Lower Darling region

Lower Darling River System

The Lower Darling River System hydrologic indicator site is located in south-western New South Wales at the end of the Darling River. It is marked by the towns of Menindee in the north and Wentworth in the south. For the purposes of the proposed Basin Plan, three separate areas, or management units, were considered: the Menindee Lakes in the north, the Darling Anabranch in the west and the Lower Darling River in the east (Figure B9.1).

The Murray–Darling Basin Authority (MDBA) used inundation extents as determined by Kingsford, Thomas and Knowles (1999) to determine the lateral and longitudinal extent of the site to the confluence of the River Murray. Some areas were excluded where water could not be prescribed for the area. The Directory of Important Wetlands in Australia dataset (Department of the Environment, Water, Heritage and the Arts 2001) was used to determine internal areas of the site. Spatial data used to define the extent of this site (Figure B9.1) is listed in Table B1.3.

Menindee Lakes

In its without-development state, the Menindee Lakes system was a series of nine ephemeral lakes covering 45,000 ha adjacent to the Darling River. These lakes filled or partially filled with rising floodwaters through a series of small creeks. Flood frequencies of the different lakes varied from 1 in 2 years to 1 in 20 years (Kingsford, Jenkins & Porter 2002). The climate of the Menindee area is hot and dry with an average annual rainfall of 200 mm, which means that evaporation levels are high and a significant volume of water is lost from these lakes when they are inundated — an average evaporation rate of 62.8 GL/month (NSW Department of Land and Water Conservation 1998).

The Menindee Lakes storage scheme began in the 1960s and resulted in the construction of a series of small dams, weirs, regulators, channels and levees to contain Darling River floodwaters (NSW Department of Land and Water Conservation 1998). The four main lakes within the Menindee storage — Wetherell, Pamamaroo (including Copi Hollow), Menindee and Cawndilla — have a full storage capacity of 1,731 GL; this amount, however, can be surcharged to 2,050 GL to mitigate adverse impacts of flooding.

The Menindee Lakes scheme delivers water to South Australia to meet part — 39% on average — of its annual entitlement. As well as the allocation to South Australia, flows are released into the Lower Darling, to a maximum rate of 9,000 ML/d, to meet monthly target storage levels for Lake Victoria and to hold it full over summer to minimise losses as a result of evaporation from the Menindee Lakes (Thoms et al. 2000).

When flows do not have to be delivered to the Murray, flows down the Lower Darling River are approximately 100–500 ML/d. In addition to releases to meet downstream demands, water is released from Menindee Lakes to mitigate flooding. When flooding occurs, a pre-release of up to 23,000 ML/d is let go to create room for impending floods down the Darling (Thoms et al. 2000).

Darling Anabranch

The Darling Anabranch covers around 630,000 ha, and can be broken into the following three components based on their hydrologic nature:

- lakes — these comprise 14 main lakes, including the northern and southern anabranch lakes
- floodplains — although information on the characteristics of these floodplains is limited, they are mentioned in the wetland survey conducted by King and Green (1993)
- channel — the anabranch channel is the ancestral path of the Darling River; it extends 480 km from its offtake at the Darling River to its downstream junction with the River Murray, 15 km west of Wentworth.

Lower Darling River

The Lower Darling River includes the river channel and adjacent billabongs and wetlands. The river extends from Menindee Lakes to the junction of the Murray and the Darling at Wentworth, covering approximately 1,400,000 ha.

Values

The Lower Darling River System has been identified as a hydrologic indicator site in the Murray–Darling Basin because it meets three of MDBA's five key environmental asset criteria (Table B9.1).

Table B9.1 MDBA key environmental assets criteria: Lower Darling River System

Criterion	Explanation
1. Formally recognised in, and/or is capable of supporting species listed in, relevant international agreements	The Lower Darling River System is formally recognised in, or is capable of supporting species listed in the Japan–Australia Migratory Bird Agreement, the China–Australia Migratory Bird Agreement or the Republic of Korea – Australia Migratory Bird Agreement. For a full list of species listed under Commonwealth legislation that have been recorded in the Lower Darling River System see Table B9.5.
3. Provides vital habitat	The water-dependent ecosystem provides vital habitat. Traditionally, large colonies of breeding waterbirds used the Menindee Lakes. The *Handbook of Australian, New Zealand and Antarctic birds* (Marchant & Higgins 1990) refers to 5,000 nests and 20,000 pairs of great cormorant (*Phalacrocorax carbo)* on the Menindee Lakes in 1974. The high numbers recorded in 1974 have not been observed in subsequent years, probably because of the effects of regulation coupled with a lack of large flooding events that occurred throughout much of Australia in 1974–76. In addition, the regulation of the Menindee Lakes has diminished the value of the Lower Darling River System to waterbirds as foraging and breeding habitat. Reduced frequency of flooding has had a detrimental effect on waterbird communities using the area (Kingsford, Jenkins & Porter 2002). Nevertheless, a number of water-dependent ecosystems within the Lower Darling River System provide drought refuge for waterbirds when the other lakes in the region have dried up (NSW Department of Environment and Climate Change 2007). During field surveys conducted in 1992, when western New South Wales was in drought, waterbirds were concentrated on the deeper anabranch lakes, Lake Nearie and Little Lakes, which suggests their value as drought refuges in the southern Basin (King & Green 1993).
4. Supports Commonwealth-, state- or territory-listed threatened species and/or ecological communities	The Lower Darling River System meets this criterion because it supports species listed as threatened under state legislation. For a full list of species that have been recorded in the Lower Darling River System see Table B9.5.

Hydrology

Water resource development in the Lower Darling River System has significantly altered the hydrology of the system (Thoms et al. 2000). In turn, the altered hydrology has contributed to changes to the system's ecology (Kingsford, Jenkins & Porter 2002), some of which are outlined below as they relate to each management unit.

