacle Lakes and Beldora wetlands can be managed independently, therefore two wetland operational plans are provided.

The two operational plans describe the phases of wetting and drying based on the management of regulating structures. These regulation structures enable the wetland complex to receive and manage an environmental water allocation from the River Murray.

The operational plans have an initial four-year cycle, between 1 July 2006 and 30 June 2010. The predicted water allocation for Spectacle Lakes and Beldora wetlands for the period 1 July 2006 to 30 June 2010 is approximately 1380 ML and 845 ML, respectively (refer Appendix 8 for further details).

SPECTACLE LAKES

The wetland operational plan for Spectacle Lakes is presented in Figure 7. This shows the recommended wetting and drying cycle between July 2006 and June 2010.

It is recommended to maintain a permanent water level in Spectacle Lakes until November 2007, to provide habitat for the native species of waterbirds, fish, frogs, macroinvertebrates, turtles, and plants. Between December 2007 and June 2009 (1.5 years) a drying event is planned (takes a long time for water levels to drawdown). This duration of dry conditions has previously shown to have a positive impact on the wetlands (increased wetland plant diversity after refilling).

Following the drying event, refilling is planned to occur during July 2009 (Figure 7). Monitoring of the response of the wetland flora and fauna communities to this wet and dry cycle will be important. That is, to see if the condition of the wetland has improved.

A detailed description of the wetland operational plan for Spectacle Lakes, including the timing and rate of inundation, and key expected responses is provided in Table 8.

BELDORA WETLANDS

The wetland operational plan for Beldora Wetlands is presented in Figure 8. This shows the recommended wetting and drying cycle between July 2006 and June 2010.

It is recommended to implement two drawdown (drying) events in the Beldora Wetlands over the next 4 years, during 2006/2007 and during 2009 (Figure 8). During the first drawdown event, the change in salinity levels and the influence of groundwater will need to be monitored. **Note:** it may not be possible to completely dry the wetlands until issues with regulating structure are resolved.

During the wetting events (inundated to pool level), the aim of management is to increase the abundance of wetland birds, frogs and other fauna, and provide a source of fresh water to the wetland. Overall, the fluctuation in water levels aims to maintain the diversity of native plants around the edges of the Beldora Wetlands, providing habitat for native wetland fauna.

A detailed description of the operational plan for the Beldora Wetlands, including the timing and rate of inundation, and key expected responses is provided in Table 9.

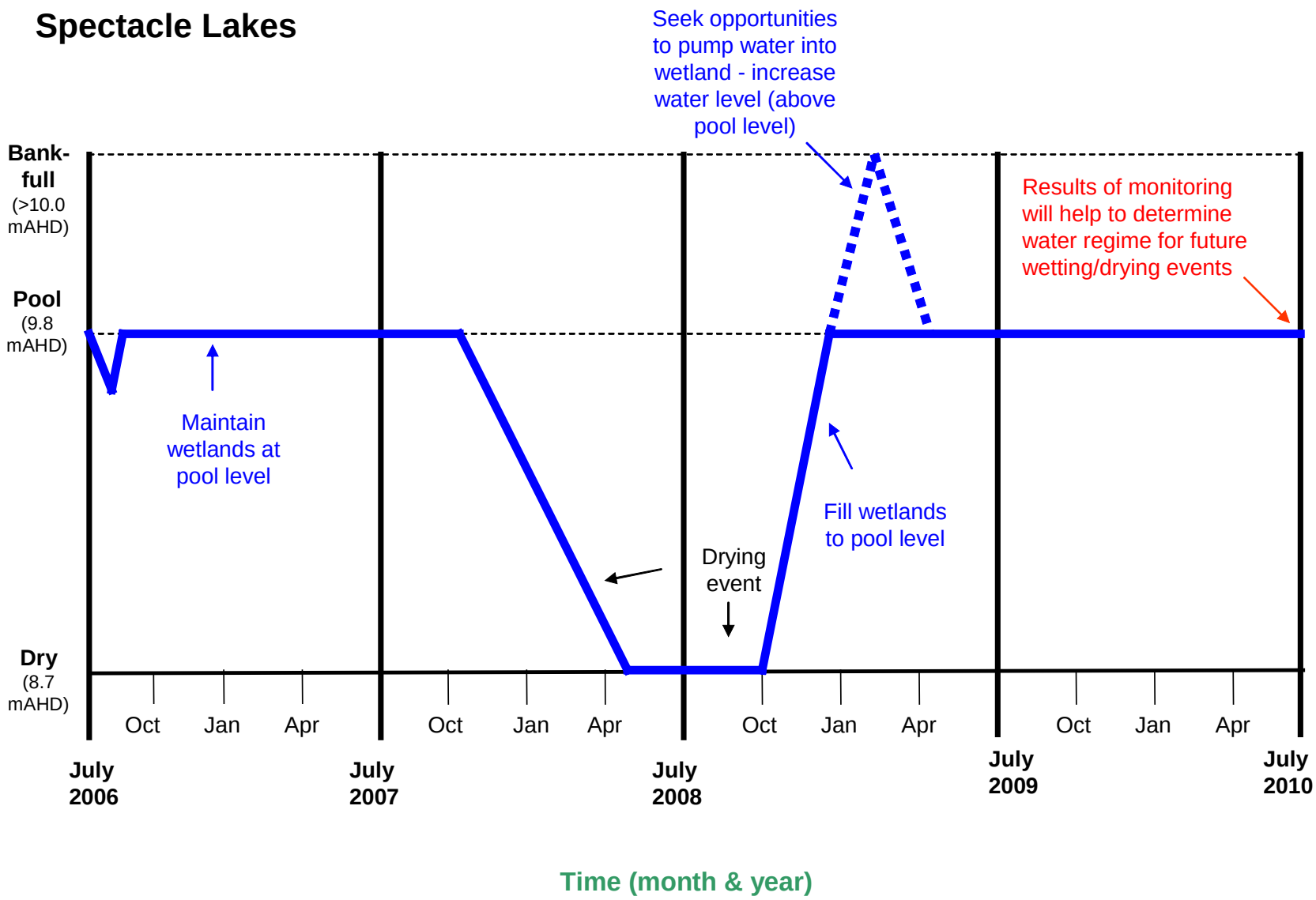


Figure 7. Wetting and drying phases of the Wetland Operational Plan for Spectacle Lakes.

Table 8. Wetland Operational Plan for Spectacle Lakes.

Year		Timing	Action	Activity	Expected response	Water Use
Year 1	July 2006 - June 2007	1 July to 31 July 2007	**Drawdown event**	Close regulator (temporarily).	▪ Slight drawdown in water level, may promote increase wetland plant diversity around wetland margins.	0 ML
		1 August 2006 to 30 June 2007	**Maintain wetland at pool level**	Acquire water licence. Keep regulator open.	▪ Provide habitat for aquatic fauna, particularly waterbirds, frogs, fish. ▪ Maintain low surface water salinity level. ▪ Possibly create freshwater lens under wetland bed. ▪ Regeneration of River Red Gum trees	395 ML
Year 2	July 2007 - June 2008	1 July to 31 Oct 2007	**Maintain wetland at pool level**	Keep regulator open.		80 ML
		1 Nov 2007 to 30 June 2008	**Drying event (evaporation)**	Close regulator.	▪ Consolidation of the wetland bed sediment. ▪ Reduced abundance of wetland flora & fauna.	0 ML
Year 3	July 2008 - June 2009	1 July to 31 Oct 2008	**Drying event (evaporation)**	Close regulator.		0 ML
		1 Nov 2008 to 30 June 2009	**Fill wetland to pool level**	Keep regulator open.	▪ Release of nutrients from wetland bed. ▪ Provide habitat for aquatic fauna, particularly waterbirds, frogs, fish. ▪ Germination of emergent plants. ▪ Reduction in surface water salinity level as wetland fills. ▪ Possibly create freshwater lens under wetland bed. ▪ Regeneration of River Red Gum trees	515 ML
Year 4	July 2009 - June 2010	1 July 2009 to 30 June 2010	**Maintain wetland at pool level**	Keep regulator open.		390 ML

