QON 12 & 13 - Attachment A

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Assessment of proposed watering actions against the CEWH's criteria for short-listing priorities in 2009-2010.

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
Hattah Lakes Lower Murray (Vic)	6,000 – 15,000	270,000 – 600,000	• Water delivery will build on spring watering, providing between 250 ha to over 792 ha of wetland habitat within the Hattah system. This area would provide an important drought refuge for waterbirds and other wetland dependent species, such as turtles and frogs. • With five lakes currently inundated there is presently the opportunity to water up to 8 other lakes in the system, which have not received water for between 4-14 years. Access to the lake system will be restricted during 2010/11 due to the intended construction of the TLM pumping station. • High certainty of benefit due to previous watering history and high certainty of negative impact if not watered (further decline in RRG condition);	**1. Ecological Significance** – Living Murray Icon Site. The Hattah Lakes are important wetlands with 12 lakes within the complex listed by the International Ramsar Convention on Wetlands (Critera 1 – supports three vegetation classes considered rare (lake bed herbland, intermittent swampy woodland and riverine grassy woodland) and two wetland classes of which a significant proportion of remaining sites within the region are found within the Ramsar site (deep freshwater marshes and permanent open freshwater wetlands) and 3 – maintains regional biodiversity by providing habitat for over 50 species of waterbirds - DEWHA). When the Lakes are inundated they provide habitat for 47 waterbird species. Twelve (12) species of migratory bird species listed under the JAMBA and CAMBA agreements inhabited the lakes as a result of the last full scale watering in 2006, including the Painted Snipe (DSE proposal 2009). **2. Expected ecological outcomes** – Provide drought refuge for waterbirds and water stressed red gums; avoid irreversible loss / catastrophic event. 5 lakes currently wet from previous watering. The watering would maintain water level in these lakes and achieve flow on to other connected lakes in the system, and in which the condition of fringing red gums is declining markedly (B. Rodgers, Parks Victoria, pers. comm.). This poor condition is consistent with previous TLM watering for the broader Hattah Lakes icon site (TLM 2008). Redgum sites across the Mallee region that have historically received watering have demonstrated a beneficial response to these actions (BL&A 2009). Benefits are also expected to the ephemeral Chalka Creek via which the water will be delivered to the lakes. Significant numbers of waterbirds have also been recorded at Hattah Lakes following watering (TLM 2008 and DSE proposal 2009) **3. Potential risks** – The risks associated with the water activity are low, as the sites have been previously watered. Mallee CMA, in conjunction with Parks Victoria, has extensive experience managing watering events at Hattah. The lakes are also terminal for environmental delivery allowing any negative outcomes to be isolated both as a whole and individually. **4. Long-term sustainability** – 6.2 GL has already been delivered to the site from the Victorian and Commonwealth environmental water holders in late spring 2009; any additional water allocated will increase the area flooded and improve the ecological benefits of watering. This will be the last opportunity to deliver water before the shut down of the delivery works during 2010/11 due to the construction of new works. The site is both a National Park and a TLM Icon site. It is supported by an integrated management plan with clear management objectives. Watering action is supported by integrated monitoring arrangements co-ordinated by Mallee CMA (consisting of basic compliance monitoring in conjunction with river red gum monitoring and bird surveys) and works to install permanent delivery pumps scheduled for spring 2010.

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
				5. Cost effectiveness – Pumping required, however reasonable cost-effectiveness for volume compared to other pumped sites.
Paiwalla Lower Murray (SA)	241	25,500	• High need (drought refuge below Lock 1) and Very high long term sustainability (commence to flow at normal pool); • Presence of diverse range of birds and amphibians, some of which are threatened species; • Strong support from community group to rehabilitation and maintenance of site; • Site Management Plan in place; • Risk of acid sulphate soils if dried; • Watered in March and June 2009 using Commonwealth water.	**1. Ecological Significance** – provision of fresh water drought refuge below Lock 1 (reach over 200 km), habitat for Painted Snipe (Vul - EPBC Act, CAMBA) and other listed bird and amphibian species, migratory birds **2. Expected ecological outcomes** – Maintain health of wetland and wetland dependent species; current condition: wet – watered in March and June 09 using Commonwealth water. **3. Potential risks** – Previously watered – no risks identified. **4. Long-term sustainability** – Long term sustainability secure (management plan and State and community commitment); previously watered using Commonwealth water. **5. Cost effectiveness** – State to provide monitoring and project management. SA will contribute to the water; operationally feasible: pumping required.
Coombool Swamp - Chowilla (including Brandy Bottle Waterhole, Werta Wert and Coombal Swamp) Lower Murray (SA)	3,650	150,000 (50,000 SA)	• Avoid further loss of mature stands of long-lived veg (black box and associated veg) that provides habitat to many spp. • Provide critical drought refuge - potentially promote Southern Bell Frog breeding events, and habitat for waterbirds (these wetlands have not been watered before and rewetting of areas provides abundant food source and breeding condition for many waterbirds) • Prevent transformation of terrestrial to salt tolerant veg - may require multiple waterings. (Coombal) • Coombal likely to act as a drought refuge as waters is likely to persist for longer than 6 months	**1. Ecological Significance** – Ramsar and DIWA listed: The Riverland Ramsar site (Chowilla Floodplain) is a representative example of a major floodplain system within the Murray Scroll Belt Subregion of the Riverina Biogeographical Region of the Murray Darling Basin. The site supports nationally threatened and contains a diverse range of habitat types and supports elements of biological diversity that are rare and particularly characteristic of the biogeographical region as well as providing critical drought refuge and summer or stopover habitat for migratory birds listed under international agreements. Chowilla regularly supports 20,000 or more waterbirds involving fifty-nine species including large populations of Freckled Duck, Red-necked Avocet and Red-kneed Dotterel whose numbers represent greater than 1% of the estimated global population. Riverland supports 14 of the 26 species of freshwater native fish species represented within the Murray-Darling Basin and the Chowilla Anabranch within the Riverland wetland is an important pathway for the migration of Golden Perch and Silver Perch around Lock 6 on the River Murray. The site also provides fish breeding and nursery habitats for these and other fish species (DEWHA, 2009) Chowilla Floodplain retains much of the area’s natural character and attributes. It has a high diversity of both terrestrial and aquatic habitats; supports populations of rare, endangered and nationally threatened species (TLM, 2006-07, vi). It contains the largest remaining area of natural River Red Gum forest in the lower River Murray (Sharley and Huggan 1995). The area also supports four nationally threatened species: Souterhn Bell Frog, Regent Parrot, Murray Cod and Murray Hardyhead and 23 state listed species (DEH 2005). **2. Expected Outcomes** – Maintain health of habitat for a range of fauna and flora. It is expected that application of environmental water will freshedn the groundwater, improving conditions and enabling recovery of flood dependent

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
				vegetation. Currently this vegetation is being replaced by salt tolerant assemblages of species. **3. Risks of watering action** – The risk has been deemed low due to success of previous watering on the Chowilla floodplain. Also, if a water quality issue did arise, this would be localised to the site as it is disconnected from the channel or anabranch. • **4. Long-term sustainability of Asset** – The site would be inundated by the proposed Chowilla Creek environmental regulator. • Coombal Swamp has not been previously watered (last overbank flow in 2000); Brandy Bottle Waterhole has been watered three times (2005, 2006 and 2009); Werta Wert has been watered three times (2004, 2005, 2008). • Previous monitoring of watering events in the floodplain indicate that many vegetation communities have benefited from the water, provided habitat for threatened bird species, and provided breeding opportunities for frogs and birds. **5. Cost effectiveness** – Site management, watering and monitoring to be undertaken by SA MDM NRM Board. Monitoring is also contributed by SARDI, DWLBC, the Murray Darling Freshwater Research Centre, DEH and other consultants. Management plans for Chowilla exist.
Lake Limbra – Chowilla, (including Hancock Creek and partial fill of Lake Limbra) Lower Murray (SA)	4,500	150,000 (50,000 SA)	• Avoid further loss of mature long-lived veg (black box and associated veg) that provides habitat to many spp. • Provide critical drought refuge - provide habitat for waterbirds (these wetlands have not been watered before and rewetting of areas provides abundant food source and breeding condition for many waterbirds) • A range of habitat types will be inundated	**1. Ecological Significance** – Ramsar and DIWA listed: The Riverland Ramsar site (Chowilla Floodplain) is a representative example of a major floodplain system within the Murray Scroll Belt Subregion of the Riverina Biogeographical Region of the Murray Darling Basin. The site supports nationally threatened and contains a diverse range of habitat types and supports elements of biological diversity that are rare and particularly characteristic of the biogeographical region as well as providing critical drought refuge and summer or stopover habitat for migratory birds listed under international agreements. Chowilla regularly supports 20,000 or more waterbirds involving fifty-nine species including large populations of Freckled Duck, Red-necked Avocet and Red-kneed Dotterel whose numbers represent greater than 1% of the estimated global population. Riverland supports 14 of the 26 species of freshwater native fish species represented within the Murray-Darling Basin and the Chowilla Anabranch within the Riverland wetland is an important pathway for the migration of Golden Perch and Silver Perch around Lock 6 on the River Murray. The site also provides fish breeding and nursery habitats for these and other fish species (DEWHA, 2009) Chowilla Floodplain retains much of the area's natural character and attributes. It has a high diversity of both terrestrial and aquatic habitats; supports populations of rare, endangered and nationally threatened species (TLM, 2006-07, vi). It contains the largest remaining area of natural River Red Gum forest in the lower River Murray (Sharley and Huggan 1995). The area also supports four

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
				nationally threatened species: Souterhn Bell Frog, Regent Parrot, Murray Cod and Murray Hardyhead and 23 state listed species (DEH 2005). **2. Expected Outcomes** - Maintain health of habitat for a range of fauna and flora. It is expected that application of environmental water will freshen the groundwater, improving conditions and enabling recovery of flood dependent vegetation. Currently the lake contains saline scalds. Benefits may not be realised in one watering event. **3. Risks of watering action** – SA has assessed the risk as low due to success of previous watering on the Chowilla floodplain. Also, if a water quality issue did arise, this would be localised to the site as it is disconnected from the channel or anabranch. • **4. Long-term sustainability of Asset** – • The site would be inundated by the proposed Chowilla Creek environmental regulator. Last received partial inundation in 2000 as a result of natural flooding. • Given current state of this wetland if will require repeated watering events. • Previous monitoring of watering events in the floodplain indicate that many vegetation communities have benefited from the water, provided habitat for threatened bird species, and provided breeding opportunities for frogs and birds. **5. Cost effectiveness** – Site management, watering and monitoring to be undertaken by SA MDM NRM Board and DEH. Monitoring is also contributed by SARDI, DWLBC, the Murray Darling Freshwater Research Centre, DEH and other consultants.. Management plans for Lake Limbra (Draft) and the whole Chowilla Flood plain exist.
Kulkurna BB site – Chowilla Lower Murray (SA)	150	8,500	• Avoid further loss of mature long-lived veg (black box and associated veg) that provides habitat to many spp. • Increase connectivity across the floodplain.	**1. Ecological Significance** – Ramsar and DIWA listed: The Riverland Ramsar site (Chowilla Floodplain) is a representative example of a major floodplain system within the Murray Scroll Belt Subregion of the Riverina Biogeographical Region of the Murray Darling Basin. The site supports nationally threatened and contains a diverse range of habitat types and supports elements of biological diversity that are rare and particularly characteristic of the biogeographical region as well as providing critical drought refuge and summer or stopover habitat for migratory birds listed under international agreements. Chowilla regularly supports 20,000 or more waterbirds involving fifty-nine species including large populations of Freckled Duck, Red-necked Avocet and Red-kneed Dotterel whose numbers represent greater than 1% of the estimated global population. Riverland supports 14 of the 26 species of freshwater native fish species represented within the Murray-Darling Basin and the Chowilla Anabranch within the Riverland wetland is an important pathway for the migration of Golden Perch and Silver Perch around Lock 6 on the River Murray. The site also provides fish breeding and nursery habitats for these and other fish species (DEWHA, 2009)

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				Chowilla Floodplain retains much of the area's natural character and attributes. It has a high diversity of both terrestrial and aquatic habitats; supports populations of rare, endangered and nationally threatened species (TLM, 2006-07, vi). It contains the largest remaining area of natural River Red Gum forest in the lower River Murray (Sharley and Huggan 1995). The area also supports four nationally threatened species: Souterhn Bell Frog, Regent Parrot, Murray Cod and Murray Hardyhead and 23 state listed species (DEH 2005). **2. Expected Outcomes** – halt the decline of mature black box, these are currently declining in health across the floodplain, increase connectivity between permanent water environments of Salt Creek and nearby watering sites. **3. Risks of watering action** – The risk has been deemed low due to success of previous watering on the Chowilla floodplain. Also, if a water quality issue did arise, this would be localised to the site as it is disconnected from the channel or anabranch. **4. Long-term sustainability of Asset** – • This site has not previously received environmental water. • Previous monitoring of watering events in the floodplain indicate that many vegetation communities have benefited from the water, provided habitat for threatened **5. Cost effectiveness** – Site management, watering and monitoring to be overseen by SA MDM NRM Board and NSW DNR. Monitoring is also contributed by SARDI, DWLBC, the Murray Darling Freshwater Research Centre, DEH and other consultants. Management plans for Chowilla exist.
Katarapko Creek Wetland – Katarapko FP Lower Murray (SA)	20	0 (4,000 SA)	• Medium need (prevent death of river red gums) and medium long term sustainability (commence to flow at 50-60,000 ML/day); • Contains River Red Gums and provide habitat for birds and frogs, including threatened species such as Southern Bell Frog and Regent Parrot (vulnerable EPBC Act); • Previously watered in 2006 under TLM River Red Gum Rescue Program; • Watering will build on 2008-09 watering of nearby wetland, Carpark Lagoons; • Proposed environmental regulator to facilitate future watering; • Part of River Murray National Park managed by DEH.	**1. Ecological Significance** – Priority floodplain identified in South Australian Murray Environmental Framework. Contains significant numbers of mature River Red Gums; habitat for Southern Bell Frog (Vul – EPBC Act) and habitat and nesting sites for the Regent Parrot (Vul – EPBC Act) **2. Expected ecological outcomes** – Protection of River Red Gums and maintain habitat for Southern Bell Frog (Vul – EPBC Act). Maintenance of River Red Gum habitat may also benefit the Regent Parrot (Vul – EBPC Act); current condition: dry – most recent watering 2006. **3. Potential risks** – Previously watered in 2006 under TLM River Red Gum Rescue Program; demonstrated positive responses in vegetation, RRG and bird and frog breeding. No risks identified. **4. Long-term sustainability** – Part of Conservation Park, managed by SA DEH, management plan in place, however not in reach of proposed Katfish reach environmental regulator. **5. Cost effectiveness** – Site management, watering and monitoring to be undertaken by DEH and SA MDM NRM Board. operationally feasible: pumping required.
Lake Wallawalla	5,000 - 12,000	203,000 – 450,000	• Water delivery will create a significant drought refuge for water birds and other wetland dependent species. This watering at full	**1. Ecological Significance** – Living Murray Icon Site. Lake Wallawalla attracts regionally significant numbers of waterbirds when flooded (SKM and

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
Lower Murray (Vic)			supply level will inundate the fringing River Red Gums which have not received water since 2001.	Roberts, 2003). 34 bird species have been recorded. Habitat for: Growling Grass Frog (nationally threatened), Regent Parrot (vulnerable under State and Commonwealth legislation), Inland Carpet Python (endangered in Victoria), White-bellied Sea-eagle (Migratory and CAMBA listed and rare in Victoria). Extensive herbland areas also become present as the lake dries (TLM 2006). Lake Wallawalla is listed under DIWA. The listing classifies it as a relatively unique wetland of its type in Victoria. This is due to a combination of the variety of eco-systems and its unique geomorphology (specifically a series of lunettes formed from both red sand sediments and saline clay sediments) (DEWHA) **2. Expected ecological outcomes** – Provide drought refuge for waterbirds, water stressed River Red Gum, box vegetation and herblands as the lake dries; Avoid irreversible loss/catastrophic event – length of time since last received water (~9 years – 2-3 times greater than recommended) increases criticality of provision of water (TLM 2006). **3. Potential risks** – Salinity credits need to be considered before watering. Review of potential credits/debits has been undertaken. Delivery is through Lindsay river which will require an increase in river height to provide maximum efficiency in pumping. Discussions with River Murray Water are currently underway. Risk of long delivery time due to relatively low rate of delivery. **4. Long-term sustainability** – This site as been identified as an important site under the Living Murray program (as part of the Chowilla – Lindsay/Wallpolla Icon site), and is part of the Murray Sunset National Park. Commitment to the site is demonstrated by the construction of 2 large regulators and levee to manage environmental water delivery to the site. Site managed by Mallee CMA in partnership with Parks Victoria. Site is in moderate to poor condition, and will continue to deteriorate without water. Proposed works by Victoria (subject to funding) would allow water to be supplied by gravity in the future. Monitoring undertaken by Mallee CMA, through Parks Victoria. **5. Cost effectiveness** – Reasonable cost effectiveness given the significance of the site. Delivery is via pumping from the Lindsay River (through regulators), and would probably require manipulation of the height of Locks 6 and 7 weir pools to raise height of the Lindsay River.
Morgan CP South Lagoon Lower Murray (SA)	120	10,000	• Medium need (prevent death of river red gums) and medium long term sustainability (commence to flow at 50-60,000 ML/day); • Contains River Red Gums and provide habitat for birds and frogs, including Southern Bell Frog and Regent Parrot (vulnerable EPBC Act). Regent parrot recorded as breeding that this site; • Previously watered in 2006 under TLM River Red Gum Rescue Program; • Part of the Morgan Cluster of wetlands – drought refuge between Locks 1 and 2, some 310- 324 km north of the Lower Lakes (expand); • Watering will build on 2008-09 watering of nearby wetland,	**1. Ecological Significance** – River Red Gums (includes stand of 500 year old trees with high conservation value, several age classes of regenerating river red gums), Prickly Bottlebrush (SA rare) and provides habitat for Southern Bell Frog (Vul – EPBC Act) and Regent Parrot (Vul – EPBC Act). **2. Expected ecological outcomes** – protection of River Red Gums and maintain habitat for Southern Bell Frog and Regent Parrot; current condition: dry – most recent watering 2006. **3. Potential risks** – Previously watered in 2006 under TLM River Red Gum Rescue Program – no risks identified. **4. Long-term sustainability** – • Part of Conservation Park, managed by SA DEH, *draft* management plan;

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
			Brenda Park.	received water in 2006 and has been dry since – it is a temporary basin. • Strategically selected as a SA priority e-water wetland cluster (Morgan cluster) in a reach (310-324 Km) of the Murray between lock 1 and 2. SA prioritisation has focused on clusters of wetlands / floodplains found along different stretches of the river to ensure a diversity of habitats are protected. **5. Cost effectiveness** – Site management, watering and monitoring to be undertaken by DEH and SA MDM NRM Board; operationally feasible: pumping required.
Morgan CP North Lagoon Lower Murray (SA)	210	14,000	• Medium need (prevent death of river red gums) and medium long term sustainability • Contains River Red Gums and provide habitat for birds and frogs, including Southern Bell Frog and Regent Parrot (vulnerable EPBC Act). Regent parrot recorded as breeding that this site; • Previously watered in 2006 under TLM River Red Gum Rescue Program; • Part of the Morgan Cluster of wetlands – drought refuge between Locks 1 and 2, some 310- 324 km north of the Lower Lakes (expand); • Watering will build on 2008-09 watering of nearby wetland, Brenda Park.	**1. Ecological Significance** – Provides breeding habitat for Southern Bell Frog (Vul – EPBC Act) and Regent Parrot (Vul – EPBC Act) **2. Expected ecological outcomes** – protection of River Red Gums and maintain habitat for Southern Bell Frog and Regent Parrot . **3. Potential risks** – Previously watered in 2006 under TLM River Red Gum Rescue Program – no risks identified. **4. Long-term sustainability** – • Part of Conservation Park, managed by SA DEH, *draft* management plan; received water in 2006 (Red Gum Rescue project). • Strategically selected as a SA priority e-water wetland cluster (Morgan cluster) in a reach (310-324 Km) of the Murray between lock 1 and 2. **5. Cost effectiveness** – Site management, watering and monitoring to be undertaken by DEH . Operationally feasible: pumping required.
Molo Flat-Western Channel Lower Murray (SA)	21 (of 327 for the complex)	1,575	• Medium need (prevent death of river red gums) and medium long term sustainability (commence to flow at 50-60,000 ML/day); • Contains River Red Gums and provide habitat for Southern Bell Frog (sighted 2006) and Regent Parrot (sighted 2009) (EPBC Act vulnerable), Gilbert's Whistler, Little Friarbird, Striped Honeyeater, White-winged Chough (lasted sighted 2009, State Rare); Supports SA Rare vegetation, Pale-fruit cherry and slender fissure plant; • Site also supported, Australasian Shoveler, Darter, White-faced heron and Glossy Ibis (State Rare) at last inundation in 2006; • Previously watered in 2006 under TLM River Red Gum Rescue Program; • Part of the Molo-Hogwash cluster of wetlands – drought refuge between Locks 1 and 2 (355 km from sea). Watering will build on 2008-09 watering of nearby wetlands, Markaranka, to create larger drought refuge.	**1. Ecological Significance** – Contains River Red Gums and provides habitat for Southern Bell Frog (Vul – EPBC Act). Maintenance of River Red Gum habitat may also benefit the and Regent Parrot (Vul – EPBC Act). **2. Expected ecological outcomes** – Protection of river red gums (support ~ 115 mature trees and ~135 intermediate trees), lignum and river Cooba; maintain habitat for Southern Bell Frog, Regent Parrot (sighted in 2009) and water birds; current condition: dry – most recent watering 2006. **3. Potential risks** – Previously watered in 2006 under TLM River Red Gum Rescue Program and positive responses from River Red Gums and Southern Bell Frogs; No negative impacts from previous watering. **4. Long-term sustainability** – Privately owned site, no management plan in place. Landowner consulted by SA and are supportive of watering; RMEM priority site - maintain investment in tree health from previous watering. **5. Cost effectiveness** – Site management, watering and monitoring to be undertaken by SA MDM NRM Board. Operationally feasible: pumping required.
Molo Flat - Western Basin Lower Murray (SA)	220	16,000	• Medium need (prevent death of river red gums) and medium long term sustainability (commence to flow at 50-60,000 ML/day); • Contains River Red Gums and provide habitat for Southern Bell Frog (sighted 2006) and Regent Parrot (sighted 2009) (EPBC Act vulnerable), Gilbert's Whistler, Little Friarbird, Striped Honeyeater, White-winged Chough (lasted sighted 2009, State Rare); Supports SA Rare vegetation, Pale-fruit cherry, slender fissure plant and prickly bottlebrush;	**1. Ecological Significance** – Contains River Red Gums and provides habitat for Southern Bell Frog (Vul – EPBC Act). Maintenance of River Red Gum habitat may also benefit the Regent Parrot (Vul – EPBC Act). **2. Expected ecological outcomes** – Protection of River Red Gums (support ~ 160 mature trees and 54 intermediate trees), lignum and river Cooba.; maintain habitat for Southern Bell Frog, Regent Parrot (sighted in 2009) and water birds; current condition: dry – most recent watering 2006. **3. Potential risks** – Previously watered in 2006 under TLM River Red Gum

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			• Site also supported, Australasian Shoveler, Darter, White-faced heron and Glossy Ibis (State Rare) at last inundation in 2006; • Previously watered in 2006 under TLM River Red Gum Rescue Program; • Part of the Molo-Hogwash cluster of wetlands – drought refuge between Locks 1 and 2 (355 km from sea). Watering will build on 2008-09 watering of nearby wetlands, Markaranka, to create larger drought refuge.	Rescue Program and positive responses from River Red Gums and Southern Bell Frogs; No negative impacts from previous watering. **4. Long-term sustainability** – Privately owned site, no management plan in place. Landowner consulted by SA and are supportive of watering; RMEM priority site - maintain investment in tree health from previous watering. **5. Cost effectiveness** – Site management, watering and monitoring to be undertaken by SA MDM NRM Board. **O**perationally feasible: pumping required.
Molo Flat - Eastern Channel Lower Murray (SA)	86	6,500	• Medium need (prevent death of river red gums) and medium long term sustainability (commence to flow at 50-60,000 ML/day); • Contains River Red Gums and provide habitat for Southern Bell Frog (sighted 2006) and Regent Parrot (sighted 2009) (EPBC Act vulnerable), Gilbert's Whistler, Little Friarbird, Striped Honeyeater, White-winged Chough (lasted sighted 2009, State Rare); Supports SA Rare vegetation, Pale-fruit cherry and slender fissure plant; • Site also supported, Australasian Shoveler, Darter, White-faced heron and Glossy Ibis (State Rare) at last inundation in 2006; • Previously watered in 2006 under TLM River Red Gum Rescue Program; • Part of the Molo-Hogwash cluster of wetlands – drought refuge between Locks 1 and 2 (355 km from sea). Watering will build on 2008-09 watering of nearby wetlands, Markaranka, to create larger drought refuge.	**1. Ecological Significance** – Contains River Red Gums and provides habitat for Southern Bell Frog (Vul – EPBC Act). Maintenance of River Red Gum habitat may also benefit the Regent Parrot (Vul – EPBC Act). **2. Expected ecological outcomes** – Protection of River Red Gums (support 119 mature trees and 62 intermediate trees), lignum and river Cooba; maintain habitat for Southern Bell Frog, Regent Parrot (sighted in 2009) and water birds; current condition: dry – most recent watering 2006. **3. Potential risks** – Previously watered in 2006 under TLM River Red Gum Rescue Program and positive responses from River Red Gums; No negative impacts from previous watering. **4. Long-term sustainability** – Privately owned site, no management plan in place. Landowner consulted by SA and is supportive of watering; RMEM priority site - maintain investment in tree health from previous watering. **5. Cost effectiveness** – Site management, watering and monitoring to be undertaken by SA MDM NRM Board. Operationally feasible: pumping required.
Wigley Reach - Western Channels Lower Murray (SA)	79	6,000	• Medium need (prevent death of river red gums) and medium long term sustainability (commence to flow at 50-60,000 ML/day); • Contains River Red Gums and provide habitat for Southern Bell Frog and Regent Parrot (EBPC Act vulnerable); • Previously watered in 2006 under TLM River Red Gum Rescue Program; • Part of the Wigley cluster, drought refuge between Lock 2 and 3 (414 to 434 km from sea); • Watering will build on 2008-09 watering of nearby wetlands, Akuna station, Overland Corner, and Banrock station; • Privately owned by two land owners one of which owns Banrock station; No management plan.	**1. Ecological Significance** – Contains River Red Gums and provides habitat for Southern Bell Frog (Vul – EPBC Act). Maintenance of River Red Gum habitat may also benefit the Regent Parrot (Vul – EPBC Act) (sighted at nearby Banrock Station). **2. Expected ecological outcomes** – Protection of river red gums (support ~ 88 mature trees, ~24 intermediate trees, 20 juvenile trees and 160 saplings), lignum and river Cooba; maintain habitat for Southern Bell Frog, Regent Parrot and water birds; current condition: dry – most recent watering 2006 **3. Potential risks** – Previously watered in 2006 under TLM River Red Gum Rescue Program and positive responses from River Red Gums and Southern Bell Frogs; No negative impacts from previous watering. **4. Long-term sustainability** – Privately owned site, no management plan in place. Landowners consulted by SA and supportive of watering; RMEM priority site - maintain investment in tree health from previous watering. **5. Cost effectiveness** – Site management, watering and monitoring to be undertaken by SA MDM NRM Board. Operationally feasible: pumping required.
Wigley Reach - Northern Channels	15	1,125	• Medium need (prevent death of river red gums) and medium long term sustainability (commence to flow at 50-60,000 ML/day); • Contains River Red Gums and provide habitat for Southern Bell Frog and Regent Parrot (EBPC Act vulnerable), Spiny Lignum	**1. Ecological Significance** – Contains River Red Gums and provides habitat for Southern Bell Frog (Vul – EPBC Act). Maintenance of River Red Gum habitat may also benefit the Regent Parrot (Vul – EPBC Act) (sighted at nearby Banrock Station).

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
Lower Murray (SA)			(Rare); • Previously watered in 2006 under TLM River Red Gum Rescue Program; • Part of the Wigley cluster, drought refuge between Lock 2 and 3 (414 to 434 km from sea); • Watering will build on 2008-09 watering of nearby wetlands, Akuna station, Overland Corner, and Banrock station; • Privately owned by two land owners one of which owns Banrock station; No management plan.	**2. Expected ecological outcomes** – Protection of river red gums (support ~ 51 mature trees, ~ 17 intermediate trees, 235 saplings), lignum and river Cooba; maintain habitat for Southern Bell Frog, Regent Parrot and water birds; current condition: dry – most recent watering 2006. **3. Potential risks** – Previously watered in 2006 under TLM River Red Gum Rescue Program and positive responses from River Red Gums and Southern Bell Frogs; No negative impacts from previous watering. **4. Long-term sustainability** – Privately owned site, no management plan in place. Landowners consulted by SA and are supportive of watering; RMEM priority site - maintain investment in tree health from previous watering. **5. Cost effectiveness** – Site management, watering and monitoring to be undertaken by SA MDM NRM Board. Operationally feasible: pumping required.
Wigley Reach - Central Channels Lower Murray (SA)	184	12,000	• Medium need (prevent death of river red gums) and medium long term sustainability (commence to flow at 50-60,000 ML/day); • Contains River Red Gums and provide habitat for Southern Bell Frog and Regent Parrot (EBPC Act vulnerable), Spiny Lignum (Rare); • Previously watered in 2006 under TLM River Red Gum Rescue Program; • Part of the Wigley cluster, drought refuge between Lock 2 and 3 (414 to 434 km from sea); • Watering will build on 2008-09 watering of nearby wetlands, Akuna station, Overland Corner, and Banrock station; • Privately owned by two land owners one of which owns Banrock station; • No management plan.	**1. Ecological Significance** – Contains River Red Gums and provides habitat for Southern Bell Frog (Vul – EPBC Act). Maintenance of River Red Gum habitat may also benefit the Regent Parrot (Vul – EPBC Act) (sighted at nearby Banrock Station). **2. Expected ecological outcomes** – Protection of river red gums (support ~ 261 mature trees, ~172 intermediate trees, 1094 juvenile trees and 3022 saplings), lignum and river Cooba. Maintain habitat for Southern Bell Frog, Regent Parrot and a range of water birds; current condition: dry – most recent watering 2006. **3. Potential risks** – Previously watered in 2006 under TLM River Red Gum Rescue Program and positive responses from River Red Gums and Southern Bell Frogs; No negative impacts from previous watering. **4. Long-term sustainability** – Privately owned site, no management plan in place. Landowners consulted by SA and are supportive of watering; RMEM priority site - maintain investment in tree health from previous watering. **5. Cost effectiveness** – Site management, watering and monitoring to be undertaken by SA MDM NRM Board. Operationally feasible: pumping required.
Weila Lower Murray (SA)	221	16,000	• Medium need (prevent death of River Red Gums) and medium long term sustainability (commence to flow at 50-60,000 ML/day); • Weila part of Riverland Ramsar site; • Contains River Red Gums and provide habitat for birds and frogs, including threatened species such as Southern Bell Frog (sighted in 2006) and Regent Parrot (sighted in 2009) (vulnerable EPBC Act); • Previously watered in 2006 under TLM River Red Gum Rescue Program; • Part of the Murtho cluster - objective is to create drought refuge between Lock 5 and 6, 600- 616 km from Murray mouth; • Privately owned, no management plan.	**1. Ecological Significance** – Ramsar and DIWA listed: The Riverland Ramsar site (Chowilla Floodplain) is a representative example of a major floodplain system within the Murray Scroll Belt Subregion of the Riverina Biogeographical Region of the Murray Darling Basin. The site supports nationally threatened and contains a diverse range of habitat types and supports elements of biological diversity that are rare and particularly characteristic of the biogeographical region as well as providing critical drought refuge and summer or stopover habitat for migratory birds listed under international agreements. Chowilla regularly supports 20,000 or more waterbirds involving fifty-nine species including large populations of Freckled Duck, Red-necked Avocet and Red-kneed Dotterel whose numbers represent greater than 1% of the estimated global population. Riverland supports 14 of the 26 species of freshwater native fish species represented within the Murray-Darling Basin and the Chowilla Anabranch within the

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				Riverland wetland is an important pathway for the migration of Golden Perch and Silver Perch around Lock 6 on the River Murray. The site also provides fish breeding and nursery habitats for these and other fish species (DEWHA, 2009) Chowilla Floodplain retains much of the area's natural character and attributes. It has a high diversity of both terrestrial and aquatic habitats; supports populations of rare, endangered and nationally threatened species (TLM, 2006-07, vi). It contains the largest remaining area of natural River Red Gum forest in the lower River Murray (Sharley and Huggan 1995). The area also supports four nationally threatened species: Souterhn Bell Frog, Regent Parrot, Murray Cod and Murray Hardyhead and 23 state listed species (DEH 2005). **2. Expected ecological outcomes** – Protection of River Red Gums (including supporting growth of 1200 saplings and 2700 juvenile trees), lignum and maintain habitat for Southern Bell Frog, Regent Parrot (sighted in 2009) and a range of water birds; current condition: dry – most recent watering 2006 **3. Potential risks** – Previously watered in 2006 under TLM River Red Gum Rescue Program and positive responses from River Red Gums; No negative impacts from previous watering. **4. Long-term sustainability** – Part of Riverland Ramsar site. Privately owned site, no management plan in place. Landowner consulted by SA and are supportive of watering; River Murray Environmental Manager (RMEM) priority site - maintain investment in tree health from previous watering. **5. Cost effectiveness** – Site management, watering and monitoring to be undertaken by DEH and SA MDM NRM Board. Operationally feasible: pumping required.
Lindsay & Wallpolla Islands Lower Murray (Vic)	1,200	99,500	• Water delivery will build on spring watering, providing water to River Red Gums in low lying areas in the Islands. This area will also provide an important drought refuge for waterbirds and other wetland dependent species, such as turtles and frogs.	**1. Ecological Significance** – Living Murray Icon Site and DIWA-listed (listed under criteria 1 – good example of wetland type for bio-region; 2 – plays an important ecological or hydrological role; and 3 – provides important habitat). It has 2 plant species of national significance and 51 of state significance, 27 fauna species of national significance and 37 of state significance and 5 species of waterbirds which are listed under the JAMBA and the CAMBA, as well as three listed under CAMBA only (TLM 2006). Habitat for: Growling Grass Frog (nationally threatened), Regent Parrot (vulnerable under State and Commonwealth legislation), Inland Carpet Python (endangered in Victoria), White-bellied Sea-eagle (Migratory, CAMBA listed and rare in Victoria) (TLM 2006). **2. Expected ecological outcomes** – Maintain drought refuge for waterbirds and water stressed River Red Gums (the success of which is supported by monitoring results in BL&A 2009 and TLM 2008 for areas that received water). **3. Potential risks** – The risks associated with the water activity are low, as the sites have been previously watered. Mallee CMA and Parks Victoria also

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
				have significant experience managing the delivery of environmental water to wetlands. **4. Long-term sustainability** – 1.7 GL has already been delivered to the site from the MDBA Living Murray Program in spring 2009. Any additional water allocated will increase the area flooded and improve the ecological benefits of watering. As the site is also a TLM icon site, future water allocations can be reasonably well assured. Sites are in the process of being established as National Parks and are TLM Icon sites, with established management plans and monitoring arrangements. The monitoring proposed for this watering event will include basic compliance monitoring (volume, time and area) as well as both bird and river red gum monitoring consistent with existing methodologies. **5. Cost effectiveness** – Cost-effective investment by the CEWH given significant other volumes committed already (4.3 GL by TLM) and previous watering actions allowing maximum benefit to be achieved from Commonwealth water.
Goulburn-Broken Wetlands Goulburn-Broken (Vic)	7,500	155,000	• Watering these wetlands would create a good spatial covering of drought refuges throughout the Goulburn Broken area.	**1. Ecological Significance** – **Doctors Swamp –** Classified by Victoria as a bio-regionally significant wetland in the watering proposal. The wetland would provide significant drought refuge. The wetland has supported large numbers of waterbirds including the threatened Eastern Great Egret (vulnerable in Victoria), Blue Billed Duck (endangered in Victoria) and Brolga (vulnerable in Victoria) (DSE proposal 2009). Spatial data lists a range of nationally listed species including Latham's Snipe (JAMBA, CAMBA, ROKAMBA, Bonn, and Migratory); White-bellied Sea Eagle (CAMBA and Migratory); Australian Painted Snipe (EPBC Vulnerable); Cattle Egret (migratory); Great Egret (migratory); and the Growling Grass Frog (EPBC vulnerable). Delivery constraints possible as channel needs to be at full supply. **Stockyard Plain -** Classified by Victoria as a bio-regionally significant wetland in the watering proposal. The cane grass dominated wetland would provide significant drought refuge and breeding habitat for Brolgas (DSE proposal 2009). Spatial data lists a range of nationally listed species including Latham's Snipe (JAMBA, CAMBA, ROKAMBA, Bonn, and Migratory); Superb Parrot (EPBC Act Vulnerable); White-bellied Sea Eagle (CAMBA and Migratory); Australian Painted Snipe (EPBC Act Vulnerable); Cattle Egret (migratory); Great Egret (migratory); and the Growling Grass Frog (EPBC Act vulnerable). **Kinnairds Swamp - –** Classified by Victoria as a bio-regionally significant wetland in the watering proposal. The wetland would provide significant drought refuge, The wetland has supported large numbers of waterbirds including the threatened Eastern Great Egret (vulnerable in Victoria), Australasian Bittern, Australasian Little Bittern, White-bellied Sea Eagle

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
				(CAMBA, Migratory and vulnerable in Victoria) and Brolgas (vulnerable in Victoria). In addition, the wetland supports relatively high densities of the EPBC Act vulnerable Rigid Water-,milfoil During previous watering events in 2008 a total of 64 birds, 35 of which were wetland species were observed (Cook et al 2008) Spatial data lists a range of nationally listed species including Latham's Snipe (JAMBA, CAMBA, ROKAMBA, Bonn, and Migratory); Superb Parrot (EPBC Vulnerable); White-bellied Sea Eagle (CAMBA and Migratory); Australian Painted Snipe (EPBC Vulnerable); Cattle Egret (migratory); Great Egret (migratory); Growling Grass Frog (EPBC Act vulnerable); River Swamp Wallaby Grass (EPBC Act vulnerable) and the Rigid Water-milfoil (EPBC Act vulnerable). **One Tree Swamp –** Listed under the Directory of Important Wetlands as part of Lower Broken Creek DIWA site (listed under criteria 1 – good example of wetland type for bio-region; 2 – plays an important ecological or hydrological role; and 3 – provides important habitat). It is a significant Cane Grass dominated wetland that would provide drought refuge for waterbirds. The wetland has supported large numbers of waterbirds including the threatened Eastern Great Egret (vulnerable in Victoria), Australasian Bittern, Little Bittern, Plains Wanderer (EPBC Act Vulnerable) and is a known breeding location for Brolga (Vulnerable in Victoria) – (DSE proposal 2009). Spatial data lists a range of nationally listed species including Latham's Snipe (JAMBA, CAMBA, ROKAMBA, Bonn, and Migratory); Superb Parrot (EPBC Act Vulnerable); White-bellied Sea Eagle (CAMBA and Migratory); Australian Painted Snipe (EPBC Act Vulnerable); Plain's Wanderer (EPBC Act Vulnerable); Cattle Egret (migratory); Great Egret (migratory); and the Growling Grass Frog (EPBC Act vulnerable). **Black Swamp -** Classified by Victoria as a bio-regionally significant wetland in the watering proposal. The wetland would provide significant drought refuge. The wetland has supported large numbers of waterbirds including the threatened Eastern Great Egret (vulnerable in Victoria), White-bellied Sea Eagle, Australasian Bittern and Australasian Little Bittern. In addition, the wetland supports the threatened River Swamp Wallaby-grass (EPBC Act vulnerable) – (DSE proposal 2009). During previous watering events in 2008 a total of 75 birds, 34 of which were wetland species were observed (Cook et al 2008) Spatial data lists a range of nationally listed species including Latham's Snipe (JAMBA, CAMBA, ROKAMBA, Bonn, and Migratory); Superb Parrot (EPBC Act Vulnerable); White-bellied Sea Eagle (CAMBA and Migratory); Australian Painted Snipe (EPBC Act Vulnerable); Plain's Wanderer (EPBC Act Vulnerable); Cattle Egret (migratory); Great Egret (migratory); Growling Grass Frog (EPBC Act vulnerable); River Swamp Wallaby Grass (EPBC Act vulnerable); and Rigid Water-milfoil (EPBC Act vulnerable).

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
				2. Expected ecological outcomes – The watering is expected to provide geographic spread of drought refuges for waterbirds across the landscape, which should provide for a more resilient population base for recovery. The creation of this refuge is supported by the monitoring undertaken during 2008 on the outcomes of environmental water delivery in the Goulburn-Broken region (Cook et al 2009). **3. Potential risks** – Minimal risk identified with watering wetlands. Further risk assessments to be undertaken before water commences. Kinnairds and Black Swamps were watered in 2007/08 by Victoria, with no issues emerging (Cook et al 2009). **4. Long-term sustainability** – Sites selected have the ability to have water provided to them now and into the future. Kinnairds Swamp has an EMP in place (DPI 2003), and the broader system is covered by the Goulburn-Broken River Health Strategy (GBCMA 2005). Integrated monitoring program targeting basic compliance and bird response will be carried out by Goulburn-Broken CMA. Vegetative response to water at wetlands demonstrated in Cook et al (2009) **5. Cost effectiveness** – Cost effective, delivery via irrigation channels.
Boort District Wetlands Lower Murray (Vic)	3,800	62,800	• Watering these wetlands would create a good spatial covering of drought refuges throughout the Boort District, watering wetlands which have not received water for a significant amount of time.	**1. Ecological Significance** – Regionally-important wetlands with high environmental values (Hydro Environmental, 2009). Lakes Leaghur and Yando are shallow freshwater marshes that consists of diverse vegetation including reeds (typha), River Red Gum, water couch, milfoils and water ribbons that provides habitat and drought refuge for waterbirds, waterfowl and frogs (Heron and Joyce, 2008). Little Lake Meran is a permanent open freshwater system which can provide important habitat for large bodied native fish, waterbirds, colonial nesting breeding sites, waterfowl and tortoises (ibid.). In November 2009 Lake Yando received 1,000 ML from Victorian environmental entitlements, having been dry since 1997. 26 bird species have subsequently been observed (Birds Australia, 2010). **2. Expected ecological outcomes** – Provide geographic spread of drought refuges for waterbirds. Until Lake Yando received water, for the last six years there has been only one inundated lacustrine water body (Little Lake Boort) along the 128km stretch of the mid-Loddon catchment (NCCMA, 2008). Watering is expected to maintain bird populations in this severely drought-affected region. **3. Potential risks** – Diverters on both wetlands, which may use water for stock and domestic purposes. Further investigation to minimise this risk would need to be undertaken in association with the water corporation. Delivery needs to be aligned with availability of delivery channels. Duck hunting is permitted in these areas. A further risk assessment to be undertaken before watering commences. **4. Long-term sustainability** – Sites selected have the ability to have water provided to them now and into the future, subject to irrigation channel operations. Sites managed by North Central CMA. No operational management plans in place, though recently recommended by NVIRP impact assessment (Hydro Environmental, 2009).

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
				5. Cost effectiveness – Delivery costs considered low compared to benefit. Delivery to all sites via irrigation channel outfalls. Monitoring by NCCMA and Parks Victoria.
Lower Lakes - Lake Albert Lower Murray (SA)	≥25,000	0 (1,400,000 SA)	• To reduce the risk of irretrievable damage - acidification of the Lake Albert. Pumping of water into Lake Albert would keep submerged areas of high concentration of acid sulfate soils (>1000 mol of H+ /tonne of soil). Drying and rewetting of such soils would potentially release of large volumes of sulphuric acid and heavy metals. • Keeping ASS inundated is the recommended management strategy (CSIRO, 2008). • To decrease the rate of rise in salinity levels – from 15,000 (current) to forecast 25,000 EC by July 2010 (instead of 50,000 without the 25 GL).	**1. Ecological Significance** (note that some of this information is for the greater Lower Lakes area) • Lake Albert is part of the Coorong, and Lakes Alexandrina and Albert Wetland Ramsar site that is listed for criteria 1-8 (of 9), and contains 23 different wetland types (DEWHA website). • Lake Albert is part of the Coorong, and Lakes Alexandrina and Albert DIWA listed wetland which is listed for criteria 1-6 (of 6). (DEWHA website) • The Lower Lakes are known habitat for Orange-bellied parrot (EPBC Act listed as critically endangered), Southern Mount Lofty Ranges emu wren (EPBC Act listed as endangered), Yarra pygmy perch (EPBC Act listed as vulnerable), Murray cod (EPBC Act listed as vulnerable) and Murray hardyhead (EPBC Act listed as vulnerable) (SA water bid). • Lake Albert supports remnant patches of Gahnia filum and extensive and Phragmites and Typha reed beds, providing sheltered habitats for fish and other vertebrates as well as long term rookery sites for various birds (SA water bid). • Supports significant populations of waterbirds. In Jan 2009 in excess of 48000 water birds were counted using Lake Albert (SA Water Bid). In recent years birds that utilise mud flats have increased, while fish-eating and those that rely on finding reeds / freshwater species have declined (correspondence from SA DWLBC). • Low water levels and increasing salinity levels are threatening freshwater habitats, particularly fringing wetland areas. (SA water bid) These factors attribute to reported decline and imminent extinction three small-bodied native fish of (Murray hardyhead, Yarra pygmy perch and the Southern pygmy perch) in the Lower Lakes (including Lake Albert). (Wedderburn and Barnes, 2009). Additionally numerous aquatic and amphibious species that were historically present in Lake Albert are no longer present (correspondence from SA DWLBC). **2. Expected Outcomes** - To keep high risk acid sulphate soils submerged until winter 2010. To decrease the rate of rise in salinity levels - from forecast 50,000 EC to 25,000 EC by July 2010. **3. Risks of watering action** – The lake has been disconnected from Lake Alexandrina by a temporary bund at Narrung. Previous pumping occurred across the bund between May 2008 and June 2009. Watering will provide a reduction in risk of acidification for the short term only. Areas of potential ASS are already exposed. Pumping relatively saline water from Lake Alexandrina will increase salinity in Lake Albert, as the bund disconnecting the two lakes prevents circulation. Risks associated with pumping include noise pollution and generation and removal of spoil where dredging is required.

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
				4. Long-term sustainability of Asset – TLM Icon Site. *The Coorong, Lower Lakes and Murray Mouth: Securing the Future* long-term plan is being developed, and is currently released as a draft. • **5. Cost effectiveness** – State to supply funding for pumping. Extensive monitoring is undertaken in the Lower Lakes, including TLM condition, specific ecological and water quality monitoring.
Lower North Redbank: Glen Avon, Auley, Riverleigh, Baupie, Balranald Common Complex Lowbidgee Wetlands Murrumbidgee	27,000	102,600	• Maintenance of long-lived vegetation including River Red Gums and provision of drought refuge • Waterbirds including several threatened and JAMBA, CAMBA species	**1. Ecological Significance** • DIWA listed, the Lowbidgee Wetlands extended over an area of 300 000 ha in the early 1900s, however, following water diversion and floodplain developments, 76.5% of the wetlands are now lost or degraded (Kingsford and Thomas 2004). • The landholder (M King, 2008) has kept records of fauna observations which include Southern Bell Frogs (EPBC Act vulnerable, last seen 2005), Great Egret (JAMBA/CAMBA, 2000), Glossy Ibis (CAMBA, 2000), Australasian Bittern (NSW vulnerable), Blue-billed duck (NSW vulnerable 2000), White-breasted Sea Eagle (CAMBA 2008), Regent Parrot (EPBC Act vulnerable 1994), Painted Snipe (CAMBA, EPBC Act vulnerable, 2000), Cattle Egret (JAMBA/CAMBA, 1996), White-tailed Eagle (JAMBA 2008), Japanese Snipe (JAMBA/CAMBA, 2006), Rainbow Bee-eater (JAMBA 2000), and Pink Cockatoo (NSW vulnerable, 1994). **2. Expected ecological outcomes** • Maintenance of River Red Gums and associated vegetation • Provision of drought refuge for waterbirds and other water-dependent species. **3. Potential risks** • NSW did not identify any risks. • The site can be isolated from the main river channel in the event of any water quality issues. • A bird breeding event may be triggered by the watering; however, future allocations to CEWH or NSW licences are forecast to be available in late spring to provide for this contingency. **4. Long-term sustainability** • Privately owned site. An agreement with the site owner to withhold stock from the area while wet will be made by DECCW if the site is to receive water. • The site has good connectivity as the site is directly on the Murrumbidgee and Yanga National Park wetlands are across the river. • Gravity fed, however, the site is at the end of the delivery system and if sites directly upstream are not watered, delivery or water here may involve significant losses. **5. Cost effectiveness** – Highly cost effective. Gravity fed, no pumping required. NSW DECCW to provide monitoring, although this will only be mapping of inundation extent and incidental bird and vegetation observations.
Springbank Complex,	7000	26,600 (11,400 this	• Maintenance of long-lived vegetation including River Red Gums and provision of drought refuge	**1. Ecological Significance** • DIWA listed, the Lowbidgee Wetlands extended over an area of

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
North Redbank Lowbidgee Wetlands Murrumbidgee	(3000 in June 2010, remaining 4000 in July/August 2010))	financial year)	• Waterbirds including several threatened and JAMBA, CAMBA species	300 000 ha in the early 1900s, however, following water diversion and floodplain developments, 76.5% of the wetlands are now lost or degraded (Kingsford and Thomas 2004). **2. Expected ecological outcomes** • Maintenance of River Red Gums and associated vegetation • Provision of drought refuge for waterbirds and other water-dependent species, potentially including the Southern Bell Frog (EPBC Act vulnerable). **3. Potential risks** • NSW did not identify any risks. • The site can be isolated from the main river channel in the event of any water quality issues. • A bird breeding event may be triggered by the watering; however, future allocations to CEWH or NSW licences are forecast to be available in late spring to provide for this contingency. **4. Long-term sustainability** • Privately owned site. An agreement with the site owner to withhold stock from the area while wet will be made by DECCW if the site is to receive water. • The site has good connectivity as the site is directly on the Murrumbidgee and Yanga National Park wetlands are directly across the river. Infrastructure is in place for reliable delivery. Gravity fed, no pumping required **5. Cost effectiveness –** Highly cost effective. Gravity fed, no pumping required. NSW DECCW to provide monitoring, although this will only be mapping of inundation extent and incidental bird and vegetation observations.
Kerang District & Surrounding Wetlands Lower Murray (Vic)	16,400	330,000	• Important drought refuges in the Kerang wetland system and surrounding areas.	**1. Ecological Significance** **Hird Swamp** (deep freshwater marsh) – Ramsar and DIWA site. 37 waterbird species recorded (DIWA). At times has supported large populations of various waterbirds, and has been a regionally significant breeding site for several threatened waterbird species (DIWA). The swamp is currently the only wetland in which the Painted Snipe (EPBC-Vulnerable) has been found in successive Victorian bird surveys (DSE Watering Proposal, December 2009). The wetland has also been a large ibis-breeding colony, supporting tens of thousands of pairs. Freckled Ducks (Endangered-Victoria), Blue-billed Ducks (Endangered-Victoria) and Royal Spoonbill (Vulnerable-Victoria) have also been recorded at this site. (DSE, 2004)). The swamp supports a large community of Tangled Lignum shrubland which is thought to be under-represented in Victorian wetlands reserves and with several other plants form an unusual vegetation assemblage (DIWA). **Lake Cullen** (permanent saline) – Ramsar and DIWA site. 51 waterbird species have been recorded (DIWA). Lake Cullen supports a high diversity and abundance of waterbird species and is frequented by a number of migratory bird species recognised under migratory bird agreements – 9 under JAMBA and 11 under CAMBA have been recorded (DIWA). The wetland

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
				supports 1% of the national population of Eurasian Coot. Hardhead duck (Vulnerable-Victoria) and Blue-billed Duck (Endangered-Victoria) have also been reported from this site (DIWA). **Richardson's Lagoon** – Victorian Wildlife Reserve. Richardson's Lagoon (also known as Baillieu's Lagoon) is a highly significant wetland for water bird breeding, feeding and roosting and is an identified drought refuge site on the northern floodplain (DSE Watering Proposal, December 2009). Threatened bird species recorded there include White Bellied Sea Eagle (CAMBA, CMS), Royal Spoonbill (Vulnerable-Victoria), Great Egret (Vulnerable-Victoria), Little Egret (Endangered-Victoria) and Freckled Duck (Endangered-Victoria) (DSE Watering Proposal, December 2009). **2. Expected ecological outcomes** – Provide drought refuge for waterbirds and migratory species. In conjunction with the wetlands proposed to be watered in the Goulburn-Broken Region (this minute) the three Kerang and district sites would provide an excellent geographic spread of drought refuges across the Murray Fans bioregion (M. Jensz, DSE – pers. comm.). **3. Potential risks** – Duck-hunting is currently permitted at all sites. Low risks associated with delivery – all sites have received environmental water previously with no negative impacts. Further risk assessments to be undertaken before water commences. **4. Long-term sustainability** – Hird Swamp and Cullen Lake are part of the Kerang Ramsar site and as such are subject to the Ramsar Strategic Management Plan. Separate operational plans have been prepared for both (DSE, 2004, DEWHA 2008), and the sites are managed by Parks Victoria. Water can be delivered to both wetlands via irrigation outfalls. Richardson's Lagoon is a Victorian Wildlife Reserve managed by Parks Victoria. Works have been undertaken to reinstate a more natural water regime in the lagoon, including the prevention of irrigation drainage flow into Richardson's Lagoon and the construction of a pipeline to allow delivery of water from the Murray River. (Hydro Environmental, 2009). An Environmental management plan is in place (Hydro Environmental, 2009). **5. Cost effectiveness** – High cost-effectiveness. Hird Swamp and Cullens Lake can be gravity fed from irrigation channels at low cost, while Richardson's Lagoon has a permanent pipeline. Sites under the overall management of North-Central CMA and the operational management of Parks Victoria. Monitoring to be undertaken by Parks Victoria.
North Redbank: Narwie, Paika Complex (Steam Engine Swamp) Lowbidgee Wetlands Murrumbidgee	10,000	38,000	• Large Waterbird rookery known as the "Steam Engine Swamp". JAMBA and CAMBA species • Maintenance of long-lived vegetation including River Red Gums and provision of drought refuge	**1. Ecological Significance** • DIWA listed, the Lowbidgee Wetlands extended over an area of 300 000 ha in the early 1900s, however, following water diversion and floodplain developments, 76.5% of the wetlands are now lost or degraded (Kingsford and Thomas 2004). • Tall Spike Rush swamp surrounded by River Red Gums which has been a significant waterbird rookery, with the well recorded breeding event of 1989-90 supporting 2000 nests of Rufous Night Herons as well as Great Egrets (JAMBA,CAMBA, 6 nests), Royal and Yellow-billed spoonbills, Intermediate Egrets and Pacific Herons (Maher 1990).

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
				• The area also has suitable habitat for Southern Bell Frogs and is within 10 km of Mercedes Wetland and the Twin Bridges Complex which currently support Southern Bell Frogs. Southern Bell Frogs were once widespread in the Lachlan and Murrumbidgee (Wassens 2008). The populations in the Lowbidgee are some of the last in the Murrumbidgee and are the closest to the Lachlan where it is now believed to be locally extinct (Wassens 2008). **2. Expected ecological outcomes** • Maintenance of River Red Gums and associated vegetation of cumbungi, tall and short spike rush and common reed. • Provision of drought refuge for waterbirds and other water-dependent species, including potentially the Southern Bell Frog. • Was watered in autumn 2009 with positive response recorded in October 2009 sampling including good water quality (low turbidity, neutral pH, low salinity), high diversity of aquatic vegetation, five species of frogs (with three species with tadpoles) and 18 waterbird species (Wassens and Spencer, unpublished). The site had one of the best responses form nine sites sampled across the Lowbidgee. **3. Potential risks** • NSW did not identify any risks. The site was watered in autumn 2009 without negative consequences. • The site can be isolated from the main river channel in the unlikely event of any water quality issues. • A bird breeding event may be triggered by the watering; however, future allocations to CEWH or NSW licences are forecast to be available in late spring to provide for this contingency. **4. Long-term sustainability** • Privately owned site. An agreement with the site owner to withhold stock from the area while wet will be made by DECCW if the site is to receive water. • The site has good connectivity as the site is directly on the Murrumbidgee and Yanga National Park wetlands are directly across the river. Infrastructure is in place for reliable delivery. Gravity fed, no pumping required **5. Cost effectiveness –** Highly cost effective. Gravity fed, no pumping required. NSW DECCW to provide monitoring, although this will only be mapping of inundation extent and incidental bird and vegetation observations.
Paul Coates (Redbank) Swamp Lowbidgee Wetlands Murrumbidgee NSW	3,000	11,400	• Drought refuge and key Southern Bell Frog recovery site to redistribute Southern Bell Frogs down the northern Redbank floodplain wetlands. If watered at the right time of year it is possible a waterbird rookery may re-establish at this site.	**1. Ecological Significance** • DIWA listed, the Lowbidgee Wetlands extended over an area of 300 000 ha in the early 1900s, however, following water diversion and floodplain developments, 76.5% of the wetlands are now lost or degraded (Kingsford and Thomas 2004). • River Red Gum forest has been a significant waterbird rookery, with the well recorded breeding event of 1989-90 supporting: Great Egrets (CAMBA, JAMBA, 200 nests) Cattle Egrets (CAMBA, JAMBA, 6 nests), as well as Little Egrets (60 nests) and Intermediate Egrets (500 nests)

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
				(Maher 1990). The event also supported Royal Spoonbills, Sacred Ibis, Rufous Night-herons (1000 nests), cormorants (600 nests) and darters (Maher 1990). • Since then, logging activities and the construction of the North Redbank channel appear to have reduced the nesting value of this site (Maguire, DECCW, pers. com.). • Has been a major site for Southern Bell Frogs (Vul-EPBC Act). For example, in 2001 92 individuals were sighted at the Swamp in one night (Wassens 2005). Since then the population appears to have declined and was recorded in only small numbers in 2004 and 2008 (Wassens et al. 2008). This is a key Southern Bell Frog recovery site to redistribute Southern Bell Frogs down the northern Redbank floodplain wetlands (James Maguire, DECCW, pers. com.). The site is only 1 km from Mercedes Swamp which provides good connectivity for Southern Bell Frogs there. The long-term persistence of this species depends on regular flooding events to promote recruitment (Wassens et al, 2008). Southern Bell Frogs were once widespread in the Lachlan and Murrumbidgee (Wassens 2008). The populations in the Lowbidgee are some of the last in the Murrumbidgee and are the closest to the Lachlan where it is now believed to be locally extinct (Wassens 2008). **2. Expected ecological outcomes** • Condition good following small watering events in 2007 and 2008-09. Watering now will build on previous watering. • Water in 2008-09 had positive response including good water quality (low turbidity, low salinity), high diversity of aquatic vegetation and four species of frogs, though only 4 species of waterbird were recorded (Spencer and Wassens, 2009). • Maintenance of River Red Gums and associated vegetation of cumbungi, tall and short spike rush and common reed. • Provision of drought refuge for waterbirds and other water-dependent species. • Support of Southern Bell Frogs and if provided with follow up watering to extend inundation into early summer could result in breeding. • A waterbird rookery may re-establish at this site (pers. com. James Maguire, DECCW) **3. Potential risks** • NSW did not identify any risks. The site was watered in 2008 without negative consequences. • The site can be isolated from the main river channel in the unlikely event of any water quality issues. • A bird breeding event may be triggered by the watering; however, future allocations to CEWH or NSW licences are forecast to be available in late spring to provide for this contingency. **4. Long-term sustainability** • Privately owned site. The owner entered into an agreement to withhold

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
				grazing when the site was watered in autumn 2009. An agreement with the site owner will again be made by DECCW if the site is to receive water. • The site has good connectivity as the site is directly on the Murrumbidgee and Yanga National Park wetlands are directly across the river. Infrastructure is in place for reliable delivery. Gravity fed, no pumping required **5. Cost effectiveness** – Highly cost effective. Gravity fed, no pumping required. NSW DECCW to provide monitoring, although this will only be mapping of inundation extent and incidental bird and vegetation observations.
Werai State Forest	6000	26,280	• Further watering at Werai in spring will consolidate the good environmental outcomes achieved during the 2009 watering.	**1. Ecological Significance** – Central Murray State Forests Ramsar Site listed for being the largest complex of tree-dominated floodplain wetlands in southern Australia and Australia's largest parcel of River Red Gum Forests having at least 11 species of birds, fish and grass identified as threatened in the Ramsar site and experts estimate on the basis of other evidence such as ground counts and breeding events that the site regularly supports 20,000 or more waterbirds. The site also provides refuge for fauna during environmentally stressful periods such as droughts and is a source of species that can utilise less productive areas during favourable conditions and provides migratory routes between habitats in the Murray River, anabranches and floodplains for native fish (DEWHA, 2009). Cormorant breeding colony (GHD, 2009), important site for Southern Myotis (*Myotis macropus*), Inland forest bat (*Vespadelus baverstocki* Vulnerable NSW TSCA), and Barking Owl (*Nixos connivens* vulnerable NSW TSCA) (NRC 2009) contains the westernmost record of brush-tailed phascogale (*Phascogale tapoatafa* vulnerable NSW TSCA) (NRC, 2009), largest areas of Common Reed (*Phragmites australis*) in the Wakool region (Green 2001). Spring 2009 monitoring found White-bellied Sea-Eagle (EPBCA migratory CAMBA) **2. Expected ecological outcomes** – To consolidate the good ecological outcomes obtained as a result of the application of 4500 ML of water (finished Jan 2010), flood out sapling River Red Gums that are growing in the creek channels and comprehensively flush the system and 'freshen up' some of the saline pools and billabongs along the system (D. Green, pers.comm). The provision of spring water is expected to re-wet Reed Bed Creek, Tummudgery Creek and a number of flood runners throughout the forest. This should result in the inundation of approximately 500ha of River Red Gum forest that has not been watered since 2001 (prior to the current 2009 spring event). Furthermore due to the flow through nature of the system some of the water will flow out the other end of the forest and result in secondary benefits in the Colligen Creek and Niemur River. The NRC assessment (2009) stated that the forests health was “poor, majority unhealthy, including 92% of SQ2 sampled- highly stressed, near dead and dead” (Jurskis, 2006). The watering in 2009 is expected to have slowed the rate of decline and in some areas resulted in marked improvement, however in order to achieve real ecological maintenance or improvement in the River Red Gums (and other vegetation) it is anticipated it will be necessary to continue to water for several years.

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
				3. Potential risks – black water event due to flows going through the forest. During watering following controls can be used: 1) increase the flow along the Colligen-Niemur System for dilution of any return flow 2) manage the initial flow rate into Reed Bed Creek by partial opening of the regulator in the first instance so that on ground monitoring can assess the potential for blackwater; and 3) Comprehensive compliance monitoring associated with the watering action focusing on inundation extent, water quality and other incidental observations (D. Green pers.comm). Given that the system was recently watered (Dec 2009) the risk of blackwater in any future event is significantly decreased. There is also a risk of saline water flowing from the Mallen Mallen Creek. This occurred in the spring watering event but the measures in place to deal with potential black water from the forest also act as a suitable control for any saline water leaving this creek. **4. Long-term sustainability** – The forest is managed under the "Werai Forest- Ecological Sustainable Management (ESFM) Plan" which is also the Ramsar Site Management Plan. Monitoring would be undertaken by NSW and would consist of inundation mapping and recording of incidental observations of birds and plant response when in the field. **5. Cost effectiveness** – NSW does not complete their environmental water planning process until later in the year so it is unclear what contribution, if any, there would be from NSW. For the delivery of the water there is potential to supplement natural flows should a higher flow event come from the Ovens River in Victoria or the Barmah Millewa Allowance is triggered (Green. D. pers.comm 2009). Delivery of water to Werai is via two regulators one on the Tummudgery Creek and a second on Reed Bed Creek. Watering of the Werai forest is possible in most water years provided that the water level in Stevens weir is high enough, there will be ongoing communication and collaboration with River Murray Operations to determine the most appropriate timing.
Edward Wakool System	10,000	43,800	• The objective of sending water through the Edward –Wakool system would be to provide sufficient flow and suitable water quality in the regulated streams during drought years so they can act as drought refuges for vulnerable fish species, flush the system and 'freshen up' some of the saline pools and billabongs along the system (D. Green, pers.comm) • Other longer term broad scale objectives for the area are: o Re-instate some of the small and medium floods o Maintain critical fish habitat in semi-regulated streams o Restore and maintain health of River Red Gum forests o Fill deflation basins (e.g. Poon Boon Lakes and Lake Agnes) to support diverse wetland vegetation	**1. Ecological Significance** – The Edward Wakool provides critical drought refuge, having the fourth and third highest abundances for Murray Cod and Silver Perch across all catchments zones with in the Murray-Darling Basin (Gilligan D, Vey A and Asmus M, 2009). The river system and adjoining forest are recognised as having high ecological value and feature the iconic River Red Gum and Murray Cod (*Maccullochella peelii peelii* - Vulnerable EPBCA), as well as a number of threatened and vulnerable species, such as the Silver perch (*Bidyanus bidyanus*- vulnerable TSCA) and Trout cod (*Maccullochella macquariensis* -endangered EPBCA) (MDBC 2007). **2. Expected ecological outcomes** – provide the flow variability to improve and restore wetland diversity, resilience and connectivity to the main river channel so they can act as drought refuges for vulnerable fish species. Restore and maintain health of River Red Gum forests and fill deflation basins (e.g. Poon Boon Lakes and Lake Agnes) to support diverse wetland vegetation. It could be possible to water up to 3,300 ha of Black Box depressions and other smaller wetlands that have been disconnected from the river by development

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
				for a number of years. It is also expected that the water will flush the system and 'freshen up' some of the saline pools and billabongs along the system (D. Green, pers.comm) which would improve the habitat for fish and other organisms. Due to a lack of water the system did not flow all of the 2008-2009 water year, resulting in some degradation, however during the 2009-2010 water year the river is operating at close to usual operating conditions. **3. Potential risks** – Risks associated with delivering environmental flows into drought affected waterways are the creation of hypoxic and toxic blackwater flows, the mobilisation of poor quality water that can impact on refugia with better quality water downstream, or rapid changes in water quality (such as temperature, pH or salinity) that exceed the acclimatisation capacity of fish (Gilligan, Vey and Asmus, 2009). Management of risks is primarily though watering early in spring (or late winter) to minimise the likelihood of extreme temperatures resulting in a blackwater event. **4. Long-term sustainability** – The Edward River is one of the main channels used by River Murray Operations to move water to Lake Victoria the Wakool River is managed by NSW under the MDB Agreement and therefore the management of this section of the system is at the discretion of NSW. **5. Cost effectiveness** – NSW does not complete their environmental water planning process until later in the year so it is unclear what contribution, if any, there would be from NSW. For the delivery of the water there is potential to supplement natural flows should a higher flow event come from the Ovens River in Victoria or the Barmah Millewa Allowance is triggered (D.Green, pers.comm 2009). Monitoring would be undertaken by NSW and would consist of inundation mapping and recording of incidental observations of birds and plant response when in the field.
Tanyaka Island Wetlands – Pike FP Lower Murray (SA)	22	11,895	• Retain health of long-lived vegetation that provides habitat to many species. • Provide a drought refuge for frogs (including the Southern Bell Frog) and waterbirds – the wetlands contain lignum which provides habitat (including breeding habitat) to many fish and bird species. • Freshen the seed bank of understorey and aquatic plants – as there has been no water on this site there is concern that the seed bank may be lost. • Prevent permanent loss of Lignum.	**1. Ecological Significance** – • The wider floodplain supports the Southern Bell Frog (*Litoria raniformis*) and habitat for the Regent Parrot - EPBC Act listed **2. Expected Outcomes** – To provide a drought refuge for birds, frogs, and improve health of understorey and canopy vegetation. Lignum shubland is dead or stressed and in poor condition, however it is known to respond rapidly to inundation. **3. Risks of watering action** – Application from the state states that there are no risks. **4. Long-term sustainability of Asset** – • No previous e-watering; Currently dry and has been since 1996 (potentially partially inundated in 2000). • A priority floodplain in a reach (542 - 564 Km) of the Murray that by-passes lock 4 for the SA e-water prioritisation, which focuses on clusters of wetlands found along different stretches of the river to ensure a diversity of habitats are protected. • Pike River Floodplain Management Plan (2008) **5. Cost effectiveness** – Site management, watering and monitoring to be undertaken by SA MDM NRM Board.
Letton's	23	44,999	• Retain health of long-lived vegetation (River Red Gum and River	**1. Ecological Significance** –

Site/s	Estimated Volume (ML)		State Rationale	DEWHA Assessment Summary - Rationale
Billabong Extension – Pike FP Lower Murray (SA)			Coobah) that provides habitat to many species. • Provide a drought refuge for Southern Bell Frog and waterbirds – the wetlands contain Lignum which provides habitat (including breeding habitat) to many fish and bird species. • Freshen the seed bank of understorey and aquatic plants – as there has been no water on this site there is concern that the seed bank may be lost. • Prevent permanent loss of Lignum. • Possible connectivity between Letton's billabong and the River Murray and hence enable dispersal of species.	• Southern Bell Frog is known to inhabit the broader floodplain area **2. Expected Outcomes** - Some water is currently in the western end of the channel due to pool levels at Lock 4. Lignum shubland is dead or stressed and in poor condition, however it is known to respond rapidly to inundation. **3. Risks of watering action** – Application from the state states that there are no risks. **4. Long-term sustainability of Asset** – • No previous e-watering; currently dry and has been since 1996 (potentially partially inundated in 2000) and some retention of water following rainfall events. • A priority floodplain in a reach (542 - 564 Km) of the Murray that by-passes lock 4 for the SA e-water prioritisation, which focuses on clusters of wetlands found along different stretches of the river to ensure a diversity of habitats are protected. • Pike River Floodplain Management Plan (2008) **5. Cost effectiveness** – Site management, watering and monitoring to be undertaken by SA MDM NRM Board. SA will contribute to the delivery costs.

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Assessment of proposed watering sites against 2008-2009 criteria for prioritisation

Priority	Site	Water Act & Business Plan	Ecological Significance	Ecological Outcomes	Risks			Commonwealth Contribution	Partner contribution	Cost effectiveness	Sustaining long-term ecology	Management Arrangements	Comment
					Watering	Not watering	Not achieving Outcomes						
VICTORIA													
1	Lindsay-Wallpolla – Lindsay Island - Mullaroo Creek - Stockyards - Webster's lagoon - Crankhandle wetland - Woodcutters	Consistent – criteria 2 & 3, avoiding irretrievable damage and providing drought refuge - Commitments under Convention on Biological Diversity (CBD)	- TLM icon site with highly significant RRG communities (incl. birds, frogs, tortoises) - Site management plans in place & no stock grazing - Large-bodied fish populations (esp. Murray Cod) in Mullaroo Creek	Maintain health of small area of RRG currently in decline, and provide drought refuge for vulnerable & threatened species - allow greater volumes in Spring 2009	Unsustainable regeneration of RRG if no follow-up (Low)	Further decline (High)	Low – based on previous experience & if used with partner water	Approx 1 GL (50%) - Medium overall but could be high at specific sites	- Rest of 2 GL (VIC) - Management arrangements in place including monitoring - $165,375 covering pumping and minor works, staff time, communications and reporting and monitoring.	- Moderate – High pumping costs @ $66/ML + minor works for total of $70,125 - low transmission losses	- High importance due to long-lived RRG - High likelihood due to VIC commitment - Pumping may not be sustainable in the long-term	Good (VIC and TLM arrangements incl. monitoring in place)	- Priming for Spring watering - In drought conditions Cwth water should be *a component of required water* allowing VIC and TLM to water further down their list - Require further information on negative risks from VIC/TLM
2	Hattah Lakes – Chalka Creek	Consistent – criteria 2 & 3, avoiding irretrievable damage and providing drought refuge - Commitments under CBD. JAMBA, CAMBA & RAMSAR conventions	- TLM icon site with highly significant RRG communities (incl. birds, frogs, tortoises) - Site management plan in place	Restore health of small area of RRG currently in severe decline, and provide drought refuge for vulnerable & threatened species	- Unsustainable regeneration of RRG if no follow-up (Medium) - Sensitivity / Community (Medium) – pumps vandalised a few years ago	Further decline (High) – Not watered in 2007-2008	Low – based on previous experience & if used with partner water	Approx 500 ML (50%) - Medium	- Rest of 1 GL (VIC) - Management arrangements in place. - Same cost share as one although exact figure still to be determined for pumping and minor works, staff time, communications and reporting and monitoring.	- Moderate – High pumping costs @ $66/ML + minor works for total of $39,050 - low transmission losses	- High importance due to long-lived RRG - Fish communities in lakes unlikely to survive without seasonal flooding - Pumping may not be sustainable in the long-term	Unclear, although VIC looking to water in autumn 2009	- Volumes sufficient for watering fringing RRG but not filling lakes - TLM planned to water with 4GL in Spring 2008 but haven't. - Not clear if works are required.
3	Lindsay-Wallpolla – Mulcra Island - Billabong - Control Billabong - Snake lagoon extension - East end	Consistent – criteria 2 & 3, avoiding irretrievable damage and providing drought refuge - Commitments under Convention on Biological Diversity (CBD)	- TLM icon site with highly significant RRG communities (incl. birds, frogs, tortoises) - Site management plans in place & no stock grazing	Maintain health of small area of RRG currently in decline, and provide drought refuge for vulnerable & threatened species - allow greater volumes in Spring 2009	Unsustainable regeneration of RRG if no follow-up (Low)	Further decline (High)	Low – based on previous experience & if used with partner water	May be up to 500 ML (0-25%) –if not supplied to Hattah- Medium overall but could be high at specific sites	- Rest of 2 GL (VIC) - Management arrangements in place - Same cost share as one although exact figure still to be determined for pumping and minor works, staff time, communications and reporting and monitoring.	- Moderate – High pumping costs @ $66/ML + minor works for total of $36,300 - low transmission losses	- High importance due to long-lived RRG - High likelihood due to VIC commitment - Pumping may not be sustainable in the long-term	- Good (VIC and TLM arrangements incl. monitoring in place)	- Priming for Spring watering - In drought conditions Cwth water should be *a component of required water* allowing VIC and TLM to water further down their list - Require further information on negative risks from VIC/TLM - May not be feasible due to TLM works
4	Lindsay-Wallpolla – Walpolla Island - Wallpolla West - Sandy Creek - Finnigan's East/West	Consistent – criteria 2 & 3, avoiding irretrievable damage and providing drought refuge - Commitments under Convention on Biological Diversity (CBD)	- TLM icon site with highly significant RRG communities (incl. birds, frogs, tortoises) - Site management plans in place; grazing allowed	Maintain health of small area of RRG currently in decline, and provide drought refuge for vulnerable & threatened species	Unsustainable regeneration of RRG if no follow-up (Low)	Further decline (High)	Low – if used with partner water	Up tp 500 ML (25%) - Medium overall but could be high at specific sites	- Rest of 2.5 GL (VIC) - TLM to pay pumping costs - Management arrangements in place	- Moderate – High pumping costs @ $66/ML + minor works for total of $38,870 - low transmission losses	- High importance due to long-lived RRG - High likelihood die to VIC commitment - Pumping may not be sustainable in the long-term	Good (VIC and TLM arrangements incl. monitoring in place)	- Priming for Spring watering - In drought conditions Cwth water should be *a component of required water* allowing VIC and TLM to water further down their list - Require further information on negative risks from VIC/TLM
5	Cardross Basin	Consistent – criteria 1, 2 & 3, avoiding critical loss of threatened species, avoiding irretrievable damage and providing drought refuge	- Critically endangered Murray Hardyhead	Provide drought refuge for endangered fish	- Potential salinity problems - Further information required	Further decline of critically threatened species (Low – watered in Spring)	Low – if used with partner water	Up to 500 ML (0%) - High	- Rest of 0.77 GL (VIC)	- Moderate – High pumping costs @ $66/ML + minor works for total of $26,533 - low transmission losses	- High importance - High likelihood given small volumes of water required	Good (VIC and TLM arrangements incl. monitoring in place)	- Watered already in Spring 2008
N/A in 2008-09	Gunbower-Koondrook-Perricoota Forests – Gunbower Forest - Little Gunbower Wetland Complex - Little Reedy Lagoon Complex	Consistent – criteria 1, 2 & 3, avoiding critical loss of threatened species, avoiding irretrievable damage and providing drought refuge	TLM icon site with highly significant and threatened flora and fauna communities	Sites were watered in 2007-08 to provide drought refuge for birds, fish and frogs. Top up would ensure wetlands continue to provide a refuge	- Undesirable RRG regeneration if no follow-up (low) - Flooding triggers a bird breeding event (low)	Further decline of flora and fauna communities (moderate)	Low – if used with partner water	0 ML (0%) - Small overall but could be high at specific sites	- 5GL (VIC & TLM) - Management arrangements in place	Good – no pumping costs, gravity fed delivery through Yarranwonga and Gunbower Creek Regulators - low transmission losses	- High importance due to long-lived RRG and signficant colonial waterbird breeding sites - High likelihood due to VIC commitment	Good (VIC and TLM arrangements incl. monitoring in place)	- Watered already in October 2008 - In drying phase for Autumn 2008

Priority	Site	Water Act & Business Plan	Ecological Significance	Ecological Outcomes	Risks			Commonwealth Contribution	Partner contribution	Cost effectiveness	Sustaining long-term ecology	Management Arrangements	Comment
					Watering	Not watering	Not achieving Outcomes						
				in 2008-09.	- Community concern over environmental watering in an extended drought (low)						- Other sites in Gunbower require pumping which may not be sustainable in the long term		
N/A in 2008-09	Gunbower-Koondrook-Perricoota Forests – Gunbower Creek	Consistent – criteria 1, 2 & 3, avoiding critical loss of threatened species, avoiding irretrievable damage and providing drought refuge	TLM icon site with highly significant and threatened flora and fauna communities	Provide a refuge for large bodied fish, especially the Murray Cod.		Further decline of and fauna communities (moderate)	Low – if used with partner water	0 ML (0%) - Small overall but could be high at specific sites	- 4GL (VIC & TLM) - Management arrangements in place	Good – no pumping costs, gravity fed delivery through Torumbarry weir pool - low transmission losses	- High importance due to long-lived fish - High likelihood due to VIC commitment and watering of the site by GMW when the creek is run to supply irrigation.	Good (VIC and TLM arrangements incl. monitoring in place)	- Contingency to maintain flows if GMW do not run the creek to supply irrigation.
N/A in 2008-09	Barmah-Millewa – Creeks	Consistent – criteria 1, 2 & 3, avoiding critical loss of threatened species, avoiding irretrievable damage and providing drought refuge	- TLM icon site with highly significant RRG communities (incl. birds, frogs, tortoises) - Endangered fish species	- Provide drought refuge for threatened species; esp. Southern Pygmy Perch & Dwarf Flat-headed Gudgeon.	Unsustainable regeneration of RRG if no follow-up (Low)	Further decline (High), although already watered in Spring	Medium – Endangered fish species may not be present	200 ML (40%) – Medium to High but unlikely to occur this year due to timing	- Rest of 0.5 GL (VIC) - Management arrangements in place	Good – gravity fed with no pumping costs - low transmission losses	- High importance - High likelihood given status and small volumes required and VIC commitment	Good (VIC and TLM arrangements incl. monitoring in place)	- Already watered in Spring. Not expected to require further VIC/TLM water this year - Requires minimum flow to activate (b/w 3,500-9,500 ML/day d/s Yarrawonga
N/A in 2008-09	Barmah-Millewa – Boals Deadwoods wetland	Consistent – criteria 1, 2 & 3, avoiding critical loss of threatened species, avoiding irretrievable damage and providing drought refuge	- TLM icon site with highly significant RRG communities (incl. birds, frogs, tortoises) - Endangered fish species	- Provide drought refuge for threatened species; esp. Southern Pygmy Perch & Dwarf Flat-headed Gudgeon.	Unsustainable regeneration of RRG if no follow-up (Medium)	Further decline (Modertate)	Low – if used with partner water	0 ML (0%) - High	- 0.5 GL (VIC & TLM) - Management arrangements in place	Good – gravity fed with no pumping costs - low transmission losses	- High importance - High likelihood given status, small volumes required and VIC commitment	Good (VIC and TLM arrangements incl. monitoring in place)	
N/A in 2008-09	Barmah-Millewa Top Island wetlands	Consistent – criteria 1, 2 & 3, avoiding critical loss of threatened species, avoiding irretrievable damage and providing drought refuge	- TLM icon site with highly significant RRG communities (incl. birds, frogs, tortoises) - Endangered fish species	- Provide drought refuge for threatened species; esp. Southern Pygmy Perch & Dwarf Flat-headed Gudgeon.	Unsustainable regeneration of RRG if no follow-up (Medium)	Further decline (Moderate)	Low – if used with partner water	0 ML (0%) - High	- 0.5 GL (VIC & TLM) - Management arrangements in place	Good – gravity fed with no pumping costs - low transmission losses	- High importance - High likelihood given status, small volumes required and VIC commitment	Good (VIC and TLM arrangements incl. monitoring in place)	
SOUTH AUSTRALIA													
CHOWILLA FLOODPLAIN													
1	Chowilla Floodplain - Slaney Billabong - Lock 6 Depression - Brandybottle waterhole - Chowilla Horseshoe	Criteria 2 and 3, avoiding irretrievable damage and providing drought refuge. - Commitments under Convention on Biological Diversity & Ramsar Convention. - Chowilla floodplain and is incorporated into the Bookmark Biosphere, under the UNESCO Man and Biosphere program.	- Part of Chowilla floodplain which is a TLM Icon site - Creeks and billabongs identified as a key wetlands in TLM Icon Site Environmental Management Plan 2006-07. - Habitats demonstrate high structural complexity with flood dependent understory, mature River Red Gums and recruitment of River Red gums, Black Box and River Cooba. Bunyip hole includes large areas of Lignum. - Six of the seven frogs recorded breeding at Chowilla have been recorded at this site, including Southern Bell Frog. When flooded, the site provides refuge for a large number of water	- Prevent significant loss of long lived flood dependent vegetation and prevent replacement by a less diverse salt tolerant community. - Provide critical drought refuge for a diverse collection of fauna including endangered species. - Encourage frog breeding and provide refuge for water birds. - Builds on previous watering which is important for maintaining health of RRG (refer to TLM Environmental Watering Report 2007-08)	- Blackwater, salinity, exotic plant infestation. - Risks are considered by RMEM to be low	- Loss of many of the River Red Gum, Black Box and River Cooba saplings, which developed from previous waterings. - Further decline in the health of mature trees. - Loss of breeding opportunity for six frog species. - Reduces drought refuges and makes recovery more difficult in the future.	Low – based on previous experience & if used with partner water	436 ML and $25,000 for pumping costs	- Management and monitoring arrangements. - 350 ML to be provided to other wetlands in Chowilla (Pilby Creek and the Bunyip Hole)	- Significant ecological outcomes possible from modest amounts of water and funding.	- Chowilla is an important ecological site supported by TLM and the State. - Proposed CEWH watering builds on watering undertaken by TLM and SA. - Construction of regulator will allow watering of large area in longer term. - Chowilla is likely to be sustainable in the long term. This area is in relatively good health.	- South Australian and TLM arrangements in place. - TLM Icon Site environmental management plan and SA Department of Environment and Heritage wetland management plan.	Previously watered in May 2005 and Oct 2006. - Good prospects of future watering. - Watering will allow site to be maintained until construction of regulator which will support longer term management of the floodplain.

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					Watering	Not watering	Not achieving Outcomes						
			birds. - Provides refuge for water birds and three species of tortoise including the State listed Broad-shelled Tortoise.										
KATARAPKO FLOODPLAIN													
2	Katarapko Floodplain - Carpark Lagoons,	Criteria 2 and 3 avoiding irretrievable damage and providing drought refuge.	Priority floodplain identified in South Australian Murray Environmental Framework. Contains significant number of mature river red gums and habitat for a range of aquatic and terrestrial animals. MDBA demonstration reach for native fish	Prevent significant loss of long lived flood dependent vegetation Maintain health of area of RRG, currently in decline (significant number <10% canopy cover). Builds on previous watering in 2005 and 2006. Previous watering, demonstrated positive responses in vegetation, RRG and bird and frog breeding.	- Blackwater, salinity, exotic plant infestation. - Risks are considered by RMEM to be low risks are all low	- Decline in the health of mature trees and habitat for aquatic and terrestrial animals.	Low – based on previous experience & if used with partner	200 ML	Pumping costs ($15,000) and monitoring and management of the watering	- Significant ecological outcomes possible from modest amounts of water and funding.	Part of the Murray River National Park. Area to receive significant infrastructure investment, including the removal of structures that impede flow and the construction of wetland regulators and major control structures. - Proposed CEWH watering builds on watering undertaken in 2005 and 2006.	Management and monitoring arrangements in place. Implementation plan for native fish demonstration reach in place.	Watering will allow site to be maintained until infrastructure works (construction of regulator and flow controls structures) are undertaken and which will support the longer term management of the floodplain.
BELOW LOCK 1													
TBC Pending receipt of additional information	Paiwalla Wetland, near Murray Bridge	Criteria 3, providing drought refuge.	Listed in the Directory of Important Wetlands of Australia (DIWA) Threatened species recorded at site (Southern Bell Frog and Painted Snipe). In addition, 161 species of birds (including 16 species of state significance), 3 species of turtle and 8 species of frogs have been recorded.	Maintain the current health of the aquatic habitat (maintain salinity and turbidity levels, increase dissolved oxygen levels). Sustain and enhance fish populations. Maintain feeding habitat for migratory and water dependent birds. Previous watering in February 2008 resulted in increased native fish population, frog and bird breeding events and increased diversity in native fringing vegetation.	Proposal identifies risks from watering and describes strategies to deal with the risks	Loss of habitat, and jeopardise benefits achieved from previous watering by TLM in 2008. Paiwalla received water from TLM in February 2008 to reduce threats from acid sulphate soils and salinisation and arrest decline in refuge habitat.	Low – based on previous experience & if used with partner	475 ML in March 2009 382 ML September 2009 Funding of $30,000 sought for pumping of water.	Monitoring and management of the site.	Pumping costs are around $35 / ML.	Community group (Wetland Habitats Trust) own some of the site and manage it. The source of future water for the Paiwalla is unclear.	Adequately covered by the Wetlands Habitats Trust, and SA MDB NRM Board.	Support on the condition that the State identifies long term strategy for meeting the watering needs of Paiwalla.
TBC Pending receipt of additional information	Boggy Creek, Hindmarsh Island	Criteria 1, 3 avoiding critical loss of threatened species, and providing drought refuge.	Part of Coorong, Lower Lakes and Murray Mouth Ramsar sites. Persisting freshwater refuge habitat with intact submergent and emergent plant communities and aquatic populations, which will support threatened fish communities. Large and healthy population of Murray hardyhead.	Maintain habitat and fish population	Proposal identifies risks from watering and describes strategies to deal with the risks.	Loss of habitat and fish population	Watering dependent on sourcing water of suitable quality.	27 ML $20,000 for pumping and construction of small embankment to pond water	3 ML to be provided by Healthy Rivers Australia (formerly Waterfind Environment Fund). An amount of $10,000 being provided by SA to contribute towards pumping and construction costs. Monitoring and management of the site.	Relatively expensive for amount of water delivered. ($1,000/ML)	Strategies for long term sustainability are unclear. Intervention identified in *State Drought Action Management Plan*. State response/ actions from this plan have not been identified.	Hindmarsh Island Wetland Management Plan. Drought plan quarterly monitoring.	Confirmation needed on - the State's long term strategy for meeting the watering needs of the site, and - the State's response/ actions arising from the *State Drought Action Management Plan*.

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TBC Pending receipt of additional information	Channels on Mundoo Island, Mundoo Island	Criteria 1, 3 avoiding critical loss of threatened species, and providing drought refuge.	Part of Coorong, Lower Lakes and Murray Mouth Ramsar sites. Persisting freshwater refuge habitat with intact submergent and emergent plant communities and aquatic populations, which will support threatened fish communities. Murray hardyhead and Southern pygmy perch recorded at this site.	Maintain habitat and fish population	Proposal identifies risks from watering and describes strategies to deal with the risks.	Loss of habitat and fish population	Watering dependent on sourcing water of suitable quality.	15 ML $30,000 to pump water and build a small embankment to pond water	Monitoring and management of the site.	Relatively expensive for amount of water delivered. ($2000/ML)	Strategies for long term sustainability are unclear. Intervention identified in *State Drought Action Management Plan*. State response/ actions from this plan have not been identified.	Management plan not yet developed. Drought plan quarterly monitoring.	Confirmation needed on - the State's long term strategy for meeting the watering needs of the site, and - the State's response/ actions arising from the *State Drought Action Management Plan*.
TBC Pending receipt of additional information	Rocky Gully, Murray Bridge	Criteria 1, 3 avoiding critical loss of threatened species, and providing drought refuge.	Not a listed wetland Refuge site for range of fish, invertebrate and bird communities, including five species of threatened native fishes recorded in 2005 (Murray hardyhead, Murray rainbow fish, catfish, dwarf flat-headed gudgeon and unspecked hardy head).	Maintain habitat and fish population	Proposal identifies risks from watering and describes strategies to deal with the risks	Loss of aquatic habitat and fish population	SA MDB MRM Board to undertake watering and monitoring of watering	80 ML $40,000 including the construction of an embankment to pond water.	Management and monitoring arrangements	Relatively expensive for amount of water delivered. ($500/ML)	Strategies for long term sustainability are unclear. Intervention identified in *State Drought Action Management Plan*. State response/ actions from this plan have not been identified.	Management plan in place Drought plan quarterly monitoring.	Confirmation needed on - the State's long term strategy for meeting the watering needs of the site, and - the State's response/ actions arising from the *State Drought Action Management Plan*.
TBC Pending receipt of additional information	Turveys Drain, Milang	Criteria 1, 3 avoiding critical loss of threatened species, and providing drought refuge.	Part of Coorong, Lower Lakes and Murray Mouth Ramsar sites. Provide existing remnant freshwater refuge habitats, for threatened fish, Murray hardy head and Southern pygmy perch.	Maintain habitat and fish population	Proposal identifies risks from watering and describes strategies to deal with the risks	Loss of aquatic habitat and fish population	SA MDB MRM Board to undertake watering and monitoring of watering	25ML and $10,000 to pump water	Management and monitoring arrangements	Relatively expensive for amount of water delivered. ($400/ ML)	Strategies for long term sustainability are unclear. Intervention identified in *State Drought Action Management Plan*. State response/ actions from this plan have not been identified.	Management plan not yet developed.	Confirmation needed on - the State's long term strategy for meeting the watering needs of the site, and - the State's response/ actions arising from the *State Drought Action Management Plan*.
NEW SOUTH WALES													
Murray River													
N/A in 2008-09	Barmah-Millewa (NSW)	Consistent with criterion 3, i.e. maintain drought refuge for the Southern Pygmy Perch (threatened in NSW) NB: see comments—Sothern Pygmy Perch no longer appear to be at site.	Refuge supports Southern Pygmy Perch which are threatened in NSW. Wetland is in *NSW Central Murray State Forests* Ramsar Site NB: see comments—Sothern Pygmy Perch no longer appear to be at site.	Maintain pools in small permanent wetlands known to contain habitat for populations of Southern Pigmy Perch (threatened in NSW).	Low: no major risks identified	Low to moderate: unlikely to have major impact as Southern Pygmy Perch are no longer believed to be at the site. However without watering habitat wil degrade	High to moderate: Southern Pygmy Perch appear to no longer be in area (see comments). However, watering will protect habitat	Commonwealth contribution no longer required.	NSW now advise they have sufficient water (125 ML) to cover this watering themselves.	N/A NSW to cover this action. No Commonwealth water now required.	Good: site is a high priority as a Ramsar site and TLM icon site. Barmah-Millewa forest have, until very recently, received frequent watering.	The area is State Forest and is covered by a management plan: The Ecologically Sustainable Forest Management Plan-Riverina Region NSW. This covers grazing, timber harvesting, pest control and fire management.	Recent monitoring has indicated that the Southern Pygmy Perch is no longer located at this site. However the site provides good habitat for this species. NSW now advise they have sufficient water to undertake this watering themselves.
N/A in 2008-09	Gunbower-Perricoota-Koondrook (NSW): Pollack Swamp	Consistent with criterion 2: avoid irretrievable loss	Area is part of the *NSW Central Murray State Forests* Ramsar Site, supports River Red Gum forests and waterbird breeding habitat.	Action will help maintenance and recovery of wetland vegetation, and will contribute to the maintenance of bird breeding and foraging habitat.	Low (Unlikely risk of minor impact if bird breeding is triggered and unsustained)	Significant (Likely moderate impact - no wetting phase this year).	Medium: High transmission losses may result in reduced water volumes reaching the site unless further water if	Commonwealth contribution no longer required.	NSW now advise they are likely to have sufficient water to cover this watering themselves, and tht any shortfall is likely to be covered by TLM.	N/A NSW and TLM to cover this action. No Commonwealth water now required.	Moderate: site is a high priority as a Ramsar site and TLM icon site, however delivery mechanisms to this site are poor.	The area is State Forest and is covered by a management plan: The Ecologically Sustainable Forest Management Plan-Riverina Region NSW.	NSW are now in a position to cover this watering

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					Watering	Not watering	Not achieving Outcomes						
							provided to account for this					This covers grazing, timber harvesting, pest control and fire management.	
Murrumbidgee River													
N/A in 2008-09	Two Bridges Wetlands in Yanga National Park, Lowbidgee Floodplain	While broadly consistent with criteria 1 & 3 (avoiding critical loss of threatened species and providing drought refuge) but given current watering does not fully meet the threshold.	Wetlands identified by Charles Sturt University as highest priority wetlands in Murrumbidgee for the nationally vulnerable state endangered Southern Bell Frog. Lowbidgee Floodplain listed as nationally important	Preserve Southern Bell Frog populations in their priority habitat and provide for limited breeding. Provide in-stream benefits through passage of water to this lower catchment asset.	May trigger larger breeding event that is not able to be sustained	Reduction of state endangered and nationally vulnerable Southern Bell Frog in their highest priority wetlands	Low, area was wetted last water year and volumes required are well known.	Commonwealth contribution no longer required.	NSW now advise they are likely to have sufficient water to cover this watering themselves.	N/A NSW and TLM to cover this action. No Commonwealth water now required.	High. Area has been purchased and gazetted as a National Park. Area has been identified as the highest priority for Southern Bell Frogs. NSW has RiverBank holdings to help preserve area into the future.	As a National Park, a management plan is required and is being developed for the area.	Watering to be undertaken in late Autum, early Winter NSW are now in a position to cover this watering
Lachlan River													
1	Below Lake Cargelligo: Murrumbidgil Swamp	Consistent – with criteria: (2) avoids irretrievable damage (the wetland is in a critical condition and has not been inundated since 1998); and (3) maintains drought refuge to allow re-colonisation following drought Consistent with international obligations- JAMBA, CAMBA and the Convention on Biological Diversity: see ecological significance in next column	DIWA listed site (wetland of national significance). Threatened species: The Superb Parrot (nationally vulnerable) and the Australian Painted Snipe (nationally vulnerable and also CAMBA listed). Species listed under JAMBA and / or CAMBA which have been recorded within these wetlands include the Great Egret, Glossy Ibis, and the Sharp-tailed Sandpiper	Maintain health of core wetland areas including River Red Gums and Lignum shrublands which are currently in decline, and provide drought refuges —Water will improve in-stream habitat for aquatic fauna and will provide water for bank-side vegetation on way to the terminal wetland	Will cause regeneration which could die off without follow-up watering. May cause a bird breeding event which may not continue to completion.	Further decline and loss of ecological character	Low to moderate – watering with this volume has been undertaken before, but not for a significant period.	5,000 ML required, including tributary flows. The proportion of environmental water the Commonwealth could contribute would be dependant on allocation available; however, it is likely the majority would come from NSW DECC.	Flow distribution rules of Lachlan Water Sharing Plan remain suspended. Should a replenishment flow occur, an additional 1,000 - 2,000 ML of environmental water would be required to fill Murrumbidgil Swamp.	High- NSW provide majority of water. No pumping costs as gravity fed.	- Medium. This is one of many assets in the Lachlan which has a call on environmental water and it has not been inundated since 1998. –The Water Sharing Plan (WSP) has 20 GL of Environmental Contingency Allowance, but this has very low security. The WSP also provides an annual replenishment flow of up to 9 GL to the Torrigany, Muggabah and Merrimajeel Creeks Trust District downstream to the Murrumbidgil Swamp. However, the WSP is currently suspended. NSW RiverBank has been purchasing entitlements and CEWH entitlements will also help improve the long term viability of site.	Low: No formal plan in place.	Requires a replenishment flow before environmental watering can be delivered. Condition currently critical and declining. Flooding is essential to retain some of the River Red Gum alive and provide best chance of preventing loss of ecological character.
1	Above Lake Cargelligo: Burrawang West Lagoons	Consistent – criterion 3 – maintains drought refuge to allow re-colonisation following drought Consistent with international obligations- JAMBA, CAMBA and the Convention on	Migratory and threatened species: The Superb Parrot (nationally vulnerable) and the Australian Painted Snipe (nationally vulnerable and listed as migratory under CAMBA). DPI Fisheries reintroduced	Maintain health of River Red Gum and reintroduced Purple spotted Gudgeon populations, and provides drought refuges –Will act to provide seed sources (plants	Will cause regeneration which could die off without follow-up watering. May cause a bird breeding event which may not	Further decline and loss of DPI reintroduced purple-spotted Gudgeons	Low - These small wetlands are strategically located such that they are readily watered and require small volumes.	An approximate maximum of 150 – 200 ML of environmental water is likely to be required if there are no flows in Goobang or Yarrabandai Creeks	- Monitoring by DECC. - NSW likely to provide majority or water.	Very high- NSW to provide majority of water and monitoring. No pumping costs as gravity fed. They are readily watered and require small volumes	High- These small wetlands are strategically located such that they are readily watered and require small volumes. Both NSW DECC	Medium- The landholder, in cooperation with the CMA has set up a wildlife refuge over the property and excluded cattle from 120 hectares where Red River Gums are	DPI Fisheries reintroduced Purple-spotted Gudgeons to this site in 2006, with the aim that recruitment will spread the species further in the Lachlan River. Riverbank is supporting this

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		Biological Diversity: see ecological significance in next column	Purple-spotted Gudgeons to this site in 2006 (listed as threatened in NSW).	and animals) for wetlands downstream	continue to completion.			and State Water restricts current flow access arrangements. The proportion from the Commonwealth would be dependant on allocation available; however, it is likely the majority would come from NSW DECC.			and the CEWH have general security holdings in this zone which should provide for the needs of this asset in the longer term.	revegetating.	reintroduction by supplying water when necessary to ensure permanent habitat.
2	Above Lake Cargelligo: Yarnel Lagoons	Consistent – criterion 3 – maintains drought refuge to allow re-colonisation following drought Consistent with international obligations- JAMBA, CAMBA and the Convention on Biological Diversity: see ecological significance in next column	Migratory and threatened species: The Superb Parrot (nationally vulnerable) and the Australian Painted Snipe (nationally vulnerable and listed as migratory under CAMBA).	Maintain health of wetlands flora including, River Red Gum which are currently in decline, and provides drought refuges –Will act to provide seed sources (plants and animals) for wetlands downstream.	Will cause regeneration which could die off without follow-up watering. May cause a bird breeding event which may not continue to completion	Further decline	Low - These small wetlands are strategically located such that they are readily watered and require small volumes	Approximately 300 ML of environmental water is required to flood this wetland for 4-6months. The proportion from the Commonwealth would be dependant on allocation available; however, it is likely the majority would come from NSW DECC.	- Monitoring by DECC. - NSW likely to provide majority or water.	Very high- NSW to provide majority of water and monitoring. No pumping costs as gravity fed. They are readily watered and require small volumes	High- These small wetlands are strategically located such that they are readily watered and require small volumes. Both NSW DECC and the CEWH have general security holdings in this zone which should provide for the needs of this asset in the longer term.	Low- No formal management plans in place.	A benchmarking ecology study highlighted the potential for this wetland to contribute to frog diversity. A resident pair of brolgas, rare in this region of NSW and threatened at a state level, has bred previously when conditions were suitable. These conditions can now only be created by active management of water
Macquarie River													
1	- Northern Sector of Macquarie Marshes (core wetland area)	Consistent – criterion 3 – maintains drought refuge to allow re-colonisation following drought Consistent with international obligations- see ecological significance in next column	Will water Northern Macquarie Marshes Nature Reserve component of the Macquarie Marshes Ramsar site. Area is DIWA listed. Supports two major and six minor bird breeding sites. Supports a variety of semi-permanent wetland types May reach north of reserve, where vegetation is in a critical condition <u>Threatened species</u>: Australasian Bittern (state vulnerable and globally endangered (on ICUN Red List)); Painted Snipe (state endangered, nationally vulnerable and listed migratory (CAMBA)); Murray Cod (nationally vulnerable); Aromatic Peppercress (nationally and state endangered). <u>Migratory species</u>: Seventeen migratory listed bird species	—Maintain health of core wetland areas including River Red Gums, woodlands and forests, Common Red beds, Water Couch meadows, Lignum shrubland and Marsh Club-rush sedgelands which are currently in decline, and provide drought refuges —Water will improve in-stream habitat for aquatic fauna and will provide water for bankside vegetation on way to these terminal wetlands —Would provide important follow-on wetting to complement previous flows in March-April 2008	Will cause regeneration which could die off without follow-up watering. May cause a bird breeding event which may not continue to completion.	Further decline	Low to low-medium – watering has been undertaken before with good results although calculations of volumes are not precise.	Approximately 50 GL required from all sources, including tributary flows and local rainfall. Previous wetting will reduce overall water needs Commonwealth contribution likely to be a very small proportion of this and will be dependant on allocation available.	- Monitoring by DECC. - Majority of water to be provided by NSW (will be less if tributary or other flows are available) - Management arrangements in place	- Moderate- NSW provide majority of water. No pumping costs as gravity fed. However, water is not able to be targeted on a tightly defined area	- Water Sharing Plan has 160 GL general security Environmental Contingency Allowance for Macquarie Marshes. NSW RiverBank have been purchasing entitlements and CEWH entitlements will also help ensure long term viability of site. High probability northern Macquarie Marshes Nature Reserve area can be supported in long-term as it has a high natural inundation frequency. Area to north of reserve has a moderate probability it can be supported in long-term (moderate inundation frequency)	Good—Reserve area has comprehensive management regime (reserve managed by NPWS)	Unlikely to take place unless there is a significant increase in allocations.
2	- Wilgara Wetland and Terrigal Creek/Gum	Consistent – criterion 3 – maintains drought refuge to allow re-colonisation	Will water Wilgara wetland component of the Macquarie Marshes	—Maintain health of core wetland areas including	Will cause regeneration which could die	Further decline	Low to low-medium – watering has	Approximately 9 GL required from all sources,	- Monitoring by DECC. - Majority of water to	- Moderate- NSW provide majority of water. No pumping	- Water Sharing Plan has 160 GL general security	Moderate–area is privately owned, but Wilgara Wetland	Unlikely to take place unless there is a significant increase in

Priority	Site	Water Act & Business Plan	Ecological Significance	Ecological Outcomes	Risks			Commonwealth Contribution	Partner contribution	Cost effectiveness	Sustaining long-term ecology	Management Arrangements	Comment
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	Cowal system of Macquarie Marshes	following drought Consistent with international obligations- see ecological significance in next column	Ramsar site. Area is DIWA listed. Supports 3 major and one minor bird breeding sites Threatened species: Australasian Bittern (state vulnerable and globally endangered (on ICUN Red List)); Painted Snipe (state endangered, nationally vulnerable and listed migratory (CAMBA)); Murray Cod (nationally vulnerable); Aromatic Peppercress (nationally and state endangered). Migratory species: Seventeen migratory listed bird species	River Red Gums, woodlands and forests, Common Red beds, Water Couch meadows, Lignum shrubland and Marsh Club-rush sedgelands which are currently in decline, and provide drought refuges —Water will improve in-stream habitat for aquatic fauna and will provide water for bankside vegetation on way to these terminal wetlands	off without follow-up watering. May cause a bird breeding event which may not continue to completion.		been undertaken before with good results although calculations of volumes are not precise.	including tributary flows and local rainfall. Commonwealth contribution likely to be a very small proportion of this and will be dependant on allocation available. May be able to piggy back on stock and domestic flows	be provided by NSW (will be less if tributary or other flows are available) - Management arrangements in place	costs as gravity fed. However, water is not able to be targeted on a tightly defined area	Environmental Contingency Allowance for Macquarie Marshes. NSW RiverBank have been purchasing entitlements and CEWH entitlements will also help ensure long term viability of site. Medium probability it can be supported in long-term (moderate inundation frequency)	section has property management plan and a memorandum of understanding	allocations.
3	- Southern section of Macquarie Marshes, including Southern Macquarie Marshes Nature Reserve	Consistent – criterion 3 – maintains drought refuge to allow re-colonisation following drought Consistent with international obligations- see ecological significance in next column	Will water Southern Macquarie Marshes Nature Reserve component of the Macquarie Marshes Ramsar site. Area is DIWA listed. Supports one major bird breeding site Threatened species: Australasian Bittern (state vulnerable and globally endangered (on ICUN Red List)); Painted Snipe (state endangered, nationally vulnerable and listed migratory (CAMBA)); Murray Cod (nationally vulnerable); Aromatic Peppercress (nationally and state endangered). Migratory species: Seventeen migratory listed bird species	—Maintain health of core wetland areas including River Red Gums, woodlands and forests, Common Red beds, Water Couch meadows, Lignum shrubland and Marsh Club-rush sedgelands which are currently in decline, and provide drought refuges — Flows will support native fish populations by replenishing two important waterhole refuges near Oxley —Water will improve in-stream habitat for aquatic fauna and will provide water for bankside vegetation on way to these terminal wetlands	Will cause regeneration which could die off without follow-up watering. May cause a bird breeding event which may not continue to completion.	Further decline	Low to low-medium – watering has been undertaken before with good results although calculations of volumes are not precise.	Approximately 60 to 90 ML required from all sources, including tributary flows and local rainfall. Commonwealth contribution likely to be a very small proportion of this and will be dependant on allocation available.	- Monitoring by DECC. - Majority of water to be provided by NSW (will be less if tributary or other flows are available) - Management arrangements in place	- Moderate- NSW provide majority of water. No pumping costs as gravity fed. However, water is not able to be targeted on a tightly defined area	- Water Sharing Plan has 160 GL general security Environmental Contingency Allowance for Macquarie Marshes. NSW RiverBank have been purchasing entitlements and CEWH entitlements will also help ensure long term viability of site. Monkeygar Swamp has a high probability it can be supported in long-term (high inundation frequency) High to moderate probability Macquarie River area (to the south of reserve) can be supported in long-term (high to moderate inundation frequency) Note there is a low probability the south Macquarie Marshes Nature Reserve can be supported in long-term (low	Good— South Macquarie Marshes Nature Reserve has comprehensive management regime (reserve managed by NPWS)	Unlikely to take place unless there is a significant increase in allocations.

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											inundation frequency)		
					Gwydir River								
=1	- Gingham Wetlands (core wetland area)	Consistent – criterion 3 – maintains drought refuge to allow re-colonisation following drought Consistent with international obligations- see ecological significance in next column	Area is DIWA listed and includes three components of the Gwydir Wetlands Ramsar site: *Goddard's Lease*, *Crinolyn* and *Windella*. Note: this watering would inundate the majority of *Goddard's Lease*, but only a limited portion of *Crinolyn* and *Windella*). Threatened species: Australasian Bittern (state vulnerable and globally endangered (on ICUN Red List)) and Painted Snipe (state endangered, nationally vulnerable and listed migratory (CAMBA)); Macquarie Perch (nationally endangered). Migratory species: Latham's Snipe (Bonn, JAMBA, CAMBA, RoKAMBA)); Black-tailed Godwit (Bonn, CAMBA, JAMBA, ROKAMBA)), Glossy Ibis (Bonn, CAMBA); and Great (CAMBA, JAMBA) and Cattle (CAMBA, JAMBA) Egret	—Maintain health of core wetland areas including River Red Gums, River Cooba-Lignum shrublands which is currently in decline, and provide drought refuges —Water will improve in-stream habitat for aquatic fauna and will provide water for bank-side vegetation on way to these terminal wetlands	Will cause regeneration which could die off without follow-up watering. May cause a bird breeding event which may not continue to completion. However, there is a further 15 GL held back in the Environmental Contingency Allowance to be used in case of bird breeding. May act to spread water hyacinth (however control measures are in place)	Further decline	Low – water with this volume has been undertaken before and results have been proven through previous experience.	5,000 ML required, including tributary flows. Commonwealth contribution of up to 500 ML (10%).	- Monitoring by DECC. - Majority of water (up to 4,500 ML) to be provided by NSW (will be less if tributary flows are available) - Management arrangements in place	- Very high- NSW provide majority of water. No pumping costs as gravity fed.	- Water Sharing Plan has 45 GL general security Environmental Contingency Allowance with this wetland and Lower Gwydir wetlands as high priorities. NSW RiverBank have been purchasing entitlements and CEWH entitlements will also help ensure long term viability of site.	Medium- Area is privately owned but property management plans in place for two of the Ramsar components, including the targeted Goddard's Lease component Community role in the management of the ECA.	Limited inundation occurred in November/December 2008 through a natural event and again in early February 2009 from a supplementary flow of 9.5 GL topped up with an ECA release of 6.5 GL for the Gingham and Lower Gwydir wetlands combined. This should sustain the core wetland areas for the remainder of the water year; however, this will be monitored.
=1	- Lower Gwydir Wetlands	Consistent – criterion 3 – maintains drought refuge to allow re-colonisation following drought Consistent with international obligations- see ecological significance in next column	Area inundated includes the *Old Dromana* component of the Gwydir Wetlands Ramsar site. Area is DIWA listed. Threatened species: Australasian Bittern (state vulnerable and globally endangered (on ICUN Red List)) and Painted Snipe (state endangered, nationally vulnerable and listed migratory (CAMBA)); Macquarie Perch (nationally endangered). Migratory species: Latham's Snipe (Bonn, JAMBA, CAMBA, RoKAMBA)); Black-tailed Godwit (Bonn, CAMBA,	—Maintain health of core wetland areas including River Red Gums, River Cooba-Lignum shrublands and Marsh Club-rush sedgelands which is currently in decline, and provide drought refuges —Water will improve in-stream habitat for aquatic fauna and will provide water for bank-side vegetation on way to these terminal wetlands	Will cause regeneration which could die off without follow-up watering. May cause a bird breeding event which may not continue to completion. However, there is a further 15 GL held back in the Environmental Contingency Allowance to be used in case of bird breeding. May act to spread water hyacinth (however control measures are in place)	Further decline	Low – water with this volume has been undertaken before and results have been proven through previous experience.	5,000 ML required, including tributary flows. Commonwealth contribution of up to 500 ML (10%).	- Monitoring by DECC. - Majority of water (up to 4,500 ML) to be provided by NSW (will be less if tributary flows are available) - Management arrangements in place	- Very high- NSW provide majority of water. No pumping costs as gravity fed.	- Water Sharing Plan has 45 GL general security Environmental Contingency Allowance with this wetland and Gingham wetlands as high priorities. NSW RiverBank have been purchasing entitlements and CEWH entitlements will also help ensure long term viability of site.	Medium- Area is privately owned but a property management plan in place for the Old Dromana Ramsar component Community role in the management of the ECA.	Limited inundation occurred in November/December 2008 through a natural event and again in early February 2009 from a supplementary flow of 9.5 GL topped up with an ECA release of 6.5 GL for the Gingham and Lower Gwydir wetlands combined. This should sustain the core wetland areas for the remainder of the water year; however, this will be monitored.

Priority	Site	Water Act & Business Plan	Ecological Significance	Ecological Outcomes	Risks			Commonwealth Contribution	Partner contribution	Cost effectiveness	Sustaining long-term ecology	Management Arrangements	Comment
					Watering	Not watering	Not achieving Outcomes						
			JAMBA, ROKAMBA)), Glossy Ibis (Bonn, CAMBA); and Great (CAMBA, JAMBA) and Cattle (CAMBA, JAMBA) Egret										
3	- Completion of breeding events in Gingham or Lower Gwydir	Consistent – criteria 1 and 2 – avoiding critical loss of threatened species; – avoiding irretrievable damage or catastrophic events Consistent with international obligations- see ecological significance in next column	Area includes Gwydir Wetlands Ramsar site and is DIWA listed. Threatened species: Australasian Bittern (state vulnerable and globally endangered (on ICUN Red List)) and Painted Snipe (state endangered, nationally vulnerable and listed migratory (CAMBA)); Macquarie Perch (nationally endangered). Migratory species: Latham's Snipe (Bonn, JAMBA, CAMBA, RoKAMBA)); Black-tailed Godwit (Bonn, CAMBA, JAMBA, ROKAMBA)), Glossy Ibis (Bonn, CAMBA); and Great (CAMBA, JAMBA) and Cattle (CAMBA, JAMBA) Egret	—Will sustain breeding populations of migratory and (potentially) endangered species. —Additional water will further rejuvenate declining wetland vegetation —Water will improve in-stream habitat for aquatic fauna and will provide water for bank-side vegetation on way to these terminal wetlands	May not be sufficient to allow breeding to continue to completion May act to spread water hyacinth (however control measures are in place)	Unsuccessful breeding.	Medium—it is hard to accurately assess how much longer water is required for breeding event to continue to completion	Dependent on needs. Up to 15,000 ML, with majority from ECA. Commonwealth to provide up to 500 ML (3%) or more if available.	- Monitoring by DECC. - Majority of water (up to 15,000 ML) to be provided by NSW - Management arrangements in place	- Very high- NSW provide majority of water. No pumping costs as gravity fed.	- Water Sharing Plan has 45 GL general security Environmental Contingency Allowance with this wetland and Lower Gwydir wetlands as high priorities. NSW RiverBank have been purchasing entitlements and CEWH entitlements will also help ensure long term viability of site.	Medium- Area is privately owned but property management plan in place for three of the four Ramsar component Community role in the management of the ECA.	Only to be considered after other two actions have taken place and there is a high likelihood of success. Alternative of carrying water over to next water year should be strongly considered before undertaking this action.

<u>Attachment E</u> - Monitoring & Evaluation for 2010-11 water use proposals in regulated rivers

Background
Following EWSAC's consideration of autumn 2010 watering actions, the committee asked for further information on the proposed monitoring and evaluation for each watering action. Additional information for watering actions in regulated rivers was sought from watering partners through the use of a proposal template that requested detail on what monitoring would be undertaken to measure the watering objectives. A summary of this information is provided below. Information on the monitoring and evaluation for supplementary events and water use in unregulated rivers will be provided in separate papers over the coming months.

Establishment of the Monitoring, Evaluation and Reporting Framework for the use of Commonwealth Environmental Water in the Murray-Darling Basin and implementation of the resulting program will better enable the suitability of proposed monitoring and evaluation to be assessed and modified where required.

Operational monitoring
Operational monitoring is mandatory for all watering events using Commonwealth environmental water. To ensure a consistent approach is used for operational reporting a template has been developed (considered at EWSAC's February 2010 meeting). The template was distributed to state jurisdictions during scoping meetings held in April/May 2010. The operational template will be revised following feedback from its first use, at which time recommendations from the Committee will also be incorporated. Currently, the template requests the following information:

- GPS coordinates/map reference;
- volume delivered, dates of delivery, mechanism of delivery and other contributions;
- description of deviation from agreed event arrangements;
- an update on risk management for the event;
- details of complementary works;
- area inundation and estimated/known inundation duration;
- species and other notable observations; and
- pre-during-post watering photographs.

For South Australian and Victorian watering actions the template will be used. New South Wales watering actions will continue to occur through the Riverbank Form B: Environmental Water Delivery Report. Where this form does not align with the CEWH template (i.e. GPS coordinates/map reference; estimated/known inundation duration; details of complementary works; and pre-during-post watering photographs) the Environmental Water Branch will negotiate to obtain this information separately.

Intervention Monitoring
The Draft Monitoring, Evaluation and Reporting Framework for the use of Commonwealth environmental water in the Murray-Darling Basin specifies that systematic intervention monitoring of all assets for all events may not necessarily occur. Intervention monitoring will generally continue to draw on monitoring currently undertaken by the delivery partners.

For most watering actions under consideration for 2010-11 intervention monitoring has been proposed, with the exceptions being: Lake Hume to Yarrawonga Reach in New South Wales; and the Mallee CMA - Murray River Wetlands, Boort Wetlands, Goulburn-Broken Wetlands and the Kerang Wetlands in Victoria. An overview of the proposed intervention monitoring for each state, including the exceptions, is provided below. Additional site-level detail is provided at <u>Appendix 1</u> of this attachment.

South Australia

All sites under consideration within South Australia have proposed intervention monitoring which relates to the watering objectives. The approach is generally consistent across the proposed sites within South Australia and follows procedures from The Living Murray[1] or Your Wetland: Monitoring Manual Data Collection, 2004.[2] Watering proposals with objectives relating to threatened fish (Paiwalla, Berri Evaporation Basin, Disher Creek Evaporation Basin, Goolwa Barrage and Rocky Gully), and the Lower Lakes have pre-existing programs in place that monitor the condition of these sites and/or fish populations.

A number of proposals have an objective to 'support frog breeding' or 'promote a successful breeding event'. In most cases the referenced procedure will only detect abundance and diversity of frog species. At these sites additional monitoring of tadpoles could be included to indicate if breeding has successfully occurred (some sites specify that tadpole monitoring will be undertaken).

Victoria

The level of intervention monitoring to be undertaken at the proposed Victorian sites varies:

- At two sites (Cardross Lakes and Lake Hawthorn) where the watering objective is to protect and/or restore populations and habitat for the Murray hardyhead, fish sampling will be undertaken by the Murray Darling Freshwater Research Centre and the Arthur Rylah Institute.

- A number of proposed watering actions will occur within the Chowilla Floodplain and the Lindsay, Mulcra and Wallpolla Islands TLM icon site (Barmah-Millewa Forest, Lake Wallawalla, Lindsay Island, Mulcra Island, Wallpolla Island, Little Reedy Complex and Black Charlie Lagoon (Gunbower Forest)). The broader icon site area has an established condition monitoring program (which includes some instances intervention monitoring such as the monitoring of bird breeding events) (Wallace 2009). The detail of intervention monitoring for the watering action with the TLM site will be discussed further with delivery partners.

- For in-stream proposals (Loddon River, Campaspe River and Goulburn River) monitoring of response to the watering action should be captured by the Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP). Monitoring under VEFMAP covers a broad range of indices aimed at assessing the benefits of environmental water provided to streams within Victoria. These indices range from fish and instream vegetation to detailed stream form surveys and are undertaken as part of a prescribed schedule (e.g. stream form is only surveyed every five years).

- Monitoring of environmental water at Dookie Campus will be undertaken as part of a research project considering the potential ecological benefits of using of wetlands as off-stream storages. Parameters monitored will include: macrophyte community dynamics; flowering and seed production; macroinvertebrate community dynamics, egg production and egg bank dynamics; and water quality parameters, including nutrients.
- No intervention monitoring is proposed for the following sites: Mallee CMA - Murray River Wetlands, Boort Wetlands, Goulburn-Broken Wetlands and the Kerang Wetlands. Victoria have indicated that intervention monitoring can be undertaken if the CEWH covers the cost. This monitoring would likely include waterbirds (using the Birds Australia methodology which involves regular surveys, with increased frequency if breeding is occurring) and aquatic vegetation (using transects surveyed before and after watering, as well as potentially during to track emergent vegetation). Negotiations will continue with Victoria around potential delivery sites and monitoring priorities.

New South Wales

Most watering actions under consideration within NSW have proposed intervention monitoring. The proposed monitoring programs are in alignment with previous or existing monitoring undertaken at each site, or using established procedures such as those used in the Sustainable Rivers Audit. Two proposed watering actions, Wakool-Yallakool and the Werai, request financial contribution from the CEWH for monitoring and evaluation. The intervention monitoring for these two proposals are outlined in more detail in Appendix 2 of this attachment.

There is no intervention monitoring proposed for the Lake Hume to Yarrawonga Reach. For this action the primary watering objective is to raise river levels by supplementing base flows, thereby inundating a large number of wetlands with commence-to-flow levels of more than 15,000 ML per day. While it is expected that this will also result in many ecological responses; the primary objective will only be monitored using inundation mapping and flow gauging and will be captured in the operational reporting of this action.

The NSW Office of Water (NOW) is yet to confirm intervention monitoring activities for their proposed stimulus flow in the Severn River. On previous occasions, NOW has monitored the response of algal (biofilm) and benthic communities in a reach of the Severn River below Pindari Dam (spanning approximately 20 km of river). In addition, operational monitoring was used to confirm that the planned release pattern and downstream hydrograph was achieved. A detailed assessment (before-after-control-impact) of potential impacts of the stimulus flow on spawning related movements of native fish species was undertaken for the 2008 release (Wilson and Ellison 2010, in prep). Monitoring in 2010 is likely to be similar in scope however, resource constraints may prevent monitoring of the response of migratory fish species for the 2010 release (pers comm. Neal Foster, NOW).

References

Nicholas Souter, S.C., Stuart Little, Todd Wallace, Bernard McCarthy, Mark Henderson & Kate Bennets. , *Draft - Ground-Based Survey Methods for The Living Murray Assessment of Condition of river red gum and black box Communities. Version 10.* 2009, Murray-Darling Basin Authority.

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Wilson and Ellison 2010 in prep, *Pindari Dam fish monitoring project*. Draft final report to the New South Wales Office of Water (unpublished report provided in confidence)

Cunningham, S. C., Mac Nally, R., Griffioen, P., and White, M. (2009) *Mapping the Condition of River Red Gum and Black Box Stands in The Living Murray Icon Sites.* A Milestone Report to the Murray-Darling Basin Authority as part of Contract MD1114. Murray-Darling Basin Authority, Canberra

Wallace, T.A. (2009) The Living Murray: Condition Monitoring Program design for Chowilla
Floodplain and the Lindsay, Mulcra and Wallpolla Islands. Development Draft 2.0. A report prepared for the Murray-Darling Basin Commission by the Murray-Darling Freshwater Research Centre.

Appendix 1 - Proposed Intervention Monitoring for 2010-11 Watering Proposals

Name of watering option	Water Quality	Fish	Tree health	Frog	Groundwater	Birds	Aquatic Veg	Photopoints	Other	Whom
South Australia										
Lake Alexandrina and Lake Albert	U	TLM				TLM	TLM		water levels TLM: Mudflats, water, invertebrates	SARDI, universities, DWLBC, SA EPA
Rocky Gully	1	2					2	1		SARDI, Aquasave consultants, DEH,
Paiwalla	1 (fortnightly for 2 months)	1, 3 (November and March)		1 (before & after, September and November)	1 (every 3 months for 5 months then every 3 months)	1 (monthly)		1 (3 monthly for 5 months then 3 monthly)		SA MDB NRMB; Wetlands Habitats Trust (incl. accredited Birds Australia recorder)
Disher Creek	2 (quarterly)	2 (quarterly)					2 (quarterly)			DEH
Berri Evaporation Basin	2 (quarterly)	2 (quarterly)					2 (quarterly)			DEH, SARDI, Aquasave consultants
Goolwa Barrage	U	4								SARDI, SA Water, DWLBC
Bunyip Reach	U (up to 6/year)		5 (annually)	1 (spring & summer)		1 (summer)		1 (tree health)		SA MDB NRMB
Weila	U (up to 6/year)		5 (6 monthly)	1 (spring & summer)		1 (spring & summer)		U (quarterly)		SA MDB NRMB
Murtho Park Depression	U (up to 6/year)		5 (6 monthly)	1 (spring & summer)		1 (summer)		U (quarterly)		SA MDB NRMB
Hogwash Bend	U (up to 6/year)		5 (6 monthly)	1 (spring & summer)		1 (summer)		U (quarterly)	regent parrot (spring)	SA MDB NRMB, RWLAP, DEH, Uni SA
Nikalapko Complex	U (up to 6/year)		5 (6 monthly)	1 (spring & summer)		1 (summer)		U (quarterly)		SA MDB NRMB
Morgan Conservation Park	U (monthly)		5 (pre and post inundation)	1 (spring & summer)					tadpole surveys (spring and summer)	DEH
Reid Flat (aka Riversleigh)	U (up to 6/year)		5 (6 monthly)	1 (spring & summer)		1 (summer)		U (quarterly)		SA MDB NRMB
Wigley Reach Wetlands	U (up to 6/year)		5 (6 monthly)	1 (spring & summer)		1 (spring & summer)		U (quarterly)	regent parrot breeding	SA MDB NRMB
Overland Corner	1 (quarterly)		5 (6 monthly)	1 (spring & summer)	1 (quarterly)	1 (summer)		1 (quarterly)	quantitative veg surveys annual (Jan-Feb) - quadrat & transect monitoring	SA MDB NRMB
Whirlpool Corner	U (up to 6/year)		5 (6 monthly)	1 (spring & summer)		1 (summer)		1 (quarterly)		SA MDB NRMB
Sweeneys Lagoon	U (up to 6/year)		1 (pre- then monthly for 6 months then every three months)	1 (spring & summer)	U (monthly for 6 months then every 3 months)			U (tree health)		SA MDB NRMB
Templeton	U			U (presence absence & density Sept/Oct)	U	U		U (tree health)		Renmark to Border Local Action Planning Association and landholders
Molo Flat Complex	U (up to 6/year)		5 (6 monthly)	1 (spring & summer)		1 (summer)		1 (tree health & general)		SA MDB NRMB
Markaranka Complex	U (up to 6/year)		5 (6 monthly)	1 (spring & summer)		1 (summer)		U (quarterly)		SA MDB NRMB
Akuna	U (up to 6/year)		5 (6 monthly)	1 (spring & summer)		1 (summer)		U (quarterly)		SA MDB NRMB
Taylor Flat	U (up to 6/year)		5 (6 monthly)	1 (spring & summer)	U	1 (summer)		U (quarterly)		SA MDB NRMB
Martin Bend	1 (quarterly)		5 (6 monthly)	1 (spring & summer)	1 (quarterly)	1 (summer)		1 (quarterly)		SA MDB NRMB
Noonawirra	1 (weekly for 1 month then monthly)		1 (quarterly)	1 (2 weeks following pumping then September & November)	1 (quarterly)		1 (September)	1 (monthly for 6 months then 3 monthly)	tadpole	SA MDB NRMB / Mid Murray Local Action Planning
Coombool Swamp and Lake Limbra			U	U		U				SARDI, SA MDB NRMB, and DEH
Katarapko Creek: South Floodrunner and Lagoon	U (monthly)		5 (pre and post inundation)	1 (spring & summer)		U (monthly)			tadpole	DEH
Katarapko Floodplain, Carpark Lagoons	U (monthly)		5 (pre and post inundation)	1 (spring & summer)		U (monthly)			tadpole	DEH
Katarapko Floodplain, Piggy Creek	U (monthly)		5 (pre and post inundation)	1 (spring & summer)		U (monthly)			tadpole	DEH
Pike Floodplain - Mundic Billabong	6	6	6	6	6	6			understorey vegetation	SA MDB NRMB
Pike Flood Plain - Inner Mundic Flood Runner	6	6	6	6	6	6			understorey vegetation	SA MDB NRMB
Pike Floodplain - Tanyaca Creek Aquadam	6	6	6	6	6	6			understorey vegetation	SA MDB NRMB
Victoria										
Lake Wallawalla [a]						TLM			TLM understorey vegetation	
Mallee CMA Murray River Wetlands [b]										
Lindsay Island		TLM	TLM	TLM	TLM	TLM			TLM understorey vegetation	
Mulcra Island		TLM	TLM	TLM	TLM	TLM			TLM understorey vegetation	

Wallpolla Island		TLM	TLM	TLM	TLM	TLM			TLM understorey vegetation	
Cardross Lakes (Murray hardyhead	U	U						U		MDFRC and Arthur Rylah Institute
Lake Hawthorn	U	U								MDFRC and Arthur Rylah Institute
Kerang Wetlands [b]								U		
Boort Wetlands [b]								U		
Loddon River[c]										
Campaspee River [c]										
Black Charlie Lagoon (Gunbower Forest)		TLM	TLM	TLM	TLM	TLM			TLM understorey vegetation	
Little Reedy Complex (Gunbower Forest)		TLM	TLM	TLM	TLM	TLM			TLM understorey vegetation	
Goulburn River [c]										
Barmah-Millewa Forest		TLM	TLM	TLM	TLM	TLM			macroinvertebrates	MDBA
Goulburn-Broken Wetlands [b]								U		
MDFRC - Dookie Campus	U						U		macroinvertebrates	MDFRC
New South Wales										
North Redbank		7	8	7		7			littoral vegetation bat monitoring using anabat detectors/CSIRO method with call recognition software	Charles Sturt University, DECCW, CSIRO (Heather McGinness) and or MDFRC, NOW
North Section of Yanga National Park	7 (Oct, Dec & Feb)	7 (Oct, Dec & Feb)	8	7 (Oct, Dec & Feb)	U	7 (Oct, Dec & Feb)	7, 8		bat monitoring using anabat detectors/CSIRO method with call recognition software	Charles Sturt University, DECCW, CSIRO (Heather McGinness) and or MDFRC, NOW
Werai State Forest	9, 10	10					10	U (tree health)		Murray CMA, NSW I&I, DECCW, MDBA, Contractor
Lake Hume to Yarrawonga Reach [d]										
Wakool-Yallakool	10	10					10	10		Murray CMA, NSW I&I
Yarnel Lagoon			U	U		U				DECCW
Queensland / New South Wales										
Severn River		TBD							algae and benthic communities	NOW

Key:
U: Unspecified methodology.
TLM: This parameter is monitored through TLM condition monitoring at this floodplain. Further negotiations with state partners will determine the extent to which the proposed watering sites are encompassed by TLM condition monitoring. Details on the monitoring methods for each parameter can be found in the following reports: The Living Murray - Lower Lakes, Coorong and Murray Mouth Icon Site Condition Monitoring Plan 2009; and Wallace, T.A. (2009); and The Living Murray: Condition Monitoring Program design for Chowilla Floodplain and the Lindsay, Mulcra and Wallpolla Islands. Development Draft 2.0. A report prepared for the Murray-Darling Basin Commission by the Murray-Darling Freshwater Research Centre.
1: Tucker, P. (2004) Your Wetland: Monitoring Manual - data collection. River Murray Catchment Water Management Board and Australian Landscape Trust. Renmark, SA.
2: Fish populations are sampled using various techniques, including fyke nets, box traps, seine netting and electro-fishing. Hall, A, Higham, J., Hammer, M., Bice, C., and Zampptti, B. (2009) Drought Action Plan for South Australian Murray-Darling Basin threatened freshwater fish populations 2009-10; Rescue to Recovery.
3: Fish monitored using Native Fish Australia Guidelines.
4: Existing monitoring program; methods described in Jennings, P., Bice, C., and Zampatti, B. (2009) Impact of drought and river regulation on the spawning and recruitment of diadromous *Galaxia maculatus* and *Pseudaphritis urvilli* in the Coorong Estuary, Australia. SARDI.
5: Souter, N., Cunnigham, S., Little, S., Wallace, T., McCarthy, B., Henderson, M., Bennets, K. (2009) Ground-based Survey Methods for The Living Murray Assessment of Condition of River Red Gum and Black Box Communities. Version 10. Murray-Darling Basin Authority.
6: A monitoring plan for the Pike floodplain is currently under preparation. TLM monitoring methodology is currently being utilised.
7: Spencer, J.A. and Wassens, S. (2009) Responses of waterbirds, fish and frogs to environmental flows in the Lowbidgee wetlands in 2008-09. Final report for the NSW Rivers Environmental Restoration Program. Rivers and Wetland Unit, NSW Department of Environment and Climate Change, Sydney and Institute for Land, Water and Society, Charles Sturt University, Wagga Wagga. July 2009.
8: Satellite image assessment ground-truthing (validation) additional monitoring at Yanga includes river red gum and aquatic vegetation transects/quadrats (existing long term program).
9: Monitoring includes observations of fish, frogs, birds and other species (no scientific monitoring method is used). Monitoring will occur as per previous monitoring of this site published in: Webster, R. (2010) Environmental Monitoring of Werai Forest Environmental Flow: 2009-10. Ecosurveys Pty Ltd. Deniliquin NSW.
10: see Monitoring and Evaluation text for a description of the monitoring to be undertaken.

Footnotes:
(a) While Lake Wallawalla is within the Chowilla Floodplain and the Lindsay, Mulcra and Wallpolla Islands TLM site, the established condition monitoring program does not encompass this site, consequently for the CEWH 2009-10 watering of this site additional monitoring was undertaken which comprises of inundation and bird monitoring (which was in alignment with broader Mallee CMA bird monitoring). It is possible that the site may be captured within TLM aerial bird surveys undertaken annually in conjunction with the Annual Eastern Australia Waterbird Survey. Tree condition monitoring was not undertaken due to similar programs being undertaken at nearby sites. The proposed watering action is a top-up of last years event, no additional monitoring will be undertaken.
(b) Intervention monitoring is only to be undertaken if requested and paid for by the CEWH.
(c) The monitoring for this watering action will be addressed in further negotiations with Victorian partners. The action is likely to be captured within VEFMAP.
(d) Operational monitoring only.

Appendix 2 - Proposed monitoring arrangements for Werai and Wakool-Yallakool

Wakool-Yallakool

The proposed monitoring of Wakool-Yallakool watering event will contribute to the *Baseline Conditions of Fish and Associated Habitat Assets with the Edward-Wakool System – management based research and objective driven monitoring for environmental water use and on-ground activities Project* being undertaken by the Murray CMA (working with NSW Industry & Investment) which will run for the next three years. A technical advisory team (Fish and Flows Expert Panel) support this project and an operational team has been formed to specifically manage the water associated with the Wakool-Yallakool component. The outputs from this project will provide information to support development of environmental watering options that maximise the ecological benefit and methods to minimise risks associated with the provision of water in the wider Edward-Wakool System.

The baseline fish project will provide for:

- identification of high conservation value aquatic species and ecosystems;
- identification of preferred fish migration routes and barriers to movement;
- understanding of the impacts of specific intervention measures and management actions; and
- identification of the response of different species of fish to changes in flow conditions and hence the flow regimes required to achieve specific fish objectives.

For the proposed watering event in the Wakool-Yallakool monitoring will be undertaken using slightly modified Sustainable Rivers Audit procedures at five sites. Themes to be measured include fish (adapted to include overnight netting to capture more cryptic species and sampling for young of year), water quality and instream/riparian habitat. These five sites are part of 40 sites in the broader study area of the baseline fish project. Sampling will occur twice, before and after watering.

Another facet of the baseline fish project involves installation of a series of acoustic arrays in the upper Wakool-Yallakool to monitor large bodied fish movement in response to replenishment and pulsed flows. Silver perch, golden perch, Murray cod and carp will be tagged (30 of each species). Up to 40 arrays will be placed throughout the system. The Yallakool Creek will be used as a control, and the Upper Wakool River as the flow manipulation site. Temporary water temperature loggers will be placed in both streams to determine if there is an interaction between flow timing-temperature-fish movement.

Additional monitoring for the CEWH watering event would include measurement of water quality at set locations along the Wakool River and Yallakool Creek to ensure return flows do not compromise water quality. Photopoints will be established at these locations and also at additional sites to monitor vegetation, inundation and instream habitat. Inundation measurements will also be taken at the peaks and during draw-down. Observations of species will be noted.

Werai

Monitoring of the proposed Werai watering action would consist of two major components. As for the 2009-10 CEWH watering, a contractor will be engaged to undertake:

- vegetation monitoring (list of understorey species) and observational notes on response of particular species of interest (e.g. phragmites).
- photopoints – using the same photopoints as last year, unless there is a reason to change i.e. vision obscured by new vegetation growth.
- Water quality - including temperature, DO, salinity, pH and depth.

Additional monitoring will be undertaken by the Murray CMA (working with NSW Industry & Investment) which includes the monitoring of seven sites across Werai (all inflow points, all forest outflow points and one point in the middle of the forest). This will be consistent with monitoring for the baseline fish project outlined above; slightly modified SRA methodologies will be used to measure fish, water quality, instream habitat and riparian habitat. Sampling will occur twice during the inundation period.

Site assessments against the EWSAC endorsed criteria for assessing 2010-11 environmental watering actions

Table of Contents

SOUTH AUSTRALIA

Akuna

DEWHA Assessment Summary	CEWH	Other
Site: Akuna Station Wetland **Floodplain/region:** Murray below choke **Catchment:** Lower Murray **Timing:** September 2010	**Volume:** 40 ML **Cost:** $5,820 ($50/ML), CEWH $2,000, State contribution $ 3,820	**Volume:** 0 ML

Description of Watering Action and Objective
A volume of 40 ML is proposed to be released into the Akuna Station Wetland, pumped directly from the River Murray in September 2010. The proposed watering will build upon the previous watering by South Australia, and the pumping undertaken in May 2010.

The proposed watering will maintain water levels over the spring and summer 2010 seasons to ensure there is enough water for frog and waterbird breeding events; and maintain the health of mature and juvenile River red gums (*Eucalyptus camaldulensis* var. *camaldulensis*) and mature Black box (*Eucalyptus largiflorens*).

Description of site / watering history
The Akuna Station Wetland is located 34km east of Waikeri on the River Murray. Akuna wetland is composed of a relatively deep (approx. 1 m) and small temporary lagoon and a floodrunner (covering 10 ha) that connects to the River Murray during high river levels.

Akuna is a series of temporary wetlands, which are estimated to be inundated between 10,000 ML/day to 40,000 ML/day (Overton *et al.* 2006). Flows of this magnitude occurred 100 to 89 per cent of years. With current extraction, these flows are estimated to occur 89 to 49 per cent of years, although this is expected to increase following the implementation of the Basin Plan.

Over the past few years Akuna has received water from a variety of sources on three occasions via pumping:

- 103 ML in April 2006 as part of the River Red Gum Rescue Project;
- 40 ML of private donation in Feb 2007; and
- 80 ML of South Australian water pumped in May 2010.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance - Within the Akuna Floodplain, 76.1 ha of floodplain fall within the top two highest ranked categories for maintenance and rehabilitation within the Floodplain Prioritisation Project (Miles *et al.* 2007) undertaken by the South Australian Murray-Darling Basin Natural Resources Management Board (SA MDB NRM). The Floodplain Prioritisation Project established broad scale floodplain priorities on the basis of environmental values, threats to the floodplain and the opportunity to manage these threats.

The Australasian shoveler (*Anas rhynchotis;* SA Rare) was last recorded in August 2009. Southern bell frogs (*Litoria raniformis*: Commonwealth vulnerable; SA vulnerable) were last recorded in December 2009.

2. Expected ecological outcomes
Maintain and improve the health of mature and juvenile river red gums (*Eucalyptus camaldulensis* var. *camaldulensis*) and mature black box (*Eucalyptus largiflorens*). The wetland supports long lived vegetation including river red gums, black box and river coobahs that are in moderate health; however the health of these species and other perennial vegetation at the site is expected to improve following watering in May 2010 and watering proposed in this bid. Avoiding the death of river red gum saplings (established in 2006) around the edge of the wetland (and hence supporting the establishment of the 'next generation' of long-lived vegetation) is an objective of the watering.

Avoid decline in health or death of mature long-lived vegetation: Without flooding of the wetland for a period of time to allow for freshening of the local groundwater and providing a water source for the older trees, there is a risk they will eventually die off, and without conditions favorable to germination and recruitment, leave no replacements.

Provide a drought refuge: Provision of water to the wetland in spring 2010 will support frog breeding and provide habitat for water-dependent bird species.

3. Potential risks - SA has identified the following risks of watering Akuna are as follows:
1. Blackwater events - Low Risk: Blackwater events have not occurred during previous watering. However, water quality parameters will be monitored throughout the inundation of the wetland. If a blackwater event occurs, water will be contained within the wetland and is highly unlikely to re-enter the River due to the presence of an embankment.

2. Water leaking back to the River - Low Risk: the downstream outlet has a regulator installed to stop water returning to the River. Pumping will be monitored closely, and if there are any issues regarding water flowing out of the wetland, the pumping will cease immediately.
3. Grazing - Low Risk: there are no cattle grazing on this floodplain.

4. Long-term sustainability The site is considered a priority for management and monitoring by the South Australian Murray-Darling Basin Natural Resources Management Board (SA MDB NRM) and landholders. A management plan does not exist for this site. The SA MDB NRM Board will manage the pumping event, and monitoring (compliance and intervention). Monitoring the release will be undertaken by SA MDB NRM Board Staff, including six monthly tree surveys, spring and summer frog surveys, bird surveys in summer and water quality parameters (salinity, temperature, pH, turbidity and dissolved oxygen) will be monitored regularly (up to six times a year during inundation and drawdown). Results of this monitoring will be available in quarterly CEWH reports. Further information regarding the alignment of the proposed monitoring with the ecological objectives may be found in the Attachment.

5. Cost effectiveness - Water delivered to the Akuna Station Wetland is by pumping directly from the River Murray, with costs to be paid by the Commonwealth and the delivery partners. SA will contribute to the delivery costs and project management and monitoring.

References
Miles et al. (2007) Prioritisation of the SA River Murray Floodplain for the Delivery and Management of Environmental Water - Map Book. Report prepared for the SA MDB NRM Board.

Overton, I.C., McEwan, K., Gabrovsek, C. and Sherra, J.R. (2006) The River Murray Floodplain Inundation Model (Rim-FIM) Hume Dam to Wellington, CSIRO Water for a Healthy Country Technical Report.

Berri Evaporation Basin Outlet Creek

DEWHA Assessment Summary	CEWH	Other
Site: Berri Evaporation Basin Outlet Creek **Floodplain/region:** Murray below choke **Catchment:** Lower Murray **Timing:** September - April 2010	**Volume:** 24.4 ML **Cost:** $0 ($0/ML)	**Volume:** 0 ML

Description of Watering Action and Objective
From September 2010 to April 2011, a volume of 24.4 ML will be gravity fed from the River Murray into the outlet channel of the Berri Evaporation Basin for the purpose of maintaining water quality to promote breeding of the Murray hardyhead (*Craterocephalus fluviatilis:* Commonwealth vulnerable).

Description of site / watering history
The evaporation basin is located south-west of Berri, SA. This site was first established as an irrigation drainage basin in 1940. Inflows to the site are saline water from the Berri Comprehensive Drainage Scheme. In recent years there has been a significant decrease in inflows due to the ongoing drought and improvement in efficiency in irrigation practises, resulting in a majority of the basin drying out in summer months (DEH 2009).

Murray hardyhead are found in an outlet channel of the basin, water levels in this channel have been previously maintained by the drainage of saline water from the basin and freshwater leaking in from the River through a regulation structure (DEH 2009). The site has not previously received environmental water.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance - The site provides habitat for one of four core populations of Murray hardyhead in South Australia. The species is rated as endangered under the Action Plan for South Australian Freshwater Fishes (Hammer *et al.* 2009).

2. Expected ecological outcomes - Providing water between September to April will replace evaporative losses from the outlet channel, improving water quality and providing a freshwater influx which will act as a breeding cue for the Murray hardyhead. Berri Evaporation Basin Channel is a high priority site for conservation of the Murray hardyhead and the fish was last captured in May 2010 during condition monitoring as part of the Drought Action Plan for Threatened Fish (DEH 2009).

3. Potential risks - Risks identified by South Australia include:
1. Movement of Murray hardyhead into the river where they may be out-competed by species better suited to fresher environments. Due to the distance the current population is from the river and their preference for semi-saline to saline water, it is considered unlikely that migration into the river will occur; and
2. Saline water: Opening delivery structures may result in the introduction of saline water into River Murray channel. It is considered that the gradient of flow will be enough to push water of higher salinities away from the river. The structure will also only be open long enough to deliver allocated volumes before closing.

4. Long-term sustainability - Management of the site is guided by the Murray hardyhead (*Craterocephalus fluviatilis)* Habitat and Population Management Plan Berri Saline Water Disposal Basin. This plan proposes that salinity levels within the Outlet Creek will be managed using irrigation drainage and allocated River Murray environmental flows (DEH 2009).

The site lies in the Katarpko Floodplain and River Murray National Park. This floodplain is a demonstration reach for native fish, commonly known as the Katfish Reach, under the MBDA Native Fish Strategy. The population of Murray hardyhead at Berri Evaporation Basin is a high priority under the South Australian Drought Action Plan for Threatened Fish 2009-10 and the Action Plan for SA Freshwater Fishes 2009.

Monitoring of the Murray hardyhead population is ongoing by the SA Department of Environment and Heritage, which is conducted quarterly through the South Australian Drought Action Plan. The proposed monitoring of this watering action is in alignment with the watering objectives stated above. Additional information on the monitoring can be found in the monitoring and evaluation attachment.

5. Cost effectiveness - Water can be gravity fed to the site. There are no costs to the CEWH for this watering action. The state will provide project management and monitoring, which will be conducted quarterly through the South Australian Drought Action Plan.

References

DEH (2009) Murray hardyhead *Craterocephalus fluviatilis* Habitat and Population Management Plan Berri Saline Water Disposal Basin.

Hammer, M. Wedderburn, S. and Van Weenen, J. (2009) Action Plan for SA Freshwater Fishes, Native Fish Australia, Adelaide

Hall, A., Higham, J., Hammer, M., Bice, C. and Zampptti, B. (2009) Drought Action Plan for South Australian Murray-Darling Basin threatened freshwater fish populations 2009-2010; Rescue to Recovery. Draft. South Australian Department for Environment and Heritage, Adelaide**.**

Bunyip Reach

DEWHA Assessment Summary	CEWH	Other
Site: Bunyip Reach **Floodplain/region:** Murray below choke **Catchment:** Lower Murray **Timing:** June 2010 – July 2011	**Volume:** 640 ML **Cost:** $1,800 ($0/ML); State contribution $1,800	**Volume:** 0 ML

Description of Watering Action and Objective
The Bunyip Reach Anabranch wetlands are located within the Riverland Ramsar site, and are proposed for a 640 ML watering, to be distributed over the period from July 2010 until June 2011. Peak flows are proposed for July 2010 (458 ML), followed by an immediate reduction in flows in the following month (6.5 ML), which will then be ramped to summer 2010-11 (22 ML/month) and subsequently steadily decreased until June 2011. This watering schedule will ensure the site is filled prior to spring 2010, and the water levels maintained throughout summer.

Watering of this site will assist in the preservation of habitat for the Commonwealth vulnerable regent parrot, southern bell frog and Murray cod, through protection of the red gums, black box, river cooba and lignum.

Description of site / watering history
Bunyip Reach Anabranch wetlands are a series of shallow lagoons linked by natural watercourses. The lagoons are typically river red gum lined wetlands with lignum fringes on the higher terraces. SA has advised that the lagoons closest to the inlets are in good health and the lagoons at the terminal end of the anabranch have severely degraded riparian vegetation and beds covered in halophytes and saltbush/bluebush species due to the extended dry period exceeding ten years. Bunyip Reach wetlands were filled October 2000 – February 2001, during a weir pool raising event. In 2005-06 parts of the system were also inundated during the Lock 6 weir pool raising event.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance - Bunyip Reach Anabranch wetlands are located within the Riverland Ramsar site, adjacent the Chowilla Floodplain. The Riverland Ramsar Site supports the following nationally threatened species defined under section 179 of the Australian *Environment Protection and Biodiversity Conservation Act 1999:* Regent parrot (Eastern) (*Polytelis anthopeplus monarchoides* Commonwealth vulnerable; SA vulnerable). The site supports a breeding population of over one hundred pairs that have been recorded nesting at ten locations adjacent to the main river channel (Smith 2001 & 2004).

Southern bell frog (*Litoria raniformis* Commonwealth vulnerable; SA vulnerable) - regionally common with populations recorded at most of the large wetlands throughout the site.

Murray cod *(Maccullochella peelii peelii* Commonwealth vulnerable). The main population of this species is located within the main channel of the River Murray and associated deep-water anabranch creeks. However in times of flood, SA has advised that individuals may move onto the floodplain via the anabranch systems and flooded lentic channels.

2. Expected ecological outcomes - Improve health (and prevent further death) of stressed mature river red gums (*Eucalyptus camaldulensis*), black box (*Eucalyptus largiflorens*) and river cooba (*Acacia stenophylla*); and support established juvenile trees. If watering is not undertaken, SA advises that there is a risk of loss of mature river red gums and failure to support next generation of juvenile river red gums.

Provide foraging and breeding habitat for wetland and floodplain dependant birds including conservation significant and migratory species (drought refuge). This wetland complex is located adjacent the Nil Nil Regent parrot breeding colony (DEH 2009). The site is fringed by healthy River red gums and there are many large mature red gums with abundant hollows present at the site providing critical habitat for this threatened species.

Prevent loss of large areas of moderately healthy Lignum (*Muehlenbeckia florulenta*) which is uncommon in such abundance at wetlands within the region and is expected to provide habitat for frogs and breeding water birds.

3. Potential risks - A risk assessment has been undertaken by SA for the proposed watering event. There is a low risk of algal bloom and blackwater events occurring. The preferred timing of the commencement of the watering event is in winter, which in turn lowers the risk of algae / black water event occurring. The outlet structures will remain closed also, so there is a low risk of water returning to the river.

4. Long-term sustainability – High - A wetland plan is currently being developed for the site, outlining the long-term management recommendations for the site (Sharley A.J. (In Press)). The SA MDB NRM Board staff will assist with the management of the watering, and monitoring. The land manager ([redacted]s responsible for the land management.

Monitoring of the watering event will be undertaken by the SA MDB NRM Board staff, including twelve monthly tree health assessments, bird surveys undertaken in summer, frog surveys undertaken in spring and summer, and water quality parameters (salinity, temperature, pH, turbidity and dissolved oxygen) will be monitored regularly (up to six times a year during inundation and drawdown). Results of this monitoring will be available in the quarterly progress report for the CEWH Watering 2010-11 and the annual DWLBC Watering Report. Further information regarding the alignment of the proposed watering action with the ecological objectives may be found in the Attachment.

5. Cost effectiveness - High - Water will be gravity fed through the anabranch filling the wetland lagoons between the watercourses. The outlet regulator will remain closed. Water levels will be managed for maximum height of 19.25 m AHD. Pumping charges will be paid by the delivery partner (SA MDB NRM). There are no costs to the Commonwealth.

References

DEH (2009) Results of the 2008 Regent Parrot Nest Surveys in the SA Murray Darling Basin, Department for Environment and Heritage Adelaide, South Australia

Sharley A.J. (In Press) Wetland Management Plan — Bunyip Reach and Queens Bend Wetlands. Report for Mark Stoeckel. Funded by SA MDB NRM Board.

Smith, K. (2001) Regent Parrot Nest Survey 2000. Unpublished report for the South Australian National Parks and Wildlife Council, Adelaide.

Smith, K. (2004) Regent Parrot Nest Survey 2003 to 2004. Unpublished report for the Threatened Species Network, Adelaide.

Coombool Swamp and Lake Limbra (Chowilla)

DEWHA Assessment Summary	CEWH	Other
Site: Coombool Swamp and Lake Limbra **Floodplain/region:** Chowilla Floodplain **Catchment:** Lower Murray **Timing:** autumn 2011	**Volume:** 9,150 ML **Cost:** $427,000 ($43/ML): CEWH $396,000; State contribution $30,000	**Volume:** 0 ML

Description of Watering Action and Objective

Coombool Swamp and Lake Limbra are located within the Chowilla Floodplain and Lindsay–Wallpolla Islands Icon Site. They are also within the Riverland Wetland of International Importance (Ramsar). This proposal covers the release of 9,150 ML to be pumped into the system, commencing in autumn 2010 (March – June). The proposed watering will deliver 4,650 ML to Coombool Swamp and 4,500 ML to Lake Limbra, with the objectives of providing a drought refuge for waterbirds, frogs and fish and maintaining floodplain vegetation.

Description of site / watering history

The Chowilla floodplain is located near the NSW, Victorian and South Australian borders on the northern side of the River Murray. The two sites are large terminal wetland sites ringed by mature stands of Black box. The inlet channels are fringed by Black box, areas of Lignum and areas of flood dependent understorey including low herblands. Coombool Swamp includes Brandy Bottle waterhole and the Werta Wert wetland and connecting floodplain. Coombool swamp was last watered in April-July 2010, using 3,650 ML of Commonwealth water and 1,000 ML of state/TLM provided water. Bottle Waterhole has been watered three times (2005, 2006 and 2009); Werta Wert has been watered three times (2004, 2005 and 2008). Lake Limbra was last watered in autumn 2010, using 4,500 ML of Commonwealth water. Prior to this, Lake Limbra last received partial inundation in 2000 as a result of natural flooding. Commence to fill occurs at Coombool Swamp at 70,000 – 75,000 ML/day and Lake Limbra at 40,000 ML/day (Sharley and Huggan 1995).

Lack of overbank flooding and rising saline ground water has led to significant decline in the condition and diversity of the floodplain understorey vegetation on the Chowilla floodplain (Marsden *et al.* 2008). Much of the environmental watering on the Chowilla Floodplain has focused on the maintenance and recovery of River red gum systems owing to the higher inundation frequencies required to maintain these communities. However it has now been nine years since the last overbank flows at Chowilla and SA advises that both lignum and black box communities are exhibiting signs of severe stress and death. The scientific monitoring program has revealed that at a similar site, Coppermine floodplain, between September 2007 and August 2008 the number of black box recorded with no live foliage has increased by 4.2 per cent—a substantial decline over a short time period. Preliminary results of the TLM stand condition model indicate that over the floodplain the current condition of black box is half as good as river red gum (Cunningham pers comm. TLM proposal). SA advises that this decline will continue across the floodplain without the application of environmental water.

Comments against criteria for assessing 2010-11 environmental watering actions

1. Ecological Significance - Ramsar and DIWA listed: The Riverland Ramsar site (Chowilla Floodplain) is a representative example of a major floodplain system within the Murray Scroll Belt Subregion of the Riverina Biogeographical Region of the Murray Darling Basin.

The site supports nationally threatened species and contains a diverse range of habitat types and supports elements of biological diversity that are rare and particularly characteristic of the biogeographical region as well as providing critical drought refuge and summer or stopover habitat for migratory birds listed under international agreements. Chowilla regularly supports 20,000 or more waterbirds involving fifty-nine species including large populations of freckled duck (*Stictonetta naevosa;* SA vulnerable), red-necked avocet (*Recurvirostra novaehollandiae*) and red-kneed dotterel (*Erythrogonys cinctus*) whose numbers represent greater than 1 per cent of the estimated global population.

It contains the largest remaining area of natural river red gum forest in the lower River Murray (Sharley and Huggan 1995). The area also supports four nationally threatened species: southern bell frog (*Litoria raniformis;* Commonwealth vulnerable; SA vulnerable*)*, regent parrot (*Polytelis anthopeplus monarchoides;* Commonwealth vulnerable; SA vulnerable*)*, Murray cod (*Maccullochella peelii peelii;* Commonwealth vulnerable) and Murray-hardyhead (*Craterocephalus fluviatilis* Commonwealth vulnerable) and 23 state listed species. The Chowilla Anabranch is an important pathway for the migration of golden perch (*Macquaria ambigua)* and silver perch (*Bidyanus bidyanus)* around Lock 6 on the River Murray. The site also provides fish breeding and nursery habitats for these and other fish species (DEWHA 2009). Lake Limbra is also habitat to the yellow-billed spoonbills (*Platalea flavipes*), whitefaced herons (*Ardea novaehollandiae*) and straw-necked ibis (*Threskiornis spinicollis*).

The Black Box woodlands at Coombool Swamp and Lake Limbra represent an important ecological asset as they contain large mature trees with well developed hollows. Black box woodlands provide refuge, breeding holes and crevices for birds, lizards and small mammals (Roberts & Marston 2000) and this will include assemblages that differ from those found in River red gum forests. Lignum at this site will benefit from the application of water at this time. Lignum provides important habitat for a range of fauna including water birds and amphibians including the Southern bell frog.

2. Expected ecological outcomes
Maintain floodplain vegetation - These sites are large outer wetland with highly saline groundwater intrusion in areas of the wetland bed. Watering this site is expected to flush salt from the soil profile and freshen underlying groundwater resulting in a greater diversity of floodplain vegetation, and recover a diverse and abundant understorey assemblage which is currently poorly represented at Chowilla owing to the ongoing decline of these systems (Marsland *et al.* 2008). It would be expected that the full benefits would not necessarily be realised in one watering event particularly in the upper portion of the lake bed where large salt scalds are apparent. While the full benefits of watering may not be realized for understorey species, the fringing Black box woodlands will respond positively. A similar site, Gum Flat, was watered in November 2006 and the monitoring program revealed that soil salinity in the upper soil profile decreased after the watering event (DWLBC unpub data). This site will be inundated on a regular basis if the proposed Chowilla environmental regulator is constructed. Watering these sites will be the first step in long term recovery of this site.

Provide a drought refuge. Watering these sites would result in the inundation of multiple habitat types including Hancock Creek - the flowpath to Lake Limbra. This portion of the site has provided excellent habitat for water birds and has the potential to provide resources for many species of water fowl and colonial nesters and waders in the shallow areas which occur as the site dries. Hancock Creek is a natural collection point for rainwater; hence it is not suffering from the soil salinisation currently occurring on the Lake Limbra bed (SA proposal). Watering Hancock Creek will play a significant role in maintaining a diverse and abundant understorey assemblage which is currently poorly represented at Chowilla owing to the ongoing decline of these systems (Marsland *et al.* 2008). Hancock Creek is lined by highly stressed Black box which would benefit from the provision of water, as will the lignum (Roberts and Marston 2000).

3. Potential risks – SA advises that there is a small risk associated with the proposed environmental watering. Negative effects such as black water events (or other water quality issues), infestation by exotic plants or salinity problems in surrounding areas may occur. However the risk of these events occurring at the nominated sites is considered by SA to be low. These site has now been watered on one previous occasion and no negative impacts associated with watering have been observed. There is now over four years of monitoring data for the Chowilla floodplain that the impacts of environmental watering are positive (SA MDB NRM). Additionally, owing to the nature of the selected sites, if a major water quality issue did arise the impounded water can be allowed to evaporate off without having to be returned to the main river channel or anabranch.

4. Long-term sustainability - High – The sites are Ramsar listed and hence the future security of water is probable. The site would be inundated by the proposed Chowilla Creek environmental regulator, allowing for regular follow-up watering. Previous monitoring of watering events in the floodplain indicate that many vegetation communities have benefited from the water, provided habitat for threatened bird species, and provided breeding opportunities for frogs and birds. Given the current state of the Lake Limbra wetland, SA advises that it will require repeated watering events (SA proposal).

The site has a management plan (Chowilla Icon site plan). Monitoring of the watering actions will include: Vegetation monitoring (completed by SARDI and the South Australian Murray-Darling Basin Natural Resource Management Board with reporting conducted every three months); and bird and frog monitoring (conducted by the Department for the Environment and Heritage (SA) staff with reports available every three months).

5. Cost effectiveness - Pumping to Coombool swamp occurs via Brandy Bottle, and water is delivered to Lake Limbra via Hancock creek. Costs to the Commonwealth associated with pumping the water to the floodplain are quoted at $396,000, representing $38.50/ML costs.

References
DEWHA (2009) The Coorong, and Lakes Alexandrina and Albert Wetland [online] available: http://www.environment.gov.au/cgi-bin/wetlands/ramsardetails.pl?refcode=25, accessed 15 Jan 2010.

Marsland, K., Nicol, J. & Weedon, J. (2008) Chowilla Icon Site–Floodplain Vegetation Monitoring 2007 – 08 Interim Report. SARDI Aquatic Sciences, West Beach, South Australia.

Nichols, J. (in prep) Review of the Understorey Vegetation Dynamics of the Chowilla Anabranch 1988-2008. SARDI Aquatic Sciences, West Beach, South Australia.

Roberts J and Marston F (2000). Water Regime of Wetland and Floodplain Plants in the Murray-Darling Basin – A Source Book of Ecological Knowledge. CSIRO Land and Water. Technical Report 30/00. October 2000.

Sharley, T. & Huggan, C. (eds) 1995, `Chowilla *resource management plan: final report, March'*, prepared by the Chowilla Working Group in consultation with the Chowilla Reference Group, Murray-Darling Basin Commission, Canberra, ACT.

TLM (2006), *The Chowilla Floodplain and Lindsay-Wallpolla Islands Icon Site Environmental Management Plan 2006–2007*, Murray Darling Basin Commission.

Disher Creek Evaporation Basin Outlet Creek

DEWHA Assessment Summary	CEWH	Other
Site: Disher Creek Evaporation Basin Outlet Creek **Floodplain/region:** Murray below choke **Catchment:** Lower Murray **Timing:** March 2011	**Volume:** 150 ML **Cost:** $0	**Volume:** 0 ML

Description of Watering Action and Objective
The proposed watering will deliver 150 ML to the Disher Creek Evaporation Basin in March 2011. The objective of this watering event is to create additional habitat for the Murray hardyhead (*Craterocephalus fluviatilis:* Commonwealth vulnerable). Water will be used to flush remnant pools of salty water within the Disher Creek Southern Arm Channel and create up to 17 ha of habitat (DEH 2009).

Description of site / watering history
The Disher Creek Basin is located downstream of Renmark within the Murray River National Park. Since 1967 the site has been used to dispose of saline irrigation water from the Renmark Irrigation Area via the Renmark Area Drainage Disposal Scheme (RADDS).Water is delivered to the Evaporation Basin through the outfall pond (DEH 2009).

Water and salinity levels fluctuate within the basin according to subsurface and overland irrigation drainage flows. Inflows of irrigation drainage water into the Disher Creek Evaporation Basin have declined significantly in recent years resulting in the majority of the main Basin drying out during the summer months and reducing fish habitat (DEH 2009).

The Disher Creek Evaporation Basin Murray hardyhead population is presently confined to the small irrigation drainage water outfall pond (approximately 1 ha in size) which is isolated from the main basin. The current Murray hardyhead habitat (outfall pond) is considered to be in moderate health, with suitable water quality conditions. Fringing vegetation is in moderate health. The main basin is too saline to support the hardyhead (SA proposal), and the broader basin area is in poor condition due to salinity. The new habitat being created will be connected to the outfall pond, and fish will be able to move from the outfall pond. Following stabilisation of the new habitat a captive population of Murray hardyhead will be released in to the site (DEH 2009).

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance - The site provides habitat for one of four core populations of Murray hardyhead in South Australia. The species is rated as endangered under the Action Plan for South Australian Freshwater Fishes (Hammer *et al.* 2009).

2. Expected ecological outcomes - Freshening remnant pools of salty water within the Disher Creek Southern Arm Channel will create additional suitable Murray hardyhead habitat, increasing habitat to up to 17 ha. Currently the population is limited to a small 1 ha area in the Outfall pond.

3. Potential risks - The following risks have been identified by South Australia:
1. Movement of Murray hardyhead into the river where they may be out-competed by species better suited to fresher environments. Due to the distance the current population is from the river and their preference for semi-saline to saline water, it is considered unlikely that migration into the river will occur;
2. Opening delivery structures may result in the introduction of saline water into River Murray channel. It is considered that all water entering the Disher Creek Southern Arm Channel will be flushed through the system into the Disher Creek Main Evaporation Basin, and not into the river; and
3. Habitat creation and structures may not be finished in time, delaying water delivery. If this occurs the CEWH will be notified.

4. Long-term sustainability - Disher creek is located in the Murray River National Park. The population of Murray hardyhead at Disher Creek Evaporation Basin is a high priority under the South Australian Drought Action Plan for Threatened Fish 2009-10 and the Action Plan for SA Freshwater Fishes 2009. A management plan been developed and implemented for this site: Disher Creek Saline Water Disposal Basin Hydrological Management Plan. (DEH 2009)

Monitoring of the Murray hardyhead population at Disher Creek is ongoing by the SA Department of Environment and Heritage, which is conducted quarterly through the South Australian Drought Action Plan. The proposed monitoring of this watering action is in alignment with the watering objectives stated above. Additional information on the monitoring can be found in the monitoring and evaluation attachment.

In the future the primary source of water for site will be the spill over of Renmark Area Drainage Disposal System (RADDS) water from the Outfall Pond, which will be supplemented by Murtho salt interception scheme water when required. To ensure salinities are maintained within the range to promote Murray hardyhead breeding events, SA has proposed to access gravity fed environment water from the River Murray via the Southern Arm Creek (DEH 2009).

5. Cost effectiveness - Water will be gravity fed to the site. There are no costs to the CEWH associated with this watering action. The state will provide project management and monitoring. Funding for the site has been secured for Disher Creek through the Murray-Darling Basin Authority Murtho SIS scheme and the Department for Water's project to improve and maintain the site in the long term.

References

DEH (2009) Disher Creek Saline Water Disposal Basin Hydrological Management Plan. Department for Environment and Heritage, Berri, South Australia, 2009

Hall, A., Higham, J., Hammer, M., Bice, C. and Zampptti, B. (2009) Drought Action Plan for South Australian Murray-Darling Basin threatened freshwater fish populations 2009-2010; Rescue to Recovery. Draft. South Australian Department for Environment and Heritage, Adelaide**.**

Hammer, M. Wedderburn, S. & Van Weenen, J. (2009) Action Plan for SA Freshwater Fishes, Native Fish Australia, Adelaide

Goolwa Barrage (Lower Lakes)

DEWHA Assessment Summary	CEWH	Other
Site: Goolwa Barrage **Floodplain/region:** Murray below choke **Catchment:** Lower Murray **Timing:** November-December 2010	**Volume:** 0 ML – TLM allocated water to this option on the 2 August 2010	**Volume:** 5,500 ML (TLM)

Description of Watering Action and Objective
The proposed 5,500 ML will be pumped from Lake Alexandrina across the Clayton regulator during November and December 2010 to allow for fishway releases through the Goolwa barrage from December through to January-February 2011.

Objective of the watering action are:
1. To allow passage for fish through the Goolwa barrage vertical slot fishway during 2010-11;
2. To enhance successful recruitment in diadromous fish species such as Congolli, Common galaxias and Lampreys; and
3. To create estuarine conditions on the saltwater side of Goolwa barrage.

Description of site / watering history
From July 2005 to March 2007 there was a consistent release of freshwater from the Lower Lakes into the Coorong through the fishways. This water was provided by entitlement flows, with a total of 660,000 ML released through all barrages during this period (around 20 ML/day through the Goolwa fishway).

No freshwater has been released into the estuary, from barrage releases or fishways, since early January 2007, in comparison to the mean long-term barrage outflow of 4,800,000 ML/yr. Because of the long period of disconnection from the Lower Lakes and the lack of freshwater outflows to create estuarine conditions, Murray mouth/Coorong area has become largely marine in nature (SA proposal). Freshwater outflows are required to re-establish estuarine conditions and trigger breeding events in key estuarine species.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance - The proposed watering site is located within the Coorong and Lakes Alexandrina and Albert Ramsar Site, and the Coorong, Lower Lakes and Murray Mouth (CLLMM) Icon Site. The site is unique being the end-point of the Murray-Darling Basin, and the only estuary in the Murray-Darling Basin. The CLLMM is the most significant site in the Murray-Darling Basin for waterbirds (Kingsford and Porter, 2009). Many migratory wading bird species listed under the EPBC Act have been recorded in summer 2010 around the Goowla weir pool.

Monitoring of diadromous fish populations in the Lower Lakes and Coorong estuary over the last three years by SARDI Aquatic Sciences has detected catastrophic declines in populations due to lack of flows and connectivity (SARDI). One of these fish species, Congolli *(Pseudaphritis urvilli)*, is only found in the Coorong and Lower Lakes within the Murray-Darling Basin. Outside the basin this species has been recorded predominately in coastal rivers along south-eastern Australia.

While Congolli is not protected under any state/national legislation; the Action Plan for South Australian Freshwater Fishes, (Hammer *et al.* 2009) rates its distribution as vulnerable, and these fish are part of the described Ramsar ecological character of the site (Phillips and Muller 2006). Monitoring shows that in recent years the disconnection appears to have almost completely prevented Congolli breeding since 2007-08. The maximum age of Congollie is five years, thus SA consider it is imperative that connectivity is reinstated in 2010-11 to allow for successful recruitment and the preservation of this species.

2. Expected ecological outcomes - Opening the Goolwa vertical slot fishway will enable connectivity between the Coorong and Lower Lakes, enabling the movement of freshwater and estuarine fishes between the Lower Lakes and the Coorong, for recruitment, habitat selection and feeding. Researchers suggest that even small volumes of freshwater inflows to estuaries can act to enhance populations of estuarine dependant species and ecological processes (Jennings *et al.* 2009).

Secondary benefits include generation of a seasonal, localised estuarine salinity gradient in the Coorong in the vicinity of Goolwa barrage. Releases would result in salinities favourable for estuarine biota and are likely to provide a source of nutrients to the Coorong, potentially boosting ecosystem productivity. Benthic invertebrates are likely to increase in abundance, providing visiting EPBC Act listed migratory waders with a better food source.

As the CLLMM is the most significant site in the Murray-Darling Basin for waterbirds; with abundances an order of magnitude greater than any other Icon Site (Kingsford and Porter, 2009), SA considers it is highly important that food resources are protected by providing freshwater flows into the estuary.

3. Potential risks - A risk assessment has been undertaken by South Australia, identified risks include:
1. Community perception of a 'loss' of water from the weir pool. This will be mitigated through a South Australian communication strategy focusing on the science behind the management decision.
2. Commercial and recreational fishing pressure on the area and during the timing of the fishway releases. This will be mitigated by potentially declaring a closure on fishing in the area.
3. Noise pollution through pumping. This will be mitigated by using housing over pumps to muffle the noise which has been used successfully in previous pumping events.

4. Long-term sustainability - Pumping is not a long term strategy for this site or for fishway releases, as when the Lake levels return to levels that will allow for fishway releases, pumping will not be required.

Complementary management actions are described in CLLMM Icon Site Environmental Management Plan (2006-2007) (MDBC 2006), the CLLMM Long Term Plan (DEH 2010) and the Action Plan for South Australian Freshwater Fishes (Hammer *et al.* 2009), and the Goolwa Channel Environmental Management Plan. The long term the aim is to increase barrage flows and fishway releases from the Lower Lakes.

The proposed monitoring of this watering action is in alignment with the watering objectives stated above. Additional information on the monitoring can be found in the monitoring and evaluation attachment.

5. Cost effectiveness - Delivery costs incurred by the Commonwealth are to pump the proposed water, operate the fishways and works. The state will provide project management and monitoring.

References
Kingsford R. & Porter J (2009) Survey of waterbird communities of the Living Murray icon sites- November 2008. School of Biological, Earth and Environmental Science, University of New South Wales. Report to the Murray-Darling Basin Authority.

Phillips, W. and Muller, K. (2006). *Ecological Character of the Coorong, Lakes Alexandrina and Albert Wetland of International Importance.* South Australian Department for Environment and Heritage.

SARDI Coorong Fish Movement and Ecology Project summaries for Spring/Summer 06-07, 07-08 and 08-09, supplied by SA Department of Water.

Hammer, M. Wedderburn, S. and Van Weenen, J. (2009) Action Plan for SA Freshwater Fishes, Native Fish Australia, Adelaide

Jennings, P., Bice, M., and, Zampatti, B. Unpublished. *Impact of drought and river regulation on the spawning and recruitment of diadromous Galaxias maculatus and Pseudaphritis urvillii, in the Coorong estuary, Australia*. Inland Waters and Catchment Ecology Program, SARDI Aquatic Sciences, South Australia.

Hogwash Bend

DEWHA Assessment Summary	CEWH	Other
Site: Hogwash Bend **Floodplain/region:** Murray below choke **Catchment:** Lower Murray **Timing:** October 2010 and June 2011	**Volume:** 24 ML **Cost:** $4,812 ($50/ML), CEWH $1,200; State contribution $3,612	**Volume:** 0 ML

Description of Watering Action and Objective
This proposal covers the pumping of water directly from the River Murray into Hogwash Bend, to be delivered as 10 ML in October 2010 and 14 ML in June 2011. Hogwash Bend is currently the largest known breeding site of the nationally vulnerable regent parrots in South Australia. The proposed watering will extend the period of inundation to maintain and improve the health of mature river red gums, maintain or improve large areas of lignum for breeding of wetland biota such as frogs and water-dependent birds and support the regent parrot breeding colony in spring 2010.

Description of site / watering history
Hogwash Bend is located between Cadell and Waikerie, and was last inundated naturally in the flood of 1993 (peak reached 117,000 ML/day), and so hasn't naturally received water for more than 15 years (SA proposal). Recently, the following waterings at Hogwash Bend have been undertaken:

- 14 ML in 2006 as part of the River Red Gum Rescue Project pumped into 3 wetland basins;
- 14 ML to be pumped in the first week of June 2010 into above three basins as part of the State Drought Framework;
- Donation of 6.8 ML in 2008-09 from Nature Foundation to irrigate specific nesting trees through the use of sprinklers; and
- Donation of 7 ML from Nature Foundation to water specific nesting trees to be delivered in 2009-10.

The proposed watering will build upon previous watering from 2006 and will maintain water levels within the wetland following the current pumping (due in June 2010) to ensure water is available over the spring months (known optimal nesting times for regent parrots). The extended period of inundation (nine months) will provide adequate water for stressed river red gums. While the river red gums at Hogwash Bend are considered to be in relatively good condition compared to other areas on the South Australian floodplain, many of the trees are beginning to show signs of stress (SA proposal). The Regent Parrot Committee agreed to pursue watering of the river red gums in order to preserve nesting habitat for the Regent parrots. The watering undertaken at Hogwash Bend and nearby Markaranka over the past few years is likely to have contributed to the positive impact on the breeding colony at Hogwash Bend (SA proposal).

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance - Nationally and State listed regent parrot (*Polytelis anthopeplus monarchoides:* Commonwealth vulnerable; SA vulnerable) breeding colony. The regent parrot colony at Hogwash Bend is currently the largest known breeding site of regent parrots in South Australia. A recent survey of ten regent parrot colonies showed that the Hogwash Bend was one of the colonies that recorded an increase in nest numbers, whilst most colonies showed a decline (DEH 2009). The ten colonies surveyed contained a total of 157 nests, 53 of which were recorded at Hogwash Bend. SA has estimated that there are about 400 breeding pairs of regent parrots in the SA MDB (DEH 2009), so the proposed watering at the cluster of sites near Hogwash Bend will assist in supporting 1/8th of the whole breeding population of this species in the state, making this site, locally, regionally and nationally significant (SA proposal).

2. Expected ecological outcomes
<u>Support Regent parrot breeding colony</u> over the spring months 2010. There are many mature river red gums (with hollows) at Hogwash Bend. These trees provide drought refuge (breeding habitat) for regent parrots.

<u>To extend the period of inundation</u> to maintain and improve the health of mature river red gums (*Eucalyptus camaldulensis var. camaldulensis*). The watering will assist in mitigating against the decline in health or death of mature long-lived vegetation. Without flooding the older trees will eventually die off, and without conditions favourable to germination and recruitment, leave no replacements (SA proposal). Watering will also prevent the death of river red gum saplings around the edge of the wetland (failure to support the establishment of the 'next generation' of long-lived vegetation). Stands of juvenile river red gum (established in 2006) are scattered around the wetland edge.

<u>Maintain or improve large areas of lignum</u>, for breeding of wetland biota such as frogs and water-dependent birds.

3. Potential risks - SA has identified the following risks as part of the proposed watering project:

1. Water returning back to the main river channel: Low Risk: the past watering in 2006 showed that the banks installed maintained their integrity. Pumping will be monitored and steps will be taken to stop pumping should bank integrity be compromised.
2. Noise impact to River Murray users: Low Risk: there was no negative feedback from local community regarding previous waterings. No action required.
3. Grazing pressure: Low Risk: No stock present on this floodplain. No action required.
4. Salinisation of watering sites, leading to reduced response of watering: Low Risk: there was minor evidence of salt impacts (salt crusts, salt tolerant plants etc) observed at the site, indicating salinisation impacting on watering is a low risk. Monitoring of water quality after pumping will be undertaken.
5. Blackwater events: Low Risk: Blackwater events have not occurred during previous waterings, however, water quality parameters will be monitored throughout the inundation of the wetland. If a blackwater event occurs, water is unlikely to re-enter the River due to the presence of banks.

4. Long-term sustainability High - Since 2008, Riverland West Local Action Planning (RWLAP) Association have been working in partnership with the SA Department of Environment and Heritage (DEH) and local landholders to improve understanding of the ecology of the Regent parrot (*Polytelis anthopeplus monarchoides*) at Hogwash Bend. The Regent Parrot Committee agreed to pursue watering of the River red gums in order to preserve nesting habitat for the regent parrots.

The site will continue to be managed by the RWLAP and Regent Parrot Committee in the future. The South Australian MDB NRM Board will assist the community group by managing and monitoring the watering project proposed in this bid. A management plan has not been written for this site.

The proposed monitoring of the watering event is in alignment with the ecological objectives outlined above. Monitoring will include: targeted extensive searches for Regent parrot breeding activity and foraging will be undertaken over a two week period in spring 2010 (undertaken by RWLAP, DEH, University of South Australia and SA MDB NRM Board Staff); six monthly tree health assessments (SA MDB NRM Board Staff); bird surveys will be undertaken in summer (SA MDB NRM Board Staff); frog surveys will be undertaken in spring and summer (SA MDB NRM Board Staff) and water quality parameters (salinity, temperature, pH, turbidity and dissolved oxygen) will be monitored regularly (up to six times a year during inundation and drawdown). Photos at established photopoints will be retaken quarterly. Results of this monitoring will be provided in the quarterly CEWH progress report and the annual Department of Water watering report. Additional information regarding the monitoring of this watering may be found in the Attachment.

5. Cost effectiveness - The water delivered to Hogwash Bend will be pumped directly from the River Murray, with costs to the Commonwealth of $1,200 for this pumping. SA will contribute towards the delivery costs and undertake the watering event and site monitoring.

References
DEH (2009) *Results of the 2008 Regent Parrot Nest Surveys in the SA Murray Darling Basin*, Department for Environment and Heritage Adelaide, South Australia.

Katarapko Creek - South Floodrunner and Lagoon

DEWHA Assessment Summary	CEWH	Other
Site: Katarapko Creek: South Floodrunner and Lagoon **Floodplain/region:** Katarapko Floodplain **Catchment:** Lower Murray **Timing:** December 2010	**Volume:** 15 ML **Cost:** $1,000 ($50/ML): CEWH $750; State contribution $250	**Volume:** 0 ML

Description of Watering Action and Objective

This proposal considers the delivery of 15ML of water to Katarapko Creek, to be pumped directly from the River Murray in December 2010.

The objectives of the proposed watering actions are:

1. Maintaining and improving the health of mature and juvenile river red gums (*Eucalyptus camaldulensis* var. *camaldulensis*) and juvenile river cooba (*Acacia stenophylla*);
2. Support frog breeding events particularly for the southern bell frog (*Litoria raniformis*); and
3. Provision of habitat and foraging grounds for water-dependent bird species.

Description of site / watering history

The Katarapko floodplain wetlands are located approximately 180 km from Adelaide opposite the town of Loxton, in the Riverland of South Australia. It is bounded on the east and the south by the Murray River, and the wetlands cover an area of nearly 9000 hectares. Katarapko Creek lagoon and floodrunner are ephemeral wetland sites within the Katarapko Floodplain.

The south floodrunner and lagoon was last watered with 20 ML of CEWH water in May 2010. It was also watered in January 2006 under the TLM River Red Gum Rescue Program. Watering will also build upon the 2008-09 watering of the nearby wetland, Carpark Lagoons. Katarapko South Floodrunner and Lagoon contain a lentic channel, temporary wetland and associated floodplain and run along the side of Katarapko Creek. SA has advised the site is considered moderate to poor, with some death and decline in mature River red gum surrounding the temporary wetland. However, mature River red gum fringing the creek are in moderate health. River red gum saplings established on the wetland bed during 2005-06 watering are also in moderate health.

Comments against criteria for assessing 2010-11 environmental watering actions

1. Ecological Significance - The Katarapko anabranch and floodplain are recognised by the Australian Government as a high conservation value aquatic ecosystem (HCVAE) because of uniqueness. It is also a priority floodplain identified in the South Australian Murray Environmental Framework. It is a diverse floodplain and wetland habitat, with relatively undisturbed vegetation, and provides important habitat for a range of terrestrial and aquatic animals (Katfish Reach Steering Group, 2008). The flora and fauna of the site also includes a diverse fish community. The vegetation is highly diverse on the floodplain, with significant stands of river red gum (*Eucalyptus camaldulensis*) and black box (*E. largiflorens*) woodland (Katfish Reach Steering Group, 2008).

The area provides habitat to three nationally threatened species listed under the EPBC Act including the southern bell frog (*Litoria raniformis:* Commonwealth vulnerable; SA vulnerable) and the regent parrot (*Polytelis antopeplus monarchoides*: Commonwealth Vulnerable; SA vulnerable).

2. Expected ecological outcomes - The proposed watering is expected to improve overall tree health of both young and mature river red gums, river cooba and black box on the associated floodplain. It is also expected to result in new recruitment of river coobah and river red gum seedlings (SA, DEH 2010-11 Watering Proposal).

SA considers it is essential that water levels are maintained in the wetland throughout spring and summer, as this is the peak breeding period for wetland biota, e.g. water birds, frogs, and macrophytes. Water delivered in December will maintain water levels and quality in the wetland into autumn (SA, DEH 2010-11 Watering Proposal).

3. Potential risks – SA has identified the following risks associated with the watering in the proposal:

1. Water depth and quality not maintained long enough for a successful frog breeding event;
2. Blackwater event; and
3. Noise pollution from pumps.

All risks have been assessed as very unlikely to occur. The site was watered in 2006 under TLM River Red Gum Rescue Program. The watering demonstrated positive responses in vegetation, river red gum and bird and frog breeding. There were no adverse results observed from the watering (SA, DEH 2010-11 Watering Proposal).

4. Long-term sustainability - Long term management and monitoring arrangements for the Katarapko Floodplain (including Katarapko Floodrunner and Lagoon) are outlined in the Katfish Reach Implementation Plan (2008). A number of plans and investigations have been undertaken by the Department of Environment and Heritage (SA). Part of the Conservation Park is managed by South Australia Department of Environment and Heritage (SA, DEH) and a management plan is in place.

Water quality monitoring will be undertaken to detect adverse affects from changes in water quality. Parameters will include: salinity, pH, dissolved, turbidity and temperature. Pre and post inundation tree condition assessments will be undertaken following the draft TLM tree methods. Frog surveys will be undertaken in spring and summer (September and November) following methods described in 'Your Wetland Monitoring Manual' (Tucker 2004). There will be monthly waterbird surveys in at least three sites at the Lagoons. Results of the monitoring will be available in a quarterly progress CEWH report and an annual DEH Watering Report.

5. Cost effectiveness - Site management, watering and monitoring will be undertaken by SA, DEH and South Australia Murray Darling Basin, Natural Resource Management Board (SA, MDB, NRM). Water will be pumped directly from the Murray River channel and no other works will be required. The delivery cost to the CEWH has been identified as $750 and the delivery partner will be contributing an additional $250.

References

Katfish Reach Steering Group (2008) *Katfish Reach Implementation Plan*

South Australia, Department of Environment and Heritage, 2010-11 *Watering Proposal for Katarapko Creek: South Floodrunner and Lagoon*, (Katarapko National Park)

Tucker, P. (2004) *Your wetland: Monitoring manual – data collection*. River Murray Catchment Water Management Board and Australian Landscape trust. Renmark, South Australia.

Carpark Lagoons (Katarapko Floodplain)

DEWHA Assessment Summary	CEWH	Other
Site: Carpark Lagoons (Katarapko National Park) **Floodplain/region:** Katarapko Floodplain **Catchment:** Lower Murray **Timing:** September 2010	**Volume:** 220 ML **Cost:** $14,000 ($50/ML): CEWH $11,000; State contribution $3,000	**Volume:** 0 ML

Description of Watering Action and Objective

The watering action involves delivering 220 ML in September 2010 to Carpark Lagoons in Katarapko National Park. The objectives of the action are:

1. Maintaining and improving the health of mature and juvenile river red gums (*Eucalyptus camaldulensis* var. *camaldulensis*) and juvenile river cooba (*Acacia stenophylla*).
2. Support frog breeding events particularly for the southern bell frog (*Litoria raniformis:* Commonwealth vulnerable; SA vulnerable).
3. Provision of habitat and foraging grounds for water-dependent bird species.

Description of site / watering history

The Carpark Lagoons are a complex of three ephemeral lagoons, within the Katarapko floodplain wetlands. The wetlands, which cover an area of approximately 9000 hectares, are located approximately 180 km from Adelaide opposite the town of Loxton, in the Riverland of South Australia. They are bounded on the east and the south by the Murray River. The Carpark Lagoons were last full in 2000-01 through natural inundation.

Due to low flows over the past ten years, the Carpark Lagoons has been identified as a watering priority. SA advises that the Lagoons are currently dry. The Lagoons have received water from a variety of sources over the past five years, via pumping:

- 170 ML in January 2005 by South Australia Department of Environment and Heritage (SA, DEH);
- 156.7 ML in January 2006 as part of the River Red Gum Rescue Project; and
- 200 ML of water from the CEWH in March 2009.

The Carpark Lagoons are generally considered by SA to be in moderate to good condition. The wetland supports river red gums and river coobahs which are in moderate to good health. However SA advises that the health of these species and other vegetation has been compromised by insufficient flows in recent years. Without inundation, the fringing adult trees are likely to be put under stress, possibly leading to widespread death. Without adequate conditions for germination there is unlikely to be new recruitment.

Comments against criteria for assessing 2010-11 environmental watering actions

1. Ecological Significance - The Katarapko anabranch and floodplain are recognised by the Australian Government as a high conservation value aquatic ecosystem (HCVAE). It is also a priority floodplain identified in the South Australian Murray Environmental Framework.

The flora and fauna of the site includes a diverse fish community. The vegetation is highly diverse on the floodplain, with significant stands of river red gum and black box (*E. largiflorens*) woodland. The floodplain and wetland habitat, with relatively undisturbed vegetation provides habitat for a range of terrestrial and aquatic animals. The Lagoons are located adjacent to a known regent parrot (*Polytelis antopeplus monarchoides*: Commonwealth vulnerable; SA vulnerable) breeding site, so they provide potential breeding and foraging ground for this species (Katfish Reach Steering Group, 2008).

The Lagoons contains three nationally threatened species as listed in the EPBC Act including the southern bell frog (*Litoria raniformis* Commonwealth vulnerable; SA vulnerable) and the regent parrot. The southern bell frog was recorded calling during both September and November 2009. The great egret (*Egretta alba* EPBC migratory) was recorded at the lagoons in September 2009. Also recorded at the site were freckled duck (*Stictonetta naevosa:* SA vulnerable).

2. Expected ecological outcomes - The proposed watering is expected to have the following benefits:

1. Major frog activity, creating habitat and conditions suitable for breeding for all frog species including the southern bell frog (listed as vulnerable EPBC Act 1988) which has previously been recorded within the lagoons.
2. Improvement in overall tree health of both young and mature river red gums.
3. Use of the lagoons by a wide range of waterbird species including for breeding events.
4. Abundant growth of aquatic vegetation such as red water milfoil whilst the wetland is inundated.
5. Abundant growth of native terrestrial species such as native licorice on the dry lagoon bed.
6. New recruitment of river coobah and river red gum seedlings.

3. Potential risks - SA has identified the following risks associated with the proposed watering:
1. There is a low risk that water depth would not be maintained long enough to ensure a successful frog breeding event. However, the wetland contains deeper refuge areas that contains suitable habitat for tadpoles (shallow banks with submerged and emergent vegetative cover). The proposed water regime provides water within these areas for 5-6 months during peak breeding times for the species and into summer which would be sufficient to ensure successful breeding.
2. There a low the risk of a blackwater event. To evaluate the degree of a potential blackwater event, vegetation cover on the wetland bed will be assessed. Carpark Lagoons contains minimal vegetation on the majority of the wetland bed with small areas of moderate vegetative cover. The species identified are predominantly perennial and not annual and will break down at a slower rate. Previous watering events at the site have been successful and have maintained water quality within desired thresholds.
3. There will be some noise from pumping the water. Carpark Lagoons are located on the Katarapko Floodplain and approximately five kilometers from the closest township. Although no negative response has been received from past watering events at Carpark Lagoons, communications to the general public will be undertaken to ensure people are aware of the project prior to its commencement. This risk has been assessed as low.

4. Long-term sustainability - Long term management and monitoring arrangements for the Katarapko Floodplain (including Katarapko Floodrunner and Lagoon) is outlined in the Katfish Reach Implementation Plan (2008). A number of plans and investigations have been undertaken by the SA, DEH. Part of the Conservation Park is managed by SA, DEH and a management plan is in place.

Water quality monitoring will be undertaken to detect adverse affects from changes in water quality. Parameters will include: salinity, pH, dissolved oxygen, turbidity and temperature. Pre and post inundation tree condition assessments will be undertaken following the draft TLM tree methods. Frog surveys will be undertaken in spring and summer (September and November) following methods described in 'Your Wetland Monitoring Manual' (Tucker 2004). There will be monthly waterbird surveys in at least three sites at the Lagoons. Results of the monitoring will be available as a quarterly progress report for the CEWH Watering 2010-11; and an Annual DEH Watering Report.

5. Cost effectiveness - Site management, watering and monitoring to be undertaken by DEH and South Australia Murray Darling Basin, Natural Resource Management Board (SA, MDB, NRMB). Water will be pumped directly from the Murray River channel and no other works will be required. The delivery costs will be covered by the CEWH and the delivery partner.

References
Katfish Reach Steering Group (2008) Katfish Reach Implementation Plan

Tucker, P. (2004) Your wetland: Monitoring manual – data collection. River Murray Catchment Water Management Board and Australian Landscape trust. Renmark, South Australia.

South Australia, Department of Environment and Heritage, 2010-2011 Watering Proposal for Carpark Lagoon, (Katarapko National Park)

Piggy Creek (Katarapko Floodplain)

DEWHA Assessment Summary	CEWH	Other
Site: Piggy Creek (Katarapko National Park) **Floodplain/region:** Katarapko Floodplain **Catchment:** Lower Murray **Timing:** September 2010	**Volume:** 300 ML **Cost:** $20,000 ($50/ML): CEWH $15,000; State contribution $5,000	**Volume:** 0 ML

Description of Watering Action and Objective
The watering action involves delivering of 300 ML in September 2010 to Piggy Creek within Katarapko National Park. The objectives of the action are:
1. Maintaining and improving the health of mature and juvenile river red gums (*Eucalyptus camaldulensis* var. *camaldulensis*) and juvenile river cooba (*Acacia stenophylla*).
2. Support frog breeding events particularly for the southern bell frog (*Litoria raniformis*).
3. Provision of habitat and foraging grounds for water-dependent bird species.

Description of site / watering history
Piggy Creek covers an area of 33 ha and contains a lentic channel, temporary wetland and associated floodplain. The wetlands, which cover an area of approximately 9000 hectares are located approximately 180 km from Adelaide opposite the town of Loxton, in the Riverland of South Australia. They are bounded on the east and the south by the Murray River. SA advises that the site is considered to be in moderate to poor condition, with some death and decline in mature river red gum surrounding the ephemeral wetland. However, mature river red gum fringing the creek are in moderate health. River red gum saplings established on the wetland bed during 2005 watering are also in moderate health. However both the creek and the wetland have not received water for five years and require water to maintain and revive both mature and juvenile trees.

The wetlands were last full in 2000-01. Due to low flows over the past ten years, the site has been identified by SA as a watering priority. Piggy Creek has received water from a variety of sources over the past 5 years, via pumping. In June 2005, 290 ML was delivered by the South Australian Department of Environment and Heritage. In January 2006, 290 ML was delivered as part of the River Red Gum Rescue Project.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance - The Katarapko anabranch and floodplain are recognised by the Australian Government as a high conservation value aquatic ecosystem (HCVAE). It is also a priority floodplain identified in the South Australian Murray Environmental Framework. The flora and fauna of the site includes a diverse fish community. The vegetation is highly diverse on the floodplain, with significant stands of river red gum and black box (*E. largiflorens*) woodland. Diverse floodplain and wetland habitat, with relatively undisturbed vegetation provides important habitat for a range of terrestrial and aquatic animals.

The Piggy Creek wetlands contain three nationally threatened species as listed in the EPBC Act including the southern bell frog and the regent parrot (*Polytelis anthopeplis monarchoides*). The southern bell frog (Commonwealth vulnerable; state vulnerable) was recorded calling during both September and November 2009. The great egret (*Egretta alba*: EPBCA migratory) was recorded at the wetlands in September 2009. Also recorded at the site were freckled duck (*Stictonetta naevosa:* SA vulnerable).

2. Expected ecological outcomes - The proposed watering is expected to have the following benefits:
1. Major frog activity, including creating habitat and conditions suitable for breeding for all frog species. including the southern bell frog.
2. Improvement in overall tree health of both young and mature river red gums and river coobah and black box on the associated floodplain.
3. A wide range of waterbird species utilising the wetland including for breeding events. The freckled duck listed as vulnerable in SA under the EPBC Act 1999 and was sighted and identified at Piggy Creek during the 2005 watering
4. Abundant growth of aquatic vegetation whilst the wetland is inundated.
5. Abundant growth of native terrestrial species on the dry wetland bed.
6. New recruitment of river coobah and river red gum seedlings.

3. Potential risks - SA has performed a risk assessment and identified the following risks:
1. SA advises that there is a risk that water depth will not be maintained long enough to ensure a successful frog breeding event. However, the wetland contains deeper refuge areas that contains suitable habitat for tadpoles (shallow

banks with submerged and emergent vegetative cover). The proposed water regime provides water within these areas for five to six months during peak breeding times for the species and into summer which would be sufficient to ensure successful breeding.

2. There is the risk of a blackwater event. To evaluate the degree of a potential blackwater event, vegetation cover on the wetland bed will be assessed. Piggy Creek wetlands contain minimal vegetation on the majority of the wetland bed with small areas of moderate vegetative cover. The species identified are predominantly perennial and not annual and will break down at a slower rate. Previous watering events at the site have been successful and have maintained water quality within desired thresholds.

3. There will be some noise from pumping the water. Piggy Creek wetlands are located on the Katarapko Floodplain and approximately five kilometers from the closest township. Although no negative response has been received from past watering events at Piggy Creek wetlands, communications to the general public will be undertaken to ensure people are aware of the project prior to its commencement.

4. Long-term sustainability - Long term management and monitoring arrangements for the Katarapko Floodplain (including Katarapko Floodrunner and Lagoon) is outlined in the Katfish Reach Implementation Plan (2008). A number of plans and investigations have been undertaken by the Department of Environment and Heritage (SA DEH). Part of the Conservation Park is managed by SA DEH and a management plan is in place.

Monitoring of the watering event will be undertaken by the Department of Environment and Heritage (SA) Wetland Ecologist and will include: pre and post inundation tree condition assessments, frog surveys in spring and summer (and tadpole surveys using fyke nets), monthly waterbird surveys at least three sites at the Lagoons and monthly water quality monitoring of salinity, pH, dissolved oxygen, turbidity and temperature. These proposed monitoring arrangements are in alignment with the ecological objectives. Further information regarding the monitoring may be found in the Attachment.

5. Cost effectiveness - Site management, watering and monitoring to be undertaken by DEH and SA MDM NRM Board. Water will be pumped directly from the Murray River channel. No other works will be required. The delivery costs will be met by the Commonwealth and delivery partners. The delivery partner will also contribute monitoring of the watering event which will involve tree condition assessments, frog surveys in spring and summer and CEWH progress reports.

References

Katfish Reach Steering Group (2008) Katfish Reach Implementation Plan

Lakes Alexandrina and Albert

DEWHA Assessment Summary	CEWH	Other
Site: Lakes Alexandrina and Albert **Floodplain/region:** Murray below choke **Catchment:** Lower Murray **Timing:** September 2010 – March 2011	**Volume:** 140,000 ML (extreme dry) / 180,000 ML (dry) / 320,000 ML (median). **Cost:** **Lake Alexandrina** $0 CEWH **Lake Albert** TBA.	**Volume:** SA has committed 170,000 ML to the Lower Lakes in 2010-11. **Cost:** **Lake Alexandrina** $0 **Lake Albert** TBA.

Description of Watering Action and Objective
The proposal seeks water for Lakes Alexandrina and Albert. The distribution of water between each Lake is still to be determined.

The objectives for the watering action are to:

1. Maintain water levels at the following target levels:

	Lake Alexandrina	Lake Albert
Extreme dry	above -0.5m AHD	above -0.75m AHD
Dry	above -0.5m AHD till Mar 2011	above -0.5m AHD till Mar 2011
Median	above -0.3m AHD till June 2011	above -0.3m AHD till June 2011

2. Maintain salinity levels within Lake Albert to within threshold tolerances of key species of fish and other biota;
3. Ensure the high risk acid sulfate soils areas remain saturated and the flux of acidity to the waterbody is minimised, thereby avoiding the acidification of the waterbody; and
4. Provision of refuge habitat for a number of global, national and state-listed threatened water-dependent species.

Description of site / watering history
Lake Alexandrina is a freshwater lake at the terminus of the Murray-Darling Basin. The Lake is separated by a series of five barrages from the more saline water of the Murray Mouth Estuary and Coorong lagoons. Surface water inflows are predominantly from the River Murray near Wellington. Rainfall and groundwater discharge are also significant inputs. (Phillips and Muller 2006).

A minimum inflow of 350 GL is delivered to Lake Alexandrina each year, as part of the dilution flow required to enable salinity at the major pumping stations to be maintained at suitable levels. In 2010-11, a further 90 GL of additional dilution flow (ADF) will also be delivered to the Lake. (SA Department of Water 2010)

In 2009, the Lake was disconnected from the Goolwa channel by a bank at Clayton. The pool created by the temporary flow regulator was initially raised to a level of +0.7 metres AHD by pumping 27 GL of water from Lake Alexandrina. Any excess water in the channel can be siphoned to Lake Alexandrina or released through the Goolwa barrage to improve the health of the upper Coorong estuary. (SA Department of Environment and Natural Resources website, 23 July 2010).

Lake Albert lies to the south east of Lake Alexandrina connected via a narrow channel (Narrung Narrows) near Point Malcolm. However, a bank built across the Narrows has disconnected Lake Albert from Lake Alexandrina and water is provided to Lake Albert by pumping over the bank.

Lake Alexandrina is the primary source of inflows to Lake Albert, with supplementation from local rainfall and groundwater discharge. As Lake Albert has no flow through connection to the Coorong it represents a local inland terminus of the River Murray system. (Phillips and Muller 2006)

In 2009-10, the Commonwealth and the southern Murray Darling Basin states allocated 408 GL to the Lower Lakes of which 124.3 GL was allocated to Lake Albert. The Commonwealth contributed 20 GL to Lake Albert which accompanied by 48.3 GL from the Living Murray (TLM) and 56 GL from South Australia.

In 2010-11, the South Australian Government has committed 170 GL to the Lower Lakes Environmental Reserve during 2010-11 which was delivered in July 2010. The Living Murray has still to consider the provision of water to the Lower Lakes.

Currently the Coorong, Lower Lakes and Murray Mouth can still be considered to be in an extreme dry scenario. The watering proposed in this bid will contribute significantly to maintaining and providing an improved capacity for recovery of the site to a healthier, functioning system in the future, as well as ensuring that avoiding catastrophic events and loss of species, and maintaining refugia are still achieved.

Comments against criteria for assessing 2010-11 environmental watering actions

1. Ecological Significance

The Coorong, and Lakes Alexandrina and Albert Wetland is Ramsar listed and incorporates 23 wetland types (under the Ramsar convention), existing as an interconnected mosaic of fresh to hypersaline and permanent to ephemeral aquatic habitats.

The Lower Lakes are known habitat for: orange-bellied parrot (*Neophema chrysogaster;* Commonwealth critically endangered; SA endangered); Southern Mount Lofty Ranges emu wren (*Stipiturus malachurus intermedius;* Commonwealth endangered; SA endangered); Yarra pygmy perch (*Nannoperca obscura;* Commonwealth vulnerable); Murray cod (*Maccullochella peelii peelii;* Commonwealth vulnerable), Murray hardyhead (*Craterocephalus fluviatilis;* Commonwealth vulnerable), southern bell frog (*Litoria raniformis;* Commonwealth vulnerable; SA vulnerable); the Metallic sun-orchid (*Thelymitra epipactoides;* Commonwealth endangered; SA endangered) (SA water bid, 2009-10 and 2010-11); Silver daisy-bush (*Olearia pannosa ssp. Pannosa*; Commonwealth vulnerable; SA vulnerable), Fat-leaved wattle (*Acacia pinguifolia*; Commonwealth endangered; SA endangered) and Osborn's eyebright (*Euphrasia collina subsp. Osbornii*; Commonwealth endangered; SA endangered) (Phillips & Muller 2006).

The site supports 49 marine, freshwater and diadromous native fish species and provides habitat for over 85 species of waterbirds. It supports over half of the waterbirds found in South Australia and is ranked within the top six waterbird sites in Australia, based on the diversity and abundance of species (MDBC, 2006). In excess of 20,000 waterbirds are supported at the site, including 1 per cent of the individuals in the populations of Cape Barren goose (*Cereopsis novaehollandiae;* SA rare), Sharp tailed (*Calidris acuminate;* EPBC migratory) and Curlew Sandpipers (*Calidris ferruginea;* EPBC migratory), three plover species, the banded stilt (*Cladorhynchus leucocephalus*; SA vulnerable), red-necked avocet (*Recurvirostra novaehollandiae)* and the Fairy Tern (*Sterna nereis*; SA endangered) (Phillips and Muller 2006).

In Jan 2009, Lake Albert supported in excess of 48,000 water birds and the remnant patches of Gahnia filum and extensive Phragmites and Typha reed beds provide sheltered habitats for fish and other vertebrates as well as long term rookery sites for various birds (SA water bid).

2. Expected ecological outcomes

South Australia has provided three proposals for the Lower Lakes seeking different volumes dependent on the water availability scenario (extreme dry, dry and median). The proposals do not identify individual volumes for Lake Alexandrina and Lake Albert. However, the environmental water needs and the expected ecological outcomes for the Lakes differ.

Watering Lake Albert is expected to produce greater ecological outcomes, in terms of avoiding acidification and reducing salinity, because its water level is expected to fall to critical acidification thresholds much sooner. According to modelling by the SA Department of Water, the water level is predicted to reach minus 0.75m AHD in January 2011. Pumping of the remaining environmental water allocated to the Lake in 2009-10 (34.4 GL of TLM water of the 124.3 GL) is scheduled for October to December and will maintain the Lake at above minus 0.75m for this time.

Further, salinity is more of a threat in Lake Albert as the main source of fresh water for the Lake is from Lake Alexandrina. Salinity is currently around 13,000 EC and is forecast to increase to 25,000 EC in October 2010. The Lake is forecast to become hypersaline (70,000 EC) by January 2011 (SA Department of Water).

By comparison, water levels are predicted to be higher in Lake Alexandrina, to reach +0.2 m AHD in September 2010 and to remain above minus 0.5m AHD until June 2011. Levels are not expected to reach the critical acidification threshold (-1.5 m AHD) until late 2012 (SA Department of Water).

3. Potential risks

Environmental water was provided to Lakes Alexandrina and Albert in 2010 with no negative outcomes reported. A risk assessment has been undertaken with only one risk identified, the inundation of aerial seeding of acidified soils. However, this would enhance the objective of the re-seeding program by providing carbon to the presently carbon limited bacterial cycle and hence reduce the existing acidity in the soils.

4. Long-term sustainability

Securing the Future: Long-term plan for the Coorong, Lower Lakes and Murray Mouth (then Department for Environment and Heritage, South Australia) is the long term plan for the area. The Plan provides a number of actions depending on the water availability scenarios. For low flows with water levels expected to fall, proposed mitigation measures include: Securing water to manage water levels, keeping acid sulphate soils saturated and preventing acidification; Limestone dosing for acid sulphate soil management; Vegetation plantings to increase soil carbon to reduce acidification; The protection of critical environmental assets (for example the off-site conservation of fish species).

The Plan cites the CSIRO Murray-Darling Basin Sustainable Yields Project which shows that maintaining the Lakes as fresh water is realistic (DEH 2010).

The proposed monitoring of this watering action is in alignment with the watering objectives stated above. The monitoring includes: Water levels and salinity monitored by DWLBC/SA Water; Acid sulphate soils and acidity monitored as part of water quality monitoring by EPA/DWLBC/University of Adelaide (Regular monthly water quality monitoring report to MDBA and published on EPA website.); TLM Icon site monitoring of global, national and state-listed threatened water-dependent species; and Condition monitoring undertaken by SARDI and universities managed by SA MDB NRM Board and CLLMM Icon Site staff. Intervention reports will be provided to MDBA, and the CEWH will receive quarterly reports to the CEWH and an annual watering report. Additional information on the monitoring is in the attachment on monitoring and evaluation.

5. Cost effectiveness

Delivery to Lake Alexandrina is gravity feed. Water sharing between Lake Alexandrina and Lake Albert is still to be decided. There will be no costs in delivering water to Lake Alexandrina. To deliver water to Lake Albert, water must be pumped over the existing structures at Narrung which is higher than historical pool level. However, if water levels in Lake Alexandrina reach levels greater than +0.3mAHD, it is possible to siphon water into Lake Albert from Lake Alexandrina, reducing the costs of delivering water to the site. SA will undertake monitoring of the Lower Lakes, as noted above, and provide project management of water delivery to the Lakes.

References

DEH 2010 *Securing the Future: Long-term plan for the Coorong, Lower Lakes and Murray Mouth,* then Department for Environment and Heritage, South Australia March 2010

MDBC 2006 *Lower Lakes, Coorong and Murray Mouth Icon Site Environmental Management Plan 2006-2007*. Murray-Darling Basin Commission; Canberra.

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SA water bid 2010-11, *2010-11 Environmental Water Bid to the Commonwealth Environmental Water Holder*, South Australian Department for Water, Land and Biodiversity Conservation

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Markaranka Complex

DEWHA Assessment Summary	CEWH	Other
Site: Markaranka Complex **Floodplain/region:** Murray below choke **Catchment:** Lower Murray **Timing:** August 2010	**Volume:** 1,200 ML **Cost:** $78,900 ($50/ML): CEWH $60,000; State contribution $18,900	**Volume:** 0 ML

Description of Watering Action and Objective

This proposal includes for 1,200 ML to be pumped directly from the River Murray in August 2010 to the Markaranka Complex to replace water lost through evaporation and maintain water level and quality in the wetland. This will promote breeding events of water birds that require longer inundation times for successful reproduction, maintain habitat for frogs, and ensure seed set for aquatic plants prior to drying. The health of fringing vegetation including river red gums (mature and juveniles) and river coobah trees, is also expected to be maintained.

The ecological objectives of the watering are to:

1. Maintain and improve the health of mature River red gums and Black box and support the growth and establishment of River red gum saplings;
2. Provide critical drought refuge for a diverse range of water dependent species including the nationally listed Regent parrot, and at least 16 other water-dependent bird species, including 4 state listed species; and
3. Support frog breeding in 6 species, including the nationally vulnerable Southern bell frog.

Description of site / watering history

The complex consists of three temporary lagoons; Markaranka, Markaranka South and Markaranka East. By far the largest of the three is Markaranka South, a deflation basin of around 64.2 ha in area and of a relatively uniform shallow (< 0.50 m) depth. The lagoons are temporary at Lock 1 pool level with several temporary flow paths located downstream that connect to the river during high flow events.

Data from the baseline survey suggests the wetland begins to fill when river flows at Lock 2 reach approximately 50,000 ML per day. This is supported by the observation that the last time the wetland was inundated during a natural high flow event was in the year 2000 (Jack Caufield pers comm. in SAMDBNRMB 2007) when river flows reached a maximum of approximately 60,000 ML per day.

Comparison of the estimated commence-to-flow level for Markaranka Wetland Complex with the historical river hydrograph (1901-2008) suggests the wetland would have been inundated approximately six years in every ten. This indicates that Markaranka is adapted to an infrequent flooding regime, i.e. based on its historical water regime it does not require flooding every year to survive.

Over the past few years water has been pumped into the wetland due to the low River levels and lack of flooding over the past ten years. The wetland received water from two pumping events: 1,977 ML in 2006 and 2,200 ML of water from CEWH in May/June 2009. Although pumping is not a long term management objective of the wetland, given the continued low flow conditions, it is necessary in the short term until flows return.

Positive response observed during the previous waterings include surface water salinity is comparable to River water salinity; low turbidity recorded in the main Southern Basin, providing conditions for the growth of aquatic vegetation; six frog species were been recorded, including the Southern bell frog (nationally threatened); a frog breeding event has occurred since the 2009 refilling; 16 water dependent bird species recorded, including 4 state listed species including the Regent parrot (nationally threatened).

The main lagoon is currently inundated; accordingly aquatic and emergent vegetation have established in the lagoon. River red gums fringing the lagoon are currently in good health. The 2006 watering resulted in River red gum regeneration and at present these juvenile trees are in good health.

Comments against criteria for assessing 2010-11 environmental watering actions

1. Ecological Significance - The main basin within the complex (Markaranka South) has been classified as DIWA wetland type B6 (seasonal/intermittent freshwater lakes >8ha). Of the 2,325 wetland polygons that have been mapped for the region, only 23 (or less than 1 per cent of the regional total) fall within this DIWA category. Markaranka South is therefore considered a relatively rare wetland type for the region.

While the Markaranka Wetland Complex is not currently listed as a wetland of international (Ramsar) or national (DIWA) significance, it is considered a priority asset at the regional level (SA proposal). This is based on the outcomes of the South Australian River Murray Floodplain Prioritisation Project.

Markaranka Wetland Complex is adjacent to the Hogwash Bend Regent parrot breeding colony, and is part of a 'cluster' of proposed watering sites located near to this important colony (DEH, 2009), so the proposed watering at the cluster of sites near Hogwash Bend will assist in supporting this breeding population.