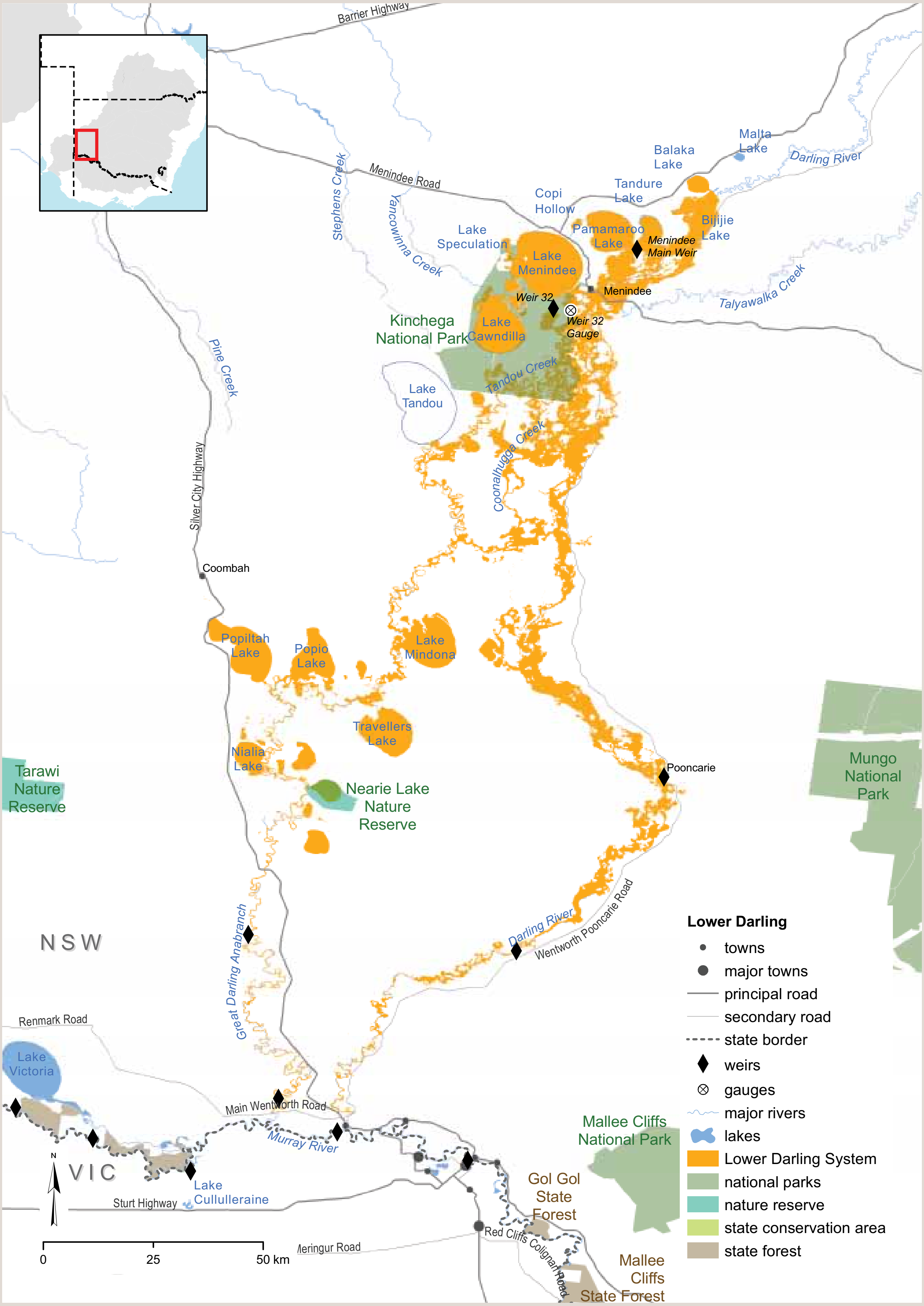

Figure B9.1 Location and extent of hydrologic indicator site: Lower Darling River System

Menindee Lakes

Significant changes to the hydrology of the lakes and their associated floodplains occurred after the Menindee Lakes storage scheme was built in the early 1960s. While most of the lakes in the system, which cover an area of 39,244 ha (the area also contains some small fringing wetlands that fill from rainfall only), now experience too much flooding, the 45,298 ha floodplain now experiences too little (Kingsford, Jenkins & Porter 2002).

This has significantly affected the vegetation and aquatic communities within the Menindee Lakes. For example, prior to the Menindee Lakes scheme, lakes Menindee and Cawndilla supported large expanses of lignum (*Muehlenbeckia florulenta*), black box (*Eucalyptus largiflorens*) and river red gum (*E. camaldulensus*). Of these two lakes, Menindee was the most vegetated while Cawndilla (being deeper and holding water for longer) was predominantly an open-water lake. Descriptions at the time the Menindee Lakes scheme was being built and reported in Kingsford, Jenkins and Porter (2002) suggest that:

- Lake Menindee was fringed by black box and river red gum, with 40% (6,600 ha) of the lakebed covered in lignum reaching 4.5 m, 30% (4,900 ha) covered by black box and the remaining area bare and colonised by aquatic species during flooding
- Lake Cawndilla was fringed by black box and river red gum, with 2% (100 ha) of the lakebed covered in black box and the remaining area bare and colonised by aquatic species during flooding.