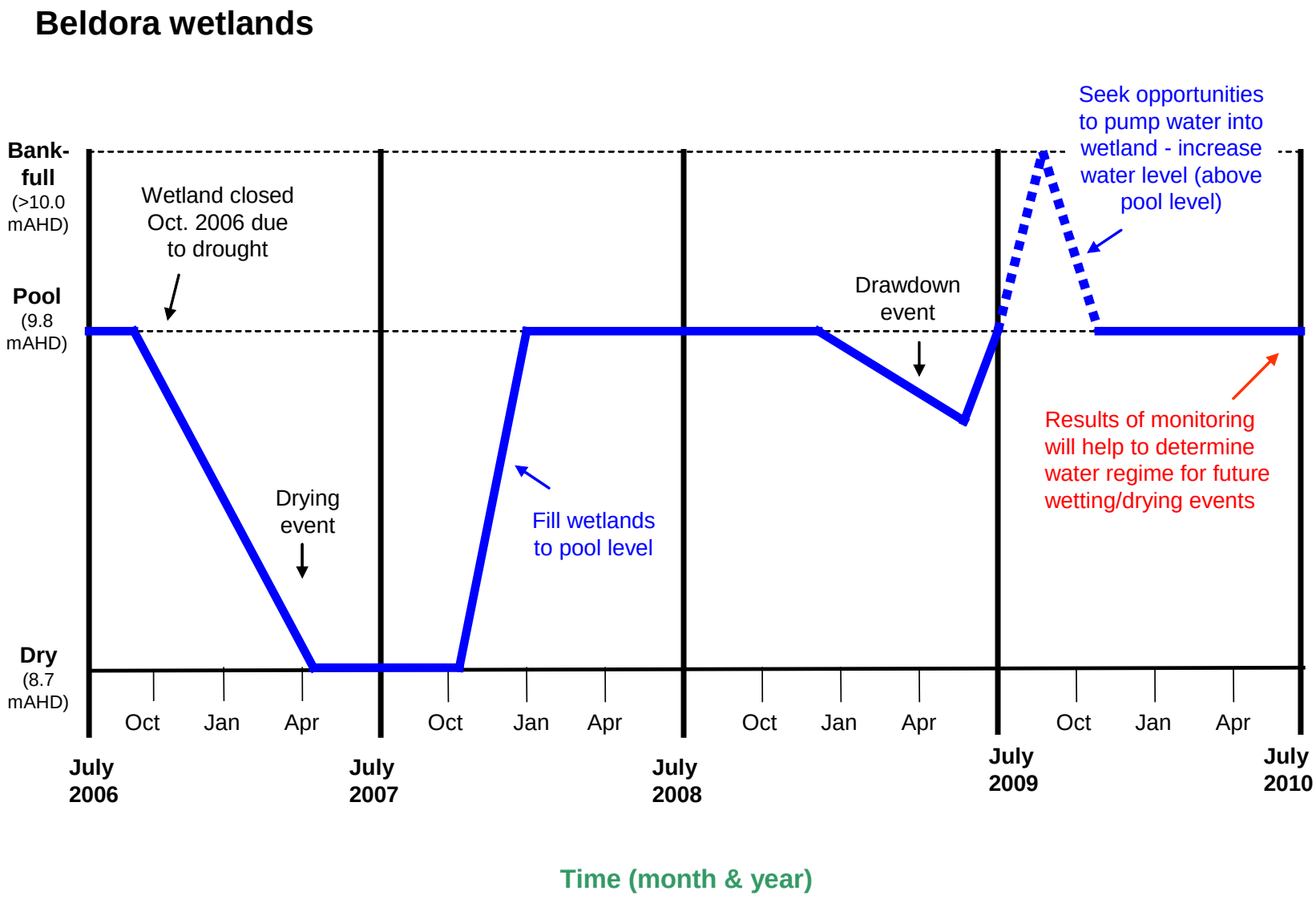


Figure 8. Wetting and drying phases of the Wetland Operational Plan for Beldora Wetlands.

Table 9. Wetland Operational Plan for Beldora wetlands.

Year		Timing	Action	Activity	Expected response	Water Use
Year 1	July 2006 - June 2007	1 July to 31Sept 2006	**Maintain wetland at pool level**	Acquire long-term water licence. Keep regulator open.	▪ Provide habitat for aquatic fauna, particularly waterbirds, frogs, fish. ▪ Maintain low surface water salinity level. ▪ Maintain freshwater lens under the wetland. ▪ Regeneration of River Red Gum trees	80 ML
		1 Oct 2006 to 30 June 2007	**Drying event (evaporation)**	Close regulator.	▪ Consolidation of the wetland bed sediment. ▪ Reduced abundance of wetland flora & fauna.	0 ML
Year 2	July 2007 - June 2008	1 July to 31 Oct 2007	**Drying event (evaporation)**	Keep regulator closed.		0 ML
		1 Nov 2007 to 30 June 2008	**Fill wetland to pool level**	Open regulator.	▪ Release of nutrients from wetland bed. ▪ Provide habitat for aquatic fauna, particularly waterbirds, frogs, fish. ▪ Germination of emergent plants. ▪ Reduction in surface water salinity level as wetland fills. ▪ Maintain freshwater lens under the wetland. ▪ Regeneration of River Red Gum trees	355 ML
Year 3	July 2008 - June 2009	1 July to 30 Nov 2008	**Maintain wetland at pool level**	Keep regulator open.		80 ML
		1 Dec 2008 to 31 May 2009	**Drying event (evaporation)**	Close regulator.	▪ As above drying event	0 ML
		1 June to 30 June 2009	**Fill wetland to pool level**	Open regulator.	▪ As above wetting event	75 ML
Year 4	July 2009 - June 2010	1 July 2009 to 30 June 2010	**Maintain wetland at pool level**	Keep regulator open.		255 ML
		1 Nov 2009 to 30 June 2010	**Fill wetland to pool level**	Keep regulator open.	▪ As above 'fill events'	355 ML

MODIFYING THE WETLAND OPERATIONAL PLAN

The wetland operational plan is only a guide and should be modified if monitoring results provide evidence to support a change in management. In addition, natural processes may also require the wetland operational plan to be modified, such as a natural flood event or drought.

When implementing a water regime it is important to consider the different stages in the wetting and drying cycle of the wetland, and their impacts on the physical and biological values of the ecosystem. These stages and their impact on the wetland are described in *Your Wetland: Hydrology Guidelines* (Tucker *et al*. 2002) and summarised in Appendix 7.

The wetland operational plan is to be reviewed in June 2010, to determine whether or not the plan and management objectives are appropriate for the Spectacle Lakes and Beldora Wetlands.

PUMPING ADDITIONAL WATER INTO SPECTACLE LAKES & BELDORA WETLANDS

Management of the water regime in Spectacle Lakes-Beldora may also benefit from pumping of additional water. Pumping of additional water may enable the wetland and floodplain areas that are above pool level to be inundated.

It is recommended to investigate options for pumping additional from the River Murray, particularly in the absence of natural flood events. It is also recommended that the volume of water pumped into the wetland be varied, to inundate the wetland to different water levels, and to increase the duration of inundation in certain years.

To inundate an area of 40 ha (~ such as End Lake) to an average water depth of 0.4 m, approximately 160 ML of water would be required (excluding water required to saturate the soil).

Infrastructure for the proposed remote watering sites (for cattle) may feasibly be used to pump water into the wetlands, but this needs to be further investigated.

FLOOD EVENTS

Flood events impact on Spectacle Lakes-Beldora during periods of high flow (e.g. > 40,000 ML/day flow in River Murray). In addition to the Wetland Operation Plan (described previously), it is important to have clear objectives and actions for the management of flood events.

The inflow of water during flood events cannot generally be managed, due to over bank flooding and subsequent inundation of the floodplain and wetlands. However, when the water level in the River Murray has receded, there are a number of options to manage the water regime within Spectacle Lakes and the Beldora Wetlands.

After the flood event has passed high water levels may be maintained by closing the Spectacle Lakes regulator (Paddy's Perry) and by closing the Beldora Wetlands regulator. The maximum water level that can be managed by the regulators is 10.6 mAHD (Paddy's Perry) and 10.4 mAHD (Beldora Wetlands).

The ecological benefits of increasing the water level and prolonging flood duration include: improved health of water-stressed wetland and floodplain vegetation, increased area of habitat for aquatic fauna such as frogs, wetland birds and macroinvertebrates, decreased surface water salinity, and providing conditions for the establishment of a freshwater lens beneath the wetland.

First Lake and End Lake (at the end of Spectacle Lakes) are two temporary wetlands in particular that will benefit from increasing the duration of flood events (incl. small increases in water levels).

Flood events will also lead to the flushing of salts from the floodplain and wetland into the River Murray. During over bank flows the flushing of salts cannot be controlled. The discharge of salt to River Murray can only be managed once the water levels in the wetland have receded (below the height of the regulators).

If the regulators are closed to maintain high water levels (described above), this will limit the removal of salt from the system. Therefore, the alternative option to holding floodwaters in the wetlands is to leave the two regulators and allow floodwaters to recede naturally. Given the high salinity levels in wetlands and floodplains along the River Murray the removal of salt from the ecosystem may be considered more important than prolonging the duration of the flood event. However, the salinity impact to the River Murray needs to be considered if this strategy is employed.

It is recommended that during and after flood events, management actions that impact on water levels in Spectacle Lakes-Beldora be undertaken in consultation with relevant stakeholders and technical experts (e.g. SA MDB NRM Board Wetland Project Officer).

PROPOSED ON-GROUND WORKS

FENCING & CATTLE WATERING SITES (STOCK MANAGEMENT)

Spectacle Lakes-Beldora has been grazed by sheep and cattle for at least 80 years. Under current land management arrangements usually 45 breeding cows (plus calves) have access to the site. Previous owners grazed up to 200 head of cattle (Beldora landholder group pers. comm. 2006).

Management of cattle grazing, including stocking rates and cattle access to wetlands, is important for the conservation of wetland ecosystems. The current leaseholders support ongoing conservation at the site and recognise the importance of the sustainable management of cattle grazing.

Removal of cattle from the floodplain may be advocated, but this may not be the best management option for Spectacle Lakes-Beldora (SKM 2006). In one section of the wetland where cattle have been excluded (and following a drying event), River Red Gum regenerated in a thicket forming a dense monoculture of saplings. This Red Gum thicket restricts the regeneration of native plants and impedes flow. Some introduced plants also established in non-grazed areas (e.g. *Polypogon monspiliensis*).

An important consideration of grazing management is stocking rates (LWRRDC 1996, Jansen & Robertson 2001, Reeves & Chapman 2004). In a comprehensive review of grazing in wetlands, Reeves and Chapman (2004) noted that "*the effects of grazing are so variable that grazing decisions should be based on conservation objectives specific to each site*".

No conclusive evidence supports the complete removal of cattle from Spectacle Lakes-Beldora under current management. Furthermore, the site is well suited to provide an example of the positive effect of restricted grazing in some wetland types.

Maintaining a low level of cattle grazing is supported for the time being, but the impacts of the cattle should be monitored over time. On-ground works to manage stocking rates are also recommended, including:

- Establishment of fencing along floodplain / high land boundary
- Installation of remote cattle watering sites on the high land (away from the wetlands).

Prior to on-ground works being undertaken at Spectacle Lakes-Beldora, approval for the works must be gained from DEH (current land owners).

Thicket of River Red Gum (*E. camaldulensis*) that has established since the removal of cattle, this excludes native understorey plants and decreases water flow and connectivity.

MONITORING

Monitoring is a vital component of wetland management. Monitoring allows the collection of physical and biological data that can be used to determine the success or failure of a management action. It can also be used to adjust or change management actions in response to changes in the wetland ecosystem.

Ongoing monitoring in Spectacle Lakes-Beldora will be undertaken by the Beldora landholders with assistance from the SA Murray-Darling Basin NRM Board and Berri Barmera LAP.

The monitoring program is outlined in Table 10, which includes monitoring of flora, fauna, groundwater and surface water. Notably, there is also the possibility for opportunistic monitoring outside the scope of the monitoring program, such as observations of threatened species of birds.

To ensure the data collected are comparable to the Baseline Survey, it is recommended monitoring sites in Spectacle Lakes-Beldora be based on those used in the Baseline Survey. Locations of the monitoring sites used during the Baseline Survey and from community monitoring are shown in Appendices 10 and 11.