Significant species identified at the site are the southern bell frog (*Litoria raniformis*: Commonwealth vulnerable; SA vulnerable), regent parrot (*Polytelis anthopeplus*: Commonwealth vulnerable; SA vulnerable), freckled duck (*Stictonetta naevosa*: SA vulnerable); the great-crested grebe (*Podiceps cristatus*; SA rare), musk duck (*Biziura lobata*; SA rare), Australasian shoveler (*Anas rhynchotis*; SA rare) and blue-billed duck (*Oxyura australis*; SA rare), and the caspian tern (*Sterna caspia:* Commonwealth migratory) and great egret (*Ardea alba;* Commonwealth migratory).

2. Expected ecological outcomes
<u>Prevent critical loss of species</u> - Decline in health or death of mature long-lived vegetation. Without flooding the older trees will eventually die off, and without conditions favourable to germination and recruitment, leave no replacements. Watering Markaranka will support the regent parrot, preventing the further decline of this species.

<u>Avoid irreversible loss/catastrophic event</u> - Death of river red gum saplings around the edge of the wetland (failure to support the establishment of the 'next generation' of long-lived vegetation). Stands of juvenile River red gum (established in 2006) are scattered around the wetland edge. Data collected during 2006 (when the southern wetland was inundated) indicated that the groundwater gradient was away from the wetland, subsequent sampling in 2008 after the wetland dried out indicated the groundwater gradient had changed direction. If the wetland was to remain dry for any length of time the wetland could potentially become a discharge point for highly saline groundwater. Re-inundating the basin will help reverse the direction of the groundwater gradient and freshen the groundwater under the wetland (possibly through the creation of a freshwater lens) reducing the risk of salinisation.

<u>Provide drought refuge</u> - The Recovery Plan for the Regent parrot (Schultz 2006) states that all known breeding colonies are considered critical habitats, and due to the decline of substantial proportions of the potential habitat, particularly within the vicinity of breeding habitat, any habitat now used for foraging should be considered as critical for the species persistence. For these reasons, Markaranka is a critical habitat for regent parrots as a foraging and potential breeding site. The wetland is also a refuge for water birds and the nationally listed Southern bell frog.

3. Potential risks - A risk assessment of the proposed watering has been performed, with overall low risks identified. Similar managed watering events have been undertaken in 2006 and 2009, which resulted in no negative impacts. There are therefore very low risks associated with the proposed watering of Markaranka Wetland Complex.
1. Noise impact to River Murray users - Low Risk: there was no negative feedback from local community regarding previous waterings. No action required.
2. Grazing pressure - Low Risk: No stock present on this floodplain. No action required.
3. Salinisation of watering sites, leading to reduced response of watering - Low Risk: there was no evidence of salt impacts (salt crusts, salt tolerant plants etc) observed at the site during the last waterings, indicating salinisation impacting on watering is a low risk. Monitoring of water quality after pumping will be undertaken.
4. Blackwater events – Low Risk: Blackwater events have not occurred during previous waterings, however, water quality parameters will be monitored throughout the inundation of the wetland. If a blackwater event occurs, water is unlikely to re-enter the River due to the presence of banks.

4. Long-term sustainability - The site is considered a priority for management and monitoring by the South Australian Murray Darling Basin NRM Board (SA MDB NRM) and Riverland West Local Action Planning Association, who have been working closely with landholders in previous watering events. A management plan is being developed to determine long term recommendations for management and on-ground works, and opportunities to improve and maintain the health of the site.

Monitoring the release will be undertaken by SA MDB NRM Board Staff, including six monthly tree surveys, spring and summer frog surveys, bird surveys in summer and water quality parameters (salinity, temperature, pH, turbidity and dissolved oxygen) will be monitored regularly (up to six times a year during inundation and drawdown). Results of the monitoring will be available in quarterly progress report for the CEWH Watering 2010-11 and the Annual DWLBC Watering Report. The monitoring proposal is in good alignment with the ecological objectives. Further information regarding the monitoring may be found in the monitoring attachment.

5. Cost effectiveness - The cost to the Commonwealth to deliver the proposed 1,200 ML to the Markarana wetlands by pumping from the Murray River is $60,000. Additional costs totalling $18,900 (additional $17,100 pumping charges and $1,800 administrative charges) will not be the responsibility of the Commonwealth.

References

DEH, (2009) Results of the 2008 Regent Parrot Nest Surveys in the SA Murray Darling Basin, Department for Environment and Heritage Adelaide, South Australia.

Murray-Darling Basin Authority (2009) Contributors: Nicholas Souter, Shaun Cunningham, Stuart Little, Todd Wallace, Bernard McCarthy, Mark Henderson & Kate Bennets. Ground-Based Survey Methods for The Living Murray Assessment of Condition of river red gum and black box Communities. Version 10.

Schultz, M.A. (2006) Recovery Plan for the Regent Parrot (eastern subspecies) *Anthopeplus polytelis monarchoides* in the South Australian Murray Darling Basin, Department for Environment and Heritage Adelaide, South Australia.

Martins Bend

DEWHA Assessment Summary	CEWH	Other
Site: Martins Bend **Floodplain/region:** Murray below choke **Catchment:** Lower Murray **Timing:** Spring 2010	**Volume:** 228 ML **Cost:** $18,664 ($50/ML): CEWH $11,400; State contribution $7,264	**Volume:** 0 ML

Description of Watering Action and Objective

A total watering volume of 228 ML is proposed to be pumped directly from the River Murray into the floodplain, to occur in spring (140 ML September and 88 ML in November) 2010. The proposed watering will maintain water levels in three wetland basins (identified as P1, T1 and T2 in the management plan) over spring 2010 seasons to ensure there is enough water for frog and waterbird breeding events.

The objectives of the watering action are to:

1. Mitigate risks of further salinisation of the wetland bed and develop a freshwater lens by providing fresh water recharge to the local groundwater;
2. Reduce the further loss of stressed long lived vegetation due to salinisation and lack of flood events;
3. Support improved health and regeneration of emergent and submerged aquatic vegetation communities; and
4. Provide refuge and habitat for water birds.

Description of site / watering history

Martins Bend is a temporary wetland complex near Berri (SA) comprising four parallel temporary wetland basins between the river and high land, described as ‘Scroll Swales’. The condition of the wetlands is considered to be Poor to Moderate (SA Department of Water Proposal). The wetland complex has not received water since 2005, and only two lagoons received water at this time under the River Red Gum Rescue project. Many stressed river red gums, river coobahs, black box and tangled lignum are present at the site and there is significant salinisation of the wetland bed.

Pumping will fill three temporary wetland basins to water level of ~14.2 m AHD. It is expected this action will create significant habitat and foraging areas for water birds, remediate salinity impacts and support regeneration and improved health of aquatic vegetation and mature trees.

Comments against criteria for assessing 2010-11 environmental watering actions

1. Ecological Significance –Martins Bend supports a population of nationally vulnerable southern bell frog (*Litoria raniformis*: Commonwealth vulnerable; SA vulnerable).

Fauna species of conservation significance: Australian darter (*Anhinga melaongaster:* SA Rare); Baillons’s crake (*Porzana pusilla*; SA rare); great egret (*Ardea alba:* EPBCA migratory); caspian tern (*Sterna caspia:* EPBCA migratory); and clamorous reed warbler (*Acrocephalus stentoreus:* EPBCA migratory).

Floodplain flora species of conservation significance: creeping boobialla (*Myoporum parvifolium:* SA rare).

2. Expected ecological outcomes

Prevent the loss of long lived vegetation- River red gum (*Eucalyptus camaldulensis*), River coobah (*Acacia stenophylla*) and Tangled lignum (*Muehlenbeckia florulenta*) and the loss of conservation significant/ migratory listed flora and fauna species. Not watering may cause the loss of conservation significant/ migratory listed flora and fauna species.

Provide drought refuge for water dependent bird species and support the improved health and regeneration of emergent and submerged aquatic vegetation communities.

Alleviate salinity: Salinity in the wetland will be alleviated by providing freshwater recharge to the local groundwater and developing a freshwater lens.

3. Potential risks - A management plan exists for this site (Robertson, 2006) and a risk assessment has been performed. Risks identified within this risk assessment are rated as low:

1. Recreation and vandalism - Low risk: No vandalism was experienced at this site during previous pumping events. The public were informed of the benefits of the pumping and were supportive of the project. This will be replicated for the proposed pumping.
2. Noise impact to River Murray users and campers at Martins Bend - Low Risk: there was no negative feedback from local community regarding previous waterings. No action required.
3. Grazing pressure - Low Risk: No stock present on this floodplain. No action required.

4. Blackwater events - Low Risk: Blackwater events have not occurred during previous waterings, however, water quality parameters will be monitored throughout the inundation of the wetland. If a blackwater event occurs, water is unlikely to re-enter the River due to the presence of banks.

4. Long-term sustainability - The site is considered a priority for management and monitoring by the South Australian Murray-Darling Basin NRM Board and Berri Barmera Local Action Planning Association. A management plan was developed in 2006 to determine long term recommendations for management and on-ground works, and opportunities to improve and maintain the health of the site (Robertson 2006).

In 2001 a regulator was installed in the inlet of the wetland complex, with pipes installed between wetlands P1, T1 and T2. This will enable greater connectivity and allow more frequent flooding of the wetlands in the future. The Martins Bend Wetland Group and Berri Barmera Local Action Planning Association have managed the site for ecological and wetland values since 1998.

Monitoring of the proposed watering event will be undertaken by the SA MDB NRM board and will include: quarterly groundwater conductivity and water depth monitoring; quarterly water quality monitoring (conductivity, temperature, turbidity, pH, and water depth); six monthly tree health assessments; quarterly photo Point monitoring; summer bird surveys; and spring and summer frog surveys. The proposed monitoring plan is in good alignment with the ecological objectives. Further information regarding the monitoring may be found in the attachment.

5. Cost effectiveness - Water will be pumped direct from the River Murray into the wetland. Pipes connect three temporary lagoons of the complex and facilitate filling from one pumping site. A sand bag bank needs to be installed at one of the temporary lagoons, with this complementary work to be paid by the SA delivery partner. SA will contribute towards delivery costs and undertake the event and site monitoring.

References

Robertson, H.A. (2006) Martin Bend Wetland Management Plan. Berri Barmera Local Action Planning Committee, Berri. Committee, Berri, SA.

Molo Flat Complex

DEWHA Assessment Summary	CEWH	Other
Site: Molo Flat Complex **Floodplain/region:** Murray below choke **Catchment:** Lower Murray **Timing:** Nov 2010 and Jan 2011	**Volume:** 298 ML **Cost:** $31,224 ($50/ML): CEWH $14,900; State contribution $16,324	**Volume:** 0 ML

Description of Watering Action and Objective
The proposed watering of the Molo Flat includes the western channel, eastern channel and western basin. Water is proposed to be pumped directly from the River Murray to the Molo Flat complex in November (121 ML) and January (177 ML) 2010, to improve river health and provide a drought refuge and habitat.

The ecological objectives of the watering are to:
1. Support regeneration of aquatic vegetation and improve health of abundant tangled lignum (*Muehlenbeckia florulenta*) on wetland bed. The latter is in unique abundance and provides habitat for southern bell frogs.
2. Improve health (and prevent further death) of stressed mature River red gums - potential breeding habitat for Regent parrots frequently recorded at site- and River coobah (*Acacia stenophylla*); and support established juvenile trees.
3. Provide foraging and breeding habitat for wetland and floodplain dependent birds including conservation significant and migratory species.
4. Provide habitat and support breeding events for frogs, including the Southern bell frog (*Litoria raniformis*) previously recorded at the wetland.

Description of site / watering history
The Molo Flat complex is located on the south-eastern side of the River Murray, approximately 20 km north-west of Waikerie. The complex consists of four temporary lagoons, three of which are proposed for watering in this proposal. SA advises that the wetland complex is currently in moderate health – many fringing mature river red gums and river coobahs are showing signs of stress; abundant tangled lignum on the bed is moderately healthy and there is no evidence of soil salinisation (SA Department of Water proposal).

No detailed survey information is available to provide accurate commence-to-flow levels for the Molo Flat wetlands. The Flood Inundation Model III estimates that commence to fill is between 20,000 ML/day to 40,000 ML/day. The last time the River was high enough to inundate the wetland was 2000-01. Over the past few years it has been necessary to pump water into the various wetland basins at Molo Flat due to the low River levels and lack of flooding. Since 2000-01, the following waterings at Molo Flat have been undertaken:
- 327 ML in 2006 as part of the River Gum Rescue Project pumped into the three wetland sections; and
- 327 ML of CEWH water to be pumped in the last two weeks of May 2010.

The proposed watering in this application will build upon previous watering from 2006 and pumping in May 2010, to ensure water levels remain relatively stable over the spring months and extend the period of inundation to provide adequate water for stressed River red gums. Although the site has not received any natural flooding since 2000, the pumping proposed at this site is being proposed in order to maintain the site until flows return. It is expected that flows required to inundate the majority of the wetland at Molo Flat will return to a more frequent regime.

Comments against criteria for assessing 2010-11 environmental watering actions
1. **Ecological Significance** – Within the Molo Flat Floodplain, 300.7ha of floodplain fall within the top two highest ranked categories for maintenance and rehabilitation within the South Australian Floodplain Prioritisation Project. Ranking is based on the health of River red gums and Black box (critical floodplain habitats), flooding frequency and low salt threats, such that those sites with healthy trees, high flooding frequency and low salt threats are ranked higher. The prioritisation process indicated that Molo Flat has the aforementioned properties. (Prioritisation of the SA River Murray Floodplain for the Delivery and Management of Environmental Water - Miles *et al.* 2007).

Wetlands within the Molo Flat complex are part of a 'cluster' of sites being proposed for watering, providing connectivity between nearby watering sites and the Hogwash Bend breeding colony of regent parrots. Significant birds identified at the site are the: Australian darter (*Anhinga melanogaste*r; SA rare), Australasian shoveler (*Anas rhynchotis* SA rare), caspian tern (*Sterna caspia:* Commonwealth migratory), clamorous reed warbler (*Acrocephalus stentoreus:* Commonwealth migratory), glossy ibis (*Plegadis falcinellus:* Commonwealth migratory; SA rare) great egret (*Ardea alba:* Commonwealth migratory), rainbow bee-eater (*Merops ornatus:* Commonwealth migratory). The southern bell frog (*Litoria raniformis*, Commonwealth vulnerable; SA vulnerable) has also been recorded at the site.

2. Expected ecological outcomes
Prevent critical loss of species: The proposed watering action will prevent the loss of large areas of moderately healthy Tangled lignum *(Muehlenbeckia florulenta*) within the wetland bed (uncommon in such abundance at wetlands within the region), which is expected to provide habitat for Southern bell frogs and breeding water birds.

Provide a drought refuge. The site provides drought refuge and foraging habitat for populations of nationally and state vulnerable (EPBC Act) Southern bell frog (*Litoria raniformis*) and Regent parrot (*Polytelis anthopeplus*). The Recovery Plan for the Regent parrot (Schultz 2006) states that all known breeding colonies are considered critical habitats, and due to the decline of substantial proportions of the potential habitat, particularly within the vicinity of breeding habitat, any habitat now used for foraging should be considered as critical for the species persistence. For these reasons, Molo Flat is a critical habitat for Regent parrots as a foraging and potential breeding site. Molo Flat wetland complex is located within 2 - 3km of the Hogwash Bend Regent parrot breeding colony, and is part of a cluster of proposed watering sites located near to this important colony.

Aviod the loss of mature River red gums and failure to support next generation of juvenile River red gums.

3. Potential risks - A risk assessment of the proposed watering event was undertaken. Risks identified by SA as part of the proposed watering project:
1. Water returning back to the main river channel: Low Risk: the past watering in 2006 showed that the banks installed maintained their integrity. Pumping will be monitored and steps will be taken to stop pumping should bank integrity be compromised.
2. Noise impact to River Murray users: Low Risk: there was no negative feedback from local community regarding previous waterings. No action required.
3. Grazing pressure: Low Risk: No stock present on this floodplain. No action required.
4. Salinisation of watering sites, leading to reduced response of watering: Low Risk: there was minor evidence of salt impacts (salt crusts, salt tolerant plants etc) observed at the site, indicating salinisation impacting on watering is a low risk. Monitoring of water quality after pumping will be undertaken.

4. Long-term sustainability The Molo Flat complex is located within a privately owned site, and hence no management plan in place. The landowners were consulted by SA during a previous release, and are supportive of watering. Additional consultation with the land owner may be required prior to the November proposed release. Molo Flat is a South Australian Floodplain priority site, maintaining investment in tree health from the previous watering.

The watering project will be managed and monitored by the South Australian MDB NRM Board in conjunction with the landholders and the Riverland West LAP. With the return of flows in the River, this site is expected to be sustained through natural flooding, although occasional pumping may be required during extended low flow periods.

Monitoring proposed to be undertaken by the SA MDB Board staff include: Six monthly tree health assessments following the draft TLM tree methods, quarterly photo point , bird surveys in summer, frog surveys spring and summer, photo point monitoring and water quality parameters (salinity, temperature, pH, turbidity and dissolved oxygen) will be monitored regularly (up to six times a year during inundation and drawdown). Results will be available quarterly in the CEWH Watering 2010-11 reports and annually in the DWLBC Watering Report.

5. Cost effectiveness - The water delivery method is by pumping directly from the River Murray. Delivery costs to be met by the Commonwealth and SA. In additional, SA will provide project management and monitoring.

References
DEH (2009) Results of the 2008 Regent Parrot Nest Surveys in the SA Murray Darling Basin, Department for Environment and Heritage Adelaide, South Australia.

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Morgan Conservation Park

DEWHA Assessment Summary	CEWH	Other
Site: Morgan Conservation Park – North and South Lagoons **Floodplain/region:** Murray below choke **Catchment:** Lower Murray **Timing:** December 2010	**Volume:** 160 ML **Cost:** $10,100 ($50/ML): CEWH $8,000; State contribution $2,100	**Volume:** 0 ML

Description of Watering Action and Objective
This proposal allows for the delivery of 60 ML to the North Lagoon and 100 ML to the South Lagoon of the Morgan Conservation Park to be delivered in December 2010. The water is proposed to be delivered by pumps from the Murray River, supplementing the watering completed in winter 2010 and maintaining water level and quality in the wetland. The site is significant due to the regent parrot breeding colony and the southern bell frog which inhabit the wetland. The proposed watering event will promote breeding events of water birds that require longer periods of inundation.

The objectives of the proposed watering events are to promote:

1. Significant improvement to general ecological health of the floodplain vegetation at the site; and
2. Significant frog breeding at the wetland area including Southern bell frogs.

Description of site / watering history
The Morgan Conservation Park is located at Morgan, adjacent to the River Murray. The site is considered by SA to be in moderate to poor condition as there has been some death and decline in mature river red gums surrounding the temporary wetlands. River red gum saplings established on the wetland bed during 2006 watering are also in moderate health.

Lower flows in the River over the past 10 to 15 years have meant that water has been unable to inundate most temporary wetlands and the floodplain in South Australia. Morgan Conservation Park floods naturally between flows of 65,000 ML to 75,000 ML/day and last received water naturally in 1996. With the return of increased flows in the future, pumping should not be required at this site on an on-going basis, and will only be necessary during extended periods of low flows. Both sites received water (330 ML) as part of the River Red Gum Rescue Project in 2006. The sites will also receive 330 ML of CEWH water in June 2010.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance - Southern bell frog (*Litoria raniformi* Commonwealth vulnerable; SA vulnerable). Morgan Conservation Park is a known regent parrot (*Polytelis anthopeplus monarchoides* Commonwealth Vulnerable; SA Vulnerable) breeding colony (DEH 2009). Despite the overall reduction, Morgan Conservation Park colony was one of a few that showed an increase in species abundance from 2004 to 2008. Breeding and foraging sites of the regent parrot are considered critical habitats for this important nationally listed species (Schultz 2006). Morgan Conservation Park is therefore locally, regionally and nationally significant.

2. Expected ecological outcomes - The objective of the watering is to provide significant improvement to general ecological health of the floodplain vegetation at the site. Morgan Conservation Park is a significant regent parrot breeding site along the lower River Murray. Watering will avoid the decline and death of mature River red gum within the wetland that support regent parrot nesting. The watering will also assist in the breeding of the southern bell frog. If the lagoon receives water during spring or early summer the site is an important frog breeding area that includes southern bell frogs.

The major benefit will be the replenishment of the fresh ground water lens thus giving the mature River red gums access to fresh water for an extended period

The proposed watering will replace water lost through evaporation from the June 2010 watering, and maintain water level and quality in the wetland. This will promote breeding events of water birds that require longer inundation times for successful reproduction, maintain habitat for frogs and ensure seed set for aquatic plants prior to drying. The health of fringing vegetation including River red gums (mature and juveniles) and River coobah trees will also be maintained.

3. Potential risks - The following risks have been identified by South Australia:
1. Noise pollution: Low risk. Although no negative response has been received from past watering events, communications to the general public will be undertaken to ensure people are aware of the project prior to its commencement. In the event of negative feedback from community members and residents, pumps can be operated in daylight hours only.

2. Black water events: Low risk. The site will receive environmental water in June 2010 and the wetland sediments will only have begun to become exposed on the wetland fringes at the time of the proposed watering in September 2010. Water quality monitoring will be undertaken to detect adverse affects from changes in water quality and is outlined in monitoring and reporting.
3. Seepage to River Channel: Low Risk. Past watering events at the site have been successful and have shown the integrity of the banks to be secure. SA Water will be notified of the watering event prior and community awareness raising through local media and to surrounding landholders will be undertaken.

4. Long-term sustainability - The Morgan Conservation Park is managed by the South Australian Department for Environmental and Heritage in accordance with the *National Parks and Wildlife Act*, 1972. Under this Act Conservation Parks are lands that should be protected or preserved to conserve the flora, fauna and natural or historic features they contain. This park was declared in 1979, primarily to protect its wetlands and River red gum woodlands.

The wetlands are managed and monitored by DEH staff on an on-going basis. Monitoring of the watering event will be undertaken by the Department of Environment and Heritage (SA) Wetland Ecologist, and includes for pre and post inundation tree condition assessments, frog surveys in spring and summer (September and November), and monthly water quality monitoring of salinity, pH, dissolved oxygen, turbidity and temperature in spring and summer (September and November) and tadpole surveys using fyke nets. This proposed monitoring is well aligned with the ecological objectives as stated above. Additional information regarding the monitoring can be found in the Attachment.

5. Cost effectiveness - The costs incurred by the Commonwealth to pump the proposed water to the North and South Lagoons of the Morgan Conservation Park is $8,000 ($50/ML). No complementary works are required and the water will be pumped directly from the River Murray channel. Costs incurred by the delivery partner are quoted at $2,100.

References
DEH (2009) Results of the 2008 Regent Parrot Nest Surveys in the SA Murray Darling Basin, Department for Environment and Heritage Adelaide, South Australia.

Schultz, M.A. (2006) Recovery Plan for the Regent Parrot (eastern subspecies) *Anthopeplus polytelis monarchoides* in the South Australian Murray Darling Basin, Department for Environment and Heritage Adelaide, South Australia.

Mundic Billabong (Pike Floodplain)

DEWHA Assessment Summary	CEWH	Other
Site: Mundic Billabong **Floodplain/region:** Pike Floodplain **Cachment:** Lower Murray **Timing:** August 2010	**Volume:** 83 ML **Cost:** $15,150 ($50/ML), CEWH $4,150 State $11,000	**Volume:** 0 ML

Description of Watering Action and Objective
A propsed volume 83 ML of water will be pumped from Mundic Lagoon into Mundic Billabong. This site will be inundated in the Tanyaca Aquadam proposal. If the Aquadam proposal is approved this water will not be required.

The objectives of the watering proposal are:

1. Improve condition of trees including river red gums, black box and river coobah;
2. Improve condition and cover of understorey vegetation, including lignum;
3. Improve habitat for waterbirds; and
4. Improve habitat for frog breeding.

Description of site / watering history
The Mundic Billabong is located on the Pike floodplain. The Pike floodplain is a major floodplain and anabranch system of the Murray River. The floodplain features several watercourses and wetlands, many of which are permanently inundated. Historically, the Mundic Billabong was inundated one in every two years. The site last received natural inundation in 1993, 1996 and presently has not been inundated since 2000.

The majority of the Pike River Floodplain is leased Crown Land and is developed for grazing or horticulture. Sites managed for conservation include the Pike River Conservation Park and land owned by the National Trust of South Australia. Mundic Billabong is a series of ‘scrolled channels’ which follow the previous location of the main channel of Mundic Lagoon. Each depression is characterised by areas of lignum shrubland (*Muehlenbeckia florulenta*). The temporary billabong is fringed by black box (*Eucalyptus largiflorens*), river coobah (*Acacia stenophylla)*, and to a lesser extent river red gum (*E. camaldulensis*) on the western fringe. Also found in the Billabong are: creeping saltbush (*Atriplex acutebractea*); ruby saltbush (*Enchylaena tomentose*); nitre goosefoot (*Chenopodium nitrariaceum*); old man saltbush (*Atriplex rhagodioides*); spreading emubush (*Eremophila divaricata*); nardoo (*Marselia drummondii*).

The condition of the site is identified by SA as moderate. The River Coobah is in moderate condition, whilst the Lignum shrubland is in moderate-poor condition and would significantly benefit from the provision of environmental water. Vegetation in the Billabong is currently stressed and in poor condition displaying extensive leaf drop (SA proposal). Also, SA advises a high proportion of Black box are stressed in the Mundic Billabong (and on the Pike Floodplain more broadly).

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance The Pike Floodplain is recognised by the Australian Government in the 2009-10 Caring for our Country business plan as a high conservation value aquatic ecosystem (HCVAE) because of its uniqueness. The Pike Floodplain has been identified as a priority floodplain for management by the South Australian Government (SA). It has also been identified as a wetland of significance under the Directory of Important Wetlands of Australia.

A wide range of fauna utilise the Pike Floodplain wetlands. Three species of national significance utilise the floodplain: the golden bell frog (*Litoria aurea*: Commonwealth vulnerable; SA vulnerable), the malleefowl (*Leipoa ocellata*: Commonwealth vulnerable; SA vulnerable) and the regent parrot (*Polytelis antopeplus monarchoides*: Commonwealth Vulnerable; SA vulnerable).

2. Expected ecological outcomes Watering the wetland will provide much needed water to water dependent vegetation communities. This is expected to improve health of black box, river red gum and lignum communities. Watering will also ensure the viability of the seedbank. Numerous water bird species utilise these habitats for feeding and breeding. Inundation of the wetland habitats will result in an increase in productivity of aquatic macro-invertebrates, frogs and fish, as well as waterbirds and larger fish that feed on smaller fauna in inundated areas.

The loss of Lignum shrubland and associated impacts to fauna as a result of loss of habitat are highly likely without an inundation event in 2010. Continued water-stress is likely to result in a range of wetland species dying and being replaced with other terrestrial species, such as chenopod species. Extensive dry periods in the Mundic Billabong may have long term impacts on the wetland communities as continued dry conditions may lead to a loss of seedbank viability for aquatic and floodplain vegetation species.

3. Potential risks There is a small risk associated with environmental watering such as: black water events (or other water quality issues); infestation by exotic plants; or salinity problems in surrounding areas. However the risk of these events occurring at the nominated sites is considered to be low. The nearby site of Inner Mundic Flood-runner has been watered previously and no negative impacts associated with that watering event were observed. There is now over four years of monitoring data for the nearby Chowilla floodplain that provides evidence that the impacts associated with this type of environmental watering initiative are minimal. Additionally owing to the nature of the selected site if a major water quality issue did arise, the impounded water can be allowed to evaporate off without having to be returned to the main river channel or anabranch.

4. Long-term sustainability - The wetland proposed for watering is located within the Pike Floodplain, and is in accordance with the environmental objectives of the Pike River Floodplain Management Plan (Ecological Associates and Australian Water Environments, 2008). Funding for other priority works at the Pike Floodplain is being sought through the Riverine Recovery Project.

The site is also considered a priority for management and monitoring by the South Australian Murray-Darling Basin NRM Board, Renmark to Border LAP and landholders. The SA MDB NRM Board staff will manage the pumping event, and monitoring (compliance and intervention). The proposed monitoring of the site is in good alignment with the ecological objectives. A monitoring plan for the Pike floodplain is currently under preparation. TLM monitoring methodology is currently being utilised, focusing on water quality, groundwater, tree condition, understorey vegetation, fish frogs and birds. The following reports will be prepared: Quarterly progress report for the CEWH Watering 2010-11 and the; Annual DWLBC Watering Report. The monitoring will be conducted by SA MDB NRM Board Staff. Water quality parameters (salinity, temperature, pH, turbidity and dissolved oxygen) will be monitored regularly (up to six times a year during inundation and drawdown). Photos at established photopoints will be taken quarterly. Further detail on the monitoring alignment may be found in the monitoring Attachment.

5. Cost effectiveness Site management, watering and monitoring to be undertaken by DEH and SA MDB NRM Board. Water will be pumped directly from the Murray River channel. The delivery costs will be covered by the CEWH and the delivery partner. Approximately 250 metres of pipeline will be required, in addition the installation of a bank 30 metres long (height of one metre). The delivery partner will also contribute monitoring of the watering event which will involve tree condition assessments, frog surveys in spring and summer and CEWH progress reports.

References

Ecological Associates and Australian Water Environments (2008) *Pike River Floodplain Management Plan. Report AQ006-1-B* prepared for the South Australian Murray-Darling Basin Natural Resources Management Board, Berri.

Murtho Park Depression

DEWHA Assessment Summary	**CEWH**	**Other**
Site: Murtho Park Depression **Floodplain/region:** Murray below choke **Catchment:** Lower Murray **Timing:** September and December 2010	**Volume:** 40 ML **Cost:** $6,820 ($50/ML): CEWH $2,000; State contribution $4,820	**Volume:** 0 ML

Description of Watering Action and Objective
Murtho Park is within the Riverland Ramsar site, adjacent the Chowilla Floodplain. This proposal covers the watering of the Murtho Park Depression, with a proposed volume of 40 ML, which will be delivered through pumping from the River Murray (20 ML in September 2010 and 20 ML in December 2010).

The objectives of the proposed watering action is to:
1. Maintain and improve the health of mature and juvenile River red gums (*Eucalyptus camaldulensis var. camaldulensis*) and mature Black box (*Eucalyptus largiflorens*).
2. Support frog breeding, especially in the Southern bell frog
3. Provide of habitat for water-dependent bird species

Description of site / watering history
Murtho Park is a small temporary basin (4 ha) within the Murtho Park complex, a component of the Riverland Ramsar site. The site is dominated by river red gums and lignum and is situated between a permanent wetland and the River Murray.

Murtho Park Depression last received water naturally under a high river in 2000-01. Although a survey of the inlet has not been undertaken at this site to determine commence to flows, it is estimated that flows of > 65,000 ML/day are required to inundate this wetland (SA proposal). Naturally these flows occurred at least 58 per cent of years. Even with current extraction rates, flows of this height would occur at least 33 per cent of years. It is expected that with the implementation of the Basin Plan, the current return rate may be higher than 33 per cent.

Since 2000-01, Murtho Park Depression has received water in January 2006 as part of the River Red Gum Rescue Project. SA advises that currently the site is in moderate condition, with a large proportion of river red gums in moderate to poor condition. At the time of the previous watering the site contained a considerable number of river red gums, generally exhibiting low to moderate levels of stress. An obvious response by the River red gums was observed following the watering in 2006 included new and epicormic growth, and colour changes in the foliage. Hence, a similar response is expected upon additional watering.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance Ramsar site (Riverland Ramsar site, adjacent the Chowilla Floodplain). The nationally listed Southern bell frog (*Litoria raniformis* Commonwealth vulnerable; SA vulnerable*)* was recorded at Murtho Park complex in 2005. No waterbird species of national or state conservation significance were observed within the Murtho Park wetland. However, two non-waterbird species of state conservation significance: peregrine falcon (*Falco peregrinus;* SA rare) and little friarbird (*Philemon citreogularis;* SA rare) were observed during the 2005 autumn survey. Creeping boobialla (*Myoporum parvifolium*), listed as state rare under the National Parks and Wildlife Act 1972, was recorded during the 2005 baseline survey.

2. Expected ecological outcomes – The watering event is intended to maintain and improve the health of mature and juvenile river red gums (*Eucalyptus camaldulensis var. camaldulensis*) and mature black box (*Eucalyptus largiflorens*) and prevent the decline in health or death of mature long-lived vegetation. Without flooding the older trees and regenerates (from the 2006 watering event) will eventually die off, and without conditions favourable to germination and recruitment, leave no replacements. The watering event will also support frog breeding, especially in the Southern bell frog and provide habitat for water-dependent bird species.

Murtho is interconnected with Weila, and as such it also contains abundant structural habitat (large and complex woody debris), good water quality (equal to that in the main channel) and higher abundances of golden perch during spring. Weila wetland is also proposed for watering in November 2010.

3. Potential risks - A similar managed watering event was undertaken in 2006, which resulted in no negative impacts. SA identified the following risks associated with this proposed watering, which are rated as low:
1. Water quality: Water returning back to the main river channel - Low Risk: Banks have been constructed at the inlet to stop water returning to the River. Pumping will be monitored closely, and if there are any issues regarding the integrity of the bank, the pumping will cease immediately.

2. Noise impact to River Murray users - Low Risk: there was no negative feedback from local community regarding previous waterings. No action required.
3. Grazing pressure - Low Risk: No stock present on this floodplain. No action required.
4. Salinisation of watering sites, leading to reduced response of watering -Low Risk: there was no evidence of salt impacts (salt crusts, salt tolerant plants etc) observed at the site during the last watering, indicating a low risk. Monitoring of water quality after pumping will be undertaken.
5. Blackwater events – Low Risk: Blackwater events have not occurred during previous watering, however, water quality parameters will be monitored throughout the inundation of the wetland. If a blackwater event occurs, water is unlikely to re-enter the River due to the presence of banks.

4. Long-term sustainability – No management plan exists for this site, however a draft management plan has been developed for the permanent sections of the Murtho Park/Weila Wetland Complex. The site is considered a priority for management and monitoring by the South Australian Murray-Darling Basin NRM Board and landholders. The SA MDB NRM Board staff will manage the pumping event, and monitoring (compliance and intervention).

Monitoring of the watering will be carried out by the SA MDB NRM, and will include bird surveys to be undertaken in summer 2010/2011, six monthly tree health assessments, frog surveys in spring and summer and water quality parameters (salinity, temperature, pH, turbidity and dissolved oxygen) will be monitored regularly (up to six times a year during inundation and drawdown). Results of this monitoring will be available in quarterly progress reports for the CEWH Watering 2010-11 and the Annual DWLBC Watering Report. Further information on the alignment of the monitoring with the ecological objectives may be found in the Attachment.

5. Cost effectiveness –The water will be delivered via direct pumping from the River Murray at a cost of $2,000 to the Commonwealth. SA will contribute towards the delivery costs and undertake the watering event and site monitoring.

References

River Murray Wetlands Baseline Survey (2005)
http://www.samdbnrm.sa.gov.au/BoardProjects/RiverMurrayEnvironmentManager/WetlandsBaselineSurvey.aspx, accessed 21/07/2010.

Nikalapko Complex

DEWHA Assessment Summary	CEWH	Other
Site: Nikalapko Complex **Floodplain/region:** Murray below choke **Catchment:** Lower Murray **Timing:** August and November 2010	**Volume:** 782 ML **Cost:** $42,900 ($0/ML): CEWH $0; State contribution $42,900	**Volume:** 0 ML

Description of Watering Action and Objective
Nikalapko complex is part of a 'cluster' of sites being proposed for watering, providing connectivity between nearby watering sites and the Hogwash Bend breeding colony of Regent parrots. A proposed volume of 552 ML is to be released in August 2010, and an additional 230 ML to be released in November 2010. The water is to be delivered to Nikalapko by pumping from the River Murray, and all costs associated with the pumping and complementary works will be paid for by the land owner and the delivery partner.

The objectives of the proposed watering are:
1. To maintain/improve the health of long-lived vegetation;
2. To promote successful breeding events in threatened water bird communities, e.g. Regent parrot; and
3. To promote successful breeding events in frog communities

Description of site / watering history
Nikalapko is located within 4 - 5km of the Hogwash Bend regent parrot breeding colony, and is part of a cluster of proposed watering sites located close to this important colony. SA has advised that the Nikalapko Complex is currently in a moderate condition. The wetland and associated floodplain are in poor condition as the wetland has been dry for more than 10 years. Consequently saline groundwater has risen, increasing soil salinity, and the watering requirements of long-lived vegetation have not been met. The wetland bed is covered in vegetation. Watering will provide excellent breeding habitat for macroinvertebrates, which will in turn provide great feeding grounds for water dependent birds such as spoonbills, avocets, dotterels, etc.

Nikalapko inundates at River flows between 65,000 ML/day to 75,000 ML/day (SA proposal). The last time the River was high enough to inundate the wetland was 1996, the peak of which reached 75,700 ML/day. Water has not entered the Nikalapko wetland basin since this time due to lower River levels and lack of flooding. The watering undertaken at Hogwash Bend and nearby Markaranka over the past few years, is likely to have contributed to the positive impact on the breeding colony at Hogwash Bend. Watering at Nikalapko is also expected to support this breeding colony.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance - A Regent parrot (*Polytelis anthopeplus monarchoides;* Commonwealth vulnerable; SA vulnerable) breeding colony has been observed in the last 10 years (Phillip Reid *pers. comm.*). Nikalapko is located within 4 - 5km of the Hogwash Bend regent parrot breeding colony, and is part of a cluster of proposed watering sites located close to this important colony. A recent survey of ten regent parrot colonies showed that the Hogwash Bend colony was one of the few that recorded an increase in nest numbers, whilst most colonies showed a decline (DEH 2009).

2. Expected ecological outcomes The proposed watering event is expected to maintain/improve the health of long-lived vegetation. Without flooding the older trees will eventually die off (this has already occurred on the western side of the lagoon), and without conditions favourable to germination and recruitment, leave no replacements.

There are many mature river red gums (with hollows) at Nikalapko and these provide drought refuge (breeding habitat) for regent parrots. Regent parrots have been observed at this wetland and the proposed watering is expected to promote successful breeding events in threatened water bird communities, e.g. regent parrot, and in frog communities.

3. Potential risks - SA has identified the following risks as part of the proposed watering project:
1. Water returning back to the main river channel - Low Risk: landholder will construct a bank at the inlet to stop water returning to the River. Pumping will be monitored closely, and if there are any issues regarding the integrity of the bank, the pumping will cease immediately.
2. Noise impact to River Murray users - Low Risk: No action required.
3. Grazing pressure - Low Risk: No stock present on this floodplain. No action required.
4. Salinisation of watering sites, leading to reduced response of watering - Low Risk: there was minor evidence of salt impacts (salt crusts, salt tolerant plants etc) observed at the site during past watering events, indicating salinisation impacts of future watering is a low risk. Monitoring of water quality after pumping will be undertaken.

4. Long-term sustainability - Pumping at this site is proposed to maintain the site until river flows return. It is expected the wetland would be inundated regularly in the future when flows return, and may only require occasionally pumping during extended periods of low flows. The watering project will be managed and monitored by the South Australian MDB NRM Board in conjunction with the landholders and the Riverland West LAP. With the return of flows in the River, this site is expected to be sustained through natural flooding, although occasional pumping may be required during extended low flow periods. A management plan does not exist for this site.

Monitoring of the watering event includes six monthly tree health assessments, bird surveys in summer, frog surveys in spring and summer and water quality parameters (salinity, temperature, pH, turbidity and dissolved oxygen) will be monitored regularly (up to six times a year during inundation and drawdown). This proposed monitoring is well aligned with the ecological outcomes outlined in the proposal. Further information on the monitoring proposal may be found in the Attachment.

5. Cost effectiveness - Water will be delivered to the Nikalapko Complex via pumping direct from River Murray. The water will be pumped into the wetland using the landholders pump. The landholder (Phillip Reid) has agreed to cover the costs of pumping by using his own pump. The small, narrow inlet creek will have to be blocked to prevent water running back to the river, but will also allow the water level to be pumped to a higher level than if the earth works did not occur. The landholder has agreed to do these works. No costs will be incurred by the Commonwealth to deliver the water. SA will contribute towards the delivery costs and undertake the watering event and site monitoring.

References

DEH (2009) Results of the 2008 Regent Parrot Nest Surveys in the SA Murray Darling Basin, Department for Environment and Heritage Adelaide, South Australia.

Noonawirra

DEWHA Assessment Summary	CEWH	Other
Site: Noonawirra **Floodplain/region:** Murray below choke **Catchment:** Lower Murray **Timing:** spring/summer 2010	**Volume:** 146 ML **Cost:** $10,200 ($62/ML): CEWH $9,000; State contribution $1,200	**Volume:** 0 ML

Description of Watering Action and Objective
Noonawirra Wetland (part of the Yarramundi, Moorundie Floodplain Complex) is proposed to receive 146 ML via pumping into the system, comprising 63 ML flow in August, 63 ML in October and 20 ML in November 2010. An extensive monitoring plan has been proposed, and a water management plan is in place.

The objective of the watering is to:
1. To promote growth and seed set in state-listed submerged aquatic plants, particularly that of the SA rare listed water milfoil (*Myriophyllum papillosum*);
2. To provide suitable refuge aquatic habitat for a successful breeding event in 5 frog species; and
3. To improve health and abundance of littoral vegetation.

Description of site / watering history
Noonawirra wetland is situated on the southern tip of the Moorundie Floodplain which contains healthy Lignum (*Muehlenbeckia florulenta*) and River red gum (*Eucalyptus camaldulensis*) communities. The prolonged drying has impacted riparian plant communities such as sedge and herblands and submerged aquatic plant communities.

Noonawirra wetland was granted 103 ML of environmental water in June 2010 by South Australia. Prior to this, the wetland had been dry since 2007 as a result of low river levels below Lock 1. Noonawirra Wetland was previously permanently connected to the River Murray. SA advises that the wetland is currently in moderate to good condition as fringing vegetation and the wetland bed sediments are currently benefiting from this watering. The watering proposal aims to build upon the previous environmental watering granted in June 2010 to ensure the seed set of the species which will rejuvenate the seed bank.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance - The water milfoil (*Myriophyllum papillosum* SA Rare) was identified at the wetland during the 2007 wetland baseline survey, when the wetland was drawing down and is one of the many species of submerged aquatic plants at Noonawirra. This is the most northerly River Murray location of this species and thrives in the sheltered shallow areas of the wetland. It provides food for water birds and shelter for small-bodied native fish. The seedbank of these species has been under threat from extended drying.

The wetland provides habitat for many species of fish, frogs and birds. Species of conservation significance recorded at the site include (Taylor 2008): swamp daisy (*Brachyscombe basaltica* var *gracilis*: SA rare); tufted burr-daisy (*Calotis scapigera:* SA rare); purple loosestrife (*Lythrum salicaria:* SA rare); great egret (*Ardea alba:* EPBC migratory); and clamorous reed-warbler (*Acrocephalus stentoreus:* EPBC migratory).

2. Expected ecological outcomes - The proposed watering will aim to rejuvenate the seedbank of the diverse submerged aquatic plant communities including state-listed species. The longevity of the seed of these aquatic species in areas of identified acid sulfate soils is unknown and the aim of this project is to ensure that the seedbank is not depleted, allowing for successful recolonisation and provision of food and habitat for water dependent and associated species upon return of water. Acid sulphate soils were identified during the South Australian Murray-Darling Basin Natural Resources Management Boards'(SA MDB NRMB) Drought Monitoring Below Lock 1 project in which CSIRO undertook detailed sampling of the wetland bed (Fitzpatrick *et al.* 2009).

The proposed watering will provide aquatic habitats for 7 species of frog and a diverse assemblage of water birds by maintaining water levels and promoting growth of a diverse community of submerged aquatic plants below Lock 1. The proposed watering will also revive degraded fringing and emergent plant communities and counter intrusion from terrestrial species. These fringes provide suitable habitat for cryptic waterbirds such as the Baillon's crake recorded in the 2007 bird component of the wetlands baseline survey.

3. Potential risks- The following risks have been identified by South Australia:
1. Water level not maintained – low risk - The proposed watering regime maintains water availability during the peak breeding/growth season. Success of these recruitment events are dependant on success of watering proposal.

2. Algal Bloom – low risk - The wetland is generally shallow (<0.6m) and is significantly shaded by the abundant River red gum (*Eucalyptus camaldulensis)* community and the cliffs. An algal bloom is considered unlikely. The water will also be isolated from the river channel, thereby not allowing backflow into the potable water supply.
3. Acidification of water column due to acid-sulfate soils – low risk - Noonawirra soil sediments have previously been assessed by CSIRO during the Drought Monitoring Below Lock 1 project conducted in 2007. A hazard rating of Moderate was given to the site. The watering event in June 2010 has to date shown no negative impacts to the wetland resulting from inundation of potential acid sulfate soils.
4. Seepage back to river channel – low risk - Due to movement of the floodplain and wetland soil as a result of extended low river levels, detection of seepage events has occurred during the June 2010 watering. Concentrated monitoring along the rivers edge detects any major seepage into the river channel. The wetland has been blocked using compacted clay at its inlet and heavy rains.

4. Long-term sustainability - Noonawirra is a priority site within the wetland program of the SA MDB NRMB and Mid-Murray Local Action Planning (MidMLAP). This partnership will continue to work with landholders of Noonawirra wetland to manage the ecological values of the site with the aim of being able to reconnect the wetland to the River Murray upon increases in river levels. This will be able to be achieved as river levels reach 0-0.2 m AHD.

A management plan exists for the site and substantial permanent sensors and monitoring is in place. The extensive monitoring plan will be conducted by the SA Murray-Darling Basin Natural Resources Management Board and the Mid Murray Local Action Planning Inc. The proposed monitoring of this watering action is in alignment with the watering objectives stated above. Additional information on the monitoring can be found in the monitoring and evaluation attachment.

5. Cost effectiveness - Costs associated with the pumping of water to the wetland are proposed to be paid by the Commonwealth. South Australia will provide project management and monitoring, and pay the administrative costs of $1,200.

References

R.W. Fitzpatrick, P. Shand, M. Thomas, R.H. Merry, M.D. Raven and S.L. Simpson. 2007, *Acid sulfate soils in subaqueous, waterlogged and drained soil environments of nine wetlands below Blanchetown (Lock 1), South Australia: properties, genesis, risks and management*. CSIRO Land and Water Science Report 42/08, Adelaide.

Nicol, J.M. (2009) *Vegetation Monitoring of River Murray Wetlands Downstream of Lock 1*. South Australian Research and Development Institute (Aquatic Sciences), Adelaide.

Taylor, P. (2008) *Noonawirra Wetland Management Plan*. Mid Murray Local Action Planning Inc. Cambrai

Overland Corner

DEWHA Assessment Summary	CEWH	Other
Site: Overland Corner **Floodplain/region:** Murray below choke **Catchment:** Lower Murray **Timing:** October 2010	**Volume:** 269 ML **Cost:** $16,250 ($50/ML): CEWH $13,450; State contribution $2,800	**Volume:** 0 ML

Description of Watering Action and Objective
This proposal covers the watering of Overland Corner in October 2010, through the delivery of 269 ML which will be pumped directly from the River Murray using the landowners pump. The site is within the Riverland Biosphere Reserve and is a significant frog and waterbird habitat and breeding site. The site was last watered in winter 2010, and strong evidence, through monitoring, of the benefit of watering this site has been acquired.

The objective of the watering action is to:
1. Ensure that the wetland is inundated over spring and summer 2010 to promote southern bell frog and bird breeding events;
2. Mitigate salinisation;
3. Reduce the loss of river red gums (RRG); and to
4. Provide refuge and habitat for conservation significant waterbirds and floodplain dependant birds.

Description of site / watering history
Overland Corner is located approximately 14 km northwest of Barmera and is located on the eastern side of the River Murray. The health of the site is considered by SA to be moderate. Many river red gums are showing signs of significant stress but response to watering in 2009 is obvious on most trees. Tangled lignum (*Muehlenbeckia florulenta*) in the wetland bed is in good health following the 2009 watering. Many River red gum saplings and juveniles established on the wetland bed after the 2006 and 2009 waterings.

Overland Corner commences to inundate at River flows of ~ 15,000 ML/day and last received water naturally in 2000/01. Even with current extraction levels, the wetland should receive water 78 per cent of years.
Since 2000, Overland Corner has received water via pumping on three occasions:
- 500 ML in May 2006 as part of the River Red Gum Rescue Project;
- 500 ML of CEWH water in June 2009; and
- 497 ML (200 ML CEWH; 297 ML State) to be pumped in June 2010.

The proposed watering will maintain water levels over the spring and summer 2010 seasons to ensure there is enough water for frog and waterbird breeding events.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance - Overland Corner is included within the Riverland Biosphere Reserve (previously known as the Bookmark Biosphere Reserve). It is also located adjacent the Banrock regent parrot breeding colony. Overland Corner is a critical habitat for regent parrots (*Polytelis anthopeplus monarchoides:* Commonwealth vulnerable; SA vulnerable) as a foraging and potential breeding site. Significant bird species identified at the site (surveyed in 2009) include: Australasian shoveler (*Anas rhynchotis*: SA rare); freckled duck (*Stictonetta naevosa* SA vulnerable); great egret (*Ardea alba*: EPBCA migratory) and caspian tern (*Sterna caspia*: EPBCA migratory). The southern bell frog (*Litoria raniformis*: Commonwealth vulnerable; SA vulnerable) has also been identified at the site in 2009.

Floodplain flora species of conservation significance (All SA rare): swamp daisy (*Brachyscome basaltica*), grass daisy (*Bracyscome graminea*), spreading goodenia (*Goodenia heteromera*), spiny lignum (*Muhlenbeckia horrida*) and tufted burr daisy (*Calotis scapigera*).

2. Expected ecological outcomes - Benefits of proposed watering are:
Increased time of inundation until February 2011_and increasing the time of inundation to 8-9 months will create suitable conditions for the majority of water birds to breed, and will allow successful recruitment of southern bell frogs *(Litoria raniformis)* – Large numbers of Southern bell frog tadpoles were recorded at Overland Corner wetland in November 2009 prior to it drying in December 2009.

Maintain large areas of habitat for southern bell frogs:_Tangled lignum (*Muehlenbeckia florulenta*) provides significant breeding habitat for southern bell frogs (*Litoria raniformis*) and habitat for the regent parrot.

Support many stressed mature and juvenile River red gums. The Recovery Plan for the Regent parrot (Schultz, 2006) states that all known breeding colonies are considered critical habitats, and due to the decline of substantial proportions of the potential habitat, particularly within the vicinity of breeding habitat, any habitat now used for foraging should be considered as critical for the species persistence.

To mitigate risks of salinisation of the wetland bed and develop a freshwater lens by providing fresh water recharge to the local groundwater.

3. Potential risks - The following risks have been identified by South Australia and are rated as low:
1. Water returning back to the main river channel: Low Risk: Banks and regulators have been constructed at the site to stop water returning to the River. Pumping will be monitored closely, and if there are any issues regarding the integrity of the bank, the pumping will cease immediately.
2. Noise impact to River Murray users: Low Risk: There was no negative feedback from local community regarding previous watering. No action required.
3. Grazing pressure: Low Risk: No stock present on this floodplain. No action required.
4. Salinisation of watering sites, leading to reduced response of watering: Low Risk: There was no evidence of salt impacts (salt crusts, salt tolerant plants etc) observed at the site during the last waterings, indicating salinisation impacting on watering is a low risk. Monitoring of water quality after pumping will be undertaken.
5. Blackwater events: Low Risk: Blackwater events have not occurred during previous waterings, however, water quality parameters will be monitored throughout the inundation of the wetland. If a blackwater event occurs water is unlikely to re-enter the River due to the presence of regulators and banks.

4. Long-term sustainability - The Overland Corner Wetland Group and National Trust of South Australia have managed the site for ecological and wetland values for over 10 years, since 1997. The site is considered a priority for management and monitoring by the South Australian Murray-Darling Basin NRM Board (SA MDB NRM) and Berri Barmera Local Action Planning Association, who have been working closely with the wetland community group over the past 10 years.

A management plan was developed (Robertson 2006) to determine long term recommendations for management and on-ground works, and opportunities to improve and maintain the health of the site.

On-ground works have included the installation of a water control structure on the inlet which will allow flood waters to be retained for longer periods of time in the future when, higher flows return to this part of the River Murray.

Monitoring of the watering will be conducted by the SA MDB NRM Board staff and includes: quarterly groundwater conductivity and water depth ; quarterly water quality monitoring (conductivity, temperature, turbidity, pH, and water depth); six monthly tree health assessments; summer bird surveys; spring and summer frog surveys; quarterly photo point monitoring and annual (Jan/Feb) quantitative vegetation quadrat and transect monitoring. This proposed monitoring is well aligned with the ecological objectives of the watering. Further details on the alignment of the monitoring schedule may be found in the Attachment.

5. Cost effectiveness – High**-** Water will be delivered to the Overland Corner will be pumped directly from the River Murray using the landowners pump. Contributions by SA entities are described in the long-term sustainability paragraph above. The Commonwealth is responsible for the pumping costs, with SA to cover the administrative charges.

References
Schultz, M.A. (2006) Recovery Plan for the Regent Parrot (eastern subspecies) *Anthopeplus polytelis monarchoides* in the South Australian Murray Darling Basin, Department for Environment and Heritage Adelaide, South Australia.

Robertson, H.A. (2006) Overland *Corner Wetland Management Plan*, Berri Barmera Local Action Planning Committee, Berri, SA.

Paiwalla

DEWHA Assessment Summary	CEWH	Other
Site: Paiwalla **Floodplain/region:** Murray below choke **Catchment:** Lower Murray **Timing:** September 2010 – May 2011	**Volume:** 745 ML **Cost:** $45,000 ($15/ML): CEWH $10,800; State contribution $34,200	**Volume:** 0 ML

Description of Watering Action and Objective
This watering action involves pumping of 745 ML into two basins at Paiwalla between September 2010 and May 2011. This watering will consolidate the good environmental outcomes achieved during previous waterings and aims to increase water levels during peak productivity times, inundating 12 hectares of fringing wetland habitats. The watering will enhance connectivity between the two basins.

The objectives of the proposed watering are:
1. To provide refuge habitat for threatened water bird communities and other wetland biota; and
2. To promote recruitment within the re-introduced population of Southern purple-spotted gudgeon (SA critically endangered) in the smaller basin*:*

Description of site / watering history
Paiwalla is located below Lock 1, near Murray Bridge, SA. Paiwalla was rehabilitated from a reclaimed dairy swamp back to a River Murray wetland in 2003 and consists of a small and large basin. Currently the basins are in good to excellent health and are inundated. The large basin has received Commonwealth environmental water in March and June 2009 and March 2010. The small basin received environmental water from other sources in March 2010. The history of watering at Paiwalla is included in the table (SA proposal).

Period	Stage	Delivery	Water provided by	Volume (if applicable	Level (if known)
September 2003	Filling – first inundation after rehabilitation works	Gravity fed via remnant irrigation infrastructure	State - Temporary Licence		0.52mAHD
September 2005	Filling	Gravity fed via remnant irrigation infrastructure	State - Temporary Licence		0.52mAHD
September 2006	Filling	Gravity fed via remnant irrigation infrastructure	State - Temporary Licence		0.52mAHD
January 2008	Filling	Gravity fed via new pipe culvert with meter	Commonwealth	220ML	-0.3mAHD
February 2008	Filling	Pumping due to fall in river levels	Commonwealth	361ML	0.1mAHD
May 2008	Filling – evaporative loss volume	Pumping	Commonwealth	231ML	0.38mAHD
March 2009	Filling	Pumping	Commonwealth	475ML	0.3mAHD
June 2009	Filling - evaporative loss volume	Pumping	Commonwealth	150ML	0.5mAHD
March 2010	Filling (still underway)	Pumping – purchase of pump by wetland group	Commonwealth	241ML + 176ML from ELMA Allocation*	0.1mAHD - rising

March 2010 (Small Basin)	Filling of small basin	Pumping	Healthy Rivers Australia	30ML	0.2mAHD
March 2010 (Small Basin)	Filling of small basin to maintain levels and water quality	Pumping	*ELMA	25ML	0mAHD

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance - The site supports a population of southern purple-spotted gudgeon (*Mogurnda adspersa*: protected SA). The populations in SA are genetically distinct to those in the northern areas of the Murray-Darling Basin. (DEH 2009). 140 juveniles were released into the small basin at Paiwalla in March 2010 with a second release planned for October 2010. This is part of the DEH Drought Action Plan for Threatened Fish (Hall et al. 2009) and the SA Action Plan for SA Freshwater Fishes (Hammer et al. 2009).

Paiwalla acts as an important refuge in the lower River Murray as it is only one of three wetlands currently with permanent water (out of 75 below Lock 1). The wetland also provides habitat for many bird species; 55 bird species have been recorded breeding at the site since active management of the wetland began in 2003 (Philcox 2008); additionally the wetland has provided habitat for 22 bird species of conservation significance since 2008, including 6 species listed as migratory under the EPBC Act.

Significant bird species identified at the site are the: Australasian bittern (*Botaurus poiciloptilus;* SA vulnerable*);* Australasian shoveler (*Anas rhynchotis*; SA rare); banded stilt (*Cladorhynchus leucocephalus*; SA vulnerable); black-tailed godwit (*Limosa limosa*; SA rare, EPBA migratory); blue-billed duck (*Oxyura australis*; SA rare); cape barren goose (*Cereopsis novaehollandiae*; Commonwealth vulnerable; SA rare); cattle egret (*Bubulcus ibis;* SA rare, EPBC migratory); common sandpiper (*Actitis hypoleucos*; SA rare; EPBC migratory*);* freckled duck (*Stictonetta naevosa*; SA vulnerable); glossy ibis (*Plegadis falcinellus*; SA rare, EPBC migratory); great crested grebe (*Podiceps cristatus*; SA rare); intermediate egret (*Ardea intermedia;* SA rare)*;* Latham's snipe (*Gallinago hardwickii;* SA rare, EPBA migratory); Lewin's rail (*Lewinia pectoralis clelandi;* SA vulnerable); little bittern (*Ixobrychus minutus*; SA endangered); little egret (*Egretta garzetta*; SA rare); musk duck (*Biziura lobata*; SA rare); painted snipe (*Rostratula australis;* Commonwealth vulnerable; SA vulnerable); pectoral sandpiper (*Calidris melanotos*; SA rare; EPBC migratory); spotless crake (*Porzana tabuensis*; SA rare); and the wood sandpiper (*Tringa glareola*; SA rare; EPBC migratory).

2. Expected ecological outcomes - Maintenance of the health of wetland and wetland dependent species and provide habitat for the reintroduced southern purple-spotted gudgeon. Allowing the wetland to dry will threaten the success of the re-introduction program of this species. The current condition is wet and water levels are drawing down. The site was watered in March and June 2009 and March 2010 using Commonwealth water. The two basins are in good to excellent health. Monitoring of previous watering events indicated that this site acts as a refuge to a variety of water species, including bird species of conservation significance. The events also improved water quality, supporting recruitment of small-bodied fish. The watering will aim to allow three periods of connection between the two basins to improve transport of food sources, nutrients and spread of submerged aquatic plant seed to maintain habitat values of the smaller basin and trigger suitable conditions for recruitment.

Provision of fresh water drought refuge below Lock 1 (reach over 200 km), habitat for painted snipe (*Rostratula australis*: Commonwealth vulnerable) and other listed bird and amphibian species, migratory birds. The watering will aim to increase water levels during peak productivity times which will inundate 12 hectares of fringing wetland habitats such as inundated emergent vegetation, mudflats and reed beds within 6 different plant communities.

3. Potential risks - The site has been previously watered successfully. South Australia has identified the following risks:
1. Seepage of water from the wetlands in to the river channel. Repairs to the levee bank outlined in the proposal costing will alleviate this problem and reduce risk of any further damage to the levee bank;
2. Algae blooms. Although blooms have not been an ecological issue at the site in the past, awareness of the potential issues to water quality is maintained. The proposed water regime will assist the prevention of major blooms by keeping water levels at a depth that maintains lower temperatures. In the event of an algal bloom, connection of the two basins will not occur.

4. Long-term sustainability - Long term sustainability is secure as the site has a current management plan and there has been significant state and community commitment including extensive complementary management activities. The Wetland Habitats Trust (WHT) are licensees to an Environmental Land Management Allocation (ELMA) (285 ML of entitlement) which is attached to land parcels and delivered to reclaimed swamps of the Lower Murray. Paiwalla

Wetland has been managed under wet and dry regimes by the Wetland Habitats Trust with support from the SA MDB NRM Board since its first watering event in 2003. Throughout this period a solid knowledge base and partnership has developed to create the foundations for secure long-term management of the wetland. Paiwalla is a high-priority site due to its ability to provide and maintain critical wetland habitat in the region and will continue to be supported by the SAMDBNRM Board, WHT, DEH and the Mannum to Wellington Local Action Planning Inc (MWLAP).

Due to low River levels below lock 1, water cannot be gravity fed into the site, although there is the capacity to deliver and meter gravity fed allocations. Until river levels increase there will be a reliance on pumping, and managers of this site have purchased a pump to facilitate water delivery to the site.

Monitoring is ongoing at Paiwalla and is undertaken by the SA MDB NRMB and Wetlands Habitats Trust. The proposed monitoring of this watering action is in alignment with the watering objectives stated above. Additional information on the monitoring can be found in the monitoring and evaluation attachment.

5. Cost effectiveness State to provide monitoring, project management and financial contribution to the event. The delivery is operationally feasible: pumping is required for the short term until River Murray water levels rise.

References

Hall, A., Higham, J., Hammer, M., Bice, C. and Zampptti, B. (2009) *Drought Action Plan for South Australian Murray-Darling Basin threatened freshwater fish populations 2009-2010; Rescue to Recovery*'. Draft. South Australian Department for Environment and Heritage, Adelaide

Hammer, M. Wedderburn, S. & Van Weenen, J. (2009) Action Plan for SA Freshwater Fishes, Native Fish Australia, Adelaide

Philcox, M. (2008) *Paiwalla Wetland Management Plan Review,* DRAFT. Mannum to Wellington Local Action Planning Inc. Murray Bridge

Inner Mundic (Pike Floodplain)

DEWHA Assessment Summary	CEWH	Other
Site: Inner Mundic Floodrunner **Floodplain/region:** Pike Floodplain **Catchment:** Lower Murray **Timing:** August – October 2010	**Volume:** 16 ML **Cost:** $10,000 ($50/ML): CEWH $800; State contribution $9,200	**Volume:** 0 ML

Description of Watering Action and Objective
16 ML of water will be pumped from Mundic Lagoon into the Inner Mundic Floodrunner during August-October 2010.

The objectives of the watering proposal are:
1. Improve condition of trees including River red gums, Black box and River coobah;
2. Improve condition and cover of understorey vegetation, including Lignum;
3. Improve habitat for waterbirds; and
4. Improve habitat for frog breeding.

Description of site / watering history
The Inner Mundic Floodrunner is located on the Pike floodplain. The Pike floodplain is a major floodplain and anabranch system of the Murray River. The floodplain features several watercourses and wetlands, many of which are permanently inundated. The majority of the Pike River Floodplain is leased Crown Land and is developed for grazing or horticulture. Sites managed for conservation include the Pike River Conservation Park and land owned by the National Trust of South Australia.

The Inner Mundic Floodrunner is an ephemeral floodplain wetland, with substantial areas of lignum shrublands (*Muehlenbeckia florulenta*) and fringed by black box (*Eucalyptus largiflorens*). Also present are river coobah (*Acacia stenophylla),* and to a lesser extent river red gum (*E. camaldulensis*) on the western fringe. Also found in the Wetland are: creeping saltbush (*Atriplex acutebractea*); ruby saltbush (*Enchylaena tomentose*); nitre goosefoot (*Chenopodium nitrariaceum*); old man saltbush (*Atriplex rhagodioides*); spreading emubush (*Eremophila divaricata*); nardoo (*Marselia drummondii*).

Under a natural watering regime, this site was inundated 1 year in 3. The Site last received significant natural inundation in 1993; was partially flooded in 1996. In May 2010, the site received 8 ML as part of the SA Drought Framework. Prior to the May 2010 watering, this site had not been inundated since 1996 during a flood (peak 75,700 ML/day). The site is considered by SA to be in a moderate condition. Black box canopy cover is at 20 per cent of original cover. The Lignum shrubland is in moderate condition and would benefit from the provision of environmental water to consolidate the ecological response generated from the 2009-10 watering.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance - The Pike Floodplain is recognised by the Australian Government in the 2009-10 Caring for our Country business plan as a high conservation value aquatic ecosystem (HCVAE) because of its uniqueness. The Pike Floodplain has been identified as a priority floodplain for management by the South Australian Government (SA). It has also been identified as a wetland of significance under the Directory of Important Wetlands of Australia.

A wide range of fauna utilise the Pike Floodplain wetlands. Three species of national significance utilise the floodplain: the golden bell frog (*Litoria aurea*: Commonwealth vulnerable; SA vulnerable), the malleefowl (*Leipoa ocellata*: Commonwealth vulnerable; SA vulnerable) and the regent parrot (*Polytelis antopeplus monarchoides*: Commonwealth vulnerable; SA vulnerable).

2. Expected ecological outcomes - Vegetation in the wetlands are currently displaying stress or are dying in sections of the Inner Mundic Flood Runner. The Lignum communities appear particularly stressed. The loss of Lignum shrubland and associated impacts to fauna as a result of loss of habitat are highly likely without an inundation event in 2010. Continued water-stress is likely to result in a range of wetland vegetation communities dying and being replaced with other terrestrial species, such as chenopod species.

Currently, a high proportion of Black box are stressed in the Inner Mundic (and on the Pike Floodplain more broadly). Several bird species and nectar feeding insects utilise canopy feeding resources provided by black box woodlands throughout the Pike River floodplain, including the temporary Mundic wetlands. Dieback of black box woodlands therefore reduces the available habitat and food resources to insectivorous and nectar feeding birds in the area. Extensive dry periods in the Inner Mundic may have long term impacts on the wetland communities as continued dry conditions may lead to a loss of seedbank viability for aquatic and floodplain vegetation species.

Delivery of water to the wetland will provide much needed moisture to water dependent vegetation communities. This will improve health of black box, river red gum and lignum communities. Watering will also ensure the viability of the seedbank. Numerous water bird species utilise these habitats for feeding and breeding. Inundation of the wetland habitats will result in an increase in productivity of aquatic macro-invertebrates, frogs and fish, as well as waterbirds and larger fish that feed on smaller fauna in inundated areas.

3. Potential risks - SA has reported a low risk associated with environmental watering such as:
1. black water events (or other water quality issues);
2. infestation by exotic plants; or
3. salinity problems in surrounding areas.

However the risk of these events occurring at the nominated sites is considered to be low. The Inner Mundic Flood-runner has been watered previously and no negative impacts associated with that watering event were observed. There is now over four years of monitoring data for the nearby Chowilla floodplain that provides evidence that the impacts associated with this type of environmental watering initiative are minimal. Additionally owing to the nature of the selected site if a major water quality issue did arise, the impounded water can be allowed to evaporate off without having to be returned to the main river channel or anabranch.

4. Long-term sustainability The wetland proposed for watering is located within the Pike Floodplain, and is in accordance with the environmental objectives of the Pike River Floodplain Management Plan (Ecological Associates and Australian Water Environments, 2008). Funding for other priority works at the Pike Floodplain are being sought through the Riverine Recovery Project.

The site is also considered a priority for management and monitoring by the South Australian Murray-Darling Basin NRM Board, Renmark to Border LAP and landholders. The SA MDB NRM Board staff will manage the pumping event, and monitoring (compliance and intervention).

A monitoring plan for the Pike floodplain is currently under preparation. Total Living Murray monitoring methodology is currently being utilised, focusing on water quality, groundwater, tree condition, understorey vegetation, fish, frogs and birds. The following reports will be prepared: Quarterly progress report for the CEWH Watering 2010-11 and the; Annual SA Department of Water, Watering Report. The monitoring will be conducted by SA MDB NRM Board Staff. Water quality parameters (salinity, temperature, pH, turbidity and dissolved oxygen) will be monitored regularly (up to six times a year during inundation and drawdown). Photos at established photo points will be taken quarterly. Further information regarding the alignment of the monitoring proposed with the ecological objectives may be found in the monitoring attachment.

5. Cost effectiveness Site management, watering and monitoring will be undertaken by DEH and SA MDM NRM Board. Water will be pumped directly from the Mundic Lagoon. The delivery cost to the CEWH will be $800 in pumping charges and the delivery partner will be contributing an additional $9200 in pumping charges and complementary works. Complementary works required are approximately 250m of pipeline, in addition to the installation of a 30m bank (height of 1m). The delivery partner will also contribute monitoring of the watering event which will involve tree condition assessments, frog surveys in spring and summer and CEWH progress reports.

References

Ecological Associates and Australian Water Environments (2008) *Pike River Floodplain Management Plan. Report AQ006-1-B* prepared for the South Australian Murray-Darling Basin Natural Resources Management Board, Berri.

Mundic Billabong (Pike Floodplain)

DEWHA Assessment Summary	CEWH	Other
Site: Mundic Billabong **Floodplain/region:** Pike Floodplain **Catchment:** Lower Murray **Timing:** August 2010	**Volume:** 83 ML **Cost:** $15,150 ($50/ML): CEWH $4,150; State contribution $11,000	**Volume:** 0 ML

Description of Watering Action and Objective
A propsed volume 83 ML of water will be pumped from Mundic Lagoon into Mundic Billabong. This site will be inundated in the Tanyaca Aquadam proposal. If the Aquadam proposal is approved this water will not be required.

The objectives of the watering proposal are:

5. Improve condition of trees including river red gums, black box and river coobah;
6. Improve condition and cover of understorey vegetation, including lignum;
7. Improve habitat for waterbirds; and
8. Improve habitat for frog breeding.

Description of site / watering history
The Mundic Billabong is located on the Pike floodplain. The Pike floodplain is a major floodplain and anabranch system of the Murray River. The floodplain features several watercourses and wetlands, many of which are permanently inundated. Historically, the Mundic Billabong was inundated one in every two years. The site last received natural inundation in 1993, 1996 and presently has not been inundated since 2000.

The majority of the Pike River Floodplain is leased Crown Land and is developed for grazing or horticulture. Sites managed for conservation include the Pike River Conservation Park and land owned by the National Trust of South Australia. Mundic Billabong is a series of 'scrolled channels' which follow the previous location of the main channel of Mundic Lagoon. Each depression is characterised by areas of lignum shrubland (*Muehlenbeckia florulenta*). The temporary billabong is fringed by black box (*Eucalyptus largiflorens*), river coobah (*Acacia stenophylla)*, and to a lesser extent river red gum (*E. camaldulensis*) on the western fringe. Also found in the Billabong are: creeping saltbush (*Atriplex acutebractea*); ruby saltbush (*Enchylaena tomentose*); nitre goosefoot (*Chenopodium nitrariaceum*); old man saltbush (*Atriplex rhagodioides*); spreading emubush (*Eremophila divaricata*); nardoo (*Marselia drummondii*).

The condition of the site is identified by SA as moderate. The River Coobah is in moderate condition, whilst the Lignum shrubland is in moderate-poor condition and would significantly benefit from the provision of environmental water. Vegetation in the Billabong is currently stressed and in poor condition displaying extensive leaf drop (SA proposal). Also, SA advises a high proportion of Black box are stressed in the Mundic Billabong (and on the Pike Floodplain more broadly).

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance The Pike Floodplain is recognised by the Australian Government in the 2009-10 Caring for our Country business plan as a high conservation value aquatic ecosystem (HCVAE) because of its uniqueness. The Pike Floodplain has been identified as a priority floodplain for management by the South Australian Government (SA). It has also been identified as a wetland of significance under the Directory of Important Wetlands of Australia.

A wide range of fauna utilise the Pike Floodplain wetlands. Three species of national significance utilise the floodplain: the golden bell frog (*Litoria aurea*: Commonwealth vulnerable; SA vulnerable), the malleefowl (*Leipoa ocellata*: Commonwealth vulnerable; SA vulnerable) and the regent parrot (*Polytelis antopeplus monarchoides*: Commonwealth Vulnerable; SA vulnerable).

2. Expected ecological outcomes Watering the wetland will provide much needed water to water dependent vegetation communities. This is expected to improve health of black box, river red gum and lignum communities. Watering will also ensure the viability of the seedbank. Numerous water bird species utilise these habitats for feeding and breeding. Inundation of the wetland habitats will result in an increase in productivity of aquatic macro-invertebrates, frogs and fish, as well as waterbirds and larger fish that feed on smaller fauna in inundated areas.

The loss of Lignum shrubland and associated impacts to fauna as a result of loss of habitat are highly likely without an inundation event in 2010. Continued water-stress is likely to result in a range of wetland species dying and being replaced with other terrestrial species, such as chenopod species. Extensive dry periods in the Mundic Billabong may have long term impacts on the wetland communities as continued dry conditions may lead to a loss of seedbank viability for aquatic and floodplain vegetation species.

3. Potential risks There is a small risk associated with environmental watering such as: black water events (or other water quality issues); infestation by exotic plants; or salinity problems in surrounding areas. However the risk of these events occurring at the nominated sites is considered to be low. The nearby site of Inner Mundic Flood-runner has been watered previously and no negative impacts associated with that watering event were observed. There is now over four years of monitoring data for the nearby Chowilla floodplain that provides evidence that the impacts associated with this type of environmental watering initiative are minimal. Additionally owing to the nature of the selected site if a major water quality issue did arise, the impounded water can be allowed to evaporate off without having to be returned to the main river channel or anabranch.

4. Long-term sustainability - The wetland proposed for watering is located within the Pike Floodplain, and is in accordance with the environmental objectives of the Pike River Floodplain Management Plan (Ecological Associates and Australian Water Environments, 2008). Funding for other priority works at the Pike Floodplain is being sought through the Riverine Recovery Project.

The site is also considered a priority for management and monitoring by the South Australian Murray-Darling Basin NRM Board, Renmark to Border LAP and landholders. The SA MDB NRM Board staff will manage the pumping event, and monitoring (compliance and intervention). The proposed monitoring of the site is in good alignment with the ecological objectives. A monitoring plan for the Pike floodplain is currently under preparation. TLM monitoring methodology is currently being utilised, focusing on water quality, groundwater, tree condition, understorey vegetation, fish frogs and birds. The following reports will be prepared: Quarterly progress report for the CEWH Watering 2010-11 and the; Annual DWLBC Watering Report. The monitoring will be conducted by SA MDB NRM Board Staff. Water quality parameters (salinity, temperature, pH, turbidity and dissolved oxygen) will be monitored regularly (up to six times a year during inundation and drawdown). Photos at established photopoints will be taken quarterly. Further detail on the monitoring alignment may be found in the monitoring Attachment.

5. Cost effectiveness Site management, watering and monitoring to be undertaken by DEH and SA MDB NRM Board. Water will be pumped directly from the Murray River channel. The delivery costs will be covered by the CEWH and the delivery partner. Approximately 250 metres of pipeline will be required, in addition the installation of a bank 30 metres long (height of one metre). The delivery partner will also contribute monitoring of the watering event which will involve tree condition assessments, frog surveys in spring and summer and CEWH progress reports.

References

Ecological Associates and Australian Water Environments (2008) *Pike River Floodplain Management Plan. Report AQ006-1-B* prepared for the South Australian Murray-Darling Basin Natural Resources Management Board, Berri.

Reid Flat - aka Riversleigh

DEWHA Assessment Summary	CEWH	Other
Site: Reid Flat (aka Riversleigh) **Floodplain/region:** Murray below Choke **Catchment:** Lower Murray **Timing:** Spring 2010 and Autumn 2011	**Volume:** 165 ML **Cost:** $25,050 ($0/ML): CEWH $0; State contribution $25,050	**Volume:** 0 ML

Description of Watering Action and Objective
Reid Flat complex is part of a 'cluster' of sites being proposed for watering, providing connectivity between nearby watering sites and the Hogwash Bend breeding colony of Regent parrots. A proposed volume of 165 ML is to be delivered to Reid Flat via pumping, with spring volumes of 30 ML per month for August, September and October 2010, and Autumn volumes of 30 ML per month in April and May, and 15 ML in June 2011.

The objectives of the proposed watering are
1. To maintain/improve health of long-lived vegetation for Regent parrot habitat;
2. To promote successful breeding events in threatened water bird communities; and
3. To promote successful breeding events in frog communities.

Description of site / watering history
Reid Flat is a temporary wetland of 58 hectares. There are four flood runners that flow from the River into the lagoon during high River levels (or weir pool manipulation). The lagoon is a shallow depression, with an average depth less than 50 centimetres.

SA advises that Reid Flat is currently in a moderate condition. The wetland and associated floodplain are in poor condition as the wetland has been dry for greater than 10 years. Consequently saline groundwater has risen, resulting in increased soil salinity. Further, the watering requirements of long-lived vegetation have not been met. The wetland bed is covered in vegetation. On watering, this will provide excellent breeding habitat for macro-invertebrates, which will in turn provide feeding grounds for water dependent birds such as spoonbills, avocets and dotterels.

Reid Flat inundates at River flows between 65,000 ML/day to 75,000 ML/day. The last time the River was high enough to inundate the wetland was 1996, the peak of which reached 75,700 ML/day. Water has not entered the wetland basin since this time due to lower River levels and lack of flooding. Pumping at this site is being proposed to maintain the site until River flows return. SA advises that because the commence to flow is relatively low for this site, the wetland should be inundated regularly in the future when flows return, and may only require occasionally pumping during extended periods of low flows.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance Nationally and state listed regent parrot (*Polytelis anthopeplus monarchoides;* Commonwealth vulnerable; SA vulnerable) breeding colony observed in the last ten years (pers. comm. John Burford). Reid Flat is located within 5 - 6km of the Hogwash Bend regent parrot breeding colony, and is part of a cluster of proposed watering sites located close to this important colony.

2. Expected ecological outcomes Watering is expected to maintain and improve health of long-lived vegetation such as river red gums. Without flooding the older trees will eventually die off (this has already occurred on the southern side of the lagoon), and without conditions favourable to germination and recruitment, leave no replacements.

Additionally. watering is expected to support a breeding colony regent parrots. There are many mature river red gums (with hollows) at Reid Flat. These trees provide habitat for regent parrots. Regent parrots have been observed breeding at this wetland. Many surrounding wetlands are also proposed for watering in spring 2010, providing additional habitat for the regent parrot. The provision of environmental water in spring is also likely to promote breeding events in frog communities.

3. Potential risks SA has identified the following risks as part of the proposed watering project:
1. Water returning back to the main river channel: Low Risk: landholder will construct a bank at the inlet to stop water returning to the River. Pumping will be monitored closely, and if there are any issues regarding the integrity of the bank, the pumping will cease immediately.
2. Noise impact to River Murray users: Low Risk: No action required.
3. Grazing pressure: Low Risk: No stock present on this floodplain. No action required.
4. Salinisation of watering sites, leading to reduced response of watering: Low Risk: there was minor evidence of salt impacts (salt crusts, salt tolerant plants etc) observed at the site in past watering events, indicating salinisation impacting on watering is a low risk. Monitoring of water quality after pumping will be undertaken.

4. Long-term sustainability - The watering project will be managed and monitored by the South Australian MDB NRM Board in conjunction with the landholders and the Riverland West LAP. With the return of flows in the River, this site is expected to be sustained through natural flooding, although occasional pumping may be required during extended low flow periods.

Monitoring of the watering event includes six monthly tree health assessments, bird surveys in summer, frog surveys in spring and summer and water quality parameters (salinity, temperature, pH, turbidity and dissolved oxygen) will be monitored regularly (up to six times a year during inundation and drawdown). This proposed monitoring is well aligned with the ecological outcomes outlined in the proposal. Further information on the monitoring proposal may be found in the Attachment E.

5. Cost effectiveness High- The water will be pumped into the wetland using the landholders pump. The landholder [redacted] has agreed to cover the costs of pumping. Three or four earthen banks will be constructed in the inlet creeks to prevent the water running back into the river. The landholder has agreed to do these works. No costs will be incurred by the Commonwealth to deliver the water.

Rocky Gully

DEWHA Assessment Summary	CEWH	Other
Site: Rocky Gully Wetland **Floodplain/region:** Murray below Choke **Catchment:** Lower Murray **Timing:** Spring 2010 and Autumn 2011	**Volume:** 25 ML **Cost:** $4,550 ($56/ML): CEWH $1,400; State contribution $3,150	**Volume:** 0 ML

Description of Watering Action and Objective
Environmental water will be pumped between October 2010 and June 2011, to secure survival of a population of Murray hardyhead (*Craterocephalus fluviatilis*: Commonwealth vulnerable) by ensuring water quality conditions remain within tolerance thresholds, and to provide suitable conditions for successful recruitment of juvenile fish by inundating prime habitat.

Description of site / watering history
Rocky Gully is located in Murray Bridge, SA. Up until January 2007, Rocky Gully was permanently connected to the River Murray. Declining river levels below Lock 1 resulted in disconnection of the wetland from the river and the wetland became dependent on storm water and catchment flows. These flows were not enough to maintain water quality thresholds for the Murray hardyhead population and Commonwealth environmental water was pumped to the site in April 2009.

Period	Stage	Delivery	Water provided by	Volume (if applicable	Level (if known)
Prior to January 2007	Full	Open connection to River Murray			0.75mAHD (previous pool level)
January 2007-March 2009	Drying	Disconnection from River Murray due to decease in river levels			
April 2009	Filling	Pumping	CEWH	10ML	0.7mAHD
February 2010	Filling to maintain levels	Pumping	CEWH	8ML	0.65mAHD
*June 2010 (To be undertaken)	Filling to maintain levels and water quality	Pumping	CEWH	10ML	0.7mAHD

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance Rocky Gully is locally, regionally and nationally significant as it has the only Murray hardyhead (*Craterocephalus fluviatilis*; Commonwealth vulnerable; SA endangered) population within the 200 km reach between Blanchetown and Wellington, and one of four core populations of Murray hardyhead in South Australia. Rocky Gully is currently one of only three wetlands (out of 75) in the River Murray Reach of Lock 1 (Blanchetown) to Wellington that holds permanent water and is therefore an important refuge.

2. Expected ecological outcomes The watering will increase water levels and inundate an additional 1.2 ha of fringing vegetation and channel habitat, and reduce salinities within the wetland by up to 40 per cent (40,000EC to 25,000EC) to levels to within tolerance range of breeding Murray hardyhead. These species are relatively short-lived, generally only surviving to a year, therefore failed recruitment over one year may result in that population's failure. Murray hardyhead were historically fairly widespread throughout the Murray-Darling Basin but now have a very restricted and declining distribution within Victoria and South Australia and are assumed 'extinct' in NSW.

Previous watering events have resulted in an improvement of water quality parameters to within tolerance levels of the fish and a successful recruitment event. Fish monitoring following the event recorded both adults and juvenile fish, with many of the adults egg-laden .

3. Potential risks Previous watering of the site was undertaken successfully. Risks identified by South Australia include:
1. Algal Bloom during summer may result in a reduction in plant growth. Increasing the water levels and time of delivery will reduce likelihood of a bloom;
2. De-oxygenation event of water column can result in fish death. Low dissolved oxygen events have occurred in the past (prior to intervention) due to low water levels and poor water quality. The timing of water delivery and achieved water level will ensure water quality parameters remain within thresholds;
3. Storm water event may affect water quality. Pollutant traps have been installed. If water quality monitoring detects high turbidity, additional traps will be installed.

4. Long-term sustainability Rocky Gully is a priority site within the South Australian Drought Action Plan for Threatened Fish 2009 and of the SA MDBNRM Board and Mannum to Wellington Local Action Planning (MWLAP). This partnership will continue to manage Rocky Gully in the long-term with the Rocky Gully Wetland Group and the Rural City of Murray Bridge Council. Under normal river conditions, the site is permanently connected to the main channel of the River Murray.

Monitoring is ongoing at this site and undertaken by the Wetland group and the SA MDB NRMB. Monitoring of the Murray hardyhead population is ongoing by the SA Department of Environment and Heritage and is conducted quarterly through the South Australian Drought Action Plan. The proposed monitoring of this watering action is in alignment with the watering objectives stated above. Additional information on the monitoring can be found in the monitoring and evaluation attachment.

5. Cost effectiveness
Due to low river levels water will be pumped to the site. The state will provide project management, monitoring and contribute to pumping costs.

References
Hall, A., Higham, J., Hammer, M., Bice, C. and Zampptti, B. (2009) Drought Action Plan for South Australian Murray-Darling Basin threatened freshwater fish populations 2009-2010; Rescue to Recovery. Draft. South Australian Department for Environment and Heritage, Adelaide**.**

Bjornsson, K.T. (2007) Rocky Gully Wetland Management Plan, Mannum to Wellington Local Action Planning Committee Inc., Murray Bridge

Sweeney's Lagoon

DEWHA Assessment Summary	CEWH	Other
Site: Sweeney's Wetland **Floodplain/region:** Murray below Choke **Catchment:** Lower Murray **Timing:** September 2010 to January 2011	**Volume:** 260 ML **Cost:** $18,900 ($50/ML): CEWH $13,000; State contribution $5,900	**Volume:** 0 ML

Description of Watering Action and Objective
The proposed watering action involves pumping directly from the Murray River 260 ML to the Sweeney's Wetland between September 2010 and January 2011. No additional works will be required to complete this watering.

The objectives of the watering are:
1. To improve the health of long-lived wetland vegetation such as river red gum (*Eucalyptus camaldulensis*) and lignum (*Muehlenbeckia florulunta*); and
2. To promote successful breeding event in threatened frog species such as the southern bell frog (*Litoria raniformis*).

Description of site / watering history
Sweeney's Lagoon is located adjacent to the township Blanchetown on the Murray River. It is part of the Portee Complex. The wetland covers an area of approximately 14.6 hectares, consisting of two lagoons, and a number of lentic channels. The vegetation associations located in Sweeneys Wetland include common spike rush sedgeland (*Eleocharis acuta*), red milfoil herbland (*myriophyllum cerrucosum*), and lignum shrubland. There is also open black box (*E. largiflorens*) and river red gum woodland.

The wetland condition is currently ranked by SA to be moderate to poor. The health of the river red gum is considered to be moderate whereas the health of the understory wetland vegetation is poor, with low cover abundance. Sweeneys wetland last received 136 ML of water in January 2006 as part of the River Red Gum Rescue Project.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance The Wetland Atlas of the South Australian Murray Valley (Jensen *et al.* 1996) lists Sweeney's wetland as having a high to moderate conservation value and to be of basin and local importance. The southern bell frog, (*Litoria raniformis:* Commonwealth vulnerable; SA vulnerable) was recorded in moderate to high abundances after the River Red Gum Rescue project in January 2006, where 136 ML were pumped into the wetland and inundated vegetation such as lignum and other plants that had become established on the wetland bed.

Sweeneys Wetland has diverse floodplain plant communities. Rare floodplain plant species occur within the area proposed for watering. The coccid emu bush, (*Eremophila gibbifolia)* and spiny lignum, (*Muehlenbeckia horrid*a) (SA rare) are two species in the area that will benefit from a watering event.

2. Expected ecological outcomes Pumping will inundate the wetland basin and 15 ha of low-lying floodplain containing River red gum and Lignum, providing suitable southern bell frog habitat. This scenario will provide optimal breeding conditions for southern bell frog populations, and the delivery times allow water to be available longer in the hottest months of the year, benefiting the health of river red gums, and providing habitat for a wide range of wetland biota.

This project will prevent further decline and death of mature stands of river red gums on the Moorundie Floodplain. The site has not been watered since 2006, and requires a follow up watering to ensure no further decline of long lived vegetation.

Low River levels below Lock 1, has seen 80 of the permanent 80 wetlands between Lock 1 and Wellington dry out. With the predicted River level rise in this reach to -0.3m AHD, only 13 out of 80 wetlands will re-wet, with lower than normal depths. If watered, Sweeneys Wetland will be the only site, in this reach where water will significantly inundate river red gums and lignum.

3. Potential risks Potential risks from the watering have been identified by SA.
There is a small risk of losing sapling river red gum individuals that have emerged within inlet channel. This is considered to be a low risk due to the period of inundation within the channel. The ages of the saplings and their girth suggest that they will withstand up to 12 months of inundation. The watering regimes proposed under this project have outlined inundation periods of no longer than six months.

There is a risk of leakage through the control structure. This is considered a low risk as this issue occurred during the watering event in January 2006 and was successfully repaired. These repairs are still in place. Earth will be available at the site if leakage becomes an issue.

4. Long-term sustainability Sweeneys Wetland is part of the Moorundie Wetland Complex, and has a wetland management plan (Bjornsson 2006). The landholders of the Moorundie wetlands have been involved in the wetland project for over 10 years, working in conjunction with the Mid Murray Local Action Planning Association and SA MDB NRM Board.

The site is considered a priority for management and monitoring by the South Australian Murray-Darling Basin NRM Board and landholders. The SA MDB NRM Board staff will manage the pumping event, and conduct all monitoring activities.

The following monitoring activities will be conducted:

Response from river red gums will be assessed using methodology outlined in the 'Your Wetland: Monitoring Manual' (Tucker 2003). This method uses a health scoring system which takes canopy cover, density and epicormic growth into account. This data will be comparable to the ongoing monitoring undertaken within the River Gum Rescue Project in 2006 and the ongoing monitoring within the SAMDBNRM Board's Wetland program. Seventeen trees are monitored in a transect which is assessed prior to watering and on a monthly basis for six months. Monitoring will be then reduced to three-monthly.

Photopoint monitoring will be conducted to record visual changes in canopy growth and general health of River red gums and understorey vegetation. There is currently one permanent photopoint located at Sweeneys Wetland and additional photos are taken of each of the individual 17 trees within the tree health transect each time it is assessed.
Photopoint monitoring will be conducted on a monthly basis for the first six months. Monitoring will be then reduced to three-monthly.

Frog surveys will be undertaken in spring and summer following methods described in 'Your Wetland Monitoring Manual' (Tucker 2004).

Groundwater salinities and levels will be assessed throughout the project to detect any freshening effects on the local groundwater table which may influence overall health of River red gums. There are four permanently installed groundwater monitoring wells (piezometers) at Sweeneys Wetland which will be monitored on a monthly basis for the first six months. Monitoring will be then reduced to three-monthly.

There is currently one permanent water quality monitoring location at Sweeneys Wetland. An additional two locations will be installed. Salinity, pH, turbidity, temperature and dissolved oxygen will be monitored at these locations and will be conducted monthly for the first six months.

Results of the monitoring will be available in quarterly progress reports for the CEWH Watering 2010-11 and the Annual DWLBC Watering Report. Further information regarding the alignment of the proposed monitoring with the ecological objectives may be found in the monitoring Attachment.

5. Cost effectiveness Water will be pumped directly from the Murray River channel. No other works will be required. CEWH will be contributing delivery cost, while the delivery partner will contribute monitoring of the watering event which will involve tree condition assessments, frog surveys, water quality monitoring and ground water monitoring. They will also prepare CEWH progress reports.

References:
Bjornsson, K. T. (2006) Sweeney's Lagoon Management Plan. Mid Murray Local Action Planning Association Inc., Murray Bridge.

Taylor Flat

DEWHA Assessment Summary	CEWH	Other
Site: Talyor Flat **Floodplain/region:** Murray below Choke **Catchment:** Lower Murray **Timing:** August 2010 to February 2011	**Volume:** 510 ML **Cost:** $30,300 ($0/ML): CEWH $0; State contribution $30,300	**Volume:** 0 ML

Description of Watering Action and Objective
A proposed total volume of 510 ML is to be delivered to the Taylor Flat / Weston Flat, delivered by pumping with the quantities of 210 ML in August 2010, 150 ML in December 2010 and 150 ML in February 2011.

The objectives of the watering is to:
1. assist in supporting the breeding colony of Regent parrots,
2. mitigate against the death of mature long-lived vegetation; and
3. improve vegetation health to promote germination and recruitment.

Description of site / watering history
The Taylor Flat complex is located on the south-eastern side of the River Murray, approximately 20 km north-west of Waikerie, and north of the Molo Flat. Taylor Flat is a temporary wetland, which has three flood runner creeks that flow into the lagoon when the River levels are higher than pool. One creek flows at relatively low levels, but the other two require a much larger flood to flow. The lagoon is a shallow depression, with an average depth of approximately 50 centimetres.

According to SA, the condition of the site is considered to be moderate. The wetland and associated floodplain are in poor condition as the wetland has been dry for more than 10 years. Consequently saline groundwater has risen, increasing soil salinity, and the watering requirements of long-lived vegetation have not been met. The wetland bed is covered in vegetation. On watering, this will provide excellent breeding habitat for macroinvertebrates, which will in turn provide great feeding grounds for water dependent birds such as Spoonbills, Avocets, Dotterels, etc.

No detailed survey information is available to provide accurate commence-to-flow levels for the Taylor Flat wetlands. The Flood Inundation Model indicates that the wetland commences to flow between 20,000 to 30,000 ML/day. The last time the River was high enough to inundate the wetland was late 2000 early 2001. Water has not entered the Taylors Flat wetland basin since this time due to low river levels and lack of flooding.

When flood events occurred more regularly (prior to the 1990s), Taylor Flat would have received water nine out of ten years (landowner [redacted]). With current levels of extraction it is estimated that flows of 20,000 to 30,000 ML/day are likely to occur 6 ½ to eight years out of ten. Pumping at this site is being proposed to maintain the site until River flows return. Because the commence to flow is relatively low for this site, the wetland should be inundated regularly in the future when flows return, and may only require occasionally pumping during extended periods of low flows.

Given the site has not received water since early 2001, and even with current extraction, it should be inundated at least 6 ½ years out of ten; therefore the site is considered a priority for water in 2010-11.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance Taylors Flat complex is part of a 'cluster' of sites being proposed for watering and is located within 4 - 5 km of the Hogwash Bend Regent parrot (*Polytelis anthopeplus monarchoides;* Commonwealth vulnerable; SA vulnerable) breeding colony. A recent survey of ten Regent parrot colonies showed that the Hogwash Bend colony was one of the few that recorded an increase in nest numbers, whilst most colonies showed a decline (DEH 2009).

2. Expected ecological outcomes Prevent the decline in health or death of mature long-lived vegetation. Without flooding the older trees will eventually die off (this has already occurred on the southern side of the lagoon), and without conditions favourable to germination and recruitment, leave no replacements. There are many mature river red gums (with hollows) at Reid Flat. These trees may provide drought refuge (breeding habitat) for regent parrots, which have been observed breeding at this wetland. Watering at the site in spring will also promote frog breeding.

3. Potential risks SA has identified the following risks as part of the proposed watering project:
1. Water returning back to the main river channel Low Risk: landholder will construct a bank at the inlet to stop water returning to the River. Pumping will be monitored closely, and if there are any issues regarding the integrity of the bank, the pumping will cease immediately.
2. Noise impact to River Murray users Low Risk: No action required.
2. Grazing pressure : Low Risk: No stock present on this floodplain. No action required.

3. Salinisation of watering sites, leading to reduced response of watering: Low Risk: there was minor evidence of salt impacts (salt crusts, salt tolerant plants etc) observed at the site in past watering events, indicating salinisation impacting on watering is a low risk. Monitoring of water quality after pumping will be undertaken.

4. Long-term sustainability The watering project will be managed and monitored by the South Australian Murray-Darling Basin Natural Resources Management Board (SA MDB NRMB) in conjunction with the landholders and the Riverland West Local Action Planning. With the return of flows in the River, this site is expected to be sustained through natural flooding, although occasional pumping may be required during extended low flow periods. Monitoring the release will be undertaken by SA MDB NRM Board staff, including six monthly tree surveys, spring and summer frog surveys, bird surveys in summer and water quality parameters (salinity, temperature, pH, turbidity and dissolved oxygen) will be monitored regularly (up to six times a year during inundation and drawdown). Results of this monitoring will be available in quarterly CEWH reports. Further information regarding the alignment of the proposed monitoring schedule with the objectives of the watering may be found in the monitoring Attachment.

5. Cost effectiveness - High - The water will be pumped into the wetland using the landholders ([redacted]pump, whom has agreed to cover the costs of pumping by using his own pump. SA will contribute to the monitoring and project management of the watering. The small inlet creek will have to be blocked to prevent water running back to the river, but will also allow the water level to be pumped to a higher level than if the earth works could not occur. The costs associated with these complementary works are to be covered by the SA delivery partner.

References

DEH (2009) Results of the 2008 Regent Parrot Nest Surveys in the SA Murray Darling Basin, Department for Environment and Heritage Adelaide, South Australia.

Templeton

DEWHA Assessment Summary	CEWH	Other
Site: Templeton **Floodplain/region:** Murray below Choke **Catchment:** Lower Murray **Timing:** September 2010	**Volume:** 80 ML **Cost:** $4,000 ($50/ML): CEWH $4,000; State contribution $0	**Volume:** 0 ML

Description of Watering Action and Objective
The proposal entails pumping 80 ML from the Murray River to the Templeton wetland in September 2010.

The following objectives of the proposal have been outlined:

1. Maintain and improve the health of mature trees and promote recruitment of juvenile river red gums (*Eucalyptus camaldulensis* var. *camaldulensis*) and Lignum
2. Support frog breeding events.

Description of site / watering history
Templeton is an ephemeral wetland located on the eastern side of the Murray River approximately fourteen kilometres north of the township of Paringa. The wetland is located on private land. It is comprised of three small creeks and depressions on a small area of floodplain enclosed by a bend in the river. The wetland is a shallow temporary anabranch that naturally experienced a regular cycle of wetting and drying. River regulation has reduced the frequency and duration of inundation events. As a result, the extent of native wetland plants has declined and exotic terrestrial species have become more abundant.

The Templeton landholders and Renmark to Border Local Action Planning Association installed regulating structures on the inlets of the temporary basins and creeks in 2000 to enable more flexible water management, so that floodwaters could be retained for longer periods of time. This also enables water to be pumped into the wetland.

The site was inundated in 2005-06 during a weir pool manipulation event, and also received 79ML as part of the River Red Gum Rescue Project in 2006.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance Templeton wetland is located within the Riverland Ramsar site which includes the wetlands and floodplain along the Murray River from Paringa to the Victorian Border. These wetlands are recognised as internationally significant and are a major centre for waterfowl breeding in south-eastern Australia.

The Templeton wetlands are also part of the Riverland Biosphere Reserve, one of 400 internationally designated protected areas around the world that are managed for conservation and sustainable use of natural resources. In 1994, the State Government and local landowners agreed to place a Heritage Agreement on the area.

The dominant habitat features at Templeton are small areas of open water, fringing wetland vegetation, and tall, dense vegetation between the wetland and the river with large hollow bearing trees. The creeks are lined by stands of reed (*Phragmites australis*) and lignum (*Muehlenbeckia florulenta).* On the floodplain are river red gum (*Eucalyptus camaldulensis*) forests, with an understory of *senecio cunninghamii*. There are also stands of black box (*E. largiflorens*) on the higher ground.

The site provides foraging and breeding habitat for waterbirds and frogs and is a nesting site for the regent parrot (*Polytelis antopeplus monarchoides*: Commonwealth Vulnerable; SA vulnerable). Five species of frogs have been recorded at the site including the southern bell frog (*Litoria raniformis:* Commonwealth vulnerable; SA vulnerable).The great egret (*Ardea alba*) which is listed as migratory under the EPBC Act, has been recorded at the wetland.

2. Expected ecological outcomes The ecological values of Templeton wetland have been adversely impacted by river regulation and by high groundwater salinity. The river red gum is in good health on the eastern side but is in declining condition towards the floodplain. Black box is also in reasonable condition, but declines towards the wetland basin.

If water is not provided the continual decline in health or death of approximately 52 mature trees and 56 intermediate trees can be expected. The older trees will eventually die off, and without conditions favourable to germination, there will be no recruitment. Continued salinisation of the wetland bed due to shallow saline groundwater discharge will also occur.

Expected ecological outcomes from the proposed water use would protect and restore the ecological significance of Templeton wetland by enhancing the health of the local flora and fauna and increasing the resilience of the wetland to future climatic and management conditions. Specifically watering will:

- Maintain and improve the health of mature river red gums and river coobah (*Acacia stenophylla)*;
- Support the growth of 297 saplings and 313 juvenile trees that have established on the basin bed;
- Provide habitat for water-dependent bird species some of which are migratory as listed above; and
- Reduce the risk of further salinisation due to discharge from local groundwater.

3. Potential risks There has been an assessment of risks.
There is a low risk of water returning back to the main river channel. However, past watering of the wetland showed that the regulators maintained their integrity. Pumping will be monitored and steps will be taken to stop pumping should bank or regulator integrity be compromised.

There is a low risk of noise impact to River Murray users. There was no negative feedback from the local community regarding previous waterings.

Grazing has been eliminated from the floodplain to prevent erosion and vegetation disturbance.

4. Long-term sustainability A wetland management plan was developed in 2006, which outlines recommendations for management in the long term (Ecological Associates 2006). Landholders have been managing and monitoring the site, with support from the Renmark to Border Local Action Planning Association since 2000. Other complementary activities have also been undertaken such as rabbit control, installation of regulators, and weed control.

The following monitoring of the Templeton Wetland will be conducted by landholders in cooperation with the South Australian Murray-Darling Basin Natural Resources Management Board (SAMDB NRMB).

- Tree health
- Groundwater depth and salinity-11 piezometers monitored on the floodplain pre and post filling.
- Surface water salinity at the inlet and outlet end during the filling event
- Frog monitoring – presence absence and density monitoring in September/October
- Waterbird counts and breeding activity observed throughout the fill period through to October 2010.

The proposed monitoring of this watering action is in alignment with the watering objectives stated above. Additional information on the monitoring can be found in the monitoring and evaluation attachment

5. Cost effectiveness Site management, watering and monitoring will be undertaken by the land holders in cooperation with SA MDB NRMB. Water will be pumped directly from the Murray River channel. No other works will be required. The delivery partner will contribute monitoring of the watering event which will involve tree condition assessments, frog surveys in spring and summer and CEWH progress reports.

References

Ecological Associates (2006) Templeton Wetland Management Plan. Renmark to Border Local Action Planning Committee, Renmark.

Weila

DEWHA Assessment Summary	CEWH	Other
Site: Weila wetland **Floodplain/region:** Murray below Choke **Catchment:** Lower Murray **Timing:** November 2010	**Volume:** 54 ML **Cost:** $6,702 ($50/ML): CEWH $2,700; State contribution $4,002	**Volume:** 0 ML

Description of Watering Action and Objective
A proposed volume of 54 ML is to be pumped directly from the River Murray into the Weila wetland, to occur in November 2010.

The objectives of the watering event are to:
1. Support dependent bird species and frog species
2. Maintain and improve the health of mature River red gums (*Eucalyptus camaldulensis* var. *camaldulensis*) and River coobah (*Acacia stenophylla)*.
3. Provide habitat for Southern bell frog *(Litoria raniformis)* habitat when inundated and maintain areas of Tangled lignum (*Muehlenbeckia florulenta*).
4. Maintain potential Regent parrot (*Polytelis anthopeplus monarchoides*) breeding habitat

Description of site / watering history
The Weila wetland is a temporary wetland basin with complex shoreline - two large wetland depressions connected by narrower deep section fringed by River red gums. The wetland has been dry for three years. Many River red gums are showing signs of stress and there is evidence of minor salinisation. There is River coobahs (*Acacia stenophylla*) and Tangled lignum (*Muehlenbeckia florulenta*) present in moderate health. Many (3,900) River red gum saplings/ juveniles have established on wetland bed, and although a number have died, SA reports that the majority are in moderate to good health.

The site last received water under a high river in 1996-97. Since this time Weila River red gum wetland received 221.2 ML water in March 2006 as part of the River Red Gum Rescue Project. The wetland also received 221 ML from the CEWH in May 2010. The proposed watering will maintain water levels over spring/summer 2010.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance - Weila River red gum wetland is located within the Riverland Ramsar site, adjacent the Chowilla Floodplain. The objective of environmental watering in 2006 was ‘to improve river red gum health’ therefore minimal species diversity monitoring was undertaken and the extent of listed threatened species/communities that will occur upon watering is unknown.

Southern bell frogs (*Litoria raniformis* Commonwealth vulnerable; SA vulnerable*)* - were recorded at Weila wetland in 2006 and the adjacent Murtho wetland complex within the same floodplain. Due to their known response of migrating to temporary wetlands upon filling and the presence of permanent water refugia close by they are expected to return to the wetland if rewet. Regent parrots (*Polytelis anthopeplus monarchoides;* Commonwealth vulnerable; SA vulnerable) were sighted in June 2009. Many large river red gums (> 1 m diameter at breast height) with hollows appearing suitable as nesting trees are present at the site.

The Riverland wetland is an important pathway for the migration of golden perch (*Macquaria ambigua*) and silver perch (*Bidyanus bidyanus*) around Lock 6 on the River Murray. The site also provides fish breeding and nursery habitats for these and other fish species (DEWHA, 2009).

2. Expected ecological outcomes - The watering of the Weila wetland will improve the health of the river red gum wetland and support the breeding and habitat of birds (particularly the regent parrot) and frogs (southern bell frog). Increased time of inundation will allow the majority of wetland biota including frogs, water birds and aquatic vegetation to complete reproductive cycles and support many stressed mature and juvenile River red gums that have not received water since 2006.

This wetland is located 3 - 5 km from the Nil Nil Regent parrot breeding colony (DEH 2009). The site is fringed by healthy River red gums, providing habitat for this threatened species.

3. Potential risks - A similar managed watering event was undertaken in 2006, which resulted in no negative impacts. South Australia has advised that the risks associated with this proposed watering are rated as low:

1. Water returning back to the main river channel - Low Risk: Banks have been constructed at the inlet to stop water returning to the River. Pumping will be monitored closely, and if there are any issues regarding the integrity of the bank, the pumping will cease immediately.
2. Noise impact to River Murray users - Low Risk: there was no negative feedback from local community regarding previous waterings. No action required.
3. Grazing pressure - Low Risk: No stock present on this floodplain. No action required.
Salinisation of watering sites, leading to reduced response of watering - Low Risk: there was no evidence of salt impacts (salt crusts, salt tolerant plants etc) observed at the site during the last waterings, indicating salinisation impacting on watering is a low risk. Monitoring of water quality after pumping will be undertaken.
4. Blackwater events - Low Risk: Blackwater events have not occurred during previous waterings, however, water quality parameters will be monitored throughout the inundation of the wetland. If a blackwater event occurs, water is unlikely to re-enter the River due to the presence of banks.

4. Long-term sustainability –The site is considered a priority for management and monitoring by the South Australian Murray-Darling Basin NRM Board and landholders. The SA MDB NRM Board staff will manage the pumping event, and monitoring (compliance and intervention). Weila is privately owned (Land manager- [redacted] and no management plan is in place. Community engagement is conducted through the Renmark to the Border Local Action Planning Association. Monitoring of the watering will be carried out by the SA MDB NRM, and will include fixed area bird search surveys to be undertaken in spring and summer 2010/2011, six monthly tree health assessments, frog surveys in spring and summer and summer targeted searches for Regent parrot breeding activity at suitable nesting trees will be undertaken. Results of this monitoring will be available in quarterly progress reports for the CEWH Watering 2010-11 and the Annual DWLBC Watering Report.

5. Cost effectiveness –The proposed water will be pumped directly from the River Murray, with the cost to the Commonwealth quoted at $2,700. SA will contribute towards the delivery costs and undertake the watering event and site monitoring.

References

DEH (2009) Results of the 2008 Regent Parrot Nest Surveys in the SA Murray Darling Basin, Department for Environment and Heritage Adelaide, South Australia.

DEWHA (2009) Riverland [online] available: http://www.environment.gov.au/cgi-bin/wetlands/ramsardetails.pl?refcode=29, accessed 15 Jan 2010.

Whirlpool Corner

DEWHA Assessment Summary	CEWH	Other
Site: Whirlpool Corner **Floodplain/region:** Murray below Choke **Catchment:** Lower Murray **Timing:** November 2010	**Volume:** 430 ML **Cost:** $32,190 ($50/ML): CEWH $21,500; State contribution $10,690	**Volume:** 0 ML

Description of Watering Action and Objective
This proposal covers the watering of the Whirlpool Corner in September (270 ML) and December (160 ML) 2010, pumping directly from the River Murray into the wetland. The site is part of the Riverland Ramsar site, and the proposed watering will maintain water in the wetland into autumn and will coincide with the peak breeding period for wetland biota. The site has been dry for approximately 5 years.

The objectives of the proposed watering are to:

1. Maintain and improve the health of mature River red gums (*Eucalyptus camaldulensis* var. *camaldulensis*) and Black box (*Eucalyptus largiflorens*) and promote recruitment of juvenile River red gums.
2. Support frog breeding; and
3. Provide habitat for water-dependent bird species.

Description of site / watering history
Whirlpool Corner wetland is a depression surrounded by Black box woodlands (total area 20 Ha). It is located between a permanent wetland to the south and the River Murray to the north. Box culverts are located at both inlets; however current river levels are too low for water to naturally enter the lagoon. Under high river levels (or with weir pool raising) the culverts can be used to manage the hydrological regime of both the temporary and permanent wetlands.

Due to continued low flows over the past ten years the last time Whirlpool Corner received water naturally was in 2000-01. Since this time the wetland was partially filled via gravity in December 2005-06, during a weir pool raising event. The wetland commences to flow at River flows of ~ 12,000 ML/day and through flows occur between 15,000 ML/day to 30,000 ML/day. The wetland and associated floodplain are in poor condition as the wetland has been dry for ~5 years (Department of Water proposal). Consequently saline groundwater has risen, increasing soil salinity, and the watering requirements of long-lived vegetation have not been met.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance Whirlpool Corner wetland is located within the Riverland Ramsar site. The southern bell frog (*Litoria raniformis*: Commonwealth vulnerable; SA vulnerable) has been identified at the site in 2003. The clamorous reed warbler (*Acrocephalus stentoreus:*EPBCA migratory) was last recorded in 2003.

2. Expected ecological outcomes
Maintain and improve the health of mature river red gums (*Eucalyptus camaldulensis var. camaldulensis*) and black box (*Eucalyptus largiflorens*) and promote recruitment of juvenile River red gums. Without flooding the older trees will eventually die off, and without conditions favourable to germination and recruitment, leave no replacements.

Provide drought refuge - This wetland is located adjacent the Gal Gal regent parrot breeding colony (DEH 2009). The site is fringed by healthy River red gums, providing habitat for this threatened species. Inundation will provide drought refuge for waterbirds and breeding opportunities for frogs.

Watering in late winter/ early spring is the optimal watering time to coincide with natural high river events and the peak breeding period for wetland biota, e.g. water birds, frogs, macrophytes. 'Top-up' pumping in November will maintain water in the wetland into autumn to increase recruitment success for peak wetland breeding over spring/summer period. Water levels will be raised to ~ 17.25 m AHD.

3. Potential risks SA had identified the following risks as part of the proposed watering project:
1. Water returning back to the main river channel: Low Risk: past watering of the wetland showed that the regulators installed maintained their integrity. Pumping will be monitored and steps will be taken to stop pumping should bank or regulator integrity be compromised.
2. Noise impact to River Murray users: Low Risk: there was no negative feedback from local community regarding previous waterings. No action required.
3. Grazing pressure: Low Risk: No stock present on this floodplain. No action required.
Salinisation of watering sites, leading to reduced response of watering: Low Risk: there was no evidence of salt impacts (salt crusts, salt tolerant plants etc) observed at the site in past watering events. Monitoring of water quality after pumping will be undertaken.

4. Blackwater events: Low Risk: Blackwater events have not occurred during previous waterings, however, water quality parameters will be monitored throughout the inundation of the wetland. If a blackwater event occurs, water is unlikely to re-enter the River due to the presence of regulators.

4. Long-term sustainability High **-** The site is considered a priority for management and monitoring by the South Australian Murray-Darling Basin Natural Resource Management (SA MDB NRM) Board and the Whirlpool Corner Wetland Group. The SA MDB NRM Board staff will manage the pumping event, and monitoring (compliance and intervention). A wetland management plan was developed in 2006 (Ecological Associates 2006), which outlines recommendations for management in the long term. Land management of the site is the responsibility of the Angoves and Renmark Paringa Council, wetland management and monitoring is undertaken by the SA MDB NRM Board and community engagement is undertaken by the Renmark to Border LAP.

The Whirlpool Corner wetland group and Renmark to Border Local Action Planning Association installed a water control structure on the inlet of the temporary section of the complex, to enable more flexible water management, i.e. retaining floodwaters for longer periods of time. This also enables operation of the structure so that water may be pumped into the wetland.

Monitoring of the watering event will include: six monthly tree health assessments; frog surveys will be undertaken in spring and summer; bird surveys will be undertaken in summer; water quality parameters (salinity, temperature, pH, turbidity and dissolved oxygen) will be monitored regularly (up to six times a year during inundation and drawdown); and photos at established photopoints will be taken quarterly. Results of the monitoring will be available in quarterly CEWH reports and the annual Department of Water Watering Report. This proposed monitoring plan is in good alignment with the ecological objectives of the watering event. Further details on the monitoring plan may be found in the Attachment.

5. Cost effectiveness –Water will be delivered to the Whirlpool Corner wetland by direct pumping from the River Murray. SA will contribute towards delivery costs and undertake event and site management. Contributions in terms of monitoring were described in the long-term sustainability section above.

References

Ecological Associates (2006) *Whirlpool Corner Wetland Management Plan*. Renmark to Border Local Action Planning Committee, Renmark.

Wigley Reach Wetlands

DEWHA Assessment Summary	CEWH	Other
Site: Wigley Reach Wetlands **Floodplain/region:** Murray below Choke **Catchment:** Lower Murray **Timing:** November 2010	**Volume:** 68.5 ML **Cost:** $9,110 ($50/ML): CEWH $3,425; State contribution $5,685	**Volume:** 0 ML

Description of Watering Action and Objective
This proposal covers the watering of the Wigley Reach Wetlands in November 2010, where 20.5 ML will be distributed to the western reach and 48 ML to the central channel. The water is to be delivered to the wetlands by pumping directly from the River Murray. The proposed spring watering will ensure that the wetland is close to capacity at the commencement of the peak spring breeding period and provide water to the River red gums and river coobah to maintain germination and recruitment. The proposed watering will also ensure that the wetland will remain inundated in summer 2010-11.

The objective of the proposed watering is to:
1. Provide habitat for water-dependent bird and frog species;
2. Maintain and improve the health of mature River red gums (*Eucalyptus camaldulensis* var. *camaldulensis*) and River coobah (*Acacia stenophylla);*
3. Maintain large areas of Tangled lignum (*Muehlenbeckia florulenta*) on wetland bed providing good Southern bell frog *(Litoria raniformis)* habitat when inundated; and
4. Maintain potential Regent parrot (*Polytelis anthopeplus monarchoides*) breeding habitat.

Description of site / watering history
The central and western channels are temporary flood runner creeks, fringed by river red gums with large area of tangled lignum on wetland bed. While many river red gums are showing signs of stress, SA report that the wetland bed vegetation including abundant tangled lignum is moderately healthy and diverse, and saplings/juvenile river red gums, and black box have established on wetland bed. Filling prior to spring will ensure the wetland is close to capacity volume at commencement of the peak spring breeding period for most wetland biota and maintain water in the wetland through summer.

Prior to the pumping undertaken in 2006, Wigley Reach was inundated naturally under a high river in 2000-01. Over the past few years Wigley Reach has received water from a variety of sources on three occasions via pumping:
- 262.8 ML in March 2006 as part of the River Red Gum Rescue Project; and
- 278 ML of CEWH water in May 2010.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance Spiny lignum (*Muehlenbeckia horrida*) and swamp daisy (*Brachyscome basaltica)* conservation significant floodplain species (SA rare) in South Australia were recorded at the site in June 2009. The site is directly downstream of the Banrock Station regent parrot breeding colony (*Polytelis anthopeplus monarchoides* Commonwealth vulnerable; SA vulnerable). The site is also likely to provide habitat for the southern bell frog (*Litoria raniformis* Commonwealth vulnerable; SA vulnerable*).*

2. Expected ecological outcomes Maintain and improve the health of mature river red gums (*Eucalyptus camaldulensis var. camaldulensis*) and river coobah (*Acacia stenophylla*). Without flooding the older trees will eventually die off, and without conditions favourable to germination and recruitment, leave no replacements.

Maintain potential regent parrot breeding habitat and maintain large areas of tangled lignum (*Muehlenbeckia florulenta*) on the wetland bed, providing good southern bell frog (*Litoria raniformis* Commonwealth vulnerable; SA vulnerable) habitat when inundated (objective to maintain habitat). Southern bell and significant/listed water bird species have been recorded at nearby Banrock Station Wetland. Many surrounding wetlands are proposed for watering in spring 2010, providing additional habitat for the regent parrot breeding colony.

3. Potential risks SA has identified the following **r**isks as part of the proposed watering project:
1. Water returning back to the main river channel: Low Risk: previous watering showed that the banks installed maintained their integrity. Pumping will be monitored and steps will be taken to stop pumping should bank integrity be compromised.
2. Noise impact to River Murray users: Low Risk: there was no negative feedback from local community regarding previous waterings. No action required.

3. Salinisation of watering sites, leading to reduced response of watering: Low Risk: there was minor evidence of salt impacts (salt crusts, salt tolerant plants etc) observed at the site, indicating salinisation impacting on watering is a low risk. Monitoring of water quality after pumping will be undertaken.
4. Blackwater events: Low Risk: Blackwater events have not occurred during previous waterings, however, water quality parameters will be monitored throughout the inundation of the wetland. If a blackwater event occurs, water is unlikely to re-enter the River due to the presence of banks.

4. Long-term sustainability The site is considered a priority for management and monitoring by the South Australian Murray-Darling Basin NRM Board and landholders. The SA MDB NRM Board staff will manage the pumping event, and monitoring (compliance and intervention). A management plan is not in place for this wetland.

Monitoring of the watering event includes six monthly tree health assessments, bird surveys in summer, frog surveys in spring and summer and water quality parameters (salinity, temperature, pH, turbidity and dissolved oxygen) will be monitored regularly (up to six times a year during inundation and drawdown). This monitoring will be undertaken by the SA MDB NRM Board Staff. This proposed monitoring is well aligned with the ecological outcomes outlined in the proposal. Further information on the monitoring proposal may be found in the monitoring attachment.

5. Cost effectiveness Water will be delivered to Wigley Reach by pumping directly from the River Murray. The Commonwealth to will contribute to delivery costs. SA will contribute towards the delivery costs and undertake the watering event and site monitoring.

VICTORIA

Barmah-Millewa Forest (Vic and NSW)

DEWHA Assessment Summary	CEWH	Other
Site: Barmah-Millewa Forest **Floodplain/region:** Murray above choke **Catchment:** Murray **Timing:** Spring	**Volume:** up to 50,000 ML net demand (100,000 ML gross demand) **Cost: est** $10,000 out of $50,000 for flow measurement and accounting to facilitate return flows.	**Volume:** up to 200,000 ML gross demand from TLM, NSW and Victoria

Description of Watering Action and Objective
Watering of the Barmah-Millewa Forest would be provided through the addition of releases from storage in conjunction with natural high flows from the Ovens River, or as a result of high flows due to river operation, to generate flows to the floodplain either through regulators into floodplain creeks or through over bank flow.

The watering would provide watering for approximately 855 ha (more refined volume verses area is being undertaken by MDBA). The areas would provide an important drought refuge for waterbirds and other wetland dependent species, such as turtles. It would provide maintain key functions of several wetlands and creeks within Barmah.

This action consists of a range of options, with potential water usage dependant on total available allocations and the level of flow in the river. The three broad scenarios being considered in terms of flow per day (including natural inflows) and the total estimated volume of environmental water allocations estimated to be required are:
1. 16,500 ML/day for 2 weeks / 155,000 ML (maximising the extent of approximately 150,000 ML);
2. 13,000 ML/day for 4 weeks / 167,000 ML (maximising the duration of approximately 150,000 ML); and
3. 16,500 ML/day for 4 weeks / 294,000 ML.

The exact magnitude and duration of these events will be dependant on flows within the system (and as result the magnitude and duration of the events may vary slightly during implementation).

The range of proposed contribution to these events, with a minimum of 50% expected to be available for further use downstream via return flows) by the CEWH is, based on conservative estimates by MDBA River Operations for flows above channel capacity;
- 20,000 ML for an event of approximately 150,00 ML (options 1 and 2);
- 50,000 ML for an event of approximately 150,000 ML (options 1 and 2); and
- 100,000 ML for an event of approximately 300,000 ML (option 3) – this will be dependant on significant increases in allocation.

Description of site / watering history
The Barmah-Millewa Forest, totalling an area of 66,000 ha (TLM 2006), is the largest River Red Gum forest in the world (Parks Victoria 2010). This forest is located on the floodplain created by the *"Barmah Choke"*, which also pushes high flows from the Murray River into the Edwards River system. The forest naturally was subject to regular flooding due to its position in the landscape (as the first major constriction below the upper catchment tributaries).

The forest last received substantial flooding as part of releases of the Barmah-Millewa Environmental Water Account in 2005. With reasonably significant flooding prior to this due to unregulated inflows from the Ovens and Kiewa Rivers, and spills from the upper Murray storages during very wet years.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
The floodplain consists of a range of creeks, numerous wetland and EVC types presenting a diverse range of habitat that supports significant number of waterbirds and aquatic fauna. Watercourses occur throughout the forest, which are important for connectivity, distribution of water, fish movement, aquatic plant and in sustaining large red gums along the banks which are important for bird roosting and nesting (TLM 2006).

The value of these habitats is demonstrated by both the Barmah Forest (Victoria) and Millewa Forest (NSW), as part of the broader NSW Murray Central Murray State Forest site, are listed under the Ramsar convention. These listings are across a range of criteria focussing on the diversity of habitats, number of species recorded (380 indigenous flora and 220 indigenous flora under the Barmah listing, and 11 threatened species and 13 migratory waterbird species under the NSW listing) and importance for breeding (DEWHA 2010).

2. Expected ecological outcomes

The key driver for the proposed medium flow event is vegetation and ensuring wetland resilience for future large scale watering events. Whilst this will also provide refuge and potential feeding habitat for a range of waterbirds, it is not envisaged any breeding would occur other than by duck species.

This watering action will also return significant volumes of water to the system for re-use at sites further downstream. Whilst not all of these actions are dependant on this event occurring, the likelihood of a number of events occurring (Werai forest and Hume to Yarrawonga wetlands in particular) is increased if over bank flooding of Barmah-Millewa occurs.

These return flows also have the potential to provide good volumes to the Lower Lakes (with TLM currently considering the majority of their return flows for this purpose). This will be partly dependant on continued negotiations with regard to water trade protocols to South Australia.

The following tables from the proposals submitted to the TLM Environmental Watering Group for its last meeting detail the range of expected outcomes for the three flow scenarios (TLM 2010).

13 GL for 4 weeks				
Issue	Benefit category	Response		
		September	October	November
Carbon cycling to waterways	Ecological	Low	Low	Low
Fish recruitment: large bodied	Ecological	Low	Moderate	Moderate
Fish recruitment: small bodied	Ecological	Moderate	Moderate	Moderate
Waterfowl and common duck recruitment	Ecological	Moderate	Moderate	Moderate
Vegetation resilience through drought	Ecological	High	High	High
Wetland vegetation recruitment	Ecological	High	High	High
Turtle feeding	Ecological	High	High	High
Frog recruitment	Ecological	Low	Low	Low
Recreation	Community	Low	Low	Low

16 GL for 2 weeks				
Issue	Benefit category	Response		
		September	October	November
Carbon cycling to waterways	Ecological	Moderate	Moderate	Moderate
Fish recruitment: large bodied	Ecological	Low	Moderate	Moderate
Fish recruitment: small bodied	Ecological	Moderate	Moderate	Moderate
Waterfowl and common duck recruitment	Ecological	High	High	High
Vegetation resilience through drought	Ecological	High	High	High
Wetland vegetation recruitment	Ecological	High	High	High
Turtle feeding	Ecological	Moderate	Moderate	Moderate
Frog recruitment	Ecological	Low	Low	Low
Recreation	Community	Low	Low	Low

16 GL for 4 weeks				
Issue	Benefit category	Response		
		September	October	November
Carbon cycling to waterways	Ecological	Moderate	Moderate	Moderate
Fish recruitment: large bodied	Ecological	Low	High	High
Fish recruitment: small bodied	Ecological	High	High	High
Waterfowl and common duck recruitment	Ecological	High	High	High
Vegetation resilience through drought	Ecological	Very High	Very High	Very High
Wetland vegetation recruitment	Ecological	Very High	Very High	Very High
Turtle feeding	Ecological	Very High	Very High	Very High
Frog recruitment	Ecological	Moderate	Moderate	Moderate
Recreation	Community	Moderate	Moderate	Moderate

3. Potential risks
A risk matrix has been developed by TLM/DSE that details a range of risks for different watering options. The key risks identified through this process are as follows (TLM 2010):

1. Blackwater – if watering extends into November this was considered as a potentially high to very high risk (depending on watering option), however with the likely flushing of the floodplain creeks during late July due to natural inflows the likelihood of this event should be further reduced. This risk can also be minimised by watering earlier in the season (September/October);
2. Fish stranding (on recession) – for the larger events (16,500 ML/day) the risk of this occurring was considered as low, however the potential negative community response was seen as moderate impact should this occur;
3. Carp breeding – this was considered as high for the larger magnitude events (16,500 ML/day). This was viewed as a trade off that was unavoidable given the greater benefits from broader scale inundation. It has been proposed to mitigate this action including by the potential engagement of a commercial carp fisherman (such as Charlie Carp) to remove fish from the system and community engagement/consultation plans should it become an issue;
4. Flooding of private land: This was considered as a moderate risk (on the basis of the response from the community should it occur). The main risk of flooding of private land with this event is at Picnic Point (area of private land at the Edward River offtake). However this risk is managed as standard practice through the opening of regulators into the floodplain creeks. Opening of these regulators pushes water into the floodplain creeks, and ultimately the floodplain itself, whilst holding river levels below flooding levels at Picnic Point. It is estimated if the regulators are fully open flows of approximately 70,000 ML/day are required to raise the level of the Murray River to a similar level as a 10,400 ML/day flow with the regulators closed. Maximum flows proposed for this event are approximately 16,000 ML/day (TLM 2010);

Other risks:

- Flooding of access tracks/roads within the forest - information has been provided demonstrating the approach to managing road closures and informing the public of the potential risks.

4. Long-term sustainability
Barmah- Millewa Forest is a TLM Icon site, with both sides of the river subject to a mixture of protected area legislation (Barmah Forest is national park, with Millewa Forest is largely national park with some state park) and obligations under the Ramsar convention. Its position in the landscape also ensures that at least some level of minor natural flooding can be expected in the future due to inflows from the Ovens and Kiewa catchments.

The presence of the Barmah-Millewa environmental water account, whilst acknowledging the current issues of borrowings from the account, also provides the potential to assist in the maintenance of the forest in the future. It should be noted that the principle purpose of this account was to extend flooding events in the forest, at a much greater magnitude than these proposals.

The ecological monitoring of this event is proposed to be undertaken as part of the broader TLM condition and intervention monitoring program. This will not only monitor outcomes against the objectives and improvements in condition as a result, but also actively monitor the risks are associated with delivery.

TLM has also identified a number of hypothesis that this action would potential allow to be further investigated. These include the following potential areas of research:

- Lateral connectivity and carbon transfer from wetlands to the main channel;
- How long should floodplains be inundated to ensure benefits to the foodweb;

- Effects of flooding on diversity and abundance of food sources on floodplains and the benefits to wetland specialist fish recruitment;
- The influence of longitudinal connectivity and rates of flood fall on seed dispersal;
- The effects of flood duration, soil moisture and flood seasonality on germination of floodplain trees;
- The effects of soil moisture on reproduction and seed fall in floodplain trees;
- Environmental watering regimes and their effect on survival of tree seedlings; and
- Effects of flood attributes on the regeneration of floodplain understorey and aquatic plants.

The implementation of theses activities needs to be further developed.

5. Cost effectiveness

Costs for the action, other than statutory fees and charges in NSW, should be negligible. It is estimated that a contribution of approximately $10,000 (as part of a combined effort with other entitlement holders) may be required to assist in the measurement and/or estimation of return flows for accounting purposes from the forest to the Murray River, and potentially Edwards Rivers (flows to the Edwards River will be dependant on the magnitude of the event). These activities are also integral to ensuring the CEWH can reuse return flows on further priority environmental assets downstream of the Barmah-Millewa Forest. It is estimated that the total budget for these activities could be as much as $50,000.

Watering arrangements are still in the process of being finalised as this action will require an adaptive approach based on trigger flows from the Ovens River, and consultation with other entitlement holders who are also contributing to the action. To facilitate this, an operational group has been formed with representatives from DEWHA, TLM, River Murray Operations, NSW, Victoria and South Australia and other water managers. This group will adaptively manage the shape of the event hydrograph to maximise outcomes (this is the process used for past watering events at Barmah-Millewa).

To achieve the desired broader outcomes of this action (including the delivery of TLM return flows to the Lower Lakes) arrangements for the accounting of return flows and the modification of trade protocols to South Australia are also being investigated by broader working groups.

6. References

DEWHA (2010) *Australian Wetlands Database – Australian Ramsar Wetlands*. Department of the Environment, Water, Heritage and the Arts

Parks Victoria (2010) http://www.parkweb.vic.gov.au/1park_display.cfm?park=43, accessed on 27 July 2010

TLM (2006) *The Chowilla Floodplain and Lindsay-Wallpolla Islands Icon Site Environmental Management Plan 2006–2007*, Murray Darling Basin Commission

TLM (2010) *Environmental flow proposal – Barmah Millewa Forest / Lower Lakes (EWG Agenda Paper Attachment, 19 July 2010)*, Murray Darling Basin Authority

Black Charlie Lagoon - Gunbower Forest

DEWHA Assessment Summary	CEWH	Other
Site: Black Charlie Lagoon **Floodplain/region:** Gunbower Forest **Catchment:** Murray below choke (Vic) **Timing:** Spring 2010	**Volume:** 0 ML – TLM allocated water to this option on the 2 August 2010	**Volume:** 1,000 ML (TLM)

Description of Watering Action and Objective
Black Charlie Lagoon is wetland situated higher in the landscape of Gunbower Forest (part of the Gunbower-Koondrook-Perricoota TLM icon site and Ramsar site). The water is intended to be provided by raising the levels of the Torrumbry Weir Pool, allowing gravity supply via Cameron's Creek.

The watering action would provide water to the lagoon which has been dry for five years, thereby providing drought refuge for a range of waterbird species and in particular the Growling Grass Frog (as the Southern Bell Frog is known in Victoria).

The provision of water will also protect the surrounding grey and yellow box communities that whilst adapted to less regular flooding than river red gums, are starting to signs of stress.

Description of site / watering history
Water delivery would provide drought refuge for birds and fish in the upstream region of Gunbower Forest. This wetland has been dry for the last 5 years, as has much of the upper forest (MDBA proposal). Black Charlie Lagoon is classified as a permanent wetland that would normally hold water for 9 out of every 10 years.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
The Black Charlie lagoon is located within the RAMSAR listed Gunbower-Koondrook-Perricoota TLM icon site. A number of significant species have previously been recorded at this wetland, including growling grass frogs (also known as southern bell frog, *Litoria raniformis*: Commonwealth vulnerable, Victorian endangered) and a range of waterbirds including egrets (JAMBA / CAMBA), darters (*Anhinga melanogaster*), royal spoonbills, blue-billed ducks (*Oxyura australi:* Victorian endangered), musk ducks (*Biziura lobata* Victoria vulnerable), nankeen night herons (*Nycticorax* caledonicus Victorian near threatened) and white-bellied sea eagles (*Haliaeetus leucogaster:* Victorian vulnerable, EPBC migratory).

2. Expected ecological outcomes
Watering this wetland will provide important wetland habitat in a currently dry part of the forest - all previous environmental watering has targeted river red gum and wetlands in the lower part of the forest. These areas provide known habitat for the nationally threatened Growling Grass Frog and will also provide important feeding habitat for waterbirds. Black Charlie Lagoon is situated within Black and Grey Box (*E. largiflorens* and *E. moluccana*) woodland. Although Box woodland requires less frequent flooding than river red gum, these trees are starting to show signs of severe stress, with weed invasion and a loss of diversity within the understorey. There is little regeneration of either Black or Grey Box trees, or of understorey species (DSE 2010).

3. Potential risks
Victoria identified no material risks in terms of ecological outcomes associated with delivery of water as part of this action due to the following factors:

- Significant experience with delivery to these, or similar sites, provides a high level of knowledge with regard to the delivery process;
- The objectives of the watering (waterbirds and aquatic vegetation) reduce the potential impact of events such as black water to negligible levels (as it will not endanger achievement of the objective); and
- Broader negative consequences from black water events are also not a risk as sites are isolated and do not return water to the supply systems.

Whilst generally this assessment is reasonable, the potential for delivery from the Torrumbury weir pool not being feasible was raised in discussions regarding delivery method. Whilst there is a low likelihood of this occurring and was not neccisarily viewed as a risk by Victoria as delivery can occur through irrigation channels, it does pose a risk to the CEWH as this would introduce delivery costs for the watering option.

4. Long-term sustainability
High – The site is within a RAMSAR listed wetland and part of the Gunbower-Koondrook-Perricoota TLM icon site. The site is also within the boundaries of the recently declared Murray River red gum national parks in Victoria.

5. Cost effectiveness

Discussions between DSE and the Goulburn-Murray Water lockmaster indicates that water can be delivered directly from the Torrumbarry weir pool to Cameron's Creek, which will feed the wetland. Water delivery does not require use of the irrigation system or temporary pumps and therefore should not incur any delivery costs. However if river operations do not allow this delivery mechanism to be implemented temporary pumps would be required, which would result in significantly higher costs.

References:

DSE (2010) Gunbower – Black Charlie Lagoon, TLM extreme dry watering proposal, Department of Sustainability and Environment.

Boort District Wetlands

DEWHA Assessment Summary	CEWH	Other
Site: Boort District Wetlands **Floodplain/region:** Boort plains **Catchment:** Loddon (Vic) **Timing:** Spring 2010/autumn 2011	**Volume:** 16,400 ML **Cost:** $442,800 ($27/ML)	**Volume:** total proposal was for 46,200 ML. No specific allocations have been made to the site.

Description of watering action and objective

The proposed watering action is to deliver water to Lake Boort and Little Lake Meran through the pyramid Boort irrigation system.

This watering action would increase the habitat available for water bird species (drought refuge) and improve the condition of the vegetation of the wetland ensuring further decline does not occur.

Description of site / watering history

Four sites within the Boort District wetlands were identified as potential watering sites during spring 2010 (or autumn 2011) by Victoria. These sites are: being Lake Lyndger; Little Lake Meran; Lake Meran; and Lake Boort. The sites are identified as being bioregionally important wetlands, with Lake Lyndger and Little Lake Meran being State Wildlife Reserves. Watering these wetlands would create a good spatial covering of drought refuges throughout the Boort District, watering wetlands which have not received water for a 8-11 years. The sites are managed by North Central CMA. It is recommended that water be initially supplied to Little Lake Meran and Lake Boort.

Lake Meran and Lake Lyndger are potentially subject to duck shooting in autumn 2011, as well as Lyndger either needing to be supplied via Lake Boort, which requires the lake to be filled, or significant works to be undertaken to facilitate independent delivery to the site. These issues, combined with the scope of potential water availability and reduced risks at the other lakes, have resulted in an initial focus on the provision of wter to Little Lake Meran and Lake Boort.

The two sites proposed for watering are currently dry, with water last received in the sites as following: Little Lake Meran (1999) and Lake Boort (1999). Lake Boort and Little Lake Meran, which usually hold freshwater on a permanent basis, have historically provided important habitat for large bodied native fish, waterbirds, colonial nesting breeding sites, waterfowl and tortoises. However, apart from Little Lake Boort (which received water from Victorian entitlements in 2009-10) and Lake Yando (which received water in 2009-10), all remaining Boort District wetland sites as well as other waterways in the Boort District have been dry since 2003 (NCCMA 2010).

Little Lake Meran has been cut off from the floodplain by a levee and relies solely on outfall water from the irrigation supply system. The wetland receives irrigation outfall from the off take of the 4/8/2 channel, which enters the wetland from the north west corner of the wetland. Little Lake Meran has, in general, been kept full as a water supply reserve, however dried in 2006 (DPI 2006).

Comments against criteria for assessing 2010-11 environmental watering actions

1. Ecological Significance

Regionally-important wetlands with high environmental values (Hydro Environmental 2009).

Sites:

Little Lake Meran is a permanent open freshwater system which can provide important habitat for large bodied native fish, waterbirds, colonial nesting breeding sites, waterfowl and tortoises (ibid.). It is a bioregionally important wetland and a State Wildlife Reserve managed by Parks Victoria. Waterbirds at the site include: Great Egret (*Ardea alba*; EPBCA migratory), australasian shoveler (*Anas rhynchotis*; SA rare), musk duck (*Biziura lobata*), painted snipe (*Rostratula australis:* Commonwealth vulnerable, EPBCA migratory) and regent honeyeater (*Xanthomyza Phrygia:* Commonwealth endangered).

Lake Boort - Waterbirds including the following: whiskered tern (*Chlidonias hybridus)*; great egret(*Ardea alba*; EPBC migratory); australasian shoveler (*Anas rhynchotis*; SA rare); freckled duck (*Stictonetta naevosa:*Vic endangered); hardhead (*Aythya australis)* and blue-billed duck (*Oxyura australis:* Vic endangered).

Other species listed on the site asset register are the southern bell frog (*Litoria raniformis*, vunerable) and the Murray cod (*Maccullochella peelii peelii*, vunerable).

2. Expected ecological outcomes
Watering any of these wetlands would increase the habitat available for water bird species (drought refuge) and improve the condition of the vegetation of the wetland ensuring further decline does not occur. Similar response to water events during 2009-10 can be found in the draft Loddon 2010-11 annual watering plan (NCCMA 2010). The final plan is expected to be completed soon, following statutory approvals by the Victorian Minister for the Environment.

3. Potential risks
Victoria identified no material risks associated with delivery of water as part of this action due to the following factors:

- Significant experience with delivery to these, or similar sites, provides a high level of knowledge with regard to the delivery process;
- The objectives of the watering (waterbirds and aquatic vegetation) reduce the potential impact of events such as black water to negligible levels (as it will not endanger achievement of the objective);
- Broader negative consequences from black water events are also not a risk as sites are isolated and do not return water to the supply systems; and
- The likelihood of colonial water bird breeding is remote due to the lack of broader food sources. As such these events are aimed at providing refuge/foraging habitat only.

Whilst generally this assessment is reasonable, it does not allow for potential issues such as capacity constraints within the irrigation system, or other operational issues. Instead it is focussed solely on ecological risks.

Whilst duck hunting is permitted in some of these wetlands, posing a risk to the achievement of the objectives, information has also been provided on the criteria used to assess the closeure of wetlands. This assessment is informed by detailed waterbird surveys at the site. The key criteria in relation to our watering events are as follows:

- If the wetland is needed as a refuge site for game ducks and other wildlife because it is in an area of restricted habitat due to drought;
- If there is evidence of waterbird breeding; and
- To protect significant numbers of rare or threatened species.

It should also be noted that divertors may be present on some of these wetlands. Diversions would be for stock and domestic supplies only; this will require further investigation prior to watering commencing.

A more detailed risk assessment has been proposed as part of the development of detailed watering plans for priority sites across northern Victoria.

4. Long-term sustainability
The Boort Wetlands have access to water from a range of sources, including a dedicated environmental entitlement and access to unregulated flows from the Loddon River during times of flood.

NCCMA are prepared to monitor water levels and delivery. If required, waterbird monitoring would be undertaken using Birds of Australia methodology (the same used by The Living Murray for its intervention monitoring). The monitoring of the event, similar to that performed during the 2008 watering, aligns well with the intended ecological objectives. Further information regarding monitoring of the watering may be found in the monitoring attachment.

5. Cost effectiveness
The water would be delivered through existing irrigation channels managed by Goulburn-Murray Water. This is at a reduced rate as it is deemed an interruptible supply, however given deliveries would occur outside peak irrigation times this should not be an issue. Future policies on pricing the delivery of environmental water in Victoria could become more affordable (proposed future charges would only be out of pocket expenses).

An operational management plan is currently being developed in conjunction with the CEWH, following the recommendations of the NVIRP impact assessment (Hydro Environmental 2009). Monitoring will be conducted by the NCCMA on the water levels and delivery of the proposed water, with additional waterbird and vegetation monitoring only undertaken if requested (and paid for) by the CEWH.

References
DPI. (2005) Surface water data on the Meran Lakes system supplied by the Department of Primary Industries, October 2005.

DPI (2006) Meran Lakes Complex Water Operational Plan, Environmental Values Assessment (Stage 2)

NCCMA (2010) *Draft 2010-11 Loddon River Annual Watering Plan*, North Central Catchment Management Authority

Hydro Environmental (2009) Northern *Victoria Irrigation Renewal Project: Wetland Short-listing Report*, version 7, August 2009
http://www.nvirp.com.au/downloads/Planning/WCMF_and_Shortlisting_reports/090907_Wetland_Short-listing_Report_Final.pdf , accessed 08 January 2010.

Campaspe River - Eppalock to River Murray

DEWHA Assessment Summary	CEWH	Other
Site: Campaspe River (Vic.) **Floodplain/region:** Eppalock to River Murray **Catchment:** Campaspe **Timing:** Spring 2010	**Volume:** 5,094 ML (defined as the current high reliability water shares held by the Commonwealth in the Campaspe system) **Cost:** TBA – estimated at $22,923 ($4.50/ML)	**Volume:** Not defined - potential passing flows and river operations contribution to flows depending on availability and system restrictions.

Description of Watering Action and Objective
The proposal for watering is requesting the use of allocation against entitlements held within the Campase system by the CEWH to provide in-stream benefits to the Campaspe River from Lake Eppalock to the Murray River. The volume of these entitlements (as of 30 June 2010) is 5,124 ML of high reliability water share and 395 ML of low reliability water share. The release into the system of any allocations is proposed to start in August 2010 and be delivered throughout 2010/11 and into 2011/12 (dependent on seasonal conditions).

This proposal does not propose the trade of any water into the Campaspe system from the broader southern connected basin.

The objective of the action is to assist in improving the condition of the Campaspe system from Category 1 to Category 4 as per the Northern Region Sustainable Water Strategy (see expected ecological outcomes for more information).

Any provided additional water will be delivered in accordance with the environmental watering plan (awaiting approval by the Victorian Government's Minister for the Environment as the statutory holder of the Loddon flora and fauna bulk entitlement).

Description of site / watering history
Campaspe River Reach 4 falls entirely within the Victorian Riverina Bioregion (NCCMA 2009). The dominant Ecological Vegetation Classes (EVCs) is still Floodplain Riparian Woodland, which is characterised by river red gum and yellow box woodland with a groundlayer of amphibious and aquatic herbs and sedges. This EVC is subject to periodic flooding and inundation, and according to the benchmark should experience episodic flooding every ten years in order to remain viable (DSE 2004). Environmental flow recommendation quantities have been approximated (SKM 2006) for the Campaspe River, with additional recommendations on flow volumes and the response of saline stratified pools also approximated (SKM 2008).

Key threats to the lower Campaspe River include changed water regime, poor water quality (nutrients and salinity) and stock access. Although the lower Campaspe River is stressed it still either retains or has the potential to retain significant environmental values.

The Campaspe River is currently qualified for critical human use, with current qualification rights evoked by the Minister for Water (valid until June 2011 (NCCMA 2009)). This impacts on the ability to access water for the environment and/or irrigation purposes.

Due to continuing low water resource levels over recent years, the Campaspe River is currently under Qualification of Rights. This has resulted in passing flows currently being suspended and withheld flows being accrued inn an account which will then be made available as conditions improve. Minor volumes will be returned to the environment prior to initial allocations, however a minimum of 15 percent allocation is required for substantial volumes to be returned, and 100% allocations for the full lifting of the provisions under the qualification. Unless renewed, the qualification will expire at the end of June 2011.

The impact of restricted access to environmental water is being partly offset through the transferring of water from the Goulburn River to the Murray River by the lower Campaspe system (with Victorian environmental entitlements covering the extra losses).

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
The Campaspe River is considered a high priority under the North Central River Health Strategy (RHS) 2005. The Campaspe River downstream of Campaspe Siphon has been identified as a priority due to minimize the risks to the connected high value assets (Murray River), as the lower Campaspe River can significantly influence the health of the Murray River (NCCMA 2009).

Significant species identified at the site are the golden perch (*Macquaria ambigua*: Vic vulnerable), Murray cod (*Maccullochella peellii peellii* ; Commonwealth vulnerable, Vic endangered), silver perch (*Bidyanus bidyanus*: Vic critically endangered) and the trout cod (*Maccullochella macquariensis* Commonwealth endangered; Vic critically endangered), and the brown treecreeper (*Climacteris picumnus:* Vic near threatened). Flora at the site includes the Pale Flax-lily (*Dianella sp. aff. longifolia* (Riverina): Vic vulnerable).

2. Expected ecological outcomes
The aims of the delivery are to avoid loss of threatened species/communities and maintain a drought refuge (NCCMA 2009). The water provided will be used to improve the current condition of the Campase River, which is rated at a category 1 using Victoria's long-term management action targets, up to a level up of a category 4 (refer to NRSWS). These categories are defined in the Northern Region Sustainable Water Strategy (DSE 2009), and are listed below:

- Category 1 – drought refuge only;
- Category 2 – Dry spell breaking only;
- Category 3 – protect priority in-stream species; and
- Category 4 – Protect all in-stream species.

The degree to which this will be achieved is dependent on seasonal conditions, water quality and volume delivered.

3. Potential risks
The main risks associated with the provision of flows in the upper Campaspe will be ensuring that there are no water quality impacts on the key refuge pools until conditions improve. The presence of inter-valley transfers through the lower Campaspe in recent years should help mitigate these issues. Once allocations improve these potential risks should be reduced due to the presence of releases in the system for irrigation which will further improve the base flow conditions for the stream.

The risk assessment completed on the lower Campaspe River as part of the assessment of impacts on the Campaspe River catchment from the Northern Victoria Irrigation Renewal Project. However this is focussed solely on the lower Campaspe and the potential impacts of the removal of channel outfalls through increasing system efficency. As such it is of minor value to assessing risks associate with environmental releases from Lake Eppalock.

Salinity
High salinity groundwater inflows have caused saline pools to form in deeper sections of the lower Campaspe River. Investigations carried out by (SKM 2008) identified the following approximate relationship between the released volume and the extent of mixing of the saline pools:

- flows greater than 25 ML/d are required to get full mixing of stratified pools, although stratification reoccurs within a relatively short period (approximately 10 days)
- flows of 10 ML/day provides a freshwater lens 60cm in depth, but does not mix the stratified pools (based on current groundwater levels).

Further detail can be obtained from the Investigation of Saline Pools in the Lower Campaspe River (SKM 2008). Mitigation against blackwater events will potentially be required (which will hopefully be addressed in the 2010-11 Campaspe Annual Watering Plan when it is completed). These risks will require further investigation as the information becomes available.

4. Long-term sustainability
Currently under Qualification of Rights. The system is currently qualified for critical human use. There have been two qualification of rights invoked by the Minster for Water for the Campaspe (including the Coliban) River system. The first qualification of rights covered the period July 2007 to June 2009. The second and current qualification covers the period July 2009 to June 2011. (NCCMA 2009). The Qualification of Rights will need to be lifted before any flows will be released to ensure Commonwealth environmental water is not substituting for withheld passing flows.

Interim watering plans are currently available (detailed environmental plan awaiting approval from NCCMA) and management plans covering the Campaspe River are the North Central Regional River Health Strategy and the Northern Region Sustainable Water Strategy. Completion of the Northern Victoria Irrigation Renewal Project (NVIRP) within the region will increase flows through improved irrigation infrastructure.

Campaspe River is being monitored under the Victorian Environmental Flow Monitoring Assessment Program and the Sustainable River Audit is also undertaken on this system to determine the Index of Stream condition.

Monitoring is performed by VEFMAP - NCCMA/DSE, SRA – MDBA and ISC – DSE, with results available in the yearly watering report (available approx. June 2011). The proposed monitoring of the water delivery is well aligned with the expected ecological outcomes, with further details on the monitoring available in the Attachment.

5. Cost effectiveness

High. As releases would occur directly from storage the costs associated should be minimal. Monitoring activities are also included as part of pre-exisiting programs.

References

DSE (2004) EVC/Bioregion Benchmark for Vegetation Quality Assessment, Department of Sustainability and Environment, Melbourne.

DSE (2009) *Northern Region Sustainable Water Strategy*, Department of Sustainability and the Environment (Victoria)

NCCMA (2009) *Campaspe River: Interim Environmental Watering Plan*, North Central Catchment Management Authority

SKM (2006) *Campaspe River Environmental Flows Assessment: Flow Recommendations*, Sinclair Knight and Merz, Melbourne.

SKM (2008) *Investigation of Saline Pools in the Lower Campaspe River*, Sinclair Knight Merz, Melbourne.

Cardross Lakes

DEWHA Assessment Summary	CEWH	Other
Site: Cardross Lakes **Floodplain/region:** Murray-Mallee Floodplain **Catchment:** Murray (Vic) **Timing:** Spring 2010	**Volume:** 450 ML **Cost:** $30,690 ($68.20/ML)	**Volume:** 1,000 ML currently (reduced to 550 ML if the CEWH allocates water).

Description of Watering Action and Objective
A proposed volume of 450 ML is to be used to water the Cardross Lakes, identified as a key site in the recovery of the nationally threatened Murray hardyhead. The 450 ML will be used to maintain water levels within the Cardross Lakes, as part of the current action to deliver 1,000 ML of water as part of the Victorian River Murray Flora and Fauna Bulk Entitlement. If the 450 ML is allocated, Victoria will reduce its contribution to 550 ML for the site and redirect their water to other environmental sites.

The objective of the watering is to maintain viable habit for the population of Murray hardy head (*Craterocephalus fluviatilis*).

This volume is also part of a broader three year proposal totalling 1,350 ML. Regardless of allocations this season, the potential for a long term agreement, and the implications of such an agreement, will be investigated further. This will be undertaken in conjunction with a similar proposal for Lake Hawthorn.

Description of site / watering history
The Cardross Lakes are a series of connected lakes 15 kilometres south-west of Mildura. Historically these lakes were used as drainage disposal basins for freshwater outfall from irrigation channels and saline drainage water from the surrounding irrigation district (DSE 2004). Initially, the entire basin (East and West) held excess drainage water and environmental water for this purpose, but the area of inundation has decreased over time due to limited water availability. The site is currently wet as flows of 1,000 ML have been used to water the lakes, to be delivered to Cardross Basin 1 East and spill into the adjoining Cardross Basin 1 West as part of the Victorian River Murray Flora and Fauna Bulk Entitlement. As the Cardross Lakes supported one of only four Murray hardyhead populations remaining in Victoria, environmental water was delivered to sustain the population.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
Site contains the nationally threatened Murray hardyhead (*Craterocephalus fluviatilis:* Commonwealth vulnerable) and the purple-spotted gudgeon (*Mogurnda adspersa:* Vic threatened) (potentially extinct). There are no internationally or nationally recognised wetlands in the region.

2. Expected ecological outcomes
The watering will aim to maintain an area of 140 ha for the Murray hardyhead and be one of four sites in Victoria protecting this species. The Recovery Plan includes a number of potential biodiversity benefits for other species and ecological communities. Principally, this will be through the protection and management of habitat and the allocation of environmental water (Backhouse 2008).

3. Potential risks
No risks have been identified in the submitted watering proposal on the basis of the significant operational experience within Mallee CMA delivering water to the site. Whilst this probably negates many of the risks present, potential risks such as the failure to adequately manage water quality, either reducing the suitability of habitat or allowing potential predators to establish, need to be actively monitored as part of the delivery process. Whilst the likelihood of negetative events occurring is minimal, the potential consequence (loss of a Murray hardyhead population) is significant.

4. Long-term sustainability
Moderate- The proposal submitted for the spring allocations 2010 requested a three year commitment from the Commonwealth on the delivery of 450 ML per annum to protect the Murray-hardyhead. The delivery of the proposed water will bolster the watering actions started in mid July 2010.

A levee bank was constructed in 2007 to split the basin into two pools (East and West), ensuring environmental water could be delivered to a smaller area to preserve the Murray hardyhead population. A five year action plan for the ongoing protection of the Murray hardyhead in Victoria is being developed by DSE in partnership with the Murray-Darling Freshwater Research Centre and in conjunction with the National Murray-hardyhead Recovery Plan. The Recovery Plan will also provide an important public education role as threatened fish have the potential to act as 'flagship' species for highlighting broader nature conservation issues in aquatic habitats, such as habitat degradation, barriers to migration and invasive species (Backhouse2008). Monitoring of the flow event will be undertaken by The Murray Darling Freshwater Research Centre and ARI and will include photo points, volume delivered, periodic fish sampling and water quality sampling. This proposed monitoring of the watering action aligns with the stated ecological objectives. Additional information regarding the monitoring can be found in the monitoring Attachment E.

5. Cost effectiveness
Moderate - The proposal to water the Cardross Lakes allowed for a three year commitment with the delivery requiring temporary pumps. The cost of these pumps is at the more expensive range of pumping prices; however the investment would contribute towards prevention the extinction of the Murray hardyhead.

References
Backhouse, G., Lyon, J. and Cant, B. (2008) National Recovery Plan for the Murray Hardyhead *Craterocephalus fluviatilis*. Department of Sustainability and Environment, Melbourne.

Department of Sustainability and Environment (2004) *Going with the Flow - Case Studies on the Use of an Environmental Water Allocation.* DSE, Melbourne." Published March 2004.

Dookie Campus

DEWHA Assessment Summary	CEWH	Other
Site: Dookie Campus **Floodplain/region:** lower Broken River **Catchment:** Broken (Vic) **Timing:** September 2010	**Volume:** 5 ML (but potentially greater volumes if allocations improve) **Cost:** $0	**Volume:** 5 ML – University of Melbourne.

Description of watering action and objective
This proposal covers the watering of a billabong located on the University of Melbourne's Dookie campus dairy. The land is managed by Dookie College (i.e not Crown land), and a small volume of water (5 ML of CEW from the Broken river and 5 ML either purchased or from the allocations held by the University of Melbourne) is proposed for use as part of a research proposal considering the potential ecological benefits of using of wetlands as off-stream storages. The water would be used to consolidate findings of small-scale pilot studies. The research project is part of the Farms Rivers and Markets Projects (FRM Project).

If allocations substantially increase given recent rainfalls, the potential for delivering the full 10 ML should be kept open as it will maximise usage of Broken entitlements that cannot be traded out of the catchment, and allow entitlements held by the University of Melbourne to be used for other activities.

Description of site / watering history
The current drought has resulted in most of the wetlands in the Broken River remaining dry for extended periods. Environmental watering of Reedy Swamp on the nearby Goulbourn River floodplain in recent years has successfully provided a drought refuge for local wetland flora and fauna, including several waterbird species listed as 'vulnerable'. Similar refuges are needed on the Lower Broken River to maintain and rehabilitate representative wetlands and wetland species. The wetland is categorised as a "deep freshwater marsh" and as such the GBCMA (2002) suggested these wetlands should be among those given the highest priority for management action given they have suffered the most decline since European settlement.

The combination of river regulation and drought has meant that wetlands in the Goulbourn-Broken catchment are flooded far less frequently than under natural conditions. If such conditions are prolonged, wetlands may move beyond the threshold for recovery, since 'egg banks' and 'seed banks' in the soil may be irreversibly damaged. Several studies have shown that wetland seed banks decline in diversity after a number of years (Leck and Brock 2000; Brock *et al.* 2003).

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
Only one significant flora species has been confirmed at the study site *Cynodon dactylon* var. *pulchellus* (Native Couch) – insufficiently known (DSE 2005).

Several other significant flora species occur in lower Broken River wetlands and these may germinate during the watering event: short-awned wheat-grass (Elymus multiflorus: Vic insufficiently known), sand rush (Juncus psammophilus: Vic rare); wetland blown-grass (Lachnagrostis filiformis var. 2: Victoria insufficiently known) (DSE 2005).

2. Expected ecological outcomes
<u>Sustain significant plant species in the region</u>
Promote aquatic plant diversity in wetlands which have not received water for up to a decade. The proposed watering action is likely to ensure aquatic diversity within the wetland is maintained by allowing replenishment of the soil seed and egg bank. Studies have shown that reproduction of plant species can occur within 16 weeks of inundation (Warwick and Brock 2003).

<u>To study the ecological impact of inundating a billabong and then extracting the water</u>.
This watering proposal is part of a research project that will attempt to assess the potential environmental benefits of using wetlands as temporary off-river storages in the Broken River catchment. In order to do this, the impact of inundating a billabong and then extracting the water will be investigated.

3. Potential risks
Use of pumps may be associated with fish death, although this risk is considered to be minimal. Risks of salinity, acidification or blackwater are considered to be insignificant.

The management scenarios to be tested on the wetland will be informed by small-scale mesocosm pilot experiments that are being undertaken by the MDFRC. Lessons from these experiments will help lessen risks.

4. Long-term sustainability
LOW. This is a one-off investigation, and requires only a single allocation of water. If the results are positive, the study may have a broader and more enduring impact on the management of wetlands on farms. The site is owned and managed by the University of Melbourne.

It is expected that minimal water will remain following the experiment due to seepage and evaporation over the warmer months. However, water which is pumped out of the wetland as part of the experiment will be pumped to either a) a nearby billabong where it will provide similar environmental benefits or b) the river channel, given risks of salinity, acidification or blackwater are considered to be insignificant (this option will depend on approval from GBCMA as the statutory river health manager).

The Goulburn-Broken Priority Action Plan covers this site within the management plan.
All monitoring will be completed by the University of Melbourne project management. Parameters monitored will include: macrophyte community dynamics; flowering and seed production; macroinvertebrate community dynamics, egg production and egg bank dynamics; and water quality parameters, including nutrients. Monitoring will take place regularly for at least 16 weeks following the watering event. Reporting of the outcomes of the watering event will form part of the reporting required by the University of Melbourne for the “Farms, Rivers, Markets” project. Scientific publications are also expected to be produced following the release.

5. Cost effectiveness
High - All complementary works are to be completed by the project team, and involves pumping water, dividing the billabong into experimental units and monitoring. Dookie College have a Water Use License to which allocations can be transferred. While the environmental benefits may be relatively modest, the potential utility of the knowledge generated is great. The value of the water represents a small component of the overall cost of the research project. The Farms, Rivers & Markets project is worth $8m while the Rivers component of the project is valued at $1.5m.

References

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GBCMA (2002) Wetlands Directions Paper for the Goulbourn Broken Catchment. Goulburn Broken Catchment Management Authority, Shepparton.

GBCMA (2005) Regional River Health Strategy 2005-2015. Goulburn Broken Catchment Management Authority, Shepparton.

Leck, M. A., and Brock, M. A. (2000) Ecological and evolutionary trends in wetlands: Evidence from seeds and seed banks in New South Wales, Australia and New Jersey, USA. *Plant Species Biology* **15**, 97-112.

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Goulburn Broken Wetlands

DEWHA Assessment Summary	CEWH	Other
Site: Doctor's and Kinnards Swamps **Floodplain/region:** Goulburn River floodplain and Borken Creek floodplain respectively **Catchment:** Goulburn and Broken (Vic) **Timing:** Through out 2010-11	**Volume:** 1,700 ML **Cost:** $59,500 ($35/ML)	**Volume:** 0 ML

Description of Watering Action and Objective

Doctors Swamp and Kinnairds Swamp are proposed to be watered within the Goulburn-Broken CMA wetlands. A volume of 1,000 ML is required for the Doctors Swamp and 700 ML required for the Kinnairds Swamp, to be delivered throughout 2010-2011.

Watering these wetlands would create a good spatial covering of drought refuges throughout the Goulburn Broken area for waterbirds. It is also expected that there would be significant aquatic vegetation response based on previous water events in the region (Cook et. al 2009)

Description of site / watering history

The catchment crosses eight bioregions (mapping units for biodiversity planning) including the Victorian Riverina, Goldfields, Murray Fans, Northern Inland Slopes, Highlands – Northern Fall, Highlands – Southern Fall, Central Victorian Uplands and Victorian Alps. The two proposed water sites are currently reported as drying. Kinnairds Swamp was watered in 2007-08 by Victoria (413 ML), and 400 ML was released into Kinnairds Swamp in 2009-10. A minor flow of 40 ML was released into Doctors Swamp (October 2009), as a trial to test the efficiency and location of the primary flow path into the wetland and exhibit the relationship of this flow with the adjoining overflow sill.

Comments against criteria for assessing 2010-11 environmental watering actions

1. Ecological Significance

The *Victorian Catchment Condition Report* (VCMC 2007) rated the Goulburn Broken Catchment's biodiversity as variable, from poor to good condition. The GBCMA (2009) rated the condition of biodiversity as poor in 2009.

Doctors Swamp – Classified by Victoria as a bio-regionally significant wetland. The wetland provides significant drought refuge. The wetland has supported large numbers of waterbirds including the threatened eastern great egret (*Ardea modesta:* Vic vulnerable), blue billed duck (*Oxyura australis:* Vic endangered) and brolga (*Grus rubicunda* Vic vulnerable) (DSE proposal 2009).

Spatial data lists a range of nationally listed species including Latham's snipe (*Gallinago hardwickii:* EPBCA migratory); white-bellied sea eagle (*Haliaeetus leucogaster*: EPBC migratory); Australian painted snipe (*Rostratula australis:* Commonwealth vulnerable); cattle egret (*Ardea ibis:* EPBCA migratory); great egret (EPBCA migratory); the southern bell frog (*Litoria raniformis:* Commonwealth vulnerable); and the Macquarie perch (*Macquaria australasica:* Commonwealth endangered).

Kinnairds Swamp - Classified by Victoria as a bio-regionally significant. The wetland provides significant drought refuge. In addition, the wetland supports relatively high densities of the EPBC Act (1999) vulnerable species.

During previous watering events in 2008 a total of 64 birds, 35 of which were wetland species were observed (Cook et. al. 2009). Spatial data lists a range of nationally listed species including Latham's Snipe (*Gallinago hardwickii:* EPBCA Migratory); regent honeyeater (*Xanthomyza Phrygia*: EPBCA endangered) superb parrot (*Polytelis swainsonii:* Commonwealth vulnerable); white-bellied sea eagle (*Haliaeetus leucogaster;* EPBCA migratory; Vic vulnerable); Australian painted snipe (*Rostratula australis;* Commonwealth vulnerable); cattle egret (*Ardea ibis;* EPBCA migratory); great egret (*Ardea alba:* EPBCA migratory); southern bell frog (*Litoria raniformis:* Commonwealth vulnerable); river swamp wallaby grass (Commonwealth vulnerable), Macquarie perch (*Macquaria australasica;* Commonwealth endangered) and the rigid water-milfoil (Commonwealth vulnerable).

2. Expected ecological outcomes

The watering is expected to improve the geographic spread of drought refuges for waterbirds across the bioregion, which should provide for a more resilient population base for recovery. The creation of this refuge is supported by the monitoring undertaken during 2008 on the outcomes of environmental water delivery in the Goulburn-Broken region (Cook *et al.* 2009).

3. Potential risks
Minimal risk identified with watering wetlands. Kinnairds Swamp was watered in 2007-08 by Victoria, with no issues emerging (Cook *et al.* 2009). A risk assessment plan exists for the sites; completed during previous watering events.

The assessment of minimal risks is informed by the following comments during discussions with DSE on this and similar watering events proposed.

- Significant experience with delivery to these, or similar sites, provides a high level of knowledge with regard to the delivery process;
- The objectives of the watering (waterbirds and aquatic vegetation) reduce the potential impact of events such as black water to negligible levels (as it will not endanger achievement of the objective);
- Broader negative consequences from black water events are also not a risk as sites are isolated and do not return water to the supply systems; and
- The likelihood of colonial water bird breeding is remote due to the lack of broader food sources. As such these events are aimed at providing refuge/foraging habitat only.

Whilst generally this assessment is reasonable, it does not allow for potential issues such as capacity constraints within the irrigation system (Doctor's Swamp). Instead it is focussed solely on ecological risks. A more detailed risk assessment has been proposed as part of the development of detailed watering plans for priority sites across northern Victoria.

Saline water and high water tables have historically been a concern for the region, however they are now deemed to be less threatening because of reduced rainfall. However, a swing back to higher rainfall, while unlikely, is possible and salinity could again pose a major threat to biodiversity, especially in the context of other multiple threats for future events (GBCMA 2010).

4. Long-term sustainability
Sites selected have the ability to have water provided to them now and into the future. Kinnairds Swamp has an EMP in place (DPI 2003), and the broader system is covered by the Goulburn-Broken River Health Strategy (GBCMA 2005).

An integrated monitoring program targeting basic compliance (water levels and delivery) and bird response (if required) will be carried out by Goulburn-Broken CMA. Vegetative response to water at wetlands demonstrated in Cook *et al.* (2009).

The GBCMA are prepared to monitor water levels and delivery. Additional monitoring such as waterbird monitoring will be undertaken if requested and paid for by CEWH. Waterbird monitoring would be undertaken using Birds Australia methodology (the same as The Living Murray uses for its intervention monitoring). The monitoring of the event, similar to that performed during the 2008 watering, aligns well with the intended ecological objectives. Further information regarding monitoring of the watering may be found in the Attachment E.

5. Cost effectiveness
Cost effective, delivery via irrigation channels. Costs associated with the delivery are approximately half of the casual use fees, with delivery constraints possible for Doctor's Swamp as channel needs to be at full supply. Additional costs which may be incurred by the Commonwealth are to cover any additional requested monitoring (such as waterbirds and aquatic vegetation).

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Goulburn River Reach

DEWHA Assessment Summary	CEWH	Other
Site: Goulburn River (below Goulburn Weir) **Floodplain/region:** lower Goulburn River **Catchment:** Goulburn (Vic) **Timing:** Spring 2010	**Volume:** 60,000 ML **Cost:** **t**o be confirmed $270,000 on the basis of a per megalitre estimated cost of $4,50/ML.	**Volume:** Standard River operations and potential passing flows (dependant on resource condition)

Description of watering action and objective
This watering proposal covers the delivery of 60,000 ML to the lower Goulburn River (Goulburn Weir to River Murray) in spring 2010. The Goulburn River is currently under Qualification of Rights, which will need to be lifted prior to any proposed watering. The proposed watering action is intended to improve the instream environment for the large number of listed and endangered species identified within the Goulburn River.

The type of flow event this volume could contribute to is a spring fresh, potentially in the order of 18,000 ML/day. This would include provision for rates of rise and fall.

The objective of the action is to assist in improving the condition of the Campaspe system from Category 1 to Category 4 as per the Northern Region Sustainable Water Strategy (see expected ecological outcomes for more information).

Description of site / watering history
The Goulburn River starts on the northern slopes of the Great Dividing Range and flows in a generally northerly direction until it joins the Murray River at Echuca. The Sustainable Rivers Audit (SRA 2004-07) assessed the Goulburn Valley river ecosystem to be in Very Poor Health. Fish were in extremely poor condition, and were the equal lowest score in the SRA study. The Goulburn Valley macroinvertebrate community was in poor condition, with sites in the slopes and upland zones lacking disturbance sensitive species. The Goulburn Valley was also assessed to be in Poor hydrological condition. Consequently, there is scope for the use of environmental water to improve the ecological health of the valley.

There are two major water regulation structures within the catchment: Lake Eildon (3,040 GL) which supports the majority of the Shepparton, Central Goulburn, Rochester and Pyramid/Boort irrigation areas (some volumes are also contributed by the Loddon and Campaspe Rivers); and Goulburn Reservoir (25,500 ML), impounded by Goulburn Weir which is used to transfer water to the Loddon or Campaspe valleys via the Waranga Basin (432,000 ML) (CRC 2003). The proposed watering action is to release 60,000 ML from the Goulburn Weir. The lower Goulburn River has not received environmental water to date. Flows through the system are a culmination of passing flows, excess flows from tributaries and transfers to the Murray system.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
The primary asset within the catchment is the Lower Goulburn Floodplain (DIWA listed) and its associated wetlands. The Floodplain is regarded as a having a high ecological value, containing major areas of natural ecosystem within a large, intensively cleared irrigation and grazing region. Within the floodplain, there are a variety of permanent and temporary wetlands which provide extensive habitat for waterbirds and fish. The system also forms an important breeding area for waterbirds, including many colonial nesting species.

The Goulburn River (from Lake Eildon to the Murray River) has also been listed as a heritage river under Victorian heritage river legislation. Numerous conservation, wildlife and streamside reserves line the banks of the river.

Significant bird species: Regent honeyeater (*Anthochaera Phrygia*: Commonwealth endangered; Vic critically endangered); swift parrot (*Lathamus discolour*: Commonwealth endangered; Victoria endangered); regent parrot *(Polytelis anthopeplus monarchoides:* Commonwealth vulnerable; Vic vulnerable); superb parrot (*Polytelis swainsonii;* Commonwealth vulnerable; Vic endangered); barking owl *(Ninox connivens connivens:* Vic endangered*);* Australian painted snipe (*Rostratula australis:* Commonwealth vulnerable; EPBC migratory; Vic critically endangered*);* blue-billed duck (*Oxyura australis;* Vic endangered*)*; freckled duck *(Stictonetta naevosa*; Vic endangered*)* and intermediate egret *(Ardea intermedia*; Vic critically endangered).

Amphibians: Southern bell frog (*Litoria raniformis;* Commonwealth vulnerable; Vic endangered)

Fish: Murray cod (*Maccullochella peelii peelii*: Commonwealth vulnerable; Vic endangered) and the Macquarie perch (*Macquaria australasica:* Commonwealth endangered; Vic endangered); Murray hardyhead (*Craterocephalus fluviatilis*: Commonwealth vulnerable; Vic critically endangered); trout cod (*Maccullochella macquariensis*:

Commonwealth endangered; Vic critically endangered); freshwater catfish (*Tandanus tandanus*: Vic endangered); flathead galaxias (*Galaxias rostratus*: Vic vulnerable), barred galaxias (*Galaxias fuscus*: Commonwealth endangered; Victoria critically endangered); silver perch (*Bidyanus bidyanus*: Victoria critically endangered) and Murray spiny crayfish (*Euastacus armatus*: Victoria near threatened).

Plants: Clover glycine (purple clover) (*Glycine latrobeana*: Commonwealth vulnerable; Victori vulnerable); river swamp wallaby-grass (*Amphibromus fluitans*: Commonwealth vulnerable); western water-starwort (*Callitriche cyclocarpa:* Commonwealth vulnerable; Vic vulnerable); ridged water-milfoil (*Myriophyllum porcatum:* Commonwealth vulnerable; Vic vulnerable).

EPBC Migratory birds: Great egret (*Ardea alba*: Vic vulnerable) ; cattle egret (*Ardea ibis*); fork-tailed swift (*Apus pacificus*); white-bellied sea-eagle (Haliaeetus leucogaster; Vic vulnerable); white-throated needletail (*Hirundapus caudacutus);* rainbow bee-eater (*Merops ornatus*); satin flycatcher (*Myiagra cyanoleuca);* and the rufous fantail (*Rhipidura rufifrons*).

Mammals and invertebrates: konoom, smoky mouse (*Pseudomys fumeus*; Commonwealth endangered; Vic critically endangered); grey-headed flying-fox (*Pteropus poliocephalus*; Commonwealth vulnerable; Vic vulnerable); striped legless lizard (*Delma impar*; Commonwealth vulnerable; Vic endangered); carpet python *(Morelia spilota;* Vic endangered) and the golden sun moth (*Synemon plana*; Commonwealth critically endangered; Vic critically endangered).

2. Expected ecological outcomes

The water provided will be used to improve the current condition of the lower Goulburn River which is rated at a category 1 using Victoria's long-term management action targets up to a level up of a category 4, thereby protecting all instream species. These categories are defined in the Northern Region Sustainable Water Strategy (DSE 2009), and are listed below:

- Category 1 – drought refuge only;
- Category 2 – dry spell breaking only;
- Category 3 – protect priority in-stream species; and
- Category 4 – Protect all in-stream species.

The degree to which this will be achieved is dependent on seasonal conditions.

3. Potential risks

The Goulburn-Broken CMA is yet to release this document due to issues they are investigating further (in particular, the understanding of the focus of these issues is around potential legal liabilities).

A risk assessment has been prepared previously, and is part of the Environmental Watering Plan (CRC 2003), which provides detailed flow recommendations. In summary, the Scientific Panel considered the following flow-related perceived risks and their mitigation as the basis for developing environmental flow recommendations for the Goulburn River (noting that only risks for the Goulburn River below Goulburn Weir are listed. This is defined as reaches 4 and 5):

1. Reduced frequency or duration of out-of-channel (flood) flows that inundate the floodplain and fill wetlands (Reaches 1-4);
2. Reduced duration of freshes that can serve as life-cycle cues for fish and invertebrates, provide a range of conditions for in-channel and littoral (bank-side) vegetation, mobilise fine particulate material that can smother submerged macrophytes and invertebrate habitat, and help maintain good water quality (Reaches 4 and 5);
3. Reduced duration of flows that inundate river benches, potentially reduced availability of deep water habitat that helps to support native fish populations (Reaches 4 and 5);
4. Lows flows (depth less than 0.2m) that prohibit the movement of native fish along the river (all reaches); and
5. Low summer-autumn flows that could potentially contribute to water stratification and a decline in water quality (Reach 4 and 5);

Potential ecological risks:

1. Increased connection between sections of the river and its floodplain may increase the ease with which carp may spread across the study area and can provide conditions suitable for carp breeding (Brown *et al*. 2003; Koehn *et al*. 2000; Stewart and Jones 2002); and
2. Floodplain and wetland inundation may increase the rates of localised bank erosion where the riparian zone is in poor condition or where desnagging has left the bank unprotected.

Potential socio-economic risks:

1. Reduced volumes of water available, and reduced security of supply for irrigators and other users if water is released for environmental purposes such as annual floods, bench inundation, or minimum flows to provide deep water habitat for fish;
2. Restrictions placed on irrigators and water users if upper limits on summer-autumn releases are applied. The water would be in storage, and of a higher security, but cannot be transferred to water users at the time required due to the release limits applied;
3. Increased flooding frequency and duration and therefore risk to private land and infrastructure; and
4. Reduced recreational opportunities if upper limits on summer-autumn releases are applied

Transmission losses when implementing environmental flow components is likely to be relatively low. Losses will be more significant when over-bank flooding occur. The Northern Sustainable Water Strategy outlines a plan to implement a policy which would enable the reuse or trade of return flows. This would significantly increase the environmental outcome that can be achieved with a set volume of water.

4. Long-term sustainability

The Goulburn-Broken CMA is responsible for on-ground delivery of water to specific sites and the delivery of monitoring activities undertaken in conjunction with watering events and ensuring working relationships with regional partners such as Parks Victoria (land manager for many of the key assets). In 2005 the Goulburn-Broken Catchment Management Authority released the Goulbourn Broken Regional River Health Strategy. The strategy fits within the broader state vision for water management and acts as a framework to integrate actions for the protection and restoration of priority river reaches. Key river health objectives, including those for improving flow regimes are outlined in the Victorian Government’s action plan for water, Our Water Our Future 2004 and the Victorian River Health Strategy 2002. Responsibility for implementing these objectives in this region is with Goulburn-Broken CMA.

The Victorian Government has established the Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP) framework which is a guide for monitoring programs in regulated rivers in Victoria, and is designed to assess the success of environmental flows against the desired ecological objectives. A monitoring program, based on VEFMAP, has been designed in order to assess implementation of the recommended flows in the Goulburn River. The monitoring program specifies what should be monitored and where this should occur along the Goulburn River below the Goulburn Weir. This region was selected for the program as it was considered to have high ecological value and be most likely to respond to environmental flow releases. The upstream reach between Goulburn Weir and Eildon Reservoir was deemed a lesser priority for the program as the region will continue to be used primarily for irrigation flows.

5. Cost effectiveness

Costs associated with the delivery of flows, and the Commonwealth liability of the costs, are yet to be determined, however they are estimated to be minor. The proposed watering would occur via release from the Goulburn weir.

References

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Kerang Wetlands complex

DEWHA Assessment Summary	CEWH	Other
Site: Kerang District and Surrounding Wetlands **Floodplain/region:** lower Loddon floodplain/Kerang plains **Catchment:** Loddon (Vic) **Timing:** Spring 2010	**Volume:** 9,400 ML **Cost:** $239,700 ($25.50/ML)	**Volume:** potential for Victoria to contribute to the broader proposal (see discussion)

Description of watering action and objective

Five wetland sites within the Kerang District were proposed for watering, and the two priority sites identified for flows are the Hird and Johnson Swamp. The volumes to be delivered to the Hird and Johnson Swamp are 5,400 ML and 4,000 ML respectively, to be delivered in spring 2010. Both sites are RAMSAR listed and particularly ecologically significant due to the large number of waterbirds and migratory birds the sites support. Inundation of the terminal Johnson swamp is recommended to open water and mudflat habitat (feeding and roosting) for waterbirds.

The objectives of the watering actions proposed are to create important drought refuges in the Kerang wetland system and begin to reintroduce a natural wetting and drying cycle to sites.

N.B. The proposal also included Lake Elizabeth (bioregionally significant), Lake Cullen and McDonald Swamp, with an estimated additional required volume of 3,000 ML, 13,000 ML and 900 ML respectively. (Pumping charges to deliver to the five proposed sites are quoted at $670,560, and thus must be adjusted to account for the non-watering of these sites.) The values of these sites are generally consistent with those of Hird and Johnson Swamps.

Description of site / watering history

The two sites proposed for watering in the Kerang Wetlands are currently dry.
A management plan was drafted in 1990 for Hird and Johnson Swamps (DCNR 1990), where it was determined that complete drying of each swamp for one year in four, with the swamps not to be dry in the same years, would be the best management approach.

Johnson Swamp is classified as a deep freshwater marsh (NCCMA 2009) and is located within the Pyramid Creek sub-catchment in the Victorian Riverina and Murray Fans (eastern edge) bioregions. Currently the wetland is dry. Johnson Swamp is a terminal system with no outflows. The majority of water is lost through evaporation. The EWP commissioned by the NCCMA recommends filling of the wetland to capacity every one in five years, with top volumes provided the following year to maintain the open water assemblage inundation (to at least 30cm for an additional 6 months), and then allowed to dry the year following (NCCMA 2009). Johnson Swamp has historically received (prior to 1998) significant outfalls from the 4/7/2 channel system from rainfall rejection events occurring after heavy rains, and surplus flows. Since the 1990s due to system upgrades and increased efficiencies, outfall water to Johnson Swamp has been reduced (NCCMA 2009). Over the past decade, Johnson Swamp has experienced more frequent drying phases due to the drought, increased efficiencies in the irrigation system and the lack of environmental water (NCCMA 2009). Part of the Murray Flora and Fauna Bulk Entitlement (27,600 ML) has frequently been provided for Johnson Swamp to provide a drought refuge for waterbirds (DSE 2006). The natural flooding of Johnson Swamp from Pyramid Creek is prevented by levees and the dredging of the creek (NCCMA 2009). The wetland is not actively managed for the distribution or storage of floodwater.

Comments against criteria for assessing 2010-11 environmental watering actions

1. Ecological Significance

Hird Swamp (deep freshwater marsh) – Ramsar and DIWA site. 37 waterbird species recorded (DIWA). The site intermittently has supported large populations of waterbirds, and has been a regionally important breeding site for several threatened waterbird species (DIWA). The swamp is currently the only wetland in which the painted snipe (*Rostratula australis:* Commonwealth vulnerable; EPBCA migratory) has been found in successive Victorian bird surveys (DSE Watering Proposal, December 2009). The wetland has also been a large ibis-breeding colony, supporting tens of thousands of pairs, hence is recognised as an important breeding site for straw-necked ibis and the sacred ibis (DSE 2004). Freckled ducks (*Stictonetta naevosa;* FFG listed; Vic endangered), blue-billed ducks (*Oxyura australis;* Vic endangered), hardhead (*Aythya australis:* Vic vulnerable) and royal spoonbills (*Platalea regia;* Vic vulnerable) have also been recorded at this site (DSE 2004). The swamp supports a large community of tangled lignum shrub land which is thought to be under-represented in Victorian wetlands reserves and with several other plants form an unusual vegetation assemblage (DSE 2004).

Johnson Swamp (deep freshwater marsh) - RAMSAR and DIWA site. It is a wetland of international and national significance being part of the Kerang Wetlands Ramsar site and listed in the Directory of Important Wetlands in

Australia. Johnson Swamp is a State Wildlife Reserve under the *Crown Land (Reserves) Act 1978* and is managed by Parks Victoria under the *Wildlife Act 1975*. Johnson Swamp is known to support a number of species listed under the *EPBC Act.* The site has the potential to support a high diversity of invertebrates, waterbirds and flora, and is recognised as having a high conservation value, particularly as the Lignum/Black Box wetland has the capacity to support a high diversity and abundance of waterbird species and provides an important drought refuge during its wetting cycle (NCCMA 2009). The conservation significance of Johnson Swamp is primarily due to its high carrying capacity, species diversity and level of breeding of waterbirds, regularly supporting large numbers of waterfowl, Black Duck and White Ibis (Lugg et. al. 1989), making the wetland internationally significant (DSE 2006). Bird species recorded at Johnson include the Australian painted snipe (*Rostratula australis:* Commonwealth vulnerable; EPBCA migratory*)* and the Australasian bittern (*Botaurus poiciloptilus:* Vica endangered) (NCCMA 2009). Other species include: eastern great egret (*Ardea modesta*: EPBCA migratory), freckled duck (*Stictonetta naevosa*; FFG Listed, Vic endangered), great egret (*Ardea alba*: EPBCA migratory; Vic vulnerable), intermediate egret (*Ardea intermedia*), musk duck (*Biziura lobata*; Victoria vulnerable), hardhead (*Aythya australis;* Victoria vulnerable), royal spoonbill (*Platalea regia;* Victoria vulnerable), brolga (*Grus rubicunda;* Victoria vulnerable*)* and the white-bellied sea-eagle (*Haliaeetus leucogaster*: Commonwealth migratory).

The southern bell frog (*Litoria raniformis:* Commonwealth vulnerable; Victoria endangered) has also been recorded at Johnson Swamp. Six significant flora species have been recorded at Johnson Swamp including cane grass (Vic vulnerable) and the Drooping, Rough and Thin-leafed Wattles (Commonwealth protected).

2. Expected ecological outcomes

Provide drought refuge for waterbirds and migratory species. Watering any of these wetlands would increase the habitat available for water bird species and also improve the condition of the vegetation of the wetland ensuring further decline does not occur. Low groundwater and salinity levels assessed in 2009 (NCCMA 2009) suggest a low risk of salinisation by rising groundwater levels. The wetlands are acknowledged to contribute to watertable levels, periodic environmental watering will have a temporary impact on local watertable, with the potential to move salt from the lake without significant risk to adjacent areas (NCCMA 2009). Maintaining a dry (or predominantly dry) wetland may lead to the accumulation of salt within the system, potentially impacting plant species composition/health. The proposed watering actions are anticipated to dilute any saline water quality issues.

3. Potential risks

Low risks associated with delivery – all sites have received environmental water previously with no negative impacts. Further risk assessments to be undertaken before water commences. A management plan exists for this site.

Specific comments with Victoria clarified that the assessment of no material risks associated with delivery of water as part of this action was due to the following factors:

- Significant experience with delivery to these, or similar sites, provides a high level of knowledge with regard to the delivery process;
- The objectives of the watering (waterbirds and aquatic vegetation) reduce the potential impact of events such as black water to negligible levels (as it will not endanger achievement of the objective);
- Broader negative consequences from black water events are also not a risk as sites are isolated and do not return water to the supply systems; and
- The likelihood of colonial water bird breeding is remote due to the lack of broader food sources. As such these events are aimed at providing refuge/foraging habitat only.
- For the larger sites delivery rates also mean that if any breeding does occur, it is likely to commence during the process of filling, extending the duration of suitable habitat (across both the filling and recession phases of the wetland)

Whilst generally this assessment is reasonable, it does not allow for potential issues such as capacity constraints within the irrigation system, or other operational issues. Instead it is focussed solely on ecological risks.

Both Hird and Johnson Swamps are also potentially subject to duck hunting, posing a risk to the achievement of the objectives. Discussions with Victoria identified the following criteria used to assess the closeure of wetlands. This assessment is informed by detailed waterbird surveys at the site. The key criteria in relation to our watering events are as follows:

- If the wetland is needed as a refuge site for game ducks and other wildlife because it is in an area of restricted habitat due to drought;
- If there is evidence of waterbird breeding; and
- To protect significant numbers of rare or threatened species.

These criteria should assist in protecting waterbirds at these wetlands if they are particularly significant (especially during drought). However they mat provide little to no protection for common species.

A more detailed risk assessment has been proposed as part of the development of detailed watering plans for priority sites across northern Victoria.

Other risks identified during the assessment include:

- Johnson Swamp requires monitoring to ensure the inundation period of Lignum/Black Box areas does not exceed two to three months (NCCMA 2009). Monitoring of water levels and the period of inundation will be performed by the NCCMA as part of the operational monitoring at the site; and
- Low risk assessed for salinity by rising groundwater, although monitoring may be required.

4. Long-term sustainability

Hird Swamp and Johnson Swamp are part of the Kerang Ramsar site and as such are subject to the Ramsar Strategic Management Plan. Separate operational plans have been prepared for both (DSE 2004; DEWHA 2008), and the sites are managed by Parks Victoria. Water can be delivered to both wetlands via irrigation outfalls. Other sources of water for this proposal are not yet determined.

Works to upgrade the outfalls servicing Johnson Swamp are due to be completed in Winter 2010 to improve water transferral from Pyramid creek. Following the recommendations in the EWP, additional top up water will be required next year to maintain the open water assemblage inundation (to at least 30cm for an additional 6 months). Monitoring of the watering event will be undertaken by the catchment management, whom are prepared to monitor water levels and the delivery of the water. Other monitoring arrangements can be performed if requested and paid for by the CEWH. Additional information regarding the adequacy of the monitoring at this site is included in the monitoring Attachment E.

5. Cost effectiveness

High cost-effectiveness. Hird Swamp can be gravity fed from irrigation channels at low cost. The sites are under the overall management of North-Central CMA and the operational management of Parks Victoria. The Johnson Swamp outfall structure has a delivery capacity of 70 ML/day which equates to a minimum of 20 days to fill the wetland from dry (NCCMA 2009). The automation works on the 4/7/2 channel are planned to be undertaken in the winter of 2010.

References

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Lake Hawthorn

DEWHA Assessment Summary	CEWH	Other
Site: Lake Hawthorne **Floodplain/region:** Mallee floodplain **Catchment:** Murray below choke (Vic) **Timing:** Spring 2010 and winter 2011	**Volume:** 6,400 ML **Cost:** $428,571 (~$71.50/ML)	**Volume:** 0 ML

Description of Watering Action and Objective
A proposed volume of 6,000 ML is to be delivered to Lake Hawthorne in spring 2010 (4,000 ML) and winter 2011 (2,000 ML). The objective of the watering is to re-establish a habitat for the nationally endangered Murray hardyhead. Water to fill the Lake would be from temporary pumps from the Murray River, additional water to maintain levels provided through Lower Murray Water infrastructure.

The volume is also part of a broader proposal for a five year long-term agreement to support the site (totalling 14,000 ML and $1,000,000). This potential long term arrangement is something that should be investigated in conjunction with a similar proposal for Cardross Lakes.

Description of site / watering history
The Lake was previously a natural floodplain deflation basin lake that has been managed as an irrigation drainage basin since 1968. The Lake was originally freshwater but is now brackish to saline because of its use as an irrigation drainage basin, the influx of saline groundwater, and infrequent flushing from Murray River flood flows. Levee banks and flow regulating structures now separate the Lake from the Murray River except at times of very high flow in the river (MCMA 2007). The lake is currently dry.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
Lake Hawthorne previously contained the nationally threatened Murray hardyhead (*Craterocephalus fluviatilis;* Commonwealth vulnerable; Vic critically endangered), which are currently in a captive breeding program. The site has been identified as a possible translocation site.

2. Expected ecological outcomes
The watering will aim to restore an area of 200 ha habitat for the Murray hardyhead and be an additional site in Victoria for protecting this species. Once conditions are appropriate, the captive Murray hardyhead breeding programme, which includes individuals taken previously from this site, could be released back into the site.

3. Potential risks
No potential risks have been identified during the preparation of the proposal. Whilst there is likely to be low levels of risk present, well understood management options being in place make this assessment reasonable.

The key risk would be the success, or otherwise of this event would be the reintroduction of the Murray hardyhead. If this was not successful it would be unlikely that the site would be supported for other values, and the objective of the action would fail. The proposed management arrangements for for reintroduction require more detail to ensure that the certainity of success is high before the site is refilled.

4. Long-term sustainability
The proposal submitted for the spring 2010 allocations requested the Commonwealth make a five year commitment to watering the site, requesting a total of 14,000 ML to be delivered through the next five years. Without agreement to the longer term commitments the sustainability of the site would be questionable. If this agreement was in place it would provide greater certainty for the decision to reintroduce the fish to the site.

Long term agreements would also address the key threat to the species survival, lack of water for key habitat as a result of the recent drought (as defined in Backhouse *et al.* 2008).

The Murray Darling Freshwater Research Centre will undertake the monitoring of water levels and water quality and fish sampling would be undertaken by MDFC and ARI using standard fish sampling techniques. The proposed monitoring of this watering action is in alignment with the watering objectives stated above. Additional information on the monitoring can be found in Attachment E.

The management of Murray hardyhead is also informed by the national Murray hardyhead recovery plan (Backhouse *et al.* 2008).

5. Cost effectiveness

Water to fill the Lake would be from temporary pumps from the Murray River, additional water to maintain levels provided through Lower Murray Water infrastructure.

References

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Lake Wallawalla

DEWHA Assessment Summary	CEWH	Other
Site: Lake Wallawalla **Floodplain/region:** Lindsay-Wallpolla floodplain (Vic) **Catchment:** Murray below choke (Vic) **Timing:** Spring 2010 and autumn 2011	**Volume:** 5,000 ML spring (with a further potential 5,000 ML in autumn) **Cost:** Spring - $165,000 ($33 /ML)	**Volume:** 0 ML – option has also been proposed to TLM

Description of Watering Action and Objective
Two top-up volumes of 5,000 ML each are proposed to be released into Lake Wallawalla (part of the Living Murray Icon Site Chowilla-Lindsay-Wallpolla), to occur in both spring and autumn (total 10,000 ML). Currently it is proposed that only the spring volume be considered, with the autumn volume to be considered once initial outcomes of the 2010 watering are known.

The objective under this proposal is to provide additional water to Lake Wallawalla, to increase the duration of wetland habitat in the area following initial seepage and evaporative losses from water previously allocated, This should consolidate the benefits expected from the delivery of 12,000 ML of Commonwealth environmental water currently under way. This will ensure drought refuge provided for waterbirds, turtles and frogs continues to be present over summer, and extend the duration of access to water by the river red gums.

The timing of the delivery of 5,000 ML during spring will be dependant on the completion of the current deliveries. This may result in a smaller volume being required.

Description of site / watering history
A 12,000 ML allocation to Lake Wallawalla in 2009-10 was the first watering at the site since 2000, prior to which the site was dry. The repeat, or top-up volumes, are intended to aid in the re-establishment of the fringing vegetation (currently in poor condition), lakebed vegetation and wetland habitat restoration.

The decline in river red gum communities along the Murray floodplain is ongoing, with 72% in a stressed condition in 2009 (Cunningham *et al.* 2009). TLM icon sites in the Mallee are in worse condition than those further upstream. The only areas where stand condition have increased are those where environmental watering has occurred. Lake Wallwalla has remained dry since 2000 - water is currently being pumped into the lake for the first time (12,000 ML allocated in 2009-10). Fringing vegetation is in poor condition and is expected to improve with repeat watering. This will also allow the establishment of wetland vegetation within the lakebed and maintain a large area of wetland habitat as drought refuge for waterbirds, frogs and turtles (DSE 2010).

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
Living Murray Icon Site. Lake Wallawalla attracts regionally significant numbers of waterbirds when flooded (SKM and Roberts, 2003). 34 bird species have been recorded. Habitat for: southern bell frog (*Litoria raniformis:* Commonwealth threatened), regent parrot (*Polytelis anthopeplus:* Commonwealth vulnerable; Vic vulnerable), inland carpet python (*Morelia spilota metcalfei:* Vic endangered), white-bellied sea-eagle (*Haliaeetus leucogaster:* EPBCA migratory; Vic rare). Extensive herb-land areas also become present as the lake dries (TLM 2006).

Lake Wallawalla is listed under DIWA. The listing classifies it as a relatively unique wetland of its type in Victoria. This is due to a combination of the variety of ecosystems and its unique geomorphology (specifically a series of lunettes formed from both red sand sediments and saline clay sediments) (DEWHA online).

2. Expected ecological outcomes
The proposal suggests a high risk to the ecology of the site if the proposed volumes are not delivered, with a high benefit to the ecosystems for the volume of water. The repeat watering will assist the condition of the fringing vegetation and allow the establishment of wetland vegetation, providing a drought refuge for waterbirds, frogs and turtles. (DSE 2010).

3. Potential risks
DSE identified no major risks within the proposal. The assessment islargely based upon experience watering wetlands in the broader region, and the terminal nature of the delivery to this site. In particular Victoria specifically mentioned the following issues in relation to this type of event:

- Significant experience with delivery to these, or similar sites, provides a high level of knowledge with regard to the delivery process;

- The objectives of the watering (waterbirds and aquatic vegetation) reduce the potential impact of events such as black water to negligible levels (as it will not endanger achievement of the objective); and
- Broader negative consequences from black water events are also not a risk as the watering will be building upon deliveries over the autumn-winter 2010 period.

Whilst generally this assessment is reasonable, it does not allow for potential issues such as capacity constraints with regard to delivery, or other operational issues. Instead it is focussed solely on ecological risks.

The delivery issues with low flows during autumn have receded, with delivery rates now increased to approximately 100 ML/day. This should continue due to increased flows to South Australia being present within the system, and likely flows to over the border due to river operations in the immediate future.

4. Long-term sustainability
This site as been identified as an important site under the Living Murray program (as part of the Chowilla – Lindsay/Wallpolla Icon site), and is part of the Murray Sunset National Park. Commitment to the site is demonstrated by the construction of 2 large regulators and levee to manage environmental water delivery to the site. Site managed by Mallee CMA in partnership with Parks Victoria.

5. Cost effectiveness
Whilst the delivery of these sites is by temporary pumps, the size of the infrastructure used results in the cost effectiveness of the proposed watering action being similar to gravity delivery from irrigation systems within Victoria. As a result the ccost effectiveness can be viewed as high. Potential works which are in the process of development of detailed proposals may allow gravity delivery to the site in the future.

References
Cunningham SC, Mac Nally R, Griffioen P and White M (2009) *Mapping the Condition of River Red Gum and Black Box Stands in The Living Murray Icon Sites. A Milestone Report to the Murray-Darling Basin Authority as part of Contract MD1114*. Murray-Darling Basin Authority, Canberra

DSE (2010) *Lake Wallawalla, TLM watering proposal*, Department of Sustainability and Environment

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SKM and Roberts, J. (2003). *Assessment of water management options for Lindsay and Wallpolla Islands - Final Report.* Melbourne: Sinclair Knight Merz for the Mallee Catchment Management Authority.

TLM (2006) *The Chowilla Floodplain and Lindsay-Wallpolla Islands Icon Site Environmental Management Plan 2006–2007*, Murray Darling Basin Commission

Lindsay Island

DEWHA Assessment Summary	CEWH	Other
Site: Lindsay Island **Floodplain/region:** Lindsay-Wallpolla floodplain (Vic) **Catchment:** Murray below choke (Vic) **Timing:** Spring 2010 and autumn 2011	**Volume:** 0 ML – TLM allocated water to this option on the 2 August 2010	**Volume:** 2,800 ML (TLM)

Description of watering action and objective
Lindsay Island is within the Chowilla-Lindsay-Wallpolla Icon Site and is DIW listed. A total of 2,800 ML is proposed for release (1,100 ML in spring 2010 and 1,700 ML in autumn 2011).

This proposal will provide an expanded area of drought refuge in wetlands and prevent critical loss of river red gums (RRG).

Description of site / watering history
Lindsay and Wallpolla Island floodplains contain a wide array of once ephemeral aquatic environments that are now either permanently inundated, permanently dry, or flood less frequently with altered seasonality. Flows between 10,000 and 60,000 ML/day roughly approximate in-channel flows for much of Lindsay and Wallpolla Islands, and start to affect higher backwaters, anabranches and wetlands off the main river channel. Overbank flows begin to occur on Lindsay Island at approximately 60,000 ML/day - 90,000 ML/day, these flows cause flooding of low-lying parts of the floodplain and connecting anabranches. Flows of 100,000 ML/day and higher start to inundate extensive areas of floodplain and island hydrology is characterised by broad flow paths (MCMA 2005).

The decline in RRG communities along the Murray floodplain is ongoing, with 72% in a stressed condition in 2009 (Cunningham *et al.* 2009). TLM icon sites in the Mallee are in worse condition than those further upstream. The only areas where stand condition have increased are those where environmental watering has been provided. This demonstrates that ongoing delivery is vital to maintain small areas of these communities on Lindsay Island in reasonable condition. The response of waterbirds, frogs and wetland vegetation to environmental water delivery has also been monitored. The response of waterbirds to environmental water delivery is almost immediate, with diversity and abundance increasing with time since watering.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
Lindsay Island is within the Chowilla-Lindsay-Wallpolla Icon Site and is DIWA listed. Lindsay Island is a series of tangled lignum (*Muelenbeckia cunninghamii*) swamps interconnected by a series of streams with river red gum (*Eucalyptus camaldulensis*) and surrounded by black box (*E. largiflorens*) woodland (DEWHA online). The nationally threatened southern bell frog (*Litoria raniformis*; Victoria endangered) has been found at this site. Significant bird species identified at Lindsay Island include the Australian painted snipe (*Rostratula australis:* Commonwealth vulnerable; EPBCA migratory; Vic critically endangered), malleefowl (*Leipoa ocellata;* Commonwealth vulnerable; Vic endangered), regent parrot (*Polytelis anthopeplus monarchoides:* Commonwealth vulnerable; Vic vulnerable), fork-tailed swift (*Apus pacificus*: EPBCA migratory), Latham's snipe (*Gallinago hardwickii* ; Victoria near threatened; EPBCA migratory). Significant fish species include the Murray cod (*Maccullochella peelii peelii;* Commonwealth vulnerable; Vic endangered) and Murray hardyhead (*Craterocephalus fluviatilis;* Commonwealth vulnerable; Victoria critically endangered). Significant flora species: Erect pepper-cress (*Lepidium pseudopapillosum*, FFG 1988 Listed). Other species: Broad-shelled tortoise (*Chelodina expansa:*, Vic endangered), a water dependent skink – the Eastern water skink (*Eulamprus quoyii:* Vic threatened).

2. Expected ecological outcomes
This proposal will provide an expanded area of drought refuge in wetlands and prevent critical loss of RRG. Habitat will be provided in wetlands for waterbirds, small fish, turtles and frogs, including the nationally threatened southern bell frog. The additional water provided will inundate an additional 30 ha of wetland and 10 km of creekline.

- Increase the diversity of structural aquatic habitat;
- Increase the diversity and distribution of native fish;
- Provide occasional breeding and roosting habitat for waterbirds; and
- Provide habitat suitable for migratory waterbird species

3. Potential risks
No specif risks have been identified for this action. This assessment is informed by the watering history of the site and the terminal nature of the delivery (removing any potential impact from poor water quality on the broader system). Mallee CMA and Parks Victoria also have significant experience managing the delivery of environmental water to

wetlands through out the region, and the delivery of the proposed water will be informed by their management experience.

4. Long-term sustainability

As the site is also a TLM icon site, future water allocations can be reasonably well assured. Lindsay Island is part of the Murray Sunset National Park (with associated management plans). As part of a TLM Icon sites, it has established management plans and monitoring arrangements. Monitoring of the watering event and the alignment of the watering outcomes with the objectives are considered to be adequate.

5. Cost effectiveness

Medium - In the absence of high natural flows, temporary pumps are the only method of delivering water to the Lindsay Island floodplain. The watering of Wallpolla Island and Lake Wallawalla, also proposed for spring, would potentially provide additional water to the surrounding regions. No return flows are expected from this watering.

References

Cunningham SC, Mac Nally R, Griffioen P and White M (2009) *Mapping the Condition of River Red Gum and Black Box Stands in The Living Murray Icon Sites. A Milestone Report to the Murray-Darling Basin Authority as part of Contract MD1114*. Murray-Darling Basin Authority, Canberra

DEWHA online, http://www.environment.gov.au/cgi-bin/wetlands/report.pl, (accessed 27/07/2010)

MCMA (2005) *Chowilla Floodplain and Lindsay-Wallpolla Islands Icon Site: Environmental Management Plan, Part C: Lindsay-Wallpolla Islands*, Murray Darling Basin Commission.

Little Reedy Complex (Gunbower Forest)

DEWHA Assessment Summary	CEWH	Other
Site: Little Reedy Complex **Floodplain/region:** Gunbower Forest (Vic) **Catchment:** Murray below choke (Vic) **Timing:** Spring 2010	**Volume:** 5,000 ML – TLM allocated water to this option on the 2 August 2010 **Cost:** Spring - $165,000 ($33 /ML)	**Volume:** 0 ML – option has also been proposed to TLM

Description of Watering Action and Objective
The Little Reedy wetland proposed watering requirement is 5,000 ML, which will flood the permanent wetland that is currently dry, to be released over September 2010 (and no later than October 2010). This site is part of the Gunbower-Koondrook-Perricoota TLM icon site and is Ramsar listed.

Delivery of water in Spring 2010 would water fringing river red gum forests and provide important feeding habitat for waterbirds (e.g. egrets, ducks, spoonbills and cormorants), as well as frogs and turtles.

Description of site / watering history
The Little Reedy Wetland Complex is currently dry. It has not received water since 2008 and requires watering soon to avoid impacts on ecosystem function. It is classified as a permanent wetland and would normally hold water nine years in ten. Delivery of environmental water will flood a large area of permanent wetland and provide important feeding habitat for waterbirds (e.g. egrets, ducks, spoonbills and cormorants), as well as frogs and turtles. Little Reedy also supports egret breeding colonies.

The broader TLM icon site objectives are to maintain 80 percent of in a healthy condition, providing feeding and breeding habitat for a range of waterbirds, fish, frogs and turtles (TLM 2006).

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
The Little Reedy Wetland Complex is within the RAMSAR listed Gunbower-Koondrook-Perricoota TLM icon site. Significant species identified include: blue-billed duck (*Oxyura australis:* Vic endangered), regent honeyeater (*Xanthomyza phrygia:* Commonwealth endangered; Vic critically endangered*);* Australasian bittern (*Botaurus poiciloptilus;* Victoria endangered); and Murray cod (*Maccullochella peelii peelii;* Commonwealth vulnerable; Vic endangered).

The only record of intermediate egret (*Ardea intermedia*; Victoria critically endangered) breeding in Victoria is in the Gunbower Forest (in 1974 there were an estimated 500 nests, and in 1982 there were over 100 nests). Breeding colonies of the rufous night heron (*Nycticorax caledonicus*), the little egret (*Egretta garzetta nigripes;* Vic endangered), and the great egret (*Ardea alba:* EPBCA migratory; Vic vulnerable) have also been recorded in the Forest. Fish such as: golden perch (*Macquaria ambigua*; Vicvulnerable), silver perch (*Bidyanus bidyanus*: Vic critically endangered), flathead gudgeon (*Philypnodon grandiceps*), flat-headed galaxias (*Galaxias rostrata*; Vic vulnerable), flyspecked hardyhead (*Craterocephalus stercusmuscarum;* Vic data deficient) and rrimson spotted rainbowfish (*Melanotaenia fluviatilis;* Vic data deficient) use the Forest as habitat and for breeding and recruitment when flooding allows.

2. Expected ecological outcomes
Delivery of environmental water will flood a large area of permanent wetland that is currently dry. This will provide feeding and breeding habitat for a range of waterbirds, fish, frogs and turtles. Little Reedy also supports egret breeding colonies, this watering should assist in maintaining the resilience of the system for future larger events. Watering of the fringing river red gum forests is expected to result in some improvement of tree condition due to the 2 years since the site was last watered. This timing is in line with generally expected watering regimes for rived red gum fringed wetlands.

3. Potential risks
DSE states in their proposal that no risks have been identified. This is due to the following factors identified during discussions with DSE:

- Significant experience with delivery to these, or similar sites, provides a high level of knowledge with regard to the delivery process;
- The objectives of the watering (waterbirds, frogs, turtles and aquatic vegetation) reduce the potential impact of events such as black water to negligible levels (as it will not endanger achievement of the objective); and
- Broader negative consequences from black water events are also not a risk as there will be no return flows to the Murray River.

One risk not covered though is the remote potential for water bird breeding as during 2009-10 there was minor watering of Gunbower, which resulted in some water bird breeding. If this was to occur it is not clear if this would result in further water requirements to support the event. This and similar contingencies (and the resultant associated risks) need to further explored.

4. Long-term sustainability
The broader Gunbower forest (including this site) is RAMSAR listed, part of national parks in Victoria and a TLM Icon Site, as well as being subject to numerous integrated management planning processes. This indicates a high sustainability of future management arrangements. The site will also be in the footprint of the Hipwell's Road environmental water regulator to be constructed as part of the TLM works program. This will assist in the provision of broad scale watering events in the future, ensuring the environmental sustainability of the site is high as well.

5. Cost effectiveness
Little Reedy - Water will be delivered through the Torrumbarry Irrigation System using "interruptible supply". This option will have only minimal charges attached but the actual cost is currently being confirmed with Goulburn-Murray Water (estimated at approximately $35/ML). No complementary works are required.

References
TLM (2006) *The Gunbower-Koondrook-Perricoota Forest Icon Site Environmental Management Plan 2006–2007*, Murray Darling Basin Commission

Loddon River Reach

DEWHA Assessment Summary	CEWH	Other
Site: Loddon River (reach 1 to reach 3b) **Floodplain/region:** Loddon River (Vic) **Catchment:** Loddon (Vic) **Timing:** August 2010 – June 2011	**Volume:** 1,179 ML (as defined by high reliability water entitlements held in the Loddon as of 30 June 2010) **Cost:** $5310 (based on an estimated cost of $4.50 /ML)	**Volume:** Not defined - potential passing flows and river operations contribution to flows depending on availability and system restrictions.

Description of Watering Action and Objective
The proposal for watering is requesting the use of allocation against entitlements held within the Loddon system by the CEWH to provide in-stream benefits to the Loddon River from Cairn Curran Reservoir to the Loddon Weir (unless there is significant natural instream flows which would allow the extent of watering to expanded to the reach between the Loddon and Kerang Weirs). The volume of these entitlements (as of 30 June 2010) is 1,179 ML of high reliability water share and 527 ML of low reliability water share.

This proposal does not propose the trade of any water into the Loddon system from the broader southern connected basin.

The release into the system of any allocations is proposed to start in August 2010 and be delivered throughout 2010-11 and into 2011-12 (dependent on seasonal conditions). The objective of the action is to assist in improving the condition of the Loddon River from Category 1 to Category 4 as per the Northern Region Sustainable Water Strategy (see expected ecological outcomes for more information). Any additional water provided will be delivered in accordance with the environmental watering plan (awaiting approval by the Victorian Government's Minister for the Environment as the statutory holder of the Loddon flora and fauna bulk entitlement).

This proposal does not consider the provision of water to reach 5 of the Loddon River (below Kerang Weir).

Description of site / watering history
The Victoria BE established in 2004 and 2005 for the Loddon River covers the area between Cairn Curran Reservoir and Kerang Weir. In the Loddon River system, the 2010-11 season will probably start under extremely dry conditions (NCCMA 2009), with only 600 ML of water from the LSWFA available and no river flow. As such, there are likely to be no environmental flow management decisions able to be made during the first one to two months of the season. Any unregulated flows arriving at Loddon Weir should be diverted to the first Boort District wetland on the priority list, to keep the Loddon River below Loddon Weir dry (Reach 4).

The use of environmental water through 2009-10 is highlighted below (NCCMA 2009),
Under the Qualification rules no environmental flow releases were administered in Reach 1 in 2009-10, although water transfer releases (between Cairn Curran and Laanecoorie Reservoirs) were undertaken through the season.

Tullaroop Creek (Reach 2) received a flow regime of 5 ML/day for three days and 2 ML/day for four days throughout summer. Two 6 ML/day events were delivered for approximately one week each. Tullaroop Creek remained under Qualification of Rights during 2009-10. 875 ML was available for environmental use through the whole of the season so a base flow of 1 ML/day was provided through to December 2009. During December, the summer flow regime was started with 5 ML/day released for three days, and 2 ML/day for four days. This regime was continued through the season, with two 6 ML/day freshes provided for 6-8 days each (NCCMA 2009).

Under the Qualification rules no environmental flow releases were delivered in reach 3a, although some water releases occurred for stock and domestic proposes early in the season, and for irrigation demand later in the season. Reach 3a (Laanecoorie Reservoir to Serpentine Weir) is considered to have the highest ecological value of the Loddon River under low flow conditions (high levels of instream woody habitat and drought refuge provided by Bridgewater and Serpentine Weir pools). As such, it will be the maintenance of this reach through the provision of freshes and additional flows that will occur first when water becomes available.

Loddon River between Serpentine Weir and Loddon Weir (Reach 3b) received 450 ML of environmental water from the LSWFA which was transported through this reach for delivery to Little Lake Boort.

Reach 4: No flows were released from Loddon Weir during 2009-10 due to being unable to commit to maintaining water through 2009-10 and 2010-11. As was observed in 2008-09, the growth of instream vegetation (particularly River Red Gum) and the questions surrounding likelihoods and threats of exacerbating Acid Sulphate Soils through the reach meant that under the dry scenarios observed, Reach 4 was kept dry.

There has been a slight decline in the creek health over the past year, noted by local community members (LEWAG 2010). From a monitoring perspective, dissolved oxygen dropped to 1.3mg/L in this section of the creek. Electrical conductivity reached approximately 4,600µS/cm. Fish monitoring undertaken through the reach found that there were more individuals caught this season than in the previous two (SKM 2009). Only two River Blackfish were found through the whole creek which was less than were caught in the previous season (SKM 2009).