However, many of the lakes are now open water with dead trees; in places, the lakes are surrounded by black box and river red gum woodlands. It is estimated that permanent inundation has caused a total loss of 13,800 ha of lignum and 8,700 ha of black box (Kingsford, Jenkins & Porter 2002). The vegetation communities that formerly colonised the lakebeds provided organic matter and productivity for aquatic communities during subsequent flooding. They also provided important nesting sites for waterbirds; there are reports of thousands of black swans (*Cygnus atratus*) breeding in the lignum shrubland covering Lake Menindee in the early 1960s and again in the late 1970s, signifying the value of this habitat (Kingsford, Jenkins & Porter 2002).

Using annual bird survey data collected from 1983 to 2001, Jaensch et al. (2002) showed that waterbird communities on the regulated lakes in Menindee were depauperate and considerably less dense than waterbird communities found on unregulated lakes within the Murray–Darling Basin. These authors concluded that variable wetting and drying probably contributed to most of the increased diversity on unregulated lakes (Jaensch et al. 2002).

Darling Anabranch

Although it supports a number of large lakes, the Darling Anabranch is normally dry, only flowing through to the River Murray under large flood events. In the past, flows down the anabranch were dominated by a stock and domestic flow volume of 50,000 ML delivered over about three months from late winter to early spring. This flow was restricted by a number of small weirs along the anabranch that ponded water in a series of weir pools (Thoms et al. 2000). These more permanent weir pools have influenced the nature of vegetation communities and limited fish passage along the anabranch.

Over the past 130 years, European settlers have lowered the main offtake of the anabranch to the Darling River. Undoubtedly this has increased the potential for flows down the anabranch. However, the reduction of flows to the main river caused by the Menindee Lakes storage scheme cancelled this out, resulting in flooding frequencies at the end of the anabranch system similar to those experienced under without-development conditions (Thoms et al. 2000).

A pipeline was completed in 1997 to deliver stock and domestic water to properties along the anabranch to improve flow transmission down the channel. Before the pipeline, only 3,000 ML was actually used for stock and domestic purposes out of a total flow volume of 50,000 ML (Earthtech Engineering 2004). The water savings from this project are committed to The Living Murray program to be used for environmental flows down the lower Darling; however, because of drought, no flows were released down the anabranch between 2002 and 2010 (SKM 2009b). Flows have been received down the anabranch in response to large flood volumes received from northern New South Wales in early 2010.

Lower Darling River

The hydrology of the Lower Darling River has been heavily modified by the operation of the Menindee Lakes storage scheme. Flow seasonality has been reversed, with higher flows now occurring in summer rather than in spring to autumn under without-development conditions (Thoms et al. 2000). Winter flow variability has been reduced, with flows of 200–500 ML/d occurring 65% of the time, while 10,000 ML/d flows have been reduced from occurring 25% of the time under without-development conditions to 10% of the time under current arrangements. The changes caused by the Menindee Lakes storage scheme together with other development in the Darling region have reduced flow volumes by 50% (Thoms et al. 2000).

Hydrologic changes to the Lower Darling have reduced the health of fish populations within the river, with native species diminishing in abundance and alien fish species such as European carp (*Cyprinus carpio carpio*) increasing in number (Gilligan 2009). However, the river reach between Menindee and Pooncarie supports one of the more robust (in terms of age structure) populations of Murray cod (*Maccullochella peelii peelii*) in the lower Murray–Darling Basin (C Sharp 2009, pers. comm., 16 December 2009).

Reductions to flows that inundate in-channel bench surfaces have affected the health of river red gum trees growing on the high-level benches (Green et al. 1998), and have also potentially reduced the supply of leaf litter and organic matter transported into the main channel ecosystem (Thoms & Sheldon 1997). The construction of several weirs along this stretch of channel has also affected fish movement and migration (Green et al. 1998).

Environmental objectives and targets

The following proposed environmental objectives have been determined for the Lower Darling River System using MDBA's key environmental asset criteria. Targets to achieve these objectives have been specified for flood-dependent vegetation communities considered essential to support wetland processes and to provide crucial habitat for identified flora and fauna species. These are outlined in Table B9.2.

Table B9.2 Environmental objectives and targets: Lower Darling River System

Objectives	Justification of targets	Target
To protect and restore ecosystems that support migratory birds listed under international agreements (Criterion 1)	The Menindee Lakes are a significant breeding site for migratory waterbirds listed under international agreements. Species listed under several international agreements are found in the lakes along the Darling Anabranch, particularly Nearie Lake. The wetlands along the Lower Darling River provide feeding and roosting sites for waterbirds listed under several international agreements.	Reinstate a more natural, variable flow regime in lakes Menindee and Cawndilla, one which is capable of supporting a diverse and productive range of wetland communities and waterbird breeding events (particularly colonial nesting waterbirds). Maintain Darling Anabranch floodplains and lakes in good condition. Maintain 100% of wetlands along the Lower Darling River to provide feeding and roosting sites for waterbirds.
To protect and restore water-dependent ecosystems that provide vital habitat (Criterion 3) To protect and restore water dependent ecosystems that support Commonwealth-, state or territory-listed threatened species and communities (Criterion 4)	The Menindee Lakes provide vital refuge for waterbirds and other biota in times of drought. The Lower Darling between Menindee and Pooncarie supports one of the most robust Murray cod populations in the Darling system. Increased inundation of benches and wetlands would improve river red gum health and increase nutrient and organic matter supply to the main river channel. The ecological communities of the Lower Darling drainage system are listed as threatened under the Fisheries *Management Act 1994* (NSW).	Maintain lakes Wetherell and Pamamaroo (upper lakes) as predominantly permanent water bodies to act as drought refuge for biota. Maintain longitudinal connections down the Darling Anabranch to support threatened ecological communities. Maintain riparian red gums and higher level wetlands in good condition. Maintain low-lying wetlands in good condition, and provide conditions to enable fish movement.