The techniques for monitoring physical and biological parameters in Spectacle Lakes-Beldora should be based on the methods outlined in the *Your Wetland: Monitoring Manual* (Tucker 2004).

Photopoint monitoring at Spectacle Lakes (2005)

Table 10. Monitoring Program for Spectacle Lakes and Beldora wetlands

	Monitoring Activity	Technique	Time required	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Priority	Responsibility / Coordination
Flora	Vegetation	Photopoint assessment	½ day ^			√			√			√			√	HIGH	Beldora landholders with support from BBLAP & NRM Board
		Quadrat based survey and line intercept	2 days ^									√				LOW	NRM Board with support from Beldora landholders & BBLAP
		Visual health assessment (e.g. River Red Gums)	1 day			√			√			√			√	HIGH	Beldora landholders with support from BBLAP & NRM Board
		Mapping of pest plants (e.g. Cumbungi, Burr)	2 days									√				MEDIUM	
Fauna	Birds	Fixed area search	½ day			√									√	MEDIUM	Beldora landholders with support from BBLAP & NRM Board
		Colonial nesting	½ day			√									√	MEDIUM	Beldora landholders with support from BBLAP & NRM Board
	Fish	Fyke, dip, seine nets and shrimp traps	2 days ^			√						√				HIGH	NRM Board with support from Beldora landholders & BBLAP
	Frogs	Recording frog calls	2 hours										√		√	MEDIUM	NRM Board with support from Beldora landholders & BBLAP
	Macroinvertebrates	Dip net sampling	½ day ^												√	MEDIUM	NRM Board with support from Beldora landholders & BBLAP
Management - related	Groundwater	Groundwater depth and salinity from piezometers *	½ day			√			√			√			√	HIGH	Beldora landholders with support from BBLAP & NRM Board
	Surface water	Water quality (e.g. salinity, pH, turbidity)	½ day			√			√			√			√	HIGH	Beldora landholders with support from BBLAP & NRM Board
		Water level monitoring *	1 hour	√	√	√	√	√	√	√	√	√	√	√	√	HIGH	Beldora landholders with support from BBLAP & NRM Board
	Structure management	Log all structure management actions (date, action, reason for action, flow conditions)	1 hour	On going												HIGH	Beldora landholders with support from BBLAP & NRM Board
		Maintain structures to ensure adequate free passage for water flow and aquatic organisms	1 day ^	On going												HIGH	Beldora landholders with support from BBLAP & NRM Board
Other	Data management	Update and file all data (2 copies kept in separate locations)	1-2 hours per month	On going												HIGH	NRM Board Wetland Project Officer with support from BBLAP
		Analyse biological and physical data and relate to management actions	1 day		√			√			√			√		HIGH	NRM Board Wetland Project Officer
		Update Monitoring Log Book	1 hour	On going												HIGH	NRM Board Wetland Project Officer with support from BBLAP
		Review wetland operational plan	1-2 days ^	As required - minimum every 4 years												HIGH	Beldora landholders with support from BBLAP & NRM Board
		Report to DWLBC of any changes to the management plan	2 hours	As required												HIGH	Beldora landholders with support from BBLAP & NRM Board

Refer to *Your Wetland: Monitoring Manual* (Tucker 2004) for details of monitoring methods.

^ More than one person is required to perform monitoring method
^ ^ Dependent on the installation of nested piezometers
* Increase frequency of water level monitoring during drawdown and refilling.

Note:
There is also the possibility for opportunistic monitoring outside the scope of the monitoring program, such as observations of threatened species of birds.

EVALUATION AND REVIEW

Evaluation and review of the objectives and actions is required throughout the period of the Wetland Management Plan. This informs the community and wetland managers of the effect that the management actions are having on the wetlands' physical and biological characteristics.

Under an adaptive management approach, the results from the monitoring program can provide evidence to reconsider or alter the management objectives and actions. This may include evidence of increased surface water salinity, which threatens aquatic biota and triggers an immediate management response, or evidence that takes longer to become obvious, such as seeing improvements in long-lived vegetation. The BBLAP and the SA Murray-Darling Basin NRM Board can assist with the analysis and evaluation of the monitoring program.

The wetland operational plan will need to be evaluated at the end of the initial four-year cycle (30 June 2010). The Spectacle Lakes-Beldora Wetland Management Plan is also to be reviewed by June 2010.

REPORTING

In order to comply with the water licence from the Department of Water, Land and Biodiversity Conservation (DWLBC), a reporting element is required. DWLBC require that they be informed of any changes to the management objectives, wetland operational plan and/or the monitoring program. This is to ensure that the changes are in agreement with the wetland management plan guidelines, and to ensure the water allocation arrangements for the wetland are still appropriate.

It is important that records be kept of all monitoring data and management actions, indicating dates, actions carried out and results. This data should be stored in an easy to use and accessible format in a central location.

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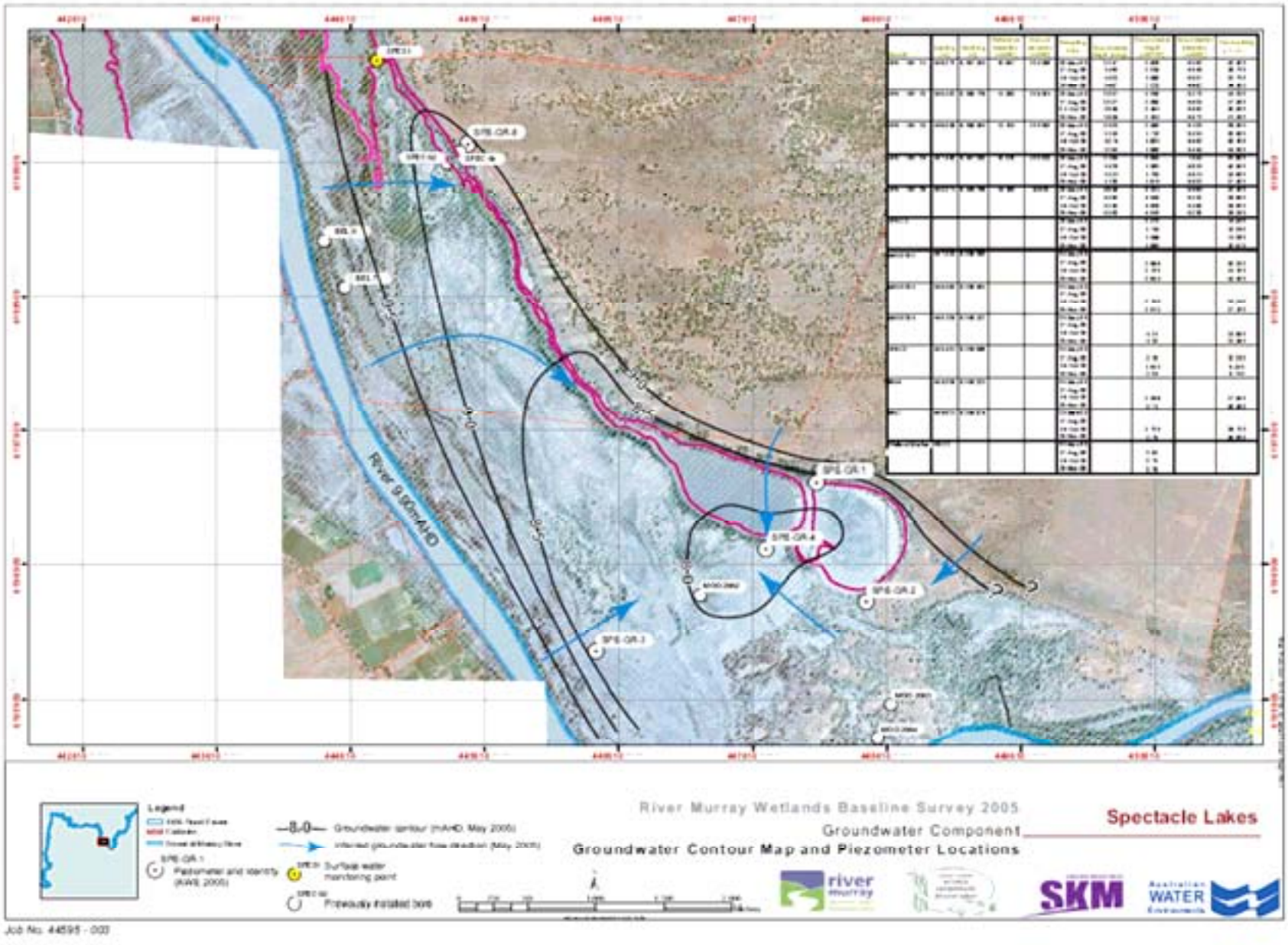
APPENDICES