The Loddon River catchment is influenced by water imported from the Goulburn and Murray rivers, and water is diverted into the Loddon River catchment from the Campaspe, Goulburn Broken and Murray River systems for use as potable and irrigation water.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
The Loddon River is considered a high priority under the North Central River Health Strategy (RHS) 2005.

Significant bird species recorded include: regent honeyeater (*Anthochaera Phrygia;* Commonwealth endangered; Vic critically endangered); Swift Parrot (*Lathamus discolor;* Commonwealth endangered; Vic endangered); malleefowl (*Leipoa ocellata:* Commonwealth vulnerable; Vic endangered); plains-wanderer (*Pedionomus torquatus;* Commonwealth vulnerable; Victoria critically endangered); Australian painted snipe (*Rostratula australis;* Commonwealth vulnerable; EPBCA migratory; Victoria critically endangered).

Migratory birds under the EPBC Act: great egret (*Ardea alba*; Vic vulnerable); cattle egret *(Ardea ibis);* Latham's snipe (*Gallinago hardwickii ;* Victoria near threatened); fork-tailed swift (*Apus pacificus*); and the white-bellied sea-eagle (*Haliaeetus leucogaster;*Vic vulnerable).

Significant fish species: Murray cod (*Maccullochella peelii peelii* Commonwealth vulnerable, FFG1988 listed, Vic endangered) and Macquarie perch (*Macquaria australasica*; Commonwealth endangered); silver perch (*Bidyanus bidyanus*, FFG 1988 listed, Victoria critical), Murray-Darling rainbowfish (*Melanotaenia fluviatilis:* FFG 1988 listed), unspecked hardyhead (*Craterocephalus stermuscuscarum fulvus* FFG1988 listed).

Other species identified at the site: spot-tailed quoll (*Dasyurus maculatus maculatus* Commonwealth endangered; Vic endangered), golden sun moth (*Synemon plana;* Commonwealth critically endangered; Victoria critically endangered), striped legless lizard (*Delma impar;* Commonwealth vulnerable; Vic endangered).

Plants: river swamp wallaby-grass (*Amphibromus fluitans*; Commonwealth vulnerable), plains rice-flower (*Pimelea spinescens;* Commonwealth critically endangered).

2. Expected ecological outcomes
The water provided will be used to improve the current condition of the Loddon River which is rated at a category 1 using Victoria's long-term management action targets up to a level up of a category 4, thereby protecting all instream species. These categories are defined in the Northern Region Sustainable Water Strategy (DSE 2009), and are listed below:

- Category 1 – drought refuge only;
- Category 2 – Dry spell breaking only;
- Category 3 – protect priority in-stream species; and
- Category 4 – Protect all in-stream species.

The degree to which this will be achieved is dependent on seasonal conditions. It should be noted that if increased flows can be reinstated into the Loddon River then the river is likely to support a greater diversity of species and reinstate fish habitats and populations (NCCMA 2009).

3. Potential risks

1. Water Quality - local catchment erosion delivering a substantial amount of sediment to the Loddon River and the lack of high flows in recent years, has resulted in this material accumulating in the bottom of the channel and smothering important habitat features. (NCCMA 2009). A formal written risk assessment is to be included in the long term EWP to be available winter 2010.

2. Acid sulfate soils – There are significant potential issues with acid sulfate soils in reach 4 of the Loddon River. To manage these risks it is proposed that flows any flows reaching Loddon Weir would be diverted for delivery to wetlands in the region, unless there is a significant (bank full) flow through reach 4 of the Loddon River prior to deliberate releases. (NCCMA 2009)

4. Long-term sustainability
The Loddon River has an allocated Bulk Entitlement, however is currently under Qualification of Rights, and hence this qualification must be lifted prior to any release. The current Qualification commenced in 2009-10, and will be in operation until the Qualification of Rights is revoked; or until the 30th of June 2011, whichever is earlier. Interim watering plans are currently available (detailed environmental plan awaiting approval from NCCMA) and management plans covering the Loddon River are the North Central Regional River Health Strategy and the Northern Region Sustainable Water Strategy. Environmental flow requirements have been determined during estimation of the BE and are available in (Loddon 2002). To effectively manage the Environmental Water Reserve, the North Central CMA has established the Loddon Environmental Water Advisory Group (LEWAG). The LEWAG provides advice at key decision points in the planning process to the North Central CMA on the best use of environmental water for the Loddon System, as defined by the Loddon System Bulk Entitlements (NCCMA 2009).

Loddon River is being monitored under the Victorian Environmental Flow Monitoring Assessment Program and the Sustainable River Audit is also undertaken on this system to determine the Index of Stream condition. Monitoring is performed by VEFMAP - NCCMA/DSE, SRA – MDBA and ISC – DSE, with results available in the yearly watering report (available approx. June 2011).

Loddon Stressed River project
This large-scale project has aimed to complement the potential river health improvements to be gained through the delivery of environmental flows by implementing a range of integrated activities, including on-ground works in the riparian zone, investigations, capital works and community engagement (NCCMA 2009).

5. Cost effectiveness
High – Water is delivered to the Loddon River via direct release from storages in the upper catchment (mainly Cairn Curran and Laanecoorie Reservoirs.

References
DSE (2009) *Northern Region Sustainable Water Strategy*, Department of Sustainability and the Environment (Victoria)

Loddon River Environmental Flows Scientific Panel. (2002) *Environmental Flow Determination of the Loddon River Catchment: Final Report*. Unpublished Report to the North Central Catchment Management Authority and Department of Natural Resources and Environment.

Loddon Environmental Water Advisory Group (2010) Meetings held on 28 April and 25 May 2010, North Central Catchment Management Authority, Huntly, Victoria.

NCCMA (2009) *Draft 2010-11 Loddon River Annual Watering Plan*, North Central Catchment Management Authority

SKM (2009) *Monitoring response to environmental flows in the Loddon and Campaspe Rivers: 2009 Fish Survey Report*. Melbourne

Mallee CMA group

DEWHA Assessment Summary	CEWH	Other
Site: Mallee CMA Group – 24 floodplain wetlands **Floodplain/region:** Mallee CMA – Murray floodplain (Vic) **Catchment:** Murray below choke (Vic) **Timing:** Spring 2010	**Volume:** 12,000 ML out of a proposed 24,000 ML for Spring (a further 24,000 ML is also proposed for autumn 2011) **Cost:** Spring - $720,000 ($60 /ML)	**Volume:** 0 ML – proposal will also be considered by DSE and TLM

Description of watering action and objective
Proposed watering action is to deliver water to a range of temporary wetlands on the Murray River floodplain within the Mallee CMA. The exact volume of water delivered to the 24 individual sites is yet to be determined, as the volumes will vary depending on climate, rainfall, evaporation and seepage.

The objective of the watering is to prevent the loss of the river red gum communities and provide a drought refuge. Watering in spring 2010 will support the important refuge habitat species associated with river red gum communities.

Description of site / watering history
Given there are 24 sites it is reasonable to expect that the health of sites is mixed. Detailed information is not accessible for all sites. Some sites have received environmental water in the last 12 months. All sites are understood to be RRG-fringed wetlands located close to the Murray River (DSE proposal 2010). The decline in RRG communities along the Murray floodplain is ongoing, with 72% in a stressed condition in 2009.

The sites in the Murray Floodplain proposal are redgum dominated communities. The wetland types represented include deep freshwater marsh and shallow freshwater marsh. The watering would inundate ecological vegetation classes including: floodplain riparian woodland; grassy riverine forest; riverine grassy woodland; intermittent swampy woodland; riverine swamp forest; riverine swampy woodland; sedgy riverine forest; and shrubby riverine woodland.

Sites proposed for watering form part of the Murray-Mallee Sunset Country National Park and the Murray River Forest Area National Park. Surrounding the proposed watering sites are the: Mallee Cliffs State Forest (NSW), the Kemendok Nature Reserve, Gol Gol State Forest, Redcliffs Scenic Reserve, River Mallee Reserve, Lambertr Island Flora Reserve, Red Cliff Scenic Reserve and the Kings Billabong Wildlife Reserve.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
System health is supported by having a diversity of wetland habitats available along the system. While no site is critical in itself, taken collectively the sites provide important refuge habitat species associated with river red gum communities.

Key water dependent biota include: Australasian shoveller (*Anas rhynchotis*: Vic vulnerable), blue-billed duck (*Oxyura australis*: Vic endangered), freckled duck (*Stictonetta naevosa;* Vic endangered), hardhead (*Aythya australis*: Vic vulnerable), musk duck (*Biziura lobata* Vic vulnerable). Colonial nesting waterbirds: Eastern great egret (*Ardea alba*: Vic vulnerable) and the royal spoonbill (*Platalea regia*: Vic vulnerable). Invertebrates: river snail (*Notopala sublineata*: Vic critically endangered).

2. Expected ecological outcomes
The objective of the proposed watering action is to provide water to prevent the loss of River Redgum communities and provide a drought refuge. When flooded, temporary wetlands support an abundant community of small macro-invertebrates, particularly micro-crustaceans that appear from resting stages on the lakebed and the larvae of flying insects such as notonectids and corixids. Small vegetation-dependent fish such as western carp gudgeon (*Hypseleotris klunzingeri*) and big-headed gudgeon will use these food sources and shelter in the reeds and fringing snags. The principal bird species are expected to be large waders and dabbling ducks, which are favoured by the sheltered habitat of the reeds and the availability of soft-leaved plants and macro-invertebrates.

3. Potential risks
No potential risks have been identified by Victoria. This is as a result of a combination of factors listed below:

- Significant experience within Mallee CMA with delivery to these, or similar sites, provides a high level of knowledge with regard to the delivery process;
- The objectives of the watering (waterbirds and aquatic vegetation) reduce the potential impact of events such as black water to negligible levels (as it will not endanger achievement of the objective);

- Broader negative consequences from black water events are also not a risk as sites are isolated and do not return water to the supply systems; and
- The likelihood of colonial water bird breeding is remote due to the small size of the wetlands, with larger potential breeding areas (Hattah Lakes for example) nearby.

As the watering sites are largely surrounded by national park and state reserves, there is a potential risk associated with cutting off access roads and forest trails during delivery. This will be mitigated through normal flood warning processes by the relevant state department.

Risk assessments will also be developed as part of the environmental watering plans being developed for sites across northern Victoria.

4. Long-term sustainability
Water may be provided by Victorian Environmental Entitlements or Living Murray Entitlements dependent on how they rank there sites against their criteria. Volumes required vary depending on climate, rainfall, evaporation and seepage. The delivery of water to sites will be determined by Mallee CMA and they will have the capacity to change volumes depending on operational constraints and environmental outcomes. The CEWH would be advised of changes as they occur.

Site specific management plans are currently being developed by Mallee CMA in conjunction with Victorian DSE and the CEWH. These plans will sit under the Regional River Health Strategy for the Mallee CMA region.

The Mallee CMA are prepared to monitor the water levels of the delivery and provide photo points, however additional monitoring (such as waterbirds) will only be performed if requested and paid for by CEWH. Further consultation with the Mallee CMA is required to determine the most appropriate monitoring regime to assess the watering against the ecological objectives. Further monitoring details may be found in the monitoring paper at Attachment E.

5. Cost effectiveness
Low. Water will be delivered to the 24 wetland sites using temporary pumps. Due to the size of the wetlands and pumps required the costs will be towards the higher end of the range of pumping charges.

Mulcra Island

DEWHA Assessment Summary	CEWH	Other
Site: Mulcra Island **Floodplain/region:** Lindsay to Wallpolla floodplain (Vic) **Catchment:** Murray below choke (Vic) **Timing:** Autumn 2011	**Volume:** 5,000 ML net demand (20,000 ML gross demand) **Cost:** $0 (delivered through lock operations – there may be some minor costs for out of pocket expenses)	**Volume:** 0 ML – option has also been proposed to TLM

Description of watering action and objective
The proposed delivery over autumn (delivered March-June) 2011 would utilise the new TLM infrastructure, allowing broad scale flooding to be achieved by the use of a regulator on Potterwalkagee Creek. It is proposed to release 20,000 ML into the system, 15,000 ML of which are expected as return flows (result in a net consumption of 5,000 MLof environemtnal water).

Provision of the proposed water will provide connectivity between the river and floodplain, watering RRG, wetlands, Black Box and Lignum. This will provide habitat in wetlands for waterbirds, fish, turtles and frogs, including the nationally threatened Growling Grass Frog (more detail in ecological outcomes section).

Description of site / watering history
Mulcra Island is formed by the Potterwalkagee Creek, an anabranch of the Murray River, and provides important breeding and feeding habitat for waterbirds, frogs, fish and turtles, as well as supporting river red gums. The site is part of the Chowilla-Lindsay-Wallpolla TLM Icon Site. Lindsay Island and Wallpolla Island are linked by Mulcra Island, and although it has ecological values, Mulcra Island is not part of the Significant Ecological Asset.

A lack of regular flooding due to river regulation and a drier climate has impacted significantly on the health of Mulcra Island, leaving approximately 80% of river red gums on the island either dead or dying. Altered connectivity between the Murray River and Mulcra Island has also had a significant impact on the plants and animals it supports – in particular, small native fish like the crimson-spotted rainbow fish (MDBA 2010).

River regulation has significantly altered the natural flooding regime of Mulcra Island. Prior to regulation, the island's floodplain contained a wide array of aquatic environments of variable permanence, which supported a variety of plant and animal species. These areas are now either permanently inundated, permanently dry, or flood less frequently and with altered seasonality. Both wet and dry periods are critical in maintaining habitats for plant and animal species on Mulcra Island (MCMA 2009). The recently completed TLM infrastructure will assist in re-establishing these types of flow regimes.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
Mulcra Island provides habitat for a variety of species that are significant at national, state and regional levels. When flooded, the island's wetlands offer food and breeding habitat for waterbirds, turtles, frogs and fish, including the great egret (*Ardea modesta:* Commonwealth migratory), the regent parrot (*Polytelis anthopeplus monarchoides:* Commonwealth vulnerable: Vic vulnerable), the southern bell frog (*Litoria raniformis:* Commonwealth threatened: Vic endangered) and the red-naped snake (*Furina diadema:* Vic vulnerable).

2. Expected ecological outcomes
Provision of the proposed water will provide connectivity between the river and floodplain, watering RRG, wetlands, Black Box and Lignum. This will provide habitat in wetlands for waterbirds, fish, turtles and frogs, including the nationally threatened Growling Grass Frog. Raising Lock 8 will generate flows through 26 km of creekline, providing flowing habitat for native fish and watering RRG.

- Increase the diversity of structural aquatic habitat;
- Increase the diversity and distribution of native fish;
- Provide occasional breeding and roosting habitat for waterbirds; and
- Provide habitat suitable for migratory waterbird species.

3. Potential risks
No potential risks have been identified in the submission of the watering proposal; this is unlikely as the watering event will involve the first use of new infrastructure. The risks associated with this should be developed as part of final operating plans, and are not yet finalised. The assessment of these risks will occur before any use of the structure occurs.

Risks are expected to be minimal due to the issues with delivery to wetlands in the area being well understood, with well developed management options being in place. This assessment of the likely magnitude of risks associated with the provision of water to wetlands is informed by the experience held by Mallee CMA watering these sites, as well as broader experience across the region.

Water quality risks are also viewed as minimal given the volume of water to be provided to the site compared to the volume of expected return flows (enabling significant dilution of any porer quality water).

4. Long-term sustainability
High. Mulcra Island is located within a TLM Icon site and has recently had works completed to improve the delivery of proposed water.

The infrastructure project will also mean that following the flooding period, the majority of water on the floodplain will be returned to the Murray River and can be re-used downstream for other environmental benefits (75% of delivered water assumed to be returned to the Mulcra). The infrastructure will help restore a more natural flooding regime to the island, similar in frequency and duration to that which occurred before river regulation. Surrounding Lindsay Island and Wallpolla Island are also proposed for watering in Spring 2010 and Autumn 2011, providing additional benefits for this proposed watering.

5. Cost effectiveness
Utilising the newly completed TLM infrastructure to deliver water to the floodplain, Lock 8 will be raised to generate flows through Potterwalkagee Creek, operated by SA Water. There may be some minor associated costs, this is currently being confirmed with SA Water River Murray Operations Unit.

References
MCMA (2009) *TLM Mulcra Island - Restoring the balance,* Mallee Catchment Facts

MDBA (2010) *The Living Murray: Planned works on Mulcra Island,* Murray Darling Basin Authority

Wallpolla Island

DEWHA Assessment Summary	CEWH	Other
Site: Wallpolla Island **Floodplain/region:** Lindsay-Wallpolla floodplain (Vic) **Catchment:** Murray below choke (Vic) **Timing:** Spring 2010 and autumn 2011	**Volume:** 0 ML – TLM allocated water to this option on the 2 August 2010	**Volume:** 2,800 ML (TLM)

Description of Watering Action and Objective

A proposed volume of 3,200 ML is to be pumped to the Wallpolla Island floodplains, to be comprised of 700 ML delivered in Spring (September) 2010 and an additional 2,500 ML to be delivered in Autumn (April/May) 2011. Wallpolla Island is located within the Chowilla-Lindsay-Wallpolla TLM Icon Site and is DIWA listed.

The stated objective of the watering is to provide drought refuge in wetlands and prevent loss of river red gum. Habitat will be provided in wetlands for waterbirds, small fish, turtles and frogs, including the nationally threatened Growling Grass Frog.

Description of site / watering history

Wallpolla Island is bordered by the Murray River and the Wallpolla Creek, west of Mildura in Victoria. Naturally the wetlands within this system would have been watered through a combination of natural floods and high flows within the Murray River. AS with the broader system, the regulation of the system has reduced the occurrence of these flows and as a result the site has degraded over time. This decline across the Murray floodplain is ongoing and in 2009 72% of trees were reported to be in a stressed condition, with sites in the lower Murray, including Wallpolla Island, in generally worse condition than those upstream (Cunningham *et al.* 2009).

Wallpolla Island has a reasonable history of watering over recent years. This has been assisted by the construction of small regulators within the wetlands by MDBA to assist with the management of water levels. The only areas of recent improvement in tree health on Wallpolla Island coincide with past watering events. The response of waterbirds, frogs and wetland vegetation to environmental water delivery has also been monitored. The response of waterbirds to environmental water delivery is almost immediate, and that diversity and abundance increases with time since watering (DSE 2010).

Comments against criteria for assessing 2010-11 environmental watering actions

1. Ecological Significance

Wallpolla Island is within the Chowilla-Lindsay-Wallpolla Icon Site and is DIW listed. Significant bird species identified at Lindsay Island include the Australian painted snipe (*Rostratula australis:* Commonwealth vulnerable), Mallefowl (*Leipoa ocellata:* Commonwealth vulnerable), regent parrot (*Polytelis anthopeplus monarchoides:* Commonwealth vulnerable) and the Menindee nightshade (*Solanum karsense:* Commonwealth vulnerable).

Significant bird species covered by international agreements include: fork-tailed swift (*Apus pacificus*: EPBCA migratory), great egret (*Ardea alba:* EPBCA migratory), Latham's snipe (*Gallinago hardwickii*: EPBCA migratory) and the white-bellied sea-eagle (*Haliaeetus leucogaster*: EPBCA migratory).

Significant fish species include the Murray cod (*Maccullochella peelii peelii:* Commonwealth vulnerable) and Murray hardyhead (*Craterocephalus fluviatilis:* Commonwealth vulnerable) and the site also contains habitat for the southern bell frog (*Litoria raniformis*: Commonwealth vulnerable).

Thirty-nine waterbird species have been recorded at water sites on Wallpolla Island between 2006 and 2010 (DSE 2010). Six species were also recorded breeding at these sites. Up to six species of frogs were recorded at sites on Wallpolla Island after watering.

2. Expected ecological outcomes

Given the past experiences with watering this site it can be expected that response by river red gums should occur. The use of the wetlands by waterbirds and other fauna is also consistent with the outcome of previous watering events as discussed in the watering history.

3. Potential risks

No specif risks have been identified for this action. This assessment is informed by the watering history of the site and the terminal nature of the delivery (removing any potential impact from poor water quality on the broader system). Mallee CMA and Parks Victoria also have significant experience managing the delivery of environmental water to wetlands through out the region, and the delivery of the proposed water will be informed by their management experience.

4. Long-term sustainability
High. As the site is also a TLM icon site, future water allocations can be reasonably well assured. Sites are in the process of being established as National Parks and are TLM Icon sites, with established management plans and monitoring arrangements. The TLM monitoring plan is sufficient to measure the ecological objectives of the watering.

5. Cost effectiveness
Temporary pumps will be used to deliver water to Wallpolla Island floodplain in the absence of natural high flows. Works to allow large scale gravity delivery to the site are not proposed for this section of the TLM icon site.

References:
Cunningham SC, Mac Nally R, Griffioen P and White M. (2009) *Mapping the Condition of River Red Gum and Black Box Stands in The Living Murray Icon Sites. A Milestone Report to the Murray-Darling Basin Authority as part of Contract MD1114*. Murray-Darling Basin Authority, Canberra

DSE (2010) *Wallpolla Island, TLM extreme dry watering proposal*, Department of Sustainability and Environment

NEW SOUTH WALES

Lake Hume to Yarrawonga Reach

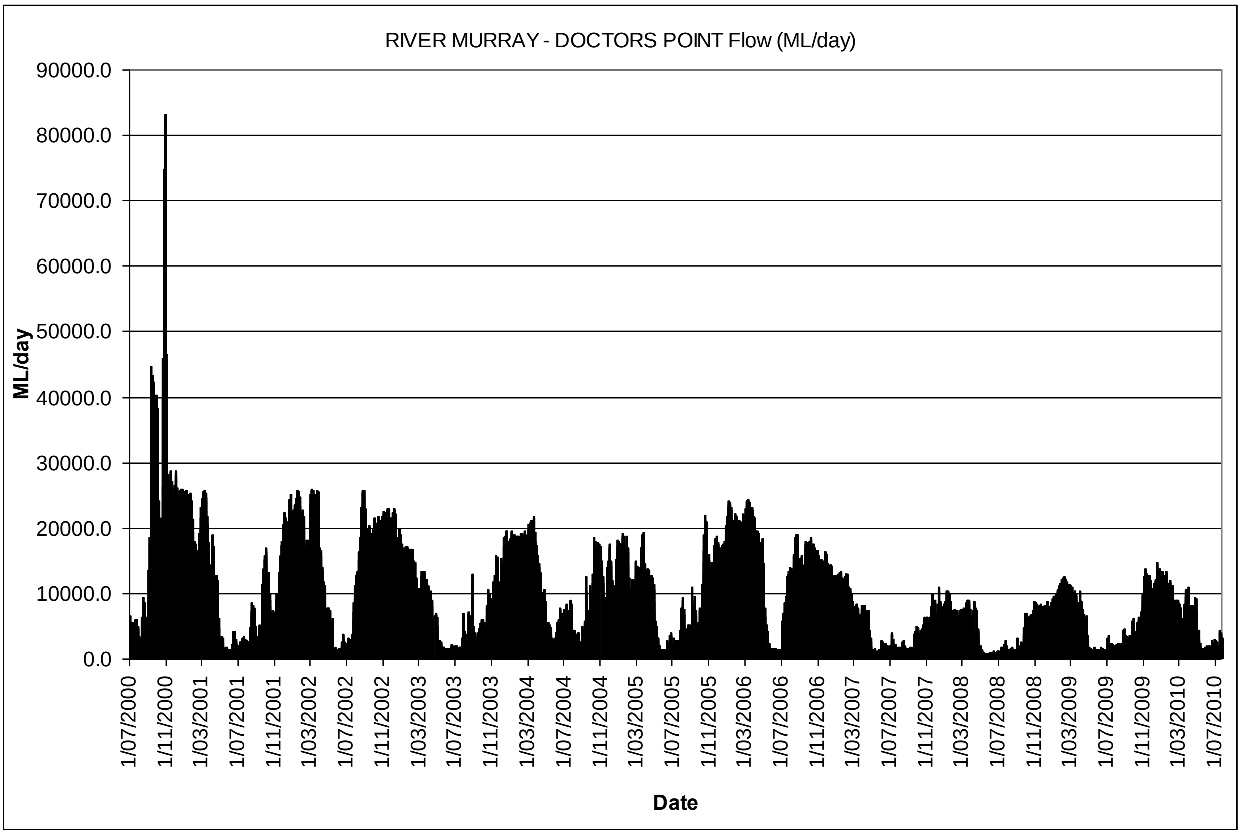
DEWHA Assessment Summary	**CEWH**	**Other**
Site: Hume to Yarrawonga **Floodplain/region:** Murray above choke **Catchment:** Murray River **Timing:** During peak seasonal flow in the Murray River	**Volume:** 6,000 ML **Cost:** $30,360 ($5.06/ML – fees and charges)	**Volume:** DECCW may allocate extra water. To be confirmed.

Description of Watering Action and Objective
6,000 ML of Commonwealth water would be used on top of Murray River regulated base flows to inundate lower benched wetlands along the Lake Hume to Yarrawonga (including Lake Mulwala) river reach.

The objective is to use regulated river flows to aid in the delivery of environmental water to a maximum number of wetlands in the river reach which as a result of drought conditions, and lower than historical average river flows, are now displaying drought stress.

Description of site / watering history
The Lake Hume to Yarrawonga Weir reach of the Murray River has approximately 771 wetlands, located on both the NSW and Victorian side of the river (Green and Alexander 2006). There are a number of large anabranches that are connected to the Murray when the flows along the Murray are greater than 5,000 ML/day at Doctors Point, however many of these wetlands relay on higher flows to receive water.

The hydrograph below shows the gauged flows down the Murray River at Doctors Point since July 2000. In 2009-10 flows peaked at 15,400 ML/day which is estimated to have inundated approximately 170 wetlands. Wetlands which have a commence-to-flow greater than 15,500 ML/day, which would have under normal conditions been inundated annually, have been through a prolonged drying phase.



Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance

NSW listed endangered species (NSW National Parks and Wildlife Service 2010): southern bell frog (*Litoria raniformis* Commonwealth vulnerable), swift parrot (*Lathamus discolor* Commonwealth endangered), regent honeyeater (*Xanthomyza phrygia* Commonwealth endangered) and bush stone-curlew (*Burhinus grallarius*)

NSW listed vulnerable species ((NSW National Parks and Wildlife Service 2010): Sloane's Froglet (*Crinia sloanei*), speckled warbler (*Pyrrholaemus saggitatus*), spotted harrier (*Circus assimilis*), little eagle (*Hieraaetus morphnoides*), blue-billed duck (*Oxyura australis*), freckled duck (*Stictonetta naevosa*), magpie goose (*Anseranas semipalmata*), Australasian bittern(*Botaurus poiciloptilus*), gang-gang cockatoo (*Callocephalon fimbriatum*), red-tailed black-cockatoo (*Calyptorhynchus banksii*), brown treecreeper (*Climacteris picumnus*), brown treecreeper (*Climacteris picumnus victoriae* -eastern subspecies), diamond firetail (*Stagonopleura guttata*), grey falcon (*Falco hypoleucos*), brolga (*Grus rubicunda*), black-chinned honeyeater (*Melithreptus gularis gularis* -eastern subspecies), varied sittella (*Daphoenositta chrysoptera*), hooded robin (*Melanodryas cucullata*), hooded robin (*Melanodryas cucullata cucullata* -south-eastern form), scarlet robin (*Petroica boodang*), flame robin (*Petroica phoenicea*), grey-crowned babbler (*Pomatostomus temporalis temporalis* -eastern subspecies), little lorikeet (*Glossopsitta pusilla*), turquoise parrot (*Neophema pulchella*), superb parrot (*Polytelis swainsonii* Commonwealth endangered), barking owl (*Ninox connivens*), spotted-tailed quoll (*Dasyurus maculatus* Commonwealth endangered), yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*), squirrel glider (*Petaurus norfolcensis*), koala (*Phascolarctos cinereus*), eastern bentwing-bat (*Miniopterus schreibersii oceanensis*), and pink-tailed legless lizard (*Aprasia parapulchella*).

The proposal area also includes the “aquatic ecological community in the natural drainage system of the lower Murray River catchment”. Further more the off-channel habitats, such as wetlands and backwaters along the stretch of river are recognised as “important for the productivity of river systems and for many species of native fish” (Lyon, Stuart *et al.* 2010). The off-channel wetlands provide feeding and nursery zones for small-bodied fish and connection of shallow wetlands to the main river channel sees significant movement of carp gudgeon species. “The current drought has resulted in complete drying of many off-channel habitats and lateral repopulation of billabongs from the Murray River is likely to be an important aspect of drought recovery” and “for short-lived fish, annual access to low-lying wetlands is still likely to be important in maximising recruitment and population recovery following drought”(Lyon, Stuart et al. 2010).

A study completed in 2003 identified the following features along the river stretch: an egret and ibis rookery directly below Hume Dam, a cormorant rookery on St Leonard’s Bend and a duck breeding ground near Lake Moodemere (Baldwin, Campbell *et al.* 2003).

2. Expected ecological outcomes
The water provided by the Commonwealth will be on top of base river flows (managed by River Murray Operations, MDBA). The event would only be possible if base river flows reach at least 12,000 ML/day. However this is likely to be achieved with irrigators ordering water or in conjunction with other watering events such as watering of the Barmah-Millewa Forest. The duration of the peak flow down the river would be 3-4 days but this is contingent on downstream demands and the ability of River Murray Operations to re-regulate the water at Lake Mulwala.

Objectives:
- “Emergency drought intervention to test how regulated river flows can be used to delivery environmental water to the maximum number of wetlands along a river reach” (Department of Environment Climate Change and Water 2010);
- increase the availability of off channel habitats by providing shallow wetland habitat for small bodied fish species (lateral connectivity);
- provide water to fringing vegetation that has been dry since 2006; and
- mobilise nutrients from the floodplain (in the disconnected wetlands) into the river channel.

Limited information about the current health of the system is available though a paper from 2001 (ID& A 2001) notes the following:
- Hume Dam to Albury: vegetation is in poor condition, poor instream habitat and low morphological diversity (de-snagging and erosion);
- Albury to Howlong: vegetation highly variable from very poor to good, poor instream habitat, low morphologic diversity;
- Howlong to Corowa: vegetation good to excellent, some high value bed diversity and snag densities in anabranches, bank erosion helping to create snags;
- Corowa Throat: vegetation condition poor despite good continuity - poor structure, weeds common and low regeneration, poor instream habitat and morphologic diversity; and
- Corowa to Lake Mulwala: excellent vegetation condition, poor in-stream habitat and low morphologic diversity (de-snagging and sedimentation).

The proposal states that wetlands with a commence-to-flow of >15,000 ML/day, that normally would have been inundated every year (pre drought) have been in a prolonged drying phase and the vegetation communities within these areas are now displaying signs of drought stress (Department of Environment Climate Change and Water 2010).

3. Potential risks

Following discussions with the MDBA and DECCW the following issues have been identified:

1. **Risk of flooding private property** - requires flows of above 25,000 ML/day. This is unlikely to occur during this event as flows can be precisely managed from Hume Dam and can be adjusted should a change in condition of the river occur (e.g. flood from one of the tributary rivers);
2. **Blackwater** generated when wetlands that have been dry since 2006 re-fill. Blackwater is a natural occurrence, however flows in the main Murray River channel would be sufficient to dilute any blackwater; and
3. **Adequate monitoring not undertaken** - DECCW will monitor using satellite imagery and ground-truthing via boat (both the Victorian and NSW of the River).

4. Long-term sustainability

The River Murray channel is the main mechanism for moving water from Hume Dam. Should allocations return to levels closer to long-term average then it is anticipated that river flows will return to higher levels and there will be no need to provide environmental water to the wetlands that are currently disconnected.

Murray CMA and North East CMA conduct a number of programmes such as riparian works, fencing, revegetation etc.

The only monitoring that is proposed for this watering action is the use of satellite imagery and ground-truthing via boat to determine the extent of inundation achieved. The MDBA will also be able to provide information on the volume of water used between Doctors Point and Lake Mulwala. No ecological monitoring is proposed.

5. Cost effectiveness

Water would be delivered as a release from Hume Dam and the Commonwealth environmental water would be provided on top of normal Murray River base flows (of anywhere between 10,000 to 20,000 ML/day).

The event may also be undertaken in conjunction with watering of the Barmah-Millewa Forest so could therefore be significantly extended.

An estimation of increased river losses (therefore the environmental watering of the wetlands) would be undertaken by the MDBA by examining changes in river losses observed on their Daily Operations Spreadsheets.

6. References

Baldwin, D. S., B. Campbell, et al. (2003) Regional Evaluation Group Assessment of Reference Point Flow Scenarios for Zone B of the River Murray System (Hume Dam to Yarrawonga Weir). Living Murray Regional Evaluation Group B (Hume Dam to Yarrawonga Weir) Final Report.

Department of Environment Climate Change and Water (2010) Adaptive Environmental Water Proposal: Lake Hume to Yarrawonga Reach - inundation of lower benched wetlands.

Green, D. and P. Alexander (2006) River Murray Wetland Database: NSW, Victoria. Wetland Commence-to-flow levels: June 2006, Murray Wetlands Working Group.

ID& A (2001) Summary Report, Scoping Study, Waterway Management Plan, Hume to Yarrawonga Reach of the Murray River, Murray Darling Basin Commission.

Lyon, J., I. Stuart, et al. (2010) The effect of water level on lateral movements of fish between river and off-channel habitats and implications for management.. Marine & Freshwater Research **61**: 271-278.

NSW National Parks and Wildlife Service. (2010) "Atlas of NSW Wildlife." Retrieved 20 June 2010, 2010, from http://wildlifeatlas.nationalparks.nsw.gov.au/wildlifeatlas/watlas.jsp.

North Redbank – Murrundi, Baupie and the Balranald Common

DEWHA Assessment Summary	CEWH	Other
Site: Lower North Redbank Wetlands **Floodplain/region:** Lowbidgee FLoodplain **Catchment:** Mururmbidgee, NSW **Timing:** September-October	**Volume:** 5,000 ML **Cost:** $18,900 ($3.78/ML – fees and charges)	**Volume:** 5,000 ML (NSW)

Description of Watering Action and Objectives
The action would extend the current inundation of 3,000 hectares of Lower North Redbank wetlands (on the properties Murrundi, Springbank, Glen Avon, Auley, Moola, River Leigh, Baupie and Balranald Common) into mid summer.

Objective 1: To improve the condition of the river red gum (*Eucalyptus camaldulensis*) forest and associated wetland systems. This area also includes vegetation types such as lignum (*Muehlenbeckia florulenta*), black box (*Eucalyptus largiflorens*) and native reed (*Phragmites australis*).

Objective 2: Create habitat for numerous waterbird species including great egret, glossy ibis, blue billed duck, freckled duck, Australasian bittern and also the recently detected fishing bat (*Myotis macropus*: NSW vulnerable).

Objective 3: Create suitable habitat to facilitate the re-colonisation of the top end of the North Redbank system with southern bell frogs (*Litoria raniformis*: Commonwealth vulnerable, NSW endangered).

Description of site / watering history
River red gum dominated wetlands at the lower end of North Redbank wetlands, off North Redbank Channel on the Lowbidgee Floodplain. 3,000 ha of the Lower Redbank wetlands were inundated in autumn 2010 with 1,600 ML of CEWH supplementary water, 400 ML of NSW supplementary water, approximately 1,000 ML of Lowbidgee share and 5,000 ML of NSW environmental water allowance water. This was the first watering for 5 years.

Comments against criteria for assessing 2010-11 environmental watering actions

1. Ecological Significance
<u>Threatened species and ecological communities and migratory species</u>
The landholder of Riverleigh and Baupie (King, 2008) has kept records of fauna observations which sighting of many species of conservation significance:

- Southern bell frogs (*Litoria raniformis:* Commonwealth vulnerable vulnerable, NSW endangered, last seen 2005). The area is 20 km from Redbank (Paul Coates) Swamp where southern bell frogs were recorded in 2001 and summer 2007-08 (Wassens *et al.* 2008). Southern bell frogs continue to be recorded (summer 2007-08, 2008-09, 2009-10) in Yanga National Park at Mercedes Wetland and Piggery Lake/Twin Bridges Complex (Wassens *et al.* 2008; Spencer and Wassens 2009; Maguire pers comm. - email 2009), which are 20 km across the river.
- Regent parrot (*Polytelis anthopeplus monarchoides:* Commonwealth vulnerable, NSW endangered; last seen 1994)
- Australasian bittern (*Botaurus poiciloptilus*, NSW vulnerable; last seen 2000), which is listed as endangered internationally on IUCN Red List, and has also been recorded 6 km away at Narwie (Maher, 1990)
- Blue-billed duck (*Oxyura australis*: NSW vulnerable; last seen 2000) which was also recorded by Maher (1990) at Paul Coates Swamp, 20 km to the north.
- White-bellied sea-eagle (*Haliaeetus leucogaster*; EPBC migratory, last seen 2008) which was recorded by Maher (1990) as nesting at Glen Avon and as present at Baupie in May 2010 (J. Maguire pers comm.).
- Glossy ibis (*Plegadis falcinellus*: EPBC migatory, last seen 2000) which were also recorded by Spencer (2009) 6 km away at Steam Engine Swamp, Paika.
- Great egret (*Ardea alba*: EPBC migratory, last seen 2000), which Maher (2006) also recorded with 200 nests 6 km away at Paika.
- Cattle egret (*Ardea ibis*: EPBC migratory; last seen 1996) which Maher (1990) also recorded with six nests 6 km away at Paika.
- Australian painted snipe (*Rostratula australis*: Commonwealth vulnerable, last seen 2000).
- Japanese snipe (*Gallinago hardwickii*: EPBC migratory, last seen 2006)
- Rainbow bee-eater (*Merops ornatus:* EPBC migratory; last seen2000)
- Pink cockatoo (*Cacatua leadbeateri*: NSW vulnerable, recorded 1994).

The fishing bat is likely to occur in the North Redbank system, based on the close proximity of recent detections in Yanga National Park and similar habitat.

The North Redbank wetlands are part of the Aquatic ecological community in the natural drainage system of the lower Murray River catchment endangered ecological community (*Fisheries Management Act* 1994).

Ecological values of asset
DIWA listed, the Lowbidgee Wetlands extended over an area of 300 000 ha in the early 1900s. However, following water diversion and floodplain developments, 76.5 per cent of the wetlands are now lost or degraded (Kingsford and Thomas 2004).
The Lowbidgee Floodplain is also listed in "Refugia for biological diversity in arid and semi-arid Australia" (Morton *et al.* 1995) as a significant wetland refuge in the NSW Murray-Darling Depression (along with the neighbouring Great Cumbung Swamp).
The Lowbidgee is listed as a draft High Conservation Value Aquatic Ecosystem (HCVAE; Australian Government 2010) and a key hydrological indicator site by the MDBA (2010).

2. Expected ecological outcomes
Feasibility of achieving objectives
Objective 1: (improve condition of the red gum forest and associated wetland systems) Previous watering has shown improvements in river red gum health. Sharon Bowen (DECCW), who has undertaken extensive vegetation monitoring of the Lowbidgee will monitor vegetation.
Objective 2: (create habitat for waterbird species and fishing bat)
The site has previously supported a number of threatened and migratory species including for breeding (see above). Sampling will be undertaken for bats and waterbirds.
Objective 3: (create habitat to facilitate the re-colonisation of southern bell frogs)
Southern bell frogs have not been recorded at the site recently. However, they continue to be recorded 20 km from this site on the south side of the river in Yanga National Park. They have been recorded at Paul Coates Swamp, 20 km to the north in 2007-08.
This species is known to migrate across the landscape, therefore it is possible they will recolonise newly watered areas. Even so, it may take several years before the southern bell frog reaches this system as it is likely that the northern areas of North Redbank (particularly Paul Coates Swamp) will need to be recolonised before this area is colonised. Frog monitoring will be undertaken.

Consistency with CEWH objectives
Objectives 1, 2 and 3 help prevent critical loss of species and provide drought refuge.

Current health of asset
As a whole, the North Redbank System the condition is considered to be poor and declining (DECCW 2010). However, the area is now is in moderate health due to the winter 2010 flooding.
The site has moderate impact from grazing and limited selective forestry of river red gums.

Improvement in health expected from watering option
Watering in 2010 has improved the health of this asset; however, growth and recruitment have been limited due to the late autumn/winter timing (which was dictated by supplementary water availability). Follow up watering is required to consolidate the gains made and provide for the spring/early summer growing seasons.

During the recent watering Spencer and Wassens (unpublished 2010a, b) recorded 17 species of waterbird with three breeding, five species of native fish with at least three breeding and five species of frog with at least three breeding. A number of frog species that are only active during spring and summer, including the southern bell frog, were not recorded (Spencer and Wassens unpublished 2010a). Spencer and Wassens (unpublished 2010a) suggest that these species may use the site if the inundation remains through spring and summer. The same may be the case for waterbird, as many species commence breeding in early spring (August-September).

Spencer and Wassens (unpublished 2010a, b) reported low dissolved oxygen levels (lowest 27 per cent after 15 days, second lowest 30 per cent after 2 days) at sites which had recently been watered (2-15 days); however, the levels were much higher in sites which had water for longer (generally 70 to 100 per cent, one exception having 43 per cent). DECCW (Justen Simpson pers. comm.) reported some black water on the front of the inundation. No fish kills were reported though, as the site contained no waterholes with fish and there were large areas behind the front for fish to utilise.

Change in health if environmental water not provided
The health of river red gums and associated vegetation of cumbungi (*Typha orientalis*), spike rush (*Eleocharis spp.*) and common reed will decline and drought refuge and breeding habitat for waterbirds and frogs will not be provided.

<u>Secondary benefits</u>
This site is part of the larger North Redbank wetlands and is across the river from Yanga National Park, so it will contribute to the larger wetland system providing nesting areas for species that forage elsewhere it the complex and vice versa.

3. Potential risks
Risks and management actions have been identified in the DECCW proposal. Key risks identified in the proposal include:
1. **Unauthorised diversion** of environmental water by surrounding landholders. Regular channel inspections by State Water, NSW Office of Water and DECCW will be scheduled prior to and during the event. Rated as low. New flow recording stations will enable for shared use of the North Redbank Channel as flows will be metered both upstream and downstream of the irrigation offtakes.
2. **Carp**: Although sampling of the Autumn watering event (Spencer and Wassens unpublished 2010a,b) reported high proportions of carp in the system, the impact is likely to be low to moderate impact (no return flow to river and large area of habitats for frogs to hide from carp). The risk of carp must be seen in light of the fact that carp are likely to be a problem for any watering in the MDB – not something that applies to this action more than any other put forward.
3. **Water quality** in light of heavy load of organic matter from selective forestry in some areas. This is likely to have minimal impact due to the fact that there will be no return flows to the river from this section. Note also that although the current watering caused initial low dissolved oxygen levels (see criterion 2) the fact the area was watered in autumn 2010 and is still wet would mean a subsequent event is unlikely.
4. **Bird breeding**: it is anticipated that further NSW Environmental Water Allowance water, NSW Riverbank water and Commonwealth environmental water will become available to sustain a bird breeding event should it occur, unless severe drought conditions return to the catchment.

4. Long-term sustainability
<u>Adequacy of long term monitoring arrangements</u>
No management plan is in place for this site; however, the system is covered by the Murrumbidgee CMAs Lower Murrumbidgee Land and Water Management Plan and environmental water sharing rules are currently being developed as part of the New South Wales Office of Water (NOW) led Lowbidgee Water Management Plan.

Arrangements have been made with most landholders to exclude stock from watered wetlands until they are dry or aquatic plants have flowered/seeded.

Some properties are currently de-stocked with no view to restocking in the current season (“Murrundi”)

The water sharing plan provides an environmental water allowance. NSW also possesses over 13,000 ML of general security water and 5,000 ML of supplementary water entitlements for environmental use in the Murrumbidgee. The Commonwealth possesses over 64,000 ML of general security and 20,000 ML of supplementary water entitlements in the Murrumbidgee.

Selective logging is carried out on most properties and is governed by the property vegetation plan process overseen by Murrumbidgee CMA and DECCW.

The site is able to be watered via gravity feed.

<u>Complementary natural resource management activities</u>
There are currently no complementary natural resource activities; however, the Lowbidgee has been identified as a target for investment under Caring for our Country due to its identification as a draft HCVAE (Australian Government 2010).

<u>Effectiveness of monitoring, evaluation and reporting arrangements</u>
The proposed intervention monitoring of this watering action is in alignment with the watering objectives stated above. Additional information on the monitoring can be found at Attachment E.

5. Cost effectiveness
The action requires 5,000 ML with 5,000 ML matching from NSW. There are no delivery costs as this water will be gravity fed off the Redbank Weir pool through Glenn Dee Regulator and down Redbank Channel, however there are statutory fees and charges associated with delivery. Transmission losses will be limited as the Redbank Channel is already wetted from recent flows. New flow recording stations will enable shared use of channel flows as flows will be metered upstream and downstream of irrigation offtakes. NSW will manage the event and cover the costs of monitoring.

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North Redbank - Paika Lake, Paika Creek wetlands

DEWHA Assessment Summary	CEWH	Other
Site: Paika Creek, Paika Lake wetlands **Floodplain/region:** North Redbank Wetlands, Lowbidgee Floodplain **Catchment:** Murrumbidgee, NSW **Timing:** September-October	**Volume:** 4,500 ML **Cost:** $17,010 ($3.78/ML – fees and charges)	**Volume:** 3,500 ML (NSW)

Description of Watering Action and Objectives
Action would inundate 700 hectares of Paika Cree, Paika Lake area from spring lasting until mid summer.

Objective 1: To improve the condition of the river red gum (*Eucalyptus camaldulensis*) forest and associated wetland systems. This area also includes vegetation types such as lignum (*Muehlenbeckia florulenta*), black box (*Eucalyptus largiflorens*) and native reed (*Phragmites australis*).

Objective 2: Create habitat for numerous waterbird species including great egret, glossy ibis, blue billed duck, freckled duck, Australasian bittern and also the recently detected fishing bat (*Myotis macropus*: NSW vulnerable).

Description of site / watering history
River red gum dominated creek and lake system to the west of North Redbank Channel on the Lowbidgee Floodplain. It is understood that this area has not received water for ten years.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
<u>Threatened species and ecological communities and migratory species</u>

No data is available for this site and it is 5 km further west from the Murrumbidgee River and Yanga than other Redbank sites. However, it borders Paika – Narwie so information for that area has relevance to this area.

- 15 km from Redbank (Paul Coates) Swamp where southern bell frogs were recorded (Wassens *et al.* 2008).
- 10 km from Yanga, where the fishing bat has been recorded.
- Borders Narwie where the Australisian bittern ((*Botaurus poiciloptilus*, NSW vulnerable), which is listed as endangered internationally on IUCN Red List, has been recorded (Maher 1990)
- Borders Paika where glossy ibis (*Plegadis falcinellus*: EPBC migratory) were recorded by Spencer (2009) at Steam Engine Swap.
- Borders Paika where Maher (2006) also recorded 200 great egret nests (*Ardea alba*: EPBC migratory) Maher(1990) also recorded 6 great egret nests a Paika an dover 200 great egret nests and six cattle egret nests (*Ardea ibis*: EPBC migratory) at Paul Coates Swamp, 15 km to the north.
- Blue billed duck (*Oxyura australis*: NSW vulnerable) was recorded by Maher (1990) at Paul Coats Swamp 15 km to the north.

The North Redbank wetlands are part of the Aquatic ecological community in the natural drainage system of the lower Murray River catchment endangered ecological community (*Fisheries Management Act* 1994).

<u>Ecological values of asset</u>
DIWA listed, the Lowbidgee Wetlands extended over an area of 300 000 ha in the early 1900s. However, following water diversion and floodplain developments, 76.5 per cent of the wetlands are now lost or degraded (Kingsford and Thomas 2004).
The Lowbidgee Floodplain is also listed in "Refugia for biological diversity in arid and semi-arid Australia" (Morton *et al.* 1995) as a significant wetland refuge in the NSW Murray-Darling Depression (along with the neighbouring Great Cumbung Swamp).
The Lowbidgee is listed as a draft High Conservation Value Aquatic Ecosystem (HCVAE; Australian Government 2010) and a key hydrological indicator site by the MDBA (2010).

2. Expected ecological outcomes
Feasibility of achieving objectives
<u>Objective 1</u>: (improve condition of the red gum forest and associated wetland systems) Previous watering at neighbouring sites has shown improvements in river red gum health. Sharon Bowen (DECCW), who has undertaken extensive vegetation monitoring of the Lowbidgee will monitor vegetation.
<u>Objective 2</u>: (create habitat for waterbird species and fishing bat)
Neighbouring sites have previously supported a number of threatened and migratory species including for breeding (see above). Sampling will be undertaken for bats and waterbirds.

Consistency with CEWH objectives
Objectives 1, and 2 help prevent critical loss of species and provide drought refuge.

Current health of asset
As a whole, the condition of the North Redbank System is considered to be poor and declining (DECCW 2010). The site has moderate impact from grazing and limited selective forestry of river red gums.

Improvement in health expected from watering option
Uncertain due to lack of information. However, based on experience from neighbouring wetlands vegetation health improvement is expected and habitat for waterbirds would be provided.

Change in health if environmental water not provided
Expected continued decline in vegetation.

3. Potential risks
Key risks identified by DECCW include:
1. Unauthorised diversion of environmental water by surrounding landholders. Regular channel inspections by State Water, NSW Office of Water and DECCW will be scheduled prior to and during the event. Rated as low. New flow recording stations will enable for shared use of the North Redbank Channel as flows will be metered both upstream and downstream of the irrigation offtakes.
2. Carp: Likely to be low to moderate impact (no return flow to river and large area of habitats for frogs to hide in from carp). This risk must also be seen in the light of the fact that carp are likely to be a problem for any watering the MDB - not something that applies to this action more than any other put forward.
3. Water quality in light of heavy load of organic matter from selective forestry in some areas. This is likely to have minimal impact due to the fact that there will be no return flows to the river from this section.
4. Bird breeding: it is anticipated that further NSW Environmental Water Allowance water, NSW Riverbank water and CEWH water will become available to sustain a bird breeding event should it occur, unless severe drought conditions return to the catchment.

4. Long-term sustainability
Adequacy of long term monitoring arrangements
No management plan is in place for this site; however, the system is covered by the Murrumbidgee CMA's Lower Murrumbidgee Land and Water Management Plan and environmental water sharing rules are currently being developed as part of the NOW led Lowbidgee Water Management Plan.

Arrangements have been made with most landholders to exclude stock from watered wetlands until they are dry or aquatic plants have flowered/seeded. Landowners at "Dundomallee (part of Paika Lake)" have legally binding 10 year property vegetation plan agreements with the DECCW and Murrumbidgee CMA.

The water sharing plan provides an environmental water allowance. NSW also possesses over 13,000 ML of general security water and 5,000 ML of supplementary water entitlements for environmental use in the Murrumbidgee. The Commonwealth possesses over 64,000 ML of general security and 20,000 ML of supplementary water entitlements in the Murrumbidgee.
Selective logging is carried out on most properties and is governed by the property vegetation plan process overseen by Murrumbidgee CMA and DECCW.

The site is able to be watered via gravity feed.

This site is further from the Murrumbidgee River channel and is therefore seen as less of a 'core' site than other North Redbank wetlands and so its long term sustainability may be less.

Complementary natural resource management activities
There are currently no complementary natural resource activities; however, the Lowbidgee has been identified as a target for investment under Caring for our Country due to its identification as a draft HCVAE (Australian Government 2010).

Effectiveness of monitoring, evaluation and reporting arrangements
The proposed intervention monitoring of this watering action is in alignment with the watering objectives stated above. Additional information on the monitoring can be found at Attachment E.

5. Cost effectiveness

The action requires 4,500 ML with 3,500 ML matching from NSW. There are no delivery costs as this water will be gravity fed off the Redbank Weir pool through Glenn Dee Regulator and down Redbank Channel, however there are statutory fees and charges associated with delivery. Transmission losses will be limited as the Redbank Channel is already wetted from recent flows. New flow recording stations will enable shared use of channel flows as flows will be metered upstream and downstream of irrigation offtakes. NSW will manage the event and cover the costs of monitoring.

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North Redbank - Narwie/Paika/Wynburn complex

DEWHA Assessment Summary	CEWH	Other
Site: Paika/Narwie/Wynburn complex **Floodplain/region:** North Redbank Wetlands, Lowbidgee Floodplain **Catchment:** Murrumbidgee, NSW **Timing:** September-October	**Volume:** 7,500 ML **Cost:** $28,350 ($3.78/ML – fees and charges).	**Volume:** 7,500 ML (NSW)

Description of Watering Action and Objectives
Action would inundate 1,400 hectares of the Paika-Narwie-Wynburn complex (including Steam Engine Swamp) from spring lasting until mid summer.

Objective 1: To improve the condition of the river red gum (*Eucalyptus camaldulensis*) forest and associated wetland systems. This area also includes vegetation types such as lignum (*Muehlenbeckia florulenta*), black box (*Eucalyptus largiflorens*) and native reed (*Phragmites australis*).

Objective 2: Create habitat for numerous waterbird species including great egret, glossy ibis, blue billed duck, freckled duck, Australasian bittern and also the recently detected fishing bat (*Myotis macropus*: NSW vulnerable).

Objective 3: Create suitable habitat to facilitate the re-colonisation of the top end of the North Redbank system with southern bell frogs (*Litoria raniformis*: Commonwealth vulnerable, NSW endangered)

Objective 4: To improve river health by managing floodplain wetland return flows back to the Murrumbidgee River.

Description of site / watering history
Tall spike rush swamp surrounded by river red gums at the middle of North Redbank wetlands, off North Redbank Channel on the Lowbidgee Floodplain. 1,800 ha of Paika-Narwie were flooded with NSW environmental water allowance water in winter 2009 and dried out in summer. This was the first watering for four years in that system.

Comments against criteria for assessing 2010-11 environmental watering actions

1. Ecological Significance
<u>Threatened species and ecological communities and migratory species</u>
10 km from Redbank (Paul Coates) Swamp where southern bell frogs were recorded in 2001 and summer 2007-08 (Wassens *et al*. 2008). Southern bell frogs continue to be recorded (summer 2007-08, 2008-09, 2009-10) in Yanga National Park at Mercedes Wetland and Piggery Lake/Twin Bridges Complex (Wassens *et al.* 2008; Spencer and Wassens 2009; Maguire pers comm. - email 2009), which are 10 km across the river. Southern bell frogs were once widespread in the Lachlan and Murrumbidgee (Wassens 2008). The populations in the Lowbidgee are some of the last in the Murrumbidgee and are the closest to the Lachlan where it is now believed to be locally extinct (Wassens 2008). As such it is on the distribution limit of this species.

The fishing bat is likely to occur in the North Redbank system, based on the close proximity of recent detections in Yanga National Park and similar habitat (DECCW proposal 2010).

The Australasian bittern (*Botaurus poiciloptilus*, NSW vulnerable), which is listed as endangered internationally on IUCN Red List, has been recorded at Narwie (Maher 1990)

Glossy ibis (*Plegadis falcinellus*: EPBC migratory) were recorded by Spencer (2009) at Steam Engine Swamp, Paika. Maher (2006) also recorded 200 great egret nests (*Ardea alba*: EPBC migratory) at Paika. Maher (1990) also recorded 6 great egret nests at Paika and over 200 great egret nests and six cattle egret nests (Ardea ibis: EPBC migratory) at Paul Coates Swamp, 10 km to the north.

Blue-billed duck (*Oxyura australis*: NSW vulnerable) was recorded by Maher (1990) at Paul Coates Swamp, 10 km to the north.

White-bellied sea-eagle (*Haliaeetus leucogaster*; EPBC migratory) was recorded by Maher (1990) as nesting at nearby Glen Avon and as present at Baupie in May 2010 (J. Maguire pers. comm.).

The North Redbank wetlands are part of the Aquatic ecological community in the natural drainage system of the lower Murray River catchment endangered ecological community (NSW *Fisheries Management Act* 1994).

<u>Ecological values of asset</u>

DIWA listed, the Lowbidgee Wetlands extended over an area of 300 000 ha in the early 1900s. However, following water diversion and floodplain developments, 76.5 per cent of the wetlands are now lost or degraded (Kingsford and Thomas 2004).

The Lowbidgee Floodplain is also listed in "Refugia for biological diversity in arid and semi-arid Australia" (Morton *et al.* 1995) as a significant wetland refuge in the NSW Murray-Darling Depression (along with the neighbouring Great Cumbung Swamp).

The Lowbidgee is listed as a draft High Conservation Value Aquatic Ecosystem (HCVAE; Australian Government 2010) and a key hydrological indicator site by the MDBA (2010).

2. Expected ecological outcomes

Feasibility of achieving objectives

Objective 1: (improve condition of the red gum forest and associated wetland systems) Previous watering has shown improvements in river red gum health. Sharon Bowen (DECCW), who has undertaken extensive vegetation monitoring of the Lowbidgee will monitor vegetation.

Objective 2: (create habitat for waterbird species and fishing bat)
The site has previously supported a number of threatened and migratory species including for breeding (see above). Sampling will be undertaken for bats and waterbirds.

Objective 3: (create habitat to facilitate the re-colonisation of southern bell frogs)
Southern bell frogs have not been recorded at the site recently. However, they continue to be recorded 10 km from this site on the south side of the river in Yanga National Park. They have been recorded at Paul Coates Swamp, 10 km to the north in 2007-08.

This species is known to migrate across the landscape, therefore it is possible they will recolonise newly watered areas. Even so, it may take several years before the southern bell frog reaches this system as it is likely that the northern areas of North Redbank (particularly Paul Coates Swamp) will need to be recolonised before this area is colonised. Frog monitoring will be undertaken.

Objective 4: (return flows to the river) Wynburn escape regulator located on the Murrumbidge River at Paika can be operated to release flows of up to several hundred ML per day to the river, water quality permitting. This will be monitored for water quality and fish, carbon and zooplankton upstream and downstream.

Consistency with CEWH objectives

Objectives 1, 2 and 3 help prevent critical loss of species (particularly southern bell frog) and provide drought refuge.

Current health of asset

As a whole, the condition of the North Redbank System is considered to be poor and declining (DECCW 2010). However, Paika-Narwie is in moderate health due to the winter 2009 flooding.

The site has moderate impact from grazing and limited selective forestry of river red gums.

Improvement in health expected from watering option

Watering in 2009 has improved the health of this asset; however, follow up watering is required to consolidate the gains made in vegetation health. Previous watering has provided breeding for listed waterbirds (see notes under criterion 1). In addition to listed birds the breeding event of 1989-90 supported 2000 nests of rufous night herons as well as royal and yellow-billed spoonbills, intermediate egrets and Pacific herons (Maher 1990).

The site was watered in winter 2009 with positive response recorded in October 2009 sampling including good water quality (low turbidity, neutral pH, low salinity), high diversity of aquatic vegetation, five species of frogs (with three species with tadpoles) and 18 waterbird species (Wassens and Spencer, unpublished). The site had one of the best responses form nine sites sampled across the Lowbidgee.

Change in health if environmental water not provided

Southern bell frog recolonisation will not be achieved without the provision of water to the site. The long-term persistence of this species depends on regular flooding events to promote recruitment (Wassens *et al.* 2008). The health of river red gums and associated vegetation of cumbungi (*Typha orientalis*), spike rush (*Eleocharis spp.*) and common reed will continue to decline and drought refuge and breeding habitat for waterbirds will not be provided.

Secondary benefits

Returning water to the river in a through-flow system will increase connectivity and return highly productive, carbon rich water back to the river. It will also allow the passage of fish, eggs and seeds to the river.

This site is part of the larger North Redbank wetlands and is across the river from Yanga National Park, so it will contribute to the larger wetland system providing nesting areas for species that forage elsewhere it the complex and vice versa.

3. Potential risks
Key Risks identified by DECCW include:
1. Unauthorised diversion of environmental water by surrounding landholders. Regular channel inspections by State Water, NSW Office of Water and DECCW will be scheduled prior to and during the event. Rated as low. New flow recording stations will enable for shared use of the North Redbank Channel as flows will be metered both upstream and downstream of the irrigation offtakes.
2. Carp: Likely to be low to moderate impact (limited return flow to river and large area of habitats for frogs to hide in from carp). The risk of carp must be seen in light of the fact that carp are likely to be a problem for any watering in the MDB - not something that applies to this action more than any other put forward.
3. Water quality in light of heavy load of organic matter from selective forestry in some areas. This is likely to have minimal impact due to the fact that there will be controlled return flows to the river from this section. Note also that Paika-Narwie was watered in winter 2009, therefore there has been less time for organic matter to build up. Dissolved oxygen, conductivity, turbidity and temperature were measured and found to be in normal ranges during the last watering at this site (Wassens and Spencer, unpublished).
4. Bird breeding: it is anticipated that further NSW Environmental Water Allowance water, NSW Riverbank water and Commonwealth environmental water will become available to sustain a bird breeding event should it occur, unless severe drought conditions return to the catchment.

4. Long-term sustainability
<u>Adequacy of long term monitoring arrangements</u>
No management plan is in place for this site; however, the system is covered by the Murrumbidgee CMAs Lower Murrumbidgee Land and Water Management Plan and environmental water sharing rules are currently being developed as part of the NOW led Lowbidgee Water Management Plan.

Arrangements have been made with most landholders to exclude stock from watered wetlands until they are dry or aquatic plants have flowered/seeded.

The water sharing plan provides an environmental water allowance. NSW also possesses over 13,000 ML of general security water and 5,000 ML of supplementary water entitlements for environmental use in the Murrumbidgee. The Commonwealth possesses over 64,000 ML of general security and 20,000 ML of supplementary water entitlements in the Murrumbidgee.

Selective logging is carried out on most properties and is governed by the property vegetation plan process overseen by Murrumbidgee CMA and DECCW.

The site is able to be watered via gravity feed.

<u>Complementary natural resource management activities</u>
There are currently no complementary natural resource activities, however, the Lowbidgee has been identified as a target for investment under Caring for our Country due to its identification as a draft HCVAE (Australian Government 2010).

<u>Effectiveness of monitoring, evaluation and reporting arrangements</u>
The proposed intervention monitoring of this watering action is in alignment with the watering objectives stated above. Additional information on the monitoring can be found at Attachment E.

5. Cost effectiveness
The action requires 7,500 ML with 7,500 ML matching from NSW. There are no delivery costs as this water will be gravity fed off the Redbank Weir pool through Glenn Dee Regulator and down Redbank Channel, however there are statutory fees and charges associated with delivery. Transmission losses will be limited as the Redbank Channel is already wetted from recent flows. New flow recording stations will enable shared use of channel flows as flows will be metered upstream and downstream of irrigation offtakes. NSW will manage the event. The CEWH has been requested to contribute towards monitoring activities during the watering.

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North Redbank - Redbank (Paul Coates) Swamp

DEWHA Assessment Summary	CEWH	Other
Site: Redbank (Paul Coates) Swamp **Floodplain/region:** North Redbank Wetlands, Lowbidgee Floodplain **Catchment:** Murrumbidgee, NSW **Timing:** September-October	**Volume:** 3,000 ML **Cost:** $11,340 ($3.78/ML – fees and charges)	**Volume:** 0 ML

Description of Watering Action and Objectives
Action would inundate 421 hectares of Redbank Swamp (also known as Paul Coates Swamp) from spring lasting until mid summer.

Objective 1: To improve the condition of the river red gum (*Eucalyptus camaldulensis*) forest and associated wetland systems. This area also includes vegetation types such as lignum (*Muehlenbeckia florulenta*), black box (*Eucalyptus largiflorens*) and native reed (*Phragmites australis*).

Objective 2: Create habitat for numerous waterbird species including great egret, glossy ibis, blue billed duck, freckled duck, Australasian bittern and also the recently detected fishing bat (*Myotis macropus*: NSW vulnerable).

Objective 3: Create suitable habitat to facilitate the re-colonisation of the top end of the North Redbank system with southern bell frogs (*Litoria raniformis*: Commonwealth vulnerable, NSW endangered)

Description of site / watering history
River red gum dominated swamp at the upper end of Redbank Channel, nearest Redbank Weir on the Lowbidgee Floodplain. Redbank (Paul Coates) Swamp was flooded in 2007-08 and 2008-09.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
Threatened species and ecological communities and migratory species
Some 92 southern bell frogs were recorded at Paul Coates Swamp in one night in 2001 and a number of adults were recorded during the watering in summer 2007-08 (Wassens *et al.* 2008). Southern bell frogs continue to be recorded (summer 2007-08, 2008-09, 2009-10) in Yanga National Park at Mercedes Wetland and Piggery Lake/Twin Bridges Complex (Wassens *et al.* 2008; Spencer and Wassens 2009; Maguire pers comm. - email 2009), which are directly across the river. Southern bell frogs were once widespread in the Lachlan and Murrumbidgee (Wassens 2008). The populations in the Lowbidgee are some of the last in the Murrumbidgee and are the closest to the Lachlan where it is now believed to be locally extinct (Wassens 2008). As such it is on the distribution limit of this species.

The fishing bat is likely to occur in the North Redbank system, based on the close proximity of recent detections in Yanga National Park and similar habitat (DECCW proposal 2010).

The Australasian bittern (*Botaurus poiciloptilus*, NSW vulnerable), which is listed as endangered internationally on IUCN Red List, has been recorded at Narwie, approximately 10 km to the south (Maher, 1990)

Glossy ibis (*Plegadis falcinellus*: EPBC migatory) were recorded by Spencer (2009) at Steam Engine Swamp, Paika, approximately 15 km to the south.

Maher (1990) recorded over 200 great egret nests (*Ardea alba*: EPBC migratory) and six cattle egret nests (*Ardea ibis*: EPBC migratory) at Paul Coates Swamp. Maher (2006) also recorded 200 nests at nearby Paika.

Blue-billed duck (*Oxyura australis*: NSW vulnerable) was recorded by Maher (1990) at Paul Coates Swamp.
The North Redbank wetlands are part of the Aquatic ecological community in the natural drainage system of the lower Murray River catchment endangered ecological community (*Fisheries Management Act* 1994).

Ecological values of asset
DIWA listed, the Lowbidgee Wetlands extended over an area of 300 000 ha in the early 1900s. However, following water diversion and floodplain developments, 76.5 per cent of the wetlands are now lost or degraded (Kingsford and Thomas 2004).

The Lowbidgee Floodplain is also listed in "Refugia for biological diversity in arid and semi-arid Australia" (Morton *et al.* 1995) as a significant wetland refuge in the NSW Murray-Darling Depression (along with the neighbouring Great Cumbung Swamp).

The Lowbidgee is listed as a draft High Conservation Value Aquatic Ecosystem (HCVAE; Australian Government 2010) and a key hydrological indicator site by the MDBA (2010).

2. Expected ecological outcomes
Feasibility of achieving objectives
Objective 1: (improve condition of the red gum forest and associated wetland systems) Previous watering has shown improvements in river red gum health. Sharon Bowen (DECCW), who has undertaken extensive vegetation monitoring of the Lowbidgee will monitor vegetation.

Objective 2: (create habitat for waterbird species and fishing bat)
The site has previously supported a number of threatened and migratory species including for breeding (see above). Sampling will be undertaken for bats and waterbirds.

Objective 3: (create habitat to facilitate the re-colonisation of southern bell frogs)
Southern bell frogs were not detected last time (2008-09) Paul Coates Swamp was watered. However, they continue to be recorded just a few hundred metres from this site on the south side of the river in Yanga National Park. They have been recorded in the past, and during previous watering events (last recorded in 2007-08 summer watering at Paul Coates Swamp) This species is known to migrate across the landscape, therefore it is possible they will recolonise newly watered areas. Frog monitoring will be undertaken.

Consistency with CEWH objectives
The objectives help prevent critical loss of species (particularly southern bell frog) and provide drought refuge.

Current health of asset
As a whole, the North Redbank System is considered to be in poor and declining condition (DECCW 2010). However, Redbank (Paul Coates) Swamp is in good to moderate health as it was flooded in summer 2007-08 and summer 2008-09.

The site has moderate impact from grazing and limited selective forestry of river red gums.

Improvement in health expected from watering option
Watering in 2007-08 and 2008-09 by NSW has improved the health of this asset; however, follow up watering is required to consolidate the gains made in vegetation health. Previous watering has provided breeding for waterbirds (see notes under criterion 1). In addition to the 200 great egret and 6 cattle egret nests recorded by Maher in 1990, little egrets (60 nests), intermediate egrets (500 nests), royal spoonbills, sacred ibis, rufous night-herons (1000 nests), cormorants (600 nests) and darters (Maher 1990) were also recorded. Since then, logging activities and the construction of the North Redbank channel appear to have reduced the nesting value of this site (Maguire, DECCW, pers. comm.). However, good waterbird responses are still anticipated. It is highly likely that southern bell frog will breed at the site due to their presence at the site historically and the presence of southern bell frogs at Mercedes Swamp, which is only 1 km across the river.

The 2008-09 watering event had a positive response including good water quality (low turbidity, low salinity), high diversity of aquatic vegetation and four species of frogs, although only four species of waterbird were recorded (Spencer and Wassens, 2009).

Change in health if environmental water not provided
Southern bell frog recolonisation will not be achieved without the provision of water to the site. The long-term persistence of this species depends on regular flooding events to promote recruitment (Wassens *et al.* 2008). The health of river red gums and associated vegetation of cumbungi (*Typha orientalis*), spike rush (*Eleocharis spp.*) and common reed will decline and drought refuge and breeding habitat for waterbirds will not be provided.

Basin-wide significance of ecological response:
Recolonisation of southern bell frogs will extend the limit of the species and help secure the Lowbidgee population which is one of the last in the Murrumbidgee. This site is also the closest to the Great Cumbung Swamp in the Lachlan and presents a path for recolonisation to the Lachlan where it is now believed to be locally extinct (Wassens 2008).

Secondary benefits
This site is part of the larger North Redbank wetlands and is across the river from Yanga National Park, so it will contribute to the larger wetland system providing nesting areas for species that forage elsewhere it the complex and vice versa.

3. Potential risks

Key risks identified by DECCW include:
1. **Unauthorised diversion** of environmental water by surrounding landholders. Regular channel inspections by State Water, NSW Office of Water and DECCW will be scheduled prior to and during the event. Rated as low. New flow recording stations will enable for shared use of the North Redbank Channel as flows will be metered both upstream and downstream of the irrigation offtakes.
2. **Carp**: Likely to be low to moderate impact (no return flow to river and large area of habitats for frogs to hide in from carp). This risk should also be considered in light of the fact that carp are a problem for any watering the MDB - not something that applies to this action more than any other put forward.
3. **Water quality** in light of heavy load of organic matter from selective forestry in some areas. This is likely to have minimal impact due to the fact that there will be no return flows to the river from this section. Note also that Paul Coates Swamp was watered in January 2009, therefore there has been less time for organic matter to build up. Dissolved oxygen, conductivity, turbidity and temperature were measured and found to be in normal ranges during the last watering at this site (Spencer and Wassens, 2009).
4. **Bird breeding**: it is anticipated that further NSW Environmental Water Allowance water, NSW Riverbank water and Commonwealth environmental water will become available to sustain a bird breeding event should it occur, unless severe drought conditions return to the catchment.

4. Long-term sustainability

Adequacy of long term monitoring arrangements

No management plan is in place for this site; however, the system is covered by the Murrumbidgee CMAs Lower Murrumbidgee Land and Water Management Plan and environmental water sharing rules are currently being developed as part of the NOW led Lowbidgee Water Management Plan.

Arrangements have been made with most landholders to exclude stock from watered wetlands until they are dry or aquatic plants have flowered/seeded.

The water sharing plan provides an environmental water allowance. NSW also possesses over 13,000 ML of general security water and 5,000 ML of supplementary water entitlements for environmental use in the Murrumbidgee. The Commonwealth possesses over 64,000 ML of general security and 20,000 ML of supplementary water entitlements in the Murrumbidgee.

Selective logging is carried out on most properties and is governed by the property vegetation plan process overseen by Murrumbidgee CMA and DECCW.

The site is able to be watered via gravity feed.

Complementary natural resource management activities

There are currently no complementary natural resource activities, however, the Lowbidgee has been identified as a target for investment under Caring for our Country due to its identification as a draft HCVAE (Australian Government 2010).

Effectiveness of monitoring, evaluation and reporting arrangements

The proposed intervention monitoring of this watering action is in alignment with the watering objectives stated above. Additional information on the monitoring can be found at Attachment E.

5. Cost effectiveness

The action requires 3,000 ML; however, NSW will be providing contributions to neighbouring wetlands. There are no delivery costs as this water will be gravity fed off the Redbank Weir pool through Glenn Dee Regulator and down Redbank Channel, however there are statutory fees and charges associated with this action. Transmission losses will be minimal as the site is adjacent to Redbank Weir and transmission distance is negligible. There is a new flow metering station at Glen Dee Regulator. NSW will manage the event and cover the costs of monitoring.

References

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North Redbank - Tori/Lake Marimley/ Jindeena/ Athen complex

DEWHA Assessment Summary	CEWH	Other
Site: Tori/Lake Marimley/ Jindeena/ Athen complex **Floodplainregion**: North Redbank Wetlands, Lowbidgee Floodplain **Catchment:** Murrumbidgee, NSW **Timing:** September-October	**Volume:** 15,000 ML **Cost:** $56,700 ($3.78/ML – fees and charges)	**Volume:** 15,000 ML

Description of Watering Action and Objectives
Action would inundate 4,000 hectares of the Tori/ Lake Marimley/ Jindeena/ Athen complex from spring lasting until mid summer.

Objective 1: To improve the condition of the river red gum (*Eucalyptus camaldulensis*) forest and associated wetland systems. This area also includes vegetation types such as lignum (*Muehlenbeckia florulenta*), black box (*Eucalyptus largiflorens*) and native reed (*Phragmites australis*).

Objective 2: Create habitat for numerous waterbird species including great egret, glossy ibis, blue billed duck, freckled duck, Australasian bittern and also the recently detected fishing bat (*Myotis macropus*: NSW vulnerable).

Objective 3: Create suitable habitat to facilitate the re-colonisation of the top end of the North Redbank system with southern bell frogs (*Litoria raniformis*: Commonwealth vulnerable, NSW endangered)

Description of site / watering history
River red gums at the middle of North Redbank wetlands, off North Redbank Channel on the Lowbidgee Floodplain. The wetland has not been watered for 5 years.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
<u>Threatened species and ecological communities and migratory species</u>
No information was available for the properties covered by this complex. However, it borders Redbank Swamp to the north and the Paika-Narwie complex to the south and is opposite Mercedes Swamp and Piggery Lake in Yanga National Park (directly across the river). Below, information for Redbank Swamp and Paika-Narwie are referenced to give an indication of the species likely to be present in this wetland complex.

Southern bell frogs were recorded at Redbank Swamp in 2001 and summer 2007-08 (Wassens *et al.* 2008). Southern bell frogs continue to be recorded (summer 2007-08, 2008-09, 2009-10) in Yanga National Park at Mercedes Wetland and Piggery Lake/Twin Bridges Complex (Wassens *et al.* 2008; Spencer and Wassens 2009; Maguire pers comm. - email 2009). Southern bell frogs were once widespread in the Lachlan and Murrumbidgee (Wassens 2008). The populations in the Lowbidgee are some of the last in the Murrumbidgee and are the closest to the Lachlan where it is now believed to be locally extinct (Wassens 2008). As such it is on the distribution limit of this species.

The fishing bat is likely to occur in the North Redbank system, based on the close proximity of recent detections in Yanga National Park and similar habitat (DECCW proposal 2010).

The Australasian bittern (*Botaurus poiciloptilus*, NSW vulnerable), which is listed as endangered internationally on IUCN Red List, has been recorded at Narwie (Maher, 1990)

Glossy ibis (*Plegadis falcinellus*: EPBC migatory) were recorded by Spencer (2009) at Steam Engine Swamp, Paika.

Maher (2006) also recorded 200 great egret nests (*Ardea alba*: EPBC migratory) at Paika. Maher (1990) also recorded 6 great egret nests at Paika and over 200 great egret nests and six cattle egret nests (*Ardea ibis*: EPBC migratory) at Redbank Swamp.

Blue-billed duck (*Oxyura australis*: NSW vulnerable) was recorded by Maher (1990) at Redbank Swamp.

The North Redbank wetlands are part of the Aquatic ecological community in the natural drainage system of the lower Murray River catchment endangered ecological community (*Fisheries Management Act* 1994).

<u>Ecological values of asset</u>
DIWA listed, the Lowbidgee Wetlands extended over an area of 300 000 ha in the early 1900s. However, following water diversion and floodplain developments, 76.5 per cent of the wetlands are now lost or degraded (Kingsford and Thomas 2004).

The Lowbidgee Floodplain is also listed in "Refugia for biological diversity in arid and semi-arid Australia" (Morton *et al.* 1995) as a significant wetland refuge in the NSW Murray-Darling Depression (along with the neighbouring Great Cumbung Swamp).

The Lowbidgee is listed as a draft High Conservation Value Aquatic Ecosystem (HCVAE; Australian Government 2010) and a key hydrological indicator site by the MDBA (2010).

2. Expected ecological outcomes
Feasibility of achieving objectives
Objective 1: (improve condition of the red gum forest and associated wetland systems) Previous watering at neighbouring sites has shown improvements in river red gum health. Sharon Bowen (DECCW), who has undertaken extensive vegetation monitoring of the Lowbidgee will monitor vegetation.

Objective 2: (create habitat for waterbird species and fishing bat)
Neighbouring sites have previously supported a number of threatened and migratory species including for breeding (see above). Sampling will be undertaken for bats and waterbirds.

Objective 3: (create habitat to facilitate the re-colonisation of southern bell frogs)
Southern bell frogs have been recorded at neighbouring Redbank Swamp (although not in the most recent 2008-09 watering). They continue to be recorded across the river in Yanga National Park. This species is known to migrate across the landscape, therefore it is possible they will recolonise newly watered areas. Frog monitoring will be undertaken.

Consistency with CEWH objectives
Objectives 1, 2 and 3 help prevent critical loss of species (particularly southern bell frog) and provide drought refuge.

Current health of asset
As a whole, the condition of the North Redbank System is considered to be poor and declining (DECCW 2010). The site has moderate impact from grazing and limited selective forestry of river red gums.

Improvement in health expected from watering option
Watering is likely to improve vegetation health and provided breeding for listed waterbirds as has occurred as a result of past water events in neighbouring sites (see notes under criterion 1).

Change in health if environmental water not provided
Southern bell frog recolonisation will not be achieved without this water. The long-term persistence of this species depends on regular flooding events to promote recruitment (Wassens *et al.* 2008). The health of river red gums and associated vegetation of cumbungi (*Typha orientalis*), spike rush (*Eleocharis spp.*) and common reed will decline and drought refuge and breeding habitat for waterbirds will not be provided.

Secondary benefits
This site is part of the larger North Redbank wetlands and is across the river from Yanga National Park, so it will contribute to the larger wetland system providing nesting areas for species that forage elsewhere it the complex and vice versa.

3. Potential risks
Key risks identified by DECCW include:
1. Unauthorised diversion of environmental water by surrounding landholders. Regular channel inspections by State Water, NSW Office of Water (NOW) and DECCW will be scheduled prior to and during the event. Rated as low. New flow recording stations will enable for shared use of the North Redbank Channel as flows will be metered both upstream and downstream of the irrigation offtakes.
2. Carp: Likely to be low to moderate impact (no return flow to river and large area of habitats for frogs to hide in from carp). This risk must also be seen in the light of the fact that carp are likely to be a problem for any watering the MDB - not something that applies to this action more than any other put forward.
3. Water quality in light of heavy load of organic matter from selective forestry in some areas. This is likely to have minimal impact due to the fact that there will be no return flows to the river from this section.
4. Bird breeding: it is anticipated that further NSW Environmental Water Allowance water, NSW Riverbank water and Commonwealth environmental water will become available to sustain a bird breeding event should it occur, unless severe drought conditions return to the catchment.

4. Long-term sustainability
Adequacy of long term monitoring arrangements

No management plan is in place for this site; however, the system is covered by the Murrumbidgee CMAs Lower Murrumbidgee Land and Water Management Plan and environmental water sharing rules are currently being developed as part of the NOW led Lowbidgee Water Management Plan.

Arrangements have been made with most landholders to exclude stock from watered wetlands until they are dry or aquatic plants have flowered/seeded. Landowners at "Athen" have legally binding 10 year property vegetation plan agreements with the DECCW and Murrumbidgee CMA.

The water sharing plan provides an environmental water allowance. NSW also possesses over 13,000 ML of general security water and 5,000 ML of supplementary water entitlements for environmental use in the Murrumbidgee. The Commonwealth possesses over 64,000 ML of general security and 20,000 ML of supplementary water entitlements in the Murrumbidgee.

Selective logging is carried out on most properties and is governed by the property vegetation plan process overseen by Murrumbidgee CMA and DECCW.

The site is able to be watered via gravity feed.

<u>Complementary natural resource management activities</u>
There are currently no complementary natural resource activities; however, the Lowbidgee has been identified as a target for investment under Caring for our Country due to its identification as a draft HCVAE (Australian Government 2010).

<u>Effectiveness of monitoring, evaluation and reporting arrangements</u>
The proposed intervention monitoring of this watering action is in alignment with the watering objectives stated above. Additional information on the monitoring can be found at Attachment E.

5. Cost effectiveness
The action requires 7,500 ML with 7,500 ML matching from NSW. There are no delivery costs as this water will be gravity fed off the Redbank Weir pool through Glenn Dee Regulator and down Redbank Channel, however there are statutory fees and charges associated with this action. Transmission losses will be limited as the Redbank Channel is already wetted from recent flows. New flow recording stations will enable shared use of channel flows as flows will be metered upstream and downstream of irrigation offtakes. NSW will manage the event and cover the costs of monitoring.

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Severn River

DEWHA Assessment Summary	CEWH	Other
Site: Severn River below Pindari Dam **Floodplain/region:** Severn River **Catchment:** Border Rivers **Timing:** September-December	**Volume:** 260 ML **Cost:** $2,483 ($9.55/ML statutory fees and charges)	**Volume:** 8,000 ML

Description of Watering Action and Objective

The action will provide a pulse of water lasting around 4-7 days to simulate natural ecological processes in the Severn River below Pindari Dam. The objectives of the release are to:

1. Provide a flow that mirrors a naturally occurring hydrograph
2. Provide the pre-season cues to fish breeding
3. Repeatedly wet and interconnect riparian areas
4. Add to the environmental benefits of translucency releases from Pindari Dam.

Stimulatory effects are focused on the reach of the Severn from below the dam to the confluence with Frazers Creek (22 km). However, as the volume available is more than twice that of releases in previous stimulus flows, aquatic benefits are likely to extend further downstream, including the length of the Severn (60 km) and potentially as far as Holdfast on the Macintyre River (122 km downstream of the dam).

The value of Commonwealth water is to achieve higher peak flows and velocities (and extend the duration of these) and extend transmission of the flow pulse downstream. High velocity flows are required to tumble boulders to scour algae and reset biofilm processes and (in conjunction with intervals of low flow) may disrupt access by the exotic mosquitofish (*Gambusia holbrooki*) to riparian slackwater and backwater areas in the Severn River (Wilson and Ellison 2010 *in prep*).

The Commonwealth water will enhance in-stream flows through the length of the Macintyre River as far as Mungindi. Alternatively, if a robust and operationally feasible option for off-stream use (e.g. to fill a floodplain lagoon or effluent channel etc) in the lower Macintyre is identified and arranged before the stimulus release is made, the Commonwealth water could be diverted from the river to undertake this secondary watering action.

The action requires a high degree require cooperation between NSW and Queensland scheme operators and agencies and coordination of river operations in both states.

Description of site / watering history

The asset watered in this action is the in-stream and riparian environments of the NSW Severn and Macintyre Rivers in the reach from Pindari Dam to the confluence of the Severn and Macintyre Rivers (60kms) and a further 60 km of the Macintyre to Holdfast.

Stimulus flows have been provided from Pindari Dam from around 1996, in accordance with rules set out in the Environmental Impact Statement for the enlargement of the dam (DWR 1991). Releases were made automatically, generally twice a year, if there were 90 consecutive days of less than 400 ML/day flow at Ashford, then at a rate of 150 ML/d for 2 days, 2 days at 400 ML/d and 2 days of 150 ML/day. The most recent releases occurred in May 2009 and September 2010.

The release this year will be the first made under the revised stimulus flow rules in the 2009 NSW Border Rivers Water Sharing Plan (WSP). The rules provide for 4,000 ML/year to be released between 1 August and 1 December, triggered by inflow of greater than 1,200 ML/day in the preceding four months (April-August). Water set aside but not released can be carried over to the next water year to a maximum of 8,000 ML. Trigger inflows did not occur in 2009-10, so 4,000 ML/d has been carried over to 2010-11.

The release pattern for the increased volume (8,000+ ML) available for the 2010 stimulus flow, is still being considered by DECWW and the NSW Office of Water (NOW). A pattern recently proposed for a volume of 4,000 ML is for a peak discharge of 1,200 ML/day on Day 1, stepping down at a progressively slower rate over the following six days (i.e. 900 ML/day, 600 ML/day, 450 ML/day, 300 ML/day, 250 ML/day, 200 ML/day). (*pers. comm*. Neal Foster, NOW).

Comments against criteria for assessing 2010-11 environmental watering actions

1. Ecological Significance

Wetlands on the Severn River downstream of Duncanmara Creek, upstream of Ashford power station and within Kwiambal National Park are identified as important ecological features that rely on natural flow variability and medium floods to maintain health and diversity (DWE 2009).

The target river reaches sustain high fish diversity and provide good refuge conditions for native fish, particularly the Macintyre River. Native fish recorded include: silver perch (*Bidyanus bidyanus*: NSW vulnerable); purple spotted gudgeon (*Mogurnda adspersa*: NSW endangered); olive perchlet (*Ambassis agassizi:* NSW endangered population) and Murray Cod (*Maccullochella peelii peelii*: Cwth vulnerable – has not been documented in reach just below Pindari

Dam). There are unconfirmed, though widely accepted, reports of the eel-tailed catfish (*Tandanus tandanus*: NSW endangered population) throughout the Severn and Macintyre Rivers.

Other threatened aquatic species and ecological communities documented in the area are:

- Invertebrates and frogs: river snail (*Notopala sublineata*: NSW endangered); the boorolong frog (*Litoria boorolongensis*: Cwth & NSW endangered); sphagnum frog (*Philoria sphagnicolus*: NSW vulnerable); yellow-spotted bell frog (*Litoria castanea*: Cwth & NSW endangered) and the tusked frog (*Adelotus brevis:* NSW endangered population)
- Waterbirds: black-necked stork (*Ephippiorhynchus asiaticus*: NSW endangered; Qld rare); blue-billed duck (*Oxyura australis*; NSW vulnerable, EPBC migratory); brolga (*Grus rubicunda*; NSW vulnerable); comb-crested Jacana (*Irediparra gallinacean*: NSW vulnerable); freckled duck (*Stictonetta naevosa*: NSW vulnerable, Qld rare, EPBC migratory); painted snipe (*Rostratula australis*: Cwth & Qld vulnerable; NSW endangered; EPBC migratory); regent honeyeater (*Anthochaera phrygia*: Cwth & NSW endangered).
- Endangered ecological communities

  (Threatened Species Conservation Act 1995):
  - Upland Wetlands of the Drainage Divide of the New England Tablelands (occurs in areas of the Tenterfield, Guyra, Severn, Dumaresq and Uralla local government areas, including in the catchments of the Severn and Macintyre Rivers in the target reach)

  (Fisheries Management Act 1994):
  - Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River. Listing includes the Severn (NSW) and Macintyre Rivers

(Source for previous 4 paragraphs is NSW Officer of Water, unpubl data)

Kwiambal national park covers 7,157 ha of the area around the junction of the Severn and Macintyre Rivers. The park contains diverse plant communities, including significant patches of dry rainforest and white cypress-pine woodlands that are poorly represented in the NSW reserve network and the Northern Complex Province of the Nandewar Biogeographical Region. Other ecologically significant features are caves that provide important habitat for rare cave fauna including a viable population of the large bent-wing bat (*Miniopterus schreibersii*, vulnerable NSW) and the eastern horseshoe bat (*Rhinolophus megaphyllus*), plus a large number of rare or threatened plant and animal species. The river reaches within the park have high scenic value featuring huge in-stream granite boulders and spectacular gorges, including Macintyre Falls and the Severn River Falls. (NPWS 2004)

2. Expected ecological outcomes

Water requirements (volume, pattern of release, timing) to achieve the ecological objectives of the stimulus flow were investigated in the EIS for the enlargement of Pindari Dam (DWE 1991) and more recently at length within DECCW (and its forerunners) and a community consultative committee as part of the preparation of the 2009 WSP. The effectiveness of previous flows in meeting desired objectives in the Severn River has been assessed in before and after monitoring and in a focused study on the effects of the flow on the recruitment of native fish species (Wilson and Ellison 2010 in prep).

Objectives 1, 2 and 3 of this action are consistent with the CEWH environmental watering objectives for dry condition, i.e to support the survival and growth of threatened species and communities, including limited small-scale recruitment; maintain diverse habitats.

Three subcatchments that cover the reaches of the Severn and Macintyre River targeted in this action were rated as being in fair condition (score of 4, with 5 being the poorest category) using a Riverine Condition Assessment that incorporated water quality, hydrology, physical form, aquatic life (macroinvertebrates) and riparian vegetation indicators (DLWC 2001). The Yetman subcatchment, which covers the lower part of the NSW Macintyre River, had one of the worst levels of erosion (gully and streambank) in the 21 subcatchments of the Macintyre River valley.

3. Potential risks

The main risks identified for delivery of this action are:

Channel capacity: Peak discharge rates may drown and prevent use of low level river crossings in the Servern River below the dam. However, the duration of the high flow is short and is within the range of maximum irrigation releases made from the Dam

Cold water pollution: At higher discharge rates, releases from Pindari Dam may have thermal effects in the Severn River that could potentially compromise the fish breeding objectives of the stimulus flow (Wilson and Ellison 2010 in prep). This extent of this risk and possible mitigation strategies will be explored further with NOW prior to the Commonwealth water being made available for this action. Potential impacts on fish may be minimised by delaying stimulus release till late in the spawning season (December to January) to safeguard recruitment of success of native fish species, particularly the eel-tailed catfish, for which a rise in ambient river temperature appears the primary trigger for spawning.

Pindari Dam has multiple offtakes at various depths. Cold water pollution impacts would be minimised by utilising a highest possible level offtake for the stimulus flow release.

Downstream diversion: The NSW stimulus flow is protected from downstream diversion to the Frazers Creek confluence only (~ 22km). However, NOW is proposing to negotiate with irrigators (through the Border Rivers Food and Fibre organisation) to delay or minimise ordering and accessing irrigation water during the release, to preserve the pulse as far as possible down the river . The Commonwealth will nominate a works for the delivery of its water as far downstream as possible, either at Goondiwindi (~190 km downstream of Pindari) if the water is to be used again for a secondary watering action, or Mungindi (~360 km downstream), ensuring the full volume (260 ML) is protected to these points.

4. Long-term sustainability

Complementary natural resource management activities: The Pindari Dam stimulus flow and translucency rules (i.e. inflows up to 50 ML/day between September and May passed downstream; up to 200 ML/d between June-August) in the Border Rivers WSP recognise and attempt to mitigate the impacts of the dam on the natural hydrological regime and aquatic ecosystems in the Severn River. Kwiambal National Park protects stretches of the Severn and Macintyre Rivers and their catchment of high conservation and scenic value. It is not known if other legal or voluntary mechanisms to protect riparian and in-stream environments are in place in the target river reach.

Adequacy of long-term monitoring: NOW is yet to confirm intervention monitoring activities for the 2010 stimulus flow. On previous occasions, they have monitored the response of algal (biofilm) and benthic communities in the Severn River below Pindari Dam as far as its confluence with Frazers Creek (~22 km). Hydrological data is also monitored to determine if the planned release pattern and downstream hydrograph was achieved. Monitoring in 2010 is likely to be similar in scope. A comprehensive 5 year (before-after-control-impact) study assessed the potential effects of the stimulus flow discharges on spawning and recruitment success of native fish populations (Wilson and Ellison 2010 in prep). This work provides guidance on the optimal timing and concurrent flow management activities to achieve fish management objectives.

5. Cost effectiveness

The volume contributed by the Commonwealth (260 ML) to this action is very small, with the majority of the water (8,000 ML) coming from NSW. There are no delivery costs as water will be released directly from Pindari Dam, however fees will apply for Queensland statutory water use charges and transfer fees. The NSW water will incur natural transmission losses flowing down the Severn (60km) and Macintyre (60 km) Rivers as well as some degree of diversionary loss within this reach below Frazer Creek confluence. However, the Commonwealth volume will be preserved in full through the target reach and beyond to a delivery/accounting point as far down the system as possible, probably Goondiwindi if an option for off-stream (lagoon) use is identified, or Mungindi at the end of the system if the water is used to enhance in-stream flows. Release at Pindari Dam enables the Commonwealth water to provide environmental benefits at multiple locations, further increasing the cost effectiveness of this action.

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Wakool-Yallakool

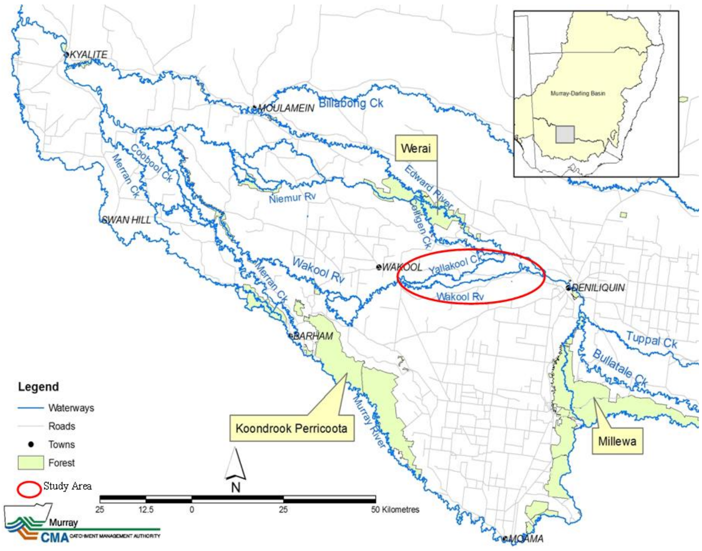
DEWHA Assessment Summary	CEWH	Other
Site: Wakool River and Yallakool Creek to the Junction and beyond **Floodplain/region:** **Catchnment: Timing:** August to December	**Volume:** 4,800 to 16,000 ML **Cost:** up to $186,560 (based on a maximum of $11.66/ML – fees and charges thorough the MIL system)	**Volume:** 0 ML – supported by river operations

Description of Watering Action and Objective
The provision of water to the Wakool River and Yallakool Creek via a hydrograph specifically developed to encourage a native fish response.

The primary objective is to assess the movement of large bodied native fish in relation to a manipulated flow regime, under the assumption that upstream movement of large bodied native fish in spring is a precursor to spawning.

Secondary objectives are to maintain and enhance available habitat within the system and provide improvements in water quality in shallow pools and off channel billabongs.

Description of site / watering history
The upper Wakool - Yallakool system holds good populations of large bodied native fish and is suspected as acting as a recruitment area for native fish (juveniles caught when fish sampling conducted (Conallin 2010)).



The Wakool System has only previously received conveyance and stock and domestic water as per usual water management operations. Environmental cue flows, using a specifically designed hydrograph for fish or other flora and fauna, have not been implemented before.

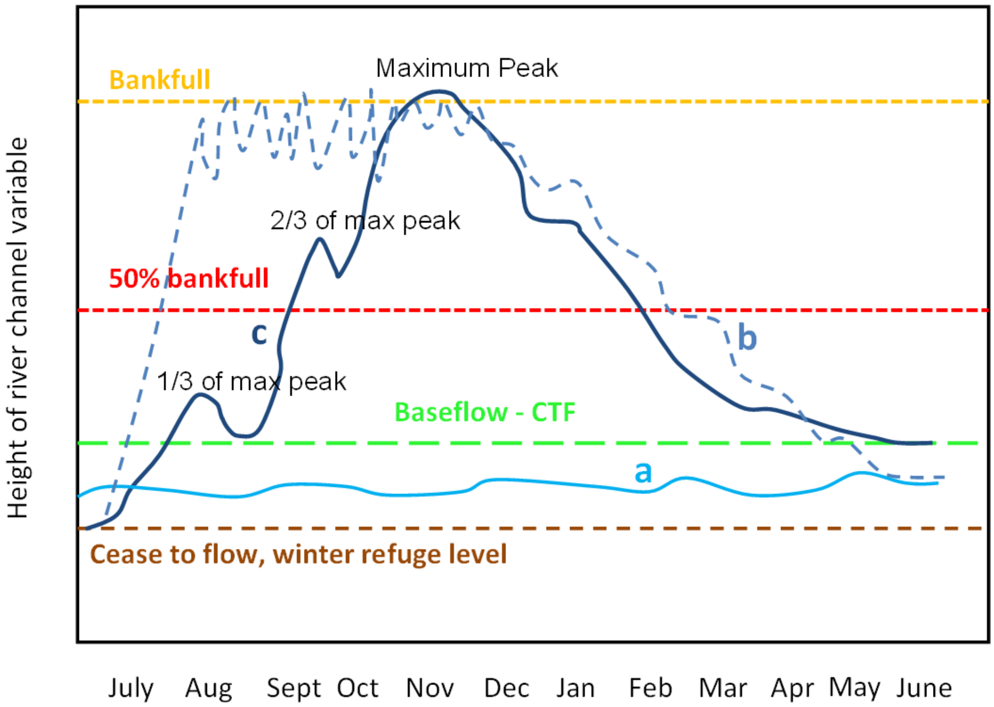
Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
Species listed as endangered on NSW legislation: trout cod (*Maccullochella macquariensis*, commonwealth endangered), bush stone-curlew (*Burhinus grallarius*), regent honeyeater (*Xanthomyza phrygia*), and Australian painted snipe (*Rostratula australis* commonwealth vulnerable) (NSW National Parks and Wildlife Service 2010).

Species listed as vulnerable on NSW legislation: silver perch (*Bidyanus bidyanus*), speckled warbler (*Pyrrholaemus saggitatus*), spotted harrier (*Circus assimilis*), little eagle (*Hieraaetus morphnoides*), square-tailed kite (*Lophoictinia isura*), blue-billed duck (*Oxyura australis*), freckled duck (*Stictonetta naevosa*), Australasian bittern (*Botaurus poiciloptilus*), Major Mitchell's cockatoo(*Cacatua leadbeateri*), brown treecreeper(*Climacteris picumnus*), diamond firetail (*Stagonopleura guttata*), brolga(*Grus rubicunda*), pied honeyeater (*Certhionyx variegatus*), white-fronted chat (*Epthianura albifrons*), painted honeyeater (*Grantiella picta*), black-chinned honeyeater (*Melithreptus gularis gularis* - eastern subspecies), varied sittella (*Daphoenositta chrysoptera*), hooded robin (*Melanodryas cucullata*), scarlet robin (*Petroica boodang*), flame robin (*Petroica phoenicea*), grey-crowned babbler (*Pomatostomus temporalis temporalis* eastern subspecies), superb parrot (*Polytelis swainsonii* Commonwealth vulnerable), barking owl (*Ninox connivens*), powerful owl (*Ninox strenua*), brush-tailed phascogale (*Phascogale tapoatafa*), yellow-bellied glider (*Petaurus australis* Commonwealth vulnerable), southern Myotis (*Myotis macropus*), great knot (*Calidris tenuirostris* Commonwealth migratory), and black-tailed godwit (*Limosa limosa* Commonwealth migratory) (NSW National Parks and Wildlife Service 2010).

The Murray cod (*Maccullochella peelii peelii* commonwealth vulnerable) is also known to inhabit the proposed watering areas (Conallin 2010).

2. Expected ecological outcomes
Objectives
The watering will be spread over a 60 day period and will follow the hydrograph below as closely as possible:

Three different hydrographs (blue lines), a) low level, b) variable bankfull, and c) three peak smooth.
(Not to scale)



Objective 1:
- To use environmental water to encourage movement and possibly spawning responses of large bodied native fish in the Wakool-Yallakool system

Objective 2:
- Maintain and enhance associated habitat assets (riparian and aquatic vegetation) within the Wakool River and Yallakool Creek; and
- Flush water from shallow holes, improving water quality, mobilise carbon (leaf litter) from benches (productivity increase), refresh off channel billabongs, enhance movement of aquatic plants seed, and generally increase habitat though levels of higher inundation.

The watering action will also allow experimental monitoring to occur to answer the following questions:
- To determine if more fish move up the treatment stream as opposed to the control stream;
- To determine if fish move in relation to CTF+30 ML/Day rising, and falling in the treatment stream;
- To determine if fish move in the Wakool - Yallakool system at a particular Commence to Flow (CTF) level; and
- To determine which pools fish move to after a certain CTF level has been reached and if they return to the same drought refuge pools in response to changes in flow level.

The upper Wakool-Yallakool is a known area for significant populations of native fish including silver perch, golden perch, and Murray cod (Conallin 2010; Lyon, Stuart *et al.* 2010). Current riparian and instream physical condition is good. There is an intact riparian zone, and good instream large woody debris to provide suitable fish habitat (Conallin, 2010).

It is expected that the provision of water will initiate fish spawning and by following the proposed hydrograph, that theoretically support juveniles, the population has the opportunity to become self sustaining and provide recruits to other areas (either downstream movement, or the Yallakool fishway when it is completed this year) (Conallin 2010).

Other benefits associated with the provision of water include an improvement in water quality with the higher flows flushing the pools and possible bed scouring. Off-channel billabongs will be refreshed and it is expected that there will be a lot of movement of small-bodied fish into these areas (Lyon, Stuart *et al.* 2010), and spawning could occur. Macrophyte seed dispersal is likely and riparian vegetation such as river red gums will benefit from the hydraulic pressure increase on the banks. A general increase in habitat area due to inundation levels will benefit other aquatic organisms. Carbon input from banks and benches being inundated will provide much needed carbon for instream organisms such as the new recruits if spawning occurs (Conallin 2010).

Not all the water will be attenuated and the majority of the water will travel downstream and continue to refresh water holes, and provide environmental benefits such as those described above.

3. Potential risks

It has been identified that the main risks associated with delivering environmental flows into drought affected waterways are: "the creation of hypoxic and toxic blackwater flows, the mobilisation of poor quality water that can impact on refugia with better quality water downstream, or rapid changes in water quality (such as temperature, pH or salinity) that exceed the acclimatisation capacity of fish" (Gilligan, Vey *et al.* 2009). Investigations following a blackwater event and associated fish deaths that occurred in the Edward–Wakool system in 2009 suggested that depending on antecedent conditions there is potential for short-term decline and issues associated with environmental watering events (Murray Darling Basin Authority 2010).

A risk assessment was undertaken by Murray CMA in collaboration with NSW Office of Water and State Water. At a workshop (held on 30/06/10) with NOW and SW ecological risk was discussed and considered low as long as volume downstream of the confluence of the Wakool-Yallakool Junction does not exceed 600 ML/day.

- Flooding of low level crossings - above 250 ML/day some crossings will be inundated. A communication plan is being established to inform the landholders affected and they will be further consulted by State Water and alternative access arrangements made for the period of inundation.
- Being in the upper part of the system, there is no risk of sulfidic sediments or saline pools, and keeping the flow at the confluence below 600 ML/Day, there will be no downstream flooding or risk disturbance (SW- Col Hood pers comm.). The infrastructure that currently exists can be accurately managed to ensure that flows are below this threshold level.
- Salinity was not considered a problem.
- Black water not expected to be a problem as the water is simply increasing existing in-channel flows, not running water down dry channels. Furthermore the system has been wetted each year for the last two years, and the watering will start before the peak litter fall season (January-February).
- End of year re-credit – the proposal indicated that not all of the water would be used in the target streams and the majority of the water would continue to flow through to the Murray. NOW and SW have informed EWB that it is not possible in this instance to do 'real-time' accounting so there would need to be an end of year re-credit. As this is a new method of water delivery the finer details of accounting and the timeline will need to be negotiated with NOW and SW.

4. Long-term sustainability

This site is intended to become the focus of a long-term flow manipulation experiment due to the ability to control flow inputs at multiple inputs, and the ability to swap the control and treatment options of the streams on a seasonal basis. Murray CMA has a collaborative agreement with both NOW and State Water to endeavour to set this section of the Wakool system up as an ongoing experimental site, which will eventually be added to the Environmental Water Management Plan (Conallin 2010).

Due to the ecological and operational complexity two technical teams were set up to work on the two components. The technical advisory team (Fish and Flows Expert Panel) consists of: Dr John Conallin (CMA, manager), Dr Lee Baumgartner (I&I, head scientist), Dr Gavin Butler (I&I, acoustics), Ian Wooden (I&I, field logistics), Dr Paul Humphries (CSU, Fish ecology, flows), Dr Rick Stoffels (MDFRC, fish ecology, experimental design), Wayne Robinson (CSU, statistics), Dr Martin Mallen-Cooper (Consultant, strategist, fishways expert), Dr Ivor Stuart (Consultant, fish, flows, carp migration). The operational team will consist of staff from Murray CMA, DECCW, NOW, SW, MDBA and DEWHA (EWB).

Fish Monitoring: a spatially explicit sampling program has been set up for the entire Edward-Wakool including both a site specific sampling (using a modified SRA methodology) and monitoring of fish, water quality, instream habitat and riparian habitat, and 5 of the 40 sites are situated within this study area. In addition an acoustic array system is being set up in the upper Wakool-Yallakool to monitor large bodied fish movement out of refuge holes when replenishment flows are instigated. Silver perch, golden perch, Murray cod and carp will be tagged (30 of each species). A minimum of 20 arrays (there is potential for the CEWH to purchase an additional 20 arrays that would be placed strategically throughout the watering site) will be placed throughout the Wakool system to monitor upstream and downstream movement and the movement will be assessed to see if they have any correlations with the pulse flows. As the Yallakool fishway is under construction the Yallakool Creek will be used as a control (water kept at CTF for entire season), and the Upper Wakool River as the flow manipulation site.

Water Quality: water quality (DO, Temp, pH, EC, Turbidity) will be monitored at the top, middle, lower (above confluence), and the confluence of the two water courses weekly. Temporary water temp loggers will be placed in both streams to try and assess if there is an interaction between flow-timing-temperature- fish movement.

Photo points: photo points will be established at the same points where the water quality sampling will be taken, and additional sites added to monitor vegetation change, inundation heights, instream habitat area coverage, and instream vegetation change (infestations are a potential barrier to fish movement). Inundation measurements will also be taken at the peaks of each initiated flow along the system to get an idea of habitat area coverage, but also attenuation as it moves down the system.

5. Cost effectiveness

Water accounting: Water accounting was discussed at a workshop (30-06-10) held with NOW and SW and upstream and downstream points where accounting could be measured were discussed. For the Yallakool most of the water will be delivered through Murray Irrigation Limited (MIL) structures (Yallakool Escape, 10kms downstream). This will be kept at 80 ML/day and is fully accountable. The Wakool will receive water from two sources, its baseflow coming from the SW controlled regulator at the top of the Wakool system (approx. 100 ML/day). Additional water (max 400-500 ML/day) will be supplied at the Wakool Escape (10kms downstream). At the confluence of the Wakool - Yallakool there are height gauges. During the flow events height will be measured everyday and related back to gauging tables created for the system to work out flow rates at the confluence. Due to the downstream ecological benefits of the environmental water, accounting will also be performed at specific points to gauge environmental water use further down the Wakool River. Flow would be gauged at both Moulamein bridge, Coonamit bridge, and the finally at Gee Gee bridge. Allowances for the additional environmental water and re-crediting would be worked out at Gee Gee bridge.

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Werai Forest

DEWHA Assessment Summary	CEWH	Other
Site: Werai Forest **Floodplain/region:** **Catchment:**, NSW **Timing:** September-November	**Volume:** 5,000 ML **Cost:** $25,300 ($5.06/ML – fees and charges)	**Volume:** 0 ML

Description of Watering Action and Objective
The provision of 5,000 ML of water via the Tumudgery Creek and Reed Bed Creek systems to Werai Forest (Future Indigenous Protected Area - vested in the NSW Minister for the environment in the interim) from the Edward River, to consolidate previous watering and benefits to fish populations.

The passage of flows through the forest is either: from the Tumudgery Creek system and then into the Colligen Creek; or from Reed Bed Creek and then into the Neimur River. Measurement of these flows will allow net use of water for the event to be deducted from accounts, with any returns flows re-regulated for consumptive purposes (consistent with 2009-10 watering).

Objectives:
1. Flood the forest to enhance connectivity for fish between the Edward River and the Colligen - Neimur River (via Tumudgery Creek and Reed Beds Creek) which will allow recolonisation and genetic exchange between fish populations (Conallin 2010);
2. Continued improvement of the vegetation community following on from the water provided in 2009-10 by the CEWH; and
3. Flush the system and 'freshen up' some of the saline pools and billabongs along the system (Green 2010).

Description of site / watering history
The river red gum forest currently considered to be in "very poor condition" with 92 per cent "highly stressed, near dead and dead" (Natural Resources Commission 2009).

Werai watering history (Green 2010):
- Sept- Dec 2000 – regulators into Werai opened for about 100 days as flows exceeded 2,900 ML/day. This would have extended into the floodplain.
- 2001 – 3,261 ML (this included covering of 10 per cent of losses in system and 466 ML which flowed into the forest) in November 2001 (Green 2001). This would have been mostly in the lowland wetland areas.
- Sept 2003 – regulators into Werai opened for 20 days as flows exceeded 2,900 ML/day. Flows into lowland wetland areas.
- Sept-Oct 2004 – regulators into Werai opened for 15 days. Flows into lowland wetland areas.
- Sept 2005 – (prior to release of Barmah-Millewa Environmental Water Allowance (EWA)) - regulators into Werai opened for about 20 days.
- Oct-Dec 2005 (during release of Barmah-Millewa EWA) – regulators into Werai opened for about 60 days. The amount of water used was not specifically accounted as it was included in the Barmah Millewa Allowance. Water would have extended into the floodplain.
- 2009-10 – 4500 ML of Commonwealth e-water used between November and January – regulators partially opened for 56 days

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
Threatened species and ecological communities: trout cod (*Maccullochella macquariensis*, endangered NSW Fisheries Management Act, and endangered EPBCA) (Conallin 2010) southern bell frog (*Litoria raniformis* vulnerable EPBCA), bush stone-curlew (*Burhinus grallarius*, endangered NSW TSCA), silver perch (*Bidyanus bidyanus*, vulnerable NSW FMA) (MDFRC Edward-Wakool monitoring program 2005-2009).
Species listed as vulnerable on the NSW *Threatened Species Conservation Act:* speckled warbler (*Pyrrholaemus saggitatus*), little eagle(*Hieraaetus morphnoides*), blue-billed duck (*Oxyura australis*), freckled duck (*Stictonetta naevosa*), Australasian bittern (*Botaurus poiciloptilus*), brown treecreeper (*Climacteris picumnus*), white-fronted chat (*Epthianura albifrons*), black-chinned honeyeater (*Melithreptus gularis gularis*), varied sittella (*Daphoenositta chrysoptera*), grey-crowned babbler *(Pomatostomus temporalis temporalis*), superb parrot (*Polytelis swainsonii*), great knot (*Calidris tenuirostris*), black-tailed godwit (*Limosa limosa*), brush-tailed phascogale(*Phascogale tapotafa*), southern myotis (*Myotis macropus*) (NSW National Parks and Wildlife Service 2010).

Werai has been recorded as a breeding area for cormorants (GHD 2009) and is considered an important site for inland forest bat (*Vespadelus baverstocki* Vulnerable NSW TSCA) and barking owl (*Nixos connivens* vulnerable NSW TSCA) as well as containing the western most record of brush-tailed phascogale (*Phascogale tapoatafa* vulnerable NSW TSCA) (Natural Resources Commission 2009) and provides drought refuge for the white-bellied sea-eagle (*Haliaeetus leucogaster* migratory EPBCA, CAMBA).

Wetlands in the Werai State Forest include deep lagoons that have very little aquatic vegetation, and shallow depressions that contain extensive areas of common reed (*Phragmites australis*) and other aquatic plants such as water ribbons (*Triglochin procera*) and water milfoil (*Myriophyllum* sp.) growing beneath relatively recently developed stands of river red gum (*Eucalyptus camaldulensis*) (Green 2001). These shallow depression wetlands are the single largest area of common reed that have been identified within the Edward-Wakool System (Green 2001) and provides drought refuge for more cryptic fish and bird species.
* DIWA B1, B4, B10, B14 Reasons for inclusion are 1, 2 and 5 (DEWHA 2009)

2. Expected ecological outcomes
It is expected that the water will continue to improve the health of river red gums (Department of Environment Climate Change and Water 2010) and other wetland specific vegetation found in the forest (such as the phragmites).
The delivery of the water has been planned in a manner to maximise the period of connectivity across the forest between the Edward River and the Colligen-Neimur to allow movement of fish between the rivers and provide the best possible conditions for spawning and recruitment of native fish and create conditions where native fish can exert predation pressure on carp (Conallin 2010).

A secondary outcome would be that the monitoring under taken will be able to inform future decisions on the use of environmental water in the Edward-Wakool System.

If the water is not provided is it anticipated that the improvement in the health obtained from the watering in the 2009-10 water year would diminish.

3. Potential risks
Risk assessment undertaken by MDBA (River operations), State Water, and DECCW (Green 2010). It was identified that there is a risk of a blackwater event occurring due to flows going through the forest, where until the 2009-10 watering had been dry with significant leaf litter. In the watering that took place in Nov 09 - Jan 2010 the following controls were put in place and would be put in place again in 2010-11:

1) increase the flow along the Colligen-Neimur System from 100 to 170 ML/day to enable dilution of any return flow (already implemented);
2) manage the initial flow rate into Reed Bed Creek by partial opening of the regulator in the first instance (2 boards removed from each bay expected to provide about 60 ML/day) so that on-ground monitoring can assess the potential for blackwater; and
3) comprehensive compliance monitoring associated with the watering action focusing on inundation extent, water quality and other incidental observations (undertaken by consultant). This will provide 'early warning' for the closure of the Tumudgery and/or Reed Bed Regulators if monitoring indicates that outflows have the potential to have an impact on the receiving waters of the Colligen-Neimur System (Green 2009).

To address the risk of blackwater impacting on the downstream receiving environment, River Murray Operations have indicated they would start running water down the Colligen-Neimur approximately 1 month before the Werai watering begins to properly flush the receiving environment so that adequate dilution of water of poor quality from the forest can occur. However it was thought that given the system was watered in 2009-10 the risk of a blackwater event as a result of watering in 2010-11 is significantly decreased.

Another risk identified is that of saline water flowing from the Mallen Mallen Creek (further downstream) this occurred in 2009-10 as a result of higher water levels in the adjoining creeks, but the measures in place to deal with potential blackwater from the forest also acted as a suitable control for any saline water leaving this creek.

4. Long-term sustainability
Werai State Forest is part of the NSW Central Murray State Forests Ramsar for which there is the Ecological Sustainable Management (ESFM) Plan which is also the Ramsar Site Management Plan.

On July 1 2010 the bill passed to transfer Werai from state forest to an Indigenous Protected Area, vested in the NSW Minister for the environment in the interim. Due to the change in land tenure it is difficult to determine what management activities may be undertaken in the future – but DECCW has informed EWB that currently all logging has stopped and stock grazing has ceased.

Monitoring will be split into two major components.

1. NSW DECCW staff will be liaising with the science division within DECCW to ensure that monitoring is consistent with NSW Monitoring Evaluation and Reporting (MER) requirements. To determine the extent of inundation as accurately as possible satellite imagery will be used, in addition to ground-truthing, this will reduce the time required in the field to map area of inundation.

A contractor will be engaged to undertake:

- Vegetation monitoring will include as a minimum a list of understorey species and where possible observation notes on response of particular species of interest (e.g. phragmites).
- Photo points – using the same photos points as last year, unless there is a reason to change i.e. vision obscured by new veg growth.
- Water quality - including temperature, DO, salinity, pH and depth – include 3 monitoring sessions within the Edward, Neimur, and Colligen prior to water entering the forest to have some baseline information.

2. Murray CMA (working with NSW Industry & Investment) will undertake monitoring of 7 sites across Werai (all inflow points, all forest outflow points and one point in the middle of the forest) using a slightly adapted SRA methodology looking at 4 themes: fish (adapted to include overnight netting to capture more cryptic species and sampling for young of year - to determine it spawning and recruitment occurred), water quality, instream habitat and riparian habitat. An initial overview will be obtained and sampling for the fish theme will be repeated. There is an intention to produce data that could be published in a scientific journal.

This monitoring component will be consistent with a wider monitoring program currently underway by MCMA and NSW I&I studying the whole Edward-Wakool System. The two objectives of the larger project are:

1. The spatial identification of high conservation value aquatic species and ecosystems to allow the development of environmental watering options to maximise the ecological benefit to these assets and identification of areas requiring more intensive management to minimise risks associated with the provision of water.
2. Monitoring the movements of fish to allow environmental water managers to: identify preferred fish migration routes and barriers to fish movement; determine the impacts of specific intervention measures and management actions; determine the response of different species of fish to changes in flow conditions and therefore flow regimes required to achieve specific fish objectives.

This larger project is currently committed to sampling a total 42 sites over a 3 year period (in addition to the seven sites proposed through this watering action), PIT tagging up to 2000 fish over 80 mm and acoustic tagging a minimum of 80 fish (Murray cod, silver perch, golden perch and possibly carp) which will be detected with a minimum of 20 arrays. The acoustic tagging and tracking is directly complementary to the fish monitoring proposed for the Wakool-Yallakool watering proposal, which would also inform the larger project.

The information obtained from this study could be used in the future to directly inform future decisions by the CEWH on use of water.

5. Cost effectiveness

The CEWH has been asked to contribute 5,000 ML of water, should this not be possible the site has been listed as a priority under a 'moderate' water availability scenario in the 2010-11 "Adaptive Environmental Water Plan for the Murray Valley". NSW DECCW has indicated that the Werai has been identified as an important asset in the Murray Valley and will endeavour to water it as necessary contingent on water availability.

The watering event will be managed by a committee of relevant stakeholders from DECCW, MDBA, NOW, SW, DEWHA, the monitoring contractor and Murray CMA through regular teleconferences. The ability to deliver water to the forest is contingent on having flows in the Edward River greater than 2,200 ML/day downstream of Stevens Weir to enable the water to be gravity fed through opening the Tumudgery Creek regulator and the Reed Bed Creek regulator. Water delivered to the forest will be accounted for by the MDBA using the same methodology as was applied in the 2009-10 watering event (where only net water use was debited from the account though gross water use was gauged).

As a result of the high storage levels in the Menindee Lakes (due to the summer 2010 Queensland floods) the amount of water being transferred from Lake Hume to Lake Victoria via the Edward River will be less than last year. Therefore there is a possibility that this watering event could only to take place if the watering of the Barmah-Millewa forest occurs, which is partially contingent on a natural high flows from the Ovens River.

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Yanga National Park – Southern half of North Section

DEWHA Assessment Summary	CEWH	Other
Site: Tarwille (south) and Piggery (south) water management areas of Yanga National Park and Tala Lake. **Floodplain/region:** Lowbidgee Floodplain **Catchment:** Murrumbidgee, NSW **Timing:** September-October	**Volume:** 20,000 ML **Cost:** $75,600 ($3.78/ML – fees and charges)	**Volume:** 10,000 ML

Description of Watering Action and Objectives
Action would target the middle section of Yanga National Park and Tala Lake, which were watered over winter, to extend inundation of the wetlands until mid summer.

Objective 1: To improve the condition of the red gum (*Eucalyptus camaldulensis*) forest and associated wetland systems. This area also includes vegetation types such as lignum (*Muehlenbeckia florulenta*), black box (*Eucalyptus largiflorens*), river cooba (*Acaia stenophylla*) and native reed (*Phragmites australis*).

Objective 2: Create breeding and feeding habitat for threatened species including the southern bell frog (*Litoria raniformis*: Commonwealth vulnerable, NSW endangered) and fishing bat (also known as the large-footed myotis; *Myotis macropus*: NSW vulnerable) as well as numerous waterbird species including great egret (*Ardea alba*: EPBC migratory), glossy ibis (*Plegadis falcinellus*: EPBC migatory), blue-billed duck (*Oxyura australis*: NSW vulnerable), freckled duck (*Stictonetta naevosa*: NSW vulnerable), and Australasian bittern (*Botaurus poiciloptilus*, NSW vulnerable).

Description of site / watering history
Tarwille (south) and Piggery (south) water management areas are river red gum dominated swamps in the middle of Yanga National Park and Tala Lake is an open water lake fringed by river red gums on the Lowbidgee Floodplain. The sites were watered in 2005-06 and are currently receiving water from winter CEWH/NSW watering.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
<u>Threatened species and ecological communities and migratory species</u>

- Southern bell frogs continue to be recorded (summer 2007-08, 2008-09, 2009-10) in Yanga National Park to the north in Mercedes Wetland and Piggery Lake/Twin Bridges Complex (Wassens *et al.* 2008; Spencer and Wassens 2009; Maguire pers comm. - email 2009). Southern bell frogs were once widespread in the Lachlan and Murrumbidgee (Wassens 2008). The populations in the Lowbidgee are some of the last in the Murrumbidgee and are the closest to the Lachlan where it is now believed to be locally extinct (Wassens 2008). As such it is on the distribution limit of this species.
- The fishing bat has recently been detected in Yanga National Park (Grant, 2009).
- The Australasian bittern, which is listed as endangered internationally on IUCN Red List, has been recorded at Breer Swamp in the southern part of the Piggery water management area and at Tarwillie Swamp (Maher, 2006)
- Great egrets (over 100 pairs) bred to the north at Top Narockwell during the last watering in January 2010, and were sighted at Tarwillie Swamp in January 2010 (Paul Childs, DECCW, pers. comm.) and Maher (2006) recorded 100 pairs breeding there in the environmental flow of 2005-06.
- Maher (2006) recorded blue-billed duck were recorded at River Smyths wetlands in Piggery water management area (south).
- Maher (2006) recorded freckled duck directly to the north at Tarwillie Swamp
- White-bellied sea-eagle (*Haliaeetus leucogaster*; EPBC migratory) was recorded at Tala Swamp (pers. comm. James Maguire, DECCW), River Smyths in Piggery water management area (south) and to the north at Tarwillie Swamp and Top Narockwell (Maher 2006)
- Maher (2006) recorded Latham's snipe (*Gallinago hardwickii*; EPBC migratory) to the north at Tarwillie Swamp
- Maher (2006) recorded Australian painted snipe (*Rostratula australis*; Commonwealth vunerable, NSW endangered) at River Smyths in the southern part of Piggery water management area.
- Maher (2006) recorded glossy ibis at River Smyths wetland in Piggery water management area (south).

The North Redbank wetlands are part of the Aquatic ecological community in the natural drainage system of the lower Murray River catchment endangered ecological community (*Fisheries Management Act* 1994).

<u>Ecological values of asset</u>
DIWA listed, the Lowbidgee Wetlands extended over an area of 300 000 ha in the early 1900s. However, following water diversion and floodplain developments, 76.5 per cent of the wetlands are now lost or degraded (Kingsford and Thomas 2004).

The Lowbidgee Floodplain is also listed in "Refugia for biological diversity in arid and semi-arid Australia" (Morton *et al.* 1995) as a significant wetland refuge in the NSW Murray-Darling Depression (along with the neighbouring Great Cumbung Swamp).

The Lowbidgee is listed as a draft High Conservation Value Aquatic Ecosystem (HCVAE; Australian Government 2010) and a key hydrological indicator site by the MDBA (2010).

2. Expected ecological outcomes
Feasibility of achieving objectives
Objective 1: (improve condition of the red gum forest and associated wetland systems) Previous watering has shown improvements in river red gum health. Sharon Bowen (DECCW), who has undertaken extensive vegetation monitoring of the Lowbidgee will monitor vegetation.

Objective 2: (create habitat for southern bell frog, waterbird species and fishing bat)
The site has previously supported a number of threatened and migratory species including for breeding (see above). Sampling will be undertaken for frogs, bats and waterbirds.

Consistency with CEWH objectives
The objectives help prevent critical loss of species and provide drought refuge.

Current health of asset
The asset is in good condition following recent watering.

Improvement in health expected from watering option
Watering has improved the health of this asset; however, follow up watering is required to consolidate the gains made in vegetation health as a result of the previous CEWH/NSW watering, particularly as this will extend inundation into the spring/early summer growing season. Previous watering in 2005-06 provided breeding for waterbirds (Maher 2006).

Change in health if environmental water not provided
Southern bell frog recruitment is unlikely to be achieved without the allocation of the water. The long-term persistence of this species depends on regular flooding events to promote recruitment (Wassens *et al.* 2008). The health of river red gums and associated vegetation will decline in Tarwillie, which is recovering from less frequent watering and drought refuge and breeding habitat for waterbirds will not be provided.

Basin-wide significance of ecological response:
Recruitment of southern bell frogs will extend the limit of the species and help secure the Lowbidgee population which is one of the last in the Murrumbidgee. This site is also close to the Great Cumbung Swamp in the Lachlan and presents a path for recolonisation to the Lachlan where it is now believed to be locally extinct (Wassens 2008).

Secondary benefits
This site is part of the larger Yanga wetlands and is across the river from North Redbank wetlands, so it will contribute to the larger wetland system providing nesting areas for species that forage elsewhere it the complex and vice versa.

3. Potential risks
Childs (2009) has undertaken a risk assessment for Yanga.
Key risks identified in the proposal include:
1. Carp: If carp are not stranded in annual dry-down they are likely to breed to very high numbers. This will reduce success of frog breeding. May also allow carp back into the Murrumbidgee during the following years flows. Spencer and Wassens (2009) found dominance by alien fish in terms of abundance (79 to 86 per cent) and biomass (99 to 94 per cent) in nearby Mercedes Swamp and Twin Bridges Wetland. However carp are likely to only have low to moderate impact (no return flow to river and large area of habitats for frogs to hide in from carp). It should be noted that carp are likely to be a problem for any watering in the MDB - not something that applies to this action more than any other put forward.

2. Water quality including black water events. During the current winter watering, Spencer and Wassens (unpublished 2010) found low dissolved oxygen (36 per cent) at Tarwillie Swamp after 21 days of inundation. Conductivity, turbidity and temperature where measured and found to be in normal ranges. Water quality problems are likely to be a low risk due to the fact that there will be no return flows to the river from this section. Note also that the area is currently inundated and excess organic matter is likely to already to have been broken down.

3. Bird breeding: if a bird breeding event occurs further water is likely to be required to ensure the success of the event. It is anticipated that further NSW Environmental Water Allowance water, NSW Riverbank water and Commonwealth

environmental water will become available through out the season and that this could be used to sustain a bird breeding event should it occur, unless severe drought conditions return to the catchment.

4. Long-term sustainability

Adequacy of long term monitoring arrangements

The site is a National Park and there is a draft Yanga Wetland Management Plan (Childs 2009). Additionally, the system is covered by the Murrumbidgee CMAs Lower Murrumbidgee Land and Water Management Plan and environmental water sharing rules are currently being developed as part of the NSW Office of Water led Lowbidgee Water Management Plan.

The water sharing plan provides an environmental water allowance. NSW also possesses over 13,000 ML of general security water and 5,000 ML of supplementary water entitlements for environmental use in the Murrumbidgee. The Commonwealth possesses over 64,000 ML of general security and 20,000 ML of supplementary water entitlements in the Murrumbidgee.

The site is able to be watered via gravity feed.

Complementary natural resource management activities

NSW National Parks undertake extensive management including pest control, long-term monitoring and works. The Lowbidgee has been identified as a target for investment under Caring for our Country due to its identification as a draft HCVAE (Australian Government 2010).

Effectiveness of monitoring, evaluation and reporting arrangements

The proposed intervention monitoring of this watering action is in alignment with the watering objectives stated above. Additional information on the monitoring can be found at Attachment E.

5. Cost effectiveness

The action requires 20,000 ML; NSW will be providing 10,000 ML of water. There are no delivery costs as this water will be gravity fed off the Redbank Weir pool through 1 AS regulator, however there are statutory fees and charges associated with the event. From 1AS, water flows through Top Narockwell water management area and then through both Piggery water management area (north) and Tarwillie water management area (north). Any ‘losses’ will benefit these areas. There is a new flow metering station at 1 AS.

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Yanga National Park – Northern half of north section

DEWHA Assessment Summary	CEWH	Other
Site: Mercedes/Top Narockwell/ north Piggery/north Tarwille, Yanga National Park **Floodplain/region:** Lowbidgee Floodplain **Catchment:** Murrumbidgee, NSW **Timing:** September-October	**Volume:** 7,500 ML **Cost:** $28,350 ($3.78/ML – fees and charges)	**Volume:** 7,500 ML

Description of Watering Action and Objectives
Action would target the northern areas of Yanga National Park watered over winter to extend inundation until mid summer.

Objective 1: To improve the condition of the river red gum (*Eucalyptus camaldulensis*) forest and associated wetland systems. This area also includes vegetation types such as lignum (*Muehlenbeckia florulenta*), black box (*Eucalyptus largiflorens*), river cooba (*Acaia stenophylla*) and native reed (*Phragmites australis*).

Objective 2: Create breeding and feeding habitat for threatened species including the southern bell frog (*Litoria raniformis*: Commonwealth vulnerable, NSW endangered) and fishing bat (also known as the large-footed myotis; *Myotis macropus*: NSW vulnerable) as well as numerous waterbird species including great egret (*Ardea alba*: EPBC migratory), glossy ibis (*Plegadis falcinellus*: EPBC migatory), blue-billed duck (*Oxyura australis*: NSW vulnerable), freckled duck (*Stictonetta naevosa*: NSW vulnerable), and Australasian bittern (*Botaurus poiciloptilus*, NSW vulnerable).

Description of site / watering history
River red gum dominated swamps at the upper end of Yanga National Park on the Lowbidgee Floodplain. Apart from Tarwillie, the sites have been watered in summer 2005-06, summer 2008-09, spring/summer 2009-10 and currently receiving water from winter flood. Tarwillie was watered in 2005-06 and is currently receiving water from winter CEWH/NSW watering.

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
Threatened species and ecological communities and migratory species

- Southern bell frogs continue to be recorded (summer 2007-08, 2008-09, 2009-10) in Yanga National Park at Mercedes Wetland and Piggery Lake/Twin Bridges Complex (Wassens *et al.* 2008; Spencer and Wassens 2009; Maguire pers comm. - email 2009). Southern bell frogs were once widespread in the Lachlan and Murrumbidgee (Wassens 2008). The populations in the Lowbidgee are some of the last in the Murrumbidgee and are the closest to the Lachlan where it is now believed to be locally extinct (Wassens 2008). As such it is on the distribution limit of this species.
- The fishing bat has recently been detected in Yanga National Park (Grant, 2009).
- The Australasian bittern, which is listed as endangered internationally on IUCN Red List has been recorded at Tarwillie Swamp and Breer Swamp (Maher, 2006)
- Great egrets bred (over 100 pairs) at Top Narockwell during the last watering in January 2010, and were sighted at Tarwillie Swamp in January 2010 and in the environmental flow of 2005-06 Maher (2006) also recorded breeding by great egret (100 nests) there.
- Freckled duck was recorded at Tarwillie Swamp (Maher 2006)
- Maher (2006) recorded blue-billed duck were recorded to the south at River Smyths wetlands in Piggery water management area (south)
- White-bellied sea-eagle (*Haliaeetus leucogaster*; EPBC migratory) was recorded at Tarwillie and Top Narockwell (Maher 2006)
- Latham's snipe (*Gallinago hardwickii*; EPBC migratory) was recorded at Tarwillie (Maher 2006)
- Australian painted snipe (*Rostratula australis*; Commonwealth vunerable, NSW endangered) was seen by Maher (2006) at nearby River Smyths in the southern part of Piggery water management area.

The North Redbank wetlands are part of the Aquatic ecological community in the natural drainage system of the lower Murray River catchment endangered ecological community (*Fisheries Management Act* 1994).

Ecological values of asset
DIWA listed, the Lowbidgee Wetlands extended over an area of 300 000 ha in the early 1900s. However, following water diversion and floodplain developments, 76.5 per cent of the wetlands are now lost or degraded (Kingsford and Thomas 2004).

The Lowbidgee Floodplain is also listed in "Refugia for biological diversity in arid and semi-arid Australia" (Morton *et al.* 1995) as a significant wetland refuge in the NSW Murray-Darling Depression (along with the neighbouring Great Cumbung Swamp).
The Lowbidgee is listed as a draft High Conservation Value Aquatic Ecosystem (HCVAE; Australian Government 2010) and a key hydrological indicator site by the MDBA (2010).

2. Expected ecological outcomes
Feasibility of achieving objectives
Objective 1: (improve condition of the red gum forest and associated wetland systems) Previous watering has shown improvements in river red gum health. Sharon Bowen (DECCW), who has undertaken extensive vegetation monitoring of the Lowbidgee will monitor vegetation.
Objective 2: (create habitat for southern bell frog, waterbird species and fishing bat)
The site has previously supported a number of threatened and migratory species including for breeding (see above). Sampling will be undertaken for frogs, bats and waterbirds.

Consistency with CEWH objectives
The objectives help prevent critical loss of species (particularly southern bell frog) and provide drought refuge.

Current health of asset
The asset is in good condition following recent watering.

Improvement in health expected from watering option
Watering has improved the health of this asset; however, follow up watering is required to consolidate the gains made in vegetation health as a result of the previous CEWH/NSW watering, particularly for Tarwillie, which has had less frequent watering recently. Previous watering has provided breeding for waterbirds and frogs (see notes under criterion 1). It is highly likely that southern bell frog will breed at the site due to their presence here during the last watering. Recent watering has resulted in a positive response including good water quality (high dissolved oxygen, low turbidity, low salinity), high diversity of aquatic vegetation (Spencer and Wassens, 2009).

Change in health if environmental water not provided
Southern bell frog recruitment is unlikely to be achieved without this water. The long-term persistence of this species depends on regular flooding events to promote recruitment (Wassens *et al.* 2008). The health of river red gums and associated vegetation will decline in Tarwillie, which is recovering from less frequent watering and drought refuge and breeding habitat for waterbirds will not be provided.

Basin-wide significance of ecological response:
Recruitment of southern bell frogs will extend the limit of the species and help secure the Lowbidgee population which is one of the last in the Murrumbidgee. This site is also close to the Great Cumbung Swamp in the Lachlan and presents a path for recolonisation to the Lachlan where it is now believed to be locally extinct (Wassens 2008).

Secondary benefits
This site is part of the larger Yanga wetlands and is across the river from North Redbank wetlands, so it will contribute to the larger wetland system providing nesting areas for species that forage elsewhere it the complex and vice versa.

3. Potential risks
Childs (2009) has undertaken a risk assessment for Yanga.

Key risks identified in the proposal include:
1. Carp: If carp are not stranded in annual dry-down they are likely to breed to very high numbers. This will reduce success of frog breeding. May also allow carp back into the Murrumbidgee during the following years flows. Spencer and Wassens (2009) found dominance by alien fish in terms of abundance (79 to 86 per cent) and biomass (99 to 94 per cent) in Mercedes Swamp and Twin Bridges Wetland. However carp are likely to only have low to moderate impact (no return flow to river and large area of habitats for frogs to hide in from carp). Carp screens will remain installed for Mercedes Swamp excluding large carp. It should be noted that carp are likely to be a problem for any watering in the MDB - not something that applies to this action more than any other put forward.

2. Water quality including black water events. Dissolved oxygen, conductivity, turbidity and temperature where measured and found to be in normal ranges during the last watering at this site (Spencer and Wassens, 2009), with the exception of two readings at Mercedes (3.2 and 3.6 mg/L oxygen). Water quality problems are likely to be a low risk due to the fact that there will be no return flows to the river from this section. Note also that the area is currently inundated and excess organic matter is likely to already to have been broken down.

3. Bird breeding: : if a bird breeding event occurs further water is likely to be required to ensure the success of the event. It is anticipated that further NSW Environmental Water Allowance water, NSW Riverbank water and Commonwealth environmental water will become available through out the season and that this could be used to sustain a bird breeding event should it occur, unless severe drought conditions return to the catchment.

4. Long-term sustainability

Adequacy of long term monitoring arrangements

The site is a National Park and there is a draft Yanga Wetland Management Plan (Childs 2009). Additionally, the system is covered by the Murrumbidgee CMAs Lower Murrumbidgee Land and Water Management Plan and environmental water sharing rules are currently being developed as part of the NSW Office of Water led Lowbidgee Water Management Plan.

The water sharing plan provides an environmental water allowance. NSW also possesses over 13,000 ML of general security water and 5,000 ML of supplementary water entitlements for environmental use in the Murrumbidgee. The Commonwealth possesses over 64,000 ML of general security and 20,000 ML of supplementary water entitlements in the Murrumbidgee.

The site is able to be watered via gravity feed.

Complementary natural resource management activities

NSW National Parks undertake extensive management including pest control, long-term monitoring and works. The Lowbidgee has been identified as a target for investment under Caring for our Country due to its identification as a draft HCVAE (Australian Government 2010).

Effectiveness of monitoring, evaluation and reporting arrangements

The proposed intervention monitoring of this watering action is in alignment with the watering objectives stated above. Additional information on the monitoring can be found at Attachment E.

5. Cost effectiveness

The action requires 7,500 ML; NSW will be providing 7,500 ML of water. There are no delivery costs as this water will be gravity fed off Redbank Weir through 1 AS regulator, however there are statutory fees and charges associated with the action. Transmission losses will be minimal as the site is adjacent to Redbank Weir. There is a new flow metering station at 1 AS.

DECCW has also requested $5,000 from the CEWH towards monitoring activities associated with the watering event.

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Yarnel Lagoon - Lachlan

DEWHA Assessment Summary	CEWH	Other
Site: Yarnel Lagoon (Wallaroi Creek, Lachlan River) **Floodplain/region:** Lachlan Plains **Catchment:** Lachlan, NSW **Timing:** Propose Sept-Nov; however, actual start date of water delivery is dependent on the timing of cessation of managed water delivery flows	**Volume:** 73 ML **Cost:** $1,173 ($16.06/ML - statutory fees and charges)	**Volume:** 0 ML

Description of watering action and objective
The objective is to improve wetland condition and habitat values for frogs and birds, by providing a small volume of water from Commonwealth high security entitlements after a replenishment flow in spring. This will extend the hydroperiod of Yarnel Lagoon to approximately three months, before allowing the lagoon to dry down.

This will result in improvements in the vegetation communities of the wetlands, and allow recruitment of frog species through the maintenance of viable habitat.

Description of site / watering history Yarnel Lagoon is a small wetland located on Wallaroi Creek, approximately 15km south of Condobolin. Wallaroi Creek is operated as part of the regulated Lachlan River. There is no dedicated environmental allocation for the Wallaroi Creek. To date, Yarnel Lagoon has only received flows during natural high flow events and when water deliveries are made down the Wallaroi Creek. The pattern of river management does not provide the extent and duration of shallow inundation required by Yarnel Lagoon to support frog breeding and maintenance of foraging habitat for water birds. It has been identified as a target for environmental water under the *RiverBank Water Use Plan (No 1)* (NSW Office of Water, 2007).

Comments against criteria for assessing 2010-11 environmental watering actions
1. Ecological Significance
Threatened Species:
The following species listed under the NSW TSCA have been recorded at, or in similar habitats within five kilometres of Yarnel Lagoon: brolga (*Grus rubicunda;* NSW vulnerable), freckled duck (*Stictonetta naevosa;* NSW vulnerable), grey-crowned babbler (eastern sub-species *Pomatostomus temporalis temporalis;* NSW vulnerable), speckled warbler (*Pyrrholaemus saggitatus;* NSW vulnerable), magpie goose (*Anseranas semipalmata;* NSW vulnerable). Both the southern bell frog (*Litoria raniformis;* ***Commonwealth vulnerable; NSW endangered)*** and Sloane's froglet (*Crinia sloanei;* NSW vulnerable) are listed for the region, however, their status at the site is uncertain. It is possible that the southern bell frog has become extinct within the catchment (Wassens and Maher 2010). Two plants which provide forage for ducks are also recorded from the area. These are the Austral pillwort (*Pilularia novae-hollandiae;* NSW endangered) and a spear grass (*Austrostipa wakoolica;* NSW endangered).

Endangered ecological communities
Yarnel Lagoon is also part of the lower Lachlan River Endangered Ecological Community under the NSW *Fisheries Management Act*. This includes the natural drainage system of the lowland catchment of the Lachlan River. All fish and aquatic invertebrates within all natural rivers, creeks, streams and associated lagoons, billabongs, lakes, wetlands, paleochannels, floodrunners, effluent streams and the floodplains of the Lachlan River within the State of New South Wales, and including Lake Brewster, Lake Cargelligo and Lake Cowal, are protected. Recovery strategies to improve the health of the Lachlan EEC have been developed. The Priority Action Statement identifies *inter alia* improving the share of water for the environment in regulated rivers and restoring natural seasonal flow patterns (NSW Dept. Primary Industries website; accessed 26 July 2010).

Ecological and conservation values - While Yarnel Lagoon has not been recognised by any international agreements, it provides habitat for the above listed and other species. In particular, Yarnel Lagoon provides ***habitat for a number of animal taxa at a vulnerable stage in their life cycles,*** particularly frogs. This would provide one of the few drought refuges in a highly regulated catchment, which has been experiencing very low flows for a number of years. This wetland has potential to contribute to frog diversity ***with at*** least seven species of breeding frog populations recorded over recent years (Wassen *et al.* 2007; Mazzer and Shelley 2008; Packard in prep.). ***It is also known to support the breeding and foraging of brolgas (P. Packard, NSW DECCW; pers. comm.)***

2. Expected ecological outcomes
It is expected that providing additional water to extend the hydroperiod up to three months, and will have the following outcomes:

1. Improve the condition of the wetland and associated fringing river red gum vegetation communities of Yarnel Lagoon (approximately 30 hectares). This will provide a range of inundated habitat types and a range of foraging opportunities for birds and other fauna.
2. Create a mosaic of wetland habitats with different hydroperiods of inundation. This will induce and/or sustain breeding and increase the probability of successful metamorphosis for most of the different species in the frog population recorded at Yarnel.

The expected outcomes (improved wetland condition and a mosaic of inundated wetland areas) are considered realistic, as the fringing vegetation and aquatic macrophytes are in good condition as a result of previous watering events and slightly improved climatic conditions (see below). Maintaining the hydroperiod is expected to improve recent ecological gains.

Condition of the site – According to the Environmental Watering Plan for the Lachlan Valley 2009-10, Yarnel Lagoon is currently in “good” condition (DECCW, 2009). The open water lagoon is fringed with dense stands of cumbungi and a range of aquatic macrophytes is in evidence. While the lagoon received water in summer 2008, inundation of the fringing wetland habitat was limited. The high flow events of late summer 2009, associated with heavy local rains and run-off have resulted in recent wetting of much of the fringing river red gum forest/woodland.

Improvement in health - Lengthening the hydroperiod to approximately three months will provide a mosaic of wetland habitats that should induce and/or sustain breeding of the different species of the recorded frog populations. DECCW anticipate that this will increase the probability of successful metamorphosis and subsequent recruitment of most recorded frog species (P. Packard, NSW DECCW; pers.comm). In addition, retaining or reintroducing ecologically sustainable water flows to wetland habitat is noted as a key driver to support brolga populations (DECC website; accessed July 2010). The improved health of the system is expected to improve foraging opportunities for birds and other fauna.

Basin-wide significance –Yarnel Lagoon is a drought refuge in an otherwise dry catchment. The lagoon ***provides drought refuge*** particularly for a ***range of taxa that require wetland conditions to complete their lifecycle. Its*** importance for frog (Wassens *et al.* 2007; Mazzer and Shelley 2008; Packard in prep.) and brolga breeding (P. Packard (NSW DECCW) pers.comm) is noted. It has the potential to assist with recolonisation of other parts of the catchment when conditions are more suitable.

Change in the health of the system if water not provided - The Lachlan catchment has received little inflow over the past several years and is currently experiencing extremely dry conditions. The planned short duration replenishment flow may stimulate frog and fish breeding and a vegetation response. If not extended by environmental water, this event may end prematurely resulting in failed recruitment. This wastes limited ecological resources (e.g. energy store in recruiting adults, seeds and eggs in soils) (P. Driver, NSW Office Water; pers.comm). In addition, less breeding and foraging habitat will be available for brolgas, Australian bittern and other regionally important birds. Drought refuges also assist with the survival of macropods and other native species during the hotter months.

3. Potential risks

Risk identification and mitigation measures will be undertaken through the preparation of the *Yarnel Wetland Management Plan* (completion expected in October).

While water quality issues, such as black water, have been identified by DECCW as a risk, the environmental flow will be delivered after a managed delivery of a ‘replenishment flow’ by the NSW Office of Water, which is expected to have flushed out or already triggered any adverse event. Hence, DECCW consider the risk of black water and any adverse impacts associated with the 73 ML of Commonwealth environmental water to be low (P. Packard, NSW DECCW; pers.comm).

4. Long-term sustainability

Adequacy of long term management and delivery - DECCW consider the long term sustainability of Yarnel Lagoon is good. DECCW have targeted Yarnel for watering under their RiverBank Water Use Plan. A management plan for Yarnel Lagoon is currently being prepared by DECCW and will be finalised prior to the period within which the proposed watering event would occur.

The CEWH holds 81,993 ML in general security and 733 ML in high security entitlements. DECCW currently hold 25,000 ML of general security entitlements in the Lachlan Regulated River Water Source area and are currently finalizing the acquisition of 1,000 ML of high security, which may provide an additional 100 ML that could potentially be used for Yarnel Lagoon for subsequent flows. DECCW would deliver the water through natural, gravity-fed channels with licensed weirs and regulators to manage flows.

While the site is on private property, the title is held by one owner and is used for grazing cattle. The property has been managed conservatively since it was registered as a Wildlife Refuge in the 1970s (P. Packard, NSW DECCW; pers.comm).

Monitoring – Monitoring of the objectives will be undertaken by DECCW staff, with opportunistic input by the land owner. Monitoring techniques and strategy will build upon scientifically conducted research already being undertaken by DECCW, and discussed previously. The inundation extent will be assessed and river red gum and aquatic vegetation condition/responses will be monitored fortnightly. Fortnightly frog call recordings and frog/tadpole surveys, woodland and waterbird bird and bat surveys will also be undertaken (P. Packard, NSW DECCW; pers.comm). Further details of monitoring are at Attachment E.

5. Cost effectiveness

Yarnel receives flows only during natural high flow events and as the site is gravity fed, there are no pumping fees. Flows are managed and delivered down Wallaroi Creek to Wallaroi weir through water access works. Due to good preceding rainfall in the area, the risk of ground seepage losses are likely to be minimised. The requested environmental water will be delivered on top of a replenishment flow through Wallaroi Creek, which is operated as part of the regulated Lachlan River. While the proponents have requested 73 ML, they are not proposing to contribute any water at this stage. As previously discussed, there may be scope for DECCW to contribute to RiverBank holdings at a later time in the watering year.

Operational feasibility - DECCW note that the channel of Wallaroi Creek upstream of the main lagoon area exhibits dense stands of cumbungi in some places. The potential for the dense cumbungi to inhibit flow will need to be assessed / managed. As native vegetation, this process and any proposed operations may require assessment under the *Native Vegetation Management Act 2003* (NSW) undertaken through the Lachlan CMA. DECCW have also indicated the need to install temporary metering at the site to record inflows. This cost of the metering will be shared with the Commonwealth.

6. References

DECCW (2009) *Environmental Watering Plan for the Lachlan Valley* 2009/10.

DECC Threatened Species website *Brolga profile*
http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10382

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http://www.dpi.nsw.gov.au/fisheries/species-protection/conservation/what-current/endangered/lachlan-river-eec

NSW Office of Water (2007) *RiverBank Water Use Plan for the Lachlan Water Management Area No 1.*
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Mazzer, T. and Shelly, D. (2008) *Frog populations at "Burrawang West" and "Yarnel" Lagoons – Supplementary Report.* Department of Environment and Climate Change: Scientific Services Division.

Wassens, S., Arnaiz, O.L. and Watts, R.J. (2007) *Assessing the diversity, abundance and hydrological requirements of frog populations at 'Burrawang West' and 'Yarnel' Lagoons, two small wetlands on anabranch creeks of the mid-Lachlan River*. Department of Environment and Climate Change: Queanbeyan.

Wassens, S. and Maher, M. (2010) *River regulation influences the composition and distribution of inland frog communities*. River. Res. Applic. Published online in Wiley InterScience.

Water Use Strategy 2011-12: Border Rivers Regulated System

1.1. Introduction

This document sets out the proposed objectives and approach to using Commonwealth environmental water in the Border Rivers catchment during the 2011-12 water year. This strategy was developed based on information available to Commonwealth Environmental Water including through consultation with the QLD Department of Environment and Resource Managements and the NSW Office of Water.

The strategy includes watering options appropriate to recent climatic and riverine conditions and forecast water availability under a range of hydrologic scenarios. The strategy will evolve over the course of the year as conditions in the catchment change and more information becomes available. This strategy covers use of the Commonwealth's regulated holdings in the Queensland and New South Wales portions of the Border Rivers catchment. Management of the Commonwealth's unregulated entitlements in Border Rivers is covered in the *Water Use Strategy 2011-12: Northern Murray-Darling Basin Unregulated Rivers*.

Importantly, the potential watering options included in this document do not form an exhaustive list – alternative suggestions for using environmental water are welcome. All relevant options will be assessed to ensure the best possible use of environmental water within the catchment and across the Murray-Darling Basin.

1.2. The Border Rivers Catchment

The Border Rivers catchment (43,630 km^2) straddles southern Queensland and north eastern New South Wales, with roughly the same area in each state (CSIRO 2007). The catchment is based around the Macintyre and Dumaresq Rivers (Figure 1) which join upstream of Boggabilla. The Macintyre River drains in a north-westerly direction. Its principal tributary, the Severn River (NSW), rises in elevated country around Emmaville. Draining the eastern part of the catchment, the Dumaresq River is formed by the junction of the Severn River (QLD) and Tenterfield Creek (NSW). Principal tributaries in the upper reaches are Pike Creek (QLD) and the Mole and Beardy Rivers (NSW). Ottleys Creek (NSW) and Macintyre Brook (QLD) join in the lower reaches of the Dumaresq upstream of its confluence with the Macintyre River (NSW Office of Water 2011a). The main stem continues as the Macintyre River from this point.

Below Goondiwindi, effluent creeks and anabranches break off the Macintyre River channel and form a meandering complex of billabongs and wetlands across an extensive floodplain. These breakouts include Callandoon and Dingo Creeks in QLD and Whalan Creek and Boomi River in NSW. The only significant tributary in the floodplain zone is the Weir River (QLD). Below the confluence of the Weir and Macintyre Rivers, the trunk stream becomes the Barwon River.

The dominant land use in the catchment is livestock grazing, particularly on the tablelands, with a shift to cropping on the slopes and plains. Irrigated cotton accounts for the majority of the cropped area. In addition, high value irrigated crops (including salad vegetables, wine and table grapes and orchard fruits) are grown on small acreages in the area around Stanthorpe.

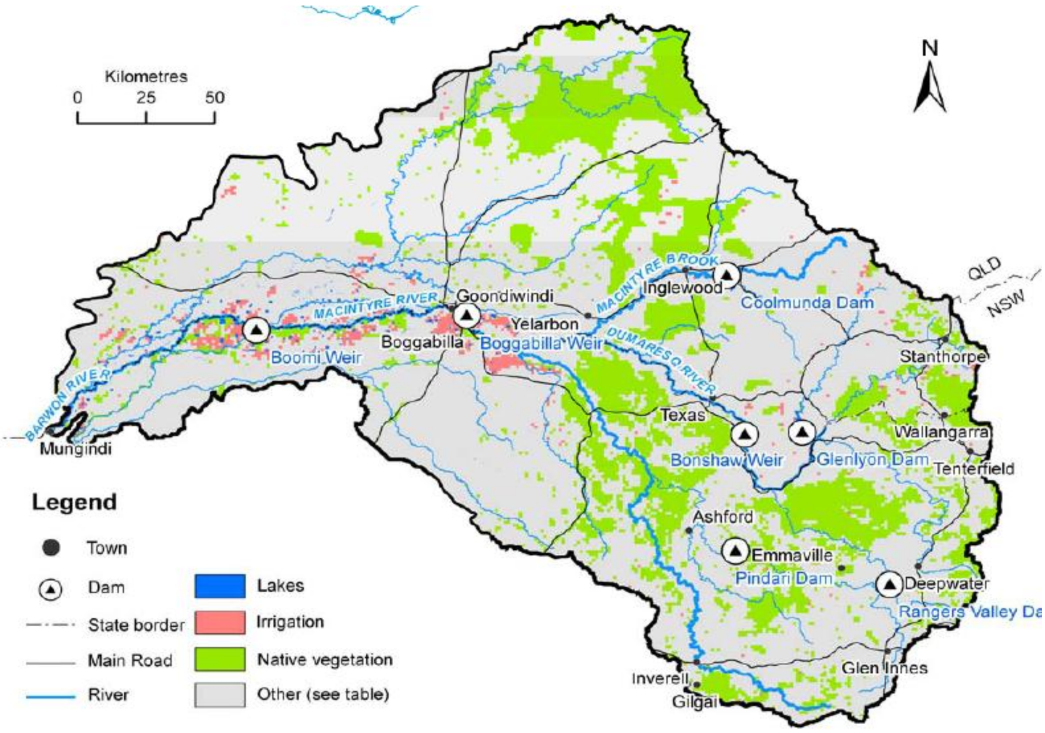

Figure 1: The Border Rivers Catchment (taken from CSIRO 2007)

On average, the majority of water use in the Border Rivers catchment is based on opportunistic access to unregulated flows (supplementary water access in NSW and unsupplemented water allocations in QLD). Regulated water entitlements (supplemented water allocations in QLD, high and general security licences in NSW) comprise a smaller component of overall water use.

Collectively, public storages providing regulated supplies have a capacity of 635 GL, comprising Pindari Dam on the Severn River in NSW (312 GL), Glenlyon Dam on Pike Creek in QLD (254 GL) and Coolmunda Dam on Macintyre Brook in QLD (69 GL). Inflows to Glenlyon Dam are shared in the ratio 57:43 between NSW and QLD. The other dams provide dedicated supply to water users in the state in which they are located. The volume of on-farm storage is comparable to public storage, reflecting the importance of unregulated flows (diversion of river and overland flows) to irrigation supplies in the catchment.

Regulated water resources in each state are managed separately. Queensland entitlements are managed under the Border Rivers Resource Operations Plan 2008, whereas NSW entitlements are managed under the Water Sharing Plan for the NSW Border Rivers Regulated River Water Source 2009. The statutory plans are highly consistent, particularly in relation to interstate trading rules, environmental water provisions and requirements for monitoring ecological outcomes. Common provisions are also restated and expanded upon in the NSW-Queensland Border Rivers Intergovernmental Agreement 2008 (IGA)

1.3. Environmental Assets in the Border Rivers Catchment

The streams of the Border Rivers system provide diverse habitat for aquatic organisms including river channel itself, in-stream features such as bars, benches, riparian areas and low level wetlands (SKM 2009). In-channel benches act as sediment and nutrient sinks and are an important source of dissolved nutrients (Southwell 2008).

The Border Rivers supports a relatively rich native fish fauna. Seventeen species have been documented, including a number of threatened species, namely: Murray cod (*Maccullochella peelii*, Commonwealth vulnerable); silver perch (*Bidyanus bidyanus*, NSW vulnerable); purple-spotted gudgeon (*Mogurnda adspersa*, NSW endangered); and the olive perchlet (*Ambassis agassizii*) and eel-tailed catfish (*Tandanus tandanus)* which are endangered populations in NSW (Butcher 2007; Wilson and Ellison 2010 in prep). In recognition of this diverse but threatened fish fauna, the Macintyre, Severn (NSW) and Dumaresq Rivers are included in Lowland Darling River aquatic endangered ecological community declared under the *NSW Fisheries Management Act 1994* and the whole length of the Macintyre River is a proposed Native Fish Strategy Demonstration Reach (Australian Wetlands 2009).

The Border Rivers contains a wide range of in-stream and floodplain wetland habitats that support the breeding of waterbirds including brolgas *(Grus rubicunda),* magpie geese (*Anseranas semipalmata*) (vulnerable) and black-necked storks (*Ephippiorhynchus asiaticus*) (endangered), listed under the NSW Threatened Species Conservation Act 1995 (CSIRO 2007).

Semi-permanent and intermittent billabongs and lagoons bordering the main channel and on prior river channels are a feature of the area from Yetman on the Macintyre River and Texas on the Dumaresq River to 20 km downstream of Goondiwindi. These include Boobera, Punbougal and other nationally significant lagoons on the Morella watercourse to the south of Goondiwindi (Figure 5). Lagoons in this area support communities of river red gum (*Eucalyptus camaldulensis*), coolibah (*E. coolabah*) and river sheoak (*Casuarina cunninghamiana*) (Environment Australia 2001).

Downstream of Goondiwindi to Mungindi at the end of the system, the small effluent creeks and anabranch channels that break off the main channel of the Macintyre River form a complex floodplain of lagoons and other waterbodies that rely on overbank flows (Kingsford 1999). These channels and floodplain wetlands provide significant habitat and when flooded contribute large amounts of dissolved organic carbon to the riverine ecosystem which is essential to aquatic ecosystem functioning (Thoms et al. 2005). River coobah (*Acacia stenophylla*) and coolibah are the predominant riparian trees, with lignum (*Muehlenbeckia florulenta*) common in the understorey (SKM 2009).

Further details on in-stream, lagoon and floodplain wetland assets are provided in 1.16.

1.4. Long-term Watering Objectives in the Border Rivers Catchment

There is no history of entitlement-based environmental water use in the Border Rivers, and its flow-dependent assets and water requirements are not as well studied as in many other parts of the Basin (e.g. the Gwydir River catchment). The following broad objectives have been developed to guide environmental watering in the Border Rivers catchment with input from state agencies, river managers and other stakeholders:

- Reinstate elements of the natural flow and flooding regimes in the main river channel and distributary and anabranch systems to improve key ecosystem functions;
- Maintain lateral connectivity between the main river channel and near channel and floodplain lagoons to provide carbon and nutrient inputs to the system and support flora and fauna communities dependent on intermittent inundation; and
- Increase end-of-system flows to provide benefits to downstream catchments.

1.5. Delivering Water in the Border Rivers Catchment

Regulated water is supplied to NSW water users in the Dumaresq and Macintyre-Barwon Rivers and Boomi River from the NSW state share of Glenlyon Dam and 100 per cent of the volume in Pindari Dam. QLD users on the Dumaresq and Macintyre-Barwon main stem in the Border Rivers Water Supply Scheme (BRWSS) are supplied from the state share of Glenlyon Dam only. The majority of Commonwealth holdings are in the BRWSS (refer Table 1). Delivery is managed by Sun Water and DERM in Queensland and State Water Corporation in NSW.

In the regulated water supply systems, user accounts are debited when a water order is accepted by the relevant river operator, independent of:

- how the water was supplied i.e. via a dam release or from tributary inflows;
- whether the water is taken by the user within the designated period for supply; and
- whether a water harvesting/supplementary event occurs in the period between the water order and delivery and the water user is able to access unregulated flows in this period (in some other valleys in the Basin accounts for regulated entitlements are not debited in this situation).

State Water operates Glenlyon and Pindari Dams in an integrated fashion. Releases to satisfy the irrigation and town water requirements of NSW users downstream of the Dumaresq-Macintyre River junction are made from either Glenlyon or Pindari Dams in order to minimise potential spills and conveyance losses. State Water and DERM also cooperate to maximise available water resources in the valley and as a result releases from Pindari Dam may in some circumstances be used to meet QLD water orders, with the volume in Glenlyon Dam allocated for QLD users adjusted accordingly.

Set delivery times apply to various reaches along the main stem and water orders must be submitted in advance and taking these times into account. Supply time Mungindi is 21 days from either Glenlyon or Pindari Dams; to Goondiwindi it is 7 days, illustrating the slowing passage of flows in the lower (floodplain zone) reaches of the river.

Figure 2 shows flow regulation infrastructure in the Border Rivers catchment.

Water from regulated entitlements can be delivered to authorised works essentially anywhere along the shared main stem in either state without incurring losses. Regulated water must be ordered to an approved diversionary works. Commonwealth entitlements in the Border Rivers do not have an approved water supply works nominated on/linked to them**.** This must be addressed before watering actions can commence in the valley.

In NSW it is a statutory requirement that water can only be delivered to/diverted at an approved water supply works nominated on the access licence supplying the allocation, or by assigning (trading) allocation to an access licence with an appropriate works approval. To deliver NSW holdings to off-stream lagoon sites, a Commonwealth access licence will need to be linked to approved private works at a location for the watering action. Options to enable in-stream delivery include to obtain a ‘miscellaneous works’ approval for river infrastructure (e.g. gauging station, regulator) in the appropriate river reach that will permanently link this works to a Commonwealth access licence, or to link a Commonwealth access licence to State Water’s overall works approval for the river infrastructure it operates.

Water from Queensland entitlements can be delivered to authorised works at any location provided that meter details and the permission of the works approval holder are included with the water order. Seasonal assignment, or trade of allocation, is required for out-of-zone deliveries (there are only two zones in the BRWSS) and deliveries to works in NSW.

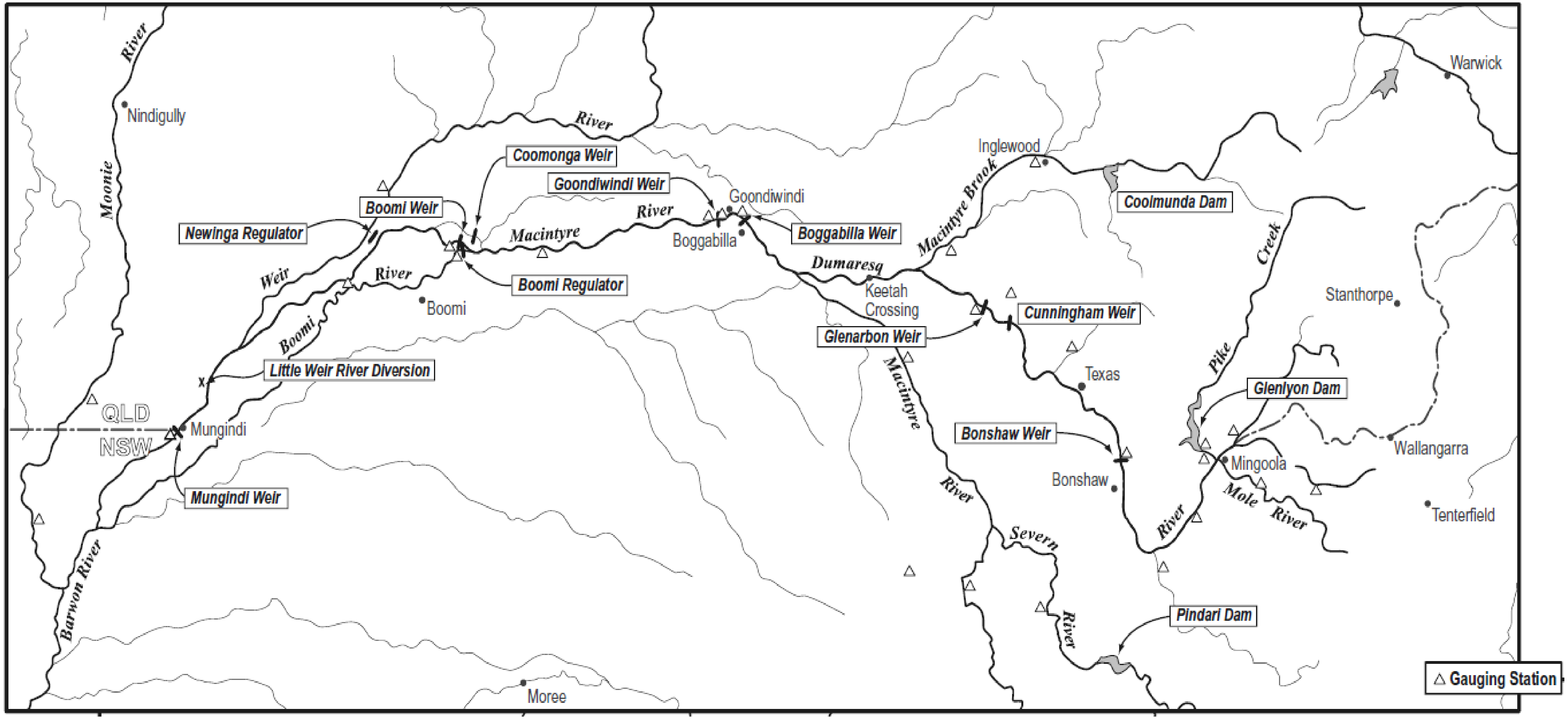

Figure 2: Key water supply infrastructure in the Border Rivers catchment (taken from Border Rivers Commission 2011)

1.6. Current Catchment Status and Outlook

From 2002 to 2010 (except 2004) the Border Rivers was drier than average experiencing only small magnitude flow events. In 2009-10 rainfall and runoff was very low, in contrast to the neighbouring Condamine-Balonne, Nebine, Warrego, and Moonie catchments, which experienced major flooding. However, it was very wet in 2010-11 (see Figure 3). Prolonged and exceptionally high stream flows occurred across the catchment from early spring through summer as a result of heavy rainfall in headwater areas. The largest floods on record were observed in the Severn (QLD), Macintyre and Dumaresq Rivers. Major flooding also occurred in the Weir River on several occasions. The NSW Border Rivers catchment recorded its wettest summer in 29 years.

Glenlyon and Pindari Dams spilled for the first time in 10 years. Glenlyon spilled in December 2010 and January 2011 and Pindari from late September 2010 to late June 2011 and again in September 2011.

The extensive flooding in 2010-11 inundated the majority of floodplain and lagoon assets in the catchment, the first time in a decade that many of these assets had received good inflows.

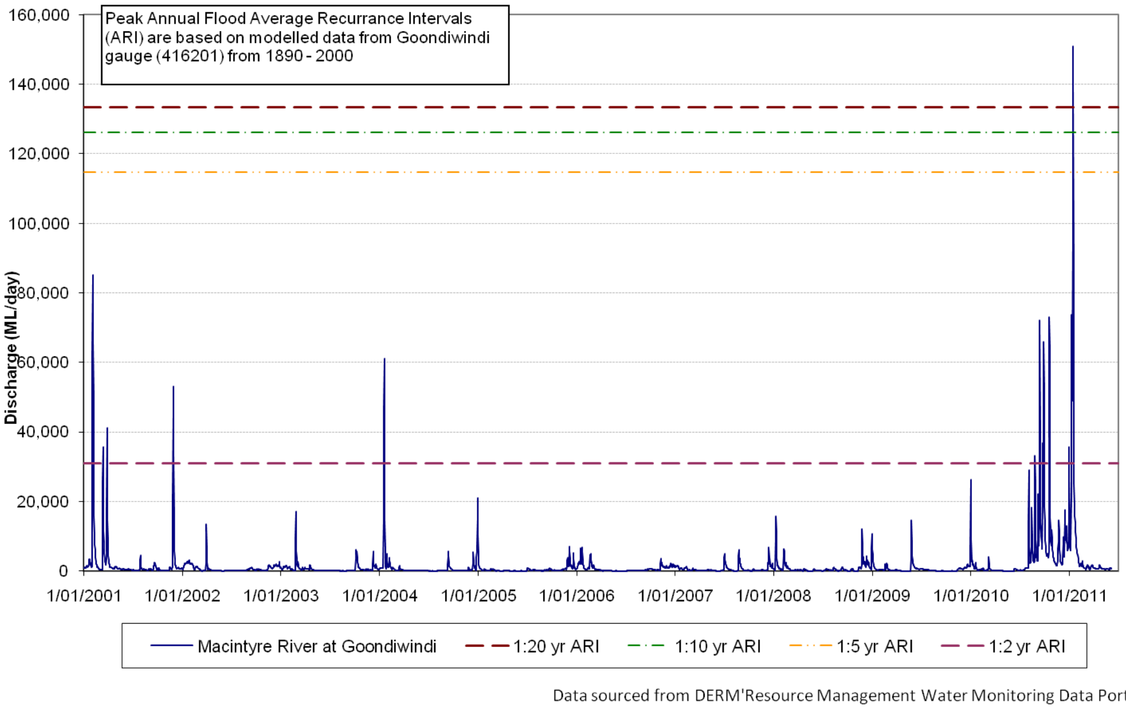

Figure 3 – Annual discharge of the Macintyre River at Goondiwindi 2000-2011 showing peak annual flood Average Recurrence Intervals (ARI)

The seasonal rainfall forecast in the Border Rivers catchment for November 2011 to January 2012 is for a 70 to 80 per cent chance of exceeding median rainfall (**Figure 1**).

During spring 2011, evidence of re-emerging La Niña event consolidated, although the strength of the current La Niña is considerably less than the 2010-11 event that saw record rainfall and flooding events across the majority of the Murray Darling Basin (Watkins 2011). BOM forecasts indicate that a weak La Niña will persist across the southern Australian summer.

The long range climate and 3-month rainfall outlooks suggest that **above median** water availability conditions are likely in the Border Rivers in the remainder of 2011-12.

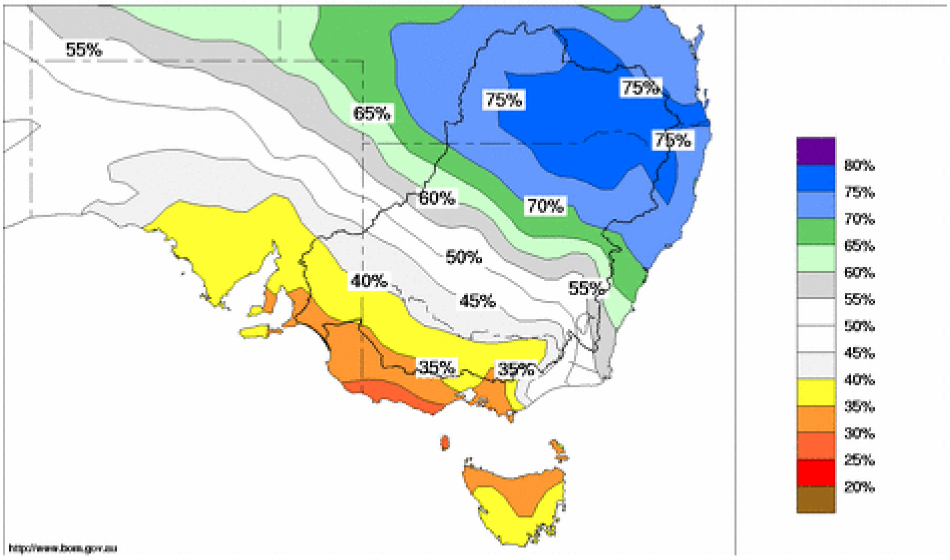

Figure 4: Seasonal rainfall outlook for south-eastern Australia, November 2011 to January 2012 (BoM).

1.7. Commonwealth Environmental Water

The Commonwealth holds just over 10.5 GL of entitlement in the Border Rivers, the majority of which is in the Queensland Border Rivers Water Supply Scheme (BRWSS), with only minor holdings in the NSW regulated water source (Table 1). Small additional volumes in the BRWSS are expected to be transferred to the Commonwealth during the year from the Queensland Healthy Headwaters Project (*pers. comm*. Water Efficiency Division).

As at November 1 2011 just over 9 GL is available to use in the catchment. Indicative total distributions (BRWSS entitlements) and allocations (NSW general security) under median, wet and very wet water availability scenarios are shown in Table 1 . These are not actual forecasts as they are not based on historical allocation patterns (this data is not publicly available in this catchment). Under all three scenarios, though, the total volume available for use will be constrained by the annual use limit set in statutory water plans (100% of entitlement volume) rather than potential distributions/ allocations over the year.

Table 1 - Commonwealth environmental water holdings in the Border Rivers

Reliability	Entitlement (ML)	Long term Cap equivalent [ML] (cap factor[1])	Carryover from 2010-11	Volume available at 1 November 2011	Maximum use in 2011-12	Indicative total distributions/allocations in 2011-12[2]		
						Median (QLD–30% NSW–40%)	Wet (QLD & NSW–70%)	Very Wet (QLD-85% NSW-100%)
QLD Medium Priority (Border Rivers Water Supply Scheme)	10,265	3,394 (0.33)	5,631[3]	8,742[4]	10,265	11,822	15,928	17,484
NSW General B	269	108 (0.4)	124	269[5]	269	377	457	538
Total	**10,554**	**3,502**	**5,755**	**9,011**	**10,554**	**12,197**	**16,385**	**18,022**

<u>Notes to Table 1</u>

1. Factors adopted by Environmental Water Branch for the Commonwealth Water Holdings Register.
2. Estimates assume that existing (full) accounts are drawn down to zero and replenished by distributions (QLD) and allocations (NSW) through the year at rates indicated for each scenario.
3. Carryover from 2010-11 is based on total BRWSS holdings of 6,625 ML and distributions made to February 2011.
4. Based on BRWSS holdings of 10,265 ML (3,640 ML was transferred to the Commonwealth between February and August 2011) and the distribution on 25 August 2011 that filled all accounts to 85% of entitlement volume.
5. NOW announced a 100 per cent allocation to NSW general security entitlements on 1 July 2011.

A complication for estimating total distributions/allocations is that Commonwealth BRWSS accounts are currently full (85 per cent of entitlement volume), they must be drawn down below this limit through use (watering action or trade) before any further distributions can be received. The timing and volume of draw down will potentially influence the volume of additional distributions in the remainder of 2011-12. With delay in drawdown, opportunities to receive further distributions are reduced. Using a large volume of water maximises airspace in the storage accounts and the volume of distributions that can potentially be received in the rest of the water year, but could also jeopardise carryover volumes.

1.8. Other Sources of Environmental Water

The Commonwealth is the sole holder of environmental water in the Border Rivers. NSW does not administer any adaptive environmental water licences in the Border Rivers, and as such there is no approved Adaptive Environmental Water Use Plan and no existing delivery arrangements for NSW holdings.

Commonwealth's regulated holdings in the valley can potentially be used in conjunction with planned environmental water provided under the NSW and Queensland statutory water plans and the Border Rivers IGA for in-stream watering actions (Table 2). Rules in these plans to protect in-stream low flows and a portion of all unregulated tributary flows will potentially assist delivery of in-stream flows.

Delivery of in-stream flows in the NSW Severn and Macintyre Rivers could also be undertaken in conjunction with translucent releases from Pindari Dam and/or the NSW stimulus flow release, to extend the beneficial effects of such a flow into the lower reaches of the Macintyre River in NSW.

Additionally, stock and domestic replenishment flows provided to the Boomi River (NSW) could be used to assist delivery of in-stream flows below Boggabilla weir and in the Boomi system.

Table 2: Other potential sources of environmental water in the Border Rivers catchment for 2011-12.

<table>
<tr><th>Source</th><th>Instrument</th><th>Management Authority</th><th>Potential Allocation</th></tr>
<tr><td>Stimulus flow Pindari Dam
(Purpose is to provide a flow that mirrors a natural hydrograph, provides preseason cues to fish breeding and inundates interconnected riparian areas in the Severn River below the Dam)</td><td rowspan="2">NSW Water Sharing Plan</td><td>NSW OEH and NOW

NSW State Water (delivery)</td><td>4,000 ML p.a. reserved for a stimulus flow. The trigger for release (August to December) is an inflow of more than 1,200 ML to the dam on any day in the preceding months of April to August. Water not released from the annual reserve can be carried over to a maximum of 8,000 ML.</td></tr>
<tr><td>Translucency flows Pindari Dam</td><td>NSW State Water</td><td>Up to 50 ML/day (September-May)
Up 200 ML/day (June-August)
Maximum of 30 GL/year (low likelihood in 2010-11)</td></tr>
<tr><td>Improving low flows at end of system</td><td rowspan="2">NSW Water Sharing Plan

NSW-Queensland Intergovernmental Agreement on the Border Rivers 2008</td><td rowspan="2">QLD DERM

NSW State Water/NSW OEH</td><td>Tributary inflows protected to maintain flow at Mungindi on the Barwon above 100 ML/day (September-March)</td></tr>
<tr><td>High flow protection</td><td>25% of unregulated flows in main trunk and Macintyre River in NSW protected from point of inflow to Mungindi</td></tr>
</table>

Source	Instrument	Management Authority	Potential Allocation
Low flow allowance Coolmunda Dam	QLD Border Rivers Resource Operations Plan	QLD SunWater	The first 100 ML/day of inflows released to 6,000 ML p.a.

There has been no use of Commonwealth regulated water holdings in the Border Rivers to date. Due to prolonged antecedent dry conditions, up until late in 2010 minimal distributions were made to Queensland BRWSS entitlements and the volume available from Commonwealth holdings was insufficient for an independent watering action. By the time distributions resulting from large inflows into dams in the spring and summer of 2010-11 were made, ecological needs were low as multiple large unregulated flows throughout the catchment had met in-stream and wetland watering objectives. Given that the benefits of additional environmental water were likely to be marginal, in March 2011 the CEWH decided to defer use of regulated water in the Border Rivers until 2011-12.

1.9. Watering Objectives for 2011-12

Watering objectives for the Border Rivers catchment have been developed based on the *Framework for Determining Commonwealth Environmental Watering Actions* (refer Appendix B). Objectives have been considered with regard to the high volume of carryover from 2010-11, very wet antecedent conditions and large reserves of water in the region's dams going into 2011-12. As a result, the 2011-12 strategy is oriented towards achieving outcomes reflecting higher water availability.

The overall watering objective for the Border Rivers in 2011-12 is to maintain ecological health and resilience. This includes the following management objectives and actions:

- Providing top-up water to floodplain lagoons to consolidate the anticipated ecological benefits of drought-breaking inflows in 2010-11;
- Promote nutrient cycling and availability of feeding and foraging habitats for native fish by wetting benches, banks and in-stream habitat – by prolonging duration and volume of medium flows ('freshes') in the lower system;
- Promote connectivity of the river channel and adjacent low-level lagoons and anabranches/effluents to improve nutrient cycling and availability of feeding and foraging habitats for native fish – by prolonging medium to high (in-channel) flow duration and extent at key sites and river reaches;
- Contribute inflows to the Barwon River to contribute to in-stream needs in that system and provide shepherded volumes for use below the Menindee Lakes system; and
- Ensure sufficient carryover to improve the ability to meet ecological needs in subsequent drier years.

Due to delivery constraints in delivering regulated supplies from Glenlyon or Pindari Dams to the lower Macintyre River and the small volume (relative to natural flow events) of Commonwealth environmental water available in the Border Rivers, it is not possible to provide the large volumes needed to augment high/overbank flows in order to inundate high-level floodplain lagoons and connect all anabranch and effluent streams to the main river channel. Hence, objectives for river-higher floodplain connectivity (wetter conditions) are not considered in this strategy.

Watering actions in the Border Rivers catchment, consistent with the objectives for a range of climate conditions in 2011-12, are outlined in Table 3.

1.9.1. Managing storage account balances and carryover in 2011-12

Border Rivers regulated storage accounts will be managed in 2011-12 to ensure sufficient water is carried over to 2012-13 while opportunities to receive distributions over the water the year and the volume of distributions are maximised.

Given that the volume of available water for use from BRWSS entitlements (10.3 GL) in 2011-12 in median and wetter scenarios is three times the long term cap equivalent and conditions were extremely wet in 2010-11, it is prudent to carryover a relatively high volume to provide a reserve of environmental water for use in coming years when drier conditions are likely and distributions are in line with or below average.

Accordingly, this strategy aims to carryover approximately 50 per cent of BRWSS entitlement volume (5,200 ML) to 2012-13. To enable this, it is proposed to limit initial environmental water use in the catchment to 50 to 60 per cent of BRWSS entitlement volume (i.e. 5,200 – 6,240 ML) on the basis that if average distributions (33 per cent of entitlement volume) are received during 2011-12, storage accounts will be at 55 to 60 per cent at year's end. Climate and catchment conditions will be reviewed closer to the time of the first watering action to determine if the volume limit should be changed. If conditions are likely to be wetter than average, a larger initial watering volume and/or additional watering actions may be warranted as this would maximise the 'space' in storage accounts and the volume that could be received in subsequent distributions.

1.10. Watering Options for 2011-12

A summary of watering priorities under the range of climatic scenarios is provided at Table 3. Details of watering options and objectives appropriate to median to high water availability conditions are provided in Table 4. Known operational considerations for these options, including delivery mechanisms, target flows and volumes, timing and duration of watering, is provided at Table 5.

The watering options outlined in Table 3 to Table 5 are preliminary and comprise numerous potential watering actions targeting four broad groups of assets based on river and/or floodplain reach. Potential target river reaches are shown on Figure 5 and individual lagoons on Figure 6.

Further investigation of the ecological values of specific assets, operational requirements and delivery arrangements is required before watering actions can be implemented. These arrangements will be progressed with relevant river manager, state agencies and private infrastructure owners. Additional operational details include trigger points for use associated with natural flows and cut-off dates if those flows did not eventuate.

Commonwealth holdings are insufficient to implement all watering options canvassed in this document. A prioritisation process will be undertaken, in consultation with state agencies and other stakeholders, to determine which of these options should be pursued.

Figure 5: Location of potential watering sites in the Border Rivers in 2011-12

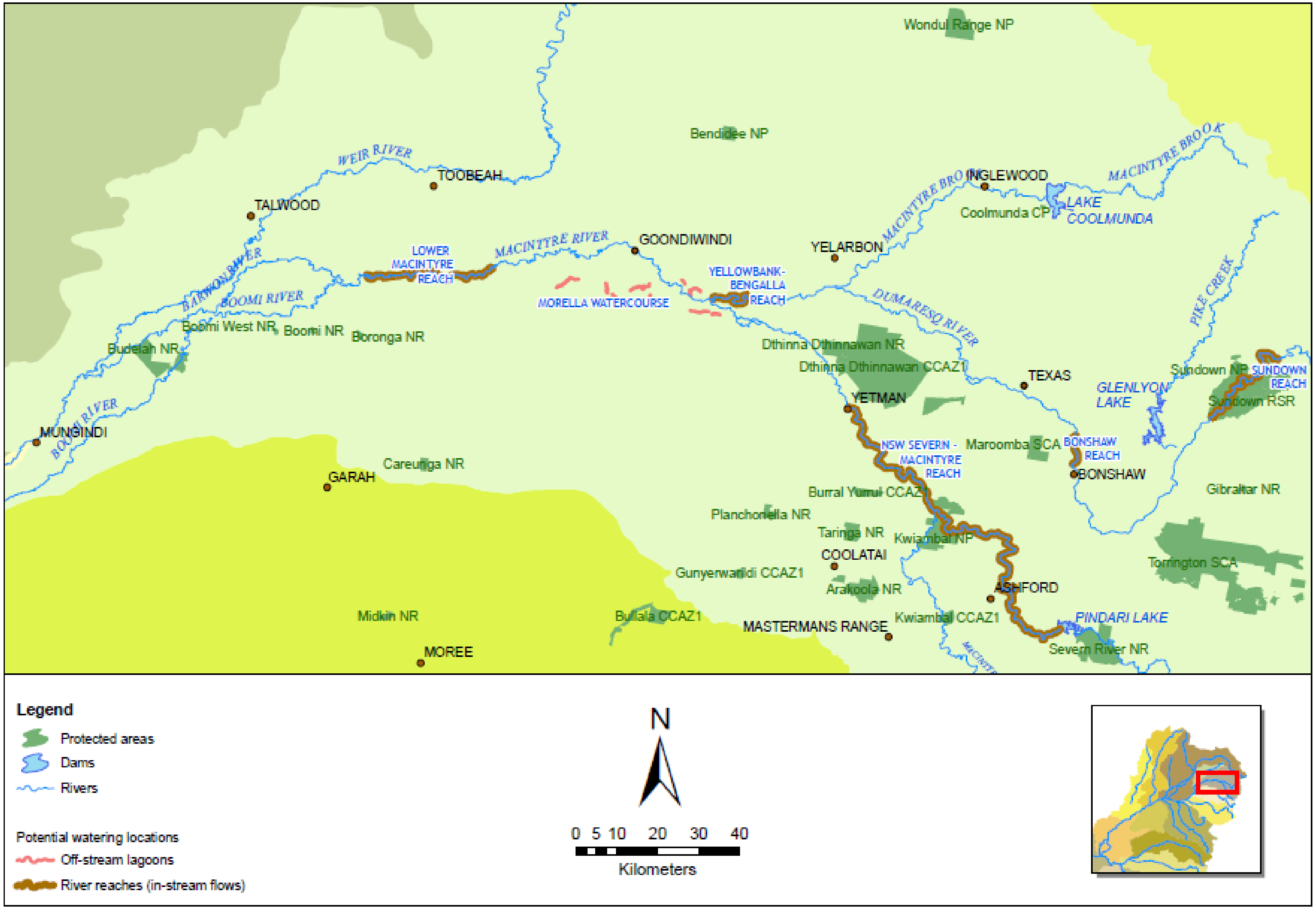

Figure 6: Potential lagoon watering sites in the Border Rivers

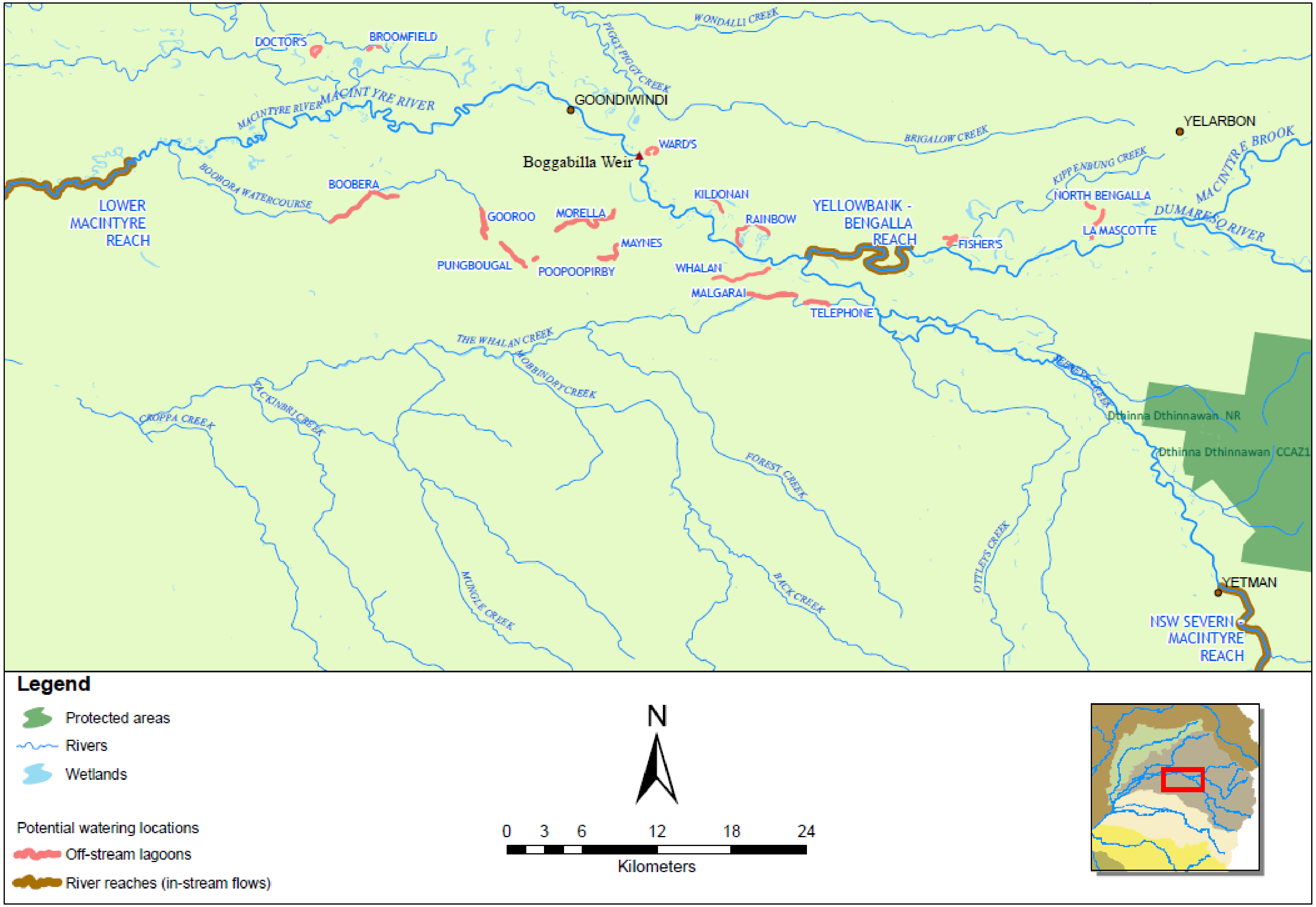

Table 3: Summary of potential watering options in the Border Rivers under different water availability scenarios

Environmental Asset	Management objectives for specific water availability scenarios				
	Extreme Dry **Goal: Avoid damage to key environmental assets**	**Dry** **Goal: Ensure ecological capacity for recovery**	**Median** **Goal: Maintain ecological health and resilience**	**Wet** **Goal: Improve and extend healthy and resilient aquatic ecosystems**	**Extreme Wet** **Goal: Improve and extend healthy and resilient aquatic ecosystems**
Severn and Macintyre Rivers from Pindari Dam to Yetman (NSW)	• No water to be delivered under extremely dry conditions.	• In combination with other water releases to increase low flow and base flows to provide drought refuge and contribute to fish passage	• In combination with other water releases and natural flow provide wetting and increase connectivity with low and moderate level benches and riparian vegetation.	• Limited options due to wet conditions but where appropriate provide wetting and increase connectivity high level benches and riparian vegetation. NSW stimulus flow likely to	• Not required as ecological objectives are likely to be satisfied by unregulated flows and NSW stimulus flow.
The Mid Macintyre/Dumaresq River lagoons (NSW & QLD)	• No water to be delivered in-channel under dry conditions. Investigate pumping options for inundation of critically stressed lagoons.	• No water to be delivered in-channel under dry conditions. Investigate pumping options and private diversion channels to provide flows to stressed floodplain lagoons.	• In combination with other water releases and natural flow events, provide flows to inundate lagoons adjoining the main river channel and low on the floodplain. • Investigate pumping options to provide water to moderate and higher level floodplain lagoons.	• In combination with other water releases and natural flow events provide flows to moderate and higher level floodplains and lagoons, subject to limiting risk of deleterious flooding of farmland.	• Not required as ecological objectives are likely to be satisfied by unregulated flows.
Lower Macintyre River below Goondiwindi (NSW & QLD)	• No water to be delivered under extremely dry conditions.	• In combination with other water releases to increase low flow and base flows to provide drought refuge and contribute to fish passage.	• In combination with other water releases and natural flows, increase in-channel flow pulses and overbank flows to improve floodplain and lagoon connectivity and contribute to fish passage.	• Limited options due to wet conditions but where appropriate contribute to overbank flows to improve river-floodplain connectivity and fish movement and habitat in connected lagoons.	• Not required as ecological objectives are likely to be satisfied by unregulated flows.
Dumaresq River e.g. Bonshaw and Yellowbank-Bengalla reaches	• Unlikely to be delivered in conjunction with natural flows	• Provide additional water to top-up refuge pools and maintain aquatic habitat (wetted perimeter), fish and other aquatic organisms and riparian vegetation, during periods when low flows in these reaches are reduced as a result of Glenlyon Dam capturing inflows (Autumn-Winter).	• Ideally in conjunction with natural flows, provide additional river flows, in spring-summer, to fill and re-connect refuge pools in these key river reaches and improve availability of feeding and foraging habitats for native fish.	• Not required as ecological objectives are likely to be satisfied by unregulated flows.	• Not required as ecological objectives are likely to be satisfied by unregulated flows.

Environmental Asset	Management objectives for specific water availability scenarios				
	Extreme Dry Goal: Avoid damage to key environmental assets	**Dry** Goal: Ensure ecological capacity for recovery	**Median** Goal: Maintain ecological health and resilience	**Wet** Goal: Improve and extend healthy and resilient aquatic ecosystems	**Extreme Wet** Goal: Improve and extend healthy and resilient aquatic ecosystems
Trade and Carryover	• Use water carried over from previous years to meet most critical ecological needs. Small potential for carryover if antecedent conditions are dry.	• Use water carried over from previous years. • Consider buying water on temporary market to augment available environmental water volumes, subject to suitable market price. • Small potential for carryover if antecedent conditions are dry.	• Aim to carryover LTCE volume (i.e. 33% of entitlement volume for BRWSS entitlements and 40% of entitlement volume for NSW general security entitlements) to balance ability to meet ecological needs in the current and subsequent years. • Consider buying water on temporary market to augment available water if there is low carryover going into the new water year and ecological needs are high (subject to prevailing market prices).	• Maximise carryover volumes whilst meeting ecological objectives. • Aim to carryover between from 50% of to 85% of the entitlement volume to provide optimal seasonal flow in subsequent years. • Consider option to trade (seasonal assignment) distributions/allocation if there is high carryover at year's start and a reasonable expectation of high distributions in the remainder of the water year, and ecological needs are not high (considering antecedent conditions). Ability to obtain favourable market price would also be a consideration.	• Carryover the maximum possible volume to the next water year (i.e. storage account limit of 85 per cent of entitlement volume in QLD, 100 per cent in NSW) to provide optimal seasonal flow in subsequent years. • Consider option to trade (seasonal assignment) distribution/allocation if there is a high possibility that accounts will be topped up again before season's end. Ability to obtain favourable market price would also be a consideration.

Table 4: Potential watering options for 2011-2012 in the Border Rivers catchment for median and wet scenarios.

Asset	Watering Option Objective
Severn and Macintyre Rivers from Pindari Dam to Yetman (NSW)	To provide a pulse flow to stimulate ecological processes in these reaches. In the Severn River (NSW) below the Dam, these pulses would scour algal mats to reset biofilm processes and replicate a natural seasonal 'fresh' flow during spring/summer. Up to 4,000 ML (4-8,000 ML NSW water)
The Mid Macintyre/Dumaresq River lagoons (NSW & QLD)	Objective 1 – areas with lower commence to flow Provide inflows to recently inundated lagoons, in conjunction with natural flows where possible. Confirmation of environmental values to be supported by this option is required. Many lagoons make up this asset. Indicative targets could include: - Fisher's Swamp (QLD) - Rainbow Lagoon (QLD) - Kildonan Lagoon (QLD) - Telephone-Malgarai Lagoon (NSW).
	Objective 2 – areas with higher commence to flow Provide inflows to recently inundated lagoons. Confirmation of environmental values to be supported by this option is required. Many lagoons make up this asset. Indicative targets include: - Telephone Lagoon (NSW) - Punbougal Lagoon (NSW) - Whalan Lagoon (NSW)
Lower Macintyre River below Goondiwindi	Objective 1 (in-channel/median conditions) – Enhance a fresh flow through the Lower Macintyre river system to provide wetting of benches and inset floodplains and in-stream habitat to promote nutrient and carbon cycling. Objective 2 (in-channel/higher flows) – enhance lateral connectivity between the main river and adjacent wetlands, anabranches and still water habitats and and support native fish spawning and recruitment. Serial reconnection of fringing lagoons the reach of the Macintyre commencing around 40 km below Goondiwindi (including Booberoi and other lagoons) has been shown to be important for lateral movement of the olive perchlet (*Ambassis agassizii* ; endangered in NSW) and spangled perch (*Leiopotherapon unicolour)* from spawning and nursery sites in the lagoons and survival of recruits (Hutchinson et al 2008). Commonwealth environmental water would be piggy-backed on an appropriate unregulated flow to enhance the probability and duration of a reconnection event. Delivering an in-channel flow in the window September to December may also benefit locally other resident native fish species for whom lateral connection with wetlands and anabranch is important for spawning and survival of larvae and juveniles e.g. flathead gudgeons (*Philypnodon grandiceps*) and Australian smelt (*Retropinna semoni*), (Humphries et al. 1999) and/or for which freshes and flow variability are important for spawning success and larval survival (e.g. Murray cod (*Maccullochella peeli*), golden perch (*Macquaria ambigua ambigua*) and silver perch (*Bidyanus bidyanus*) (NSW I&I, 2011). An additional objective for both the median and higher in-channel

Asset	Watering Option Objective
	flow is to Increase end-of-system flows to the Barwon-Darling River, for shepherding through downstream systems.
	Objective 3 (bankfull to overbank/wet conditions) - Provide flow to increase connectivity with lower Macintyre floodplain anabranches and billabongs to promote native fish recruitment and movement as well as carbon and nutrient cycling within the system.
Dumaresq River	Provide a top up flow to maintain connection between pools, inundate low flow channel and increase wetted perimeter of in-stream pools, to benefit native fish and maintain riparian vegetation. Target areas which have good in-stream and relatively diverse native fish communities and a largely intact riparian zone (Butcher 2007) are the Bonshaw and/or Yellowbank-Bengalla reaches. Note: a site assessment for this option has not been prepared due to a lack of data.

Table 5: Operational details for potential watering options for 2011-12 in the Border Rivers catchment.

Asset	Water Management Objective	Target flow rate/Volume to fill	Estimated volume	Timing & Duration	Delivery mechanism	Operational considerations
Severn and Macintyre Rivers from Pindari Dam to Yetman (NSW)	Provide a pulse flow to stimulate ecological processes in the NSW Severn and Macintyre Rivers, including scouring algal mats to reset biofilm processes and pre-season cues for fish spawning	1,000 – 2,000 ML/d to achieve effective scouring velocities	CEWH: 4,000 ML NSW: 4,000 - 8,000 ML	August – December 4-7 days	Release from Pindari Dam	Will require an arrangement with state river managers to release Commonwealth water from Queensland holdings from Pindari Dam in NSW. CEW will be released in conjunction with the NSW Stimulus Flow (4,000-8,000 ML). The stimulus flow is released if there has been an inflow to Pindari Dam of >1200 ML/d in the preceding months of April to August. Could be undertaken in conjunction with the Mid Macintyre/Dumaresq River lagoons option to maximise use of Commonwealth environmental water. Will requirement the agreement of State Water to provide CEW in addition to the NSW stimulus flow volume. Under standard system operating procedures, water orders from below Frazers Creek, the downstream limit of the reach in which the stimulus flow is protected from extraction, would be supplied from the stimulus flow volume itself. CEW will be ordered to an appropriate gauging station in the Macintyre River e.g. Holdfast, although will depend on whether some water is diverted to an in-stream lagoon in the region of the Macintyre and Dumaresq River junction.
Mid Macintyre/ Dumaresq River lagoons	Areas with lower commence to flow Provide inflows to lagoons inundated in summer 2010-11	commence to flow is approximately 13,000 - 30,000 ML/d at Goondiwindi	Rainbow Lagoon: 600-800 ML Kildonan Lagoon: TBC Telephone-Malgarai: TBC	To be confirmed based on catchment conditions	Release from Glenlyon Dam or Pindari Dam, either diverted and delivered to lagoon(s) using private irrigation infrastructure or via increased in-stream flows	Confirmation of environmental values of lagoon assets is required. Depending on water availability, the Commonwealth could choose to utilise private pumps and diversionary channels to deliver water directly to target lagoon(s), or in conjunction with natural flows if these are sufficient to inundate floodplain lagoons by overbank flows. This event could be carried out in conjunction with the watering option in the Severn and Macintyre Rivers from Pindari Dam to Yetman (NSW) to maximise efficient and effective use of Commonwealth environmental water.
	Areas with higher commence to flow Provide inflows to recently inundated lagoons	Commence to flow between 25,000 - 150,000 ML/d at Goondiwindi	Maynes: 200-400 ML Morella watercourse lagoons: >3300 ML	To be confirmed based on catchment conditions	Release from Glenlyon Dam or Pindari Dam and delivered using private irrigation infrastructure.	

Asset	Water Management Objective	Target flow rate/Volume to fill	Estimated volume	Timing & Duration	Delivery mechanism	Operational considerations
Lower Macintyre River below Goondiwindi	Objective 1 - Increase extent and duration of a natural 'fresh' flow in the Lower Macintyre River	4000 – 9000 ML/d at Mungindi Trigger for watering action: projected natural flows of 3,000 – 5,000 ML/d at Mungindi	20,000 ML – 45,000 ML (total event) 5,000-8,000 ML CEW	October to December for 5 days.	Release from Glenlyon Dam or Pindari Dam and delivered to Mungindi at the end of system.	Watering option is contingent on a natural end of system flow occurring in the target period which, without additional water, may not meet the target flow rate or duration. CEW would be ordered to Mungindi and be delivered in full with minimal losses (as flows would remain in-channel and system is regulated to this point). As Commonwealth holdings are not sufficient to provide for a fresh flow in its entirety, CEW would be piggybacked on a natural (near threshold) event. Suitable upstream flow triggers for the action (to provide more time for a coordinated environmental release) and antecedent criteria e.g. interval since last target event, will need to be defined.
	Objective 2 – Augment high flows in increase connectivity with lower Macintyre floodplain anabranches and billabongs	20,000 ML/d at Goondiwindi Trigger for watering action: projected natural flows of at least 16,000 ML/d at Goondiwindi	20,000 ML – 40,000 ML. 2,000 – 4,000 ML CEW (TBC)	October to March for 1-2 days	Release from Glenlyon or Pindari Dam and delivered (using reserve in Boggabilla weir first if possible) Storage and release from a private storage in the vicinity of the target reach may also be feasible, although operational and contractual arrangements need to determined	Option is contingent on a natural end of system flow occurring in the target period which, without additional water, may not meet the target flow rate or duration. CEW would be ordered to an appropriate location (gauging station) between Goondiwindi and Mungindi. Due to limited Commonwealth holdings and release constraints at Boggabilla weir, the CEW contribution to this event is limited to approximately 1,000 – 2,000 ML/d (to be confirmed). Therefore, to reach desired river levels, the natural event on which CEW is piggy backed will need to be very close to target range. It is likely that in delivering water to achieve Objective 2 will also achieve Objective 1.
Dumaresq River	Top up and maintain connection between in-stream pools to increase habitat area for native fish and to maintain riparian vegetation	Triggered by dry conditions	Minimum 500 ML (Bonshaw Reach) Yellowbank-Bengalla reach TBC	Autumn-Winter	Release from Glenlyon Dam	Watering could be carried out independently or in conjunction with a natural flow event. Cold water pollution is potential issue at higher release rates from Glenlyon Dam: at 350 ML/day, cold water plumes may extend for 30-40 km downstream, at 1000 ML/d the plume could potentially extend much further downstream and have significant impact on native fish (Butcher 2007). Attenuation of released water due to travel distance and effect of in-stream weirs may dampen the stimulatory effect of the flow pulse on river fauna.

1.11. Key Constraints

Delivery and governance arrangements need to be resolved with river managers, agencies and private landholders before environmental watering can occur in the Border Rivers. In particular, delivery arrangements, including appropriate contractual arrangements, to water higher level floodplain lagoons on private land need to be developed. Due to the lack of appropriate State or Commonwealth government infrastructure, delivery to these sites in 2011-12 will require pumping from the main river using private pump and irrigation delivery infrastructure, and appropriate agreements with landholders and river managers on details on the arrangements. Water accounting and security of environmental water are concerns for both state river managers and the Commonwealth.

Asset and site-specific delivery issues are outlined in more detail in the assessment of 2011-12 watering options (0). Key delivery issues include:

- The long travel times and corresponding lag time for water orders (e.g. 21 days for a release from Glenlyon or Pindari Dam ordered to Mungindi) makes it difficult to use regulated holdings in conjunction with unregulated flow to enhance the environmental outcomes of natural flow events. This is a significant issue for the proposed in-stream options below Goondiwindi. Options to address this such as using Boggabilla weir as an immediate water source to downstream reaches and/or storage and release of environmental water from private on-farm storages close to target river reaches, requires further investigation.
- In-stream weirs and the long travel distances (and lag times for water orders) to target river reaches will also impact the ability to achieve and maintain a desired hydrograph in the Dumaresq River using releases from Glenlyon Dam.
- As is standard practice for irrigation deliveries, orders for environmental water may at times be met using unregulated flows in preference to releases from storage. Tributary inflows are preferentially used to meet water orders in the Border Rivers regulated water supply schemes. Without variation to this existing practice, at times of unregulated system operation, Commonwealth environmental water may not be addition to unregulated flows (i.e. no piggybacking). In-stream watering options for the lower Macintyre River and the Mid Macintyre/Dumaresq Rivers (Table 4) require piggybacking on natural flows.
- Release capacities of dams and weirs could potentially constrain delivery of in-stream flows. The storage capacity (5.9 GL) and restricted rate of draw down (0.5 m/day or approximately 650-700 ML/d) of Boggabilla weir will limit its ability to supply the required volumes to augment a natural flow to meet in-stream flow targets in the lower Macintyre River (noting that releases from Glenlyon or Pindari Dam ordered at this time would take many days to refill the weir and other users may have orders in the system);
- The capacity of the Boomi regulator (60-70 ML/d in low flow conditions, 120-130 ML/d when the weir is being overtopped) could potentially constrain delivery of in-stream flows to the lower reaches of that system, including Budelah Nature Reserve;
- The release capacity of Pindari Dam (5,000 ML/d) may be a constraint if Commonwealth environmental water is released in conjunction with the NSW stimulus flow and/or if there were a large volume of water orders from other users to deliver;
- Losses from the Macintyre to the Weir River at Newinga, where the two systems are connected by low-level channel, is a potential issue for an end-of-system flow undertaken during unregulated flow conditions. The Newinga regulator has been operated to prevent uncontrolled loss of water ordered to locations in the lower

Macintyre to the Weir River under regulated conditions but has not been operated under unregulated flow conditions for this purpose.

- Environmental water release needs to consider other water orders being placed as well as natural flows as orders may not be accepted when made in isolation to other users due to high delivery losses to the order location (Department of Environment, Resources Management 2010).

1.12. Assessing Environmental Watering Options

Watering actions for 2011-12 have been assessed as consistent with the Criteria for Assessing Environmental Watering Actions (see Appendix C). The criteria includes the:

1. ecological significance of the asset(s);
2. expected ecological outcomes from the proposed watering action;
3. potential risks of the proposed watering action at the site and at connected locations;
4. long-term sustainability of the asset(s) including appropriate management arrangements; and
5. Cost-effectiveness and operational feasibility of undertaking the watering.

A preliminary assessment of watering options for the four general groups of assets against the Commonwealth criteria is provided at 0.

A more detailed assessment of specific actions within each group of options will be undertaken closer to the critical time for water delivery, and as and when outstanding operational and legal requirements for these options are determined. The assessment will include a site-specific risk assessment and will consider in more detail costs, delivery, monitoring and accounting arrangements. For additional options outside the scope of the four groups identified in Table 4, advice from the Environmental Water Scientific Advisory Committee may also be sought.

1.13. Water Use Accounting

For watering off-stream lagoons, the volume diverted for use will be measured at the nominated diversion works (water meter). If the Commonwealth uses private works including pumps, irrigation channels and ring tanks, to divert, store and/or deliver environmental water to specific assets it will bear the associated transmission losses. The method for determining the volume diverted for a watering action, i.e. delivered to assets and transmission losses, will need to be agreed between the Commonwealth and the relevant river manager and landholder(s).

Water for in-stream flows ordered and accounted at an appropriate gauging station or river regulatory works (weir, regulator etc.). Appropriate in-stream works relevant to specific watering options are listed in Table 6.

DERM has informally indicated it is willing to deliver (and account for) Commonwealth water held in the BRWSS to regulatory infrastructure operated by QLD or the Border Rivers Commission. A corresponding arrangement for in-stream delivery of NSW holdings is yet to be agreed with NSW. In the interim, NSW holdings will be preferentially used for watering options involving diversion from the river.

If the Commonwealth chooses to pass any residual water from environmental watering events into the Barwon-Darling River, it will be necessary to confer with Queensland and NSW on a method to tag this water and shepherd it through that system.

1.14. Risk Management

A full risk assessment will be undertaken for each watering action as part of the assessment and prioritisation process, building upon the preliminary assessment of risks for groups of assets at 0. Some of the more likely risks associated with delivering environmental water in the catchment include:

- Diversion of Commonwealth environmental water by water users in the Dumaresq River who can extract water when reach-wide flow thresholds are met ('Class A' supplementary access in NSW, unsupplemented entitlements in QLD)
- Loss of environmental water from stock and domestic extractions (not entitlement based) is a risk for in-stream watering options in the Dumaresq and Boomi Rivers, and for most lagoon watering options;
- undesirable flooding of property and infrastructure;
- event does not meet the desired hydrological/ecological outcomes;
- misalignment of a rain event and delivery of Commonwealth environmental water due to long delivery times from the dams in the Border Rivers;
- cold water pollution associated with large releases from Pindari Dam and Glenlyon Dams, which could potentially undermine the benefits to native fish of the NSW Severn-Macintyre and Dumaresq River in-stream flow options, respectively;
- a possible increase in alien species population or range e.g. carp (*Cyprinus carpio)*, goldfish (*Carassius auratus)*, redfin perch (*Perca fluvatilis)* and willows (*Salix spp*.);
- accurate water accounting and security of Commonwealth environmental water extracted, stored and/or delivered using private irrigation infrastructure is a risk for options requiring direct application to floodplain lagoons on private land; and
- forfeiting potential distributions as a result delayed use and/or use of insufficient volumes of environmental water in 2011-12 (refer section 1.7).

The Commonwealth will negotiate operational procedures with NSW and QLD delivery partners, including private landholders where relevant, to address and mitigate risks associated with specific watering actions.

An important action to avoid and/or mitigate risks from watering actions will be to engage and seek the cooperation of the local community and other water users to implement actions.

1.15. Event Monitoring

A robust approach to monitoring and evaluation is critical to determining the long-term outcomes of the use of environmental water, and to provide information to support good governance and adaptive management. The monitoring of Commonwealth watering actions will be undertaken in accordance with the Monitoring, Evaluation and Reporting framework being developed for Commonwealth environmental water. This framework will facilitate the assessment and achievement of specific environmental outcomes to Commonwealth watering actions.