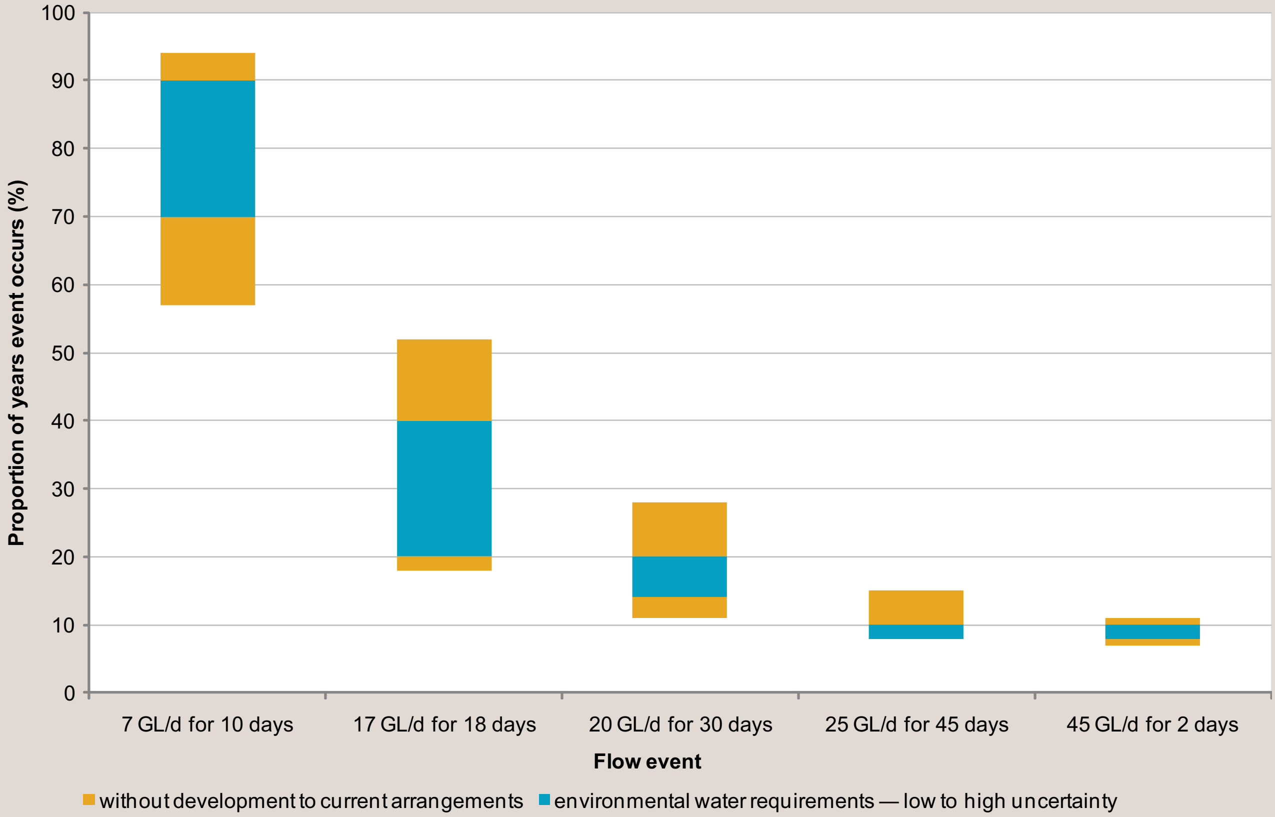

Figure B9.2 Recommended environmental water requirements and the proportion of their occurrence under without-development flows and current arrangements, 1985–2009: Lower Darling River System

Environmental water requirements

The environmental water requirements for the Lower Darling River System are outlined in Table B9.3, along with a summary of the flow parameters suggested at the Weir 32 gauge on the Darling River. A range of flow proportions are reported for each flow event, including the low and high uncertainty proportions suggested as necessary to sustain this asset. For comparison, the modelled without-development proportions and those experienced with current arrangements in place are also presented (see Figure B9.2 for a graphical representation of this information), as is the justification for the flow parameters chosen to fulfil each target.

Menindee Lakes

The Menindee Lakes management unit includes all the lakes within the Menindee lakes storage scheme, from Malta Lake in the north to Lake Cawndilla in the south.

The targets set for this management unit are to:

- conserve the permanent flow regimes of several lakes (the upper lakes — Menindee Lakes, target 1)
- restore more variable flows in other lakes (the Lower Lakes — Menindee Lakes, target 2).

More stable water levels in the Menindee Lakes have negatively affected the flora and fauna within these areas (Kingsford, Jenkins & Porter 2002). It is suggested that reinstating a variable flow regime in either or both Lake Menindee and Lake Cawndilla would provide additional feeding habitats for resident waterbirds, which could increase their diversity and abundance, especially of some migratory shorebird species that inhabit this system (Jaensch et al. 2002).

For example, the drying of both Lake Menindee and Lake Cawndilla in 1995 and early 1996 was accompanied by significant increases in the number and density of birds using the lakes when they were full (Kingsford, Jenkins & Porter 2002). It is thought that a more variable flow regime in these lakes would also increase the diversity and abundance of aquatic plants, invertebrates and native fish, and might encourage terrestrial vegetation such as lignum and black box to re-establish in some parts of the lakebeds, which would provide roosting and breeding habitat for waterbirds (SKM 2009a).

A report by Jaensch et al. (2002) made several recommendations for the environmental management of the Menindee Lakes system, including that:

- highest priority should be given to protecting and enhancing shallow freshwater marsh, recently exposed lakebed (mudflats), floodplain woodland and lignum swamp with *Eleocharis* sedgeland
- current water regimes generally should be maintained at Malta Lake, Lake Wetherell, Bijijie Swamp and Lake Speculation because they exhibited the highest conservation value for waterbirds (however, the report also recommend delaying or slowing drawdown to increase breeding activity and use by some vulnerable species)
- substantial drawdown, ideally at close to without-development rates, of at least one of the large open lakes (Lake Cawndilla or Lake Menindee) may be required if internationally significant numbers of migratory shorebirds are to be attracted to the system.