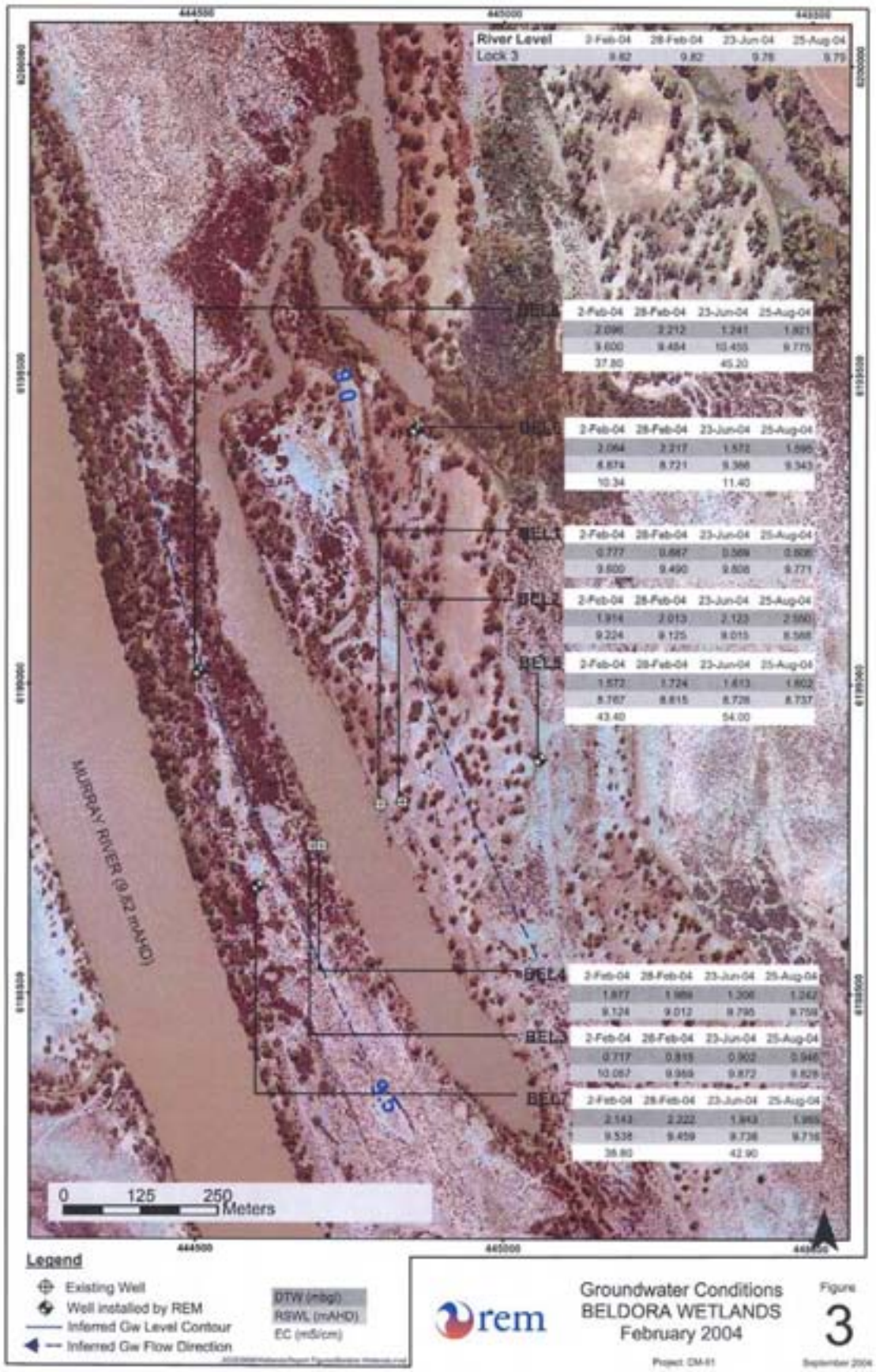
APPENDIX 1. Groundwater table elevation and groundwater salinity levels

Site	Reference Elevation	Ground Elevation	Date	Groundwater (mbgL)	Groundwater (mBTOC)	Groundwater (mAHD)	Salinity (EC) (µS/cm)
SPE GR 1	10.89	10.33	25-May-05	2.25	2.81	8.08	42,400
			17-Aug-05	1.48	2.04	8.85	36,700
			18-Oct-05	1.40	1.96	8.93	32,700
			29-Nov-05	1.47	2.03	8.86	34,300
SPE GR 2	11.36	10.83	25-May-05	2.56	3.09	8.27	44,200
			17-Aug-05	2.03	2.56	8.80	37,300
			01-Oct-05	1.95	2.48	8.88	30,500
			29-Nov-05	1.96	2.49	8.87	31,300
SPE GR 3	11.10	10.53	25-May-05	2.40	2.98	8.12	59,400
			17-Aug-05	1.14	1.71	9.39	50,900
			18-Oct-05	1.07	1.65	9.45	42,100
			29-Nov-05	1.08	1.66	9.44	44,500
SPE GR 4	10.58	10.05	25-May-05	2.17	2.69	7.88	52,600
			17-Aug-05	1.43	1.95	8.62	45,900
			18-Oct-05	1.23	1.76	8.82	35,600
			29-Nov-05	1.15	1.67	8.90	37,400
SPE GR 8	14.17	13.60	25-May-05	4.64	5.20	8.96	32,400
			17-Aug-05	4.38	4.95	9.22	28,600
			18-Oct-05	4.24	4.81	9.36	26,800
			29-Nov-05	4.35	4.92	9.25	26,350
			29-Nov-05	1.15	1.67	8.90	37,400
BEL 1	11.43	10.38	02-Feb-04	0.78		9.60	
			28-Feb-04	0.89		9.49	
			23-Jun-04	0.57		9.81	
			25-Aug-04	0.61		9.77	
BEL 2	11.53	11.14	02-Feb-04	1.91		9.22	
			28-Feb-04	2.01		9.13	
			23-Jun-04	2.12		9.02	
			25-Aug-04	2.55		8.59	
BEL 3	11.95	10.77	02-Feb-04	0.72		10.06	
			28-Feb-04	0.82		9.96	
			23-Jun-04	0.90		9.87	
			25-Aug-04	0.95		9.83	
BEL 4	11.45	11.00	02-Feb-04	1.88		9.12	
			28-Feb-04	1.99		9.01	
			23-Jun-04	1.21		9.80	
			25-Aug-04	1.24		9.76	
BEL 5	10.84	10.34	02-Feb-04	1.57		8.77	
			28-Feb-04	1.72		8.62	
			23-Jun-04	1.61		8.73	
			25-Aug-04	1.60		8.74	
BEL 6	11.61	10.94	02-Feb-04	2.06		8.87	10,340
			28-Feb-04	2.22		8.72	11,400
			23-Jun-04	1.57		9.37	
			25-Aug-04	1.60		9.34	
BEL 7	12.58	11.68	02-Feb-04	2.14		9.54	38,800
			28-Feb-04	2.22		9.46	42,900
			23-Jun-04	1.94		9.74	
			25-Aug-04	1.97		9.72	
BEL 8	12.52	11.70	02-Feb-04	2.10		9.60	37,800
			28-Feb-04	2.21		9.48	45,200
			23-Jun-04	1.24		10.46	
			25-Aug-04	1.92		9.78	

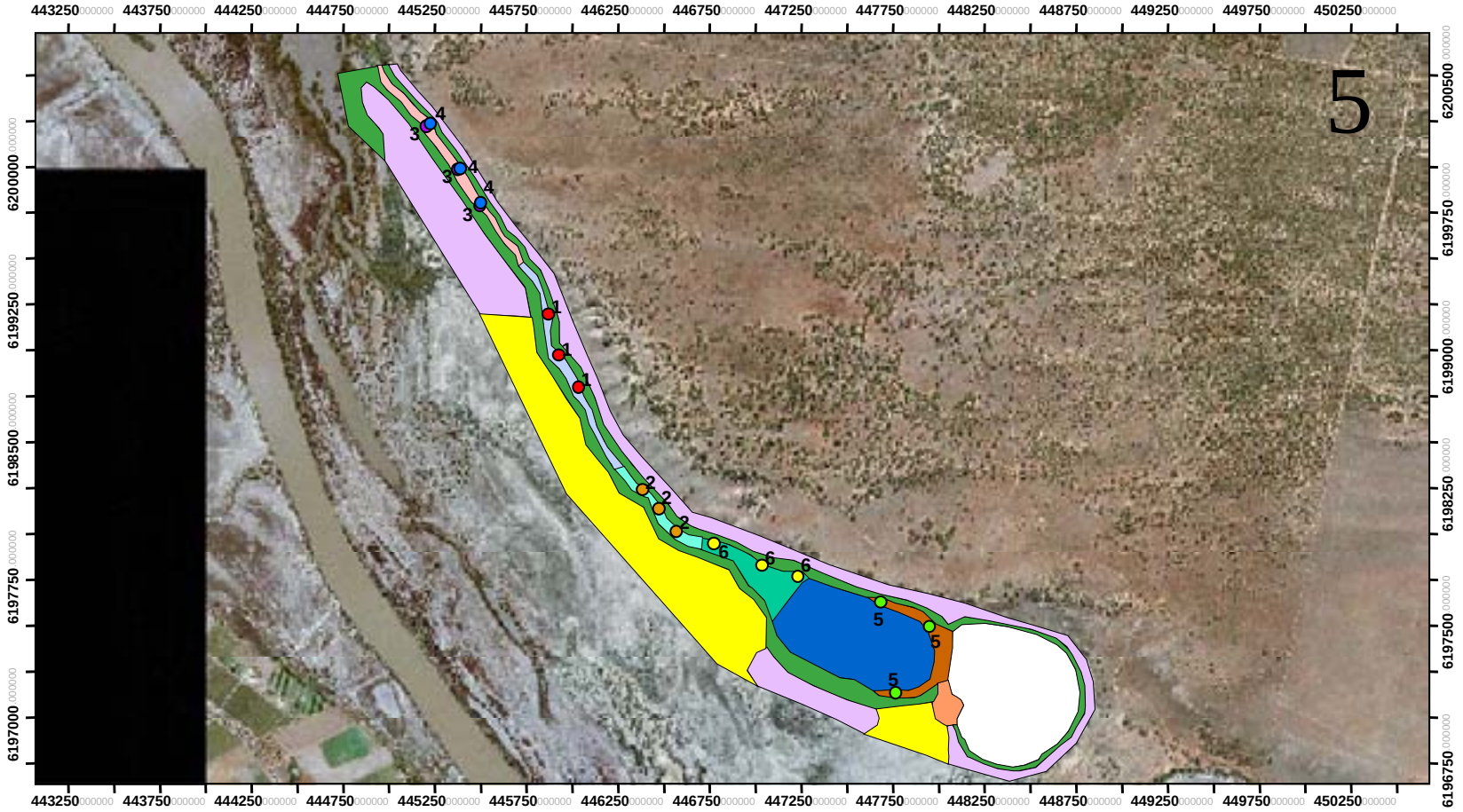
APPENDIX 2a. Map of groundwater table levels: Spectacle Lakes [Source: SKM (2006)].



APPENDIX 2b. Map of groundwater table levels: Beldora Wetlands [Source: SKM (2004)].