In 2011-12 operational monitoring will be undertaken primarily by State Water and Sun Water/DERM. For in-stream watering options, the purpose of this monitoring is to account for discharged/delivered volumes at appropriate dams/gauging stations and to track the passage of released environmental water and associated natural flows, through the system. For options involving delivery to off-stream lagoons, operational monitoring will comprise measuring volumes of environmental water diverted at the nominated works, volumes delivered to specific assets and losses (refer to Table 6).

Other than monitoring in relation to the NSW stimulus flow release from Pindari Dam (scope in 2011-12 is still to be confirmed) by NSW Office of Water, there is no ongoing monitoring of ecological responses to environmental flows currently undertaken in the Border Rivers, although data from a study tracking movements of Murray Cod and other large bodied native fish in the Dumaresq and Macintyre Rivers (shown in Table 6) could potentially provide useful data on the response of fish to in-stream environmental flows in these systems.

Ecological response monitoring requirements for watering actions in 2011-12 will be evaluated in more detail as part of the assessment and prioritization process. Commonwealth investment in response monitoring in the Border Rivers is unlikely to be a priority compared to other catchments where volumes of Commonwealth water used will be greater. The extent of monitoring in 2011-12 is likely be contingent on delivery partners being able to make on-ground resources available in appropriate timeframes, on an event-by-event basis. Monitoring will most likely focus on the specific ecological objectives and potential risks of the action. To reduce costs, remotely sensed data such as satellite imagery and aerial photography, to provide data on indicators such as inundation and vegetation response, will be used wherever possible.

Table 6 lists work underway or expected to be finalised in 2011-12 that will improve understanding of ecological responses to environmental flows and longer term monitoring needs in the catchment. This includes studies investigating fish and algal response to the Pindari Dam stimulus flow undertaken as part of the NSW Integrated Monitoring of Environmental Flows (IMEF) (NSW Office of Water 2011c). These studies will inform operational planning should the Commonwealth decide to contribute additional water to an in-stream flow in NSW Severn and Macintyre River in conjunction with the NSW stimulus flow.

In Queensland, the Environmental Flow Assessment Program (EFAP) monitors the success and suitability of environmental flow provisions within Water Resource Plans. In the Border Rivers EFAP studies have focused on environmental water requirements (flow, time, and water temperature) for spawning and recruitment of golden perch. EFAP studies aim to guide the environmental flow objectives and monitoring requirements in future water plans (DERM 2011).

Neither the IMEF nor EFAP involve ongoing ecological response monitoring.

Environmental water requirements to sustain refuge waterholes in the Border Rivers and ecological values of these refuges (fish population assemblages, primary production, recruitment and recolonisation) has been examined in the recent Dryland Refugia Project led by Griffith University and a small EFAP study in the (unregulated) Weir River. A current study funded by the National Water Commission is examining ecological responses in waterholes and floodplains in the Border Rivers to changing in water flows in more detail. This work, along with a proposed joint study (NSW Office of Water, DERM and Cotton CRC) to examine the regeneration of floodplain plant communities under different hydrologic regimes and critical flow thresholds, will also inform both the assessment process and monitoring requirements.

Table 6: Monitoring arrangements for environmental flows in the Border Rivers

Location	Parameters	Timing/frequency	Responsibility
Compliance/operational monitoring Severn and Macintyre Rivers from Pindari Dam to Yetman (NSW)			
Severn and Macintyre Rivers - NSW stimulus flow	Discharge from Pindari Dam (ML/day) Flow (ML/day) and river height in Severn River below Dam and at Ashford Flow velocity (m s^{-1}) in channel and backwater sites Severn River	During release of stimulus flow	State Water
- Stimulus flow + CEW	Flow (ML/day) and river height at Holdfast and other sites on Macintyre River to track flow pulse	Duration of watering action	State Water, DERM
Mid-Macintyre/ Dumaresq River lagoons (NSW & QLD) * delivery via private irrigation infrastructure	Volume extracted at nominated works (ML)* Volume delivered to lagoon(s) CEW transmission losses (storage, delivery) * Water levels in receiving lagoon(s)	Period of take of ordered water Duration of watering action Before & during action, weekly for rest season	Private landholder, SEWPAC, Sun Water (QLD sites), State Water (NSW sites) Border Rivers-Gwydir CMA, QMDBC (TBC)
Lower Macintyre River below Goondiwindi	Flow (ML/day) and river height at gauging station/ weir to which water ordered (O) and intermediate sites (I) Rainfall and river flows at relevant tributary sites (if action in conjunction with natural flow event)	Ongoing daily monitoring	NSW State Water and Sun Water
- end of system flow	Barwon River @ Mungindi (O)		
- Lower Macintyre below Goondiwindi	Macintyre @ Terrewah (for Booberoi and adjacent lagoons) (O) Macintyre River @ Goondiwindi, Boomi, Kanowna (I)		
Dumaresq River in-stream options	Dumaresq @ Glenabron (Bengalla-Yellowbank reach) Dumaresq @ Bonshaw weir (Bonshaw Reach)		
Intervention/response monitoring			
Severn and Macintyre Rivers - NSW stimulus flow +/- CEW	Water temperature in Severn at Wells Crossing, Three Mile Bridge, Riverbend (TBC) Algal and benthic community response (TBC)	Before and immediately after release of stimulus flow	State Water, NSW Office of Environment and Heritage
Mid-Macintyre/ Dumaresq River lagoons	TBC	Before and after addition of CEW (at regular intervals)	TBC
Condition monitoring			

Location	Parameters	Timing/frequency	Responsibility
Severn (NSW), Macintyre and Mole Rivers *Pindari fish monitoring project*	Species composition of recruitment across these river systems, and to analyse temporal links between flow variability (and water temperature) and spawning activity	Finalised One off assessment in 2006-2008	NSW Office of Water
Severn (NSW), Macintyre Rivers downstream of Pindari Dam *Pindari benthic algae monitoring project*	To determine the species composition and biomass of periphyton and macroinvertebrates before and after flow events in order to determine whether the stimulus flows had a positive environmental benefit	Finalised One -off assessment	NSW Office of Water
Macintyre River downstream of Glenlyon *Golden perch monitoring project*	To determine the response of the golden perch to different flow types and environmental variables (water temperature and food resource availability) in different river reaches	Finalised October 2008 - April 2010	DERM
Macintyre and Dumaresq Rivers *Murray cod population and breeding behaviour and impacts of stocking program*	- Age/size composition Murray cod population - Cod breeding period, reproductive development and diet in different reaches - Movements of cod and other large migratory fish e.g. golden and silver perch, eel-tailed catfish in the Dumaresq River (acoustic tagging of adult fish, fluorescent chemical marking of stocked fingerlings)	In progress	Border Rivers-Gwydir CMA and Queensland Murray Darling Basin Committee QLD Employment, Economic Development and Innovation (Fisheries) NSW Industry and Investment (Fisheries) NSW Recreational Fishing Trust
Border Rivers and Condamine Balonne *Ecological responses of waterholes and floodplains to different flow regimes*	Spatial requirements for waterholes at landscape scale) and influence of river flow regimes on food availability and quality in waterholes Develop environmental flow requirements (timing, duration and frequency of flow events) to maintain healthy waterhole assemblages	To commence in 2011-12	National Water Commission (funding) DERM (field work and analysis)

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Appendix A Environmental Assets

Severn and Macintyre Rivers from Pindari Dam to Yetman (NSW)

In-channel benches in the Border Rivers act as sediment and nutrient sinks and are an important source of dissolved nutrients (SKM 2009).

The Macintyre, Dumaresq and Severn (NSW) Rivers have been listed as part of the endangered aquatic ecological community of the Lowland Darling River under the *NSW Fisheries Management Act 1994*.

Wetlands on the Severn River (NSW) downstream of Pindari Dam, upstream of Ashford power station and within Kwiambal National Park are important ecological features that rely on natural flow variability and medium floods to maintain health and diversity (Department of Water and Energy 2009).

The target reaches of the Severn (NSW) and Macintyre Rivers sustain high fish diversity and provide good refuge conditions for native fish. Native fish recorded include: silver perch (*Bidyanus bidyanus*, NSW vulnerable); purple spotted gudgeon (*Mogurnda adspersa*, NSW endangered); olive perchlet (*Ambassis agassizii,* NSW endangered population) and Murray Cod (*Maccullochella peelii*, Commonwealth vulnerable). There are anecdotal reports of the eel-tailed catfish (*Tandanus tandanus*, NSW endangered population) throughout the Severn (NSW) and Macintyre Rivers. Five species were observed in the Severn River (NSW) (Wells Crossing) in a fish monitoring study from 2005-2009: eel-tailed catfish: carp gudgeons (*Hypseleotris* spp.), Murray Cod, unspecked hardyhead (*Craterocephalus stercusmuscarum fulvus*) and Australian smelt (*Retropinna semoni*) (Wilson and Ellison 2010 in prep).

Channel and refuge pools in the regulated of the Severn (NSW) and Macintyre Rivers below Pindari are particularly important for maintaining fish populations in periods of low or no flow (SKM 2009). In-stream connectivity is an essential prerequisite for successful fish populations and there is evidence that golden perch and silver perch are no longer breeding downstream of the Pindari Dam (Kingsford 1999). In addition, purple-spotted gudgeon have not been caught in recent fish surveys carried out in the Border Rivers, suggesting that river regulation is having an impact of fish populations (Kingsford 1999).

The Mid Macintyre/Dumaresq River lagoons (NSW & QLD)

This asset extends from Yetman on the Macintyre River and Texas on the Dumaresq River to approximately 20km downstream of Goondiwindi on the Macintyre (SKM 2009). This area contains large a series of lagoons which provide essential ecosystems functions such mobilisation and transportation of organic carbon and other nutrients (Thoms et al. 2005). Lagoons occur on both sides of the lower Dumaresq and the Macintyre River downstream to below Goondiwindi and include Morella watercourse which is located on a prior course of the Macintyre River and is a listed as wetland of national importance (Environment Australia 2001). In the lower Border Rivers catchment a number of other lagoons, such as Rainbow Lagoon (QLD), Kildonan Lagoon (QLD), Telephone-Malgarai Lagoon (NSW) and Maynes Lagoon (NSW), flow away from the truck stream when certain river levels are reached (SKM 2009).

Lower areas of this asset are hydrologically connected to the river channel when the flow exceeds 20,000 ML - 30,000 ML/day at Goondiwindi (Reid 2006) whilst areas of the asset higher in the landscape are hydrologically connected to the river channel when flows exceed 25,000 ML/d - 80,000 ML/d at Goondiwindi (CSIRO 2007; SKM 2009). These lagoons often support diverse populations of water birds including brolgas, black-necked storks and magpie geese and are the most southerly breeding areas for several northern dwelling species (Border Rivers-

Gwydir Catchment Management Authority 2008). Riparian vegetation communities in the lagoons are typically dominated by the common reed and cumbungi understory and river coolibah/river red gum communities (SKM 2009).

The lagoons are known to provide habitat for many fish including the golden perch, silver perch Murray cod, eel-tailed catfish, spangled perch and bony herring, purple-spotted gudgeon, Darling River hardyhead and the olive perchlet (SKM 2009).

Lower Macintyre River below Goondiwindi

This asset stretches from Goondiwindi to Mungindi including the main channel and the floodplain. This asset is characterised by extensive floodplains up to 20km wide, a network of anabranch channels that dissect the floodplain and a mosaic of other water bodies such as lagoons (SKM 2009). The ephemeral channels are disconnected from the main channel for most of the year, though pools can retain water for several months. There are no semi-permanent water bodies that exist away from the channel (SKM 2009). The Border Rivers are made up of a number of streams which provide a wide range of aquatic habitats (CSIRO 2007). In particular, the floodplains between Goondiwindi and Mungindi contain extensive anabranches and billabongs. These provide large amounts of organic carbon during flood events, essential to aquatic ecosystem functioning (CSIRO 2007).

The asset has high native fish value, as the asset is listed as part of the threatened aquatic ecological community of the lowland catchment of the Darling River under the *NSW Fisheries Management Act 1994*. Small Murray cod (Commonwealth vulnerable) juveniles (below stocking size) suggest this area is breeding site. Other native fish species recorded include silver perch (vulnerable, NSW); olive perchlet (endangered population, NSW); spangled perch (*Leiopotherapon unicolor*); Murray-Darling rainbowfish (*Melanotaenia fluviatilis)*, carp gudgeons; unspecked hardyhead; golden perch (*Macquaria ambigua*), and bony herring (*Nematalosa erebi)* (Davies et al. 2008, Butcher 2007). The reach has provided the only known record of flathead gudgeon *(Philypnodon grandiceps)* from the Border Rivers (Hutchison et al. 2008).

Ephemeral lagoons associated with the asset are important habitat for some native fish species; one lagoon in the area (Booberoi) has been shown to be used for breeding by olive perchlet and spangled perch. Recruitment in these sites is dependent on connectivity to the river (Hutchison et al. 2008).

DERM has identified golden perch as the top priority flow-dependent asset for monitoring to determine whether the ecological objectives of the Border Rivers Water Resource Plan are being met (Department of Natural Resources and Water 2009). This species, along with Murray cod, silver perch and spangled perch (medium to large bodied fish that undergo long distance migrations) were assessed as being at moderate risk of not having their critical water requirements met throughout the Border Rivers, including the reach downstream of Goondiwindi. High, overbank and flood flows, relevant to migration and spawning of these species

Inundation of the floodplains and lagoons downstream of Goondiwindi is also recognised as a significant provider of dissolved organic carbon to aquatic systems (Thoms et al. 2005). This occurs when the carbon and nutrients, released by inundation, are subsequently carried to the river channel where they provide an important energy input for primary production.

Appendix B CEWH Ecological Watering Objectives

	Ecological Watering Objectives	Management Objectives	Management Actions
Extreme Dry	Avoid damage to key environmental assets	Avoid critical loss of threatened species and communities Maintain key refuges Avoid irretrievable damage or catastrophic events	Water refugia and sites supporting threatened species and communities Undertake emergency watering at specific sites of priority assets Use carryover volumes to maintain critical needs
Dry	Ensure ecological capacity for recovery	Support the survival and growth of threatened species and communities, including limited small-scale recruitment Maintain diverse habitats Maintain low-flow river and floodplain functional processes in sites and reaches of priority assets	Water refugia and sites supporting threatened species and communities Provide low flow and freshes in sites and reaches of priority assets Use carryover volumes to maintain follow-up watering
Median	Maintain ecological health and resilience	Enable growth and reproduction and small-scale recruitment for a diverse range of flora and fauna; Promote low-lying floodplain-river connectivity; Support medium-flow river and floodplain functional processes	Prolong flood/high-flow duration at key sites and reaches of priority assets Contribute to the full range of in-channel flows Use carryover to provide optimal seasonal flow patterns in subsequent years
Wet	Improve and extend healthy and resilient aquatic ecosystems	Enable growth, reproduction and large-scale recruitment for a diverse range of flora and fauna Promote higher floodplain-river connectivity Support high-flow river and floodplain functional processes	Increase flood/high-flow duration and extent across priority assets Contribute to the full range of flows, including overbank Use carryover water to provide optimal seasonal flow patterns in subsequent years

For further information please refer to the *Framework for Determining Commonwealth Environmental Watering Actions* (available at http://www.environment.gov.au/water/policy-programs/cewh/index.html)

Appendix C Criteria for Assessing Commonwealth Environmental Watering Actions

In undertaking its activities, the Commonwealth Environmental Water Holder (CEWH) is required to act consistently with the requirements of the *Water Act 2007* (Cwlth) (hereafter referred to as 'the Act'). The relevant functions are outlined in s.105. This includes a requirement that the environmental water holdings are managed in accordance with the environmental watering plan of the Murray-Darling Basin Authority (MDBA). Close consultation is occurring with the MDBA to ensure that use of Commonwealth water is consistent with the emerging objectives of the environmental watering plan that is currently being developed.

A long-term framework for the prioritisation of environmental water allocations has been prepared in consultation with delivery partners, interested stakeholders and experts, and the Environmental Water Scientific Advisory Committee.

The framework includes ecological objectives that will change under the different water availability scenarios (i.e. extreme dry, dry, median, wet). Proposed watering actions will need to be supported by available evidence, and consistent with current water availability scenarios and the framework.

Commonwealth environmental water is being acquired to supplement existing flows. Proposals for use of the water will not be agreed to if this use substitutes for other water uses, including historical system operations (e.g. provision of water for conveyance, stock and domestic, or planned environmental water).

Through adaptive management processes, the CEWH will consider opportunities for a more informed and diverse range of water uses as knowledge and modelling. All 2011-12 proposals will be assessed against the following five criteria:

1. The ecological significance of the asset(s).
2. The expected ecological outcomes from the proposed watering action.
3. The potential risks of the proposed watering action at the site and at connected locations.
4. The long-term sustainability of the asset(s) including appropriate management arrangements.
5. The cost effectiveness and operational feasibility of undertaking the watering.

Appendix D Preliminary Assessment of Watering Options Criteria for Assessing Commonwealth Environmental Watering Actions

Severn and Macintyre Rivers from Pindari Dam to Yetman (NSW)	
Criteria	**Assessment**
1. Ecological significance of the asset	The proposed asset includes reaches of the Severn (NSW) and Macintyre Rivers downstream of Pindari Dam which includes the wetlands on the Severn River (NSW) upstream of Ashford power station and within Kwiambal National Park. This area has important ecological features that rely on natural flow variability and medium floods to maintain health and diversity (Department of Water and Energy 2009). The reach sustains high fish diversity and provides good refuge conditions for native fish. Native fish recorded include: silver perch (*Bidyanus bidyanus*, NSW vulnerable); purple spotted gudgeon (*Mogurnda adspersa*, NSW endangered); olive perchlet (*Ambassis agassizii,* NSW endangered population) and Murray Cod (*Maccullochella peelii*, Commonwealth vulnerable). There are anecdotal reports of the eel-tailed catfish (*Tandanus tandanus*, NSW endangered population) throughout the Severn (NSW) and Macintyre Rivers. Five species were observed in the Severn River (NSW) (Wells Crossing) in a fish monitoring study from 2005-2009: eel-tailed catfish: carp gudgeons (*Hypseleotris* spp.), Murray Cod, unspecked hardyhead (*Craterocephalus stercusmuscarum fulvus*) and Australian smelt (*Retropinna semoni*) (Wilson and Ellison 2010 in prep). Other threatened aquatic species and ecological communities documented in the area are: • **Invertebrates and frogs**: river snail (*Notopala sublineata*; NSW endangered); the Boorolong frog (*Litoria boorolongensis*; Cwth and NSW endangered); sphagnum frog (*Philoria sphagnicolus*; NSW vulnerable); yellow-spotted bell frog (*Litoria castanea*; Cwth & NSW endangered) and the tusked frog (*Adelotus brevis;* NSW endangered population) • **Waterbirds**: black-necked stork (*Ephippiorhynchus asiaticus*: NSW endangered; Qld rare); blue-billed duck (*Oxyura australis*; NSW vulnerable, EPBC migratory); brolga (*Grus rubicunda*; NSW vulnerable); comb-crested Jacana (*Irediparra gallinacea*; NSW vulnerable); freckled duck (*Stictonetta naevosa*; NSW vulnerable, Qld rare, EPBC migratory); painted snipe (*Rostratula australis*; Cwth and Qld vulnerable; NSW endangered; EPBC migratory); regent honeyeater (*Anthochaera phrygia*; Cwth and NSW endangered). • **Endangered ecological communities** Threatened Species Conservation Act 1995: Upland Wetlands of the Drainage Divide of the New England Tablelands (occurs in areas of the Tenterfield, Guyra, Severn (NSW), Dumaresq and Uralla local government areas, including in the catchments of the Severn (NSW) and Macintyre Rivers in the target reach) Fisheries Management Act 1994: The NSW Severn River is part of the threatened aquatic ecological community of the lowland catchment of the Darling River. Channel and refuge pools in the regulated of the Severn (NSW) and Macintyre Rivers below Pindari Dam are particularly important for maintaining fish populations in periods of low or no flow. In-stream connectivity is essential for successful fish populations. There is evidence that golden perch and silver perch are no longer breeding downstream of the Pindari Dam and purple-spotted gudgeon have not been caught in recent fish surveys in the Border Rivers, suggesting that river regulation is having an impact on fish populations (Kingsford 1999).
2. Expected ecological outcomes	This watering option is intended to stimulate ecological processes in the Severn River (NSW) below Pindari dam, primarily by resetting algal biofilm processes to stimulate production through all levels of the aquatic food chain. Subsidiary aims are to provide pre-season cues for fish, repeatedly wet and interconnect riparian areas below the dam and to provide a flow that mirrors a naturally occurring hydrograph. Stimulatory effects of the NSW component of the release are focused on reach of the Severn from below the dam to the confluence with Frazers Creek (22km). With addition of CEW to this action, the beneficial effects of the flow pulse will extend further downstream, potentially as far as Holdfast on the Macintyre River, 125 km downstream of the dam. Addition of CEW will achieve higher peak flows and velocities (and extend the duration of these). High discharge rates are required to tumble boulders and scour nuisance algal mats and may also help to disrupt access by the exotic mosquitofish (*Gambusia holbrooki*) to riparian slack and backwater areas in the Severn River (Wilson and Ellison 2010 *in prep*`). Recent NSW study found that discharges from Pindari Dam are unlikely to alter periphyton (algae attached to rocks) communities greatly at below 1,000 ML/d. However, if releases are increased to above 2,000 ML/d (or are piggybacked onto unregulated tributary flows to achieve these flow rates), there is likely to be a positive change in periphyton communities towards early-successional-stage species which are a better food source for macroinvertebrates (NSW Office of Water 2011c). In other areas of the Murray-Darling Basin, flow patterns and variability have been shown to be important for native fish and their lifecycles. Species like the silver perch and the golden perch require flow pulses and floods for spawning (Humphries and Lake 2000). Murray cod, silver perch and golden perch species undertake large scale migration during their lifecycles and rely on increased flow rates to cue spawning (Butcher 2007). Commonwealth environmental water would be contributing to flow variability which provides a range of seasonal ecological cues, particularly important for a number of native fish species.
3. Potential Risks	A full risk assessment will be completed for this watering event as part of the assessment and prioritisation process. Possible risks associated with the delivery of the water include: <u>Cold water pollution</u>: Pindari Dam has multiple offtakes at varying depths and with small to medium releases, cold water pollution is not likely to be a significant issue other than during blue green algal blooms (relatively common in Pindari Dam) when bottom and surface water are mixed for releases to reduce the risk of transmitting blooms downstream and affecting Ashford town water supply. With large release volumes form the Dam, thermal effects have been observed in the Severn River that could potentially compromise the fish breeding objectives of the stimulus flow (Wilson and Ellison 2010 in prep). Numerous discrete drops in temperature averaging 7.5°C were observed in the Severn River at Wells Crossing in field seasons (August and January) from 2005-2009. These drops in downstream temperature were associated with releases from the dam. Temperature drops were not observed in the study period in the reference Mole River or with natural inflows into Wells Crossing. Fish monitoring following irrigation releases in October (970 ML) and November 2008 (1088 ML), similar in magnitude to likely stimulus flow discharges, detected significantly greater abundances of juvenile mosquitofish in the Severn River but no increase in native fish abundances was detected. Thermal risks with the increased volume of water available for a combined NSW-Commonwealth 2011 stimulus flow, and strategies to mitigate these impacts will be explored further with NOW prior to the Commonwealth water being made available for this action. Potential impacts on fish could be minimised by delaying stimulus releases till late in the spawning season (December to January) to safeguard recruitment of success of native fish species, particularly the eel-tailed catfish, for which rise in water temperature (and not flow characteristics) appears the primary

	trigger for spawning (Wilson and Ellison 2010 in prep). Downstream diversion: The NSW stimulus flow is protected from downstream diversion to the Frazers Creek confluence only (approx 22km). However, NOW is proposing to negotiate with downstream irrigators (Border Rivers Food and Fibre) so they delay or minimise ordering and accessing irrigation water during the release, to preserve the pulse as far as possible down the river. The increased volume available for this release (8,000 ML+) will also improve downstream penetration. The Commonwealth will nominate a works for delivery of its water in the vicinity of Boggabilla (175 km downstream from Pindari Dam), ensuring the full volume (260ML) is protected right through to this point. Alien species: Environmental flows may support an increase in alien species population or range e.g. carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), redfin perch (*Perca fluvatilis*) and Willows (*Salix* spp.). Environmental water deliveries will be aligned to support or favour native fish species spawning and dispersal events. Possible pumping to fill fringing wetlands will utilise fish exclusion mesh to prevent introductions through environmental water delivery.
4. The long term sustainability of the asset	In-stream habitat and values have been identified by NSW and QLD as having ecological importance and both states have rules in their respective water management arrangements in place with a view to improving the health and condition of in-stream habitat and values. In addition, *the NSW Fisheries Management Act 1994* identifies Lowland Darling River aquatic ecological community as threatened which guides management activities to protect and restore this reach. Commonwealth environmental water would be in addition to these measures and provide increased benefits to in-stream assets. These provisions will support the long term sustainability of the asset. Complementary natural resource management activities: The Pindari Dam stimulus flow and translucency rules (i.e. inflows up to 50 ML/day between September and May are passed downstream; up to 200 ML/d between June-August) in the Border Rivers WSP recognise and attempt to mitigate the impacts of the dam on the natural hydrological regime and aquatic ecosystems in the Severn River (NSW). Kwiambal National Park protects stretches of the Severn (NSW) and Macintyre Rivers and their catchment of high conservation and scenic value (National Parkes and Wildlife Service 2004).
5. Cost-effectiveness	Usage charges applicable for Border Rivers Water Supply scheme ($11.25/ML) would apply to CEW Queensland holdings released from Pindari Dam. The majority of Commonwealth holdings in the Border Rivers are in this scheme. If NSW general security holdings are used, usage charges are considerably higher at $30.79/ML as they include a user levy of $19.54/ML which is paying off the cost of the enlargement of Pindari Dam in the early 1990s. Additional but unknown costs would apply to delivery through private pumps and irrigation infrastructure if a portion of the CEW released from Pindari Dam is extracted downstream from the Macintyre River to water a floodplain lagoon. NSW water in this action will incur transmission losses flowing down the Severn (NSW) (60km) and Macintyre (60 km) Rivers as well as diversionary loss within this reach below Frazer Creek confluence (22km). NSW stimulus flow is only protected from extraction to this point. However, the Commonwealth volume will be preserved in full through the target reach and beyond to the specified delivery point (likely to be Bas far down the system as possible, likely at Goondiwindi if water is to be used in conjunction with a lagoon watering event, or Mungindi at the if the water is used to enhance in-stream flows throughout the system. Release at Pindari Dam enables the Commonwealth water to provide environmental benefits at multiple locations, further increasing the cost effectiveness of this action.

The Mid Macintyre/Dumaresq River lagoons (NSW & QLD)	
Criteria	**Assessment**
1. Ecological significance of the asset	This asset is expected to contribute to nutrient and carbon cycling within the river system, which is key ecosystem function. Inundation of the floodplain and lagoons downstream of Goondiwindi are recognised as a significant provider of dissolved organic carbon to aquatic systems (Thoms et al. 2005). This occurs when the carbon and nutrients, released by inundation, are subsequently carried to the river channel where they provide an important energy source for primary production. It is likely that the lagoons further upstream within this asset will make a similar contribution. In addition, the lagoons also provide important habitat and refuge. The Morella Watercourse is located within this asset and is listed as a nationally important wetland. It is one of the few permanent water bodies in the arid northern Murray-Darling Basin (SKM 2009). This area supports populations of Brolga and glossy-black cockatoo (*Calyptorhynchus lathami*), which have been listed as vulnerable under *NSW Threatened Species Act 1995*. Species listed under JAMBA and /or CAMBA which have been recorded in the area include the great egret (*Ardea alba*) and cattle egret (*Ardeola ibis*). The values of many other lagoons within this asset are no known at this stage however, many are known to support river red gum (*Eucalyptus camaldulensis*), river cooba (*Acacia stenophylla*) and coolibah (*Eucalyptus coolabah*) stands as well as some lignum, and spike rush stands (pers. comm., Jane Humphries Wetland Conservation Officer, OEH).
2. Expected ecological outcomes	Floodplain lagoons of the mid Macintyre River depend on overbank and flooding flows and local catchment inflows to reconnect and refill (CSIRO 2007). Due to water resource development, temporary wetlands flood less often and for shorter duration, resulting in a sharp reduction in organic input to the system. The CSIRO Sustainable Yields assessment for the Border Rivers found that the average period between flows that reconnect the lagoons and anabranches of the Macintyre River has increased by 18 per cent, the volume of individual events has been reduced by 8 percent and average annual volume of events reduced by 25 per cent compared to pre-development conditions (CSIRO 2007). The two objectives for this asset are expected to contribute to habitat maintenance for vulnerable bird species as well as to support key ecosystem functions such as nutrient cycling and movement of dissolve organic carbon. It is also expected that the watering actions would support riparian vegetation. For example, Morella Lagoon supports river spike rush meadows, water primrose, cumbungi and coolibah. Mature river red gums are supported by flows many of the lagoon and have shown signs of new growth and recruitment since the recent (2010-11) large flows (pers. comm. Jane Humphries, Wetland Conservation Officer, OEH)
3. Potential Risks	A formal risk assessment has not been completed for this watering event. Possible risks associated with the delivery of the water include: Downstream diversion: Basic stock and domestic rights currently exist on all these lagoons, and in addition some have irrigation works licenses for storing and/or pumping water and these factors will have implications is the lagoons are targets for environmental water. If environmental water was to be used in these lagoons, it would most likely require agreements with the

The Mid Macintyre/Dumaresq River lagoons (NSW & QLD)	
Criteria	**Assessment**
	surrounding landholder(s) about fencing off (where fencing not already in place) and if required putting in alternative watering points for livestock if alternative water sources are available. Landholders would be likely to seek funding assistance to achieve this alternative watering. <u>Undesirable flooding of property and infrastructure:</u> Given that the Commonwealth is the only environmental water holder in the catchment, it is likely that the Commonwealth will be seen, in a legal sense, as the proponent of any watering actions which are undertaken. Monitoring flows and communicating increases in water level to landholders can help ensure water levels do not exceed desirable limits. <u>Weed dispersal:</u> Increased water availability may support *Harrissia* cactus which is common in these lagoon areas. While some landowners are actively trying to manage this weed, sometimes in conjunction with the Border Rivers-Gwydir CMA, it is difficult to control (pers. comm. Jane Humphries, Wetland Conservation Officer, OEH). Alien species: Environmental flows may support an increase in alien species population or range e.g. carp, goldfish, redfin perch and Willows. Environmental water deliveries will be aligned to support or favour native fish species spawning and dispersal events. Possible pumping to fill fringing wetlands will utilise fish exclusion mesh to prevent introductions through environmental water delivery.
4. The long term sustainability of the asset including appropriate management arrangements	The lagoons have been identified by community groups and state and the Commonwealth governments through the development of water management arrangements and listing of part of the asset as a wetland of national importance. Further, Boobera Lagoon is one of the most important Aboriginal sites in south-eastern Australia. The local Aboriginal people, the Gamilaraay (Kamilaroi - various spellings) hold to the belief that the lagoon is the resting place of the rainbow serpent. Both states have water management rules in place which aim to provide additional flows to the system. Commonwealth environmental water would be in addition to these rules and provide increased benefits this asset. However, some lagoons have irrigation works licenses for storing and/or pumping water which has implications for the effectiveness of environmental water delivered to these lagoons. Without agreement or shepherding arrangements these lagoons might not be suitable or would be lowest priority for environmental water. When contributing to natural flows monitoring of flows to lagoons can be performed through existing state hydrological monitoring sites (gauges). However, in the case of extracting water from the river to provide flows into the lagoons, accounting and monitoring would occur at the extraction infrastructure e.g. pump or diversionary channel. There is no formal monitoring strategy to observe environmental benefits of Commonwealth environmental water.
5. Cost-effectiveness	When contributing to natural flows, the cost of the event to the Commonwealth would be limited to fees and charges related to delivery. Queensland supplemented usage charges are not yet released for 2011-12 however are estimated to be $11/ML. If all lagoons under this option were to be watered, then the volume could be as much as 4500-5000ML. Costs associated with usage of this volume could be as much as $49,500 - $55,000. However, in the case of extracting water from the river to provide flows into the lagoons there may be additional costs associated with using private infrastructure and pumping costs. These costs will be scoped when further investigating delivery options. In cases where it would be necessary for landholders not use a particular lagoon in order for the Commonwealth to achieve environmental objectives, landholders would likely seek funding assistance to achieve any alternate watering for livestock and there is currently no funding program to achieve this. Conservation management agreements with landholders to remove livestock from lagoon areas would be an option to achieve further environmental outcomes. (pers. comm. Jane Humphries, Wetland Conservation Officer, OEH)

Lower Macintyre River below Goondiwindi (NSW & QLD)	
Criteria	**Assessment**
1. Ecological significance of the asset	This asset stretches from Goondiwindi to Mungindi including the main channel as well as anabranches and ephemeral lagoons). The asset has high native fish value, in recognition of which, the asset is listed as part of the threatened aquatic ecological community of the lowland catchment of the Darling River under the *NSW Fisheries Management Act 1994*. Small Murray cod (vulnerable, Cwth) juveniles (below stocking size) suggest this area is a breeding site. Other native fish species recorded include silver perch (vulnerable, NSW); olive perchlet (endangered population, NSW); spangled perch (*Leiopotherapon unicolor*); Murray Darling rainbowfish (*Melanotaenia fluviatilis)*, carp gudgeons; unspecked hardyhead; golden perch (*Macquaria ambigua*), and bony herring (*Nematalosa erebi)* (Davies et al. 2008, Butcher 2007). The reach has provided the only known record of flathead gudgeon *(Philypnodon grandiceps)* from the Border Rivers (Hutchison et al. 2008). Ephemeral lagoons associated with the asset are important habitat for some native fish species; one lagoon in the area (Booberoi) has been shown to be used for breeding by olive perchlet and spangled perch. Recruitment in these sites is dependent on connectivity to the river (Hutchison et al. 2008). DERM have identified golden perch as the top priority flow-dependent asset for monitoring to determine whether the ecological objectives of the Border Rivers Water Resource Plan are being met (DERM 2010). This species, along with Murray cod, silver perch and spangled perch (medium to large bodied fish that undergo long distance migrations) were assessed as being at moderate risk of not having their critical water requirements met throughout the Border Rivers, including the reach downstream of Goondiwindi. High, overbank and flood flows, relevant to migration and spawning of these species. Inundation of the floodplains and lagoons downstream of Goondiwindi are also recognised as a significant provider of dissolved organic carbon to aquatic systems (Thoms et al. 2005). This

Lower Macintyre River below Goondiwindi (NSW & QLD)	
Criteria	**Assessment**
2. Expected ecological outcomes	occurs when the carbon and nutrients, released by inundation, are subsequently carried to the river channel where they provide an important energy source for primary production. Floodplain lagoons of the mid Macintyre River depend on overbank and flooding flows and local catchment inflows to reconnect and refill (CSIRO 2007). The majority of the floodplain between Goondiwindi and Mungindi is hydrologically connected to the Macintyre River when flows at Goondiwindi exceed 20,000 ML/d (CSIRO 2007). Freshes in the Macintyre River which will wet the majority of in-channel surfaces are thought to occur at approximately 4,000-9,000ML/d (MDBA unpublished) Preliminary modelling performed by the MDBA shows that the occurrence of flows of this magnitude at Goondiwindi have halved and the occurrence of flows of optimal fresh magnitudes at Mungindi are also likely to have halved as under current arrangements as compared to without development conditions (MDBA unpub.) The CSIRO Sustainable Yields assessment for the Border Rivers found that the average period between flows that reconnect the lagoons and anabranches of the Macintyre River has increased by 18 per cent. The degree of connectivity between the main channel and a floodplain lagoon appear to drive differences in native fish behaviour (Reid et al. 2011). Without serial reconnection of the lagoons along the main river, native fish, including new recruits, can be lost to the system as was observed at Booberoi lagoon which dried up after a single connection event in January 2006 (Hutchinson et al. 2008). This watering option has two objectives; delivery of either of these objectives is dependent on water availability. The first objective would seek to provide in-stream benefit by increasing end of system flow whereas the second objective would provide increased flows below Goondiwindi to reconnect the main river to ephemeral anabranches and lagoons. Both objectives will help to simulate a more natural flow regime and to close the gap between modelled without development conditions and current arrangement conditions. This will have benefits for fish habitat, both through recruitment and movement as well as carbon and nutrient cycling through the end of system.
3. Potential Risks	A formal risk assessment has not been completed for this watering event. Possible risks associated with the delivery of the water include: <u>Poor ecological response</u>: Balcombe, Arthington, Thoms and Wilson (2011) found that fish assemblages in two river sites in the lower Macintyre (around Goondiwindi and upstream of Weir River junction) did not increase in richness or abundance in response to channel flow, indicating there was no increased fish recruitment and movement associated with flow connectivity. However, a strong response to channel flows was found in assemblages of the same species in river reaches/waterholes in the Moonie and Weir Rivers. The authors contend that assemblages in the Macintyre river sites (and upper Barwon River) were under stress, most likely from historical flow regulation. Whilst this watering action seeks to address flow regulation impacts, the ability of fish populations in this reach to respond to flow cues may be less than anticipated. <u>Downstream diversion</u>: Ordering Commonwealth environmental water to Mungindi ensures that the full volume ordered will be delivered protected from extraction and with minimal losses. Extraction further downstream of Mungindi is a risk with this watering option. Shepherding arrangements in some form would need to be in place to ensure efficient and effective use of Commonwealth water downstream of Mungindi. <u>Undesirable flooding of property and infrastructure:</u> Given that the Commonwealth is the only environmental water holder in the catchment, it is likely that the Commonwealth will be seen by the community as the proponent of any watering actions which are undertaken. Monitoring flows and communicating increases in water level to landholders can help ensure water levels do not exceed desirable limits. Alien species: Environmental flows may support an increase in alien species population or range e.g. carp, goldfish, redfin perch and Willows. Environmental water deliveries will be aligned to support or favour native fish species spawning and dispersal events. Possible pumping to fill fringing wetlands will utilise fish exclusion mesh to prevent introductions through environmental water delivery.
4. The long term sustainability of the asset including appropriate management arrangements	In-stream assets, such the target reach downstream of Goondiwindi, have been identified by NSW and QLD as areas of ecological importance and both have rules in their respective water management arrangements in place with a view to improving the health and condition of in-stream assets. Commonwealth environmental water would be in addition to these rules and provide increased benefits this asset. There are a number of measures in place to help protect the ecological values of this asset. The Native Fish Strategy Demonstration reach in the Border Rivers is supported by both NSW and QLD state governments and the MDBA; the third phase of the project covers the target reach from Goondiwindi to Mungindi (Australian Wetlands Pty Ltd 2009). Also, the Macintyre river is part of the threatened aquatic ecological community of the lowland catchment of the Darling River under the *NSW Fisheries Management Act 1994* which guides management activities to protect and restore this reach. No other natural resource management plans or protected areas identified for this area. As the proposed watering actions contribute to natural flows monitoring can be performed through existing state hydrological monitoring sites (gauges), at Mungindi for objective 1 and at Goondiwindi for objective 2. There is no formal monitoring strategy to observe environmental benefits of Commonwealth environmental water relevant to this asset.
5. Cost-effectiveness	The proposed water event under both objectives would incur costs related to ordering water to Mungindi or Goondiwindi. The majority of the Commonwealth environmental water held in the Border Rivers is Queensland supplemented water. Usage charges have not yet been released for 2011-12 however they are estimated to be $11/ML. The volume of water to be ordered and contributed to an event will effect overall cost. While there is significant in-stream benefit related to increasing end of system flow relating to carbon and nutrient cycling, there are considerable benefits to be gained from this option in relation to increased flows into the Barwon-Darling. Both options have varying levels of capacity to deliver some water to the end of system and into the Barwon-Darling. With adequate shepherding arrangements, increased end of system flow from the Border Rivers could increase the likelihood of activating Commonwealth entitlements held on the Barwon-Darling or increasing Commonwealth holdings in Menindee Lakes.

Water Use Strategy 2011-12: Gwydir River Catchment

1.1. Introduction

This document sets out the proposed objectives and approach to using environmental water in the Gwydir catchment (Figure 1) during the 2011-12 water year. This strategy was developed based on information available to Commonwealth Environmental Water including through consultation with NSW Office of Environment and Heritage.

The document includes watering options given recent climatic and riverine conditions in the catchment and forecast water availability. The proposed approach will adapt over the course of the year as conditions in the catchment change and more information becomes available. Importantly, the potential watering options included in this document do not form an exhaustive list - alternative suggestions for using environmental water are welcome. All relevant options will be assessed to ensure the best possible use of environmental water within the catchment and across the Murray-Darling Basin.

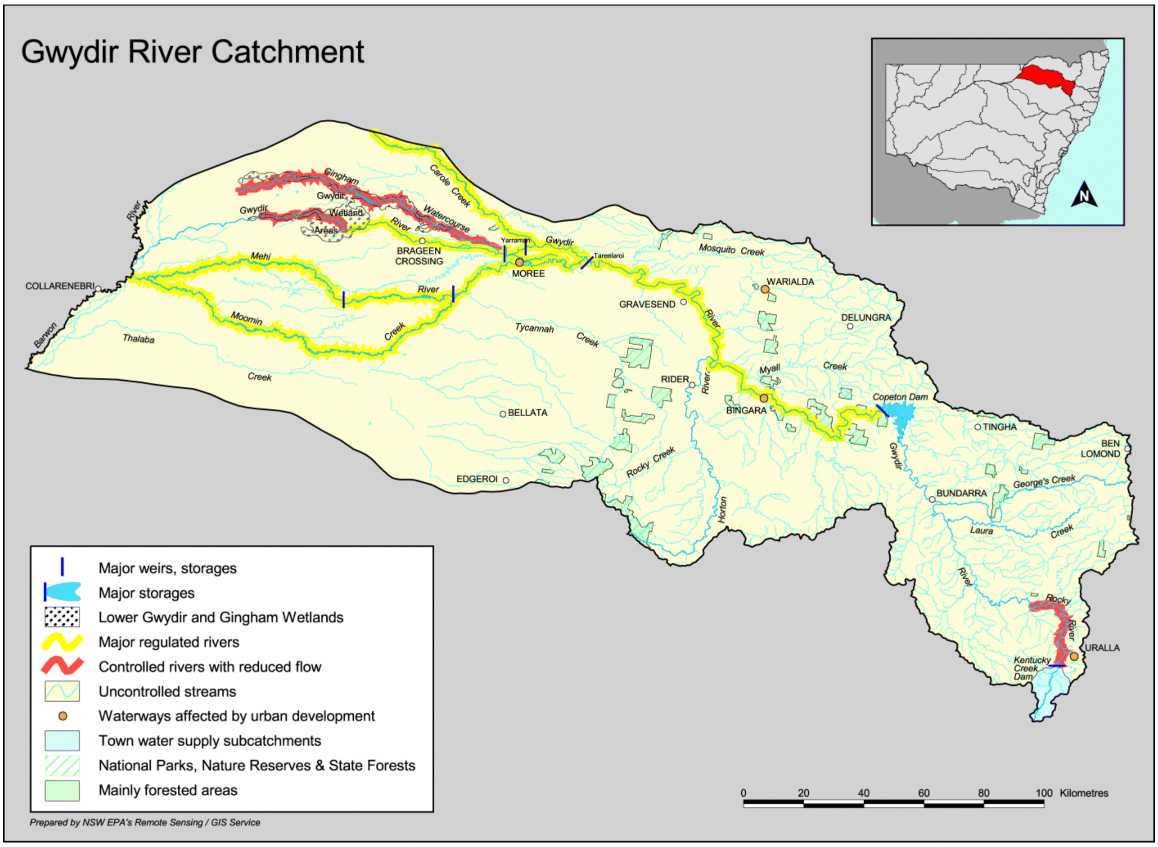

Figure 1: The Gwydir River Catchment

1.2. The Gwydir River Catchment

The Gwydir River rises on the western slopes of the Great Dividing Range near Uralla and flows west towards Collarenebri where it reaches a confluence with the Barwon River. The Gwydir River is regulated by Copeton Dam. Near Moree it divides into distributaries including:

- Mehi River which then feeds into Moomin Creek and Mallowa Creek;
- Carole Creek; and
- Gingham and Lower Gwydir watercourses, which feed wetland complexes.

Inflows from unregulated tributaries that enter below Copeton Dam are also a significant source of water supply and provide a near natural flow variability for many kilometres of river channel. These tributaries include:

- Halls Creek which enters upstream of Bingara;
- Myall Creek which enters the river downstream of Bingara;
- Horton River which enters north west of Bingara; and
- Warialda Creek which enters upstream of Gravesend.

The CSIRO Sustainable Yields Project (CSIRO 2007) found the flow regime of the Gwydir Valley to be characterised by substantial reductions in annual volumes and high flow magnitudes, coupled with changes in seasonality in most tributaries and the Gwydir River downstream of Copeton Dam. The long-term average annual flow in the Gwydir River is 875,000 ML/annum, however, a large proportion of the total flows occur in a small number of years with many years having extremely low flows such as the 11 years between 1984-85 and 1994-95, and most recently since 2002-03 (Figure 2). This characteristic is an important consideration for environmental water managers who may decide to carry over volumes to reduce damage should there be extended dry conditions. Water resources within the Gwydir River catchment are managed according to the Water Sharing Plan for the Gwydir Regulated River Water Source (this plan took effect on the 01 July 2004 and ceases 10 years after that date).

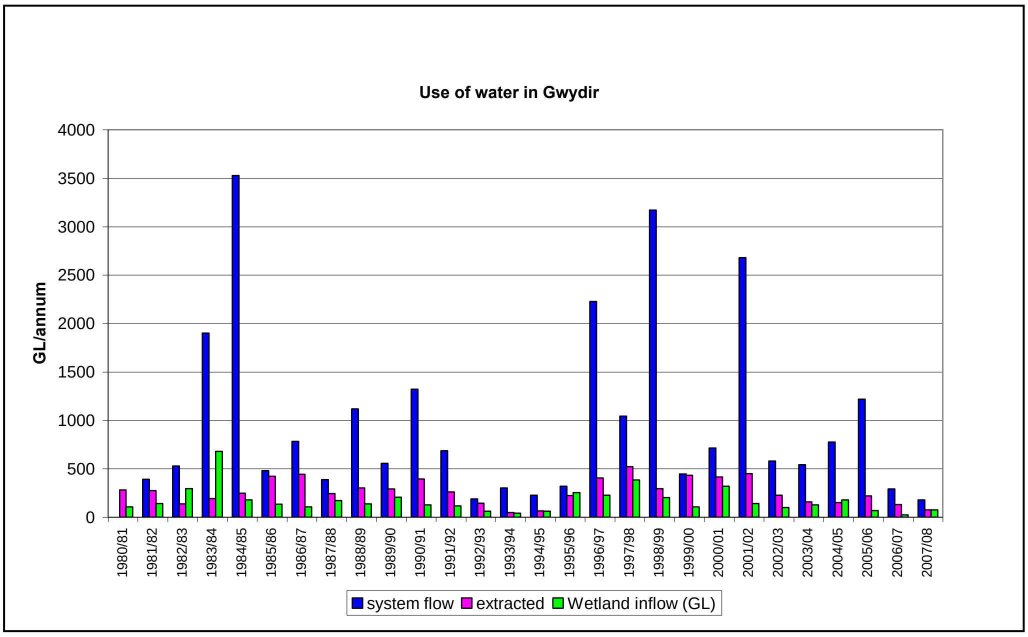

Figure 2: Historic Gwydir catchment water use (NSW Department of Environment, Climate Change and Water (DECCW) 2010)

1.3. Environmental Assets in the Gwydir River Catchment

The Gwydir wetlands include 823 ha of listed Ramsar sites including Old Dromana, Goddard's Lease, Crinolyn, and Windella. Notably it is a good example of an inland terminal wetland, it supports a large assemblage of rare endangered and vulnerable species (for example the Australian painted snipe (*Rostratula australis*: EPBC vulnerable; NSW vulnerable)), has high biodiversity and supports critical life stages for a range of waterbirds including migratory species for example the eastern great egret (*Ardea alba*), nankeen night heron (*Nycticorax caledonicus*), glossy ibis (*Plegadis falcinellus*), straw-necked ibis (*Threskiornis spinicollis*), and little pied cormorant (*Phalacrocorax melanoleucos*).

Significant sites also include the Lower Gwydir wetlands and Gingham Watercourse wetlands which are listed in the Directory of Important Wetlands. Other assets include the Gwydir River channel and the distributaries including Mallowa Wetlands on Mallowa Creek. The aquatic community of the Gwydir River forms part of the endangered ecological community under the *NSW Fisheries Management Act 1994* known as the aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River.

The core wetlands depend on frequent flooding to maintain their structural integrity and condition with vegetation communities including marsh club-rush (*Bolboschoenus fluviatilis*: NSW endangered), water couch (*Paspalum distichum*), cumbungi (*Typha domingensis/orientalis*) and common reed (*Phragmites australis*) (Bowen and Simpson 2010). The Gwydir wetlands contain one of the largest remaining marsh club-rush expanses in New South Wales.

The floodplain wetland and fringing vegetation require flooding at some stage for regeneration, can tolerate prolonged flooding (up to several months) and are able to survive dry periods of several years. River cooba (*Acacia stenophylla*) and lignum (*Muehlenbeckia florulenta*) shrublands are common in and around the margins of the core semi-permanent wetlands. Coolibah (*Eucalyptus coolabah*: NSW endangered) and river red gum forests (*E. camaldulensis*) are also found along water courses. The coolibah and black box (*E. largiflorens*: NSW endangered) woodlands and weeping myall woodland (*Alectryon oleogolius*: Commonwealth endangered) occur on the outer floodplains or higher grounds of the wetlands. Approximately 8,289 hectares of these woodlands existed in the Gwydir Wetlands in 2010 (DECCW 2010).

The Gingham Watercourse supports a small core of semi-permanent wetland vegetation (3,700 ha in 2008) as well as extensive areas of floodplain vegetation (Bowen and Simpson 2010). Gingham Waterhole is a permanent lagoon within the main channel that provides significant waterbird breeding habitat. Towards the lower end of the Gingham Channel water spreads out over the floodplain forming extensive areas of water couch pasture with rushes and some lignum. During shallow flooding these pastures form valuable wetland habitat, particularly as feeding grounds for spoonbills and ibis.

The Lower Gwydir Watercourse supports similar wetland habitats to those in the Gingham Watercourse to the north. In 2008 the core of the Lower Gwydir Watercourse supported 3,076 ha of semi-permanent wetlands including water couch, marsh club rush, cumbungi and common reed (Bowen and Simpson 2010). The Lower Gwydir is characterised by poorly defined channels and extremely flat country with a gradient of less than 1 per cent which leads to widespread inundation when flows are higher.

The Mallowa Wetlands comprise 1,642 ha of coolibah-lignum-river cooba and also supports a number of threatened bird species (water dependent and terrestrial). Maintaining the ecological condition of the Mallowa Wetlands can help support the vitality of the greater Gwydir Wetlands by providing additional feeding grounds for waterbirds (MDBA 2010).

Further detail on the significant flora and fauna in the Gwydir River catchment is presented at Appendix A, and additional information on ecological significant sites is also provided as part of the assessment of watering options at Appendix E.

1.4. **Delivering Water in the Gwydir River Catchment**

Water supplies in the Gwydir catchment are provided from a combination of Copeton Dam (capacity 1,364,000 ML) and downstream unregulated tributary inflows. Due to the number of unregulated tributaries that flow into the Gwydir River below Copeton Dam, the dam only controls 55% of Gwydir system inflows (Keytes 1994 in MDBA 2010). Existing infrastructure limits the opportunity for controlled releases to meet the environmental requirements of the Gwydir Wetlands. In the Gwydir the most effective overall environmental outcome may be achieved by using environmental water reserves in combination with the unregulated natural stream flows.

In order to water wetland assets in the catchment using high and general security entitlements, releases are required from Copeton Dam in the headwaters of the system and gravity fed via the river channel using the downstream weirs and regulators to control the direction, volume and duration of flows. Delivery to the Gwydir Wetlands is limited to up to 300 ML per day through to the Gingham Channel (near Gingham Bridge) and up to 300 ML per day through the Lower Gwydir (Barma 2011). Delivery capacity represents a significant constraint on environmental flows in the Gwydir system. Once flows exceed these rates, agricultural land within the wetland may be inundated. Further information on delivery constraints in the Gwydir are provided in section 1.12.

1.5. **Current Catchment Status and Outlook**

For much of the 2000s the catchment experienced drought conditions. However conditions were wet in 2010-11, with 141,000 ML flowing into the Gwydir Wetlands of which 86,000 ML passed Teralba gauge on the Gingham and 55,000 ML passed Millewa gauge on the Lower Gwydir (Table 1). As a result 10,000 hectares of wetland habitat was inundated for a period of 6-8 months and a range of ecological responses were recorded. Notably Marsh club rush stands have flowered en masse in response to these flows, to an extent not observed since the late 1990s (DECCW 2011).

In August 2010, Commonwealth Environmental Water took advantage of local rainfall and high downstream tributary flows and delivered 3,056 ML of supplementary entitlement. This helped to build soil moisture across core wetland areas with post flow monitoring indicating a soil store of 1-1.15 metres. Natural river flows ceased on 20 January 2011 and subsequently, from late January to early March 2011, 20,000 ML was delivered from a range of environmental reserves (including 10,000 ML of Commonwealth environmental water, 5,000 ML of NSW RiverBank environmental water and 4,657 ML of environmental contingency allowance).

The 2010-11 watering year was unusual because it was characterised by above average rainfall in winter 2010 followed by an extended period (7 months) of low flow conditions, this provided filling of the low lying wetlands in winter 2010 without broadscale flooding.

Table 1: Environmental water use in the Gwydir River catchment during 2010-11.

Asset/Site	Date	Commonwealth volume (ML)	NSW volume (ML)	Environmental Contingency Allowance (ML)	Total flows into wetlands (ML)
Lower Gwydir Wetlands (4,500 hectares)	August 2010	1,528	-	-	55,000 @ Millewa
	January to March 2011	5,000	2,329	2,500	
Gingham Wetlands (5,500 hectares)	August 2010	1,528			
	January to March 2011	5,000	2,328	2,500	86,000 @ Teralba
Mehi system	July 2010 - March 2011	0	0	0	67,000
Whittakers Lagoon	Dec 2010	0	70	0	70

The national outlook for late winter to early spring (August to October 2011) shows a moderate shift in the odds favouring drier than median rainfall for late winter to early spring over parts of the southeast of Australia. The outlook is a result of cool conditions in the central tropical Pacific Ocean, as well as warm conditions in the Indian Ocean (BOM 2011).

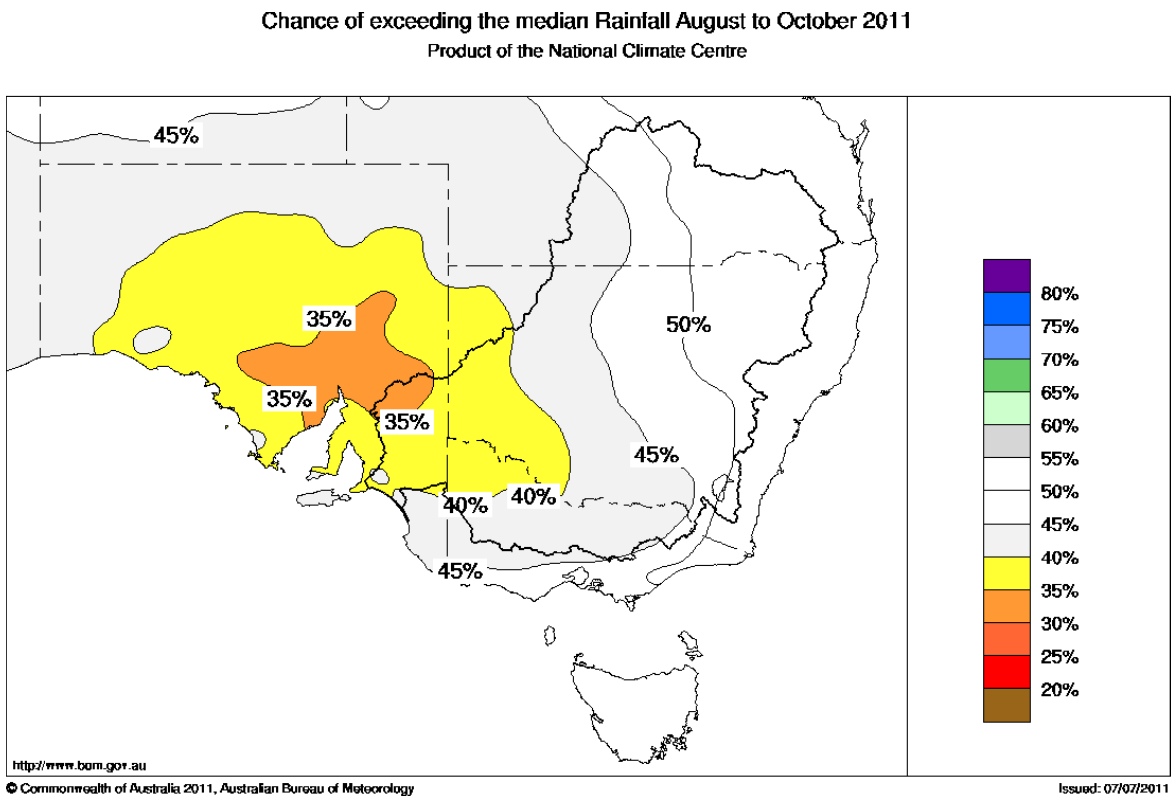

Figure 3: Seasonal rainfall outlook for south-eastern Australia (BoM).

The Gwydir River catchment lies in the band with a 45 to 50 per cent chance of exceeding the median seasonal rainfall for the region (Figure 3).

1.6. **Commonwealth Environmental Water**

The Commonwealth holds almost 90 GL of general security entitlement. Due to high inflow events in the 2010-11 water year, Commonwealth environmental water holdings at the beginning of the 2011-12 water year are higher than in previous years. As of 6 July 2011, Copeton Dam held 51 per cent of its capacity with an available water determination of 0.47 per cent for general security entitlements. 63,635 ML general security was carried over from the 2010-11 water year with the minimum total available for use in 2011-12 being 64,430 ML (general security carryover plus high security) with up to a further 19,100 ML available subject to a supplementary access announcement (refer to Table 2).

Table 3 shows forecast allocations for Commonwealth environmental entitlements under the range of most likely climatic scenarios (based on inflows). Forecast allocations are based on State Water forecasts and analysis of water reserves, high priority access licence requirements and historical inflows. Supplementary entitlements and additional entitlements that may be obtained and registered by the Commonwealth during 2011-12 are not included in forecasts. Under median inflow conditions, State Water forecast a 22 per cent general security allocation by the end of 2011. Commonwealth regulated water holdings in the Gwydir River Catchment by the end of the 2011-12 (including carryover from 2010-11) are most likely to be in the range of 90 to 128 GL.

The Water Sharing Plan for the Gwydir River places limitations on the use of general security entitlement allocations including 125 per cent per annum and 300 per cent cumulative total over 3 years (Table 4). The 3 year cumulative total will not be exceeded with only 10,000 ML (or 11.2 per cent) of entitlement used in 2009-10 and no Commonwealth water used in 2008-09. A maximum of 134,288 ML general security entitlement allocations can be carried over into 2012-13.

Table 2: Commonwealth Environmental Water allocation 6 July 2011

Account	Entitlement (ML)	Current Uncommitted Allocation (ML) carried over from 2010-11 to 2011-12	Water available for use 06 July 2011 (0.47 % general security, 100% high security)
High Security	375	0	375
General Security	89,525	63,635	64,056
Supplementary	19,100	0	19,100[1]
Total callable	109,000	63,635	64,430

[1] Subject to a supplementary access announcement.

Table 3: Forecast allocations of Commonwealth environmental water.

Account	Entitlement (ML)	2010-11 carryover (ML)	2011-12 uncommitted allocation to date (ML)	Additional allocation forecast for end 2011-12 (ML)		
				Dry	Median	Wet
High security	375	0	375 (100%)	375	375	375
General	89,525	63,635	421 (0.47%)	26,858 (30%)	49,239 (55%)	64,458 (72%)
Supplementary	19,100	0	19,100 (100%)	Event based. Predicted moderate probability of supplementary flow event by Dec 2011		
Forecast total callable (ML) (carryover plus forecast 2011-12 allocation)				**90,492**	**112,873**	**128,092**

Table 4: Gwydir catchment general entitlement water use limitations

Continuous accounting use restrictions	Percentage of entitlement (%)	Volume based on current entitlement (ML)
Maximum allocation balance at any time	150	134,288
Maximum use in a single water year	125	111,906
Maximum allowable usage over three consecutive years	300	268,575

1.7. Other Sources of Environmental Water

In addition to Commonwealth environmental water, there are other sources of environmental water that may be available to supplement Commonwealth environmental watering in the catchment during 2011-12 (Table 5). The Water Sharing Plan for the Gwydir Regulated River Water Source (2004) provides, on a long-term average basis, that approximately 66 per cent of yearly flows are protected from diversion. The Plan's range of rules based flow provisions also aid the restoration of lower system flows and provide some natural flow variability.

Table 5: Sources of environmental water

Sources of other water	Management authority	Assigned water right (ML)
Planned environmental flows as per WSP		
Supplementary flow rules	NSW State Water Corporation	Event based determination, • Up to 500 ML/day of inflows from tributaries downstream of Copeton Dam are passed through the Gwydir Wetlands • 50% of unregulated high flows entering the regulated system downstream of Copeton Dam are protected from extraction
Environmental Contingency Allowance (ECA)	NSW OEH	45,000 ML/yr with 15,000 ML reserved for bird breeding. 90,000 ML can be stored in Copeton Dam.
NSW RiverBank environmental water holdings		
NSW Environmental Water Licences	NSW OEH	Allocations against 17,092 ML General Security entitlement and 441 ML of Supplementary entitlement

1.8. Medium to long-term watering Objectives in the Gwydir River Catchment

In 2010-11, Commonwealth Environmental Water engaged external advice to identify and develop large-scale watering options for Commonwealth environmental water, including in the Gwydir River catchment, in order to reflect growth in water holdings and improved water availability across the Basin (Barma 2011). The early stages of this work have identified the following medium to long-term ecological and hydrological objectives for the Gwydir River catchment:

- Improve longitudinal and lateral connectivity within the Gwydir River and floodplain system to protect and restore the endangered ecological community, including its threatened species;
- Maintain and improve semi-permanent wetland vegetation communities (communities that require frequent inundation) to good condition;
- Maintain and improve inner floodplain and fringing vegetation (communities characterised by overstorey species that can survive longer dry periods) to good condition;
- Maintain open water areas and exposed muddy margins;
- Maintain known colonial waterbird breeding sites in 'event ready' condition, and support breeding events;
- Maintain seasonal habitats for migratory waterbirds;
- Contribute to end of system connectivity between the Mehi River and the Barwon River; and
- Maintain or improve ecosystem condition in the Gwydir River channel.

For much of the 2000s the catchment experienced drought conditions. However conditions were wet in 2010-11, and there was extensive inundation and growth of vegetation in the Gwydir Wetlands. Subject to water availability and system delivery capacity constraints, the water use strategies in the next couple of years will aim to maintain this core wetland inundation and build on previous watering year outcomes with the overarching watering objective for the Gwydir being to improve and maintain ecological health and resilience.

Providing/maintaining core wetland inundation should improve ecosystem function in the Gwydir Wetlands allowing for the completion of fauna life cycles and subsequently contribute to improved health of wetland fauna populations. The Gwydir wetlands may support water birds when other wetlands in the basin are dry as periods of wetting on major wetlands are not always concurrent.

1.9. Watering Objectives for 2011-12

Watering objectives for the Gwydir system have been developed based on the *Framework for Determining Commonwealth Environmental Watering Actions* (refer Appendix B). Options have been considered having regard to the large volume of carryover available from unused 2010-11 allocations.

Water availability at the beginning of the 2011-12 season is relatively high as a result of carryover. The reserves of environmental water held in Copeton Dam and moderate possibility of a supplementary flow event by December 2011 mean that the strategy is oriented towards achieving outcomes reflecting higher water availability, even in the event of dry conditions. Management objectives for the Gwydir in 2011-12 consistent with the overarching watering objective to improve and maintain ecological health and resilience include:

- ensure survival of native biota that recruited in 2010-11;
- enable growth, reproduction and small-scale recruitment for a diverse range of flora and fauna

- promote low-lying floodplain-river connectivity; and
- support medium flow river and floodplain functional processes.

Commonwealth Environmental Water has identified watering actions for the Gwydir River catchment that are consistent with these objectives for a range of climate conditions in 2011-12 (refer to appendix C).

1.10. **Watering Options for 2011-12**

In 2011-12 the focus is on maintaining condition of assets by supporting flow events which inundate low-lying floodplain wetlands. Table 6 summaries the watering options proposed for 2011-12, and tables 7, 8 and 9 provide further detail on delivery arrangements for watering actions. The watering actions proposed for 2011-12 are consistent with the objectives listed above and include:

- prolong flood/high-flow duration at key sites and reaches of priority assets;
- contribute to the full range of in-channel flows; and
- use carryover to provide optimal seasonal flow patterns in subsequent years.

The volumes of Commonwealth environmental water that will be required to undertake these actions will depend on conditions and inflows that occur through the 2011-12 season. Operational considerations will include the provision of flows in a manner that does not promote alien species (refer table 7- column 7 and section 1.14).

Providing/maintaining core wetland inundation should improve ecosystem function in the Gwydir wetlands allowing for the completion of fauna life cycles and subsequently contribute to improved health of wetland fauna populations. The Gwydir wetlands may support water birds when other wetlands in the basin are dry as periods of wetting on major wetlands are not always concurrent.

The objectives of watering options focus on maintaining and improving the condition of vegetation communities and supporting waterbird breeding events should they be triggered. In the future water delivery options may specifically target other ecological objectives such as improvements in fish or frog populations. Watering decisions will also recognise the requirement for drying sequences, which are equally important for the sustained health of wetland systems.

Table 6: Potential watering options for 2011-2012 in the Gwydir River catchment

Asset/ Objective	Watering Option
Spring-Summer-early Autumn 2011-12	
1) To build on ecological responses resulting from the wet 2010-11 water year inundation of **semi-permanent wetland vegetation** is a priority in 2011-12. A sequential inundation event will ensure survival of native biota that recruited in 2010-11 and encourage extensive growth of core wetland and inner floodplain vegetation to achieve, over time, measured improvements in plant species density and diversity. Monitoring quadrants have been established for this purpose. This should improve the resilience of the wetland system. The successful completion of waterbird breeding events will also be supported. Operational considerations will include the provision of flows in a manner that limits alien species development (refer table 7- column 7 and section 1.14). Providing/maintaining core wetland inundation should improve ecosystem function in the Gwydir Wetlands allowing for the completion of fauna life cycles and subsequently contribute to improved health of wetland fauna populations.	Provide up to 35 GL of CEW to contribute, in combination with natural flows and other sources of environmental water, to the inundation of the assets. NSW OEH estimate that approximately 68-82 GL could wet around 6,776 ha of core semi-permanent vegetation (3,700 ha in the Gingham and 3,076 ha in the Lower Gwydir). Vegetation species targeted include water couch, spike rush, common reed, marsh club rush and cumbungi with inundation regime of a depth of at least 30-60 cm between September and March for up to 6 months. These species exist due to their connection with regular flow paths and are estimated to require inundation 8 in 10 years. Significant environmental reserves in Copeton Dam are available to achieve significant ecological responses which would build upon the extensive wetland vegetation growth during the previous 2010-11 season. Therefore inundation is a priority in 2011-12. The option may arise to extend the inundation period and slow the recession of water throughout March-April thereby allowing the completion of some wetland species' life cycles.
a) Gingham - in 2010-11 the full 3,700 ha of core semi-permanent vegetation was inundated for 6-8 months and a follow-up inundation this season is desirable to improve condition and build resilience.	The priority under all water availability scenarios is to maintain core areas of wetland above Gingham Bridge including water couch and spike rush on Goddard's lease Ramsar site, marsh clubrush on Bunnor and low-lying areas on Lynworth. In addition to supporting semi-permanent wetland vegetation the area includes known bird breeding and feeding sites. Further east a small remanent wetland of semi-permanent vegetation (250+ hectares) on the Gully may also be inundated. Downstream of Gingham Bridge in-channel sites (such as Boyanga Waterhole) and surrounding core wetlands will also be prioritised for inundation. These sites are important refuge for fish and waterbirds in the Gingham Wetland system. Being further west these areas are more difficult to water and it is estimated that once 20 GL has been delivered to the wetlands upstream of Gingham bridge, flows at the bridge rise sharply and begin to flow downstream of the bridge.
b) Lower Gwydir - in 2010-11 the full 3,076 ha of semi-permanent vegetation was inundated for 6-8 months and a follow-up inundation this season is desirable to improve condition and build resilience.	A priority under all water availability scenarios is to maintain core areas on Old Dromana (including the Ramsar site and club marsh reed bed) and maintain water levels at the end of system target Wondoona waterhole. However, under median conditions, it is anticipated that a much larger inundation extent and ecological response can be achieved.

2) To build on ecological responses resulting from the wet 2010-11 water year inundation of **inner floodplain wetland vegetation** is a priority in 2011-12. A sequential inundation event will ensure survival of native biota that recruited in 2010-11 and encourage extensive growth of core wetland and inner floodplain vegetation to achieve, over time, measured improvements in plant species density and diversity. Monitoring quadrants have been established for this purpose. This should improve the resilience of the wetland system. The successful completion of waterbird breeding events will also be supported. Operational considerations will include the provision of flows in a manner that does not promote alien species (refer table 7- column 7 and section 1.14). Providing/maintaining core wetland inundation should improve ecosystem function in the Gwydir Wetlands allowing for the completion of fauna life cycles and subsequently contribute to improved health of wetland fauna populations.	Provide up to 35 GL[2] of CEW to contribute, in combination with natural flows and other sources of environmental water, to the inundation of the assets. Vegetation species targeted include River cooba swamp, lignum shrubland, coolibah and river red gum which are often disconnected, interspersed between large areas of cultivated land. The desired inundation regime is a depth of between 10-30 cm between September and March for about 3 months at least 5 in 10 years. Inundation is a priority in 2011-12. It is estimated that approximately 95-125GL could wet around 6,776 ha of core semi-permanent vegetation (3,700 ha in the Gingham and 3,076 ha in the Lower Gwydir) and 6700ha of semi permanent vegetation. The areas of semi-permanent vegetation will inundate before these vegetation communities located higher in the system. Existing infrastructure limits the opportunity for controlled releases to meet the environmental requirements of the inner floodplain areas so although substantial environmental water reserves are now available the 35 GL of CEW would be used to achieve this watering objective as well as objective 1 above. The achievement of the desired duration and extent of inundation of this watering objective will be dependent on the occurrence of significant high flow natural stream flows and rainfall events. Deliveries must take advantage of and prolong these natural events. Noting that to minimise the risk of flooding of cultivated land, deliveries will need to cease during natural high flow events. The option may arise that extending the inundation period and slowing the recession of water from floodplain throughout March-April may allow the completion of some wetland species' life cycles.
a) Lower Gwydir - in 2010-11 about 1,400 ha of inner floodplain wetland vegetation was inundated for 6-8 months and a follow-up inundation this season is desirable to improve condition and build resilience	In 2010-11 the total flow of 55,000 ML passing Millewa gauge on the Lower Gwydir provided for the inundation of semi-permanent vegetation and approximately 1,400 ha of inner floodplain vegetation.
b) Gingham - in 2010-11 about 1,800 ha of inner floodplain wetland vegetation was inundated for 6-8 months and a follow-up inundation this season is desirable to improve condition and build resilience.	In 2010-11 the total flow of 86 GL passing Teralba gauge inundated semi-permanent vegetation and approximately 1,800 ha of inner floodplain vegetation. The rehabilitation works to the Gingham Channel have greatly benefitted the ability to water the inner floodplain upstream of the Gingham bridge with significant wetlands assets, including Yarrol and Lynworth where there are known historical colonial waterbird breeding sites, and Glendara. In 2010-11 Crinolyn and Windella Ramsar sites of west of Gingham bridge were also extensively inundated. There are a number of small remnant inner floodplain wetlands areas between Teralba and Tillaloo. These areas are inundated during high flow supplementary events when the channel capacity (of more than 480 ML/day) is exceeded. Delivered water targeting these sites can't be achieved without inundating cultivated land. In addition, Coolibah woodlands and waterholes known as important bird breeding sites east of Gingham Bridge in the north around Talmoi, Tillaroon and Baroona are not expected to be within scope. These sites lie within an old river channel that will start to fill during moderate floods but maintaining the desired inundation is only likely during very wet conditions including when overland flows contribute from outside the catchment in the north. Delivered water targeting these sites can't be achieved without inundating cultivated land.
c) Mallow wetlands and assets identified on other regulated distributaries (Mehi River, Moomin and Carole Creeks)	Throughout the water year ongoing advice will be obtained to identify significant vegetation communities on the other distributaries that may require inundation to protect, enhance or restore their values.
3) Contribute to the full range of in-channel flows including in regulated distributaries (Mallow wetlands, Mehi River, Moomin and Carole Creeks) to support fish spawning events and provide natural flow variability; and end of system flows to Barwon-Darling.	Throughout the water year advice will be sought regarding the opportunity to contribute to end of system flows in Mehi River, Moomin and Carole Creeks (refer table 9). Regular communication between State Water and Fisheries will be undertaken to deliver flows that support fish spawning events and provide natural flow variability.
Min Autumn to Winter 2012	
Use carryover to provide optimal seasonal flow patterns in subsequent years	Estimated carry over at the end of 2011-12 is 70 to 100 GL. Maximum allowable carryover is CEW 134 GL.

[2] Note the 35GL of CEW listed for objective 2 is not additional to the 35GL provided for objective 1 above. The additional outcomes are associated with the additional volume and sequence of unregulated inflows anticipated by moderate possibility of high flow supplementary flow event(s) by December 2011. Existing infrastructure limits the opportunity for controlled releases to meet the environmental requirements of the inner floodplain areas.

Table 7: Potential watering actions for 2011-12 in the Gwydir River catchment.

Asset	Watering Objective	Target flow regime[1]	Estimated volume to fill and maintain water levels (from all water sources)	Timing & Duration	Delivery mechanism	Operational considerations^
The Lower Gwydir wetlands including Old Dromana Ramsar site, 3,700 ha of semi-permanent vegetation and up to 908 ha of inner floodplain vegetation.	1a 2a	Inundate semi-permanent vegetation to a water depth of 30 up to 60 cm for 6 months between September and March Inundate inner floodplain vegetation to a water depth of 10 up to 30 cm for 3 months between September and March	It is estimated that 56 GL (from all water sources) is required to fill (23 GL) and maintain (33 GL) water levels close to 3,700 ha of semi-permanent wetland vegetation for 6 months. It is estimated that 76-90 GL (from all water sources) is required to inundate (the 3,700 ha of SPWV and) up to 908 ha of inner floodplain vegetation.	October to April. Monthly review to determine suitability and need for CEW delivery. Delivery plan to be developed to identify trigger flows and environmental delivery volumes.	Delivery is constrained to channel capacity of up to 300 ML/day at Millewa. Continuous flows at 250 ML/day over 180 days would achieve 45 GL. Deliveries must take advantage of any significant natural flows in the system, when these occur. Delivery and accounting point for water is at Millewa. In addition there is a new gauging station 2-3 km downstream for recording flows directed to the Old Dromana Ramsar site.	Provide up to 17.5 GL of CEW to contribute to the inundation of the asset. Delivery of CEW will occur in combination with natural flows and other environmental water sources to meet asset needs. Hence the final volume of CEW will depend on flows from other sources Depending on the forecast conditions and the availability of supplementary water, it may be appropriate to access supplementary water in early spring to build the soil moisture across the core wetlands. The risk of encouraging lippia (*Phyla canescens*) germination and spread should conditions turn drier than expected should be considered. The risk of inundation of cultivated land will also need to be monitored closely. To support adaptive event management, environmental water order (covering the lower Gwydir and Gingham) may be placed with State Water by OEH in 20 GL lots (consisting of a mixture of CEW, NSW RiverBank and WSP ECA). Depending on conditions water deliveries may commence in October. Prior to submitting a new order of water options will be reviewed on the basis actual flow and catchment conditions and updated information on climate forecasts. Regular communication between State Water and Fisheries to delivery variable flows (within system constraints). A prolonged and stable flow regime benefits feral fish species such as carp. To minimise the risk of flooding of cultivated land, deliveries will need to cease during natural high flow events or when substantial volumes of other water are being delivered. Piggy backing not available when irrigation water is above channel capacity at Tyreel (750 ML/day).
The Gingham wetlands east of Gingham bridge including Goddard's lease Ramsar site and Bunnor marsh club rush.	1b	Inundate semi-permanent vegetation to a water depth of 30 up to 60 cm for 6 months between September and March	Approximately 39 GL (from all water sources) is required to fill (23 GL) and maintain (16 GL) water levels close to 1,907 ha of priority areas of semi-permanent wetland vegetation for 6 months.	October to April. Monthly review to determine suitability and need for CEW delivery. Delivery plan to be developed to identify trigger flows and environmental delivery volumes.	Delivery constrained to channel capacity of 480 ML/day at Teralba and up to 300 ML/day at Tillaloo. Accounting point for water is at Teralba.	Provide up to 17.5 GL of CEW to contribute to the inundation of the asset. Delivery of CEW will occur in combination with natural flows and other environmental water sources to meet asset needs. Hence the final volume of CEW will depend on flows from other sources. Same operational considerations as listed above. Piggy backing not available when irrigation water is above channel capacity at Tyreel (750 ML/day) or Teralba (480 ML/day), Tillaloo (300 ML/day). This can occur during full allocation years between December and March and through September and October.
The Gingham wetlands east of Gingham bridge	1b	Inundate semi-permanent vegetation to a water depth of 30 up to 60 cm for 6 months.	Approximately 3-4 GL (from all water sources) is required to inundate 300 ha (this can be done	Delivery could occur with option provided above.	Delivery constrained to channel capacity of 480 ML/day at Teralba and up to 300 ML/day at	Same operational considerations as listed above. Channel needs to breach before surrounding inner floodplain

Asset	Watering Objective	Target flow regime[1]	Estimated volume to fill and maintain water levels (from all water sources)	Timing & Duration	Delivery mechanism	Operational considerations^
between Teralba to Tillaroo			without exceeding channel capacity limits).		Tillaloo. Delivery and accounting point is at Teralba. There is also a gauge at Tillaloo.	vegetation is inundated. This could occur during high flow supplementary events.
The Gingham wetlands west of gingham bridge (including Boyanga waterhole Crinolyn and Windella Ramsar).	1b 2b	Inundate semi-permanent vegetation as described above. Inundate inner floodplain vegetation to a water depth of 10 to 30 cm for 3 months between September and March	Modelling estimates that at least 100 GL (from all water sources) recorded at Yarraman Bridge GL is required to wet the majority of these sites for duration and depth to achieve ecological response.	October to April. Monthly review to determine suitability and need for CEW delivery. Delivery plan to be developed to identify trigger flows and environmental delivery volumes.	Deliveries to western areas are directly related to inflows at Tillaloo (upstream Gingham bridge) which has channel capacity up to 300 ML/day. Once 20 GL has been delivered to the wetlands upstream of Gingham bridge, flows at the Gingham bridge rise sharply and begin to flow west. Deliveries must take advantage of any significant natural flows in the system, when they occur. Delivery and accounting point for water is at Teralba, although there is a gauge at Tillaloo.	Same operational considerations as listed above. Once the core areas of semi-permanent vegetation have been inundated (previous two options) with at least 20 GL then water will start to inundate inner floodplain areas. Much larger volumes of water such as tributary flows experienced in medium to wet conditions are needed to inundate large areas of these assets, located further west in the Gingham water course.
Mallowa wetlands	3	Inundate inner floodplain vegetation to a water depth of 10 up to 30 cm for 3 months	Modelling estimates that 2,200-4,961 ML will reach all assets (To be confirmed)	October to April Monthly review to determine suitability and need for CEW delivery. Delivery plan to be developed to identify trigger flows and environmental delivery volumes.	Tareelaroi Weir diverts water to the Mehi and then Gundare Regulator diverts water to Mallowa Creek. Delivery and accounting point is at Mallowa Creek off-take.	Stock and domestic flows required under the water sharing plan may meet the environmental watering requirements of this area. In Mehi and Mallowa piggybacking is a good option throughout the year.
distributaries Mehi River, Moomin Creek, and Carole Creeks	4	TBC	TBC	September to March Monthly review to determine suitability and need for CEW delivery. Delivery plan to be developed to identify trigger flows and environmental delivery volumes.	Boolooroo Weir diverts water to Carole. Tareelaroi Weir diverts water to the Mehi River, and Combadello diverts flows to Moomin Creek.	Water requirements of Moomin Creek, a distributary of the Mehi River, and Carole Creek are knowledge gaps.

Table 8: Indicative estimate of Commonwealth environmental water release volume (GL) (based on median inflow conditions)

Asset	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Delivery to Millewa gauge (Lower Gwydir watercourse)	0	0	0	0-1.25	0-1.25	0-2.5	0-2.5	0-2.5	0-5	0	0	0	7-17.5
Delivery to Teralba gauge (Gingham Channel watercourse)	0	0	0	0-1.25	0-1.25	0-2.5	0-2.5	0-2.5	0-5	0	0	0	7-17.5
Total at Tyreel Weir	0	0	0	0-2.5	0-2.5	0-5	0-5	0-5	0-10	0	0	0	14-35

NB. This delivery schedule has been developed from analysis of potential available channel capacity and assumes a median scenario, but will be reassessed throughout the year based on updated forecasts. Delivery of CEW will occur in combination with natural flows and other environmental water sources to meet asset needs. Hence the final volume of CEW will depend on flows from other sources.

Table 9: Estimated end-of-system return flows

Asset	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Gwydir Wetlands (terminal wetlands)	0	0	0	0	0	0	0	0	0	0	0	0	0
Mehi River													TBC
Mallowa Creek													TBC
Carole Creek													TBC

NB. This table has not been completed as Water requirements of Moomin Creek, a distributary of the Mehi River, and Carole Creek are knowledge gaps. *Delivery of CEW will occur in combination with natural flows and other environmental water sources to meet asset needs. Hence the final volume of CEW will depend on flows from other sources.*

1.11. Key Constraints for water delivery

Due to upstream system constraints and channel capacity restrictions in the lower catchment, delivery to the Gwydir Wetlands is limited to a maximum of approximately 300 ML per day through to the Gingham Channel (near Gingham Bridge) and approximately 300 ML per day through the Lower Gwydir (Barma, 2011). Once flows exceed these rates, agricultural land on the edge of the wetland is likely to be inundated.

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Channel capacities in these streams limit piggybacking opportunities to certain areas to shoulder periods (that is prior to and following unregulated flow periods). For the Mehi and Mallowa, piggybacking is a good option throughout the year.

The length of time it takes for environmental water to reach a target asset from a water storage is an important consideration in providing effective water delivery (table 10).

Table 10: Gwydir Catchment weirs and regulators (NSW Office of Water 2011)

Weir	Location	Purpose	Gwydir River travel times (days) from Copeton Dam
Tareelaroi Weir	Gwydir River 30 km upstream of Moree	Diversions to the Mehi River	4
Boolooroo Weir	Gwydir River downstream of Moree	Diversions to Carole Creek	5
Tyreel Regulator	Gwydir River downstream of Moree	Diversions to Tyreel Anabranch and then to the Lower Gwydir Watercourse	5
Combadello Weir	Mehi River 20 km southwest of Moree	Diversions to Moomin Creek	6
Gundare Regulator	Mehi River 50 km southwest of Moree	Diversions to Mallowa Creek	7
Mallowa Creek Regulator	Mallowa Creek 50 km southwest of Moree	Control of stock and domestic flows along Mallowa Creek	7
River gauge			
Lower Gwydir River at Millewa	Gwydir River downstream of Tyreel Regulator	Channel flow gauging station and accounting point for flows into Lower Gwydir wetlands	8
Gingham Channel at Teralba	Gingham Channel downstream of Tyreel Regulator	Channel flow gauging station and accounting point for flows into Gingham wetlands east of	TBC by State Water

		Gingham Bridge	
Gingham Channel at Tillaloo	Gingham Channel downstream of Tyreel Regulator	Channel flow gauging station and accounting point for flows into Gingham wetlands west of Gingham Bridge	TBC by State Water

1.12. Assessing Environmental Watering Options

Watering actions for 2011-12 have been assessed as consistent with the Criteria for Assessing Environmental Watering Actions (see Appendix D). The criteria includes the:

1. ecological significance of the asset(s)
2. expected ecological outcomes from the proposed watering action
3. potential risks of the proposed watering action at the site and at connected locations
4. long-term sustainability of the asset(s) including appropriate management arrangements
5. Cost-effectiveness and operational feasibility of undertaking the watering.

Detailed assessment of the environmental watering actions against each criteria is provided at Appendix E. The assessment will be reviewed as individual watering actions are closer to their proposed timing for delivery. The review will include a more comprehensive risk assessment which is subject to the prevailing catchment and river flow conditions, and will consider in more detail proposed costs, delivery, monitoring and accounting arrangements. Any additional watering options identified during the course of the year will also be subject to an assessment against the criteria. For instance there is usually some warning of the likelihood of a colonial bird breeding event in the Gwydir catchment, which are usually initiated during very wet conditions after very high flood flows from tributaries downstream of Copeton Dam, and/or from dam spills.

1.13. Water Use Accounting

In the regulated Gwydir River and associated systems, environmental flows are delivered by State Water. The river gauges provided in Table 10 above are where water is generally delivered and measured. Transmission losses to deliver the water to the nominated points are not accounted against the Commonwealth water entitlements.

Assessment of residual in-channel flow during an augmented flow event will be undertaken through consultation with State Water based on their CAIRO water balance spreadsheet using observed flow hydrograph volumes, tributary inflows, irrigation diversions and drainage return flows.

1.14. Risk Management

A full risk assessment will be undertaken for each watering option as part of the assessment process, building upon the risk assessment included for groups of assets at Attachment E. Some of the more likely risks associated with delivering environmental water in the catchment include:

- Unpredictable weather - turns drier than expected leading to inadequate volumes of environmental water available to complete lifecycles of species with the following consequences:

  - failed bird breeding events;
  - insufficient inundation of vegetation communities contributing to further decline; and
  - insufficient inundation to suppress lippia growth (depth of >20cm desirable);
- Unpredictable weather - turns wetter than expected leading to undesirable flooding of property and infrastructure. Environmental Water Branch and NSW will manage this risk by monitoring forecast rainfall and water heights and gathering information on the status of commercial crops when delivering water. SWC will manage releases so delivery flow rates do not exceed channel capacities to avoid flooding of crops;
- Increase of exotic species, particularly carp, lippia or water hyancith;
  - flow regimes can support native species to better compete with invasive species e.g.
    - Lippia: 3 month inundation level of over 20 cm for over 3 months can suppress lippia.
    - Water hyacinth: small flows may be an option to stimulate growth without stimulating broadscale hyacinth growth. Once these flows recede, the plants become desiccated (MDBA 2010). Water hyacinth remains a major threat to the wetlands and the risk of spread is an important consideration; and
    - CARP: providing variable regimes, using control devices and drying out remanent habitats during summer may assist in reducing the carp population.
- Commonwealth environmental water diverted by downstream water users.

1.15. **Event Monitoring**

A robust approach to monitoring and evaluation is critical to determining the long-term outcomes of the use of environmental water, and to provide information to support good governance and adaptive management. Over the long term the monitoring of Commonwealth watering actions will be undertaken in accordance with the Monitoring, Evaluation and Reporting framework developed for Commonwealth environmental water. Once in place, this framework will facilitate the assessment and achievement of specific environmental outcomes to Commonwealth watering actions.

A number of monitoring programs are being undertaken by a variety of agencies in the Gwydir Wetlands with some having a Basin-wide focus. These programs range from ecological to hydrological in nature. Commonwealth funding in the next 12 months in the Gwydir Catchment for monitoring and evaluating the ecological response of Commonwealth watering actions will be considered on an event-by-event basis.

Operational monitoring of each watering action will be undertaken for all individual actions. In relation to the Gwydir Wetlands, NSW OEH will report on the total volumes entering the Gwydir Wetlands and flows through the gauged Ramsar sites such as Old Dromana and Goddard's Lease within the Gwydir Wetlands. Informal reports will also be provided through participation in the regular meetings of the Environmental Contingency Allowance Operations and Advisory Committee. Observations on the extent of flooding and incidental observations on responses by birds and vegetation will also be made from ground and air surveys and provided to the Commonwealth.

NSW OEH will investigate likely colonial bird breeding sites following all flooding events. Where colonies are identified, regular monitoring will be conducted for the duration of the event to report on colony size, diversity and fledging success. Regular updates will be provided.

Table 12: Monitoring arrangements for environmental flows in the Gwydir catchment.

Monitoring activities				
Location	**Watering objective** **(refer Table 6)**	**Parameters**	**Timing/frequency**	**Responsibility**
Compliance/operational monitoring				
Tyreel Regulator, Millewa gauge, Teralba gauge	All	Flow (ML/day) and water levels (metres AHD)	Ongoing daily monitoring	NSW State Water monitors the flow and water levels at each of the gauges in NSW
Tyreel Regulator and the Gwydir Wetlands	All	Flow (ML/day), approximate quantity delivered, approximate spread of inundation	Weekly informal updates	NSW Office of Environment and Heritage will provide weekly informal updates via email
Tyreel Regulator, Millewa gauge, Teralba gauge	All	Flow (ML/day), total quantity delivered	Monthly *	NSW Office of Environment and Heritage
Intervention/response monitoring				
Various sites in the Gwydir Wetlands	1a 1b	IMEF monitoring program (see detail above)	3 to 4 times per year	NSW Office of Water
Various sites in the Gwydir Wetlands	1a 1b 2a 2b	Vegetation condition assessment**	1 to 2 times per year	NSW Office of Environment and Heritage
Colonial nesting sites	1a 1b 2a 2b 3	Number of nesting birds Stage of event Success of event	Regularly throughout breeding events	NSW Office of Environment and Heritage
Gwydir Wetlands	1a 1b 2a 2b	Extent of inundation monitored both with aerial photography and satellite imagery	Regularly throughout an inundation event	NSW Office of Environment and Heritage
Condition Monitoring				
Various sites throughout the Gwydir Wetlands	1a 1b 2a 2b 3	Vegetation condition and extent. Combination site survey and satellite image analysis**	Full mapping of vegetation condition and extent every 5 years	NSW Office of Environment and Heritage
Various sites throughout the Gwydir Wetlands	1a 1b	Fish monitoring Frog monitoring	Conducted throughout 2010-11	NSW Office of Environment and Heritage University of New England

* Official monthly reports from OEH to the Commonwealth are yet to be formally confirmed.

** These monitoring programs are limited by the availability of funds. In 2010-11 the full suite of sites were not able to be assessed due to insufficient funds.

Reporting requirements in relation to this strategy
A consolidated report offering key results and highlighting beneficial and adverse results and outcomes should be compiled after each event, and annually. The report should also include 'lessons learnt', and provide advice on future adaptive management measures.

1.16. References

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Appendix A - Environmental Assets

Gwydir River Catchment

The Gwydir River rises on the western slopes of the Great Dividing Range, near Armidale (northern New South Wales) and flows westwards towards Pallamallawa and Moree through part of the Darling Riverine Plains (NSW DECCW, 2010). Terminating in the Gwydir Wetlands, the Gwydir River is included in the Murray Darling Basin Authority's Key Environmental Assets for the Barwon-Darling region under the proposed Basin Plan (MDBA, 2010).

The Gwydir River and its floodplain are included in the Lowland Darling River Endangered Ecological community, listed under the *Fisheries Management Act*, 2004 (NSW). This listing includes all native fish and aquatic invertebrates within all natural creeks, rivers, streams and associated lagoons, billabongs, lakes, anabranches, flow diversions to anabranches and floodplains of the Darling River. Aquatic species found within this asset include river snail (*Notopala sublineata*), the olive perchlet (*Ambassis agassizii*), silver perch (*Bidyanus bidyanus*) and the Murray Cod (*Maccullochella peelii*). In-channel river assets maintain the processes for river health such as geomorphic structures, organic carbon transfer and nutrient cycling, as well as direct impact on vegetation condition and habitat availability. Relevant distributaries include the regulated Mehi River (and Mallowa Creek), Moomin and Carole Creeks, the Gingham and Lower Gwydir watercourses, which feed the Gwydir Wetlands.

Gwydir Wetlands Complex

The wetlands lie on the Lower Gwydir, Gingham Channel and Mallowa Watercourses, forming a mosaic of wetlands types which are amongst the most extensive and significant semi-permanent wetlands in north-west New South Wales, ranging from marshes and waterholes to intermittent floodplains (MDBA, 2010). The wetlands also support the largest stand of marsh club-rush (*Bolboschoenus fluviatilis*) and water couch (*Paspalum distichum*) in New South Wales. River cooba (*Acacia stenophylla*) and lignum (*Muehlenbeckia florulenta*) shrubland occur around the wetland margins, with Coolibah (*Eucalyptus coolabah*) woodlands fringing the less frequently flooded parts of the floodplain. The riverine plains of the Gwydir and Mehi Rivers also support remnant areas of Carbeen Open Forest which is characterised by carbeen (*Corymbia tessellaris*) and white cypress-pine (*Callitris glaucophylla)*.

The wetlands support a wide variety of species listed as threatened under Commonwealth or state legislation, and, when inundated can sustain large numbers of waterbirds, including the eastern great egret (*Ardea alba*), intermediate egret (*A. intermedia*), little egret (*Egretta garzetta*) and the glossy ibis (*Plegadis falcinellus*). Colonial nesting waterbirds have been recorded as breeding in their thousands, especially, nankeen night heron (*Nycticorax caledonicus*), Australian white ibis (*Threskiornis molucca*), straw-necked ibis (*T.spinicollis*), little pied cormorant (*Phalacrocorax melanoleucos*) and little black cormorant (*P. sulcirostris*)

In recognition of the capacity of the wetlands to support migratory species listed under the Japan-Australia, China-Australia, or the Republic of Korea-Australia migratory bird agreements (JAMBA, CAMBA, RoKAMBA), four sites in the Gwydir Wetland: Old Dromona, Goddard's Lease, Crinolyn, and Windella form an 823 hectares listing under the Ramsar Convention on Wetlands. These four parcels of land, a mixture of freehold, perpetual leasehold lands and national park estate, meet four of the nine Ramsar listing criteria: representing a good example of an inland terminal wetland, in particular for the Murray-Darling Basin; supporting rare, endangered and vulnerable species, as well as a number of common species at the edge of their range;

supporting a high degree of biodiversity through the provision of breeding and feeding habitat for large numbers of colonial waterbirds; and, through supporting critical life stages, particularly for a wide range of waterbirds and frogs (NSW OEH, 2011b). The site is also a critical migration stop-over for the migratory Latham's snipe (*Gallinago hardwickii*).

The lower Gwydir and Gingham Watercourses (102,120 ha) are also listed in the Directory of Important Wetlands in Australia as nationally important,

A description of the key assets within this site can be found below. A further four sites representing key ecosystem functions have been identified on the Gwydir River at Stoneybatter, Copeton Dam, Pallamallawa and Collymongle (MDBA, 2010).

Gingham

Gingham Watercourse starts at the Gwydir Raft/Tyreel weir, which is seven kilometres west of Moree. Areas of semi-permanent and floodplain wetland (in varying condition) can be found on a number of privately owned and/or managed properties, such as Bunnor, Westholme, Lynworth, Yarrol, Munwonga, Baroona, Jacksons, Boyanga, Talmoi, Tillaloo, Glen Idol, Te Mona, Wayholm, Glendara, Curragundi, Molladree, Townsberry and other properties east of Te Mona. The Gingham watercourse also includes small components of the Ramsar site on Goddard's Lease, Crinolyn and Windella. Some of the previously privately owned and managed Old Dromana, now managed by NSW National Parks and Wildlife Service, is also located on the Gingham watercourse (DECCW, 2010).

There are a number of known and potential colonial waterbird breeding sites on these properties, including several relatively deep and protected open water lagoons such as the Gingham Waterhole, Pear Paddock Lagoon and Boyanga Waterhole, which provide habitat for colonies of egret, heron, cormorant, spoonbill, ibis and darter. In 1998, McCosker and Johnson counted 800 glossy ibis nests in river cooba on Tillaloo.

Lower Gwydir Wetlands

The Lower Gwydir Watercourse extends from the Gwydir Raft, a log-jam which extends for about 1.6 kilometres along the Gwydir River downstream of Moree, through a number of remnant semi-permanent wetland areas and waterholes and contains the 'Big Leather' section of the Gwydir Wetlands Ramsar site on Old Dromana, which is now public land. Prior to expansion of irrigation development in the 1970s, flows terminated in these intermittent and semi-permanent wetlands and large floods inundated wetlands, woodlands and grasslands to the west (Keyte 1994 in DECCW, 2010).

The Lower Gwydir watercourse contains open-water lagoons and provides important feeding habitat for colonially nesting species, especially ibis and spoonbill. Under suitable conditions it supports threatened species including brolga (*Grus rubicunda*), magpie goose (*Anseranas semipalmata*), Australian painted snipe (*Rostratula australis*), Australasian bittern (*Botaurus poiciloptilus*), blue-billed duck (*Oxyura australis*) and black-necked stork (*Ephippiorhynchus asiaticus),* as well as species that are listed under international agreements.

Appendix B CEWH Ecological Watering Objectives

	Ecological Watering Objectives	Management Objectives	Management Actions
Extreme Dry	▪ Avoid damage to key environmental assets	▪ Avoid critical loss of threatened species and communities ▪ Maintain key refuges ▪ Avoid irretrievable damage or catastrophic events	▪ Water refugia and sites supporting threatened species and communities ▪ Undertake emergency watering at specific sites of priority assets ▪ Use carryover volumes to maintain critical needs
Dry	▪ Ensure ecological capacity for recovery	▪ Support the survival and growth of threatened species and communities, including limited small-scale recruitment ▪ Maintain diverse habitats ▪ Maintain low-flow river and floodplain functional processes in sites and reaches of priority assets	▪ Water refugia and sites supporting threatened species and communities ▪ Provide low flow and freshes in sites and reaches of priority assets ▪ Use carryover volumes to maintain follow-up watering
Median	▪ Maintain ecological health and resilience	▪ Enable growth, reproduction and small-scale recruitment for a diverse range of flora and fauna ▪ Promote low-lying floodplain-river connectivity ▪ Support medium flow river and floodplain functional processes	▪ Prolong flood/high-flow duration at key sites and reaches of priority assets ▪ Contribute to the full range of in-channel flows ▪ Use carryover to provide optimal seasonal flow patterns in subsequent years
Wet	▪ Improve and extend healthy and resilient aquatic ecosystems	▪ Enable growth, reproduction and large-scale recruitment for a diverse range of flora and fauna ▪ Promote higher floodplain-river connectivity ▪ Support high-flow river and floodplain functional processes	▪ Increase flood/high-flow duration and extent across priority assets ▪ Contribute to the full range of flows, including overbank ▪ Use carryover water to provide optimal seasonal flow patterns in subsequent years

For further information please refer to the *Framework for Determining Commonwealth Environmental Watering Actions* (available at http://www.environment.gov.au/water/policy-programs/cewh/index.html)

Appendix C Watering Options for the Gwydir River Catchment

Table C.1: Potential watering options for 2011-2012 in the Gwydir River catchment*.

Environmental Asset	Management objectives for specific water availability scenarios			
	Extreme Dry **Goal: Avoid damage to key environmental assets** **River systems may cease to flow and dry down to a series of pools that act as refuge for native fish populations which will repopulate the river systems when flows return.** **Water availability is limited to remaining volumes in environmental account, carried over from previous years.** **CEW – 63,635 ML carryover from 2010-11 and 421 ML forecast allocation in 2011-12. Supplementary event unlikely.**	**Dry** **Goal: Ensure ecological capacity for recovery** **River systems will have minimum baseflows within the regulated channel and minor inflows from unregulated tributaries.** **Water availability is limited to remaining volumes in environmental account, carried over from previous years. General security allocations are not likely to increase more than 20 per cent during the year.** **CEW – 63,635 ML carryover from 2010-11 and 26,858 ML forecast allocation in 2011-12. Significant supplementary events unlikely.**	**Median** **Goal: Maintain ecological health and resilience** **River systems will have inflows from unregulated tributaries.** **Water availability will include volumes carried over from previous year and General security allocations may increase by 50 per cent during the year. There is a likelihood of supplementary events.** **CEW – 63,635 ML carryover from 2010-11 and 49,239 ML forecast allocation in 2011-12. Moderate probability of supplementary flow event(s) providing additional water available against the 19,100ML of Commonwealth supplementary entitlement**	**Wet to very wet** **Goal: Improve and extend healthy and resilient aquatic ecosystems.** **River system will have high flood level flows inundating large areas of the floodplain including outer floodplain vegetation. Options for delivering Commonwealth water will be limited as objectives will be satisfied by unregulated high flows.** **Under wet conditions account volumes are likely to be greater than 80 per cent general security allocation. Supplementary events are also likely.** **CEW – 63,635 ML carryover from 2010-11 and 64,458 ML forecast allocation in 2011-12. High probability of supplementary flow event(s) providing additional water available against the 19,100ML of Commonwealth supplementary entitlement.**
Maintain in channel flow paths and water quality in the regulated distributaries Mehi River, Moomin and Carole Creeks and the Gingham and Lower Gwydir	▪ Water deliveries to assist the survival of native fish populations in refuge pools in priority reaches will be required before dissolved oxygen drops to <5mg/L and water levels reach critical levels.	▪ Support fish habitat and spawning events and provide natural flow variability. ▪ Water requirements for distributaries are knowledge gaps.	▪ Support fish spawning events and provide natural flow variability. ▪ Water requirements for distributaries are knowledge gaps.	▪ Support fish spawning events and provide natural flow variability. ▪ Support end of system flows to Barwon-Darling ▪ Water requirements for distributaries are knowledge gaps.
The Lower Gwydir and Gingham Watercourses Wetlands	▪ Based on analysis of available channel capacity between September and March in very dry years up to 84 GL **(42 GL CEW)** of environmental reserves may be delivered to Lower Gwydir and Gingham Watercourses Wetlands	▪ Based on analysis of available channel capacity between September and March in dry years up to 80 GL (**40GL CEW)** of environmental reserves may be delivered to Lower Gwydir and Gingham Watercourses Wetlands.	▪ Options for delivering Commonwealth water will be limited as objectives will be satisfied by unregulated tributary flows. Based on analysis of average available channel capacity between September and March in median years up to 70 GL **(35GL CEW)** of environmental reserves may be delivered to Lower Gwydir and Gingham Watercourses Wetlands.	▪ Options for delivering Commonwealth water will be limited as objectives will be satisfied by unregulated high flows. Based on analysis of average available channel capacity between September and March in wet to very wet years up to 38 GL **(19 GL CEW)** of environmental reserves may be delivered to Lower Gwydir and Gingham Watercourses Wetlands.

Environmental Asset	Management objectives for specific water availability scenarios			
	Extreme Dry **Goal: Avoid damage to key environmental assets** **River systems may cease to flow and dry down to a series of pools that act as refuge for native fish populations which will repopulate the river systems when flows return.** **Water availability is limited to remaining volumes in environmental account, carried over from previous years.** **CEW – 63,635 ML carryover from 2010-11 and 421 ML forecast allocation in 2011-12. Supplementary event unlikely.**	**Dry** **Goal: Ensure ecological capacity for recovery** **River systems will have minimum baseflows within the regulated channel and minor inflows from unregulated tributaries.** **Water availability is limited to remaining volumes in environmental account, carried over from previous years. General security allocations are not likely to increase more than 20 per cent during the year.** **CEW – 63,635 ML carryover from 2010-11 and 26,858 ML forecast allocation in 2011-12. Significant supplementary events unlikely.**	**Median** **Goal: Maintain ecological health and resilience** **River systems will have inflows from unregulated tributaries.** **Water availability will include volumes carried over from previous year and General security allocations may increase by 50 per cent during the year. There is a likelihood of supplementary events.** **CEW – 63,635 ML carryover from 2010-11 and 49,239 ML forecast allocation in 2011-12. Moderate probability of supplementary flow event(s) providing additional water available against the 19,100ML of Commonwealth supplementary entitlement**	**Wet to very wet** **Goal: Improve and extend healthy and resilient aquatic ecosystems.** **River system will have high flood level flows inundating large areas of the floodplain including outer floodplain vegetation. Options for delivering Commonwealth water will be limited as objectives will be satisfied by unregulated high flows.** **Under wet conditions account volumes are likely to be greater than 80 per cent general security allocation. Supplementary events are also likely.** **CEW – 63,635 ML carryover from 2010-11 and 64,458 ML forecast allocation in 2011-12. High probability of supplementary flow event(s) providing additional water available against the 19,100ML of Commonwealth supplementary entitlement.**
	▪ Allow sites to dry down if sufficient flooding received in previous years (for semi-permanent vegetation - 6 months inundation, 8 years in 10 or inner floodplain - 3 months inundation, 5 years in 10). ▪ Otherwise maintain core wetland areas in Lower Gwydir and Gingham Watercourses - with priority being the Old Dromana and Goddard's Lease Ramsar sites - by delivering sufficient water to allow wetland biota to complete life cycles.	▪ Allow sites to dry down if sufficient flooding received in previous years (for semi-permanent vegetation - 6 months inundation, 8 years in 10 or inner floodplain - 3 months inundation, 5 years in 10). ▪ Otherwise maintain core wetland areas in Lower Gwydir and Gingham Watercourses - with priority being the Old Dromana and Goddard's Lease Ramsar sites - by delivering sufficient water to allow wetland biota to complete life cycles. ▪ Support any bird breeding event(s). ▪ Provide flows (as required) to reduce the extent of water hyacinth.	▪ Maintain semi-permanent vegetation and inner floodplain vegetation in wetland areas in Lower Gwydir and Gingham Watercourses by delivering sufficient water to allow wetland biota to complete life cycles. ▪ At least 95-125 GL is required to wet the majority of Lower Gwydir and Gingham Wetlands (6,776 ha SPWV and 6,719 ha inner floodplain vegetation) for duration and depth to achieve ecological response. Such a large volume of water would inundate majority of the Crinolyn and Windella Ramsar sites further west as well as farming and cultivated land. ▪ Support any bird breeding event(s). ▪ Provide flows (as required) to reduce the extent of water hyacinth.	▪ At least 95-125 GL is required to wet the majority of Lower Gwydir and Gingham Wetlands (6,776 ha SPWV and 6,719 ha inner floodplain vegetation) for duration and depth to achieve ecological response. A greater amount of over a number of years water would be required to extend the restoration area. Such a large volume of water would inundate majority of the Crinolyn and Windella Ramsar sites further west as well as farming and cultivated land. ▪ At least 200 GL is required to wet the outer floodplain area (71,230 ha). In the past large scale flooding events have only inundated such wide area for short periods of 15-60 days. Coolibah - Blackbox woodland can be inundated for at least 3 months to a 20cm depth 1 in 10-20 years but sequential flooding may improve woodland ecology. ▪ Support any bird breeding event(s). ▪ Provide flows (as required) to reduce the extent of water hyacinth.
Mallowa wetlands	▪ Under extreme conditions environmental releases to maintain downstream wetlands is not anticipated.	▪ Inundate inner floodplain vegetation up to 4,961 ML will inundate all assets (To be confirmed).	▪ Inundate Lignum and River Cooba inner floodplain up to 4,961 ML will inundate all assets (To be confirmed).	▪ Support Lignum and River Cooba inner floodplain vegetation and Coolibah/Cooba/ Lignum woodlands up to 4,961 ML. Water volumes to be confirmed.
Carryover: Maximum allowable carryover is CEW 134,288 ML; NSW 25,638ML and ECA 90,000 ML. Total is 249,926 ML.	• Retaining and carrying over water may be recommended to ensure there are sufficient volumes to avoid damage should there be extended dry conditions. • Under multiple dry years carryover is progressively reduced.	• Retaining and carrying over water may be considered to ensure there are sufficient volumes to avoid damage should there be extended dry conditions. Under multiple dry years carryover is progressively reduced.	• Carryover of environmental reserves may occur to ensure that there are sufficient volumes to avoid damage should conditions turn drier than expected, or provide a subsequent inundation to further improve ecological health and resilience.	• Carryover of environmental reserves may occur to : • avoid damage should conditions turn drier than expected; or • provide a subsequent inundation to further improve ecological health and resilience.

Appendix D Criteria for Assessing Commonwealth Environmental Watering Actions

In undertaking its activities, the Commonwealth Environmental Water Holder (CEWH) is required to act consistently with the requirements of the *Water Act 2007* (Cwlth) (hereafter referred to as 'the Act'). The relevant functions are outlined in s.105. This includes a requirement that the environmental water holdings are managed in accordance with the environmental watering plan of the Murray-Darling Basin Authority (MDBA). Close consultation is occurring with the MDBA to ensure that use of Commonwealth water is consistent with the emerging objectives of the environmental watering plan that is currently being developed.

A long-term framework for the prioritisation of environmental water allocations has been prepared in consultation with delivery partners, interested stakeholders and experts, and the Environmental Water Scientific Advisory Committee.

The framework includes ecological objectives that will change under the different water availability scenarios (i.e. extreme dry, dry, median, wet). Proposed watering actions will need to be supported by available evidence, and consistent with current water availability scenarios and the framework.

Commonwealth environmental water is being acquired to supplement existing flows. Proposals for use of the water will not be agreed to if this use substitutes for other water uses, including historical system operations (e.g. provision of water for conveyance, stock and domestic, or planned environmental water).

Through adaptive management processes, the CEWH will consider opportunities for a more informed and diverse range of water uses as knowledge and modelling. All 2011-12 proposals will be assessed against the following five criteria:

1. The ecological significance of the asset(s).
2. The expected ecological outcomes from the proposed watering action.
3. The potential risks of the proposed watering action at the site and at connected locations.
4. The long-term sustainability of the asset(s) including appropriate management arrangements.
5. The cost effectiveness and operational feasibility of undertaking the watering.

Appendix E Assessment of Watering Options

Gwydir Wetlands - inundation of semi-permanent wetland vegetation and inner floodplain vegetation	
Previous watering actions in the Gwydir Catchment have been assessed by Environmental Water Scientific Advisory Committee as satisfying the assessment criteria (January 2011).	
Criteria	**Assessment**
1. Ecological Significance	The Gwydir wetlands are among the most extensive and significant semi-permanent wetlands in north-west New South Wales and contain one of the state's largest remaining marsh club-rush expanses (*Bolboschoenus fluviatilis*). The semi-permanent wetland vegetation in the floodplain provides important feeding areas for a diverse range of waterbirds. River cooba and lignum shrublands are common in and around the margins of the core wetlands and provide valuable waterbird breeding habitat, especially for colonially nesting species. Over 235 different species of birds have been recorded in the Lower Gwydir wetlands. The Gwydir Wetlands have been identified as a hydrologic indicator site (environmental asset) in the Murray-Darling Basin by meeting all five of the MDBA's key environmental asset criteria. The wetlands are formally recognised in, and are capable of supporting species listed in relevant international agreements, they are natural or near-natural, rare or unique; they provides vital habitat; they supports Commonwealth-, state- or territory-listed threatened species and/or ecological communities and they support, or are capable of supporting, significant biodiversity (MDBA, 2010). The lower Gwydir and Gingham Watercourses (102,120 ha) have also been nationally important, meeting three criteria under the Directory of Important Wetlands in Australia: ecosystem representativeness and habitat provision for threatened species, under commonwealth or state legislation, both endemic and migratory. These wetlands provide habitat for colonial waterbirds and migratory birds listed under international agreements with Japan, China and the Republic of Korea (JAMBA, CAMBA and ROKAMBA Of these, 134 have been observed to use the wetlands for breeding. In recognition of this, four parcels of land within Gingham and Lower Gwydir watercourses (comprising 823 ha), including (the now publically managed) Old Dromana, Goddard's Lease, Crinolyn and Windella listed under the Ramsar Convention on Wetlands, as they meet four (out of the nine) listing criteria: • Representativeness: the site is a particularly good example of an inland terminal wetland in the Darling Riverine Plains bioregion and the whole of the Murray-Darling Basin. It contains probably the largest stand of marsh club-rush and water couch (*Paspalum distichum*) • Threatened species: the site supports a large assemblage of rare, endangered and vulnerable species, particularly the Australian painted snipe (*Rostratula australis*: EPBC vulnerable; NSW vulnerable) and Australasian bittern (*Botaurus poiciloptilus*) • Biodiversity: the sites key value is as one of few functioning inland wetlands. The small area listed supports at least 75 waterbird species as well as a variety of vegetation types (DECCW, 2010) • Supports critical life stages: the site supports major water bird breeding events with 34 species of waterbird recorded to have bred at Old Dromana alone. The site is also a critical migration stop-over for the Latham's snipe (*Gallinago hardwickii*: EPBC migratory). Species recorded as utilising the wetlands include: • eastern great egret (*Ardea alba*) • intermediate egret (*A. intermedia*) • little egret (*Egretta garzetta*) • cattle egret (*A. Ibis)*; • Australian painted snipe; • Latham's/Japanese Snipe; • sharp-tailed sandpiper (*Calidris acuminata*); and • glossy ibis (*Plegadis falcinellus*) The Gwydir wetlands lie within the Darling River Endangered Ecological community, which is listed under the NSW *Fisheries Management Act* 2004 (DPI, 2011) All native fish and aquatic invertebrates within all natural creeks, rivers, streams and associated lagoons, billabongs, lakes, anabranches, flow diversions to anabranches and floodplains of the Darling River within NSW. Aquatic species includes the river snail (*Notopala sublineata*), the olive perchlet (*Ambassis agassizii*), silver perch (*Bidyanus bidyanus*) (and Murray Cod (*Maccullochella peelii*). Other species that depend on wetland habitat within the Gwydir system include: • the large-eared pied bat (*Chalinobus dwyeri);* • the little pied bat (*Chalinobus picatus);* • the greater long-eared bat (or fishing bat) (*Nyctophilus timoriensis*); • yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*); and, • the five-clawed worm skink (*Anomalopus mackayi*). In addition, the weeping myall woodland (Commonwealth endangered) occurs on the outer floodplains or higher grounds of the wetlands. The wetlands also provide important habitat

Gwydir Wetlands - inundation of semi-permanent wetland vegetation and inner floodplain vegetation	
Previous watering actions in the Gwydir Catchment have been assessed by Environmental Water Scientific Advisory Committee as satisfying the assessment criteria (January 2011).	
Criteria	**Assessment**
	for approximately 14 different frog species, which provide an important food source for water birds and for snakes (DECCW, 2010). The most common are barking marsh frog (*Limnodynastes fletcheri*), broad palmed frog (*Litoria latopalmata*), crucifix frog (*Notaden bennettii*), green tree frog (*Litoria caerulea*), salmon striped frog (*Limnodynastes salmini*), spotted marsh frog (*Limnodynastes tasmaniensis*) and the water-holding frog (*Cyclorana platycephala*).
2. Expected ecological outcomes	River regulation and water extraction (water resource development) in the Gwydir catchment means that the period between flood events that inundate 20,000 of the wetlands (20 per cent) has increased by 75 per cent. Some of the water that would have once reached the Lower Gwydir wetlands is now diverted for irrigation, stock and domestic use (McCosker 2001; in DECCW, 2010). Coupled with drought conditions for the past decade, there has been considerable change in extent and condition of both semi-permanent vegetation and floodplain vegetation communities (MDBA, 2010). The wetland vegetation can provide a good indicator of the overall health and is classified into groups: • Semi-permanent wetland vegetation (SPWV) - communities that depend on frequent flooding to maintain their structural integrity and condition. The core wetland areas are semi-permanent, with vegetation typified by marsh club-rush (*Bolboschoenus fluviatilis*) and water couch (*Paspalum distichum*). The Gwydir wetlands contain one of the largest remaining marsh club-rush expanses in New South Wales • Floodplain wetland and fringing vegetation communities, whose dominant over-storey species require flooding at some stage for regeneration, can tolerate prolonged flooding (up to several months) and are able to survive dry periods of several years. Since 1996, the overall area of wetland vegetation has decreased from more than 14,000 hectares to less than 7,000 hectares (DECCW, 2010; MDBA, 2010). The Gingham watercourse has been most affected with the area of water couch-spike rush communities decreasing from 9,393 hectares in 1996 to 3,485 hectares in 2008 (MDBA, 2010) In this system, the area of marsh-club rush has increased very slightly, however. In the Lower Gwydir, marsh club rush communities have decreased (from 317 hectares in 1996 to 181 hectares in 2008). From mid- 2010-11 1, 41,000 ML flowed into the Gwydir Wetlands, with around 10,000 hectares being inundated for a period of 6-8 months. A range of ecological responses were recorded, notably flowering of marsh club rush to an extent not observed since the late 1990s. Lignum once occurred throughout the Gwydir Wetlands as an understorey plant but has now depleted to form shrub lands in only a few areas on the Gingham Watercourse and Mallowa Creek Inundating the wetland to a depth of at least 30-60 cm between September and March for up to 6 months, is expected to support a range of wetland species, including water couch, spike rush, common reed, marsh club rush and cumbungi. Inundating these core wetland values should improve ecosystem function enabling the completion of fauna life cycles and subsequently contribute to improved health of wetland fauna populations. This watering is expected to provide Basin-wide benefits by improving the ecological condition of a Ramsar listed wetland area, providing drought refuge areas and contributing to basin wide biodiversity values, by supporting at least 58 waterbird species as well as a variety of vegetation types. Called water will travel the length of the river and flow into terminal wetlands and contribute to in-stream and riparian values. The Gwydir River and its associated waterways would benefit from improved flows that may wet river benches and riparian zones along the river As prolonged inundation of core wetland areas was achieved during the 2010-11 water year, the health of the wetland has improved. Extensive ecological response, including mass flowering/seeding of marsh club-rush stands, was observed following this watering. Consecutive wet years are expected to further improve the viability and resilience of core wetland communities. Continuing to inundate the wetlands will facilitate improvements made during the wet 2010-11 water year by providing a sequential inundation event encouraging core wetland to expand and inner floodplain vegetation to achieve, over time, measured improvements in plant species density and diversity at established monitoring quadrants This should improve the resilience of the wetland system. The Gwydir Wetlands play an important role in the biology and ecological functioning of the Murray Darling Basin. The large stands of marsh-club rush sedgelands and other wetland vegetation support migratory birds, colonial nesting species and migratory waders as well a large range of both State and Commonwealth threatened species. Inundation of the Gwydir wetlands is not always concurrent with inundation in other nearby wetlands such as the Macquarie Marshes. Therefore the Gwydir wetlands are likely to be important for the maintenance of large waterbird populations by providing drought refuge and more breeding sites (Green & Bennett 1991, in DECCW, 2010) Flows to the Gwydir wetlands will also support the ecology of nearby wetland areas such as Mallowa Creek and associated wetlands, as well as provide in-stream values to the Gwydir River asset, maintaining geomorphic features and improving ecological processes such as carbon cycling. In addition, the Gwydir Wetlands are known for being highly significant to Aboriginal communities for a range of values, including plants and animals that have cultural value.

Gwydir Wetlands - inundation of semi-permanent wetland vegetation and inner floodplain vegetation	
Previous watering actions in the Gwydir Catchment have been assessed by Environmental Water Scientific Advisory Committee as satisfying the assessment criteria (January 2011).	
Criteria	**Assessment**
3.Potential Risks	A comprehensive risk assessment including control measures will be submitted with the approvals minute. The following risks have been identified: • Preference being given to the delivery of irrigation water during environmental water season, with potential consequence of a decline in extent and condition of ecological assets. • Unpredictable weather - turns drier than expected leading to inadequate volumes of environmental water available to complete lifecycles of species leading to failed bird breeding events; o insufficient inundation of vegetation communities contributing to further decline; o insufficient inundation to suppress lippie growth (depth of >20cm desirable). *The Commonwealth holds reserves of water and will liaise with OEH regularly to assess the need for follow up water.* • Undesirable flooding of property and infrastructure; • Increase of Exotic species, particularly carp, lippia or water hyancith; o In terms of lippia and carp control, flow regimes can support native species to out compete invasive species e.g. 3 month inundation level of over 20 cm for 3 months can suppress lippia growth. For the management of water hyacinth, small flows may be an option to stimulate growth without stimulating broadscale hyacinth growth. Once these flows recede, the plants become desiccated (MDBA 2010). Water hyacinth remains a major threat to the wetlands and the risk of spread into the Barwon River and the Murray-Darling Basin is an important consideration • Commonwealth environmental water diverted by downstream water users; *Compliance is a matter for SWC and NOW. Following the delivery of Commonwealth water an operational audit will be of river flows and extraction figures will be undertaken to confirm that environmental allocations have been delivered. In the situation that the volume ordered has not been delivered, accounts will be credited. Compliance identifying all reasons for water loss is particularly difficult during high flow unregulated supplementary events and where possible high resolution imagery will be sourced.* • Uncoordinated flow management is a risk managed through regular communication with delivery partners (OEH, ECAOAC, State Water, NOW); • Cold water pollution exists below Copeton Dam. Water temperatures believed to return to normal temperature ranges before reaching Gwydir Wetlands. (David Ward, Department of Industry and Investment, pers. comm. 10 January 2011).

Gwydir Wetlands - inundation of semi-permanent wetland vegetation and inner floodplain vegetation	
Previous watering actions in the Gwydir Catchment have been assessed by Environmental Water Scientific Advisory Committee as satisfying the assessment criteria (January 2011).	
Criteria	**Assessment**
4. The long term sustainability of the asset including management & monitoring arrangements	Many of the actions required for the maintenance of the Gwydir Wetlands are planned under existing funding programs, policy or legislation. Old Dromana a property on the Lower Gwydir was recently purchased with Commonwealth funds through the Rivers Environmental Restoration Program (RERP) and has been reserved as a conservation area. There are specific planning processes for the newly established conservation area and the Old Dromana portion of the Ramsar site as well as more holistic plans such as the 2010 Gwydir Wetlands Adaptive Environmental Management Plan. There is clear evidence for long term environmental planning and management in the Gwydir Wetlands. In addition to the environmental water management aspect there are a number of other natural resource management programs in place in the Gwydir Wetlands managed by OEH in conjunction with livestock health, pest authorities and landholders. These programs include vegetation mapping, land clearing awareness campaigns and pest control programs targeting pigs, foxes and feral fish. There was also research into managing and controlling the weed lippia (*Phyla canescens*) funded by the NSW Wetland Recovery Program. NSW OEH manages 90,000 ML of environmental contingency allowance, 17,092 ML of RiverBank general security entitlements and 441 ML of RiverBank supplementary entitlement. This water is managed in accordance with the annual environmental watering plan, developed by OEH, which (like this plan) identifies short-term watering priorities based on various climatic scenarios. An Environmental Contingency Allowance Operations and Advisory Committee (ECAOAC) has been established that advises on the most appropriate water use scenarios which form part of these plans. The group includes representatives from irrigation, landholders, environmental groups, NSW Fisheries, NSW Office of Water, National Parks and Wildlife Service and OEH. The Environmental Water Branch has a representative who attends ECAOAC meetings as an observer. Executive and technical support for the ECAOAC is provided by the regional Wetlands and Rivers Conservation Officers. This strategy has been prepared in consultation with the OEH Senior Regional Wetlands and Rivers Conservation Officer, to ensure consistency with the annual environmental watering plan. <u>Short-term</u> Daily monitoring of flow rates and water heights throughout the Gwydir Wetlands are incorporated into adaptive management of the flows. OEH will provide weekly updates of the progress of the event. In addition OEH will provide a full operational report at the end of the event, outlining the delivery of the complete event and any significant outcomes such as the success of the bird breeding. NSW OEH will report annually to the CEWH on the total volumes entering the Gwydir Wetlands. Informal reports will also be provided through participation in the regular meetings of the ECAEOC. Observations on the extent of flooding and incidental observations on responses by birds and vegetation will also be made from ground and air surveys. NSW OEH will investigate likely colonial bird breeding sites following all flooding events. Where colonies are identified, NSW OEH will be monitor the colonies of breeding birds and adaptively manage the inflows accordingly, for the duration of the event. Reports will be provided on colony size, diversity and fledging success. Birds will be observed by site inspection every two weeks and an aerial inspection will be conducted to determine the stage of the breeding. Remote cameras may also be positioned in the main colonies to allow feedback during the event. Wetland vegetation condition will be measured for each event using a combination of methods. The Integrated Monitoring of Environmental Flows (IMEF) Program which is delivered by the Office of Water aims to establish the relationships between water regimes and the diversity and abundance of wetland plants. Information has been collected under this program since 1999. Additional sites beyond those monitored by IMEF are required to cover all the areas likely to be targeted for environmental water delivery (See Bowen and Simpson 2010) and these will be assessed using comparable methods. Techniques based on remote imagery are also being trialled as a rapid, cost effective method to provide an index of vegetation condition. Wetland vegetation extent will be assessed for each community every five years. This information will be used to measure progress toward achieving long-term targets for maintenance/recovery. <u>Median to longer term</u> There are considerable efforts underway at a range of scales to provide an overarching monitoring framework for assessing changes in resource condition in response to management interventions. The outcomes from these efforts will therefore determine monitoring activities in the Gwydir Wetlands in the longer-term. Methods currently applied in the short-term approach above are expected to be continued or be compatible with recommendations arising from the efforts referred to below. NSW has developed a number of targets for natural resource condition, including wetlands. In order to assess progress toward these targets, a monitoring, evaluation and reporting framework has been developed and trialled for important wetlands. Refinements are currently being made to ensure meaningful and cost-effective information is derived. SEWPAC is currently developing a monitoring and evaluation framework for watering activities involving Commonwealth holdings. The MDBA is also developing a monitoring framework as a component of the Environmental Watering Plan within the MDB Plan. Experience from implementation of The Living Murray Initiative is informing these frameworks.

Gwydir Wetlands - inundation of semi-permanent wetland vegetation and inner floodplain vegetation	
Previous watering actions in the Gwydir Catchment have been assessed by Environmental Water Scientific Advisory Committee as satisfying the assessment criteria (January 2011).	
Criteria	**Assessment**
5. Cost-effectiveness	Water in the Gwydir is gravity fed; there are no pumping costs involved. Usage charges for the Gwydir Regulated River Source for the 2012-12 are $12.53/ML water year (State Water 2011) and $0.99/ML (NSW Office of Water).

Mallowa Wetlands	
Criteria	**Assessment**
1. Ecological Significance	The woodland and wetland habitat of the Mallowa Creek system supports a number of threatened bird species (both terrestrial and water dependent). These include Grey-crowned babbler, hooded robin, brown treecreeper, bush stone curlew, black-necked stork, brolga, square-tailed kite, glossy black cockatoo, magpie goose and grey falcon (Torrible et al 2009). They also support at least 3 bird species listed under international bird agreements. The Mallowa wetlands consist of disconnected wetland areas separated by cultivated land. Maintaining the ecological condition of the Mallowa wetlands can help support the waterbird breeding and waterbird habitat in the greater Gwydir wetlands. The area can act as additional feeding grounds, and the vegetation communities can provide seeds to maintain diversity of wetland plants throughout the area (Burns 2002).
2. Expected ecological outcomes	The objectives of this watering action, which are to promote recovery of wetland vegetation and create habitat for threatened and migratory listed bird species, are consistent with median or wet water availability CEWH objectives. Providing/maintaining wetland vegetation inundation is expected to improve ecosystem function along Mallowa Creek allowing for the completion of fauna life cycles and subsequently contribute to improved health of Gwydir catchment as a whole. Called water will travel the length of the river and flow into the wetlands. Consequently, part of the Gwydir River, Mehi River and Mallowa creek would have improved flows that may wet river benches and riparian zone along the river, maintaining geomorphic features and improving ecological processes such as carbon cycling
3.Potential risks	The risks and mitigation strategies listed for the above Lower Gwydir and Gingham watercourse wetlands apply to the Mallowa Wetland option. However, lippia has not yet overtaken key wetland habitat, it is likely that extending the inundation event will assist water couch to out-compete lippia. While increased inundation periods may provide opportunities for exotic fish breeding, spring and summer flooding provides important spawning cues for most native fish.
4. The long term sustainability of the asset including management & monitoring arrangements	The action, programs and policies that apply to risks and mitigation strategies listed for the above Lower Gwydir and Gingham watercourse wetlands apply to the Mallowa Wetland option. The management and monitoring arrangement listed for the above Lower Gwydir and Gingham watercourse wetlands apply to the Mallowa Wetland option.
5. Cost-effectiveness	The cost per ML associated with the above Lower Gwydir and Gingham watercourse wetlands apply to the Mallowa Wetland option.

Water Use Strategy 2011-12: Lachlan River Catchment

1.1. Introduction

This document sets out the proposed objectives and approach to using environmental water in the Lachlan catchment during the 2011-12 water year. This strategy was developed based on information available to the Commonwealth Environmental Water through consultation with stakeholders including state governments, local river operators and wetland managers. Local community input has been sought through the Lachlan Riverine Watering Group which includes jurisdictional representatives such as the NSW Office of Environment and Heritage, the Office of Water and the Lachlan Catchment Management Authority, as well as local water users and landholders.

The document includes watering options, recent climatic and riverine conditions in the catchment and forecast water availability under a range of hydrological scenarios. The proposed approach will adapt over the course of the year as conditions in the catchment change and more information becomes available. Importantly, the potential watering options included in this document do not form an exhaustive list, the Department welcomes further suggestions for using environmental water. All relevant options will be assessed to ensure the best possible use of environmental water..

1.2. The Lachlan River Catchment

The Lachlan River catchment is located in the central west of New South Wales and has an area of 84,700 km^2, which is equivalent to about eight percent of the Murray-Darling Basin (CSIRO 2008). The Lachlan catchment borders the Murrumbidgee catchment to the south and the Macquarie-Bogan catchment to the north. The Lachlan River rises near Gunning in the east, and travels approximately 1,400 kilometres almost due west towards Oxley. The Lachlan terminates in the Great Cumbung Swamp, although under extremely rare circumstances (extreme flood conditions) it is possible it may connect to the Murrumbidgee River, although this would occur rarely. The landscape is diverse, ranging from temperate forests, woodlands and grasslands in the east, to semi-arid woodlands, mallee and shrublands in the west. Much native vegetation has been cleared to make way for agricultural activities. The main land use in the Lachlan is agriculture, with 75 per cent of the catchment used for livestock grazing and 15 per cent for dryland cropping. Local councils, water utilities, mining and agriculture, as well as irrigated cropping around Hillston (on the lower Lachlan floodplain) are the major water users.

Collectively, the Lachlan catchment storages have a capacity of 1,455 GL. Wyangala Dam, which has a capacity 1,220 GL, provides most of the regulated water in the catchment. Lake Cargelligo (36 GL) and Lake Brewster (154 GL), are both natural lakes that have been modified for use as water storages. Carcoar Dam (35.5 GL) is a relatively small storage on the Belubula River and supplies water for irrigation, stock and domestic use within the Belubula valley.

Water resources within the Lachlan River catchment are managed according to the *Water Sharing Plan for the Lachlan Regulated Water Source 2004*. However, this plan was suspended in 2006 as a result of severe drought, which saw the introduction of extraordinary water sharing arrangements (drought contingency plans) implemented to secure water supplies for towns and critical water-dependent industries. The decade long drought has now ended following wet conditions in 2010-11 and the water sharing plan recommenced on 1 July 2011.

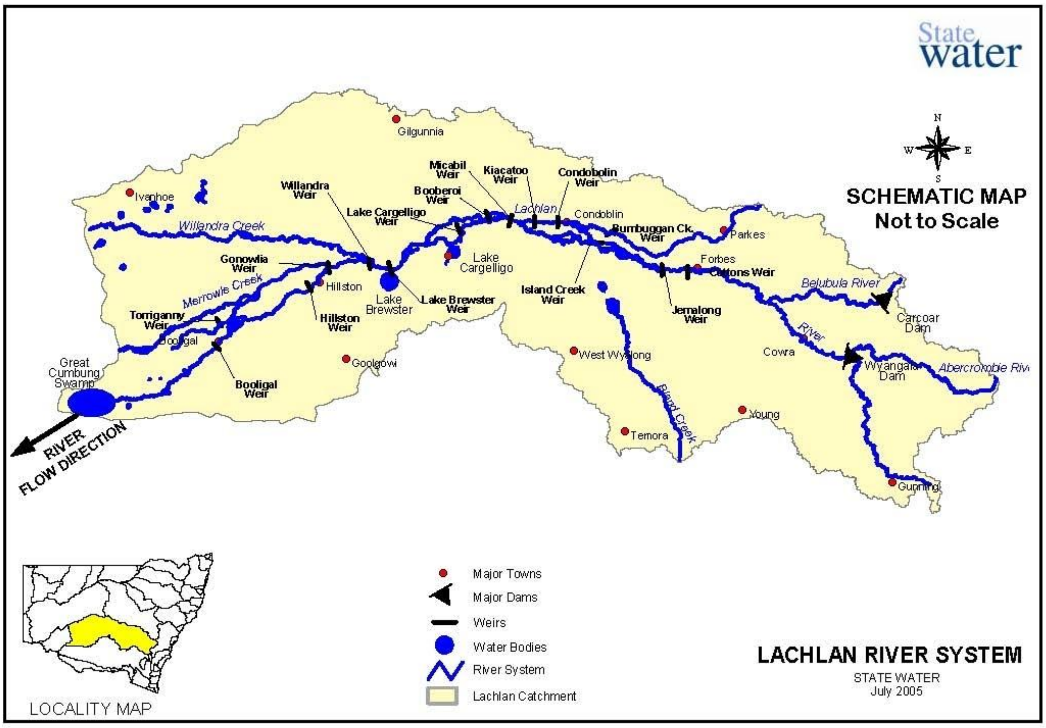

Figure 1: The Lachlan River Catchment

1.3. Environmental Assets in the Lachlan River Catchment

The Lachlan catchment contains a number of water dependent biotic and abiotic assets such as areas of semi-permanent wetland vegetation, river red gum forest and woodland, reed grasslands, black box woodlands, lignum, gilgai depressions, open water lagoons and chain of ponds (swampy meadows). These assets provide habitat for migratory birds, colonial bird breeding sites and other water dependent threatened species, such as frogs, crustaceans, other aquatic invertebrates and insects.

The Lachlan river floodplain contains many wetlands areas, of which 470,000 hectares are in the lower reaches. Many of these wetlands are recognised as being of national significance, particularly as waterbird habitat. Due to the capacity to support large colonial nesting waterbird events and rare, endangered and vulnerable species, nine wetlands feature in the Directory of Important Wetlands in Australia (DIWA) and several others are considered to be of regional significance (CSIRO, 2008; in Barma, 2011; LRWG, 2010).

Nationally significant wetlands in the Lachlan include:

- the Booligal Wetlands;
- Murrumbidgil Swamp and Lake Merrimajeel;
- Cuba Dam (on Merrowie Creek);

- Merrowie Creek (from Chilichill Creek to Lake Tarwong);
- the Lachlan Swamps (including Peppermint Swamp, Lake Waljeers); and,
- the Great Cumbung Swamp.

Wetland assets noted for their regional significance include: Lake Ita; Baconian Swamp and Moon Moon Swamp. Lake Ita has recently been acquired by NSW OEH and will be managed as a State Conservation Area (SCA). Both Baconian Swamp (part of Oxley State Forest) and Moon Moon Swamp (located in Moon Moon State Forest) are considered able to sustain a range of conservation and Indigenous values and have recently been included in the Riverina Red Gum National Park (NRC, 2010).

Further details on the location, condition, type and extent of significant flora and fauna at each locality is presented at Appendix A.

1.4. Watering Objectives in the Lachlan River Catchment

A number of broad system objectives have been developed for assets within the Lachlan catchment. These can be found in a range of statutory and policy instruments, including the NSW RiverBank *Water Use Plan No 1* which identifies targets for environmental watering.

During 2010-11, preparatory work was undertaken to identify and develop large-scale watering options for Commonwealth environmental water, including in the Lachlan River catchment and in order to reflect growth in water holdings and improved water availability across the Basin (Barma, 2011). Through this work, a number of medium to long-term ecological and hydrological objectives for the Lachlan River catchment have been identified. These include to:

- reduce the duration between flow events;
- provide drought refuge for native fish species and waterbirds;
- promote aquatic biodiversity, including the protection of fish passage and habitat;
- promoting ecosystem productivity and function, including food-webs;
- support wetland vegetation, including nesting and foraging habitat for waterbirds; and,
- increase floodplain connectivity to improve hydrological connectivity between channel and the floodplain.

1.5. Delivering Environmental Water in the Lachlan River Catchment

Delivering water in the Lachlan River catchment, particular the lower part, is complex as it is a very long system with many meandering anabranches and distributary creeks that terminate in wetlands. While Wyangala Dam is the major water storage, Lake Cargelligo and Lake Brewster act as re-regulating storages. Water for delivery to the lower Lachlan is primarily stored in Lake Brewster, which has itself been identified for its wetland values.

Barma (2011) has identified a number of factors that need to be considered in the delivery of environmental water more generally, including system constraints. These include:

- the time it takes for environmental water to travel through the system (for example water takes 20 days to travel from Lake Brewster to Booligal Weir);
- storage release capacity in particular, the release capacity of Lake Brewster;

- channel capacity limitations, particularly Merrowie Creek and into the Lake Waljeers area;
- opportunity to piggy-back onto conveyance water, which can assist with delivery efficiency. This includes stock and domestic replenishments, translucency and un-regulated flows;
- the lack of availability of conveyance water for some assets means the potential need for additional environmental water (to convey environmental water to these sites). The *RiverBank Water Use Plan No 1* specifies these locations;
- Lake Brewster operation, particularly towards the end of the water year when it may be dry; and,
- other issues, such as blue-green algae, including the effectiveness of recently constructed artificial wetlands within Lake Brewster designed to improve water quality within the lake for local and downstream benefit.

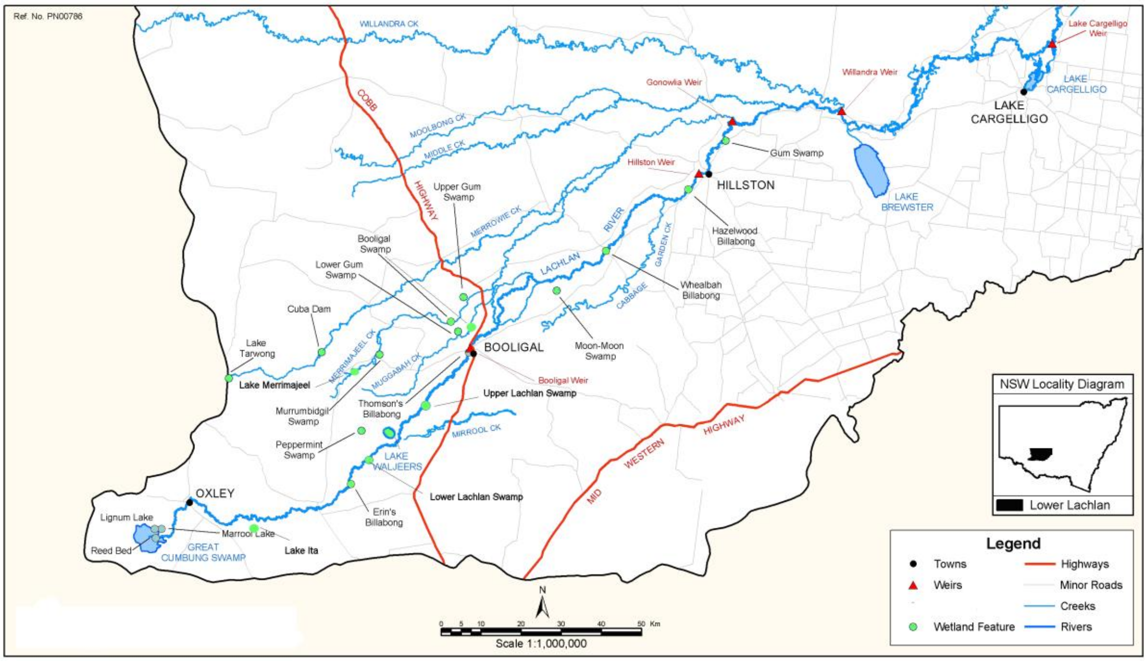

Figure 2: Map of the Lower Lachlan indicating the relationship between Lake Brewster and Lower Lachlan assets.

1.6. Current Catchment Status

Prior to the 2010-11 floods, the catchment experienced a decade of drought conditions, which prompted the delivery of several managed flows in the catchment to key environmental assets. Due to the changed catchment conditions, the Commonwealth provided environmental water to support two bird breeding events in the Merrowie Creek and Merrimajeel Creek systems (Booligal Swamp) in late 2010. Further environmental water was then provided to these systems to prolong the inundation of nationally significant wetlands, so as to enhance their capacity for recovery and improve resilience (see Table 1).

Antecedent conditions – The Lachlan River catchment is considered to be 'wet' due to major flooding in 2010-11. However, the floodwaters have now receded from the floodplain and conditions are expected to dry over the winter to spring period, unless significant rainfall leads

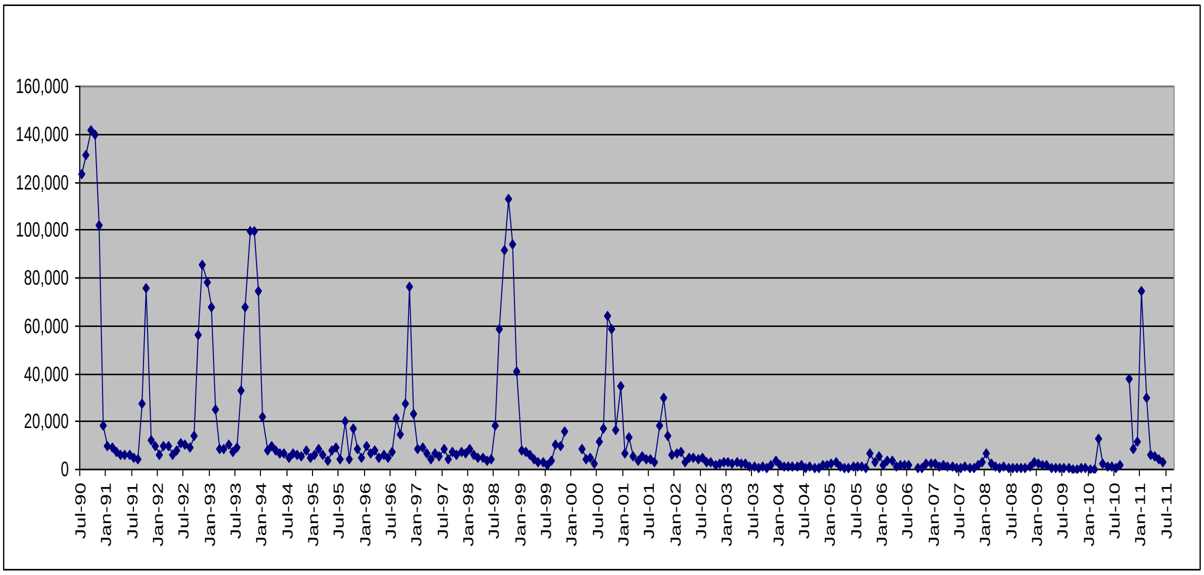

Figure 3: Total monthly flow past the Booligal gauge on the Lachlan River since July 1990.

Table 1: Commonwealth environmental water use in the Lachlan River catchment during 2010-11.

Asset	Site	Date	Commonwealth volume (ML)	NSW volume (ML)	Total volume (ML)
Booligal Wetlands	Merrimajeel Creek	12 October 2010	Action withdrawn due to flooding from unregulated flows	830	830
Booligal Wetlands	Booligal Swamp Booligal Station	29 Oct 2010	1,573	787	2,360
	Merrimajeel Creek/Murrumbidgil Swamp/Lake Merrimajeel[a]	3 June 2011	512	188	700
Lachlan Other	Merrowie Creek/Cuba Dam/Lake Tarwong	12 Nov 2010	2,145	855	3,000
	Merrowie Creek/Cuba Dam/Lake Tarwong[a]	3 June 2011	2,448	912	3,400

1.7. Water Availability Scenario

Spring 2010 saw the beginning of a wetter than average period, with many assets being inundated and water storages reaching or exceeding capacity. The headwaters of the Lachlan River catchment lie in the band with a 45 to 50 per cent chance of exceeding the median seasonal rainfall for the region to October 2011 (Figure 4).

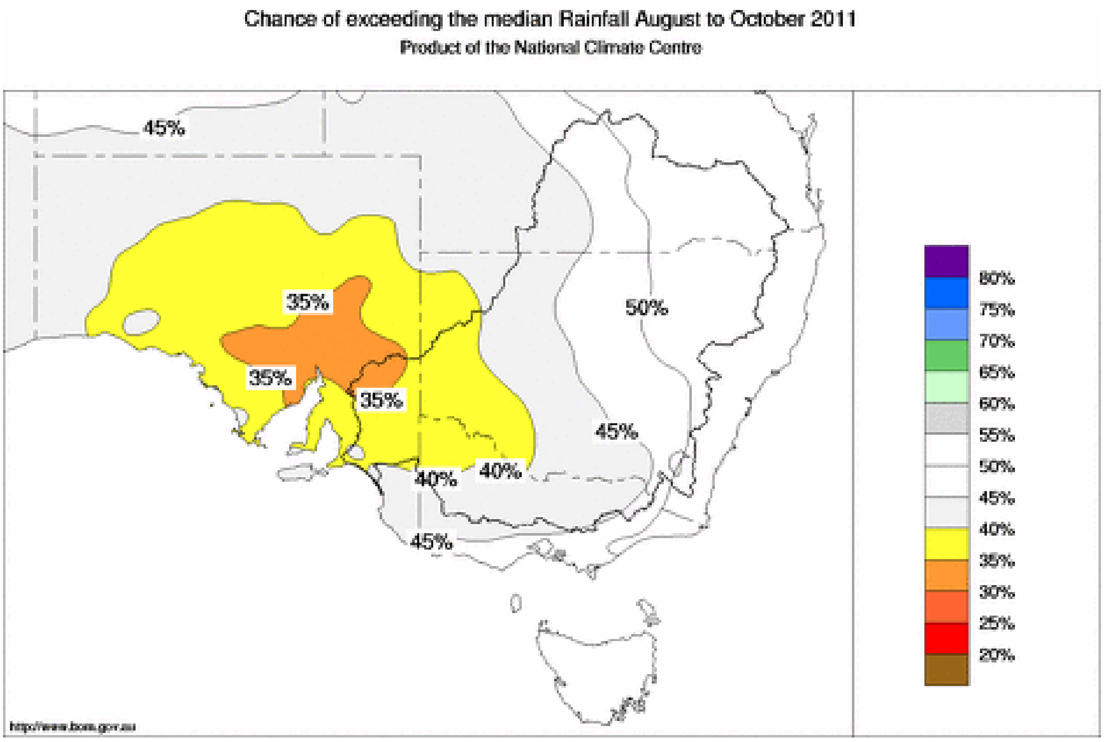

Figure 4: Seasonal rainfall outlook for south-eastern Australia (BoM) for August to October 2011.

1.8. Commonwealth Entitlements

The Commonwealth holds 83,442 ML of regulated entitlements in the Lachlan catchment (

Table 2). The estimated volume of unused allocation from 2010-11 to be carried-over is 92,326 ML. Under the water sharing plan take-limit rules, the annual maximum use is limited to 100 per cent of entitlement. Hence 83,442 ML is available for use in 2011-12with 8,881 ML potentially able to be carried over into 2012-13.

Table 2: Commonwealth entitlements in the Lachlan catchment (as at 4 July 2011).

Account	Entitlement (ML)	Current Uncommitted Allocation (ML)
High Security	733	733
General Security	82,709	92,326

1.9. Other Sources of Environmental Water

In addition to Commonwealth environmental water, there are other sources of environmental water that may be available to supplement Commonwealth environmental watering in the catchment during 2011-12 (Table 3).

After a period of suspension, the *Water Sharing Plan for the Lachlan Regulated River Water Source* will be activated for the first time on 1 July 2011. The water sharing plan is made under the *Water Management Act 2000* (NSW) and provides an environmental contingency allocation (ECA) for Wyangala Dam and Lake Brewster. This act also provides for adaptive environmental water licences (AEWL) acquired under the NSW RiverBank program, to be used in accordance with the *RiverBank Water Use Plan No 1.* The NSW Office of Environment and Heritage (NSW OEH) is responsible for managing the use of this water.

In addition to specified environmental water, the water sharing plan provides for the release of up to 350 GL of 'translucency flows' between May and mid-November, depending upon the amount of inflows from 1 January of that year. Translucency flows are intended to mimic natural flows in the system and restore some natural flow characteristics. The water sharing plan also provides for water quality allowances (WQA) so to assist in mitigating blue-green algae load in the downstream storages.

As a result of the Lake Brewster Water Efficiency Project, a further 12,000 ML are available, which is to be shared between consumptive and environmental users. During 2010-11, water was used to support a pelican breeding event in the Lake Brewster outflow wetland.

Table 3: Other potential sources of environmental water in the Lachlan River catchment for 2011-12.

Source	Management Authority	Entitlement (ML)
RiverBank AEWL General Security	NSW OEH	24,575 ML
High Security	NSW	1,000 ML
Lake Brewster AEWL	State Water / NSW Office of Water	12,000 (partially rules based)
Ecological Contingency Allowance (ECA)	NSW OEH/State Water	20,000 ML (Rules based)
Water Quality Allowance (WQA)	NSW OEH/State Water	20,000 ML (Rules based)
Translucent flows from the dam	State Water	350,000 ML (Rules based)

1.10. Forecast Allocations

Current storage levels in the Lachlan catchment are high and a dam spill is possible between July and October 2011. As of 2 August 2011, allocations are at 0 per cent. If Wyangala Dam was to spill, the general security (GS) allocation will be equalised and be 're-set' to 136 per cent (112,484 ML) in accordance with the water sharing plan rules. This means that carryover volumes exceeding 136 per cent would be forfeited. However, in any water year, the GS entitlement volume that may be used is limited to 100 per cent (82,709 ML). In addition, the Commonwealth holds 733 ML of High Security entitlement which is not able to be carried over from year to year and hence, must be used, traded or forfeited. This provides a limit of a total of 83,442 ML of Commonwealth environmental water that can be used in 2011-12. Table 4 outlines all Commonwealth and NSW environmental water holdings and water available for use under the range of climatic scenarios.

Table 4 outlines available environmental water held by the Commonwealth and also water managed by NSW, within the context of allocations under the range of climate scenarios.

Table 4: Forecast allocations of environmental water in the Lachlan River catchment for 2011-12.

	ML	Extreme Dry	Dry	Median	Wet	Very Wet
	Water type	carryover plus 0% GS, 100% HS allocation	carryover plus 3% GS, plus 100% HS	136% allocation, 100 % HS, carryover spilled	136% GS allocation, 100 % HS, carryover spilled	136% GS allocation, 100 % HS, carryover spilled
Commonwealth	High Security	733	733	733	733	733
	General Security	0	2,481	112,484	112,484	112,484
	Carryover	92,327	92,327			
	Total CEW	**93,060**	**95,541**	**113,217**	**113,217**	**113,217**
	total available for take	**83,442**	**83,442**	**83,442**	**83,442**	**83,442**
	High Security	1,000	1,000	1,000	1,000	1,000
NSW	General Security	0	767	34,782	34,782	34,782
	Carryover	25,860	25,860			
	LBAEWL	0	360	16,320	16,320	16,320
	Total holdings	26,860	27,627	35,782	35,782	35,782
	Total available for take	26,860	26,860	26,860	26,860	26,860

1.11. Watering Objectives for 2011-12

The *Framework for Determining Commonwealth Environmental Watering Actions* establishes four water availability scenarios and the types of watering objectives that align with each (Appendix B.) Table 5 outlines a range of watering options for 2011-12 in the Lachlan catchment under the range of potential climatic scenarios. Given the volume of carryover, current and antecedent conditions, options have been developed within the context of a 'median' water availability scenario for the first half of 2011-12.

The overall watering objectives for a median scenario are to "maintain ecological health and resilience." These objectives seek to enable growth, reproduction and large-scale recruitment for a diverse range of flora and fauna, in particular colonial nesting and other waterbirds, promote higher floodplain-river connectivity and support high flow riverine and floodplain functional processes. Watering actions that are consistent with these objectives include:

- prolonging flood/high-flow duration at key sites and reaches of priority assets;
- contributing to the full-range of in-channel flows; and
- using carryover to provide optimal seasonal flow patterns in subsequent years.

More detailed information surrounding proposed watering options under a median scenario are provided in Tables 6 and 7.

Table 5.Watering Options for 2011-12 for the Lachlan River Catchment

Environmental Asset	Options for use under a range of climatic scenarios				
	Extreme Dry **Goal: Avoid damage to key environmental assets**	**Dry** **Goal: Ensure ecological capacity for recovery**	**Median** **Goal: Maintain ecological health and resilience**	**Wet** **Goal: Improve and extend healthy and resilient aquatic ecosystems**	**Very Wet** **Goal: Improve and extend healthy and resilient aquatic ecosystems**
	Total in accounts: 93 GL **Available for use: 83GL** **Most likely total use: up to 63 GL**	**Total in accounts: 95 GL** **Available for use: 83GL** **Most likely total use: up to 63GL**	**Total in accounts: 113 GL** **Available for use: 83GL** **Most likely total use: up to 81 GL**	**Total in accounts: 113 GL** **Available for use: 83GL** **Most likely total use: up to 81 GL**	**Total in accounts: 113 GL** **Available for use: 83GL** **Most likely total use: up to 27 GL**
Booligal Wetlands					
Current action down Merrimajeel Creek and Murrumbidgil Swamp	Complete action 18 GL	Complete action 18 GL	Complete action 18 GL	Complete action 18 GL	Complete action 18 GL
Bird Breeding contingency	Support bird breeding if required 9 GL	Support bird breeding if required 9 GL	Support bird breeding if required 9 GL	Breeding likely to be supported by unregulated and translucency flows 9 GL	Breeding likely to be supported by unregulated and translucency flows 9 GL
Muggabah Creek and Lower Gum Swamp	Up to 4 GL to inundate priority semi-permanent wetland (river red gum forest) for up to 3 months.	Up to 4 GL to inundate priority semi-permanent wetland (river red gum forest) for up to 3 months.	Up to 4 GL to inundate priority semi-permanent wetland (river red gum forest) for up to 3 months.	Up to 4 GL on top of unregulated flows to inundate priority semi-permanent wetland (river red gum forest) for up to 3 months.	Objectives likely to be satisfied by translucency and unregulated flow.
Lachlan Wetlands					
Lake Ita - Lower Lachlan River and associated wetlands, including Lake Ita, Lachlan Swamps, Moon Moon Swamp and the Great Cumbung Swamp - Reed Bed	Nil action - Watering action dependent upon Translucency flows which will not occur in an extreme dry scenario.	Nil action - Watering action is dependent upon translucency flows, which are not likely in a dry scenario.	Provide up to 50 GL on top of a translucency flow. (Medium probability of translucency flow)	Provide up to 50 GL of CEW on top of translucency flow (high probability of translucency flow)	Limited options. Creeks will be full with dam spill and tributary flows. Objectives likely to be satisfied by translucency and unregulated flow.
Lake Waljeers – and lower Lachlan	Provide up to 32 GL to inundate semi-permanent wetland, and support migratory birds.	Provide up to 32 GL to inundate semi-permanent wetland, and support migratory birds.	Will be watered as a result of Lake Ita option.	Will be watered as a result of Lake Ita option.	Limited options. Creeks will be full with dam spill and tributary flows. Objectives are likely to be satisfied by translucency and unregulated flows.
Great Cumbung Swamp					
Baconian Swamp	Nil action Options dependent upon translucency flows which will not occur in an extreme dry scenario	Nil action - Watering action is dependent upon translucency flows, which are not likely in a dry scenario.	Will be watered as a result of Lake Ita option	Will be watered as a result of Lake Ita option	Limited watering options. Objectives likely to be satisfied by translucency and unregulated flow.
Cumbung Reed bed	Reed bed would be watered in conjunction with *Lake Waljeers* option.	Reed bed would be watered in conjunction with *Lake Waljeers* option	Reed bed would be watered in conjunction with *Lake Waljeers* option	Would be watered in conjunction with the *Lake Ita* option.	Limited watering options. Objectives likely to be satisfied by translucency and unregulated flow.
Other Lachlan sites					
Yarnel Lagoon	Provide up to 300 ML to inundate 20 ha on top of replenishment flow	Provide up to 300 ML to inundate 20 ha on top of a replenishment flow	Provide up to 300 ML to inundate 20 ha on top of a replenishment flow	Provide up to 300 ML to inundate 20 ha on top of a replenishment flow	Limited options. Objectives likely to be satisfied by translucency and unregulated flow.
Morrison's Lake on Willandra Creek	Option currently being investigated	Option currently being investigated.	Option currently being investigated.	Option currently being investigated.	Limited options.
Lachlan River	Operational regime	Operational regime	In-stream flows as a result of deliveries to floodplain wetlands	In-stream flows as a result of deliveries to floodplain wetlands	Overtop all weirs - in-stream flows
Carryover	Use is limited due to the lack of translucency flows to piggyback upon. Carryover will provide optimal seasonal flow patterns in subsequent years.	Use is limited in a dry scenario (due to the lack of translucency flows to piggyback upon). Carryover will provide optimal seasonal flow patterns in subsequent years.	Moderate volume of carryover expected due to take limit. Carryover will be used to provide optimal seasonal flow patterns in subsequent years.	High unregulated flow and translucency flows are likely to satisfy the majority of objectives. A high volume of carryover is likely. Aim to maximise carryover to provide optimal seasonal flow patterns in subsequent years.	High unregulated flow and translucency flows are likely to satisfy the majority of objectives and will also limit capacity for delivery. High volume of carryover likely. Carryover to provide optimal seasonal flow patterns in subsequent years

Table 6: Potential watering options for 2011-2012 in the Lachlan River catchment*.

Asset	Watering Options and Objectives
Winter 2011/12	
Merrowie Creek[a] Cuba Dam/Lake Tarwong	1. Provide 14,634 ML from early June 2011 to increase connectivity and improve lignum and other wetland vegetation values for colonial nesting birds; create the conditions to trigger breeding and population recruitment for Sloane's froglet and prolong the inundation of Lake Tarwong to improve the health of river red gum, lignum, nitre goosefoot, macrophytes and floating aquatic species; and, provide habitat for water fowl and migratory bird species.
Booligal Wetlands[b] Merrimajeel Creek/Murrumbidgil Swamp/Lake Merrimajeel	2. Provide 7,024 ML from early June to increase connectivity between (at least) 201 hectare of wetland assets; re-wet the fringing areas and extend the period of inundation, to between 3 – 6 months, of central, deeper water areas, to protect and restore the health of red gum, lignum, nitre goosefoot, aquatic macrophytes and floating plant communities; and, provide habitat for listed threatened and migratory water bird species.
Spring-Summer 2011/12	
Muggabah Creek and Lower Gum Swamp	3. Provide up to 3,400 ML to extend the benefits of recent inundation to support the survival and growth of critically stressed river red gums and to provide habitat for egrets and threatened waterfowl, including blue-billed and freckled duck.
Support colonial nesting **waterbird bird breeding event**	4. As required, provide up to 11,500 ML during September - November, on top of natural inflows/translucency event, to extend the period of inundation of lignum to support colonial bird breeding events, most likely comprising straw-necked, white and the migratory glossy ibis.
Lower Lachlan River and associated wetlands, including **Lake Ita, Lachlan Swamps**, **Moon Moon Swamp** and the **Great Cumbung Swamp** - **Reed Bed**	5. Provide up to 50,000 ML on top of a translucency flow between August and September, to inundate 800 hectares of Lake Ita for 3 to 6 months. Flows from the extra water will benefit Moon Moon Swamp, Baconian Swamp and the reed bed in the Great Cumbung Swamp. This action will improve the health of river red gum forest, black-box woodland, lignum, nitre goosefoot, macrophytes and floating aquatic species; and, provide habitat for native fish, frogs and waterfowl, including blue-billed and freckled duck and migratory waterbirds and increase system connectivity and to protect and restore the health of common reed and cumbungi.
Autumn 2012	
Nil action	Allow natural / seasonal drying of the system.
Winter 2012	
Carry over Volume for use in winter – spring 2012	6. Carry over unused water (estimated between 10 and 34 GL) from 2011-12 into 2012-13 to prepare for a drier climate scenario during 2012-13 and so as to provide optimal seasonal flow refugia and sites that support threatened species and communities and/or providing freshes to priority reaches/sites and or/ repeat watering for highly stressed sites. These sites may include the Great Cumbung Swamp and the Booligal Wetlands.

* *The Department has also identified watering actions for the Lachlan River catchment that are consistent with the objectives for wet, dry and extreme dry conditions.*

1 Target flow rate and volume to fill should consider the antecedent conditions of the asset

a, b –Approved actions (currently being delivered)

Table 7: Operational details for potential watering actions for 2011-12 in the Lachlan River catchment

Asset	Water Management Objective*	Target flow rate/Volume to fill[1]	Estimated volume (ML)	Timing & Duration	Delivery mechanism	Operational considerations^
Other Lachlan sites – current action						
Merrowie Creek/Cuba Dam/Lake Tarwong	1	200 ML/day down the creek	CEW: 11,500 ML OEH: 4,294 ML	This action commenced in June 2011. Water is expected to arrive at Lake Tarwong in September 2011.	Gravity fed release from Lake Brewster. Accounted for at Merrowie Creek off-take.	When flow reaches Cuba Dam water to be released downstream into Lake Tarwong. Delivery to Lake Tarwong intended to maintain capacity for next 2 years.
Booligal Wetlands complex – current action						
Merrimajeel Creek	2,4	Limited to 100 ML/day	CEW: 5,524 ML OEH: 2,076 ML	This action commenced in June 2011 and is expected to continue into September 2011to maintain inundation in both Murrumbidgil Swamp and Lake Merrimajeel (see below)	Gravity fed release from Brewster Weir. Accounted for at Merrimajeel Regulator.	Flow being managed to 100 ML/d to minimise risk of local flooding.
Murrumbidgil Swamp	2	600 ML - 1,400 ML to fill asset at 40 ML/day for 35 days	**Component of current Action as described above**	Delivery from July to September is expected to inundate site for up to 8 months	Gravity fed release from Lake Brewster into Torriganny Weir. Accounted for at Merrimajeel Regulator.	70 days to travel from Torriganny Weir and 15 - 35 days to fill swamp. Cold month release preferred (delivery between Dec and March is inefficient and contributes to in-channel plant growth).
Lake Merrimajeel	2	500 ML– 1,200 ML to fill asset – need an additional 600 ML for an additional 30 days	**Component of current action as described above**	Delivery from July to September is expected to inundate site for up to 6 months	Gravity fed release Murrumbidgil Swamp via Torriganny Weir Accounted for at Merrimajeel Regulator.	As above. Requires 12 – 30 days to fill lake following the filling of Murrumbidgil Swamp.

Booligal Wetlands complex – future actions						
Booligal Swamp colonial nesting bird breeding contingency	4,5	50-100 ML/day for up to 100 days	CEW: up to 9,000 ML OEH: up to 3,000 ML	Inundate site from September to January 2012	Gravity fed from Lake Brewster into Torriganny Weir. Accounted for at Merrimajeel Regulator.	There is a high probability that the Merrimajeel action will stimulate a waterbird breeding event. . This action provides a contingency to enable the completion of such an event.
Muggabah Creek and Lower Gum Swamp	3,6	5,000 ML 50-200 ML/day for 50 days	CEW: 300 – 4,000 ML OEH: 100 – 850 ML	August 2011 to early 2012	Water accounted for Muggabah Creek Regulator	High creek flows are required to fill the swamp (due to a sill) and some water will drain back out once the creek flows subside. Environmental water could be delivered in conjunction with operational flows. However due to recent conditions as a result of water currently being delivered in the Merrimajeel system there may be an opportunity to put additional water down Muggabah Creek early in the water year rather than depending on replenishment flow (scheduled for until March 2012). However, the swamp has a natural flow control sill and the required volume will need to be determined.
Lower Lachlan River and associated wetlands (**Lake Ita, Lachlan Swamps**, **Moon Moon Swamp** and the **Great Cumbung Swamp**)						
Lake Ita With benefits also to Willandra Creek, Merrowie Creek, the Booligal System, Moon Moon Swamp, the Lachlan Swamps, Baconian	5	7,200 – 14,400 ML required for site. A flow of 140 GL of (2,000 ML/day plus) at Booligal for 72 days is needed for the lake to receive flows.	CEW: up to 50,000 ML OEH: 6,000 ML - 15,000 ML Operational/ translucency of approximately 80 GL	Between June – December for up to 8 months.	In channel augmented river flow. Water accounting point is Booligal Weir. High volumes are required at	This action will also provide flows to a range of other assets although the exact inundation volume cannot be precisely determined. The lower Lachlan River swamps and wetlands can only be watered in conjunction with additional flows. There are no replenishment flows and

Swamp and the Great Cumbung Swamp.		Flow into the lake will be 600- 800 ML per day Corrong for 100 days. Inundation will depend on both river height and duration of high flows.			Booligal Weir to commence inundation at Corrong gauge,	the action depends on high volume translucency and/or unregulated flows in the Lachlan River and wet antecedent conditions. The relationship between Corrong inflows and inflow volumes to the lake are currently unknown. A previously existing blockbank (with pipes and regulator) has now been removed. A revised commence to fill is currently being investigated by NSW OEH. A works approval for a pump near the river will also be investigated.

* *From* Table. *^ Options for piggybacking natural flows, travel times, linking actions etc*

NB. This delivery schedule assumes a median-wet scenario, but will be reassessed throughout the year based on updated forecasts.

1. *Assuming a bird breeding contingency October to December*
2. *Assuming the Lake Ita option is viable – if not, could opt for Great Cumbung Swamp in either Spring 2011, or some in June 2012. If so, the total water used would be 35.55 GL*

Table 8: **Total release volume estimate and monthly water allocation profile (GL)**

Asset	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Merrowie Creek	4.0	4.0	4.0										12
Booligal Wetlands	2.2	2.2	2.2										6.6
Muggabah Creek		1	1	1									3
Lower Lachlan			17	17	16								50
Bird breeding contingency				3	3	3							9

3. NB. This delivery schedule assumes a median scenario, but will be reassessed throughout the year based on updated forecasts.

1.12. Key Constraints for water delivery

Factors that need to be considered in planning environmental water delivery in the Lachlan catchment are addressed in section 1.5. However, environmental water delivery may be constrained by the following:

1. Delivering water to assets affected by a "sill" - a particular flow height in the delivery channel is required before assets will commence to fill. This may only be achievable under certain climatic conditions. In this case, extra water may be needed to convey the environmental flow into wetland assets. This may affect both the time taken to fill the asset and may result in "losses" within the system, although these flows may be of benefit to wetlands upstream and downstream (to the river channel and to other floodplain assets).
2. The need to manage flows so as to avoid flooding of private property which may particularly impact on local grazing activities. This is managed by restricting delivery to a relevant flow rate and will vary from channel to channel. Consultation with relevant landholders will be undertaken by NSW OEH, the agency responsible for delivering the water, prior to commencing delivery.

1.13. Assessing Environmental Watering Options

To determine which watering actions will be progressed an assessment and, where required, prioritisation of each option or (suite of options), has been carried out against the assessment criteria for watering actions. Briefly, these criteria are the:

- ecological significance of the asset(s);
- expected ecological outcomes from the proposed watering action;
- potential risks of the proposed watering action at the site and at connected locations;
- long-term sustainability of the asset(s) including appropriate management arrangements;
- cost-effectiveness and operational feasibility of undertaking the watering.

Detailed description of the criteria for assessing watering actions is provided at Appendix C. An assessment of the range of potential watering options against these criteria is provided at Appendix D. This assessment considers watering the suite of options in scope in groups of similarly located and managed assets. This allows the benefit of watering individual assets to be considered at the individual asset scale through the course of the year, while also considering complementary actions and potential integration of watering actions proposed for a group of assets collectively.

It is highly likely that the Commonwealth will be able to contribute up to 80 GL to actions that maintain inundation of high conservation wetlands, particularly in the Lower Lachlan reaches, during dry and median scenarios. It is also likely that current actions may provide the right conditions to trigger a colonial nesting bird breeding event in either the Booligal Wetlands, or the Merrowie Creek system, or both. Having a contingency to support such an event in a drier scenario is a high priority. If a drought scenario does eventuate, the Commonwealth should be able to contribute to the maintenance of high value other drought refugia such as Yarnel Lagoon and Moon Moon Swamp. If a very wet scenario eventuates, options may be limited as objectives may be satisfied by unregulated flows from dam spills and tributary flow.

The assessments will be reviewed as individual watering actions are closer to their proposed timing for delivery. The review will include a more comprehensive risk assessment which is subject to the prevailing catchment and river flow conditions, and will consider in more detail proposed costs, delivery, monitoring and accounting arrangements.

Any additional watering options identified during the course of the year will also be subject to an assessment against the criteria.

1.14. Water Use Accounting

In the regulated Lachlan River and associated systems, environmental flows are delivered by NSW State Water Corporation. In general, environmental water for the Lower Lachlan assets would be delivered from Lake Brewster, whereas some assets (ie., Moon Moon Swamp) will receive water from Wyangala Dam. Environmental water is generally accounted for at the relevant diversion off-take or regulator (refer to Table 8). The Lachlan River is very long and depending on the location of the asset, the relevant storage point and catchment conditions, water may take between one and three months to arrive at the asset. Transmission losses that occur as a result of delivering the water to the accounting point are not accounted against the water entitlement holder.

Table 8: Water accounting arrangements for assets in the Lachlan River catchment.

Asset	Accounting Arrangement
Moon Moon Swamp	Whealbah gauge
Merrowie Creek	Merrowie off take
Booligal Wetlands	Merrimajeel regulator
Lake Ita	Booligal Weir
Baconian Swamp	Booligal Weir
Great Cumbung Swamp	Booligal Weir

1.15. Risk Management

A full risk assessment will be undertaken for each watering option as part of the assessment process, building upon the preliminary risk assessment included for groups of assets at Attachment D. Some of the more likely risks associated with delivering environmental water in the Lachlan catchment is:

- recruitment of carp which are found throughout the catchment; and
- unintended flooding of grazing land and access ways, particularly in the event of a significant rainfall/natural flow event during the action - should this occur, the delivery will be halted until the risk abates.

1.16. Event Monitoring

A robust approach to monitoring and evaluation is critical to determining the long-term outcomes of the use of environmental water, and to provide information to support good governance and adaptive management. The monitoring of Commonwealth watering actions will be undertaken in accordance with the Monitoring, Evaluation and Reporting framework that is being developed. This framework will facilitate the assessment and achievement of specific environmental outcomes to Commonwealth watering actions. This poses many challenges, but through considered study design and cooperation with existing jurisdictional and MDBA monitoring programs it is anticipated that the MER framework will provides important evidence base to enable a assessment of Commonwealth approaches to environmental watering.

In relation to operational monitoring NSW OEH will report weekly on a range of matters related to water delivery including volumes of water delivered to the assets, estimated delivery periods entering the assets and flows through the gauged channels within the regulated Lachlan system. Informal reports will also be provided through participation in the regular meetings of the Lachlan Riverine Working Group. Observations on the extent of flooding and incidental observations on responses by birds, frogs and vegetation will also be made from ground and air surveys. Some of the data collected will inform other ecological and hydrological programs being developed by the Lachlan CMA and the NSW Office of Water. Additional monitoring will be considered on an event–by-event basis closer to the time of the action.

Table 9: Monitoring arrangements for environmental flows in the Lachlan River catchment.

Monitoring activities			
Location	Parameters	Timing/frequency	Responsibility
Compliance/operational monitoring			
Merrowie Creek/Cuba Dam/Lake Tarwong	- flow, delivery, local rainfall and weather - inundation patterns - risk assessment - communications	Weekly	State Water (gauges) NSW OEH and landholders and local landholders to monitor extent of inundation.
Merrimajeel Creek/Murrumbidgil Swamp/Lake Merrimajeel	- flow, delivery, local rainfall and weather - inundation patterns - risk assessment - communications	Weekly	State Water (gauges) NSW OEH and landholders and local landholders to monitor extent of inundation.
Lower Lachlan Swamps including Lake Ita	- flow, delivery, local rainfall and weather - inundation patterns - risk assessment - communications	Weekly	State Water (gauges) NSW OEH and landholders and local landholders to monitor extent of inundation.
Intervention/response monitoring			
Colonial nesting sites	Number of nesting birds Stage of event Success of event	Weekly from onset of breeding event to completion	NSW Office of Environment and Heritage
Various sites in the Lachlan Catchment	IMEF monitoring program	3 to 4 times per year (TBC)	NSW Office of Water
Condition Monitoring			
Merrowie Creek/Cuba Dam/Lake Tarwong	-Vegetation responses- lignum, aquatic macrophytes - Waterbirds, frogs and bats	Monthly Monthly/Opportunistic	NSW OEH Local landholders
Merrimajeel Creek/Murrumbidgil Swamp/Lake Merrimajeel	-Vegetation responses- lignum, aquatic macrophytes - Waterbirds, frogs and bats	Monthly Monthly/Opportunistic	NSW OEH Local landholders
Muggabah Creek/Lower Gum Swamp	-Vegetation responses- lignum, aquatic macrophytes - Waterbirds, frogs and bats	Monthly Monthly/Opportunistic	NSW OEH Local landholders
Lower Lachlan Swamps including Lake Ita	-Vegetation responses- lignum, aquatic macrophytes -Waterbirds, frogs and bats	Monthly Monthly/Opportunistic	NSW OEH Local landholders

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Appendix A - Environmental Assets

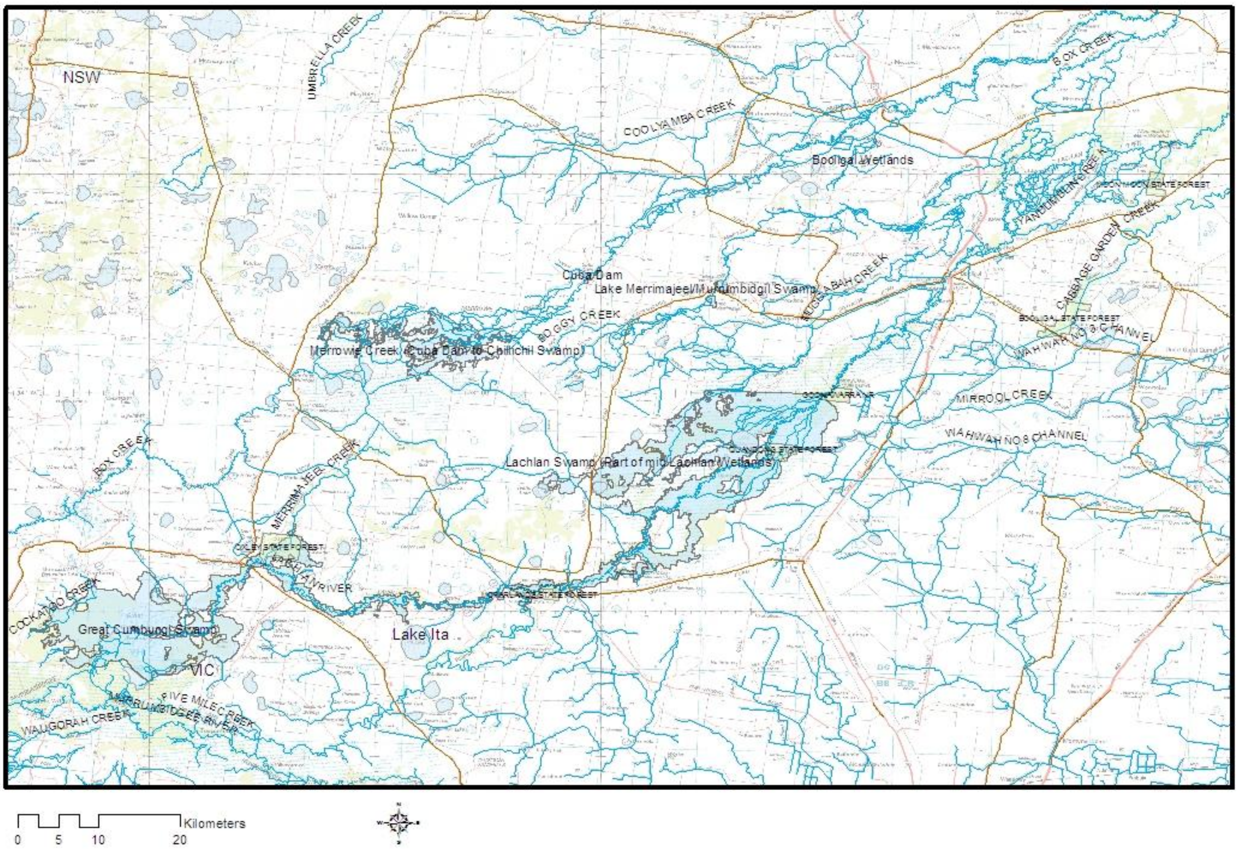

Figure 1: Map showing assets proposed to receive environmental water during 2011-12

Lower Lachlan River channel

After rising near Gunning in the east, the Lachlan River travels approximately 1,400 kilometres through temperate forests, woodlands and grasslands. As the river travels west towards Hay, the landscape becomes more semi-arid with *Callitris* dominated woodlands and mallee. A unique array floodplain wetlands provide diverse habitats for a wide range of species. During high inflow periods, the Lachlan may join up with the Murrumbidgee River at the Great Cumbung Swamp terminus.

The *Lachlan River Endangered Ecological Community* is listed under NSW *Fisheries Management Act 1994* (FM Act). This community resides within a large area of high quality habitat and riparian vegetation and snags are generally intact and in good condition (Lugg, 2011). Habitat and passage for Murray cod (*Maccullochella peelii peelii*), golden perch (*Macquaria ambigua*) and the eel-tailed catfish (*Tandanus tandanus*) are found between Wyangala Dam and Lake Cargelligo (including Goobang Creek). Murray Cod has been found in the Euabalong to Booligal reach, the most diverse native fish community in the catchment. The only population of Agassiz's Perchlet (Olive Perchlet) (*Ambassis agassizii)* found in the southern MDB is in Bensons

Drop weir, Mountain Creek and Lachlan River (in the vicinity of Brewster weir). An endangered eel-tailed catfish population has been identified in upstream Booberoi Creek.

Permanent water is normally held in the main channel between Lake Cargelligo and Lake Brewster and the Great Cumbung Swamp, however this is less likely during period of low inflows (drought). Assets that need to be protected, particularly in the mid and lower reaches of the Lachlan River, are water quality, flows and fish passage. A fishway is being built at Cargelligo Weir to improve fish passage to Lake Brewster.

Endangered flora listed for the area includes the Austral pillwort (*Pilularia novae-hollandiae*), a spear grass (*Austrostipa wakoolica*), the Mossgiel daisy (*Brachycome papillosa*) and the slender Darling-pea (*Swainsonia murrayana*).

Associated floodplain wetlands

Moon Moon Swamp - Moon Moon Lake/Swamp comprises approximately 300 hectares of Lachlan River floodplain, about 30 km upstream of Booligal township. Some of the Swamp forms a part of the Riverina Red Gum Forests National Park. It is a predominately a river red gum swamp, with fringing black box. To date, the swamp has not been the subject to the collection of information of flora or fauna. However, habitat for waterfowl swans and fish, blue billed duck and freckled duck may be provided. Eastern great egret has been known at the site and is likely to breed there. Indigenous cultural values are also associated with the river red gum dominant nature of the swamp (NRC, 2010).

Lachlan Swamps (including Lake Ita)-The 30,000 hectare Lachlan Swamps complex, extends from about 5 km upstream of the Great Cumbung Swamp to just beyond the township of Oxley. The complex includes Lake Ita, which is located in Kalyarr State Conservation Area (MDBA, 2010). The shallow depressions and undulating surfaces predominate the system are forested with black box (*Eucalyptus largiflorens*) and river cooba (*Acacia stenophylla*). River red gum communities occur adjacent to the river and on the wetland margins. Approximately 10,000 hectares of this system comprises Lake Waljeers, Peppermint Swamp, Lake Bullogal (nationally significant wetlands) and Ryan's Lake. However, the latter two wetlands are only inundated during major flood events. Peppermint Swamp is vegetated by a river red gum forest which provides habitat for many species of waterbirds and can support substantial egret breeding. The other lakes in the system, Lakes Waljeers, Bullogal and Ryan’s Lake are primarily lignum and nitre goosefoot low shrubland.

When inundated, ***Lake Ita*** provides foraging for a diverse range of waterfowl, including the freckled and blue-billed ducks, the Australasian shoveler (*Anas rhynchotis*), the pink-eared duck (*Malacorhynchus membranaceus*), as well as spoonbills. In this semi-arid climate zone, provides an open lagoon habitat, with fringing black-box-lignum woodland. Lake Ita is also known for its Aboriginal cultural significance (Barma, 2011). Ducks, swan, pelican, fish, turtle, crayfish and other aquatic invertebrates formed an integral part of the diet for Aboriginal communities who depended on Lake Ita and other Lachlan wetlands, for water, food and shelter (LEWMP, 2011). Shell middens, stone tools, scarred and carved trees, campsites, burial and sand quarry sites have been found at wetland sites throughout the Lachlan system (Lachlan Catchment Management Authority, 2006).

Great Cumbung Swamp (GCS)

The main channel of the Lachlan River terminates in the nationally significant Great Cumbung Swamp. The various wetlands areas, such as Boocathan (Lake and Swamp), Bunumburt Lake, Narran Lake, Brittens Lake and Little Brittens Lake, Dead Tree Swamp, Clear Lake, Dry Lake, Hut Swamp and Sapling Swamp cover approximately 15,000 hectares and support one of NSW's largest areas of common reed *Phragmites australis*. River red gum-black box communities are found closer to the floodplain. The 800 hectare ***Baconian Swamp*** is located north of the Great Cumbung Swamp complex on the property Tupra, just upstream of Oxley. Baconian Swamp is partially included in the Riverina River Red Gum Forests National Park, as it is dominated by river red gum with a margin of black box trees.

When inundated the GCS complex provides major refuge and breeding for habitat significant waterbird populations of threatened waterbirds that can be found other parts of the catchment, including the Australian bittern (*Botuarus poiciloptilus*) and also supports migratory species, including Latham's (or Japanese) snipe (*Gallinago hardwickii*).

Booligal Wetland system

The Booligal Wetland complex provides 10,000 - 15,000 hectares of unique wetland located on the Merrimajeel/Muggabah effluents of Torriganny Creek, just north Booligal in the Lower Lachlan. Merrimajeel Creek flows through the nationally significant Booligal Wetlands: Blockbank (private land) and Booligal Station (2,500 hectares managed by NSW OEH) and through Murrumbidgil Swamp, terminating in Lake Merrimajeel (both co-listed on DIWA). The smaller Lower Gum Swamp lies on Muggabah Creek.

Apart from potentially providing habitat for frogs, including the threatened southern bell frog (*Litoria raniformis*) (Wassens and Maher, 2010), this system provides breeding and foraging habitat for large numbers of threatened waterfowl, such as freckled duck (*Stictonetta naevosa*) and blue-billed duck (*Oxyura australis*) and migratory waders such as the sharp-tailed sandpiper(*Calidris acuminata*). The Booligal wetlands are also considered extremely significant for colonial nesting species, particularly after significant flooding (Magrath, 1992; Brandis, et al., 2009). Since 1990, at least three significant ibis breeding events have occurred at the **Booligal Wetlands** (Magrath, 1992; Maher and Driver, 2000; LRWG, 2010), the most recent being in late 2010, which included than 60,000 breeding pairs of mainly straw necked (*Threskiornis spinicollis*) and white ibis (*T. aethiopica*). The migratory glossy ibis (*Plegadis falcinellus)* are known for nesting here, often in their thousands (Macgrath, 1992). During this event, however, only about 600 were recorded. Spoonbills and other listed waterbirds were also recorded breeding during this event.

Murrumbidgil Swamp comprises about 110 hectares of seasonally flooded river red gum woodland and giant rush, scattered lignum and nitre goosefoot shrublands. River red gum (*Eucalyptus camaldulensis*) swamps provide habitat and perches for terrestrial fauna, including the greater long eared bat or fishing bat (*Nyctophilus timoriensis*: Commonwealth vulnerable; NSW vulnerable) and substrates for aquatic fauna. When inundated, ***Lake Merrimajeel*** provides about 100 hectares of open freshwater habitat, with fringing lignum (*Muehlenbeckia florulenta*) and nitre goosefoot (*Chenopodium nitrariaceum*) shrubland. Aquatic macrophytes including eel grass (*Vallisneria spirallis*), red water milfoil (*Myriophyllum verrucusum*) and duckweeds (*Azolla filiculoides* and

Lemna spp) have been recorded (Briggs and Maher, 1985). ***Lower Gum Swamp*** retains water after Muggabah Creek ceases to flow. Like nearby Murrumbidgil Swamp, Lower Gum Swamp supports large stands of river red gum with few understorey species (Moore, 1992; Armstrong, 2009). The great crested grebe and the nankeen night heron were recorded at Lower Gum Swamp after the 1990-92 spring floods include (McGrath, 1992). It is also known to have supported breeding egrets.

Merrowie Creek and associated wetlands

Merrowie Creek is extremely long, leaving the Lachlan River just upstream of Hillston. It travels though a number of wetland sites many on private property. The endangered Sloane's froglet (*Crinia sloanei*) was recorded near Tom's Lake in spring 2010. Merrowie Creek, Cuba Dam and the Lake Tarwong to Chilichil Swamp reach are listed as nationally important wetlands.

Cuba Dam - Under the right conditions, scattered lignum clumps at Cuba Dam, an earthen construction, supports foraging and breeding habitat for a large range of waterbirds, such swans, grebes, darters, pelicans, ibis, herons and spoonbills. A large colonial nesting water bird breeding event, comprising 10,000 breeding pairs of straw necked ibis took place at Cuba Dam in November 2010. Nine species of ducks have been recorded, including the pink-eared duck and the Australian shelduck, the threatened freckled duck and blue-billed duck.

Lake Tarwong - During high flow periods, water can extend past Cuba Dam reaching the Tarwong Lake and Swamp system and beyond depending on the size of the flood event. Valuable drought refuge is provided for listed migratory species, such as glossy ibis and great egrets. In very large flood events water can flow beyond Lake Tarwong and onto Chilichil swamp.

Appendix B - CEWH Ecological Watering Objectives

	Ecological Watering Objectives	Management Objectives	Management Actions
Extreme Dry	▪ Avoid damage to key environmental assets	▪ Avoid critical loss of threatened species and communities ▪ Maintain key refuges ▪ Avoid irretrievable damage or catastrophic events	▪ Water refugia and sites supporting threatened species and communities ▪ Undertake emergency watering at specific sites of priority assets ▪ Use carryover volumes to maintain critical needs
Dry	▪ Ensure ecological capacity for recovery	▪ Support the survival and growth of threatened species and communities, including limited small-scale recruitment ▪ Maintain diverse habitats ▪ Maintain low-flow river and floodplain functional processes in sites and reaches of priority assets	▪ Water refugia and sites supporting threatened species and communities ▪ Provide low flow and freshes in sites and reaches of priority assets ▪ Use carryover volumes to maintain follow-up watering
Median	▪ Maintain ecological health and resilience	▪ Enable growth and reproduction and large-scale recruitment for a diverse range of flora and fauna ▪ Promote higher floodplain-river connectivity ▪ Support high-flow river and floodplain functional processes	▪ Prolong flood/high-flow duration at key sites and reaches of priority assets ▪ Contribute to the full range of in-channel flows ▪ Use carryover to provide optimal seasonal flow patterns in subsequent years
Wet	▪ Improve and extend healthy and resilient aquatic ecosystems	▪ Enable growth, reproduction and large-scale recruitment for a diverse range of flora and fauna ▪ Promote higher floodplain-river connectivity ▪ Support high-flow river and floodplain functional processes	▪ Increase flood/high-flow duration and extent across priority assets ▪ Contribute to the full range of flows, including overbank ▪ Use carryover water to provide optimal seasonal flow patterns in subsequent years

For further information please refer to the *Framework for Determining Commonwealth Environmental Watering Actions* (available at http://www.environment.gov.au/water/policy-programs/cewh/index.html)

Appendix C - Criteria for Assessing Commonwealth Environmental Watering Actions

In undertaking its activities, the Commonwealth Environmental Water Holder (CEWH) is required to act consistently with the requirements of the *Water Act 2007* (Cwlth) (hereafter referred to as 'the Act'). The relevant functions are outlined in s.105. This includes a requirement that the environmental water holdings are managed in accordance with the environmental watering plan of the Murray-Darling Basin Authority (MDBA). Close consultation is occurring with the MDBA to ensure that use of Commonwealth water is consistent with the emerging objectives of the environmental watering plan that is currently being developed.

A long-term framework for the prioritisation of environmental water allocations has been prepared in consultation with delivery partners, interested stakeholders and experts, and the Environmental Water Scientific Advisory Committee.

The framework includes ecological objectives that will change under the different water availability scenarios (i.e. extreme dry, dry, median, wet). Proposed watering actions will need to be supported by available evidence, and consistent with current water availability scenarios and the framework.

Commonwealth environmental water is being acquired to supplement existing flows. Proposals for use of the water will not be agreed to if this use substitutes for other water uses, including historical system operations (e.g. provision of water for conveyance, stock and domestic, or planned environmental water).

Through adaptive management processes, the CEWH will consider opportunities for a more informed and diverse range of water uses as knowledge and modelling. All 2011-12 proposals will be assessed against the following criteria:

- ecological significance of the asset(s)
- presence of threatened species and ecological communities, and listed migratory species
- ecological and conservation values of the assets(s) including those recognised by international agreements
- current health of the asset(s)
- expected ecological outcomes from the proposed watering action
- the basin-wide significance of the ecological response from the watering action
- improvement in health of the asset(s) expected from the watering action
- how well defined and realistic the objectives are for the proposed watering action
- consistency of these objectives with the overall CEWH ecological objectives for the current forecast water availability scenario
- any secondary environmental effects expected to result from the watering action (e.g. connected system benefits)
- change in the health of the asset(s) expected if environmental water is not provided
- potential risks of the proposed watering action at the site and at connected locations
- how thoroughly the potential risks have been assessed for the proposed watering
- adequacy of measures proposed to minimise these risks

- likelihood and consequence of variance from the expected ecological outcome (including negative impacts on biota and water quality)
- long-term sustainability of the asset(s) including appropriate management arrangements
- adequacy of long-term management and delivery arrangements
- existence of complementary natural resource management activities supporting the long-term management arrangements, including those that improve water quality
- effectiveness of monitoring, evaluation and reporting arrangements for the watering activity including clear links to the defined objectives
- cost effectiveness and operational feasibility of undertaking the watering
- amount of Commonwealth water and resources needed, including relative to the contribution of the State and delivery partner to (i) the watering event and (ii) subsequent monitoring of actions and outcomes
- arrangements for the delivery of water to the asset(s), including the potential for transmission losses and the adequate accounting of flows
- opportunity to supplement natural flows or other water releases
- operational feasibility of undertaking the watering action (e.g. channel capacity, infrastructure constraints, etc).

Appendix D - Assessment of Watering Options

Note: Assessments for actions in Merrimajeel Creek and Merrowie Creek (to Lake Tarwong) have been completed. Refer Minute 60, 3 June 2011.

Name of action: Booligal Wetlands Complex, Muggabah Creek, Lower Gum Swamp		
Criteria		**Assessment**
1. Ecological Significance		Lower Gum Swamp is a red gum forest wetland component of the Booligal Wetlands complex (MDBA, 2010). The swamp provides vital waterbird habitat in particular non-colonial waterbird species, including egrets (Magrath 1992). All natural watercourses and the floodplains of the Lachlan River are listed as the *Lachlan River endangered ecological community* (NSW *Fisheries Management Act* 1994) (MDBA, 2010; SEWPaC, 2010) and the swamp would provide related in-stream and nursery habitat values. Water dependent threatened and migratory species that may be found in the Booligal Wetlands include: • Sloane's froglet • southern bell frog – (status uncertain; Wassens and Maher, 2010) • freckled duck (recorded in the Booligal Wetlands summer 2011) • blue-billed duck • Australasian bittern • glossy ibis – (recorded late 2010) • great egret • sharp-tailed sandpiper Wetland related plants include: • the Austral pillwort • spear grass (*Austrostipa wakoolica)* • Mossgiel daisy • slender Darling-pea
1.1	Ecological significance of the asset(s)	
1.2	Presence of threatened species and ecological communities, and listed migratory species	
1.3	Ecological and conservation values of the assets(s) including those recognised by international agreements	
2. Expected Improvement		River red gum swamps in the Lachlan catchment have been dramatically affected by the cumulative impacts of river regulation, water extraction and a decade of drought (Kingsford, 2000a; in Armstrong et al, 2009). While the overall health of the Lachlan catchment is considered poor, some parts of the Booligal Wetlands are considered to be in moderate condition (Davies *et al.,* 2008; NSW DECCW, 2010). The condition of Lower Gum Swamp is critical and declining, largely as a result of river regulation (Armstrong *et al.*, 2009; MDBA, 2010; NSW DECCW, 2010; Roberts, 2007). In 2008, most river trees in the swamp were dead, while remaining live trees showed signs of severe water stress (Armstrong *et al*., 2009). Changed catchment conditions may have assisted recovery. Invasive species, such as lippia (*Phyla canescens*) and the European carp (Gilligan, 2010; P. Packard, NSW OEH; pers. comm., 4 April 2011) are extant within the catchment. Good inflows into the system over the past year have resulted in good water quality and
2.1	Current health of the asset(s)	
2.2	Expected ecological outcomes from the proposed watering action	
2.3	Improvement in health of the asset(s) expected from the watering action	
2.4	Change in the health of the asset(s) expected if environmental water is not provided	
2.5	Basin-wide significance of the ecological response from the watering action	
2.6	Any secondary environmental effects expected to result from the watering action (e.g. connected system benefits)	

Name of action: Booligal Wetlands Complex, Muggabah Creek, Lower Gum Swamp		
Criteria		**Assessment**
2.7	How well defined and realistic the objectives are for the proposed watering action	there have been no known black water events (P. Packard, NSW OEH; pers. comm., 4 April 2011). Agricultural activities are largely low impact (sheep grazing) and during drought vegetation may be under some grazing pressure. Landholders actively participate in environmental watering activities. There is a small amount of water extraction, primarily for stock purposes and small irrigation activities (Brandis *et al*., 2009; P. Packard, NSW OEH; pers. comm., 4 April 2011). Inundation will improve the swamps ecological character and its capacity to support water dependent species. Maintaining the health of river red gums is essential for maintaining a swamps character and its self-sustainability (Armstrong *et al*., 2009; Roberts, 2007). The watering action would extend the inundation of the site by providing up to 2,550 ML) to Lower Gum Swamp in conjunction RiverBank water in either 2011. This will take advantage of recent inundation and high system flows. The objectives of the action are to: 1) protect and restore wetland vegetation health, particularly highly stressed river red gums; and 2) Provide habitat for listed threatened and migratory waterbirds including freckled duck; blue-billed duck, glossy ibis; the great egret and the sharp-tailed sandpiper (*Calidris acuminata*).
2.8	Consistency of these objectives with the overall CEWH ecological objectives for the current forecast water availability scenario	Should water not be allocated to this site, river red gum and general ecosystem health is expected to continue to decline (Roberts, 2007). The recent dieback in river red gum vegetation in this swamp (2005-2008) signals a critical change in state of the swamps ecosystem and an increasing risk of damage to the system's natural resilience (Armstrong *et al*., 2009). Whilst the swamp received water over summer 2010-11, results from recent research at nearby Yanga National Park suggest that river red gums which have been deprived of water for an extended period can show a strong response to flooding. However, this growth may over extend their capacity to sustain themselves once the flooding has receded, leading to high tree mortalities (Tanya Doody, pers comm. April 2011). Rewatering is expected to help consolidate any improved health and avoid such post watering mortalities. From a Basin perspective, Lower Gum Swamp is capable of supporting migratory species, is natural or near-natural and provides rare and unique waterbird breeding habitat (Magrath, 1992; MDBA, 2010). Flows provided to this wetland will also provide flows to the upstream Booligal wetlands, which provide valuable drought refuge habitat when wetlands in other parts of the inland are dry (Morton et al, 1995), The objectives of the watering action are well defined and realistic, in particular: **Objective 1:** Providing environmental water to extend the benefits of recent inundation and support wetland vegetation - the improved condition of nearby Murrumbidgil Swamp and Yanga National Park (Tanya Doody, pers comm. April 2011), suggest similar improvements in Lower Gum Swamp, should it be inundated at the appropriate time (TBC). **Objective 2:** Habitat for waterbirds –the Lower Lachlan wetlands provide important habitat for significant numbers of

Name of action: Booligal Wetlands Complex, Muggabah Creek, Lower Gum Swamp		
Criteria		**Assessment**
		waterbirds. Three species of ibis, freckled duck, blue billed duck, spoonbills and other species were recorded at Booligal Swamp following inundation in early 2011 (LEWMP, 2011). OEH will undertake waterbird monitoring. The CEWH objectives under a median availability scenario are to maintain ecological health and resilience and improve and extend healthy and resilient aquatic ecosystems. The management objectives and actions under these scenarios include: enabling growth, reproduction and small to large scale recruitment for a diverse range of flora and fauna; promoting low-lying to higher floodplain-river connectivity; supporting medium to high flow river and floodplain functional processes. These objectives are compatible with the objectives of watering assets in the Lower Lachlan River system. SEWPaC considers the watering objectives for Muggabah Creek and Lower Gum Swamp appropriate to meet the ecological requirements of the assets and contribute to system benefits.
4. Risk		A comprehensive risk assessment including control measures will be submitted with the approvals minute. All potential risks are classified as 'low risk' apart from the risk that carp may increase in the system which is which is classified as 'medium risk'.
4.1	Potential risks of the proposed watering action at the site and at connected locations	
4.2	How thoroughly the potential risks have been assessed for the proposed watering	
4.3	Adequacy of measures proposed to minimise these risks	
4.4	Likelihood and consequence of variance from the expected ecological outcome (including negative impacts on biota and water quality)	
5. Management & Monitoring Arrangements		There is no management plan for Lower Gum Swamp, however, the water can be delivered through Muggabah Creek, which is identified as a potential target for environmental flows under the NSW RiverBank water use plan (DECC, 2008; Armstrong et al., 2009) and the NSW DECCW *Lachlan Environmental Watering Plan 2010 – 11* (LEWMP, 2010). The specific watering objectives for each action will need to be prioritised and linked clearly to the ecological targets. In general, only operational monitoring is proposed for this event, as this action is considered to be relatively low risk and is not considered novel in terms of its operations or intended outcomes. While intervention monitoring of this event would provide some beneficial information, it is not considered a cost effective use of available resources. Operational monitoring is mandatory for all watering events using Commonwealth environmental water in 2011-12 and will be undertaken for all of the proposed watering actions in the Lachlan by NSW OEH. Operational monitoring includes inundation extent (at least monthly) and fortnightly where feasible). NSW OEH will complete and submit a NSW Form B, which meets the Commonwealth's requirements for operational reporting. NSW OEH will also provide fortnightly updates and final report, within three months of completion of the event. Other monitoring includes vegetation and fauna observations, focusing on threatened waterbirds and frogs. Monthly frog call recordings and frog/tadpole, vegetation and waterbird bird surveys will be undertaken by NSW OEH staff.
5.1	Long-term sustainability of the asset(s) including appropriate management arrangements	
5.2	Adequacy of long-term management and delivery arrangements	
5.3	Existence of complementary natural resource management activities supporting the long-term management arrangements, including those that improve water quality	
5.4	Effectiveness of monitoring, evaluation and reporting arrangements for the watering activity including clear links to the defined objectives	

Name of action: Booligal Wetlands Complex, Muggabah Creek, Lower Gum Swamp		
Criteria		**Assessment**
6. Cost-effectiveness		Depending on the climate / antecedent conditions the amount of Commonwealth water can range from CEWH: 300 ML – 2,550 ML; OEH: 100 ML – 850 ML. As the system has been wet and the seasonal forecast is for drier than normal conditions the volume can be expected to be in the higher range. There are no pumping fees as the site is gravity fed. Flows are managed and delivered down Merrimajeel Creek, which has had a regulator installed to assist the delivery of flows to associated wetlands. The proponents note that due to good preceding rainfall in the area, the risk of ground seepage water losses is better than expected previously, however, it would be timely to ensure environmental water is delivered to take advantage of this and to risk losses as in drier seasons. According to Barma (2011), delivery into Muggabah Creek is achievable under “dry to wet conditions”. This action has been designed to take advantage of recent natural inundation in the catchment and will be linked as closely as possible with operational flows.
6.1	Amount of Commonwealth water and resources needed, including relative to the contribution of the State and delivery partner to (i) the watering event and (ii) subsequent monitoring of actions and outcomes	
6.2	Cost effectiveness and operational feasibility of undertaking the watering	
6.3	Arrangements for the delivery of water to the asset(s), including the potential for transmission losses and the adequate accounting of flows	
6.4	Opportunity to supplement natural flows or other water releases	
6.5	Operational feasibility of undertaking the watering action (e.g. channel capacity, infrastructure constraints, etc).	

Name of action: Lachlan River/ Lake Ita / with secondary benefits to Moon Moon Swamp/Lachlan Swamps and GCS complex		
Criteria		**Assessment**
1. Ecological Significance		Included in the Lachlan Swamps, Lake Ita (500 ha) is a regionally significant wetland located in Kalyarr State Conservation Area (MDBA, 2010). It provides open water habitat, with fringing black-box-lignum woodland and nitre goosefoot understorey. The Lachlan Swamps complex (10,000 ha) also includes comprises Lake Waljeers, Peppermint Swamp, Lake Bullogal and Ryan's Lake (the latter only inundated during major flood events) (MDBA, 2010). Peppermint Swamp is a river red gum forest that has supported substantial egret colonies, whereas Lake Waljeers is lignum/nitre goosefoot low shrubland. Upstream, Moon Moon Swamp (300 ha) sits within 8,000 hectares of floodplain downstream of Hillston Weir. Predominately river red gum, with fringing black box, it is partly included in the Riverina Red Gum Forests National Park. While there little information on specific habitat values, fish, swans, waterfowl and egrets would benefit from inundation. Indigenous cultural values are also associated with Moon Moon swamp. The Lachlan River terminates into the nationally significant Great Cumbung Swamp, which comprises various wetlands including the Reed Bed and the 800 hectare red gum dominated Baconian Swamp (upstream of Oxley), some of which is also included in the Riverina River Red Gum Forests National Park. When inundated this swamp complex provides major refuge and breeding habitat for significant waterbird populations and supports migratory species. Water dependent threatened and migratory species that may be found in the Lachlan Swamps include: • southern bell frog - status uncertain; Wassens and Maher, 2010). • freckled duck • blue-billed duck • magpie goose • eastern great egret • glossy ibis • sharp-tailed sandpiper • common greenshank • Latham's snipe Wetland related plants include: • Mossgiel daisy • Menindee nightshade All natural watercourses and the floodplains of the Lachlan River are listed as the *Lachlan River endangered ecological community* (NSW *Fisheries Management Act* 1994) (MDBA, 2010; SEWPaC, 2010) and the swamp would provide related in-stream and nursery habitat values.
1.1	Ecological significance of the asset(s)	
1.2	Presence of threatened species and ecological communities, and listed migratory species	
1.3	Ecological and conservation values of the assets(s) including those recognised by international agreements	

<table>
<tr><th colspan="3">Name of action: Lachlan River/ Lake Ita / with secondary benefits to Moon Moon Swamp/Lachlan Swamps and GCS complex</th></tr>
<tr><th colspan="2">Criteria</th><th>Assessment</th></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="2">2. Expected Improvement</td><td rowspan="9">In general, the overall health of the Lachlan catchment is considered very poor (Davies et al., 2008; NSW DECCW, 2010) and most wetlands in the Lower Lachlan affected by the cumulative impacts of river regulation, water extraction and a decade of drought (Benson; 2006; Kingsford, 2000a; in Armstrong et al., 2009; MDBA, 2010; NRC, 2010). Due to being disconnected from the main channel, Lake Ita is in rated as being poor – moderate condition (BWR 2010). Recent inflows may have improved the condition of the lake, however mustard weed dominates the lake bed (OEH 2011). The Great Cumbung Swamp is rated as being in critical - poor condition. Until recently, the swamp has been used primarily for grazing and still considered ‘relatively natural’.

The proposed action will:
consolidate improvements in wetland vegetation health;
provide in-stream benefits;
improve waterbird habitat;
contribute to the management of invasive terrestrial species.
The action is expected to support the growth and reproduction of black box by inundating at least 500 hectares of Lake Ita for four months. It will re-establish semi-permanent wetland values (aquatic macrophytes) and support other wetland vegetation. Inundation of the other associated wetlands will improve the health of range of wetland species ranging from river red gum to lignum and reed beds. This will provide a diverse array of habitats to support wide range of wetland dependent species. Inundating Lake Ita will also benefit to Moon Moon Swamp, Lake Waljeers and Peppermint Swamp Baconian Swamp and the reed bed core of the Great Cumbung Swamp. As the water travels through the lower catchment, in-stream benefits will also be provided. The action may also support relevant Aboriginal cultural heritage values (TBC in consultation with NSW OEH and Lachlan CMA).

The three objectives of the watering action are well defined and realistic, in particular:
Provide up to 7,000 ML on top of a translucency flow in August to September to inundate 800 hectares of Lake Ita. Wyangala Dam is predicted to spill late winter / spring 2011. This will provide the “translucent event” necessary to undertake this action.
Secondary inundation to benefit Moon Moon Swamp, Baconian Swamp and the reed bed in the Great Cumbung Swamp. As the river will be running high enough to fill Lake Ita, the associated “losses” to the above assets are likely.
Improve the health of river red gum forest, black-box woodland, lignum, nitre goosefoot, macrophytes and floating aquatic species; and, provide habitat for native fish, frogs and waterfowl, including blue-billed and freckled duck and migratory waterbirds and increase system connectivity and to protect and restore the</td></tr>
<tr><td>2.1</td><td>Current health of the asset(s)</td></tr>
<tr><td>2.2</td><td>Expected ecological outcomes from the proposed watering action</td></tr>
<tr><td>2.3</td><td>Improvement in health of the asset(s) expected from the watering action</td></tr>
<tr><td>2.4</td><td>Change in the health of the asset(s) expected if environmental water is not provided</td></tr>
<tr><td>2.5</td><td>Basin-wide significance of the ecological response from the watering action</td></tr>
<tr><td>2.6</td><td>Any secondary environmental effects expected to result from the watering action (e.g. connected system benefits)</td></tr>
<tr><td>2.7</td><td>How well defined and realistic the objectives are for the proposed watering action</td></tr>
<tr><td>2.8</td><td>Consistency of these objectives with the overall CEWH ecological objectives for the current forecast water availability scenario</td></tr>
</table>

Name of action: Lachlan River/ Lake Ita / with secondary benefits to Moon Moon Swamp/Lachlan Swamps and GCS complex		
Criteria		**Assessment**
		health of *Phragmites* and *Typha* spp. The objectives under a median availability scenario are to maintain ecological health and resilience and improve and extend healthy and resilient aquatic ecosystems. The management objectives and actions under these scenarios include: enabling growth, reproduction and small to large scale recruitment for a diverse range of flora and fauna; promoting low-lying to higher floodplain-river connectivity; supporting medium to high flow river and floodplain functional processes. These objectives are compatible with the objectives of watering in the Lower Lachlan River channel and ensuring that the associated floodplain wetlands are also watered. This action is consistent with a management response under a median climate scenario: prolonging flood/high flow duration at key sites and priority reaches /assets, contributing to in-channel flows and using carryover to provide optimal seasonal flow patterns in subsequent years. Availability of similar refuge habitat for the species: wetland vegetation values across the Lachlan catchment have declined over the last decade, particularly in the Great Cumbung Swamp (Brandis et. al., 2009). Prolonging inundation during this spring is expected to consolidate recent improvements in wetland vegetation health as a result of partial inundation last summer. Providing two to three consecutive years of high river flows and flooding is believed to facilitate significant improvements in ecological responses over time (Overton et. al., 2009). This action will also provide habitat for water birds, support the outcomes of recent bird breeding events and providing conditions for future events. Sloane's froglet is extant in the region. Improved water quality and seasonally appropriate flows could also provide conditions which may benefit the southern bell frog, which is extant in the Mid-Murrumbidgee wetlands, but the status of which is uncertain in the Lachlan (Wassens and Maher, 2010). This action is consistent with a management response under a median climate scenario: prolonging flood/high flow duration at key sites and priority reaches /assets, contributing to in-channel flows and using carryover to provide optimal seasonal flow patterns in subsequent years.
4. Risk		A comprehensive risk assessment including control measures will be submitted with the approvals minute. All potential risks are classified as 'low risk' apart from the risk that carp may invade the system which is which is classified as 'medium risk'. • If this translucency flow does not occur, then environmental water may be required to fill up the river and provide the flow triggers. An estimated cost would be required. • carp recruitment - while it is not possible to exclude carp from the system. Professional harvesting and carp traps (for large bodied individuals) may mitigate the impact of this risk. A high European population dominates off-channel water sources (Gilligan et. al., 2010) and lippia is present in the catchment. Good inflows over the past year have minimised the risk of water quality issues, and there have been no
4.1	Potential risks of the proposed watering action at the site and at connected locations	
4.2	How thoroughly the potential risks have been assessed for the proposed watering	
4.3	Adequacy of measures proposed to minimise these risks	
4.4	Likelihood and consequence of variance from the expected ecological outcome (including negative impacts on biota and water quality)	

Name of action: Lachlan River/ Lake Ita / with secondary benefits to Moon Moon Swamp/Lachlan Swamps and GCS complex		
Criteria		**Assessment**
		known black water events (P. Packard, NSW OEH, pers. comm. 4 April 2011). While the predominant land use in the region is grazing for sheep, Lake Ita now in Kalyarr State Conservation Area and managed by NSW OEH.
5. Management & Monitoring Arrangements		Lake Ita is identified under the NSW RiverBank plan as a target for environmental water. It was recently purchased by the NSW Government to improve OEH's capacity to deliver water. In addition, 3 km of channels from the Lachlan River to Lake Ita have also been bought by NSW OEH to enable more efficient delivery. As this is now National Parks Estate, a plan of management should be drafted by NSW OEH (TBC)
5.1	Long-term sustainability of the asset(s) including appropriate management arrangements	
5.2	Adequacy of long-term management and delivery arrangements	
5.3	Existence of complementary natural resource management activities supporting the long-term management arrangements, including those that improve water quality	
5.4	Effectiveness of monitoring, evaluation and reporting arrangements for the watering activity including clear links to the defined objectives	
6. Cost-effectiveness		A volume of 40,000 ML has been proposed and requires evaluation with regard to water availability (such as after a dam spill translucency) and need. There are no pumping fees as the site is gravity fed.
6.1	Amount of Commonwealth water and resources needed, including relative to the contribution of the State and delivery partner to (i) the watering event and (ii) subsequent monitoring of actions and outcomes	NSW will also manage the event and provide monitoring. NSW OEH staff will undertake the abovementioned activities as part of regular duties.
6.2	Cost effectiveness and operational feasibility of undertaking the watering	
6.3	Arrangements for the delivery of water to the asset(s), including the potential for transmission losses and the adequate accounting of flows	Flows are managed and delivered down the Lachlan River. The regulator has been modified to assist the delivery of flows into Lake Ita. The proponents note that due to good preceding rainfall in the area, the risk of ground seepage water losses is better than expected previously, however, it would be timely to ensure environmental water is delivered to take advantage of this and to risk any losses as the drier season progresses.
6.4	Opportunity to supplement natural flows or other water releases	The Lower Lachlan was well inundated in spring/summer 2010-11. It is advantageous to piggy-back onto operational flows to minimise transmission losses. This system has a history of supplementing natural events with environmental water with good results.
6.5	Operational feasibility of undertaking the watering action (e.g. channel capacity, infrastructure constraints, etc).	Lake Ita fills via Pimpama Creek (adjacent to the south end of the lake) during large floods in either the Lachlan (or the Murrumbidgee) via backwater. A flow of approximately 144GL of (more than 2,000 ML/day at Corrong for 72 days) is needed for the lake to receive flows (Barma, 2011). This action only becomes feasible once there is a long and high pulse of translucent or natural flood flows in the main channel, for example, a translucent event that may result from a dam spill. As noted above extra water in the system will provide both in-stream benefits and benefits to other floodplain assets.