Table B9.3 Environmental flow requirements: Lower Darling River System

Target	Event				Proportion of years event required to achieve target (%)		Proportion of years event occurred under modelled without-development condition (%)	Proportion of years event occurred under modelled current arrangements (%)
	Flow rule	Flow required (measured at Weir 32)	Duration	Timing	Low uncertainty	High uncertainty		
Maintain lakes Wetherell and Pamamaroo (upper lakes) as predominantly permanent water bodies to act as drought refuge for biota	Maintain current operating rules							
Reinstate a more natural, variable flow regime in lakes Menindee and Cawndilla that is capable of supporting a diverse and productive range of wetland communities, and waterbird breeding events (particularly colonial nesting waterbirds)	1	56.0 m in Menindee^ 53.8 m in Cawndilla^	Fill to level and drawdown at near natural rate	January to December	80	80	81	85
	2	56.5 m in Menindee^ 54.5 m in Cawndilla^			50	50	50	80
	3	57.5 m in Menindee and Cawndilla^			15	15	16	70
	4	58.5 m in Menindee and Cawndilla^			9	9	9	58
Maintain longitudinal connections down the Darling Anabranch to support threatened ecological communities[a]	6	20,000 ML/d	30 days		20	14	24	10
Maintain Darling Anabranch floodplains and lakes in good condition	7	25,000 Ml/d	45 days	January to December	10	8	13	7
Maintain 100% of wetlands along the Lower Darling River to provide feeding and roosting sites for waterbirds	8	45,000 ML/d	2 days		10	8	10	8
Maintain low-lying wetlands in good condition, and provide conditions to enable fish movement long the Lower Darling River	9	7,000 ML/d	10 days		90	70	95	57
Maintain riparian red gums and higher level wetlands in good condition along the Lower Darling River[a]	10	17,000 ML/d	18 days		40	20	44	18

^ Lake flows are presented as lake-full levels in metres above Australian Height Datum (AHD), which approximate the metres above sea level.

a It is envisaged that flow rule 7 will be increased to 20,000 ML/d for 30 days every second delivery (one year in five) to provide flow rule 3 and fulfil this.

The targets outlined for the Menindee Lakes management unit in Table B9.3 reflect recommendations made by Jaensch et al. (2002). The current operation trend for the Menindee Lakes storage scheme is to keep water levels in the upper lakes (i.e. lakes Pamamaroo and Wetherell) as high as possible. It is envisaged that by using this strategy, these lakes would act as more secure water sources for the biota that inhabit the area and possibly provide drought refuges. Lake Wetherell also provides a relatively diverse range of habitats for the biota compared to the other lakes in the system (SKM 2009b).

Lakes Menindee and Cawndilla (the Lower Lakes) experience more variable flow regimes under both without-development and current conditions, although this variability has been severely reduced with development. Without development these lakes would fill every second year and stay inundated for an average of 0.8 years for Menindee and, because of its increased depth, 4 years for Cawndilla (SKM 2009b). Under current arrangements the lakes stay full for much longer, being inundated for an average of 4.3 years for Menindee and 11.4 years for Cawndilla (SKM 2009b). However, both lakes remained dry for a 7-year period (2002–09) because of severe drought conditions and low inflows.

It is proposed that a more variable flow regime be reinstated to lakes Menindee and Cawndilla, with targets set around a range of identified lake levels (Table B9.3). The intention is for these lake levels to be reached by filling the lake(s) and then drawing down at a rate consistent with the without-development rate of drawdown (see text on Cawndilla). It should be noted that the environmental watering targets are proposed to be indicative of variable and adaptive management through a long-term environmental watering plan. Actual events will vary in their magnitude and frequency, to promote diverse vegetation communities and respond to changes in climatic conditions over time (i.e. larger, more frequent watering in wet periods and smaller, less frequent watering in dry periods).

56 m Australian Height Datum in Lake Menindee

A low-level fill to 56 m in Lake Menindee is proposed in 80% of years. Filling Lake Menindee to this level would result in a lake level of around 53.8 m in Lake Cawndilla, corresponding to volumes of around 60 GL in Menindee and 50 GL in Cawndilla. At this level, approximately 10,000 ha of Lake Menindee and 6,200 ha of Lake Cawndilla would be covered in water to a maximum depth of around 1.5 m. This frequent filling event is expected to produce conditions suitable for the establishment of aquatic wetland species and lignum in the lower sections of Menindee's lakebed.

The specific result in Lake Cawndilla would depend on rates of drawdown in the lake (see section on drawdown options below).

56.5 m Australian Height Datum in Lake Menindee

Bathymetry of Menindee and Cawndilla lakebeds suggests that the lakes are 'saucer' shaped. This means that as the lakes fill initially, large increases in surface area are seen with relatively small increases in lake level. Critical areas of the surface area/lake level relationship can be targeted to achieve maximum surface area of water coverage in the lakes for the least amount of water. Most of the surface area for Cawndilla is obtained at a lake level of around 54.5 m AHD. In Lake Menindee, this level is around 57 m AHD.

It is estimated that filling Lake Menindee to 56.5 m will fill Lake Cawndilla to around 54.5 m. At the 54.5 m level, 7,000 ha of Lake Cawndilla would be inundated and the lake would contain a volume of around 84 GL. At 56.5 m, approximately 13,000 ha of Lake Menindee would be inundated and the lake would contain a volume of about 116 GL, with a maximum depth of 1.8 m. It is proposed that this event be provided in 50% of years, and it is anticipated that it will provide conditions suitable to the re-establishment of lignum and, potentially, river red gum communities in these areas of the lakes.