APPENDIX 3a. Vegetation Associations - Spectacle Lakes



Surveyed Quadrats

- *Cyperus gymnocaulos/Juncus usitatus sedgeland*
- *Ludwigia peploides* herbland
- *Vallisneria spiralis* submerged herbland
- *Cyperus gymnocaulos sedgeland*
- *Polypogon monspeliensis* grassland
- Regenerating *Eucalyptus camaldulensis* var. *camaldulensis* woodland

RIVER MURRAY
WETLANDS BASELINE
SURVEY

Spectacle Lakes

1:29,000

0 160 320 640 960 1,280 Metres

Large-scale Vegetation Communities

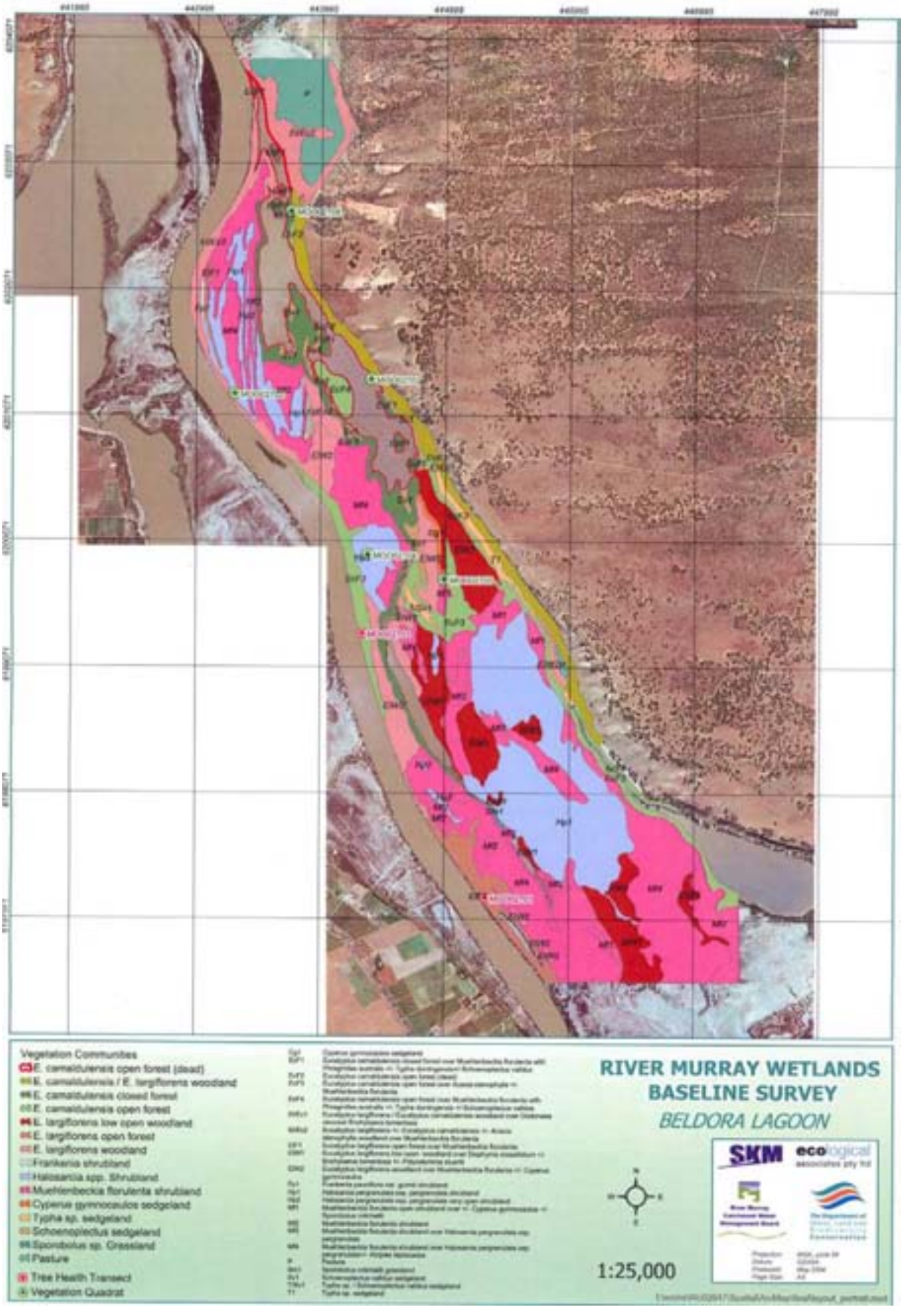
- Bare soil with scattered *Halosarcia pergranulata* ssp. *Pergranulata* plants*
- Open Water*
- *Polypogon monspeliensis* grassland
- Regenerating *Eucalyptus camaldulensis* var. *camaldulensis* woodland
- *Muehlenbeckia florulenta* shrubland*
- *Eucalyptus camaldulensis* var. *camaldulensis* woodland*
- *Ludwigia peploides* ssp. *montevidensis* herbland
- *Eucalyptus largiflorens* woodland*
- *Carpobrutes ?rossii* herbland +/- *Mesembryanthemum crystallinum* and *Halosarcia pergranulata* ssp. *pergranulata**
- *Cyperus gymnocaulos/Juncus usitatus* sedgeland
- *Vallisneria spiralis* submerged herbland with *Cyperus gymnocaulos* sedgeland riparian zone

* Denotes community not quantitatively surveyed

\# Denotes area too small to map

Quadrat numbers refer to vegetation associations in wetland summary

APPENDIX 3b. Vegetation Associations: Beldora Wetlands



APPENDIX 4. List of flora recorded in Spectacle Lakes and Beldora Wetlands

Scientific Name	Common Name	Source				Conservation Status		
		1	2	3	4	SA CS	SA PS	NAT
Native species								
Acacia stenophylla	River Cooba				+			
Angianthus tomentosus	Hairy Angianthus	+						
Atriplex lindleyi ssp. *lindleyi*	Baldoo	+						
Atriplex semibaccata	Berry Saltbush	+						
Austrostipa sp.	Spear grass		+		+			
Azolla filiculoides	Pacific Azolla	+	+	+				
Azolla pinnata	Ferny Azolla	+						
Brachycome lineariloba	Hard-head Daisy	+						
Carpobrotus rossii	Angular Pigface		+					
Cotula coronopifolia	Water Buttons	+	+					
Crassula colorata var. *acuminata*	Dense Crassula	+						
Cressa cretica	Rosinweed	+						
Cyperus gymnocaulos	Spiny Flat-sedge	+	+	+	+			
Disphyma crassifolium ssp. *clavellatum*	Round-leaf Pigface	+						
Einadia nutans ssp. *nutans*	Climbing Saltbush	+						
Eleocharis acuta	Common Spike-rush		+		+			
Enchylaena tomentosa var. *tomentosa*	Ruby Saltbush		+					
Epaltes australis	Spreading nut-heads	+	+					
Eragrostis dielsii	Mulka		+					
Eucalyptus camaldulensis var. *camaldulensis*	River Red Gum		+	+	+			
Eucalyptus largiflorens	Black Box		+	+	+			
Euphorbia drummondii	Caustic Weed		+					
Frankenia pauciflora var. *gunnii*	Southern Sea-heath	+						
Halosarcia indica ssp. *leiostachya*	Brown-head Samphire	+						
Halosarcia pergranulata ssp. *pergranulata*	Black-seed samphire	+	+					
Halosarcia sp.	Samphire	+						
Hymenolobus procumbens	Oval Purse	+						
Juncus aridicola	Inland Rush	+						
Juncus usitatus	Common Rush		+	+	+			
Lachnagrostis filiformis	Common Blown-grass	+	+					
Lemna sp.	Duckweed				+			
Ludwigia peploides ssp. montevidensis	Water Primrose		+		+			
Lythrum hyssopifolia	Lesser Loosestrife	+						
Maireana microcarpa	Swamp Bluebush		+					
Marsilea drummondii	Nardoo		+					
Mimulus repens	Creeping Monkey-flower	+						
Morgania floribunda	Bluerod		+					
Muehlenbeckia florulenta	Lignum	+	+	+	+			
Myriocephalus stuartii	Poached-egg daisy		+					
Myriophyllum papillosum	Robust Milfoil	+						
Myriophyllum simulans	Amphibious Milfoil	+						
Myriophyllum verrucosum	Red Milfoil		+		+			
Nitella sp.	Nitella		+					
Paspalum distichum	Water Couch	+						
Phragmites australis	Common Reed		+	+	+			
Potamogeton crispus	Curly Pondweed	+						
Pseudognaphalium luteo-album	Jersey Cudweed		+					
Sarcocornia sp.	Samphire			+				
Schoenoplectus validus	River Club-rush	+		+	+			
Sclerolaena brachyptera	Short-wing Bindyi	+						
Sclerolaena muricata var. *muricata*	Five-spine Bindyi	+						
Sclerolaena stelligera	Star Bindyi	+						

Scientific Name	Common Name	Source				Conservation Status		
		1	2	3	4	SA CS	SA PS	NAT
Senecio glossanthus	Annual Groundsel	+						
Senecio sp.	Groundsel		+					
Spirodela punctata	Thin Duckweed	+						
Sporobolus mitchellii	Rat-tail couch	+	+					
Tetragonia tetragonoides	New Zealand Spinach		+					
Typha sp.	Cumbungi		+	+	+			
Vallisneria spiralis	Ribbon weed	+	+	+	+			
Wahlenbergia fluminalis	River Bluebell		+					
Zygophyllum sp.	Twinleaf	+						
Introduced species								
Arctotheca calendula	Cape Weed		+					
Asphodelus fistulosus	Onion Weed	+	+					
Aster subulatus	Aster-weed	+						
Bromus rubens	Red Brome		+					
Bromus unioloides	Prairie grass		+					
Cotula bipinnata	Ferny Cotula	+						
Hordeum marinum	Barley Grass		+					
Hordeum murinum ssp. glaucum	Blue Barley-grass	+						
Cynara cardunculus	Stemless Thistle		+					
Echium plantagineum	Salvation Jane		+					
Euphorbia terracina	False Caper		+					
Heliotropium curassavicum	Smooth Heliotrope	+	+					
*Hypochaeris radicata**	Flat Weed		+					
Lactuca saligna	Wild Lettuce		+					
Lycium ferocissimum	African Boxthorn		+					
Malva parviflora	Small-flowered Marshmallow		+					
Marrubium vulgare	Horehound		+					
Medicago sp.	Medic		+					
Mesembryanthemum crystallinum	Common Iceplant		+					
Mesembryanthemum nodiflorum	Slender Iceplant	+						
Onopordum acanthium	Scotch Thistle		+					
Phalaris minor	Canary Grass		+					
Phyla canescens	Lippia		+		+			
Polypogon monspeliensis	Annual Beard-grass	+	+					
Sonchus oleraceus	Common Sow-thistle		+					
Spergularia diandra	Lesser Sand-spurrey	+						
Spergularia marina	Salt Sand-spurrey	+						
Xanthium occidentale	Noogoora Burr		+					

Conservation status based on the *2003 Review of the Status of Threatened Species in South Australia* (NPWC & DEH 2003) and the *Environment Protection and Biodiversity Conservation Act 1999*.