Water Use Strategy 2011-12: Lower Darling River System

1.1. Introduction

This document sets out the proposed objectives and approach to using environmental water in the Lower Darling River system during the 2011-12 water year. This strategy was developed based on information available to the Department of Sustainability, Environment, Water, Population and Communities (the Department) through consultation with delivery partners such as state governments, local river operators and wetland managers.

The document includes watering options given current and expected climatic and riverine conditions in the system. The proposed approach will adapt over the course of the year as conditions change and more information becomes available. Importantly, the potential watering options included in this document do not form an exhaustive list – the Department welcomes proposed suggestions for using water. All relevant options will be assessed to ensure the best possible use of environmental water within the system and across the Murray-Darling Basin.

1.2. The Lower Darling River System

The Lower Darling River system is located in south-western New South Wales at the end of the Darling River, from Menindee Lakes to its junction with the Murray River (Figure 1). It is marked by the towns of Menindee in the north and Wentworth to the south. A key feature of the area is the clusters of large floodplain lakes located near Menindee and along the Great Darling Anabranch (hereafter referred to as the Darling Anabranch). Billabongs, channel complexes, backwaters, riverine benches, saline lakes, lignum swamps, deep riverine pools and extensive floodplains also occur in the region.

The entire Darling River system is characterised by a variable flow regime and unpredictable flooding events that spread onto the floodplain and lakes (MDBC nd). Consequently the plants and animals of the Lower Darling River system are adapted to high flow variability and dynamic wetting and drying cycles, and exhibit 'boom and bust' ecology (MDBC nd). Flooding that occurs in winter and spring, is a result of rainfall in central and north eastern NSW. Flooding can also occur in autumn, after summer monsoon rainfall in Queensland. In the past, larger flood events often occurred in clusters of 2-3 years (DWR 1994).

When the Darling River floods, water moves slowly down the system, flows attenuate, and by the time they reach Menindee are characterised by a long duration, flat hydrograph. Large floods can occur in any month of the year, although most have occurred in March, as a result of the northern Australia wet season. Table 1 shows that there have been 43 floods in the Darling River that exceeded a height of 11 m at Bourke (this corresponds to 50,000 ML per day) between 1864 and 1995. Flooding in this region of Australia is thought to be influenced in part by El Nino-Southern Oscillation (ENSO) climate patterns (Walker *et al.* 1995 in Jenkins 1999).

Table 1: Seasonal distribution of large flood events in the Darling River (floods above 11 m at Bourke, which is 840 km upstream of Menindee Main Weir).

Month	Flood (year and height)
January	1974 (14.1 m)
February	1891 (12.42 m), 1910 (11.94 m), 1996 (12.4 m)
March	1864 (14.53 m), 1893 (11.95 m), 1911 (11.79 m), 1917 (11.2 m), 1953 (11.84 m), 1955 (12.42 m), 1956 (13.75 m), 1971 (13.56 m), 1976 (14.18 m)
April	1890 (14.39 m), 1894 (11.86 m), 1977 (11.4 m)
May	1950 (11.48 m), 1990 (12.99 m)
June	1956 (11.96 m), 1977 (11.69 m), 1983 (13.27 m)
July	1890 (12.66 m), 1893 (13.68 m), 1920 (12.75 m), 1956 (13.61 m), 1983 (12.38 m)
August	1886 (12.83 m), 1887 (12.52 m), 1921 (13.00 m), 1931 (12.22 m), 1950 (13.93 m)
September	1886 (12.75 m), 1891 (11.21 m), 1893 (11.04 m), 1952 (11.43 m), 1984 (12.55 m), 1998 (13.77 m)
October	1852 (?)
November	1886 (12.52 m), 1890 (14.39 m), 1950 (13.16 m)
December	1892 (11.2 m), 1950 (13.56 m), 2000 (12.28 m)

Source; Menindee Lakes Storages: Flood Operations Manual (draft), Sept 1995, NSW Government

The climate of the Lower Darling region is semi-arid with hot summers and mild winters, an annual average rainfall of 200 mm at Menindee (monthly averages range between 16 and 23 mm), and potential annual evaporation of 2,335 mm (Westbrooke *et al*. 2001). It is hot in summer (18.5 -34.3 °C mean high and low daily temperatures for January) and mild to cold in winter (4-17 °C mean high and low daily temperatures for July) (BOM).

Land use in the Lower Darling area is predominantly sheep grazing, with a small number of properties running cattle. Lakebed cropping, irrigated cropping and tourism also occur in the region (Jenkins *et al.* 2003). Riverine and lake habitats are also used for recreational pursuits such as yabbying, fishing, walking, and hold high amenity value for landholders and the wider community.

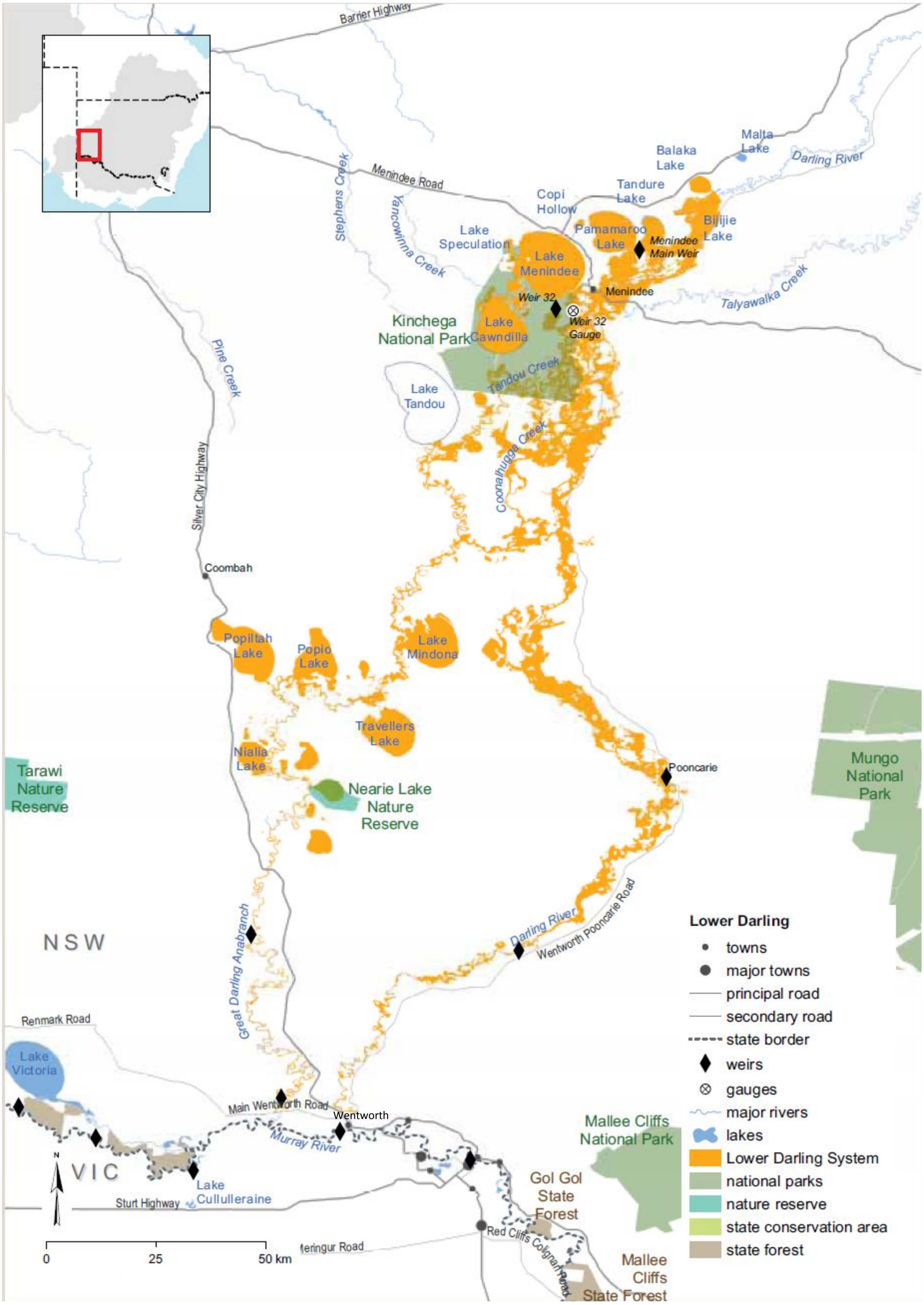

Figure 1: The Lower Darling River system (source MDBA 2010).

1.3. Environmental Assets in the Lower Darling River System

The Lower Darling River system has been identified as a hydrologic indicator site by the Murray-Darling Basin Authority (MDBA) (MDBA 2010). Freshwater-dependent biotic and abiotic assets in the Lower Darling River system include areas of black box and river red gum woodland, lignum, herbfield/grassland/sedgeland, and river and wetland habitats. These habitats provide permanent and temporary refuge and foraging opportunities for migratory and threatened waterbirds, fishes, amphibians and a suite of terrestrial fauna.

The Lower Darling River system can be divided in to three separate components:

- Menindee Lakes;
- Great Darling Anabranch (Darling Anabranch); and
- Lower Darling River.

The Menindee Lakes consists of nine lakes which were naturally ephemeral. Completion of the Menindee Lakes storage scheme in the 1960's, resulted in many of these lakes being used for water storage. The Darling Anabranch consists of braided intermittent water courses and contains 14 large overflow lakes (deflation basins), with 480 km of channel and associated floodplain. The Lower Darling River travels southward to the east of the Anabranch. It has fewer associated lakes; the main wetland features include billabongs adjacent to the river and some extensive low lying areas that support stands of lignum. The hydrology of the Lower Darling River has been altered significantly by the Menindee Lakes storage scheme.

Further details on the location, condition, type and extent of significant flora and fauna at each locality is presented at Appendix A.

1.4. Watering Objectives in the Lower Darling River System

Long-term watering objectives specific to the Lower Darling River system (as identified by MDBA 2010) are:

1. Maintain the upper Menindee Lakes (Pamamaroo and Wetherell) as predominantly permanent water bodies to act as drought refuge for biota;
2. Reinstate a more natural, variable flow regime in Lakes Menindee and Cawndilla that is capable of supporting a range of wetland communities and waterbird breeding events;
3. Maintain longitudinal connection down the Darling Anabranch to support threatened ecological communities[1];
4. Maintain Darling Anabranch floodplain lakes in good condition;
5. Maintain wetlands along the Lower Darling River to provide feeding and roosting sites for a range of waterbirds, amphibians and terrestrial fauna;
6. Maintain low-lying wetlands in good condition, and provide conditions supportive of fish movement along the Lower Darling River; and

[1] *Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River* listed under the *Fisheries Management Act* 1994

7. Maintain riparian River red gum and higher level wetlands in good condition along the Lower Darling River.

This strategy proposes watering options that support the objectives relating to the Darling Anabranch and the Lower Darling River (3 to 7 above). Watering options for the Menindee Lakes (1 and 2 above) are not considered in this strategy as the storage scheme is currently surcharged (June 2011) and being utilised for water storage. Objective four encompasses all of the Darling Anabranch floodplain Lakes; this strategy focuses on Nearie Lake.

1.5. Delivering Water in the Lower Darling River System

Key points:

- The Darling Anabranch is an unregulated water source, whereas the Lower Darling River is a regulated water source.
- The Menindee Lakes are currently under Murray-Darling Basin Authority (MDBA) control.
- Water can be released from Lake Cawndilla (part of the Menindee Lakes storage scheme), and then through Packers Crossing regulator to target the Darling Anabranch.
- Water can be released from outlets on the Menindee Lakes (Wetherall, Pamamaroo and Menindee) to target the Lower Darling River.

Management of the water resource within the Lower Darling River occurs according to the *Water Sharing Plan for the NSW Murray and Lower Darling Regulated Rivers Water Sources, 2003* (requirement of the NSW *Water Management Act 2000*). According to this plan the Lower Darling regulated water source includes the Darling River from the upper limit of the Main Weir pool, to the upper limit of the Wentworth weir pool along the Darling River.

The Darling Anabranch is an unregulated water source, and is not part of the Lower Darling regulated water source. Management of the water resource within the Darling Anabranch is dictated by the New South Wales *Water Act 1912.* A draft water sharing plan for this area, (Lower Murray-Darling Unregulated and Alluvial Water Sources) is proposed to commence in 2011, and will supersede prescriptions for this area under the *Water Act 1912*.

Water enters the Lower Darling River system from the Darling River, floodwaters also enter the system from Talyawalka Creek, a complex anabranch system of the Darling River which leaves the Darling River near Wilcannia and enters just downstream of Menindee (and also a number of locations upstream of Menindee) (see Figure 1).

The Menindee Lakes storage scheme, Weir 32 and Burtundy Weir, flow control structures along the Darling Anabranch, and regulators on some floodplain lakes contribute to regulating the Lower Darling River system (Jenkins *et al*. 2003).

The four main lakes in the Menindee Lakes storage scheme – Wetherell, Pamamaroo (including Copi Hollow), Menindee and Cawndilla – have a full storage capacity of 1,731 GL; however this amount can be surcharged to 2,050 GL to mitigate adverse impacts of flooding (MDBA 2010).

The major lakes in the Scheme (Cawndilla, Menindee, Pamamaroo and Wetherell) are owned by the NSW government, although currently the MDBA controls the lakes, and will retain control until the total storage volume drops below 480 GL. When this occurs control passes to the NSW government, and remains under their control until the stored volume subsequently exceeds 640 GL (known as the 480/640 rule – Murray-Darling Basin Agreement, Schedule 1 of the *Water Act 2007*). Appendix F provides a summary of the status and the likely operation of the storage scheme for 2011-12.

The Menindee Lakes storage scheme delivers water to South Australia to meet part (39 per cent on average) of its annual entitlement. As well as the allocation to South Australia, flows are released into the Lower Darling to maintain 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 in MDBA 2010). In addition to releases to meet downstream demands, water is released from Menindee Lakes to mitigate flooding. When flooding occurs, a pre-release is initiated to create room for impending floods down the Darling River (Thoms *et al*. 2000 in MDBA 2010). When flows do not need to be delivered to the Murray River, for the purposes described above, flows down the Lower Darling River are maintained at approximately 100-500 ML per day[2]. Flows are released from outlet regulators on Lakes Menindee, Pamamaroo and Wetherell, and the Main Weir.

The Darling Anabranch is an ephemeral channel that carries floods from the Darling River, and flows through to the Murray River only under large flood events. The Darling Anabranch commences to flow when flow rates in the Darling River exceed 9,000 ML per day (measured at Weir 32). Flows spill over a sill into a shallow inlet that pass through a series of lagoons about 55 km south of Menindee (Harrington 2004). Water may also enter the Darling Anabranch, via Tandou Creek when flows in the Lower Darling reach between 16,000 and 20,000 ML per day (King and Green 1993; and J. Wall pers. comm. 16/6/2011), when a floodrunner that feeds Tandou Creek commences to fill. The area above the Darling Anabranch, between Redbank and Tandou Creeks and the Darling River is a low lying floodplain (areas 2 and 3 on Figure 2) consisting of a complex system of tributaries (including Connalhugga Creek) and small lakes (King and Green 1993). During periods of very high flow in the Darling River, hydrological connectivity across this area to the Darling Anabranch increases.

High flow and flood events still enter the Darling Anabranch via the paths described above, however environmental flows can be released from Lake Cawndilla via Cawndilla Channel, Tandou Creek, passing through Packers Crossing regulator and then Redbank Creek, which meets the Darling Anabranch (see Figure 2).

Lake Cawndilla is connected to Menindee Lake by Cawndilla Creek, which allows water to flow in either direction, depending on the water levels and head difference between the two lakes. The two lakes are connected when water levels are above 56.0 m AHD, until full supply at 59.8 m AHD or surcharged at 60.45 m AHD (Lake Cawndilla/ Lake Menindee water levels). When Lake Cawndilla falls below 56.0 m AHD water can only be released from the Cawndilla outlet to Cawndilla Channel, at this point the Lake holds 212 GL. Releases through the outlet are possible until the Lake lowers to 54.0 m AHD, at which point the remaining 48 GL in the Lake is trapped (MDBA 2010a). Water may be released from Lake Cawndilla outlet in anticipation of floodwaters over-filling the storage scheme (MDBA 2010a).

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[2] When Menindee Lakes are surcharged the minimum release from the Lakes is 500 ML per day; at other times the minimum release varies from between 200 and 350 ML per day deepening on the month.

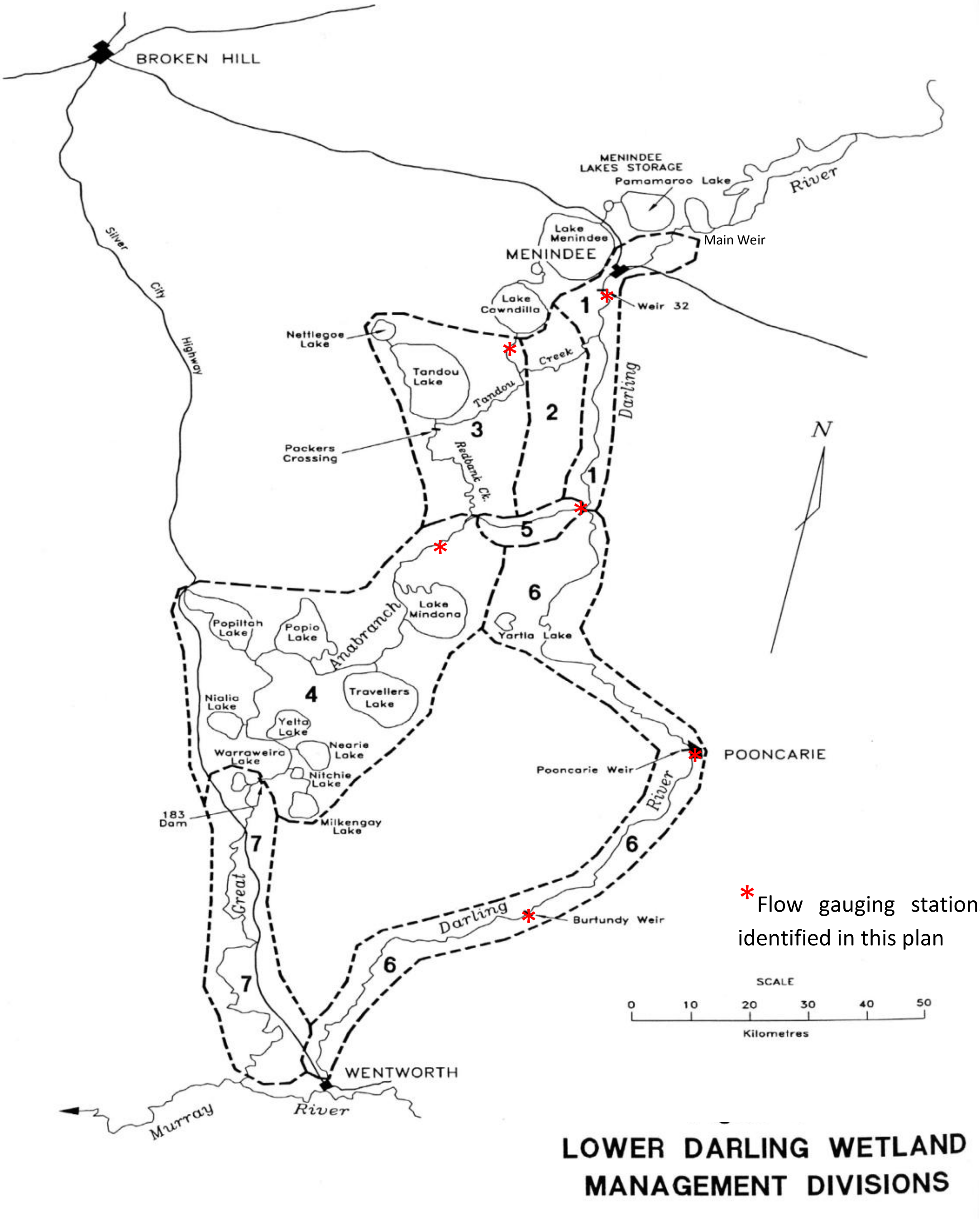

Figure 2: Map of the Lower Darling River system including weirs and flow gauging station (source Green and King 1993).

Table 2 summarises key flow rates and river levels in the Lower Darling River (i.e. flood levels, commence to flows, rates required for fish passage) and also provides an indication of the amount of wetlands inundated and at what flow bench features become inundated. Table 3 provides further detail on key delivery issues for the Darling Anabranch and Lower Darling River, including channel capacities, accounting issues. Additional information on issues and constraints is provided at Section 1.12.

Table 2: Significant flow bands at Lower Darling River Gauging Stations.~

Weir 32	Pooncarie Weir	Burtundy Weir	Implication
7,000 ML per day	2,000 ML per day	2,300 ML per day	Required for fish passage over each weir. Note that weir 32 now has a functional fish passage (Fishways at Burtundy and Pooncarie are not yet operational). It is considered that a minimum period of 10 days at these bands is required for passage (Green *et al.* 1998).
Approx. 6,400 ML per day		5,000 ML per day	Small low bench features inundate.
7,000 ML per day (small freshes)		6,000 ML per day*	13% of wetlands fill. Fish passage would be possible over all weirs.
> 9,000 ML per day		8,500 ML per day*	Darling Anabranch commences to flow from the Lower Darling River (MDBA 2010).
Approx. 15,200 ML per day		11,000 ML per day	Larger bench features, usually supporting river red gums inundate. At least 50% of bench features inundated.
7,000 - 17,000 ML per day (medium sized flows)		6,000 to 12,500 ML per day*	55% of wetlands fill.
Approx. 30,000 ML per day		17,000 ML per day	Large high bench features supporting river red gums inundate. 50% or bench area inundated. 77% of wetlands fill.
16,000 - 20,000 ML per day			Flood runner that connects Darling River and Tandou Creek commence to fill (King and Green 1993; and J. Wall pers. comm. 16/6/2011).
Unknown		22,000 ML per day	Very high bench features supporting river red gums inundate.

~ Unless referenced separately information in this table is sourced from Green *et al.* (1998).
* Flow calculated using flow conversion table provided in Green *et al.* (1998).

Table 3: Water delivery considerations for each asset.

Asset	Delivery Considerations
Darling Anabranch	▪ Environmental flows can be delivered from Lake Cawndilla to Tandou Creek and through Packers Crossing regulator, down Redbank Creek to where it enters the top of the Darling Anabranch. ▪ The system may also receive flows from the Darling River when flow rates in the river reaches between 9,000 and 12,000 ML per day (reported flow threshold varies). For the purposes of this document 9,000 ML per day will be used. ▪ A flow of 1,500 ML per day has been reported to exceed the banks of the Darling Anabranch in many places (GHD 2008 in MDBA 2010). ▪ The Lake Cawndilla regulator is limited to delivering 2,000 ML per day (dependent on water levels in the lake). The delivery of environmental water may be further limited when deliveries are being made to Tandou. When used to deliver allocations in the past the usual flow rate is 500 ML per day through this regulator. ▪ Packers Crossing regulator is rated at 2,000 ML per day, but flows above 1,400 ML per day will inundate crossing structures on the Darling Anabranch. ▪ The lower end of the Darling Anabranch system is hydrologically connected to the Murray River (owing to Lock 9 weir pool– The influence of the Lock 9 weir pool extends about 30 km up the Great Darling Anabranch, but is also dependent on the flow in the Murray). Depending on conditions in the Darling Anabranch, water quality may need to be considered to avoid (or manage) delivery of high salt, sediment and carbon loads. Oatbank Regulator has in the past been used to control flow into the Murray (until higher flows overtop the structure), though the condition of the regulator is not well known. ▪ Minimal in-stream conveyance loss is anticipated from end-of-system flows in the Darling Anabranch channel because it is currently (June 2011) wet along its length. ▪ The use of environmental water in the Darling Anabranch will require consultation with Darling Anabranch landholders/Anabranch Water, NSW OEH, NOW, MDBA (currently control Menindee Lakes), State Water Corporation (operate Lake Cawndilla and Packers crossing regulators), and MDFRC (contracted to undertake monitoring of flows in the Darling Anabranch). ▪ There are currently no provisions for the recrediting or sheperding of return flows from the Darling Anabranch in to the Murray regulated water source.
Lower Darling River	▪ The storage levels in Menindee Lakes and other storages in the southern connected basin and inflows in the Darling River and broader southern connected basin all influence releases made from the Menindee Lakes, and hence flows in the Lower Darling River. The considerations for releases made

Asset	Delivery Considerations

	from Menindee Lakes during 2011-12 are summarised in Appendix F.
	▪ At flows above 9,000 ML per day at Weir 32 there is increased overbank flow and connection to the Darling Anabranch.
	▪ Flows in the Lower Darling River of 16,000 to 20,000 ML per day will activate flows in a floodrunner to Tandou Creek, and the Darling Anabranch will begin to receive water at flows of >9,000 ML per day (flows measured at Weir 32).
	▪ Properties begin to be isolated when flows reach 19,000 ML per day (measured at Weir 32); flooding of houses commences at 22,000 ML per day (measured at Weir 32) (S. Jaensch pers. comm. 31/6/2011); and the Menindee to Pooncarie Roads is cut off at flows of around 26,000 ML per day (measured at Weir 32) (MDBA 2011).
	▪ Flood levels according to the Bureau of Meteorology (BOM) for the Lower Darling River are: (http://www.bom.gov.au/nsw/flood/outerwest.shtml)[3]
	  ▪ Darling River at Pooncarie - Minor: 6.80 m (approx. 15,000 ML/d); Moderate: 7.60m (approx. 27,000 ML/d); Major: 8.70 m (>30,000 ML/d).[4]
	  ▪ Darling River at Burtundy - Minor: 6.10 m (approx. 13,700 ML/d); Major: 7.70 m (approx. 21,800 ML/d).[5]
	  ▪ Darling River at Menindee Weir 32 - Minor: 6.00 (approx. 18,150 ML/d) Moderate: 6.60 m (approx. 25,900 ML/d); Major: 7.30 m (approx. 42,300 ML/d).[6]
	▪ There are currently no provisions for the recrediting or shepherding of return flows in from the Lower Darling regulated rivers water source to the Murray.
	▪ Maximum regulator capacities: Main Weir (100,000 ML per day); Lake

[3] Definitions sourced from BOM (http://www.bom.gov.au/water/floods/floodWarningServices.shtml): Minor flooding: Causes inconvenience. Low-lying areas next to watercourses are inundated which may require the removal of stock and equipment. Minor roads may be closed and low-level bridges submerged; Moderate flooding**:** In addition to the above, the evacuation of some houses may be required. Main traffic routes may be covered. The area of inundation is substantial in rural areas requiring the removal of stock; Major flooding**:** In addition to the above, extensive rural areas and/or urban areas are inundated. Properties and towns are likely to be isolated and major traffic routes likely to be closed. Evacuation of people from flood affected areas may be required.

[4] Corresponding flow data is an approximation made using NOW rating tables HYDRATAB 159 output 29/6/2011 which were classed as 'not quality coded or subject to change.'

[5] Corresponding flow data is an approximation made using NOW rating tables HYDRATAB 159 output 29/6/2011 which are coded as reliable.

[6] Corresponding flow data is an approximation made using NOW rating tables HYDRATAB 159 output 29/6/2011 which were classed as 'not quality coded or subject to change.'

Asset	Delivery Considerations
	Wetherall (5,000 ML per day); Lake Pamamaroo outlet (5,000 ML per day); and Lake Menindee outlet (5,000 ML per day).

1.6. Current System Status and Outlook

Prior to minor flooding in 2010 the Lower Darling River system had experienced drought conditions. Lake Cawndilla and the Darling Anabranch dried and remained dry for several years, and the Lower Darling River experienced low flow conditions for much of the 2000s. In 2010, rainfall over the upper catchment of the Murray-Darling Basin resulted in flood conditions in the Darling River, with unregulated flows down the Darling Anabranch. This event reached as far as the Yelta/Nearie Lakes region, approximately half-way down the Darling Anabranch channel. Further inundation of the system occurred in early 2011, causing the Menindee Lakes to be surcharged, and the Darling Anabranch to experience an end-of-system flow. Figure 3 shows flow in the Lower Darling River, at Pooncarie, between 2003 and 2011.

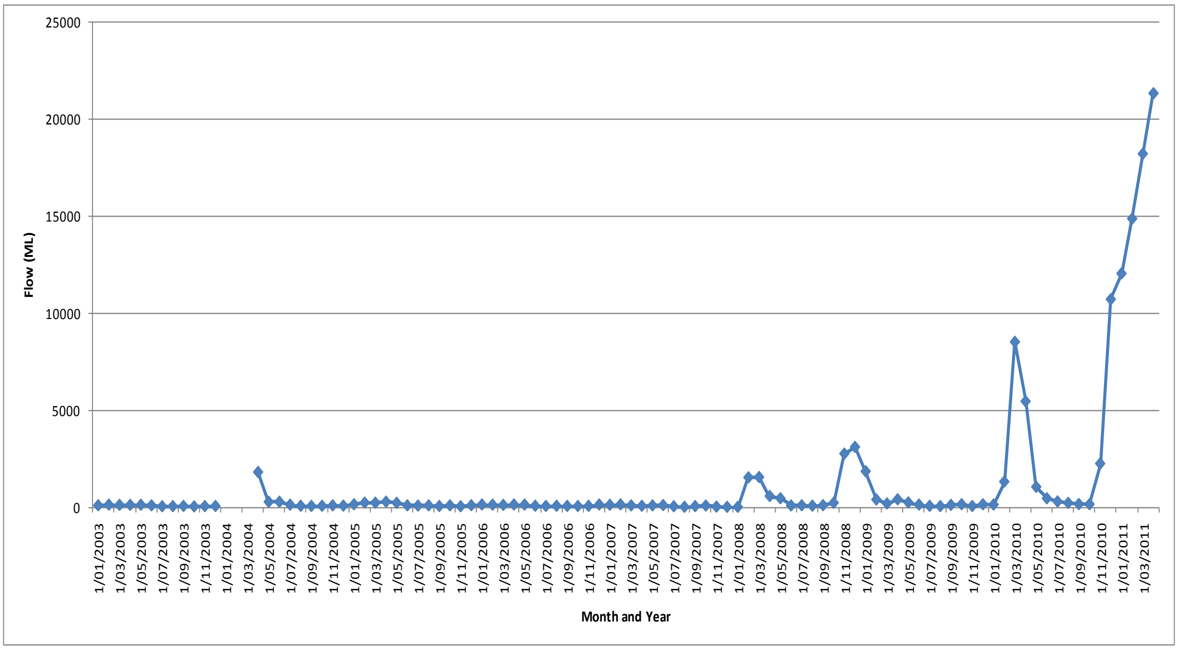

Figure 3: Mean monthly flows in the Lower Darling River at Pooncarie from 2003 to March 2011. (Source: http://waterinfo.nsw.gov.au/water.shtml?ppbm=SURFACE_WATER&rs&3&rskm_url)

The Commonwealth participated in environmental watering in the Lower Darling River system in October 2010, directing 6,580 ML of environmental water (residual shepherded flows from the Toorale Darling entitlements) to an environmental flow in the Darling Anabranch. This watering event also included volumes from The Living Murray and NSW Office of Environment and Heritage (OEH).

The seasonal outlook over south-eastern Australia over the next three months (July to September) favours a drier than normal season in the Lower Darling River system (Figure 4), with a 40 per cent chance of exceeding the long term average (BOM http://www.bom.gov.au/climate/ahead/rain.seaus.shtml).

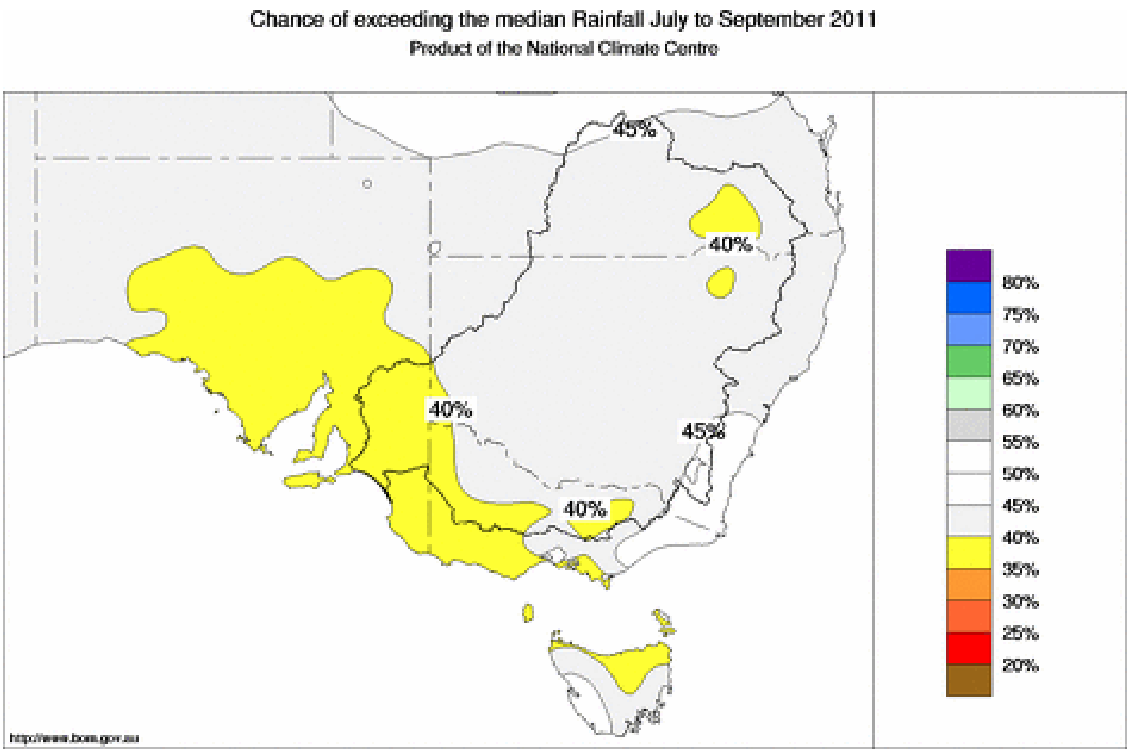

Figure 4: Predicted chance of exceeding the long-term median rainfall average for July to September 2011 in south-eastern Australia (BoM).

1.7. Forecast Allocations

Key points:

- Forecasting indicates that up to 650 GL of Commonwealth environmental water could be available for use in the southern connected basin by the end of 2011-12.
- Trade in and out of the Lower Darling regulated water source was permitted within the southern connected basin for 2011-12. Trade through the Barmah Choke is permitted for the beginning of the water year, however, this may change throughout the season.
- Shepherded environmental water from northern New South Wales may be available for use in the Lower Darling River system in 2011-12.
- The Commonwealth holds 0.5 GL of general security entitlement in the Lower Darling regulated water source.

Current storage levels in the southern Murray-Darling Basin are high (Figure 5). Thus, it is expected that water available against Commonwealth environmental water entitlements in 2011-12 will be high.

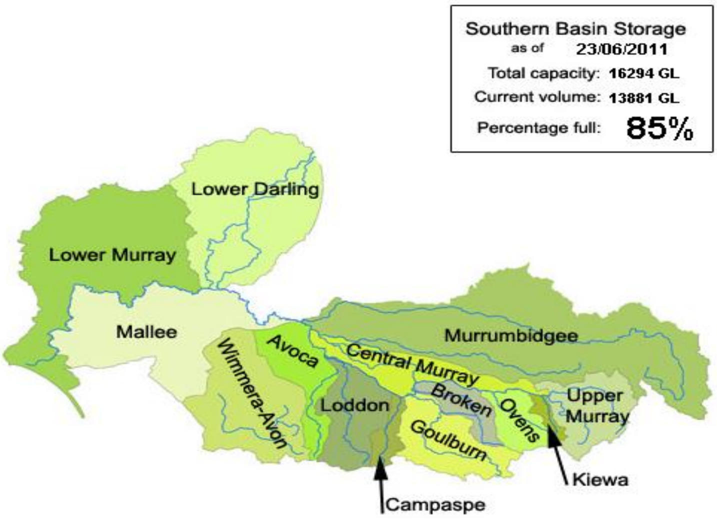

Figure 5: Current water storage levels in the southern Murray-Darling Basin (as at 23 June 2011) (http://www.mdba.gov.au/water/waterinstorage/southern?run-date=2011-06-23).

The volume of Commonwealth environmental water available in the southern connected basin and the Lower Darling at the beginning of 2011-12, and forecasts for the rest of 2011-12 water year are described in Table 4.

Table 4: Commonwealth environmental water availability in 2011-12.

Catchment	Entitlement (GL)	Water available for use (GL)	Water available for use forecasts					
			31 July 2011 (GL)		30 September 2011 (GL)		30 June 2012 (GL)	
Lower Darling (NSW)			**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
General Security	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total - Southern Connected Basin	**652.5**	**317.7**	**318.0**	**388.9**	**354.7**	**608.9**	**539.9**	**649.7**

Note: Southern connected basin includes Murray (NSW, Vic, SA), Murrumbidgee, Lower Darling, Campaspe, Goulburn, Loddon. The figures may change following reconciliation of accounts for the end of the 2010-11 water year.

The forecasts presented in Table 4 were determined by the Department based on the following:

- There would be no barriers to trade within southern connected basin during 2011-12, except the 100 GL net trade limit out of the Murrumbidgee;
- The southern connected basin includes the NSW Murray, Vic Murray, SA Murray, Murrumbidgee, Goulburn, Campaspe, Lower Darling and the Loddon;
- Forecasts were based on information available at 1 July 2011, and the Commonwealth's registered entitlements at this date;
- Supplementary entitlements and additional entitlements that may be obtained and registered by the Commonwealth during 2011-12 were not included in forecasts; and

- Forecasts were based on dry and wet climate year scenarios.

At times trade of water allocations between the Lower Darling from other parts of the southern connected basin can be restricted. However, for 2011-12, trade will be permitted between the Lower Darling and the southern connected basin (NSW Murray, Murrumbidgee, Victoria - for valleys where trade out is permitted, and South Australia). Trade through the Barmah Choke is currently open, however, this may become restricted as the season progresses (NOW 2011, and State Water Corporation officer pers. comm. 4/07/2011). As the Commonwealth holds limited entitlements in the Lower Darling (492 ML general security), trading water from other areas of the southern connected basin would enable larger watering options to be pursued.

Shepherded environmental water, originating from New South Wales catchments upstream of the Lower Darling River, may also be available for the Commonwealth Environmental Water Holder to direct to watering events in the Lower Darling River system. Table 5 provides a summary of the possible volumes that may be available from these sources. These forecasts are only indicative; utilisation of the maximum annual volume depends on suitable flow events that trigger access to the entitlement.

Table 4: Sources and potential volumes of shepherded environmental water that may be available for use in the Lower Darling River system[1].

Water Source and entitlement reliability	Entitlement at 1 July 2012 (ML)	Maximum Water Available in 2011-12[2]	Forecast Water Available on entitlement [3]	Estimate of residual volume at Menindee[4]
NSW Warrego River - at Toorale (unregulated)	8,106	8,106	4,992 – 8,106	4,243 – 6,890
NSW Darling River - at Toorale (unregulated)	7,672	7,672	122 – 7,672	0 – 6,521
NSW Barwon River - near Collarenebri (unregulated)	14,603	14,603	13,223 – 14,603	7,934 – 8,762
Total	**30,381**	**30,381**	**18,337– 30,381**	**12,177 – 22,173**

1. The arrangements for the shepherding environmental water to the Menindee Lakes will be established on a case-by-case basis in accordance with interim-shepherding arrangements agreed with NSW for 2011-12.
2. According to access conditions and accounting rules for each entitlement.
3. Volumes forecast to accrue on entitlements under the expected Dry – Median water availability scenario in 2011-12 (internal SEWPAC analysis). Actual volumes accrued will depend on suitable flow events that trigger access to the entitlements (cannot be predicted).
4. Based on forecast water availability and transmission losses of 40 per cent for water available from the Barwon River and 15 per cent from the Toorale Darling and Warrego entitlements (latter is consistent with previous Toorale shepherding trials). Potential evaporation losses in Menindee Lakes are not included in estimate. The total residual volume available at Menindee could be greater if: water shepherded from a potential Commonwealth entitlement in the Lower Balonne (Culgoa River), which would require completion of acquisition process, negotiation of shepherding arrangements with Qld and NSW and the event occurring. Also, if NSW Office of Water allow access to account water for the Toorale Darling entitlement in 2011-12, a larger volume may accrue to it.

1.8. Other Sources of Environmental Water

In addition to Commonwealth environmental water, there are other sources of environmental water that may be available to supplement watering options outlined in this strategy (Table 5).

NSW Office of Environment and Heritage (NSW OEH) manages environmental water allowances according to the *Water Sharing Plan for the NSW Murray and Lower Darling Regulated Rivers Water Sources 2003*. The Murray Additional Environmental Allowance (AEA) which can accrue over a number of years up to 0.15 ML multiplied by total high security unit shares (currently about 191,000 shares) which is about 28,700 ML. The water sharing plan also prescribes a contingency allowance for the Lower Darling, however this allowance is set aside to manage algal blooms.

NSW also hold adaptive environmental water entitlements in the NSW Murray Valley. In the past allocations against these entitlements have been used in the Lower Darling River system.

The Living Murray (TLM) program holds water entitlements in the Lower Darling regulated water source which could be accessed for watering actions that are in accordance with TLM environmental watering plan. Alternatively, allocations against TLM entitlements in the Lower Darling may be traded out for use at the icon sites.

Table 5: Other potential sources of environmental water in the Darling River system for 2011-12.

Source	Management Authority	Maximum Capacity (ML)
AEW river conveyance (NSW Murray)*	NSW OEH	30,000
AEW high security (NSW Murray)*	NSW OEH	2,027
Planned water (Murray Additional Environmental Allowance)**	NSW OEH	0.15 ML multiplied by total high security unit shares (currently up to 28,700 ML)
TLM general security - Lower Darling^	MDBA	47,8000
TLM high security - Lower Darling^	MDBA	500
TLM (all entitlements, including the Lower Darling)^*	MDBA	230,000 – 405,000[#]

* The availability of this water for use in the Lower Darling River system will depend on trade being permitted between the Murray and Lower Darling water sources.

** At this stage it is uncertain if this allowance can be used in the Lower Darling River system.

^ The water available against these entitlements may be used elsewhere in the Basin.

[#] Forecast water available in 2011-12 (TLM Annual Environmental Watering Plan 2011-12).

1.9. Watering Objectives for 2011-12

The types of objectives for possible watering options in the Lower Darling River system during 2011-12 are outlined below. These objectives are broad, and were developed based on available information. A priority for the next twelve months is to improve our understanding of this area, and continue refine the watering objectives and options.

- Improve flow variability by using environmental water to providing freshes, longer periods of high flow to:
  - trigger breeding and movement of fish in the system;

  - support recruitment and health of riparian vegetation, particularly river red gums on high benches. Improved riparian vegetation conditions will also improve habitat for other species;
  - increase instream habitat diversity; and
  - provide invertebrates with an opportunity to move and breed.
- Manage high-flow recession rates to replicate a more natural rate-of-fall, thereby providing the cue for native fish to vacate off-stream habitats;
- Inundate key sites (such as Nearie Lake) to maintain natural condition and thereby supporting:
  - the maintenance of key refuge areas;
  - local survival and recruitment of black box;
  - macrophyte communities;
  - fish movement and transfer of energy, nutrients and micro-organisms between the Darling Anabranch and floodplain lake habitat;
  - natural ephemeral lake processes; and
  - aquatic habitat for yabbies, waterbirds and frogs.
- Provide throughflows to:
  - support fish movement and transfer of energy, nutrients and micro-organisms between the Lower Darling River system and the Murray River;
  - promote natural riverine processes, such as biofilm scouring, and recreation of scour holes; and
  - maintain instream aquatic habitat for water dependent species.

1.10. Watering Options for 2011-12

Key points:

- There are watering options in the Lower Darling River, Darling Anabranch and Nearie Lake; however, some operational arrangements need to be developed before these are viable.

The watering options presented provide a range of possibilities at a scale that is relevant to the volume of Commonwealth environmental water available for use in 2011-12 (see section 1.7). Potential watering options for the Lower Darling River system focus on providing flows to the Lower Darling River, Darling Anabranch, and Nearie Lake. The options presented are not a definitive list; other watering actions can be considered and assessed outside of this strategy.

As mentioned in the previous section, a focus over the course of the next twelve months is to improve our understanding of the hydrological and ecological state of this region to refine and priorities the options presented in this plan. The watering options will also be refined as more information becomes available regarding the operational feasibility and delivery arrangements.

If an opportunity arises to implement one of the watering options described in this strategy, the option will be reconsidered taking into account the expected ecological benefits, cost effectiveness and risk in light of the antecedent conditions.

Ongoing discussions with relevant agencies have indicated that there are potential watering options during 2011-12 in the Darling Anabranch. Throughflows in the Darling Anabranch would contribute to improving system resilience and capitalise on recruitment and regeneration stimulated during recent inundation events while allowing fish movement to occur between the Menindee Lakes and the Murray system.

The Darling Anabranch could also be used to deliver an environmental flow to Nearie Lake Nature Reserve, completing the inundation event that commenced when the Darling Anabranch flowed during 2010-11. There are impediments to providing environmental water to Nearie Lake, such as the lack of appropriate licencing and works approvals, which need to be resolved.

Options for the Darling River focus on supporting seasonally appropriate high flows, and providing in-channel freshes to maintain riverine function, habitat value and provide spawning cues for fish. Environmental flows could also be used opportunistically to mitigate unnatural flood recessions, allowing aquatic fauna time to respond to receding water levels, and exit floodplain habitats.

Throughflows in the Darling Anabranch, and flows provided in the Lower Darling River contribute to maintaining connectivity between the Murray River, and the Darling catchment, providing biota the opportunity to disperse. When there is hydrological connectivity fish can move between the Murray, the Darling Anabranch and Lower-Darling River (provided flows are sufficient to provide passage over the weirs and/or fishways are operational[7]).

More detail on the watering options for 2011-12 is provided at Table 6. Further details on the watering options, including consideration of the delivery mechanisms, and the target flow rate, timing and duration are provided at Table 7.

[7] A fishway is operational on Weir 32, fishways on Pooncarie and Burtundy are not yet operational (L. Pearce (NSW DPI) pers. comm. 2011)

Table 6: Potential watering options for 2011-12 in the Lower Darling River system.

Asset	Watering Option
Spring-Summer 2011-12	
Darling Anabranch	Use a release from Lake Cawndilla to create throughflow from the Darling Anabranch to the Murray system. This is expected to improve in-stream and riparian vegetation health and contribute to carbon and nutrient exchange between the Darling Anabranch and the Murray River.
	Supplement natural flows in the Darling Anabranch, increasing flow magnitude or duration. This will benefit in-stream and riparian vegetation health and contribute to carbon and nutrient exchange between the Darling Anabranch and its floodplain.
	Use a managed flow in the Darling Anabranch to deliver environmental flows to inundate Nearie Lake. The Lake is currently almost full, but the drought-stressed riparian Black box woodland has not been inundated during the recent flooding. This would require the use of Dam 183 on the Darling Anabranch to pool water so it can enter Nearie Lake through the Stoney Creek regulator.
Lower Darling River	Provide in-channel freshes to promote fish spawning and migration. This is particularly important in September to November, as this is when water temperatures are suitable for many species (for example Murray cod, Western carp gudgeon, golden and silver perch) to migrate and/or spawn. Freshes will also support and maintain the conditions of core river channel habitat, and low lying benches and enable longitudinal dispersal of other aquatic organisms (including downstream drift of eggs and larvae).
	Maintain higher wetlands and benches and associated vegetation in good condition to provide feeding and roosting sites for waterbirds and additional habitat for other aquatic organisms.
	Mitigate unnatural rates of high flow recession. Environmental water can be used to ‘fill-in’ the shortfall between natural and regulated rates of fall in the Lower Darling River to provide fish and other aquatic fauna sufficient time to respond to falling water levels and leave floodplain habitat.
Autumn and Winter 2012	
	Completion of spring-summer watering options.
Darling Anabranch	Supplement natural flows in the Darling Anabranch, increasing flow magnitude or duration. This will improve in-stream and riparian vegetation health and contribute to carbon and nutrient exchange between the Darling Anabranch and its floodplain.
	If not implemented in summer/spring, use a managed flow in the Darling Anabranch to deliver environmental flows to inundate Nearie Lake. The Lake is currently almost full, but the drought-stressed riparian black box woodland has not been inundated during the recent flooding. This would require the use of Dam 183 on the Darling Anabranch to pool water so it can enter Nearie Lake through the Stoney Creek regulator.
Lower Darling River	As above

Table 7: Operational details for potential watering options for 2011-12 in the Lower Darling River system.

Asset	Target flow rate/Volume to fill[#]	Estimated volume	Timing & Duration	Delivery mechanism	Operational considerations
Darling Anabranch					
Use a release from Lake Cawndilla to create throughflow in the Darling Anabranch.	Up to 1,400 ML per day at Packers Crossing.	At least 50,000 ML**	October to December for at least 36 days (duration is based on a release threshold at Packers Crossing. The event is likely to take longer to include rise and fall, and flow variation).	Release from Lake Cawndilla	The Lake Cawndilla regulator has a capacity of 2,000 ML per day at full supply. Packers Crossing regulator is rated at 2,000 ML per day, but flows above 1,400 ML per day will inundate a crossing structure on the Darling Anabranch. This watering option could be combined with environmental watering by The Living Murray and NSW OEH. In the absence of return flows policy, downstream water demand could be assessed to influence timing of releases. By delivering water down the Darling Anabranch in conjunction with flows down the Murray and Murrumbidgee it would be possible to create unregulated conditions to maximise the delivery of environmental water to South Australia.
Supplement natural flows in the Lower Darling River to increase flow magnitude or duration in the Darling Anabranch.	Up to 9,000 ML per day (measured at Weir 32).	Up to 580,000 ML^^	Any time of the year for 40 days.	Release from Menindee Main Weir	Landholders/Anabranch Water will need to be made aware that the water is an environmental flow and in instances where there may be inundation of private property. This may require written permission from affected landholders. Higher flows down the Darling River will also result in activation of the Darling Anabranch. Agreements may be required with landholders to ensure environmental

Asset	Target flow rate/Volume to fill#	Estimated volume	Timing & Duration	Delivery mechanism	Operational considerations
					water is not captured and used in lakes for agriculture. The threshold for the Darling River sill into the Darling Anabranch is >9,000 ML per day (measured at Weir 32). Flows >16,000 ML per day will inundate upstream flood-runners from the Lower Darling River (measured at Weir 32).
Use a managed flow in the Darling Anabranch to inundate Nearie Lake.	Up to 1,400 ML per day at Packers Crossing.	10,000 to 20,000 ML	Any time of the year for at least 10 days (duration based on a release threshold at Packers Crossing, the event is likely be longer to include rise and fall).	Release from Lake Cawndilla	The Lake Cawndilla regulator has a capacity of 2,000 ML per day at FSL. The usual flow rate for regulated flows is 500 ML per day. A number of potential issues relating to the watering of Nearie Lake have been raised by NOW and OEH. The extent to which these will restrict watering in 2011-12 need to be further investigated. This watering event could be linked with the previous two. It is estimated that approximately 45,000 ML is required to provide flows down the Anabranch and fill Nearie Lake. The lake would be filled through operation of Dam 183, and then drain back into the Anabranch.

Lower Darling River					
Provide in-channel freshes to promote fish migration, recruitment and longitudinal connectivity, and to maintain condition of core river channel habitat, and low lying wetlands and benches.	7,000 ML per day (measured at Weir 32).	91,000 ML^^	Any time, most important in spring (September to November) for at least 14 days.	Release from Menindee Main Weir	Flows >16,000 ML per day at Weir 32 will inundate the floodplain, and cause Tandou Creek and the Darling Anabranch to commence-to-flow. Through flow from the Lower Darling River could help meet downstream water demands.
Maintain higher floodplain wetlands in good condition to provide feeding and roosting sites for waterbirds.	17,000 ML per day (measured at Weir 32).	297,000 ML^^	Any time of the year for 18 days.	Release from Menindee Main Weir	
Mitigate unnatural or extend high flow recessions in the Lower Darling River.	Not known	Volume related to target flow rates	As required	Release from Menindee Main Weir	This will require close liaison with river operators to determine the likely rates of fall, and predict the volume and release regime required to create a more natural rate of fall. There are provisions in the sharing plan to manage the rate of fall, the requirement for additional environmental water will require consideration of the predicted flood hydrograph, and expected ecological benefit, on a case-by-case basis.

* *From Section 1.4.*

 # Target flow rate and volume-to-fill should consider the antecedent conditions of the asset.

^^This number is based on minimum base flow in the Darling River of 500 ML per day (this is the required minimum when Menindee Lakes are surcharged, at other times it varies between 200 and 350 ML per day at Weir 32 depending on the month), and does not include reduction in volume for raising and lowering. Flows are likely to be higher than this and actual volume required would be much less than this and vary depending on flow rates at the time of water use.

*** Additional water could be provided to extend the period of connectivity. 50,000 ML is a conservative estimate of the volume required to make an end of system flow, as the Darling Anabranch remains wet (although not flowing in the upstream sections) from flows in 2010-11.This assumes no water is provided from other sources (i.e. NSW AEW or TLM). SEWPaC have received a proposal from OEH for between 10,000 and 50,000 ML of environmental water or the Anabranch, to potentially contribute to water provide d from NSW OEH and TLM. A hydrograph for the combined event (based on 62,000 ML) is provided at Appendix D.*

Table 8: Total release volume estimate and possible monthly water allocation profile. All figures are in ML, and shaded green areas indicate when water could be used

Asset	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Ma y	Jun	Total
Darling Anabranch												
Use a release from Lake Cawndilla to create throughflow in the Darling Anabranch			21,000	29,000								50,000
Supplement natural flows in the Darling River to increase flow magnitude or duration in the Darling Anabranch*	449,500	130,500										580,000
Use a managed flow in the Darling Anabranch to inundate Nearie Lake*	10,000 - 20,000^											20,000
Lower Darling River												
Provide an in-channel fresh*	91,000											91,000
Maintain higher floodplains wetlands in good condition to provide feeding and roosting sites for waterbirds*	297,000											297,000
Mitigate unnatural flood recessions *~	Event dependent											Event dependent

** Positive ecological outcomes for these options will occur irrespective of the release timing. Opportunities to conduct these watering options at any time during the year should be considered.*

^ It has been estimated that 45,000 ML would be required this season for delivery down the Darling Anabranch and to fill Lake Nearie Lake. This volume will change as conditions in the Darling Anabranch alter.

~ No estimate for the volumetric requirement to mitigating unnatural rates of fall is offered because it will depend on the flows being managed. The NSW Murray and Lower Darling sharing plan stipulates rules for the rate of fall in the Lower Darling River:

- *Where total storage volume in the Menindee Lakes will exceed 1,680,000 ML, flow release patterns should be implemented to provide a hydrograph of similar shape to that of a 'natural flood event', consistent with the protection of property as far as possible.*

- *Following extended periods of high flow greater than three weeks, apply the following recommended rates of reductions and monitor and record the effect of this action:*
  - *For within channel flows greater than 20,000 ML/day downstream of Menindee, reduce at a similar rate of recession as occurred upstream of the lakes at Wilcannia.*
  - *For flows greater than 10,000 ML/day and less than 20,000 ML/day, releases should be reduced at no greater than 1,000 ML/day each day.*
  - *For flows greater than 5,000 ML/day and less than 10,000 ML/day, releases should be reduced at no greater than 500 ML/day each day.*
  - *For flows less than 5,000 ML/day, releases should be reduced at no greater than 250 ML/day each day.*

Note that a number of assumptions were made in creating Table 7 and Table 8:

1. The total release volume estimate and monthly water allocation profile provided in the Tables are indicative only, and need an event-by-event analysis to ensure the antecedent conditions of the asset are taken into consideration;
2. Nearie Lake is currently nearly full, and is expected to remain inundated for approximately 12 months. The estimated volume required for Nearie Lake (10,000 to 20,000 ML; 45,000 ML including delivery down the Darling Anabranch (S. Healy, pers. com. 4/7/2011)) assumes it is almost full and requires only a top-up to completely inundate the lake and its riparian vegetation. If antecedent conditions for the Lake are dry the estimated total volume of water required to inundate the Lake is 55,000-85,000 ML; and
3. The figures provided don't include any consideration of transmission losses or evaporative losses (for water stored in the Menindee Lakes storage scheme):
   - Modelling of the Darling Anabranch system provides an indication of the likely transmission losses and potential end-of-system flows for three release volume scenarios (Pendelbury & Ribbons 2006). Their work suggested a 40,000 ML release at Lake Cawndilla would likely inundate most of the channel, but would not create a flow to the Murray River; a 70,000 ML release would generate an end-of-system flow and contribute approximately 12,000 ML to the Murray River, and a 110,000 ML release would also generate an end-of-system flow and contribute approximately 18,000 ML to the Murray River. These studies indicate that as more water is pushed through the system, the greater the volume of water that flows to the floodplain, and is lost from the channel; and
   - Transmission losses in the Lower Darling River depend on antecedent conditions, flow rates, and whether the river is rising or falling. Basic analyses of recent flows between Weir 32 and Burtundy Weir in the Lower Darling River provide the following indicative transmission losses: very low flows (up to 200 ML per day) reduce by up to 45 per cent; low flows (around 500 ML per day) reduce by about 30-35 per cent; medium flows (7,000 ML per day) reduce by about 30 per cent; high flows (17,000 ML per day) reduce by about 25-30 per cent, and very high flows (35,000 ML per day) reduce by about 45-55 per cent (pers. comm. Brian Graham NOW 16/06/11).

1.11. Assessing Environmental Watering Options

An assessment of the watering options against the Commonwealth Environmental Water Holder's criteria for assessing watering actions has been undertaken, with the options satisfying the criteria. The assessment includes consideration of the:

- ecological significance of the asset(s);
- expected ecological outcomes from the proposed watering action;
- potential risks of the proposed watering action at the site and at connected locations;
- long-term sustainability of the asset(s) including appropriate management arrangements; and
- cost-effectiveness and operational feasibility of undertaking the watering.

Detailed description of the Commonwealth Environmental Water Holder's criteria for assessing watering actions is provided at Appendix B. An assessment of the range of potential watering options against these criteria is provided at Appendix C. This assessment considers watering the suite of options in scope in groups of similarly located and managed assets. For this strategy assessments of the Lower Darling; Darling Anabranch and Nearie Lake have been undertaken.

The assessments will be reviewed as individual watering options are considered for implementation. The review will include an assessment of prevailing catchment and river flow conditions. It will also further consider of risks, costs, delivery, monitoring, water requirements and accounting arrangements.

Any additional watering options identified during the course of the year that are not encompassed by those provided at Appendix C1.1, will also be subject to a separate assessment against the criteria.

1.12. Key Constraints for Water Delivery

There are a number of issues (potential constraints) that need to be resolved before Commonwealth water can be utilised in the Lower Darling River system. A key activity for the next twelve months will involve investigating these issues and developing robust arrangements to permit use of environmental water in this system for the years to come.

Some of the constraints and issues that have been identified that may affect the use of Commonwealth environmental water in the Lower Darling River system are described below.

- Channel capacities and regulator capacities described in Table 3 may dictate the rate of environmental water delivery, depending on the purpose of the watering option (i.e. overbank or instream watering).
- A fishway in Pooncarie Weir (Lower Darling River) is under construction; construction is likely to recommence after being delayed due to high flows in 2010-11 (L. Pearce (NSW DPI) pers. comm. 2011).
- Delivering water to Nearie Lake is currently hampered by the lack of clear rules regarding the treatment of water (especially environmental water) in the Darling Anabranch. Arrangements for the use of environmental water according to the water sharing plan for the unregulated Lower Darling water source (expected to commence early 2011-12) will need to be developed.
- Additionally, the Stoney Creek regulator (on the effluent stream connecting Nearie Lake to the Darling Anabranch) is dysfunctional, with only one of the two gates operational. The other gate is inoperable, and there is a crack in the earth wall (R. Enke pers. comm. June 2011).

1.13. Water Use Accounting

Key points:

- Trade of available water into the Lower Darling is likely to be permitted in 2011-12 (this is not always the case and may change throughout the water year).
- There is currently no policy base to enable the recredit of return flows or shepherding water through the system.
- A water access licences with appropriate works approvals will need to be sourced for environmental water use in the Lower Darling River system.

Water use accounting is conducted according to the *Water Sharing Plan for the NSW Murray and Lower Darling Regulated Rivers Water Sources, 2003.* Each year general security account holders have access to a maximum of 100 per cent of licensed entitlement.

Under the water sharing plan, a maximum of 50 per cent of entitlement can be carried over in general security accounts in the Lower Darling water source. From 1 July 2011, the carry-over limits in the water sharing plan (50 per cent general security entitlements only), will apply. Water carried over in these accounts will 'spill' when combined carry-over plus allocation exceeds 100 per cent. Water that is spilt is re-distributed among users. Additional water may be used in any particular year (e.g. by allocation trade), but carry-over rules apply to end-of-year account balances.

Trade of water into the Lower Darling River valley from other areas in the southern connected Basin is likely to be permitted in early 2011-12. Thus, Commonwealth water held in other catchments could be traded into the Lower Darling for use. At other times there may be trading restrictions that may prevent trade of water allocations into this area. The restrictions depend on which agency has control of the Menindee Lakes, the storage volume, channel capacity through the Barmah Choke in the Murray River, and the availability of back-trade allowance (refer to the Murray-Darling Basin Agreement (Schedule D); and the NSW Murray and Lower darling Regulated River Water Sources Sharing Plan).

In the NSW Lower-Darling River, licensed general security water users may divert water from the river during periods of announced supplementary flow, provided general security allocation is less than 60 per cent. This water is not debited from the allocation accounts and diversion under these conditions is limited to 100 per cent of entitlement minus allocations already in the account. This rule is not likely to apply in 2011-12 as allocations over the season are predicted to be greater than 60 per cent.

The Darling Anabranch is located outside of the bounds of the regulated water sharing plan. It is covered by the NSW *Water Act 1912*, which will be replaced by the water sharing plan for the Lower Murray-Darling Unregulated and Alluvial Water Sources. This plan is proposed to commence early 2011-12.

Table 9 provides a summary of key water use accounting issues and opportunities in the Lower Darling River system.

Table 9: Water accounting arrangements for assets in the Lower Darling River system.

Asset	Accounting Arrangement
Darling Anabranch	Flows within the Darling Anabranch are managed by Anabranch Water. State Water Corporation manages releases from Lake Cawndilla and Packers Crossing regulators. NOW have rated gauging stations in several locations down the Darling Anabranch to measure flow volumes: Wycot (GS425013); at the offtake (GS425050); and at Lake Cawndilla outlet (GS425014). Currently there is no provision for the recrediting or shepherding of return flows from the Darling Anabranch into the River Murray. Currently trade of water allocations from the regulated water source to an unregulated water source (i.e. the Darling Anabranch) is not permitted.

Asset	Accounting Arrangement
Lower Darling River	A WAL with an attached works approval that permits instream watering will need to be sourced to enable delivery in the system. There is no provision for the recrediting of return flows from the Lower Darling River into the River Murray. There are flow gauging devices on Weir 32, Pooncarie Weir and Burtundy in the Lower Darling River.

1.14. Risk Management

A full risk assessment will be undertaken for each watering action as part of the assessment process, building upon the preliminary risk assessment included for groups of assets at Appendix C. The more likely risks associated with delivering environmental water in the catchment and their context and mitigation measures are presented at Table 10.

Table 10: Likely risks, their context and potential mitigation.

Risk	Context and Mitigation
Rapid water level decline resulting in fauna stranding and failed breeding events	Colonial-breeding waterbirds and aquatic fauna are particularly susceptible to rapid water declines in wetland habitats. For fish and amphibians the risk is greatest during spring and summer, when fingerlings and tadpoles are too small to move or metamorphose (respectively) before their nursery habitats dry. Breeding stimuli for waterbirds is less season dependent (Scott 1997). Mitigation is best achieved by using environmental water maintain a suitable hydrograph, as well as monitoring and adaptively managing releases if breeding events occur.
Invasive species introduction and spread	Common carp are a problem species in the Lower Darling River system, and may use environmental flows to move and breed.
Flooding of properties and infrastructure.	Some environmental watering events have the potential to flood and perhaps isolate properties that use the floodplain for agricultural activities and general property access. An information campaign prior to any releases will contribute to keeping the community informed and minimising risk to property and infrastructure. Agreements with affected landholders will be obtained where necessary. All in-channel regulatory structures are to remain open during environmental releases. Alternative stock watering points may also need to be established for the duration of the flow.
Poor water quality delivered to the Murray River.	Water quality of flows delivered to the Murray River from the Darling Anabranch may be of poor water quality (including salinity, blackwater and blue-green algae). Water quality will be monitored by the Murray Darling Freshwater Research Centre (MDFRC) and arrangements could be made to cease flows into the Murray River if required. Poor water quality can also be managed by manipulating flows in the Murray River.
Unauthorised water diversions.	Compliance inspections by the NOW could be conducted to prevent any water theft. The local community should be engaged and informed about the watering events.

1.15. Event Monitoring

The following monitoring and reporting activities are expected to be undertaken in 2011-12 (Table 11). Monitoring will be considered on an event-by-event basis closer to the time of the action.

Most monitoring in the system is focused on the Darling Anabranch, and is undertaken by the MDFRC. The MDFRC was engaged by the then NSW Department of Environment, Climate Change and Water (now OEH) to undertake monitoring of the effect of environmental flows in the Darling Anabranch channel from late 2010 for three years. The program is designed for ten years.

Table 11: Monitoring arrangements for environmental flows in the Lower Darling River system.

Location	Parameters	Timing/frequency	Responsibility
Operational Monitoring			
Darling Anabranch	Hydrological monitoring (flow rates and volumes) Any parameters which evidence any negative impacts generated by a watering action (e.g. salt loads, blackwater, blue-green algal bloom)	Event-by-event Event-by-event	NOW, State Water and or Anabranch Water. Murray Darling Freshwater Research Centre
Intervention/response Monitoring			
Darling Anabranch	Fish, frogs, birds, invertebrates, water quality, hydrological data, groundwater and soil	Event-by-event	Murray Darling Freshwater Research Centre
Lower Darling River	Fish	Event-by-event	NSW Fisheries, in cooperation with the Commonwealth. Fisheries can monitor sites throughout the system, but this will likely need to be negotiated with the Commonwealth when finalising the action.
Nearie Lake	Floodplain and wetland vegetation, waterbirds, frogs	Event-by-event	NSW NPWS (or their agent) would conduct post-event monitoring of key fauna at Nearie Lake.
Condition Monitoring			
Darling Anabranch	Floodplain vegetation, channel geomorphology	Annual surveys	Murray Darling Freshwater Research Centre

An operational monitoring report must be provided to the Commonwealth for all watering events using Commonwealth environmental water. When intervention monitoring is undertaken a consolidated report offering key results against the watering objectives, and highlighting beneficial and adverse results and outcomes should be compiled after each event. The report should also include ‘lessons learnt’, and provide advice on future adaptive management measures.

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Appendix A Environmental Assets

The Great Darling Anabranch

The Great Darling Anabranch is located in south-western NSW, extending approximately 460 km from its junction with the Darling River south of Menindee, to the Murray River downstream of Wentworth. It is an ancestral channel of the Darling River. The entire Darling Anabranch system occupies approximately 630,000 hectares of riverine and floodplain habitats and includes 14 lakes (MDBA 2010).

Hydrological condition

The Darling Anabranch receives water from the following sources (Earth Tech 2004):

- Water released from the outlet of Lake Cawndilla;
- Overland flows from the Darling River during floods. These can enter the Darling Anabranch from a number of locations, depending on the magnitude of the flood;
- The lower reaches of the Anabranch system receives backwater from the Murray River;
- Groundwater inflows; this is more prevalent in the lower reaches of the Darling Anabranch; and
- Overland run-off after rainfall; however, this tends to be a minor contributor due to the low rainfall typical of this region.

Flows in the Darling Anabranch were not recorded until a gauging station at Bulpunga (120 km upstream of the Murray, and well downstream of Nearie Lake) was established in 1954. A second gauging station in the upper section of the Anabranch at Wycot (380 km upstream of the Murray) was operational from 1962. Thus, flows were not recorded before construction of the Menindee Lakes storage scheme (1960s). Despite the limited data record of flows in the Darling Anabranch prior to this, a number of studies have documented and estimated the natural flow regime in the Darling Anabranch (Irish 1993; DWR 1984 in Irish 1993; and Withers 1994).

Under natural conditions the Darling Anabranch was ephemeral, flowing only during high flow conditions in the Darling River. The Darling River used to spill into the Anabranch about 55 km south of Menindee when flows reached 10,000 ML per day (near Karoola) (Jones *et al.* 2010); or when Lake Cawndilla filled and spilled to the south. In moderate floods water also entered the Anabranch from Tandou Creek, via Redbank or Connalhugga Creeks (Jones *et al*. 2010). The Darling Anabranch flowed every two of three years in the upper reaches and less frequently in the lower reaches. The Lakes would have most likely filled sequentially down the Anabranch (Irish 1993).

In 1869 the commence to flow level to the Darling Anabranch was lowered, so that water flowed from the Darling River when flows at Menindee exceeded 9,000 ML per day. By 1885 settlers had placed several dams along the Darling Anabranch, and on streams and effluent creeks feeding the Lakes. In 1917 the Water Trust of the Great Anabranch of the Darling River was created to manage stock and domestic water use, and was also responsible for the construction and operation of works to manipulate and mitigate floods (Withers 1994).

Prior to construction of the Menindee Lakes scheme, significant flows down the Darling Anabranch only occurred during floods, and only in major flooding did water flow through to the Murray River. Between 1890 and 1961, water flowed through to the Murray River nine times (Withers 2004). Water reached the Murray River when flows in the Darling River were above the 9,000 ML per day for at least 3 months. During this period, about every two and a half years flows reached half way down the Anabranch (Withers 1994).

The commencement of the Menindee Lakes storage scheme in the 1960s further altered the natural hydrological regime of the Darling Anabranch. After construction of the scheme, water releases were made annually from Lake Cawndilla, essentially changing the system from an ephemeral stream to a permanent water body. The annual ’replenishment’ flow was approximately 50,000 ML, and was provided for stock and domestic purposes. The flow was ponded in 17 weir pools along the Darling Anabranch. Only 3,000 ML of the 50,000 ML annual replenishment flow was used by landholders for consumptive purposes, with the rest lost to evaporation and seepage.

The change from an ephemeral stream to a chain of semi-permanent ponds (in conjunction with adjacent land use) caused a significant change in ecosystem structure and function of the Darling Anabranch. Water quality in the Darling Anabranch was widely regarded as poor, particularly in the lower reaches. Salinity levels were typically elevated, and outbreaks of blue-green algae were reportedly becoming more common (Earth Tech 2004).

Since 2007, stock and domestic flows to landholders along the Darling Anabranch have been piped. This has achieved substantial water savings by providing stock and domestic supplies without the losses associated with the replenishment flows. It was intended that the Darling Anabranch receive environmental flows, in absence of the ‘replenishment’ flow, to support improved environmental condition and function. However, no held or planned environmental water is set aside for this purpose.

Drought conditions caused the cessation of flows in the Darling Anabranch between 2002 and 2010. In March 2010, the Darling Anabranch received minor flows from the Lower Darling River that reached approximately half way down the Anabranch (near Yelta Lake). Later in 2010, the Anabranch received a much larger flood event that resulted in substantial end of system flow, and filled all Lakes. More than 1,300 GL passed the Wycot gauge (upstream of most of the Lakes) between December and May 2011 (NOW 2011); and it is estimated that approximately 300 GL flowed through the system between September and April 2011 (OEH 2011).

During this larger flood event the Darling Anabranch received water spilling from the Lower Darling River, as flows remained mostly above 17,000 ML per day at Weir 32. Just prior to this event, between September and mid October 2010, environmental water was released from Lake Cawndilla. Water continued to be released from Cawndilla to manage storage levels in the Menindee Lakes during the unregulated event (see Figure 6 for releases from Cawndilla outlet during this period). Water remains in the Darling Anabranch from this large flow event. The upper reach has stopped flowing, however, water currently remains in most of the channel, and the stream will continues to flow as water drains back from the Lakes (OEH pers. comm. 21/7/2011).

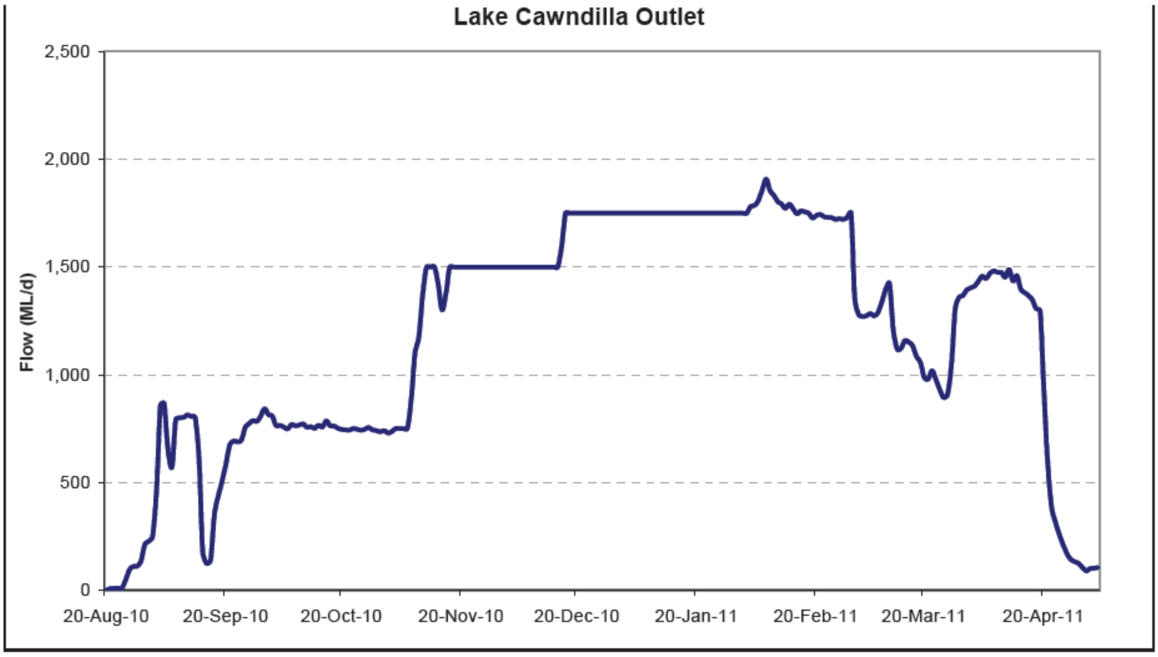


Figure 6: Releases from lake Cawndilla between August 2010 and April 2011.

Description of the environment

The Darling Anabranch is characterised by the large freshwater lakes. These are found in the northern half of the system, and provide expansive areas of productive waterbird and fish habitat when flooded. The southern reach of the Darling Anabranch is characterised by a complex meander, billabongs and backwaters. The channel of the Darling Anabranch is broad, contains many deep holes and is connected to a complex network of channels (Jenkins 1999).

Vegetation along the Darling Anabranch is relatively intact; although it has been over grazed in the past. The main vegetation communities are river red gum, lignum and river cooba in the riparian zone, with black box and sandalwood communities higher on the floodplain. River red gums occur on areas that receive water more regularly (upper reaches), and are particularly common in the area where the Murray River water backs up.

As part of the Darling Anabranch Adaptive Management Monitoring Program (DAAMMP), river red gum condition surveys were undertaken at 16 sites along the Darling Anabranch in August 2010. Of these sites, only two were assessed to be in good conditions, while the rest were stressed. Lignum condition was also measured and was variable; however, most sites were in poor health (S. Healy (OEH) pers. comm. 22/07/2011). More recent observations in autumn 2011 noted that black box, river red gum and lignum had put on new growth and were in flowerbud/flower (pers.obs. Sascha Healy, April 2011).

Aquatic vegetation commonly found in the Darling Anabranch includes: common rush (*Juncus usitatus*), red myriophyllum (*Myriophyllum verrucosum*), austral mudwort (*Limosella australis*), nardoo (*Marsilea* sp.) and *Nitella.* Emergent macrophytes are less common, however, cumbungi (*Typha domingensis*) is spreading in places (Earth Tech 2004). Cumbungi is well established near the confluence of the Darling Anabranch with the Murray River. Areas that permanently hold water (particularly in the southern area of the Anabranch) have experienced a loss of riparian vegetation, siltation and a general loss of aquatic plants.

The lower end of the Darling Anabranch has been reported as having a high diversity of fish abundance and diversity (King and Green 1993); however it is noted that fish have not been widely surveyed in the Darling Anabranch (Jenkins 1999). Recent surveys of fish in the Darling Anabranch during flows in 2010-11 recorded the following species: goldfish, carp, hardyheads, mosquito fish, carp gudgeon, spangled perch, golden perch, rainbow fish, bony bream and flat headed gudgeon and smelt (S. Healy (OEH)pers. comm.). Monitoring of fish populations in the broader Lower Darling River System (including the Darling Anabranch) since 2004 has recorded 14 different native species. An additional 11 species have been recorded historically in this area, that have not been recorded during this monitoring program (refer to Appendix E for detail).

The Anabranch Lakes are important habitat for invertebrates. Within days after flooding the lakes experience a surge of microinvertebrates which in turn provide food for species higher in the food chain: Microinvertebrates are a vital food source for larval fish, and also provide food for waterbirds and macroinvertebrates. The Darling Anabranch supports three large macroinvetbrate species including the floodplain mussel, freshwater prawn and common yabbie (Earth Tech 2004).

Lakes which dry and wet intermittently, such as the Lakes on the Darling Anabranch, are considered to support a higher diversity of microinvertbrates compared to lakes which rarely flood (Seddon and Briggs 1998). However, increased dry periods have been associated with declines in diversity and density of microinvertebrates in the lakes of the Lower Darling River system (Jenkins and Boulton 1999 in MDBC nd).

Land use surrounding the Darling Anabranch is predominately sheep grazing. Additionally opportunistic cropping of the Lake beds and floodplains is carried out after floodwaters recede.

Ecological significance

Deeper pools and lagoons of the Darling Anabranch are noted as drought refuges (MDBA 2010). In periods of drought in western NSW, deeper lakes in the Darling Anabranch have retained water and provided habitat for water birds (MDBA 2010). The wetlands on the Lower Darling River system as a whole (including the Darling Anabranch) provide habitat for waterbirds that links upper NSW/QLD to the lower parts of the Murray-Darling Basin, which is important for the movement of species across the landscape (King and Green 1993).

The Darling Anabranch is one of the three management units of the Lower Darling River system, which were identified by the MDBA as a hydrologic indicator site in the Guide to the Proposed Basin Plan. Additionally, the lakes of the Darling Anabranch are recognised in the Directory of Important Wetlands of Australia, meeting the following crtieria:

- a good example of a wetland type occurring within a biogeographical region in Australia;
- play an important ecological or hydrological role in the natural functioning of a major wetland system/complex; and
- support native plant of animal taxa or communities which are considered endangered or vulnerable at the national level.

The Darling Anabranch supports: several species listed in international agreements; an endangered ecological community (NSW Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River); and threatened species listed under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act), the NSW *Fisheries Management* Act 1994 and the NSW *Threatened Species Conservation Act* 1995 . A list of these species is provided at Appendix E.

The Darling Anabranch may also support the following Commonwealth listed Endangered ecological communities: the Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions; and the Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions. However, the later has not been recorded in the area (refer to http://www.environment.gov.au/biodiversity/threatened/communities/maps/murray-darling-buloke.html, and Earth Tech 2004).

Nearie Lake

Nearie Lake Nature Reserve is situated in south-western NSW approximately 80 km north of Wentworth within the Wentworth Shire (DECC 2008). The reserve was gazetted on 13 May 1973 and is 4,347 hectares in size. It was once part of the Avoca-Para holding and became a nature reserve after the western lands lease for the property expired (DECC 2008). The most significant feature of the reserve is Nearie Lake, which comprises approximately 2,140 ha (44%) of the reserve.

The NSW National Parks and Wildlife Service manages the Nearie Lake Nature Reserve according to the following objectives:

- The protection and restoration of natural river flows in the Great Anabranch of the Darling River and Darling River systems.
- To maintain as far as possible natural flow regimes in and out of the lake to protect wetlands and waterbird breeding areas in the reserve.
- The protection of aquatic and terrestrial plants and animals.
- The protection of Aboriginal burial sites and potential megafauna sites.
- The provision of opportunities for scientific research and environmental education use which are compatible with the conservation of the area.

According to the NPWS (2007), the site also supports a number of natural and cultural heritage values, such as:

- Landform, geology and soils indicative of the southern end of the Darling Riverine Plains Region;
- Five vegetation communities, including the threatened species Menindee nightshade (*Solanum karsense*);
- Significant habitat for waterbirds and other native fauna; and
- Aboriginal and non-Aboriginal cultural heritage.

Threats to these values include introduced plants and animals, presence of introduced fish species, degradation of the riparian zone, and inappropriate fire management regimes, but the most significant threat is alteration of the natural wetting and drying flow regime of the Darling Anabranch and associated lakes (DECC 2008).

Hydrological condition

Nearie Lake is ephemeral, and only fills after moderate to major flooding of the Darling Anabranch. This occurs approximately one or two times every seven to ten years (DECC 2008). Irish (1993) investigated the historic flooding regime of Nearie Lake. This study assumed that major flooding occurred in Nearie Lake when 500 GL passed Wycot. Using this threshold, it was estimated that between 1864 and 1993 significant flows in to Nearie Lake would have occurred naturally on 14 occasions (about 1 in 10 years on average) and supplementary flooding in succeeding year (or years) would have occurred on about half of these occasions (Irish 1993).

The natural flow regime at Nearie Lake was first altered in 1869 when dams, blockbanks and channels were first constructed in the Darling Anabranch. However, implementation of the Menindee Lakes Scheme the 1960s and the introduction of regular managed flows down the Darling Anabranch, created the biggest deviation from natural flows in Nearie Lake (DECC 2008).

Due to its downstream location, Nearie Lake is one of the last Lakes to fill as the Darling Anabranch floods. Flows into the lake can be regulated by a structure on Stoney Creek, however the structural integrity of this regulator is uncertain. Water levels in the Anabranch in this region can be manipulated by the operation of Dam 183. The regulator, and operation of Dam 183, can be used to direct water into Nearie Lake at lower flows, however they both impede the natural flow of floods into and out of the lake.

Nearie Lake received flows in the 2010-11 water year, and filled to about 85 per cent capacity (pers. comm. Sascha Healey NSW OEH 16/06/11). This inundation event did not reach the black box vegetation surrounding the Lake. Prior to this recent inundation event Nearie Lake had not received water since 1998. The site would benefit from additional water to fill it completely to inundate riparian vegetation.

Description of the environment

The Nearie Lake Nature Reserve consists of four main vegetation communities: lake bed herbland, lignum, blackbox woodland and shrubland (Llyod 1992). The ephemeral herbland occurs on the heavy clays around the foreshore of the lake, and follows the receding water line. Spiny lignum grows on the higher parts of the lake bed, and around the floodplain of Stoney Creek. This vegetation provides floodplain structure and provides shelter and breeding habitat for fish, when inundated. This community is less common on the other Darling Anabranch Lakes.

Black box woodland fringes the lake bed and also occurs on the Stoney Creek/Anabranch floodplain. The understorey is variable, and includes nitre goosefoot, spiny lignum and ruby saltbush. This woodland provides roosting and breeding habitat for waterbirds. Hollows in mature and dead trees provide nesting sites for ducks and parrots. The shrubland occurs beyond the dune boundary of the lake (Lloyd 1992) (DECC 2008).

While black box woodland is resilient to prolonged drought, to thrive, it must be flooded appropriately. Black box populations in good condition are generally found in areas flooded every one in three to ten years (Johns *et al.* 2009).

Black box condition monitoring at Nearie Lake was undertaken in early 2011. It was evident that much of the black box in the reserve has been under some stress, with many trees dying in the last two years (R. Enke OEH 12/07/2011). Given the extended period since Nearie Lake was last filled (1998), it is considered that if this community is not flooded in the next few years a significant portion of the trees could be lost (R. Enke (OEH)/Dr H McGinness (CSIRO) pers. comm. 12/07/2011).

Ecological significance

The Darling Anabranch and its lakes are a significant ephemeral wetland system and most of the Lakes are listed in the Directory of Important Wetlands in Australia (including Nearie Lake). Nearie Lake Nature Reserve is listed on the Register of National Estate and is the only protected area on the Darling Anabranch system (all other floodplain lakes in the system are privately owned, and are opportunistically cropped).

Nearie Lake also provides an important refuge for waterbirds as floodwaters dry up in the system (DECC 2007). Nearie Lake is one of the deepest lakes in the Darling Anabranch system (2-3 metres compared with 1-2 metres for the other lakes) and holds water for 3 to 4 years after flooding (DECC 2007).

Several NSW threatened species have been recorded at the site; including the freckled duck; black-breasted buzzard; brolga; pink cockatoo; redthroat and pied honeyeater. Additionally, a number of migratory bird species listed on international agreements have been recorded at the site, including great egret, glossy ibis, Capsian tern and common sandpiper (NPWS 2008). The Lake is also part of the endangered NSW Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River.

Lower Darling River

The Lower Darling River includes the river channel and adjacent billabongs and wetlands. The river extends from Menindee Lakes to its junction with the Murray River at Wentworth, approximately 500 km downstream. The total area of riverine and floodplain habitats associated with the Lower Darling River is approximately 1,400,000 hectares.

Hydrological environment

Operation of the Menindee Lakes Scheme has had the following impacts on flow in the Lower Darling River (Gippel and Blackham 2002):

- Seasonality has been altered, so that high flows now occur in summer;
- Winter flows are less variable: Flows in the range of 200-500 ML per day now occur more than 65 per cent of the time;
- Extraction upstream and capture of flows in the Menindee Lakes have resulted in the reduction in frequency and duration of small to medium floods:
    - Bank-full events (10,000 ML per day) are less frequent, and flows greater than bank-full occur less than 10 per cent of the time (compared to 25 per cent pre-regulation);
    - Floods that inundate high benches (15,000 ML per day) now occur in 30 per cent of years (compared to 60 per cent pre regulation);
    - A reduction in flows by 50 per cent; and
- Flows in summer are relatively constant to deliver South Australia’s entitlement flow, and there is a reduction in the number of days per year that the Lower darling ceases to flow.

This has resulted in (Gippel and Blackham 2002):

- Complex inchannel benches becoming eroded by constant regulated flows, and the habitat of these benches is reduced due to unseasonal inundation;
- A lack of macrophytes in the Lower Darling River, resulting from relatively constant flows;
- The health of the riparian and floodplain vegetation has been compromised by the reduction in flooding frequency, which has also reduced in input of organic matter into the river; and
- The fish assemblages in the Lower Darling River are relatively healthy; however fish movement, recruitment and recolonisation are adversely affected by flow barriers, constant flows and reduced access to floodplain habitat.

Water enters the Lower Darling River system from the Darling River, floodwaters also enter the system from Talyawalka Creek, which leaves the Darling River near Wilcannia and enters just downstream of Menindee (see Figure 1). The Menindee Lakes storage scheme, Weir 32 and Burtundy Weir, control flow in the Lower Darling River system (Jenkins *et al*. 2003).

Description of the environment

Wetland habitat in the Lower Darling River comprises deep oxbow lagoons and channel benches. Low-floodplain billabongs along the Darling River flood frequently (1 in 2-3 years), are deep (1-2 m), support river red gum woodland, and provide aquatic habitat for periods of 6-24 months after flooding (Green *et al*. 1998). These oxbow billabongs occur throughout the system, but are especially prevalent in the Pooncarie area. The large area of highly connected, high quality habitat with riparian vegetation and snags are generally intact and in good condition provides habitat for a range of riparian vegetation, fish, macroinvertebrates and waterbirds known to use arid river system in-channel and floodplain habitats. Macroinvertebrate communities in the Lower Darling River are reported to have not been affected by river regulation (Gippel and Blackham 2002).

The Lower Darling River supports a diverse native fish community with a robust population of Murray cod (listed as vulnerable under the EPBC Act), a remnant population of silver perch (listed as vulnerable under the *Fisheries Management Act* 1994), and a remnant population of freshwater catfish (listed as endangered under the *Fisheries Management Act* 1994). Monitoring of fish species in the Lower Darling River System since 2004 recorded 14 different native species. An additional 11 species have been recorded historically in this area (see Appendix E).The Murray cod population is considered to be one of the more robust populations (in terms of age structure) in the lower Murray-Darling Basin (C Sharp 2009, pers. comm., in MDBA 2010). Unlike the Murray River, the Darling River has predominately native fish fauna (Gippel and Blackham 2002).

Fish monitoring during high flow events in the southern Murray-Darling Basin during 2010-11 suggested that the Darling River was a significant area for fish recruitment, compared to the Murray River system. This was likely due to poor water quality in the Murray system (S. Jaensch pers. comm. 29/06/2011).

The long-term condition of the Lower Darling River is considered poor (Sustainable Rivers Audit). However, the river experienced high flows and flooding throughout summer 2010-11, which has contributed to a short- to medium-term improvement in condition.

Ecological significance

The entire Lower Darling River system was identified as a hydrologic indicator site by the Murray-Darling Basin Authority (MDBA) in the Guide to the Proposed Basin Plan (2010) as the site meets three of MDBA's five key environmental asset criteria. The Lower Darling River is noted specifically for providing feeding and roosting sites for waterbirds (MDBA 2010).

The Lower Darling River supports: several species listed in international agreements; an endangered ecological community (NSW Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River); and threatened species listed under the EPBC Act, the NSW *Fisheries Management Act* 1994 and the NSW *Threatened Species Conservation Act* 1995. A list of these species is provided at Appendix E.

There are records for 21 bird, 2 mammal, 1 reptile, 4 plant amd 3 bat species, and 1 endangered ecological community listed under the NSW *Threatened Species Conservation Act* 1995 in the Menindee Lakes and Lower Darling River (NSW threatened species search engine accessed 26/07/2011).

The Lower Darling River provides habitat that may or is likely to support: 3 bird; 2 fish, 1 frog, 1 bat and 5 plant threatened species listed under the EPBC Act. Additionally, the area may, or is likely to, provide habitat for 8 migratory bird species. These species are provided at Appendix E.

The Lower Darling River region may also support the following Commonwealth listed endangered ecological communities: Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions; and the Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions. However, the later has not been recorded in the area (refer to http://www.environment.gov.au/biodiversity/threatened/communities/maps/murray-darling-buloke.html, and Earth Tech 2004).

The river also provides secure drought refuge for a suite of flora and fauna in the lower reaches where water is backed up from Wentworth Weir (Lock 10). The wetlands on the Lower Darling provide habitat for waterbirds that links upper NSW/QLD to the lower parts of the Basin, which is important for the movement of species across the landscape (King and Green 1993).

Appendix B Criteria for Assessing Commonwealth Environmental Watering Actions

In undertaking its activities, the Commonwealth Environmental Water Holder (CEWH) is required to act consistently with the requirements of the *Water Act 2007* (Cwlth) (hereafter referred to as 'the Act'). The relevant functions are outlined in s.105. This includes a requirement that the environmental water holdings are managed in accordance with the environmental watering plan of the Murray-Darling Basin Authority (MDBA). Close consultation is occurring with the MDBA to ensure that use of Commonwealth water is consistent with the emerging objectives of the environmental watering plan that is currently being developed.

A long-term framework for the prioritisation of environmental water allocations has been prepared in consultation with delivery partners, interested stakeholders and experts, and the Environmental Water Scientific Advisory Committee.

The framework includes ecological objectives that will change under the different water availability scenarios (i.e. extreme dry, dry, median, wet). Proposed watering actions will need to be supported by available evidence, and consistent with current water availability scenarios and the framework.

Commonwealth environmental water is being acquired to supplement existing flows. Proposals for use of the water will not be agreed to if this use substitutes for other water uses, including historical system operations (e.g. provision of water for conveyance, stock and domestic, or planned environmental water).

Through adaptive management processes, the CEWH will consider opportunities for a more informed and diverse range of water uses as knowledge and modelling. All 2011-12 proposals will be assessed against the following criteria:

1. **Ecological significance of the asset(s)**

Issues to be considered will include:

- the presence of threatened species and ecological communities, and listed migratory species; and
- ecological and conservation values of the assets(s) including those recognised by international agreements.

2. **Expected ecological outcomes from the proposed watering action**

Issues to be considered will include:

- how well defined and realistic the objectives are for the proposed watering action;
- the consistency of these objectives with the overall CEWH ecological objectives for the current forecast water availability scenario;
- the current health of the asset(s);
- the improvement in health of the asset(s) expected from the watering action;

- the Basin-wide significance of the ecological response from the watering action;
- any secondary environmental effects expected to result from the watering action (e.g. connected system benefits); and
- the change in the health of the asset(s) expected if environmental water is not provided.

3. Potential risks of the proposed watering action at the site and at connected locations

Issues to be considered will include:

- how thoroughly the potential risks have been assessed for the proposed watering;
- the adequacy of measures proposed to minimise these risks; and
- the likelihood and consequence of variance from the expected ecological outcome (including negative impacts on biota and water quality).

4. Long-term sustainability of the asset(s) including appropriate management arrangements

Issues to be considered will include:

- the adequacy of long-term management and delivery arrangements;
- the existence of complementary natural resource management activities supporting the long-term management arrangements, including those that improve water quality; and
- the effectiveness of monitoring, evaluation and reporting arrangements for the watering activity including clear links to the defined objectives.

5. Cost effectiveness and operational feasibility of undertaking the watering

Issues to be considered will include:

- the amount of Commonwealth water and resources needed, including relative to the contribution of the State and delivery partner to (i) the watering event and (ii) subsequent monitoring of actions and outcomes;
- opportunity to supplement natural flows or other water releases; and
- the operational feasibility of undertaking the watering action (e.g. channel capacity, infrastructure constraints, etc).

Appendix C Assessment of Watering Options against the CEWH's criteria for assessing the use of Commonwealth water

Great Darling Anabranch
1. Ecological significance of the asset(s)
The Darling Anabranch is the ancestral path of the Darling River, and is important for biodiversity within the arid landscape of western NSW. The entire Lower Darling River system (including the Darling Anabranch) is identified as a hydrologic indicator site (MDBA 2010), and the site meets three of MDBA's five key environmental asset criteria. The associated Darling Anabranch Lakes are recognised in the Directory of Important Wetlands of Australia and are primarily fed by the Darling Anabranch channel. The Darling Anabranch supports: several species listed in international agreements; an endangered ecological community (NSW Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River); and threatened species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the NSW *Fisheries Management Act* 1994 and the NSW *Threatened Species Conservation Act* 1995. A list of these species is provided at Appendix E. Numerous water-dependent fauna have been observed in the Darling Anabranch during recent flow events (late 2010 through to mid 2011). White-necked heron and pink-eared duck were recorded nesting in Darling Anabranch habitats. Several species of native fish were also recorded with possible evidence of recruitment (including golden and spangled perch[8]). The wetlands in the Lower Darling region provide habitat for waterbirds that links upper NSW/QLD to the lower parts of the Basin, which is important for the movement of species across the landscape (King and Green 1993). Deeper pools and lagoons in the Darling Anabranch are noted as drought refuge (MDBA 2010).
2. The expected ecological outcomes from the proposed watering action
The Darling Anabranch received flows (estimated to be above 300,000 ML) in the 2010-11 water year (between September and April 2011), but experienced drought conditions for several years prior to this. Before receiving a minor flow earlier in 2010, the Anabranch had not flowed since 2002. Overall, mature river red gums, black box and lignum were considered stressed when surveys were undertaken in October 2010, and the understorey was considered in reasonable condition (this is likely because stock watering points have been established away from the riparian zone, enabling the understorey to recover). During March and April 2011 black box, river red gums and lignum had responded to the environmental flows with new growth and flowering (pers. comm. Sascha Healey NSW OEH 15/06/11). It is expected that the proposed watering will continue to restore the health of vegetation. The Darling Anabranch is expected to benefit from watering to follow up flows received in 2010-11. Through flows will facitate the movement of fish recruits between Lake

[8] Spangled perch are not common in the Lower areas of the Murray-Darling Basin (Lintermans 2009); however, they have moved into the Lower Darling system with the floodwaters received during 2010-11.

Great Darling Anabranch

Cawndilla and the Lower Murray River. As the Darling Anabranch had not received water in such a long period prior to flows in 2010-11, it expected that follow-up watering will consolidate improvement in vegetation health. Historically, flooding the Lower Darling occurred in a variable pattern. Typically flooding occurred in winter and spring following winter rainfall in central and north eastern NSW, however, flooding also occurred in autumn after summer monsoon rainfall in Queensland. Additionally, flooding typically occurred in clusters of 2-3 years. Thus, providing water in 2011-12, following the high season just experienced is not different to what would have occurred naturally in this system.

It is expected an environmental flow in the system would: encourage movement and recruitment of native fishes; improve the health of drought stressed vegetation communities, particularly riparian river red gum; provide yabbies an opportunity to move and recruit; and provide breeding and foraging habitat for a range of terrestrial and amphibious fauna such as woodland birds and frogs. A secondary environmental outcome is the benefits arising from hydrological connectivity between the Menindee Lakes and the Murray River, such as carbon exchange, improved recreational value, and increased water volumes available to downstream sites (e.g. the Lower Lakes).

If environmental water is not provided, the opportunity to capitalise on the benefit from high flows in 2010-11 would be missed. It is considered by several researcher and managers that the benefits of inundation ramp up over entrained runs of two to three years of bigger than average river flows and flooding (Puckridge *et al.* 2000; Mike Harper, SA DEH, Berri; Dr Mike Maher, NSW DECC, Queanbeyan; Dr S.V. Briggs, NSW DECC, Gungahlin). Additionally, the benefits of repeat watering on stressed river red gums has been observed at discrete watering sites on the Chowilla floodplain. When water was applied in multiple years the decline in health of trees was reduced (proposal from DWLBC to the Commonwealth for environmental water, 2009).

An environmental flow for the Darling Anabranch would assist with the ecological rejuvenation of a large and significant part of the Murray-Darling Basin, particularly for fish and waterbirds. The watering option will contribute to maintaining refuge and breeding habitat for a range of aquatic and terrestrial flora and fauna, facilitating optimum possible conditions for movement, recruitment and recolonisation.

End-of-system flows in the Darling Anabranch contribute flows to the Murray River and physically link the lower Murray River with the Menindee Lakes system. Watering options in the Darling Anabranch will also provide conditions suitable for delivering managed flows to Nearie Lake Nature Reserve.

The proposed water options have the following objectives:

- Support the survival of river red gum, black box and macrophyte seedlings that germinated in response to floods in the 2010-11 water year;
- Improve water quality in the system, by providing a ‘fresh’;
- Support fish movement and transfer of energy, nutrients and micro-organisms between the Darling Anabranch and Murray River;
- Promote natural riverine processes, such as biofilm scouring, and recreation of scour holes; and
- Maintain aquatic habitat for yabbies, waterbirds and frogs.

Preliminary responses from the 2010-11 flows in the Anabranch indicate that objectives identified above are realistic. The responses reported so far include: an increasing diversity of bird species in the area, with some opportunistic breeding observed; fish migration and potential recruitment; several frog species utilising the habitat including tree frogs (*Litoria peronii* and *L. caerulea*) and ground frogs (*Limnodynastes spp.*, *Notoden benetii* and *Crinia spp.*); and new growth and flowering of river red gum, black box and lignum. Golden perch have been recorded moving through the Darling Anabranch, and providing a pulse of water during their spawning period (around spring/early summer) is expected to trigger spawning (OEH 2011).

Great Darling Anabranch

When watering options are being considered by the Commonwealth for implementation, the suitability of the watering objective in relation to the water availability scenarios and corresponding objectives as defined in the Commonwealth's Framework for Determining Environmental Watering Actions will be assessed.

3. The potential risks of the proposed watering action at the site and at connected locations

Preliminary identification of risks revealed the following potential issues:

- The water flow out of the Darling Anabranch into the Murray River may be of poor quality (including salinity, blackwater and blue-green algae). Water quality could be monitored by MDFRC and arrangements could be made to cease flow into the Murray if required. This can be controlled through the Oakbank regulator (located near the Darling Anabranch/Murray junction). Poor water quality as a result of a blue-green algae bloom may also be mitigated using the Lower Darling Environmental Contingency Allowance;
- Unauthorised diversions of environmental water may occur at some time by surrounding landholders. NOW could undertake additional compliance inspections along the Darling Anabranch to prevent these activities, and communication of the event with landholders should ensure there is awareness of the environmental flow;
- Third party impacts may include damage to infrastructure; and
- There is a small possibility that the water levels down the Darling Anabranch could be sufficient to meet commence to fill levels of some of the Darling Anabranch lakes, which may currently be used for cropping. This could occur due to faulty water control infrastructure. On ground officers could undertake compliance inspections and monitor and manage flow levels along the Darling Anabranch to treat this risk.

The Darling Anabranch is currently flowing after a long dry period, and would benefit from repeat watering this water year. Potential negative outcomes from a watering event include pest animal movement and breeding (e.g. common carp) and weed recruitment.

Risks will be reconsidered prior to implementation of a watering action in the Darling Anabranch.

4. The long-term sustainability of the asset(s) including appropriate management arrangements

The Darling Anabranch Pipeline and Environmental Flows Project management plan has resulted in the removal of in-stream structures and fencing off of the Darling Anabranch and installed alternative watering points, which has improved water flow and quality, and enabled the riparian vegetation to recover from grazing pressure. However, there is no longer a commitment to provide replenishment flows to the Darling Anabranch; it only receives water when natural flooding occurs in the Darling River. While the water savings from the pipeline were provided to the TLM for environmental watering, this water could be directed to any of the Icon sites, and therefore it may not be used in the Darling Anabranch.

The Darling Anabranch received environmental flows in October 2010 watering event (25,400 ML in total) comprising of contributions from NSW, TLM and water from Toorale entitlements directed by the CEWH. The entire Lower Darling River system (including the Darling Anabranch) is identified as a hydrologic indicator site (MDBA 2010). Complementary management activities are prescribed in the Lower Murray Darling CMA Catchment Action Plan, which includes targets based on riverine health, salinity and vegetation. A 10 year monitoring program has begun focusing on the Darling Anabranch which commenced in 2010. These factors indicate there is a long-term commitment to this area at a national, state and local level.

NSW OEH have engaged the MDFRC to monitor the environmental outcomes of flows as part of a ten year monitoring program associated with the Darling Anabranch Stock and

Great Darling Anabranch
Domestic Pipeline project (completed in 2009) (i.e. Wallace *et al*. 2009 *Darling Anabranch Adaptive Management Monitoring Plan: Condition and Intervention Monitoring Program*). MDFRC have been engaged for the first three years of the program which commenced late 2010. The monitoring includes parameters measuring the response of vegetation, groundwater and soils, fauna (such as fishes, frogs, invertebrates, and birds) and water quality. Monitoring and evaluation arrangements will be refined as watering options are considered for implementation.
5. The cost-effectiveness and operational feasibility of undertaking the watering
The watering actions in the Darling Anabranch are likely to involve significant contribution from delivery partners: Commonwealth environmental water could be used in conjunction with environmental water provided from NSW and TLM; OEH, State Water Corporation, NOW and Darling Anabranch landholders/Anabranch Water could potentially contribute to planning implementation of the watering options; and monitoring being undertaken by MDFRC could be utilised to measure outcomes of the watering events. Infrastructure is in place to enable delivery of water down the Darling Anabranch from Lake Cawndilla. Water will be gravity fed, and therefore is a cost effective method of delivery. Most regulatory structures on the Darling Anabranch have been removed, or are kept permanently open to allow flows to run unimpeded to the Murray River. There may be opportunities to piggyback natural high flows in the Darling River. As the Darling Anabranch is still wet from flows in 2010-11 there are likely to be minimal transmission losses, however, there is no policy enabling the recrediting/reuse of return flows. Releases of between 500-2,000 ML per day can be made from Lake Cawndilla and 1,400 ML per day at Packers Crossing regulator. Overbank flows in the Darling Anabranch are estimated to occur at 1,500 ML per day; flows from Packers Crossing could be managed to keep flows below this threshold. Usage fees in the Lower Darling regulated water source are $4.89/ML (State Water Corporation) and $0.90/ML (NOW).

Nearie Lake

1. The ecological significance of the asset(s)

The Darling Anabranch and its lakes are a significant ephemeral wetland system and most of the Lakes are listed in the Directory of Important Wetlands in Australia (including Nearie Lake). Nearie Lake Nature Reserve is listed on the Register of National Estate and is the only protected area on the Darling Anabranch system (all other floodplain lakes in the system are privately owned, and are opportunistically cropped).

Several NSW threatened species have been recorded at the site; including the freckled duck; black-breasted buzzard; brolga; pink cockatoo; redthroat and pied honeyeater. Additionally, a number of migratory bird species listed on international agreements have been recorded at the site. These include great egret, glossy ibis, Capsian tern and common sandpiper (NPWS 2008). The Lake is also part of the endangered NSW Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River.

Nearie Lake makes up approximately 2,140 hectares (44 per cent) of the reserve. This lake only fills after moderate to major flooding of the Darling Anabranch (typically two times every seven to ten years). Nearie Lake is one of the deepest lakes in the Darling Anabranch system (2-3 m compared with 1-2 m for the other lakes) and holds water for 3-4 years after flooding. As such Nearie Lake provides an important refuge for waterbirds as floodwaters dry up in the system. The deeper Darling Anabranch lakes are recognised as important drought refuges; and in period of drought in western NSW, deeper lakes in the Darling Anabranch retained water and provided habitat for water birds (MDBA 2010). Furthermore, the wetlands on the Lower Darling River system provide habitat for waterbirds that links upper NSW/QLD to the lower parts of the Basin, which is important for the movement of species across the landscape (King and Green 1993).

2. The expected ecological outcomes from the proposed watering action

Nearie Lake received flows in the 2010-11 water year (between September 2010 and April 2011), and filled to about 85 per cent capacity (pers. comm. Sascha Healey NSW OEH 16/06/11). Prior to this recent inundation event Nearie Lake had not been watered since 1998. The site would benefit from additional water to fill it completely to inundate riparian vegetation and continue to support fish movement/recruitment between the Lake, the Darling Anabranch and the Lower Murray River.

Improved growth and vigour of the riparian black box vegetation has been noted since the watering event in 2010-11, this is considered a short-term improvement. In the medium to long-term this community is considered at risk of dying without further watering which inundates the black box woodland in the riparian zone.

The watering option to fill Nearie Lake would inundate black box woodland in the riparian zone, and providing optimum opportunities for aquatic ecosystem processes, and improved foraging, refuge and breeding conditions for a suite of flora and fauna. Providing top-up flows to Nearie Lake will help to re-build the resilience of the system against drought, as before last year the site had not received water since 1998. If environmental water is not provided, the condition of Nearie Lake is expected to remain fair in the short- to medium-term, and decline in the long-term. This is because the current inundation levels are not sufficient to inundate riparian black box vegetation, which is stressed after a prolonged dry period.

Nearie Lake is significant within the Darling Anabranch, as it is the only one which is not cropped, and therefore supports natural lake functional processes. Nearie Lake is also the only lagoon in the Lower Darling River system which is protected for the conservation of waterbird habitat.

A secondary benefit of providing water to Nearie Lake is the flow in the Darling Anabranch (to Dam 183) necessary to deliver the water.

The watering option should be consistent with the following objectives:

Nearie Lake
• Maintain a key refuge; • Support the survival and recruitment of black box; • Support recruitment within macrophyte communities; • Support fish movement and transfer of energy, nutrients and micro-organisms between the Darling Anabranch and floodplain lake habitat; • Promote natural ephemeral lake processes; and • Maintain aquatic habitat for yabbies, waterbirds and frogs. When watering options are being considered by the CEWH for implementation, the suitability of the watering objective in relation to the water availability scenarios and corresponding objectives as defined in the Commonwealth's Framework for Determining Environmental Watering Actions will be assessed.
3. The potential risks of the proposed watering action at the site and at connected locations
Preliminary identification of risks revealed the following potential issues: • Unauthorised diversions of environmental water may occur at some time by surrounding landholders. NOW could undertake additional compliance inspections along the Darling Anabranch to prevent these activities, and communication of the event with landholders should ensure there is awareness of the environmental flow; • Release rates higher than 1,400 ML per day at Packers Crossing would cause some crossing structures to become inundated, and possible be damaged. Release levels should be held below this threshold; • There is a possibility that water levels in the Darling Anabranch may be sufficient to meet commence-to-fill levels of some of the other ephemeral lakes (due to faulty water control structures). On ground officers could undertake compliance inspections and monitor and manage flow levels along the Darling Anabranch to monitor and manage this risk; and • There is a low likelihood of variance from the expected ecological outcome. The Darling Anabranch is currently flowing, and Nearie Lake is wet. After such a long dry period these areas would benefit from repeat watering this water year to help restore the health and resilience of the system. Potential negative outcomes from a watering event include pest animal movement and breeding (e.g. common carp) and weed recruitment. Risks will be assessed as watering options are prepared for implementation.
4. The long-term sustainability of the asset(s) including appropriate management arrangements
Nearie Lake is situated in Nearie Lake Nature Reserve, which is managed by the NSW NPWS for conservation purposes according to the Nearie Lake Nature Reserve Plan of Management. Complementary natural resource management activities conducted by NSW NPWS at the site include feral animal control programs, soil and water conservation actions and fire management. The Darling Anabranch received environmental flows in October 2010 watering event (25,400 ML in total) comprising of contributions from NSW, TLM and water from Toorale entitlements directed by the CEWH. The entire Lower Darling River system (including Nearie Lake) is identified as a hydrologic indicator site by the Murray-Darling Basin Authority (MDBA) in the Guide to the Proposed Basin Plan (2010). Complementary management activities are prescribed in the Lower Murray Darling CMA Catchment Action Plan, which

Nearie Lake
includes targets based on riverine health, salinity and vegetation. These factors and activities indicate there is a long-term commitment to this particular site and the system that feeds it. NSW NPWS could undertake event monitoring at Nearie Lake, with a focus on waterbirds, frogs and vegetation condition and response. NOW could also contribute to operational monitoring by conducting an audit of hydrometric data. Monitoring and evaluation arrangements will be refined as watering options are considered for implementation.
5. The cost-effectiveness and operational feasibility of undertaking the watering
Watering Nearie Lake is likely to involve contribution from other external stakeholders: Commonwealth environmental water could be used in conjunction with environmental water provided from other sources; OEH, State Water, NOW, NSW NPWS and local land holders could all contribute to implementation of the watering options; and the pre-existing monitoring being undertaken by MDFRC could be utilised to measure outcomes of the watering event (in the Darling Anabranch – Nearie Lake cannot be watered without watering the Anabranch). Water will be gravity fed, and therefore is a cost effective method of delivery. Infrastructure is in place to enable delivery of water down the Darling Anabranch from Lake Cawndilla to Dam 183, where it will pool and spill into Stony Creek which flows into Nearie Lake. There is a regulator on Stony Creek that can control inundation of the Lake. However, Stony Creek regulator is only partially functional (one of the two culverts in the earthern bank is broken and cannot be opened), which may impair delivery of water to Nearie Lake. The arrangements necessary to utilise these works (Stony Creek regulator and Dam 183), and also the accounting arrangements to trade water from the regulated water source into the unregulated water source need to be further investigated before watering can occur. Managing an environmental flow to Nearie Lake would require consultation with local landholders (along with NOW and OEH). As the Darling Anabranch is still wet from flows in 2010-11 there are likely to be minimal transmission losses as water travels to Dam 183. Additional water would be required to let water pool behind the structure and fill Nearie Lake, however after filling this can be released to benefit the Darling Anabranch downstream of the Dam. There is no policy enabling the recrediting/reuse of return flows. Releases of between 500-2,000 ML per day can be made from Lake Cawndilla and 1,400 ML per day at Packers Crossing regulator. Overbank flows in the Darling Anabranch are estimated to occur at 1,500 ML per day; thus flows from Packers Crossing could be managed to keep flows below this threshold. Usage fees in the Lower Darling regulated water source are \$4.89/ML (State Water Corperation) and \$0.90/ML (NOW).

Lower Darling River

1. The ecological significance of the asset(s)

The Lower Darling River supports: several species listed in international agreements; an endangered ecological community (NSW Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River); and threatened species listed under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act), the *NSW Fisheries Management Act* 1994 and the NSW *Threatened Species Conservation Act* 1995. A list of these species is provided at Appendix E. The entire Lower Darling River system was identified as a hydrologic indicator site by the Murray-Darling Basin Authority (MDBA 2010). The site meets three of MDBA's five key environmental asset criteria. The Lower Darling River is noted specifically for providing feeding and roosting sites for waterbirds (MDBA 2010).

The large area of highly connected, high quality habitat with riparian vegetation and snags generally intact and in good condition provides habitat for a range of riparian vegetation, fish, macroinvertebrates and waterbirds known to use arid river system in-channel and floodplain habitats. The river also provides secure drought refuge for a suite of flora and fauna in the lower reaches where water is backed up from Wentworth Weir (Lock 10). The wetlands on the Lower Darling provides habitat for waterbirds that links upper NSW/QLD to the lower parts of the Basin, which is important for the movement of species across the landscape (King and Green 1993).

The Lower Darling River supports a diverse native fish community, including a population of Murray cod (listed as vulnerable under the EPBC Act), a remnant population of silver perch (listed as vulnerable under the *Fisheries Management Act* 1994), and a remnant population of freshwater catfish (listed as endangered under *the Fisheries Management Act* 1994). The Murray cod population is considered to be one of the more robust populations (in terms of age structure) in the lower Murray-Darling Basin (C Sharp 2009, pers. comm., in MDBA 2010). Monitoring of fish populations flowing high flow events in the southern Murray-Darling Basin during 2010-11 has shown the Darling River was the significant area for fish recruitment compared to other part of the system. This was likely due to poor water quality in the Murray system (S. Jaensch pers. comm. 29/06/2011). Unlike the Murray River, the Darling River has predominately native fish fauna (Gippel and Blackham 2002).

2. The expected ecological outcomes from the proposed watering action

The hydrology of the Lower Darling River has been heavily modified by operation of the Menindee Lakes Scheme. The seasonality of flows has been reversed, winter flow variability has been reduced, and the frequency of high flows has been reduced (MDBA 2010). Volumes in the River have also been reduced by 50 per cent (Thoms *et al*. 2000 in MDBA 2010). These changes have reduced the health of fish populations in the river, affected the health of river red gum riparian vegetation, and potentially reduced the supply of leaf litter and organic matter transported into the main channel ecosystem (Thoms & Sheldon 1997 in MDBA 2010). The long-term condition of the Lower Darling River is considered poor (Sustainable Rivers Audit). However, the river experienced high flows and flooding throughout summer 2010-11, which has contributed to a short- to medium-term improvement in condition.

Watering options in 2011-12 will: capitalise on recent natural watering events in the system; support the health of riparian vegetation and improved habitat conditions for a suite for flora and fauna; provide additional habitat for instream biota; create opportunities for fish movement and breeding. River red gum on higher benches (inundate at flows above 15,000 ML per day, measured at Weir 32) are not receiving adequate inundation frequency following river regulation (Green *et al.* 2003). An environmental flow for the Lower Darling River would promote connectivity between the Menindee Lakes system and the Murray River, affording aquatic fauna the opportunity to move widely throughout the lower and upper reaches of the Darling River. Environmental water delivered to the Lower Darling River would provide secondary benefits downstream by transporting nutrients and carbon, boosting primary production.

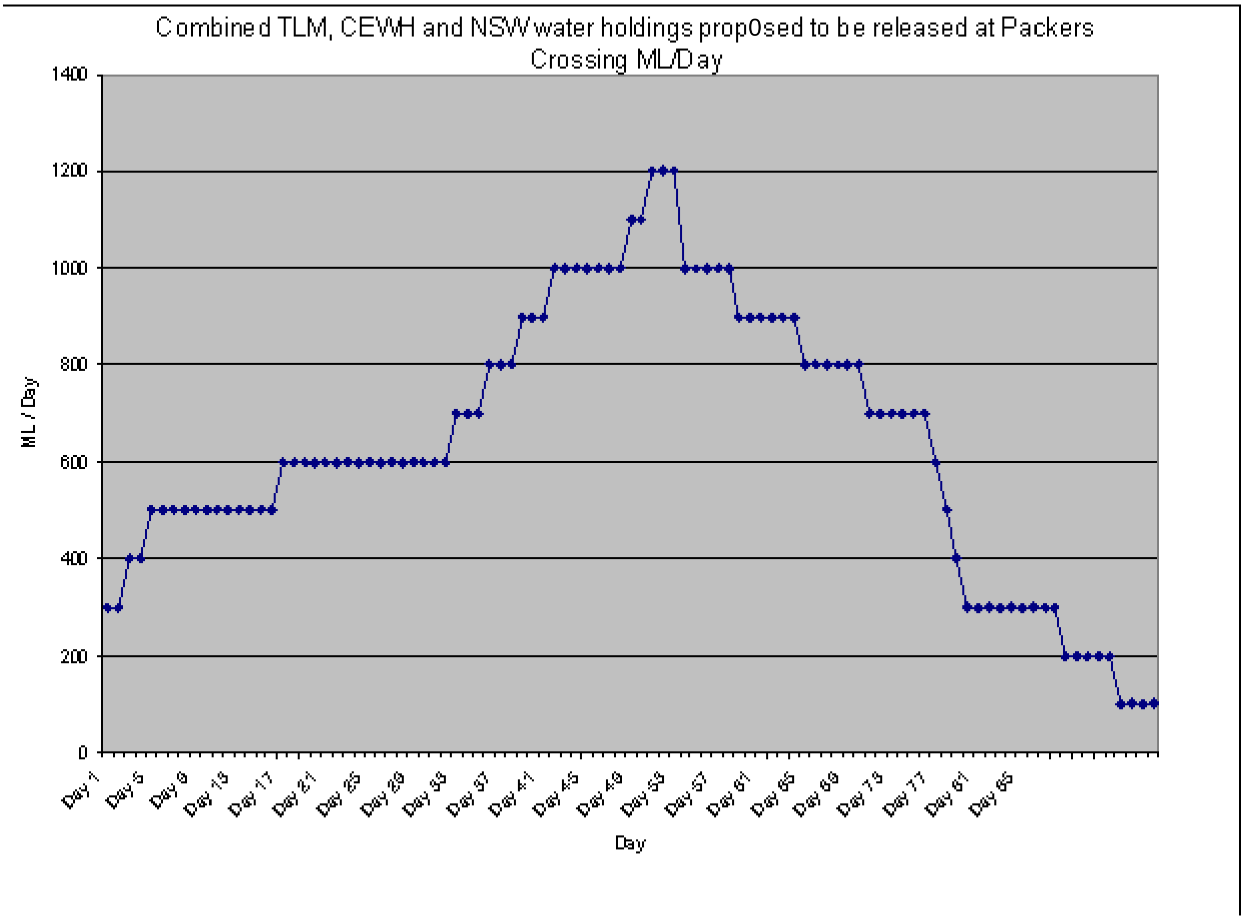
Lower Darling River

The proposed water options have the following objectives:
If environmental water is not provided, the condition of the Lower Darling River system is expected to remain good in the short- to medium-term, and continue to decline in the long-term.
• To improve flow variability in the Lower Darling River, by using environmental water to providing freshes, longer periods of high flow, and manage recession of floods. Variation in flow may provide:
  ○ triggers for breeding and latitudinal and longitudinal movement of fish in the system, ultimately resulting in improved age structure of fish populations in the system;
  ○ opportunities for recruitment of vegetation communities and improve the health of vegetation, particularly river red gums in the riparian zone. Improved riparian vegetation conditions will also provide habitat for other plant and animal species;
  ○ and support instream habitat diversity; and
  ○ invertebrates with an opportunity to move and breed, thereby providing further food production for fish, birds and large invertebrates.
When watering options are being considered by the Commonwealth for implementation, the suitability of the watering objective in relation to the water availability scenarios and corresponding objectives as defined in the Commonwealth's Framework for Determining Environmental Watering Actions will be assessed.

3. The potential risks of the proposed watering action at the site and at connected locations
No formal risk assessment has been conducted. Preliminary identification of risks revealed the following potential issues: • Unauthorised diversions of environmental water may occur at some time by surrounding landholders. NOW could undertake compliance inspections along the Lower Darling River to prevent these activities; and There is a low likelihood of variance from the expected ecological outcome. The Lower Darling River has recently experience high flow conditions after a long drought period, and would benefit from repeat watering this water year. Potential negative outcomes from a watering event include pest animal movement and breeding (e.g. common carp) and weed recruitment. Risks will be assessed as watering options are prepared for implementation.
4. The long-term sustainability of the asset(s) including appropriate management arrangements
Long-term management and delivery arrangements are well-established, with flows routinely delivered from Menindee Main Weir and Weir 32 to the Murray River via the Lower Darling River. The entire Lower Darling River system (including the Darling Anabranch) is identified as a hydrologic indicator site by the Murray-Darling Basin Authority (MDBA) in the Guide to the Proposed Basin Plan (2010). Complementary management activities are prescribed in the Lower Murray Darling CMA Catchment Action Plan, which includes targets based on riverine health, salinity and vegetation. These factors indicate there is a long-term commitment to this area at a national, state and local level. NSW Department of Primary Industries and Lower Murray-Darling Catchment Authority have undertaken fish monitoring in the Lower Darling since 2004 (Gilligan 2010). This program could provide a useful basis for monitoring the use of environmental water in this area. Monitoring and evaluation arrangements will be refined as watering options are

Lower Darling River
considered for implementation.
5. The cost-effectiveness and operational feasibility of undertaking the watering
Watering actions in the Lower Darling River by the Commonwealth would likely involve contribution from other stakeholders: Commonwealth environmental water could be used in conjunction with environmental water provided from NSW and TLM; and OEH, State Water Corporation and NOW are also likely to contribute to implementation of watering actions. The watering option is operationally feasible. Water will be gravity fed, and therefore is a cost effective method of delivery. The water would be delivered out of Menindee Main Weir (or from the outlets on the Menindee Lakes), and flow down the Darling River past Weir 32, and Pooncarie and Burtundy Weirs. Transmission losses are highly variable in the Lower Darling River and depend on antecedent conditions, flow rates and whether the river is rising or falling. Indicative transmission losses from Weir 32 to Burtundy Weir are: • Very low flows (up to 200 ML per day) – 45%; • Low flows (around 500 ML per day) – 30-35%; • Medium flows (7000 ML per day) – 30%; • High flows (17000 ML per day) – 25-30%; and • Very high flows (35000 ML per day) – 45-55%. Usage fees in the Lower Darling are $4.89/ML (State Water Corperation) and $0.90/ML (NOW).

Appendix D Proposed hydrograph of delivery of water through the Darling Anabranch in 2011-12 based on 62,000 GL (OEH 2011)



Appendix E Species of conservation significance in the Lower Darling River System

Fish species recorded in the Lower Darling River System

Table A: The change in the abundance of species recorded in the Lower Darling River System between surveys in 2004, 2009 and 2010 (Gilligan 2010) (* denotes a statistically significant change in abundance).

Species	EPBC Act status	NSW Status	Change between 2004 and 2010	Change between 2009 and 2010
Eastern mosquito fish			2167% increase*	21% decrease
Silver perch		Vulnerable	967% increase*	54% increase
Unspecked hardyhead			421% increase*	1% increase
Bony herring			349% increase*	759% increase*
Goldfish (alien)			184% increase*	227% increase*
Common carp (alien)			83% increase*	101% increase*
Murray cod	Vulnerable		81% increase*	55% increase
Golden perch			78% increase*	115% increase*
Murray hardyhead	Vulnerable	Critically endangered	No change	No change
Carp-gudgeon species complex			33% decrease	245% increase
Australian smelt			45% decrease	8% increase
Murray-Darling rainbow fish			61% decrease	21% decrease
Redfin perch (alien)			75% decrease	No change
Flat-headed gudgeon			78% decrease	90% decrease
Freshwater catfish			86% decrease	50% increase
Spangled perch			Increase*	Increase*
Dwarf flat-headed gudgeon			Increase	Increase

Historic records: The following species have not been sampled in surveys between 2004-2010, however have been recorded in the Lower

Darling previously (Gilligan 2010)				
Brown trout (alien -Murray only)				
Congoli (vagrant)				
Flat-headed galaxias				
Hyrtl's tandan (vagrant Darling only)				
Macquarie perch	Endangered	Endangered		
Murray hardyhead	Vulnerable	Critically endangered		
Olive perchlet		Endangered population		
Short-headed lamprey				
Southern purple spotted gudgeon		Endangered		
Southern pygmy perch		Endangered		
Spotted galaxias (alien)				
Tench (alien)				
Trout cod	Endangered	Endangered		

Table B: Darling Anabranch Threatened and Migratory Species Records (excludes fish).

Species	**Scientific name**	**Status NSW**	**EPBC Act**
Birds			
Australasian Bittern	*Botaurus poiciloptilus*	Endangered	
Australian Bustard	*Ardeotis australis*	Endangered	
Barking Owl	*Ninox connivens*	Vulnerable	
Bar-Tailed Godwit	*Limosa lapponica*		Migratory (Bonn; CAMBA; JAMBA; ROKAMBA)
Black-Breased Buzzard	*Hamirostra melanosternon*	Vulnerable	
Black-Tailed Godwit	*Limosa limosa*		Migratory (Bonn; CAMBA; JAMBA; ROKAMBA)
Black-Eared Miner	Manorina melanotis	Critically Endangered	Endangered
Blue-Billed Duck	*Oxyura australis*	Vulnerable	
Brolga	*Grus rubicunda*	Vulnerable	
Bush Stone-Curlew	*Burhinus grallarius*	Endangered	
Capsian Tern	*Sterna caspia*		Migratory (CAMBA; JAMBA)
Chestnut Quail-Thrush	*Cinclosoma castanotus*	Vulnerable	
Clamorous Reed-Warbler	*Acrocephalus stentoreus*		Migratory (Bonn)
Common Greenshank	*Tringa nebularia*		Migratory (Bonn; CAMBA; JAMBA; ROKAMBA)
Common Sandpiper	*Actitis hypoleucos*		Migratory (Bonn; CAMBA; JAMBA; ROKAMBA)
Curlew Sandpiper	*Calidris ferruginea*		Migratory (Bonn; CAMBA; JAMBA; ROKAMBA)
Double-Banded Plover	*Charadrius bicinctus*		Migratory (Bonn)
Eastern Curlew	*Numenius madagascariensis*		Migratory (Bonn; CAMBA; JAMBA; ROKAMBA)
Fork-Tailed Swift	*Apus pacificus*		Migratory (CAMBA; JAMBA; ROKAMBA)
Freckled Duck	*Stictonetta naevosa*	Vulnerable	
Glossy Ibis	*Plegadis falcinellus*		Migratory (Bonn; CAMBA)
Grass Owl	*Tyto capensis*	Vulnerable	
Great Egret	*Egretta alba*		Migratory (CAMBA; JAMBA)
Grey Falcon	*Falco hypoleucos*	Endangered	
Grey Plover	*Pluvialis squatarola*		Migratory (Bonn; CAMBA; JAMBA; ROKAMBA)
Little Eagle	*Hieraaetus morphnoides*	Vulnerable	
Latham's Snipe	*Gallinago hardwickii*		Migratory (Bonn; CAMBA; JAMBA; ROKAMBA)
Lesser Sand Plover	*Charadrius mongolus*	Vulnerable	Migratory (Bonn; CAMBA; JAMBA; ROKAMBA)
Little Curlew	*Numenius minutus*		Migratory (Bonn; CAMBA; JAMBA; ROKAMBA)
Long-Toed Stint	*Calidris subminuta*		Migratory (Bonn; CAMBA; JAMBA; ROKAMBA)
Magpie Goose	*Anseranas semipalmata*	Vulnerable	
Major Mitchell's Cockatoo	*Cacatua leadbeateri*	Vulnerable	
Malleefowl	*Leipoa ocellata*	Endangered	Vulnerable
Marsh Sandpiper	*Tringa stagnatilis*		Migratory (Bonn; CAMBA; JAMBA; ROKAMBA)
Pectoral Sandpiper	*Calidris melanotos*		Migratory (Bonn; JAMBA; ROKAMBA)
Pied Honeyeater	*Certhionyx variegatus*	Vulnerable	
Rainbow Bee-Eater	*Merops ornatus*		Migratory (JAMBA)
Red-Necked Stint	*Calidris ruficollis*		Migratory (Bonn;

			CAMBA;JAMBA;ROKAMBA)
Red-Tailed Black Cockatoo	*Calyptorhynchus banksii samueli*		Vulnerable
Redthroat	*Pyrrholaemus brunneus*	Vulnerable	
Regent Parrot	*Polytelis anthopeplus monarchoides*	Endangered	Vulnerable
Ruddy Turnstone	*Arenaria interpres*		Migratory (Bonn; CAMBA; JAMBA; ROKAMBA)
Sanderling	*Calidris alba*	Vulnerable	Migratory (Bonn; CAMBA; JAMBA)
Satin Flycatcher	*Myiagra cyanoleuca*		Migratory (Bonn)
Sharp-Tailed Sandpiper	*Calidris acuminata*		Migratory (Bonn; CAMBA; JAMBA; ROKAMBA)
Spotted Harrier	*Circus assimilis*	Vulnerable	
Square-Tailed Kite	*Lophoictinia isura*	Vulnerable	
Whimbrel	*Numenius phaeopus*		Migratory (Bonn; CAMBA; JAMBA; ROKAMBA)
White-Bellied Sea-Eagle	*Haliaeetus leucogaster*		Migratory (CAMBA)
White-Fronted Chat	*Epthianura albifrons*	Vulnerable	
White-Throated Needletail	*Hirundapus caudacutus*		Migratory (JAMBA; CAMBA ROKAMBA)
White-Winged Black Tern	*Chlidonias leucopterus*		Migratory (CAMBA; JAMBA; ROKAMBA)
Mammals			
Kultarr	*Antechinomys laniger*	Endangered	
Southern Ningaui	*Ningaui yvonneae*	Vulnerable	
Southern Hairy-Nosed Wombat	*Lasiorhinus latifrons*	Endangered	
Yellow-Bellied Sheathtail-Bat	*Saccolaimus flaviventris*	Vulnerable	
Little Pied Bat	*Chalinolobus picatus*	Vulnerable	
Inland Forest Bat	*Vespadelus baverstocki*	Vulnerable	
Greater Long-Eared Bat	*Nyctophilus timoriensis (South-eastern form)*	Vulnerable	Vulnerable
Amphibians			
Painted Burrowing Frog	*Neobatrachus pictus*	Endangered	
Southern Bell Frog	*Litoria raniformis*	Endangered	Vulnerable
Plants			
Aromatic Peppercress	*Lepidium hyssopifolium*	Endangered	
	Phyllanthus maderaspatanus	Endangered	
Purple-Wood Wattle	*Acacia carneorum*	Vulnerable	Vulnerable
Menindee Nightshade	*Solanum karsense*	Vulnerable	Vulnerable

This species list was created using a consolidated list of records presented in Jenkins (1999). This publication indicated which species were listed under NSW legislation at 1999. Additional NSW threatened species were identified using the NSW Wildlife Atlas (accessed through http://threatenedspecies.environment.nsw.gov.au/tsprofile) (species known to occur in the Darling Anabranch subregion). The records in Jenkins (1999) was checked against migratory species listed under the EPBC Act (as at 25/07/2011); and against the list of EPBC threatened species that may or are likely to occur in the area (EPBC Map search tool output from 19/07/2011).

Table C: NSW threatened species known to occur in the Lower Darling River (Menindee and Pooncarie-Darling CMA sub regions) (excludes fish).

Scientific Name	**Common Name**	**Status**
Chalinolobus picatus	Little Pied Bat	Vulnerable
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	Vulnerable
Vespadelus baverstocki	Inland Forest Bat	Vulnerable
Anseranas semipalmata	Magpie Goose	Vulnerable
Ardeotis australis	Australian Bustard	Endangered
Botaurus poiciloptilus	Australasian Bittern	Endangered
Burhinus grallarius	Bush Stone-curlew	Endangered
Cacatua leadbeateri	Major Mitchell's Cockatoo	Vulnerable
Calyptorhynchus banksii samueli	Red-tailed Black-Cockatoo (Inland subspecies)	Vulnerable
Charadrius mongolus	Lesser Sand-plover	Vulnerable
Circus assimilis	Spotted Harrier	Vulnerable
Epthianura albifrons	White-fronted Chat	Vulnerable
Falco hypoleucos	Grey Falcon	Endangered
Grus rubicunda	Brolga	Vulnerable
Hamirostra melanosternon	Black-breasted Buzzard	Vulnerable
Hieraaetus morphnoides	Little Eagle	Vulnerable
Limosa limosa	Black-tailed Godwit	Vulnerable
Lophoictinia isura	Square-tailed Kite	Vulnerable
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	Vulnerable
Ninox connivens	Barking Owl	Vulnerable
Oxyura australis	Blue-billed Duck	Vulnerable
Pachycephala inornata	Gilbert's Whistler	Vulnerable
Polytelis anthopeplus monarchoides	Regent Parrot (eastern subspecies)	Endangered
Stictonetta naevosa	Freckled Duck	Vulnerable
Antechinomys laniger	Kultarr	Endangered
Sminthopsis macroura	Stripe-faced Dunnart	Vulnerable
Lerista xanthura	Yellow-tailed Plain Slider	Vulnerable
Acacia loderi Shrublands	*Acacia loderi* shrublands	Endangered Ecological Community
Atriplex infrequens	A saltbush	Vulnerable
Calotis moorei	A burr-daisy	Endangered
Lepidium monoplocoides	Winged Peppercress	Endangered
Leptorhynchos waitzia	Button Immortelle	Endangered
Phyllanthus maderaspatanus	*Phyllanthus maderaspatensis*	Endangered
Solanum karsense	Menindee Nightshade	Vulnerable

Swainsona adenophylla	Violet Swainson-Pea	Endangered
Acacia carneorum	Purple-wood Wattle	Vulnerable

Table D: Species and ecological communities listed under the EPBC Act that may occur or are likely to occur in the Lower Darling River.

Species	Common Names	Status	Occurrence
ECOLOGICAL COMMUNITIES			
Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions		Endangered	Community may occur within area
BIRDS			
Amytornis textilis modestus	Thick-Billed Grasswren (Eastern) [59460]	Vulnerable	Species or species habitat likely to occur within area
Leipoa ocellata	Malleefowl	Vulnerable	Species or species habitat likely occur within area
Manorina melanotis	Black-Eared Miner	Endangered	Species or species habitat may occur within area
Polytelis anthopeplus monarchoides	Regent Parrot (Eastern)	Vulnerable	Species or species habitat likely occur within area
Rostratula australis	Australian Painted Snipe	Vulnerable	Species or species habitat likely occur within area
FISH			
Craterocephalus fluviatilis	Murray Hardyhead	Vulnerable	Species or species habitat likely to occur within area
Maccullochella peelii peelii	Murray Cod, Cod, Goodoo	Vulnerable	Species or species habitat may occur within area
FROGS			
Litoria raniformis	Growling Grass Frog, Southern Bell Frog, Green And Golden Frog, Warty Swamp Frog	Vulnerable	Species or species habitat likely to occur within area
MAMMALS			
Nyctophilus timoriensis (South-eastern form)	Greater Long-Eared Bat, South-Eastern Long-Eared Bat	Vulnerable	Species or species habitat may occur within area
PLANTS			
Acacia carneorum	Needle Wattle, Dead Finish, Purple-Wood Wattle	Vulnerable	Species or species habitat likely to occur within area
Swainsona pyrophila	Yellow Swainson-Pea	Vulnerable	Species or species habitat likely to occur within area

Swainsona murrayana	Slender Darling-Pea, Slender Swainson, Murray Swainson-Pea	Vulnerable	Species or species habitat likely to occur within area
Solanum karsense	Menindee Nightshade	Vulnerable	Species or species habitat likely to occur within area
Lepidium monoplocoides	Winged Pepper-Cress	Endangered	Species or species habitat likely to occur within area
Austrostipa metatoris		Vulnerable	Species or species habitat likely to occur within area
MIGRATORY SPECIES			
Apus pacificus	Fork-Tailed Swift		Species or species habitat may occur within area
Haliaeetus leucogaster	White-Bellied Sea-Eagle		Species or species habitat likely to occur within area
Hirundapus caudacutus	White-Throated Needletail		Species or species habitat may occur within are
Merops ornatus	Rainbow Bee-Eater		Species or species habitat may occur within are
Ardea alba	Great Egret, White Egret		Species or species habitat may occur within area
Ardea ibis	Cattle Egret		Species or species habitat may occur within area
Gallinago hardwickii	Latham's Snipe, Japanese Snipe		Species or species habitat may occur within area
Rostratula benghalensis s. lat.	Painted Snipe		Species or species habitat may occur within area

Table E: Species and ecological communities listed under the EPBC Act that may occur or are likely to occur in the Darling Anabranch.

	Common names	**Status**	**Occurrence**
ECOLOGICAL COMMUNITIES			
Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions		Endangered	Community may occur within area
BIRDS			
Leipoa ocellata	Malleefowl	Vulnerable	Species or species habitat likely occur within area
Manorina melanotis	Black-eared Miner	Endangered	Species or species habitat may occur within area
Pachycephala rufogularis	Red-lored Whistler	Vulnerable	Species or species habitat likely to occur within area
Polytelis anthopeplus monarchoides	Regent Parrot (eastern)	Vulnerable	Species or species habitat likely occur within area

Rostratula australis	Australian Painted Snipe	Vulnerable	Species or species habitat likely occur within area
FISH			
Craterocephalus fluviatilis	Murray Hardyhead	Vulnerable	Species or species habitat likely to occur within area
Maccullochella peelii peelii	Murray Cod, Cod, Goodoo	Vulnerable	Species or species habitat may occur within area
FROGS			
Litoria raniformis	Growling Grass Frog, Southern Bell Frog, Green and Golden Frog, Warty Swamp Frog	Vulnerable	Species or species habitat likely to occur within area
MAMMALS			
Nyctophilus timoriensis (South-eastern form)	Greater Long-eared Bat, South-eastern Long-eared Bat	Vulnerable	Species or species habitat may occur within area
PLANTS			
Acacia carneorum	Needle Wattle, Dead Finish, Purple-wood Wattle	Vulnerable	Species or species habitat likely to occur within area
Austrostipa metatoris		Vulnerable	Species or species habitat likely to occur within area
Swainsona pyrophila	Yellow Swainson-pea	Vulnerable	Species or species habitat likely to occur within area
Swainsona murrayana	Slender Darling-pea, Slender Swainson, Murray Swainson-pe	Vulnerable	Species or species habitat likely to occur within area
Solanum karsense	Menindee Nightshade	Vulnerable	Species or species habitat likely to occur within area
MIGRATORY SPECIES			
Apus pacificus	Fork-tailed Swift		Species or species habitat may occur within area
Ardea alba	Great Egret, White Egret		Species or species habitat may occur within area
Ardea ibis	Cattle Egret		Species or species habitat may occur within area
Haliaeetus leucogaster	White-bellied Sea-Eagle		Species or species habitat likely to occur within area
Hirundapus caudacutus	White-throated Needletail		Species or species habitat may occur within are
Merops ornatus	Rainbow Bee-eater		Species or species habitat may occur within are
Gallinago hardwickii	Latham's Snipe, Japanese Snipe		Species or species habitat may occur within area
Rostratula benghalensis s. lat.	Painted Snipe		Species or species habitat may occur within area

Appendix F Summary of Menindee Lakes operating environment for 2011-12

- As at 20 July 2011 Menindee Lakes were 113 per cent full holding 1952 GL (surcharged) http://www.mdba.gov.au/water/waterinstorage/southern/lowerdarling/?run-date=2011-07-20.
- Menindee Lakes are currently under MDBA control.
- Regulated released from Menindee Lakes will aim to be below 6,000 ML per day at Weir 32; until the Lakes return to NSW control. Regulated releases up to 9,000 ML per day (at Weir 32) may be implemented if required (MDBA 2011a).
- Minimum releases of 500 ML per day from Menindee Lakes will be targeted while the Lakes are surcharged (surcharge is from 1731 to 2050 GL) until Harmony Rules between Lake Victoria and Menindee Lakes trigger higher releases (MDBA 2011a). The Harmony Rules aim to reduce evaporative losses in the Menindee Lakes, while minimising the chance of spill from Lake Victoria.
- If the Menindee Lakes falls below surcharge, then the minimum flow releases would be between 200 and 350 ML per day (MDBA 2010a).
- The actual volume released from Menindee Lakes, and subsequent levels in Lake Victoria will also consider water demands of SA and Lake Victoria (as specified in the Lake Victoria Operating Strategy), water supply in the Lower Darling (especially under extreme dry conditions) and cultural work scheduled for Lake Victoria.
- Due to the current high storage levels in Menindee Lakes, and the combined storage in Hume and Dartmouth, Additional Dilution Flow (ADF) to South Australia will continue into 2011-12. If there is not sufficient water in Lake Victoria to meet ADF; then the Harmony Rules would be triggered, and water would be released from Menindee Lakes.
- The Menindee Lakes should not be surcharged between 1 January and 1 March 2011 unless flows at Weir 32 would otherwise exceed 20,000 ML per day.
- Forecasts under wet and very wet scenarios indicate that Menindee Lakes may be in flood operation and surcharged for much of the coming year. Under drier scenarios the lakes are expected to be gradually lowered to meet downstream demand (MDBA 2011a).
- Flood releases are directed by NSW Office of Water, and would be expected to pass inflows while the Lakes are close to maximum.

Water Use Strategy 2011-12: Lower Murray River region

1.1. Introduction

This document sets out the proposed objectives and approach to using environmental water in the Lower Murray River region during the 2011-12 water year. This strategy was developed based on information available to the Department of Sustainability, Environment, Water, Population and Communities through consultation with delivery partners such as the South Australian Department for Water and Department of Environment and Natural Resources, local river operators and wetland managers.

The document includes watering options given current and expected climatic and riverine conditions in the region. The proposed approach will adapt over the course of the year as conditions in the region change and more information becomes available. Importantly, the potential watering options included in this document do not form an exhaustive list – the Department welcomes proposed suggestions for using water. All relevant options will be assessed to ensure the best possible use of environmental water within the region and across the Murray-Darling Basin.

1.2. The Lower Murray River region

For the purpose of this document, the Lower Murray River region is defined as the area between the Chowilla floodplain on the New South Wales/South Australia border through to the Murray Mouth, where the River reaches the Southern Ocean (Figure 1). Total flow length of the Murray River within South Australia is approximately 648 river kilometres (Ecological Associates in prep.). There are no significant tributaries in South Australia that connect to this river system; however there are ecologically significant branches, creek systems and wetlands within the catchment. The region includes three Ramsar listed wetland sites; Riverland, Banrock Swamp Wetland Complex and The Coorong, and Lakes Alexandrina and Albert Wetland. There is a high diversity of wetland dependent flora and fauna within the Lower Murray River region including a number of threatened and migratory species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act 1999) (GHD 2011).

Primary users of water in the region include irrigation and domestic consumption for metropolitan and country town water supply. Flows to South Australia are highly modified by diversions, regulation and inter-valley transfers upstream, and regulated through the use of six locks and weirs in the state. Management of the water resource within the catchment occurs in accordance with the Water Allocation Plan for the Murray River Prescribed Watercourse, enabled by the *Natural Resources Management Act 2004* (South Australia) (SA DFW 2011).

Average annual rainfall of the Lower Murray River region is between 200-300 mm at the New South Wales/Victoria/South Australia border and 400-500 mm at the Lower Lakes. Average annual rainfall does not vary significantly for the Lock 1 to South Australia border area between winter and summer, however below Lock 1 to the Lower Lakes does see an increase in average annual rainfall between the seasons. Rainfall in winter averages between 50-100 mm per year and increases to 100-200 mm. Average annual temperature varies between 24-33°C for summer and 15-18°C for winter (Bureau of Meteorology accessed 29 June 2011).

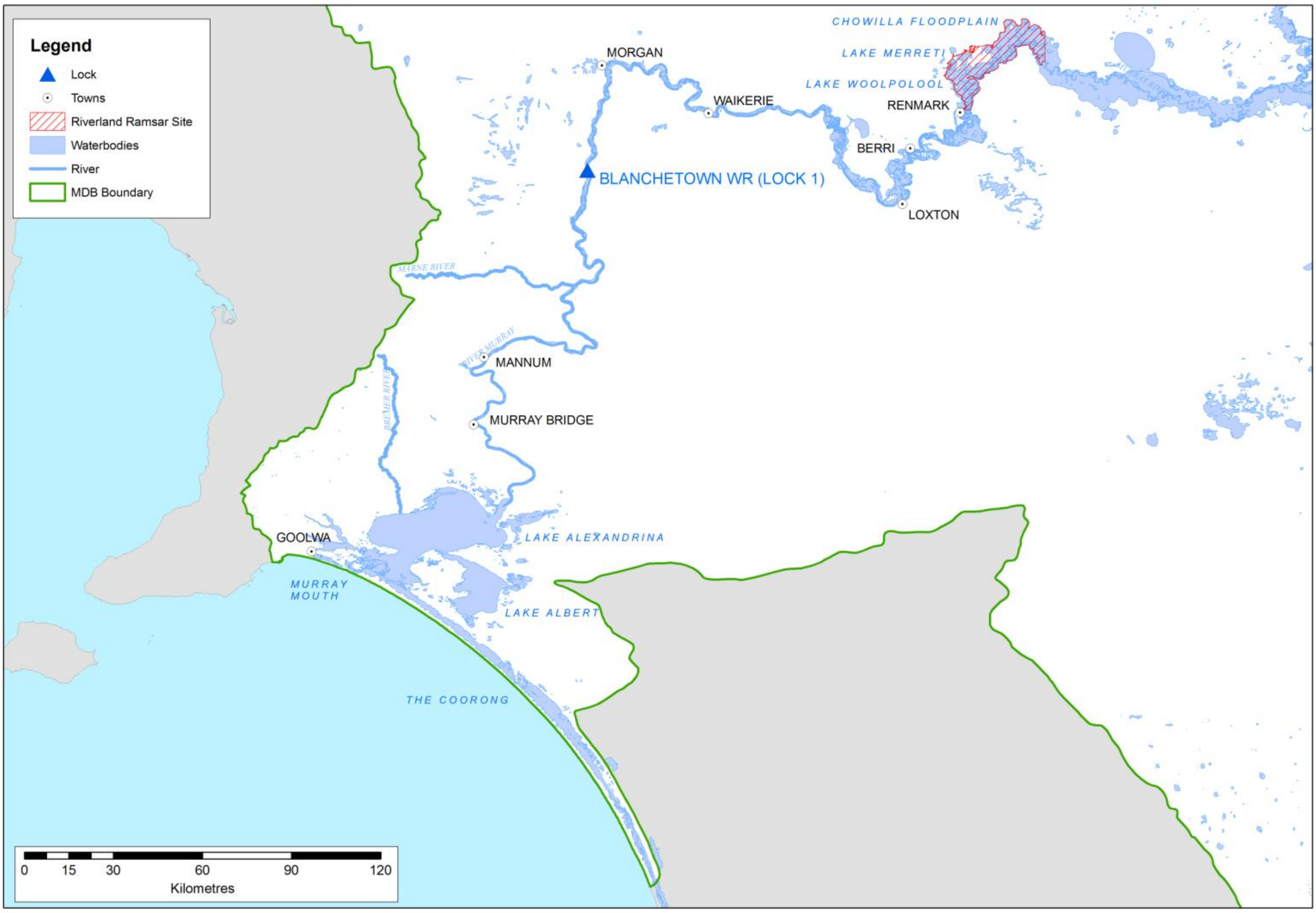


Figure 1: The Lower Murray River region (Source: Department of Sustainability, Environment, Water, Population and Communities 2011).

1.3. Environmental Assets in the Lower Murray River region

Freshwater dependent biotic and abiotic assets in the Lower Murray River region include areas of river red gum forest and woodland, black box woodland, lignum, river-fed wetlands, Ramsar-listed wetlands and habitat for several species listed under the EPBC Act 1999. Further details on the location, condition, type and extent of significant flora and fauna at each locality is presented at Appendix A. Known significant environmental assets include:

- Lower Murray River channel;
- Fringing wetlands and floodplains from the Chowilla Floodplain to Wellington; and
- Lower Lakes, Coorong and Murray Mouth Estuary.

1.4. Broad Watering Objectives in the Lower Murray River region

During 2010-11, the Department (SEWPaC) undertook work to identify and develop large-scale watering options for the use of Commonwealth environmental water, including in the Lower Murray River region. This has been documented in GHD (2011) and Ecological Associates (in prep.). This work has identified a range of medium to long-term ecological and hydrological objectives for the Lower Murray River including:

- Maintain and improve water quality (particularly salinity) in the Lower Lakes;
- Maintain and improve wetland vegetation condition;
- Maintain and improve floodplain, riparian and aquatic vegetation condition;
- Restore longitudinal and lateral connectivity within the Lower Murray river and floodplain and wetlands assets;
- Prevent acidification of vulnerable soils in the Lower Lakes;
- Support spawning, recruitment and movement of fish species throughout the Lower Murray;
- Maintain seasonal habitats for migratory waterbirds;
- Maintain an open Murray Mouth; and
- Support fauna species that are water-dependent or that rely on water-dependent habitat.

These objectives are broadly consistent with the objectives specified for the Murray region in the *Guide to the proposed Basin Plan* published by the Murray-Darling Basin Authority in 2010.

1.5. Delivering Water in the Lower Murray River region

Owing to the volume of entitlements held by the Commonwealth Government in South Australia (67,000 ML as at 1 July 2011), it is highly likely that environmental watering in the state will be supplemented by trade of allocations from interstate and return flows. Constraints surrounding these transfers are described in section 1.11.

Due to the location of Lake Victoria (Victoria) and Menindee Lakes (New South Wales) relative to South Australia, these storages may be used to supply flows. Volumes, where possible, will also be sourced from the Lake Hume Reservoir storage and Murray River tributaries, including northern Victorian rivers and the Murrumbidgee River.

Environmental water delivery will be largely confined to gravity fed flows with limited pumping to wetlands as necessary. Potentially, environmental watering could augment natural river flows including unregulated flow events, however, this will be opportunistic and further investigation is needed for this to occur. Weir pool manipulation remains a valuable mechanism for watering however this will be limited in the 2011-12 water year due to on-going works at five of the weirs.

1.6. Current System Status and Outlook

Antecedent condition

The Lower Murray River region has experienced significant ecosystem decline as a result of human-induced changes to river flow. Increased diversion and regulation of river flows to meet irrigation and critical human needs has fundamentally changed hydrology and affected, in particular, floodplain inundation, groundwater levels and salinity and soil quality. Vegetation health has significantly declined in the region, with river red gum and black box populations experiencing increased salinity and hydrological stress, and a change in the composition of understorey vegetation (Overton et al. 2006; Newall et al. 2009).

To support the ecological assets in the region, environmental watering by the Commonwealth occurred throughout 2010-11 and these actions are described in Table 1 below.

Table 1: Commonwealth environmental water use in the Lower Murray River region during 2010-11.

Asset	Site	Duration of action	Commonwealth volume (ML)	SA/TLM volume (ML)	Total volume (ML)
Coorong, Lower Lakes and Murray Mouth	Lake Alexandrina, lake Albert, Coorong	February – June	139,037*	92,000 (SA) 157,210 (TLM) 8,873 (Vic)	397,120*
	Kulkurna (Chowilla floodplain)	October - November	57	-	57
	Coombool Swamp (Chowilla floodplain)	April - August	506	1,000	1,506
	Carpark Lagoons (Katarapko floodplain)	October - November	154	-	154

*This volume includes 52,440 ML of return flows delivered from the Goulburn River.

2011-12 seasonal outlook

The seasonal outlook over south-eastern Australia over the next three months (July to September) favours a drier than normal season in the Lower Murray River region. The region occurs in the band with a 40 per cent chance of exceeding the median seasonal rainfall (Figure 2).

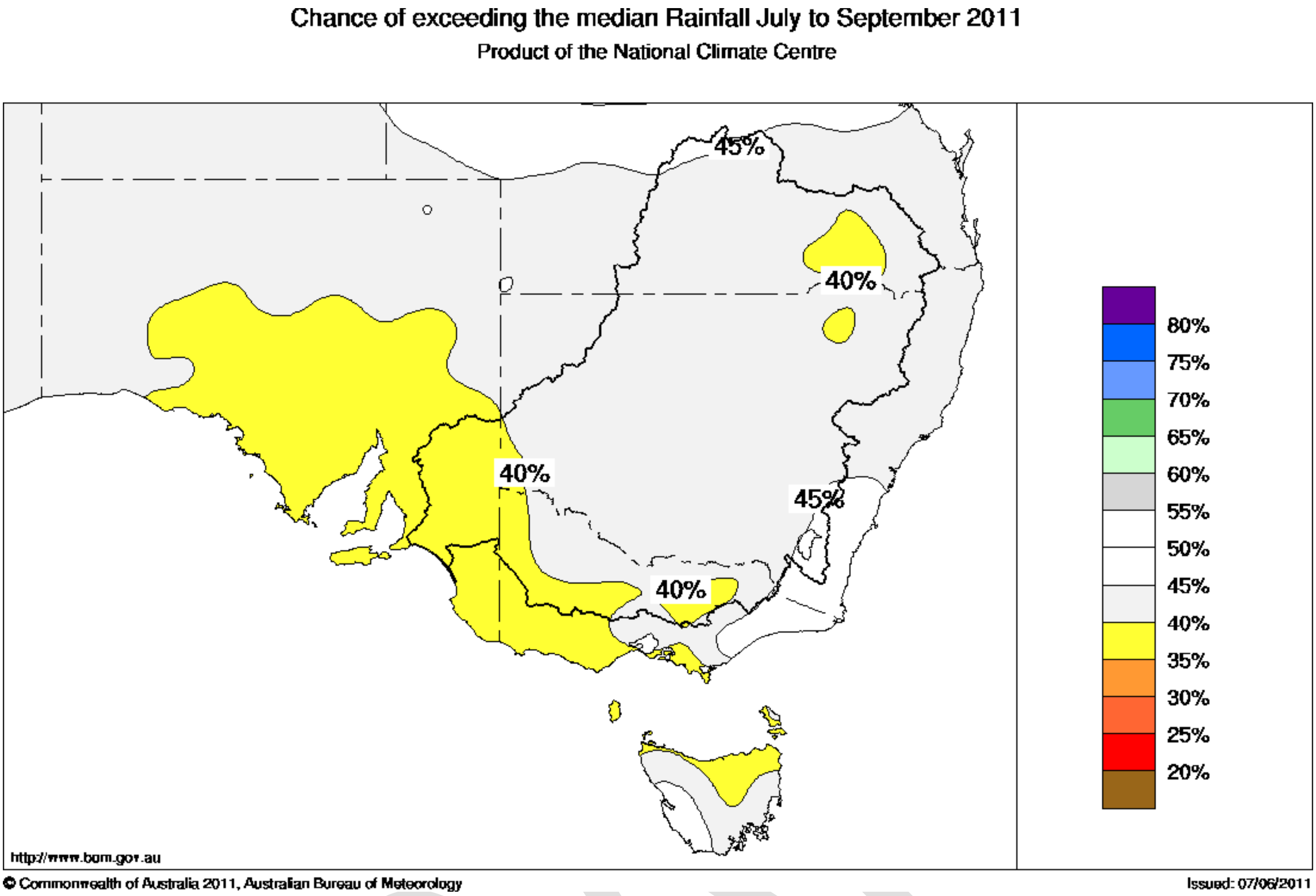


Figure 2: Seasonal rainfall outlook for south-eastern Australia (Bureau of Meteorology, accessed 1 July 2011).

The monthly outlook for flows to the South Australian border is presented in Figure 3 on Page 18. Under the dry scenario (75 per cent probability of excedence) unregulated conditions are forecast to persist in the upper parts of the Murray until September, and extending to October under a wetter 50th percentile scenario; depending on system inflows. These conditions are expected to translate to moderate flows into SA during the September-October period.

As an indication of expected flows through the system for 2011-12, modelled barrage release volumes were developed by the Murray Darling Basin Authority and are described in Table 6 on Page 19.

1.7. Forecast Allocations

Key points:

- Forecasting indicates that allocations for the Southern Connected Basin are between 320,000 ML (dry) to 650,000 ML (wet). This means that up to 650,000 ML of Commonwealth environmental water could be available for use in the Southern Connected Basin by the end of 2011-12.
- The Commonwealth holds 67,000 ML of Class 1 and Class 3 entitlements in the Lower Murray River regulated water source.

The volume of Commonwealth environmental water allocations available for use in the Southern Connected Basin and the Lower Murray River region at 1 July 2011, and forecasts for the rest of the 2011-12 water year are described in Table 2.

Table 2: Commonwealth environmental water availability in 2011-12

Catchment	Entitlement (GL)	Water available for use (GL)	Water available for use forecasts					
			31 July 2011 (GL)		30 September 2011 (GL)		30 June 2012 (GL)	
Murray (SA)			**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
Class 1 and Class 3	67.0	67.0	67.0	67.0	67.0	67.0	67.0	67.0
Total - Southern Connected Basin	**652.5**	**317.7**	**318.0**	**388.9**	**354.7**	**608.9**	**539.9**	**649.7**

Note: These figures may change following reconciliation of accounts for the end of the 2010-11 water year.

The forecasts presented in Table 2 were determined by the Department based on the following:

- There would be no barriers to trade within the Southern Connected Basin during 2011-12, except the 100 GL net trade limit out of the Murrumbidgee;
- The Southern Connected Basin includes the NSW Murray, Vic Murray, SA Murray, Murrumbidgee, Goulburn, Campaspe, Lower Darling and the Loddon;
- Forecasts were based on information available at 1 July 2011, and the Commonwealth's registered entitlements at this date;
- Supplementary entitlements and additional entitlements that may be obtained and registered by the Commonwealth during 2011-12 were not included in forecasts; and
- Forecasts were based on dry and wet climate year scenarios.

1.8. Other Sources of Environmental Water

In addition to Commonwealth environmental water, there are other sources of environmental water that may be available to supplement Commonwealth environmental watering in the region during 2011-12 and these are listed at Table 3. It is important to note that the volume of water these licences (excluding the Class 9 licence) will contribute to environmental water use options within South Australia is dependent upon the availability of credited return flows.

Table 3: Other potential sources of environmental water in the Lower Murray River region for 2011-12

State	Management Authority	Licence Type	Maximum Capacity
The Living Murray	Murray-Darling Basin Authority	Multi-state entitlements for use on icon sites	230 to 410 GL*
Barmah-Millewa Forest	Murray-Darling Basin Authority, NSW Office of Environment and Heritage, Victorian Environmental Water Holder	Environmental water allowance	242 to 342 GL
South Australia	Department for Water	Class 9**	200 GL

* Murray-Darling Basin Authority (2011) *TLM Annual Environmental Watering Plan* in draft.

** South Australia will be receiving 100 per cent of allocations for 2011-12. Approximately 32,000 ML has been transferred to the new Ministerial wetland water licence for use in specific wetlands along the river. The remainder cannot be used for targeted flows as many wetlands lack regulators to control flows; rather they will be inundated during normal river flows.

1.9. Watering Objectives for 2011-12

Based on forecast conditions and rainfall for 2011-12 the Commonwealth will seek to undertake watering actions that will contribute to the following watering objectives in each of the main assets:

Coorong, Lower Lakes and Murray Mouth

- Water quality in Lake Alexandrina targeting a salinity range of between 750 and 1,000 $\mu S\ cm^{-1}$ over a rolling three-year period;
- Variable lake levels to support a healthy and diverse riparian vegetation community whilst maintaining lake levels at sufficient heights to avoid acidification;
- Sufficient flows to enable export of salt and nutrients from the Basin through an open Murray Mouth;
- Minimum of 55 GL to maintain flows through the barrage fishways at all times to promote fish passage between Lake Alexandrina and the Murray River estuary; and
- A range of estuarine, marine and hypersaline conditions in the Coorong to support healthy populations of “keystone” species.

SA Border to Wellington

- Wetland vegetation in healthy condition, particularly in fringing wetlands with river red gum forest and lignum;
- Floodplain, riparian and aquatic vegetation in healthy condition, including higher elevation black box vegetation;

- Longitudinal and lateral connectivity within the Lower Murray River and floodplain and wetlands assets;
- Fish movement, breeding and recruitment throughout the Lower Murray River; and
- Waterbird breeding and feeding through supporting healthy wetland habitat.

1.10. Watering Options for 2011-12

Potential watering options for the Lower Murray River region focus on providing in-channel flows to achieve greater connectivity between the river channel and wetland assets. This will aim to improve vegetation condition and support native water-dependent species. Options also seek to provide flows to the Lower Lakes to increase barrage flows, with the aim of improving freshwater and estuarine habitat and flushing salts and nutrients from the Lower Lakes and the Coorong. Watering of individual wetlands may also be considered depending on river and climatic conditions.

It is also important that barrage releases remain high in 2011-2012 while there is more water available within the system. Then, in the event of dry years in the future, it will be more feasible to implement the targeted barrage releases (3 year rolling average of 6000 GL) that are needed to meet Lake Alexandrina salinity targets. Environmental water requirements have been modelled that maintain the desired barrage releases and stay within the proposed lake water level envelope of 0.85 metres to 0.5 metres AHD (see Appendix E).

A summary of the options is provided at Table 4. More details on the watering options, including consideration of the delivery mechanism, target flow volume and timing and duration is provided at Table 5.

It is important to note that actions to increase in-channel flows are interrelated to those for the Lower Lakes and Coorong as in-channel flows will flow downstream to the Lower Lakes. Implementation of a spring pulse will need to consider timing to support lake level management.

Table 4: Potential watering options for 2011-12 in the Lower Murray River region

Asset	Watering Option
Lower Lakes, Coorong and Murray Mouth	1. Boost flows to the Lakes to increase flows through the barrages. Depending on water availability and river conditions, aim to increase total flows through the barrages to a minimum of 650 - 1,000 GL or preferably higher for the year for the purposes of: • Improving water quality and maintaining salinity in Lake Alexandrina between 700 and 1,000 µS cm^{-1}; • Supporting variable lake levels to restore riparian vegetation; • Supporting an open Murray Mouth; • Promoting fish passage between Lake Alexandrina and the Murray River estuary; and • Contributing to maintaining a range of estuarine, marine and hypersaline conditions in the Coorong. GHD (2011) provides additional information on the range of water

	use strategies for the Lakes and Coorong.
	2. Create or enhance (depending on flow conditions) a spring pulse of up to 15,000 ML per day for a period of up to three months between October and December with the main peak occurring in November. This will also contribute to flows over the barrages in watering option 1. Potentially a volume of 420 GL would be required to contribute to: • Improving the health of semi-permanent wetlands; • Improving hydraulic conditions in the River channel and increased water level variations; • Restoring lateral and longitudinal connectivity; • Supporting movement, breeding and recruitment of large bodied native fish such as golden and silver perch; and • Maximising ecological benefits for the River through delivery of water to the Lower Lakes.
Murray River channel (flows < 15,000 ML/d)	3. Raise the weir pool at Lock 1 for two to three months during spring summer (October/November to December/January). For flows < 10,000 ML/day the regime will follow the 'background cycle' outlined in the SA Murray River Weir Operating Strategy (Lloyd et al. 2010) in terms of the timing of weir raising. For flows > 10,000 ML/day (e.g. spring pulse or unregulated flows) the regime will be in accordance with the flow peak enhancement operating rules outlined in the SA Murray River Weir Operating Strategy. No weir lowering is proposed in the short term due to constraints regarding irrigation pump heights and extraction ability. The proposed raising will be limited to approximately 0.5 metres above normal operating pool level to reduce potential negative impacts, e.g. infrastructure inundation. The proposed weir pool manipulation at Lock 1 is estimated to use approximately 500 ML. The weir raising is for the purposes of: • Maintaining and improving riparian vegetation; • Inundating semi-permanent wetlands; and • Increasing habitat for water dependent biota.
Murray River channel and associated floodplain wetlands (flows > 20,000 ML/d)	4. Under unregulated flows in excess of 20,000 ML per day we will investigate options to augment river flows to increase areas of inundation and/or to extend event duration and reduce recession rates. The purposes of the options would be to contribute to: • Supporting native fish and water bird species; • Maintaining and improving aquatic, riparian and floodplain vegetation condition, including black box communities; • Maintaining and improving wetland vegetation condition, particularly in fringing wetlands; and • Increasing carbon and nutrient cycling, salt and sediment

	transportation.
Floodplain wetlands	5. Targeted semi-permanent wetlands will be considered for environmental water via pumping if: • Expected river conditions will not inundate the wetlands; • The watering would correspond to an appropriate wetting and drying cycle for the wetlands; • There is identified ecological benefit from the use of water; • The long term sustainability can be demonstrated; and • The action is cost effective. Pumping to wetlands may also be considered when augmented high river flows (> 20,000 ML/d) do not inundate a wetland. The objectives of the provision of water are to contribute to: • Building on ecological responses to the 2010-11 flood; • Providing habitat for water dependent species including the southern bell frog; • Maintaining and improving water-dependent habitat for threatened species such as the regent parrot; and • Maintain long lived vegetation such as river red gum, black box and lignum. Wetlands that could be considered (for example) include: • Those that previously received Commonwealth environmental water (Chowilla and Katarapko Floodplains, Markaranka, Morgan Conservation Park, Molo Flat, Murbpook Lagoon, Overland Corner, Paiwalla, Rocky Gully, Weila and Wigley Reach); • Sites on the Chowilla Floodplain (Coombool Swamp and Lake Limbra); • Long lived vegetation sites considered in the 2010-11 watering actions (Akuna, Markaranka, Martins Bend, Molo Flat, Noonawirra, Taylors Weston Flat); • Sites important to threatened fish species (Paiwalla, Rocky Gully, Berri Evaporation Basin and Disher Creek); • Sites that support threatened species, including water-dependent species and species reliant upon water-dependent habitat (Bunyip Reach, Hogwash Bend, Morgan Conservation Park, Murtho Park, Nikalapko, Overland Corner, Reid Flat, Sweeney's Lagoon, Templeton, Weila, Whirlpool Corner, Wigley Flat); • Wetland sites on Banrock Station and Calperum Station (see options 6 and 7 below); and • Other sites that meet the objectives and the CEWH criteria set out above.
Lake Merreti	6. A partial refill of Lake Merreti from December 2011 to June 2010 has

	been identified (approximately 1,200 ML) to maintain current hydraulic gradients and the current littoral zone within the lake providing habitat for flood dependent vegetation and water birds.
Lake Woolpolool	7. The short term inundation of restoration sites around Lake Woolpolool floodplain in November/December 2011 has been identified (approximately 50 ML). The watering aims to maintain soil moisture over summer to support revegetation works.

Table 5: Operational details for potential watering actions for 2011-12 in the Lower Murray River region.*

Asset	Water Management Options*	Target flow rate/Volume to fill	Estimated volume of allocation required	Timing & Duration	Delivery mechanism	Operational considerations^
Lower Lakes, Coorong and Murray Mouth	1	1,000 GL per annum or higher depending on flow conditions.	720GL	Seasonal distribution of flows at the barrages is presented in Table 6 (modelled 75th percentile flows) and Table 7 (SA water use proposal assuming minimum barrage release of 650 and 1,000 GL). Refer to Table 7 for potential monthly barrage releases under minimum flow scenarios. Beginning October.	River and barrage operation.	Action managed in conjunction with SA (DFW, DENR and SA Water) and the MDBA and through the SA Barrage Operations Advisory Committee. Target flow envelopes for a variable lake level regime for Lake Alexandrina can be found at Appendix E. Ability to augment unregulated flows is constrained in South Australia; see section 1.11 for further details. Water trading must consider ambient river conditions in, and upstream of, South Australia. The regulated/unregulated conditions will determine if
		Minimum barrage release 650GL/a.	370GL			

Asset	Water Management Options*	Target flow rate/Volume to fill	Estimated volume of allocation required	Timing & Duration	Delivery mechanism	Operational considerations^
						trade is possible. This is particularly relevant to trade of return flows into South Australia from upstream.
Murray River channel (flows < 15,000 ML/d)	2	Peak flow of 15,000 ML/d occurring in October to December. Refer to Appendix F for a modelled hydrograph.	Up to 418 GL depending on river flow conditions.	October to December 2011	river channel operations	This watering action will be implemented if flows across the border during spring are between entitlement (October entitlement is 5,500 ML/d) and 15,000 ML/day. Flow to be restricted to 15,000 ML/d. Higher flows would disrupt construction works occurring at Locks 2, 4 and Chowilla. This action requires further discussion with SA DFW and MDBA regarding its implementation.

Asset	Water Management Options*	Target flow rate/Volume to fill	Estimated volume of allocation required	Timing & Duration	Delivery mechanism	Operational considerations^
						Storage of these volumes in the Lower Lakes prior to barrage releases is subject to some constraints. Refer to section 1.11.
	3	Net volume required is approximately 500 ML.	Approximately 500 ML.	Two to three months during spring/summer.	River operations and raising of weir at Lock 1 by ~0.50 metres.	2011-12: Weir pool manipulation will follow the background strategy for river flow conditions < 10,000 ML/d (Lloyd et al. 2010). Manipulation will follow the peak enhancement operating rules for river flow conditions between 10,000 ML/d and the maximum possible weir level. Ceasing manipulation: If flows exceed capacity of weir, normal operating rules will resume. Weir 1 cannot be manipulated when flows exceed 30,000 ML/d.
Murray River channel and	4		Dependent on river flows.	Dependent on timing of unregulated flows.	River channel operations – and	A detailed proposal would be developed if unregulated

Asset	Water Management Options*	Target flow rate/Volume to fill	Estimated volume of allocation required	Timing & Duration	Delivery mechanism	Operational considerations^
associated floodplain wetlands (flows > 20,000 ML/d)		Augment natural flows if unregulated flows occur above 20,000 ML/d. Significant ecological response will occur within the 45,000 – 60,000 ML/d band.		Opportunistic.	targeted releases from storages.	flows in excess of 20,000 ML/d are announced. Proposals to augment river flows to increase areas of inundation and/or to extend event duration and reduce recession rates would consider: • Mechanisms for releasing water from storages upstream of SA (Lake Victoria and Menindee Lakes and Hume) to boost flows; and • Expected ecological outcomes from the timing and extent of flows. The proposal would be developed in conjunction with relevant key stakeholders. For proposals to manage flow recession rates, the rate of recession should not

Asset	Water Management Options*	Target flow rate/Volume to fill	Estimated volume of allocation required	Timing & Duration	Delivery mechanism	Operational considerations^
						exceed the equivalent of a 5 cm decrease in water level per day. Ideally, the decrease should be less than the equivalent of a 3 cm drop in water level per day.
Floodplain wetlands	5	In the absence of natural high flows, pumping to wetlands will be a contingency watering option. Flow volumes and rates will be site specific.	Dependent on sites	Spring and autumn	Pumping	The need for any targeted pumping watering actions will be determined during the year dependent on climatic and river conditions. Wetland condition will be monitored by the SA MDB NRM Board, SA DFW and DENR and will advise on potential watering actions. Actions will be considered according to: • Whether expected river conditions will/will not inundate the wetlands; • Whether the watering corresponds to an appropriate wetting and drying cycle for the wetlands;

Asset	Water Management Options*	Target flow rate/Volume to fill	Estimated volume of allocation required	Timing & Duration	Delivery mechanism	Operational considerations^
						• The ecological benefit from the use of water; • The long term sustainability can be demonstrated; • The action is cost effective; and • Cost effectiveness.
Lake Merreti	6	200 ML to fill plus 1,000 ML for maintenance	1,200 ML	Late spring - summer Maintenance watering December 2011 – June 2012.	Diversion from channel flow via Ral Ral Creek anabranch.	Precise timing of fill event will depend on when Lake Merreti dries out. If this is after December, then it is assumed less water will be required for maintenance.
Lake Woolpolool	7	Approximately 50 ML	Approximately 50 ML		November or December 2011	Timing for event will be dependent on local rainfall.

^ Options for piggybacking natural flows, travel times, linking actions etc

Figure 3 below details the flow outlook for South Australia as modelled in a multi-history run by MDBA. This flow outlook shows the likely scenario (75 per cent probability of excedence) used to develop total release volume estimates at the barrages, and a possible distribution of Commonwealth environmental water to meet those barrage requirements, as described in Table 6.

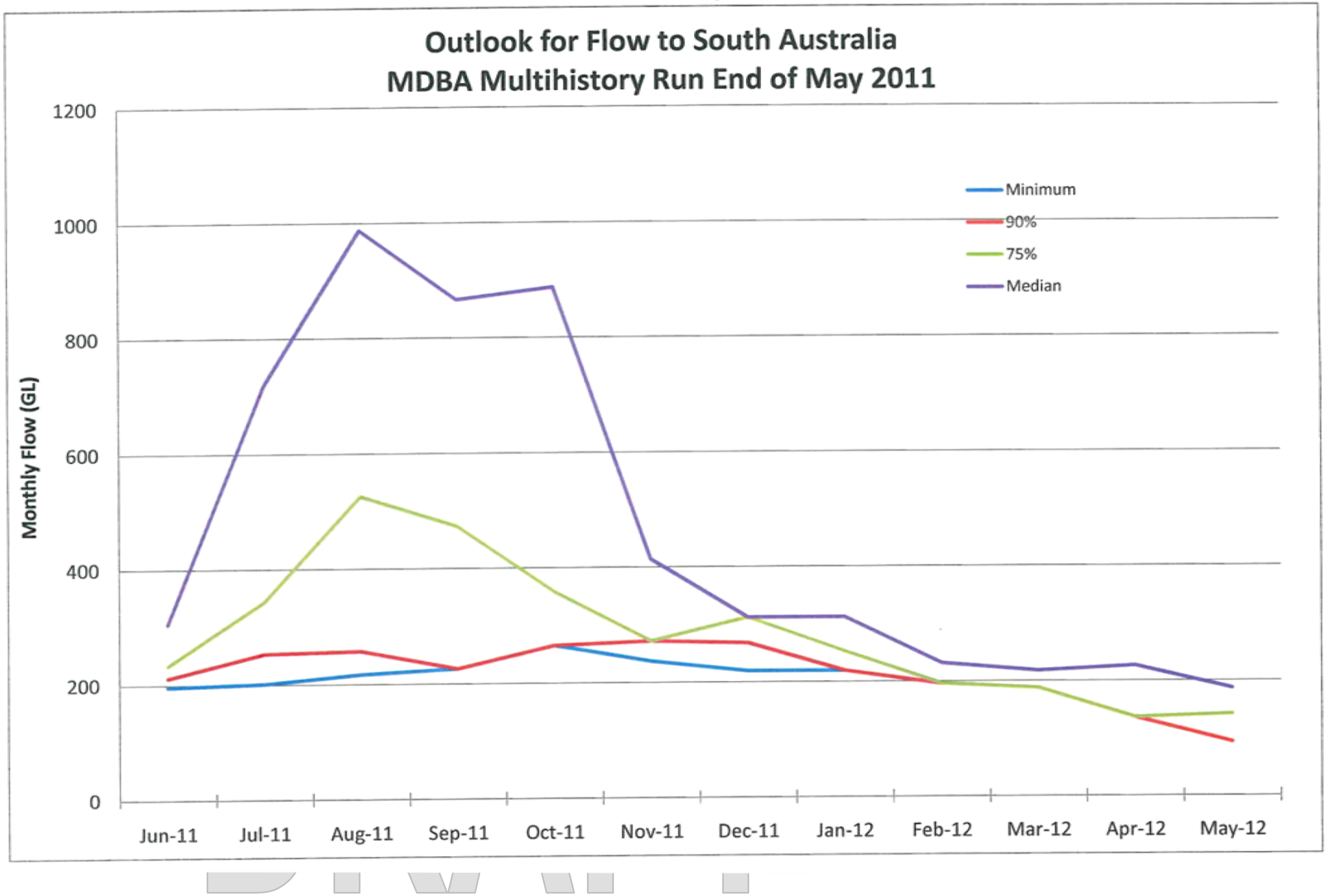


Figure 3: Outlook for flow to South Australia (Source: MDBA multi-history run end of May 2011)

Table 6 provides a modelled estimated of total release volumes at the barrages however it does not include augmented water use options. Additional flows to the barrages as a result of augmenting natural flows will be opportunistic and so cannot be reflected in the table below. Decisions regarding the delivery of environmental water in the Lower Murray River region will be considered in relation to channel constraints and flow thresholds for flooding property and infrastructure.

Table 6: Total release volume estimate at the Barrages (GL) under a dry scenario (75 % probability of excedence)

		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
75 % probability of excedence (Dry scenario)	Expected flow rate into SA	350	525	475	350	275	300	250	200	190	150	150	150	3,365
	Expected flow rate with CEW contribution	350	525	526	521	455	387	331	204	190	150	150	150	3,939

Source: Murray-Darling Basin Authority, 2011.

Table 7: Proposed volumes for barrage releases as proposed by South Australia Department for Water (GL)

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	**Total**	**E-water required**
650 Scenario	27.9	51.15	49.5	85.5	97.65	79.05	69.75	56.55	41.85	31.5	32.55	27	**650**	**370**
1000 Scenario	32.55	69.75	76.5	139.5	162.75	134.85	116.25	91.35	60.45	49.5	41.85	27	**1000**	**720**
Entitlement + ADF	56	78	108	5	5	5	5	5	31	51	43	30	**422**	**n/a**

1.11. Key Constraints for water delivery

The following constraints in the Lower Murray River will be relevant to environmental watering actions in 2011-12 watering year:

1. Construction of an environmental regulator on the Chowilla floodplain and works on Murray River operating structures (locks and weirs) limit the use of weir pool manipulation for environmental watering for 2011-12. For this watering year South Australia have proposed to manage flows below 15,000 ML/d flow at the SA border, where possible, to enable construction and works to recommence.

   As of April 2011, the feasibility of manipulating each weir was:

   - Lock 1: unaffected;
   - Locks 2 to 4: awaiting completion of construction/stability studies;
   - Lock 5: unaffected, however manipulations are not recommended until works on the Chowilla Regulator have been completed; and
   - Lock 6: unaffected, however manipulations are not recommended until works on the Pipeclay and Slaney have been completed.

   It is unknown precisely when the works at Chowilla, or studies/upgrades on Locks 2, 3 and 4 will be completed as these projects are on hold due to recent high flows in South Australia. Completion could occur anytime from 2012 (subject to flows returning relatively quickly to entitlement level). The Chowilla Regulator is being constructed to assist environmental watering of the Chowilla Floodplain.

   However, it should be noted that unregulated flows during 2011-12 in excess of the 15,000 ML/d flow limit will cause inundation of works on the Chowilla Regulator and will delay its finalisation. Works at Locks 2 and 4 will be affected by flows greater than 20,000 ML/d.

2. As the Commonwealth Government's entitlements held in South Australia are only small relative to the environmental water requirements within the State, there will be a requirement to trade water from interstate. Further, the delivery of larger volumes of water to South Australia may be restricted by capacity for releases from upstream storages (Lake Victoria, Menindee Lakes and Hume Dam) and other channel constraints.

3. During periods of unregulated flow to South Australia, water trades to South Australia are first met by surplus water within the system. This is a likely constraint to the use of environmental water holdings as trading water to South Australia during unregulated flow conditions would not result in additional regulated releases of water into the system. Other ways of releasing water from storages that would result in increased flows at the South Australian border are being investigated and likely to include releases from tributary storages and the use of return flows from upstream watering actions.

4. Storage of water within the Lower Lakes prior to barrage releases may be constrained by difficulties in shifting water out of the Lakes due to high tides. Therefore, water may not be able to be stored and will be required to be released as barrage flows.

1.12. Assessing Environmental Watering Options

As part of this strategy, assessments have been completed for the watering options against the Commonwealth's criteria for watering actions. Briefly, these criteria are:

- Ecological significance of the asset(s);
- Expected ecological outcomes from the proposed watering action;
- Potential risks of the proposed watering action at the site and at connected locations;
- Long-term sustainability of the asset(s) including appropriate management arrangements; and
- Cost-effectiveness and operational feasibility of undertaking the watering.

A detailed description of the Commonwealth's criteria for assessing watering actions is provided at Appendix B. The assessment demonstrating whether the range of potential watering options meets these criteria is provided at Appendix C. This assessment considers watering the suite of options in scope in groups of similarly located and managed assets. This allows the benefit of watering individual assets to be considered at the individual asset scale through the course of the year, while also considering the potential integration of watering actions proposed for a group of assets.

The watering options outlined in this strategy will be subject to review against the criteria closer to their proposed timing for delivery, on an action by action basis. The review will include a more comprehensive risk assessment which is subject to the prevailing catchment and river flow conditions, and will consider in more detail proposed costs, delivery, monitoring and accounting arrangements.

Any additional watering options identified during the course of the year will also be subject to an assessment against the criteria.

1.13. Water Use Accounting

Accurate flow measurement in South Australia is restricted with only limited flow rate accounting points including at the SA border and several of the locks. However, the locks are only useful as a guide. Previous studies have indicated that flows calculated at the locks can have significant errors (Stace and Greenwood 2004). The nature of the structures, method used to calculate data and the difficulty in accounting for leakages through the weirs contribute to inaccuracies (Stace and Greenwood 2004).

Water level can be measured at several other data points along the system. Transmission losses within South Australia are not recorded because the entitlement flow provides the conveyance water.

Current water accounting for flows to South Australia is provided in Table 8.

Table 8: Water accounting arrangements for assets in the Lower Murray River catchment

Asset	Accounting Arrangement
Flow to South Australia	Gauging Station 426200 on the Murray River downstream of confluence with Rufus River. If the river height at Gauging Station 426200 is: • < 5.80 m then flow to South Australia = Flow at GS 426200 + Flow at Mullaroo Creek Offtake (AW414211) – Lindsay River Allowance. • > 5.80 m then flow to South Australia = Flow at GS 426200.

Source: GHD 2011.

1.14. Risk Management

A full risk assessment will be undertaken for each watering option as part of the Commonwealth's environmental water use assessment process and in relation to real time river flow conditions; a summary of this as presented against the Commonwealth's assessment criteria is at Appendix C. Some of the more likely risks associated with delivering environmental water in the region are:

- Potential to spread invasive pest species;
- Negative public response to delivering environmental watering during flood conditions; and
- Risk of flooding private property as a result of boosting flows above natural pool levels.

A detailed risk assessment will be undertaken at the time each action is being considered for delivery, and appropriate mitigation of these risks will be considered and implemented in conjunction with the relevant state agencies.

1.15. Event Monitoring

In relation to this strategy and associated watering actions the following monitoring and reporting activities are currently being undertaken (Table 9); however this is not expected to comprehensively capture all monitoring being conducted by state agencies and regional groups. Additional monitoring may be considered on an event–by-event basis closer to the time of the action.

Table 9: Monitoring arrangements for environmental flows in the Lower Murray River catchment

Location	Parameters	Timing/frequency	Responsibility
Operational Monitoring			
Flow at each lock and weir, and barrages*	Flow (ML/day) and water levels (m AHD)	Ongoing daily monitoring	Department for Water / SA Water monitors the flow and water levels at each of the Locks
Environmental monitoring			
LLCMM*	- fish monitoring in the Lower Lakes targeting threatened small-bodied species; - barrage fishway monitoring targeting diadromous species; and - Coorong fish monitoring targeting commercial species and the small-mouthed hardyhead.	- 2 per year (spring and autumn); - Fortnightly in spring/early summer; and - Monthly over spring/ summer.	Monitoring is undertaken through the Commonwealth Government funded The Living Murray program through the SA Department for Water, and the CLLMM Murray Futures program through the SA Department of Environment and Natural Resources, through a collaborative approach.
Lower Lakes along the elevation gradient*	Aquatic vegetation	2 per year (spring and autumn).	As above
Set sites in the Lower Lakes and Coorong*	Aquatic benthic invertebrate monitoring	December annually.	As above
Set sites in the Lower Lakes and Coorong*	Bird monitoring	Monthly (with the exception of June and July).	As above
Lower Lakes and Coorong*	Complete census of the birds	January/February annually.	As above
Lower Lakes,	Aerial bird survey to	November annually.	MDBA

Location	Parameters	Timing/frequency	Responsibility
Coorong and Murray Mouth*	compare numbers to other Icon Sites.		
Lower Lakes**	Water quality	Water quality (fortnightly) Phytoplankton (monthly)	EPA (SA)
Lower Lakes**	Benthic macroinvertebrates	Bimonthly	Flinders University
Lower Lakes**	Zooplankton	Monthly	University of Adelaide
Lower Lakes**	Vegetation	Spring and autumn each year	SARDI Aquatic Sciences
Lower Lakes**	Fish - Boundary Creek and Mundoo Channel fish assemblage below the barrages	Bimonthly	University of Adelaide
Lower Lakes**	Fish – the 'whole' fish community (i.e. small-bodied and large-bodied and larval life stages) and detect spawning and recruitment.	May and Nov each year	SARDI Aquatic Sciences
Lower Lakes**	Birds – three separate studies	Annually – one in January, one in February. Third study conducted monthly.	University of Adelaide AWSG SAMDBNRM Board, Coorong Tours Data maintained by DEH in digital database (SVY 177).
Riverland***	Vegetation: submerged, emergent and terrestrial.	Every 2 years	South Australia Department of Environment and Natural Resources (SA DENR (co-ordination role)
Riverland***	Vegetation: fringing and terrestrial	Every 2 years – prior to flooding and just after draw down	SA DENR (co-ordination role)
Riverland***	Wetland diversity and extent	Every 2 years	SA DENR (co-ordination role)

Location	Parameters	Timing/frequency	Responsibility
Riverland***	Representative terrestrial bird: Bush Stone Curlew	Spring, every 5 years.	SA DENR (co-ordination role)
Riverland***	Waterbirds	Monthly when inundated, annually.	SA DENR (co-ordination role)
Riverland***	Representative aquatic fauna: Southern Bell Frog	When wetlands are inundated, annually.	SA DENR (co-ordination role)
Riverland***	Fish	When wetlands begin to fill, every 2 years.	SA DENR (co-ordination role)
Riverland***	Macro-invertebrates	When wetlands are inundated, every 5 years.	SA DENR (co-ordination role)
Banrock Swamp Wetland Complex****	Fauna monitoring including fish, invertebrates, amphibians, mammals and birds.	Species dependent from weekly, monthly and annually.	Banrock Station in conjunction with South Australia Department of Environment and Natural Resources
Banrock Swamp Wetland Complex****	Flora monitoring including photopoint, vegetation composition, weed control and tree health assessments.	Ranging from weekly to annually.	Banrock Station in conjunction with South Australia Department of Environment and Natural Resources

*South Australian Murray River Watering Proposals 2011.
**GHD 2011.
***These monitoring actions have been taken from the Management Plan for the Riverland Ramsar Site: A plan for Wise Use 2010-2015. The Management Plan detailed monitoring activities undertaken by a range of government and non-government bodies, including community groups. Existing monitoring programs selected for this monitoring plan were chosen on the basis of their practicality, cost effectiveness and relevance to specific water management activities.
****Banrock Station Wetland Complex: Management Plan 2008-2014 2008.

Reporting requirements in relation to this strategy
An operational monitoring report must be provided to the Commonwealth for all watering events using Commonwealth environmental water. Where available, monitoring results associated with environmental water deliveries should be provided to highlight the achieved environmental outcomes and to inform future adaptive management of water resources.

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Appendix A Environmental Assets

The Coorong, and Lakes Alexandrina and Albert Wetland

The Coorong, and Lakes Alexandrina and Albert Wetland site forms the endpoint of the Murray River as it empties into the Southern Ocean through the Murray Mouth Estuary. Lakes Albert (16,800 hectares) and Alexandrina (76,000 hectares including all islands) are large shallow freshwater wetlands which receive inflows from the Murray River. The Coorong (47,700 hectares) is a 140 kilometre long estuarine lagoon separated from the Southern Ocean by a narrow coastal dune barrier. During high flows the Coorong receives freshwater from the Murray River, and also receives flows from local runoff and groundwater inputs. The Coorong, and Lakes Alexandrina and Albert Wetland site is listed as a Wetland of International Importance under the Convention on Wetlands (Ramsar, Iran, 1971) also known as the 'Ramsar Convention'. It is a major waterbird habitat supporting a significant proportion of Australia's waterbirds and international migratory species.

The Coorong and Lakes Alexandrina and Albert Wetland site supports a number of national and state-listed threatened water-dependent species. There are 12 nationally-listed threatened species occurring within this site: six plant taxa and six animal taxa. Phillips & Muller (2006) provides detailed lists.

Examples of the ecologically significant species located at The Coorong, and Lakes Alexandrina and Albert Wetland site include:

- The Swamps of the Fleurieu Peninsula ecological community, which is partially found within the Ramsar site (The Coorong, and Lakes Alexandrina and Albert Wetland 2011);
- Migratory listed waterbirds (EPBC Act 1999);
- Numerous state/nationally listed waterbird species; and
- Key aquatic species including the
    - Murray Cod (Vulnerable, EPBC Act 1999; Endangered under the Action Plan for South Australian Freshwater Fishes);
    - Murray Hardyhead (Vulnerable, EPBC Act 1999; Citically Endangered under the Action Plan for South Australian Freshwater Fishes);
    - Yarra Pygmy Perch (Vulnerable, EPBC Act 1999; Protected Fisheries Management Act 2007; Critically Endangered under the Action Plan for South Australian Freshwater Fishes); and
    - Southern Pygmy Perch (Protected Fisheries Management Act 2007; Endangered under the Action Plan for South Australian Freshwater Fishes) (Hammer et al. 2009).

The Murray Mouth Estuary and Goolwa Estuary support migratory wader species listed under the EPBC Act 1999.

Lower Murray River channel and associated floodplains and wetlands from the Chowilla Floodplain to Wellington

<u>Murray River Channel</u>

The Lower Murray River flows for approximately 648 river kilometres from the New South Wales/Victoria/South Australia state border towards the Southern Ocean (Environmental Water

Delivery: Lock 1 to SA Border 2011). It passes through several distinct geomorphic regions within South Australia, including the Mallee Trench, the Mallee Gorge and the Lower Lakes and Coorong (Butcher 2009). The Mallee Trench defines a broad floodplain that the Murray River traverses as a single, well-defined channel cutting deeper into the landscape as it flows downstream. From Overland Corner, the region becomes known as the Mallee Gorge and is defined by limestone rock as the dominant geology. The Murray River cuts through the limestone via a gorge, intersecting with both the regional water table and exposed saline groundwater aquifers. The Mallee Gorge extends for approximately 280 river kilometres to Mannum, where the Murray River then flows downstream towards The Coorong and Lakes Alexandrina and Albert Wetland Ramsar Site (Butcher 2009) (MDBC 2008).

Key native vegetation species and communities located along the stretch of the river include river red gum and black box, however vegetation communities are suffering significant decline due to previous drought conditions and increased modification of the river system (Overton et al. 2006; Newall et al. 2009). Numerous threatened native fauna species are also supported along the Lower Murray River channel including:

- Large-bodied native fish (Murray Cod, Freshwater Catfish, Silver Perch); and
- Small-bodied native fish (Murray Hardyhead, Unspecked Hardyhead, Dwarf Flathead Gudgeon, Murray Rainbowfish) (South Australian Murray River Watering Proposals 2011).
- Regent Parrot
- Southern Bell Frog

Riverland Ramsar Site, including Chowilla Floodplain

The Riverland Ramsar Site covers an area of 30,615 hectares of the Murray River floodplain between the New South Wales/Victoria/South Australia border and the town of Renmark in South Australia. It consists of two main anabranches, the Ral Ral Creek Anabranch and the Chowilla Anabranch that cover an 80 kilometre stretch of the Murray River (Newall et al. 2009). There is extensive flooding of areas between these two anabranches during times of high river levels, with a number of depressional wetland features retaining water temporarily (Riverland 2011). The Riverland site is composed of three main land blocks – Murtho, Calperum and Chowilla.

The Riverland Ramsar Site supports four nationally threatened species including:

- Southern bell frog (Vulnerable, EPBC Act 1999; SA vulnerable*)*;
- Regent parrot (Vulnerable, EPBC Act 1999; SA vulnerable*)*;
- Murray cod (Vulnerable, EPBC Act 1999); and
- Murray-hardyhead (Vulnerable, EPBC Act 1999) (Riverland 2011).

The Riverland Ramsar Site covers only part of the total Chowilla Floodplain, and the anabranch is an important pathway for the migration of golden perch and silver perch around Lock 6 on the Murray River. The Chowilla Floodplain in its entirety is the largest area of natural riverine forest remaining along the Lower Murray River and contains a series of mixed wetland types. It provides critical habitat for the above species (Environmental Watering: Murray Catchment 2011).

Key wetlands located identified by Newall (2009) within the Riverland Ramsar site include: Lake Woolpolool and Lake Meretti (Calperum Station), Lake Limbra, Lake Coombool, Lake Littra, Clover Lake, Horseshoe Lagoon, Isle of Man, Lake Werta Wert, Punkah Island, Weila/Murtho Park, Nil Nil, Bunyip Reach and Whirlpool Corner, among others.

Banrock Swamp Wetland Complex

The Banrock Swamp Wetland Complex is listed under the Ramsar Convention and is located on the Murray River floodplain south-west of the main channel, opposite Overland Corner. It forms the boundary of the Mallee Trench and Mallee Gorge geomorphic regions and covers an area of 1,375 hectares adjacent to Weir and Lock 3 (Butcher 2009). The site consists of two lagoons (Banrock Lagoon and Eastern Lagoon) that connect only during high flows, as well as several intermittent wetlands that fill during overbank flows (Butcher 2009).

A range of different habitat types are supported by the Banrock Swamp Wetland Complex and this is attributed to its location as a transition between two geomorphic regions and the provision of longitudinal connectivity around lock and weir 3. Species supported by the site include:

- Southern bell frog (Vulnerable, EPBC Act 1999; SA vulnerable*)*; and
- Regent parrot (Vulnerable, EPBC Act 1999; SA vulnerable*)*.

In particular, this Site supports one of the largest regional breeding colonies of the regent parrot (Banrock Swamp Wetland Complex 2011).

Other significant floodplain wetlands

There are an extensive number of wetlands that fringe the Murray River channel between the Chowilla Floodplain and Wellington that are implicitly linked to the River channel and share the environmental values as detailed above. The flow thresholds for these vary: pool level fringing wetlands are inundated by the operation of individual flow regulators or flooded out at flow thresholds ranging between 7,500 to 15,000 ML/d; and, higher elevation floodplains receiving significant inundation above 30,000 ML/d (Ecological Associates, in prep).

These fringing wetlands support migratory waterbirds listed under the EPBC Act 1999 (Ecological Associates, in prep.), including:

- Eastern great egret (Marine, Migratory, EPBC Act 1999); and
- Red-necked stint (Marine, Migratory, EPBC Act 1999).

Significant amongst these additional floodplains and fringing wetlands are:

- Pike-Mundic Wetland Complex;
- Katarapko-Eckert Creek Complex;
- Markaranka;
- Morgan Conservation Park;
- Molo Flat;
- Murbpook Lagoon;
- Overland Corner;
- Paiwalla;
- Rocky Gully;
- Weila;
- Wigley Reach;
- Martins Bend;

- Molo Flat;
- Noonawirra;
- Taylors Weston Flat;
- Berri Evaporation Basin;
- Disher Creek;
- Bunyip Reach;
- Hogwash Bend;
- Nikalapko;
- Reid Flat;
- Sweeney's Lagoon;
- Templeton; and
- Whirlpool Corner.

Appendix B Criteria for Assessing Commonwealth Environmental Watering Actions

In undertaking its activities, the Commonwealth Environmental Water Holder (CEWH) is required to act consistently with the requirements of the *Water Act 2007* (Cwlth) (hereafter referred to as 'the Act'). The relevant functions are outlined in s.105. This includes a requirement that the environmental water holdings are managed in accordance with the environmental watering plan of the Murray-Darling Basin Authority (MDBA). Close consultation is occurring with the MDBA to ensure that use of Commonwealth water is consistent with the emerging objectives of the environmental watering plan that is currently being developed.

A long-term framework for the prioritisation of environmental water allocations has been prepared in consultation with delivery partners, interested stakeholders and experts, and the Environmental Water Scientific Advisory Committee.

The framework includes ecological objectives that will change under the different water availability scenarios (i.e. extreme dry, dry, median, wet). Proposed watering actions will need to be supported by available evidence, and consistent with current water availability scenarios and the framework.

Commonwealth environmental water is being acquired to supplement existing flows. Proposals for use of the water will not be agreed to if this use substitutes for other water uses, including historical system operations (e.g. provision of water for conveyance, stock and domestic, or planned environmental water).

Through adaptive management processes, the CEWH will consider opportunities for a more informed and diverse range of water uses as knowledge and modelling develops. All 2011-12 proposals will be assessed against the following criteria:

1. Ecological significance of the asset(s)

Issues to be considered will include:

- the presence of threatened species and ecological communities, and listed migratory species; and
- ecological and conservation values of the assets(s) including those recognised by international agreements.

2. Expected ecological outcomes from the proposed watering action

Issues to be considered will include:

- how well defined and realistic the objectives are for the proposed watering action;
- the consistency of these objectives with the overall CEWH ecological objectives for the current forecast water availability scenario;
- the current health of the asset(s);
- the improvement in health of the asset(s) expected from the watering action;
- the Basin-wide significance of the ecological response from the watering action;
- any secondary environmental effects expected to result from the watering action (e.g. connected system benefits); and

- the change in the health of the asset(s) expected if environmental water is not provided.

3. Potential risks of the proposed watering action at the site and at connected locations

Issues to be considered will include:

- how thoroughly the potential risks have been assessed for the proposed watering;
- the adequacy of measures proposed to minimise these risks; and
- the likelihood and consequence of variance from the expected ecological outcome (including negative impacts on biota and water quality).

4. Long-term sustainability of the asset(s) including appropriate management arrangements

Issues to be considered will include:

- the adequacy of long-term management and delivery arrangements;
- the existence of complementary natural resource management activities supporting the long-term management arrangements, including those that improve water quality; and
- the effectiveness of monitoring, evaluation and reporting arrangements for the watering activity including clear links to the defined objectives.

5. Cost effectiveness and operational feasibility of undertaking the watering

Issues to be considered will include:

- the amount of Commonwealth water and resources needed, including relative to the contribution of the State and delivery partner to (i) the watering event and (ii) subsequent monitoring of actions and outcomes;
- opportunity to supplement natural flows or other water releases; and
- the operational feasibility of undertaking the watering action (e.g. channel capacity, infrastructure constraints, etc).

Appendix C Criteria Assessment of Watering Options

Lower Murray River channel, fringing wetlands and associated floodplains between Chowilla Floodplain and Wellington including water use options to:

- **Create or enhance a spring pulse**
- **Raise the weir pool at Lock 1**
- **Augment natural flows in excess of 20,000 ML/d**

Lower Murray River channel, fringing wetlands and associated floodplains
1. Ecological significance of the asset(s)
The Lower Murray River asset (Chowilla Floodplain to Wellington) includes a high diversity of aquatic ecosystem habitat types in association with the Murray River channel, fringing (pool level) wetlands, and extensive floodplains and floodplain wetlands. River red gum (*Eucalyptus camaldulensis*) and black box (*Eucalyptus largiflorens*) vegetation communities represent a foundational component of the habitat types represented throughout this region. Lignum (*Muehlenbeckia florulenta)* contributes significantly to the habitat diversity, and collectively with river red gum and black box, supports a myriad of nationally significant water-dependent fauna through the provision of refuge and breeding habitat for birds, lizards and small mammals. They also contribute to a range of other biological and physio-chemical processes that are essential for maintaining broader river system health. Sites of particular significance within this River asset are the internationally recognised Ramsar-listed Riverland site (including Chowilla Floodplain) and Banrock Swamp Wetland Complex and the nationally significant Pike-Mundic Wetland (listed under the Directory of Important Wetlands in Australia (DIWA)) and Katarapko-Eckert Creek Complexes. These sites will benefit from the full range of watering options proposed in this strategy. The Lower Murray River asset supports a number of international, national and state-listed threatened water-dependent species. These are well documented in the ecological character descriptions for the Riverland Ramsar Site and Banrock Swamp Wetland Complex (Newall et al. 2009; Butcher 2009), and a range of other ecological studies for other significant sites within the region (Management Plan for the Riverland Ramsar Site, 2010). These species include, but are not limited to the following: • Four nationally threatened species listed as vulnerable under the *Environmental Protection and Biodiversity Act 1999* (EPBC Act): southern bell frog (*Litoria raniformis*)*;* regent parrot (*Polytelis anthopeplus monarchoides*); Murray cod (*Maccullochella peelii peelii*); and Murray-hardyhead (*Craterocephalus fluviatilis*);

Lower Murray River channel, fringing wetlands and associated floodplains
Species of state significance (*Protected Fisheries Management Act 2007* (South Australia)) include the freshwater catfish and silver perch, which are both identified as critically endangered under the Action Plan for South Australian Freshwater Fishes (Hammer et al. 2009). The Chowilla Anabranch is recognised as particularly important as a migratory pathway for the golden perch (*Macquaria ambigua)* and silver perch (*Bidyanus bidyanus)* around Lock 6 on the Murray River, and also provides fish breeding and nursery habitats for these and other fish species; The Riverland Ramsar Site is recognised for regularly supporting 20,000 or more waterbirds involving 59 species (Newall et al. 2009) with numerous species common across assets in the site. Species at the Chowilla Floodplain include the little-pied cormorant (*P. melanoleucos*); Australian grey teal (*Anas gracilis*); and masked lapwing (*Vanellus miles*). Species found at Lake Merreti include the straw-neck ibis (*Threskiornis spinicollis*) and Australian white ibis (*Threskiornis molucca*) (Newall et al., 2009). Species found at Banrock Swamp Wetland Complex include the Australian wood duck (*Chenonetta jubata*); Australasian darter (*Anhinga novaehollandiae*); and black-winged stilt (*Himantopus himantopus*) (Butcher 2009); and Migratory bird species listed under international agreements for migratory birds such as the sharp-tailed sandpiper (*Calidris acuminata);* curlew sandpiper *(Calidris ferruginea);* and greenshank *(Tringa nebularia*) (Newall et al. 2009). Paiwalla, located downstream of Mannum, supports a population of southern purple-spotted gudgeon (*Mogurnda adspersa*: protected SA). The populations in South Australia are genetically distinct to those in the northern areas of the Murray-Darling Basin. Other species of significance that are supported by the proposed water use action include Murray hardyhead, regent parrots, and southern bell frogs.
2. The expected ecological outcomes from the proposed watering action

Lower Murray River channel, fringing wetlands and associated floodplains
Current condition The extended duration of low flows resulting from five years of drought prior to 2010 and extensive river regulation placed ecological communities in the Lower Murray River and its floodplain under extreme stress (DFW 2011). Specifically, this has resulted in: reduced variability of river (pool) levels; virtual elimination of flowing habitats under regulated conditions; loss of connectivity within the river channel and laterally with floodplain habitats; and a decline in the frequency of small to medium floods. Associated with the changes in hydrology and hydrodynamics, changes in the ecological character of wetland and riverine communities in the region have been well documented (Overton et al. 2006; Newall et al. 2009; Dexter et al. 2006; O'Malley and Sheldon 1990). These changes relate to extensive decline in the health of river red gums and black box trees and the transition of floodplain vegetation communities from water-dependent to terrestrial and salt tolerant species. Effects of these changes include a decline in the population of regent parrots (reliant on river red gum communities for breeding habitat), and the significant decline in the abundance and diversity of waterbirds and other water-dependent fauna species. *Ecological response to water use options* In-channel spring pulse: The improvement in hydraulic habitat conditions in the river channel and anabranches through the provision of spring pulses is expected to stimulate fish breeding and recruitment, and maximise longitudinal connectivity and migratory potential for a range of threatened native fish species including silver perch, freshwater catfish and Murray cod. This water use proposal is modelled on a 15,000 ML/day flow event that occurred in 2005 (South Australian Murray River Watering Proposals 2011) that coincided with spawning and widespread recruitment of golden perch, and the expected benefits are supported by technical findings documented in Overton et al. (2009) and Zampatti (2011). Floodplain wetlands: The inundation of semi-permanent wetlands, either through the provision of low flows (< 15,000 ML/d) for pool level fringing wetlands or augmented high flows (> 20,000 ML/d) for higher elevation floodplain wetlands, is expected to: support the recovery of wetland fauna species (e.g. waterbirds, frogs and fish) through the provision of habitat and increased biomass production; generate germination, growth or recovery of aquatic and semi-aquatic vegetation; provide inundated habitat for frog breeding (including the southern bell frog); and freshen the soil profile and localised groundwater aquifers. Inundation of the floodplain in 2011-12 will capitalise on flow events that occurred in late 2010, and it is expected that significant improvement in the health of river red gum and black box will continue. Where river conditions are insufficient to allow for the augmentation of flows to inundate higher elevation floodplain habitats, pumping may be considered to target high value wetlands and maintain the impetus of ecological recovery at these sites. Lock 1 weir pool manipulation: This water use option aims to inundate 18 semi-permanent fringing wetlands and provide hydrological variability for littoral riparian vegetation through the delivery of elevated flows in spring. The benefits of these flows will be maximised through the weir pool raising at Lock and Weir 1. The benefits of weir pool manipulations are well documented (Ecological Associates, 2010 and Lloyd et al., 2010) and aims to improve the lateral extent of wetland inundation and inundation extent of fringing wetlands within a highly regulated system. Whilst this option is currently limited to Lock and Weir 1, this option provides opportunities for river management that targets habitat preferences for a range of species rather than focusing on the requirements for individual species or isolated sites

Lower Murray River channel, fringing wetlands and associated floodplains
inundation (Kilsby and Walker 2010). This water use option will compliment other proposals for Commonwealth environmental water for the Lower Murray River region, for example the spring pulse flow. It is expected that this action will contribute to improving condition of stressed riparian vegetation (particularly river red gums) and promote the growth and seed set of submerged aquatic plants, particularly the South Australian-listed rare water milfoil (*Myriophyllum papillosum*). It is believed that the water use options outlined in this strategy for the Lower Murray region are compatible with the broad Commonwealth objectives for the Lower Murray River region and will contribute to improvements in the condition and function of the broader riverine system, whilst still addressing the individual requirements of key wetland sites and species. Should the proposed watering actions not occur, then the ecological benefits from current wet conditions will not be further capitalised on. This means that the extent of ecological benefits possible will not be achieved.
3. The potential risks of the proposed watering action at the site and at connected locations
Potential risks have been evaluated for watering actions within the Lower Murray River channel as related to: flows < 15,000 ML/d (including contributing to spring pulses and Lock 1 weir pool raising); and actions occurring > 20,000 ML/d (augmented natural flows) (SEWPaC 2011). Risks considered were: adverse impacts/damage to infrastructure and property from inundation (including damage to TLM construction works); impact to channel geomorphology and vegetation structural integrity; providing conditions that promote invasive species such as carp; decline in water quality as a result of salt mobilisation, low dissolved oxygen (blackwater) or by-products of oxidised acid sulphate soils; and adverse community perceptions. In the majority, these risks were classified as 'low' in relation to the provision of Commonwealth environmental water either due to the likeliness of occurrence, the low consequence of impact, pre-existing conditions that would occur even in the absence of Commonwealth environmental water, or given the adequacy of mitigation measures. The single exception being the augmentation of flows greater than 20,000 ML/d (MDBA works program) of greater than 60,000ML/d (property inundation) where a medium risk persists. At these flow thresholds any damage caused to infrastructure or property would occur due to natural flood inundation, and contributions of environmental water would have negligible added adverse impact on either property/infrastructure damage or water quality. Regardless, flooding risks associated with any environmental watering event will be thoroughly assessed on a case-by-case basis and risks to property/infrastructure will be mitigated where possible. Given the channel morphology of the Lower Murray River and the limited development on the floodplains targeted for inundation it is expected that the risk to the Commonwealth for the provision of environmental water is low. Risks related to water quality such as mobilisation of floodplain salt, blackwater events and acid sulphate soils are not expected due to the wet antecedent conditions

Lower Murray River channel, fringing wetlands and associated floodplains
and the dilution effect of flows created by the spring pulse, the high base flows (up to 15,000 ML/d) and the likely unregulated conditions (anticipated to at least October 2011). The contribution of Commonwealth environmental water to the Lower Murray River will be in accordance with established operational procedures and guidelines for River Murray operations and undertaken by SA Water, under direction by MDBA River Murray Operations. There has also been good consultation with stakeholders in the development of these proposed environmental water actions and the existence of strong general community support. During past watering actions SA Department for Water has demonstrated to have maintained good communication with stakeholders prior to, during and following events. Measures to mitigate identified potential risks are considered adequate.
4. The long-term sustainability of the asset(s) including appropriate management arrangements
Management arrangements and NRM Extensive planning has been undertaken within South Australia aimed at providing enduring management arrangements for the Lower Murray riverine environment and associated floodplain wetlands. Wetland management plans exist for: • Riverland (SA DEH 2010) and Banrock Swamp Wetland Complex (Constellation Wines Australia 2008) Ramsar sites; • Chowilla Floodplain and Lindsay-Walpolla Islands Environmental Management Plans 2011 *in prep.* (MDBA 2011); • *Katfish Reach Implementation Plan* (2008) and *Pike River Floodplain Management Plan* (2008); and • Individual management plans also exist for a significant number of pool level wetlands that are managed through flow regulating structures, including wetlands associated with the Lock 1 weir pool. Complementary management actions are currently being undertaken within these individual wetland complexes including the operation of flow regulators and carp screens, vegetation management and rehabilitation, and community engagement. The development of the weir pool manipulation strategy (Lloyd et al. 2010; Ecological Associates 2010) provides a holistic river management regime that aims to address the hydrological requirements of the system and the reinstatement of the functional processes that underpin the broader ecosystem health. While this operating regime is yet to be fully implemented, the augmentation of flows to meet targeted flow objectives and the manipulation of the Lock 1 weir pool will

Lower Murray River channel, fringing wetlands and associated floodplains

contribute to the medium-long term adoption of an enhanced river management regime.