57.5 m Australian Height Datum in Lake Menindee

The height of connection through Morton Bulka is a significant constraint to filling Lake Cawndilla. A lake height of 57.5 m in Menindee will cause significant flows through Morton Bulka, and provide similar water heights in Lake Cawndilla to those experienced in Lake Menindee. At 57.5 m in both lakes, 14,800 ha (around 90%) of Lake Menindee is inundated to a maximum depth of 2.8 m and 9,900 ha (around 80%) of Lake Cawndilla is inundated to a maximum depth of 4.8 m. Inundating the lakes to this level in 15% of years is expected to provide conditions suitable for the re-establishment of black box and lignum communities over most of the lakebed.

58.5 m Australian Height Datum in Lake Menindee

The highest lake-filling target is set to the estimated without-development lake-full levels of both Menindee and Cawndilla lakes. The lake-full levels were informed by modelling undertaken by Bewsher Consulting (2000), as reported by Taylor-Wood et al. (2001). This report suggests the lake-full surface area of Lake Menindee was around 16,000 ha, which corresponds to a lake level of 58.5 m AHD. Lake Cawndilla was reported to have a without-development lake-full surface area of 9,400 ha, corresponding to a lake-level of 58.1 m AHD. Therefore, the height suggested for the largest lake-full level is 58.5 m in both lakes, corresponding to 410 GL in Menindee and 470 GL in Cawndilla. Providing this level in 9% of years would encourage the re-establishment of fringing black box communities.

Drawdown options

Lake Menindee

Lake Menindee drains via a channel between the lake and the Darling River. With the development of the Menindee Lakes scheme, the without-development channel was regulated. This regulator severely restricts the peak capacity of the channel, and the lakes now drain at a slower rate than they would have done under without-development conditions.

It is recommended that this regulator be closed during the filling of Lake Menindee to the intended level and then fully opened to allow Lake Menindee to drain as quickly as possible.

Cawndilla Lake

Under without-development conditions, the only way Lake Cawndilla drained was back through the channels of Morton Bulka to Lake Menindee; there was no other channel to or from the lake. During the Menindee Lakes scheme, a channel was cut between Lake Cawndilla and the Darling Anabranch, to provide flows out of the lake into the anabranch channel, and a regulator was installed in this channel to control flows. Therefore, water levels in Lake Cawndilla can be drawn down more quickly using the current infrastructure than under without-development conditions.

Two options are presented for the drawdown of water in Lake Cawndilla:

- Option 1 — no release from Lake Cawndilla outlet regulator

Minimising the use of the regulator would mean that water would stay in the lake for longer and be drawn down by evaporation only once the lake reached below the level of Morton Bulka. The resultant longer duration of inundation in the lake would prevent the establishment of perennial species such as lignum, river red gum and black box, and would maintain the lake in a more open water state, similar to how it would have been without development.

- Option 2 — release water from the Lake Cawndilla regulator to provide anabranch flows

By using the Lake Cawndilla outlet channel, water could be delivered to the anabranch, providing flows to Tandou, environmental flows to the anabranch and potentially flows to the Murray via the anabranch. Drawing down of Lake Cawndilla using the outlet channel would potentially return up to 160 GL of water, resulting in significantly improved water savings and potentially providing some environmental benefits to the anabranch. However, it would change the character of the lake from that indicated under option 1. A faster rate of drawdown would reduce the duration of inundation, making the lakebed suitable for colonisation by perennial species such as lignum, river red gum and black box. It is uncertain whether this would have a positive or negative environmental impact.

It is worth noting that lakes Wetherell and Pamamaroo are maintained as near-permanent water bodies, providing additional open water habitat that would not be available without development. This may potentially offset some of the impacts of losing the open water habitat in Cawndilla.

Darling Anabranch

This management unit includes the anabranch channel, associated channels floodplains and wetlands and the larger anabranch lakes.

The targets and water requirements set for the Darling Anabranch management unit reflect the need to provide:

- more frequent smaller flows to inundate deep pools and areas close to the channel
- fish passage
- a larger, less infrequent flow to inundate wetlands, lakes and floodplains within the system.

The Darling Anabranch Management Plan (Nias 2002) proposed an environmental flow for the Darling Anabranch of 60 to 75 GL per release with a two-year frequency averaged over 10 years, along with requirements that:

- an end-of-stream flow should occur for each event
- between 1,500 and 2,000 ML/d for 30 to 45 days should be released to the anabranch
- periods between environmental flows should not exceed three years.

A flow of 1,500 ML/d has been reported to exceed the banks of the anabranch in many places (GHD 2008). Analysis of the modelled flow data at Wycot on the anabranch revealed that a flow of 1,500 ML/d for 30 days would have occurred with a frequency of 1 in 5 years under without-development conditions, and 1 in 10 years under current arrangements. Modelling suggests that a flow of 20,000 ML/d (measured at Weir 32) down the Darling River would provide a flow of around 1,500 ML/d down the anabranch; therefore, this threshold was adopted as one of the Darling Anabranch targets, with a duration of 30 days for 1 year in 5.

Most information about the inundation thresholds of the wetlands, lakes and floodplains along the Darling Anabranch is anecdotal, and hard data on flow levels for out-of-channel features is scarce (GHD 2008). King and Green (1993) undertook a wetland survey from 1990 to 1992 and noted the extent of inundation and duration of wetting that resulted from a large flood event in 1990. Successive field surveys in late 1992 provided some indication of the duration of inundation for many of the larger lakes and wetlands within the system. This level of inundation was identified as a target to maintain Darling Anabranch floodplains and lakes in good condition. Stipulating a flow of the magnitude required by flow rules 4 and 5 (Table B9.3) is justified, because it would invigorate floodplain communities such as black box and river red gum, provide vital habitat for significant species that inhabit the anabranch and potentially provide drought refuge in successive years.