Key:
CS - Current status of threatened flora in schedules declared under the *National Parks and Wildlife Act 1972*
PS - Proposed of threatened flora following revisions to the schedules
NAT - National listings

Source:
1 - River Murray Wetlands Baseline Survey (SKM 2004)
2 - River Murray Wetlands Baseline Survey (SKM 2006)
3 - Baseline Data Snapshot of Ten Managed Lower Murray Wetlands (Wetland Care Australia 2003)
4 - Incidental/miscellaneous records for Spectacle Lakes & Beldora wetlands

APPENDIX 5. Examples of photopoints used to monitor Spectacle Lakes and Beldora wetlands

Photopoint: SPE PP01 (126°) 2/08/2003

7/02/2004

17/08/2004

17/10/2005

Photopoint: SPE PP03 (170°) 2/08/2003

7/02/2004

17/08/2004

17/10/2005

APPENDIX 6. List of fauna recorded in Spectacle Lakes and Beldora Wetlands

Common Name	Scientific Name	Source						Conservation Status		
		1	2	3	4	5	6	SA CS	SA PS	NAT
Mammals (Native)										
Western Grey Kangaroo	*Macropus fuliginosus*						+			
Mammals (Introduced)										
European Rabbit	*Oryctolagus cuniculus*			+			+			
Fish (Native)										
Australian Smelt	*Retropinna semoni*			+						
Bony Bream	*Nematalosa erebi*	+	+							
Carp Gudgeon Complex	*Hypseleotris* sp.	+	+							
Dwarf flathead Gudgeon	*Philypnodon* sp.	+								
Flathead Gudgeon	*Philypnodon grandiceps*	+	+							
Fly-specked hardyhead	*Craterocephalus stercusmuscarum*	+							R	
Murray River Rainbowfish	*Melanotaenia fluviatilis*	+								
Unspecked Hardyhead	*Craterocephalus stercusmuscarum fulvus*		+							
Fish (Introduced)										
Carp	*Cyprinus carpio*	+	+	+			+			
Eastern Gambusia	*Gambusia holbrooki*	+	+	+						
Goldfish	*Carassius auratus*	+	+							
Frogs (Native)										
Common Eastern Froglet	*Crinia signifera*	+								
Eastern Banjo Frog	*Limnodynastes dumerilii*		+							
Eastern Sign-bearing Froglet	*Crinia parinsignifera*	+	+							
Long-thumbed Frog	*Limnodynastes fletcheri*	+								
Painted Frog	*Neobatrachus sudelli*	+	+							
Peron's Tree Frog	*Litoria peronii*	+	+							
Southern-bell Frog	*Litoria raniformis*	+	+					V	V	Vu
Spotted Grass Frog	*Limnodynastes tasmaniensis*	+	+							
Reptiles (Native)										
Shingleback	*Tiliqua rugosa*						+			
Eastern Brown Snake	*Pseudonaja textilis*						+			
Birds (Native)										
Australasian Shoveller	*Anas rhynchotis*				+	+		R	R	
Australian Kestrel	*Falco cenchroides*				+	+				
Australian Magpie	*Gymnorhina tibicen*				+	+	+			
Australian Owlet-nightjar	*Aegotheles cristatus*				+					
Australian Pelican	*Pelecanus conspicillatus*	+	+		+	+	+			
Australian Raven	*Corvus coronoides*				+	+				
Australian Shelduck	*Tadorna tadornoides*	+	+		+	+				
Australian White Ibis	*Threskiornis molucca*	+	+		+					
Australian Wood Duck	*Chenonetta jubata*	+	+	+	+	+				
Banded Lapwing	*Vanellus tricolor*				+	+				
Banded Stilt	*Cladorhynchus leucocephalus*				+				V	
Barking Owl	*Ninox connivens*				+			R	R	
Black Falcon	*Falco subniger*				+	+				
Black Kite	*Milvus migrans*				+	+				
Black Swan	*Cygnus atratus*	+	+		+	+				
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*				+	+				
Black-faced Woodswallow	*Artamus cinereus*				+					
Black-fronted Dotterel	*Elseyornis melanops*	+								
Black-shouldered Kite	*Elanus notatus*				+	+				
Black-tailed Native-hen	*Gallinula ventralis*	+			+	+				

Common Name	Scientific Name	Source						Conservation Status		
		1	2	3	4	5	6	SA CS	SA PS	NAT
Black-winged Stilt	*Himantopus himantopus*		+		+	+				
Blue Bonnet	*Psephotus haematogaster*				+	+				
Brown Goshawk	*Accipiter fasciatus*		+							
Brown Treecreeper	*Climacteris picumnus*				+				R	
Budgerigar	*Melopsittacus undulatus*				+	+				
Buff-banded Rail	*Rallus philippensis*				+					
Caspian Tern	*Sterna caspia*	+			+					C
Cattle Egret	*Ardea ibis*				+				R	C J
Chestnut Teal	*Anas castanea*				+	+				
Clamorous Reed-warbler	*Acrocephalus australis*	+	+							
Cockatiel	*Nymphicus hollandicus*				+	+				
Collared Sparrowhawk	*Accipiter cirrhocephalus*				+					
Common Bronzewing	*Phaps chalcoptera*				+	+				
Crested Pigeon	*Ocyphaps lophotes*				+	+				
Darter	*Anthinga melanogaster*	+	+		+	+				
Dusky Moorhen	*Gallinula tenebrosa*	+								
Dusky Woodswallow	*Artamus cyanopterus*				+	+				
Emu	*Dromaius novaehollandiae*				+	+				
Eurasian Coot	*Fulica atra*	+	+	+	+	+				
Fairy Martin	*Hirundo ariel*				+	+				
Fork-tailed Swift	*Apus pacificus*				+	+				
Freckled Duck	*Stictonetta naevosa*				+			V	R	
Galah	*Cacatua roseicapilla*				+	+				
Glossy Ibis	*Plegadis falcinellus*				+			R	R	C
Great Cormorant	*Phalacrocorax carbo*	+		+	+	+				
Great Crested Grebe	*Podiceps cristatus*				+			R	R	
Great Egret	*Ardea alba*		+		+	+	+			C
Grey Butcherbird	*Cracticus torquatus*				+	+				
Grey Currawong	*Strepera versicolor*				+	+				
Grey Fantail	*Rhipidura fuliginosa*				+					
Grey Shrike-thrush	*Colluricincla harmonica*				+	+				
Grey Teal	*Anas gracilis*	+	+	+	+	+				
Hardhead	*Aythya australis*				+	+				
Hoary-headed Grebe	*Poliocephalus poliocephalus*		+		+					
Horsfields Bronze Cuckoo	*Chrysococcyx basalis*				+	+				
Jacky Winter	*Microeca leucophaea*				+					
Laughing Kookaburra	*Dacelo novaeguineae*				+	+				
Lewins Rail	*Rallus pectoralis*				+			V	V	
Little Bittern	*Ixobrychus minutus*				+			R	E	
Little Black Cormorant	*Phalacrocorax sulcirostris*	+	+		+	+				
Little Button Quail	*Turnix velox*				+					
Little Corella	*Cacatua sanguinea*				+	+				
Little Crow	*Corvus bennetti*				+	+				
Little Eagle	*Hieraaetus morphnoides*				+	+				
Little Egret	*Ardea garzetta*				+				R	
Little Grassbird	*Megalurus gramineus*		+							
Little Pied Cormorant	*Phalacrocorax melanoleucos*	+	+							
Magpie-lark	*Grallina cyanoleuca*				+	+	+			
Mallard	*Anas platyrhynchos*				+					
Mallee Ringneck Parrot	*Platycercus zonarius*				+	+				
Masked Lapwing	*Vanellus miles*	+	+	+	+	+				
Masked Woodswallow	*Artamus personatus*				+	+				
Mistletoebird	*Dicaeum hirundinaceum*				+					
Mulga Parrot	*Psephotus varius*				+					
Musk Duck	*Biziura lobata*				+			R	R	
Noisy Minor	*Manorina melanocephala*				+	+				
Pacific Black Duck	*Anas superciliosa*	+	+	+	+	+				
Pallid Cuckoo	*Cuculus saturatus*				+	+				
Peaceful Dove	*Geopelia striata*				+	+				
Peregrine Falcon	*Falco approximans*				+	+		R	R	