Monitoring, evaluation and reporting

Monitoring and reporting activities associated with these water use options are listed in section 1.15 of this strategy.

Monitoring related to the proposed water use options will be undertaken as part of existing monitoring programs, however, these programs are currently limited to discrete sites or research studies and a system wide program of monitoring is yet to be established.

Operationally, the volume of Commonwealth environmental water delivered to the Lower Murray region will be accounted for at the South Australian border, with flow rates and water levels at six locks monitored daily by the DFW and SA Water. Operational reports on the water use delivery will be provided by South Australia.

An existing SA Department for Water program is being considered for evaluating the outcomes associated with the spring pulse use option. This includes providing comparisons of the range of velocities experienced as a result of a 15,000 ML/day flow, achieved through the monitoring of cross sections at selected points along the River to determine changes in flow velocities before the spring pulse, during the peak flow and after the pulse (South Australian Murray River Watering Proposals 2011).

In addition, existing monitoring programs undertaken by SA MDB NRM Board and SARDI could be utilised to assess changes in fish assemblages and species abundance at a limited number of locations within the Murray River channel and connected wetlands. This needs to be further investigated and collaborations with these agencies may support a broader survey.

Extent of inundation and changes in vegetation condition within targeted floodplains and wetlands will be monitored through a number of photo points. Vegetation condition is generally limited to discrete locations and further work is required to establish a more comprehensive monitoring program. Existing monitoring programs and baseline condition assessments undertaken on the Chowilla Living Murray icon site, the Riverland Ramsar Site and the Banrock Swamp Wetland Complex will contribute to the evaluation of medium to long term improvements in vegetation condition associated with environmental water delivery and improved river management (Cunningham et al. 2009; Nicol 2009).

5. The cost-effectiveness and operational feasibility of undertaking the watering

Lower Murray River channel, fringing wetlands and associated floodplains

Whilst the water use options in this strategy are presented as discrete actions, they would in fact be undertaken as a series of integrated actions that creates efficiencies in water use whilst maximising environmental outcomes. Environmental water delivered to create the spring pulse would also be used in the Lock 1 weir pool raising, and its subsequent release managed to meet flow requirements at The Coorong, and Lakes Alexandrina and Albert Wetland during the peak demand period of October to December.

The actual volume required to deliver the spring pulse will depend on a number of factors such as: river flow conditions during spring; the provision of additional dilution flow (ADF); desired timing of the pulse in relation to other natural triggers; rates of rise and fall in daily flows; and the delivery pattern. It is, however, estimated that the volume required to deliver the spring pulse is up to 418 GL, but the actual volume will be determined closer to the delivery dates. This watering option will be implemented if flow rates during spring are between entitlement (5,500 ML/d for October) and 15,000 ML/day.

Flow augmentation (> 20,000 ML/d) will be opportunistic and managed in response to natural flow triggers and in close consultation with DFW and MDBA River Murray Operations. The volume for this option will need to be determined at the time of delivery, however is reliant on the presence of high natural flows (unregulated conditions) for achieving the most effective use of Commonwealth environmental water, particularly to meet the desired flow targets of between 45,000 to 60,000 ML/d.

The delivery of Commonwealth environmental water will be used in conjunction with entitlement and additional dilution flows, and where possible in association with unregulated flows to generate benefits throughout the system. Allocations at 100 per cent of SA Class 9 entitlements are assumed for 2011-12 and exact figures around this allocation will be considered in the final determination of Commonwealth environmental water use.

There will be no delivery costs associated with either the spring pulse or flow augmentation options as delivery will be via normal river operations. Costs associated with monitoring and reporting are currently being met by DFW and SA Water.

The water use options for the spring pulse (including Lock 1 weir pool raising) and flow augmentation are considered an effective and efficient use of Commonwealth environmental water and will provide system wide benefit.

Several of the Murray River wetlands received Commonwealth environmental water during the drought via pumping. Where augmented natural high flows are not able the meet water requirements in 2011-12 then options for pumping will be considered to capitalise on the prior investment at these high value sites. Water pumped to the assets will incur costs to be paid by the Commonwealth and the delivery partners. SA will contribute to the delivery costs and project management and monitoring. Pumping costs are often variable and the cost effectiveness of these options will need further consideration when a specific proposal is provided to the Commonwealth.

Weir pool raising is currently limited to Lock 1 due to current construction works and stability assessments being undertaken at all other river operating structures

Lower Murray River channel, fringing wetlands and associated floodplains
between Lock 6 to Lock 1. No weir lowering is proposed in 2011-12. Weir pool raising will be limited to approximately 0.5 metres above normal operating pool level to reduce potential impacts of infrastructure inundation and to encourage public acceptance of the activity.

Lower Lakes, Coorong and Murray Mouth including water use options to increase flows through the barrages

Lower Lakes, Coorong and Murray Mouth	
Criteria	**Response/Assessment**
1. The ecological significance of the asset(s)	
The Coorong, and Lakes Alexandrina and Albert Wetland support critically endangered, endangered, threatened and vulnerable species and ecological communities. It also supports extensive and diverse waterbird, fish and plant assemblages. Species being reliant on the assets complex mosaic of wetland types are recognised under international agreements (CAMBA, JAMBA, ROKAMBA) and listed under the EPBC Act 1999, *Protected Fisheries Management Act 2007* (South Australia) and/or Threatened Species Schedules under the *National Parks and Wildlife Act 1972* (South Australia). The Coorong, and Lakes Alexandrina and Albert Wetland is listed under the Ramsar Convention and the ecological values that are supported by these wetlands have been well documented in the site's ecological character description, icon site management plan, and a extensive range of ecological studies. The Coorong, Lower Lakes and Murray Mouth (CLLMM) is recognised as supporting 25 waterbirds listed under international migratory bird agreements (JAMBA, CAMBA, ROKAMBA) and 16 species regularly recording 1 per cent of the global population; notably, Cape Barron goose (*Cereopsis novaehollandiae*), sharp tailed (*Calidris* acuminata) and curlew sandpiper (*Cadidris ferruginea*), banded stilt (*Cladorhynchus leucocephalus*), red-necked avocet (*Recurvirostra novaehollandiae*), and fairy tern (*Sternula nereis*). Other waterbird species listed under the EPBC Act 1999 and state legislation are tabled in the *Environmental Water Delivery document: Coorong, Lower Lakes and River Murray channel below Lock 1* (2011). Monitoring during January 2010 indicated that the Coorong and Murray Estuary alone supported 170,000 waterbirds comprising 54 species, and seven species were in	

Lower Lakes, Coorong and Murray Mouth	
Criteria	**Response/Assessment**
numbers that exceeded 1 per cent of the flyway population (Paton 2010). This indicated that despite the change in the ecological state of the Coorong, it continues to be a significant habitat for birds. Notable fish species supported by the asset and listed as vulnerable under the EPBC Act 1999 include: Murray cod (*Maccullochella peelii peelii*), Murray hardyhead (*Craterocphalus fluviatilis*) and Yarra pygmy perch (*Nannoperca obscura*). These species have also been identified as endangered under the *Action Plan for South Australian Freshwater Fishes* (Hammer et al. 2009).	
2. The expected ecological outcomes from the proposed watering action	

Lower Lakes, Coorong and Murray Mouth

Criteria	Response/Assessment

As a direct result of continued low inflows in the Murray River from March 2007 until September 2010, there was a complete disconnection of Lake Alexandrina from the Coorong and Murray Mouth Estuary and a drop in water levels of the Lower Lakes to more than -1.0m AHD. These conditions resulted in localised acidification of exposed sulfidic sediments, salinisation and disconnection of fringing wetlands in the Lakes.

Rising salinity in the Coorong has led to a reduction and in some instances, a complete absence, of keystone species such as small-mouthed hardyhead (*Atherinosoma microstoma*), *Ruppia tuberosa* and chironomid larvae in the South Lagoon. Local extinctions have been observed for some species such as the Yarra pygmy perch.

Substantial inflows to the Lower Lakes and over the barrages during 2010-11 have resulted in significant responses from some biota (e.g. estuarine and diadromous fish) as a direct result of reconnecting habitat, salinity reductions and improved connectivity. However many species such as benthic invertebrates, waders and submerged aquatic plants have not yet shown signs of recovery.

To enhance the ecological benefits achieved in 2010-11 it is essential that further environmental water is provided to the site. Flow recommendations for the Coorong and Lower Lakes focus on a two to three year return interval for managing salinity targets (Jensen et al. 2000; GHD 2011). The provision of environmental water in 2011-12 to the site is essential to continue the positive trajectory of recovery, including the provision of benefits relating to: maintenance of an open Murray Mouth without the need for dredging; reduced salinity in the Coorong South Lagoon; management of lake water levels to inundate riparian edge vegetation and re-connect fringing wetlands; and releases through the barrages to maintain fish passage.

The water use options proposed in this strategy, and their expected ecological responses, is based on modelling work undertaken by Heneker (2010) and Lester et al. (2010) in determining the environmental flow requirements for the CLLMM asset. These studies link the ecological objectives and outcomes to flow-related requirements, including water quality, lake water levels, system connectivity, and return intervals for flooding and barrage flows.

Commonwealth objectives are to maintain and improve ecological health through actions that would enable the growth, reproduction and recruitment for a diverse range of flora and fauna, promote floodplain-river connectivity, and supporting medium to high flow river and floodplain functional processes. It is believed that the water use options outlined in this strategy for the CLLMM, as supported by the modelling reports, are compatible with the Commonwealth objectives and will contribute to improvements in the condition and function of the CLLMM wetland complex.

Lower Lakes, Coorong and Murray Mouth	
Criteria	**Response/Assessment**
3. The potential risks of the proposed watering action at the site and at connected locations	
Potential risks have been evaluated for CLLMM watering actions and have been deemed as low on all accounts. Risks considered include: damage to public infrastructure and private property, adverse public attitudes to water use and impacts to social activities; disturbance of acid sulphate soils, destabilisation of banks along the River channel, Lower Lakes, and Coorong, promoting the distribution of non-native flora and fauna species, and security of allocated Commonwealth environmental water. The contribution of Commonwealth environmental water to the CLLMM is relatively small in relation to the modelled total inflow to the barrages (between 3,900 to 6,000 GL/a); equating to approximately 10 - 15 per cent assuming full use of Commonwealth allocated resources and under both a dry and medium inflow scenarios (75 and 50 per cent probability of excedence, respectively). As such, the risk to inundating or damaging property, destabilising banks, etc. whilst may be likely, has an insignificant consequence for the Commonwealth, and of only minor consequence in the overall context of the total inflows. The management of water delivered to the CLLMM is directed by the MDBA River Murray Operations, under advice by the Barrage Operating Committee with key members including the South Australian government agencies, SA Water, MDBA, and other scientific and technical advisors. This governance arrangement for the use of allocated environmental water is considered appropriate and mitigates the risks to the Commonwealth associated with meeting the strategic objectives of lake level variability, barrage flow discharges, water quality management, and any other environmental impacts. Any transmission loss associated with the transfer of allocated environmental water specifically for barrage operations is expected to be met by entitlement flow, ADF or unregulated flow. Losses associated with environmental water volumes that are delivered for multiple benefits, for example spring pulse and inundation of wetlands, is difficult to calculate exactly however given the wet antecedent conditions and forecasted flow conditions ‘losses’ incurred during delivery is expected to be minimal if not insignificant. Unauthorised diversion is unlikely and considered insignificant under the conditions highlighted above.	
4. The long-term sustainability of the asset(s) including appropriate management arrangements	

Lower Lakes, Coorong and Murray Mouth	
Criteria	**Response/Assessment**

The *Coorong, and Lakes Alexandrina and Albert Ramsar Management Plan* was developed by the South Australian Department for Environment and Heritage (now SA DENR) in 2000, and reviewed in 2008, in accord with Ramsar Convention guidance and the Australian Ramsar Management Principles under the EPBC Act. In conjunction with this Plan, the site is also subject to management planning developed through other instruments including:

- *Securing the Future, Long-Term Plan for the Coorong, Lower Lakes and Murray Mouth* long-term management plan developed by the South Australian Department for Environment and Natural Resources (2010), which specifies a commitment to a freshwater solution as the long-term solution for the site and actions to conserve the site;
- *Native Fish Strategy for the Murray-Darling Basin 2003-13* developed by the Murray-Darling Basin Commission (2003);
- *South Australia Murray-Darling Basin Natural Resource Management Board Regional Plan* developed by the SA NRM Board (2009); and
- *Environmental Water Management Plan for the Coorong, Lower Lakes and Murray Mouth icon site* (in prep.) under The Living Murray program.

In addition, the Australian Government has committed over $330 million to build a more resilient environment and improve water security and water quality for Coorong and Lower Lakes local communities. This includes $200 million to assist the South Australian Government in developing and implementing the Long Term Plan that addresses the problems facing this icon site, $10 million towards bioremediation to help manage the risks of acidification, and $120 million for pipelines

Complementary management actions currently being undertaken include: measures for the maintenance of channel habitat (reed control); soil conservation (DEH 2000); management of flows from the South East into the Coorong South Lagoon; barrage fishway operation; additional flow control on structures on fringing lakes wetlands; up-grade of current structures; and revegetation to create ‘nature corridors’ between aquatic and riparian zones (South Australian Murray River Watering Proposals 2011).

Monitoring, evaluation and reporting

Monitoring and reporting activities related to the proposed water use options are listed in section 1.15 of this strategy. Monitoring of these proposed 2011-12 actions will be undertaken through the MDBA funded The Living Murray program through the SA Department for Water, and the CLLMM Murray Futures program through the SA Department of Environment and Natural Resources. Monitoring activities include:

Lower Lakes, Coorong and Murray Mouth	
Criteria	**Response/Assessment**

- Long-running CLLMM Icon Site TLM Condition Monitoring Program with fish monitoring in the Lower Lakes targeting threatened small-bodied species, barrage fishway monitoring targeting diadromous species, and Coorong fish monitoring targeting commercial species and the small-mouthed hardyhead;
- Aquatic vegetation monitoring (TLM Condition Monitoring Program);
- Aquatic benthic invertebrate monitoring (TLM Condition Monitoring Program);
- Monthly bird monitoring (TLM Condition Monitoring Program); and
- The CLLMM Murray Futures program. Until recently, this program has funded water quality monitoring (including phytoplankton) in the Lakes and Coorong, zooplankton monitoring and frog monitoring, with an emphasis on the Southern Bell Frog. However, funding for 2011-12 is currently undetermined.

Current monitoring arrangements are considered adequate, however would be improved by the addition of frog monitoring and on-going water quality monitoring. Reporting on the monitoring results currently aligns with the existing TLM and CLLMM programs however this requires further consideration on whether the timeliness of these reports are adequate for Commonwealth environmental water.

5. The cost-effectiveness and operational feasibility of undertaking the watering

The proposal to increase flows over the barrages would be implemented as part of a series of integrated actions that create efficiencies in water use whilst maximising environmental outcomes. Managed releases for the Coorong, Lakes Alexandrina and Albert, and the Murray Mouth would be integrated with the spring pulse flow and Lock 1 weir raising. The delivery of Commonwealth environmental water will be used in conjunction with entitlement and ADF, and where possible in association with unregulated flows to generate benefits throughout the system. Flows will be managed according to a monthly release pattern (see Appendix D). In particular, water must be provided to the CLLMM directly after the end of ADF in early September 2011 to counter increased evaporation losses into summer. Maximum releases will occur in spring to support critical ecological processes in a timely manner.

Environmental water will be delivered to the site via normal river operations and managed at the barrages by the Barrage Operations Committee (South Australian Murray River Watering Proposals 2011). There will be no delivery costs associated with this watering option as delivery will be via normal river and barrage operations. This water use option is considered an effective and efficient use of Commonwealth environmental water and will provide significant ecological and hydrological benefit.

Lower Lakes, Coorong and Murray Mouth	
Criteria	**Response/Assessment**
Small-scale wetland management at fringing lake wetlands, which are fitted with a flow regulator (i.e. Waltowa, Narrung, Shadows Lagoon) may provide complimentary benefits. Wetland managers may be encouraged to operate these wetlands to coincide with peaks in lake levels.	

Appendix D Proposed barrage flow hydrograph

Hydrograph *(optional)*

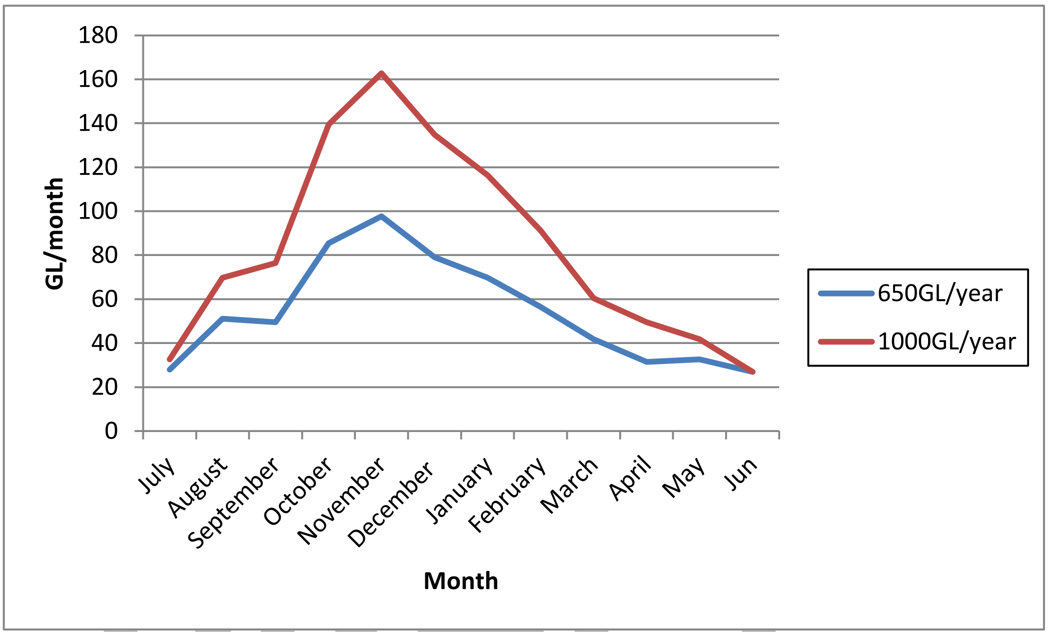


Figure 1. Monthly barrage outflow pattern required to deliver total volumes of 650 GL and 1000 GL over a period of one year (adapted from data developed by Jason Higham, DENR).

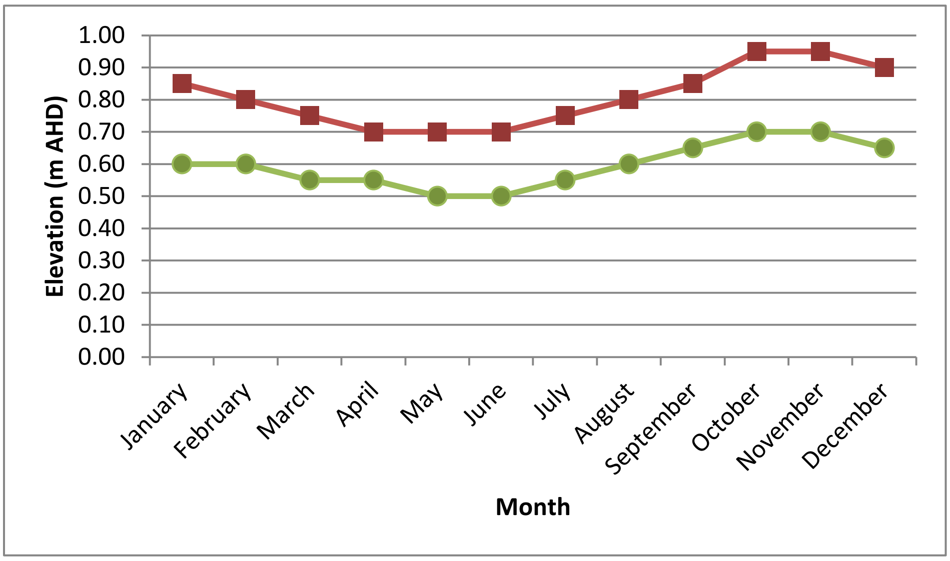


Figure 2. Proposed lake level operating envelope (showing maximum and minimum operating levels) (from Lester *et al.* 2010). Environmental flows are required in early spring to raise lake levels and allow for barrage releases over spring and summer.

Appendix E Target flow envelopes for Lake Alexandrina

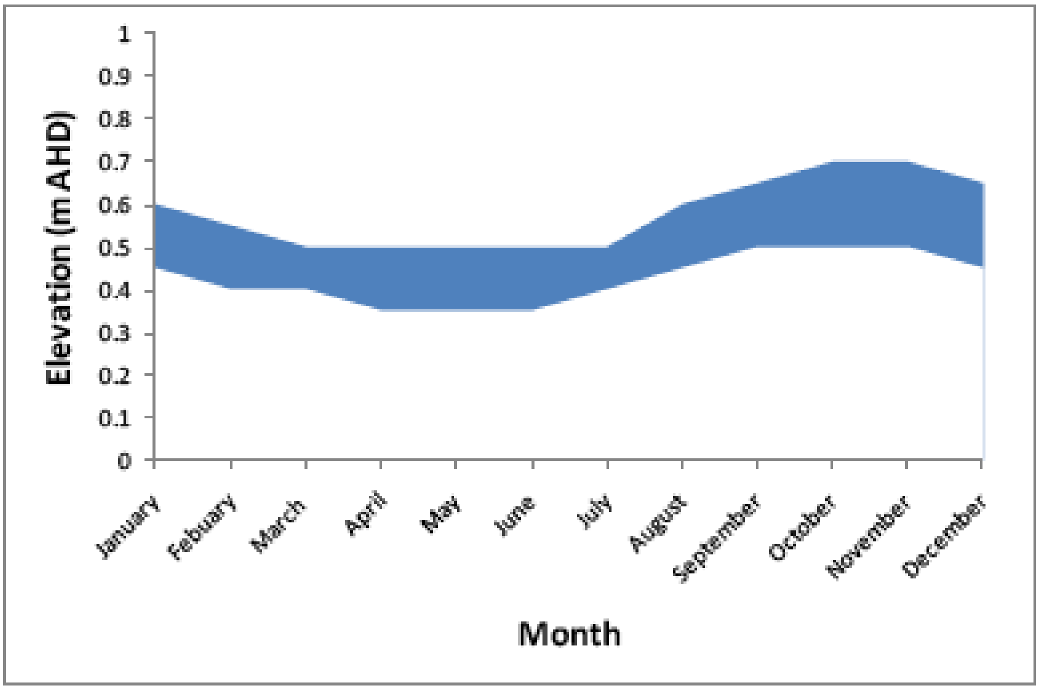


Figure 0-2: Proposed target envelope for water level in Lake Alexandrina at an Annual Return Interval of one year showing upper and lower limits (Adapted from Muller 2010, In Lester *et al.* (2010))

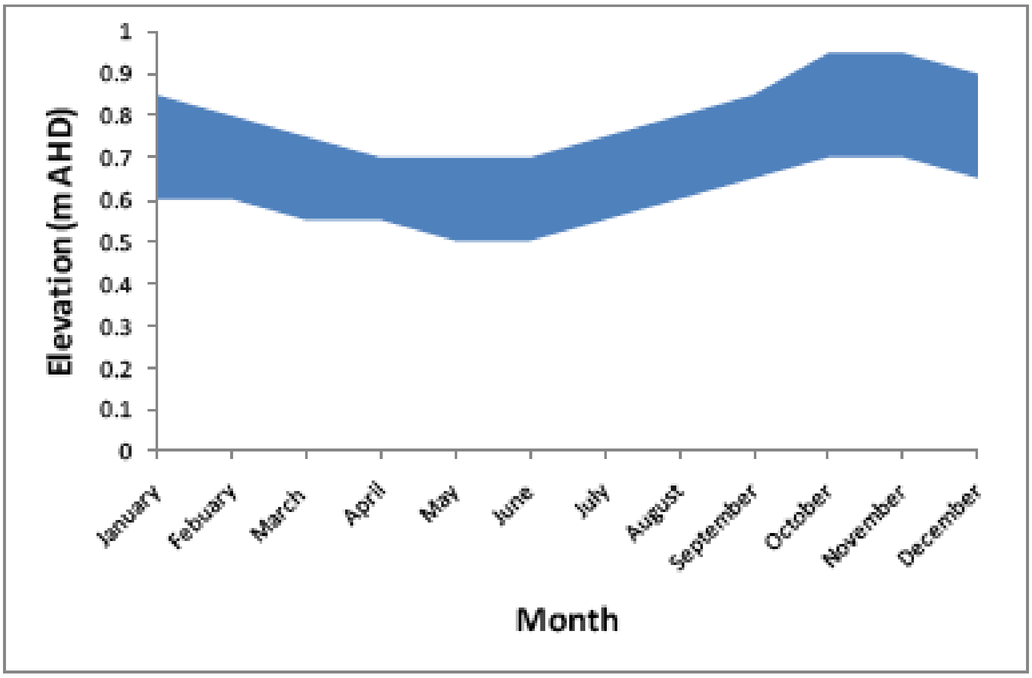
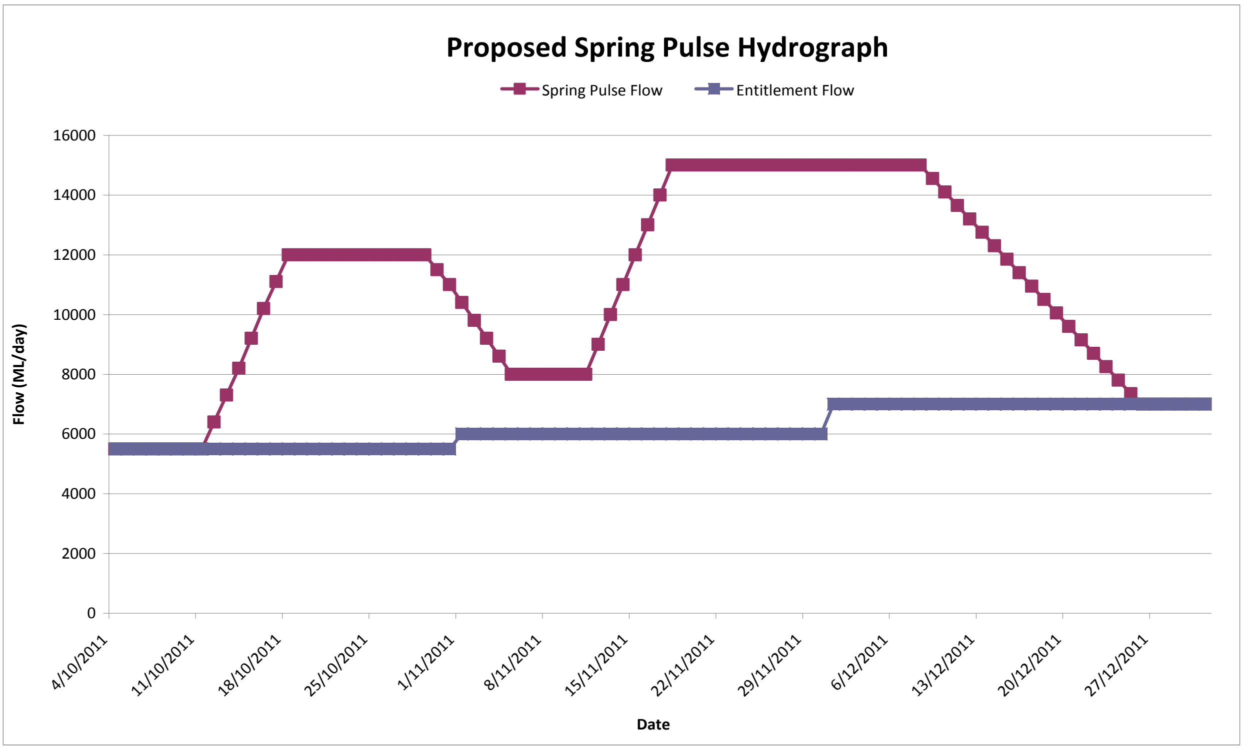


Figure 0-3: Proposed target envelope for water level in Lake Alexandrina at an Annual Return Interval of three years showing upper and lower limits (Adapted from Muller 2010, In Lester *et al.* (2010))

Appendix F Proposed spring pulse hydrograph

Hydrograph *(optional)*



Above is the general shape of the indicative spring pulse. Note that variability of flows, rather than constant flow rates – indicated by straight lines within this hydrograph, would be preferred.

(SA bid)

Water Use Strategy 2011-12: Macquarie River Catchment

1.1. Introduction

This document sets out the proposed objectives and approach to using environmental water in the Macquarie catchment during the 2011-12 water year. This strategy was developed based on information available to the Commonwealth Environmental Water through consultation with stakeholders including state governments, local river operators and wetland managers. Local community input has been sought through the Environmental Flows Reference Group (EFRG) which provides advice to the NSW government on environmental water use in the Macquarie catchment.

The document includes watering options given recent climatic and riverine conditions in the catchment and forecast water availability under a range of hydrologic scenarios. The proposed approach will adapt over the course of the year as conditions in the catchment change and more information becomes available. Importantly, the potential watering options included in this document do not form an exhaustive list – alternative suggestions for using environmental water are welcome. All relevant options will be assessed to ensure the best possible use of environmental water within the catchment and across the Murray-Darling Basin.

1.2. The Macquarie River Catchment

The Macquarie River is located in central western NSW, running from near Oberon on the western side of the Blue Mountains to the Barwon River (which downstream becomes the Darling River) near Carinda. The catchment contains two major storages, Windamere Dam (capacity 361 GL) on the Cudgegong River and Burrendong Dam (1,154 GL) on the Macquarie.

There are several rivers and creeks that enter the Macquarie River downstream of Burrendong Dam, with the main ones being:

- Bell River which enters at Wellington;
- Little River which enters upstream of Dubbo; and,
- Talbragar River which enters just downstream of Dubbo.

The primary environmental asset in the catchment is the Macquarie Marshes complex, which has been listed in the Directory of Important Wetlands in Australia (DIWA) and contains three areas that have been Ramsar listed. Other assets in the catchment include the Macquarie River itself, the Lower Macquarie River, and the effluent creeks on the western side of the Marsh, feeding into the Bogan River.

The primary users of water in the region are the major irrigation districts that occur along the Cudgegong and Macquarie Rivers. Water resources within the Macquarie River catchment are managed according to the *Water Sharing Plan for the Macquarie and Cudgegong Regulated Rivers Water Source 2003* (This Plan took effect on 1 July 2004 and ceases 10 years after that date).

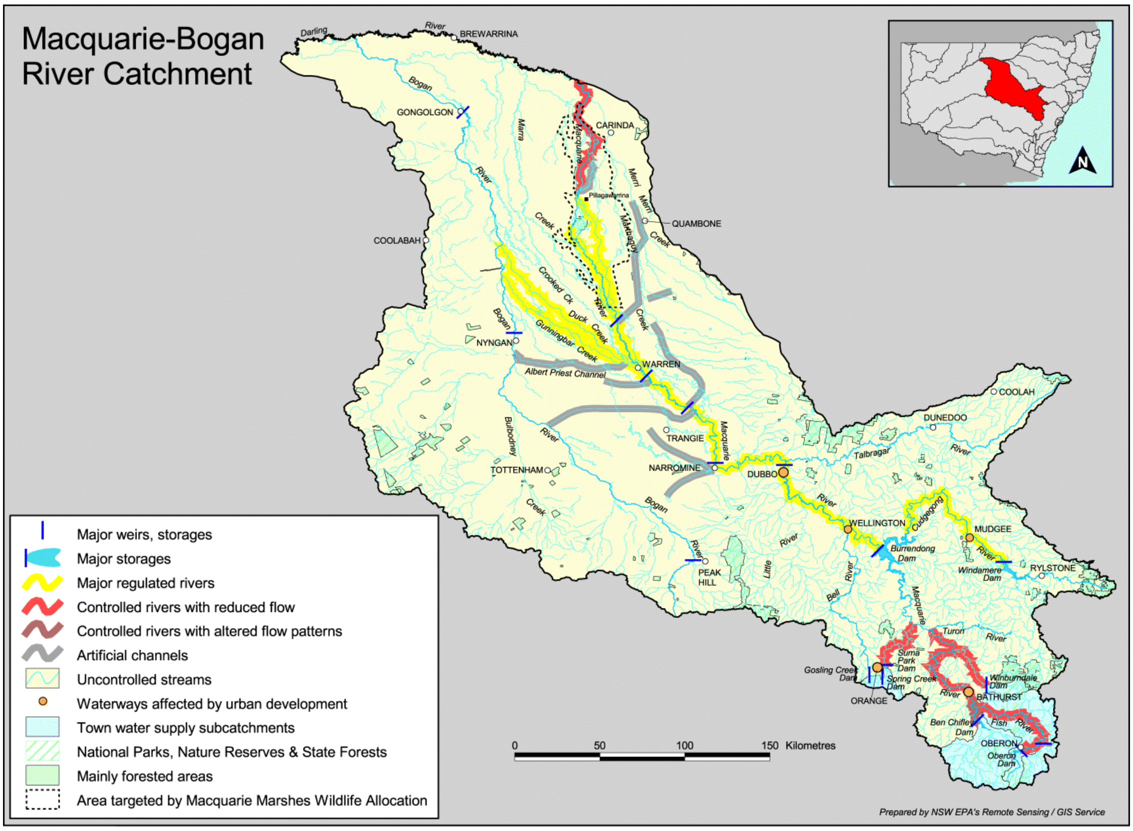


Figure 1: The Macquarie River Catchment

1.3. Environmental Assets in the Macquarie River Catchment

Freshwater-dependent biotic and abiotic assets in the Macquarie River catchment include areas of river red gum (*Eucalyptus camaldulensis*) forest and woodland, black box (*E. largiflorens*) woodland, lignum (*Muehlenbeckia florulenta*), river-fed wetlands, Ramsar-listed wetlands and other migratory bird habitats. The most significant habitat for these assets is the Macquarie Marshes. Other significant assets include the Macquarie River, and the effluent creeks, including the Marra Creek, Crooked Creek, and Duck Creek. Further details regarding the effluent creeks are currently being gathered.

Further details on the location, condition, type and extent of significant flora and fauna at each locality is presented at Appendix A.

1.4. Watering Objectives in the Macquarie River Catchment

During 2010-11, work was initiated to identify and develop large-scale watering options for Commonwealth environmental water, including in the Macquarie River catchment, in order to reflect growth in water holdings and improved water availability across the Basin. Through this work, the following median to long-term ecological and hydrological objectives for the Macquarie River catchment have been identified:

- Restore longitudinal and lateral connectivity within the Macquarie River and floodplain system to protect and restore the endangered ecological community, including its threatened species;
- Maintain and improve wetland vegetation communities to good condition;

- Maintain and improve river red gum forest and woodland communities to good condition;
- Maintain and improve black box woodlands to good condition;
- Maintain and improve lignum shrublands to good condition;
- Maintain open water areas and exposed muddy margins;
- Maintain known colonial waterbird breeding sites in ‘event ready’ condition, and support breeding events;
- Maintain seasonal habitats for migratory waterbirds; and
- Maintain or improve ecosystem condition in the Macquarie River channel.

1.5. Delivering Environmental Water in the Macquarie River Catchment

Water Management in the Macquarie River catchment is complex with two large reservoirs, several tributaries, and numerous extractions for irrigation and drinking water supply. Water supplies in the Macquarie catchment are stored in Burrendong Dam and Windamere Dam. Water orders are provided from a combination of these regulated sources, and from unregulated tributary inflows, occurring at the time. The Cudgegong River downstream of Windamere Dam, the Macquarie River downstream of Burrendong Dam, and major distributary channels of the Macquarie are designated regulated watercourses. Water entitlements are separated into Cudgegong entitlements (above Burrendong Dam) and Macquarie entitlements (below Burrendong Dam).

In order to water wetland assets in the catchments, releases are usually required from Burrendong Dam in the headwaters of the system. Environmental water is delivered via the Macquarie River and tributaries and gravity fed to the Macquarie Marshes.

1.6. Current Catchment Status

Antecendent conditions in the Macquarie River catchment are considered to be ‘wet’ due to major flooding in 2010-11. From July 2010 to June 2011, 925 GL have passed Marebone Weir and entered the Macquarie Marshes. This resulted in the inundation of approximately 175,000 hectares of wetland habitats. An event of this magnitude has not occurred in the Marshes for ten years and good moisture levels persist throughout the Marshes. Prior to the 2010-11 flood the catchment had experienced drought conditions for a long period. During that time, several managed environmental flows were delivered by NSW OEH, to key environmental assets within the Macquarie Marshes. Figure 2 shows the history of inflows to the Marshes since 1983 illustrating the component of managed environmental water. Figures 3 illustrates the seasonality of inflows. Table 1 outlines the quantity of Commonwealth water delivered in the Macquarie catchment during 2010-11.

Table 1: Environmental water use in the Macquarie River catchment during 2010-11.

Asset	Site	Date of delivery	Commonwealth volume (ML)	NSW volume (ML)	Total volume (ML)
Macquarie-Cudgegong Catchment	Macquarie Marshes	August 2010	1,888	1,302	3,190
	Macquarie Marshes	September 2010	0	60,376	60,376
	Macquarie Marshes	March 2011	25,000	110,594	135,594

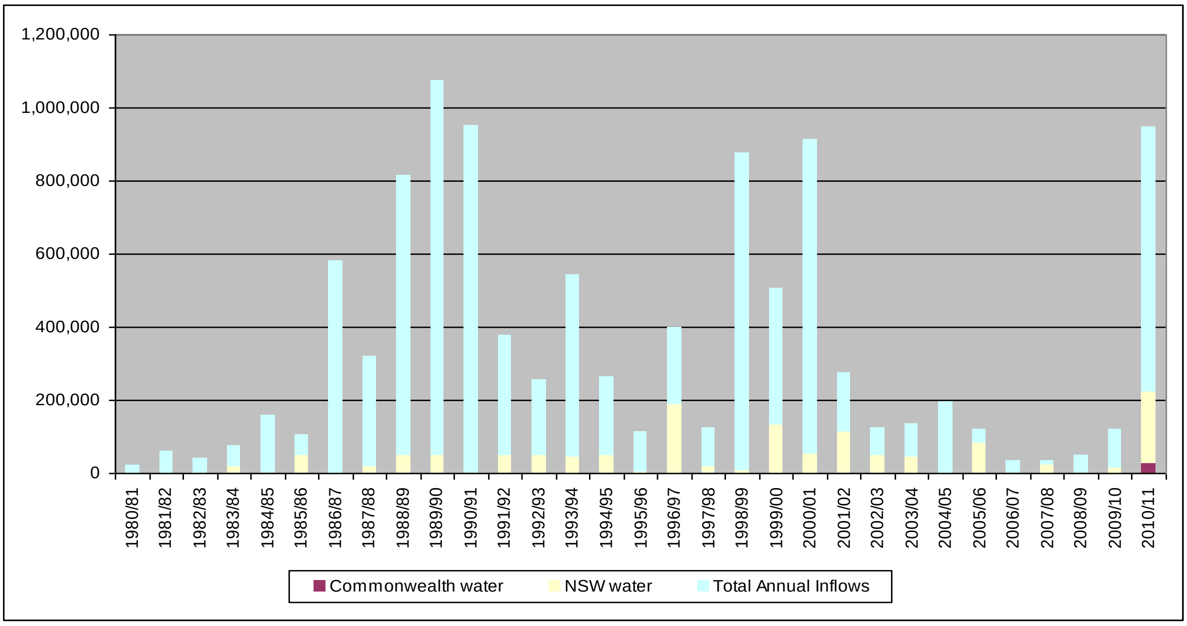


Figure 2: Total annual Inflows (ML) to the Macquarie Marshes since 1986 including environmental water deliveries (measured at Marebone Weir and Marebone Break)

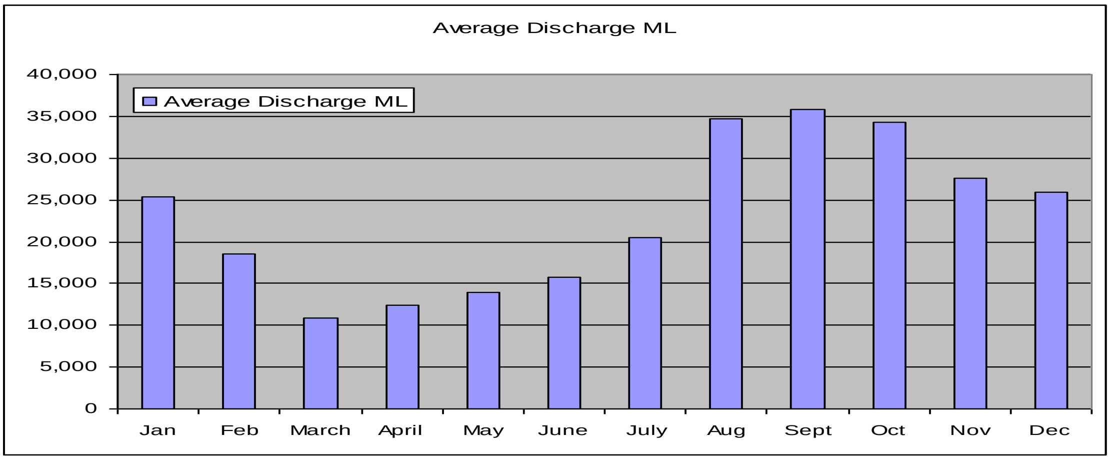


Figure 3: Average inflows (ML) per month to the Macquarie Marshes demonstrating the seasonality of flooding.

1.7. Water Availability Scenario

The national outlook for late winter to early spring (July to September) shows a moderate shift in the odds favouring drier than median rainfall for late winter to early spring over parts of the southeast of Australia. The outlook is a result of cool conditions in the central tropical Pacific Ocean, as well as warm conditions in the Indian Ocean. The CSIRO (2008) Sustainable Yields Report states Rainfall-runoff modelling with climate change projections from global climate models indicates that future runoff in the Macquarie-Castlereagh region is more likely to decrease than increase.

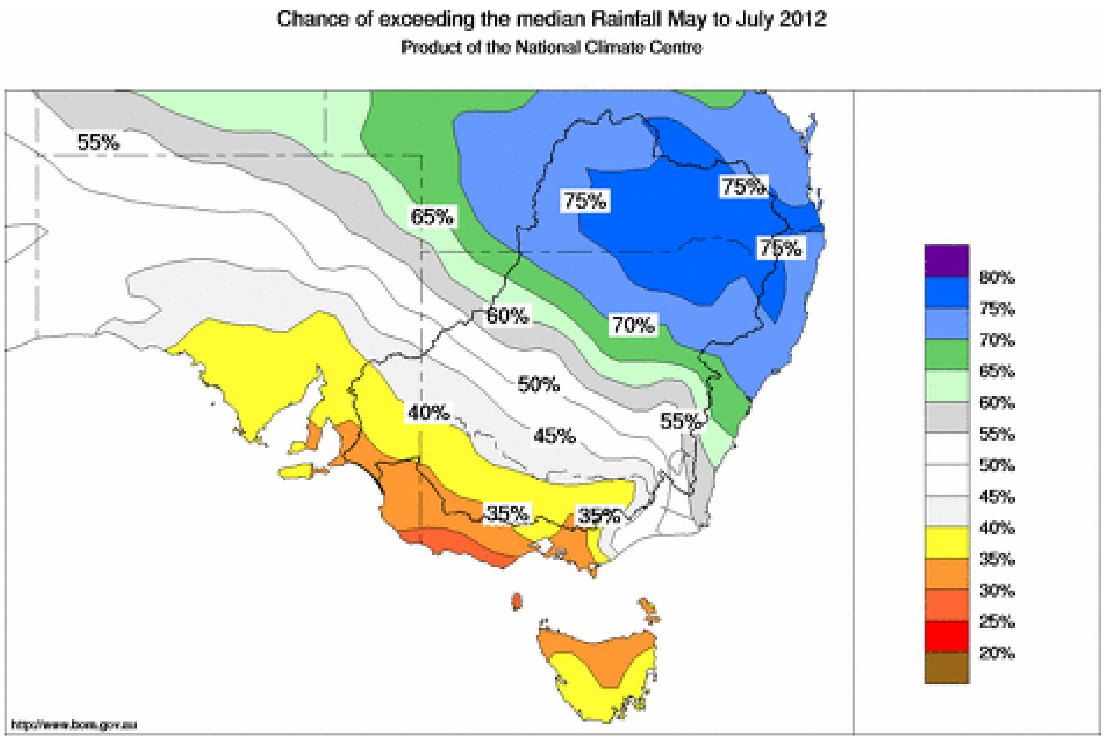


Figure 5: Seasonal rainfall outlook for south-eastern Australia (BoM).

The Macquarie River catchment lies in the band with a 45 to 50 per cent chance of exceeding the median seasonal rainfall for the region. However antecedent conditions in the catchment are wetter than average and streamflow responses can be expected to be higher than normal.

1.8. Commonwealth Environmental Water

Table 2 outlines Commonwealth water holdings in the Macquarie Catchment and current water available for use as at 1 July 2011.

Table 2: Commonwealth environmental water in the Macquarie Catchment

Account	Entitlement	Current Uncommitted Allocation (ML) for 2010-11 to be carried over to 2011-12	Water available for use 1 July 2011 (28 % allocation)
General Security	71,145	32,631	52,552
Supplementary	1,888	0	n/a
Total	**73,033**	**32,631**	**52,552**

1.9. Other Sources of Environmental Water

In addition to Commonwealth environmental water, there are other sources of environmental water that may be available to supplement Commonwealth environmental watering in the catchment during 2011-12 (Table 3). In accordance with the Water Sharing Plan, NSW Office of Environment and Heritage (NSW OEH) manages translucent releases from Windamere Dam of up to 10 GL per year, at any time of the year, to achieve a flow within the range of 150 to 1,500

ML per day at Rocky Water Hole on the Cudgegong River upstream of Mudgee when the storage level in Windamere Dam water storage is above 110,000 ML.

Table 3: Other sources of environmental water in the Macquarie River catchment for 2011-12.

Source	Management Authority	Entitlements
Environmental Water Allowances		
EWA1	NSW OEH	160,000 ML
Adaptive e-water	NSW OEH/Macquarie EWAG	48,154 ML General security 1,442 ML Supplementary
Translucent releases from Windamere Dam	NSW OEH	10,000 ML

1.10. Forecast Allocations

Current storage levels in the Macquarie Catchment are high at approximately 89 per cent as of June 27. However there is a high amount of carry over from 2010-11 (approximately 500 GL). State Water advised that allocations are 28 per cent at July 1. The Commonwealth will carry over nearly 33 GL of unused allocations from 2010-11. Under a median scenario the Commonwealth is forecast to hold approximately 70 GL of water (including carryover) available for use in 2011-12. Table 4 shows forecast allocations for all sources of environmental entitlements under the range of climatic scenarios (based on inflows). Under a median scenario the Commonwealth and NSW governments are forecast to have combined 278 GL available for watering options in 2011-12.

Table 4: Forecast allocations (ML) for all environmental water entitlements. Source: NSW Macquarie Customer Service Committee.

	Extreme Dry	Dry	Median	Wet	Very Wet
October	All carryover plus 28 % allocation	All carryover plus 28% allocation	Carryover plus 53% allocation	100% allocation, and carryover spilled	100% allocation, and carryover spilled
January	All carryover plus 28 % allocation	All carryover plus 28% allocation	Carryover plus 67% of allocation	100% of allocation, and carryover spilled	100% of allocation, and carryover spilled
Commonwealth (October)	**52,552**	**52,552**	**70,338***	**71,145****	**71,145****
NSW (October)	155,846	155,846	207,882	208,154	208,154
Total CEW and NSW water October 2011	208,395	208,395	278,220*	279,299**	279,299**

* There is a 50 per cent chance of a dam spill once allocations reach 50 per cent, hence some spill of carryover may occur in a median scenario.
** This figure assumes all carryover spills. There may be an opportunity to use some carryover prior to a spill under this scenario resulting in a greater quantity of water available.

1.11. Watering Objectives for 2011-12

The Department's *Framework for Determining Commonwealth Environmental Watering Actions* establishes four water availability scenarios and the types of watering objectives that align with each (Appendix B). As there is a large volume of carryover available against the Commonwealth's entitlements, the overall watering objective has been reviewed and adjusted to maintain ecological health and resilience which is consistent with "median" objectives described in the Framework. This overall objective includes the following management objectives:

- enable growth, reproduction and small-scale recruitment for a diverse range of flora and fauna;
- promote low-lying floodplain-river connectivity; and
- support medium flow river and floodplain functional processes.

Hence the focus is on maintaining the condition of riverine and floodplain assets by supporting flow events that inundate river benches and low-lying floodplain wetlands.

The types of watering actions that are consistent with these objectives may include:

- prolong flood/high-flow duration at key sites and reaches of priority assets;
- contribute to the full range of in-channel flows; and
- use carryover to provide optimal seasonal flow patterns in subsequent years.

1.12. Watering Options for 2011-12

Potential watering options for the Macquarie River catchment focus on attempting to inundate wetlands and rookeries to facilitate waterbird and frog breeding events and support improved resilience in these populations in the catchment; creating end-of-system flows in the Macquarie River, and creating a mosaic of wetting and drying floodplain wetlands throughout the catchment. A summary of watering options under the range of climatic scenarios is provided at Table 5. More details on the watering options and objectives under a median scenario are provided in Table 6. Operational considerations for these options, including consideration of the delivery mechanism, and the target flow volume and its timing and duration is provided at Table 7.

Table 5: Watering Options for the Macquarie River Catchment under the full range of climate scenarios

Environmental Asset	**Extreme Dry** Goal: Avoid damage to key environmental asset	**Dry** Goal: Ensure ecological capacity for recovery	**Median (options described in more detail in Table 6)** Goal: Maintain ecological health and resilience	**Wet** Goal: Improve and extend healthy and resilient aquatic ecosystems	**Very Wet** Goal: Improve and extend healthy and resilient aquatic ecosystems
	Available environmental water **CEW: 52 GL** NSW: 156 GL Total: 208 GL Total estimated use: up to 35 GL Projected carryover to 2012-13: 17 GL	**Available environmental water** **CEW: 52 GL** NSW: 156 GL Total: 208 GL Total estimated Use: up to 35 GL Projected carryover to 2012-13: 17 GL	**Available environmental water** **CEW: 70 GL** NSW: 208 GL Total: 278 GL Total estimated Use: up to 65 GL Projected carryover to 2012-13: 5 GL	**Available environmental water** **CEW: 71 GL** NSW: 208 GL Total: 279 GL (dam spill likely resulting in carryover forfeit.) Total estimated Use: 25 GL Projected carryover to 2012-13: 46 GL	**Available environmental water** **CEW: 71 GL** NSW: 208 GL Total: 279 GL (dam spill highly likely resulting in carryover forfeit.) Total estimated Use: 0 GL Projected carryover to 2012-13: 71 GL
1. Macquarie Marshes	Use carryover from 2010-11 and allocations to inundate core semi permanent wetland vegetation communities and core parts of the river red gum communities with up to 35 GL of CEW (in cooperation with NSW - total event size 150 GL) for 3 months (30,000-35,000 hectares). Parts of the stressed river red gum communities will not be watered in this scenario. There will be little of no tributary inflows to enhance this option. Some carryover is retained to provide optimal seasonal flow patterns in 2012-13 and 2013-14. Under multiple dry years carryover is progressively reduced.	Use carryover from 2010-11 and allocations to inundate core semi permanent wetland vegetation communities and core parts of the river red gum communities with up to 35 GL of CEW (in cooperation with NSW - total event size 150 GL) for 3 months. (30,000-35,000 hectares). Parts of the stressed river red gum communities will not be watered in this scenario. Tributary inflows are unlikely to enhance this event. Some carryover is retained to provide optimal seasonal flow patterns in 2012-13 and 2013-14. Under multiple dry years carryover is progressively reduced.	Use Carryover from 2010-11 and increased allocations to increase the area and duration of inundation of high conservation value and improve semi-permanent aquatic vegetation communities and river red gum woodlands to good condition with up to 55 GL of CEW (in cooperation with NSW - total event size 225 GL) for 3-4 months (approaching 50,000 hectares). Tributary inflows are possible and if available will assist in maximising the inundation of the above option, and will possibly increase the area of inundation to 50,000 hectares. In this situation environmental water will be piggybacked onto significant tributary freshes inundating the majority of river red gum woodlands and increasing high flow duration and extent across the floodplain. Maintain and complete priority colonial waterbird breeding events initiated by natural flood event or environmental flows. If bird breeding contingency is not required, carryover will be retained to provide optimal seasonal flow patterns in 2012-13 and 2013-14.	Increase the area and duration (greater than 7 months) of inundation of the Macquarie Marshes, to maintain and/or improve semi-permanent aquatic vegetation communities to good condition. Inundate these communities for at least five months, commencing in spring. It is anticipated that tributary flows will contribute significantly to the above action. Environmental water releases will be piggybacked onto significant tributary freshes inundating all of river red gum woodlands and increasing high flow duration and extent across the floodplain. Maintain and complete all colonial waterbird breeding events initiated by natural flood event or environmental flows. Use carryover to provide optimal seasonal flow patterns in subsequent years.	Options for delivering holdings will be limited as objectives will be satisfied by dam spill and tributary flow. In addition rivers and channels will be at capacity and unable to take further water orders. The primary option will be to ensure carryover is maximised to provide optimal seasonal flow patterns in subsequent years. Particularly to support core wetland areas of semi-permanent wetland communities and drought refuge.
2. effluent creeks	No options – requires median to wet conditions.	No options – requires median to wet conditions.	Provide trial flow - 2 GL (5 GL total event) to Crooked Creek to inundate key asset areas such as Talga and Moon Moon Swamp.	Provide trial flow - 2 GL (5 GL total event) to Crooked Creek to inundate key asset areas such as Talga and Moon Moon Swamp.	Limited options. Creeks will be full with dam spill and tributary flows.
3. Macquarie River	Provide flush during late winter spring.	Provide flush during late winter spring.	Provide flush during late winter spring.	Provide flush during late winter spring, if river capacity permits	Limited options under this scenario, asset catered for by dam spill and tributary flows.
Carryover	Carryover may provide optimal seasonal flow patterns in subsequent years.	Carryover may provide optimal seasonal flow patterns in subsequent years.	If all actions completed minimal carryover, estimate Carryover may be used to provide optimal seasonal flow patterns in following year.	High unregulated flow and dam spill likely to satisfy the majority of objectives. A medium to high volume of carryover is likely. Carryover may provide optimal seasonal flow patterns in subsequent years.	High unregulated flow and dam spill are likely to satisfy the majority of objectives and will also limit capacity for delivery. High volume of carryover likely. Carryover may provide optimal seasonal flow patterns in subsequent years

Table 6: Potential watering options and objectives for 2011-12 in the Macquarie River catchment under a median scenario.

Asset	Watering Options and Objectives
Late winter spring 2011	
1. Macquarie Marshes North, South and East Marsh	Provide up to 55 GL (of a total event of 225 GL) over 3 months to inundate 40,000 hectares in the north, south and eastern Marsh to build on the condition improvements achieved from the 2010-11 flooding. Figure 6 illustrates the expected inundation resulting from 250 GL of inflows delivered over 3 months and the extent of semi-permanent wetland vegetation inundated. A 225 GL inflow would inundate slightly less area. This action would have the following objectives: • Flood all core semi-permanent aquatic communities throughout the Macquarie Marshes to improve condition and build resilience; • Ensure the survival of native biota recruited from flooding in 2010-11; • Inundate river red gum woodlands, restore condition, build resilience and promote recruitment in degraded areas. Ideally this action would be combined with a natural event to increase the quantity of inflows to 250 GL. This would inundate 50,000 hectares and target more of the stressed river red gum communities.; • Combat the intrusion of invasive terrestrial vegetation communities such as roly poly (*Scleraleana sp.*), into semi-permanent wetland communities by reducing the viability of the terrestrial seed bank; and, • Provide some inundation to the open-water lagoon systems of the southern Nature Reserve and Monkey Swamp to restore the condition of habitat for migratory wader birds.
2. Effluent creeks/ Crooked Creek	Provide 2,000 ML (of a total event of 5,000 ML) to the Crooked Creek via Gunningbar Creek to restore a more natural flooding regime and provide water to semi-permanent wetland vegetation communities in Talga and Half Moon wetlands to improve condition and resilience. This action would also provide an opportunity for recruitment of riparian vegetation including canopy trees.
3. Marshes/ effluent creeks	Deliver supplementary water opportunistically as events arise, to replicate natural floodplain inundation patterns, favouring late winter/spring delivery.
Spring/Summer 2011-12	
4. Macquarie Marshes	Bird breeding may be triggered in numerous locations by unregulated inflows or possibly by the spring watering option. It may be feasible to provide environmental water to prolong inundation to ensure the success of the breeding event. The quantity of water required to do this will vary depending on natural flows and the location of the breeding sites. A contingency of a minimum of 10 GL (of a total event of 50 GL) will be retained to support bird breeding where possible. In the event that the volume of CEW required for option 1 above is reduced as a result of tributary contributions, volumes to support for bird breeding may be increased.
5. Macquarie River *	Enhance natural flows during summer which drown out barriers such as weirs, can facilitate native fish movement , facilitating recruitment *
6. Macquarie River *	Support peak flows during spring summer to facilitate native fish spawning*.
Autumn/Winter 2012	
7. Carryover	Any unused allocations may be carried over to provide optimal seasonal flow patterns in 2012-2013.

* The Macquarie River options will only be available when they are delivered in conjunction with delivery to another asset.

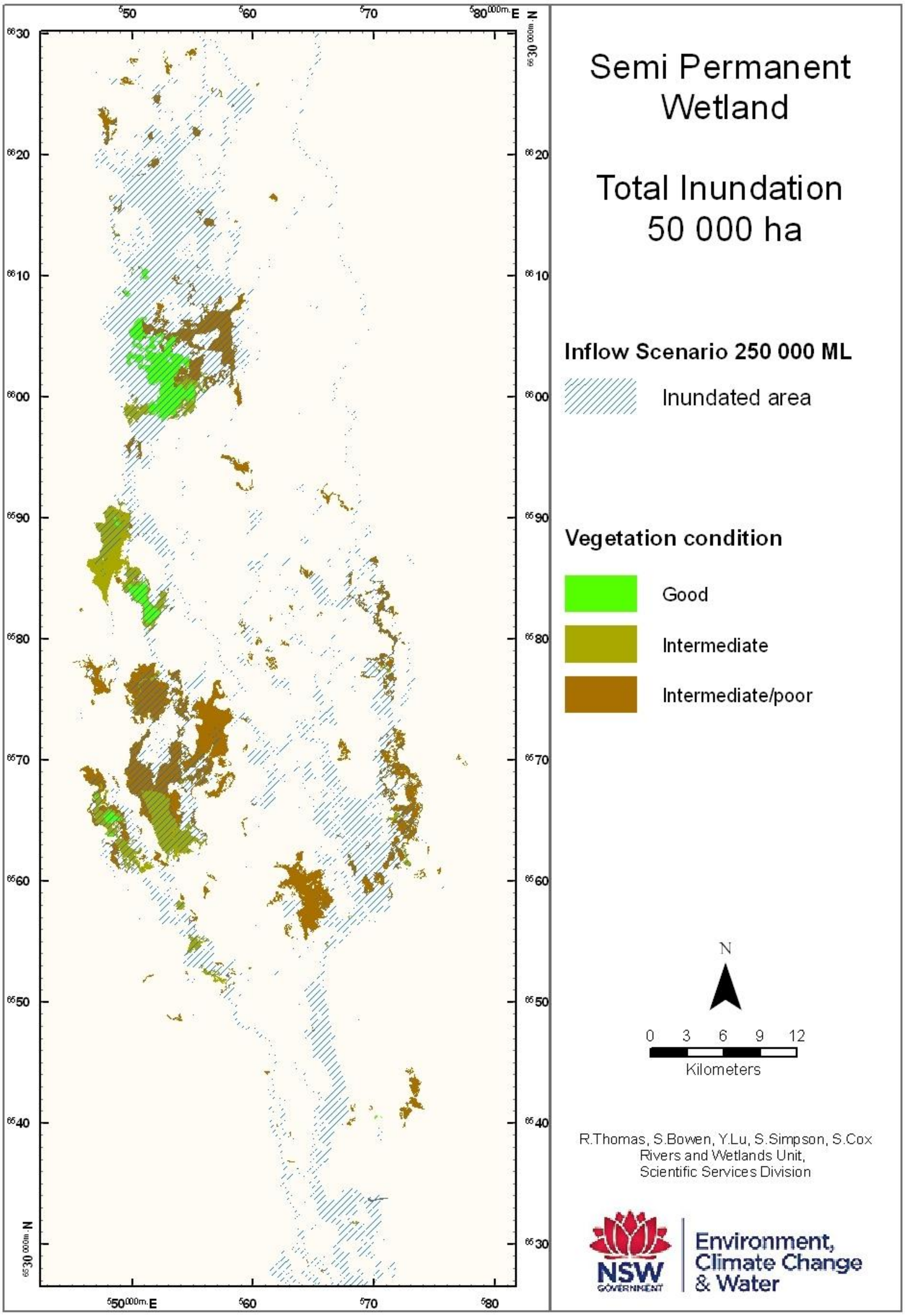


Figure 6: The expected extent of inundation within the Macquarie Marshes and the inundation of semi-permanent wetland vegetation as a result of 250 GL of inflows.

Table 7: Operational details for potential watering actions for 2011-12 in the Macquarie River catchment (assuming median scenario and combined with NSW water equates to 280 GL of available water (including carryover).

Asset	Water Management Objective*	Target flow rate	Estimated volume	Timing & Duration	Delivery mechanism	Operational considerations^
Macquarie Marshes						
1. North, South and East Marsh (see Figure 6)	late winter/ spring	1,000 - 4,000 ML per day at Marebone Weir	CEW 55 GL Total event: 225 GL	spring – 3 months	Natural river channel	Although a flow trigger would be ideal and would help to increase the volume and duration of the watering event, a trigger is not essential and the action can be completed using Commonwealth and NSW environmental water alone. In the event that natural flows exceed the target flow rate of 4,000 ML per day, environmental water delivery will be delayed until flows subside. If a prolonged natural event occurs it is likely that there will be greater potential to deliver environmental water. In the event that a dry scenario eventuates and allocations are not as high as expected the watering proposal will be scaled back. (see dry scenario in Table 6).
4. North, South and East Marsh	summer	1,0 00 – 2,000 ML per day at Marebone Weir	CEW 10-55 GL Total event: 50 - 225 GL	summer – 1-2 months	Natural river channel	This water would be delivered in the event that bird breeding is triggered by unregulated flows or the spring delivery, and flows are insufficient to see the breeding event through to completion. In the event that this contingency is not required (likely under a wet and very wet scenario, or because breeding did not commence), unused water may be carried over to 2012-13 to support a broad range of options in 2012-13.
effluent creeks						
2. Crooked Creek	winter/spring	Pending further information. Event will be managed	CEW 2 GL Total Event:: Up to 5 GL	spring- late spring	Natural river channel and regulated	This option is dependent upon favourable inflows to deliver environment water via the Gunningbar system. It is also subject to availability of resources for monitoring and surveillance of the outcomes. Further information is currently being compiled by

Asset	Water Management Objective*	Target flow rate	Estimated volume	Timing & Duration	Delivery mechanism	Operational considerations^
		adaptively.			structures	Torrible and Wettin on asset values, water requirements and delivery details. Further details on this option will be provided prior to any action.
Macquarie River						
5., 6., Dependent/associated with options 1. and/or 2.	spring/summer	2,500 - 4,000 ML per day at Marebone Weir	CEW 55 GL Total event up to 225 GL	spring – 3 months	Natural river channel	Macquarie River will receive a system flow with the delivery of environmental water during winter/spring to the Macquarie Marshes. In addition, if environmental water is delivered during summer to support bird breeding, an additional flush will be provided. The temperature of the water is a primary driver of native fish recruitment. Environmental water delivered from the dam can come from the bottom of the storage resulting in cold water being released. This is most pronounced immediately downstream of the dam, this effect diminishes with distance downstream as the water warms. Although the distance over which cold water effects vary due to ambient temperature and mixing with tributary inflows. Options for addressing cold water pollution of the Macquarie River are also being investigated. Further details will be provided when they are available. The magnitude of flow in the Macquarie River is affected by operational decisions, including delivery to consumptive users, and environmental water delivery alone is unlikely to be large enough to drown out barriers to fish movement.

** See detailed objective From Table 5.*

Table 8: Total release volume estimate and monthly water allocation profile under the Median scenario (GL)

Asset	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Macquarie Marshes		10	20	25		5	3						63
effluent creeks				2									2

NB: All watering events will be managed adaptively and respond to conditions and events as they occur within the catchment and the asset.

1.13. Key Constraints for water delivery

The outlet capacity of Burrendong Dam is 8,200 ML per day. As the majority of environmental water will be delivered in spring and the peak irrigation demand is in summer, this is likely to reduce the impact of delivery constraints.

1.14. Assessing Environmental Watering Options

To determine which watering actions will be progressed an assessment and, where required, prioritisation of each option or suite of options, has been carried out against the Commonwealth Environmental Water Holder criteria for assessing watering actions. Briefly, these are the:

- ecological significance of the asset(s);
- expected ecological outcomes from the proposed watering action;
- potential risks of the proposed watering action at the site and at connected locations;
- long-term sustainability of the asset(s) including appropriate management arrangements;
- cost-effectiveness and operational feasibility of undertaking the watering.

Detailed description of the Commonwealth Environmental Water criteria for assessing watering actions is provided at Appendix C. An assessment of the range of potential watering options against these criteria is provided at Appendix D. Data is currently being compiled on the effluent creeks and further assessments will be provided upon completion. This assessment considers watering the suite of options in scope in groups of similarly located and managed assets. This allows the benefit of watering individual assets to be considered at the individual asset scale through the course of the year, while also considering complementary actions and potential integration of watering actions proposed for a group of assets collectively.

It is highly likely that the Commonwealth will be able to contribute up to 70 GL to an action to inundate core areas of the north south and eastern Marsh in drought, dry or median scenarios. If a very wet scenario eventuates, options may be limited as objectives may be satisfied by unregulated flows from dam spills and tributary flow.

This assessment will be reviewed as individual watering actions are closer to their proposed timing for delivery. The review will include a more comprehensive risk assessment which is subject to the prevailing catchment and river flow conditions, and will consider in more detail proposed costs, delivery, monitoring and accounting arrangements.

Any additional watering options identified during the course of the year will also be subject to an assessment against the criteria.

1.15. Water Use Accounting

In the regulated Macquarie River and associated systems, environmental flows are delivered by NSW State Water Corporation. The water is delivered from Burrendong Dam and takes approximately eight days to travel to the accounting point at Marebone Weir, where there is a gauging station that is most reliable at lower flows. In high flows greater than 4,000 ML per day, there is overbank flooding and the accuracy of the flows recorded at the gauge declines. However Commonwealth water is expected to be delivered at rates of less than 4,000 ML per day to Marebone Weir. Deliveries to the effluent creeks will have a range of accounting points and these details are still to be confirmed.

Table 8: Water accounting arrangements for assets in the Macquarie River catchment.

Asset	Accounting Arrangement
Macquarie Marshes	Holdings used accounted for at Marebone Weir.
Effluent Creek – Crooked Creek	Holdings used at Crooked Creek accounted for at the regulator on the Gunningbar Creek (details to be confirmed)
Macquarie River	Holdings used accounted for at Marebone Weir.

1.16. Risk Management

A full risk assessment will be undertaken for each watering option as part of the assessment process, building upon the preliminary risk assessment included for groups of assets at Attachment D. Some of the more likely risks associated with delivering environmental water in the catchment are:

- failed bird breeding events due to unregulated flow pattern combined with inadequate volumes of environmental water;
- undesirable flooding of property and infrastructure;
- increase of exotic species, particularly carp; environmental water delivery may cause channel and bank erosion. This is known to be a problem particularly in the Southern Macquarie Marsh Nature Reserve;
- insufficient inundation of river red gum woodland contributing to further decline of the community; and
- Commonwealth environmental water diverted by downstream water users.

Commonwealth Environmental Water will work closely with the NSW OEH to ensure all events are closely monitored. This will assist in mitigating a range of risks particularly unsuccessful bird breeding, and undesirable inundation.

1.17. Event Monitoring

A robust approach to monitoring and evaluation is critical to determining the long-term outcomes of the use of environmental water, and to provide information to support good governance and adaptive management. The monitoring of Commonwealth watering actions will be undertaken in accordance with the Monitoring, Evaluation and Reporting framework developed by Commonwealth Environmental Water. This framework will facilitate the assessment and achievement of specific environmental outcomes to Commonwealth watering actions. This poses many challenges, but through considered study design and cooperation with existing jurisdictional and MDBA monitoring programs it is anticipated that the MER framework will provide a strong evidence base to enable a robust validation of Commonwealth approaches to environmental watering.

A number of monitoring programs are being undertaken by a variety of agencies in the Macquarie with some having a Basin-wide focus. These programs range from ecological to hydrological in nature and are listed below. Additional monitoring will be considered on an event–by-event basis closer to the time of the action.

In relation to operational monitoring NSW OEH will report annually to Commonwealth Environmental Water on the total volumes entering the Marshes and flows through the gauged channels within the Marshes. Informal reports will also be provided through participation in the regular meetings of the Environmental Flows Reference Group. Observations on the extent of flooding and incidental observations on responses by birds and vegetation will also be made from ground and air surveys and provided to Commonwealth Environmental Water.

NSW OEH will investigate likely colonial bird breeding sites following all flooding events. Where colonies are identified, regular monitoring will be conducted for the duration of the event to report on colony size, diversity and fledging success. Regular updates will be provided to Commonwealth Environmental Water.

Wetland vegetation condition will be measured using a combination of methods. NSW OEH conduct opportunistic field based vegetation sampling. In addition, techniques based on remote imagery are also being trialled as a rapid, cost effective method to provide an index of vegetation condition. Wetland vegetation extent will be assessed for each community every five years. This information will be used to measure progress toward achieving the long-term targets.

NSW has developed a number of targets for natural resource condition, including wetlands. In order to assess progress toward these targets, a monitoring, evaluation and reporting framework has been developed and trialled for important wetlands. Refinements are currently being made to ensure meaningful and cost-effective information is derived.

The MDBA is also developing a monitoring framework as a component of the Environmental Watering Plan within the MDB Plan. Experience from implementation of The Living Murray Initiative is informing these frameworks.

Table 8: Monitoring arrangements for environmental flows in the Macquarie catchment.

Monitoring activities			
Location	**Parameters**	**Timing/frequency**	**Responsibility**
Compliance/operational monitoring			
Marebone Weir	Flow (ML/day) and water levels (metres AHD)	Ongoing daily monitoring	NSW State Water monitors the flow and water levels at each of the gauges in NSW.
Marebone Weir and the Macquarie Marshes	Flow (ML/day), approximate quantity delivered, approximate spread of inundation.	Weekly informal updates	OEH will provide weekly informal updates via email
Marebone Weir	Flow (ML/day), total quantity delivered	Monthly *	OEH
Intervention/response monitoring			
Various sites in the Macquarie Marshes	Vegetation condition assessment**	1 to 2 times per year	NSW Office of Environment and Heritage
Colonial nesting sites	Number of nesting birds Stage of event Success of event	Regularly throughout breeding events.	NSW Office of Environment and Heritage
Macquarie Marshes	Extent of inundation monitored both with aerial photography and satellite imagery	Regularly throughout an inundation event.	NSW Office of Environment and Heritage
Condition Monitoring			
Various sites throughout the Macquarie Marshes	Vegetation condition and extent. Combination site survey and satellite image analysis.**	Full mapping of vegetation condition and extent every 5 years.	NSW Office of Environment and Heritage
Various sites throughout the Macquarie Marshes	Fish monitoring Frog monitoring	Conducted throughout 2010-11.	University of NSW

* Official monthly reports from OEH to the Commonwealth are yet to be formally confirmed.

** These monitoring programs are limited by the availability of funds. In 2010-11 the full suite of sites were not able to be assessed due to insufficient funds. Vegetation may not be assessed after each watering event.

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Appendix A Environmental Assets

Macquarie Marshes

The Macquarie Marshes are a large and diverse wetland system, containing a variety of wetland types. These range from semi-permanent marshes and lagoons to ephemeral wetlands that are inundated by only the largest floods.

The values of the Macquarie Marshes are recognised at all levels of government within Australia and are listed in the DIWA (Australian Nature Conservation Agency 1996). They are included as areas of conservation importance by the National Trust of Australia and the Australian Heritage Commission (NPWS 1993). The Marshes are also listed as refugia for biological diversity in arid and semi-arid Australia. Morton (et al. 1995) notes the massive complex of wetlands, the wide range of habitats available, and the major drought refuge for waterbirds. The Marshes regularly supports more than 20,000 waterbirds. The Marshes have regularly recorded more than this number of waterbirds, with greater than 500,000 in major floods. Within the Macquarie Marshes 18,143 hectares of public and 583 hectares of private land are listed as a Ramsar site.

The Marshes represent an outstanding example of the river red gum-common reed-water couch vegetation association and contain the largest and most northerly area of common reed (*Phragmites australis*) in south-eastern Australia. It also contains a major area of river red gum, which is recognised as the largest in northern NSW (NSW NPWS 2000), the most northerly stand of black box and one of the most southerly stands of coolibah (*E. coolabah*), (NPWS 1993).

The Macquarie Marshes can be seen as three core areas; the east marsh, south marsh and north marsh. Figure 7 illustrates these core areas in red. The whole Macquarie Marsh system is interconnected and although there is some ability to direct water to these core areas, generally the inundation of the Marshes occurs according to the inundation zones illustrated in Figure 8. The watering action proposed for the Marshes in winter/spring this year (assuming median scenario) will flow roughly in accordance with the red boundary (250 GL zone).

Macquarie Marshes

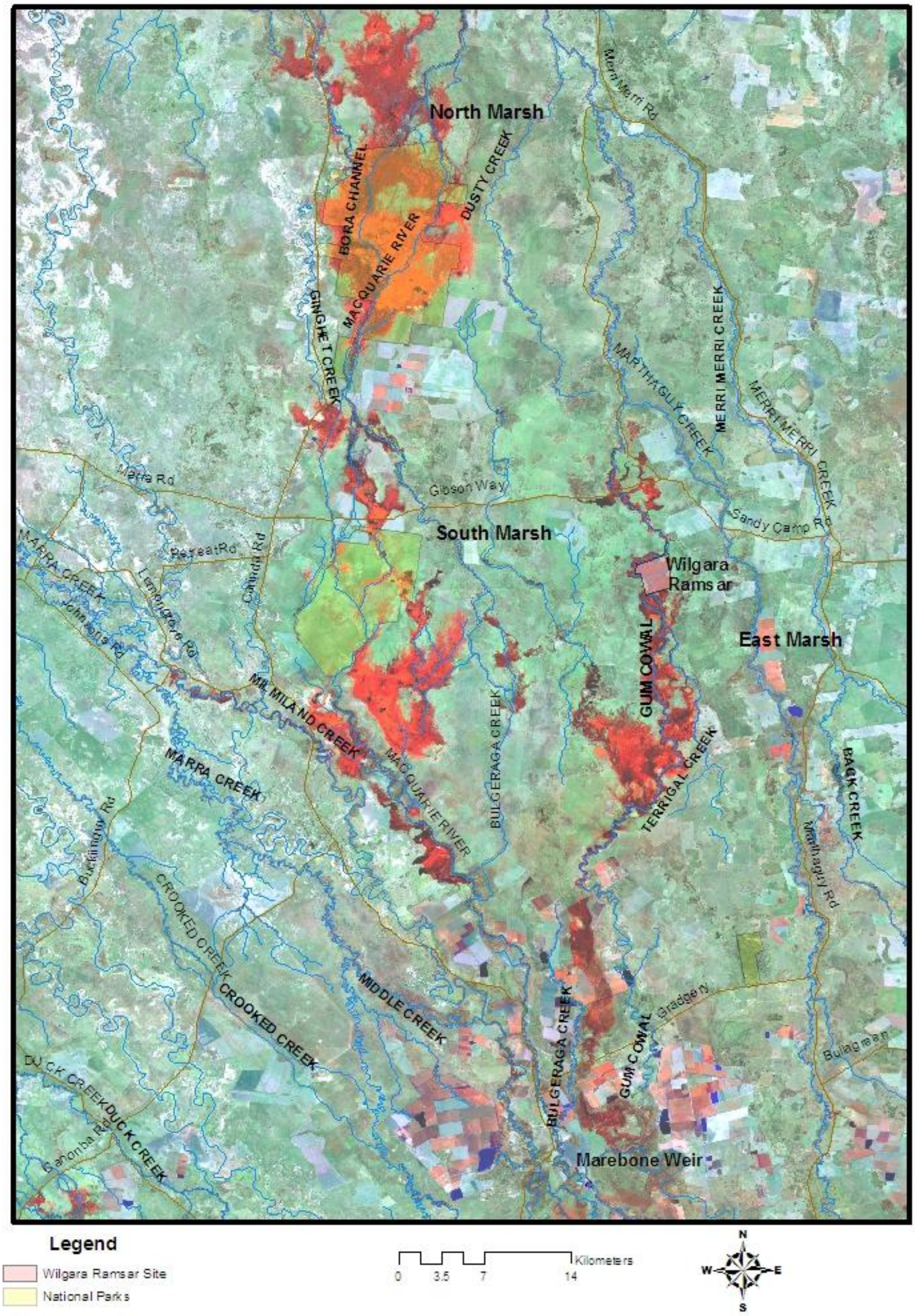

Figure 7: Satellite image (Landsat Thematic Mapper 2000) of the Macquarie Marshes highlighting the core wetland areas in red.

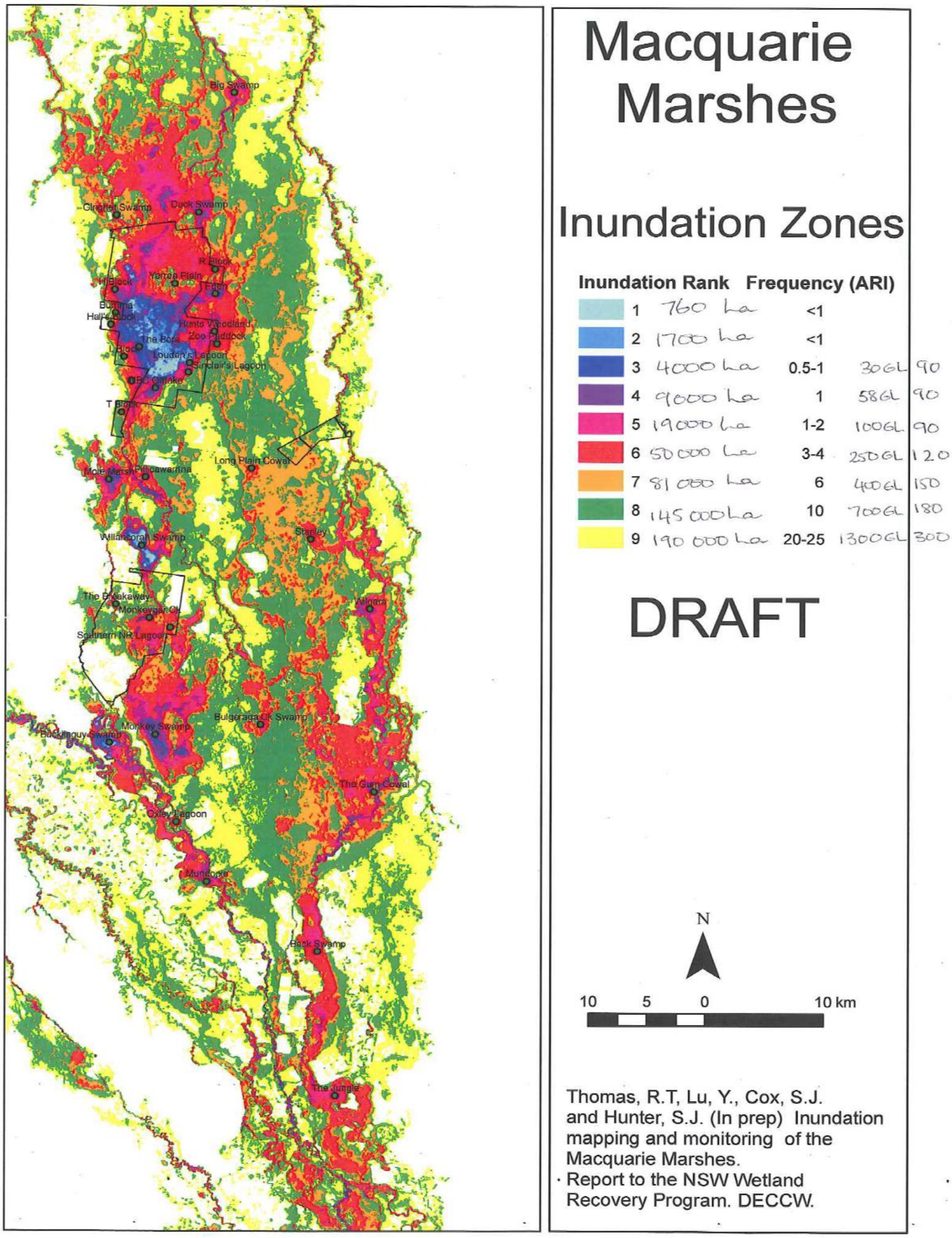

Figure 8: Inundation zones in the Macquarie Marshes

Effluent Creeks – Crooked Creek

The Commonwealth is currently gathering more detailed data on the environmental values of these creeks and also hydrological data to determine watering regimes to support identified values. Further details will be provided when they are available.

The effluent creeks are a complex of natural creeks which leave the Macquarie River upstream from Warren and flow to west, northwest and which now receive regulated water supplies from Warren Weir (Figure 7). The Crooked Creek is one of these effluent creeks. An ecological assessment of the Creek during the drought in 2008 found that local residents believed the creek had changed as a consequence of water management and the development of Burrendong Dam in particular. An oral history reported that the Talga Floodplain adjacent to Crooked Creek and a property known as “Half Moon” used to flood regularly, up to at least a meter in depth. From the oral history, the wetland received water from Crooked Creek, but also from flows from Duck Creek and the total area flooded was almost 2,500 hectares.

Vegetation assessments undertaken in 2008 (Torrible and Wettin 2009) for Crooked Creek identified that the vegetation value was poor for the in-stream and floodplain vegetation assemblages and moderate for the riverbank. This assessment was consistent with the geomorphic assessment from the same study that concluded that the physical diversity in the creek was low and based on riverbank vegetation and woody debris. Widespread regeneration of the riparian trees is not evident so there is a major risk of loss of riparian trees as the current mature trees die.

The river channel vegetation downstream of “Raby” (near the Mumblebone Weir) was observed to have sections that appeared to have had no flow for years and supported an assemblage of terrestrial plants. Almost all the canopy species recorded were mature aged, and the trees with more regular flooding requirements (eg river red gum and black box) showing moderate to severe levels of loss of foliage and dead branches. For the channel upstream of the weir, cumbungi dominated resulting in a reduced habitat and ecological value of the Creek. Due to the available water, the riparian trees were observed to be in better condition than those downstream of the Weir (Torrible and Wettin 2009).

Macquarie River

The Macquarie River rises near Oberon, in the Central Highlands of New South Wales, and flows northwest through the Macquarie Marshes to join the Barwon River between Walgett and Brewarrina. The Macquarie system is a network of tributaries, anabranches and distributary streams. The hydrology of the lower reaches is complex, with water moving in either direction among the anabranches and the Castlereagh and Barwon, depending on relative flows. The Bogan River also flows through the Valley, joining the Darling near Bourke.

The Macquarie Valley river ecosystem was in very poor health when rated by the Sustainable Rivers Audit in 2008. The catchment was rated as very poor condition for fish health, poor condition for macro invertebrate health and moderate to good for hydrological condition (Davies et al. 2008). In general, the flow regime for most Macquarie lowland sites, and several slopes and upland sites, showed reductions in the magnitude of annual and high flows, changes in low and zero-flow events, seasonality and variability. In terms of faunal distribution most sites demonstrated sparse fauna, lacking most of their expected disturbance–sensitive families. Fish abundance and biomass are dominated by alien species, and many expected fish species were absent. Many expected and disturbance-sensitive macroinvertebrate families were absent from the report.

Native overstorey riparian vegetation includes river red gum, black box, and river oak (*Casuarina cunninghamiana*). Plant communities are generally degraded with a high proportion of exotic species particularly among ground cover communities and poor regeneration of native species.

The Macquarie River between Burrendong Dam and Narromine, receives significant unregulated inflows from the Bell, Little and Talbragar Rivers. The regulated flow releases are for town water supply, stock and domestic requirements, irrigation orders and for environmental requirements, largely for the Macquarie Marshes needs. In general the lowest flows are in the late-autumn to winter period to town and stock and domestic needs which are continuous and provide water for lower part of the river channel and habitats such pools (including weir pools). Higher flows occur in spring to late summer for irrigation orders and environmental water releases. As a result there is a degree of seasonal flow reversal. This is the section most impacted by cold water releases from Burrendong Dam. Additional environmental water releases only for this section of the river may exacerbate this cold water pollution impact.

Within the Macquarie River downstream of Narromine, the floodplain “delta” commences and the river channel starts to lose integrity with a broader floodplain and distributary creeks developing. Water delivery to this section of the river is dominated by regulated releases from Burrendong Dam for the majority of the time, although there are significant unregulated flows into this section. The regulated flow releases are for town water supply, stock and domestic requirements, irrigation orders and for environmental requirements, largely for the Macquarie Marshes needs. In general the lowest flows are in the late-autumn to winter period to town and stock and domestic needs which are continuous and provide water for lower part of the river channel and habitats such pools (including weir pools). Higher flows occur in spring to late summer for irrigation orders and environmental water releases. As a result there is a degree of seasonal flow reversal.

Appendix B Commonwealth Environmental Water Ecological Watering Objectives

	Ecological Watering Objectives	Management Objectives	Management Actions
Extreme Dry	▪ Avoid damage to key environmental assets	▪ Avoid critical loss of threatened species and communities ▪ Maintain key refuges ▪ Avoid irretrievable damage or catastrophic events	▪ Water refugia and sites supporting threatened species and communities ▪ Undertake emergency watering at specific sites of priority assets ▪ Use carryover volumes to maintain critical needs
Dry	▪ Ensure ecological capacity for recovery	▪ Support the survival and growth of threatened species and communities, including limited small-scale recruitment ▪ Maintain diverse habitats ▪ Maintain low-flow river and floodplain functional processes in sites and reaches of priority assets	▪ Water refugia and sites supporting threatened species and communities ▪ Provide low flow and freshes in sites and reaches of priority assets ▪ Use carryover volumes to maintain follow-up watering
Median	▪ Maintain ecological health and resilience	▪ Enable growth, reproduction and small-scale recruitment for a diverse range of flora and fauna ▪ Promote low-lying floodplain-river connectivity ▪ Support medium flow river and floodplain functional processes	▪ Prolong flood/high-flow duration at key sites and reaches of priority assets ▪ Contribute to the full range of in-channel flows ▪ Use carryover to provide optimal seasonal flow patterns in subsequent years
Wet	▪ Improve and extend healthy and resilient aquatic ecosystems	▪ Enable growth, reproduction and large-scale recruitment for a diverse range of flora and fauna ▪ Promote higher floodplain-river connectivity ▪ Support high-flow river and floodplain functional processes	▪ Increase flood/high-flow duration and extent across priority assets ▪ Contribute to the full range of flows, including overbank ▪ Use carryover water to provide optimal seasonal flow patterns in subsequent years

For further information please refer to the *Framework for Determining Commonwealth Environmental Watering Actions* (available at http://www.environment.gov.au/water/policy-programs/cewh/index.html)

Appendix C Criteria for Assessing Commonwealth Environmental Watering Actions

In undertaking its activities, the Commonwealth Environmental Water Holder (CEWH) is required to act consistently with the requirements of the *Water Act 2007* (Cwlth) (hereafter referred to as 'the Act'). The relevant functions are outlined in s.105. This includes a requirement that the environmental water holdings are managed in accordance with the environmental watering plan of the Murray-Darling Basin Authority (MDBA). Close consultation is occurring with the MDBA to ensure that use of Commonwealth water is consistent with the emerging objectives of the environmental watering plan that is currently being developed.

A long-term framework for the prioritisation of environmental water allocations has been prepared in consultation with delivery partners, interested stakeholders and experts, and the Environmental Water Scientific Advisory Committee.

The framework includes ecological objectives that will change under the different water availability scenarios (i.e. extreme dry, dry, median, wet). Proposed watering actions will need to be supported by available evidence, and consistent with current water availability scenarios and the framework.

Commonwealth environmental water is being acquired to supplement existing flows. Proposals for use of the water will not be agreed to if this use substitutes for other water uses, including historical system operations (e.g. provision of water for conveyance, stock and domestic, or planned environmental water).

Through adaptive management processes, opportunities will be considered for a more informed and diverse range of water uses as knowledge and modelling. All 2011-12 proposals will be assessed against the following criteria:

- ecological significance of the asset(s);
- presence of threatened species and ecological communities, and listed migratory species;
- ecological and conservation values of the assets(s) including those recognised by international agreements;
- current health of the asset(s);
- expected ecological outcomes from the proposed watering action;
- the basin-wide significance of the ecological response from the watering action;
- improvement in health of the asset(s) expected from the watering action;
- how well defined and realistic the objectives are for the proposed watering action;
- consistency of these objectives with the overall CEWH ecological objectives for the current forecast water availability scenario;
- any secondary environmental effects expected to result from the watering action (e.g. connected system benefits);
- change in the health of the asset(s) expected if environmental water is not provided;
- potential risks of the proposed watering action at the site and at connected locations;
- how thoroughly the potential risks have been assessed for the proposed watering;
- adequacy of measures proposed to minimise these risks;

- likelihood and consequence of variance from the expected ecological outcome (including negative impacts on biota and water quality);
- long-term sustainability of the asset(s) including appropriate management arrangements;
- adequacy of long-term management and delivery arrangements;
- existence of complementary natural resource management activities supporting the long-term management arrangements, including those that improve water quality;
- effectiveness of monitoring, evaluation and reporting arrangements for the watering activity including clear links to the defined objectives;
- cost effectiveness and operational feasibility of undertaking the watering;
- amount of Commonwealth water and resources needed, including relative to the contribution of the State and delivery partner to (i) the watering event and (ii) subsequent monitoring of actions and outcomes;
- arrangements for the delivery of water to the asset(s), including the potential for transmission losses and the adequate accounting of flows;
- opportunity to supplement natural flows or other water releases; and
- operational feasibility of undertaking the watering action (e.g. channel capacity, infrastructure constraints, etc).

Appendix D: Assessment of Watering Options

Criteria assessments for additional assets in the effluent creeks and Macquarie River will be provided upon receipt of contracted work.

Macquarie Marshes	
The Macquarie Marshes have been assessed previously against the CEWA criteria by EWSAC as satisfying the CEW criteria in minutes number, 28 , September 2010 and 45, March 2011.	
Criteria	**Assessment**
1. Ecological significance of the asset	The Macquarie Marshes are a large and diverse wetland system, containing a variety of wetland types. These range from semi-permanent marshes and lagoons to ephemeral wetlands that are inundated by only the largest floods. The values of the Macquarie Marshes are recognised at all levels of government within Australia and are listed in the (DIWA) (Australian Nature Conservation Agency 1996). They are included as areas of conservation importance by the National Trust of Australia and the Australian Heritage Commission (NPWS 1993). The Marshes are also listed as refugia for biological diversity in arid and semi-arid Australia. Morton (et al. 1995) notes the massive complex of wetlands, the wide range of habitats available, and the major drought refuge for waterbirds. The Marshes provide habitat for a range of threatened species. The Marshes support colonial breeding waterbirds, being habitat for a diversity of other waterbirds, many of which also breed in the Marshes and provides habitat for migratory species under the JAMBA and CAMBA agreements. The Marshes regularly supports more than 20,000 waterbirds. The Marshes have regularly recorded more than this number of waterbirds, with greater than 500,000 in large floods. These events are among the largest waterbird breeding events in Australia. In 2010-11, 100,000 pairs of colonial nesting birds bred in the Marshes.
2. Expected ecological outcomes	The North Marsh: Vegetation condition varies across the North Marsh. The wetter areas of reed and red gum are in very good

Macquarie Marshes	
The Macquarie Marshes have been assessed previously against the CEWA criteria by EWSAC as satisfying the CEW criteria in minutes number, 28 , September 2010 and 45, March 2011.	
Criteria	**Assessment**
	condition. In the drier areas there are large areas of dead red gum woodland (30% of trees have died). A decrease in flooding incidence over the past ten years has resulted in a shift towards increased dryland species. The flooding over the past year has provided much needed moisture to semi-permanent wetland vegetation communities. Large areas of the north marsh asset areas were flooded in 2010-11 for an extended period. Aerial observation during 2010-11 indicates a degree of recovery in canopy densities in all parts of the red gum woodland except those areas where dead trees are dominant. Follow up flooding during 2011-12 will provide valuable inundation for semi-permanent wetland vegetation, and also critical water for areas of stressed river red gums. Depending on tributary flows, the environmental water may not reach all of the stressed river red gum communities. The South Marsh: The change in the Southern Marsh Nature Reserve since 1991 was described in 2009 (DECC, 2009) as catastrophic with the loss of 95 per cent of semi-permanent wetland vegetation, a decline in condition of river red gum, coolibah and black box communities and a 100 per cent loss of grassland communities. However, the southern marsh is demonstrating capacity for regeneration. The environmental watering in 2009-10 improved the condition of couch fields, and mixed marsh (spike rush) communities. In addition reed beds expanded in Buckiinguy and Mole Marsh under the 2009-10 environmental watering (DECCW 2010). Aerial observations following the 2010-11 flooding suggest modest potential recovery in water couch and mixed marsh species and a good improvement in red gum canopy density in most areas. There has been considerable expansion of reeds in Buckiinguy and vigorous growth of water couch and mixed marsh areas. The southern Nature Reserve received good flooding in 2010-11 . Increases in the area of common reed were observed and positive signs of change in the lagoon systems, with roly poly declining and modest areas of aquatic plant establishment including areas of water couch, cumbungi and mixed marsh species. Lagoon areas were particularly noted for their high degree of productivity as frog habitat and were also well utilised as waterbird foraging areas. Follow up flooding during 2011-12 will provide good moisture for semi-permanent wetland vegetation. If environmental water is able to be delivered in conjunction with tributary flows, the Southern Nature Reserve and lagoons will be inundated and this will assist in hindering the growth of terrestrial vegetation. Without water this year terrestrial vegetation will recolonise. The East Marsh**:** Surveys prior to the 2010-11 flooding indicated that condition of the site ranged from fair to stressed and all trees were considered to be vulnerable in terms of their regenerative potential. The understorey contained water couch, reduced in area and condition; lignum; and river red gum woodlands assessed as fair to moderate condition at the Wilgara

Macquarie Marshes	
The Macquarie Marshes have been assessed previously against the CEWA criteria by EWSAC as satisfying the CEW criteria in minutes number, 28 , September 2010 and 45, March 2011.	
Criteria	**Assessment**
	Ramsar site. The Gum Cowal-Terrigal system has mostly been replaced by chenopod (dryland) shrubland. However the area benefited from summer 2009-10 rainfall which improved tree health markedly (DECCW 2010). Since the 2010-11 floods the area was extensively inundated and provided valuable foraging habitat for frog recruitment and waterbird foraging. Observations indicated a strong response in water couch and mixed marsh species and an improvement in canopy density in river red gum woodland. Follow up flooding during 2011-12 will provide another good flooding event for semi-permanent wetland vegetation, and also critical water for areas of stressed river red gums. Depending on the contribution of tributary flows, the environmental water may not reach all of the stressed river red gum communities. Bird Breeding: Following the flooding in 2010-11, there has been extensive breeding of ibis (50,000-70,000 pairs) and egrets (24,000-30,000 pairs in two major colonies), herons (pied in small numbers, white-necked in moderate numbers and rufous night herons in large numbers) and cormorants. Eleven colonies were confirmed as active, though 3 colonies make up the bulk of the numbers. Large numbers of water birds were observed breeding including magpie geese, black swans, brolgas, coots, ducks, grebes, white-faced herons, swamp hens, stilts etc. Migratory bird species (sandpipers) have been observed in small numbers, however there have been no sightings of large groups of migratory birds. Migratory waders appeared to have been largely absent from the marsh this year. The strategy above outlines a contingency to support colonial nesting birds should an event be triggered by the winter/spring action. This will increase the chance of successful bird breeding events.
3. Potential Risks	Failed bird breeding event: There is a risk that the winter/spring action could trigger a bird breeding event and the contingency amount is insufficient to ensure event completion of all sites. This could potentially lead to a high rate of nest abandonment and bird mortality as the waters recede. Any bird breeding events will be closely monitored, and the

Macquarie Marshes	
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Criteria	**Assessment**
	contingency water will be adaptively managed to be as effective as possible. Insufficient inundation of river red gum woodland: The Marshes have just experienced an extended period of drought which has resulted in significant decline in the health and resilience of ecosystems. Research strongly indicates that after prolonged dry periods, wetlands ideally require good flooding for two to three consecutive years to build resilience. Significant areas of the stressed river red gums put on a spurt of growth as a result of the 2010-11 floods and there is a risk that unless follow up water is supplied this year, those trees may struggle to survive. With environmental holdings alone it will not be possible to inundate all areas of stressed river red gums, favourable tributary flows will be required to ensure thorough inundation. Undesirable flooding: The risk of undesirable flooding has been considered. The NSW State Water and OEH will manage this risk by monitoring forecast rainfall and water heights, and adjusting releases accordingly. Landholders of the Marshes are represented on the Environmental Flows Reference Group where the current proposal was discussed. There were no issues of undesirable flooding raised at the meeting. Exotic species: There is a risk that carp populations may increase due to the spring watering. However it is expected that the event may also provide opportunities for native fish as summer flooding can provide important spawning cues for most native fish. Erosion: Flows can cause channel and bank erosion; this is known to be a problem particularly in the Southern Macquarie Marsh Nature Reserve (Brock 1998). However, larger flooding events are more likely to create a depositional environment. As large volumes of water reach the flat landscape of the Marshes it is forced to spread out and slow down. The sediment carried by fast moving flows from further upstream is then deposited into the Marshes and surrounding floodplain (DPI 2008). Commonwealth water diverted: A range of licence holders exist downstream of Marebone Weir that are permitted to extract water at certain flows. Compliance with licence conditions is a matter for State Water and the NSW Office of Water. Given the magnitude of flows previously flooding through the system there is a low risk of Commonwealth holdings being taken or diverted by other water users downstream of Marebone Weir.
4. The long term sustainability of the asset	NSW OEH manages 160,000 ML of environmental contingency allowance and 48,154 ML of RiverBank general security entitlements. NSW OEH prepares annual environmental watering plans which identify short-term watering priorities based on various

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Criteria	**Assessment**
	climatic scenarios. An Environmental Flow Reference Group (EFRG) has been established that advises on the most appropriate water use scenarios which form part of these plans. The group includes representatives from irrigation, landholders, environmental groups, NSW Fisheries, NSW Office of Water, National Parks and Wildlife Service and NSW OEH. The Environmental Water Branch has a representative who attends EFRG meetings as an observer. Many of the actions required for the maintenance of the Marshes are planned under existing funding programs, policy or legislation (DECCW 2010). There are specific planning processes for the Nature Reserve and the Wilgara portion of the Ramsar site. The environmental requirements are captured in the Environmental Management Plan (reviewed annually by NSW OEH and the Central West CMA), the 1993 Macquarie Marshes Nature Reserve Plan of Management and the 2010 Macquarie Marshes Adaptive Environmental Management Plan. There is clear evidence for long term environmental planning and management in the Macquarie Marshes. In addition to the environmental water management aspect there are a number of other natural resource management programs in place in the Macquarie Marshes managed by NSW OEH in conjunction with livestock health, pest authorities and landholders. These programs include vegetation mapping, investigations to determine the impacts of grazing on the vegetation, land clearing awareness campaigns and pest control programs targeting pigs, foxes and feral fish (DECCW 2010). There is also research into managing and controlling the weed lippia (Phyla canescens) which is being funded by the NSW Wetland Recovery Program. Activities in the Nature Reserve are guided by the Macquarie Marshes Nature Reserve Plan of Management, and undertaken by the National Parks and Wildlife Service within NSW OEH NSW OEH will be monitoring the colonies of breeding birds and adaptively managing the inflows accordingly. Birds will be observed by site inspection every two weeks and an aerial inspection will be conducted on 24 February 2011 to determine the stage of the breeding. A camera has been positioned in one of the main colonies. This will be able to provide feedback at the end of the event. Daily monitoring of flow rates and water heights throughout the Marshes will also be incorporated into adaptive management

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Criteria	**Assessment**
	of the flows. NSW OEH will provide weekly updates of the progress of the event. In addition NSW OEH will provide a full operational report at the end of June, outlining the delivery of the complete event and the success of the bird breeding event.
5. Management & Monitoring Arrangements	Short-term NSW OEH will report annually to the Commonwealth Environmental Water on the total volumes entering the Marshes and flows through the gauged channels within the Marshes. Informal reports will also be provided through participation in the regular meetings of the EFRG. Observations on the extent of flooding and incidental observations on responses by birds and vegetation will also be made from ground and air surveys. NSW OEH will investigate likely colonial bird breeding sites following all flooding events. Where colonies are identified, monitoring will be conducted for the duration of the event to report on colony size, diversity and fledging success. Wetland vegetation condition will be measured for each event using a combination of methods. The Integrated Monitoring of Environmental Flows (IMEF) Program which is delivered by the Office of Water aims to establish the relationships between water regimes and the diversity and abundance of wetland plants. Information has been collected under this program since 1999. Additional sites beyond those monitored by IMEF are required to cover all the areas likely to be targeted for environmental water delivery (See Bowen and Simpson 2010) and these will be assessed using comparable methods. Techniques based on remote imagery are also being trialled as a rapid, cost effective method to provide an index of vegetation condition. Wetland vegetation extent will be assessed for each community every five years. This information will be used to measure progress toward achieving the long-term targets in Table 2. Median to longer term There are considerable efforts underway at a range of scales to provide an overarching monitoring framework for assessing changes in resource condition in response to management interventions. The outcomes from these efforts will therefore determine monitoring activities in the Macquarie Marshes in the longer-term. Methods currently applied in the short-term approach above are expected to be continued or be compatible with recommendations arising from the efforts referred to below.

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Criteria	**Assessment**
	NSW has developed a number of targets for natural resource condition, including wetlands. In order to assess progress toward these targets, a monitoring, evaluation and reporting framework has been developed and trialled for important wetlands. Refinements are currently being made to ensure meaningful and cost-effective information is derived. DSEWPAC is currently developing a monitoring and evaluation framework for watering activities involving Commonwealth holdings. The MDBA is also developing a monitoring framework as a component of the Environmental Watering Plan within the MDB Plan. Experience from implementation of The Living Murray Initiative is informing these frameworks.
6. Cost-effectiveness	Water will be gravity fed and there will be no pumping costs involved. Commonwealth general security holdings carry a usage

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Criteria	**Assessment**
	fee of $12.68 per ML. The Commonwealth will also incur a $150 transfer fee when transferring Commonwealth entitlements to OEH. The total expenses incurred in the delivery of the spring/winter action would be $760,800. Under the proposed arrangements Commonwealth water is delivered to and accounted for at Marebone Weir (at the head of the Macquarie Marshes). The Water Sharing Plan does not allow for the delivery of environmental water downstream of Marebone Weir from licences held upstream of the weir. Any transmission losses from Marebone Weir are from the environment's allocation. However, these are occurring within the Marshes and can be viewed as having an environmental benefit. Following the delivery of Commonwealth water an operational audit of river flows and extraction figures will indicate if the environmental allocations have been delivered. In the situation that the volume ordered has not been delivered, accounts will be credited. Environmental Water Branch will coordinate the use of Commonwealth water with NSW OEH to maximise the volume that is made available for the Macquarie Marshes.

Water Use Strategy 2011-12: mid-Murray catchment

1.1. Introduction

This document sets out the proposed objectives and approach to using environmental water in the mid-Murray catchment during the 2011-12 water year. This strategy was developed based on information available to the Department of Sustainability, Environment, Water, Population and Communities through consultation with delivery partners such as state governments, local river operators and wetland managers.

The document includes watering options given current and expected climatic and riverine conditions in the catchment. The proposed approach will adapt over the course of the year as conditions in the catchment change and more information becomes available. Importantly, the potential watering options included in this document do not form an exhaustive list – the Department welcomes proposed suggestions for using water. All relevant options will be assessed to ensure the best possible use of environmental water within the catchment and across the Murray-Darling Basin.

1.2. The mid-Murray catchment

The mid-Murray catchment straddles New South Wales and Victoria, extending along the length of the Murray River from its headwaters in the Great Dividing Range to the South Australian Border. The Murray River originates on the western slopes of the Great Dividing Range, south of Thredbo, and flows in a westerly direction. The upper Murray River from Hume reservoir to the Wakool River junction is a braided stream with a complex network of major and minor anabranches, including the Edward-Wakool River system which offtakes between Yarrawonga and Barmah and converges with the main stem of the Murray River at the Wakool River junction downstream of Swan Hill. Downstream of Albury, below Hume Dam, the major tributaries of the Murray River include Billabong Creek, the Murrumbidgee River and the Darling River, which enter from the north, and the Kiewa, Ovens, Goulburn, Campaspe and Loddon Rivers and Broken Creek, which enter from the south (CSIRO 2008).

Topography differs widely across the region, ranging from rugged alpine terrain with high altitude plateaus and steep, narrow valleys, grading to undulating foothill slopes, flat to gently undulating country in the Riverina plains, and low relief floodplains (CSIRO 2008).

The major flow regulating structures in the upper Murray are Dartmouth Dam (3,856 GL capacity), Hume Dam (3,005 GL capacity) and Yarrawonga Weir (118 GL capacity).

1.3. Environmental assets in the mid-Murray catchment

Freshwater-dependent biotic and abiotic assets in the mid-Murray River catchment include significant areas of river red gum forest and woodland, black box woodland, lignum, river-fed wetlands, Ramsar-listed wetlands and other migratory bird habitats, colonial bird breeding sites, and habitat important to the survival of a number of threatened species listed on the *Environment Protection and Biodiversity Conservation Act 1999* such as the southern bell frog (*Litoria raniformis)* and Murray cod (*Maccullochella peelii*). The significant assets for the mid-Murray catchment have been aggregated into the following areas for consideration against the *"Criteria for Assessing 2011-12 environmental watering actions"* and have been assessed as meeting the criteria:

1. Hume to Yarrawonga;
2. Yarrawonga to Barmah including the Barmah-Millewa Forest and Tuppal Creek;

3. Edward-Wakool system;
4. Gunbower-Koondrook-Perricoota Forest and Kerang Wetlands;
5. Swanhill to Mildura including Hattah Lakes, Lake Caringay and Bengallow Creek; and
6. Mildura to the South Australian Border including Wallpolla Island, Mulcra Island and Lindsay Island.

Further details on the location, condition, type and extent of significant flora and fauna at each locality is presented at Appendix A.

1.4. Broad watering objectives in the mid-Murray catchment

During 2010-11, the Department undertook work to identify and develop large-scale watering options for Commonwealth environmental water, including a number of assets in the mid-Murray catchment (EA & SKM 2011a; 2011b; 2011c), in order to reflect growth in the water holdings and improved water availability across the Basin. Through this work, the following medium to long-term objectives for the mid-Murray catchment have been identified:

1. Restore the structure and distribution of aquatic habitat and plant communities on the floodplain including permanent wetlands, seasonal wetlands, moira grass plains, red gum forest and red gum woodlands;

2. Maintain the health and productivity of floodplain forests and woodlands;

3. Sustain the river channel ecosystem with a supply of organic matter provided by seasonal managed floodplain inundation;

4. Promote flowing-water habitat in the principal river channels and floodplain watercourses to support flow-dependent aquatic fauna;

5. Maintain aquatic refuges in times of drought;

6. Maintain known colonial waterbird breeding sites in 'event ready' condition and support breeding events;

7. Maintain seasonal habitats for migratory waterbirds;

8. Provide hydraulic connection between the principal river channels and floodplain on a seasonal basis; and

9. Provide a flow profile in the principal river channels that has a spring peak and multiple freshes to provide cues for fish breeding and to maintain riparian aquatic plant and animal communities.

These objectives are broadly consistent with the objectives specified for the mid-Murray assets by the Murray Darling Basin Authority (MDBA 2010a).

1.5. Delivering water in the mid-Murray catchment

Key point: *The mid-Murray catchment has been split into six river reaches extending from Hume to the South Australian Border.*

The hydrology of the mid-Murray catchment is complex, with various tributaries and flow control structures varying in importance along the length of the system. For the purpose of this strategy, the mid-Murray catchment has been split into six river reaches. Maps of each of these reaches can be found from Figure 8 - Figure 15 in Appendix A.

a) Hume to Yarrawonga

The hydrology of this river reach is mainly driven by catchment inflows to Hume reservoir and the releases the reservoir provides. Flows from Hume are regulated and augmented by inflows from the largely unregulated Ovens River catchment.

b) Yarrawonga to Barmah including the Barmah-Millewa Forest and Tuppal Creek

Inflows to this river reach are as discharge downstream of Yarrawonga Weir. At moderate river flows (greater than 15,000 ML/day), discharge at Yarrawonga Weir can be used to estimate flows and flood levels in the Barmah-Millewa Forest and the Edward-Wakool system. At lower flows, local regulators within the Barmah-Millewa Forest system provide greater local control over the distribution of water through watercourses and wetlands.

Natural flows of approximately 40,000 ML/day downstream of Yarrawonga - two thirds of flow continues downstream via the Murray River and one third is diverted to the Edward-Wakool system via Gulpa Creek and the Edward River. At higher discharges almost all additional flow passes to the Edward-Wakool system.

Under current conditions natural flows into the upper Tuppal Creek from the Murray rarely occur as they require flows of greater than 100,000 ML/day downstream of Yarrawonga (or greater than 6.7 m at the Tocumwal gauge) (Brownbill & Warne 2010). Further investigation is required into the use of irrigation infrastructure to deliver water to Tuppal Creek.

c) Edward-Wakool system

a. Northern system: Edward River, Werai Forest, Colligen Creek - Niemur River (Niemur National Park), Jimaringle, Cockran and Gwynnes Creeks, Murrain and Yarrein Creeks;

b. Southern system: Wakool River and Yallakool Creek; and

c. Western system: Merran Creek, Waddy Creek, Coobool Creek, Speewa Creek and Wee Wee Creek.

The main sources of water into the Edward-Wakool system under regulated flow conditions are from the Murray River via the Edward River and Gulpa Creek, which originate in the Millewa Forest and from the outlets of the Mulwala Canal, such as the Edward, Wakool and Yallakool escapes.

During high flows the Edward-Wakool system is supplemented with water from the Murray River via a number of other creeks. These include creeks running through the Millewa Forest such as Toupna, Bullatale and Tuppal Creeks that enter the Edward River upstream of Deniliquin, and the Thule, Barbers, Little Merran and Waddy Creeks, which flow out of the Murray River between Echuca and Swan Hill and flow into the lower Wakool River. There are also inflows to the Edward-Wakool system from the north-east via Billabong Creek, which flows into the Edward River at Moulamein. The intermittent stream network in the west of the Wakool system also connects to a number of large deflation basins such as the Poon Boon Lakes, Coobool Swamp and Lake Agnes.

The main flow regulating structure within the Edward-Wakool system is Stevens Weir, which allows water to be diverted down Colligen and Yallakool Creeks and the Wakool River under regulated flow conditions. During high flow conditions the gates at Stevens Weir are lifted clear of the water, reducing flow impediments and allowing fish passage. Flow regulators have been placed on the inlets to the Werai Forest, which allow flow deliveries to be controlled when flow in the Edward River is regulated.

Additional distributary creeks from the Murray River, such as Tuppal and Bullatale Creeks, can commence to flow and become a major source of water entering the Edward River. During large floods, the volume flowing through the Edward-Wakool system in some locations can be in the order of five times that flowing through the Murray River.

Ongoing investigation is required prior to undertaking watering actions in the Gwynnes and Murrain-Yarrein Creeks.

d) Gunbower-Koondrook-Perricoota Forest and Kerang Wetlands

The hydrology of the river reach that feeds these systems is driven by flow leaving the Barmah-Millewa system downstream of the Barmah Choke and the main regulating structure is Torrumbarry Weir. These flows are generally limited to 30,000 ML/day and larger flows are achieved by the additional contribution of flows from the Goulburn River.

Flow to the forest areas is reported in relation to discharge downstream of Torrumbarry Weir. At flows up to 18,000 ML/day inflows to the Gunbower-Koondrook-Perricoota Forest occur via minor effluents in the river bank and regulated releases from the Torrumbarry Weir pool via environmental regulators. At higher flows, approximately greater than 35,000 ML/day overbank flooding commences and forest water management is largely unregulated.

Water may be delivered to Gunbower Forest at a rate of up to 1,900 ML/day under regulated flow conditions. The Hipwell Road regulator, which is not yet operational, will in the future deliver water to the forest at a rate of up to 1,650 ML/day, inundating up to 4,710 ha.

Work has commenced on flood enhancement works at Koondrook-Perricoota forest and should be available for operation in 2012. The works will allow up to 6,000 ML/day to be diverted to the forest from the Torrumbarry weir pool. Structures downstream of the forest including levees and regulators will retain water in the forest and inundate up to 17,500 ha.

Below Koondrook-Perricoota Forest, diversions into the Edward-Wakool system occur via the Merran and Waddy Creeks.

e) Swanhill to Mildura including Hattah Lakes, Lake Caringay and Bengallow Creek

The Murray River in the vicinity of Swan Hill has a lower bank-full capacity and inundation of floodplain wetlands and watercourses such as Parnee-Malloo Creek commences at flows as low as 15,000 ML/day (downstream of Torrumbarry Weir) and significant inundation of Red Gum forest at Nyah-Vinifera forest occurs at flows of 25,000 ML/day (downstream of Torrumbarry Weir).

Upstream of Euston Weir, flows from the Murray River are augmented by return flows from the Edward-Wakool system and flows from the Murrumbidgee River.

Lake Caringay is the largest of three wetlands commonly known as the Euston Lakes and has been isolated from flood flows in the Murray River since the 1960s following the installation of levee banks on Washpen and Caringay Creeks. Despite not having received water in any significant quantity since the 1960s, the lake exhibits evidence of the ecosystem that prevailed prior to this time.

Inflows to Hattah Lakes commence at 30,000 ML/day at Euston Weir and the area of inundation significantly increases beyond flows of 150,000 ML/day. A pumping station will be constructed at Hattah Lakes in 2011-12 under the Murray-Darling Basin Authority’s The Living Murray program. The works will allow the floodplain to be inundated to 45 m Australian Height Datum (AHD) (equivalent to 70,000 ML/day) at low, regulated Murray River flows.

Bengallow Creek is a long complex wetland composed of a series of creeks, flood runners, and oxbow billabongs that extend for more than 100 km. This section of floodplain supports large tracts of river red gum forest, black box woodland and lignum swamps. The Creek connects to the Murray River in three separate locations, with varying commence-to-fill heights, though inflows can commence at 37,900 ML/day through Mindook Creek.

f) Mildura to the South Australian Border including Wallpolla Island, Mulcra Island and Lindsay Island.

Flow in this river reach is augmented by flows from the Darling River. At regulated flows, Lock 9 is the main regulating feature against which flows are reported.

Potterwalkagee Creek diverts water from Lock 8 into Mulcra Island at normal weir levels. Inflows to the creek can be increased by raising Lock 8, which also initiates flow in an upper section of Potterwalkagee Creek. The lower Potterwalkagee regulator can be used to inundate areas of floodplain while the weir is raised.

Water is normally diverted from the Lock 7 weir pool to Lindsay River via Mullaroo Creek which features turbulent, fast flow over the first 4 km before reaching the weir pool of Lock 6. Work is underway in 2011 to lower and regulate two additional effluents that contribute to Lindsay River. The Lindsay River North effluent will provide permanently flowing habitat and the Lindsay River South effluent will provide additional inflows at elevated weir levels or peaks in river flow.

Inflows to Lake Wallawalla from Lindsay River commence at Murray River discharges exceeding 40,000 ML/day at Lock 7 and may be detained by regulators on the connecting channel. The lake is otherwise watered by pumping.

1.6. Current catchment status and outlook

Key points:

- *The catchment is currently wet.*
- *The seasonal forecast for late winter-spring is average to drier conditions.*
- *Streamflow forecast until September for downstream of Hume reservoir is for median flows.*

During the 2010-11 water year the mid Murray has experienced significantly wetter conditions than the ten years previously (Figure 1), which resulted in extensive flooding across the catchment.

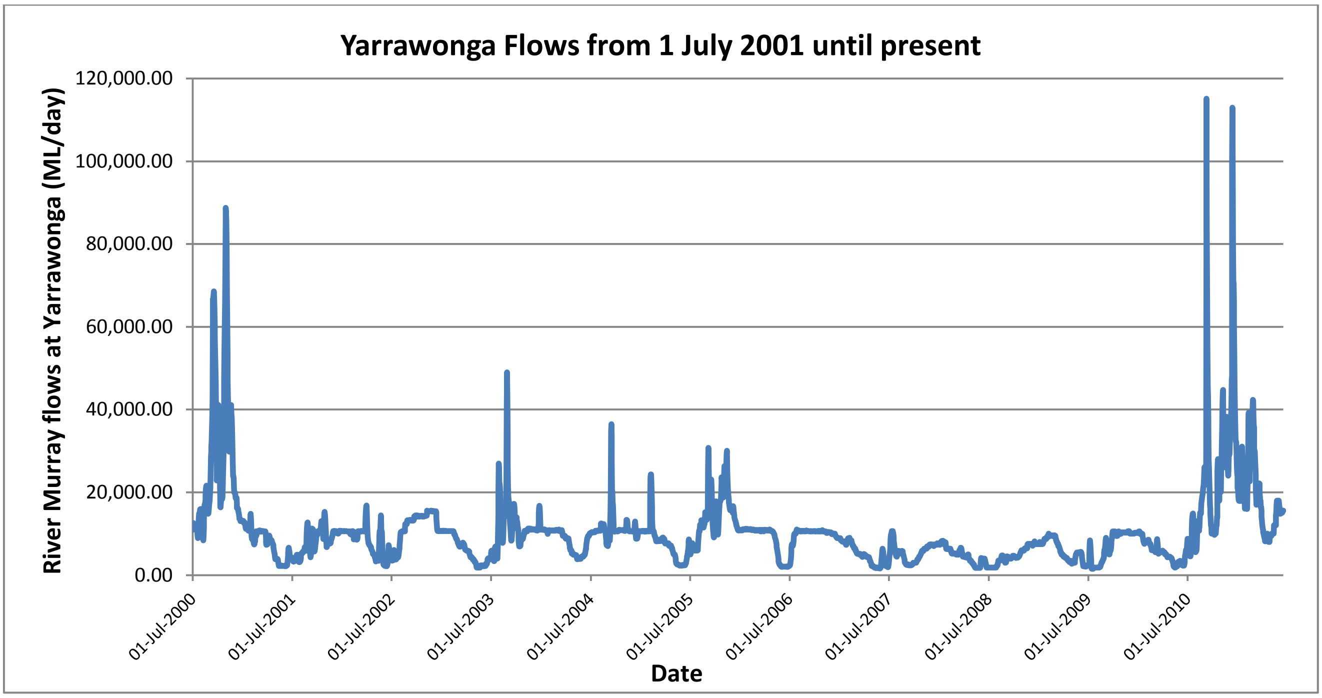

Figure 1: Flows at Yarrawonga from July 2001 to present (NOW 2011).

The rainfall along the NSW and Victorian mid-Murray over the past three months from 1 May to 31 July 2011 has been significantly less than average (Figure 2).

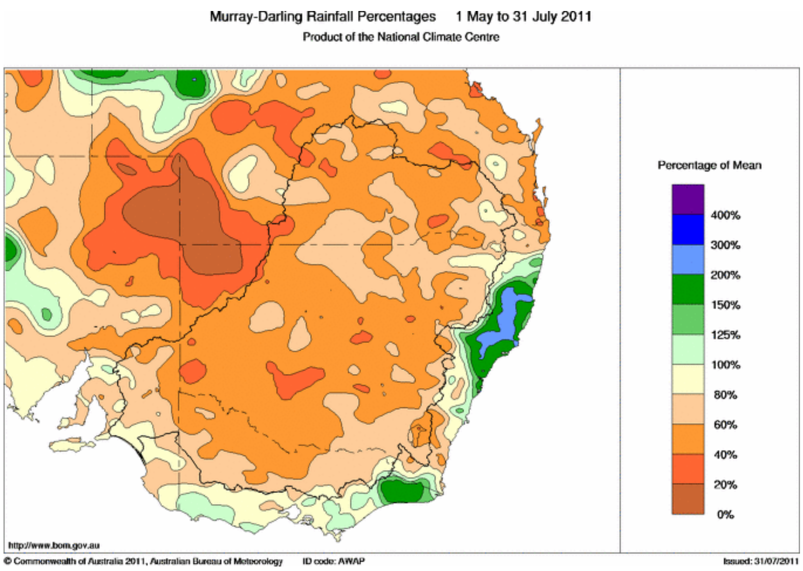

Figure 2: Rainfall from 1 May to 31 July across the Murray Darling Basin (per cent of mean) (BOM 2011a).

Significant volumes of Commonwealth environmental water were delivered during the 2010-11 water year (Table 1). A number of other environmental watering events managed by other environmental water holders also took place in the mid-Murray catchment during 2010-11. The most significant event was the watering of the Barmah-Millewa Forest. A total of 428 GL of environmental water was provided from a number of sources: 219 GL Barmah-Millewa Environmental Water Allowance; 199 GL the Living Murray water and 10 GL NSW environmental water.

Table 1: Commonwealth environmental watering actions in the mid-Murray catchment during 2010-11.

Complex	Site	Date of water delivery	Commonwealth volume delivered (ML)	Water from other sources delivered (ML)	Total volume delivered (ML)
Edward Wakool system	Wakool River and Yallakool Creek	1 January to 2 Feb	18,667		18,667
	Jimaringle – Cockran Creek	7 April to 3 May	1,100	2,457	3,557
Hattah Lakes	Hattah Lakes	1 July to 22 September	9,342	Victorian contribution to be confirmed	9,342
Riverland Chowilla	Lake Wallawalla	1 July to 30 September	7,850		7,850

The seasonal outlook for south-eastern Australia for late winter to early spring (August to October) shows a shift in the odds favouring a drier than normal season over southern South Australia and western Victoria and average season over most of the remainder of the Murray Darling Basin (Figure 3).

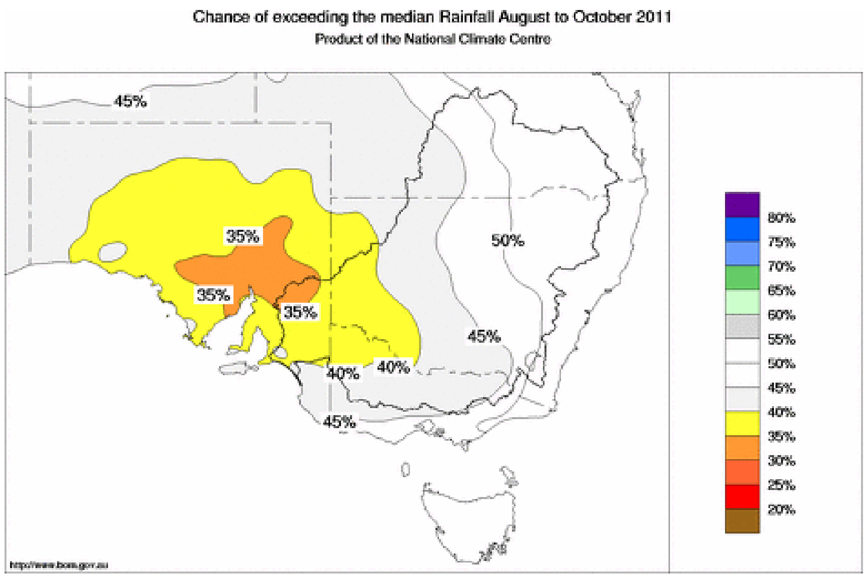

Figure 3: Seasonal rainfall outlook for south eastern Australia (Source: BOM 2011a).

The La Niña event in the Pacific has ended and catchments have experienced some drying in recent months but soil moisture levels remain high. Higher than median flows could be produced from near median rainfall in the coming months. Below average rainfall occurred in June over much of inland New South Wales and Victoria. Although the majority of forecast locations reported streamflows that were above median for June, they were closer to median than during May. For the July to September period, near median to low flows are the most likely outcome for the Loddon and Campaspe basins, near median flows are most likely for the Murrumbidgee, Broken and Kiewa basins and near median to high flows are most likely for the Ovens, Goulburn and Upper Murray basins (BOM 2011b). The most relevant sites to the mid-Murray catchment are Hume and the Ovens. As Figure 4 shows the streamflows for Hume are forecast to be median and the forecast for the streamflow in the Ovens is median or high.

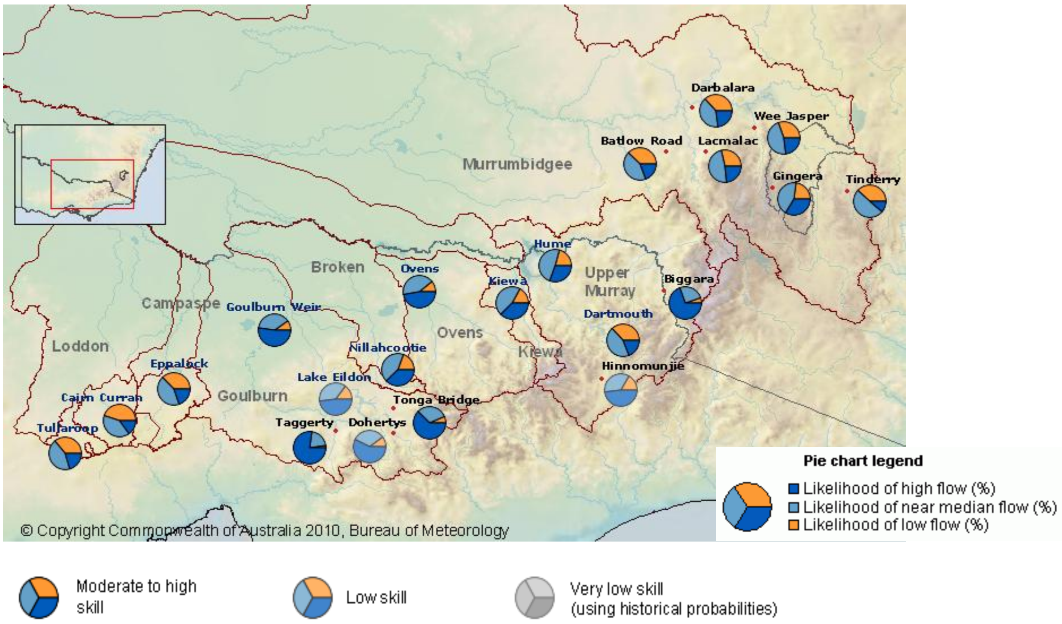

Figure 4: South-east Murray-Darling seasonal streamflow forecasts for July to September 2011 (BOM 2011b).

1.7. Forecast allocations

Key point: *Forecasting indicates up to 650 GL of Commonwealth environmental water could be available for use in the southern connected by the end of 2011-12.*

Current storage levels in the southern Murray-Darling Basin are high with the overall storage in the Southern Connected Basin at 85 per cent of capacity at the end of May (Figure 5).

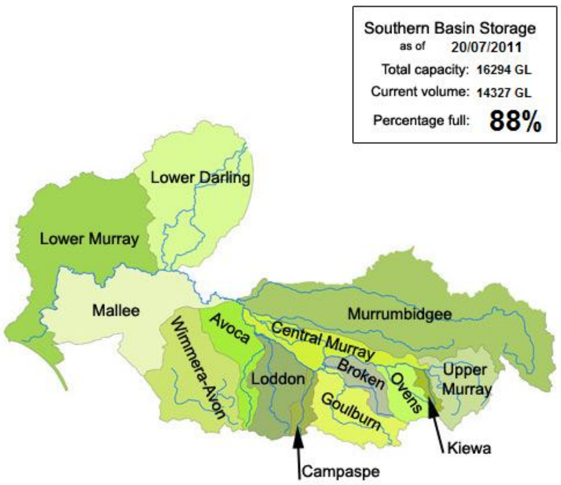

Figure 5: Current water storage levels in the southern Murray-Darling Basin at 20 July 2011 (Source: MDBA 2011).

Average storage level of the individual MDBA storages exceeds 80 per cent (Table 2). Table 3 shows storage levels in other southern connected basin state storages.

Table 2: Water in MDBA storages (MDBA Murray River Weekly Report for the week ending 22 July 2011).

MDBA Storages	Full Supply Level (m AHD)	Full Supply Volume (GL)	Current Storage Level (m AHD)	Current storage (GL)	Current Storage (per cent)
Dartmouth Reservoir	486.00	3,856	462.72	2,559	66%
Hume reservoir	190.00	3,005	191.08	2,823	94%
Lake Victoria	27.00	677	25.67	520	77%
Menindee Lakes	N/A	1,731	N/A	1,952	113%
Total		**9,269**		**7,730**	**83%**

Table 3: Water in other southern connected basin state storages (Source: MDBA Murray River Weekly Report for the week ending 22 July 2011).

State Storages	Full Supply Volume(GL)	Current storage (GL)	Current Storage (per cent)
Burrinjuck Reservoir	1,026	945	92%
Blowering Reservoir	1,631	1,598	98%
Eildon Reservoir	3,334	3,004	90%

The volume of Commonwealth environmental water available in the southern connected basin and the in the mid-Murray catchment at the beginning of 2011-12, and forecasts for the rest of 2011-12 water year are described in Table 4.

Table 4: Commonwealth environmental water availability in 2011-12 (as at 1 July 2011).

Catchment	Entitlement (GL)	Water available for use (GL)	Water available for use forecasts					
			31 July 2011 (GL)		30 September 2011 (GL)		30 June 2012 (GL)	
Murray (NSW)			**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
High/General Security	196.3	19.6	19.6	19.6	19.6	215.3	156.6	215.3
Murray (Vic)								
High/Low	149.1	102.5	113.9	148.6	145.6	148.6	149.1	149.1
Total - Southern Connected Basin	**652.5**	**317.7**	**318.0**	**388.9**	**354.7**	**608.9**	**539.9**	**649.7**

Note: Southern connected basin includes Murray (NSW, Vic, SA), Murrumbidgee, Lower Darling, Campaspe, Goulburn, Loddon. The figures may change following reconciliation of accounts for the end of the 2010-11 water year.

The forecasts presented in Table 4 were determined by the Department based on the following:

- There would be no barriers to trade within southern connected basin during 2011-12, except the 100 GL net trade limit out of the Murrumbidgee;
- The southern connected basin includes the NSW Murray, Vic Murray, SA Murray, Murrumbidgee, Goulburn, Campaspe, Lower Darling and the Loddon;

- Forecasts were based on information available at 1 July 2011, and the Commonwealth's registered entitlements at this date;
- Supplementary entitlements and additional entitlements that may be obtained and registered by the Commonwealth during 2011-12 were not included in forecasts; and
- Forecasts were based on dry and wet climate year scenarios.

1.8. Other sources of environmental water

In addition to Commonwealth environmental water, there are other sources of environmental water that may be available to supplement Commonwealth environmental watering in the catchment during 2011-12 (Table 5).

Table 5: Other sources of environmental water for 2011-12.

	Management Authority	Licence Type	Maximum Capacity
New South Wales	Office of Environment and Heritage	River Conveyance High Security Planned water (Murray Additional Environmental Allowance#)	30 GL 2.03 GL Up to 28.74 GL (0.15 ML multiplied by total High Security unit shares)
Victoria	Victorian Environmental Water Holder	High Security Unregulated (Murray Flora and Fauna entitlement)	27.6 GL 40 GL
The Living Murray	Murray-Darling Basin Authority	Multi-state entitlements for use on six icon sites	230 to 410 GL*
Barmah-Millewa Forest	Murray-Darling Basin Authority, NSW Office of Environment and Heritage, Victorian Environmental Water Holder	Environmental water allowance	242 to 342 GL*

* Forecast availability for 2011-12
# as Hume dam has already spilled during the 2011-12 water year this will not be available.

1.9. Watering objectives for 2011-12

The water requirements of target ecological assets have been determined. The water requirements have been used to formulate the objectives as specified in

Table 6.

<u>Fish</u>
Low flow wetland specialists:

- Un-specked hardyhead (*Craterocephalus stercusmuscarum fulvus*): peak spawning season from October-February when water temperature exceeds 24^{o}c, preference for slow flowing rivers/backwaters and billabongs, requires small insects such as mosquito larvae and crustaceans to feed on.
- Carp gudgeons (*Hypselotris* spp.): peak spawning season October-April when water temperature exceeds 22^{o}c, preference for slow flowing rivers/backwaters and billabongs, requires invertebrates, zooplankton and detritus to feed on.

- Murray Darling rainbowfish (*Melanotaenia fluviatilis*): peak spawning November-February, when water is above 20^{o}c, preference for lowland rivers, wetlands and billabongs, requires invertebrates, zooplankton and detritus to feed on.

Main channel generalists / wetland opportunists

- Flatheaded gudegons (*Philynodon grandiceps*): peak spawning season October-April, flows may initiate spawning when water temperature is above 15 ^{o}c, opportunistic use of floodplain wetlands, preference for covered areas, carnivorous.
- Bony bream (*Nematalosa erebi*): peak spawning is October-February when water is above 20 ^{o}c, lateral connectivity important for nursery habitats, herbivorous.
- Australian smelt (*Retropinna semoni*): peak spawning September-February when temperatures reach 11-15^{o}c, tolerant of a wide variety of habitats, carnivorous.

Main channel specialists

- Murray cod (*Maccullochella peelii*): peak spawning season September-December when temperatures reach 15 ^{o}c, preference for slow-flowing waters and cover, requires crustaceans, fish and frogs to feed on.
- Trout cod (*Maccullochella macquariensis*): peak spawning September-November triggered by day length and when water temperatures are between 14-22^{o}c, territorial around a home snag, carnivorous.

Flood spawners

- Golden perch (*Macquaria ambigua*): peak spawning season October-December during floods when temperatures exceed 20^{o}c, preference for warm, turbid, slow-flowing waters including backwaters, anabranches and billabongs with woody material as a source of cover, the main channel is important for nursery habitat, carnivorous.
- Silver perch (*Bidyanus Bidyanus*): peak spawning season November-January when water temperatures are between 23-30^{o}c following major flows and when the floodplain is inundated, inhabits wide variety of conditions with a preference for areas with cover from littoral vegetation and woody debris, carnivorous.

<u>Birds</u>

- Fish eating species such as: grebes, cormorants, egrets and herons (Rogers and Ralph 2010) require inundation for up to four months.
- Deep-water foraging species such as: black swans, hardheads, blue-billed ducks (Rogers and Ralph 2010) require deep water conditions from August through to December and inundation for up to eight months.
- Dabbling duck species such as grey teal, pink-eared duck, freckled duck and pacific black duck (Rogers and Ralph 2010) require water June to December and inundation for up to nine months.
- Grazing water fowl and shore-line forages such as plumed whistling ducks, Australian shelducks and purple swamp hens (Rogers and Ralph 2010) require water from August through to December and inundation for up to six months.
- Wading bird species such as spoonbill species, ibis species, brolga and dottrels (Rogers and Ralph 2010) require water from September through to February and inundation for up to twelve months.

<u>Frogs</u>

- *Crinia* species require pooled water for three months in winter and six weeks in spring/summer.
- Broad palmed frog (*Litoria latopalmata*) is usually associated with permanent and semi-permanent wetlands, requires pooled water for two to four months.
- Peron's tree frog (*Litoria peronii*) requires pooled water for three to four months.
- Southern bell frog (*Litoria raniformis*) and barking marsh frogs (*Limnodynastes fletcheri*) breed in spring/summer following flooding, completion of metamorphosis can take

between three and twelve months, water should be pooled for six months to maximise recruitment.

- Banjo frog comples (*Limnodynastes interiosis, dumerili, terrareginae*) maximise recruitment by maintaining pooled water for up to six months.
- Spotted grass frogs (*Limnodynastes tasmaniensis*) respond best to spring/summer flooding and require pooled water for at least three months.

Vegetation

Vegetation - permanent wetlands and in-channel species

- Ribbonweed (*Vallisneria*) and wavy marshwort (*Nymphoides crenata*) both requiring permanent inundation of between 50-100 cm.

Vegetation - Semi-permanent wetlands

- Cumbungi association: cumbungi (*Typha*), rushes (*Juncus*), spike rush (*Eleocharis* spp) and wavy marshwort (*Nymphoides crenata*) require up to 200 cm of inundation annually for between nine to twelve months especially spring and summer.
- Reed association: spike rush (*Eleocharis* spp), common reed (*Phragmites australis*) require approximately 30 cm of inundation annually for up to six months during spring and summer.
- Water couch association: water couch (*Paspalum distichum*), primrose (*Ludwigia peploides*), and species of sedges (*Cyperus*), isotomes (*Isotoma*), nardoo (*Marsilea*) and buttercup (*Ranunculus*) require shallow annual inundation for two to three months during spring and summer.

Vegetation – Ephemeral wetlands

- River red gum (*Eucalyptus camaldulensis*) forest and woodlands require water one in every two to three years for between two to six months.
- Lignum shrublands (*Muehlenbeckia florulenta*) require approximately 60 cm of water three in ten years for up to six months during spring and summer.
- Blackbox woodland (*E. Largiflor*ens) requiring water one in every 10 years for approximately two months during summer to autumn.

Table 6: Objectives for the mid-Murray catchment.

Ecological Objective	Hydrological objective	Targeted feature
Inundation		
1. Maintain the health, structure and composition of wetland and riparian vegetation communities.	Sufficient volume provided to meet desired level of inundation.	Jimaringle-Cockran Creek, Murrain-Yarrein Creek, Bengallow Creek, Lake Caringay, Tuppal Creek.
Water Quality		
2. Provide early inundation of floodplain organic debris to reduce the risk of low dissolved oxygen blackwater events later in the year.	Provide a pulse or higher flows late winter/ early spring to inundate key wetland areas (25,000 ML/day at Yarrawonga, 8,000 ML/day at Deniliquin).	Hume-Yarrawonga-floodplain, Barmah-Millewa, Werai Forest, Niemur National Park, Gunbower Koondrook Perricoota Forest.
Ecosystem function		
3. Stimulate ecosystem productivity – use a floodpulse to move nutrients and carbon between main channel, upper benches and smaller low commence to flow floodrunners (Young 2001). 4. Provide migration and dispersal opportunities for aquatic fauna	Provide a pulse or higher flows late winter/ early spring to inundate key wetland areas (25,000 ML/day at Yarrawonga, 8,000 ML/day at Deniliquin), continuous variable flow to enable longitudinal connectivity, inundate low benches,	All water permanent water courses in the catchment area.

between permanent and seasonal aquatic habitats (Young 2001).	floodrunners, billabongs wetlands and backwaters.	
5. Use environmental water to create flow variability to enable increased diversity in riverine biofilms (reduce domination of algae and increase bacteria and fungi) to support invertebrates, and higher order consumers such as fish (Young 2001).	Ensure periods of flow variability to inundate low benches, floodrunners, billabongs wetlands and backwaters.	Hume to Yarrawonga and the Edward-Wakool system.
Fish		
6. Cue large-bodied fish movement (golden perch, Murray cod, and silver perch) and determine flow rates at which large-bodied fish begin to move through the water course, including whether or not the rate of increase of flow impacts on fish movement. 7. Determine broad patterns of fish movement and whether or not individual fish (golden perch, silver perch, Murray cod and carp) return to their place of origin within / after a flow event. 8. Determine approximate commence-to-flow levels for key flood-runners used by large-bodied-fish.	Series of three pulses of variable size, duration, rate of rise and fall during the spring period. Pulse 1 August: 25 days peak 300 ML/day Pulse 2 September/ October: 40 days peak 600 ML/day Pulse 3 November 25 days peak flow 800 ML/day. Provide flows to ensure full connectivity, to allow movement of mobile species.	Wakool River-Yallakool Creek
9. Improved habitat, spawning and recruitment of low-flow / wetland opportunist fish species (Rogers and Ralph 2010).	Ensure inundation of target features during October. Provide flows to ensure full connectivity, to allow movement of mobile species.	Barmah-Millewa watercourses, smaller creeks, floodrunners and billabongs of the Wakool system, Werai Forest, Niemur National Park, Gunbower Creek.
10. Improved habitat, spawning and recruitment of main channel generalists / wetland opportunists (Rogers and Ralph 2010).	Ensure there is a rising flow pulse during September or October when water temperatures are above 15^{o}c. Provide flows to ensure full connectivity, to allow movement of mobile species.	Murray River, Barmah-Millewa watercourses, smaller creeks, floodrunners and billabongs of the Wakool system, Gunbower Creek, Mullaroo Creek.
11. Improved habitat, spawning and recruitment of main channel specialists (Rogers and Ralph 2010).	Ensure there are flows along major water courses when water temperature is above 15 ^{o}c when day length has increased sufficiently to trigger spawning (September / October). Provide flows to ensure full connectivity, to allow movement of mobile species.	Murray River especially Yarrawonga to Barmah (for Trout Cod), Goulburn River, Gunbower Creek, principal watercourses of the Edward-Wakool system, Mullaroo Creek.
12. Improved habitat, spawning and recruitment of flood spawners (Rogers and Ralph 2010).	Provide a pulse flow with a sustained peak when water temperature is above 20^{o}c during October – November. Provide flows to ensure full connectivity, to allow movement	Murray River especially Yarrawonga to Barmah (for Trout Cod), Goulburn River, Gunbower Creek, principal watercourses of the Edward-Wakool

	of mobile species.	system, Mullaroo Creek.
Birds		
13. Use environmental water to stimulate breeding through inundating key floodplain areas from September through to December, where possible maintaining inundation for up to four months.	Pulse in September to inundate key wetland areas (25,000 ML/day at Yarrawonga, 8,000 ML/day at Deniliquin) and maintain inundation of key floodplain areas by maintaining a minimum flow at Yarrawonga of 10,000 ML/day between late August and December. Use water to ensure that drawdown of flood peaks from 25,000 to 15,000 ML/day is limited to 15 cm/d at Yarrawonga.	Floodplain open water and River Red Gums: Barmah-Millewa Forest, Werai, Niemur National Park, Gunbower.
14. Provide suitable foraging and breeding habitat for fish eating species such as: grebes, cormorants, egrets and herons (Rogers and Ralph 2010)	Maintain inundation of key floodplain areas by maintaining a minimum flow at Yarrawonga of 10,000 ML/day between late August and December.	Floodplain open water and River Red Gums: Barmah-Millewa Forest, Werai, Niemur National Park, Gunbower.
15. Provide suitable foraging and breeding habitat for deep-water foraging species such as: black swans, hardheads, blue-billed ducks (Rogers and Ralph 2010).	Maintain inundation of key floodplain areas by maintaining a minimum flow at Yarrawonga of between 10,000 -15,000 ML/day and above 4,000 ML/day at Stevens Weir between late August and December. Provide deep water conditions from August through to December; maintain inundation for up to eight months where possible.	Open water: Moira Lake, Barmah Lake, Reedbeds (Werai) .
16. Provide suitable foraging and breeding habitat for dabbling duck species such as grey teal, pink-eared duck, freckled duck and pacific black duck (Rogers and Ralph 2010).	Maintain inundation of key floodplain areas by maintaining a minimum flow at Yarrawonga of between 10,000 -15,000 ML/day and above 4,000 ML/day at Stevens Weir between late June and December, maintain inundation for up to nine months where possible.	Wetlands: Barmah-Millewa watercourses and floodplain, smaller creeks, floodrunners and billabongs of the Wakool system, Werai Forest, Niemur National Park, Gunbower Creek.
17. Provide suitable foraging and breeding habitat for grazing water fowl and shore-line forages such as plumed whistling ducks, Australian shelducks and purple swamp hens (Rogers and Ralph 2010).	Provide water from August through to December, use a pulse of higher flows to inundate key wetland areas in September (25,000 ML/day at Yarrawonga, 8,000 ML/day at Deniliquin), follow up pulse in November to maintain inundation levels if required. Maintain inundation for up to six months where possible.	Wetlands: Barmah-Millewa watercourses and floodplain, smaller creeks, floodrunners and billabongs of the Wakool system, Werai Forest, Niemur National Park, Gunbower Creek.
18. Provide suitable foraging and breeding habitat for wading bird species such as spoonbill species, ibis species, brolga and dottrels (Rogers and Ralph 2010).	Provide environmental water from September through to February, where possible maintaining inundation for up to twelve months. Pulse in September to inundate key	Wetlands, ephemeral watercourses, open landscapes with emergent vegetation: Barmah-Millewa floodplains, Reedbeds (Werai),

	wetland areas (25,000 ML/day at Yarrawonga, 8,000 ML/day at Deniliquin), follow up pulse in November if required.	floodrunners and billabongs of the Edward-Wakool system.
Frogs		
19. Maintain a hydroperiod of up to seven months to enable completion of metamorphic process to maximise potential for recruitment success (Rogers and Ralph 2010).	Use a pulse of higher flows to initially inundate key wetland areas in September (25,000 ML/day at Yarrawonga, 8,000 ML/day at Deniliquin), follow up pulse to maintain inundation levels if required. Maintain inundation of key floodplain areas by maintaining a minimum flow at Yarrawonga of between 10,000 -15,000 ML/day and above 4,000 ML/day at Stevens Weir between late August and December.	Barmah-Millewa watercourses and floodplain, smaller creeks, floodrunners and billabongs of the Wakool system, Werai Forest, Niemur National Park, Gunbower Creek, Mullaroo Creek.
Macroinvertebrates		
20. Use flow variability to increase habitat diversity, encourage growth of aquatic and littoral vegetation and provide suitable food sources for macro-invertebrates.	Series of three pulses of variable size, duration, rate of rise and fall during the spring period.	All water courses.
Vegetation		
Permanent wetlands and in-channel species 21. Maintain permanent to near-permanent inundation to maintain vegetation community (Rogers and Ralph 2010).	Maintain inundation of all water courses by maintaining a minimum flow at Yarrawonga of between 10,000 -15,000 ML/day and above 4,000 ML/day at Stevens Weir between late August and December.	All water courses.
Semi-permanent wetlands 22. Maintain condition of vegetation by ensuring that annual inundation occurs (Rogers and Ralph 2010)	Use a pulse of higher flows to initially inundate key wetland areas in September (25,000 ML/day at Yarrawonga, 8,000 ML/day at Deniliquin), follow up pulse to maintain inundation levels if required. Maintain inundation of key floodplain areas by maintaining a minimum flow at Yarrawonga of between 10,000 -15,000 ML/day and above 4,000 ML/day at Stevens Weir between late August and December.	Edges of watercourses, floodplain sites with fluctuating water levels: Barmah-Millewa floodplains, Reedbeds (Werai), floodrunners and billabongs of the Edward-Wakool system (Jimaringle and Cockran Creek).
Ephemeral wetlands 23. Maintain condition of ephemeral wetlands which have irregular flooding and significant drying periods (Rogers and Ralph 2010).	Use a pulse of higher flows to initially inundate key wetland areas in September. Maintain inundation of key floodplain areas by maintaining a minimum flow at Yarrawonga of between 10,000 - 15,000 ML/day and above 4,000 ML/day at Stevens Weir between late August and December.	Depressions on the floodplain, banks of water courses, billabongs: Central Murray Floodplain.

1.10. Watering options for 2011-12

Based on current catchment conditions and forecast holdings in 2011-12 a number of ecological objectives for the mid-Murray catchment have been identified. From these objectives there are a number of possible watering actions in scope for 2011-12.

One possible approach detailed in this strategy is to adaptively manage the environmental water releases from appropriate storages in the system based on natural inflows and catchment conditions, combined with delivery of environmental water to specific environmental assets via regulators, structures and irrigation infrastructure to meet environmental water requirements.

Five broad water delivery mechanisms for use of environmental water have been considered as part of this strategy.

a) Target an appropriate baseflows downstream of Yarrawonga Weir;
b) boost natural high flows;
c) manage recession of a flood peak;
d) create a fresh; and
e) Site specific delivery using regulating infrastructure.

Options a-d are based on meeting environmental water requirements using higher river flows as a result of releases from upstream storages. These options are demonstrated conceptually in Figure 6 below. Option e addresses the environmental watering actions that cannot be met by higher river flows and require the use of irrigation infrastructure or regulators to deliver specific volumes of water to the asset.

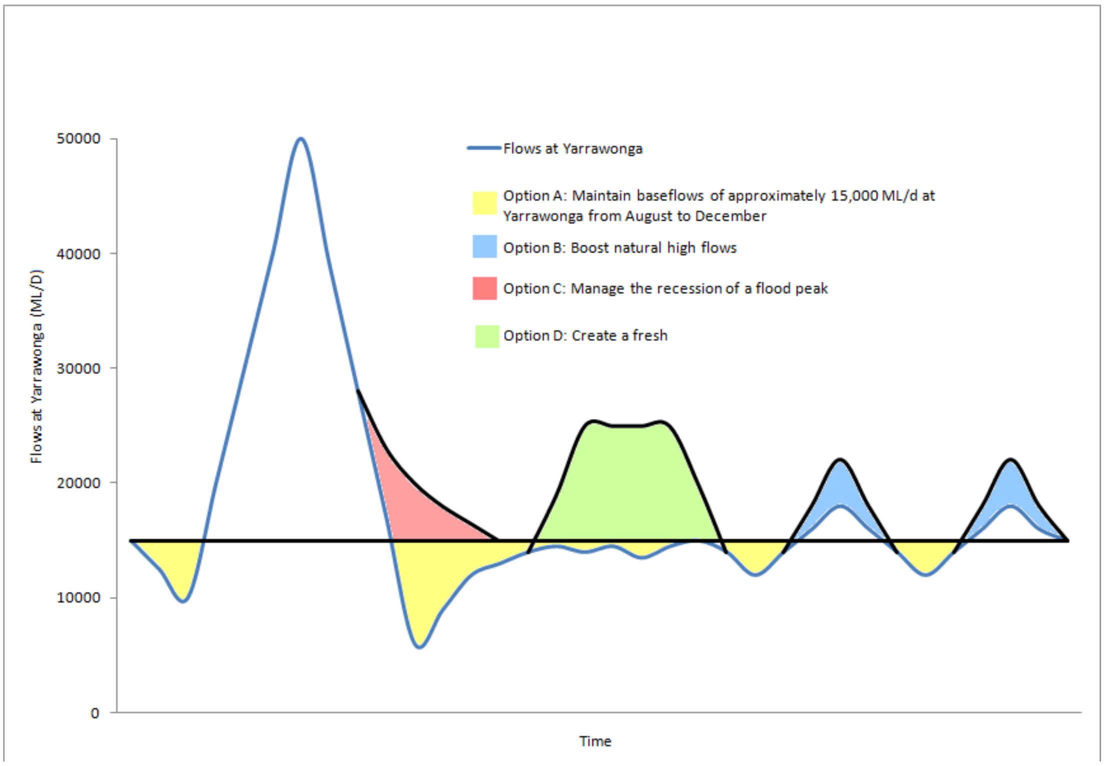

Figure 6: Conceptual model demonstrating water use options a-d for the mid-Murray.

This strategy is built on the notion that water delivered from an upstream storage, such as Hume or Lake Eildon, could have multiple uses downstream.

a) Target an appropriate baseflows downstream of Yarrawonga Weir

Key point:

- *Target a flow of 15,000 ML/day at Yarrawonga for the period September to December.*
- *Objectives met (refer*
- *Table* 6*): 3, 4, 9, 10, 11, 14, 15, 16, 20, 21.*

The seasonal streamflow forecast for Hume (Figure 7) is based on probabilities of water flowing into a stream or catchment determined by relationships with recent climate and catchment conditions. Figure 7 indicates that in the period to September 2011 the most likely scenario is high or median flow. Advice from the Murray Darling Basin Authority has indicated that the current operation plan for Hume reservoir is to pass all inflows into the reservoir over the winter period to maintain airspace in the dam as a flood mitigation measure. It is anticipated that this mode of operation will continue until late August when operations will shift to managing inflows to fill the reservoir. This means that while this mode of operation is employed for Hume reservoir, flows downstream will represent close to 'natural flows' and the use of Commonwealth environmental water should not be required.

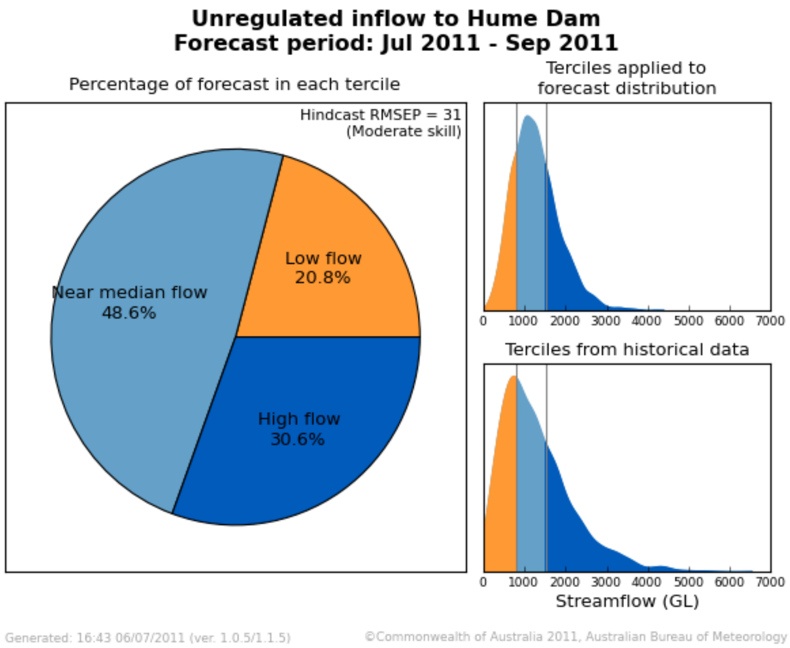

Figure 7: Streamflow forecast for Hume reservoir in the period to September 2011 (BOM 2011b).

Without intervention, river flows can fluctuate between near-natural levels during unregulated peaks and very low flows, well below natural levels, when water is captured in storages and there is low demand for water. The very low flows disrupt a number of ecological processes associated with higher baseflows in spring including fish and waterbird breeding and plant growth and reproduction.

Following the change in operation of Hume reservoir, anticipated to occur in late August- early September (though this is highly weather dependent), the water use option will be to maintain a baseflow in the remainder of the spring period that would be more akin to natural baseflows pre-regulation. It is therefore proposed that environmental water could be used to supplement some river flows to aim to provide a target flow of 15,000 ML/day downstream of Yarrawonga during the spring period (see option a in Figure 6).

The flow target downstream of Yarrawonga will require making releases from Hume reservoir to complement good inflows from other connected water courses such as the Ovens River and existing reservoir releases including transfer flows and any potential irrigation flows[1]. Releases from Hume to meet the flow targets downstream of Yarrawonga would by default result in the objectives for Hume to Yarrawonga being met.

The strategy to maintain baseflow would involve a large, sustained commitment of environmental water, but is considered feasible in a median year when storages are near full and allocations are good. The anticipated high ambient flows will limit the requirement of environmental water releases to maintain the target baseflow threshold.

The target flow of 15,000 ML/day downstream of Yarrawonga reaches environmental flow thresholds identified in asset watering plans (Table 7). This flow at Yarrawonga relates to a discharge of approximately:

- 4,000 ML/day at Stevens Weir, therefore providing water to Werai Forest, the Wakool River, Colligen Creek and Yallakool Creek;
- 3,000 ML/day at the Barham to Moulamein Road on the Niemur River to provide water to Niemur National Park; and
- 10,000 ML/day at Barmah in the Murray River, which when combined with anticipated Goulburn River flows of 2,000 to 4,000 ML/day in the winter spring period, it will provide a baseflow of approximately 14,000 ML/day at Torrumbarry Weir and benefit other sites in Barmah such as Boals, Deadwood and Gulf Creek.

Downstream of Barmah fewer environmental assets are affected. Therefore environmental regulators could be used to divert water from the Torrumbarry Weir pool to provide an environmental flow in Gunbower Creek and releases to the forest. In the future, structures at Koondrook-Perricoota should allow similar actions at these sites.

If flows at Yarrawonga are maintained between the time when natural inflows into Hume are no longer passed and the end of November, this will provide sustained flooding to low-lying wetlands, floodplain watercourses and the principal watercourses of the Edward-Wakool system (Table 7). Sustained flooding for 3 months or more is the minimum requirement for the maintenance of plant community structures on the lower floodplain and successful waterbird breeding. Many colonial water birds remain in the vicinity of the Barmah-Millewa Forest and Victoria have indicated a preference to ensure that water is provided to meet the requirements of the birds that have remained in the area and encourage any breeding events to initiate early in the spring season.

Releases to increase Murray River channel flows are effective in targeting features in the Yarrawonga-Tocumwal, Barmah-Millewa and Edward-Wakool systems. Downstream of Barmah fewer environmental assets are affected and channels and other mechanism are required to deliver water to a number of important assets.

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[1] There would be environmental benefits from a similar release strategy from Lake Eildon, but constraints on flooding private property downstream of the storage are restrictive.

Table 7: Assets and features affected by maintaining flow at Yarrawonga Weir above 1[illegible],[illegible]00 ML/day (or less if natural) between August and November.

Asset	Features	Hydrological Objective	Flow Thresholds / target
Barmah-Millewa Forest	Wetlands, floodplain watercourses and riparian habitat	Maintain flow and sustain inundation in the seasonal high-flow period	3,000 ML/day to 15,000 ML/day at Yarrawonga Weir
Edward-Wakool system	Permanent, semi-permanent regulated rivers and creeks[2] (>1,000 km)	Maintain flow throughout the seasonal high-flow period	1,500 ML/day to 4,000 ML/day at Stevens Weir
	Wetlands (Reed Beds Wetlands – Werai Forest)	Sustained inundation in the seasonal high-flow period	4,000 ML/day at Stevens Weir
Gunbower Forest	Wetlands (Black Swamp, Reedy Lagoon, Little Reedy Complex, Gunbower Complex)	Sustained inundation in the seasonal high-flow period	Regulated diversions to Yarran Creek and Little Gunbower Regulators via Gunbower Creek of 900 ML/day
	Gunbower Creek	Maintain flow at Koondrook Weir throughout the seasonal high-flow period	Regulated diversions Gunbower Creek of 500 ML/day
	Red Gum with Flood-dependent understorey	Sustained inundation in the seasonal high-flow period	Possible regulated diversions to Hipwell Road[3] via Gunbower Creek from September to November of 1,650 ML/day
Koondrook-Perricoota Forest	Swan Lagoon	Sustained inundation in the seasonal high-flow period	14,000 ML/day at Torrumbarry Weir

[2] Edward River, Wakool River, Niemur River, Colligen Creek, Yallakool Creek.

[3] Note: the Hipwell Road works are due to become operational during 2011-12.

b) Boost natural high flows.

Key point:

- *Environmental water could be used to boost higher flows in the Murray River to 25,000 ML/day at Yarrawonga.*
- *Objectives met (refer*
- *Table* 6*): 2, 3, 4, 5, 6, 7, 8,10, 11, 12, 13, 14, 15,16, 17, 18, 19, 20, 21, 22, 23.*

The second option will be to boost higher flows that occur in the spring period by allowing unregulated inflows to create peaks which may be added to with flows provided from Hume reservoir. Peaks in flow will result from rain events which create additional inflows, particularly from the Ovens and Goulburn catchments, and reduce irrigation demand to create rain-rejection flows.

The use of environmental water should be cued on the modelled natural flow, and fluctuations in flow rates downstream of Yarrawonga Weir between 15,000 ML/day, up to 25,000 ML/day are highly desirable. It is probable that a rainfall event that boosts flow downstream of Yarrawonga may also result in a boost of flows from the Goulburn River, Campaspe River and Broken Creek into the Murray River leading to higher flows downstream of Torrumbarry Weir.

These higher flows in the Murray (see option b in Figure 6) will be more effective in addressing ecological objectives such as providing spawning cues for fish. Peaks are likely to occur when wetlands are inundated and aquatic fauna are present and likely to respond to elevated flow and more widespread flooding. These higher flows are anticipated to reach higher floodplain levels than would otherwise occur without the addition of environmental water.

Table 8: Assets and features affected by boosting flows above 15,000 ML/day at Yarrawonga Weir.

Asset	Features	Hydrological Objective	Flow Thresholds
Yarrawonga-Tocumwal	Red Gum forest with Flood-dependent Understorey	More than four weeks total inundation in the seasonal high-flow period	20,000 to 35,000 ML/day at Yarrawonga Weir
Barmah-Millewa Forest	Moira Grass Plains	More than six weeks total inundation in the seasonal high-flow period	15,000 to 25,000 ML/day at Yarrawonga Weir
	Red Gum forest with Flood-dependent Understorey	More than four weeks total inundation in the seasonal high-flow period	20,000 to 35,000 ML/day at Yarrawonga Weir
Edward-Wakool system	Red Gum forest with Flood-dependent Understorey (Werai Forest, Niemur National Park)	More than four weeks total inundation in the seasonal high-flow period	6,000 ML/day at Stevens Weir
Gunbower Forest	Red Gum forest with Flood-dependent Understorey	More than four weeks total inundation in the seasonal high-flow period	30,000 ML/day at Torrumbarry Weir
Swan Hill	Parnee Malloo Creek	Two or more freshes or more than two weeks duration in the seasonal high-flow period	16,000 ML/day at Torrumbarry Weir
	Nyah-Vinifera Forest	More than four weeks total inundation in the seasonal high-flow period	25,000 ML/day at Torrumbarry Weir
Mulcra Island	Red Gum with Flood-dependent Understorey	More than four weeks total inundation in the seasonal high-flow period	30,000 ML/day at Lock 9

c) Manage high flow recessions

Key point:

- *Commonwealth environmental water would be used to ensure that floods do not recede too quickly below 25,000 ML/day at Yarrawonga.*
- *Objectives met (refer*
- *Table 6): 2, 3, 4, 5, 6, 7, 8,10, 11, 12, 13, 14, 15,16, 17, 18, 19, 20, 21, 22, 23.*

The third option will be to prevent excessively steep recessions in river flows following a flood peak, demonstrated conceptually as option c in Figure 6.

River levels can drop rapidly following unregulated peaks in flow as water is captured in storages. There is usually little or no demand for irrigation water following such events and storage releases are therefore reduced to reflect downstream water demand to conserve water. This has the effect of rapidly taking river levels from near-natural flows during the peak to levels well-below the natural flow. Excessively steep recessions interrupt flood-dependent ecological processes that are triggered by flow peaks resulting potentially in collapse of moira grass beds, stranding of fish on the floodplain, abandonment of nests by waterbirds and bank slumping.

These ecological processes relate mainly to the recession of river levels from 25,000 ML/day and this is where intervention is proposed to manage peak recessions. Under current operating rules river levels downstream of Yarrawonga Weir may fall as fast as 300 mm/day which is double what is possible at Doctors Point (downstream of Hume reservoir).

Environmental water could be released to achieve a maximum rate of drawdown downstream of Yarrawonga Weir of 150 mm/day or mimic the natural modelled recession (as was undertaken during the 2010-11 Barmah-Millewa watering) on the falling hydrograph from 25,000 ML/day to 15,000 ML/day (refer to Table 9).

The water management actions required to achieve this rate must be decided in relation to each event and must consider the anticipated rate of fall and the short term forecast for river flows.

Table 9: Assets and features affected by the strategy to limit the rate of drawdown of flow peaks between 25,000 ML/day to 15,000 ML/day at Yarrawonga Weir.

Asset	Features	Hydrological Objective
Barmah-Millewa Forest	Floodplain wetlands	Rate limited to 15 cm/day at Yarrawonga
	Moira Grass Plains	Rate limited to 15 cm/day at Yarrawonga
	Red Gum forest with Flood-dependent Understorey	Rate limited to 15 cm/day at Yarrawonga
	Native fish on the floodplain	Rate limited to 15 cm/day at Yarrawonga
Edward-Wakool system	Reed Beds	Rate limited to 15 cm/day at Yarrawonga
	Red Gum forest with Flood-dependent Understory (Werai Forest, Niemur National Park)	Rate limited to 15 cm/day at Yarrawonga
	Native fish on the floodplain	Rate limited to 15 cm/day at Yarrawonga

d) Create a fresh

Key point:

- *provide two freshes of up to 25,000 ML/day during the period August to December.*
- *Objectives met (refer*
- *Table* 6*): 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 17, 19, 21, 22, 23*

In a median year rainfall events in the August to November period would be expected to create at least two freshes of two or more weeks duration with a discharge exceeding 25,000 ML/day at Yarrawonga. This corresponds to a flow of approximately 8,000 ML/day at Stevens Weir and 15,000 ML/day at Barmah. Concurrent elevated flows in the Goulburn catchment of approximately 10,000 ML/day are expected to provide similar freshes exceeding 25,000 ML/day at Torrumbarry Weir, which would provide water to low-lying river benches downstream of the weir, such as those found in the Nyah-Vinifera Forest. Option d (see Figure 6) is to use Commonwealth environmental water to create freshes in the system that would mimic those that would naturally have occurred during the spring period.

Due to ongoing work at the flood enhancement projects occurring at Koondrook-Perricoota Forest, Hattah Lakes, Mulcra Island and Lindsay Island, and works in Millewa forest, it is unlikely that Commonwealth environmental water would be used under this option to create flows higher than 25,000 ML/day downstream of Yarrawonga. Temporary structures will be used at these sites to exclude higher flows to a point to allow works to continue. However, if a large peak occurs early in the season (e.g. over 35,000 ML/day downstream of Torrumbarry in August or September) the works may be postponed as exclusion of flows may not be possible. Should the postponement of works occur it may be possible to use Commonwealth environmental water to create a fresh.

e) Site specific delivery using regulating infrastructure

Key points:

- *Options a-d will not meet the requirements of a number of environmental assets*
- *Irrigation infrastructure of pumping may be required to water a number of assets.*
- *Objectives met (refer*
- *Table* 6*): 1, 3, 9, 10, 13, 14, 16, 17, 19, 20, 21, 22.*

There are a number of watering actions which cannot be met simply by providing higher flows down the Murray River and associated systems. In most instances the needs of these assets cannot be met due to the requirement to have extremely high river flows which pose an unacceptable risk to private property or infrastructure. Examples of this include Hattah Lakes and the Jimaringle Cockran Creek. The use of irrigation infrastructure and pumping are the main alternative mechanisms to delivering water to these assets in the absence of high flows. Table 10 below summarises the possible regulated flow option.

Table 10: Summary of potential regulated water use

Option	Volume	Delivery Mechanism
Lake Kramen (Hattah Lakes)*	3,000 ML	Pumping: water will only be delivered to Lake Kramen if Murray River flows exceed 40,000 ML/day; this is to avoid delays to TLM construction works which are scheduled to commence late 2011.

Option	Volume	Delivery Mechanism
Lake Wallawalla Wallpolla Island (Lindsay –Wallpolla Island)*	8,700 ML 2,000 ML	Pumping
Mulcra Island	2,000 ML	Pumping
Round Lake, Lake Elizabeth, Johnson's Swamp, Richarson's Lagoon (Kerang Wetland System)*	3,900 ML	Targeted sites in the Kerang Lakes can also be supplied with water diverted at Torrumbarry via the Torrumbarry Irrigation System or by pumping from the Murray River. Watering is proposed at Round Lake, Lake Elizabeth, Johnson's Swamp and Richardson's Lagoon, requiring a total of 3.5 GL.
Heywoods Lake, Nurrang Wetlands, Lakes Powell and Carpul, Merbein Common, Sandilong Creek, Liparoo, Cardross Lakes, Lake Koorlong (Mallee River Murray wetlands)*	10,920 ML	Delivery mechanism for each site to be determined, likely to be a mixture of use of regulators and pumping.
Black Charlie Lagoon, Little Gunbower Creek Complex, Little Reedy Complex, Reedy Lagoon, Gunbower Creek (Gunbower system)*	91,800 ML	Use of Torrumbarry Irrigation infrastructure, fed from the Torrumbarry weir pool.
Jimaringle-Cockran Creeks (Edward-Wakool system)	11,000 ML	Use of Murray Irrigation Limited (MIL) infrastructure (additional cost of $1.50 and 10% water loss) to drop water into the creek using the Mascott Escape (at Mascott Sihpon 125 ML/day), Northern 1b and Jimaringle 1 escape (both 20 ML/day) and possible siphoning from Colligen Creek into Gwynnes creek.
Niemur National Park (Edward-Wakool system)	Up to 15,000 ML	Deliver water into the Colligen Creek using the Edward Escape to boost river flows. Additional water could be delivered using MIL infrastructure (in addition to the Edward Escape) such as the Niemur Escape (150 ML/day), Number 8 Southern Escape and Jimaringle Main Escape.
Murrain-Yarrein Creek (Edward-Wakool system)	Up to 5,000 ML	Delivery mechanism to be determined. Possible use of MIL infrastructure.
Wakool River – Yallakool Creek (Edward –Wakool system)	30,000 ML	If water cannot be supplied through higher river flows then it may be necessary to use the MIL infrastructure to deliver water into the Wakool River using the escape.
Total	**Up to 183,320 ML**	

* Proposals have not yet been received for these watering actions. The volumes presented are the total requirement of the system and are likely to be met by contributions from Victoria, The Living Murray and Commonwealth environmental water holdings.

Potential water use

The use of water under this strategy, in particular options a-d will be determined over the course of the high flow period by a range of factors. High catchment inflows may meet watering targets so that the requirement to release water is reduced. Peaks in catchment inflows may trigger responses to prolong recessions. High irrigation demand may result in high releases from Hume which fill the channel and reduce the requirement for environmental water to meet a target baseflow level. Conversely low irrigation demand at the same time as low catchment inflows will require very high environmental water releases.

Releases that increase flooding at sites where works are planned will be avoided unless natural flow peaks inundate the sites. If works are abandoned or postponed in 2011 due to high flows then the strategy will be used to guide the release of Commonwealth environmental water as per the options discussed above.

Table 11 presents the potential timing and rate of releases from Hume and Eildon to meet the requirements of the strategy. The table is illustrative only because of the contingencies outlined above.

Table 11: Total release volume estimate and monthly water allocation profile. All figures are in gigalitres.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	TOTAL
Hume Releases													
Provision of base flow	0	0	80	80	80								240
Flood recession management	0	0	60	60	60								180
Two freshes			105	105									210
Eildon Releases													
Provision of base flow	0	0	30	30	30	0	0	0	0	0	0	0	90
Return Flows													
from Gunbower Forest[4]	0	0	11	11	11								33

[4] Return flows from Gunbower Creek are approximated as a 25 per cent loss of 500 ML/d flow in September, October and November.

The expected outcomes from the range of watering options could include the following which would be established on an event by event basis:

- at least one spawning event by fish which depend on flow cues (golden perch (*Macquaria ambigua*) and silver perch(*Bidyanus bidyanus*);
- successful breeding by waterbirds with intermediate breeding cycles including white-faced heron *(Egretta novaehollandiae)*, white-necked heron *(Ardea pacifica)*, royal spoonbill (*Platalea regia*)and yellow-billed spoonbill (*Platalea flavipes*) and little black cormorant (*Phalacrocorax sulcirostris*) and great cormorant (*Phalacrocorax carbo)*;
- increase in the population and distribution of small-bodied fish specialising in riparian and wetland habitat including carp gudgeons (*Hypseleotris spp*), Murray rainbowfish (*Melanotaenia fluviatilis*), southern pygmy perch (*Nannoperca australis*), Murray hardyhead (*Craterocephalus fluviatilis*), olive perchlet (*Ambassis agassizii*) and purple-spotted gudgeon (*Mogurnda adspersa*);
- increase in the population and distribution of floodplain aquatic fauna including yabbie, turtle species, frogs (including the southern bell frog *Litoria raniformis*);
- filling of floodplain waterbodies to provide aquatic habitat over the summer of 2011-12;
- growth, flowering and seed set by aquatic plants throughout floodplain wetlands; and
- growth and seed set of moira grass in the Barmah-Millewa Forest.

As stated above flows downstream of Hume reservoir are likely to reflect close to natural flows in the period up to the end of August so use of Commonwealth environmental water during this period would be minimal. However, should conditions become significantly drier than the outlook suggests from September onwards, then it will be necessary to adapt to a different water use strategy.

Drier conditions

A baseflow of 15,000 ML/day below Yarrawonga Weir can only be sustained in the seasonal high-flow period if there are high ambient flows in the river.

Lower ambient flows could occur if there is a very dry spring. A dry spring may result in river flows less than 10,000 ML/day prior to the irrigation season beginning and depending on downstream irrigation demand once the season begins, in which case large daily releases of environmental water would be required to reach the baseflow target.

Environmental allocations would be quickly exhausted and the potential to address water requirements later in the water year would be reduced. Under these circumstances, a more appropriate strategy may be to operate under options b, c and e (refer to Figure 6) boosting higher flows, managing the recessions of larger natural flows and site specific water delivery.

It is anticipated that there will be significant irrigation demand during the spring and summer of 2011-12, this will most likely result in close to maximum in channel flows downstream of Yarrawonga through the Barmah Choke during the irrigation season. In this instance the strategy for use of Commonwealth environmental water would be to create variability above the baseflow (a lower flow version of option d) by providing a number of freshes, which would over top banks providing water to the floodplain of the Barmah-Millewa Forest and when appropriate managing the recession (option c) of higher flows that may occur as a result of rainfall events in the Ovens and Goulburn catchments.

Under this water use scenario most assets identified as part of this water use strategy would still receive Commonwealth environmental water, though the extent and duration of inundation would be reduced.

1.11. Assessing environmental watering options

A range of watering options for the mid-Murray catchment have been assessed against the Commonwealth Environmental Water Holder criteria for assessing watering actions. Briefly, these criteria are the:

- ecological significance of the asset(s);
- expected ecological outcomes from the proposed watering action;
- potential risks of the proposed watering action at the site and at connected locations;
- long-term sustainability of the asset(s) including appropriate management arrangements; and
- cost-effectiveness and operational feasibility of undertaking the watering.

Detailed description of the Commonwealth Environmental Water Holder criteria for assessing watering actions is provided at Attachment B. Watering options across the mid-Murray catchment that have been assessed and determined to have met the criteria are provided at Attachment C.

The assessments have been undertaken at the macro-scale for groups of individual assets that are similarly located and managed.

The assessments will be reviewed as individual watering actions are closer to their proposed timing for delivery. The review will include a more comprehensive risk assessment which is subject to the prevailing catchment and river flow conditions, and will consider in more detail proposed costs, delivery, monitoring and accounting arrangements. Any additional watering options identified during the course of the year will also be subject to an assessment against the criteria.

1.12. Key constraints for water delivery

Key constraints on delivering environmental water in the Mid-Murray catchment are:

- With the current rules and regulations the only mechanism to ensure that Commonwealth environmental water is used predominantly for environmental benefit, as far down the system as the Murray Mouth, is to deliver the environmental water when the Murray system is in unregulated conditions.
- Under the MDBA 75% scenario (a drier scenario) unregulated conditions are forecast to continue until September. With the addition of Commonwealth environmental water this could extend until November. Under the MDBA 50% scenario (which is a wetter scenario), unregulated conditions are forecast to continue until October but this depends on the pattern of inflows.
- The multi-site Mid-Murray strategy (options a to d) relies on additional releases of Commonwealth environmental water being made from Hume Dam. This can only be achieved by obtaining the agreement of the storage stakeholders and the decision must be made by the Basin Officials Committee. Option e does not have this requirement.
- Regulated flows in the Goulburn River must not contribute to or prolong flooding of private land. The maximum release to avoid flooding is about 10,000 ML/day below Lake Eildon. The irrigation supply component of this flow can reach 100 per cent when there is peak

irrigation demand and spare capacity in Waranga Basin. However, irrigation demand is more typically 60 to 70 per cent of this flow, which allows for a contribution of 3,000 to 4,000 ML/day at McCoy Bridge to baseflows in the Murray River.

- The releases required to maintain the baseflow target will vary according to seasonal rainfall. If rainfall is high, irrigation demand for water will be low and a greater release of environmental water will be required to reach the baseflow target. If spring rainfall is low, high irrigation demand will require high releases so that less environmental water will be required to reach target flows. Low irrigation demand will exhaust environmental water reserves more quickly and it may be necessary to adjust water use to a drier scenario.
- At low flows (less than 20,000 ML/day) the relationship between flow at Yarrawonga Weir and Stevens Weir varies according to the settings on regulators supplying the Edward River. To achieve a flow of 4,000 ML/day at Stevens Weir, flows below Yarrawonga Weir must be at least 15,000 ML/day and releases must be made from the Edward Escape which requires coordination with NSW State Water and use of Murray Irrigation Limited infrastructure, which would incur fees.
- Works are planned to construct or repair Living Murray flood enhancement works at Koondrook-Perricoota, Mulcra Island, Chowilla and Lindsay Island. Infrastructure, fishway and maintenance works are also planned for the Millewa group of forests and the Edward-Wakool system. The key thresholds are approximately 18,000 ML/day at Yarrawonga, 2,000 ML/day at Stevens Weir, 20,000 ML/day at Torrumbarry and 25,000 ML/day at Lock 9.

1.13. Water use accounting

Key points:

- *No return flow policy is in place in NSW.*
- *A return flow policy exists for Victoria though there are challenges to implement this policy for flows out of Barmah Forest.*
- *It is not currently possible to formally track water releases from Hume reservoir through the Murray system.*

Water use accounting in the mid-Murray catchment is complex and will need to be refined during the planning phase for each specific action. The multi-jurisdictional nature of the catchment means that consideration of both NSW and Victorian accounting procedures would be required in some actions.

In the NSW Murray, water allocated against regulated river (high security) access licences and regulated river (conveyance) access licences cannot be carried over. For regulated river (general security) access licences in the Murray Water Source, up to 50 per cent may be carried over. These carry over rules are based on the *Water Sharing Plan for the New South Wales Murray and Lower Darling Regulated Rivers Water Sources 2003*.

Water storage accounting for the Victorian Murray system is annual water accounting (July to June) with some carryover. Unlimited storage carryover is allowed, but water above 100 per cent of the water share volume can be quarantined in a spillable water account when there is risk of spill. Goulburn-Murray Water does not charge for carryover up to 100per cent of entitlement volume, but does charge per megalitre for water shares transferred from the Spillable Water Account to an Allocation Bank Account for the Murray system. The fee for transferring water from spillable water account back to allocation bank account is $3.25/ML for the Murray system.

Environmental water delivered to sites in New South Wales cannot currently be re-credited. In NSW, Section 45 of the *Water Sharing Plan for the NSW Murray and Lower Darling Regulated Rivers Water Sources* allows water allocations to be re-credited in accordance with return flow rules established under Section 75 of the NSW *Water Management Act 2000*. However, the return flow rules by which the application is to be assessed have not been formally established yet. At present no return flow policy exists within NSW. This constraint could possibly be managed by using environmental water to keep the river in an unregulated state where environmental water cannot all be re-regulated into Lake Victoria.

In Victoria, the policy position presented in the Northern Region Sustainable Water Strategy is to allow all entitlement holders to reuse or trade their return flows downstream provided that (DSE, 2009):

- There is adequate rigour in the calculation and/or measurement of return flows;
- The return flows meet relevant water quality standards;
- Additional losses (if any) are taken into account;
- The return flows can be delivered in line with the timing requirements of the downstream user, purchaser or environmental site;
- The system operator can re-regulate the return flows downstream, with a known and immaterial spill risk, if the entitlement holder is requesting credits on a regulated system; and
- This policy position has not yet translated into bulk entitlement amendments for all entitlements relevant to the CEWH.

Opportunities are currently being explored to implement the Victorian return flow policy for flows out of the Barmah Forest.

1.14. Risk management

A full risk assessment will be undertaken for each watering option as part of the decision-making process, building upon the preliminary risk assessment included for groups of assets at Attachment C. The more likely risks associated with delivering environmental water in the catchment and their context and mitigation measures are presented at Table 12.

Table 12: Likely risks, their context and potential mitigation.

Risk	Context and Mitigation
Low dissolved oxygen blackwater	Low dissolved oxygen blackwater events are caused by the decomposition of inundated organic matter by micro-organisms which depletes the dissolved oxygen from water. Severe and persistent blackwater events occurred in 2010-11 in floodplain wetlands and watercourses and in the main Murray River channel. A contributing factor to the severity of the 2010-11 event was the accumulation of organic matter on the floodplain over several preceding dry years, which sustained the high biological oxygen demand. The likelihood of severe blackwater events in 2011-12 is considered lower than last year. After the 2010 floods there is less accumulated organic matter. If flooding is initiated in late winter or spring, the cooler temperatures should result in slower decomposition which does not result in anoxia. Nevertheless, blackwater remains a risk in 2011-12. It is best mitigated by promoting floodplain inundation prior to October and from October onwards by only promoting flooding of previously inundated areas.

<table>
<tr><th>Risk</th><th>Context and Mitigation</th></tr>
<tr><td>Insufficient water to complete stated objectives</td><td>
The 2011-12 watering strategy is based on responding actively to catchment conditions. It is more difficult to predict the water required to provide these flows when the forthcoming river flows are not known. It is possible that the planned watering strategy will exhaust water allocations earlier in the season than planned. Risks include that:
- large scale watering breeding events are initiated but cannot be sustained because there is insufficient environmental water to maintain the river at appropriate levels; or
- flood recessions cannot be prolonged late in the season when there may be higher risks of fish stranding or vegetation impacts.
Mitigation of this risk could involve:
- Setting a baseflow target in August on what could reasonably be sustained in the rest of the season; and
- Selecting the peaks where recessions will be prolonged on the basis of ecological risk and available reserves.
</td></tr>
<tr><td>Flooding of private land</td><td>
Private landholders, particularly in the Edward-Wakool system where roads and tracks within private properties are readily cut at high flows, may be affected by environmental watering actions.
Mitigation of this risk requires early engagement with landholders who may be affected by elevated spring baseflows and prolonged flood recessions.
Flows should be managed to remain below BOM classified flood levels (BOM 2011b):
“Minor flooding: Causes inconvenience. Low-lying areas next to watercourses are inundated which may require the removal of stock and equipment. Minor roads may be closed and low-level bridges submerged.
Moderate flooding: In addition to the above, the evacuation of some houses may be required. Main traffic routes may be covered. The area of inundation is substantial in rural areas requiring the removal of stock.
Major flooding: In addition to the above, extensive rural areas and/or urban areas are inundated. Properties and towns are likely to be isolated and major traffic routes likely to be closed. Evacuation of people from flood affected areas may be required.”
<table>
<tr><th>Flood level</th><th>Minor (m)</th><th>Moderate (m)</th><th>Major(m)</th></tr>
<tr><td>Murray River at Doctors Point:</td><td>5.5</td><td>6.5</td><td>7.0</td></tr>
<tr><td>Murray R at D/S Yarrawonga Weir - Height</td><td>6.4</td><td>6.7</td><td>7.8</td></tr>
<tr><td>Murray R at D/S Yarrawonga Weir - Flow</td><td>82,000 ML/day</td><td>98,000 ML/day</td><td>182,000 ML/day</td></tr>
<tr><td>Edward R at Deniliquin</td><td>4.6</td><td>7.2</td><td>9.4</td></tr>
<tr><td>Murray R at Barmah</td><td>6.0</td><td>6.5</td><td>7.0</td></tr>
<tr><td>Murray R at Torrumbarry DS</td><td>7.3</td><td>7.6</td><td>7.8</td></tr>
<tr><td>Murray R at Euston Weir DS - Local</td><td>9.1</td><td>9.8</td><td>10.3</td></tr>
</table>
</td></tr>
<tr><td>Carp</td><td>
Floodplain inundation will promote carp spawning and will result in a larger carp population in the river. This would equally result from a natural or unregulated flood event.
There are limited options for mitigation of this risk, as native fish have a similar requirement for flooding as carp.
</td></tr>
</table>

Risk	Context and Mitigation
Rapid water level decline resulting in fauna stranding and failed breeding events	Colonial-breeding waterbirds and aquatic fauna are particularly susceptible to rapid water declines in wetland habitats. For fish and amphibians the risk is greatest during spring and summer, when fingerlings and tadpoles are too small to move or metamorphose (respectively) before their nursery habitats dry. Mitigation is best achieved by using environmental water to maintain a suitable hydrograph, as well as monitoring and adaptively managing releases if breeding events occur.

1.15. Event monitoring

The following monitoring and reporting activities are expected to be undertaken in the mid-Murray region. Monitoring will be considered on an event-by-event basis closer to the time of the action.

Table 13: Monitoring arrangements for environmental flows in the mid-Murray catchment.

Location	Parameters	Timing/frequency	Responsibility
Compliance/operational Monitoring			
All watering sited within the catchment	Hydrological monitoring (flow rates, deliver dates and volumes) Any parameters which evidence any negative impacts generated by a watering action (e.g. salt loads, blackwater, blue-green algal bloom)	Event-by-event	NSW OEH and Victorian Environmental Water Holder
TLM Icon sites: •Barmah–Millewa Forest •Gunbower–Koondrook–Perricoota Forest •Hattah Lakes •Chowilla Floodplain and Lindsay–Wallpolla Islands •Murray River channel	Monitoring includes the volume of water used at icon sites and the timing, volume and quality of return flows in order to account and report for the use and management of environmental water at the icon sites.	Event-by-event	Murray Darling Basin Authority
Intervention/response Monitoring			
TLM Icon sites: •Barmah–Millewa Forest •Gunbower–Koondrook–Perricoota Forest •Hattah Lakes •Chowilla Floodplain and Lindsay–Wallpolla Islands •Murray River channel	Focus in 2011-12 will be on (MDBA in prep): •Monitoring the impacts of fishways and resnagging on fish populations throughout the Murray River •Monitoring the direct impacts of watering events at icon sites in relation to the event watering objectives. •Addressing key information gaps on the response of	Event-by-event. This monitoring will be focused on the specific objectives and risks of the TLM watering event and is targeted in both temporal and spatial scales. Event monitoring will be prioritised according to the	Murray Darling Basin Authority

Location	Parameters	Timing/frequency	Responsibility
	vegetation, birds, habitat and fish recruitment to watering and works interventions.	water available for environmental watering and key knowledge gaps that may be addressed by specific watering actions. It is possible that events may not be monitored if resources are not available in appropriate timeframes.	
TLM: whole of Murray River system.	Monitoring at the Murray River system-scale will include (MDBA in prep): •A coordinated fish monitoring approach to monitor fish response to TLM. •An Annual Aerial Waterbird Survey which will be linked to the Eastern Australian Aerial Waterbird Survey so that geographical context is incorporated. •A red gum and black box stand condition assessment which uses remote sensing approaches to allow annual reporting on stand condition.	Ongoing.	Murray Darling Basin Authority.
Wakool-Yallakool (as part of ongoing fish response project). In July 2010 30 sites were monitored. Sites included both flowing (rivers, creeks) and non-flowing (off-channel billabongs, floodplain wetlands) sites. Monitoring of the same 30 sites plus an additional seven sites in Werai forest is planned for July 2011.	Water quality parameters measured will include temperature, pH, Electrical Conductivity (EC), turbidity and Dissolved Oxygen (DO). Fish monitoring at the 37 sites will follow a modified SRA methodology and will include: electrofishing, overnight netting and acoustic tracking.	Water quality will be monitored on a weekly basis, with temperature monitoring being logged continually through the whole project. Acoustic arrays used for fish monitoring will be downloaded at three monthly intervals.	Murray CMA in collaboration with NSW Office of Environment and Heritage, State Water and NSW Dept. of Primary Industries (fisheries).
Niemur National Park	Vegetation response through establishment of a series of photo points along the river in different vegetation communities. Colonial waterbird nesting through bird counts (only if	Monthly during event.	NSW Office of Environment and Heritage.

Location	Parameters	Timing/frequency	Responsibility
	event is triggered). Flood extent through satellite imagery and ground-truthing.		
Jimaringle, Cockran and Gwynnes Creeks (JCGC)	Vegetation using established transects plus photo points. Frog monitoring through call surveys. Fish monitoring of exotic species in particular *gambusia*.	10 sites along the JCGC system will be monitored on a fortnightly basis for vegetation, frog and fish responses.	NSW Office of Environment and Heritage and Murray CMA.
Condition Monitoring			
TLM Icon sites: •Barmah–Millewa Forest •Gunbower–Koondrook–Perricoota Forest •Hattah Lakes •Chowilla Floodplain and Lindsay–Wallpolla Islands •Murray River channel	Any parameters which evidence a change in the environmental condition of individual icon sites. Focus will be on fish, bird and vegetation communities as they relate to the ecological objectives of each TLM icon site.	Icon site condition monitoring is specifically tailored to determine if the objectives for each icon site are being met. Monitoring and evaluation at the icon site-scale is surveillance in type and typically undertaken on a medium frequency (months to years).	Murray Darling Basin Authority
Kerang Wetlands: as part of the Murray Hardhyhead Recovery Action Plan (see Backhouse et al. 2008)	Water quality parameters include salinity, temperature, dissolved oxygen, nutrients, blue-green algae, heavy metals, pesticides and suspended solids., Hardyhead population parameters include area, extent, size, structure and estimation of population change.	Monitoring is to occur at least annually.	Organisations involved in monitoring may include Murray Darling Freshwater Research Centre, Arthur Rylah Institute and North Central CMA.

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Appendix A: Environmental Assets

Hume to Yarrawonga

The Hume reservoir to Yarrawonga Weir reach of the Murray River is a naturally "braided" stream, consisting of a complex network of anabranches in addition to the main stem of the Murray River and has approximately 771 wetlands, located on both the NSW and Victorian side of the river (Green and Alexander 2006). There are a number of large anabranches that are connected to the Murray when the flows along the Murray are greater than 5,000 ML/day at Doctors Point. Downstream of Hume reservoir to Yarrawonga, the river flows in a 50 m wide channel. The banks are 3-5 m high and there is a continuous line of riparian vegetation of mostly mature red gums along both banks. A scarcity of instream snags reduces the value of this river reach as fish habitat though populations of larger fish such as Murray cod (*Maccullochella peelii*), small numbers of trout cod (*Maccullochella macquariensis*), golden perch (*Macquaria ambigua ambigua*), silver perch (*Bidyanus bidyanus*) are present. The river reach includes the "aquatic ecological community in the natural drainage system of the lower Murray River catchment" and the off-channel habitats, such as wetlands and backwaters along the stretch of river are recognised as important for the productivity of river systems and for many species of native fish.

Figure 8: Hume to Yarrawonga (Google Maps 2011).

Yarrawonga to Barmah Reach including Barmah-Millewa Forest and Tuppal Creek

The Murray River floodplain between Yarrawonga and Tocumwal is confined to a corridor approximately 1.5 kilometres wide. The floodplain comprises predominantly river red gum (*Eucalyptus camaldulensis*) forest and features wetlands, anabranches and floodrunners. This reach provides habitat for the nationally endangered trout cod (*Maccullochella macquariensis*). This reach also supports populations of silver perch (*Bidyanus bidyanus*) and Murray hardyhead (*Craterocephalus fluviatilis*). The nationally vulnerable Murray cod (*Maccullochella peelii*) are abundant.

The Barmah-Millewa Forest, composed of the Barmah Forest in Victoria and the Millewa group of forests in New South Wales, is the largest river red gum forest in Australia. It covers approximately 66,000 hectares of floodplain between Tocumwal, Deniliquin and Echuca. Barmah Forest and Millewa Forest (within the NSW Central Murray State Forest) are Ramsar sites and form an Icon Site under the Murray-Darling Basin's The Living Murray program.

Watercourses divert water from the main stem of the Murray River into the floodplain. The streams provide important seasonal habitat for a range of aquatic fauna, particularly fish. Freshes in spring trigger spawning in some species and provide fish with access to adjacent floodplain habitat. Flow in watercourses supports riparian plant communities and localised waterbird breeding habitat.

The forest includes extensive wetlands including permanent sites which act as drought refuges and a range of seasonally inundated habitats. The wetlands of Barmah-Millewa forest support breeding by large numbers of waterbirds.

At higher elevations the forest features moira grass (*Pseudoraphis spinescens*) plains, which are important botanically and provide foraging habitat for nesting waterbirds and productive habitat for fish and macroinvertebrates. Higher elevations again support river red gum forest and woodland.

Tuppal Creek is an ephemeral flood runner connecting the Murray River to its major anabranch, the Edward River. The Tuppal Creek area has been confirmed to contain 2 species listed as endangered and 7 species listed as vulnerable under NSW and Commonwealth legislation (Brownbill & Warne 2010). Tuppal Creek has a continuous riparian corridor - apart from the top end - providing habitat connectivity for 121 terrestrial native species (Brownbill & Warne 2010). A total of 45 wetlands have been identified as being associated with the Tuppal Creek (Brownbill & Warne 2010).

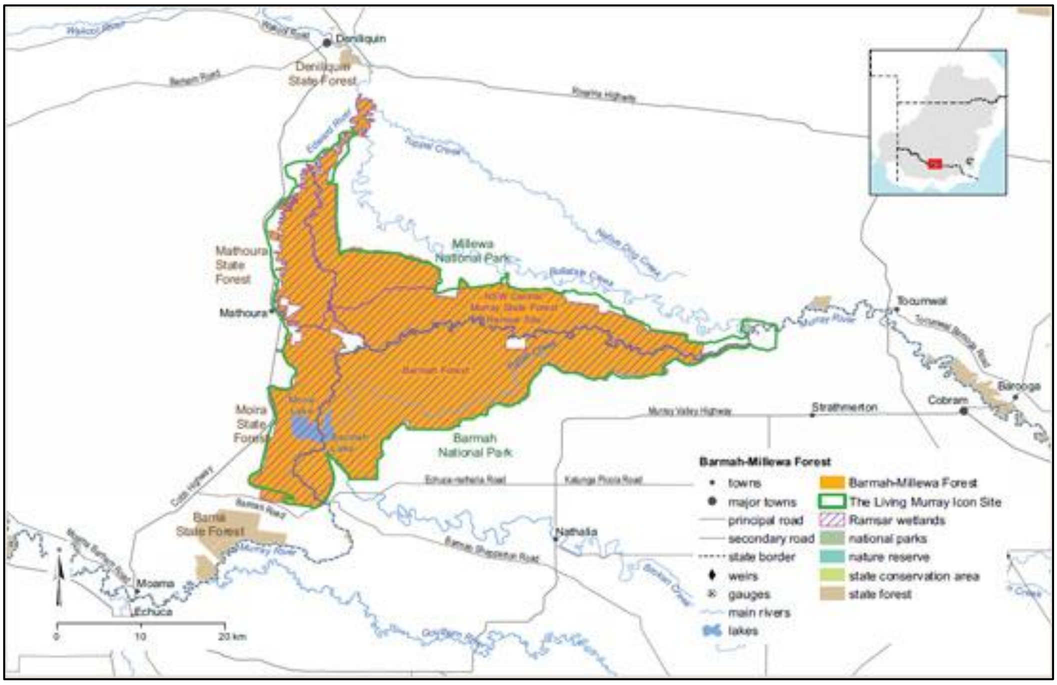

Figure 9: Yarrawonga to Barmah Reach and Barmah-Millewa Forest (MDBA 2010a).

Edward-Wakool system

The Edward-Wakool River System is an anabranch and floodplain system of the Murray River located in southern New South Wales. The system diverges from the Murray River in Millewa Forest and rejoins the Murray River near Kyalite. The system is a network of inter-connecting rivers, creeks, floodrunners and wetlands covering more than 1,000 square kilometres.

The Edward-Wakool system supports over twenty significant flora and fauna species and is listed as an endangered ecosystem, the "aquatic ecological community in the natural drainage system of the lower Murray River catchment", in NSW. The system includes flood-dependent forest and wetland systems including parts of the NSW Central Murray State Forests Ramsar Site.

The system supports a high proportion of native fish species and is considered to be important in a bioregional context for its role in aquatic species recruitment. In addition, the Edward-Wakool system contains a number of permanent pools that provide drought refuge for native fish (Gilligan et al. 2009) including threatened species such as Murray cod (*Maccullochella peelii*), trout cod (*Maccullochella macquariensis*), Eel-tailed catfish (*Tandanus tandanus*) and silver perch (*Bidyanus bidyanus*).

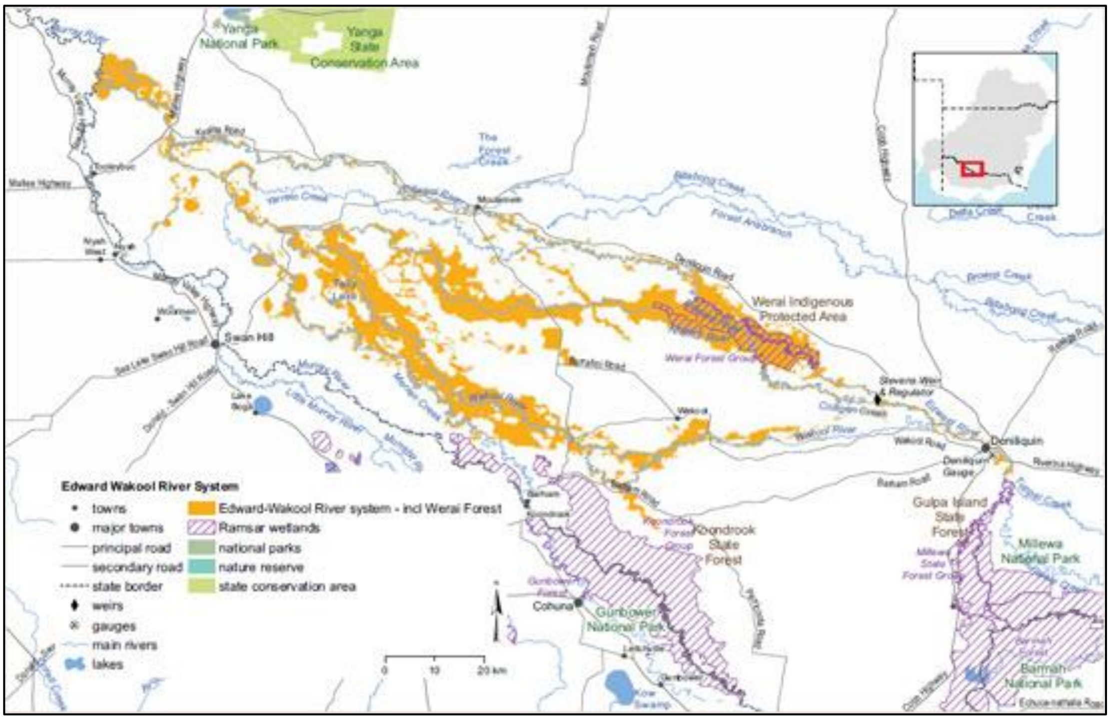

Figure 10: Edward-Wakool system (MDBA 2010a).

Gunbower Forest, Koondrook-Perricoota Forest and Kerang Wetlands

Gunbower Forest

Gunbower Forest is a 19,450 ha floodplain system located in northern Victoria on the southern bank of the Murray River between Torrumbarry and Koondrook. The northern bank of the river is occupied by the Koondrook-Perricoota Forest.

Torrumbarry Weir, which is located directly upstream of the Gunbower Forest, provides a weir pool for diversion along the National Channel into the Torrumbarry Irrigation Area. The National Channel also supplies Gunbower Creek, which forms the southern border of the forest and is an anabranch of the Murray River. Gunbower Creek has several weirs to allow diversion for irrigation, as well as regulators which can release water to the forest.

Gunbower Forest is a wetland of international significance recognised under the Ramsar Convention. The forest is public land that is managed for conservation, recreation and education (National Park, Murray River Reserve, Education Area and Public Land Water Frontage). Gunbower Forest is part of the Gunbower-Koondrook-Perricoota Forest Icon Site under The Living Murray program of the Murray-Darling Basin Authority.

The forest contains a highly diverse wetland system covering 10,000 ha; important feeding, nesting and breeding habitat for more than 22 waterbird species are available and is one of only two known breeding sites for intermediate egret in Victoria. The site is listed on the Register of the National Estate for its value as a waterfowl breeding area and is also subject to migratory bird agreements with China and Japan.

The forest provides habitat for a range of threatened plants and animals. Notable plant species include the nationally vulnerable river swamp wallaby-grass (*Amphibromus fluitans*) and western water-starwort (*Callitriche cyclocarpa*) and the endangered winged peppercress (*Lepidium monoplocoides*). Fauna of conservation significance include the nationally endangered trout cod (*Maccullochella macquariensis*) and the vulnerable southern bell frog (*Litoria raniformis*).

Koondrook-Perricoota Forest

Koondrook-Perricoota Forest is a 34,500 ha floodplain area located on the northern side of the Murray River in New South Wales on the opposite bank to Gunbower Forest, with which it forms a continuous floodplain system. It comprises extensive internal watercourses and localised wetlands but is vegetated largely by river red gum and black box (*Eucalyptus largiflorens*) forest and woodland with some small patches of grey box (*Eucalyptus moluccana*).

Upon completion of the infrastructure works it will be possible to inundate the forest by using Murray River flows averaging 18,000 ML/day (measured downstream of Torrumbarry Weir), which initiate flooding in low-lying wetlands. At flows exceeding 35,000 ML/day water would enter the forest through over bank flows and at 50,000 ML/day the forest is almost entirely inundated. Forest topography directs nearly all flow that enters the forest to Barber Creek which then flows to the Wakool River.

There are poor records for the ecological responses of Koondrook-Perricoota forest to floods, however it is considered to be an important foraging habitat for waterbirds and nursery habitat for fish.

Koondrook-Perricoota Forest is part of the NSW Central Murray State Forest Ramsar Site and is an Icon Site under the Murray-Darling Basin Authority's The Living Murray program.

Kerang Wetlands

The Kerang Wetlands, recognised as internationally important under the Ramsar Convention, are located in northern Victoria on the floodplains associated with the Murray, Avoca and Loddon Rivers. As well as receiving international recognition, eighteen wetlands in the Kerang wetlands complex are also individually recognised under the Directory of Important Wetlands in Australia (DIWA) as nationally significant.

The Kerang wetlands comprise a diverse system of over 50 lakes, swamps and lagoons which differ widely in permanence, depth, salinity and amounts of aquatic vegetation.

More than 150 species of native plants have been recorded at the Kerang Wetlands, including the threatened river swamp wallaby-grass (*Amphibromus fluitans*) and slender darling-pea (*Swainsona murrayana*). Also present is lignum (*Muehlenbeckia florulenta*) which provides shelter and nesting material for Australian white ibis (*Threskiornis molucca*) and straw-necked ibis (*Threskiornis spinicollis*).

Under their Ramsar listing, the Kerang wetlands have special value because they support a high diversity and abundance of waterfowl species – some, such as the black-tailed godwit (*Limosa limosa*) and the caspian tern (*Hydroprogne caspia*), are listed under the JAMBA and the CAMBA international migratory bird agreements respectively.

The wetlands also provide critical habitat for Murray cod (*Maccullochella peelii*) and southern bell frog (*Litoria raniformis*), both of which are listed as vulnerable under *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The system also supports the Macquarie perch (*Macquaria australasica*), listed under the EPBC Act as endangered.

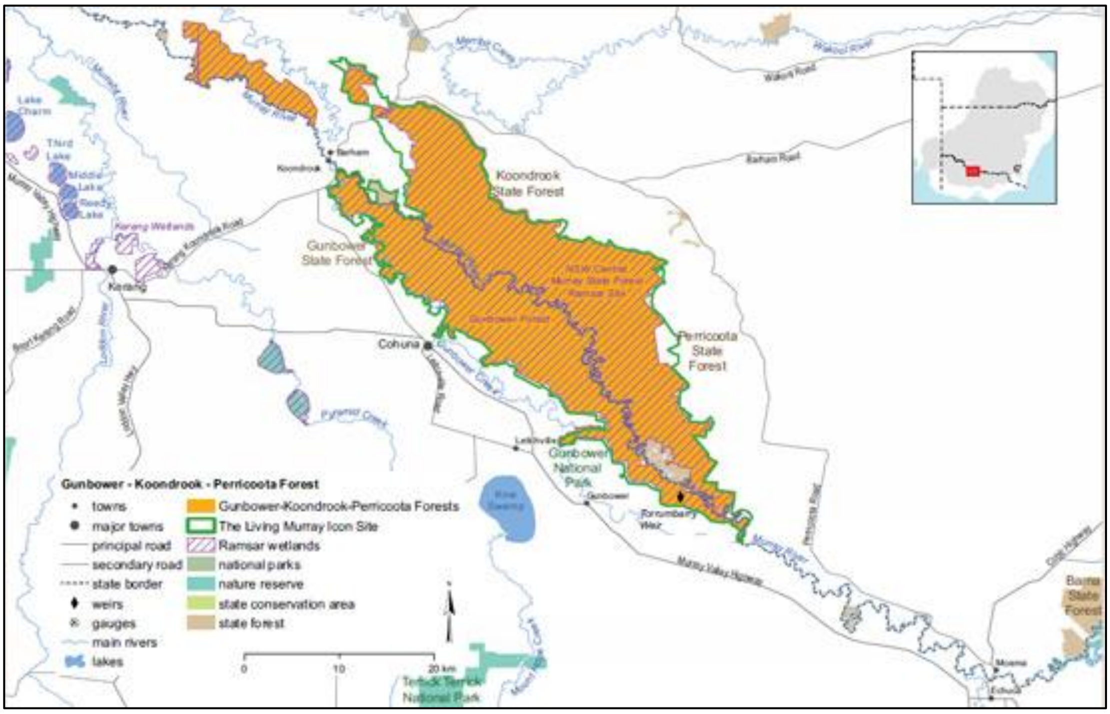

Figure 11: Gunbower Forest, Koondrook-Perricoota Forest and Kerang Wetlands (MDBA 2010a).

Swanhill to Mildura

The Murray River stretch between Swanhill and the South Australian border also includes the following wetland areas that may benefit from environmental water flows : Heywoods Lake, Nurrang Wetlands, Lakes Powell and Carpul, Merbein Common, Sandilong Creek, Liparoo, Cardross Lakes and Lake Koorlong.

Hattah Lakes

Hattah Lakes is a complex of small (<10 ha) to medium (up to 195 ha) sized lakes adjacent to the Murray River in Victoria between Robinvale and Mildura. The lakes are set within a mosaic of floodplain and terrestrial dune vegetation. The lakes are connected to the Murray River via Chalka Creek by peaks in flow between approximately 30,000 and 50,000 ML/day but by general overbank flow at higher discharges. The highest floodplain lakes are filled by flows exceeding 175,000 ML/day downstream of Euston Weir.

Eleven of the lakes form a Ramsar Site. The system is an Icon Site under the Murray-Darling Basin Authority's The Living Murray program. Hattah Lakes provides habitat for large numbers of breeding waterbirds, with over 192 species reported form the site. Historically the lakes have held water for decades without drying and supported populations of native fish including Murray hardyhead (*Craterocephalus fluviatilis*). The system supports the nationally endangered winged peppercress (*Lepidium monopolocoides*).

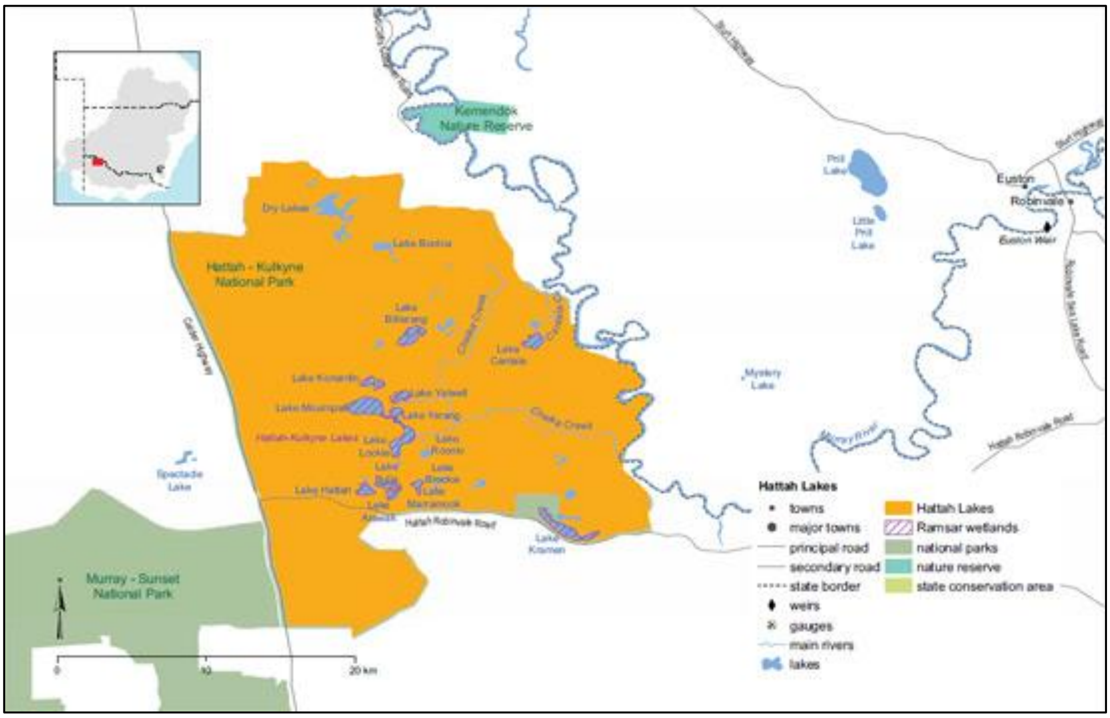

Figure 12: Hattah Lakes (MDBA 2010a).