The actual flow hydrograph for the Darling River at Weir 32 and the Darling Anabranch at the Wycot gauge is presented in Figure B9.3. As seen in the hydrograph, the flooding experienced down the anabranch in August 1990 (with an approximate peak of 17,000 ML/d) resulted from a 45,000 ML/d peak flow at Weir 32. Analysis of the flow data suggests that without development, a flow of this magnitude would have occurred 11 times between 1900 and 2009, with a return interval of approximately 10 years. Under the current arrangements model scenario, it would have occurred 9 times over the same 109-year period, or approximately once every 12 years. Therefore, the frequency of flow suggested to maintain the floodplains and lakes of the Darling Anabranch is close to the without-development value — 1 in 10 years.

The magnitude of this flow was set at 25,000 ML/d at the Weir 32 gauge, which provides a significant flow into the anabranch — the anabranch offtake from the Darling begins to flow at around 9,000 ML/d. By comparing without-development flows with a flow peak of around 45,000 ML/d (one comparison done in 1955 and another in 2001), a duration of 45 days is stipulated.

Lower Darling River

This unit includes the main channel below Weir 32 and the associated wetlands and floodplains that occur when riverbanks are breached by floods along the Darling River.

The suggested targets and water requirements were based primarily on findings presented in Green et al. (1998). That report identified the key flows required for a number of environmental and ecological outcomes (including wetlands, channel benches, water quality, riparian vegetation, fish, macroinvertebrates and waterbirds) along the Lower Darling from Menindee to Wentworth. The report's authors identified specific flow bands that would inundate a number of wetlands and bench surfaces (Table B9.4).

One of the Darling River targets was aimed at:

- providing conditions suitable for fish passage
- flushing the Lower Darling channel
- inundating a small percentage (21%) of wetlands along the Lower Darling.

A threshold of 7,000 ML/d (suggested in Green et al. 1998) was adopted for the purposes of the proposed Basin Plan.

A second target was chosen for the Lower Darling River to maintain riparian red gums and higher level wetlands in good condition. From Table B9.4, it appears that a significant increase in wetland inundation (68% of wetlands inundated) occurs at a flow level of 17,000 ML/d at Weir 32. This flow level would also inundate at least 50% of bench surfaces sampled in the reach and associated fringing river red gum. Thus, 17,000 ML/d was considered an appropriate flow level to target in this reach, for both fringing red gums and wetlands. Wetlands along the Lower Darling River can hold water from between 7 to 12 months after inundation (Shaikh, Green & Cross 2001). The suggested flow frequency of 2 in 5 years would allow the wetlands to stay wet for a period and then dry, reinstating a more without-development flow regime.