Common Name	Scientific Name	Source						Conservation Status		
		1	2	3	4	5	6	SA CS	SA PS	NAT
Pied Butcherbird	*Cracticus nigrogularis*				+	+				
Pied Cormorant	*Phalacrocorax varius*	+		+	+	+				
Pink Cockatoo	*Cacatua leadbeateri*				+	+		V	R	
Pink-eared Duck	*Malacorhynchus membranaceus*				+	+				
Purple Swamphen	*Porphyrio porphyrio*	+	+		+	+				
Rainbow Bee-eater	*Merops ornatus*				+	+				
Red Wattlebird	*Anthochaera carunculata*				+	+				
Red-browed Pardalote	*Pardalotus rubricatus*				+					
Red-kneed Dotterel	*Erythrogonys cinctus*		+		+	+				
Red-necked Avocet	*Recurvirostra novaehollandiae*				+	+				
Red-rumped Parrot	*Psephotus haematonotus*				+	+				
Regent Parrot	*Polytelis anthopeplus*		+		+	+	+	V	V	Vu
Restless Flycatcher	*Myiagra inquieta*				+				R	
Royal Spoonbill	*Platalea regia*		+		+	+				
Rufous Night Heron	*Nycticorax caledonicus*				+					
Sacred Kingfisher	*Todiramphus sanctus*				+	+				
Sharp-tailed Sandpiper	*Calidris acuminata*		+							C J
Silver Gull	*Larus novaehollandiae*			+	+	+				
Silvereye	*Zosterops lateralis*				+	+				
Singing Honeyeater	*Lichenostomus virescens*				+	+				
Skylark	*Alauda arvensis*				+					
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*				+	+				
Spotted Nightjar	*Caprimulgus guttatus*				+					
Spotted Turtle-Dove	*Streptpelia chinensis*				+	+				
Square-tailed Kite	*Lophoictinia isura*				+			V	E	
Straw-necked Ibis	*Threskiornis spinicollis*		+		+	+				
Striated Pardalote	*Pardalotus striatus*				+	+				
Striped Honeyeater	*Plectorhyncha lanceolata*				+			R	R	
Stubble Quail	*Coturnix pectoralis*				+	+				
Sulphur-crested Cockatoo	*Cacatua galerita*				+	+				
Swamp Harrier	*Circus approximatus*				+	+				
Tawny Frogmouth	*Podargus strigoides*				+					
Tree Martin	*Hirundo nigricans*	+								
Variegated Fairy-wren	*Malurus assimilis*				+	+				
Wedge-tailed Eagle	*Aquila audax*				+	+				
Weebill	*Smicrornis brevirostris*				+	+				
Welcome Swallow	*Hirundo neoxena*				+					
Whistling Kite	*Haliastur sphenurus*	+	+		+	+				
White-backed Swallow	*Cheramoecaleucosternum*				+	+				
White-bellied Sea-eagle	*Haliaeetus leucogaster*				+			V	E	C
White-browed Babbler	*Pomatostomus superciliosus*				+	+				
White-eared Honeyeater	*Lichenostomus leucotis*				+					
White-faced Heron	*Egretta novaehollandiae*	+	+	+	+	+	+			
White-fronted Chat	*Ephithianura albifrons*				+	+				
White-fronted Honeyeater	*Phylidonyris novaehollandiae*				+					
White-necked Heron	*Ardea pacifica*		+							
White-plumed Honeyeater	*Lichenostomus penicillatus*				+	+				
White-winged Chough	*Corcorax melanorhamphos*				+	+			R	
Willie Wagtail	*Rhipidura leucophrys*				+	+				
Yellow-billed Spoonbill	*Platalea flavipes*	+	+	+	+	+				
Yellow-plumed Honeyeater	*Lichenostomus ornatus*				+					
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*				+	+				
Zebra Finch	*Poephila guttata*				+	+				
Birds (Introduced)										
Blackbird	*Turdus merula*				+					
Common Starling	*Sturnus vulgaris*				+	+				
House Sparrow	*Passer domesticus*				+	+				
Ostrich	*Struthio camelus*				+	+				

Common Name	Scientific Name		Source						Conservation Status		
			1	2	3	4	5	6	SA CS	SA PS	NAT
Macroinvertebrates											
Nematodes											
Roundworm	Nematoda		+	+							
Cnidaria											
Hydra	Hydridae		+								
Annelids											
Segmented worm	Oligochaeta (Class)										
Arachnids											
Freshwater mite	Oribatida		+	+							
Freshwater mite	Acarina (Order)		+								
Freshwater mite	Acaridae		+								
Freshwater mite	Astigmata		+								
Molluscs											
Physid snail	Physidae	*Physa*	+	+							
Snail	Gastropoda (Order)		+			+					
Small snail	Planorbidae		+								
Crustaceans											
Freshwater shrimp	Atyidae	*Caridina*		+							
Freshwater shrimp	Atyidae	*Paratya*		+	+						
Freshwater prawn	Palaemonidae	*Macrobrachium*		+							
Freshwater shrimp	Atyidae		+								
Freshwater prawn	Palaemonidae		+								
Freshwater crayfish/yabby	Parastacidae		+								
Copepods	Copepoda	*Calanoidea*			+						
Ceinid Amphipod	Ceinidae		+								
Collembola											
Springtails	Isotomidae			+							
Springtails	Hypogasturidae		+								
Springtails	Sminthuridae		+								
Insects											
Beetle	Coleoptera (Order)		+								
Diving beetle	Dytiscidae		+	+							
Scavenger beetle	Hydrophilidae	*Berosus*		+							
Scavenger beetle	Hydrophilidae	*Helochares*		+							
Scavenger beetle	Hydrophilidae		+	+							
Crawling water beetle	Hydraenidae		+								
Mayfly	Ephemeroptera (Order)		+								
Mayfly	Baetidae				+						
Damselfly	Zygoptera (Suborder)		+								
Damselfly	Coenagrionidae		+								
Damselfly	Lestidae		+								
Dragonfly	Aeshnidae		+								
Dragonfly	Libellulidae		+								
Sand fly	Ceratopogonidae	Ceratopogoninae		+							
Sand fly	Ceratopogonidae	Dasyheleinae		+							
Sand fly	Ceratopogonidae		+								
Non-biting midge	Orthocladiinae		+								
Non-biting midge	Chironomidae	Chironominae	+	+	+						
Non-biting midge	Chironomidae	Orthocladinae		+							
Non-biting midge	Chironomidae	Tanypodinae		+							
Non-biting midge	Tanypodinae		+								
Mosquito larvae	Culicidae	Anophelinae		+							

Common Name	Scientific Name		Source						Conservation Status		
			1	2	3	4	5	6	SA CS	SA PS	NAT
Mosquito larvae	Culicidae	Culicinae		+							
Mosquito	Culicidae		+								
Ephyrid	Ephydridae			+							
Soldier fly	Stratiomyidae		+								
Caddisfly	Hydrobiosidae		+								
Caddisfly	Hydroptilidae		+								
Caddisfly	Leptoceridae		+								
Aquatic catepillar	Pyralidae		+								
Water boatmen	Corixidae		+	+	+						
Water boatmen	Corixidae	*Micronecta*		+							
Water treader	Mesoveliidae	*Mesovelia*		+							
Water treader	Mesoveliidae		+								
Backswimmer	Notonectidae		+	+	+						
Small water strider	Veliidae		+	+							
Small water strider	Veliidae	*Microvelia*		+							
Velvet water bug	Hebridae		+								
Creeping water bug	Naucoridae		+								

South Australian conservation status follows (NPWC & DEH 2003).

Key:
SA CS - Current status of threatened fauna in schedules declared under the *National Parks and Wildlife Act 1972*
SA PS - Proposed status of threatened fauna following revisions to the schedules
NAT - National listings
R - Rare in South Australia
V - Vulnerable in South Australia
E - Endangered in South Australia
Vu - Vulnerable under the *EPBC Act*
C - Listed under the China Australia Migratory Bird Agreement (CAMBA)
J - Listed under the Japan Australia Migratory Bird Agreement (JAMBA)

Source:
1 - River Murray Wetlands Baseline Survey (SKM 2004)
2 - River Murray Wetlands Baseline Survey (SKM 2006)
3 - Directory of Important Wetlands in Australia: Spectacle Lakes – SA049 (Environment Australia 2003)
4 - D. Dalziel bird observation records (1995-2006) (D. Dalziel pers. comm. 2006)
5 - B. Dalziel bird observation records (1995-2006) (B. Dalziel pers. comm. 2006)
6 - Incidental/miscellaneous records

APPENDIX 7. Key stages in wetland water regime management.

Summary of the key stages in wetland water regime management - summarised from *Your Wetland: Hydrology Guidelines* (Tucker *et al*. 2002).

Drying the wetland

Complete drying of the wetland is beneficial to the wetland as it provides ideal conditions for the germination of dry wetland bed plants. These plants then go on to provide shelter for fish and macroinvertebrates once the wetland is re-filled. Nutrients from these plants will also be released into the water to be available for use by other emergent and submerged plants. When the wetland has been dried for six months or longer, the wetland bed sediments can be consolidated and therefore the sediments will not be re-suspended when the wetland is filled. Also with this extended dry period, some native plants are able to complete their life cycles and release their seed into the seed bank for germination on the next drying event. Drying the wetland will also help to reduce carp numbers. Large carp will be stranded by the loss of water and die or be eaten by birds. Carp eggs that are laid around the fringes of the wetland will die when dried out.

Drying of a wetland should best commence in late summer and last until early spring. The decision to dry a wetland should also be dependant on the submerged vegetation. The wetland should contain water until this vegetation has flowered and set seed. Monitoring can determine when is the correct time for drying to begin.

Filling the wetland (pool level)

When wetlands are filled after being dry for a period of time there are a number of benefits to the wetland ecosystem. When water re-enters the wetland the consolidated sediments are not re-suspended, which allows light to penetrate through the water column and support the germination of aquatic plant species. These plants provide food and habitat for aquatic fauna. Re-filling after drying also evokes the release of nutrients from sediment, which are taken up by algae and plants.

Wetlands should be filled slowly, typically during spring. The wetland should remain full for at least one growing season (spring to the end of summer) to allow aquatic plants, to complete their life cycle and set seed. Inundation for two growing seasons is preferable. Filling can also support the longer lived vegetation such as the Black box and River Red Gums as well as creating or improving a freshwater lens under the wetland. Salinity levels in the lagoon can also be lowered through the influx of fresh water diluting the salts.

Partial drying of the wetland

Partial drying of the wetland involves lowering the water level in the wetland. The advantage of a partial dry is that by exposing the sediment, emergent vegetation has greater area to grow. Partial drying also favours species that respond to a fluctuating water level. However, reducing the water level can also have negative impacts by promoting the spread of undesired plant species

Over bank flooding

The final management phase is over bank flooding. This involves holding water in the wetland higher than pool level. The affects of flooding are well documented with the most significant impacts being on the riparian zone vegetation such as River Red Gums. Currently, over bank floods only occur in Spectacle Lakes-Beldora during flood events in the River Murray when the river is significantly higher that the water level maintained by the locks and weirs.

APPENDIX 8. Wetland inundation model - Spectacle Lakes

APPENDIX 9. Water volume calculation

The following calculation was used to determine the volume of water used by the Spectacle Lakes and Beldora wetlands (based on the Wetland Operational Plan).

Both the Spectacle Lakes and Beldora wetlands were inundated to pool level (as of June 2006). Therefore, no water was required to fill the wetlands prior to implementing the Operational Plan.