Lake Caringay

Lake Caringay is a large (1022 ha) deflation basin that has not been watered from the Murray River since the 1960s. The lake is the largest of three wetlands commonly known as the Euston Lakes located approximately 25 km east of Euston in New South Wales.

The presence of degraded and dead standing river red gums and black box on the lake fringe indicates the wetland was historically watered quite frequently. However, the construction of blocking banks and a regulator on both Washpen Creek and Caringay Creek in the 1960s has prevented any natural flow to Lake Caringay from occurring. Subsequently, the wetland is much degraded, exhibiting few of the vegetation and habitat features common to healthy wetlands of the region.

Unlike the majority of other large deflation basins in the region, Lake Caringay has not been used for water storage nor is it adversely impacted by salinity. Such wetlands have been known to be important as bird and native fish breeding sites. The lake therefore provides a unique opportunity to reinstate a wetting/drying regime to such a system.

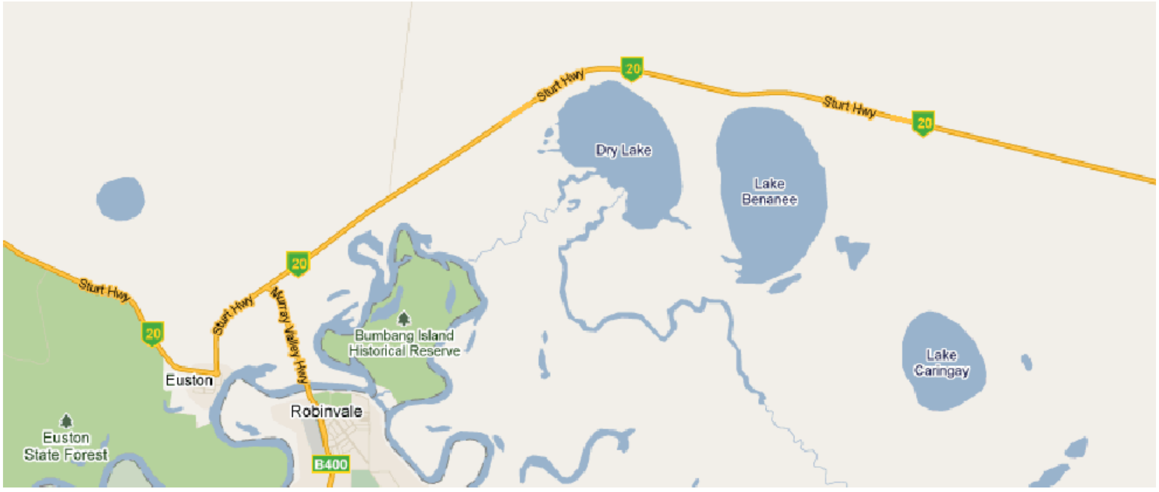

Figure 13: Lake Caringay (Google Maps 2011).

Bengallow Creek

Bengallow Creek is a large wetland system that extends from Tarpaulin Bend (opposite Hattah-Kulkyne National Park) to Mindook Station upstream of Paringi. The wetland extends for more than 100 km through the Mallee Cliffs State Forest and is a complex network of small creeks, flood runners and oxbow billabongs. This section of floodplain supports large tracts of river red gum forest, black box woodland and lignum swamps.

Whilst the Bengallow Creek area has been historically used for forestry, firewood collection and grazing, the region still remains of significant importance to a wide range of protected and threatened flora and fauna species. The system is considered to provide particularly significant habitat to a range of native fish, due to the presence of many deep waterholes which are regarded as being near permanent by local landholders.

Bengallow Creek is connected to the Murray River at three separate locations with differing commence to flow heights. The downstream inlet near Mindook station is inundated under regulated flows, the midstream inlet opposite Iraak (Victoria) has a commence-to-flow of 37,900 ML/day and is inundated on medium floods, whilst the main upstream inlet at Tarpaulin Bend has a commence-to-flow of 170,100 ML/day and is only inundated from large floods (Val et al. 2007).

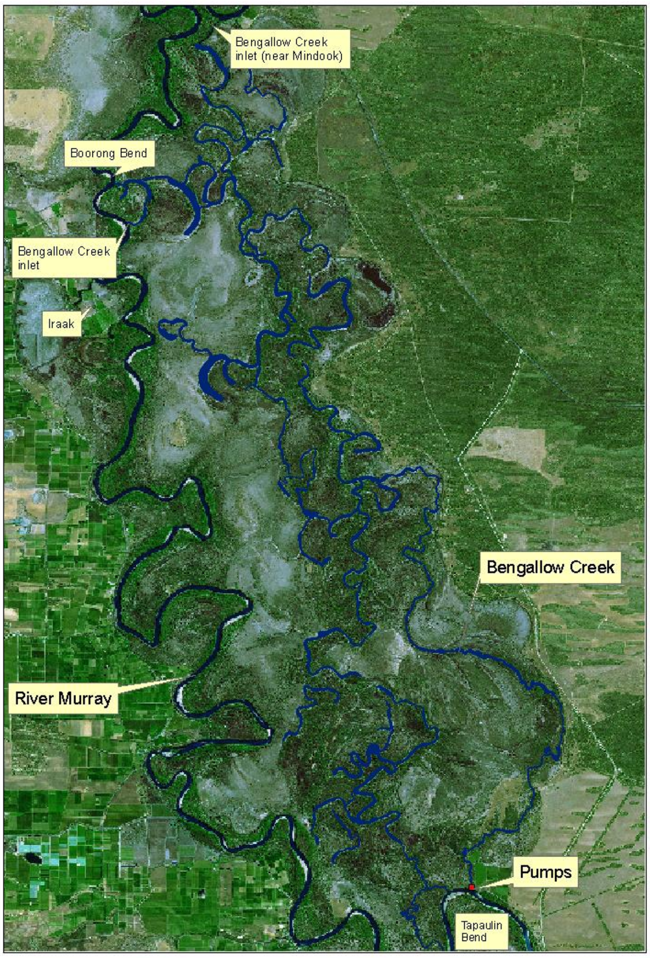

Figure 14: Bengallow Creek (Val et al. 2007)

Mildura to the South Australian Border

Wallpolla Island

Wallpolla, Mulcra and Lindsay Islands are the Victorian component of The Living Murray 'Chowilla and Lindsay- Wallpolla Islands' Icon Site. They occur in northwest Victoria, downstream of Mildura.

Wallpolla Island consists of approximately 9,000 ha of land bounded by Wallpolla Creek, a Murray anabranch, and the Lock 9 weir pool on the Murray River (MDBC, 2006). The island is listed in the Directory of Important Wetlands in Australia.

Wallpolla Island is considered a high value wetland for its flora, fauna and geomorphologic features and includes some areas of state-wide and possibly nationwide botanical significance (MDBC 2006). The island supports 12 threatened flora species and three threatened bird species – the great egret (*Ardea alba*), the white-bellied sea-eagle (*Haliaeetus leucogaster*) and the blue-billed duck (*Oxyura australis*) – all listed under the Victorian *Flora and Fauna Guarantee Act 1988* (MDBC 2006). Other significant fauna recorded on Wallpolla Island include the paucident planigale (*Planigale gilesi*), the red-naped snake (*Furina diadema*) the barking marsh frog

(*Limnodynastes fletcheri*), the common death adder (*Acanthopis antarcticus*), the beaked gecko (*Rhynchoedura ornate*), the tesselated gecko (*Diplodactylus tessellatus*) and the eastern water skink (*Eulamprus quoyii*) (Land Conservation Council 1987). Native fish, including Murray cod (*Maccullochella peelii*), silver perch (*Bidyanus bidyanus*) and freshwater catfish (*Tandanus tandanus*), have all been recorded at Wallpolla Island (Environment Australia 2001).

Mulcra Island

Mulcra Island covers approximately 2156 ha of forest between Wallpolla and Lindsay islands and is formed by an anabranch of the Murray River – Potterwalkagee Creek (MDBC 2006). The creek leaves the Murray River downstream of Lock 9 and rejoins the river in the Lock 7 weir pool. In addition to Potterwalkagee Creek, Mulcra Island also incorporates several smaller creeks and wetlands.

Potterwalkagee Creek receives continuous inflows from the weir pool of Lock 8, which is located at the mid-point of the island. The creek provides perennial, fast flowing habitat and is important habitat for a range of native fish including silver perch (*Bidyanus bidyanus*) and unspecked hardyhead (*Craterocephalus stercusmuscarum fulvus*), both of which are listed under the *Flora and Fauna Guarantee Act 1988* in Victoria. The site is expected to provide breeding habitat for the nationally vulnerable Murray cod (*Maccullochella peelii*).

Lindsay Island

Lindsay Island consists of approximately 15,000 ha of land bounded by the Lindsay River anabranch and both the Lock 6 and Lock 7 weir pools (MDBC 2006). Lindsay Island lies within the Murray-Sunset National Park, extending approximately 28 km from east to west and incorporating a range of landforms including creeks, temporary anabranches, wetlands, floodplain woodlands and grasslands.

Lindsay Island is critical to the fish community of the lower Murray River because of the fast-flowing habitat it provides. Fast-flowing stream flow is essential to the survival of a number of aquatic species and has largely been eliminated from the lower 900 km of the river. The hydraulic head provided by Lock 7 directs water through floodplain watercourses providing continuous fast flow. Mullaroo Creek provides one of only two significant Murray cod breeding habitats in the lower Murray River and promotes the growth and breeding of a number of other native fish.

The largest wetland on Lindsay Island is Lake Wallawalla, a deflation basin to the south of the floodplain that receives inflow from Lindsay River at elevated Murray River flows. Lake Wallawalla and Lindsay Island are both listed in the Directory of Important Wetlands in Australia.

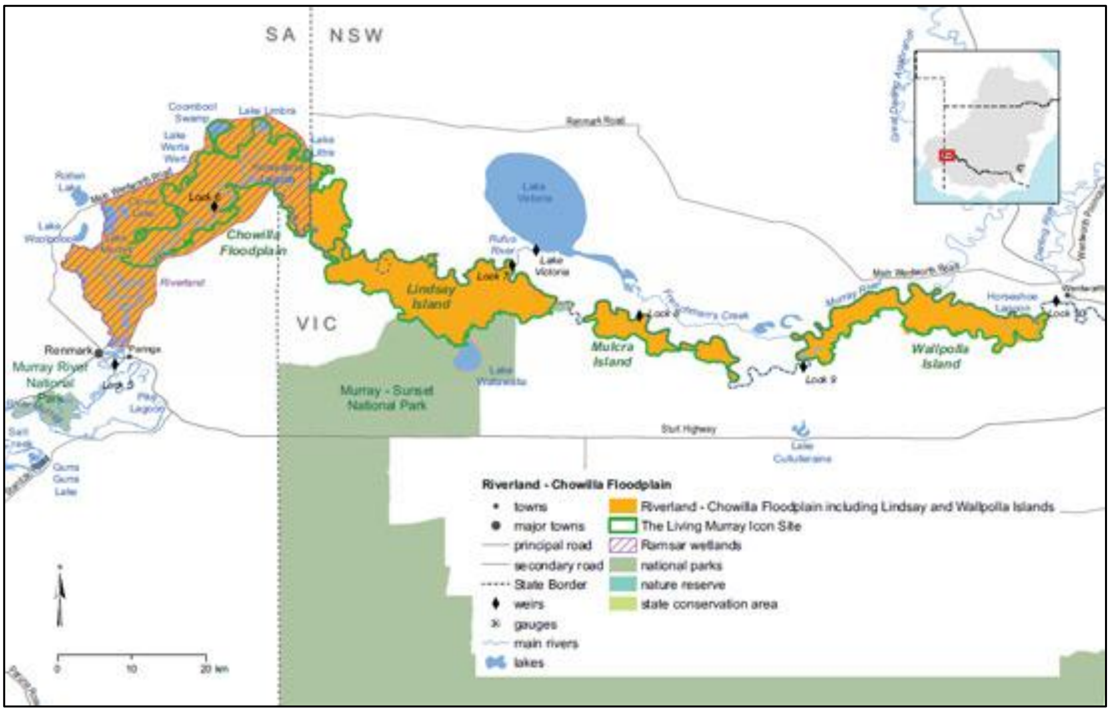

Figure 15: Mildura to the South Australian Border (MDBA 2010a).

Appendix B: Criteria for Assessing Commonwealth Environmental Watering Actions

In undertaking its activities, the Commonwealth Environmental Water Holder (CEWH) is required to act consistently with the requirements of the *Water Act 2007* (Commonwealth) (hereafter referred to as 'the Act'). The relevant functions are outlined in s.105. This includes a requirement that the environmental water holdings are managed in accordance with the environmental watering plan of the Murray-Darling Basin Authority (MDBA). Close consultation is occurring with the MDBA to ensure that use of Commonwealth water is consistent with the emerging objectives of the environmental watering plan that is currently being developed.

A long-term framework for the prioritisation of environmental water allocations has been prepared in consultation with delivery partners, interested stakeholders and experts, and the Environmental Water Scientific Advisory Committee.

The framework includes ecological objectives that will change under the different water availability scenarios (i.e. extreme dry, dry, median, wet). Proposed watering actions will need to be supported by available evidence, and consistent with current water availability scenarios and the framework.

Commonwealth environmental water is being acquired to supplement existing flows. Proposals for use of the water will not be agreed to if this use substitutes for other water uses, including historical system operations (e.g. provision of water for conveyance, stock and domestic, or planned environmental water).

Through adaptive management processes, the CEWH will consider opportunities for a more informed and diverse range of water uses as knowledge and modelling. All 2011-12 proposals will be assessed against the following criteria:

1. Ecological significance of the asset(s)

Issues to be considered will include:

- the presence of threatened species and ecological communities, and listed migratory species; and
- ecological and conservation values of the assets(s) including those recognised by international agreements.

2. Expected ecological outcomes from the proposed watering action

Issues to be considered will include:

- how well defined and realistic the objectives are for the proposed watering action;
- the consistency of these objectives with the overall CEWH ecological objectives for the current forecast water availability scenario;
- the current health of the asset(s);
- the improvement in health of the asset(s) expected from the watering action;
- the Basin-wide significance of the ecological response from the watering action;
- any secondary environmental effects expected to result from the watering action (e.g. connected system benefits); and

- the change in the health of the asset(s) expected if environmental water is not provided.

3. Potential risks of the proposed watering action at the site and at connected locations

Issues to be considered will include:

- how thoroughly the potential risks have been assessed for the proposed watering;
- the adequacy of measures proposed to minimise these risks; and
- the likelihood and consequence of variance from the expected ecological outcome (including negative impacts on biota and water quality).

4. Long-term sustainability of the asset(s) including appropriate management arrangements

Issues to be considered will include:

- the adequacy of long-term management and delivery arrangements;
- the existence of complementary natural resource management activities supporting the long-term management arrangements, including those that improve water quality; and
- the effectiveness of monitoring, evaluation and reporting arrangements for the watering activity including clear links to the defined objectives.

5. Cost effectiveness and operational feasibility of undertaking the watering

Issues to be considered will include:

- the amount of Commonwealth water and resources needed, including relative to the contribution of the State and delivery partner to (i) the watering event and (ii) subsequent monitoring of actions and outcomes;
- opportunity to supplement natural flows or other water releases; and
- the operational feasibility of undertaking the watering action (e.g. channel capacity, infrastructure constraints, etc).

Appendix C: Assessment of Watering Options

1.1. Murray River – Hume to Yarrawonga

Murray River – Hume to Yarrawonga	
Criteria	**Response/Assessment**
1. Ecological Significance of the asset(s)	The Hume reservoir to Yarrawonga Weir reach of the Murray River has approximately 771 wetlands, located on both the NSW and Victorian side of the river. The area contains 4 species listed as endangered and 32 species listed as vulnerable under NSW and Commonwealth legislation. The off-channel habitats, such as wetlands and backwaters along the stretch of river are recognised as important for the productivity of river systems and for many species of native fish. A study completed in 2003 identified the following features along the river stretch: an egret and ibis rookery directly below Hume Dam, a cormorant rookery on St Leonard's Bend and a duck breeding ground near Lake Moodemere.
2. Expected ecological outcomes from the proposed watering action	Prior to high flows experienced during 2010-11 a large number of wetlands between Hume and Yarrawonga had not been inundated since March 2006. Consequently the vegetation communities within these wetlands were showing signs of drought stress. Watering of the Hume to Yarrawonga wetlands would involve piggy-backing onto higher regulated flows to enable the watering of lower benched wetlands within the reach. Expected improvements in the health of the Hume-Yarrawonga wetlands include improved floodplain vegetation health and opportunities for movement and recruitment of fish. Objectives for the Hume to Yarrawonga wetlands are to: - increase the availability of off channel habitats by providing shallow wetland habitat for small bodied fish species (lateral connectivity); - provide water to fringing riparian vegetation; and - mobilise nutrients and avoid organic matter build up from the floodplain (in the disconnected wetlands) into the river channel. SEWPAC considers the watering objectives for the Hume to Yarrawonga wetlands as appropriate to meet the ecological requirements of the assets and contribute to system benefits.

Murray River – Hume to Yarrawonga	
Criteria	**Response/Assessment**
3. Potential risks of the proposed watering action at the site and at connected locations	Potential risks involved in providing environmental water to supplement base flows within the Murray River between Hume and Yarrawonga are inundation of private property and triggering of a low dissolved oxygen blackwater event. Inundation of private property is unlikely under the proposed strategy and is considered a low risk. This low risk rating is on the basis that inundation of private property requires flows above 25,000 ML/day at Doctor's Point, which can be avoided as flows can be managed from Hume Dam and can be adjusted should a change in condition of the river occur. A low dissolved oxygen blackwater event is also unlikely and is considered a low risk. This is because high-flows in 2010-11 would have provided an initial flush to many wetlands in the region and flows in the main Murray River channel would be sufficient to dilute any blackwater that could be released. Also, SEWPAC aims to conduct the bulk of environmental watering during Spring to avoid warmer temperatures which further reduces the low dissolved oxygen blackwater risk.
4. Long-term sustainability of the asset(s) including appropriate management arrangements	The Murray River channel is the main mechanism for moving water from Hume Dam and is considered to be sustainable over the long-term. Murray CMA and North East CMA conduct a number of programmes such as riparian works, fencing and revegetation along the Murray River system. Monitoring for watering of this region would be determined based on specific event requirements however monitoring would most likely focus on inundation mapping, frog sampling and fish sampling.
5. Cost-effectiveness and operational feasibility of undertaking the watering	Delivery costs for the NSW Murray system for 2011-12 will be: NSW State Water charges of $4.89/ML and NSW Office of Water charges of $0.9 resulting in a total of $5.79/ML. Victoria does not have specific fees attached to water delivery. Any watering action for this asset will likely involve a combination of environmental water from Victorian and NSW licences. The ability to piggy-back onto higher regulated flows makes watering of the Hume-Yarrawonga stretch of the Murray River a resource and cost-effective approach to watering a large number of wetlands. Commonwealth environmental water would be provided by piggybacking on top of normal Murray River base flows and flows from the Ovens River. Other sources of environmental water may be available to compliment the Commonwealth environmental water provided. The event may also be undertaken in conjunction with a repeat watering of the Barmah Millewa Forest so could therefore be significantly extended. Previous discussions with the MDBA and

Murray River – Hume to Yarrawonga	
Criteria	**Response/Assessment**
	Victoria have indicated that use of Victorian return flows may be possible though no return flow policy exists in NSW.

1.2. Murray River – Yarrawonga to Barmah (including Barmah-Millewa Forest and Tuppal Creek)

Murray River – Yarrawonga to Barmah (including Barmah-Millewa Forest and Tuppal Creek)	
Criteria	**Response/Assessment**
1. Ecological Significance of the asset(s)	Potential sites for environmental watering along the Murray River from Yarrawonga to Barmah include the Barmah-Millewa Forest and Tuppal Creek. The Barmah-Millewa Forest is the largest river red gum forest in Australia. It contains a diverse range of habitat that supports significant numbers of waterbirds and aquatic fauna. Watercourses occur throughout the forest, which are important for connectivity, distribution of water, fish movement, aquatic plants, and in sustaining large red gums along the banks which are important for bird roosting and nesting. The value of these habitats is demonstrated by both the Barmah Forest (Victoria) and Millewa Forest (NSW) being listed under the Ramsar convention (as part of the NSW Central Murray State Forest site). These listings are across a range of criteria focussing on the diversity of habitats, number of species recorded (380 indigenous flora and 220 indigenous flora under the Barmah listing, and 11 threatened species and 13 migratory waterbird species under the Millewa listing) and importance for breeding. Tuppal Creek is an ephemeral flood runner connecting the Murray River to its major anabranch, the Edward River. The Tuppal Creek area has been confirmed to contain 2 species listed as endangered and 7 species listed as vulnerable under NSW and Commonwealth legislation (Brownbill & Warne 2010). Tuppal Creek has a continuous riparian corridor - apart from the top end - providing habitat connectivity for 121 terrestrial native species (Brownbill & Warne 2010). A total of 45 wetlands have been identified as being associated with the Tuppal Creek (Brownbill & Warne 2010).
2. Expected ecological outcomes from the proposed	In Spring/Summer 2010-11 the Barmah forest experienced substantial flooding that initiated the best bird

Murray River – Yarrawonga to Barmah (including Barmah-Millewa Forest and Tuppal Creek)	
Criteria	**Response/Assessment**
watering action	breeding occurring for 60 years. Providing flows during spring 2011 will build on the improvements made by the 2010-11 event by specifically targeting open wetland vegetation, providing fish connectivity and spawning opportunity (including Murray cod and golden perch) and providing habitat for turtles (DSE 2011). Watering will also provide opportunity for colonial waterbird breeding in wetlands through the forest. The provision of environmental water in 2010-11 provided clear evidence of the benefit of environmental water delivery ensuring the successful breeding of colonial water birds (DSE 2011). Application of environmental water to Barmah-Millewa Forests in 2011-12 will also serve to mobilise small amounts of organic material reducing the build up in future years and thus reducing the risk of a low dissolved oxygen blackwater event as was observed last year. Flows in Tuppal Creek have rarely reached Edward River in the past decade, however high flow events within 2010-11 discharged significant volumes of water into the Edward River (as measured at Aratula road/Tuppal Creek). These events were driven by inflows into the middle-lower reaches of Tuppal Creek however the upper reaches are likely to remain in poor condition. Expected improvements in the health of Tuppal Creek following environmental watering include improved riparian vegetation condition; improved habitat for yabbies, fish, freshwater tortoise; reduced growth of invasive plants; net export of salt; improved water quality, opportunities for movement of fish and increased habitat for terrestrial fauna (Brownbill & Warne 2010). If environmental water is not provided to Tuppal Creek, there are concerns that soil acidification may increase, red gum health will decline, and salt and nutrients will accumulate in the bed of the stream (Brownbill & Warne 2010). Objectives for Barmah-Millewa are to: - provide low level flooding of the Forests which will allow for connectivity and spawning opportunities for fish, small-scale recruitment of colonial water birds and breeding opportunities for turtles; - improve vegetation health including that of giant rush, moira grass, and river red gums; and - mobilise small amounts of organic material from the forest floor to reduce build up in future years. Objectives for Tuppal Creek are to:

Murray River – Yarrawonga to Barmah (including Barmah-Millewa Forest and Tuppal Creek)	
Criteria	**Response/Assessment**
	- Provide water for riparian and aquatic vegetation to build on the improvements in vegetation health that occurred as a result of the 2010-11 flows; and - undertake a trial watering event to determine the volume of water that would be required to minimise risks to the Edward River while maximising environmental benefits to Tuppal Creek. SEWPAC considers the above watering objectives as appropriate to meet the ecological requirements of the assets and to contribute to overall system benefits.
3. Potential risks of the proposed watering action at the site and at connected locations	Barmah-Millewa potential watering risks include low-oxygen blackwater, fish stranding, carp breeding and flooding of private land. Blackwater – A low dissolved oxygen blackwater event is considered unlikely and is rated as a low risk. The basis for this rating is that much of the organic matter on the forest floor was mobilised during flooding of 2010-11. Also any environmental watering event will be sough to be undertaken early in the season which will further reduce the likelihood of a low dissolved oxygen blackwater event. Fish stranding (on recession) – This risk is considered unlikely and is rated as low. This risk is minimised by managing the rate of water recession. Nearing the conclusion of an environmental watering event, sufficient water will be released to achieve a maximum rate of drawdown below Yarrawonga Weir of 15 cm/d. Carp breeding – this is considered as a high risk for larger magnitude events (16,500 ML/day). However this is viewed as a trade off that is unavoidable given the greater benefits from broader scale inundation. It may be possible to mitigate this action by the engagement of a commercial carp fisherman (such as Charlie Carp) to remove fish from the system as well as implementation of community engagement/consultation plans should it become an issue. Flooding of private land - This is considered as unlikely and is rated as a low risk. The main risk of private land flooding is at Picnic Point (area of private land at the Edward River offtake) however this risk is managed as standard practice through the opening of regulators into the floodplain creeks. Opening of these regulators pushes water into the floodplain creeks, and ultimately the floodplain itself, whilst holding river levels below flooding levels at Picnic Point. It is estimated if the regulators are fully open flows of approximately 70,000 ML/day are required to raise the level of the Murray River to a similar level as a 10,400 ML/day flow with the regulators closed.

Murray River – Yarrawonga to Barmah (including Barmah-Millewa Forest and Tuppal Creek)	
Criteria	**Response/Assessment**
	A further minor risk is flooding of access tracks/roads within the forest. This is considered as a low risk as information would be provided prior to watering which would describe to the public any possible road closures and potential risks. Tuppal Creek potential watering risks include mobilisation of salts and sediment into the Edward River, poor quality water arising from wetting Acid Sulphate Soils (ASS) and low dissolved oxygen blackwater events. Poor water quality arising from mobilisation of salts and sediment is considered likely and is rated as a medium risk whilst poor water arising from wetting of ASS is considered possible and is also rated as a medium risk. The primary measure to mitigate the potential impacts of poor quality outflows arising from ASS, salts and other sediments is to provide either ensure that all water delivered remains within the Tuppal Creek and no end of system flow is achieved or provide adequate flows to fully flush the poor quality water into a high flow Edward River. A further mitigation technique to reduce the long-term presence of salts and sediments is to upgrade the two stormwater escape channels in the upper reaches of Tuppal Creek which are known to discharge salt and sediment into the system (Brownbill & Warne 2010). A low dissolved oxygen blackwater event is considered to be unlikely and is rated as a low risk. Mitigation techniques for low dissolved oxygen blackwater events include provision for flushing flows and conducting watering in the system during cooler months. Community perceptions pose a further risk for environmental water delivery to Tuppal Creek. Anecdotal evidence suggests that the Tuppal Creek community wish to secure a constant year-round flow within the creek. However, studies have indicated that the ability to obtain constant flow seems quite remote and management may be better directed at returning the Tuppal Creek system to a semi-permanent 'chain-of-ponds' which is considered the normal state for this system (Baldwin 2008).
4. Long-term sustainability of the asset(s) including appropriate management arrangements	Barmah- Millewa Forest is a TLM Icon site, with both sides of the river subject to a mixture of protected area legislation (Barmah Forest is national park, while Millewa Forest is largely national park with some state forest) and obligations under the Ramsar convention. Its position in the landscape also ensures that at least some level of minor natural flooding can be expected in the future due to inflows from the Ovens and Kiewa catchments. The presence of the Barmah-Millewa Environmental Water Account (EWA) also provides the potential to assist in

Murray River – Yarrawonga to Barmah (including Barmah-Millewa Forest and Tuppal Creek)	
Criteria	**Response/Assessment**
	the maintenance of the forest in the future. Ecological monitoring of watering this asset may be undertaken as part of the broader TLM condition and intervention monitoring program. Murray Catchment Management Authority has produced a detailed Tuppal Creek Strategic Plan on behalf of the Tuppal Creek Landholder Group (cited as Brownbill & Warne 2010). This plan consolidates information from previous studies on Tuppal Creek and identifies key priorities to improve the health of the creek over the next two decades (Brownbill & Warne 2010). Long term approaches for the delivery of water to Tuppal Creek will likely require significant infrastructure upgrades (eg installation of regulator at Murray River offtake). Feasibility assessments are yet to be carried out on the possible infrastructure and funding requirements (Brownbill & Warne 2010). Conducting a small event in 2011-12 is expected to generate significant knowledge on the Tuppal Creek system including stream flow capacity and flow impediments.
5. Cost-effectiveness and operational feasibility of undertaking the watering	<u>Barmah-Millewa Forest</u> Commonwealth water may be used in conjunction with other sources of environmental water such as the Barmah-Millewa EWA to achieve objectives within the Barmah-Millewa Forest. Delivery costs for the NSW Murray system for 2011-12 will be: NSW State Water charges of $4.89/ML and NSW Office of Water charges of $0.9 resulting in a total of $5.79/ML. Victoria does not have specific fees attached to water delivery. Any watering action for this asset will likely involve a combination of environmental water from Victorian and NSW licences. This watering action may be triggered by flows from the Ovens River. The mechanisms for water accounting that were applied in 2010-11 are unlikely to be applied again in 2011-12. This has significant implications for the use of Commonwealth environmental water in the Murray River.

Murray River – Yarrawonga to Barmah (including Barmah-Millewa Forest and Tuppal Creek)	
Criteria	**Response/Assessment**
	Tuppal Creek Delivery costs for the NSW Murray system for 2011-12 will be: NSW State Water charges of $4.89/ML and NSW Office of Water charges of $0.9 resulting in a total of $5.79/ML. Delivery of environmental water to Tuppal Creek may also require the use of MIL infrastructure which would incur additional costs of $1.50/ML and losses of 10 per cent on the water diverted at Yarrawonga Weir. The commence to flow volume for Tuppal Creeks is approximately 100,000 ML/day (in the Murray River downstream of Yarrawonga). Native Dog Creek allows flows to be delivered into the lower reaches of Tuppal Creek, however watering of the upper reaches of Tuppal Creek will likely require infrastructure development that is beyond the scope of this strategy. Under current conditions the flow into the upper reaches direct from the Murray rarely occurs (1 in 100 years). Some irregular small flow events are also provided to the upper reaches of Tuppal Creek by two MIL stormwater escape channels.

1.3. Southern Edward-Wakool (incorporating Wakool River and Yallakool Creek)

Southern Edward-Wakool (incorporating Wakool River and Yallakool Creek)	
Criteria	**Response/Assessment**
1. Ecological Significance of the asset(s)	18,667 ML of Commonwealth water was provided to the Wakool-Yallakool system between 01/01/11 – 02/02/11. The Southern Edward-Wakool system has good populations of large bodied native fish and is suspected of acting as a recruitment area for native fish. The area contains four species listed as endangered and 29 species listed as vulnerable under NSW and Commonwealth legislation. The system is known for having a significant population of silver perch (*Bidyanus bidyanus*) when compared to the rest of the Murray-Darling Basin.
2. Expected ecological outcomes from the proposed watering action	The current riparian and instream physical condition of the system is good. There is an intact riparian zone, and good instream large woody debris to provide fish habitat. There was a large blackwater event in this system in 2010-11 and the impact on fish populations remains uncertain. Watering of this area is expected to promote spawning and recruitment in large bodied native fish, improve and maintain water quality, mobilise carbon (leaf litter) from benches, refresh off channel billabongs, enhance movement of aquatic plants seed and generally increase habitat inundation (OEH 2011b) The majority of environmental water provided to this system will travel downstream and continue to provide fresh water to the system. The provision of water to this system in a series of peaks is expected to initiate fish movement which may result in fish spawning and provide recruits to other areas of the Edward-Wakool system and greater MDB. <u>Objectives for the Southern Edward-Wakool system are to:</u> - support movement of large bodied native fish; and - maintain and enhance available habitat within the system and maintain water quality in shallow pools and off channel billabongs. SEWPAC considers the Southern Edward-Wakool system watering objectives as appropriate to meet the ecological requirements of the assets and contribute to system benefits.

Southern Edward-Wakool (incorporating Wakool River and Yallakool Creek)	
Criteria	**Response/Assessment**
3. Potential risks of the proposed watering action at the site and at connected locations	Potential risks of watering the Southern Edward-Wakool system include low dissolved oxygen blackwater events, cuts to road access, flooding of private property, exotic fish breeding and stranding of fish after flooding (OEH 2011a). A proposal has been put forward by NSW OEH for watering this system in 2011-12 with a risk assessment as follows: A low dissolved oxygen blackwater event is considered to be possible and is rated as a low risk. The reason for this low risk rating is because the proposed options involve providing environmental water for increasing existing in-channel flows, not running water down dry channels or floodplains. Cuts to road access and flooding of private property are considered possible and have been rated as low to medium risks. These risks can be mitigated as long as the volume downstream of the confluence of the Wakool-Yallakool Junction does not exceed 500 ML/day (EA & SKM 2011a). Volumes above 500 ML/day can cause flooding at Bookit Island, which in turn can cut access to nearby farmland. The infrastructure that currently exists can be accurately managed to ensure that flows are maintained below this threshold level. SEWPAC will further manage this risk by ensuring that any watering of this asset will be undertaken in close consultation with landholders. Exotic fish breeding is considered almost certain and is rated as a medium risk. This is viewed as a trade off that is unavoidable given the greater benefits from watering actions in the system. Stranding of fish after flooding is considered unlikely and is rated a medium risk (OEH 2011a). This risk can be mitigated by managing recession rates to prevent a rapid drawdown in water levels.
4. Long-term sustainability of the asset(s) including appropriate management arrangements	The Wakool-Yallakool system is considered to be sustainable in the long-term. The objectives described in this site assessment will inform the long-term 'Wakool-Yallakool Fish Flow Project' being conducted in the Southern Edward-Wakool system (OEH 2011a). The first stage of the project was initiated in 2010-2011 and managed by the Murray CMA utilising Commonwealth environmental water. A specific objective of this project is to identify where fish move in this system under different flow rates and determine whether fish return to their original refuge pools following movement. The proposed watering action will help identify possible flow thresholds. Charles Sturt University in partnership with Murray CMA undertook monitoring throughout 2010-11 on the various ecological processes in relation to pulse flows in the Southern Edward-Wakool system (OEH 2011a). The results

Southern Edward-Wakool (incorporating Wakool River and Yallakool Creek)	
Criteria	**Response/Assessment**
	have not yet been provided to the Commonwealth. Monitoring included flow rate, water quality and the response of target fish species to watering. One full watering seasons monitoring (July 2010 – June 2011) has been completed, and arrangements are being negotiated for monitoring in the 2011-12 water year.
5. Cost-effectiveness and operational feasibility of undertaking the watering	There are opportunities to link Commonwealth water with NSW environmental water allocations to achieve objectives within this system. Delivery costs for the NSW Murray system for 2011-12 will be: NSW State Water charges of $4.89/ML and NSW Office of Water charges of $0.9 resulting in a total of $5.79/ML. Watering of this system may also require use of MIL infrastructure which would incur additional costs of $1.50/ML and an additional loss of 10% of the water allocated. The existing operating rules for the Wakool River penalise NSW for losses rather than sharing losses between all jurisdictions, as is the case for flows passing through sections of the Murray River and Edward River that parallel the Wakool. The Wakool River offtake from Stevens Weir operates at 150 ML/day, with the Wakool escape adding up to a further 500 ML/day. Low level road crossings are overtopped and some landholders might lose access when the Wakool River exceeds 200-300 ML/day. SEWPAC will manage any watering events in this system in close consultation with key stakeholders and local landholders. The Yallakool Creek offtake from Stevens Weir has a capacity of 600 ML/day, but low level road crossings are overtopped and some landholders might lose access at flows above 200-300 ML/day.

1.4. Northern Edward-Wakool (incorporating Niemur National Park; Jimaringle, Cockran and Gwynnes Creeks; Werai Forest; Edward River; Murrain and Yarrein Creeks)

Northern Edward-Wakool (incorporating Niemur National Park; Jimaringle, Cockran and Gwynnes Creeks; Werai Forest; Edward River; Murrain and Yarrein Creeks)	
Criteria	**Response/Assessment**
1. Ecological Significance of the asset(s)	4,500 ML of Commonwealth water was delivered to Werai Forest in November 2009. 5,000 ML of Commonwealth water was proposed to be provided to Werai Forest in 2010-11 but was not required due to high natural flows. 1,100 ML of Commonwealth environmental water was released into the Jimaringle-Cockran system between 07/04/11 – 03/05/11. The Northern Edward-Wakool system contains significant communities of river red gums forest (river red gum) and provides habitat for various threatened species. Key sites within this system are the Niemur and Werai Forests, the Edward River, and several small and ephemeral creeks of ecological significance described below. River red gum are the dominant vegetation type within the Niemur and Werai Forests. Werai Forest has been previously assessed as providing habitat for four threatened species and 15 vulnerable species. Niemur Forest is considered an important area for breeding colonial birds, and two migratory species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) were recorded during the 2010-11 flood event (OEH 2011b). Niemur Forest is located in a National Park, whilst Werai Forest is part of the Ramsar-listed Central Murray Forests. The Jimaringle, Cockran and Gwynnes Creeks (JCGC) region is considered a biodiversity hotspot of significant regional value. Six species listed in NSW as vulnerable or endangered have been found previously in the region. There is no known documentation of the environmental values of the Murrain and Yarrein Creek system. Anecdotal evidence from landholders in the region suggest that there are significant ecological values within the creek system that would benefit from receiving targeted delivery of environmental water. There is a good riparian corridor along the creeks providing habitat for birds and bats. There are also a number of permanent water holes along the creek providing habitat for frogs. It is anticipated that a project will be undertaken during the 2011-12 water year to establish the ecological significance of this Creek system and possible options for a watering action.

Northern Edward-Wakool (incorporating Niemur National Park; Jimaringle, Cockran and Gwynnes Creeks; Werai Forest; Edward River; Murrain and Yarrein Creeks)	
Criteria	**Response/Assessment**
2. Expected ecological outcomes from the proposed watering action	Niemur and Werai Forests were extensively inundated during 2010-11 due to higher Murray River flows and the release of environmental water for the Barmah-Millewa Forest which resulted in higher flows through the Edward-Wakool system and overbank flooding (OEH 2011b). Prior to the 2010-11 flood event the river red gum forest/woodland within Niemur Forest was considered to be in generally poor condition (OEH 2011b). River red gum communities at both sites responded well to the 2010-11 flooding and inundation of the Niemur Forest in 2010-11 resulted in a significant breeding event of colonial waterbirds (OEH 2011b). Flooding of the Niemur and Werai Forests in 2011-12 will ensure that the health of the river red gum forest/woodland and wetland understorey plants is further improved which will build ecological resilience into the system in case drought conditions return before the next major flood event (OEH 2011b). Watering of Niemur and Werai Forests is expected to result in a range of secondary benefits including greater connectivity of floodplains along the Edward/Niemur River systems and potential provision of environmental water for use downstream with other environmental assets (OEH 2011b). The JCGC system is considered to be in moderate to poor condition (OEH 2011c). The JCGC is an ephemeral system which has been in steadily declining health due to lack of flooding, salinity and stock access (OEH 2011c). Providing an end-of-system environmental flow to this region is expected to improve water quality, export salt and improve vegetation health (OEH 2011c). Providing an end-of-system flow to the JCGC system will also provide connectivity with the Niemur River, which may provide secondary benefits for native fish populations. If environmental watering does not occur, the remnant native vegetation is expected to decline due to salinity and associated acid sulphate problems. The Murrain-Yarrein Creek received some water at either end of the creek during 2010-11. Advice from local landholders is that full connectivity along the creek has not occurred since approximately 1996. It is expected that environmental water would improve the health of stressed river red gums, allow for some regeneration of aquatic vegetation and general improve the vegetation communities along the creek. Objectives for the river red gum forests (Niemur and Werai) are to: - maintain and improve the health and resilience of the floodplain and in-channel vegetation; and - manage flood recession rates to support bird breeding events to enable successful fledging of young waterbirds

Northern Edward-Wakool (incorporating Niemur National Park; Jimaringle, Cockran and Gwynnes Creeks; Werai Forest; Edward River; Murrain and Yarrein Creeks)	
Criteria	**Response/Assessment**
	where possible. Objectives for Jimaringle, Cockran and Gwynnes Creeks are to: - provide an end-of-system flow to further the improvement of instream and riparian habitats; and - identify suitable water delivery mechanisms, risks, flow impediments and flowrates for Gwynnes Creek. Objectives for the Edward River are to: - support movement and spawning opportunities of large bodied native fish. Objectives for the Murrain and Yarrein Creeks are to: - investigate possibilities for the delivery of environmental water to this system. If delivery of water is possible and desirable then objectives would be generally to improve the health of riparian and in-channel vegetation, provide suitable habitat for frogs and water birds and improve understanding of how water moves through the system. SEWPAC considers the Northern Edward-Wakool system watering objectives as appropriate to meet the ecological requirements of the assets and contribute to system benefits.
3. Potential risks of the proposed watering action at the site and at connected locations	Potential risks of watering the Northern Edward-Wakool system include a low dissolved oxygen blackwater event, mobilisation of salinity, poor water quality arising from wetting previously exposed acid sulphate soils, fish stranding on the floodplain when water levels recede too rapidly, an increase in the abundance and diversity of invasive species, and interruptions to waterbird breeding if inundation is of insufficient duration or water levels recede too rapidly. A low dissolved oxygen blackwater event in this system is considered possible and is rated as a medium risk. This risk is rated only as possible due to prior inundation of large sections of the river red gum forests that took place in 2010-11. A range of controls have been further identified to manage the risk of a low dissolved oxygen blackwater events including provision of higher instream flows in receiving streams to dilute possible return flows, instigating floodplain inundation in cooler months and early warning systems for closing regulators to limit spread of blackwater. Poor water quality arising from the mobilisation of salinity and wetting previously exposed acid sulphate soils are considered likely and are rated as medium risks. The technique to overcome this is to seek to provide adequate

Northern Edward-Wakool (incorporating Niemur National Park; Jimaringle, Cockran and Gwynnes Creeks; Werai Forest; Edward River; Murrain and Yarrein Creeks)	
Criteria	**Response/Assessment**
	flushing flows to dilute any potentially poor quality flows or ensure that flows remain within the creek system and connectivity to other watercourses is not achieved. A specific risk identified of watering Werai Forest is that of saline water flowing from the Mallen Mallen Creek as a result of higher water levels in the adjoining creeks. Measures put in place to manage potential low dissolved oxygen blackwater events will also serve to negate this risk. An increase in invasive species abundance is considered to be likely and is rated as a medium risk. A proposed measure to minimise this risk is to investigate flow options for disruption of carp spawning (whilst maintaining native fish spawning regimes). Gambusia are known to occur in high numbers in the JCGC system so environmental water managers will be required to monitor fish response to watering in this region closely (OEH 2011c). Fish stranding on the floodplain and interruptions to waterbird breeding are both considered possible and are rated as medium risks. These risks will be mitigated by managing flows to maintain water levels as far as possible; preventing a rapid recession and ensuring adequate flow duration is provided to ensure waterbird breeding events can be completed. As a further risk, the maximum flow rate that can be achieved through Gwynnes Creek before inundating properties is currently unknown (OEH 2011c). Flowrates through the creek will need to be monitored closely as a consequence (OEH 2011c).
4. Long-term sustainability of the asset(s) including appropriate management arrangements	Neimur Forest, Werai Forest, Edward River and Jimaringle, Cockran and Gwynnes Creeks are all considered sustainable over the long-term. Not enough is currently known about the Murrain-Yarrein Creek system to determine whether it can achieve long-term sustainability. A project is proposed to further investigate the ecological significance, water requirements, delivery mechanisms and risks associated with the Murrain-Yarrein system. Werai Forest has an Ecological Sustainable Management Plan that outlines objectives for the system. A Jimaringle-Cockran Creek Action Plan was developed in 2010 that outlines management options for the system (Mathers & Pisasale 2010). The local community have been committed to seeing water return to the system, and have worked

Northern Edward-Wakool (incorporating Niemur National Park; Jimaringle, Cockran and Gwynnes Creeks; Werai Forest; Edward River; Murrain and Yarrein Creeks)	
Criteria	**Response/Assessment**
	closely with NSW OEH, MCMA and MIL. Previous monitoring within the Northern Edward-Wakool system has included inundation mapping, vegetation monitoring, fish response, frog response, photo points and water quality testing. Monitoring of a potential JCGC watering event is also proposed to include landholder feedback during and after the event in order to gauge the success of the project and the rapport that agencies may have with community/landholders (OEH 2011c).
5. Cost-effectiveness and operational feasibility of undertaking the watering	There are opportunities to link Commonwealth environmental water with NSW environmental water allocations to achieve objectives within this system. Delivery costs for the NSW Murray system for 2011-12 will be: NSW State Water charges of $4.89/ML and NSW Office of Water charges of $0.9 resulting in a total of $5.79/ML. An additional fee of $1.50 and 10% water losses for the use of MIL infrastructure may be incurred. Flooding of the Niemur and Werai Forests will occur once average release rates of the Yarrawonga Weir were to range between 20,000 – 25, 000 ML/day for a month. The use of environmental water within Werai and Neimur Forests is possible by piggy-backing onto higher flows to assist with the duration of flooding events (OEH 2011b). For watering in the JCGC system, a trial watering project in April-May 2011 identified a number of blockbank structures that will require removal prior to a follow-up watering action (OEH 2011c). A constraint impacting upon environmental water delivery in the Edward River is the winter draw down period during which restricts release of any environmental flows during the winter months. The Edward River channel capacity downstream of Stevens Weir is 2,700 ML/day, above which water starts to flow over the top of the regulators in the Werai Forest. This is not a constraint when intentionally delivering environmental flood flows.

1.5. Western Edward-Wakool (incorporating Speewa Creek; Wee Wee Creek; Merran Creek; Coobool Creek)

Western Edward-Wakool (incorporating Speewa Creek; Wee Wee Creek; Merran Creek; Coobool Creek)	
Criteria	**Response/Assessment**
1. Ecological Significance of the asset(s)	1,000 ML of Commonwealth water was provided to Wee Wee Creek in 2009-10, inundating approximately 80 Ha. Sections of the Western Edward-Wakool system contain communities of mature river red gums and lignum. A range of significant fauna species have been sighted or are known to be formerly distributed within the Western Edward-Wakool system. 11 threatened species (under NSW and Commonwealth legislation) were observed during a 2007 ecological condition report on Coobool Creek and the surrounding area. A further 28 bird species listed in international conventions are thought to potentially use the system when migrating (Durant & Nielsen 2008). Six species of frogs, nine species of fish, and various waterbirds including hundreds of grey teal (*Anas gracilis*) have been observed at Wee Wee Creek.
2. Expected ecological outcomes from the proposed watering action	During 2010-11 high system flows in the Murray River inundated sections of the Western Edward-Wakool system. Prior to this event parts of the system (such as Speewa Creek) had been dry since 2001 resulting in the fringing river red gums showing signs of moisture stress. Vegetation in this system is considered to be in a poor to moderate condition and would benefit from follow-up environmental watering after the high flows of 2010-11 (OEH in prep). Expected outcomes from watering this system include improved health amongst river red gums; improved health amongst lignum; and increased abundance and diversity of fish and frogs. Previous monitoring of Wee Wee Creek noted that food for fish increased by an order of magnitude following watering in 2009-10 which served to provide resources for fish recruitment. As such there is the potential for Wee Wee Creek to support a diverse fish assemblage. <u>Objectives for watering Speewa, Wee Wee, Merran and Coobool Creeks are to:</u> - improve the condition of riparian and instream vegetation within the creeks; and - increase the abundance of fish and frogs. SEWPAC considers the Western Edward-Wakool system watering objectives as appropriate to meet the ecological requirements of the assets and contribute to system benefits.

Western Edward-Wakool (incorporating Speewa Creek; Wee Wee Creek; Merran Creek; Coobool Creek)	
Criteria	**Response/Assessment**
3. Potential risks of the proposed watering action at the site and at connected locations	Potential risks of watering the Western Edward-Wakool system include increased salinity, increased acidity from wetting previously exposed acid sulphate soils, a low dissolved oxygen blackwater event, and an increase in the abundance of invasive species. Increased salinity is considered to be likely and is rated as a medium risk whilst increased acidity is considered possible and is rated as a low risk. The primary mitigating technique to overcome poor water quality arising from increased salinity/acidity in this system is to seek to provide adequate flushing flows. Salinity has been identified as a particular issue when watering Merran Creek. This may be managed by trying to keep Murray flow high when a salinity spike from the Wakool is on its way to the Murray. A low dissolved oxygen blackwater event is considered to be possible and is rated as a medium risk. Controls identified to manage the risk of a low dissolved oxygen blackwater event include targeting instream flows to dilute possible return flows and instigating floodplain inundation in cooler months. An increase in the abundance of invasive species is considered to be likely and is rated as a medium risk. There may be opportunities for investigating flow options that cause a disruption of carp spawning (whilst maintaining native fish spawning regimes). Even if minimisation of carp spawning is not possible, an increase in invasive species is viewed as a trade off that is unavoidable given the greater benefits from watering actions in the system.
4. Long-term sustainability of the asset(s) including appropriate management arrangements	The long-term sustainability of this system is moderate. Although there are limited management plans in place, the system can continue to receive inflows during periods of high-flow within the Murray River. There is evidence of strong landholder support for environmental watering actions within the system. Both Speewa and Wee Wee Creek have received environmental water previously, with NSW providing water for both assets and the Commonwealth contributing to Wee Wee Creek. This indicates a level of long term commitment to the waterways. For Speewa Creek, a total of 269 ha across 5 properties has been fenced through assistance from the Murray CMA as part of a riparian management project to exclude stock. This includes more than 185 ha of fringing vegetation dominated by river red gum. Wee Wee Creek is privately owned though there has been significant landholder involvement in previous watering events. Coobool Creek has a management plan that lists a variety of watering options developed by the Murray Darling Freshwater Research Centre (see Durant & Nielsen 2008). These management options were investigated during a

Western Edward-Wakool (incorporating Speewa Creek; Wee Wee Creek; Merran Creek; Coobool Creek)	
Criteria	**Response/Assessment**
	period of prolonged drought and are focused on proposing arrangements for the long-term management of the region. The options provided in the Coobool Creek report may also be valuable for informing management options within the wider Western Edward-Wakool system. Monitoring of environmental watering in the Western Edward-Wakool system include vegetation monitoring, fish monitoring, frog monitoring, water quality, inundation mapping and tree monitoring (crown extent and density; epicormic growth; flowers/buds; distance from water etc.)
5. Cost-effectiveness and operational feasibility of undertaking the watering	There are opportunities to link Commonwealth environmental water with NSW environmental water allocations to achieve objectives within this system. Delivery costs for the NSW Murray system for 2011-12 will be: NSW State Water charges of \$4.89/ML and NSW Office of Water charges of \$0.9 resulting in a total of \$5.79/ML. Local landholders are very supportive of watering Speewa Creek, and are willing to provide in-kind contributions by managing the delivery of environmental water using their private pumping infrastructure as well as conduct preparatory works. Water could be delivered via the Speewa Island Trust's supply channel (approx 2.4 km) and the 'Willow Bend' supply channel (600 m). There are potential water losses of up to 25 per cent depending on channel conditions. The natural bank height at the west end of Speewa Creek will prevent water from flowing back into the Murray River. Providing environmental water to Wee Wee Creek requires pumping direct from the Murray River. In the 2009-10 watering event that the Commonwealth supplied water for, the Murray Wetlands Working Group supplied the pumps, the landowner refuelled the pumps and NSW serviced the pumps. This resulted in costs of approximately \$25 per ML (ex GST), which compared well to pumping costs of \$65 per ML when contractors are used. The regulated flow range of Merran Creek is 20-200 ML/day. The channel capacity at Franklings Bridge (upper end of Merran Creek) is 300 ML/day because at higher flows the St Helena regulator and Erigin Creek Rock Weir are overtopped (MDBA, 2010).

1.6. Gunbower - Koondrook – Perricoota Forests and Kerang Wetlands

Gunbower - Koondrook – Perricoota Forests and Kerang Wetlands	
Criteria	**Response/Assessment**
1. Ecological Significance of the asset(s)	Both Gunbower Forest and Koondrook-Perricoota Forest (Gunbower-Koondrook-Perricoota) together, are Ramsar listed. The Koondrook-Perricoota forms part of the NSW Central Murray State Forest Ramsar Site. Both sites are classified as an Icon Site under the Murray-Darling Basin Authority's The Living Murray program. A number of significant species have previously been recorded in this asset, including southern bell frog (*Litoria raniformis*: Commonwealth vulnerable, Victorian endangered) and a range of waterbirds including egrets (JAMBA / CAMBA), darters (*Anhinga melanogaster*), royal spoonbills, blue-billed ducks (*Oxyura australi*: Victorian endangered), musk ducks (*Biziura lobata* Victoria vulnerable), nankeen night herons (*Nycticorax caledonicus* Victorian near threatened) and white-bellied sea eagles (*Haliaeetus leucogaster*: Victorian vulnerable, EPBC migratory). The Kerang Wetlands Ramsar Site is located on the western edge of the Riverine Plain, to the west of the Gunbower Forest. It forms part of a system of over 100 permanent and freshwater wetlands comprised of freshwater lagoons, lakes and marshes and saline and hypersaline lakes (DSE 2004). Features of the Kerang Wetlands system include: - More than 150 native plant species including 8 that are threatened under the *Flora and Fauna Guarantee Act 1988* (FFGA); - More than 102 native animal species with 32 listed as threatened under the FFGA, such as the Macquarie perch (*Macquaria australasica*), Murray hardyhead (*Craterocephalus fluviatilis*), southern bell frog (*Litoria raniformis*) and plains-wanderer (*Pedionomus torquatus*); - An abundant water bird population including the freckled duck (*Stictonetta naevosa*) and blue-billed duck (*Oxyura australis*) which are listed in the FFGA; and - The largest Ibis (*Threskiornis molucca*) rookery in Victoria (DSE 2011).

Gunbower - Koondrook – Perricoota Forests and Kerang Wetlands	
Criteria	**Response/Assessment**
2. Expected ecological outcomes from the proposed watering action	Watering Gunbower-Koondrook-Perricoota Forests will consolidate the benefits of natural flooding in 2010-11 allowing reestablishment of native aquatic species and providing suitable conditions for waterbird breeding. Watering will also carry organic matter from the forest into waterways, facilitating carbon and nutrient cycling. This will increase the food source for invertebrates and, in turn, native fish and other biota (e.g. frogs, turtles). Watering Gunbower Creek will also provide benefits to native fish populations, which suffered from blackwater events in the creek in 2010-11. Watering Kerang wetlands will assist in maintaining habitat for large numbers of waterbirds that visit the system. Delivery of environmental water to Kerang Lakes will also serve to improve water quality in individual hypersaline wetlands and improve the health of vegetation in the region. Objectives for Gunbower and Koondrook-Perricoota Forests are to: - provide suitable habitat for wetland and floodplain dependent fauna, e.g. waterbirds, macroinvertebrates, frogs and fish; - provide for successful recruitment of wetland and floodplain vegetation resulting in a structurally diverse landscape; - facilitate an increase of threatened flora species; - allow for movement of native fish in and out of habitat types (creek, river, wetlands and floodplain) for feeding and breeding; and - support waterbird breeding events that are proportionate to the scale of flooding across the forest. Objectives for Kerang wetlands are to: - provide suitable resting, nesting and feeding habitat for large numbers of waterbirds; and - support waterbird breeding events. SEWPAC considers the watering objectives described above as appropriate to meet the ecological requirements of the assets and contribute to system benefits.

Gunbower - Koondrook – Perricoota Forests and Kerang Wetlands	
Criteria	**Response/Assessment**
3. Potential risks of the proposed watering action at the site and at connected locations	Key risks for watering Gunbower-Koondrook-Perricoota Forests are low dissolved oxygen blackwater, fish stranding, and carp breeding. Blackwater – A low dissolved oxygen blackwater event is considered unlikely and is rated as a low risk. The basis for this rating is that much of the organic matter on the forest floor was mobilised during flooding of 2010-11 and any watering event will be sought to be undertaken early in the season. Fish stranding (on recession) –This risk is considered unlikely and is rated as low. This risk is minimised by managing the rate of water recession. Nearing the conclusion of an environmental watering event, sufficient water will be released to achieve a maximum rate of drawdown below Yarrawonga Weir of 15 cm/d. Carp breeding – this is considered as a high risk for larger magnitude events. However this is viewed as a trade off that is unavoidable given the greater benefits from broader scale inundation. It may be possible to mitigate this action by the potential engagement of a commercial carp fisherman (such as Charlie Carp) to remove fish from the system. Key risks for watering Kerang Wetlands relate to poor water quality arising from salinity, inundation of private land and an increase in invasive species. Poor water quality arising from the spread of saline water is considered likely and is rated as a medium risk. Rising groundwater levels and salinisation of wetlands are major issues in the Kerang Lakes area. Providing environmental water to sections of this system may spread some saline water into previously less affected areas. To mitigate this risk, environmental water delivery will target sites within Kerang Lakes that will limit hypersaline discharge. Inundation of private land is considered unlikely and is rated as a low risk. Techniques to mitigate this risk will include monitoring rainfall and climate data and adapting environmental water delivery to account for potential flood events. An increase in invasive species is considered to be possible and is rated as a medium risk. Watering this system could increase the presence of cumbungi (*Typha* sp. - there is both an introduced and a native species of *Typha* which are often difficult to distinguish). Cumbungi is a perennial plant that plays an important role as habitat for numerous fauna and fish species, but only when it is a component of a more diverse plant community. Cumbungi

Gunbower - Koondrook – Perricoota Forests and Kerang Wetlands	
Criteria	**Response/Assessment**
	extends over large sections of some wetlands in this system which is considered detrimental to most waterbird species (DSE 2004). Increases in invasive species are seen as an unavoidable tradeoff that must be balanced against the benefits of providing environmental water to this asset.
4. Long-term sustainability of the asset(s) including appropriate management arrangements	The long-term sustainability of Gunbower-Koondrook-Perricoota Forests and the Kerang Wetlands is high. Gunbower-Koondrook-Perricoota is a wetland of international significance recognised under the Ramsar Convention and listed as an Icon Site under the Living Murray program of the Murray-Darling Basin Authority. The Koondrook-Perricoota Forest is public land that is managed for conservation and timber harvesting (State Forest) and Gunbower is managed for conservation, recreation and education (National Park, Murray River Reserve, Education Area and Public Land Water Frontage). There are a range of existing plans and strategies that provide for the protection and enhancement of the natural and cultural values of the Kerang Wetlands Ramsar site. The Kerang Wetlands Ramsar Site Strategic Management Plan (DSE 2004) outlines a broad management strategy for the region that is complemented by a range of other more specific strategies developed by the North Central Catchment Management Authority (NCCMA). Of the 22 wetlands that make up Kerang Wetlands Ramsar site, 7 are State Wildlife Reserves, 8 are Water Supply Reserves, 3 are Salinity Disposal Reserves and 4 are Crown Land without specific reservation.

Gunbower - Koondrook – Perricoota Forests and Kerang Wetlands	
Criteria	**Response/Assessment**
5. Cost-effectiveness and operational feasibility of undertaking the watering	Torrumbarry Weir, which is located directly upstream of the Gunbower Forest, provides a weir pool for diversion along the National Channel which can supply Gunbower Creek. Gunbower Creek then has regulators which can release water into Gunbower Forest. Water is provided to Koondrook-Perricoota Forest by using Murray River flows. Upon completion of the infrastructure works within Koondrook-Perricoota Forest it will be possible to inundate the forest by using Murray River flows averaging 18,000 ML/day (measured downstream of Torrumbarry Weir). Forest topography directs nearly all flow that enters Koondrook-Perricoota Forest to Barber Creek which then flows to the Wakool River. Delivery costs for the NSW Murray system for 2011-12 will be: NSW State Water charges of $4.89/ML and NSW Office of Water charges of $0.9 resulting in a total of $5.79/ML. Victoria does not have specific fees attached to water delivery. Any watering action for this asset will likely involve a combination of environmental water from Victorian and NSW licences. Costs associated with water delivery infrastructure use (i.e. channels) in the Torrumbarry region (operated by Goulburn-Murray Water) is $7.11/ML. Cost effectiveness for water delivery to Kerang wetlands may vary according to the specific sites that are being targeted for watering. Some of the wetlands will require use of irrigation infrastructure for environmental water delivery which may incur pumping and administrative fees of between $20-$26.

1.7. Murray River – Swan Hill to Mildura (including Hattah Lakes, Bengallow Creek and Lake Caringay)

River Murray – Swan Hill to Mildura (including Hattah Lakes, Bengallow Creek and Lake Caringay)	
Criteria	**Response/Assessment**
1. Ecological Significance of the asset(s)	Key sites identified as watering options along this section of the River Murray include Hattah Lakes, Bengallow Creek and Lake Caringay. Hattah Lakes is a complex of 20 freshwater lakes that are recognised as a TLM icon site. Hattah Lakes is also listed in the Directory of Important Wetlands in Australia and 12 of the lakes are recognised internationally under the Ramsar convention. Hattah Lakes provides important feeding, nesting and breeding habitat for more than 50 waterbird species, including the freckled duck (*Stictonetta naevosa*), pacific black duck (*Anas superciliosa*), grey teal (*Anas gracilis*) and Australian pelican (*Pelecanus conspicillatus*). The river red gum forests fringing the wetlands also provide habitat for the regent parrot (*Polytelis anthopeplus*) listed under the *Environmental Protection and Biodiversity Conservation Act 1999*. Bengallow Creek is a long complex wetland composed of a series of creeks, flood runners, and oxbow billabongs that extend for more than 100km from Tarpaulin Bend (opposite Hattah-Kulkyne national park) to Mindook station upstream of Paringi. This section of floodplain supports large tracts of river red gum forest, black box woodland and lignum swamps. 18 species listed as endangered or vulnerable under NSW and Commonwealth legislation have been identified to potentially occur within the Bengallow Creek area (Val et al. 2007). Many of the deep waterholes along the creek are regarded as being near permanent by local landholders, though the importance of the creek system to native fish species is poorly recognised and documented (Val et al. 2007). Lake Caringay is the largest of three wetlands commonly known as the Euston Lakes. The lake is a mix of river red gum, black box and lignum which show signs of stress caused by lack of flooding (OEH in prep). While the Euston Lakes exhibit many of the ecological features typical of River Murray floodplains/wetlands in the region, they also contain particular assets of ecological and statutory importance, including eeltail catfish (*Tandanus tandanus*) and swamp sheoak (*Casuarina obesa*) (Aquaterra 2010). Unlike the majority of other large deflation basins in the region, Lake Caringay has not been used for water storage nor is it adversely impacted by salinity. Such wetlands have been known to be important as bird and native fish breeding sites (OEH in prep).

River Murray – Swan Hill to Mildura (including Hattah Lakes, Bengallow Creek and Lake Caringay)	
Criteria	**Response/Assessment**
2. Expected ecological outcomes from the proposed watering action	Environmental water delivery to Hattah Lakes will build upon watering actions of this site in recent years. Watering of this site in 2011-12 will maintain water level in the lakes previously watered for a longer period, thereby increasing the potential benefits to river red gums fringing these lakes through increased inundation and seepage of water into the soil profile surrounding the lakes. Expected ecological outcomes include improved foliage growth and canopy cover of vegetation and increased waterbird diversity and abundance. Benefits are also expected to the ephemeral Chalka Creek via which the water will be delivered to the lakes. An assessment of the ecological condition of Bengallow Creek in 2005-06 found that the tree population was in poor condition with 74 per cent of the trees sampled in a stressed or worse condition (Val et al. 2007). Approximately 25 per cent of the Bengallow Creek system was watered in 2005-06 using 2,380 ML of Snowy River Recovery Water as part of the NSW 'Red Gum Rescue Project'. Reporting on this event recommended future watering in the creek system as there were still large areas unwatered with river red gums in critical condition (Val et al. 2007). The majority of the system was again inundated during high flows of 2010-11 (OEH in prep). Lake Caringay has been isolated from flood flows in the Murray River since the 1960s following the installation of levee banks on Washpen and Caringay Creeks. Despite not having received water in any significant quantity since the 1960s, the lake exhibits evidence of the ecosystem that prevailed prior to this time. Many stags of both river red gum and black box are evident in the bed of the lake. The perimeter of the lake bed exhibits evidence of a significant community of black box woodland in poor health but which continues to persist in the dry conditions. Understorey is very poorly represented in Lake Caringay. Management regimes that restore moderate to frequent flooding in Lake Caringay are very likely to result in significant positive response by floodplain species (Aquaterra 2010). Objectives for Hattah Lakes are to: - maintain and extend refuge habitat; - support river red gum health; and - provide suitable feeding, breeding and nesting habitat for waterbirds. Objectives for Bengallow Creek are to: - maintain or improve the health of riparian vegetation, particularly black box and river red gum, to build on

River Murray – Swan Hill to Mildura (including Hattah Lakes, Bengallow Creek and Lake Caringay)	
Criteria	**Response/Assessment**
	improvements in vegetation condition that have occurred due to recent good rainfall in the region; and - inundate as much of the system as possible. Objectives for Lake Caringay are to: - investigate the possibility of delivering water to this system. - provide water to a lake that has been dry for many years to determine the capacity of the lake ecosystem to regenerate, especially aquatic and riparian vegetation. SEWPAC considers the watering objectives for the River Murray from Swan Hill to Mildura as appropriate to meet the ecological requirements of the assets and contribute to system benefits.
3. Potential risks of the proposed watering action at the site and at connected locations	The risks associated with watering Hattah Lakes are low, as the broader site has been previously watered. Mallee CMA, in conjunction with Parks Victoria, has extensive experience managing watering events at Hattah. The lakes are also terminal for environmental delivery allowing any negative outcomes to be isolated both as a whole and for individual lakes. One concern that will need to be considered prior to watering is that Hattah Lakes may potentially be at risk from increased salinity caused by the frequent watering of these lakes. Potential risks of watering Bengallow Creek and Lake Caringay include mobilisation of salinity, increased acidity from wetting previously exposed acid sulphate soils, a low dissolved oxygen blackwater event and an increase in the abundance of invasive species. Mobilisation of salinity is considered to be possible and is rated as a low risk. For Lake Caringay, there is a particular risk of salinisation from groundwater. Though this risk is considered low, monitoring is recommended during initial filling cycles (Aquaterra 2010). Increased acidity arising from acid sulphate soils is considered to be possible and is rated as a low risk. Prior to a watering event in 2006, black oozy sediments were seen at one of the sites within the Bengallow Creek system. However, if water quality issues were to arise from watering this area the poor quality water could be contained within the Creek system (Val et al. 2007). No evidence of acid sulphate soils have been detected within the Lake Caringay region. A low dissolved oxygen blackwater event is considered to be unlikely and is rated as a low risk. This low risk rating

River Murray – Swan Hill to Mildura (including Hattah Lakes, Bengallow Creek and Lake Caringay)	
Criteria	**Response/Assessment**
	is firstly because any environmental watering action will be undertaken during cooler months early in the year and secondly because much of Bengallow Creek was inundated during high flows of 2010-11. There will also be a provision for flushing flows as a further mitigation technique to minimise the risk of low dissolved oxygen blackwater events in this system. An increase in the abundance of invasive species is considered possible within this system and is rated as a low risk. A particular risk for this system is the expanded distribution of the invasive weed *Egeria densa*, however spread of this weed can be controlled by wet-dry watering regimes (Aquaterra 2010).
4. Long-term sustainability of the asset(s) including appropriate management arrangements	Hattah Lakes is actively managed consistent with its recognition as a national park and Ramsar site, and is priority for watering under TLM. An integrated multi-stakeholder Environmental Management Plan, has been developed and is being implemented through the TLM program, which sets out clear management objectives for the site. Long-term condition monitoring of water bodies, along with monitoring of specific watering actions, is coordinated by Mallee Catchment Management Authority. Land management, including management of feral and invasive species, is undertaken by Parks Victoria. The long-term commitment to the site is demonstrated by the proposed construction of a permanent pumping station and water regulating structures to provide water to and manage water within the lakes. Bengallow Creek received water in 2005-06 as part of a coordinated environmental watering program titled 'Red Gum Rescue Project' run by the NSW Department of Natural Resources. The long term sustainability of Bengallow Creek is considered to be good. Although vegetation in the area has been stressed from lack of flooding in recent years, the system is considered to have good chances of recovery from a strategic watering program. Management options for Lake Caringay have been described in a 2010 report for the NSW Office of Water which details options for the Euston Lakes (of which Lake Caringay is the largest). A key conclusion of the report was that Lake Caringay should be considered as a critical component of the system, which will support vital ecosystem once restored (Aquaterra 2010). As the current management regime for Lake Caringay is a dry basin with zero usage, there will need to be ongoing management and monitoring to determine if the lake presents a long-term sustainable asset.
5. Cost-effectiveness and operational feasibility of	Pumping is required to deliver water to Hattah Lakes via Chalka Creek. Estimated pumping costs for water delivery

River Murray – Swan Hill to Mildura (including Hattah Lakes, Bengallow Creek and Lake Caringay)	
Criteria	**Response/Assessment**
undertaking the watering	are $33-$44/ML. Despite the pumping costs, the delivery of water to Hattah Lakes is likely to provide good value for money. This is because the opportunities to cooperatively water this site with Victorian and TLM allocations will thereby provide for maximum environmental outcomes for the river red gum communities fringing the wetland and provide significant increases in refuge habitat at a key site. A series of works planned through TLM program will further improve the operational feasibility of watering Hattah Lakes. Planned works include lowering the bed of Chalka Creek (the main inlet to the lakes), construction of three new regulators and three levees and a construction of a pumping station near the confluence of the River Murray and the Chalka Creek (MDBA 2010b). As the Bengallow Creek system is connected to the River Murray at three separate locations there are a number of options for delivering environmental water. During the 2006 Red Gum Rescue Project, the inlet into Bengallow Creek from Tapaulin Bend was used as the delivery point due to accessibility, greater likelihood of inundating a greater area of the Bengallow Creek system, low banks and large areas of stressed trees (Val et al. 2007). There are a number of issues that require addressing prior to providing water to Lake Caringay such as licensing of structures and landholder negotiations (OEH in prep). The removal or alteration of the block banks and regulators that prevent flow to Lake Caringay provide an opportunity to deliver water to the lake on a more frequent basis. The structures were installed to manage flow so that cropping could occur on the bed of the lake on a consistent basis. As this practice has now ceased, it is feasible to consider removing these banks and replace them with purpose designed water regulating structures capable of managing flow to and from Lake Caringay (Aquaterra 2010). There may be opportunities to link Commonwealth water with NSW environmental water allocations to achieve objectives within Bengallow Creek and Lake Caringay. Delivery costs for the NSW Murray system for 2011-12 will be: NSW State Water charges of $4.89/ML and NSW Office of Water charges of $0.9 resulting in a total of $5.79/ML. Victoria does not have specific fees attached to water delivery. Any watering action for these assets will likely involve a combination of environmental water from Victorian and NSW licences. For Hattah Lakes, Commonwealth water may be delivered in conjunction with TLM and Victorian water allocations.

Mildura to the South Australian border (including Lindsay-Mulcra-Wallpolla Islands)	
Criteria	**Response/Assessment**
1. Ecological Significance of the asset(s)	Following approval from the CEWH, 1,000ML of Commonwealth water was delivered in May-June 2009. Sites identified for potential watering along the Murray River from Mildura to the South Australian border include Lindsay Island, Muclra Island and Wallpolla Island. Lindsay, Mulcra and Wallpolla Islands are part of the Chowilla and Lindsay-Wallpolla Living Murray Icon Site, one of six such sites identified for their particular environmental values by The Living Murray program. Lindsay and Wallpolla Islands are wetlands of national significance and are listed on the Directory of Important Wetlands in Australia. Lindsay and Wallpolla Islands have 2 flora species of national significance and 51 of state significance, 27 fauna species of national significance and 37 of state significance and 5 species of waterbirds which are listed under the Japan and Australia Migratory Bird Agreement (JAMBA) and the China and Australia Migratory Bird Agreement (CAMBA), as well as three listed under CAMBA only. Mulcra Island is part of the same landform system as Lindsay and Wallpolla islands. At least 46 bird species have been identified on Mulcra Island, including the regent parrot (*Polytelis anthopephus*), considered vulnerable under both the Victorian *Flora and Fauna Guarantee Act 1988* and the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*, and the bush stone-curlew (*Burhinus grallarius*), which is listed as endangered under the *Flora and Fauna Guarantee Act 1988*. The island also supports three mammals and at least five species of frog, including the southern bell frog (*Litoria raniformis*), which is considered endangered under the Victorian Act and vulnerable under the Commonwealth Act.
2. Expected ecological outcomes from the proposed watering action	A lack of regular flooding due to river regulation and a drier climate has impacted significantly on the health of Lindsay-Mulcra-Wallpolla Islands. The decline in river red gum communities along the Murray floodplain is ongoing, with 72 per cent in a stressed condition in 2009. TLM icon sites in the Mallee are in worse condition than those further upstream. The only areas where stand condition have increased are those where environmental watering has been provided. This demonstrates that ongoing delivery is vital to maintain small areas of these communities on Lindsay-Mulcra-Wallpolla Islands in reasonable condition. Provision of environmental water to Lindsay-Mulcra-Wallpolla Islands will provide connectivity between the river and floodplain, watering river red gums, wetlands, black box and lignum. This will provide habitat in wetlands for

Mildura to the South Australian border (including Lindsay-Mulcra-Wallpolla Islands)	
Criteria	**Response/Assessment**
	waterbirds, fish, turtles and frogs. Flows to Lindsay-Mulcra-Wallpolla Islands will continue down the Murray River channel to provide further system benefits. Objectives for Lindsay, Mulcra and Wallpolla Islands are to: - provide a diversity of structural aquatic habitats; - increase diversity and extent of distribution of native fish; - increase diversity and abundance of wetland aquatic vegetation; - maintain and improve the populations of threatened flora and fauna that are flow dependent; and - restore productivity linkages between the river and floodplain habitats. SEWPAC considers the Lindsay-Mulcra-Wallpolla Islands watering objectives as appropriate for meeting the ecological requirements of the assets and overall contribution to system benefits.
3. Potential risks of the proposed watering action at the site and at connected locations	Risks for watering this asset are expected to be minimal. This is because issues with delivery to wetlands in the area are well understood and well developed management options are in place. This low risk assessment is informed by the experience held by Mallee CMA in watering these sites, as well as broader experience across the region.
4. Long-term sustainability of the asset(s) including appropriate management arrangements	The long term sustainability of this system is high. As part of a TLM icon site, Lindsay-Mulcra-Wallpolla Islands have established environmental management plans and monitoring arrangements. Lindsay Island also has a management plan associated with the Murray Sunset National Park. Mulcra, Lindsay and Wallpolla Islands are managed by the Mallee Catchment Management Authority (CMA), which has established environmental water monitoring and assessment practices. Mallee CMA and Parks Victoria have significant experience managing the delivery of environmental water to wetlands throughout this region, and the delivery of any environmental water will be informed by their management experience.

Mildura to the South Australian border (including Lindsay-Mulcra-Wallpolla Islands)	
Criteria	**Response/Assessment**
5. Cost-effectiveness and operational feasibility of undertaking the watering	The Living Murray project recently funded the construction of several regulators on Potterwalkagee Creek as part of a large infrastructure project at Mulcra Island. These works enable increased flow within the Potterwalkagee Creek and also allow for large amounts of water on the floodplain to be returned to the Murray River. Victoria has a returns flow policy in place whereby a percentage of environmental water provided to Lindsay-Mulcra-Wallpolla Islands may be recredited for use further downstream. There may be opportunities to link Commonwealth water with TLM and state environmental water allocations to achieve objectives within this system. Victoria does not have specific fees attached to water delivery. Any watering action for this asset will likely involve a combination of environmental water from Victorian and NSW licences. Temporary pumps may be required to deliver environmental water to Wallpolla Island floodplain in the absence of natural high flows. Works to allow large scale gravity delivery to Wallpolla Island are not proposed for this section of the TLM icon site. Watering each of Lindsay-Mulcra-Wallpolla Islands simultaneously is expected to achieve additional benefits rather than watering any of the islands in isolation.

Water Use Strategy 2011-12: Murrumbidgee River Catchment

1.1. Introduction

This document sets out the Department of Sustainability, Environment, Water Population and Communities (SEWPaC or 'the Department') objectives and proposed approach to using Commonwealth environmental water in the Murrumbidgee River catchment during the 2011-12 water year. This strategy was developed based on information available to the Department and in consultation with delivery partners such as the NSW Office of Environment and Heritage (OEH), NSW Office of Water (NOW), State Water Corporation, local river operators and wetland managers.

The strategy establishes the approach that the Department will take to using Commonwealth environmental water, and includes watering options given current and expected climatic and riverine conditions in the catchment. The strategy will evolve over the course of the year as conditions in the catchment change and more information becomes available. Importantly, the potential watering options included in this document do not form an exhaustive list – the Department welcomes proposed options for using water that meet the stated objectives for the water year at any time during the water year. All relevant options will be assessed to ensure the best possible use of environmental water within the catchment and across the Murray-Darling Basin.

1.2. The Murrumbidgee River Catchment

The Murrumbidgee River catchment has an area of 87,348 km^2 which is equivalent to about 11 per cent of the total land area of New South Wales (Murrumbidgee CMA 2006), and eight per cent of the Murray-Darling Basin (CSIRO 2008). The river originates in the alpine area of Kosciuszko National Park and flows through the Monaro High Plains and the low-lying plains of the western Riverina, joining the Murray River south of Balranald (Figure 1). Main tributaries include the Tumut, Queanbeyan, Yass and Cotter Rivers in the upper reaches of the Murrumbidgee, and Tarcutta Creek downstream of the Tumut junction.

The primary users of water in the region are the two major irrigation districts in the catchment – Murrumbidgee (MIA) and Coleambally Irrigation Areas (CIA). Irrigation also occurs around Hay and Balranald and in eastern parts of the catchment, including around Wagga Wagga. The 2005-06 Agricultural Census identified cereal cropping as the largest area of irrigated agriculture (110,000 ha) in the catchment, followed by rice (65,000 ha). Regulated water is provided by Burrinjuck and Blowering Dams. Burrinjuck Dam is situated in the upper catchment on the Murrumbidgee River and Blowering Dam is also situated in the upper catchment on the Tumut River. Collectively these storages have a capacity of 2,654 GL. Management of the water resource within the Murrumbidgee River catchment occurs according to the *Water Sharing Plan for the Murrumbidgee Regulated River Water Source 2003*.

Figure 4 shows the change in flows greater than 35,000 ML /day (at Wagga Wagga) between the modelled natural flow regime and actual flows as a result of development in the Murrumbidgee catchment. The impact of water extraction (which includes storage of flows in the dams) is most pronounced between May and August (MDBA 2010a).

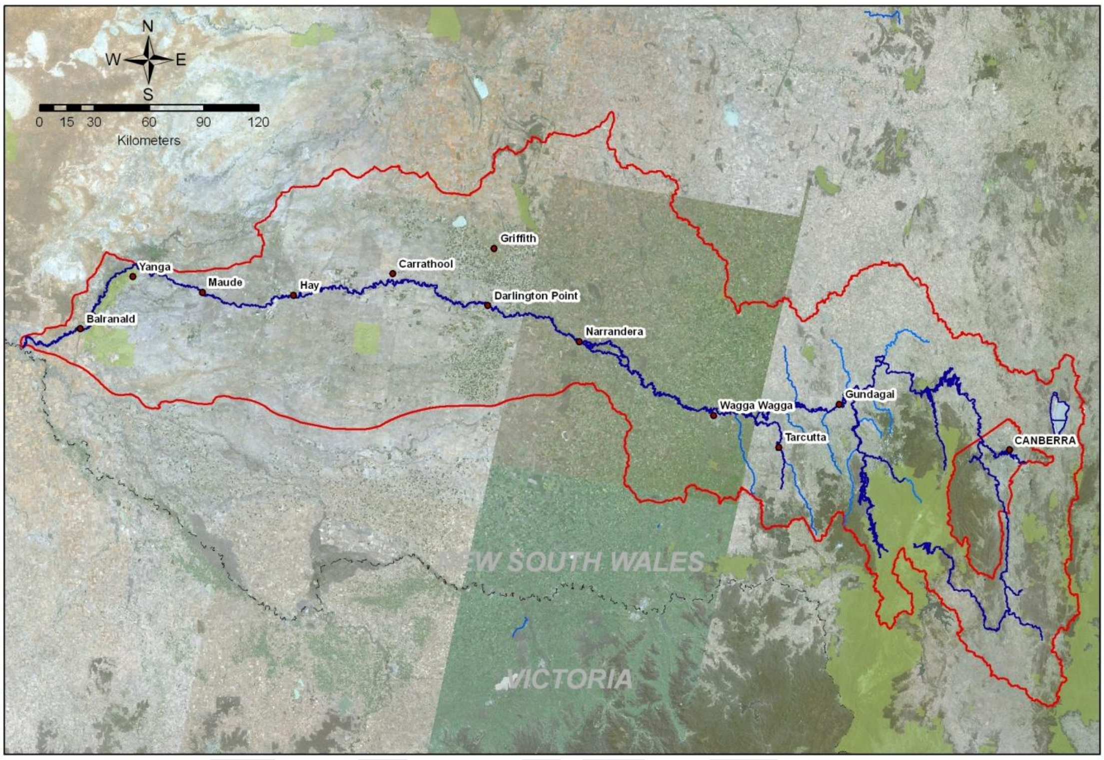

Figure 1: The Murrumbidgee River Catchment

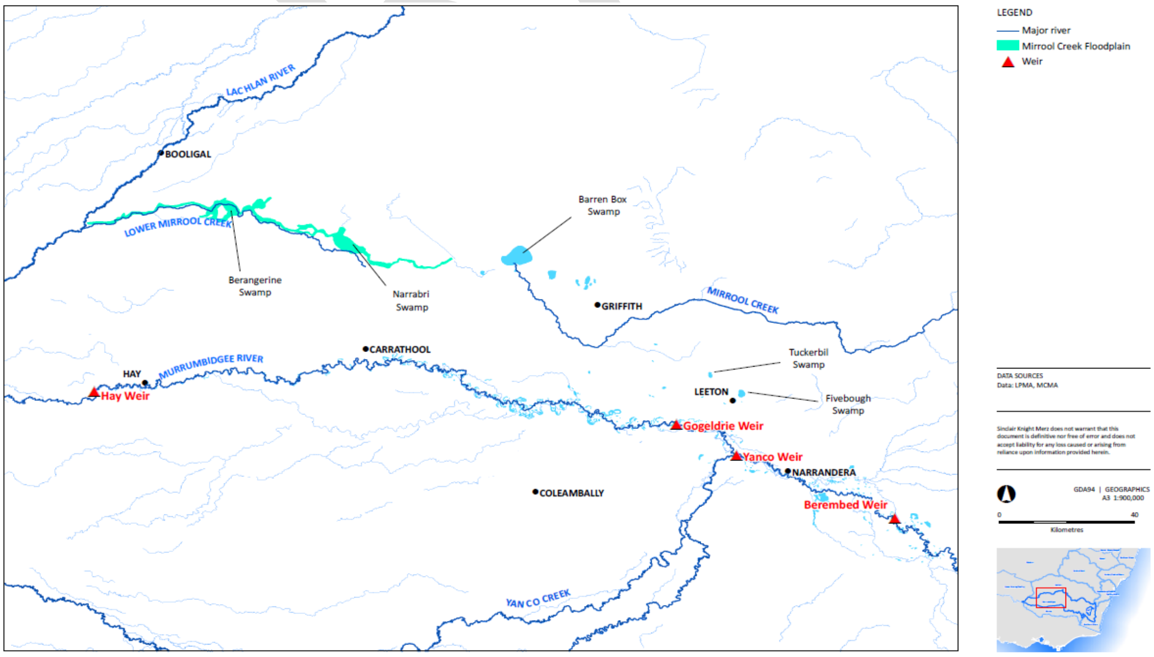

Figure 2: The mid-Murrumbidgee and Mirrool Creek system

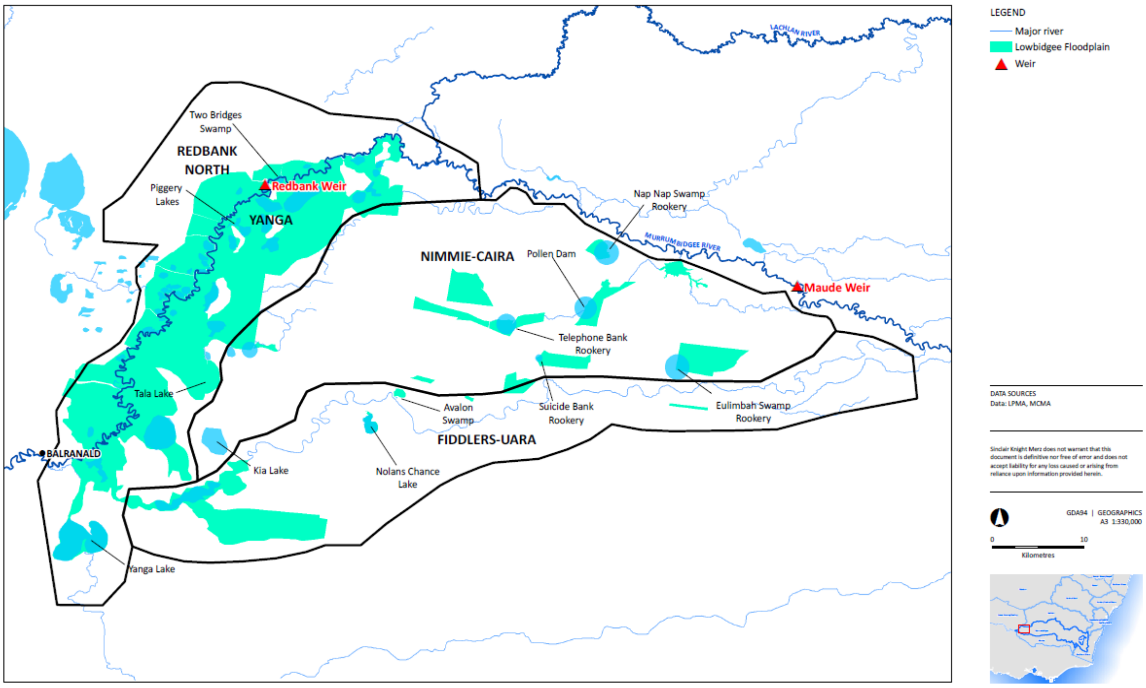

Figure 3: The Lowbidgee Floodplain

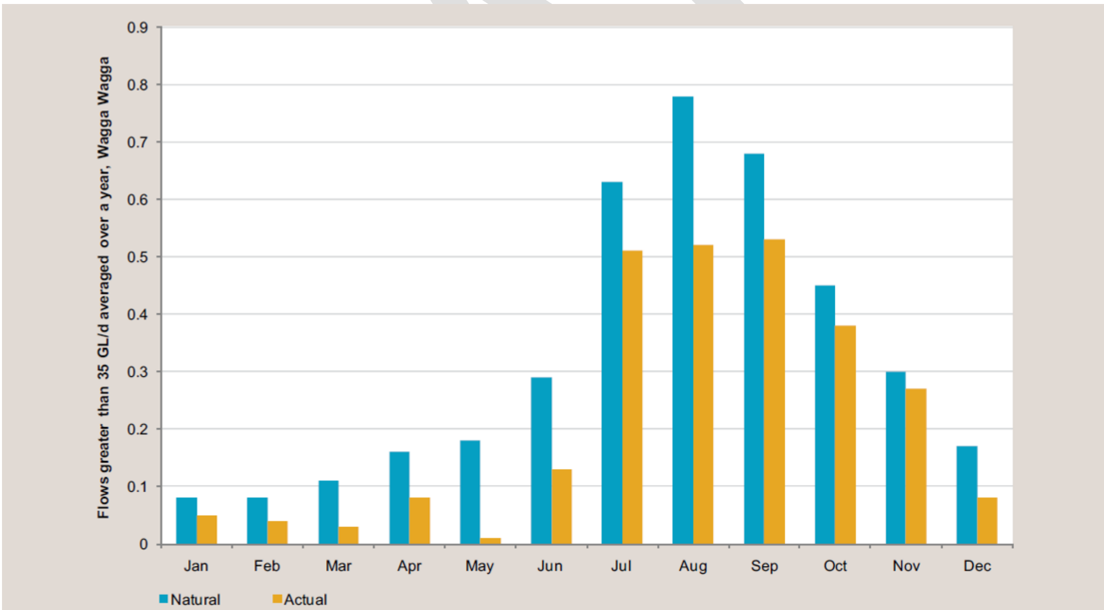

Figure 4: seasonal comparison of without development and actual flows of >35,000 ML/day at Wagga Wagga: Mid-Murrumbidgee Wetlands (Source: MDBA 2010a).

1.3. Environmental Assets in the Murrumbidgee River Catchment

Freshwater-dependent biotic and abiotic assets in the Murrumbidgee River catchment include areas of river red gum (*Eucalyptus camaldulensis*) forest and woodland, black box (*Eucalyptus largiflorens*) woodland, lignum (*Muehlenbeckia florulenta*), river-fed wetlands, Ramsar-listed wetlands; migratory bird habitats, colonial bird breeding sites, and southern bell frog (*Litoria* *raniformis*) and fishing bat (*Myotis macropus*) habitat. Known significant areas for these assets include:

- Murrumbidgee River channel;
- Mirrool Creek System (including Fivebough Swamp, Tuckerbil Swamp, Barren Box Swamp and the Lower Mirrool Creek Floodplain);
- River-fed wetlands in the Murrumbidgee River system (from Gundagai to Maude, including the Mid-Murrumbidgee wetlands);
- Lowbidgee floodplain;
- Lowland floodplain wetlands below Balranald (from Balranald to the Murray River junction, including 'the Junction' wetlands); and
- River-fed wetlands in the Yanco-Colombo-Billabong Creek system (from the Murrumbidgee River to Moulamein).

Further details on the location, condition, type and extent of significant flora and fauna at each locality is presented at Appendix A.

1.4. Long-term Watering Objectives in the Murrumbidgee River Catchment

During 2010-11, the Department undertook work to identify and develop large-scale watering options for Commonwealth environmental water, including in the Murrumbidgee River catchment. Through this work, the Department has identified the following ecological and hydrological objectives for the Murrumbidgee River catchment:

1) Restore longitudinal and lateral connectivity within the Murrumbidgee River and floodplain system to protect and restore the *Aquatic ecological community in the natural drainage system of the lower Murray River catchment* (NSW *Fisheries Management Act 1994*) including its threatened species;
2) Maintain and improve wetland vegetation communities to good condition;
3) Maintain and improve river red gum forest and woodland communities to good condition;
4) Maintain and improve black box woodlands to good condition;
5) Maintain and improve lignum shrublands to good condition;
6) Maintain open water areas and exposed muddy margins to provide habitat for fauna;
7) Maintain known colonial waterbird breeding sites in 'event ready' condition, and support breeding events;
8) Protect and restore habitats for migratory waterbirds;
9) Maintain known southern bell frog breeding sites in 'event ready' condition, and support breeding events; and
10) Maintain or improve ecosystem condition in the Murrumbidgee River channel.

These objectives are broadly consistent with the objectives specified for the Murrumbidgee assets in the "*Guide to the proposed Basin Plan*" published by the Murray Darling Basin Authority (2010a).

1.5. Delivering Water in the Murrumbidgee River Catchment

Most of the flow in the Murrumbidgee River comes from the upper portion of the catchment, and is delivered by the main tributary rivers – Yass, Molonglo, Queanbeyan, Bredbo, Numeralla, Cotter, Goodradigbee and Tumut (Kingsford & Thomas 2001). The Murrumbidgee River is heavily regulated with 26 dams and weirs and over 10,000 km of irrigation canals (Kingsford 2003). Storages include those in the Snowy Mountain Hydro-electric Scheme, those forming the ACT Water Supply System and the major New South Wales irrigation dams (Blowering Dam and Burrinjuck Dam) (CSIRO 2008).

There are seven main weirs downstream of the major NSW storages used to manage water levels for diversion - Berembed, Yanco, Gogeldrie, Hay, Maude, Redbank and Balranald Weirs. The weirs contain relatively small storage volumes (1-13 GL) and have limited capacity for re-regulation of flow. There is also an off river en-route storage (Tombullen) with a capacity of 11 GL that offers some re-regulation opportunity.

The MIA and CIA are located downstream of Wagga Wagga and are responsible for approximately three quarters of the irrigation diversions in the catchment though other river pumpers and private irrigation schemes are located further downstream. The MIA is supplied by the Main Canal which diverts water from the Berembed weir pool and Sturt Canal which diverts water from the Gogeldrie Weir pool. The Coleambally Irrigation District is also supplied by a canal which diverts water from the Gogeldrie Weir Pool. Flows into Yanco-Colombo-Billabong Creek system are regulated by Yanco Weir. Diversions into the Nimmie-Caira portion of the Lowbidgee Floodplain are taken from the Maude Weir pool, whilst diversions into South and North Redbank are taken from the Redbank Weir Pool.

The two NSW state storages, seven weirs and Tombullen Storage are operated by State Water Corporation to meet customer orders. Since the weirs and Tombullen have relatively small storages, most orders are supplied by releases from either of the two dams and customers are required to place orders sufficiently early to allow for the travel time to their diversion structure, plus one day processing time. Any transmission losses between the dams and the customer's diversion structure are met by State Water Corporation.

A schematic depicting the location of dams, regulators and weirs in the Murrumbidgee River catchment is provided at Figure 5. Table 1 provides further detail on key delivery issues to specific assets.

Table 1: Water delivery considerations for each asset.

Asset	Delivery Considerations
Murrumbidgee Irrigation Area (Mirrool Creek system): Fivebough, Tuckerbil and Barren Box Swamps	▪ Supply of managed environmental water from the Murrumbidgee River to assets in the system is via the MIA supply channels. Water is delivered into the MIA system at Berembed Weir and Gogeldrie Weir. ▪ The optimum time for delivery is either September/October or March/April, to avoid peak irrigation season.
Murrumbidgee River Channel	▪ In-stream flows have been altered by regulation, creating constant flow levels, unseasonal flows, rapid rates of rise and fall, and areas of permanent inundation. Improving in-stream conditions will involve providing variable moderate flows, freshes and high flows, thereby

Asset	Delivery Considerations
	reintroducing natural flow variability, rates of change in water levels and natural inundation patterns. ▪ This requires thorough management of piggybacking and stand alone flow events, with careful timing of releases.
Mid-Murrumbidgee Wetlands	▪ Watering of the Mid-Murrumbidgee wetlands is closely linked to management of the main Murrumbidgee River channel. ▪ The key watering strategy for these wetlands is to augment natural flows to shift inundation patterns towards a more natural seasonal regime (refer Figure 4). This requires careful management of piggybacking and stand alone flow events. ▪ Triggers for augmentation include time of year (best period is May-October), catchment wetness, current and forecast rainfall and runoff, low irrigation demand, and volume of environmental water available.
Lowbidgee Floodplain	▪ The Lowbidgee floodplain includes three distinct water delivery areas – Nimmie-Caira, Fiddlers-Uara and Redbank. ▪ Much of the South Redbank system is managed by OEH as Yanga National Park. The Nimmie-Caira and Fiddlers-Uara are largely privately owned. ▪ Delivering water to these assets is via a series of interconnected channels and the Murrumbidgee River channel. Various regulators and channel capacities dictate delivery regimes in the system. Privately owned channels in the Nimmie-Caira system can only be used with the owners consent. ▪ Water allocation in the Nimmie-Caira system is based on a 'tiered allocation' system.
Lowland floodplain wetlands below Balranald	▪ Delivery of > 5,000 ML/day downstream of Balranald in addition to Murray River flows > 10,000 ML/day at Barham for a period of several weeks is necessary to inundate lowland floodplain wetlands downstream of Balranald.
Yanco-Colombo-Billabong Creek System	▪ At times of high flow demand up to 1,400 ML/day can be directed into the system but considerable flooding occurs at several points in local areas. ▪ State Water Corporation estimates losses of approximately 52 per cent in the system (Beal *et al.* 2004). ▪ Finley Escape (from Murray Irrigation Limited) is used during the irrigation season to supplement flows in Billabong Creek below Jerilderie with water from the Murray River.

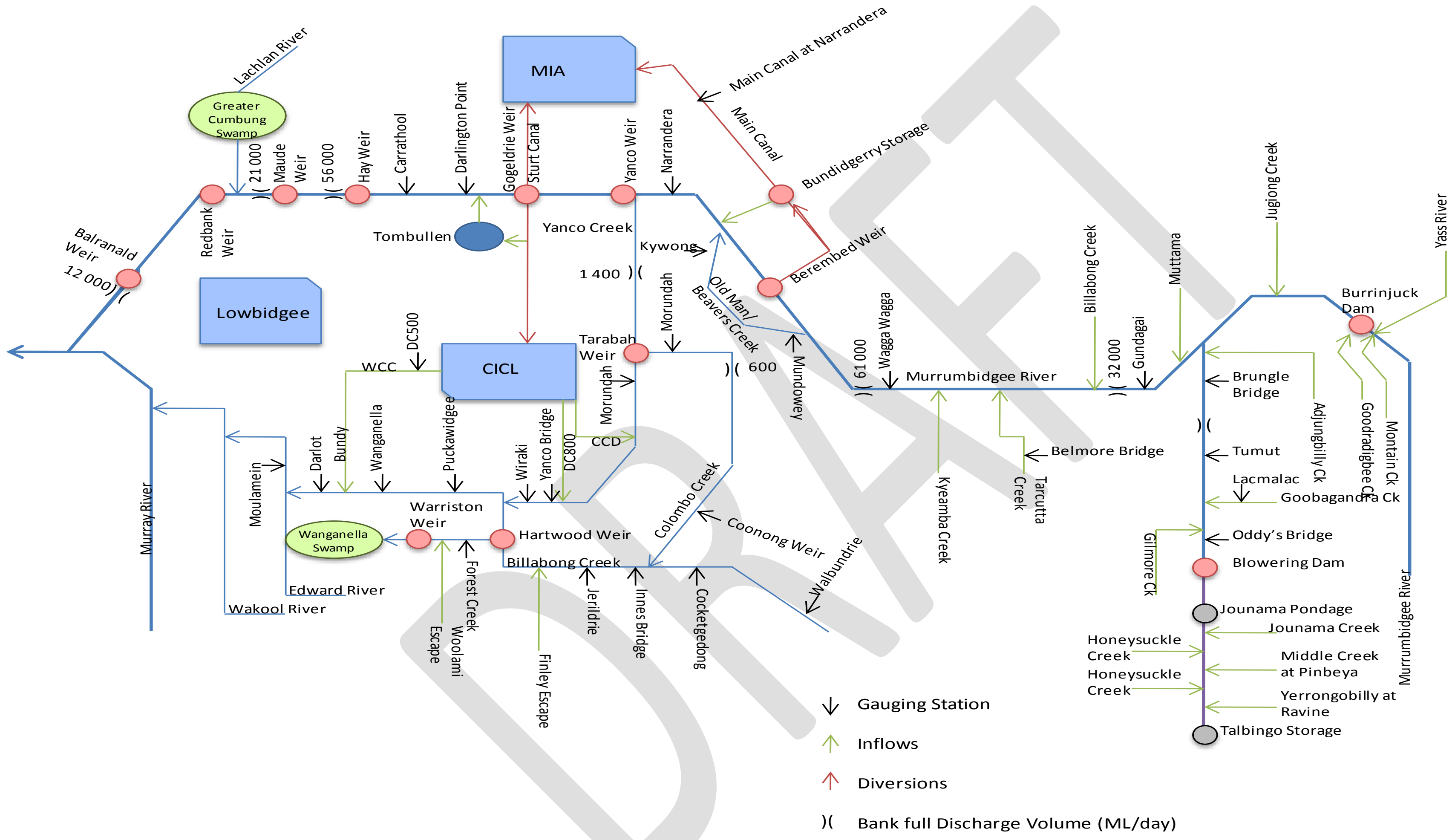

Figure 5: Schematic of the Murrumbidgee River operating environment.

1.6. Current Catchment Status and Outlook

Extensive flooding occurred in the Murrumbidgee River catchment during the spring and summer of 2010-11 (Figure 6). However, prior to the 2010-11 flood the catchment experienced drought conditions for much of the 2000s, prompting the delivery of several environmental water flows in the catchment to key environmental assets in the Lowbidgee and Murrumbidgee Irrigation Area. Commonwealth environmental water has been delivered, along with water from the NSW government to a number of assets in the Murrumbidgee catchment since 2009 including a number of deliveries in 2010-11 as shown in Table 2.

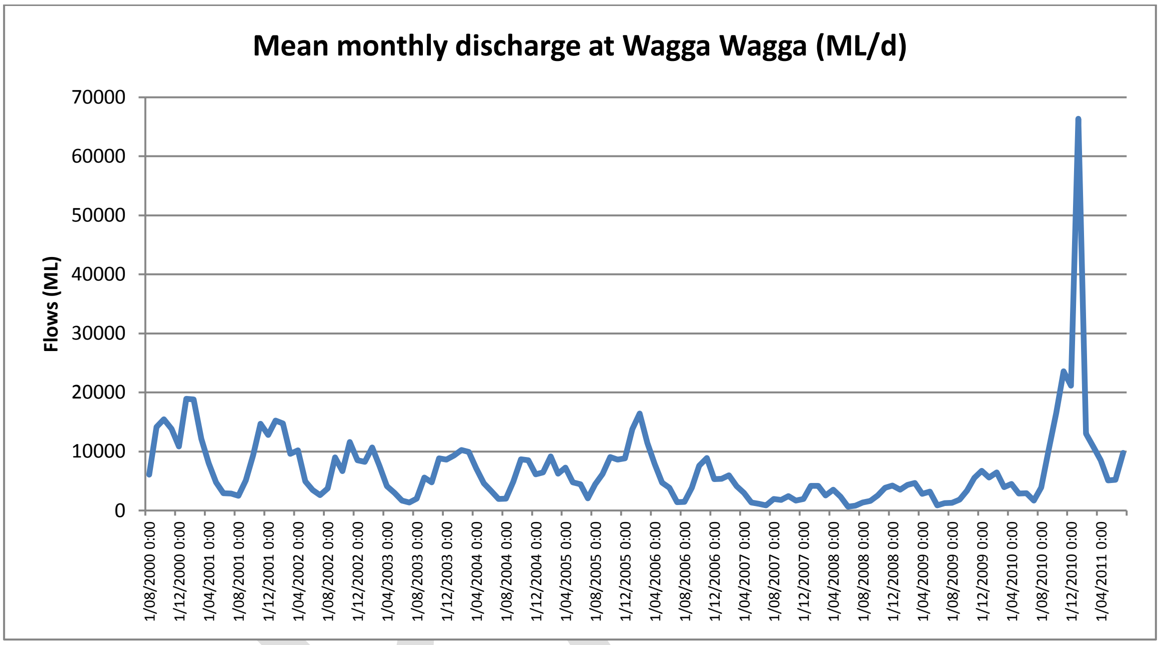

Figure 6: Mean monthly flows in the Murrumbidgee River at Wagga Wagga from 2000 to current. (Source: http://waterinfo.nsw.gov.au/water.shtml?ppbm=SURFACE_WATER&rs&3&rskm_url)

Table 2: Commonwealth environmental water use in the Murrumbidgee River catchment 2010-11.

Asset	Site	Delivery Dates	Commonwealth volume (ML)	NSW volume (ML)	Total volume (ML)
Lowbidgee Floodplain	Yanga National Park (Tala Lake & North Redbank)	01-Jul-10 to 26-Aug-10	7,533	32,058	39,591
	Yanga National Park	20-Aug-10 to 26-Aug-10	13,287	21,622	34,909
	North Redbank	08-Oct-10 to 20-Oct-10	2,525	6,925	9,450
	In channel and downstream Maude Weir	04- Feb-10 to 25-Mar-10	57,751	0	57,751
Mirrool Creek system	Barren Box Swamp	25-Oct-10 to 09-Nov-10	3,000	0	3,000

Murrumbidgee River and Mid-Murrumbidgee Wetlands	Mid-Murrumbidgee Wetlands, Yanco-Colombo-Billabong Creek system and the Lowbidgee Floodplain.	14-Jun- 11 to 25-Jun-11	109,250	29,300*	161,600

* This included water from TLM and private donations.

The seasonal outlook for south-eastern Australia over the next three months favours below average seasonal conditions (Figure 7). Most of the Murrumbidgee River catchment has a forecast chance of exceeding the median seasonal rainfall of between 40 and 45 per cent.

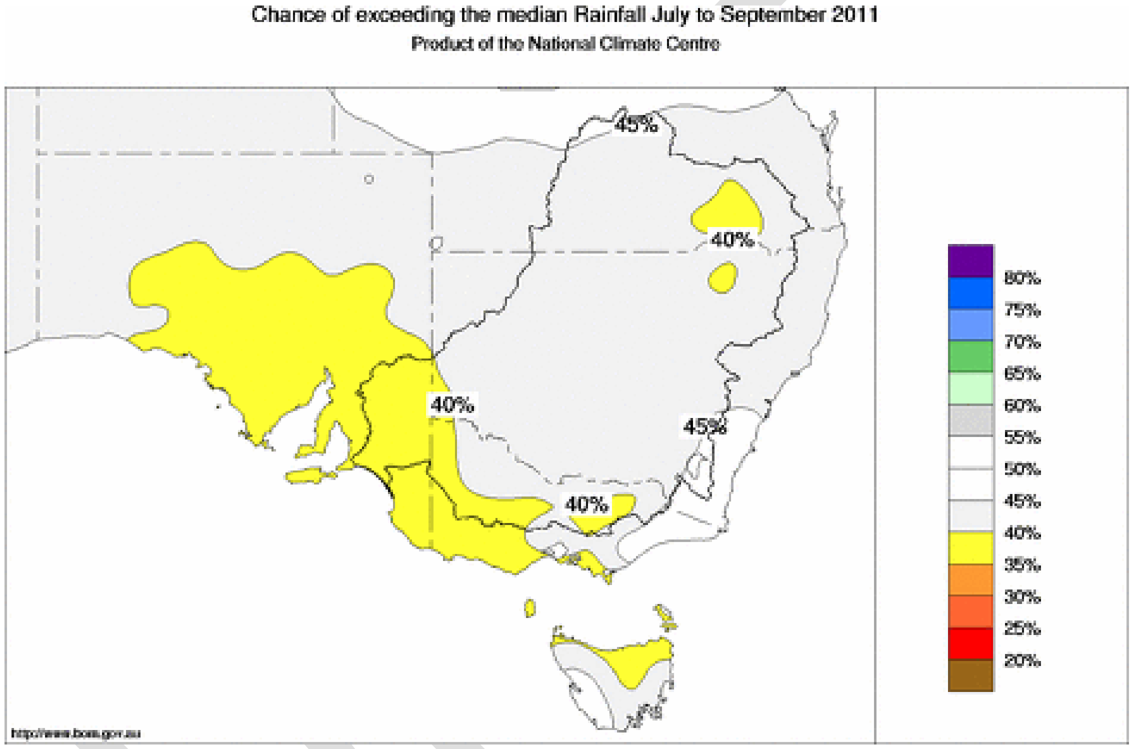

Figure 7: Seasonal rainfall outlook for south eastern Australia (Source: BoM 2011).

The La Niña event in the Pacific has ended and close to average rainfalls occurred in May over most of New South Wales and Victoria. Although the majority of forecast locations reported streamflows that were above median for May, they were closer to median than during April (BOM 2011b). Catchments have experienced some drying in recent months but soil moisture levels remain high and we are now entering the southern wet season. Higher than median flows could be produced from near median rainfall in the coming months. Near median or higher than median flows are the most likely outcome for seventeen of the twenty-one sites for the June to August period (Figure 8), (BOM 2011b). The sites in the Murrumbidgee catchment that should be considered are: the Darbalara, Wee Jasper, Lacmalac, and Batlow Road, all of which have the highest likelihood of having median flow.

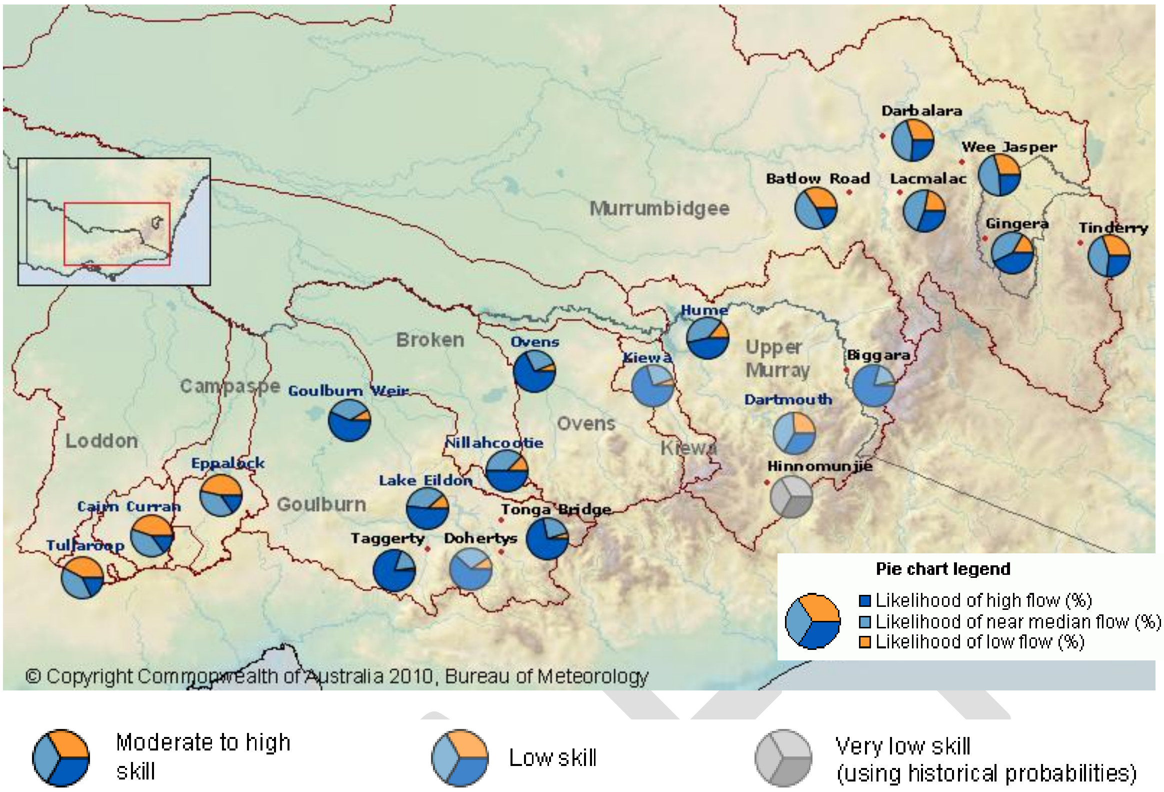

Figure 8: South-east Murray-Darling Seasonal Streamflow Forecasts for June to August 2011

1.7. Forecast Allocations

Current storage levels in the southern Murray-Darling Basin are high (Figure 9).

Allocations against Commonwealth regulated water holdings in the southern connected basin are forecast to be 320 GL (dry) to 650 GL (wet) in 2011-12.

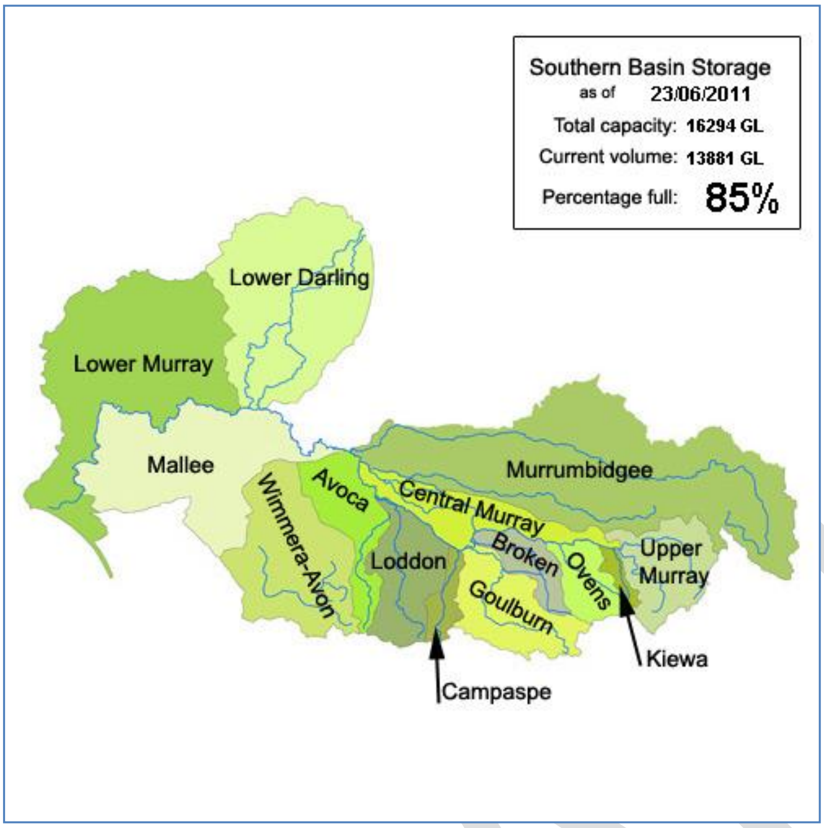

Figure 9: Current water storage levels in the southern Murray-Darling Basin (as at 23 June 2011).

The volume of Commonwealth environmental water available in the southern connected basin and the Murrumbidgee catchment at the beginning of 2011-12, and forecasts for the rest of 2011-12 water year are described in Table 3.

Table 3: Commonwealth environmental water availability in 2011-12.

Catchment	Entitlement (GL)	Water available for use (GL)	Water available for use forecasts					
			31 July 2011 (GL)		30 September 2011 (GL)		30 June 2012 (GL)	
Murrumbidgee (NSW)			Dry	Wet	Dry	Wet	Dry	Wet
High/General Security	101.1	44.5	44.6	60.7	44.6	60.7	50.7	101.1
Supplementary	20.8	20.8	n/a	n/a	n/a	n/a	n/a	n/a
Total - Southern Connected Basin	**652.5**	**317.7**	**318.0**	**388.9**	**354.7**	**608.9**	**539.9**	**649.7**

Note: total allocations available excludes supplementary.

The forecasts presented in Table 3 were determined by the Department based on the following:

- There would be no barriers to trade within southern connected basin during 2011-12, except the 100 GL net trade limit out of the Murrumbidgee;

- The southern connected basin includes the NSW Murray, Vic Murray, SA Murray, Murrumbidgee, Goulburn, Campaspe, Lower Darling and the Loddon;
- Forecasts were based on information available at 1 July 2011, and the Commonwealth's registered entitlements at this date;
- Supplementary entitlements and additional entitlements that may be obtained and registered by the Commonwealth during 2011-12 were not included in forecasts; and
- Forecasts were based on dry and wet climate year scenarios.

1.8. Other Sources of Environmental Water

In addition to Commonwealth environmental water, there are other sources of environmental water that may be available to supplement Commonwealth environmental water in the catchment during 2011-12 (Table 4). NSW OEH manages environmental water allowances according to the *Water Sharing Plan for the Murrumbidgee Regulated River Water Source 2003.*

Table 4: Other potential sources of environmental water in the Murrumbidgee River catchment for 2011-12 as at 1 July 2011.

Source	Management Authority	Entitlement (ML)	Available for use 1 July 2011 (ML).
Environmental Water Allowances 1, 2 and 3	OEH/ Murrumbidgee Environmental Water Advisory Group (EWAG)	Planned environmental water, maximum available 150,000	50,000-65,000*
NSW RiverBank	OEH/ Murrumbidgee EWAG	21,535 General Security	9,475.4
		5,679 Supplementary	Supplementary allocations are available as announced by NSW Office of Water.

*Prior to the 1 July allocation announcement NSW OEH forecast 54,000 ML based on 95% HS and 35% GS,

1.9. Watering Objectives for 2011-12

Objectives common to all possible watering options in the Murrumbidgee during 2011-12 would include:

- Support the survival of river red gum, black box and littoral zone seedlings that germinated in response to floods in the 2010-11 water year;
- Top up wetlands, lagoons, and billabongs to maintain water levels to enable vegetation to respond quickly when improved growing conditions arise in spring;
- Reconnect wetlands and lagoons along the Murrumbidgee River;
- Support longitudinal and lateral fish movement and transfer of energy, nutrients and micro-organisms, within channel and between river and floodplain wetland habitats;
- Provide breeding habitat for frogs;
- Provide suitable wetland habitat to support waterbird breeding and foraging; and
- Promote natural riverine processes, such as biofilm scouring.

Additionally, the following objectives are specific to the following assets.

Mid-Murrumbidgee wetlands:

- Reconnect wetlands and lagoons along the Murrumbidgee River and provide higher flows to the Yanco Creek system, including Yanco, Colombo, Forest and Billabong Creeks.

Lowbidgee Floodplain:

- Provide breeding habitat for frogs, and create habitat to facilitate re-colonisation of the top end of North Redbank system with southern bell frogs.

1.10. Watering Options for 2011-12

Potential watering options for the Murrumbidgee River catchment focus on providing seasonal river flows and pulses that would inundate wetlands and rookeries to facilitate waterbird and frog breeding events and support improved resilience in these populations in the catchment; creating an end-of-system flow in the Yanco-Colombo-Billabong Creek System, and creating a mosaic of wetting and drying floodplain wetlands throughout the catchment. A summary of the options is provided at Table 5. More details on the watering options, including consideration of the delivery mechanism, and the target flow volume and its timing and duration is provided at Table 6.

Supplementary flows may be used in addition to regulated entitlements to meet the environmental objectives for the assets as detailed in this strategy.

Table 5: Potential watering options for 2011-12 in the Murrumbidgee River catchment*.

Asset	Watering Option
Spring-Summer 2011-12	
Mid-Murrumbidgee wetlands	Stand alone or piggyback releases onto tributary freshes inundating the low-lying river-fed wetlands from Gundagai to Maude Weir and increasing high flow duration. If required, top-up the wetlands to maintain inundation duration using irrigation infrastructure (where necessary and possible).
Fivebough Swamp	Inundate Fivebough Swamp to maintain or improve wetland vegetation communities to good condition. Requires approximately 200 ML.
Tuckerbil Swamp	Inundate Tuckerbil Swamp to maintain or improve wetland vegetation communities to good condition. Requires approximately 500 ML.
Barren Box Swamp	Inundate the wetland area of the 'wetland cell' to promote growth, recruitment and survival of black box grassy woodland vegetation, and support waterbird breeding. This requires 3-5 GL.
Lowland floodplain wetlands below Balranald ('the Junction' wetlands)	Stand alone or piggyback releases combining Murrumbidgee and Murray River flows to inundate the Junction wetlands south of Balranald. This requires the managed delivery of >5 GL/day at Balranald in addition to Murray River flow >10 GL/day at Barham on the Murray River for a period of 3-7 weeks.
Lowbidgee Floodplain	Flood southern sections of river red gum forest and black box communities in Yanga National Park (south of Tala Lake) using the privately owned channel systems from Maude Weir to greatest efficiency, and through flows from North Yanga (which may have more environmental benefit). Delivery through North Yanga may not be possible if an ecologically beneficial drying down of North Yanga is required. This watering option requires approximately 50-60 GL.
	Inundate key rookeries and other wetlands of the Nimmie-Caira floodway,

Asset	Watering Option
	potentially initiating a waterbird breeding event that may need sustaining. This option requires consent to use privately owned channels. Requires 60-70 GL.
	Flood larger southern bell frog wetland habitats in the northern Redbank North and Yanga systems to facilitate expansion of the distribution of the population (e.g. Eulimbah Swamp requires 6 GL, Twin Bridge requires 4 GL). This may not be possible if ecological drying of the North Yanga system is required.
	Flood prioritised sections of privately owned river red gum forest/woodland and lignum creeks/swamps in the Redbank North area, including the continuation of the watering action for Paika Lake. Requires approximately 50-60 GL.
	Inundate extensive areas of Yanga Nature Reserve and other significant wetlands located outside the Lowbidgee Flood Control and Irrigation District (e.g. Paika Lake).
Yanco-Colombo-Billabong Creek System	Inundation of Wanganella Swamp to build on positive ecological outcomes that occurred as a result of flooding in 2010-11. The provision of water to Wanganella Swamp may also trigger a colonial waterbird breeding event that may need to be supported to completion.
	Create an end-of-system flow to Moulamein, including inundation of the Forest Creek system downstream of Wanganella Swamp.
Autumn 2012	
Lowbidgee Floodplain	Provide maintenance flows to support important colonial waterbird breeding events which may establish.
Winter 2012	
Murrumbidgee River channel and Mid Murrumbidgee wetlands	Completion of Autumn watering actions. Stand alone or piggyback releases onto tributary freshes inundating the low-lying river-fed wetlands from Gundagai to Maude Weir and increasing high flow duration.

* *The Department has also identified watering actions for the Murrumbidgee River catchment that are consistent with the objectives for dry and extreme dry conditions. These options are tabulated at Appendix B.*

Note that a number of assumptions were made in creating Table 6 and Table 7:

- Where possible the target flow rate and volume to fill are as accurate as possible, and incorporate a range of antecedent conditions (from dry to wet) for the asset. The volumes included generally represent the maximum that would be required. The lower volumes indicated in Table 6 would apply for wet antecedent conditions. However there are some areas in the catchment where there is little hydrologic data to inform estimates for commence-to-fill and volume-to-fill targets for assets. This particularly applies to the unregulated portion of the Yanco-Colombo-Billabong Creek system, most notably below Warriston Weir. The figures in Table 6 and Table 7 for these assets should be treated as indicative amounts.
- Water usage as a result of environmental flows delivered to unregulated portions of the catchment is generally not known. For example the Yanco-Colombo-Billabong Creek system below Warriston Weir is unregulated, and a conservative estimate for water usage in the unregulated portion of the Billabong - Forest Creek section of the system is 30-50 per cent.

- The total release volume estimate and monthly water allocation profile provided at Table 7 is indicative only, and needs an event-by-event analysis to ensure the antecedent conditions of the asset are understood prior to a release.

Table 6: Operational details for potential watering options for 2011-12 in the Murrumbidgee River catchment.

Asset	Water Management Objective Met*	Target flow rate/Volume to fill	Estimated volume	Timing & Duration	Delivery mechanism	Operational considerations
Mid-Murrumbidgee Wetlands						
Low commence to fill floodplain wetlands	1, 2, 3, 5, 6, 8, 9, & 10	32,000 ML/d at Gundagai	Up to 150,000 ML delivery volume	Aug – Dec 2011 and May – June 2012 3-5 days duration at Gundagai	Augmented river flow	Commit water resources when a natural peak in the system has occurred to manage the recession once flows return to below 32,000 ML/day at Gundagai. Or undertake a standalone event using dam releases only to generate the desired hydrograph.
Murrumbidgee Irrigation Area: Mirrool Creek System						
Fivebough Swamp	2, 6, 8	200 ML fill volume	240 ML (inc. 20% transmission loss)	Sep - Dec 2011 Approximately 16 days duration at the Swamp	Murrumbidgee irrigation infrastructure	Allow 5-20% transmission loss. Flow rates of 15 ML/d are typical for a filling event.
Tuckerbil Swamp	2, 6, 8	500 ML fill volume	600 ML (inc. 20% transmission loss)	Sep-Dec 2011 Approximately 16 days duration at the Swamp	Murrumbidgee irrigation infrastructure	Allow 5-20% transmission loss. Flow rates of 15 ML/d are typical for a filling event.
Barren Box Swamp	2, 4, 8	3,000-5,000 ML fill volume	Up to 6,000 ML (inc. 20% transmission loss)	Sep - Dec 2011	Murrumbidgee irrigation infrastructure	Inundates the entire Wetland Cell. 250-610 ML inundates only the wettest portion of the Wetland Cell. Allow 5-20% transmission loss.
Lowland floodplain wetlands below Balranald ('the Junction' wetlands)						
Junction floodplain wetlands	1, 2, 3, 6, 8 & 10	Target flow rate of >5,000 ML/d at Balranald plus > 10,000 ML/d in the Murray River at Barham.	Volume related to target flow rates	Sep - Dec 2011 3-7 weeks	In-channel	Requires a period of extended high flows through the Lowbidgee Floodplain and along the Murray River at the junction.
Lowbidgee Floodplain						
Yanga National	1-10	>11,000 ML/d at	50,000-60,000	Sep - Dec 2011	In-channel to off take.	Water delivery in the Lowbidgee Floodplain will

Asset	Water Management Objective Met*	Target flow rate/Volume to fill	Estimated volume	Timing & Duration	Delivery mechanism	Operational considerations
Park (south of Tala Lake)		Redbank Weir ML			Can also use channel systems from Maude Weir (i.e. through the Nimmie-Caira system) to deliver water directly to Tala Lake and downstream.	be dependent on the ability of those targeted wetlands to undergo a period of drying out prior to re-wetting.
Nimmie-Caira	1, 2, 4, 5, 6, 7, 8 & 9	Regulated flow via Maude weir pool.	60,000-70,000 ML	Sep – Dec 2011	In-channel to off take	This volume inundates key rookeries and other wetlands throughout the system. The option can only be implemented with agreement from the owners of the channels.
Redbank North and Yanga systems	1, 2, 3, 6, 7, 8, 9 & 10	>11,000 ML/d at Redbank Weir for overbank inundation	60,000 ML	Sep – Dec 2011	In-channel to off take	Regulated flows into Yanga via Yanga regulator (capacity up to 1,000 ML/d) and Waugorah regulator (up to 200 ML/d capacity). Regulated flows to north Redbank via Glen Dee and Juanbung regulators. Flows can be managed from Redbank Weir This option will only be possible if significant drying of the Yanga system occurs during late winter and early spring of 2011.
Yanga Nature Reserve and other significant wetlands outside the Lowbidgee Flood Control & Irrigation District	1, 4, 5, 6 & 8	>11,000 ML/d at Redbank Weir	15,000 ML	Sep – Dec 2011	In-channel to off take	15,000 ML diverted into the lower section of Fiddlers Creek from the South Caira/Warwaegae off take regulator will water the western portion of Fiddlers Creek and Yanga Nature Reserve. This option is contingent on access being granted by local landowners for use of key water delivery channels.

Asset	Water Management Objective Met*	Target flow rate/Volume to fill	Estimated volume	Timing & Duration	Delivery mechanism	Operational considerations
Yanco-Colombo-Billabong Creek System						
River-fed wetlands; particularly Dry Lake and Molley's Lagoon	1, 2, 3 & 8	22,500 ML/d at Narrandera	2,000-4,000 ML	Sep – Dec 2011	In-channel from Yanco Creek.	Flows in excess of 22,500 ML/d at Narrandera will cause Dry Lake and Molley's Lagoon (in the upper catchment) to commence to fill. Volumes required depend on antecedent conditions, i.e. 2,000 ML if wet. Regulators are currently being built to manage flows between the Lake and Creek. Bankfull flows down the top of the Yanco system occur at approximately 1,400 ML/day. A flow of approximately 32,000 ML/day at Gundagai will result in flows of greater than 2,000 ML/day down this system.
Wanganella Swamp, Forest Creek and Billabong Creek	2, 6, 7 & 8	100 ML/day along Forest Creek downstream of Warriston Weir	15,000 ML	Sep – Dec 2011	Hartwood Weir diversions into regulated Forest Creek, to Warriston Weir and hence to Swamp (via unregulated Forest Creek)	Delivery of water to Wanganella Swamp is challenging. Use of Murrumbidgee irrigation infrastructure may be possible but has not been trialled. The main mechanism for delivery is using Murray Irrigation Limited infrastructure to deliver water out of the Finley escape into Billabong Creek, from which water can then be diverted to Forest Creek via Hartwood Weirpool.

* *From Section 1.4.*

Table 7: Total release volume estimate and monthly water allocation profile. All figures are in ML. Olive green cells indicate optimum delivery time in 2011-12.

Asset	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Total
Murrumbidgee River Channel and Mid-Murrumbidgee Wetlands													
Murrumbidgee River and the Mid-Murrumbidgee wetlands	0	75,000	75,0000	0	0	0	0	0	0	0	0	150,000	300,000^
Murrumbidgee Irrigation Area: Mirrool Creek System													
Fivebough Swamp	0	0	240	0	0	0	0	0	0	0	0	0	240
Tuckerbil Swamp	0	0	465	135	0	0	0	0	0	0	0	0	600
Barren Box Swamp	0	0	3,000	3,000	0	0	0	0	0	0	0	0	6,000
Lowland floodplain wetlands below Balranald (‘the Junction’ wetlands)													
Junction wetlands *	0	0	100,000	80,000	0	0	0	0	0	0	0	0	180,000
Lowbidgee Floodplain													
Yanga National Park (south of Tala Lake)	0	0	15,000#	15,000	15,000	15,000	0	0	0	0	0	0	60,000
Nimmie-Caira	0	0	20,000#	20,000	20,000	10,000	0	0	0	0	0	0	70,000
Redbank North and Yanga systems	0	0	15,000#	15,000	15,000	15,000	0	0	0	0	0	0	60,000
Yanga Nature Reserve and other wetlands	0	0	4,000#	4,000	4,000	3,000	0	0	0	0	0	0	15,000
Yanco-Colombo-Billabong Creek System													
River-fed wetlands	0	0	1,000	1,000	1,000	1,000	0	0	0	0	0	0	4,000
Wanganella Swamp	0	0	6,000	6,000	3,000	0	0	0	0	0	0	0	15,000

Notes:
^ It is likely that only one piggy back / stand alone event may be undertaken during the 2011-12 water year.
 # pink shading indicates that there a significant constraints to the delivery of these volumes of water, in some instances the floodplain requires a drying phase (such as northern Yanga National Park) and in other areas use of water delivery channels may not be possible.
** It is possible that a flow delivered from Burrinjuck / Blowering to water the Mid-Murrumbidgee wetlands during August / September may meet part of this requirement.*

1.11. Assessing Environmental Watering Options

Possible watering actions for 2011-12 have been considered against the Criteria for Assessing Environmental Watering Actions (see Appendix D). Briefly, the criteria are the:

- ecological significance of the asset(s)
- expected ecological outcomes from the proposed watering action
- potential risks of the proposed watering action at the site and at connected locations
- long-term sustainability of the asset(s) including appropriate management arrangements
- Cost-effectiveness and operational feasibility of undertaking the watering.

Detailed description of the criteria for assessing environmental watering actions is provided at Appendix C.

The assessment will be reviewed as individual watering actions are closer to their proposed timing for delivery. The review will include a more comprehensive risk assessment which is subject to the prevailing catchment and river flow conditions, and will consider in more detail proposed costs, delivery, monitoring and accounting arrangements. Any additional watering options identified during the course of the year will also be subject to an assessment against the criteria.

1.12. Water Use Accounting

In the regulated Murrumbidgee River and associated systems, environmental flows are delivered by State Water Corporation. The water delivered is generally measured at the user's diversion off take and any transmission losses are met by State Water. However, any transmission losses incurred whilst using private irrigation channels to water assets will be debited against the water shareholder.

Recrediting of return flows to individuals is not possible in NSW. While a number of alternative accounting mechanisms were trialled during the 2010-11 water year it is likely that these mechanism will not be available during 2011-12. While a policy for management and use of return flows does not exist in NSW it is expected that their CAIRO water balance model would contain the necessary information such as observed flow hydrograph volumes, tributary inflows, irrigation diversions and drainage return flows.

Table 8 provides a summary of key water use accounting issues and opportunities in the Murrumbidgee River catchment

Table 8: Water accounting arrangements for assets in the Murrumbidgee River catchment.

Asset	Accounting Arrangement
Mirrool Creek System (MIA)	No transmission losses would be accounted against the entitlement holder to the bulk off takes for the MIA (Main Canal and Sturt Canal). Once environmental water enters the MIL drainage network, MIA will assess transmission losses for water delivered, and reduce the volume of water at the asset accordingly. Any environmental water temporarily stored in Barren Box Swamp would also incur evaporative losses.

Asset	Accounting Arrangement
Mid-Murrumbidgee Wetlands	When a flow augmentation event has been managed to target the Mid-Murrumbidgee wetlands it is expected a portion of these releases will remain in-stream and may be available for downstream uses, such as watering the Lowbidgee Floodplain. The volume of water would need to be assessed on an event-by-event basis.
Lowbidgee Floodplain	Environmental water delivered to bulk off takes for Nimmie-Caira, Yanga or North Redbank assets would not incur any transmission loss. However, losses in the Lowbidgee Irrigation District would be debited against the water holder. There is potential for return flows to be delivered to the Murray River, though this requires a change in policy by NSW.
Lowland floodplain wetlands below Balranald ('the Junction' wetlands)	Balranald Weir is the last water control structure on the Murrumbidgee River. Flows delivered to this point would not incur transmission losses.
Yanco-Colombo-Billabong Creek System	For deliveries to wetlands and anabranches on the regulated Yanco-Colombo- Billabong Creek system there will be no transmission losses accounted against the Commonwealth. Any delivery to the system using Coleambally Irrigation Limited irrigation infrastructure may need to account for transmission losses. Any environmental flows targeting the Forest Creek system could generate end-of-system flows into the Edward River.

1.13. Risk Management

A full risk assessment will be undertaken for each watering action on an event by event basis as part of the assessment process, building upon the preliminary risk assessment included for groups of assets at Appendix D. A summary of some of the key risks are presented at Table 9.

Table 9: Likely risks, their context and potential mitigation.

Risk	Context and Mitigation
Rapid water level decline resulting in fauna stranding and unsuccessful breeding	Colonial-breeding waterbirds and aquatic fauna are particularly susceptible to rapid water declines in wetland habitats. For fish and amphibians the risk is greatest during spring and summer, when fingerlings and tadpoles are too small to move or metamorphose (respectively) before their nursery habitats dry. Breeding stimuli for waterbirds differs between the species, but many respond primarily to flooding, and the season in which the flood occurs. This means that flooding induces breeding in most waterbirds, and the best responses are in spring following inundation of previously dry wetlands (Scott 1997). Hence actions to mitigate rapid water declines are most likely required during spring and summer, but for waterbirds could occur at any time throughout the year. Mitigation is best achieved by delivering freshes to maintain steady water levels, or a slow recession.
Prolonged inundation of floodplain vegetation	Different wetland vegetation communities require different inundation periods. Some wetland species can tolerate permanent inundation, but most woody species cannot tolerate flooding for longer than 12-24 months.

Risk	Context and Mitigation
	As a general rule wetlands in the Murrumbidgee River catchment should be inundated for a maximum 12 months before they are allowed to dry.
Inappropriate watering regime	Unseasonal flooding events and durations between floods may affect fauna and flora responses. Adaptive management of watering opportunities to maximise delivery to assets in the most appropriate season is recommended.
Invasive species introduction (in the case of the Mirrool Creek system)	Small patches of alligator weed (*Alternanthera philoxeroides*) are known to occur in the Wah Wah Irrigation District, and in Barren Box Swamp. The species is highly invasive, and known to be distributed on floodwaters. The use of booms and weed traps, and inspection and physical removal is recommended. Barren Box Swamp should be avoided as a storage facility for environmental water. If a watering event for the Lower Mirrool Creek Floodplain is planned the relevant state and local weed control authorities must be given at least three months to prepare, and then implement control actions.

Flooding of properties and infrastructure.	Water will be delivered by State Water Corporation using normal procedures. This includes State Water Corporation informing the community and landholders of rising water levels.
	▪ Flood levels according to the Bureau of Meteorology (BOM) for the Murrumbidgee are: (http://www.bom.gov.au/nsw/flood/southwest.shtml)[1]
	  ▪ Murrumbidgee River at Gundagai - Minor: 6.10 m; Moderate: 7.60m; Major: 8.50 m.
	  ▪ Murrumbidgee River at Wagga Wagga - Minor: 7.30 m; Moderate: 9.00, Major: 7.70 m.
	Note the Tenandra Bridge on the Mundarlo Road near Gundagai is affected when flows reach 5.15 m.

1.14. Key Constraints

Key constraints on delivering environmental water in the Murrumbidgee River catchment are:

[1] Definitions sourced from BOM (http://www.bom.gov.au/water/floods/floodWarningServices.shtml): Minor flooding: Causes inconvenience. Low-lying areas next to watercourses are inundated which may require the removal of stock and equipment. Minor roads may be closed and low-level bridges submerged; Moderate flooding**:** In addition to the above, the evacuation of some houses may be required. Main traffic routes may be covered. The area of inundation is substantial in rural areas requiring the removal of stock; Major flooding**:** In addition to the above, extensive rural areas and/or urban areas are inundated. Properties and towns are likely to be isolated and major traffic routes likely to be closed. Evacuation of people from flood affected areas may be required.

- During winter (June and July) some parts of the MIL water supply system may be closed for maintenance and upgrade works. Depending on the location of works, water supply from the Murrumbidgee River may be restricted.
- Flows in Tumut River downstream of Blowering Dam are limited to less than 9,300 ML/day to minimise bank erosion.
- Yanco Weir has a maximum diversion capacity of 1,400 ML/day to Yanco Creek. Higher volumes can be managed; however this tends to cause floodplain inundation.
- Some weirs in the Yanco-Colombo-Billabong Creek System limit small to medium natural flood events.
- Flows downstream of Gundagai are not to exceed a maximum of 32,000 ML/day to avoid inundation of the Tenandra Bridge on the Mundarlo Road.

1.15. Event Monitoring

In relation to this strategy and associated watering options the following monitoring and reporting activities are expected to be undertaken (Table 10). Additional monitoring will be considered on an event-by-event basis closer to the time of the action.

Table 10: Monitoring arrangements for environmental flows in the Murrumbidgee River catchment.

Location	Parameters	Timing/frequency	Responsibility
Compliance/operational Monitoring			
Selected wetlands and floodplain assets throughout the system.	Hydrologic connectivity; wetland inundation levels	Event-by-event	State Water Corporation, OEH, NOW, and local irrigation cooperatives (if appropriate).
Intervention/response Monitoring			
Selected wetlands throughout the system.	Amphibians	Event-by-event and/or annual surveys in spring/summer	OEH and Charles Sturt University monitor frog populations at selected sites throughout the system, especially southern bell frog sites in Lowbidgee.
Selected waterbird rookeries throughout the system.	Waterbirds	Event-by-event and/or annual surveys in spring/summer	OEH monitor waterbird populations at selected sites throughout the system, especially rookeries in the Lowbidgee. Waterbird populations at Tuckerbil and Fivebough Swamps are monitored by the Fivebough and Tuckerbil Wetlands Trust.
In-stream channel and pool habitats (especially weir pools), and selected wetland habitats throughout	Algae	Monthly	NOW manages an algal program that provides counts of blue-green algae at selected sites.

Location	Parameters	Timing/frequency	Responsibility
the system.			
Wetlands and pool habitats throughout the system	Fish	Event-by-event and/or annual surveys in spring/summer	Fisheries, in cooperation with the Commonwealth. Fisheries can monitor sites throughout the system, but this will likely need to be negotiated with the Commonwealth when finalising the action.
Condition Monitoring			
Selected sites throughout the system.	Floodplain vegetation	Event-by-event and/or annual surveys in spring/summer	OEH and NOW monitor the condition of selected wetlands throughout the system. Murrumbidgee Irrigation monitors vegetation rehabilitation in Barren Box Swamp.
Selected wetlands throughout the system, and in-channel	Water physico-chemistry	Event-by-event and/or annual surveys in spring/summer	NOW manages current instantaneous salinity, dissolved oxygen, turbidity, pH and temperature monitoring at a number of gauging stations in the system.

Reporting requirements in relation to this strategy
A consolidated report offering key results and highlighting beneficial and adverse results and outcomes should be compiled after each event, and annually. The report should also include 'lessons learnt', and provide advice on future adaptive management measures.

Appendix A Environmental Assets

Murrumbidgee River Channel

The character and context of the Murrumbidgee River changes from confined gorges and valleys in the cool and humid uplands, through lower confined floodplains and riverine plains with large meander scars and anabranches in the temperate slopes, to open floodplains in the arid lands of the western plains (MDBC 2002). Bankfull channel width varies from 80 m at Wagga Wagga to less than 50 m at Balranald, and stream energy is generally low (Page *et al*. 2005).

Native overstorey riparian vegetation includes river red gum, black box, grey box (*Eucalyptus microcarpa*), river oak (*Casuarina cunninghamiana*) and white cypress pine (*Callitris glaucophylla*). However, plant communities are generally degraded with a high proportion of exotic species and poor regeneration of native species (Jansen & Robertson 2001 in MDBC 2002). Common exotic species include willow (*Salix* spp.), osage-orange (*Maclura pomifera),* pepper tree *(Schinus areira)* and *Prunus* spp. Overall condition of the Murrumbidgee River downstream of Burrinjuck Dam is considered poor (MDBC 2002), such that the Murrumbidgee River is included as part of *Aquatic ecological community in the natural drainage system of the lower Murray River catchment* (NSW *Fisheries Management Act 1994*). There are some isolated patches of plant communities that are in good condition, and the Murrumbidgee River channel in the Lowbidgee is recognised as a fish biodiversity hotspot (pers. comm. Lorraine Hardwick, NOW 2011).

The Murray Darling Basin Plan Key Fish Assets – Information supporting the development of the Murray Darling Basin Plan (Lugg and Baumgartner 2011) identified the following assets in the Murrumbidgee River channel as extending from:

1. Wantabadgery to Hay; and
2. Redbank weir to Murray confluence.

The values of these assets include:

1. Diverse native fish community including a robust population of Murray cod (*Maccullochella peelii*: Commonwealth vulnerable);
2. Robust reintroduced population of trout cod (*Maccullochella macquariensis:* Commonwealth endangered*);*
3. Large area of connected, high quality habitat. Riparian vegetation and snags generally intact and in good condition.
4. *Aquatic ecological community in the natural drainage system of the lower Murray River catchment* (NSW *Fisheries Management Act 1994*); and
5. Recruiting population of silver perch (*Bidyanus bidyanus:* vulnerable*;* NSW *Fisheries Management Act 1994*).

Mid-Murrumbidgee Wetlands (Gundagai to Maude)

The Mid-Murrumbidgee wetlands are located on the Murrumbidgee River floodplain between Gundagai and Maude (Figure 10). They support open water habitat and include aquatic macrophytes such as spike rushes (*Juncus* spp. or *Eleocharis* spp.), garland lily (*Calostemma* *purpureum*) and blanket fern (*Pleurosorus rutiflolius*) (CSIRO 2008). Riparian overstorey vegetation is dominated by river red gum forest and woodland, with black box woodland on the floodplain (NRC 2009). Several of the wetlands rarely dry out, providing important drought refuge for a range of flora and fauna, including threatened species (MDBA 2010a).

The Mid-Murrumbidgee wetlands have been recognised as a hydrologic indicator site in the Murray-Darling Basin, and identified as part of the Natural Drainage System of the Lower Murray River Catchment aquatic endangered ecological community, listed under the NSW *Fisheries Management Act 1994*.

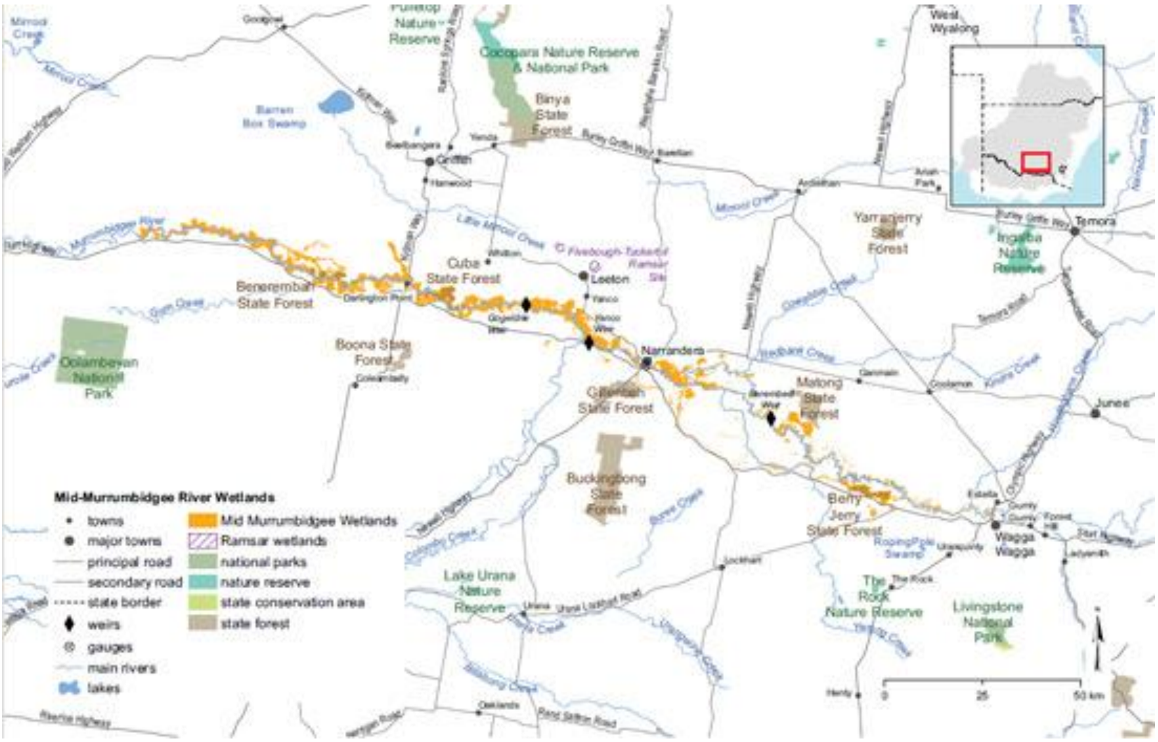

Figure 10: Location and extent of hydrologic indicator site: Mid-Murrumbidgee-River Wetlands (Source: MDBA 2010a).

Fivebough and Tuckerbil Swamps

Tuckerbil and Fivebough Swamps are listed under the Convention on Wetlands of International Importance (Ramsar Convention) because they support habitat for threatened migratory and local waterbirds. Both Swamps were originally terminating wetlands in separate natural depressions. Tuckerbil Swamp was naturally ephemeral, filling from local runoff during winter and spring then gradually drying out over summer. Its current regime is drier, with managed inundation events occurring every second year on average. Wetland habitats at Tuckerbil Swamp include gilgai, saline flats (dominated by samphire *Sclerostegia tenus* and seablite *Sueda bacciflora),* areas of black box, belah (*Casuarina cristata*), lignum and cumbungi (*Typha domingensis*) (Fivebough & Tuckerbil Wetlands Trust Inc. 2002).

Fivebough Swamp was also naturally ephemeral, filling each winter from local rainfall and runoff and remaining wet until the following spring/summer (Fivebough & Tuckerbil Wetlands Trust Inc. 2002). The current regime is significantly changed from natural, with several water sources (including treated sewage effluent discharge) creating permanent and ephemeral wetland habitats in the Swamp. This provides a range of foraging and refuge habitats for waterbirds. The dominant vegetation species are cumbungi, water couch (*Paspalum distichum*), common couch (*Cynodon dactylon*), and barley grass (*Hordeum leporinum*). Some gilgai also support seablight (Fivebough & Tuckerbil Wetlands Trust Inc. 2002).

Barren Box Swamp

Barren Box Swamp is located in the MIA, approximately 30 km north-west of Griffith. Prior to water resource development the Swamp was a large ephemeral wetland, supporting black box woodland with a lignum understorey (DEC 2008). From the 1960s the Swamp was used as a permanent storage facility, causing the loss of ephemeral wetland vegetation, and creating a lake environment with declining water quality and habitat value. It was also an inefficient water storage facility, with high evaporative losses. Engineering works in the early 2000s divided the wetland into three 'cells', creating two operational cells for irrigation water storage and delivery, and another wetland cell set aside for conservation purposes. The wetland cell is being rehabilitated to support black box woodland, with some managed releases into a small wetland area. The site likely provides habitat for local and migratory wetland birds when the wetland is inundated, with the rehabilitated black box woodland potentially providing un-grazed woodland habitat for terrestrial fauna and flora.

Lowland floodplain wetlands below Balranald ('the Junction' wetlands)

The Balranald to Murray River junction reach of the Murrumbidgee River extends 21 km south west of Balranald until its confluence with the Murray River. At Balranald the floodplain consists of a narrow band of land either side of the Murrumbidgee River, but it expands into a broad delta west of Waldaira Lake, incorporating a number of creeks and lagoons (e.g. Jack O'Brien's, Mainie and Peacock Creeks), and areas of river red gum woodland, black box and mallee.

The area is environmentally significant with a number of threatened species reliant on the riparian and woodland habitats known to occur, in addition to ibis (*Threskiornis* spp. and *Plegadis falcinellus*), cormorant (*Phalacrocorax* spp.) and spoonbill (*Platalea* spp.) rookeries at wetlands on the floodplain. Specific assets include Waldaira Lake, Bulumpla Lagoon, Chalmers Lagoon, Pelican Lagoon, Mainie Station Lagoon, Peacock Flora Reserve and the Murrumbidgee River channel and corridor.

Lowbidgee Floodplain

The Lowbidgee Floodplain is listed on the Directory of Important Wetlands in Australia (Environment Australia 2001). The nationally significant area comprises a complex of three wetland systems with distinct hydrological characteristics and ecological features on the floodplain between Hay and Balranald (Figure 8). These are the Nimmie-Caira, Fiddlers-Uara Creek and Redbank systems. Watering of these wetlands is highly dependent upon flows from the Murrumbidgee River (Kingsford & Thomas 2004).

The Lowbidgee Floodplain wetland ecosystem is recognised as an area of high conservation value as it provides important habitat for a range of aquatic and terrestrial species including frogs, fish and waterbirds. The floodplain also supports significant areas of river red gum forests, while wetlands in the area provide habitat for the Commonwealth and State-listed threatened species southern bell frog and fishing bat, and support some of the largest recorded breeding colonies of waterbirds in NSW.

Vegetation communities of the Lowbidgee Floodplain vary considerably across the different hydrological strata and depend on specific watering regimes and soil conditions. Areas subject to more frequent flooding such as the Nimmie-Caira system support extensive areas of lignum, whilst areas subject to less frequent flooding (isolated or stranded by infrastructure), such as the Fiddlers-Uara system support lignum and black box woodland. Wetlands of the Lowbidgee Floodplain form part of the NSW *Fisheries Management Act* 1994 Aquatic Ecological Community in the Natural Drainage System of the Lower Murray River Catchment endangered ecological community. In the Redbank system, some river red gum forests remained dry for up to 10 years until recent flooding, whilst others have been more regularly inundated. In general though, regulation has reduced the frequency of natural flood events that inundate the Lowbidgee Floodplain system. Combined with the effects of agriculture, this has reduced the extent of the wetlands.

Reduced and fragmented wetland habitat combined with drought conditions has placed pressure on a number of waterbird species and also the southern bell frog. Wassens *et al.* (2008) found that wetlands that were flooding annually were more likely to support southern bell frog than those less frequently flooded. A number of wetlands in the Redbank and Nimmie-Caira systems provide core habitat for the southern bell frog.

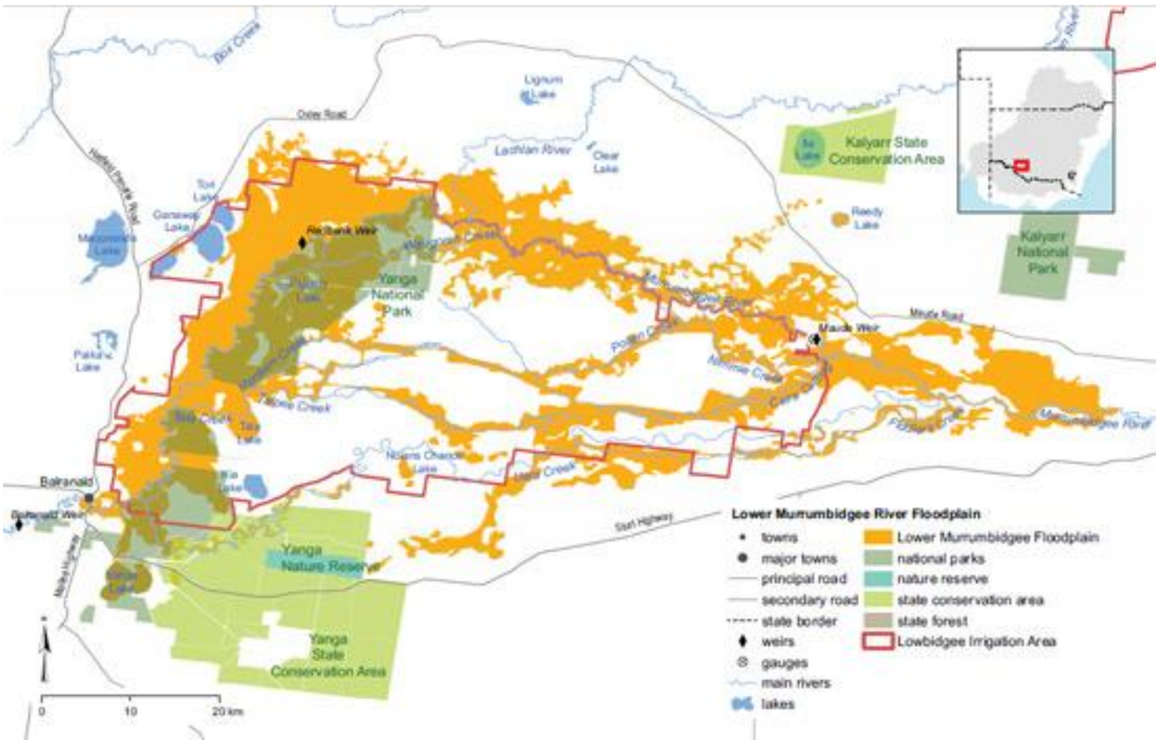

Figure 8: Location and extent of hydrologic indicator site: Lower Murrumbidgee River Floodplain (Source: MDBA 2010a).

Yanco-Colombo-Billabong Creek System

Yanco Creek is major distributary of the Murrumbidgee River, which bifurcates from the Murrumbidgee approximately 15 km west of Narrandera. Under natural conditions, the system was ephemeral with Yanco Creek receiving inflows when flows in the Murrumbidgee River exceeded 40,000 ML/day at Narrandera (White *et al.* 1985).

The system is comprised of Yanco Creek, Colombo Creek, Billabong Creek and the Forest Creek system (which consists of a number of creeks including Forest Creek, Eight Mile Creek, Back Creek, Estuary Creek and the Forest Anabranch). Flows from the Yanco-Colombo-Billabong Creek System join the Edward River at Moulamein, eventually joining the Murray River downstream of Stoney Crossing.

The Murray Darling Basin Plan Key Fish Assets – Information supporting the development of the Murray Darling Basin Plan (Lugg and Baumgartner 2011) identified the following assets in the Yanco – Colombo Creek channel as extending from:

1. Yanco weir to Billabong Creek confluence.

The values of this asset includes:

1. Diverse native fish community including a robust population of Murray cod (*Maccullochella peelii*: *Commonwealth vulnerable*);
2. Robust reintroduced population of trout cod (*Maccullochella macquariensis: Commonwealth endangered);*
3. Large area of connected, high quality habitat. Riparian vegetation and snags generally intact and in good condition.
4. *Aquatic ecological community in the natural drainage system of the lower Murray River catchment* (NSW *Fisheries Management Act 1994*);
5. Recruiting population of silver perch (*Bidyanus bidyanus:* vulnerable; NSW *Fisheries Management Act 1994*); and
6. Eel – tailed catfish (*Tandanus tandanus*: endangered population in the Murray Darling Basin; NSW *Fisheries Management Act 1994*) particularly in Colombo Creek.

Key wetland areas are Dry Lake and Molley's Lagoon, a series of floodplain wetland complexes on upper Yanco Creek, Lake Urana, Mundoora/Wilsons Creek Anabranch, Wanganella Swamp, Kerribirri Swamp, 'Rhyola' depressions and flood runners, break out areas on 'Back Nullum', and Box Swamp on 'Blue Gate'.

Wanganella Swamp is approximately 470 ha of reed wetland, located in the Forest Creek system. It is particularly significant for its waterbird breeding habitat, providing opportunities for threatened species such as blue-billed duck (*Oxyura australis*), Australasian bittern (*Botaurus poiciloptilus*), and brolga (*Grus rubicundus*) (Ecosurveys Pty Ltd 2010).

Irrigation channels and dams near Colleambally provide critical habitat for the southern bell frog (Beal *et al.* 2003). Numerous other threatened species reliant on floodplain and riverine habitats also occur in the Yanco-Colombo-Billabong Creek System.

Appendix B Watering Options for the Murrumbidgee River Catchment

Environmental Asset	Management objectives for specific water availability scenarios			
	Extreme Dry Goal: Avoid damage to key environmental assets	**Dry** Goal: Ensure ecological capacity for recovery	**Median** Goal: Maintain ecological health and resilience	**Wet** Goal: Improve and extend healthy and resilient aquatic ecosystems
River-fed wetlands (Gundagai to Maude (includes all the Mid-Murrumbidgee wetlands).	▪ No options – requires median levels of water availability.	▪ Should a suitable piggyback event occur, seek to exceed 27 GL/day at Wagga Wagga to inundate low-lying Mid-Murrumbidgee Wetlands, or use irrigation infrastructure to inundate prioritised Mid-Murrumbidgee River wetlands (e.g. McKenna's Lagoon, various MIA National Park wetlands, Sunshower Lagoon). Inundate these for at least three months to create a mosaic of wetting and drying habitats throughout the catchment, and maintain and/or improve wetland vegetation communities to good condition.	▪ Should a suitable piggyback event occur, seek to exceed 45 GL/day at Wagga Wagga to inundate low-lying Mid-Murrumbidgee Wetlands, or use irrigation infrastructure to inundate prioritised Mid-Murrumbidgee River wetlands (e.g. McKenna's Lagoon, various MIA National Park wetlands, Sunshower Lagoon). Inundate these for at least three months to create a mosaic of wetting and drying habitats throughout the catchment, and maintain and/or wetland vegetation communities to good condition. ▪ Increase the area and duration of inundation of high conservation value Mid-Murrumbidgee Wetlands to maintain or improve wetland vegetation communities to good condition. ▪ Inundate these for at least five months, commencing in spring. Use carryover to provide optimal seasonal flow patterns in subsequent years. ▪ Piggyback releases onto significant tributary freshes inundating the low-lying river-fed wetlands from Gundagai to Maude Weir, increasing high flow duration and extent across the floodplain.	▪ Should a suitable piggyback event occur, seek to exceed 60 GL/day at Wagga Wagga to inundate low-lying Mid-Murrumbidgee Wetlands, or use irrigation infrastructure to inundate prioritised Mid-Murrumbidgee River wetlands (e.g. McKenna's Lagoon, various MIA National Park wetlands, Sunshower Lagoon). Inundate these for at least three months to create a mosaic of wetting and drying habitats throughout the catchment, and maintain and/or wetland vegetation communities to good condition. ▪ Increase the area and duration (>7 months) of inundation of Mid-Murrumbidgee Wetlands, to maintain and/or improve wetland vegetation communities to good condition. ▪ Piggyback releases onto significant tributary freshes inundating the majority of river-fed wetlands from Gundagai to Maude Weir, and increasing high flow duration and extent across the floodplain. ▪ Maintain and complete any colonial waterbird breeding event initiated by natural flood event or environmental flows.
Fivebough Swamp	▪ Use whatever water is available to inundate Fivebough Swamp. Water traded in from the Murray River, or carryover, could be used.	▪ Use whatever water is available to inundate Fivebough Swamp. Water traded in from the Murray River, or carryover, could be used.	▪ Inundate Fivebough Swamp to maintain or improve wetland vegetation communities to good condition. Requires approximately 200 ML.	▪ Inundate Fivebough Swamp to maintain or improve wetland vegetation communities to good condition. Requires approximately 200 ML.
Tuckerbil Swamp	▪ Use whatever water is available to inundate Tuckerbil Swamp. Water traded in from the Murray River, or carryover, could be used.	▪ Use whatever water is available to inundate Tuckerbil Swamp. Water traded in from the Murray River, or carryover, could be used.	▪ Inundate Tuckerbil Swamp to maintain or improve wetland vegetation communities to good condition. Requires approximately 500 ML.	▪ Inundate Tuckerbil Swamp maintain or improve wetland vegetation communities to good condition. Requires approximately 500 ML.
Barren Box Swamp	▪ No options – requires median levels of water availability.	▪ No options – requires median levels of water availability.	▪ Inundate the wetland area of the Wetland Cell. This requires 3,000-5,000 ML.	▪ Increase the area and duration of inundation in the Wetland Cell, in accordance with the MI Ltd (2008) Barren Box Wetland Rehabilitation Plan. ▪ Maintain and complete waterbird breeding events initiated by environmental flows.
Lowland river-fed wetlands (Balranald to	▪ No options – requires median levels of water	▪ No options – requires median levels of water	▪ Ensure 'the Junction wetlands' are watered by	▪ Increase the area of river red gum woodland

Environmental Asset	Management objectives for specific water availability scenarios			
	Extreme Dry Goal: Avoid damage to key environmental assets	**Dry** Goal: Ensure ecological capacity for recovery	**Median** Goal: Maintain ecological health and resilience	**Wet** Goal: Improve and extend healthy and resilient aquatic ecosystems
Murray River junction, including 'the Junction' wetlands)	availability.	availability.	managing high Murrumbidgee flows to coincide with high Murray River flows. ▪ Piggyback releases onto significant Murrumbidgee and Murray River flows to inundate the Junction wetlands south of Balranald. ▪ Requires delivery of >5 GL/day downstream of Balranald Redbank Weir in addition to Murray River flow >10 GL/day at Barham on the Murray River for a period of several weeks.	communities in good condition by watering more wetlands for longer (e.g. at least five months). ▪ Requires delivery of >5 GL/day downstream of Balranald Redbank Weir in addition to Murray River flow >10 GL/day at Barham on the Murray River for a period of several weeks.
Lowbidgee Floodplain	▪ During late spring and summer use whatever water is available to fill the highest priority southern bell frog wetlands. (Core southern bell frog wetlands in the Murrumbidgee floodplain are the Lowbidgee floodplain (Maude-Balranald) (Wassens 2008, Wassens *et al*. 2010) and the new populations in the Mid-Murrumbidgee (Wassens and Amos 2011). ▪ For waterbirds, if there is no available water, then there are no options. If there is water available use this to avoid damage to as many sites as possible, in conjunction with watering for southern bell frog. ▪ Water traded in from the Murray River, or carryover, could also be used to inundate key areas.	▪ Maintain in good condition as many known southern bell frog sites and colonial nesting waterbird sites as possible. ▪ Use carryover volumes to maintain follow-up watering.	▪ Provide maintenance flows to key waterbird rookeries which may establish in Yanga National Park. ▪ Inundate key rookeries and other wetlands of the Nimmie-Caira system, creating and sustaining a waterbird breeding event. Requires 60-70 GL. ▪ Flood larger southern bell frog wetlands in the Lowbidgee (Maude and Redbank systems) to facilitate significant distribution of the population (e.g. Eulimbah Swamp requires 6 GL, Twin Bridge requires 4 GL.) ▪ Flood prioritised sections of privately owned river red gum forest/woodland and lignum creeks/swamps in the Lowbidgee from both Redbank and Maude Weirs. Requires approximately 50-60 GL. ▪ Flood the northern section of river red gum forest in Yanga National Park (above Tala Lake). Requires approximately 60 GL. ▪ Flood southern sections of river red gum forest in Yanga National Park (south of Tala Lake) using the channel systems from Maude Weir to greatest efficiency, and through flows from North Yanga (which may have more environmental benefit). Requires approximately 50-60 GL.	▪ Maintain and complete any southern bell frog and colonial waterbird breeding events initiated by natural flood event or environmental flows. ▪ Maintain river-floodplain connectivity initiated by natural flood events or environmental flows. ▪ Inundate the Lowbidgee Floodplain and river red gum forest north of Redbank Weir to Balranald. Requires approximately 100 GL. ▪ Inundate extensive areas of the Yanga Nature Reserve and other significant wetlands located outside the Lowbidgee Flood Control and Irrigation District (e.g. Yanga Lake). Requires approximately 100 GL.
Yanco-Colombo-Billabong Creek System	▪ No options – requires median levels of water availability.	▪ No options – requires median levels of water availability.	▪ Inundate extensive areas of Wanganella Swamp to maintain or improve semi-permanent aquatic communities to good condition. ▪ Inundate extensive areas of Wanganella Swamp to encourage colonial waterbird breeding event,	▪ Maintain and complete any colonial waterbird breeding events initiated by natural flood event or environmental flows. ▪ Maintain and complete any fish movement events initiated by natural flood events or environmental

Environmental Asset	Management objectives for specific water availability scenarios			
	Extreme Dry Goal: Avoid damage to key environmental assets	**Dry** Goal: Ensure ecological capacity for recovery	**Median** Goal: Maintain ecological health and resilience	**Wet** Goal: Improve and extend healthy and resilient aquatic ecosystems
			holding some water in reserve if needed to complete the breeding event. ▪ Requires 1,500 ML to inundate 470 ha of Wanganella Swamp (Webster & Davidson 2010). ▪ Inundate Forest Creek and associated downstream wetlands, creating an end-of-system flow to Moulamein.	flows.

Appendix C Criteria for Assessing Commonwealth Environmental Watering Actions

In undertaking its activities, the Commonwealth Environmental Water Holder (CEWH) is required to act consistently with the requirements of the *Water Act 2007* (Cwlth) (hereafter referred to as 'the Act'). The relevant functions are outlined in s.105. This includes a requirement that the environmental water holdings are managed in accordance with the environmental watering plan of the Murray-Darling Basin Authority (MDBA). Close consultation is occurring with the MDBA to ensure that use of Commonwealth water is consistent with the emerging objectives of the environmental watering plan that is currently being developed.

A long-term framework for the prioritisation of environmental water allocations has been prepared in consultation with delivery partners, interested stakeholders and experts, and the Environmental Water Scientific Advisory Committee.

The framework includes ecological objectives that will change under the different water availability scenarios (i.e. extreme dry, dry, median and wet). Proposed watering actions will need to be supported by available evidence, and consistent with current water availability scenarios and the framework.

Commonwealth environmental water is being acquired to supplement existing flows. Proposals for use of the water will not be agreed to if this use substitutes for other water uses, including historical system operations (e.g. provision of water for conveyance, stock and domestic, or planned environmental water).

Through adaptive management processes, the CEWH will consider opportunities for a more informed and diverse range of water uses as knowledge and modelling. All 2011-12 proposals will be assessed against the following criteria:

1. Ecological significance of the asset(s)

Issues to be considered will include:

- The presence of threatened species and ecological communities, and listed migratory species; and
- Ecological and conservation values of the assets(s) including those recognised by international agreements.

2. Expected ecological outcomes from the proposed watering action

Issues to be considered will include:

- How well defined and realistic the objectives are for the proposed watering action;
- The consistency of these objectives with the overall CEWH ecological objectives for the current forecast water availability scenario;
- The current health of the asset(s);

- The improvement in health of the asset(s) expected from the watering action;
- The Basin-wide significance of the ecological response from the watering action;
- Any secondary environmental effects expected to result from the watering action (e.g. connected system benefits); and
- The change in the health of the asset(s) expected if environmental water is not provided.

3. Potential risks of the proposed watering action at the site and at connected locations

Issues to be considered will include:

- How thoroughly the potential risks have been assessed for the proposed watering;
- The adequacy of measures proposed to minimise these risks; and
- The likelihood and consequence of variance from the expected ecological outcome (including negative impacts on biota and water quality).

4. Long-term sustainability of the asset(s) including appropriate management arrangements

Issues to be considered will include:

- The adequacy of long-term management and delivery arrangements;
- The existence of complementary natural resource management activities supporting the long-term management arrangements, including those that improve water quality; and
- The effectiveness of monitoring, evaluation and reporting arrangements for the watering activity including clear links to the defined objectives.

5. Cost effectiveness and operational feasibility of undertaking the watering

Issues to be considered will include:

- the amount of Commonwealth water and resources needed, including relative to the contribution of the State and delivery partner to (i) the watering event and (ii) subsequent monitoring of actions and outcomes;
- Opportunity to supplement natural flows or other water releases; and
- the operational feasibility of undertaking the watering action (e.g. channel capacity, infrastructure constraints, etc).

Appendix D Assessment of Watering Options

1.16. Murrumbidgee Irrigation Area (Mirrool Creek system): Fivebough, Tuckerbil and Barren Box Swamps

Fivebough, Tuckerbil and Barren Box swamps (Mirrool Creek System)	
Criteria	**Response/Assessment**
1. Ecological Significance of the asset(s)	Fivebough and Tuckerbil swamps: Fivebough and Tuckerbil Swamps are listed under the Convention on Wetlands of International Importance (Ramsar Convention), recognised for providing habitat that supports significant numbers of threatened waterbird species, and species listed under international migratory waterbird agreements (JAMBA, CAMBA). Eighty-three waterbird species have been recorded at Fivebough Swamp of which twenty-four species are listed under the EPBC Act. Notable species include: Australasian bittern (*Botaurus poiciloptilus*); glossy ibis (*Plegadis falcinellus*); sharp-tailed sandpiper (*Calidris acuminata);* whiskered tern (*Chlidonias hybridus*); and, brolga (*Grus rubicund*). Both ephemeral and permanent aquatic habitats exist within the wetlands that provide important foraging and breeding habitat, and are representative of habitat types once existing more broadly within the Riverina bioregion. The ecological significance of these wetlands is well documented in the Ramsar site's ecological character description (NSW Department for Environment and Conservation 2006) and reports from other ecological studies and waterbird surveys (reference is list provided in the Australian Wetlands Database, SEWPaC). Barren Box Swamp: Barren Box Swamp 'wetland cell' is part of the aquatic ecological community of the Lower Murray drainage system (including the Murrumbidgee River system below Burrinjuck Dam), which is listed in NSW as an endangered ecological community (*Fisheries Management Act,* 1994). Ecological studies have found that the site provides habitat supporting five frog species (Wassens *et al*. 2004) and fifty six water dependent bird species (Taylor and Schultz, 2010), notably the Australasian bittern (recorded in 2010). Other threatened and migratory listed species regularly observed at the site include: ○ glossy ibis (*Plegadis falcinellus*: EPBC migratory) ○ great egret (*Ardea alba*: EPBC migratory) ○ cattle egret (*Ardea ibis*; EPBC migratory) ○ white-bellied sea eagle (*Haliaeetus leucogaster*; EPBC migratory; breeding) ○ white-winged black tern (*Chlidonias leucopterus*; EPBC migratory) ○ marsh sandpiper (*Tringa stagnatilis*; EPBC migratory) ○ wood sandpiper (*Tringa glareola*; EPBC migratory) ○ sharp-tailed sandpiper (*Calidris acuminate*; EPBC migratory) ○ common greenshank (*Tringa nebularia*; EPBC migratory)

Fivebough, Tuckerbil and Barren Box swamps (Mirrool Creek System)	
Criteria	**Response/Assessment**
	○ double-banded plover (*Charadrius bicinctus*; EPBC migratory)
2. Expected ecological outcomes from the proposed watering action	Fivebough and Tuckerbil swamps are currently considered in good condition (pers. comm. Mike Schultz, Fivebough and Tuckerbil Swamps Wetland Management Trust, 2011). These wetlands have an annual watering regime that provides seasonal habitat for a wide range of waterbird species, and in the absence of environmental flows these sites would be subject to infrequent local rainfall events and stormwater runoff and at risk of declining in condition. The remnant wetland values within Barren Box Swamp have declined in condition in recent years with the death of black box trees being observed. However with the initiation of a rehabilitation plan in 2008, including an established water management regime and revegetation works, and with good rainfall and the provision of environmental water in 2010, on-going improvements in the condition of vegetation within Barren Box Swamp is anticipated. Environmental watering in Fivebough, Tuckerbil and Barren Box swamps would contribute to providing optimal foraging, refuge and breeding habitat for EPBC Act listed threatened species and migratory waterbirds in the Murray-Darling Basin, and a focal point for frog and waterbird diversity in the Murrumbidgee Irrigation Area. The proposed water use actions will further support management efforts aimed at maintaining littoral aquatic vegetation communities (Fivebough and Tuckerbil swamps) and supporting successful revegetation of the black box grassy woodland at Barren Box Swamp. The proposed watering actions will support the growth, reproduction and recruitment of significant water dependent flora and fauna species, enhance habitat condition and resilience by capitalising on outcomes from previous watering events, and improve water quality; the achievement of these objectives are in accord with the Commonwealth's framework for assessing watering actions.
3. Potential risks of the proposed watering action at the site and at connected locations	Risks associated with the proposed watering action that were assessed for this strategy are: spread and enhancement of weeds (alligator weed, *Alternanthera* philoxeroides) and pest animals (common carp, *Cyprinus carpio*), unauthorised diversion of environmental water for irrigation supply, competing channel capacity and unseasonal of delivery, and inability to sustain waterbird breeding events or result in protracted inundation of vegetation. In general, risks for the watering options for Fivebough, Tuckerbil and Barren Box swamps are considered low; unlikely to occur and of only minor consequence. Environmental flows are delivered to all sites via irrigation supply channels with diversion offtakes metered for accurate accounting of use. Other than some standard transmission losses, unauthorised diversion of environmental water is considered rare. All wetlands are fully regulated, therefore allowing sufficient water is available and can be supplied to the sites a successful completion of waterbird breeding can be maintained and the most appropriate inundation regime applied to encourage the desired vegetation response. This ability to control inflows and outflows from the wetlands will also mitigate the risk of enhancing and distributing weed propagules and

Fivebough, Tuckerbil and Barren Box swamps (Mirrool Creek System)	
Criteria	**Response/Assessment**
	carp. In abundance these invasive species may limit the achievement of ecological objectives at the site however the spread of these is well controlled with outflows restricted from all sites and extensive weed control program currently in operation; for example Alligator weed control program in Barren Box Swamp. The ability to deliver environmental water during peak environmental water demand period when irrigation demand is also high during September to December may be limited due to constraints on irrigation channel capacity. On-going communication is required with delivery partners to ensure the timing and volumes delivered are appropriate to maximise environmental outcomes. Experience from previous watering actions for these wetland sites have proven that channel constraints can be cooperatively managed. It is believed that the potential risks associated with providing Commonwealth environmental water to Fivebough, Tuckerbil and Barren Box swamps are low, but with a comparatively high chance of success in achieving the stated ecological objectives and expected response; given that it is a highly managed system and based on previous success of watering actions.
4. Long-term sustainability of the asset(s) including appropriate management arrangements	<u>Fivebough and Tuckerbil swamps</u>: The Fivebough and Tuckerbil Swamps are Crown Lands and as such are managed by the NSW Lands and Property Management Authority (LPMA). An advisory committee has been established and is comprised of various natural resource management agencies (i.e. NSW OEH, Murrumbidgee Irrigation, Murrumbidgee CMA, Leeton Shire Council, Charles Sturt University, and the local Aboriginal Land Council) and community representatives. According to the LPMA the wetlands are managed for environmental protection and public recreation (pers. comm. Melva Robb LPMA Griffith, 2011). The LPMA is currently in the process of having the Fivebough and Tuckerbil Swamps Management Plan (developed by the previous management authority, Fivebough and Tuckerbil Swamps Trust) formally adopted under the NSW *Crown Lands Act* 1989. As a Ramsar listed wetlands, these sites are protected as a matter of National environmental significance under the EPBC Act. This controls development impacts on the site's ecological character and stipulates the establishment of management planning in accordance with the scheduled Australian Ramsar Management Principles. The Fivebough and Tuckerbil Wetlands Trust actively participates in promoting the value and wise use of the wetlands, holding public meetings and forums, promoting and managing ecotourism at the sites (particularly bird watching) and conducting field days and revegetation works. These contribute to improving the extent and condition of wetland vegetation at the sites, water quality, community support, and the provision of habitat ecological services to support waterbirds and other water dependent fauna. The LPMA plans to create a monitoring plan for the Swamps however the details of this are yet to be determined. <u>Barren Box Swamp</u>: A rehabilitation plan has been established (Murrumbidgee Irrigation 2008) to promote long-term sustainability of the site for the purpose of achieving environmental outcomes. This plan establishes a watering regime based on the core values of the site,

Fivebough, Tuckerbil and Barren Box swamps (Mirrool Creek System)	
Criteria	**Response/Assessment**
	revegetation and pest management programs, fire management and monitoring plans. This site is actively managed by Murrumbidgee Irrigation and the rehabilitation plan is currently being implemented. The rehabilitation plan includes a two-part monitoring program: 1. intervention monitoring of revegetation success to inform on-going management effort; and, 2. long-term condition monitoring against ecological objectives and targets. Monitoring activities includes monthly waterbird monitoring, and vegetation monitoring using photo points and permanently established quadrats. In 2014 a report including monitoring data and progress towards ecological targets will be prepared. Environmental water management: The *Water Sharing Plan for the Murrumbidgee Regulated River Water Source 2003* specifies rules for planned environmental water and establishes entitlements for adaptive environmental water for achieving environmental outcomes within the Murrumbidgee River catchment. The adaptive environmental water allocation for the Murrumbidgee includes an allowance of 13,000 ML general security and 5,000 ML supplementary water entitlements that may be used at Fivebough, Tuckerbil or Barren Box swamps. These water entitlements are currently managed by NSW OEH. Environmental water is able to be delivered to all sites via gravity feed through the Murrumbidgee Irrigation infrastructure. Water requirements may be supplemented by localised rainfall, stormwater run-off (Fivebough and Tuckerbil swamps) or irrigation drainage (Barren Box Swamp). These sites are considered sustainable long-term through the established management arrangements and demonstrated commitment to on-ground improvements in environmental condition. The provision of Commonwealth environmental water will further enhance the sites ability to be successfully managed to meet the stated objectives.
5. Cost-effectiveness and operational feasibility of undertaking the watering	The delivery of Commonwealth water in the Murrumbidgee will incur NSW statutory delivery fees and charges of $4.39 per ML, paid to State Water and NOW. MIL charge members $2.66/ML for delivery of general security water, $3.57/ML for delivery of high security water, and a further 'conveyance cost' of $0.24/ ML. Assuming the use of general security allocation, the total estimated costs for implementing these water use actions are: ○ Fivebough and Tuckerbil swamps (700 ML) $4,676; ○ Barren Box Swamp (3,000 ML) $20,040. NSW OEH in conjunction with State Water Corporation and NSW OW and MIL will manage delivery of the Commonwealth environmental water via the use of River regulators and MIL irrigation infrastructure. No pumping is required. There are opportunities to ensure transmission losses are minimised by delivering as part of a bulk entitlement or to coincide with the end of

Fivebough, Tuckerbil and Barren Box swamps (Mirrool Creek System)	
Criteria	**Response/Assessment**
	the peak irrigation demand when channels are pre-wetted. Current water use proposals do not include contributions of environmental water from NSW adaptive environmental water entitlements nor financial contributions towards delivery costs. There will however be substantial un-costed in-kind contributions from Murrumbidgee Irrigation in terms of implementing the monitoring and rehabilitation programs.

1.17. Mid-Murrumbidgee Wetlands

Mid-Murrumbidgee Wetlands	
Criteria	**Response/Assessment**
1. Ecological Significance of the asset(s)	Twenty-nine threatened species, four ecological communities and nine migratory species listed under the EPBC Act, relevant NSW legislation and recognised in international agreements have been recorded along the Murrumbidgee Rive, an extensive list of significant water dependent species are documented in the Water use delivery document for the Murrumbidgee Valley (SKM 2011). Notable species include the endangered trout cod (*Maccullochella macquariensis*), silver perch (*Bidyanus bidyanus*, NSW vulnerable), the southern bell frog (*Litoria raniformis* - EPBC vulnerable), plains-wanderer (*Pedionomus torquatus*- EPBC vulnerable), superb parrot (*Polytelis swainsonii*- EPBC vulnerable) and floating swamp wallaby-grass (*Amphibromus fluitans*- EPBC vulnerable) (MDBA 2010), the fishing bat (*Myotis macropus* – NSW vulnerable), and Australasian bittern (*Botaurus poiciloptilus* – EPBC endangered and listed as endangered internationally on IUCN Red List), white-bellied sea-eagle (*Haliaeetus leucogaster*; EPBC migratory), Latham's snipe (*Gallinago hardwickii*; EPBC migratory) and Australian painted snipe (*Rostratula australis*, Commonwealth vulnerable, NSW endangered) (Maher, 2006; Grant, 2009; Wassens et al. 2008; Spencer and Wassens 2009). The Mid-Murrumbidgee Wetlands have also been recognised as a hydrologic indicator site in the Murray-Darling Basin (MDBA 2010a), and identified as part of the Natural Drainage System of the Lower Murray River Catchment aquatic endangered ecological community, listed under the NSW *Fisheries Management Act 1994*. The Mid-Murrumbidgee Wetlands system is listed on the Directory of Important Wetlands in Australia. It is significant because it is a good example of inland river and lagoon wetlands, providing a range of riparian and wetland vegetation. These habitats provide important drought refuge when wetlands in other parts of the State are dry.
2. Expected ecological outcomes from the proposed watering action	Overall condition of the Mid-Murrumbidgee Wetlands downstream of Burrinjuck Dam is considered poor (MDBC 2002). Prior to the 2010-11 flood the system experienced several years of drought, further adversely affecting wetland condition. Currently many of these assets are either wet or drying after being inundated, and as such their condition in the short-term can be considered poor to good. Watering actions in the system would support the survival of native riparian and in-stream vegetation, provide resilience in channel habitats allowing a quick response to repeated watering events, improve water quality, and promote natural riverine conditions. Watering actions are expected to boost the survival of current channel and riparian communities and capitalise on recent natural watering events on the system, creating optimum opportunities for fish movement and breeding, and improved habitat conditions for a suite of fauna and flora (such as fish, frogs, waterbirds, biofilms, macroinvertebrates and macrophytes). Providing a significant environmental water event in winter or spring is consistent with modelled natural conditions for the Murrumbidgee, and will reconnect a number of floodplain wetlands with the main river, providing further improvement to the ecological benefits created by the environmental watering of June 2011.

Mid-Murrumbidgee Wetlands	
Criteria	**Response/Assessment**
	If environmental water is not provided, the opportunity to consolidate and further improve the condition of the Mid-Murrumbidgee Wetlands may be lost. The main effects of river regulation and agricultural activities on the floodplain on wetland aquatic ecosystem and riparian condition are changed and unseasonal inundation regimes (some wetlands are permanently wet, while others are permanently dry), poor macrophyte and riparian cover, poor native fish populations with substantial barriers to movement, and lack of floodplain-channel interaction (Hillman *et al*. 2000). An environmental flow in the Murrumbidgee River of sufficient magnitude to inundate Mid-Murrumbidgee Wetlands would also contribute to flows in the Yanco-Colombo- Billabong Creek system and eventually the Murray River. There is also the potential to use water from this type of event to inundate assets in the Lowbidgee Floodplain.
3. Potential risks of the proposed watering action at the site and at connected locations	The primary risks associated with this type of action (assessed at a 'medium' risk level after controls) are: • *Impacting infrastructure*: Flow should be maintained at approximately 30,000 ML/day at Gundagai. Above 32,000 ML/day, the Tenandra low level bridge may have to be closed, and farmland may be inundated. The risk will be managed by State Water Corporation who will manage water releases in line with operating guidelines. Close monitoring of flow levels and stream flow forecasts prior to and during an event would be required. Releases may be modified at any point during the release in the event of unexpected rainfall. Flows would need to be monitored in real time taking into consideration catchment conditions including forecast weather and antecedent conditions. • *No natural triggers*: There is a chance that a suitable natural rainfall event to piggyback an environmental release on will not occur. If there is no natural event to trigger the use of environmental water, the watering action may have to occur without a naturally higher base flow, which may affect the outcomes of this action. The volume of water that is required for use in a standalone event will be more. • *Natural flood*: There is a risk that the trigger event for the action may be a significant rainfall event resulting in higher than desirable flows in the Murrumbidgee River and significant floodplain inundation.
4. Long-term sustainability of the asset(s) including appropriate management arrangements	EWB has contracted Charles Sturt University to undertake monitoring of the Mid-Murrumbidgee wetlands until February 2012. The monitoring will build on existing data for frog, vegetation, small bodied fish and wetland productivity. It will provide statistically robust and defensible data on the response of wetland communities to the June-July 2011 flow event. The monitoring will aim to quantify the rate of recovery of frog communities and aquatic and riparian plant communities by comparing the baseline pre-drying (1998-2005), immediately after natural flood events (2010) and following the delivery of environmental water in June-July 2011; describe temporal changes to tadpole and small bodied fishes communities following wetland flooding; quantify the exchange of dissolved organic carbon (DOC) and particulate organic carbon (POC) between riverine and wetland systems; assess the changes in biofilm biomass and diversity and abundance and diversity of aquatic macroinvertebrates in reaches downstream of Burrinjuck and Blowering dams in response to the flow pulse and generate knowledge to assist environmental water managers and dam operators to better predict future ecological responses to large releases of environmental water from dams.

Mid-Murrumbidgee Wetlands	
Criteria	**Response/Assessment**
	A total of 13 former IMEF wetland sites will be surveyed, with more intensive monitoring undertaken at a subset of six of these sites and, for the instream biofilm and macroinvertebrate sampling, that three sites downstream of Burrinjuck Dam in the Murrumbidgee River, three sites downstream of Blowering Dam in the Tumut River and one or two reference sites in the Goobarragandra River be surveyed.
5. Cost-effectiveness and operational feasibility of undertaking the watering	Any Commonwealth contribution of water will incur statutory delivery fees and charges of $4.39 per ML. OEH, together with State Water Corporation and the NOW, will manage the delivery of the Commonwealth environmental water and water from other sources. It may be possible to achieve multiple benefits from the Commonwealth environmental water by reusing some of the water for Yanga Nature Reserve and South Yanga by delivering water through the Nimmie-Caira channels. Possible re-use of environmental flows is contingent upon land holder agreement allowing the use of the Nimmie-Caira channels. Note access to these channels is currently not possible.

1.18. Lowbidgee Floodplain

Lowbidgee Floodplain	
Criteria	**Response/Assessment**
1. Ecological Significance of the asset(s)	Twenty-one threatened species, four ecological communities and eleven migratory species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), relevant NSW legislation and recognised in international agreements have been recorded along the Murrumbidgee River. The Lower Murrumbidgee River Floodplain has been listed as a key environmental asset (KEA) in the Guide to the Proposed Basin Plan (MDBA 2010a) for meeting four of the five criteria. The Lowbidgee Floodplain is also listed on the Directory of Important Wetlands in Australia (SEWPaC 2010). The Lowbidgee Floodplain contains the largest complex of wetlands in the Murrumbidgee system, including one of the largest lignum wetlands in New South Wales (CSIRO 2008). Other significant wetland areas include extensive areas of river red gum forest and woodland, and black box woodland. The area is an important floodplain nursery for native fish species, and nesting habitat for colonial-breeding waterbirds. It also supports critical habitat for southern bell frog, Southern Myotis (*Myotis macropus*) and Swift Parrot (*Lathamus discolor*) populations.

Lowbidgee Floodplain	
Criteria	**Response/Assessment**
2. Expected ecological outcomes from the proposed watering action	The Lowbidgee Floodplain has experienced extensive flooding in spring/summer 2010-11. This flooding has resulted in good connectivity between the main river channel and the floodplain, providing water to creeks and wetlands. Condition of specific wetlands varies from poor and declining (e.g. North Redbank, although Redbank Swamp is in good condition), to good condition (e.g. Tarwille South, Piggery South, Mercedes/Top Narockwell, Piggery North, Tarwille North) depending on whether sites were provided water during the drought. Historically changes to the flow regimes due to regulation in the Murrumbidgee River have had a significant impact on the hydrology of the Lowbidgee Floodplain (MDBA 2010b). Water resource development has more than tripled the average period between overbank events at Maude Weir. In addition the maximum period between high-flow events at Maude Weir has more than doubled. Watering actions in the system will support the survival and recruitment of native riparian and in-stream vegetation, provide resilience in channel and wetland habitats allowing a quick response to repeated watering events, improve water quality and promote connectivity between the river and floodplain assets. The action will also provide suitable wetland breeding and foraging habitat for frogs, and breeding of waterbirds. Watering actions are expected to boost the survival of current channel and riparian communities and capitalise on recent natural watering events on the system, creating optimum opportunities for fish movement and breeding, and improved habitat conditions for a suite of fauna and flora (such as fish, frogs, waterbirds, biofilms, macroinvertebrates and macrophytes). Providing a significant environmental water event in June/July is consistent with modelled natural conditions for the Murrumbidgee. If environmental water is not provided, the opportunity to improve resilience in wetlands in the system may be missed. Southern bell frog numbers in the system are currently low, and require annual breeding events to improve population stability. Environmental water contributes to maintaining refuge and breeding habitat for the species, and without it they are not expected to recolonise and recruit. The health of river red gums and associated wetland vegetation will also likely decline, creating reduced breeding and refuge opportunities for waterbirds. Environmental flows to the Lowbidgee Floodplain are delivered via the Murrumbidgee River, with potential benefits to in-stream habitats arising from the augmented flows to Maude and Redbank. There is also the potential to use water from the event satisfy watering requirements of downstream assets in the Murray River.

Lowbidgee Floodplain	
Criteria	**Response/Assessment**
3. Potential risks of the proposed watering action at the site and at connected locations	Childs (2009) conducted a risk assessment for Yanga National Park, and several risks for watering in other areas of the Lowbidgee Floodplain have been identified. Based on this work, the primary risks associated with the action are: • *Uncertainty in existing management arrangements:* The existing water management infrastructure in the Lowbidgee Floodplain may constrain the ability to deliver water to meet specific wetland requirements. For example, the Paika levee on the western edge of the floodplain restricts the extent of floodplain inundation on the northern and western side of the Redbank system. Without modification to infrastructure and/or additional infrastructure this section of the floodplain cannot be readily rehabilitated. • *Unauthorised diversion of environmental water by surrounding landholders*: Regular channel inspections by State Water Corporation, NOW and OEH could be scheduled prior to and during events. New flow recording stations in the north Redbank wetlands will enable shared use of the North Redbank Channel as flows will be metered both upstream and downstream of irrigation off takes. • *Common carp distribution:* If common carp are not stranded in an annual dry-down they are likely to breed to very high numbers. This can reduce the success of frog breeding at wetlands in the system. Wetlands may also act as source habitat for Common carp to enter the river channel under subsequent high flow conditions. • *Potential blackwater events:* Low dissolved oxygen levels were experienced in the Lowbidgee Floodplain during the 2010-11 flood. Because the area is currently inundated, excess organic matter is likely to have broken down and subsequent watering events are considered unlikely to create adverse water quality conditions.
4. Long-term sustainability of the asset(s) including appropriate management arrangements	Assets in Redbank North and Yanga occur in Yanga National Park and as such are protected areas managed for their conservation value by OEH. These sites are also managed according to a draft Yanga Wetland Management Plan (Childs 2009). Assets in Nimmie-Caira and Fiddlers-Uara occur in freehold farmland. However, major wetlands and flowpaths in these areas are managed according to private agreements which enable watering to occur using irrigation channels. The Lowbidgee Floodplain is not included in the *Water Sharing Plan for the Murrumbidgee Regulated River Water Source 2003*, however, the Plan includes provision for diversion of supplementary flows (known as the Lowbidgee Access Flows) into the system. State Water Corporation operate the regulators that divert flows into the Lowbidgee Floodplain (as well as some internal regulators) when such events occur, in conjunction with landholders. Under current arrangements water is shared equally between Nimmie-Caira and the Yanga systems, then equally between North Redbank and Yanga. There is a separate Water Sharing Plan for the Lowbidgee Floodplain currently in preparation by the NSW State government, and the system is included in the Murrumbidgee CMAs Lower Murrumbidgee Land and Water Management Plan. Complementary natural resource management activities are undertaken by OEH in Yanga National Park. This includes pest control, long-term condition monitoring, and works. The Lowbidgee Floodplain has also been identified as a target for investment under Caring for Our Country because it is a high conservation value aquatic ecosystem.

Lowbidgee Floodplain	
Criteria	**Response/Assessment**
	Monitoring in the system is undertaken by the OEH. Their operational monitoring and reporting requirements are consistent with Commonwealth requirements. OEH typically monitor condition of river red gum wetland associations, water quality, southern bell frog presence and abundance, and any waterbird breeding. Occasional monitoring includes fish community biomass and composition, and satellite imagery of inundation events.
5. Cost-effectiveness and operational feasibility of undertaking the watering	Any Commonwealth contribution of water will incur statutory delivery fees and charges of $4.39 per ML. OEH, together with State Water Corporation and the NOW, would manage the delivery of the Commonwealth environmental water and water from other sources. Delivery to assets in the middle section of Yanga National Park and Tala Lake, and North Redbank Wetlands is via gravity feed from Redbank Weir pool through Glen Dee regulator and down Redbank channel, and 1AS regulator through Top Narockwell, Piggery North, and Tarwillie water management areas. There are no delivery costs for gravity fed water. Transmission losses vary in the system, but are likely to benefit the assets and local ecology. Delivery to Nimmie-Caira and Fiddlers-Uara is via private channels and regulators, and is subject to negotiation with landholders on an event-by-event basis. Previous watering events in Nimmie-Caira incurred a $1/ML cost to use the private irrigation networks. It is also important to consider whether the watering action will coincide with delivery of irrigation water as channel capacity will be reduced if both irrigation water and environmental water are delivered at once. It is possible to ask irrigators to defer the delivery of their water if it does not cause any inconvenience. All proposed watering actions for the Lowbidgee Floodplain are operationally feasible, and have been conducted successfully previously by OEH and NOW.

1.19. Lowland Floodplain Wetlands (Balranald to Murray River)

Lowland Floodplain Wetlands (Balranald to Murray River)	
Criteria	**Response/Assessment**
1. Ecological Significance of the asset(s)	Nineteen threatened species, four ecological communities and nine migratory species listed under the EPBC Act, relevant NSW legislation and recognised in international agreements have been recorded in the Murrumbidgee River channel and associated floodplain wetlands downstream of Balranald. This portion of the river and floodplain is also part of the Natural Drainage system of the Lower Murray River Catchment aquatic endangered ecological community, listed under the NSW *Fisheries Management Act* 1994. Because the area is at a confluence of two major rivers the floodplain is a delta environment, with numerous lagoons and wetlands scattered throughout. When previously inundated the area has supported large cormorant and spoonbill rookeries south of Waldaira Lake, and the River provides habitat for important populations of native fish, including Murray Cod, Golden Perch and Silver Perch.
2. Expected ecological outcomes from the proposed watering action	Overall condition of floodplain wetlands downstream of Balranald is considered good (pers. comm. Peter Ware, Murrumbidgee CMA 2011). Prior to the 2010-11 flood the system experienced several years of drought, adversely affecting floodplain and wetland condition. Currently many of these assets are either wet or drying after being inundated, and as such their condition in the short- to medium-term can be considered good. Watering actions in the system will support the survival and recruitment of native riparian and in-stream vegetation, provide resilience in channel and wetland habitats allowing a quick response to repeated watering events, improve water quality and promote connectivity between the river and floodplain assets. The action will also provide suitable wetland breeding and foraging habitat for a range of wetland and floodplain fauna. Watering actions are expected to boost the survival of current channel and riparian communities and capitalise on recent natural watering events on the system, creating optimum opportunities for fish movement and breeding, and improved habitat conditions for a suite of fauna and flora (such as fish, frogs, waterbirds, biofilms, macroinvertebrates and macrophytes). If environmental water is not provided, the opportunity to improve resilience in wetland and floodplain habitats in the system could missed. Environmental water contributes to maintaining refuge and breeding habitat for a range of floodplain and wetland fauna and flora, and without it they are not expected to recolonise and recruit. The health of river red gums and associated wetland vegetation will also likely decline, creating reduced breeding and refuge opportunities for waterbirds. Environmental flows to the floodplain downstream of Balranald are delivered via the Murrumbidgee River, with potential benefits to in-stream habitats arising from the augmented flows. There is also the potential to use water from the event satisfy watering requirements of downstream assets in the Murray River.

Lowland Floodplain Wetlands (Balranald to Murray River)	
Criteria	**Response/Assessment**
3. Potential risks of the proposed watering action at the site and at connected locations	The following risks are based on those identified for the Lowbidgee Floodplain and for piggybacking in the Murrumbidgee River: • *No natural triggers*: If the aim is to deliver a piggyback release onto significant Murrumbidgee and Murray River flows to inundate the Junction wetlands south of Balranald, a suitable natural event to trigger the use of environmental water may not occur. • *Poor system resilience:* Given the Lowlands Floodplain experienced drought conditions for much of the 2000s, there is a risk some ecosystems may already be compromised to the point where the delivery of environmental water may not improve their resilience capacity. However, the system is currently considered in good condition, and as such could be reasonably expected to respond positively to another watering event. • *Impacting infrastructure*: Inundation of the floodplain may affect farm fences, and require de-stocking of the inundated areas. This risk would be mitigated by consulting with local landholders prior to the event to allow them sufficient time to remove their livestock from the target areas. There is low likelihood of variance from the expected ecological outcome. Lowland Floodplain assets have received some wetting after a long dry period, and would benefit from repeat watering this water year. Potential negative outcomes from an environmental watering event include pest animal movement and breeding, and weed recruitment.
4. Long-term sustainability of the asset(s) including appropriate management arrangements	Aside from Mainie State Forest and Peacock Flora Reserve, the entire Lowland Floodplain is privately owned, and primarily used for grazing. Long-term management and delivery arrangements are therefore subject to liaison with landholders in the floodplain. Complementary natural resource management activities could be negotiated with landholders. For example, stock exclusions zones could be established to maximise ecological response to watering events in the short-term, with any potential harvesting of river red gum capped or excluded in areas of the floodplain in the mid- to long-term. OEH monitored the outcomes of the 2010-11 flood, and would likely participate in monitoring a watering event in the 2011-12 watering year.
5. Cost-effectiveness and operational feasibility of undertaking the watering	Any Commonwealth contribution of water will incur statutory delivery fees and charges of $4.39 per ML. OEH, together with State Water Corporation and the NOW, will manage the delivery of the Commonwealth environmental water and water from other sources. The Lowland Floodplain may be watered by managing high Murrumbidgee River flows downstream of Redbank Weir at 5,000 ML/day or greater to coincide with high Murray River flows at Barham of 10,000 ML/day or greater. These flow rates would need to be maintained for three to seven weeks. Note a standalone release such as the June 2011 Murrumbidgee action is quarantined from take by Murrumbidgee supplementary water users. If an environmental release is piggybacked on suitable river flow and antecedent wetland conditions then the piggybacked release may reach the lower Murrumbidgee at levels necessary to support wetland inundation (OEH 2011). Note the flow used to piggyback an environmental release is subject to take from supplementary water users. This take may reduce the peak of the flows thereby reducing inundation of

Lowland Floodplain Wetlands (Balranald to Murray River)	
Criteria	**Response/Assessment**
	wetlands. There are no regulatory structures downstream of Balranald, so the watering event would initiate a relatively natural inundation pattern throughout the floodplain.

1.20. River-fed Wetlands in the Yanco-Colombo-Billabong Creek System

River-fed Wetlands in the Yanco-Colombo-Billabong Creek System	
Criteria	**Response/Assessment**
1. Ecological Significance of the asset(s)	Eighteen threatened species, four ecological communities and eleven migratory species listed under the EPBC Act, relevant NSW legislation and recognised in international agreements have been recorded in the Yanco-Colombo-Billabong Creek System. The system supports significant anabranch and riverine habitats, with several areas of wetland complex occurring. Wanganella Swamp is regionally important, providing foraging, nesting and refuge habitat for a suite of waterbirds, including threatened species such as such as blue-billed duck (*Oxyura australis)*, Australasian bittern (*Botaurus poiciloptilus*), and brolga (*Grus rubicundus*) (Ecosurveys Pty Ltd 2010). Irrigation channels and dams near Colleambally provide critical habitat for the southern bell frog (Beal *et al*. 2003). Freshwater catfish also occur in Colombo Creek.
2. Expected ecological outcomes from the proposed watering action	The upper reaches of the system (above Warriston Weir) are regulated, and as such some areas are permanently wet, and others are permanently dry (instead of ephemeral as occurred naturally). This is particularly true for the floodplain wetlands. The entire system was flooded during the spring/summer 2010 flood, and is currently considered in good condition. Watering actions in the system will support the survival of native riparian and in-stream vegetation, provide resilience in channel habitats allowing a quick response to watering events, improve water quality and promote natural riverine conditions. This is expected to boost the survival of current channel and riparian communities and capitalise on recent natural watering events in the system, creating optimum opportunities for fish movement and breeding, and improved habitat conditions for a suite of flora and fauna. If environmental water is not provided, condition of the Yanco-Colombo-Billabong Creek System is expected to remain good in the short- to medium-term, and decline in the long-term. This is because river regulation combined with adjacent land use place multiple pressures on the structural and functional integrity of the system. Environmental flows which contribute to reinstating a more natural flow regime afford the system an opportunity to retain some basic function, and physical characteristics supportive of native flora and fauna, and agricultural activities.

River-fed Wetlands in the Yanco-Colombo-Billabong Creek System	
Criteria	**Response/Assessment**
	An environmental flow of sufficient magnitude in the Yanco-Colombo-Billabong Creek System could create and end-of-system flow, delivering water to the Edward River, and subsequently the Murray River.
3. Potential risks of the proposed watering action at the site and at connected locations	A preliminary risk assessment identified the following 'medium' (after controls) risks: • *Structural impediments to flows*: The upper Yanco Creek system is highly regulated with numerous private and public weirs, blockbanks and channels, and some areas of dense Cumbungi growth. Weirs are in various states of repair, with some requiring refurbishment or removal to improve flow throughout the system. McCrabbs regulator and spillway (at Wanganella Swamp) also requires removal or modification and de-silting upstream to improve capacity and flows. These impediments contribute to inefficient delivery and greater losses of environmental water in the system. State Water Corporation has conducted a review of weirs in the system and identified those requiring removal and/or maintenance. In the interim, environmental flows can still be delivered in the system, but the volumes required may be higher and more variable. • *Unauthorised diversion of environmental water by surrounding landholders*: Regular channel inspections by State Water Corporation, NOW and OEH could be arranged prior to and during events. • *Common carp distribution:* If common carp are not stranded in an annual dry-down they are likely to breed to very high numbers. This can reduce the success of native fauna breeding at wetlands in the system. Wetlands may also act as source habitat for Common carp to enter the river channel under subsequent high flow conditions. There is low likelihood of variance from the expected ecological outcome. Many Yanco-Colombo-Billabong Creek System assets are currently wet after a long dry period, and would benefit from repeat watering this water year. Potential negative outcomes from an environmental watering event include pest animal movement and breeding, and weed recruitment.
4. Long-term sustainability of the asset(s) including appropriate management arrangements	Aside from approximately 212 ha (of 470 ha) of Crown land at Wanganella Swamp, the entire system is privately held, and primarily used for irrigated agriculture above Warriston Weir, and grazing below the Weir. Long-term management and delivery arrangements are therefore subject to liaison with landholders in the system. There are established management arrangements for water delivery to Wanganella Swamp, with previous watering actions undertaken by OEH in conjunction with State Water Corporation and YACTAC. OEH and the Yanco Creek and Tributaries Advisory Council (YACTAC) participated in monitoring the outcomes of a colonial-breeding waterbird event at Wanganella Swamp in 2010-11, and may participate in monitoring a watering event in the 2011-12 watering year.

River-fed Wetlands in the Yanco-Colombo-Billabong Creek System	
Criteria	**Response/Assessment**
5. Cost-effectiveness and operational feasibility of undertaking the watering	Any Commonwealth contribution of water will incur statutory delivery fees and charges of $4.39 per ML. OEH, together with State Water Corporation and the NOW, will manage the delivery of the Commonwealth environmental water and water from other sources. The Yanco-Colombo-Billabong Creek System is watered via the Yanco off take on the Murrumbidgee River. Environmental flows to the system can be delivered via a piggybacked high flow in the Murrumbidgee River, as an alternative to using regulated flows. Providing an environmental flow is operationally feasible, with regulated flows routinely delivered to the upper portions of the catchment. Flows to assets below Warriston Weir are also feasible. The lack of flow data connecting gauged points in the system with commence-to-flow and volumetric requirements of most assets, and the many structural impediments to flows in the system are constraints.

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Water Use Strategy 2011-12: Namoi River Catchment

1.1. Introduction

This document sets out the proposed objectives and approach to using environmental water in the Namoi catchment during the 2011-12 water year. This strategy was developed based on information available to the Commonwealth through consultation with stakeholders such as state governments, local river operators and wetland managers.

Delivery and governance arrangements need to be resolved in the Namoi catchment in order for Commonwealth environmental water use to occur in 2011-12. Unlike most other catchments in NSW, the Commonwealth is the sole holder of water entitlements intended for environmental use. Delivery arrangements will be progressed to facilitate delivery in line with watering options outlined in this document. Watering options without suitable delivery arrangements or ranked as a low priority using the framework provided in Appendix D will not be implemented.

The document includes watering options given recent climatic and riverine conditions in the catchment and forecast water availability under a range of hydrologic scenarios. The proposed approach will adapt over the course of the year as conditions in the catchment change and more information becomes available. Importantly, the potential watering options included in this document do not form an exhaustive list, alternate suggestions for using environmental water are welcome. All relevant options will be assessed to ensure the best possible use of environmental water within the catchment and across the Murray-Darling Basin.

1.2. The Namoi River Catchment

The Namoi River catchment (Figure 1) in north western New South Wales occupies approximately 39,781 km^2 (3.8 per cent of the total area of the Basin) and is bounded by the Great Dividing Range in the east, the Liverpool Ranges and Warrumbungle Ranges in the south, and the Nandewar Ranges and Mt. Kaputar in the north. Major water resources in the Namoi region include the Upper and Lower Namoi, Peel and Manilla Rivers, alluvial aquifers and wetland/lagoon stretches.

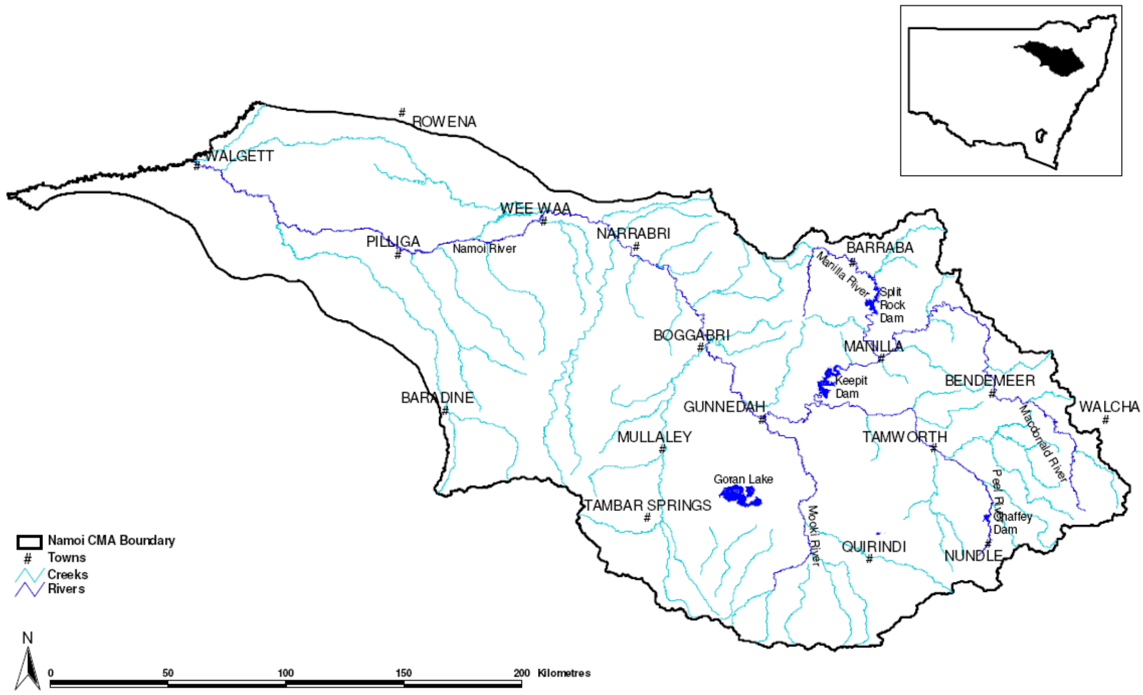

Figure 1: The Namoi River Catchment

The CSIRO Sustainable Yields Project (CSIRO 2007) found the Namoi Valley river ecosystem to be in poor health overall (lowland, slopes and upland zones were classified as moderate, while the montane zone was found to be poor). The hydrological condition for the Namoi was rated as good while stream condition was moderate to poor. There were overall reductions in volume, seasonality and high flows at sites downstream of storages. Water resource development was found to have increased the average period between flooding of the Namoi River billabongs and wetlands from 3 to 3.8 months (around 27 per cent) and decreased the average annual flooding volume by 150 GL (around 28 per cent). Groundwater use is high – representing nearly half of all water use in the region. Streamflow has reduced as a result of lowered watertables. The MDBA's Sustainable Rivers Audit (SRA) also found that overall the Namoi catchment was generally in a poor condition (http://www.mdba.gov.au/sustainable-rivers-audit/).