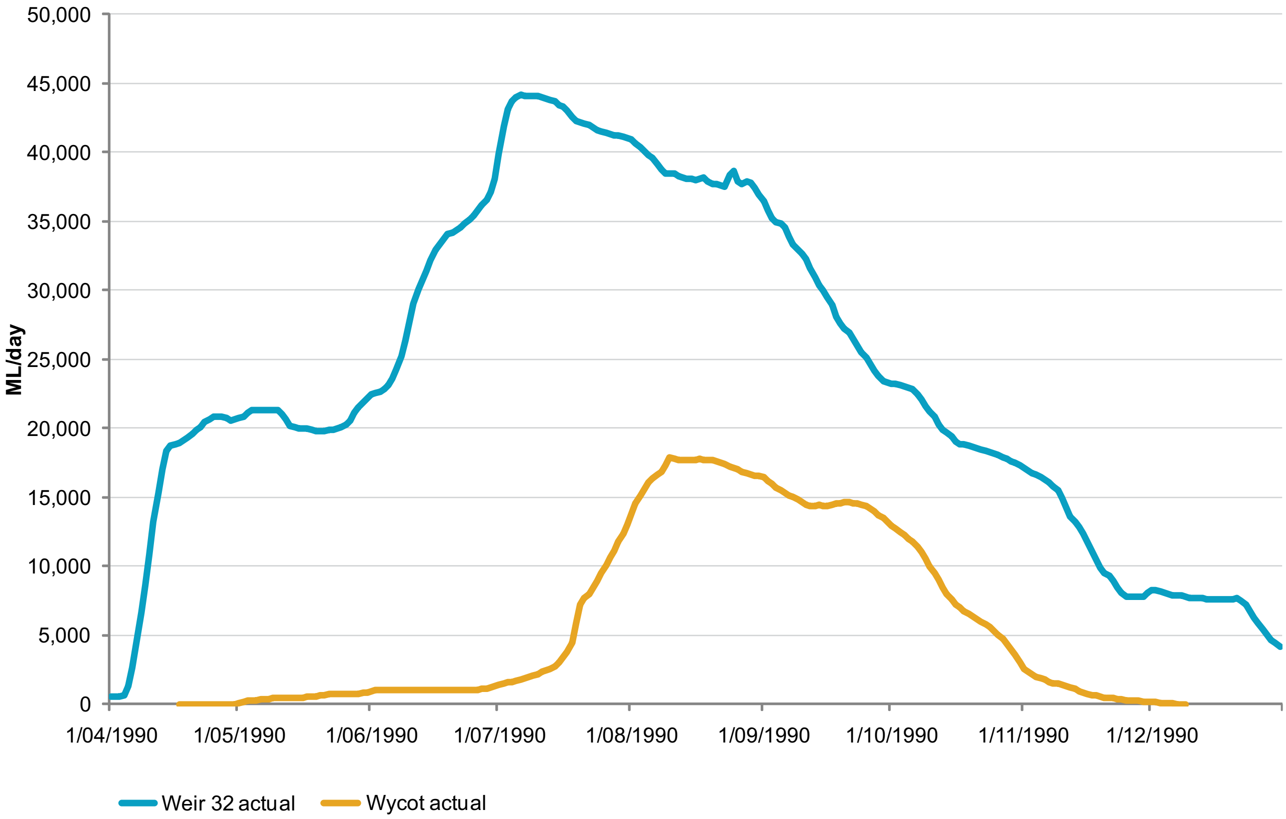

Figure B9.3 Flow hydrograph during 1990, Darling River (Weir 32) and Darling Anabranch (Wycot gauge): Lower Darling River System

Source : www.waterinfo.nsw.gov.au

Table B9.4 Number of wetlands and in-channel bench surfaces inundated within various flow bands: Lower Darling River

Wetlands			
Flow band (ML/d at Weir 32)	Number of wetlands flooded	Cumulative percentage of wetlands flooded	
<7,000	15	13	
7,000 to 17,000	63	68	
17,000 to 29,000	25	90	
>29,000	11	100	
In-channel bench surfaces			
Flow band (ML/d at Burtundy)	Number of benches sampled	Cumulative percentage of benches sampled	
		Number	Area (ha)
4,000 to 11,000	10	42	15
11,000 to 17,000	7	71	43
17,000 to 22,000	3	84	54
22,000 to 23,000	2	92	94
<23,000	2	100	100

Table B9.5 Species relevant to criteria 1 and 4: Lower Darling River System

Species	Recognised in international agreement(s)[1]	*Environmental Protection and Biodiversity Conservation Act 1999* (Cwlth)	*Fisheries Management Act 2004* (NSW)	*Threatened species conservation Act 1995* (NSW)
Birds				
Australasian bittern (*Botaurus poiciloptilus*)[3]				V
Australian bustard (*Ardeotis australis*)[4]				E
Barking owl (*Ninox connivens*)[4]				V
Black-breasted buzzard (*Hamirostra melanosternon*)[3]				V
Blue-billed duck (*Oxyura australia*)[2, 3]				V
Brolga (*Grus rubicundus*)[3]				V
Brown treecreeper (*Climacteris picumnus*)[4]				V
Bush stone-curlew (*Burhinus grallarius*)[4]				E
Caspian tern (*Hydroprogne caspia*)[3]	✓			
Common sandpiper (*Actitis hypoleucos*)[3]	✓			
Eastern great egret (*Ardea modesta*)[3]	✓			
Freckled duck (*Stictonetta naevosa*)[2, 3]				V
Glossy ibis (*Plegadis falcinellus*)[3]	✓			
Grey falcon (*Falco hypoleucos*)[4]				V
Hooded robin (*Melanodryas cucullata*)[4]				V
Lesser sand-plover (*Charadrius mongolus*)[4]				V
Major Mitchell's cockatoo (pink cockatoo) (*Lophochroa leadbeateri*)[4]				V
Malleefowl (*Leipoa ocellata*)[4]				E
Red-tailed black-cockatoo (*Calyptorhynchus banksii*)[4]				V
Redthroat (*Pyrrholaemus brunneus*)[3]				V
Sanderling (*Calidris alba*)[4]				V
Scarlet-chested parrot (*Neophema splendida*)[4]				V
Southern scrub-robin (*Drymodes brunneopygia*)[4]				V
Square-tailed kite (*Lophoictinia isura*)[4]				V
Stripe-faced dunnart (*Sminthopsis macroura*)[4]				V
Yellow-tailed plain slider (*Lerista xanthura*)[4]				V
Fish				
Freshwater catfish (*Tandanus tandanus*)[2]			E	
Murray cod (*Maccullochella peelii peelii*)[2]		V		
Silver perch (*Bidyanus bidyanus*)[2]			V	
Mammals				
Inland forest bat (*Vespadelus baverstocki*)[4]				V
Little pied bat (*Chalinolobus picatus*)[3]				V

... continued

Table B9.5 Species relevant to criteria 1 and 4: Lower Darling River System (continued)

Species	Recognised in international agreement(s)[1]	*Environmental Protection and Biodiversity Conservation Act 1999* (Cwlth)	*Fisheries Management Act 2004* (NSW)	*Threatened species conservation Act 1995* (NSW)
Plants				
Bluebush daisy (*Cratystylis conocephala*)[4]				E
Burr daisy (*Calotis moorei*)[4]				V
Button immortelle (*Leptorhynchos waitzia*)[4]				E
Menindee nightshade (*Solanum karsense*)[4]				E
Phyllanthus maderaspatensis (*Phyllanthus maderaspatanus*)[4]				V
Purple-wood wattle (*Acacia carneorum*)[4]				V
Silky swainson-pea (*Swainsona sericea*)[4]				E
Speargrass (*Austrostipa gibbosa*)[4]				E
Violet swainson-pea (*Swainsona adenophylla*)[4]				V
Yellow Darling pea (*Swainsona pyrophila*)[4]				E
Yellow-keeled swainsona (*Swainsona flavicarinata*)[4]				
Communities				
Lowland Darling River aquatic ecological community[2]			E	

E = endangered V = vulnerable

1 Japan–Australia Migratory Bird Agreement, China–Australia Migratory Bird Agreement, or Republic of Korea – Australia Migratory Bird Agreement

2 Murray–Darling Basin Commission (n.d.)

3 NSW National Parks and Wildlife Service (2007)

4 NSW Department of Environment, Climate Change and Water (2009e)