SPECTACLE LAKES (excl. End Lake)

- **Spectacle Lakes surface area:** ~ 26 ha (when inundated to Lock 3 pool level)
- **Volume to fill Spectacle Lakes** (to Lock 3 pool level): ~ 210 ML

Water Volume Calculation

Year	Period	Action	Details	Water use
2006/2007	1 July 2006 – 31 July 2006	Drawdown event	-	0 ML
	1 Aug 2006 – 30 June 2007	Maintain wetland at pool level	Fill (15 ML) Evaporation (380 ML)	395 ML
2007/2008	1 July 2007 - 31 Oct 2007	Maintain wetland at pool level	Evaporation	80 ML
	1 Nov 2007 - 30 June 2008	Dry wetland	-	0 ML
2008/2009	1 July 2008 - 31 Oct 2008	Dry wetland	-	0 ML
	1 Nov 2008 - 30 June 2009	Fill wetland to pool level	Fill (210 ML), Evaporation (305 ML)	515 ML
2009/2010	1 July 2009 - 30 June 2010	Maintain wetland at pool level	Evaporation	390 ML
Total water volume (for the period 1 July 2006 - 30 June 2010)				**1380 ML**

BELDORA WETLANDS

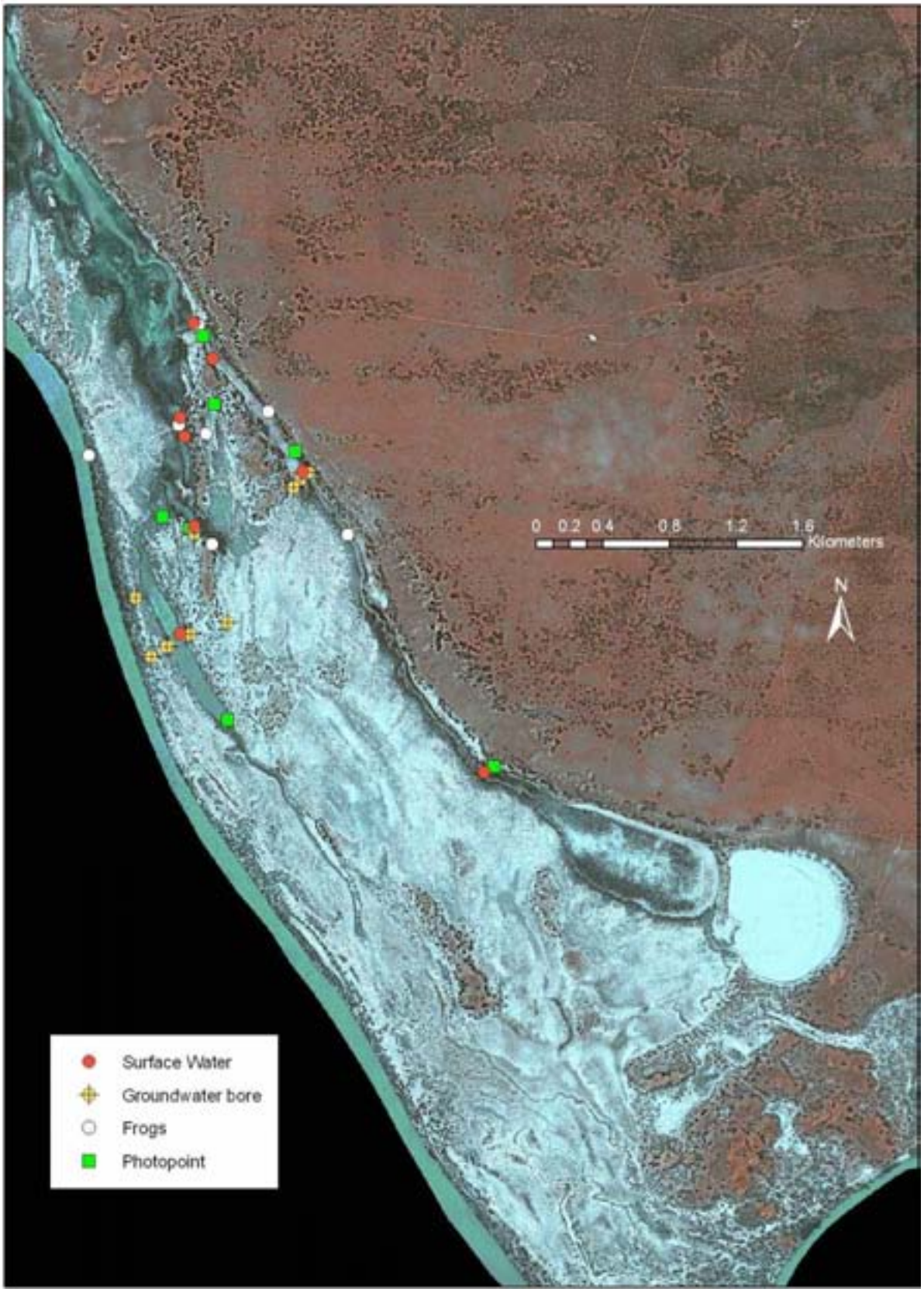
- **Beldora wetlands surface area**: ~ 17 ha (when inundated to Lock 3 pool level)
- **Volume to fill Beldora wetlands** (to Lock 3 pool level): ~ 155 ML

Water Volume Calculation

Year	Period	Action	Water use details	Water use
2006/2007	1 July 2006 – 31 Sept 2006	Maintain wetland at pool level	Evaporation	80 ML
	1 Oct 2006 – 30 June 2007	Dry wetland	-	0 ML
2007/2008	1 July 2007 - 31 Oct 2007	Dry wetland	-	0 ML
	1 Nov 2007 - 30 June 2008	Fill wetland to pool level	Fill (155 ML), Evaporation (200 ML)	355 ML
2008/2009	1 July 2008 - 30 Nov 2008	Maintain wetland at pool level	Evaporation	80 ML
	1 Dec 2008 - 31 May 2009	Drawdown event	-	0 ML
	1 June 2009 - 30 June 2009	Fill wetland to pool level	Fill (70 ML), Evaporation (5 ML)	75 ML
2009/2010	1 July 2009 - 30 June 2010	Maintain wetland at pool level	Evaporation	255 ML
Total water volume (for the period 1 July 2006 - 30 June 2010)				**845 ML**

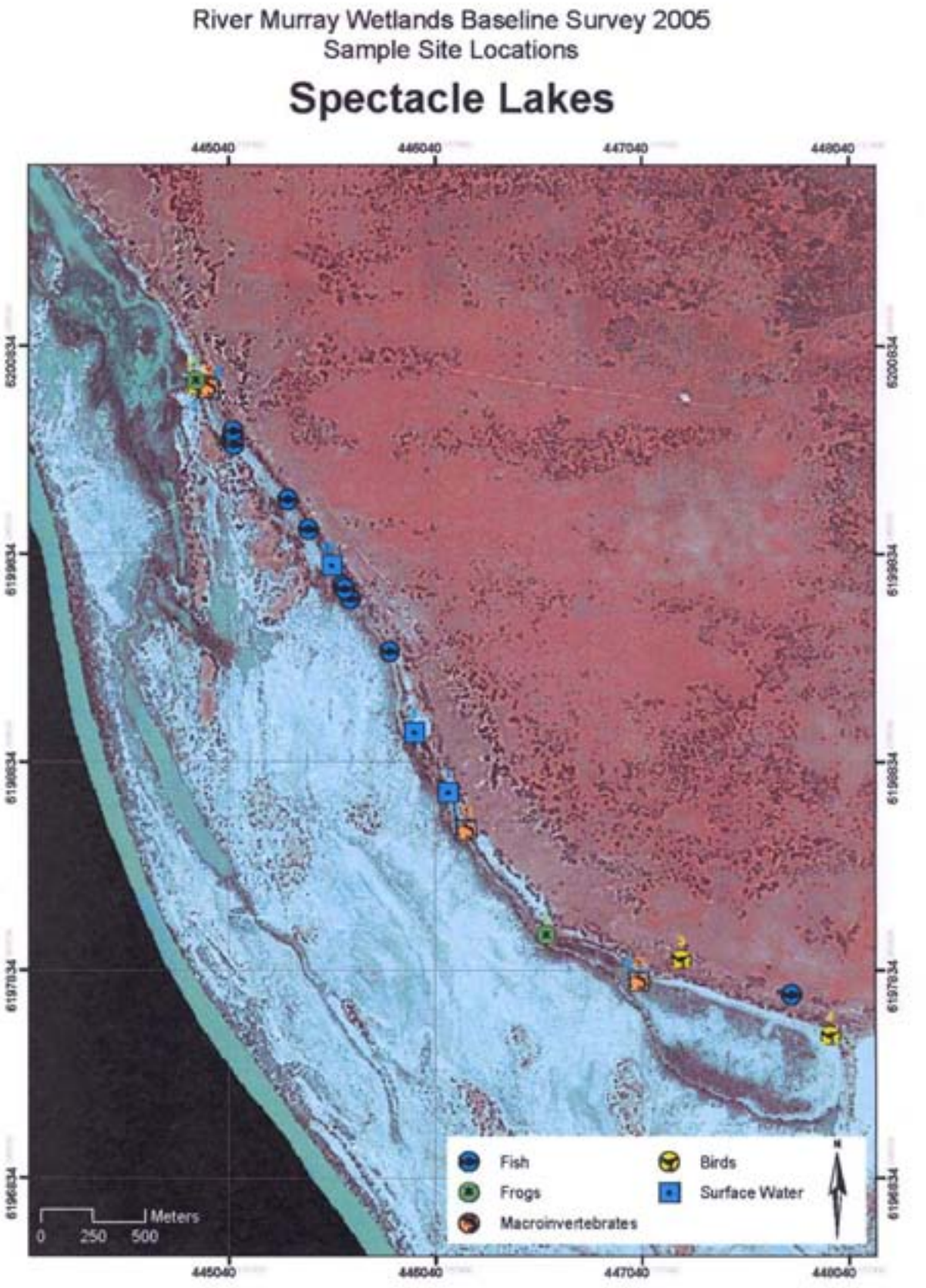
Note:
- Net loss of water (evaporation minus precipitation) determined using DWLBC Wetland Loss Calculator.
- All figures rounded to the nearest 5 ML.

APPENDIX 10. Community monitoring sites: Spectacle Lakes and Beldora wetlands



Note: Bird and fish monitoring also undertaken at Spectacle Lakes-Beldora.

APPENDIX 11a. Baseline Survey monitoring sites: Spectacle Lakes (2005)



APPENDIX 11b. Baseline Survey monitoring sites: Beldora wetlands (2004)