Barma (2011) found average annual flows at Wee Waa had reduced by over 20 per cent while the reduction in flows at Boggabri, which is upstream of the majority of irrigation, is considerably less at approximately five per cent.

These changes are likely to have had ecological consequences. Native fish populations are in poor condition with just over 80 per cent of expected native species present. While abundance was dominated by native species, biomass was dominated by aliens (CSIRO 2007). The SRA Fish assessment rated the catchment in poor condition in terms of native fish populations, with 12 native and five alien fish species captured. Macroinvertebrate condition was also poor in the Namoi.

The Namoi River is a major tributary of the Barwon-Darling River, entering the Barwon at Walgett, contributing, on average, some 30 per cent of the flow of the Darling River upstream of Bourke under current development conditions (Webb, McKeown and Associates 2007). CSIRO (2007) have given a "best" estimate for a 2030 climate scenario that there would be a five per cent reduction in water availability and an eight per cent reduction in end-of-system flows in the Namoi.

The long-term average annual flow in the Namoi River is 696,000 ML/annum at Gunnedah, however, a large proportion of the total flows occur in a small number of years with alternating wet and dry periods (Green, 2011). Table 1 depicts mean and median daily flows in major reaches of the Namoi River downstream of Keepit Dam. Dry periods usually last for less than five years at a time. However in the recent period 2001 to 2009 the catchment experienced prolonged drought and low streamflows. The longest drought on record was for 15 years between 1934 and 1949.

Table 1: Mean and median daily flows in significant reaches of the lower Namoi River (data range 1979-2011)

Namoi River Gauge	1979-2011		1999-2011	
	Mean daily flows (ML/day)	Median daily flows (ML/d)	Mean daily flows (ML/day)	Median daily flows (ML/d)
D/S Keepit - 419007			436	15
Gunnedah - 419001	1415	390	997	226
Boggabri - 419012	1137	227	1137	227
Narrabri Ck - 419003	1671	435	1099	233
Mollee - 419039	1694	444	1529	265
D/S Duncans Junction - 419094			230	22
Bugilbone - 419021	1201	136	776	69
Goangra - 419026	1240	105	781	48
U/S Walgett - 419091			1157	69

Management of the water resource within the Namoi River catchment occurs according to the *Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources* (*2004*) and the *Water Sharing Plan for the Peel Valley Regulated, Unregulated, Alluvium and Fractured Rock Water Sources (2010).*

There are currently no other sources of callable environmental water in the Namoi catchment. Planned environmental water established under the *Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated Water Sources (2003)* provides:

- protection of flows above the long-term average extraction limit (73 per cent of the long-term average annual flow is protected for the environment));
- minimum flows at Walgett during June, July and August of 21 ML/d, 24 ML/d and 17 ML/d respectively when the combined volume of Keepit Dam and Split Rock Dam is greater than 120,000 ML; and
- protection of proportions of supplementary event flows. Overall extraction may not exceed 10 per cent of the supplementary event volume for events occurring between 1 July and 31 October, and 50 per cent of the supplementary event volume for events between 1 November and 30 June.

The Water Sharing Plan for the Peel Valley Regulated, Unregulated, Alluvium and Fractured Rock Water Sources (*2010*) provides for the creation of a 5,000 ML environmental contingency allowance when the capacity of Chaffey Dam is enlarged to 100,000 ML (currently 62,000 ML).

1.3. Environmental Assets in the Namoi River Catchment

The main environmental assets in the Namoi catchment are Namoi River reaches and fringing wetlands and lagoons. The Namoi and Peel River system is ecologically important for native fish breeding. It supports endangered species and communities, and provides connectivity with the

Barwon-Darling River. While the Namoi catchment does not contain extensive, nationally recognised wetland complexes, the floodplain downstream of Narrabri supports many small lagoons, wetlands, and anabranches, as well as flood runners and extensive areas of floodplain woodlands. The catchment also has wetlands that are independent of the river system.

1.3.1. Namoi significant biodiversity

The Namoi supports 28 threatened plant species, with 11 of these being listed as endangered and 66 threatened animal species including four species of amphibians, nine bats, 37 birds, 11 mammals and five reptiles (Green et al. 2011). Threatened species associated with riverine environments have been listed in Appendix A.

Much of the native vegetation in the Namoi catchment has been cleared for cropping on the lower slopes and floodplain, and grazing on the upper slopes and tablelands. In 2002 the extent of native vegetation in the Namoi catchment was estimated at 62 per cent (Namoi CMA 2006).
The listing of the *Native vegetation on cracking clay soils on the Liverpool Plains* endangered ecological community is designed to ensure protection of remanent native grasses such as plains grass (*Austrostipa aristiglumis*), Queensland bluegrass (*Dichanthium sericeum*) and coolibah grass (*Panicum queenslandicum*).

The endangered ecological community *Coolibah-Black box woodland of the northern riverina plains in the Darling Riverine Plains and Brigalow Belt South bioregions* occurs on the floodplain of the lower Namoi River. Typically occurring as open grassy woodlands, this community has been extensively cleared for cropping or modified through grazing. It is thought that around two-thirds of the original extent of this community within NSW has been cleared (NSW Scientific Committee 2004). Other endangered ecological communities include *Myall woodlands* and *Inland grey box woodlands*, both known to occur in the Liverpool Plains, Pilliga and lower Namoi regions.

The aquatic community of the Namoi River forms part of the endangered ecological community under the *NSW Fisheries Management Act 1994* known as the aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River. Species of conservation significance in the Namoi River include: river snail (*Notopala sublineata*), olive perchlet (*Ambassis agassizii*) and the purple spotted gudgeon (*Mogurnda adspersa*) (all endangered under the *NSW Fisheries Management Act 1994*), silver perch (*Bidyanus bidyanus*) (vulnerable under the *Fisheries Management Act 1994*) and Murray Cod (*Maccullochella peelii*) (vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999).*

1.3.2. Namoi River reaches

The Namoi ecological assets are linked to reaches and are based on maintaining the processes for river health such as organic carbon transfer and nutrient cycling, as well as direct impact on vegetation condition and habitat availability.

The reach of the Namoi River between Narrabri and Boggabri forms part of the Namoi Aquatic Habitat Initiative - Namoi Demonstration Reach, a collaborative project between the Namoi Catchment Management Authority (CMA), Murray-Darling Basin Authority (MDBA), NSW Department of Industry and Investment and land owners. Restoration activities have been completed at the site and include revegetation, fencing, erosion control, de-stocking and removal of fish barriers.

Downstream of Narrabri the carrying capacity of the Namoi River reduces significantly and floodwaters spread out through an effluent system over a vast floodplain, supporting many small lagoons, wetlands, effluent creeks and anabranches, as well as flood runners and extensive areas of floodplain woodlands. The anabranches can take a considerable proportion of the flow. An example of this is Duncans Warrambool, located near Pilliga where the Namoi River splits in two for a distance of six kilometres. The northern channel, known as Duncans Warrambool, carries two thirds of the flow. There are also a number of ephemeral watercourses that flow westward across the lower Namoi floodplain, including Drildool, Cubbaroo, Dead Bullock and Chambers Warrambools.

1.3.3. Namoi fringing wetlands and lagoons

Green and Dunkerley (1992) mapped 184,000 hectares of wetlands (including 143,000 hectares of coolibah woodlands). More recently Eco Logical Australia (2008) mapped a total of 2,766 wetlands in the valley totalling 46,398 hectares. Of these, 1,829 were identified as natural wetlands and 937 were artificial wetlands (dams, weir pools and other storages). The study found that nearly half of the wetlands in the catchment would be inundated by a 1 in 2 year flood event.

While the Namoi does not contain any large scale wetland complexes, wetlands of notable size include Lake Goran, Barbers Lagoon and Gulligal Lagoon. These are all located upstream of Narrabri.

Lake Goran (6,385 ha), a disconnected water body south of Gunnedah, is the only listed wetland of national importance (listed on the Directory of Important Wetlands in Australia) in the Namoi catchment. The lake is rarely full, however in recent years the lake has been semi-permanent due to diversions of local creeks by agricultural activities and structural works (Banks 1995). The lakebed is intensively cropped when dry, but when flooded provides habitat for a large number of birds, hence its listing as a wetland of national significance (SEWPAC 2011).

Gulligal Lagoon, near Gunnedah, is a semi permanent wetland that is connected to the Namoi River, filling during flood events and from surface flows. The lagoon, a 4.2 km long depressional channel dominated by river red gum woodland, was dry between 2000 and 2008. Anecdotal evidence suggests the lagoon maintains water over a long period of time and can act as a drought refuge in the mid-Namoi region. The lagoon provides important habitat for native fish species including the threatened olive perchlet and gudgeons. This lagoon was restocked with breeding pairs of purple spotted gudgeon in late 2009 as part of the Namoi Demonstration Reach project. Fish monitoring has been undertaken in the lagoon under this initiative and will be undertaken annually until at least 2013.

The reach between Boggabri and Narrabri is characterised by a number of long, narrow lagoons that represent prior channels of the Namoi River. Barbers Lagoon, a major anabranch of this reach, is about 22 km in length covering an area of approximately 134 hectares. It is located on a travelling stock route near Boggabri. It is relatively close to Gulligal Lagoon and is likely to support similar species including river red gum (*Eucalyptus camaldulensis*) and Warrego summer grass (*Paspalidium jubiflorum*) on the higher back areas and water couch (*Paspalum distichum*) on the waters edge. The Lagoon has numerous branches from the Namoi River, it also has inflow tributaries and would fill from local rainfall.

1.4. Delivering Water in the Namoi River Catchment

Major weirs and infrastructure that regulate the Namoi River are depicted in Figure 2. Flows in the Namoi River are highly regulated: Split Rock Dam regulates 93 per cent of inflows and Keepit Dam regulates 77 per cent of inflows. Downstream of Keepit Dam flows continue within a confined channel until Gunnedah, when the floodplain begins to broaden. Major tributaries to the Namoi are located upstream of Boggabri. Two major weirs downstream of Narrabri – Mollee Weir (3,300 ML) and Gunidgera Weir (1,900 ML) – reregulate water for irrigation, stock and domestic users in the lower Namoi (Green et al 2011).

Except for the *Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated Water Sources (2003)* provisions of low base lows in June, July and August there is no conveyance base flow provided to the Namoi. Water supplies from Keepit Dam to the River are provided for irrigation and stock and domestic purposes. Walgett is the only town reliant on the Dam for town water supplies as the other towns along the River utilise bore water. The water for Walgett is provided intermittently on a "needs" basis as Walgett also has access to water from the Barwon River.

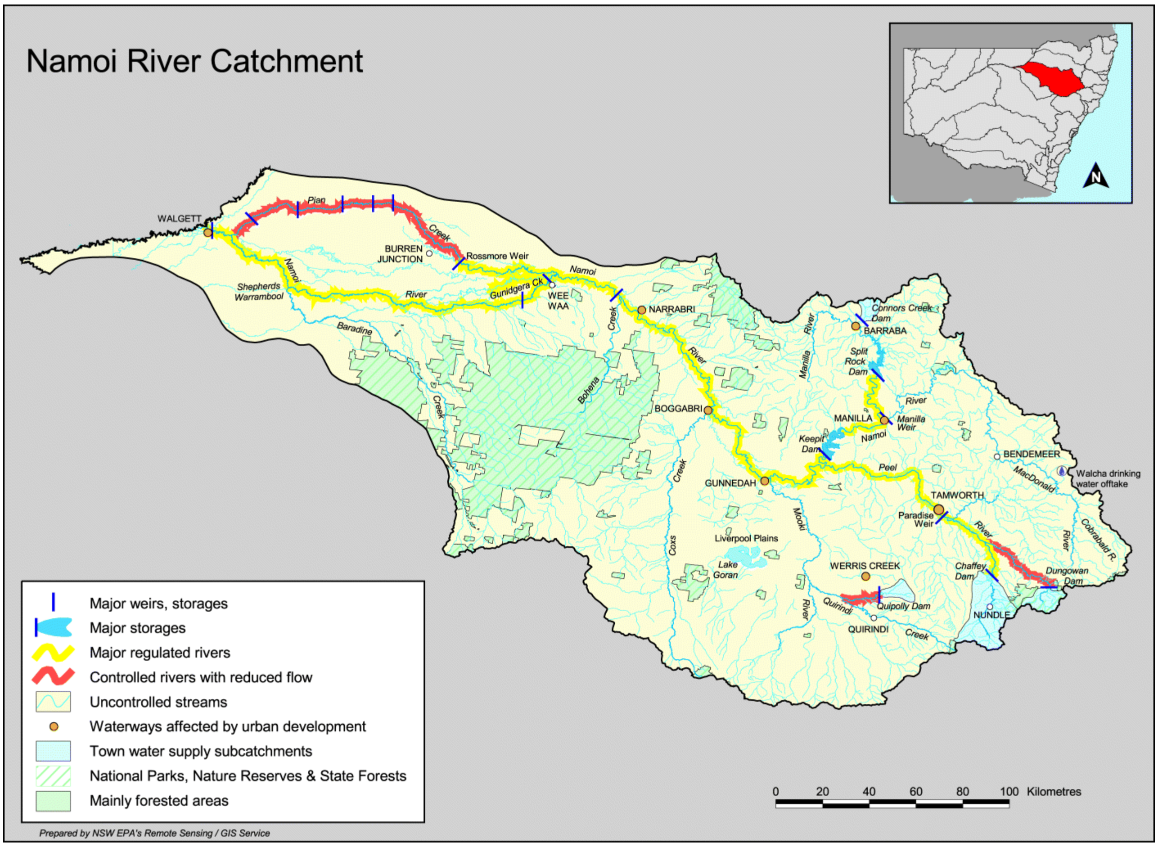

Figure 2: The Namoi River Catchment and water delivery infrastructure

Unlike large wetland complexes (such as those found in the Gwydir, Macquarie and Lachlan catchments) where duration and total flow volumes over weeks or months are important the Namoi water dependent ecosystems are largely driven by the shorter duration (or even instantaneous) flows that link the benches, cut-off channels, anabranches and floodplains. Commonwealth water may be piggy-backed on unregulated flows entering the Namoi River (e.g. from Cox Creek or Mooki River), increasing the height or extending the length of freshes thereby wetting benches, increasing connectivity or extending wetting duration.

There is also the opportunity to use Commonwealth environmental water to improve end of system flows at Walgett and therefore improve some of the flow dependent ecology of the Barwon-Darling River. In non-demand periods, and particularly in dry climate circumstances when there are no unregulated tributary inflows, the River channel may dry out (Barma 2011). Environmental water delivery transmission losses could be significant during these scenarios.

1.5. Current Catchment Status

The Namoi catchment experienced a prolonged drought with nine consecutive years of below average flow from 2001 to 2009 (Green et al 2011). However, current moisture conditions in the Namoi River catchment are considered to be wet. The most recent flooding was in August and December 2010 with peaks recorded of 30,000 ML and 54,000 ML per day respectively at Gunnedah. The wet 2010-11 water year also provided significant end of system flows into the Barwon-Darling system (Figure 3).

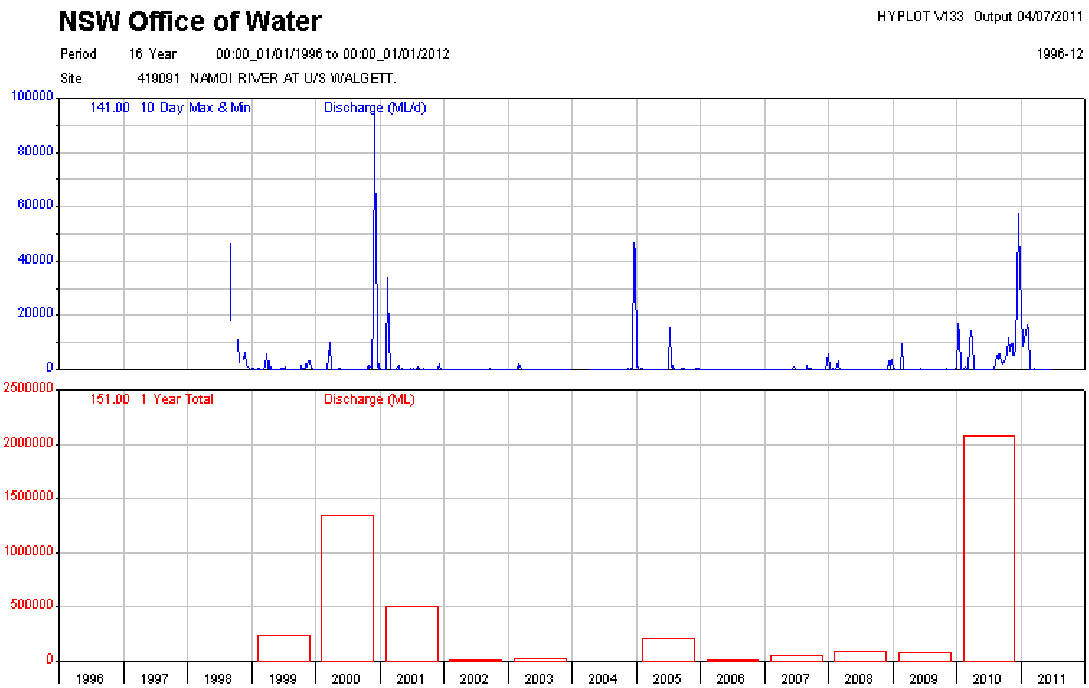

Figure 3: Plot of Namoi end of system flow discharges (NSW Office of Water website, 2011).

The national outlook for late winter to early spring (August to October 2011) favours drier than median rainfall over parts of the southeast of Australia. The outlook is a result of cool conditions in the central tropical Pacific Ocean, as well as warm conditions in the Indian Ocean (BOM 2011). The Namoi River catchment lies in the band with a 45 to 50 per cent chance of exceeding the median seasonal rainfall for the region (Figure 4).

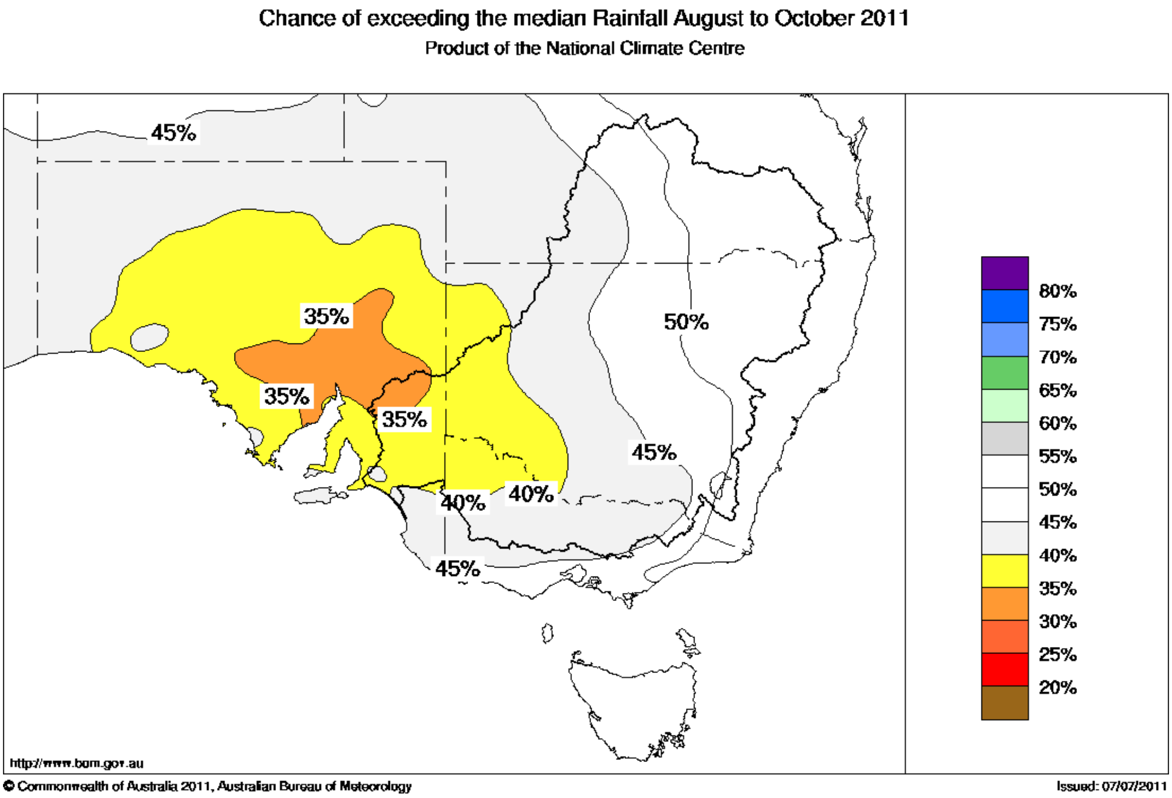

Figure 4: Seasonal rainfall outlook for south-eastern Australia (BoM).

1.6. Commonwealth Environmental Water and Forecast Allocations

In the Namoi catchment, the Commonwealth holds a total of 6,203 ML of regulated entitlements (Table 2). The Upper Namoi includes the regulated river sections between Split Rock Dam and Keepit Dam. The Lower Namoi includes the regulated river sections downstream of Keepit Dam to the Barwon River, including the regulated sections of the Gunidgera/Pian Creek system.

Table 2: Environmental water holdings by agency as at 1 June 2011

Account	Entitlement (ML)
Cwlth general security - Upper Namoi - regulated river sections between Split Rock Dam and Keepit Dam	105
Cwlth general security - Lower Namoi - regulated river sections downstream of Keepit Dam to the Barwon River, including the regulated sections of the Gunidgera/Pian Creek system	6,098
Total Commonwealth	**6,203**

Compared to neighbouring catchments, general security surface water entitlements in the Namoi are relatively reliable with a long term average yield approaching 80 per cent of entitlement volume.

Table 3 outlines limitations for use, carry over and allocations for general entitlement water specified under the *Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated Water Sources (2004).*

Available water determinations at the end of the 2010-11 water year of 100 per cent for the Upper Namoi and 110 per cent for the Lower Namoi resulted in a significant increase in Commonwealth allocations. The Commonwealth carried over a total of 6,876 ML allocations from 2010-11. As of 6 July 2011, Namoi catchment dams held 64 per cent of their combined capacity. As of 17 August 2011, in the 2011-12 water year, the NSW Office of Water has made allocations for general security licences in the Lower Namoi regulated river of 10.27 per cent providing 7,502 ML available for use.

Table 3: Namoi catchment general entitlement water use limitations

Continuous accounting use restrictions	Percentage of entitlement (%)	Volume based on current entitlement (ML)
Upper Namoi		
Maximum allocation balance at any time	100	105
Maximum carryover	50	52
Lower Namoi		
Maximum allocation balance at any time	200	12,196
Maximum carryover	200	12,196
Maximum use in a single water year	125	7623
Maximum allowable usage over three consecutive years	300	18,294

Table 4 shows predicted available water determinations for General Security access licences within the Namoi Regulated River Water Source as a percentage of unit shares using historical inflow sequences into Split Rock Dam, Keepit Dam and downstream tributaries. Based on catchment inflow modelling, water availability, water requirements and water use forecasts, allocations against Commonwealth holdings in the Lower Namoi River catchment are forecast to be 9,637 ML by June 2012 (with a range of 8,356 ML to 11,649 ML) and 105 ML in the Upper Namoi (Table 5).

Table 4: Predicted Available Water Determinations (AWD) for General Security Access Licences within the Namoi Regulated River Water Source (State Water, 2011)

Lower Namoi	**Extreme Dry** **(Minimum inflows)**	**Dry (80th percentile inflows)**	**Median (50th percentile inflows)**	**Wet (20th percentile inflows)**
3 month forecast to beginning October 2011	All carryover (6,876 ML) plus 0% allocation: **N/A**	All carryover (6,876 ML) plus 8% allocation: **N/A**	All carryover (6,876 ML) plus 10.1 % allocation: **N/A**	All carryover (6,876 ML) plus 10.8% allocation: **7,534 ML**
6 month forecast to beginning January 2012	All carryover (6,876 ML) plus 0% allocation: **N/A**	All carryover (6,876 ML) plus 17.1% allocation: **7,918 ML**	All carryover (6,876 ML) plus 27.1% allocation: **8,528 ML**	All carryover (6,876 ML) plus 28.1% allocation: **8,589 ML**
Upper Namoi	**Start 2011-2012** **water year on 100%**	**Start 2011-2012** **water year on 100%**	**Start 2011-2012** **water year on 100%**	**Start 2011-2012** **water year on 100%**
Predicted holdings for use by July 2012	105 ML	105 ML	105 ML	105 ML

Table 5: Commonwealth Environmental Water Allocations in the Namoi catchment and forecast allocations for 2011-12

Account	Entitlement (ML)	Current uncommitted allocation (ML)	Carry over allocations from 2010-11 (ML)	Allocation forecast for end 2011-12 (ML)		
				Dry	Median	Wet
General Security Upper Namoi	105	105 (100%)	0	105 (100%)	105 (100%)	105 (100%)
General Security Lower Namoi	6,098	626 (10.27%)	6,876	1,049 (25%)	2,574 (50%)	4,098 (75%)
Total forecast water availability (with 6,876 ML 2010-11 carryover)				8,030	9,555	11,079
Maximum annual water usage under Water Sharing Plan				7,727	7,727	7,727
Minimum forecast carryover potential assuming full annual usage (7,727 ML) in 2011-12 (ML)				303	1,828	3,352

1.7. Medium to Long-term Watering Objectives in the Namoi River Catchment

During 2010-11, the Commonwealth sought external advice to identify and develop watering options for Commonwealth environmental water in the Namoi catchment. The early stages of this work identified the following medium to long-term ecological and hydrological objectives for the Namoi catchment:

- provision of drought refuge for native fish species and waterbirds;
- provide for growth, reproduction and small-scale recruitment of wetland vegetation, native fish spawning and waterbird breeding;
- contribute to the ecological requirements of the Barwon-Darling;
- reduce duration between flow events;
- provide for a natural wetting and drying cycle in channels and wetlands;
- increase hydrological variability through increased flow volumes in floods and freshes; and
- improve hydrologic connectivity between the river channel and floodplain.

Watering options will, where possible, build on other flows to deliver the most effective overall environmental outcome. Decisions about when and how watering actions occur will take account of the natural hydrological cycles of environmental assets. For most assets, environmental water will be delivered during spring and summer. Irrigation water orders (generally between December and February) provide regular in-channel flows during this period. In the absence of unregulated flows which can be supplemented with regulated releases, the maximum release capacities restrict the ability to provide high flows and inundate downstream wetlands.

In median to wet climatic periods unregulated tributary inflows provide natural variability to in-stream flows from irrigation orders. Commonwealth environmental water may be piggy-backed on unregulated flows, increasing the height or extending the length of freshes thereby wetting benches, increasing connectivity or extending wetting duration or providing fish spawning opportunities. This action is dependent upon an order being placed for flows additional to unregulated flows which would ordinarily themselves be used to satisfy consumptive demands prior to releases from storage.

In the Namoi during non-demand periods, and particularly in dry climate scenarios when there are no unregulated tributary inflows, the river channel can dry into a series of pools. Environmental water delivery transmission losses could be significant during these circumstances so Commonwealth environmental water could be used to piggy-back on stock and domestic replenishment flows in order to maximise environmental outcomes.

1.8. Watering Objectives and actions for 2011-12

Watering objectives for 2011-12 for the Namoi valley have been developed based on the Commonwealth's *Framework for Determining Commonwealth Environmental Watering Actions* (Appendix B). Options have been developed within the context of a 'median' water availability scenario which has the overall watering objective to "maintain ecological health and resilience."

The Commonwealth environmental water available for use in the Namoi is modest, however options have been considered with regard to large reserves of irrigation water likely to provide in-stream flows between late spring and summer, and the moderate possibility of unregulated tributary inflows to provide high flow events. In 2011-12 the management objective is to maintain condition of assets by supporting flow events which:

- inundate low-lying floodplain wetlands;
- provide triggers for fish spawning opportunities;
- promote the transportation and dilution of nutrients, organic matter and sediment;
- increase connectivity with the Barwon-Darling River; and
- maintain known native fish habitat and waterbird habitat (e.g. Gulligal Lagoon).

Commonwealth reserves may be carried over to help maintain drought refuge and reduce damage should conditions become dry.

Watering options (Table 6) have been prioritised based on available information and through local stakeholder consultation. These options will be further developed to determine more specific detail on ecological outcomes achievable, there water requirements, delivery and monitoring arrangements, costs and risks. Once these options have been developed into detailed watering proposals a multi-criteria assessment will be conducted to prioritise watering options, using the framework and criteria described in Appendix D. Some watering options may not be implemented if suitable delivery arrangements cannot be developed or the proposals do not meet the criteria.

Delivery arrangements will be progressed to facilitate delivery in line with watering options proposed for 2011-12 summarised in Table 7. Tables 8 and 9 provide further detail on delivery arrangements but this information is still being developed to (where appropriate) include trigger points for use associated with natural flows and cut-off dates if those flows did not eventuate.

Options will be reviewed regularly throughout the year, and ongoing advice will be obtained on the condition of environmental assets and their relative needs. The Commonwealth has identified watering actions for the Namoi River catchment that are consistent with these objectives for a range of climate conditions in 2011-12 (refer to Appendix C).

Table 6: Watering options in scope for 2011-12 in the Namoi Catchment

Asset and watering objective	Watering action
1. Gulligal Lagoon a) Maintain water levels and increase the duration of inundation; b) Maintain waterbird and fish habitat c) Support existing restoration projects	Recent restoration projects at the site, including fencing and revegetation efforts, have been successful. In 2009, 100 pairs of purple spotted gudgeons (NSW endangered) were released into the lagoon. Gulligal Lagoon fills during high flood events from the Namoi River and overland floodplain flows. The wetland dries down to small remnant pools on average every three years. The lagoon was dry between 2000 and 2008. Natural flooding filled the lagoon in 2009 and high flows in 2010 helped maintain water levels, so it currently contains a significant amount of water.

revegetation and recruitment efforts.	The lagoon commences to fill (CTF) when the Namoi River reaches a height of 5.00 meters or flows over 20,000 ML/day at Gunnedah gauge. If it is not refilled naturally (given the high ctf levels), water levels could be maintained by pumping environmental water from the Namoi River. The volume of environmental water that may be required is unknown (considered to be in the order of 100 ML to keep the lagoon full over summer (Neal Foster pers comms)), and requires bathometry survey to inform volume estimates. Natural water loss (e.g. leakage, drainage and evaporation) may necessitate repeat watering events in drier years to maintain inundation levels.
2. Barbers lagoon a) Increase extent and duration of inundation and connectivity; b) support colonial waterbirds and fish	The Barbers lagoon receives runoff from a number of creeks and connects to the Namoi River more frequently than Gulligal. The lagoon dries down to a series of pools within 3 months and is completely dry within 18 months. Barbers lagoon is more degraded than Gulligal lagoon and restoration projects such as fencing off have not occurred. Under median inflows it is unlikely that opportunities will arise to flood wetlands with high commence to fill (e.g. Barbers Lagoon) with overbank flows. Water commences to flow from the Namoi River into Barbers Lagoon when 4,600 ML/day is passing Boggabri gauge (419012) and 23,000 ML is required to fill the lagoon. If natural high flows did occur then Commonwealth environmental water may be used to supplement flows to increase the extent of inundation. Maintaining water levels in remnant pools as the lagoon dries out may require pumping over a large distance. Due to the volume of water required and known delivery limitations, this option is unlikely to be pursued in 2011-12.
3. River Channel a) Provide wetting of and connectivity between low level benches and point bars and riparian zone. b) Provide spring-summer in-channel freshes to promote and support fish spawning and dispersal opportunities for native fish and support and maintain riparian vegetation. c) Increase end of system flows to enhance recruitment and movement of aquatic biota and contribute to downstream environmental watering requirements.	During this water year it is anticipated that in stream flows will be provided for by irrigation demand, unregulated tributary flows and stock and domestic replenishment flows. However Commonwealth environmental water could maximise outcomes by increasing, extending or providing some variability to these flows. In-channel watering will maintain the processes for river health such as geomorphic structures, organic carbon transfer and nutrient cycling, as well as direct impact on vegetation condition and habitat availability. Hydrologic connectivity through contributing to the full-range of in-channel flows, the inundation of anabranches and floodplain wetlands and connectivity with the Barwon-Darling River will achieve improved water quality and allow recruitment and movement of aquatic biota. The provision of Commonwealth environmental water in channel is also expected to support and improve native fish breeding, endangered species and communities and provide improved connectivity with the riparian zone and floodplain and increase inflows to the Barwon-Darling River. It is well known that the spawning success and larval survival of Murray cod (*Maccullochella peeli*), freshwater catfish (*Tandanus tandanus*), golden perch (*Macquaria ambigua ambigua*) and silver perch (*Bidyanus bidyanus*) are linked to flow conditions. Delivery of peak flows during the spawning season will encourage spawning and enhance survival of larvae and juveniles. In channel freshes are required between September and December to promote and support native fish spawning, recruitment and dispersal (NSW I&I, 2011). This translates

	to: • Flows of 1,400–2,870 ML/d at Boggabri between Sep–Dec for min. 7 days are required to support native fish spawning/recruitment in the Narrabri creek channel (between Boggabri and Narrabri; or • Flows of 1,550–3,150 ML/d at Wee Waa between Sep–Dec for min. 7 days are required to support native fish spawning/recruitment to support native fish spawning Commonwealth environmental water could also be used to supplement a natural flood event to achieve flows between 8,000-9,000 ML/d at Wee Waa over 5 days between Sep-Dec which would provide fish passage over weirs. The Namoi River system is a major left bank tributary of the Barwon-Darling River, contributing an average 800,000 ML/a to this river or 25 per cent off its long term annual flow at Menindee (Thoms et al. 1999). Water sharing rules currently provide daily end of system flows during winter months at Walgett of 21 ML/day in June, 24 ML/day in July, and 17 ML/day in August. Irrigation, stock and domestic flows and unregulated events provide some longitudinal connectivity in other months. However there remains some likelihood of very low flow conditions in early spring and autumn which are between the summer irrigation season and winter month flows. Commonwealth environmental water could be used to provide for or increase end of system flows.
4. Carryover Ensure sufficient carryover to provide for critical needs, minimum flows and drought refugia or optimal seasonal flow patterns in subsequent years.	The Commonwealth holds 6,203 ML which provides the opportunity to build a reserve of 12,301 ML (maximum). In the Namoi further investigation is required to identify and where possible prioritise refuge sites.
5. Duncans Warrambool Provide wetting and connectivity with low level benches and point bars and riparian zone.	Downstream of Wee Waa the river progresses into the distributary zone and near Pilliga the Namoi River splits in two for a distance of six kilometres. The northern channel, known as Duncans Warrambool, carries two thirds of the flow. Duncans Warrambool begins to fill when flows reach 4,000 ML/d at Bullawa gauge. 22,500 ML delivered at 4,500 ML/d (Bullawa gauge) over 5 days will achieve the watering objective. Investigation of potential to affect landholders and gain support for action may be required.

Table 7: Operational details for watering options in scope for 2011-12 in the Namoi Catchment

Asset	Water Mgt. Objective (Table 6)	Target flow rate/Volume to fill[1]	Estimated volume and duration	Timing	Delivery mechanism/ extraction point/gauge	**Operational considerations** (options for piggy backing natural flows; travel times; options for linking actions etc)
Gulligal Lagoon	1a 1b 1c 4	Volume to fill and maintain inundation will be confirmed by bathymetric survey.		Spring- Summer. Monthly review to determine need for CEW delivery.	TBC by State Water	A runner connects the Namoi River and Gulligal Lagoon and could be used to direct water into the lagoon. It is likely that water ‘losses’ would occur as water is absorbed into the runner (due to the deposited alluvium). Alternatively, the water would need to be pumped from the Namoi river using existing irrigation pump. This may require pumping the water a greater distance (hundreds of metres) to the lagoon.
Barbers Lagoon	2a 2b 4	Ctf 4,600ML/d @ Boggabri Vtf 23,000 ML	4,600-23,000 ML delivered at 4,600 ML/d for 1 to 5 days (up to 7,622 ML CEW)	Spring- Summer. Monthly review to determine suitability and need for CEW delivery. Delivery plan to be developed to identify trigger flows and environmental delivery volumes.	Namoi River @ Boggabri (419012)	Opportunity to piggy-backing medium natural flows to fill Barbers Lagoon.
River channel	3a 3b 3c 4	1,400-2,870 ML/d	9,800-20,090 ML delivered over 7 days (up to 7,622 ML CEW)	September-December. Monthly review to determine suitability and need for CEW delivery. Delivery plan to be developed to identify trigger flows and environmental delivery volumes.	Namoi River @ Boggabri (419012)	Opportunity to piggy-backing medium natural flows to support native fish spawning/recruitment. Accrediting and shepherding of flows once they enter Barwon Darling system.
		1,550-3,150 ML/d	10,850-22,050 ML delivered over 7 days (up to 7,622 ML CEW)		Namoi River @ Wee Waa	
Duncans Warrambool	4 5	Ctf 4,000 ML/d @ Bullawa	4,500-22,500 ML delivered at 4,500 ML/d for 1 to 5 days (up to 7,622 ML CEW)	Spring- Summer. Monthly review to determine suitability and need for CEW delivery. Delivery plan to be developed to	Namoi River @ Bullawa (419095)	Opportunity to piggy-backing medium natural flows to fill Duncans Warrambool. Need to consider potential inundation of private property and seek landholder

		Ctf 4,500 ML/d @ Bugilbone		identify trigger flows and environmental delivery volumes.	Namoi River @ Bugilbone (419021)	agreement and support.

1 Target flow rate and volume to fill should consider the antecedent conditions of the asset

Table 8: Total release volume estimate and monthly water allocation profile (GL)

Asset	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Gulligal Lagoon	0	0	0.2							0	0	0	0
River Channel	0	0	Up to 7									0	0

NB. This delivery schedule assumes a median scenario, but will be reassessed throughout the year based on updated forecasts.

Table 9: Estimated end-of-system return flows

Asset	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Gulligal Lagoon	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbers lagoon	0	0	0	0	0	0	0	0	0	0	0	0	0
River Channel	0	0	Due to limited holdings, negligible contribution to end of system flows is expected.									0	0

1.9. Key Constraints for water delivery

Maximum release capacities, which restrict the ability to provide high flows and inundate downstream wetlands, apply to the major Namoi catchment storages:

- Split Rock Dam has a maximum release capacity of 4,500 ML/day; and
- Keepit Dam maximum release capacity is 3,500 ML/day.

The release capacity will decrease as the storage level drops. Any environmental water order needs to consider other water orders and therefore possible valve and channel capacity sharing. The maximum channel capacity of Pian Creek is 2,000 ML/day and Gunidgera offtake, which regulates flows into Pian Creek, has a capacity of 1,250 ML/day.

The length of time it takes for environmental water to reach a targeted asset from a water storage is an important consideration. Significant travel times can impact on water delivery in the Namoi, the longer delivery times are for when the channel is dry prior to the release:

- Split Rock- Keepit- 4-5 days;
- Keepit Dam- Boggabri- 3-6 days;
- Boggabri- Narrabri- 2-4 days;
- Narrabri- Wee Waa- 2-4 days;
- Wee Waa- Walgett- 15-30 days; and
- Wee Waa- end Pian Creek regulated (Dundee weir)-10- 20 days.

1.10. Water Use Accounting

In the regulated Namoi River and associated systems, environmental flows are delivered by State Water. The water delivered is generally measured at the user's diversion offtake and any transmission loss to deliver the water to the offtake is not accounted against the water shareholder.

In order to track in-stream watering actions, assessment of residual in-channel flow during an augmented flow event will need to be undertaken through consultation with State Water based on their CAIRO water balance spreadsheet using observed flow hydrograph volumes, tributary inflows, irrigation diversions and drainage return flows.

Commonwealth licences in the Namoi do not have an approved water supply works nominated on the access licence**.** It is a statutory requirement that water can only be delivered to or extracted at an approved water supply works nominated on the licence. This issue must be resolved prior to commencing watering options.

1.11. Risk Management

A risk assessment will be undertaken for each watering option as part of the assessment process. Some of the more likely risks associated with delivering environmental water in the catchment are:

- Lack of delivery arrangements

Delivery arrangements will be determined, through consultation with delivery partners and local landholders to facilitate delivery and ensure environmental outcomes.

- Cold water releases

Cold water releases from Keepit Dam are known to affect the downstream environment for at least 100km to Boggabri. The dam is being upgraded, completion expected in 2013, to include a multilevel off-take to reduce this impact.

- Invasive species

Carp breeding may be supported by environmental flows. Environmental water deliveries will be aligned to support or favour native fish species spawning and dispersal events.

- flooding of properties and infrastructure and associated liability

Monitoring flows and communicating increases in water level to landholders can help ensure water levels do not exceed desirable limits. The likelihood of this issue occurring in the Namoi is low given the small volume of holdings at the present time.

A key mitigating action for minimising risk arising from environmental watering actions in the catchment is engaging the local community and keeping them informed.

1.12. Event Monitoring

A robust approach to monitoring and evaluation is critical to determine the long-term outcomes of the use of environmental water, and to provide information to support good governance and adaptive management. Over the long term the monitoring of Commonwealth watering actions will be undertaken in accordance with the Monitoring, Evaluation and Reporting framework which is currently under development. Once in place, this framework will facilitate the assessment and achievement of specific environmental outcomes to Commonwealth watering actions.

Over the next 12 months, Commonwealth investment in monitoring in the Namoi catchment is unlikely to be a priority compared to other catchments where volumes of Commonwealth water used will be greater. Monitoring will most likely be contingent on delivery partners being able to make resources available in appropriate timeframes, on an event-by-event basis. Monitoring will most likely focus on the specific ecological objectives, managing potential risks of the action and measuring the volumes of Commonwealth water used. The approaches and methods for monitoring will be reviewed for consistency with monitoring of Commonwealth Environmental Watering at other sites.

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Appendix A Threatened species of the Namoi catchment (Barma 2011)

The following tables list species associated with the Namoi catchment and includes their status in relation to the NSW *Threatened Species Conservation Act 1995;* NSW *Fisheries Management Act 1994; EPBC Act 1999.*

Bird					
Common name	**Scientific name**	**EPBC Act listing**	**NSW status**[i]	**Wetland dependent**[ii]	**Presence**
Great egret	*Egretta alba or Ardea alba*	Migratory		Yes	Known[iii]
Glossy ibis	*Plegadis falcinellus*	Migratory		Yes	Known
Latham's snipe	*Gallinago hardwickii*	Migratory		Yes	Known
Marsh sandpiper	*Tringa stagnatilis*	Migratory		Yes	Known
Common greenshank	*Tringa nebularia*	Migratory		Yes	Known
Sharp-tailed sandpiper	*Calidris acuminata*	Migratory		Yes	Known
Caspian tern	*Hydroprogne caspia or Sterna caspia*	Migratory		Yes	Known
White-throated needletail	*Chaetura caudacuta or Hirundapus caudacutus*	Migratory		Yes	Known
Rainbow bee-eater	*Merops ornatus*	Migratory		No	Known
Clamorous reed-warbler	*Acrocephalus stentoreus*	Migratory		Unknown	Known

Bird					
Common name	**Scientific name**	**EPBC Act listing**	**NSW status**[i]	**Wetland dependent**[ii]	**Presence**
Superb parrot	*Polytelis swainsonii*	Vulnerable	Threatened	Breeds in long-lived riverine trees	Known
Australasian bittern	*Botaurus poiciloptilus*		Vulnerable	Yes	Known[iv]
Barking owl	*Ninox connivens*		Vulnerable		Known
Black-breasted buzzard	*Hamirostra melanosternon*		Vulnerable		Known
Black-necked stork	*Ephippiorhynchus asiaticus*		Endangered	Yes	Known
Black-tailed godwit	*Limosa limosa*		Vulnerable	Yes	Known
Blue-billed duck	*Oxyura australis*		Vulnerable	Yes	Known
Brolga	*Grus rubicunda*		Vulnerable	Yes	Known
Diamond firetail	*Stagonopleura guttata*		Vulnerable	Often found in riparian veg	Known
Freckled duck	*Stictonetta naevosa*		Vulnerable	Yes	Known
Gilbert's whistler	*Pachycephala inornata*		Vulnerable	Unknown	Known

Bird					
Common name	**Scientific name**	**EPBC Act listing**	**NSW status**[i]	**Wetland dependent**[ii]	**Presence**
Magpie goose	*Anseranas semipalmata*		Vulnerable	Yes	Known
Painted snipe	*Rostratula benghalensis*		Endangered	Yes	Known
Red goshawk	*Erythrotriorchis radiatus*		Critically Endangered		Known
Regent honeyeater	*Xanthomyza phrygia*		Endangered		Known
Grey falcon	*Falco hypoleucos*		Vulnerable		Predicted
Square-tailed kite	*Lophoictinia isura*		Vulnerable		Known
Turquoise parrot	*Neophema pulchella*		Vulnerable		Known

[i] http://threatenedspecies.environment.nsw.gov.au/tsprofile/browse_veg.aspx search by habitats: Forested wetlands, freshwater wetlands
[ii] For EPBC listed species, wetland dependent was determined using MDBA recommendations. For NSW listed species this was determined from species information supplied on the website http://threatenedspecies.environment.nsw.gov.au
[iii] *Identifying habitat requirements for birds on cotton farms in the Lower Namoi* ED Cleland 2006–2008
[iv] DEC NSW Threatened species – Species found in the Namoi http://www.threatenedspecies.environment.nsw.gov.au 7/12/09

Aquatic Species				
Common name	**Scientific name**	**EPBC Act listing**	**NSW status**	**Presence**
River snail	*Notopala sublineata*		Endangered	Known
Purple spotted gudgeon	*Mogurnda adspersa*		Endangered	Known
Silver perch	*Bidyanus bidyanus*		Vulnerable	Known
Olive perchlet	*Ambassis agassizii*		Endangered	Known
Murray cod	*Maccullochella peelii peelii*	Vulnerable		Known
Freshwater Catfish	*Tandanus tandanus*		Endangered	Known
Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River	This community includes 21 native fish species and hundreds of native invertebrate species, many of which have not been comprehensively studied		Endangered Ecological Community	Known

Other species					
Common name	**Scientific name**	**EPBC Act listing**	**NSW status**	**Wetland dependent**[v]	**Presence**
Booroolong frog	*Litoria booroolongensis*	Endangered	Endangered	Yes	*Known (outside where entitlements are held)*
The Bell's turtle	*Elseya belli*	Vulnerable	Vulnerable	Yes	Known (outside where the CEWH has entitlements)
Brush-tailed phascogale	*Phascogale tapoatafa*		Vulnerable	Often found around swamps	Predicted
Davies tree frog	*Litoria daviesae*		Vulnerable	Yes	Known (outside where the CEWH has entitlements - *Walcha Plateau)*
Glandular frog	*Litoria subglandulosa*		Vulnerable	Yes	Known (outside where the CEWH has entitlements - *Walcha Plateau)*
Greater broad-nosed bat	*Scoteanax rueppellii*		Vulnerable	Forages along rivers	Known
Five-clawed worm-skink	*Anomalopus mackayi*	Vulnerable	Endangered	No - inhabits damp places	Known
Pale-headed snake	*Hoplocephalus bitorquatus*		Vulnerable	No - often found in streamside areas	Known
Sloane's froglet	*Crinia sloanei*		Vulnerable	Yes	Known[vi]

Other species					
Common name	**Scientific name**	**EPBC Act listing**	**NSW status**	**Wetland dependent**[v]	**Presence**
Squirrel glider	*Petaurus norfolcensis*		Vulnerable	Unknown – utilises RRG forest as habitat	Known
Stripe-faced Dunnart	*Sminthopsis macroura*		Vulnerable	Unknown – often found along drainage lines	Known

[v] For EPBC listed species, wetland dependent was determined using MDBA recommendations. For NSW listed species this was determined from species information supplied on the website http://threatenedspecies.environment.nsw.gov.au

[vi] This has been confirmed by Namoi CMA officers through email correspondence with Sally Eagan received 9/7/2009.

Appendix B CEWH Ecological Watering Objectives

	Ecological Watering Objectives	Management Objectives	Management Actions
Extreme Dry	▪ Avoid damage to key environmental assets	▪ Avoid critical loss of threatened species and communities ▪ Maintain key refuges ▪ Avoid irretrievable damage or catastrophic events	▪ Water refugia and sites supporting threatened species and communities ▪ Undertake emergency watering at specific sites of priority assets ▪ Use carryover volumes to maintain critical needs
Dry	▪ Ensure ecological capacity for recovery	▪ Support the survival and growth of threatened species and communities, including limited small-scale recruitment ▪ Maintain diverse habitats ▪ Maintain low-flow river and floodplain functional processes in sites and reaches of priority assets	▪ Water refugia and sites supporting threatened species and communities ▪ Provide low flow and freshes in sites and reaches of priority assets ▪ Use carryover volumes to maintain follow-up watering
Median	▪ Maintain ecological health and resilience	▪ Enable growth and reproduction and small -scale recruitment for a diverse range of flora and fauna ▪ Promote low-lying floodplain-river connectivity ▪ Support medium-flow river and floodplain functional processes.	▪ Prolong flood/high-flow duration at key sites and reaches of priority assets ▪ Contribute to the full range of in-channel flows ▪ Use carryover to provide optimal seasonal flow patterns in subsequent years
Wet	▪ Improve and extend healthy and resilient aquatic ecosystems	▪ Enable growth, reproduction and large-scale recruitment for a diverse range of flora and fauna ▪ Promote higher floodplain-river connectivity ▪ Support high-flow river and floodplain functional processes	▪ Increase flood/high-flow duration and extent across priority assets ▪ Contribute to the full range of flows, including overbank ▪ Use carryover water to provide optimal seasonal flow patterns in subsequent years

For further information please refer to the *Framework for Determining Commonwealth Environmental Watering Actions* (available at http://www.environment.gov.au/water/policy-programs/cewh/index.html)

Appendix C Watering Options for the Namoi River Catchment

Environmental Asset	**Management objectives for specific water availability scenarios** **Extreme Dry** **Goal: Avoid damage to key environmental assets** **River systems may cease to flow and dry down to a series of pools that act as refuge for native fish populations which will repopulate the river systems when flows return.** **Water availability is limited to remaining volumes in environmental account, carried over from previous years. General security allocations are not likely to increase more than 8 per cent during the year.** **CEW – 6,771 ML carryover from 2010-11 and 586 ML forecast allocation in 2011-12.**	**Dry** **Goal: Ensure ecological capacity for recovery** **River systems will have minimum baseflows within the regulated channel and minor inflows from unregulated tributaries.** **Water availability is limited to remaining volumes in environmental account, carried over from previous years. General security allocations are not likely to increase more than 26 per cent during the year.** **CEW – 6,771 ML carryover from 2010-11 and 1,690 ML forecast allocation in 2011-12.**	**Median** **Goal: Maintain ecological health and resilience** **River systems will have inflows from regulated and unregulated tributaries and contribute to end of system flows.** **Water availability will include volumes carried over from previous year and general security allocations may increase by 47 per cent during the year.** **CEW – 6,771 ML carryover from 2010-11 and 2,971 ML forecast allocation in 2011-12.**	**Wet** **Goal: Improve and extend healthy and resilient aquatic ecosystems** **River system will have high flood level flows inundating large areas of the floodplain and providing high end of system flows.** **Water availability will include volumes carried over from previous year and 80 per cent or greater of general security allocation.** **CEW – 6,771 ML carryover from 2010-11 and 4,983 ML forecast allocation in 2011-12.**
Lower Namoi River channel floodplain Inflows into Barwon-Darling System	▪ Minimum 8 ML/d flow at Boggabri to maintain drought refuge for fish generally provided by S&D, irrigation orders, unregulated and planned environmental flows. ▪ Up to 24 ML/d delivered to maintain in-stream habitat and end of system flows (discussions with Statewater are required to determined feasibility of delivery)	▪ Other water orders to maintain in-stream habitat. Provide wetting and connectivity with low level benches and point bars. ▪ A total volume of 1,900- 9,500 ML delivered at 1,900 ML/d for 1 to 5 days at Bugilbone gauge.	▪ Provide wetting and connectivity with low level benches and point bars. Increase end of system flow to Barwon-Darling. ▪ A total volume of 4,500- 22,500 ML delivered at 4,500 ML/d for 1 to 5 days at Bugilbone gauge. ▪ Small flood events (>4,500 ML/d at Bugilbone) inundate low ctf wetlands. ▪ Flows of 1,550-3,150 ML/d at Wee Waa between Sep-Dec for min. 7 days are required to support native fish spawning/recruitment ▪ 8,000-9,000 ML/d over 5 days at Wee Waa between Sept-Dec to allow 'drownout' of weirs and free fish passage.	▪ Provide wetting and connectivity with higher level benches, point bars and riparian zone. Increase end of system flow to Barwon-Darling. ▪ A total volume of 6,300- 31,500 ML delivered at 6,300 ML/d for 1 to 5 days at Bugilbone gauge. ▪ Flows of 1,550-3,150 ML/d at Wee Waa between Sep-Dec for min. 7 days are required to support native fish spawning/recruitment ▪ 8,000-9,000 ML/d over 5 days at Wee Waa between Sept-Dec to allow 'drownout' of weirs and free fish passage.
Gulligal Lagoon	▪ Gulligal Lagoon fills during high flood events (i.e. when the river reaches a height of 5.00 m at Gunnedah gauge) or could be filled by pumping water from the Namoi River. ▪ The volume of water required is unknown and requires bathometry studies on the lagoon to estimate its capacity. ▪ Natural water loss (e.g. leakage, drainage and evaporation) may necessitate repeat watering events in drier years to maintain inundation levels.	▪ Gulligal Lagoon fills during high flood events (i.e. when the river reaches a height of 5.00 m at Gunnedah gauge) or could be filled by pumping water from the Namoi River. ▪ The volume of water required is unknown and requires bathometry studies on the lagoon to estimate its capacity. ▪ Natural water loss (e.g. leakage, drainage and evaporation) may necessitate repeat watering events in drier years to maintain inundation levels.	▪ Gulligal Lagoon fills during high flood events (i.e. when the river reaches a height of 5.00 m at Gunnedah gauge) or could be filled by pumping water from the Namoi River. ▪ The volume of water required is unknown and requires bathometry studies on the lagoon to estimate its capacity. ▪ Natural water loss (e.g. leakage, drainage and evaporation) may necessitate repeat watering events in drier years to maintain inundation levels.	▪ Gulligal Lagoon fills during high flood events (i.e. when the river reaches a height of 5.00 m at Gunnedah gauge) or could be filled by pumping water from the Namoi River. ▪ The volume of water required is unknown and requires bathometry studies on the lagoon to estimate its capacity. ▪ Natural water loss (e.g. leakage, drainage and evaporation) may necessitate repeat watering events in drier years to maintain inundation levels.
Barbers Lagoon	▪ No water delivered under extremely dry conditions	▪ No water delivered under dry conditions	▪ Provide wetting and connectivity with low level benches, point bars and riparian zone ▪ A total volume of 4,600- 23,000 ML delivered at 4,600 ML/d for 1 to 5 days at Boggabri gauge - (ctf 4,600 ML/d)	▪ Provide wetting of riparian zone and floodplain red gums ▪ A total volume of 5,000- 25,000 ML delivered at 5,000 ML/d for 1 to 5 days at Boggabri gauge (ctf >4,600 ML/d)
Duncan Warranbool	▪ No water delivered under extremely dry	▪ Provide wetting and connectivity with low	▪ Provide wetting and connectivity with low level	▪ Provide wetting and connectivity with higher

Environmental Asset	Management objectives for specific water availability scenarios			
	Extreme Dry **Goal: Avoid damage to key environmental assets** **River systems may cease to flow and dry down to a series of pools that act as refuge for native fish populations which will repopulate the river systems when flows return.** **Water availability is limited to remaining volumes in environmental account, carried over from previous years. General security allocations are not likely to increase more than 8 per cent during the year.** **CEW – 6,771 ML carryover from 2010-11 and 586 ML forecast allocation in 2011-12.**	**Dry** **Goal: Ensure ecological capacity for recovery** **River systems will have minimum baseflows within the regulated channel and minor inflows from unregulated tributaries.** **Water availability is limited to remaining volumes in environmental account, carried over from previous years. General security allocations are not likely to increase more than 26 per cent during the year.** **CEW – 6,771 ML carryover from 2010-11 and 1,690 ML forecast allocation in 2011-12.**	**Median** **Goal: Maintain ecological health and resilience** **River systems will have inflows from regulated and unregulated tributaries and contribute to end of system flows.** **Water availability will include volumes carried over from previous year and general security allocations may increase by 47 per cent during the year.** **CEW – 6,771 ML carryover from 2010-11 and 2,971 ML forecast allocation in 2011-12.**	**Wet** **Goal: Improve and extend healthy and resilient aquatic ecosystems** **River system will have high flood level flows inundating large areas of the floodplain and providing high end of system flows.** **Water availability will include volumes carried over from previous year and 80 per cent or greater of general security allocation.** **CEW – 6,771 ML carryover from 2010-11 and 4,983 ML forecast allocation in 2011-12.**
	conditions	level benches and point bars ▪ A total volume of 4,000- 20,000 ML/d delivered at 4,000 ML/d for 1 to 5 days at Bullawa gauge (ctf 4,000 ML/d)	benches, point bars and riparian zone ▪ A total volume of 4,500- 22,500 ML/d delivered at 4,500 ML/d for 1 to 5 days at Bullawa gauge- (ctf >4,000 ML/d)	level benches, point bars and riparian zone ▪ A total volume of 5,500- 27,500 ML/d delivered at 5,500 ML/d for 1 to 5 days at Bullawa gauge (ctf >4,000 ML/d)
Pian Creek	▪ No water delivered under extremely dry conditions ▪ Two planned replenishment flows per water year not exceeding a combined total volume of 14,000 ML. To provide a visible flow 5 or more consecutive days at Waminda gauge.	▪ No water delivered under extremely dry conditions ▪ Two planned replenishment flows per water year not exceeding a combined total volume of 14,000 ML. To provide a visible flow 5 or more consecutive days at Waminda gauge.	▪ Provide wetting and connectivity with low level benches, point bars and riparian zone ▪ A total volume of 2,000- 10,000 ML/d delivered at 1,250 ML/d for 1 to 5 days (Max. channel capacity 2,000 ML/d, max Capacity of Gunidgera offtake is 1,250 ML)	▪ Provide wetting and connectivity with higher level benches, point bars and riparian zone ▪ A total volume of 2,000- 10,000 ML/d delivered at 1,250 ML/d for 1 to 5 days (Max. channel capacity 2,000 ML/d, max Capacity of Gunidgera offtake is 1,250 ML)
Carryover potential	▪ Negligible potential for carryover volumes	▪ Small potential to maintain carryover volumes	▪ Potential for carryover volumes	▪ High potential for carryover volumes

Appendix D Criteria for Assessing Commonwealth Environmental Watering Actions

In undertaking its activities, the Commonwealth Environmental Water Holder (CEWH) is required to act consistently with the requirements of the *Water Act 2007* (Cwlth) (hereafter referred to as 'the Act'). The relevant functions are outlined in s.105. This includes a requirement that the environmental water holdings are managed in accordance with the environmental watering plan of the Murray-Darling Basin Authority (MDBA). Close consultation is occurring with the MDBA to ensure that use of Commonwealth water is consistent with the emerging objectives of the environmental watering plan that is currently being developed.

A long-term framework for the prioritisation of environmental water allocations has been prepared in consultation with delivery partners, interested stakeholders and experts, and the Environmental Water Scientific Advisory Committee.

The framework includes ecological objectives that will change under the different water availability scenarios (i.e. extreme dry, dry, median, wet). Proposed watering actions will need to be supported by available evidence, and consistent with current water availability scenarios and the framework.

Commonwealth environmental water is being acquired to supplement existing flows. Proposals for use of the water will not be agreed to if this use substitutes for other water uses, including historical system operations (e.g. provision of water for conveyance, stock and domestic, or planned environmental water).

Through adaptive management processes, the CEWH will consider opportunities for a more informed and diverse range of water uses as knowledge and modelling. All 2011-12 proposals will be assessed against the following five criteria:

1. The ecological significance of the asset(s).
2. The expected ecological outcomes from the proposed watering action.
3. The potential risks of the proposed watering action at the site and at connected locations.
4. The long-term sustainability of the asset(s) including appropriate management arrangements.
5. The cost effectiveness and operational feasibility of undertaking the watering.

Water Use Strategy 2011-12:

Northern Victoria Rivers

Prepared by

Environmental Water Branch

Department of Sustainability, Environment, Water, Population and Communities

Table of Contents

1. Introduction

This document sets out the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC or 'the Department') objectives and proposed approach to using Commonwealth environmental water to meet the needs of ecosystem assets in the Northern Victoria river catchments during the 2011-12 water year.

The Northern Victorian rivers include the Goulburn, Campaspe, Loddon and Ovens rivers, lower Broken Creek and the Boort wetland complex on the floodplain of the Loddon River (Figure 1.1). This strategy was prepared based on available information for each asset, water availability and demand, and in consultation with delivery partners such as the Goulburn-Broken and North Central Catchment Management Authorities (GBCMA and NCCMA), the Victorian Environmental Water Holder (VEWH), Goulburn-Murray Water (G-MW) and those involved with the preparation of similar strategies for the mid-Murray region.

The strategy establishes the approach that the Department will take in using Commonwealth environmental water, and includes watering options given current and expected climatic and riverine conditions in the catchment. The strategy will evolve over the course of the year as conditions in the catchments change and more information becomes available. Importantly, the potential watering options included in this document do not form an exhaustive list – the Department welcomes proposed options for using water. All relevant options will be assessed to ensure the best possible use of environmental water within the catchment and across the Murray-Darling Basin.

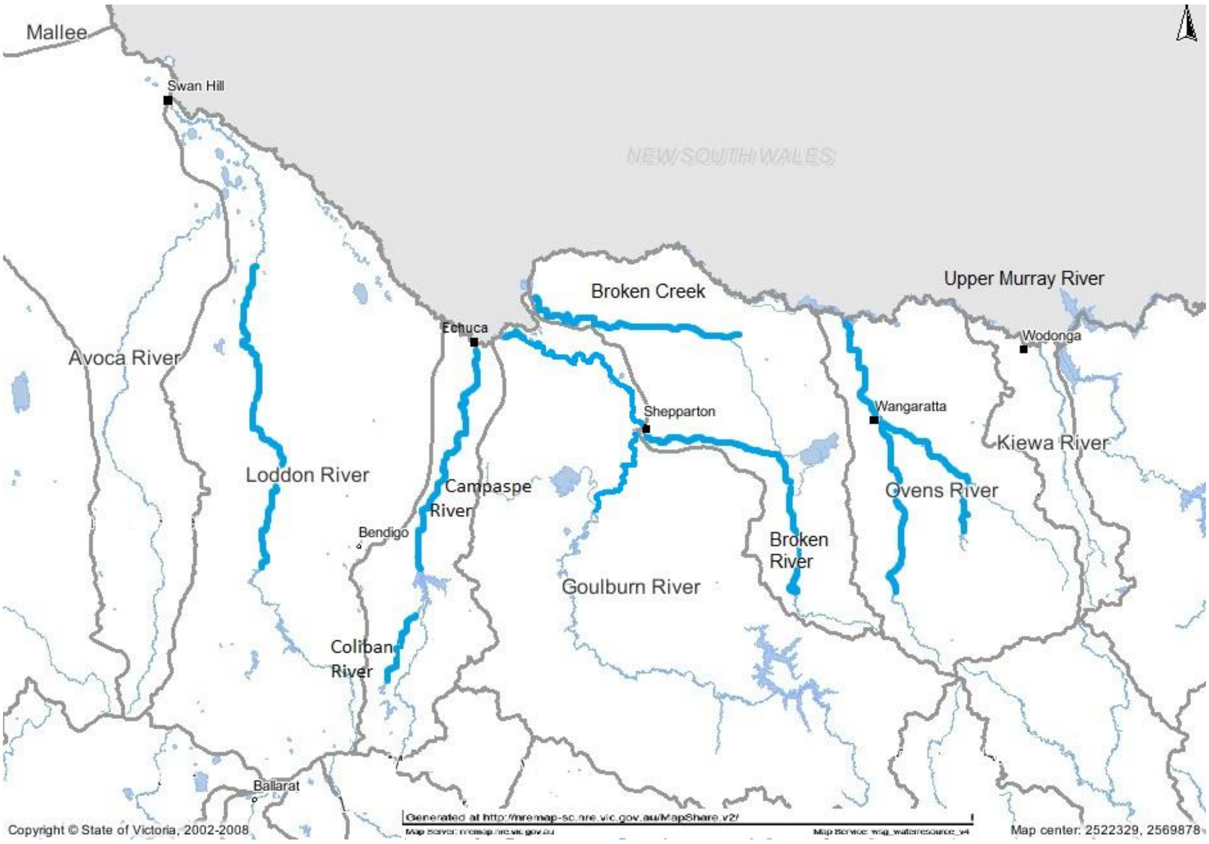

Figure 1.1: Northern Victorian rivers.
Source: DSE 2011b

2. Overview

This Strategy contains environmental watering strategies for the northern Victorian river systems in which the Commonwealth will consider environmental watering options during 2011-12. This section provides an outline of the overarching issues (event monitoring) related to the northern Victorian river systems. Sections 3 to 9 contain background information and the water use strategies for each of the seven river systems, which are:

1. Goulburn River (Lake Eildon to the Murray River);
2. Campaspe River (Lake Eppalock to the Murray River);
3. Loddon River (Laanecoorie Reservoir to Kerang Weir) and Boort district wetlands;
4. Broken Creek (Katamite to the Murray River);
5. Broken River (Lake Nillahcootie to the Goulburn River);
6. Ovens River (including lower King and Buffalo Rivers; and
7. Coliban River (Malmsbury Reservoir to Lake Eppalock).

2.1. Current system status in northern Victoria

Northern Victoria experienced prolonged drought for over a decade which ended following heavy rainfall and extensive flooding across south-eastern Australia in 2010-11. The floods provided an input of nutrients, carbon and organic matter to the stream and an exchange of sediments and biota between the river channels, floodplains and wetlands. The floods and freshes connected floodplains that had not been connected for 10 to 15 years and improved riparian vegetation health. Improved productivity on the floodplain appears to have resulted in the spawning of golden perch (*Macquaria ambigua*) in the Goulburn River for the first time in eight years (GB CMA 2011).

The rainfall outlook for south-eastern Australia favours drier than normal rainfall conditions over the Northern Victoria assets (Figure 2.1), with a 40 per cent chance of exceeding the median rainfall over the July to September 2011 period.

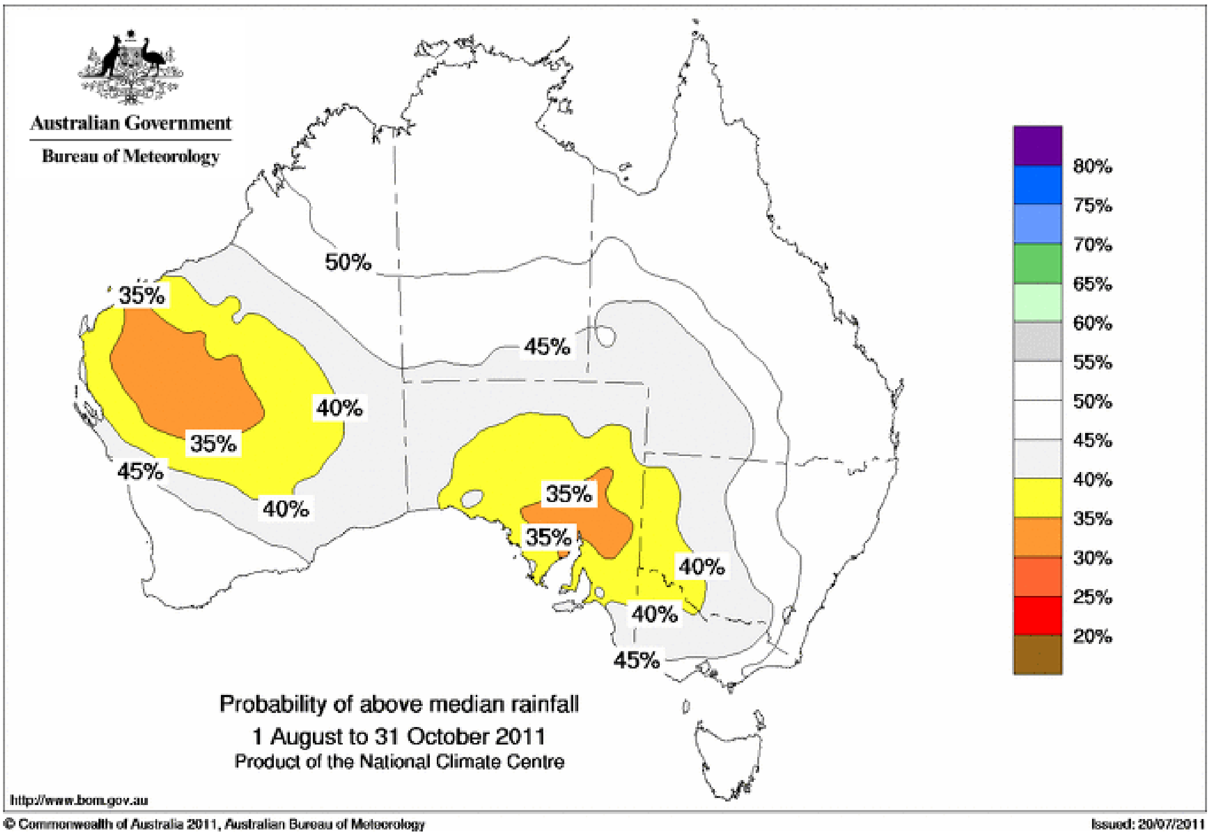

Figure 2.1: Seasonal rainfall outlook for south-eastern Australia for 1 August to 31 October issued on 20 July 2011.
Source: BoM www.bom.gov.au/climate/ahead/rain.seaus.shtml accessed on 28 June 2011

The rainfall in northern Victoria over the three months April to June has been below average as illustrated in Figure 2.2. This represents a significant contrast to the preceding three months' rainfall which was significantly above the average (Figure 2.3).

Catchments of the northern Victorian rivers have experienced some drying in recent months but soil moisture levels remain high as the southern wet season commences. For the July to September period, near median to low flows are the most likely outcome for the Loddon and Campaspe basins, near median flows are most likely for the Broken and Kiewa basins and near median to high flows are most likely for the Ovens, Goulburn and Upper Murray basins (Figure 2.4).

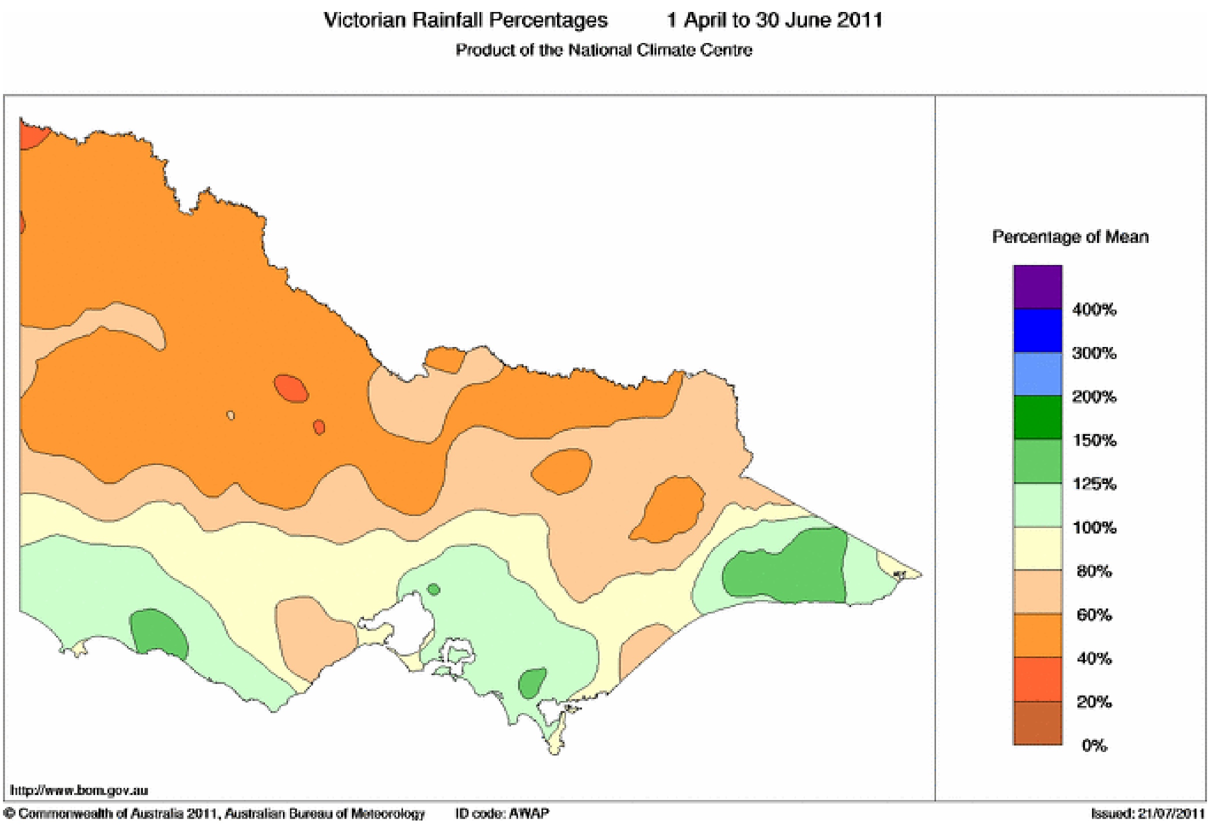

Figure: 2.2 Rainfall from 1 April to 30 June (per cent of mean).
Source: BoM www.bom.gov.au/climate/ahead/rain.seaus.shtml accessed on 28 July 2011

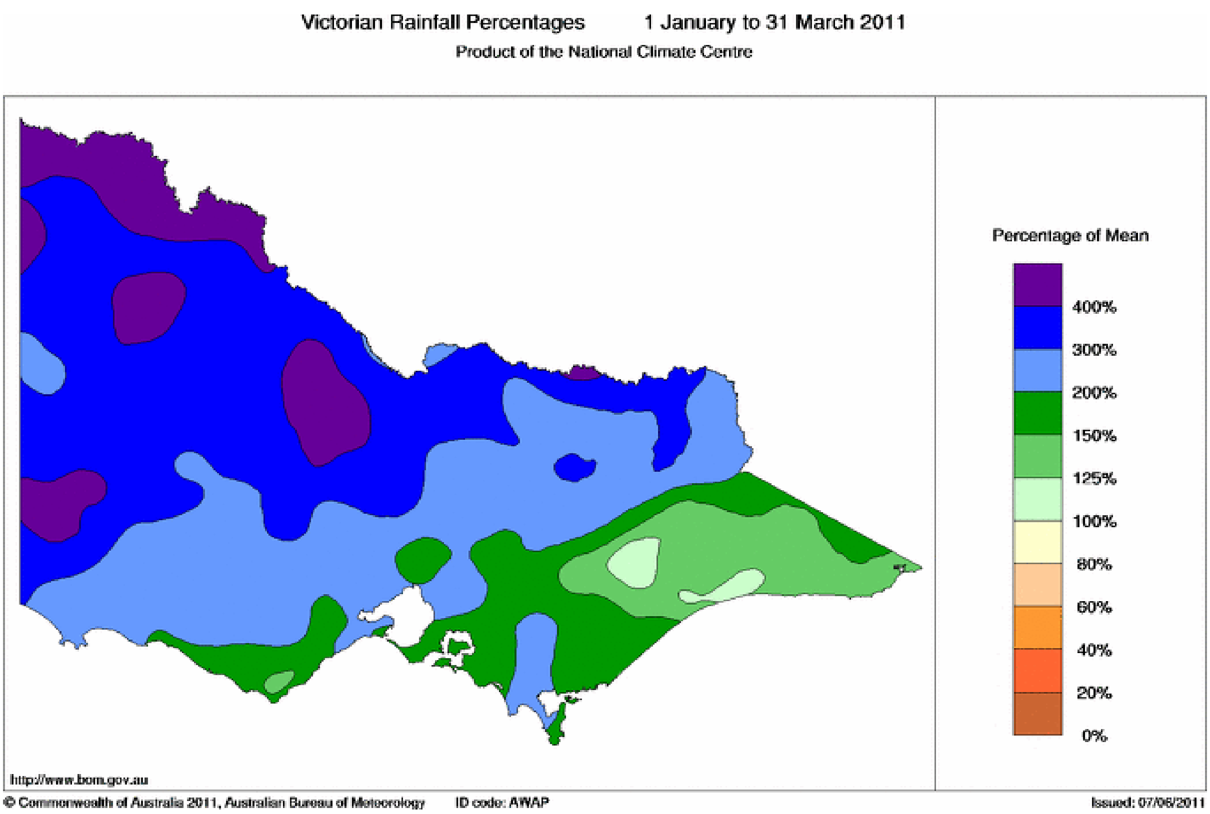

Figure 2.3: Rainfall from 1 January 31 March (per cent of mean).
Source: BoM www.bom.gov.au/climate/ahead/rain.seaus.shtml accessed on 28 July 2011

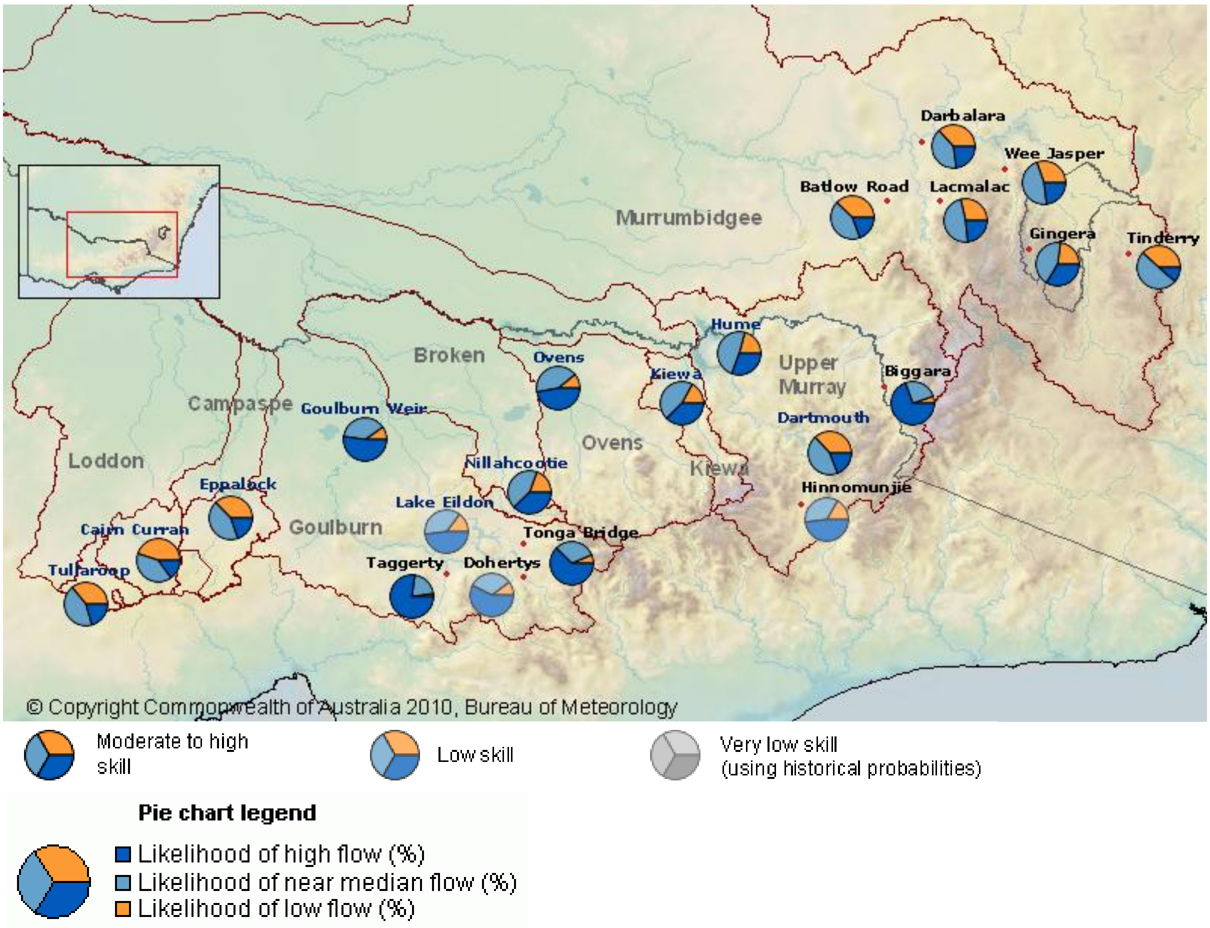

Figure 2.4: South-east Murray-Darling seasonal streamflow forecasts for July to September 2011.
Source: BoM www.bom.gov.au/climate/ahead/rain.seaus.shtml accessed on 28 July 2011

A number of watering events using Commonwealth environmental water were undertaken during the 2010-11 water year (Table 2.1).

Table 2.1: Commonwealth environmental watering actions in northern Victorian rivers during 2010-11.

River	Date of water delivery	Commonwealth volume delivered (ML)
Goulburn River (Lake Eildon to Murray River)	May / June	52,477.0
Campaspe River	June	2,140.0
Loddon River	June	427.4
Broken River	May	24.2

2.2. Forecast allocations

Key points:

- Water availability forecasts indicate that up to 650 GL of Commonwealth environmental water could be available for use in the southern connected basin by the end of 2011-12.

Current storage levels in the southern Murray-Darling Basin are high (Figure 2.5). Thus, it is expected that water available against Commonwealth environmental water entitlements in 2011-12 will be high.

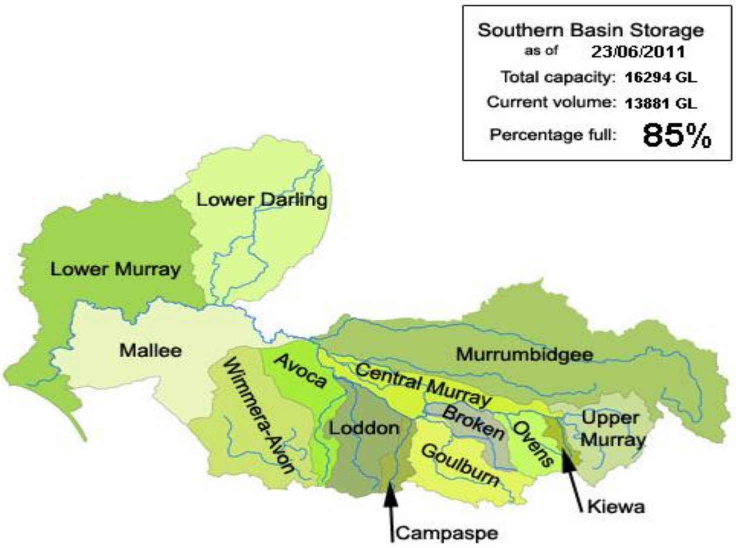

Figure 2.5: Current water storage levels in the southern Murray-Darling Basin (as at 23 June 2011). Source: (http://www.mdba.gov.au/water/waterinstorage/southern?run-date=2011-06-23).

The volume of Commonwealth environmental water available in the southern connected basin and the individual northern Victorian catchments at the beginning of 2011-12, and forecasts for the rest of 2011-12 water year are described in subsequent sections of this strategy. These forecasts were determined by the Department based on the following:

- There would be no barriers to trade within southern connected basin during 2011-12, except the 100 GL net trade limit out of the Murrumbidgee;
- The southern connected basin includes the NSW Murray, Victorian Murray, SA Murray, Murrumbidgee, Goulburn, Campaspe, Lower Darling and the Loddon;
- Forecasts were based on information available at 1 July 2011, and the Commonwealth's registered entitlements at this date;
- Supplementary entitlements and additional entitlements that may be obtained and registered by the Commonwealth during 2011-12 were not included in forecasts; and
- Forecasts were based on dry and wet climate year scenarios.

2.3. Watering objectives

During 2010-11, the Department undertook work to identify and develop large-scale watering options for Commonwealth environmental water, including for a number of northern Victorian rivers (Cottingham *et al.* 2011a, b, c & d).

Through this work, the following medium- to long-term objectives have been identified for the northern Victorian Rivers:

- protect and restore water-dependent ecosystems that: support migratory birds listed in international agreements; provide vital habitat for native aquatic flora and fauna; and support Commonwealth-, state- or territory- threatened species and/or ecological communities (MDBA 2010b);

- rehabilitate, maintain or enhance in-channel habitats, aquatic and riparian vegetation, macroinvertebrates populations and diversity, native fish communities, and off-channel wetland and floodplain habitats; and

- provide flows and water to support environmental assets downstream in the Murray River.

These objectives are broadly consistent with the objectives specified for Victorian northern rivers in the "*Guide to the proposed Basin Plan*" published by the Murray Darling Basin Authority (2010b).

2.4. Assessing environmental watering options

A range of watering options for the northern Victorian rivers have been assessed against the Commonwealth Environmental Water Holder's criteria for assessing watering actions. Briefly, these criteria are the:

- ecological significance of the asset(s);
- expected ecological outcomes from the proposed watering action;
- potential risks of the proposed watering action at the site and at connected locations;
- long-term sustainability of the asset(s) including appropriate management arrangements; and
- cost-effectiveness and operational feasibility of undertaking the watering.

Detailed description of the *Commonwealth Environmental Water criteria for assessing environmental watering actions* is provided at Appendix B.

An assessment of the range of potential watering options against these criteria is provided at Appendix C. This assessment considers the suite of options in scope for groups of similarly located and managed assets. This allows the benefit of watering individual assets to be considered at the individual asset scale through the course of the year, while also considering the complementarity and potential integration of watering actions proposed for a group of assets collectively. The assessments will be reviewed as individual watering actions are closer to their proposed timing for delivery.

As individual watering actions are recommended for delivery, a more comprehensive risk assessment will consider in more detail the proposed costs, delivery, monitoring and accounting arrangements. Any additional watering actions identified during the course of the year will also be subject to an assessment against the criteria.

2.5. Event monitoring

The following monitoring and reporting activities, which are relevant to the implementation of this strategy, are expected to be undertaken.

Operational monitoring will be undertaken for all deliveries of Commonwealth environmental water in the northern Victorian rivers and wetlands. This will be undertaken in accordance with requirements specified by SEWPaC.

SEWPaC is currently investigating monitoring and evaluation program activities for watering activities involving Commonwealth environmental water which will inform and prioritise intervention monitoring of watering actions. Intervention monitoring for individual watering actions will be considered on an event-by-event basis closer to the time of the action and in the context of that framework.

The monitoring arrangements for environmental flows in northern Victorian rivers are summarised in Table 2.2 below.

Table 2.2: Monitoring arrangements for environmental flows in northern Victorian rivers.

Location	Parameters	Timing/frequency	Responsibility
Operational Monitoring			
Goulburn River Campaspe River Loddon River Boort Wetlands Broken Creek Broken River Ovens River Coliban River	Hydrological monitoring (flow rates and volumes) Any parameters which evidence any negative impacts generated by a watering action (e.g. salt loads, blackwater, blue-green algal bloom)	Event-by-event	CMA/delivery partner
Intervention/response Monitoring			
Goulburn River Campaspe River Loddon River Broken Creek	Fish, invertebrates, water quality, hydrological data, groundwater and soil	Event-by-event	GBCMA NCCMA
Goulburn River	Adult fish abundance, larvae counts (8 established sites)	Adult fish - spring and autumn Fish larvae – every 2 weeks during spring-summer	GBCMA
Condition Monitoring			
Goulburn River Campaspe River Loddon River	Habitat availability and the response of vegetation, fish and macroinvertebrate to environmental flows		Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP)
Goulburn River Campaspe River Loddon River	Fish populations (including fish larvae) Macroinvertebrate communities	Annual surveys	Murray Darling Basin Sustainable Rivers Audit (SRA), EPA Victoria as part of its fixed sites monitoring network and also as part of the SRA (SKM 2006).
Goulburn River Campaspe River Loddon River Boort wetlands*	Vegetation condition		Index of Stream Condition CMA

* Recent monitoring by the NCCMA has included a vegetation survey at many of the wetlands and establishment of photo-points to assess vegetation changes over time. The scale and frequency of monitoring at the wetlands is currently constrained by limited resources. Additional funding will be required if the full suite of activities described below is to be implemented (Cottingham *et al.* 2011c).

3. Goulburn River

3.1. Goulburn River and environmental assets

This section outlines the delivery strategy for the Lower Goulburn River, Reach 4 (Goulburn Weir to Shepparton) and Reach 5 (Shepparton to the Murray River).

The Goulburn River extends from the northern slopes of the Great Dividing Range north to the Murray River near Echuca (Figure 3.1). It has a mean annual discharge for the catchment of approximately 3,200 GL (Davies 2007), 50 per cent of which on average is diverted for use.

The Lower Goulburn River Reach 4 (Goulburn Weir to Shepparton) and Reach 5 (Shepparton to the Murray River) is a high value wetland system for its ecological features. The floodplain consists of a large area of habitat for fauna such as waterbirds and fish. It has a wide variety of wetland types and vegetation types, and is an excellent example of a major floodplain system (Cottingham *et al.* 2011a).

The Goulburn River upstream of Lake Eildon is a natural waterway and does not need improvement to its flow regime. Between Lake Eildon and the Goulburn Weir (reaches 1, 2 and 3) flows are seasonally reversed compared to the natural flow regime. Flows are greatly reduced in winter/spring and greatly increased in summer and autumn. The majority of irrigation water is diverted from the Goulburn River at Goulburn Weir (Nagambie) into constructed channels. A large majority of the water flowing from Eildon to Goulburn Weir is for irrigation delivery and management, and somewhat limits the ability to manage the water for environmental purposes. Consequently, the management of environmental water focuses on environmental targets downstream of Goulburn Weir where the natural seasonal flow pattern is retained but substantially reduced in volume from natural conditions (GBCMA 2011). The recent decommissioning (2009-2010) of Lake Mokoan means that additional water is likely to enter the Goulburn River from the Broken River during winter-spring. This is expected to bolster the natural pattern of higher flows in winter-spring and lower flows in summer-autumn in Reach 5 of the lower Goulburn River (Cottingham *et al.* 2011a).

Further information on the Goulburn River is in Appendix A.

The Murray Darling Basin Authority (MDBA) has identified the Goulburn River and the lower Goulburn floodplain as key environmental assets (MDBA 2010b).

The volume of Commonwealth environmental water held in the Goulburn River means that the river is also an important source of water for environmental assets downstream in the Murray River.

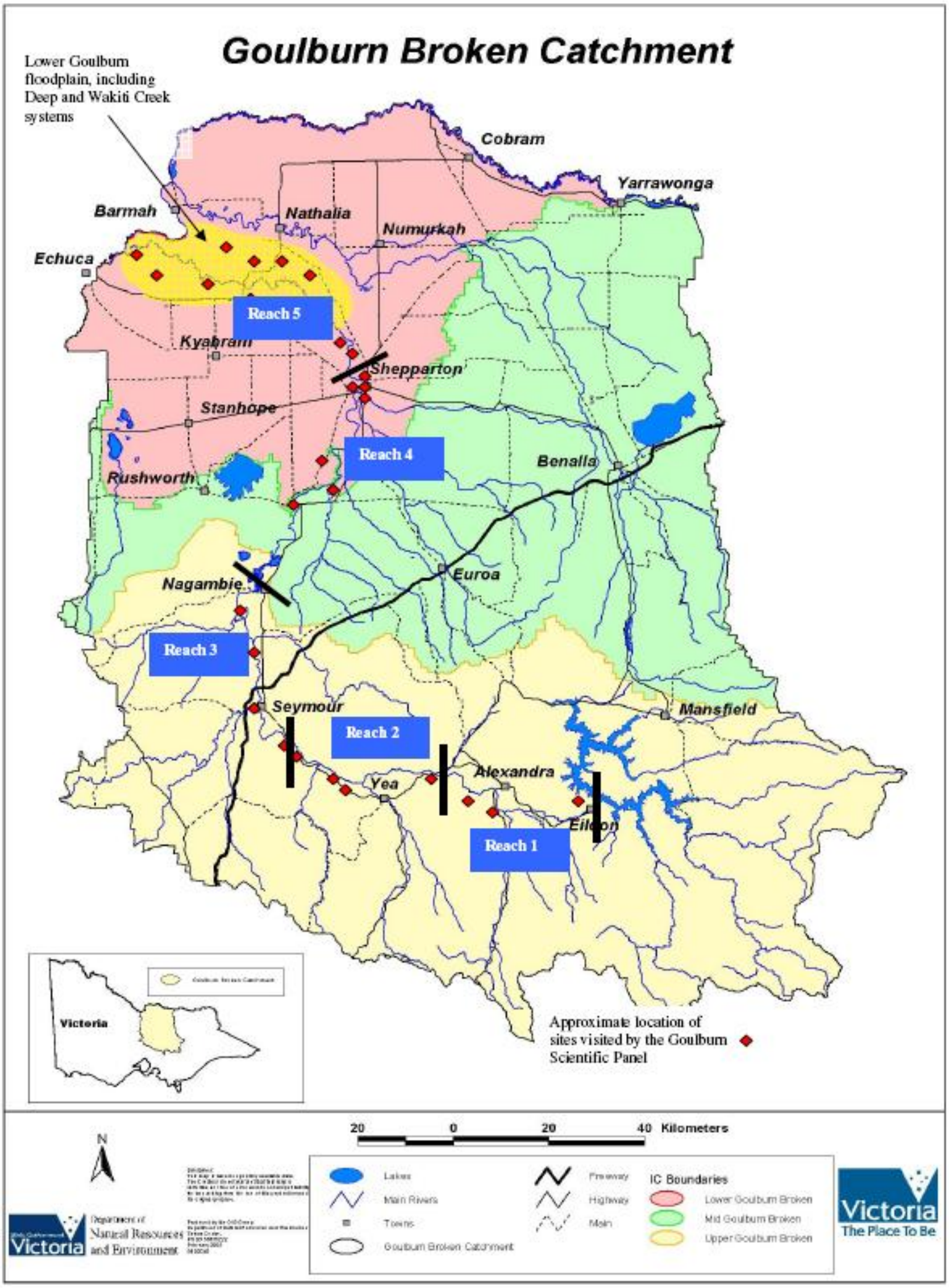

Figure 3.1: The Goulburn River environmental asset.
Source: Cottingham *et al.* 2003

3.2. Delivering water

The two major water regulation structures on the Goulburn River are Lake Eildon and Goulburn Weir. The mid sections of the Goulburn River between Lake Eildon and Shepparton have a confined floodplain (up to 4 km wide). Constructed levees confine the floodplain along the lower Goulburn River below Shepparton. Flood water leaving the channel of the lower Goulburn River downstream of

Shepparton either returns to the river channel or flows north via the Deep Creek system that discharges to the Murray River downstream of Barmah. The Broken River is a major tributary of the Goulburn River, discharging at Shepparton.

Water is released to the Goulburn River from Lake Eildon and, along with tributary inflows, travels to Goulburn Weir and then to the lower Goulburn River. Flows reaching Goulburn Weir can be diverted to the East Goulburn Main Channel and to Waranga Basin (via the Stuart Murray Canal and the Cattanach Canal) to meet irrigation, stock & domestic, and urban demand. Downstream of Goulburn Weir, the river collects tributary inflows (including the Broken River) and irrigation drainage inflows prior to discharging in the Murray River upstream of Echuca.

Flows corresponding to minor flood, moderate flood and major flood levels are shown in Table 3.1. Minor flooding results in inconvenience, with low lying areas next to watercourses inundated, requiring the removal of stock and equipment and the closure of minor roads. For moderate flooding, some houses may require evacuation. Under major flooding, properties and towns are likely to be isolated and major traffic routes closed, with numerous evacuations required (SKM 2006). It should be noted that to deliver within channel flows of 19,000 ML per day at Shepparton and overbank flows of 25,000 to 40,000 ML per day at Shepparton may result in minor flooding below Lake Eildon, consequently these flow targets are not proposed as part of this strategy.

Table 3.1: Goulburn River flood flows (SKM 2006).

Station	Name	Minor Flood (ML/d)	Moderate Flood (ML/d)	Major Flood (ML/d)
405203	Goulburn River at Lake Eildon	14,500	26,000	40,000
405201	Goulburn River at Trawool	21,700	41,500	83,000
405202	Goulburn River at Seymour	22,800	38,900	80,900
405200	Goulburn River at Murchison	29,200	58,800	79,670
405232	Goulburn River at McCoys Bridge	29,200	50,000	62,600

3.3. Current system status and outlook

The Goulburn catchment has had significant inflows over the last 12 months after years of drought. The range of high flows, including natural floods, has provided an input of nutrients and organic matter to the river and facilitated an exchange of sediments and biota between the channel, floodplain and wetlands. The higher flows improved riparian vegetation health and the improved productivity on the floodplain appears to have resulted in the spawning of golden perch (*Macquaria ambigua*) in the Goulburn River for the first time in eight years (GBCMA 2011).

Figure 3.2 shows the mean daily discharge at three Goulburn River stations over 2010-11 indicating large flows in September 2010 (up to 90,000 ML per day at Shepparton) and December 2010 (over 70,000 ML per day). The importance of flows from the tributaries are also evident, the flows at Shepparton and McCoy's being greater than upstream at Trawool. Figure 3.3 shows the antecedent discharges at McCoys Bridge over 2000 to 2011; from 2006 the river had consistently low flows until September 2010.

Wet conditions in the catchment and tributary inflows, particularly the floods of September and December 2010 and January 2011, have provided the flow events considered necessary to sustain the river and meet ecosystem objectives in 2010-11.

Table 3.2 shows the flow components (natural or managed) at McCoys Bridge. The colours on the table correspond to the flow component that was not achieved (red) and the flow component that was completely achieved (green) (GBCMA 2011). The complete suite of flow components was not delivered in the nine years prior to 2010-11, particularly for summer freshes, bankfull and overbank flows.

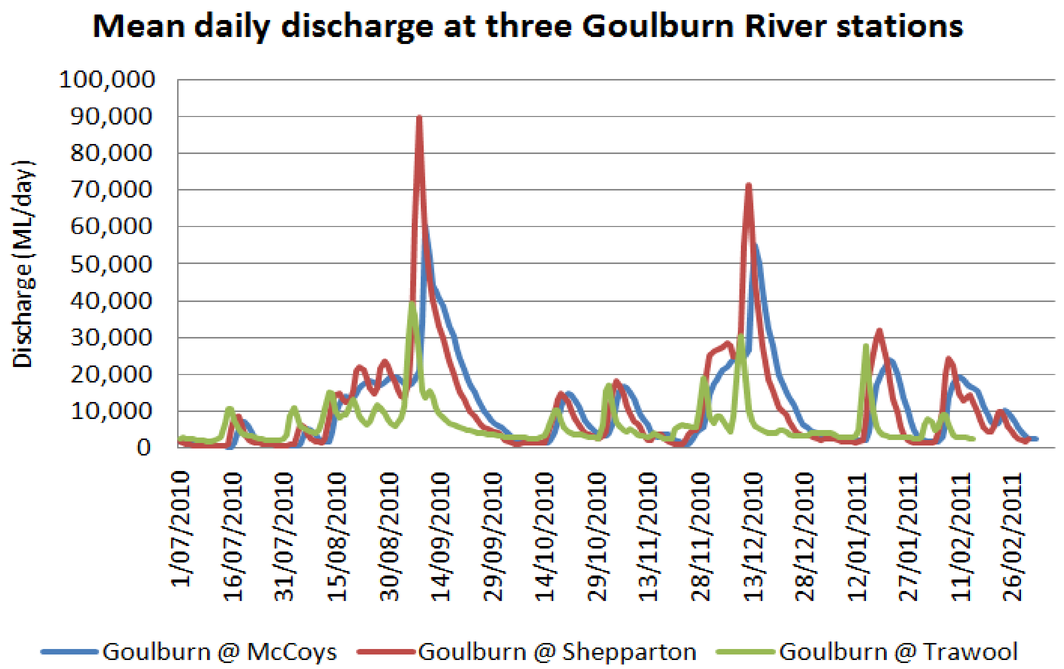

Figure 3.2: Goulburn River flows for 2010/11 at three locations downstream of Lake Eildon (from Water start to leave the main channel at flows of approximately 20,000 ML/d.
Source: GBCMA 2011

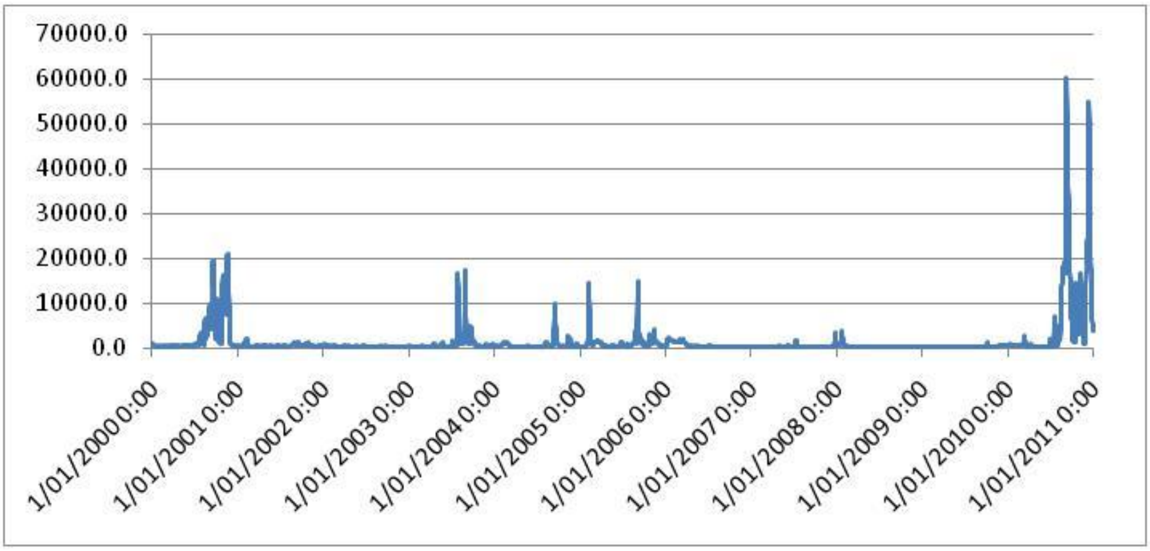

Figure 3.3: Antecedent discharge at McCoy's Bridge, 2000-2011.
Source: Victoria data warehouse http://www.vicwaterdata.net/vicwaterdata/home.aspx

Table 3.2: Flow component delivery on the Goulburn River at McCoys Bridge, 2001-02 to 2010-11

Flow component	Years									
	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
Summer baseflow	Red	Red	Green	Green	Green	Red	Green	Red	Green	Green
Summer freshes	Red	Red	Red	Green	Red	Red	Green	Red	Green	Green
Spring fresh	Green	Green	Green	Green	Green	Red	Green	Red	Red	Green
Winter bankfull	Red	Red	Green	Red	Green	Red	Red	Red	Red	Green
Winter baseflow	Green	Red	Green	Green	Green	Red	Red	Red	Red	Green
Overbank	Red	Red	Red	Red	Red	Red	Red	Red	Red	Green

Red: flow data indicates that no significant part of the flow component was provided naturally or through managed actions

Green: Flow data indicates that the flow component is considered to have been completely provided.

Source: GBCMA 2011

3.4. Forecast allocation

Key points:

- Forecasting indicates up to 650,000 ML of Commonwealth environmental water could be available for use in the southern connected basin by the end of 2011-12.

The Goulburn River is part of the southern connected basin and water can be traded in and out of the river system, although trading from some regions may be subject to conditions and restricted at times. The volume of Commonwealth environmental water available in the southern connected basin and the Victorian catchments at the beginning of 2011-12, and forecasts for the rest of 2011-12 water year are shown in Table 3.3. The basis for these forecasts are provided in section 2.2 of this document.

Table 3.3: Commonwealth environmental water availability in 2011-12.

Catchment	Entitlement (GL)	Water available for use (GL)	Water available for use forecasts					
			31 July 2011 (GL)		30 September 2011 (GL)		30 June 2012 (GL)	
Goulburn (Vic)			**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
High/Low	109.5	66.0	66.0	85.8	70.9	109.5	108.9	109.5
Total - Southern Connected Basin	**652.5**	**317.7**	**318.0**	**388.9**	**354.7**	**608.9**	**539.9**	**649.7**

Note: Southern connected basin includes Murray (NSW, Vic, SA), Murrumbidgee, Lower Darling, Campaspe, Goulburn, Loddon. The figures may change following reconciliation of accounts for the end of the 2010-11 water year.

Return flows from the Goulburn River system are likely to be available for the CEWH to direct and re-credit to watering events in the Lower River Murray, and Lower Lakes and Coorong.

3.5. Other sources of environmental water

Sources of environmental water in the Goulburn River are listed in Table 3.4. The actual volume of environmental water available in 2011-12 for each entitlement is dependent on allocation announcements.

Table 3.4: Sources of environmental water in the Goulburn River system.

Source	Management Authority	Potential Allocation
Bulk Entitlement	G-MW	• Goulburn Weir: ○ Minimum average weekly flow of 250 ML/d (daily rate no less than 200 ML/d) • McCoys Bridge: ○ Minimum average monthly flow of 350 ML/d for November to June (daily rate no less than 300 ML/d) ○ Minimum average monthly flow of 400 ML/d for July to October (daily rate no less than 350 ML/d) • Water quality reserve: 30 GL to address critical water quality issues should they arise • Wetland watering reserve: 80 GL should strict conditions be met (is unlikely to be made available). This volume can potentially be re-harvested at Goulburn Weir.
NVIRP	VEWH	Assumed 8,000 ML
IVTs	MDBA	136,000 ML of high reliability water shares plus 260,000 ML of carryover
TLM	MDBA	40,000 ML of high reliability water shares plus 157,000 ML of low reliability water shares

3.6. Watering objectives 2011-12

Broad ecosystem objectives for the Goulburn River floodplain include to protect and restore water-dependent ecosystems that: support migratory birds listed in international agreements; provide vital habitat; and support Commonwealth-, state- or territory-listed threatened species and/or ecological communities (MDBA 2010a).

Base flows aim to:

- provide suitable in-channel habitat (area of slow, shallow water) for all small bodied fish life stages;
- cause entrainment of litter packs available as food/habitat source for macroinvertebrates and maintenance of water quality suitable for macroinvertebrates;
- provide deep water habitat for large-bodied native fish; and
- submerse snag habitat within the euphotic zone to provide habitat and food source for macroinvertebrates.

Freshes aim to:

- improve macroinvertebrate and native fish habitat quality (e.g. disruption of biofilms, flushing of fine sediments);
- entrain litter packs available as food/habitat source for macroinvertebrates;
- improve planktonic algae production rates, biomass levels and community composition more resembling un-impacted sites, promoting dynamic and diverse food webs;
- provide pre-spawning and movement cues for some native fish species (e.g. golden perch); and maintain natural rates of sediment mobilisation and deposition;
- promote native fish spawning;

- maintain natural rates of sediment mobilisation and deposition; and
- increase habitat variability for macroinvertebrates, and provide typical planktonic algae production.

(Derived from Cottingham *et al.* 2003 and Cottingham *et al.* 2007).

3.7. Watering options 2011-12

This strategy focuses on the two reaches below Goulburn Weir:

- Reach 4: Goulburn River from Goulburn Weir to Shepparton; and
- Reach 5: Goulburn River from Shepparton to the Murray River.

In 2011-12 tributary inflows and bulk entitlement releases (250-400 ML per day) are likely to provide much (but not all) of the baseflow required to meet ecological objectives for the river. Commonwealth water can, therefore, be used to supplement baseflow along the river as well as increase flow variability through low level pulse flows.

Prioritisation of watering options
The priority for allocation of Commonwealth environmental water in 2011-12 is considered to be:

1. delivering up to two spring freshes;
2. increasing baseflow across the year, but particularly in winter-spring, to provide habitat for native fish and macroinvertebrate communities;
3. maintaining summer-autumn baseflow to maintain habitat for native fish, macroinvertebrates and phytoplankton, as well as maintain water quality; and
4. delivering a summer-autumn fresh to maintain habitat condition and water quality, to support macroinvertebrate and phytoplankton communities.

The extent to which all the above options can be delivered will depend on antecedent conditions, such as the timing and magnitude of unregulated tributary inflows and where they occur within the system. Under wetter conditions, the baseflow can be maintained for longer durations, and freshes (both in winter-spring and summer) can be more frequent or of larger magnitude and duration.

The potential watering options for 2011-12 in the Goulburn River are based on the *Water Use Delivery for the Goulburn River Catchment* (Cottingham *et al.* 2011a), and the Victorian Environmental Water Holder *Seasonal Watering Plan 2011-12*, and *Goulburn River Seasonal Watering Proposal for 2011-12* (Goulburn Broken Catchment Management Authority 2011).

Watering option 1: contribute to winter-spring freshes
Deliver up two spring freshes to promote the spawning of golden perch and other native fish, and to assist riparian vegetation and macroinvertebrate communities.

The first fresh event should be up to 9,000ML per day (in channel flow) to entrain material that supports the food-webs and provides food resources for native fish prior to spawning. Subsequent events of a lower magnitude should meet objectives for macroinvertebrate and phytoplankton communities and are expected to be spawning cues for native fish such as golden perch.

The option is to:

- Provide a 2011 spring fresh of between 5,600 ML per day and 9,000ML per day for 14 days to provide a significant ecological signal. A spring fresh is preferred as it has the added target of golden perch breeding; and
- Provide a second priority (earlier) winter/spring fresh.

  This is consistent with the GBCMA proposal in the *Goulburn River Seasonal Watering Proposal for 2011/12* (GBCMA 2011).

Watering options 2 and 3: increase base flows and their variability
The second priority Goulburn River watering option is to maintain all year a base flow of between 500 ML per day and 860 ML per day along Reach 4 (540 ML per day – 940 ML per day along Reach 5) to achieve the baseflow objectives listed above. Option 2 focuses on increasing the baseflows in winter spring, whilst option 3 focuses on summer/autumn baseflows.

Baseflows can be higher than 500 - 860 ML per day with little risk to river ecology in winter and spring, but there are recommended restrictions on summer flows, for instance, flows should not go beyond 1,500 ML per day for greater than 45 per cent of the time in Reach 4 and beyond 2,000 ML per day for greater than 60 per cent of the time in Reach 5 in a median year (Cottingham *et al.* 2007, Cottingham *et al.* 2011a). The Goulburn River flow studies provide a range of flows intra and inter annually to meet ecological objectives.

Modelling suggests that maintaining flows of more than 610 ML per day for Reach 4 will require up to 38 GL if applied year-round in a median year and 44 GL in a wet year (22 GL and 42 GL for median and wet years, respectively, for Reach 5) (Cottingham *et al.* 2011a).

Watering option 4: contribute to summer-autumn freshes
The delivery of one to two summer/autumn freshes would assist in maintaining habitat condition and water quality, as well as in supporting macroinvertebrate and phytoplankton communities. The fresh flow would be up to 6,600 ML per day for up to seven days.

Watering option 5: integrated watering option: meet the environmental water needs of assets in the Murray River

This option seeks the release of Commonwealth environmental water held in Lake Eildon and delivered via the Goulburn River to the Murray River to meet the environmental water needs of assets in the Murray system.

The release of water under this option would be in accordance with normal operations determined by G-MW, and should aim to maximise environmental benefit in the Goulburn River.

Victoria’s *Northern Region Sustainable Water Strategy* (DSE 2009) allows return flows to be used again or traded downstream, provided the flows can be adequately measured, meet water quality standards and approval of the system operator has been obtained.

The calculation of return flows would be undertaken by G-MW on an event-by-event basis.

Table 3.5: Operational details for potential watering options for 2011-12 in the Goulburn River.

Asset	Water management options	Target flow rate	Estimated volume of allocation required	Timing & duration	Delivery mechanism	Operational considerations
Goulburn River Reaches 4 and 5	<u>Option 1</u> Winter - spring Freshes	Up to two freshes	To be determined during the course of 2011-12 depending on catchment and flow conditions	September to December (when temperatures are suitable for breeding) for approximately two weeks per fresh	Releases from Goulburn Weir or Eildon Dam	Environmental water could supplement (piggy-back) catchment inflows and inter-valley (IVT) and other transfers of water to enhance peaks or to flatten the recessions of peaks. This will be decided on case by case depending on flows, time of year and antecedent conditions, among other things.
	<u>Option 2</u> Winter-spring baseflows <u>Option 3</u> Summer/autumn baseflows	At least 500 ML per day and up to 860 ML per day at Reach 4 (540-940 ML/d, Reach 5)	38 to 44 GL per year (610 ML/d at reach 4, modelled flows for median and wet years)	July to January and April to June (IVT releases Feb to Mar expected to meet flow targets)		Action managed in conjunction with VEWH, GBCMA and G-MW. Releases of environmental water dependent on natural river flows and inter-valley (IVT) and other transfers of water. IVT flows generally peak in February and March.
	<u>Option 4</u> Summer Fresh	One to two	To be determined during the course of 2011-12 depending on catchment and flow conditions	Summer/ autumn for two days		As for option 1
Murray River environmental assets	Deliver water downstream	To be determined based on downstream needs and available allocations		As required to meet downstream environmental demand		Release managed in accordance with normal operations determined by G-MW, and should aim to maximise environmental benefit in the Goulburn River. Releases could also contribute to base flows and freshes for the Goulburn River.

3.8. Key constraints for water delivery

The delivery of high flows to the Lower Goulburn River is constrained by the risk of flooding private property in the reaches between Lake Eildon and Goulburn Weir. Environmental water will be delivered by G-MW in accordance with established operating protocols.

Catchment inflows and the release other water (such as the MDBA's inter-valley transfers of consumptive water (IVTs)) would provide necessary water to meet flow targets and reduce the volume of environmental water required, and the potential to deliver environmental water to River Murray environmental assets.

3.9. Water accounting

Unlimited storage carryover is allowed in the Goulburn systems, but water above 100 per cent of the water share volume will be quarantined in a spillable water account when there is risk of Lake Eildon spilling. Any carryover in the spillable water account cannot be accessed until the risk of spill has passed (assessed by G-MW, the Water Resources Manager, based on storage levels and likely inflows). If a spill occurs, carryover is the first water to spill. The annual deduction for evaporation is 5 per cent of carried over volume (G-MW 2011).

The Commonwealth's environmental water holdings in the Goulburn system will incur an annual service fee, a storage fee and a fee for transferring water from spillable water account to an allocation bank account. There is no delivery cost to the Commonwealth for environmental water delivered from Lake Eildon to the Goulburn River.

Water releases are measured from Eildon Dam or Goulburn weir, whilst downstream flow targets are measured at Murchison and McCoys Bridge.

Victoria's *Northern Region Sustainable Water Strategy* allows return flows to be reused for the purpose of multi-site watering actions provided the flows can be adequately measured, meet water quality standards and approval of the system operator has been obtained. The calculation of return flows would be undertaken by G-MW.

3.10. Risk management

A full risk assessment will be undertaken for each watering option as part of the assessment process.

The main potential risks associated with the delivery of environmental water, using the Goulburn River as an example, are summarised in Table 3.6 below.

Table 3.6 Likely risks, their context and potential mitigation.

Risk	Context and mitigation
Flooding, injury, property/ infrastructure damage, stock/crop damage, road access	Flow monitoring is undertaken by the GBCMA and G-MW. Based on flows and rainfall, environmental flow releases will be managed to be confined to within channel.
Negative public response	No negative response is expected. All flows will be entirely within the channel and are based on rigorous scientific reports.
Salt mobilisation	No salt mobilisation is expected, especially from low flows.
Spread of weeds	Weed species are already present throughout the river system and future dispersal is unlikely to be exacerbated by environmental flows.
Spread of exotic fish species or increase in population	Exotic fish such as carp are common throughout the Murray Darling Basin. There are no appropriate management actions to prevent creating favourable conditions for carp. The timing of environmental flows will occur to maximise the opportunity for native fish species.
Transmission loss e.g. unauthorised diversion, bank instability	In-channel flows (baseflows and freshes) are unlikely to incur additional losses above that expected to be resulting from minimum passing flows under the bulk entitlement. Losses may be re-examined by G-MW and communicated to the CEWH should climate conditions become drier than forecasted.
Unauthorised take of Commonwealth environmental water	Consumptive diversion of water is monitored by state government organisations. G-MW allows the Commonwealth to target flow rates at the end-of-system below consumptive water offtakes.
Limited river channel capacity	Higher consumptive flows during the irrigation season may limit the delivery of environmental flows. Irrigation flows will need to be monitored and environmental flows adapted, closer to the time of delivery.
Loss of public amenity and risk to recreational users	Environmental flow recommendations include rates of rise and fall that are usually low relative to uncontrolled events. Public announcements by G-MW, GBCMA and VEWH can alert potential recreational users of changes in river level.

4. Campaspe

4.1. Campaspe River and environmental assets

The Campaspe River catchment covers approximately 4,000 km^2 and extends for 150 km from the northern slopes of the Great Dividing Range near Trentham to the Murray River at Echuca (Figure 4.1). The Campaspe River and Coliban River are the largest rivers in the catchment, but other significant tributaries include Axe, McIvor, Mt Pleasant, Forest, Wild Duck and Pipers Creeks (SKM 2006). Refer to Appendix A for further details.

Watering options are targeted at the reach of the Campaspe River extending from Lake Eppalock to the Murray River. The MDBA has identified the lower Campaspe River (Lake Eppalock to the Murray River) as a key environmental asset (MDBA 2010).

Figure 4.1: The Campaspe River asset.
Source: DSE 2011b

4.2. Delivering water

The Campaspe system is heavily regulated and significant features include Malmsbury (12 GL capacity), Lauriston (20 GL capacity) and Upper Coliban (38 GL capacity) Reservoirs on the Coliban River, as well as Lake Eppalock (305 GL capacity) and Campaspe Weir (3 GL capacity) on the Campaspe River. The Waranga Western Main Channel, which is a major seasonal (September to April) carrier channel for the Goulburn system, passes through the Campaspe system and crosses underneath the Campaspe River downstream of Rochester at the Campaspe Siphon. The regulated sections of the lower Campaspe River include three main reaches:

- Reach 2: Lake Eppalock to Campaspe Weir;
- Reach 3: Campaspe Weir to Campaspe Siphon; and
- Reach 4: Campaspe Siphon to Murray River.

4.3. Current catchment status and outlook

The Campaspe catchment experienced prolonged drought for over a decade until heavy rainfall resulted in natural flooding flows for the first time since 1996. Most of the recommended flow components were delivered in 2010-11 (NCCMA 2011a). Prior to 2010-11, IVT and environmental water was used to deliver recommended baseflows, as far as was possible with the water resources available. Tables 4.1 and 4.2 below indicate the extent to which different flow components were met over the last ten years.

The range of high flows, including floods, have scoured pools to enhance habitat for native fish; provided an input of nutrients and organic matter to the river and facilitated an exchange of sediments and biota between the channel, floodplain and wetlands. The higher flows have improved riparian vegetation health and the improved productivity on the floodplain may have triggered fish migration.

Table 4.1: Environmental flow components for Reach 2.

Flow component		**Years**									
		2001/02	**2002/03**	**2003/04**	**2004/05**	**2005/06**	**2006/07**	**2007/08**	**2008/09**	**2009/10**	**2010/11**
Summer	Cease to Flow	Red	Red	Red	Red	Red	Red	Orange	Red	Red	Red
	Baseflow	Red	Red	Red	Red	Green	Red	Green	Orange	Green	Green
	Freshes	Red	Red	Red	Red	Red	Red	Orange	Red	Red	Green
Winter	Low Flow	Red	Red	Red	Red	Red	Red	Red	Red	Red	Green
	High Flow	Red	Red	Red	Red	Red	Red	Red	Red	Red	Orange
	Bankfull	Red	Red	Red	Red	Red	Red	Red	Red	Red	Green
	Overbank flow	Red	Red	Red	Red	Red	Red	Red	Red	Red	Green

Red: flow data indicates that no significant part of the flow component was provided naturally or through managed actions
Orange: Flow data indicates that the flow component has been partially provided in terms of either magnitude, duration or frequency
Green: Flow data indicates that the flow component is considered to have been completely provided.

Source: Barnadown (gauge 406201) data from NCCMA 2011a

Table 4.2: Environmental flow components and ecological objectives for Reach 4.

Flow component		Years									
		2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
Summer	Baseflow										
	Freshes										
Winter	Low Flow										
	High Flow										
	Bankfull										

Red: flow data indicates that no significant part of the flow component was provided naturally or through managed actions

Orange: Flow data indicates that the flow component has been partially provided in terms of either magnitude, duration or frequency

Green: Flow data indicates that the flow component is considered to have been completely provided.

Source: Rochester data from NCCMA 2011a

4.4. Forecast allocations

The volume of Commonwealth environmental water available in the southern connected basin and the Campaspe River beginning of 2011-12, and forecasts for the rest of 2011-12 water year are described in Table 3.3 below. The Campaspe River system is part of the southern connected basin and water can be traded in from the Goulburn (no backtrading rules) and from other catchments subject to backtrading rules. Entitlements held in the Coliban River are not included because these are considered as part of a separate regulated system terminating in Lake Eppalock. The bases for these forecasts are provided in section 2.2 of this document.

Table 4.3: Commonwealth environmental water availability in 2011-12.

Catchment	Entitlement (GL)	Water available for use (GL)	Water available for use forecasts					
			31 July 2011 (GL)		30 September 2011 (GL)		30 June 2012 (GL)	
Campaspe (Vic)			**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
High/Low/SWA	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
Total - Southern Connected Basin*	**652.5**	**317.7**	**318.0**	**388.9**	**354.7**	**608.9**	**539.9**	**649.7**

*Water may be traded into the Campaspe system from other systems in the Southern Connected Basin. These trades are usually subject to back-trade conditions.

4.5. Other sources of environmental water

Sources of water for the Campaspe River environment are provided in Table 4.4 below.

Table 4.4 Sources of environmental water.

Source	Management Authority	Potential Allocation
Bulk Entitlement: passing flows	G-MW	• Reach 2: where Lake Eppalock storage volume is: ○ <150,000 ML, passing flow 10 ML/d or actual inflow ○ 150,000 ML - < 200,000 ML passing flow 50 ML/d or actual inflow ○ 200,000 ML - < 250,000 ML passing flow 80 ML/d or actual inflow ○ >250,000 ML, passing flow: ▪ 90 ML/d or actual inflows in Jan, Mar, May, Jun and Dec ▪ 80 ML/d or actual inflow in Feb & Apr ▪ 150 ML/d or actual inflows in Jul & Nov ▪ 200 ML/d or actual inflows in Aug, Sep, & Oct • Reach 4: where Lake Eppalock storage volume is less than 200,000 ML, passing flow required is: ○ 20 ML/d or modified natural flows Jul-Nov ○ 35 ML/d or modified natural flow Dec-Jun ○ Greater than 200,000 ML, passing flow required is 70 ML/d or modified natural flow
IVTs	MDBA	• No specific volume - flexible and at the discretion of the MDBA
TLM (For use at Icon sites)	MDBA	• 126 ML high reliability water supply • 5,048 ML low reliability water supply
Victorian River Murray Flora and Fauna Bulk Entitlement	VEWH	• 27,600 ML (For use across Victoria including the Campaspe)

4.6. Watering objectives 2011-12

The objectives of watering options for 2011-12 are:

- Winter/spring baseflow:
    - provide longitudinal connectivity for fish;
    - maintain aquatic habitat for macroinvertebrates; and
    - maintain permanent connecting flow for water quality, principally salinity and dissolved oxygen.
- Spring fresh:
    - reduce encroachment of exotics and terrestrial vegetation;
    - enhance river red gum recruitment;
    - cue fish movement;
    - flush and mix pools for water quality and macroinvertebrate habitat; and
    - prime the reach for summer and reduce channel organic load.
- Summer baseflow:
    - maintain aquatic vegetation;
    - maintain permanent connecting flow for water quality; and
    - maintain access to riffle habitat.

- Summer fresh:
    - maintain riparian and in-channel vegetation recruits;
    - provide longitudinal connectivity; and
    - flush and mix pools.

4.7. Existing watering actions

The CEWH has agreed (June 2011) to provide environmental water to supplement baseflow and contribute to freshes over winter and spring (1 July to 30 November) in the lower Campaspe River.

The target flow rates for Reaches 2 to 4 of the Campaspe River (Campaspe Weir to the Murray River) are to:

- Supplement the winter and spring (June to November) base flow to provide a total flow of up to 200 ML per day; and
- To contribute to two winter/spring high flows of 1,500 ML per day for four days with managed rates of rise and fall.

The objectives of this existing watering action are provided in section 4.6 above.

4.8. Watering options 2011-12

The Campaspe watering options outlined below apply to the lower Campaspe River (reaches 2, 3 and 4). The following watering options are supplementary to the current action (section 4.6) and may be undertaken if water is traded or transferred into the system during 2011-12. These options are not listed in order of priority, rather they will be considered based on requirements due to factors such as climatic conditions and availability of water.

Watering option 1

Provide/supplement <u>summer base flows</u> to address ecological objectives:

- maintain aquatic vegetation;
- maintain habitat for fish;
- maintain constant flow to reduce salinity and preserve oxygen levels; and
- maintain macroinvertebrate habitat.

Watering option 2

Provide/supplement <u>summer/autumn freshes</u> after 1 February to address ecological objectives:

- maintain riparian and in-channel vegetation recruits;
- provide longitudinal connectivity and cue fish movement from the Murray River;
- flush and mix river pools to reduce salinity and improve oxygenation levels; and
- inundate additional snags and wash sediments off biofilms for macroinvertebrates

Watering option 4

Provide/supplement <u>winter baseflows</u> to address ecological objectives:

- longitudinal connectivity for fish;
- limit effect of cold water releases for fish;
- maintain macroinvertebrate access to riffles and water quality; and
- maintain permanent connecting flow.

Operational information for the potential watering options are provided in table 4.5 below.

Table 4.5: Operational details for potential watering options for 2011-12 in the Campaspe River.

Asset	Water Management Options*	Minimum target flow rate	Timing	Duration and frequency	Delivery mechanism	Operational considerations^
Reach 2	Summer low flow	10-16 ML/d	December to May	5 days with managed rate of rise and fall. 3 events.	Release from Lake Eppalock	Dependent on river flows and IVT transfers
	Summer fresh	100-125 ML/d	December to May			
	Winter low flow	100-125 ML/d	June to November			
Reach 3	Summer low flow	10-20 ML/d	December to May	6 days with managed rate of rise and fall. 3 events	Release from Lake Eppalock	Dependent on river flows and IVT transfers. There is no gauging station in Reach 3 - previously operational releases from the Campaspe Weir have been used to indicate flows in the reach
	Summer fresh	100 ML/d	February to May			
	Winter low flow	200 ML/d	June to November			
Reach 4	Summer low flow	10-20 ML/d	December to May	6 days with managed rate of rise and fall. 3 events	Release from Lake Eppalock and/or delivery via Western Waranga Channel	Dependent on river flows and IVT transfers
	Summer fresh	100 ML/d	February to May			
	Winter low flow	200 ML/d	June to November			

Source: NCCMA 2011a

4.9. Water accounting

SEWPaC are consulting with DSE, VEWH and G-MW to establish arrangements for the accounting of return flows.

4.10. Risk management

A full risk assessment will be undertaken for each watering option as part of the assessment process. The more likely risks associated with delivering environmental water in the catchment and their context and mitigation measures are presented in Table 4.6.

Table 4.6: Likely risks, their context and potential mitigation.

Risk	Context and mitigation
Flooding, injury, property/ infrastructure damage, stock/crop damage, road access	Flow monitoring will be undertaken by the NCCMA and flows will be managed so as to be within G-MW's operating standards and confined entirely within the channel.
Negative public response	No negative response is expected. All flows will be entirely within the channel. Water use proposals have been developed in consultation with the local community.
Salt mobilisation	Winter low flows and summer freshes will flush saline pools. Flow rates are expected to provide adequate dilution and will result in improved water quality.
Spread of weeds	Weed species are already present throughout the river system and future dispersal is unlikely to be exacerbated by environmental flows.
Spread of exotic fish species or increase in population	Flows will be in-channel and should not result in any further geographic spread of exotic fish. There are no appropriate management actions to prevent creating favourable conditions for carp. The proposed flow conditions will be more favourable for native fish species and should benefit existing native fish populations.
Geomorphic impacts e.g. erosion	Flows are not likely to be of sufficient velocity to have significant erosion impacts.
Transmission loss e.g. unauthorised diversion, bank instability	Transmission losses will be met by river base flows operated by G-MW. Some incremental river losses (environmental use) will occur with additional environmental flows.
Unauthorised take of Commonwealth environmental water	Unauthorised take of water is monitored by state government organisations. G-MW allow environmental water to be used to meet downstream flow targets.
Limited channel capacity	There are no limits on the proposed releases from Lake Eppalock to meet targeted flow rates. If water is to be delivered to reach 4 via the Western Waranga Main Channel, there are likely to be constraints on channel delivery during summer (peak irrigation period).
Loss of public amenity and risk to recreational users	Environmental flow recommendations include rates of rise and fall that are usually low relative to uncontrolled events. Public announcements from G-MW, VEWH and GBCMA can alert potential recreational users of changes in river level.

5. Loddon River and Boort wetlands

5.1. Loddon River and environmental assets

The environmental assets dealt with in this strategy are the lower Loddon River from Laanecoorie Reservoir to Kerang Weir (reaches 3 and 4, Figure 5.1) and the Boort wetlands system (Figure 5.2). Details about the environmental assets are contained in Appendix A.

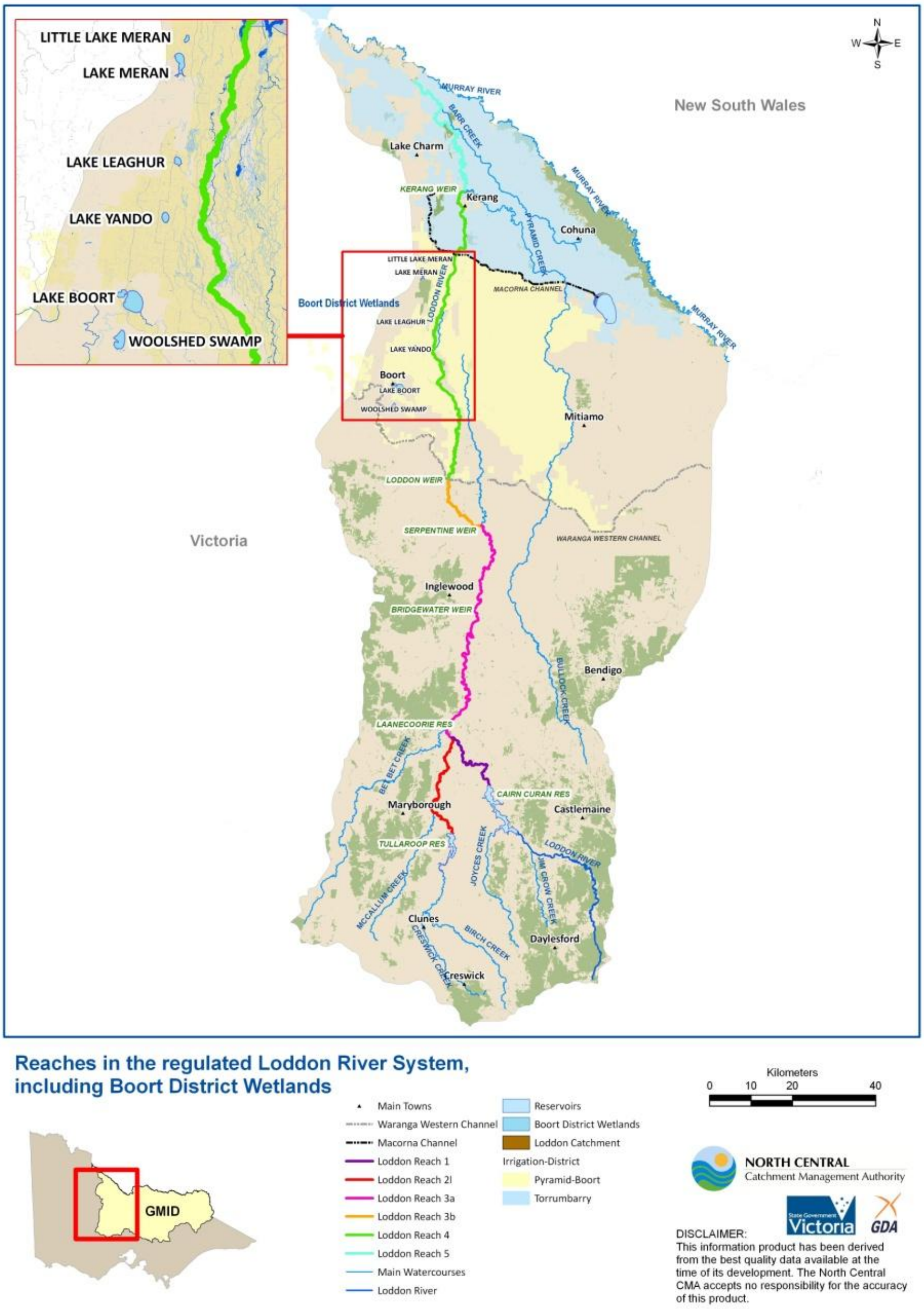

Figure 5.1: The Loddon River and Boort Wetlands asset.
Source: NCCMA 2011b

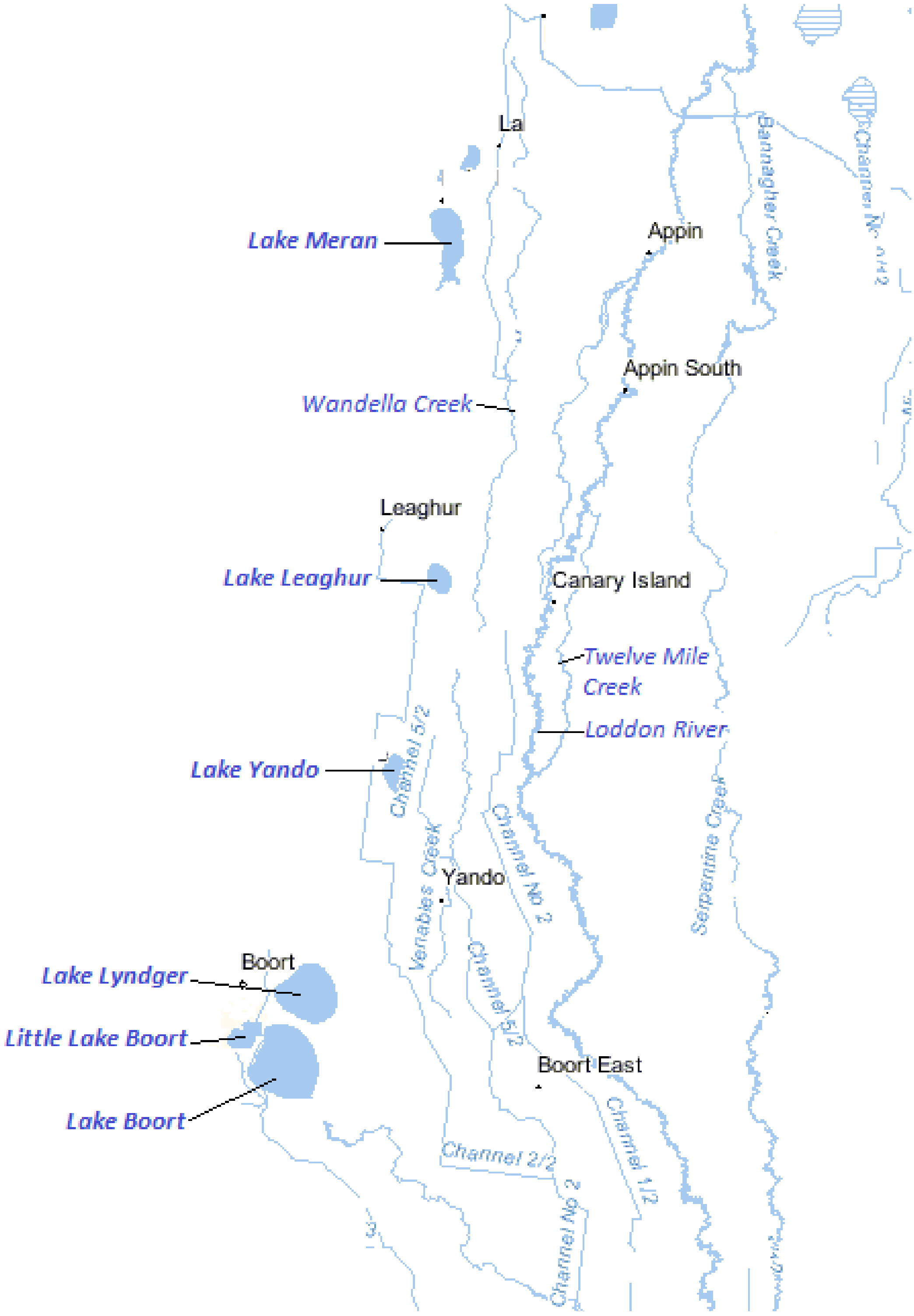

Figure 5.2: Boort wetlands.
Source: DSE 2011b

5.2. Delivering water

Under the Bulk Entitlement (BE), the Loddon River below the major storages is managed as five reaches:

- Reach 1: Loddon River - Cairn Curran Reservoir to Laanecoorie Reservoir;
- Reach 2: Tullaroop Creek - Tullaroop Reservoir to Laanecoorie Reservoir;
- Reach 3a: Loddon River - Laanecoorie Reservoir to Serpentine Weir;
- Reach 3b: Loddon River - Serpentine Weir to Loddon Weir;
- Reach 4: Loddon River - Loddon Weir to Kerang Weir; and
- Reach 5: Kerang Weir – Kerang Weir to the Little Murray River at Benjaroop.

The Waranga Western Main Channel crosses the Loddon River catchment south of Boort at the Loddon Weir, and carries water from the Goulburn system that can be released to the lower reaches of the Loddon River and Boort district wetlands.

Runoff events peaking at 3,000-5,000 ML per day downstream of Serpentine Weir have an indicative travel time of two to three days from Laanecoorie Reservoir to Loddon Weir, with a further six-day travel time from Loddon Weir to Appin South.

For Boort wetlands, the Environmental Reserve Bulk Entitlement (Schedule 3, clause 3.1) states that the wetland entitlement “shall be supplied only when there is spare channel capacity available after meeting all the consumptive demands supplied from the system waterway”. Therefore delivery timing and flow rates to any wetland in the Boort district will vary depending on channel capacity and irrigator demand. The relevant charges for the Boort area is $200 per service point plus a rate per megalitre ($6.60 in 2010-11).

5.3. Current catchment status and outlook

The Loddon system has experienced prolonged drought for over a decade, which ended following heavy rainfall and extensive flooding across northern Victoria in 2010-11. Prior to 2010-11, there was insufficient water to deliver the recommended environmental flow components, especially in Reach 4. Most of the recommended flow components were delivered in 2010-11 (NCCMA 2011b), shown in Tables 5.1 to 5.3. Natural flooding throughout the catchment in 2010-11 has filled the major wetlands of the Boort Wetland complex (*pers. comm.* B. Velik-Lord, NCCMA, June 2011).

The range of high flows, including natural floods, has provided an input of nutrients and organic matter to the river and facilitated an exchange of sediments and biota between the channel, floodplain and wetlands. The Boort wetlands were linked for the first time in many years. The higher flows have improved riparian vegetation health, provided opportunities for fish migration, and the improved productivity on the floodplain may have triggered fish spawning events.

Table 5.1: Achievement of environmental flow components and ecological objectives in Reach 2 of the Loddon River.

Flow component Reach 2	Years									
	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
Minimum all year	Green	Green	Orange	Orange	Red	Red	Red	Red	Red	Orange
Fresh	Green	Green	Green	Green	Green	Red	Red	Red	Red	Green
Early winter fresh	Green	Red	Red	Red	Red	Red	Red	Red	Red	Red
Bank full	Red	Red	Red	Red	Red	Red	Red	Red	Red	Green
Overbank	Red	Red	Red	Red	Red	Red	Red	Red	Red	Green

Red: flow data indicates that no significant part of the flow component was provided naturally or through managed actions
Orange: Flow data indicates that the flow component has been partially provided in terms of either magnitude, duration or frequency
Green: Flow data indicates that the flow component is considered to have been completely provided.
Source: NCCMA 2011b

Table 5.2: Achievement of environmental flow components and ecological objectives in Reach 3a of the Loddon River.

Flow component Reach 3a	Years									
	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
Summer – Autumn minimum	Green	Green	Green	Orange	Green	Green	Orange	Orange	Orange	Green
Summer fresh	Green	Green	Green	Green	Green	Red	Red	Red	Red	Green
Winter minimum	Green	Green	Red	Orange	Red	Red	Red	Red	Red	Green
Spring fresh	Orange	Red	Red	Red	Red	Red	Red	Red	Red	Green
Overbank	Red	Red	Red	Red	Red	Red	Red	Red	Red	Green

Red: flow data indicates that no significant part of the flow component was provided naturally or through managed actions
Orange: Flow data indicates that the flow component has been partially provided in terms of either magnitude, duration or frequency
Green: Flow data indicates that the flow component is considered to have been completely provided.
Source: NCCMA 2011b

Table 5.3: Achievement of environmental flow components and ecological objectives in Reach 4 of the Loddon River.

Flow component Reach 4	Years									
	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
Summer minimum										
Summer fresh										
Winter minimum										
Winter – Spring fresh										
Bank full										
Overbank										

Red: flow data indicates that no significant part of the flow component was provided naturally or through managed actions

Orange: Flow data indicates that the flow component has been partially provided in terms of either magnitude, duration or frequency

Green: Flow data indicates that the flow component is considered to have been completely provided.

Source: NCCMA 2011b

5.4. Forecast allocations

The volume of Commonwealth environmental water available in the southern connected basin and the Loddon River at the beginning of 2011-12, and forecasts for the rest of 2011-12 water year are described in Table 5.4 below. Loddon River system is part of the southern connected basin, however trade into the system is subject to back trade restrictions. The bases for these forecasts are provided in section 2.2 of this document.

Table 5.4: Commonwealth environmental water availability in 2011-12.

Catchment	Entitlement (GL)	Water available for use (GL)	Water available for use forecasts					
			31 July 2011 (GL)		30 September 2011 (GL)		30 June 2012 (GL)	
Loddon (Vic)			**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
High/Low	2.1	0.8	0.8	1.1	0.8	1.6	1.5	1.6
Total - Southern Connected Basin	**652.5**	**317.7**	**318.0**	**388.9**	**354.7**	**608.9**	**539.9**	**649.7**

Note: Southern connected basin includes Murray (NSW, Vic, SA), Murrumbidgee, Lower Darling, Campaspe, Goulburn, Loddon. The figures may change following reconciliation of accounts for the end of the 2010-11 water year.

5.5. Other sources of environmental water

The Loddon system receives environmental water from several sources, listed in Tables 5.5 and 5.6.

Table 5.5: Environmental water entitlements.

Source	Management Authority	Entitlements
Wetland entitlement	VEWH	2,000 ML
Wimmera Mallee Pipeline savings	VEWH	7,490 ML
Loddon system withheld flows account	VEWH	5,314 ML
Goulburn - Wimmera Mallee pipeline	VEWH	1,432 ML
Low reliability entitlement (*Valley Cap applies)*	VEWH	2,105 ML

Table 5.6 Environmental flows specified in the Bulk Entitlement (Loddon River - Environmental Reserve) Order 2005 - Consolidated Version as at 1 November 2010.

River reach	Summer / autumn minimum flow	Winter / spring minimum flow		Fresh flows
		Cairn Curran and Tullaroop reservoirs combined storage volume greater than 60,000 ML	Cairn Curran and Tullaroop reservoirs combined storage volume less than 60,000 ML	
Laanecoorie Reservoir and Serpentine Weir (Reach 3a)	15 ML/d Nov - Jul	52 ML/d Aug – Oct	15 ML/d Aug - Oct	52 ML/d 13 days 3 events Nov – Apr
Serpentine Weir and Loddon Weir (Reach 3b)	19 ML/d Nov - Apr	61 ML/d May – Oct	19 ML/d May - Oct	61 ML/d 11 days 3 events Nov – Apr
Loddon Weir to Kerang Weir (Reach 4)	7 ML/d rise to 12 ML/d in one week; 12 ML/d fall to 7 ML/d in the alternate week. Nov – Apr	61 ML/d May – Oct	10 ML/d* May - Oct	50 ML/d 14 days Jan - Feb

5.6. Watering objectives 2011-12

Objectives for the Loddon River include:

- Deliver winter-spring flows that will provide a flow regime and conditions suitable to support habitat, flora and fauna, and then sustain them beyond spring with an appropriate summer-autumn flow regime; and
- Provide ecological connection to nearby floodplain ecosystems (e.g. Boort wetlands) as well as with the Murray River.

The following actions and outcomes will be required to achieve the broad objectives listed above:

- Deliver winter-spring bankfull and baseflow to avoid the build-up of organic matter, maintain riparian vegetation health, and support natural geomorphologic processes. (A bankfull will only be delivered three to five times per decade, if there is sufficient water available and a minimal likelihood of it being delivered by unregulated flows.);
- Deliver spring freshes and baseflow to provide habitat, as well as movement and breeding cues for fauna such as native fish; and
- Summer-autumn baseflow and freshes to provide habitat and suitable water quality in the river channel, as well as provide drought refuges for vulnerable biota.

Boort wetlands
In summary, objectives for the Boort Wetlands are to (NCCMA 2011 a,b):

- Restore the distribution of live river red gums and associated floristic communities across the bed of Lake Boort, including rehabilitation of southern cane grass populations;
- Restore and rehabilitate vegetation species diversity typical of aquatic and semi-aquatic environments; and
- Reduce the likelihood of recolonisation of the bed of the lake by mustard weed by promoting native vegetation growth.

5.7. Existing watering actions

The use of Commonwealth environmental water to support winter and spring base flows and to contribute to a spring fresh has been approved for delivery from 1 July to 30 October 2011 for Reach 4 (Loddon Weir to Kerang Weir) as follows:

- a base flow 100 ML per day ± 20 per cent (this constitutes an increase of 3-43 ML per day above the passing flow); and
- a fresh 750 ML per day for 10 days.

The flow rates are from the *Review of environmental flow requirements for the lower Loddon River system* (SKM 2010) and provide a guide to the delivery of water.

The objectives of the current watering action are to:

- Enable growth, reproduction and small-scale recruitment for a diverse range of flora and fauna such as native fish in Reach 4 (Loddon Weir to Kerang):
  - provide longitudinal connectivity for fish and trigger fish movement and spawning (Murray cod, golden perch and silver perch).

- Promote longitudinal river connectivity (some of this water will leave the river through distributary channels such as Twelve Mile Creek and other flood-runners):
  - maintain permanent connecting flow in winter/spring for water quality, principally salinity and dissolved oxygen.

- Support medium flow river and floodplain functional processes.
  - flush organic material from low lying benches - reducing potential blackwater events;
  - prevent expansion and future colonisation by semi-terrestrial plants within the channel;
  - reduce the negative impacts associated with acid sulphate soils; and
  - provide flows to enhance river red gum and other native plant regeneration.

5.8. Watering options for 2011-12

Conditions may arise where it is deemed desirable to trade or transfer in water to undertake further watering actions. The Loddon watering options outlined below apply to Reach 4 (Loddon Weir to Kerang Weir) of the lower Loddon River and would be supplementary to the current watering action (section 5.7). A bankfull flow was delivered to reach 4 in 2010-11, thus the priority is to provide winter low flows and spring fresh components over the next two to three years.

Watering option 1 – Loddon River
Maintain winter baseflow at 100 ML per day ± 20%, May to October, inclusive) to prevent terrestrial vegetation from encroaching into the river channel.

Watering option 2 – Loddon River
Contribute to a spring fresh of 750 ML per day for 6 to 10 days to increase flow and thus habitat variability for macrophytes and macroinvertebrates.

Watering option 3 - Loddon River
Contribute to a summer fresh at 100 ML per day for 10 to 14 days, twice per year to reinstate or maintain a mosaic of aquatic macrophytes.

Watering option 4 – Loddon River
Contribute to a summer low flow of 25 ML per day between November and April (inclusive) to restore or maintain a natural invertebrate community and submerged in-stream macrophytes habitat.

Water option 5 – Boort wetlands
Natural flooding throughout the catchment in 2010-11 has filled the major wetlands of the Boort Wetland complex. As the NCCMA seeks to maintain a more natural cycle of filling and drying, the intention is to let the wetlands draw down by evaporation over the year.

The exception would be Lake Boort should there be a return to dry or drought conditions, whereby water could be allocated to maintain levels sufficient to control weeds on the lake bed.

The operational information relating to these options is provided in Table 5.7 below.

Table 5.7: Operational details for potential watering options for 2011-12 in the Loddon River.

Asset	Target flow rate/volume to fill	Estimated volume of allocation required (ML)	Timing & duration	Delivery mechanism	Operational considerations^
Loddon River Reach 4	Winter baseflow at 100 ML/d ± 20%)	4,245	May-October, inclusive	Release from Laanecoorie Reservoir and/or delivery via the Western Waranga Channel (except from mid May to mid August)	This flow is within channel and can be delivered from the Loddon headworks storages. This flow can also be delivered to Reach 4 via the Waranga Western Channel if sufficient water is not available from the Loddon headworks storages.
	Deliver a spring fresh of 750 ML/d for 10 days.	8,666	Spring		This event should only be delivered if both the baseflow (100 ML/d) and bankfull flow (3,500 ML/d) have been provided in full in the preceding year. If suitable conditions occurred in the preceding year, the spring fresh should be delivered to extend naturally occurring events. If an event has not commenced by the end of October, an event can be created. This flow is within channel and can be delivered via the Loddon River. Additional flow may also be delivered via the Waranga Western Main Channel.
Boort Wetlands Lake Boort	1,500 ML	1,500	Summer – autumn	Gravity	It is likely that water will continue to cover the bed of Lake Boort into the next year, but if this is not the case, then environmental water may be required to top up Lake Boort to inundate the annual weed growth on the lake bed. However, this is only a contingency if Lake Boort dries more quickly than anticipated, and no additional unregulated flows top it up.

5.9. Key constraints for water delivery

For deliveries using the Waranga channel system, G-MW requires an order four days in advance to guarantee the delivery (although order times are expected to decrease with modernisation). The implication of this is that if a rainfall runoff event occurs in the Loddon River, there is a limit to the operational flexibility to order additional environmental water from the Goulburn and Campaspe systems to supplement the natural event because the travel time along the Goulburn/Campaspe Rivers and then along Waranga Western Main Channel is longer than along the Loddon River from Laanecoorie Reservoir to Loddon Weir. However, if a rainfall event occurs, orders for water are likely to be cancelled, and water in transit in the channel system plus water in balancing storages may be able to be called upon. This would allow the Commonwealth to use Waranga Western Main Channel water from the Goulburn and Campaspe systems for long duration events where approximately four-day forecasts indicate the likely need for top-up of the natural flow event from the channel system. Modernisation of the irrigation system is helping to reduce order times.

Trade of allocations into the Loddon River upstream of Loddon Weir is subject to back trade requirements.

Storage release capacity may constrain the release of environmental water as follows:

- Tullaroop Creek: 450 ML per day when below full supply level).
- Cairn Curran Reservoir: 1,600 ML per day outlet capacity when below full supply level). Water can be released from the spillway gates once storage in the reservoir exceeds 30% of capacity. Release capacity is approximately 35,000 ML per day when the reservoir is at 40% capacity and approximately 140,000 ML per day when the reservoir is at 100% capacity (the flooding impacts of such release rates would need to be considered).
- Laanecoorie Reservoir: 1,300 ML per day for regulated supply. High flow rates released from Cairn Curran (such as high flows released through the spillway gates) would flow over the Laanecoorie Reservoir spillway.

Waranga Western Main Channel capacity constraints can occur seasonally. The channel does not operate from mid-May to mid-August. During this time G-MW undertakes maintenance. Historically, the channel has been operated every second winter to supply the Wimmera-Mallee channel system, however with the construction of the Wimmera-Mallee pipeline this will no longer be required. G-MW should be consulted if the Waranga Western Main Channel is to be used to deliver Commonwealth water to check the likelihood of spare capacity in the channel at any given time.

Local capacity constraints within the irrigation channel system west of the Loddon River may also be a constraint to the delivery of water to the Boort wetlands. Delivery of water to the Boort wetlands via the channel system should be discussed in advance with G-MW to determine potential delivery times.

The delivery of low flow environmental flow recommendations (such as summer low flows) may be limited by the ability of weirs, particularly Bridgewater Weir, to regulate low flows (SKM 2006).

Low flow control at Serpentine Weir has traditionally been limited; however a small, remotely-operated door system has recently been fitted to improve flow control at low rates.

River channel capacities are generally not a constraint to delivering the recommended environmental flows. The thresholds for significant flooding at key locations are summarised in Table 5.8. These thresholds are in excess of the recommended environmental flows at these sites.

Table 5.8: Thresholds for significant flooding.

Location	Threshold for significant flooding#
Tullaroop Creek below Tullaroop Reservoir	5,000 ML/d - bankfull capacity)*
Loddon River downstream of Cairn Curran Reservoir	21,000 ML/d*
Loddon River at Laanecoorie Reservoir #	2,000 ML/d – minor 8,500 ML/d – moderate 43,000 ML/d - major
Loddon River downstream of Serpentine Weir	10,000 ML/d- breakout towards Butchers Lagoon*
Loddon River downstream of Loddon Weir	5,000 ML/d- breakout towards Kelshes Lagoon*
Loddon River downstream of Kerang Weir	4,000 ML/d*

Source: * SKM (2006)
Bureau of Meteorology, Victorian flood class levels website. (These BoM levels identify thresholds above which the flooding of private land begins to occur)

Whilst river channel capacities are generally not a constraint to delivering the recommended environmental flows, between Loddon Weir and Kerang Weir high flows break out of the main river channel into a series of anabranches and distributary channels and the capacity of the main river channel decreases significantly to approximately 300 ML per day downstream of The Chute. This means that the recommended spring fresh for Reach 4 (750 ML per day) would be expected to engage the distributary channel system.

The largest of these distributary channels are:

- Kinypanial Creek;
- Venables Creek;
- Twelve Mile Creek; and
- Wandella Creek.

The commence-to-flow thresholds of these distributary channels are uncertain due to regular changes in channel morphology and the complexity of the channel system. Additionally, losses along this reach of the river are believed to be high, particularly during dry conditions; however the magnitude of losses is uncertain. Further investigations are required to determine likely flow paths, and whether flow through distributary channels risks flooding private and public assets.

If the Commonwealth water shares held in the Loddon storages are used to augment the winter low flows, spring fresh and bankfull events in the Loddon River, it is likely that demands from private diverters downstream of Loddon Weir will be low. This means that any flow events upstream of Loddon Weir that the Commonwealth has contributed to are likely to pass downstream without being diverted by consumptive users. The exception to this may be in the first fresh or winter low flow after a dry autumn and winter, when private diverters will want to refill their dams.

5.10. Water accounting

At present, water delivered down the Loddon River are subject to high losses because there are numerous distributaries heading both east and west from the Loddon River. Flow gauging accuracy is low at high flows in this area.

If water is delivered from Laanecoorie Reservoir, it can only be delivered in the regulated river section of the Loddon River, which ends at the Loddon Weir pool. Downstream of the Loddon Weir pool is a different trading zone and flows are considered unregulated. According to G-MW, water ordered from the Loddon headworks storages can be delivered via the Loddon River to an ordering point immediately downstream of Loddon Weir. Beyond this point, the water cannot be shepherded through to Kerang Weir and private diverters can access the water (Cottingham *et al.* 2011c).

5.11. Risk management

A full risk assessment will be undertaken for each watering option as part of the assessment process.

The more likely risks associated with delivering environmental water in the catchment and their context and mitigation measures are presented in Table 5.9 below.

Table 5.9: Likely risks, their context and potential mitigation.

Risk	Context and mitigation
Flooding, injury, property/ infrastructure damage, stock/crop damage, road access	Flow monitoring will be undertaken by the CMA and environmental flows can be managed by G-MW to avoid unintentional flooding
Negative public response	No negative response is expected. All environmental flows will be below flood level. Water use proposals were developed with community consultation.
Salt mobilisation	Salt loads in the river channel have been reduced in recent floods. Proposed increase in flows will assist in diluting the concentration of salts and prevent the formation of saline pools. End-of-system salt loads will be monitored by G-MW and NCCMA and river flows adjusted accordingly to minimise downstream impacts.
Spread of weeds	Weed species are already present throughout the river system and future dispersal is unlikely to be exacerbated by environmental flows.
Spread of exotic fish species or increase in population	Flows will be in-channel and should not result in any further geographic spread of exotic fish. There are no appropriate management actions to prevent creating favourable conditions for carp. Proposed flow conditions will be more favourable for native fish species and should benefit existing native fish populations.
Geomorphic impacts e.g. erosion	Flows are not likely to be of sufficient velocity to have significant erosion impacts.
Transmission loss	Some evaporative loss is expected. Base river losses will be met passing flows under the BE. Some incremental river losses will occur with additional environmental flows.
Unauthorised take of Commonwealth environmental water	Unauthorised take of water is monitored by state government organisations. G-MW will meet flow targets at specified locations.
Limited channel capacity	Channel constraints may occur in the Waranga Western Main Channel and Boort wetland channels and regulators. The risk may be offset by the earlier

	delivery at lower flow rates.
Loss of public amenity and risk to recreational users	Environmental flow recommendations include rates of rise and fall that are usually low relative to uncontrolled events. Public announcements by GM-W, VEWH and NCCMA can alert potential recreational users of changes in river level.

6. Lower Broken Creek

6.1. Lower Broken Creek and environmental assets

The Broken, Boosey and Nine Mile Creek system lies within the Broken River Basin in the Goulburn-Broken catchment in northern Victoria. The flow regime of Broken Creek and its anabranch, Nine Mile Creek is highly modified with irrigation development commencing over 100 years ago (Figures 6.1 and 6.2). Nine Mile Creek is excluded from this watering strategy, as it is not operated during winter, has a highly modified channel, and has less of the fish habitat that is highly valued in the lower Broken Creek.

Despite the hydrologic change, the Broken, Boosey and Nine Mile Creek system is recognised for locally and regionally significant environmental values including:

- The presence of Victorian and nationally threatened flora and fauna species dependent on the aquatic ecosystem including the nationally Vulnerable Murray Cod (*Maccullochella peelii peelii)*and the State Vulnerable golden perch *(Maquaria ambigua);*
- The presence of significant wetlands, with Broken Creek listed in the Directory of Important Wetlands in Australia and the Ramsar listed Barmah Forest on the Murray River at the downstream end of Broken Creek;
- The Broken-Boosey State Park system covering approximately 60% of the stream frontage downstream of Katamatite. The park system provides habitat for a range of threatened flora and fauna contains stands of threatened Ecological Vegetation Classes and provides an important vegetated linear corridor across a generally cleared agricultural landscape.

Lower Broken Creek is managed as three main reaches:

- Reach 1: Broken Creek from Boosey Creek to Nine-Mile Creek;
- Reach 2: Broken Creek from Nine-Mile Creek to Nathalia; and
- Reach 3: Broken Creek from Nathalia to the Murray River.

The MDBA has identified the lower Broken Creek as a key environmental asset (MDBA 2010b), meeting all five criteria of a key environmental asset:

1. formally recognised in, and/or is capable of supporting species listed in, relevant international agreements;
2. natural or near-natural, rare or unique;
3. provides vital habitat;
4. supports Commonwealth-, state- or territory-listed threatened species and/or ecological communities; and
5. supports, or is capable of supporting, significant biodiversity.

Further details about the Broken Creek environmental assets are at Appendix A.

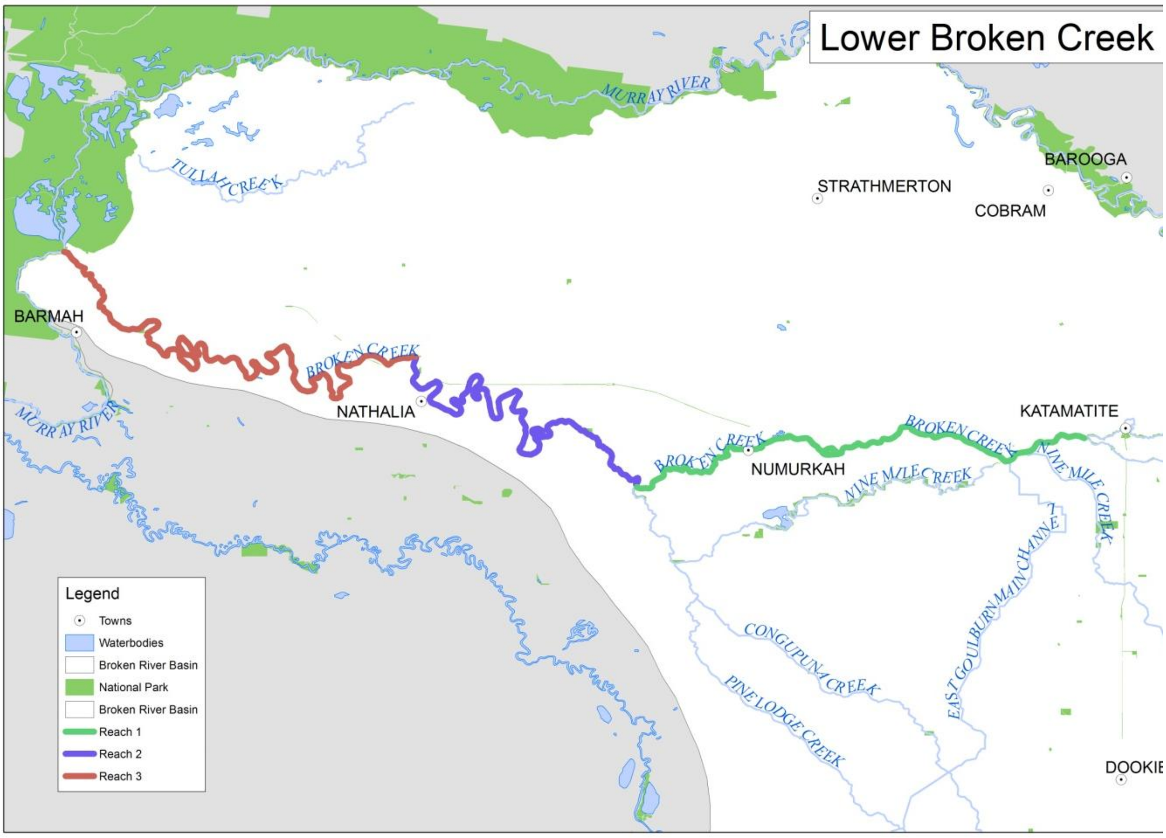

Figure 6.1: Broken Creek map.
Source: SEWPaC 2011

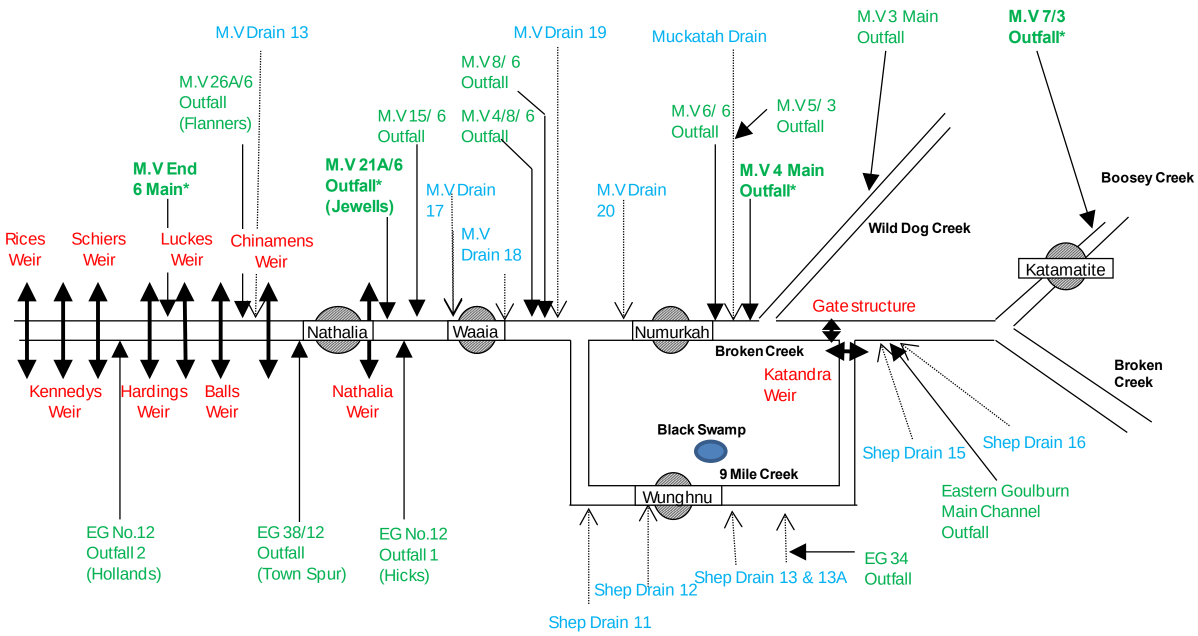

Figure 6.2: A schematic of the lower Broken Creek and Nine Mile Creek system. The names of regulating structures are in red, the names of drains are in blue and the names of outfalls are in green. Murray Valley outfall structures that will not be removed as part of the NVIRP works are shown by an asterisk. All outfall structures on the Shepparton side of the creeks are being retained.
Source: Water Technology (2010)

6.2. Delivering water

Commonwealth environmental water for use in lower Broken Creek is to be sourced from the Commonwealth's holdings in the Murray or the Goulburn using irrigation channel systems, primarily the East Goulburn Main channel and the Murray Valley 7/3 channel (Figure 6.2).

The lower Broken Creek and Nine Mile Creek have been regulated for more than 50 years. Under natural conditions the creeks would have ceased to flow during summer and autumn. Today the creeks are perennial streams with significant flows maintained through summer and autumn to supply water for irrigation, stock and domestic, and urban use. There are a number of weirs downstream of Katamatite that maintain water levels for private pumps. Water quality in the weir pools during summer and autumn is often poor, and in recent years environmental managers have passed increasing volumes of water down the creek to manage the threats posed by low dissolved oxygen levels and blooms of the water fern Azolla (Cottingham *et al.* 2011d).

Regulation of flows along the lower Broken Creek is managed by G-MW (Cottingham *et al*. 2011d). Under the Bulk Entitlement (BE) framework, the lower Broken Creek (including Nine Mile Creek) is managed as one system, although it is part of both the Murray River and Eildon-Goulburn Weir BEs.

About 40 GL of regulated water is needed in a normal year to supply the consumptive demands along the lower Broken Creek system, and to cover transmission and operational losses. This water normally comes from the Goulburn system via the East Goulburn Main Channel (Schedule 3 of the Eildon-Goulburn Weir BE). In low allocation years, the supply of water from the Goulburn system to the lower Broken Creek is reduced, and the shortfall in supply is met by the Murray system.

Environmental water management, including the Goulburn Water Quality Reserve (30 GL), is planned by the Goulburn Broken Catchment Management Authority (GBCMA), in cooperation with G-MW, the VEWH and Murray-Darling Basin Authority.

6.3. Current catchment status and outlook

Wet conditions in the catchment and tributary inflows, particularly the floods of November 2010 and January 2011, have provided the flow events considered necessary to sustain the region. The flows have provided nutrients and organic matter to the creek; improved habitats in the channel, floodplain and wetlands; and benefitted riparian vegetation.

6.4. Forecast allocation

<u>Key points:</u>

- Forecasting indicates up to 650,000 ML of Commonwealth environmental water could be available for use in the southern connected basin by the end of 2011-12.

The volume of Commonwealth environmental water available in the southern connected basin and the Victorian catchments at the beginning of 2011-12, and forecasts for the rest of 2011-12 water year are listed in Table 6.1. The bases for these forecasts are provided in section 2.2 of this document.

Table 6.1: Commonwealth environmental water availability in 2011-12.

Catchment	Entitlement (GL)	Water available for use (GL)	Water available for use forecasts					
			31 July 2011 (GL)		30 September 2011 (GL)		30 June 2012 (GL)	
Goulburn (Vic)			**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
High/Low	109.5	66.0	66.0	85.8	70.9	109.5	108.9	109.5
Murray (Vic)								
High/Low	149.1	102.5	113.9	148.6	145.6	148.6	149.1	149.1
Total - Southern Connected Basin	**652.5**	**317.7**	**318.0**	**388.9**	**354.7**	**608.9**	**539.9**	**649.7**

Note: Southern connected basin includes Murray (NSW, Vic, SA), Murrumbidgee, Lower Darling, Campaspe, Goulburn, Loddon. It excludes the Ovens River, Broken River and Coliban River. The figures may change following reconciliation of accounts for the end of the 2010-11 water year.

6.5. Other sources of environmental water

G-MW's *Monitoring and Incident Response Manual* (2004) made note of an agreement between G-MW and the River Murray Commission to provide a 40 ML per day allocation to the lower Broken Creek (via the Murray Valley channel system) to manage water quality (azolla build up). In 2003-04 the agreement was modified to 80 ML per day. The current status of this agreement is unknown, but it is believed to no longer be active (Water Technology 2010).

Excluding the above, there are no planned environmental water provisions for the lower Broken Creek. However, in recent years significant water deliveries have been made to manage water quality. These provisions have been made from a number of sources:

- Inter-valley transfers from the Goulburn system to the Murray River system through the Shepparton irrigation area channel system and lower Broken Creek (rather than directly down the Goulburn River);
- Water from the Goulburn Water Quality Reserve (Eildon-Goulburn Weir BE, 1995) via the Shepparton irrigation area channel system; and
- Murray River water diverted to bypass the Barmah-Millewa Forest.

Water from the Murray Flora and Fauna BE (1999) via the Murray Valley irrigation area channel system (which may also be back-traded to the Goulburn system and delivered via the Shepparton irrigation area channel system) may also be available in the future. The main objectives of environmental water delivered to the lower Broken Creek has been for the prevention or mitigation of poor water quality (DO) that can occur following excessive growth of the water fern Azolla, as well as over summer, and maintaining habitat and passage for native fish.

6.6. Watering objectives 2011-12

The management of Reach 3 is driven by objectives for the reach from Nathalia weir pool to the Murray River, as this has the highest ecosystem values but experiences low flows once irrigation demand has been met.

Objectives for environmental watering of the lower Broken Creek system focus on native fish:

- improve native fish habitat and passage;

- ensure persistence of aquatic habitats during migration and breeding seasons, particularly for Murray Cod; and
- supply sufficient flow to operate the fishways and provide fish access to appropriate habitat all year (Water Technology 2010).

6.7. Watering options 2011-12

The watering options for Reach 3 of Broken Creek are to supplement baseflows (August to May) and include:

Watering option 1

This option intends to maintain fish passage by contributing to a baseflow of 40 ML per day from August to May.

Watering option 2

If sufficient water is available then the baseflow will be increased up to 250 ML per day between September and summer/autumn to maintain fish passage and habitat during migration and breeding seasons, as well as fostering recruitment of fish species.

The operational considerations are provided in Table 6.2.

Table 6.2: Operational details for potential watering options for 2011-12 in lower Broken Creek.

Water management options*	Flow require't	Estimated maximum volume required*	Timing & duration	Delivery mechanism	Operational considerations
Supplement lower baseflow	40 ML/d	10,920 ML	Mid August 2011 to May 2012	Releases from Goulburn Weir and via the East Goulburn Main Channel or the Murray via the Murray Valley 7/3 channel are preferred however outfall channels further downstream may also be used if there is spare capacity.	Commonwealth's allocations to supplement creek flows as required. Consider options for use of other water (IVT and Murray water diverted around Barmah-Millewa) to meet requirements.
Supplement elevated baseflow	250 ML/d	To be determined during the course of 2011-12 depending on catchment and flow conditions	September to summer/autumn		

* Volume assumes that all flows are met by Commonwealth water

6.8. Key constraints for water delivery

The key constraint to providing the desired environmental outcomes in the lower Broken Creek is the likelihood for high irrigation demand in 2011-12, limiting the available channel capacity for delivery of water to the creek for environmental flow management (GBCMA 2011). To minimise this impact as much as possible it is proposed to source any water available from both the Goulburn and Murray Rivers to allow use of any available channel capacity to be maximised.

There may also be an opportunity to release high creek flows pre-emptively when high irrigation demand is imminent.

A further constraint is that Commonwealth water via the G-MW channel networks will incur an annual service point fee of $200 per service point, plus delivery fees of $8.92 per ML delivered through the Shepparton irrigation area and $5.48 per ML delivered through the Murray Valley irrigation area (G-MW website 6 July 2011). These rates are for interruptible supply, which is only available when there is spare capacity. If guaranteed access is required the Commonwealth would be required to purchase delivery shares which would incur different fees and charges.

6.9. Water accounting

Return Flows: For Broken Creek, water entering the Murray River from Broken Creek is treated as a Victorian tributary inflow under the MDB Agreement. Return flows for this water may be granted if the MDBA determines that the inflows have added to usable resources. If tributary credits are granted, the water is added to Victorian resources and would fall under the provisions of the Murray Bulk Entitlement. The Commonwealth would then need an agreement with G-MW to have these return flows credited to its allocation bank account for the Murray River downstream of the Barmah Choke.

Specifying Rice's Weir as the point of delivery for environmental water will ensure that the most downstream reaches of lower Broken Creek receive the required baseflows. An agreement with G-MW is required to ensure that water is released from the upper reaches of lower Broken Creek instead of the downstream outfalls to maximise the environmental benefit (Cottingham *et al.* 2011d).

6.10. Risk management

A full risk assessment will be undertaken for each watering option as part of the assessment process.

The main potential risks associated with the delivery of environmental water are summarised in Table 6.3 below.

Table 6.3 Likely risks, their context and potential mitigation.

Risk	Context and mitigation
Flooding, injury, property/ infrastructure damage, stock/crop damage, road access	Flow monitoring will be undertaken by the CMA and environmental flows can be managed by G-MW to avoid unintentional flooding.
Negative public response	No negative response is expected. All flows will be entirely within the channel.
Salt mobilisation	Salt mobilisation is not an issue in lower Broken Creek environmental flows.
Spread of weeds	Weed species are already present throughout the river system and future dispersal is unlikely to be exacerbated by environmental flows.
Spread of exotic fish species or increase in population	Flows will be in-channel and should not result in any further geographic spread of exotic fish. There are no appropriate management actions to prevent creating favourable conditions for carp. Proposed flow conditions will be more favourable for native fish species and should benefit existing native fish populations.
Geomorphic impacts e.g. erosion	Flows are not likely to be of sufficient velocity to cause erosion impacts.
Transmission losses	Unauthorised take of water is monitored by state government organisations.

Risk	Context and mitigation
	G-MW will meet flow targets at specified locations.
Unauthorised take of Commonwealth environmental water	Unauthorised take of water is monitored by state government organisations.
Limited channel capacity	Irrigation demand (which is likely to be high this year) may take up channel capacity. Delivery of environmental water should be from the Goulburn and Murray Rivers, utilising all available outfall channels.
Loss of public amenity and risk to recreational users	Flows are small and not unusual in the creek. No loss of amenity is expected.
Management of water quality	Liaise with Victoria over water quality issues and developing a long-term strategy for the sustainability of Broken Creek.

7. Broken River

7.1. Broken River and environmental assets

The Broken River is one of the main tributaries of the Goulburn River, discharging into the Goulburn River near Shepparton. The main storage is Lake Nillahcootie which has a capacity of approximately 40 GL.

The Broken River system (Figure 7.1) includes both the Broken Creek and Broken River. The lower Broken River downstream of Casey's Weir has DIWA listed wetlands (1268 ha), and meanders for over 63 km through plains country before reaching the Goulburn River at Shepparton. The MDBA has identified the lower Broken River as a key environmental asset, meeting all five criteria of a key environmental asset:

1. Formally recognised in, and/or is capable of supporting species listed in, relevant international agreements;
2. Natural or near-natural, rare or unique;
3. Provides vital habitat;
4. Supports Commonwealth-, state- or territory-listed threatened species and/or ecological communities; and
5. Supports, or is capable of supporting, significant biodiversity.

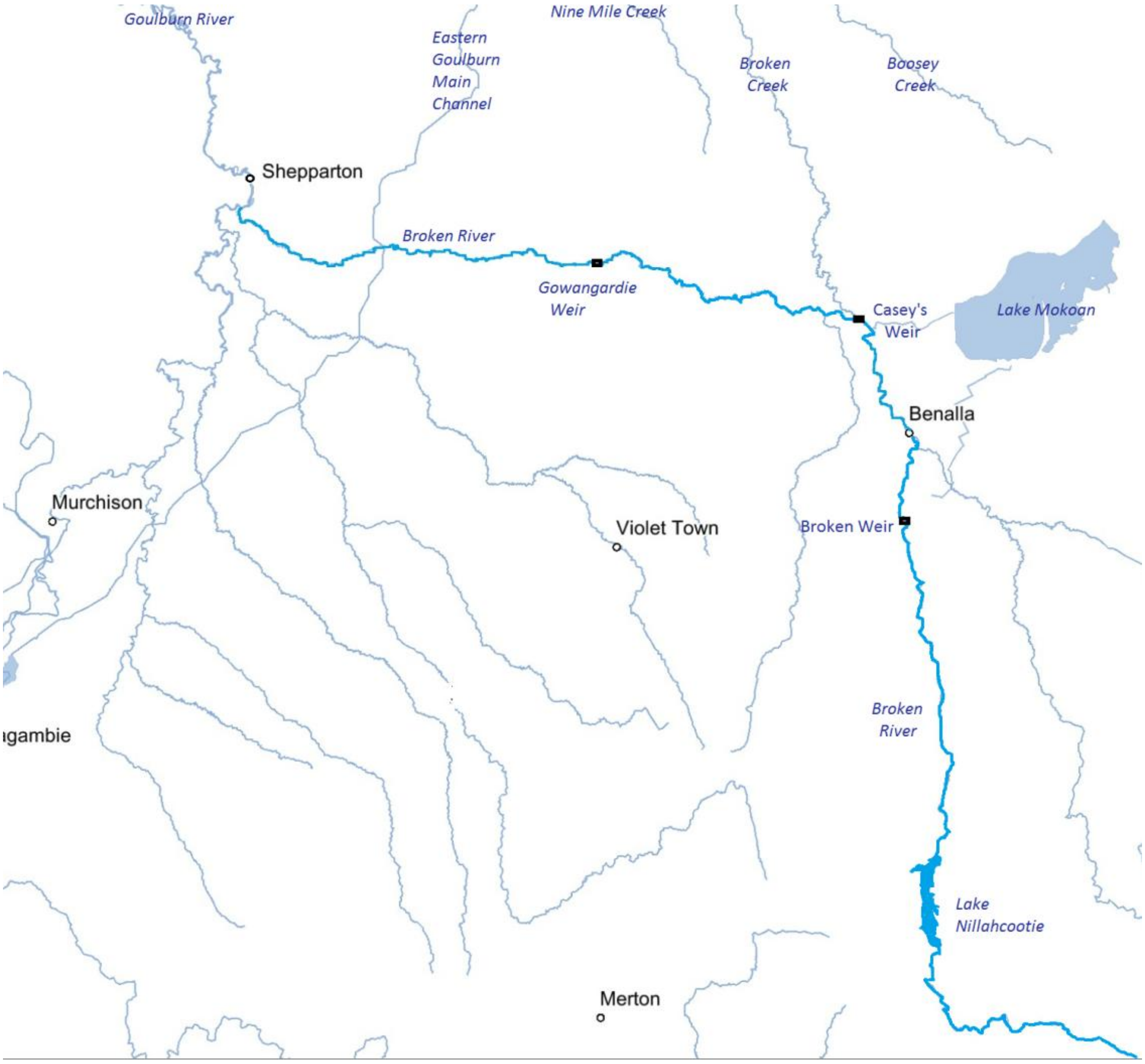

Figure 7.1: Broken River catchment map.
Source: DSE 2011b

7.2. Delivering water

Water is released to the Broken River from Lake Nillahcootie. To ensure that Commonwealth water is additional to flows in the river, the Commonwealth may specify that water be released at a time when the reservoir is not spilling.

7.3. Current catchment status and outlook

The current condition of the Broken River catchment is wet. Wet conditions and tributary inflows, particularly due to natural flooding during November 2010 and January 2011, meant that all the flow events needed to sustain the river (and floodplain wetlands) and meet ecosystem objectives were likely to have been delivered in 2010-11. Lake Nillahcootie has been at around 100 per cent capacity since that time which has led to extensive unregulated flows over the last six months and in turn likely to have contributed to an improvement in the condition of the riparian environment.

7.4. Forecast allocations

The volume of Commonwealth environmental water available in the Broken River is provided in Table 7.1.

Table 7.1: Commonwealth environmental water availability in 2011-12.

Catchment	Entitlement (GL)	Water available for use (GL)	Water available for use forecasts					
			31 July 2011 (GL)		30 September 2011 (GL)		30 June 2012 (GL)	
Broken (Vic)			**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
High	0.05	0.02	0.0	0.01	0.01	0.04	0.05	0.05

7.5. Other sources of environmental water

As a result of the decommissioning of Lake Mokoan, the lower Broken River has 87 per cent of its natural flow regime restored. In the Broken River system below Lake Nillahcootie, the majority of environmental water is contained in provisions within Goulburn-Murray Water's bulk entitlement (DSE 2010) in the table below:

Table 7.2: Bulk entitlement passing flow requirements in the Broken River.

Reach	Timing	Environmental minimum flow
Lake Nillahcootie to Broken Weir	June to November	30 ML/d or natural flow generated in all of catchment upstream of Moorngag
Broken Weir to Casey's Weir	December to May	22 ML/d or natural flow generated in all of catchment upstream of Casey's Weir
Casey's Weir to Goulburn River confluence	December to May	25 ML/d or natural flow generated in the Broken River upstream of Gowangardie Weir

7.6. Watering objectives 2011-12

Broad ecosystem objectives for the Broken River include protecting water-dependent ecosystems that: support migratory birds listed in international agreements; provide vital habitat; and support Commonwealth-, state- or territory-listed threatened species and/or ecological communities. More specific objectives are:

Aquatic and riparian vegetation objectives:

- maintain extent and diversity of aquatic and river bank vegetation; and
- maintain continuity and cover of riverbank vegetation.

Macroinvertebrates:

- maintain dynamic, diverse food webs that support higher organisms and contribute to river health.

Native fish:

- maintain suitable in-channel habitat for all life stages; and
- maintain flow continuity and thus passage for all life stages.

7.7. Watering options 2011-12

Tributary inflows, bulk entitlement releases and consumptive water are likely to provide much of the flows required to meet ecological objectives for the river.

Watering option 1

It is proposed to supplement a natural fresh at the end of summer or in early autumn to connect habitat and rejuvenate biofilms.

Watering option 2

If a natural fresh does not occur by April 2012 the water will be used to supplement baseflows to maintain the condition and functioning of the riverine ecosystem.

7.8. Key constraints for water delivery

No constraints to deliver the water have been identified.

7.9. Water accounting

Water cannot be traded in or out of the Broken River, nor can return flows be re-credited for downstream use in the Goulburn River or River Murray.

7.10. Risk management

Overall the watering action is assessed as posing minimal risks to both public and private assets within the lower Broken River. Due the size of the water share delivered relative to the flows within the system, and the capacity of the river channel to accommodate flow it will not be necessary to instigate any mitigation measures.

A full risk assessment will be undertaken for each watering option as part of the assessment process.

The main potential risks associated with the delivery of environmental water are summarised in Table 7.4 below.

Table 7.4: Likely risks, their context and potential mitigation.

Risk	Context and mitigation
Injury, property/ infrastructure damage, stock/crop damage	The proposed volume of water is a very small proportion of the waterway's stream flow, and is too small to pose a risk. Arrangements will specify that water will only be released when (1) the storage is not spilling, and (2) when all flows are entirely within the channel.
Negative public response	The proposed volume of water is a very small proportion of the waterway's stream flow.
Water quality	The impacts on water quality are negligible as the water will be of the same quality as other releases from Lake Nillahcootie.

8. Ovens River

8.1. Ovens River and environmental assets

The Ovens River catchment is located in north-eastern Victoria, beginning near the Great Dividing Range and flowing north to meet the Murray at Lake Mulwala (see Figure 8.1). A number of major tributaries join the Ovens River, including the King River which joins the Ovens at Wangaratta, and the Buffalo River which enters the Ovens River just below Myrtleford.

The environmental assets dealt with in this strategy are the lower Ovens, King and Buffalo rivers. Between its junctions with the Buffalo and the King Rivers, the Ovens River forms a number of anabranches across a wide floodplain, part-shared with the King River. From this point to the Murray, the Ovens River flows through a confined floodplain with anabranches and billabongs.

The Ovens River is unregulated upstream of Myrtleford and partly regulated downstream due to the presence of Lake Buffalo and Lake William Hovell on its tributaries. There are two in-stream storages, Lake Buffalo (24 GL) on the Buffalo and Lake William Hovell (14 GL) on the King River. The entire region generates approximately 6 per cent of the runoff within the Murray Darling Basin.

The MDBA has identified the Ovens, King and Buffalo Rivers as key environmental asset (MDBA 2010b), meeting all five criteria of a key environmental asset:

1. formally recognised in, and/or is capable of supporting species listed in, relevant international agreements;
2. natural or near-natural, rare or unique;
3. provides vital habitat;
4. supports Commonwealth-, state- or territory-listed threatened species and/or ecological communities; and
5. supports, or is capable of supporting, significant biodiversity.

8.2. Delivering water

Water is released to the King River from Lake William Hovell, and to the Buffalo River from Lake Buffalo. The flows from these two rivers converge in the lower Ovens River upstream of Wangaratta.

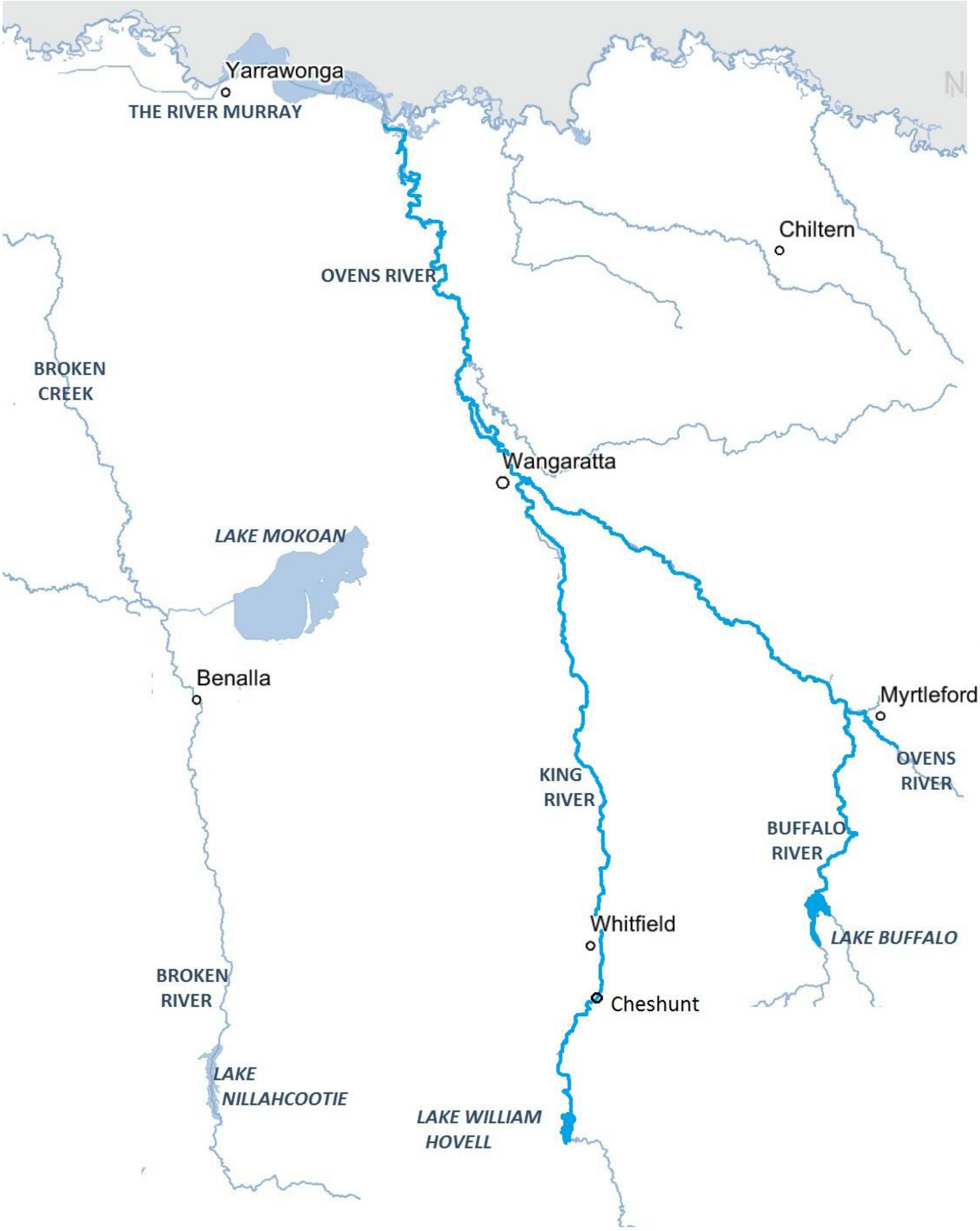

Figure 8.1: Ovens catchment map.
Source: DSE 2011b

8.3. Current catchment status and outlook

The 2010-11 water year in the Ovens River system was unusually wet. Notable characteristics of the 2010-11 water year within the system include:

- the December-March inflows in the Ovens system were the highest on record;
- major floods occurred in September and December 2010 and significant inflows also occurred in February 2011;
- the storages within the system remained in a spilling phase all summer and are likely to remain in this state to spring 2011;
- currently all inflows to Lake Buffalo and Lake William Hovell are effectively being passed; and
- current and projected inflows to Lake Buffalo and Lake William Hovell are expected to meet all operating requirements (including environmental needs) up to spring 2011 (Matt O'Connell, NECMA, *pers. comm.* May 2011).

The environment is receiving sufficient water to meet the environmental watering objectives; the flow regime in the Buffalo, King and Ovens Rivers has been in a near natural pattern for much of 2010-11.

8.4. Forecast allocation

The volume of Commonwealth environmental water available in the Ovens system at the beginning of 2011-12, and forecasts for the rest of 2011-12 water year is provided in Table 8.1.

Table 8.1: Commonwealth environmental water availability in 2011-12.

Catchment	Entitlement (GL)	Water available for use (GL)	Water available for use forecasts					
			31 July 2011 (GL)		**30 September 2011 (GL)**		**30 June 2012 (GL)**	
Ovens (Vic)			**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
High	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

8.5. Other sources of environmental water

Minimum environmental flows are specified in the Ovens system BE (DSE 2011a), and provided in table 8.2 below.

Table 8.2 Sources of environmental water in the Ovens system.

River reach		**Environmental minimum flows**	
		November – May	June - October
King River	Lake William Hovell to Cheshunt	20 ML/d or natural flow generated in catchment upstream of Cheshunt	30 ML/d or natural flow generated in catchment upstream of Cheshunt
	Cheshunt to Ovens R	40 ML/d or natural flow generated in King catchment	20 ML/d or natural flow generated in King catchment

River reach		Environmental minimum flows	
		November – May	June - October
Buffalo River	Lake Buffalo to Ovens R	60 ML/d or natural flow generated in all the Buffalo River catchment	Not specified
Ovens River	Ovens/Buffalo confluence to the Ovens/King confluence	154 ML/d or natural flow generated in all of the Ovens catchment	Not specified
	Ovens downstream of Ovens/King confluence	140 ML/d or natural flow generated in the Ovens catchment	50 ML/d or natural flow generated in all of the Ovens catchment

8.6. Watering objectives 2011-12

The environmental watering objectives are to:

- assist in maintaining the condition and functioning of riverine ecosystems; and
- assist in maintaining existing populations and the distribution of water-dependent native flora and fauna across their natural range.

8.7. Watering options 2011-12

Two potential watering options are proposed for the Ovens system. These options are not listed in order of priority, rather they will be considered based on requirements due to factors such as climatic conditions and availability of water.

Watering option 1
It is proposed to supplement a natural fresh at the end of summer or in early autumn to connect habitat and rejuvenate biofilms.

Watering option 2
If a natural fresh does not occur by April 2012 the water will be used to supplement baseflows to maintain the condition and functioning of the riverine ecosystem.

8.8. Key constraints for water delivery

During medium to wet inflow scenarios, both Lake William Hovell and Lake Buffalo are expected to be spilling, at some period of time, and consequently will reduce delivery opportunity for environmental water.

8.9. Water accounting

There are two trading zones for water shares held in the Ovens system, 9A and 9B. The boundaries of these zones are confined to the main reaches downstream of the storages of Lake William Hovell and Lake Buffalo.

Water cannot be traded in or out of the Ovens River system. There is no carry-over in the Ovens system and return flows cannot be re-credited for downstream use in the River Murray.

8.10. Risk management

A full risk assessment will be undertaken for each watering option as part of the assessment process. The main potential risks associated with the delivery of environmental water are summarised in Table 8.3 below.

Table 8.3: Likely risks, their context and potential mitigation.

Risk	Context and mitigation
Injury, property/ infrastructure damage, stock/crop damage	Arrangements will specify that water will only be released when (1) storages are not spilling and (2) when all flows are entirely within the channel.
Negative public response	The proposed volume of water is a very small proportion of the waterway's stream flow.
Water quality	The impacts on water quality are negligible as the water will be of the same quality as other releases from Lake William Hovell and Lake Buffalo.

9. Coliban River

9.1. Coliban River and environmental assets

The environmental asset dealt with in this strategy is the lower Coliban River, the largest tributary of the Campaspe River (see map in Figure 9.1 and further details at Appendix A). The lower Coliban River extends approximately 60 kilometres from Malmsbury Reservoir downstream to Lake Eppalock. It is considered to be a "working river" and has no international or national reserves or listings. The MDBA has identified the lower Coliban River as a key environmental asset, meeting two of the five criteria of a key environmental asset: (1) supports Commonwealth-, state- or territory-listed threatened species and/or ecological communities; and (2) supports, or is capable of supporting, significant biodiversity.

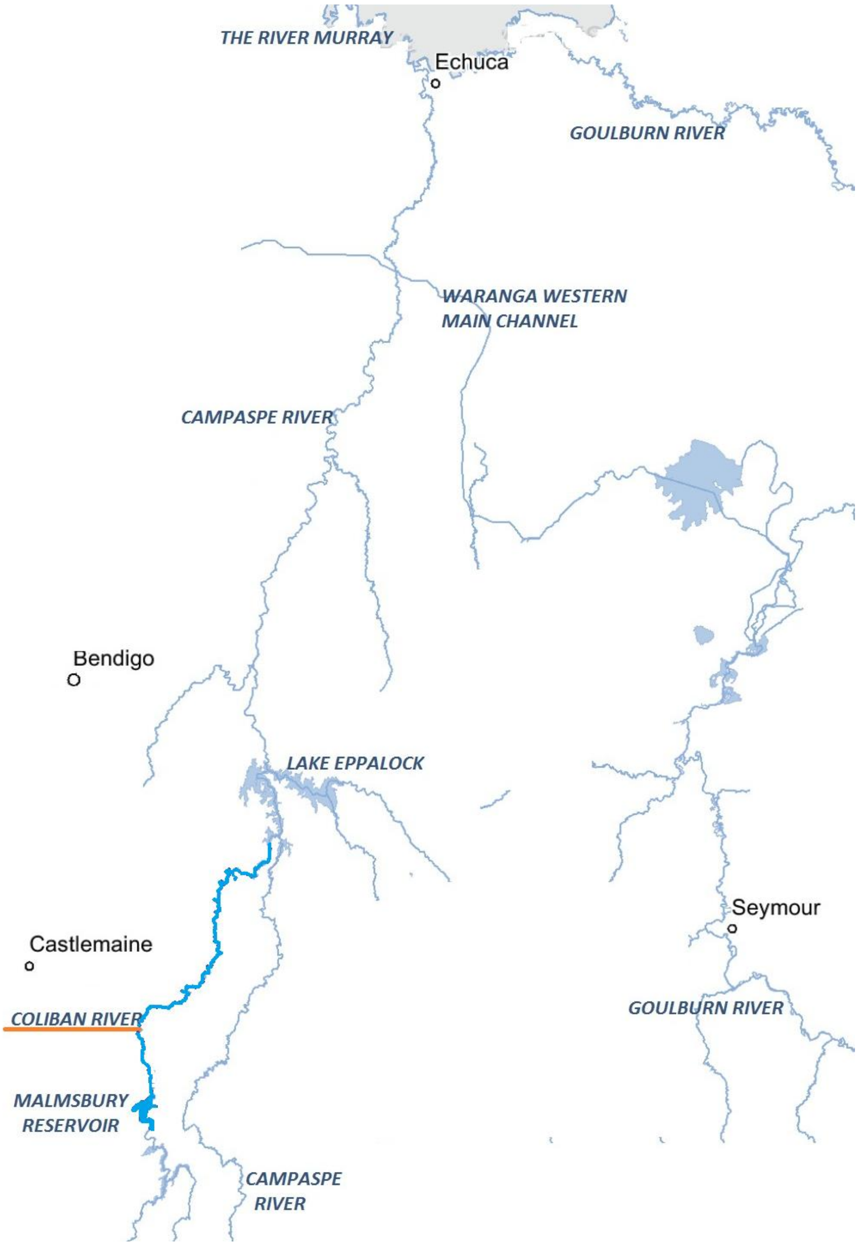

Figure 9.1: Lower Coliban River.
Source: DSE 2011b

9.2. Delivering water

Environmental flow recommendations for the lower Coliban River are provided in Campaspe River Environmental FLOWS Assessment (SKM 2006). Water is released to the lower Coliban River from Malmsbury Reservoir.

9.3. Current catchment status and outlook

The Campaspe catchment experienced prolonged drought for over a decade. The drought was ended following heavy rainfall and extensive flooding across northern Victoria in 2010-11. The Coliban River has received substantial inflows due to above average rainfall since July 2010, with the lower reaches of the river benefitting most. The flows enhanced habitat for native fish; provided an input of nutrients and organic matter to the river and facilitated an exchange of sediments and biota between the channel, floodplain and wetlands; and improved riparian vegetation health.

9.4. Forecast allocation

The volume of Commonwealth environmental water available in the Coliban River is provided in Table 9.1.

Table 9.1: Commonwealth environmental water availability in 2011-12.

Catchment	Entitlement (GL)	Water available for use (GL)	Water available for use forecasts					
			31 July 2011 (GL)		30 September 2011 (GL)		30 June 2012 (GL)	
Coliban			**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
High	0.03	0.0	0.0	0.01	0.02	0.02	0.02	0.02

9.5. Sources of environmental water

The Campaspe Bulk Entitlement specifies a passing flows 8 ML per day or natural. The Coliban River is not part of the southern connected basin, therefore water cannot be traded in or out of the system, nor can return flows cannot be re-credited downstream.

9.6. Watering objectives 2011-12

The environmental flow objectives (SKM 2006) for the lower Coliban River are to:

- rehabilitate riparian vegetation extent, structure and composition and increase diversity of in-stream vegetation;
- rehabilitate native fish community through improved conditions for recruitment, maintenance and movement;
- reduce nutrient concentrations and salinity throughout the reach;
- maintain current macroinvertebrate community diversity, increase pollution sensitive taxa; and
- maintain current channel hydraulic geometry.

The objectives of supplementing spring/summer low flows is to achieve up to 8 ML per day to meet the first four of the above-listed objectives.

9.7. Watering options 2011-12

Watering option 1

It is proposed to supplement spring / summer / autumn low flows to attain up to 8 ML per day to maintain:

- connecting flows;
- aquatic vegetation; and
- macroinvertebrate access to riffle habitat.

9.8. Key constraints for water delivery

No physical constraints to deliver environmental water have been identified.

9.9. Water accounting

The Commonwealth entitlement is 30 ML, however due to reservoir infrastructure limitations as a result of a safety audit, the allocations are capped at 70 per cent of entitlements until further notice. Therefore the net entitlement in the Coliban River is 21 ML and is subject to the following fees and charges:

Annual service fee	$704.38
Annual capacity charge ($137.68/ML)	$2,891.28
Usage charge ($147.86/ML)	$3,104.85

9.10. Risk management

Overall the watering action is assessed as posing minimal risks to both public and private assets within the lower Coliban River. Due the size of the water share delivered relative to the flows within the system, and the capacity of the river channel to accommodate flow it will not be necessary to instigate any mitigation measures.

A full risk assessment will be undertaken for each watering option as part of the assessment process. The main potential risks associated with the delivery of environmental water are summarised in Table 9.2 below.

Table 9.2: Likely risks, their context and potential mitigation.

Risk	Context and mitigation
Injury, property/ infrastructure damage, stock/crop damage	Arrangements will specify that water will only be released when (1) the storage is not spilling and (2) when all flows are entirely within the channel
Negative public response	The proposed volume of water is a very small proportion of the waterway's stream flow.
Water quality	The impacts on water quality are negligible as the water will be of the same quality as other releases from Malmsbury Reservoir.
Transmission loss – e.g. unauthorised diversion	Diversions are monitored by state government agencies.

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APPENDIX A Environmental Assets

Goulburn River (Cottingham *et al.* 2011a)

Ecosystem values associated with the lower Goulburn River include:

- The presence of intact native fish populations, including icon species such as Murray cod and golden perch.
- The intact and generally healthy riparian and floodplain areas, including river red gum and other ecological vegetation classes and complexes.
- The presence of threatened flora and fauna species.
- Its connection with other important rivers and floodplain systems along the Murray River, providing habitat diversity and connection at landscape scales.
- It's listing under the Directory of Important Wetlands in Australia as an asset of national importance, and status as a National Park.
- The presence of a number of Ecological Vegetation Classes (EVCs) in the Murray Fans bioregion, including Riverine Grassy Woodland, Sedgy Riverine Forest and Floodplain Riparian Woodland, as well as protecting areas of endangered Plains Woodland and Riverine Chenopod Woodland along the Murray River.
- The presence of a diversity of habitats including permanent and temporary wetlands found within the floodplain (including billabongs, sloughs, marginal swamps, potholes, scroll swales, anabranches and cut-off loops), and key wetlands such as the Gemmills Swamp nature conservation reserve and Reedy Swamp state wildlife reserve and Loch Garry Wildlife Management Cooperative Area.

In addition to its own intrinsic values, the Lower Goulburn River is also important at a regional scale, complementing the ecosystem values recognised for nearby assets such as the Barmah-Millewa Forest and Gunbower Forest. Water from the Goulburn River discharges to the Murray River upstream of Gunbower Forest and contributes to the watering of this important Ramsar-listed site. The Lower Goulburn River also meets a number of criteria applied by the MDBA in selecting hydrologic indicator sites (Table 2), which are recognised as key environmental assets across the Murray Darling Basin (MDBA 2010b).

Table 2: MDBA key environmental asset criteria met by the Lower Goulburn River Floodplain (from MDBA 2010b).

Criterion	Description	Values
1	The asset is recognised in, and/or is capable of supporting species listed in, international agreements.	The Lower Goulburn River Floodplain is formally recognised in, or is capable of supporting species listed in the Japan–Australia Migratory Bird Agreement (JAMBA), the China–Australia Migratory Bird Agreement (CAMBA) or the Republic of Korea–Australia Migratory Bird Agreement (ROKAMBA). For a full list of species listed under Commonwealth legislation that have been recorded at the Lower Goulburn River Floodplain refer to Appendix 3.
3	The asset provides vital habitat.	The Lower Goulburn River Floodplain's ecological features make it a high-value wetland system. The floodplain consists of a large area of habitat for fauna such as waterbirds and fish (Department of the Environment, Water, Heritage and the Arts 2009h). 34 bird species have been recorded breeding at Gemmills Swamp, including Australian white ibis (*Threskiornis molucca*); royal spoonbill (*Platalea regia*); yellow-billed spoonbill (*P. flavipes*); black swan (*Cygnus atratus*); Pacific black duck (*Anas superciliosa*); grey teal (*Anas gracilis*); musk duck (*Biziura lobata*); dusky moorhen (*Gallinula tenebrosa*); purple swamphen (*Porphyrio porphyrio*); Eurasian coot (*Fulica atra*); masked lapwing (*Vanellus miles*) (Department of the Environment, Water, Heritage and the Arts 2009h).
4	The asset supports Commonwealth-, state- or territory-listed threatened species and/or ecological communities.	The Lower Goulburn River Floodplain meets this criterion because it supports species listed as threatened under Commonwealth or state legislation. For a full list of species that have been recorded refer to Appendix 3.

Campaspe River (Cottingham *et al.* 2011b)

The Campaspe River supports flora and fauna of national, regional and local conservation significance (see e.g. SKM 2006, NCCMA 2011a). For example, 11 fish species, including 5 of significant conservation status, have been recorded in the Campaspe River below Lake Eppalock over the last 30 years (SKM 2006b). Eleven significant Ecological Vegetation Classes (EVCs) have been recorded along Reach 4, along with 2 threatened plant species (NCCMA 2009). Features such as pools (including weir pools such as Campaspe Weir and The Siphon) serve as important refugia for the survival of organisms that can recolonise reaches following periods of drought. Protecting and then connecting in-channel habitat is important for the recovery of the river following periods cease to flow periods.

In addition, the Campaspe River connects to the Murray River, providing important ecological linkages and biodiversity in a region and landscape that has been heavily modified. Water discharged from the Campaspe River can, along with water from the Goulburn River, contribute to watering environmental assets downstream along the Murray River. The Campaspe River is considered a high priority under the North Central River Health Strategy (RHS) (NCCMA 2005).

Loddon River and Boort Wetlands (Cottingham *et al.* 2011c)

Both the Loddon River and Boort Wetlands support flora and fauna of international, national, regional and local conservation significance (see NCCMA 2010a, b, c and d). This includes waterbirds listed under international agreements (Ramsar, JAMBA, CAMBA, ROKAMBA), threatened native fauna (including native fish) and plant species.

The Loddon River provides breeding habitat for important fish species (e.g. Murray cod, golden perch). Features such as pools (including weir pools) serve as important refugia for the survival of organisms that can recolonise reaches following periods of drought. After a period of cease-to-flow in the river, protecting and then connecting in-channel habitat is important for the recovery of the river. The riparian zone of the Loddon River also supports important vegetation such as River red gum, Chenopod grassland, Lignum swamp and Box-ironbark forest. The Loddon River is, therefore, a high priority for environmental water in the Regional River Health Strategy (NCCMA 2005) and Annual Watering Plans (NCCMA 2010a).

Collectively, the Boort Wetlands provide important breeding, feeding and refuge habitat for waterbirds (Parks Victoria 2003, NCCMA 2010a, b, c, d). At the landscape scale, the wetlands provide a great diversity of habitat types and drought refuges in a heavily modified landscape. The wetlands are visited by waterbird species (including those listed under JAMBA, CAMBA, ROKAMBA) such as Caspian tern, whiskered tern, great egret, Australasian shoveller, freckled duck, hardhead and blue-billed duck. The wetlands also support a variety of vegetation assemblages, including ecological vegetation classes such as River red gum swamp, Black box woodland, Tall marsh and Lignum swamp.

The Loddon River and Boort wetlands together provide habitat that supports flora and fauna of regional significance, being important refugia in a region of the southern Murray-Darling Basin that has been heavily modified.

Broken Creek (Cottingham *et al.* 2011d)

Ecosystem values associated with the Lower Broken Creek include the presence of (Water Technology 2010, GHD and URS 2005):

- Twenty ecological vegetation classes, including the following threatened and/or regionally significant examples:
  - EVC68 – Creekline Grassy Woodland;
  - EVC168 – Drainage Line Aggregate;
  - EVC259 – Plains Grassy Woodland / Gilgai Wetland Mosaic;
  - EVC803 – Plains Woodland;
- Numerous riparian plant species of conservation significance;
- Threatened and regionally significant native fish species (e.g. Murray cod), including:
  - Murray cod (*Maccullochella peelii peelii*);
  - Silver perch (*Bidyanus bidyanus*);
  - Golden perch (*Macquaria ambigua*);
  - Unspecked hardyhead (*Craterocephalus stercusmuscarum fulvus*);
  - Crimson-spotted rainbow fish (*Melanotaenia fluviatilis*).

The native fish populations of Lower Broken Creek, particularly Murray cod, are considered to be of regional significance. While a result of water resource development and regulation, the presence of weir pools along the Lower Broken Creek has provided additional habitat for deep-bodied native fish than might otherwise exist.
Overall, the Lower Broken Creek supports important plant and animal habitat and biodiversity in a region whose landscape has been greatly modified. It also complements the habitat and biodiversity values associated with nearby systems such as the lower Goulburn River and the Murray River. These values are appreciated by local communities, both from a conservation and amenity/recreation/cultural perspective.

APPENDIX B Criteria for Assessing Commonwealth Environmental Watering Actions

In undertaking its activities, the CEWH is required to act consistently with the requirements of the *Water Act 2007* (Cwlth) (hereafter referred to as 'the Act'). The relevant functions are outlined in s.105. This includes a requirement that the environmental water holdings are managed in accordance with the environmental watering plan of the MDBA. Close consultation is occurring with the MDBA to ensure that use of Commonwealth water is consistent with the emerging objectives of the environmental watering plan that is currently being developed.

A long-term framework for the prioritisation of environmental water allocations has been prepared in consultation with delivery partners, interested stakeholders and experts, and the Environmental Water Scientific Advisory Committee.

The framework includes ecological objectives that will change under the different water availability scenarios (i.e. extreme dry, dry, median, wet). Proposed watering actions will need to be supported by available evidence, and consistent with current water availability scenarios and the framework.

Commonwealth environmental water is being acquired to supplement existing flows. Proposals for use of the water will not be agreed to if this use substitutes for other water uses, including historical system operations (e.g. provision of water for conveyance, stock and domestic, or planned environmental water).

Through adaptive management processes, the CEWH will consider opportunities for a more informed and diverse range of water uses as knowledge and modelling. All 2011-12 proposals will be assessed against the following criteria:

1. Ecological significance of the asset(s)

Issues to be considered will include:

- the presence of threatened species and ecological communities, and listed migratory species; and
- ecological and conservation values of the assets(s) including those recognised by international agreements.

2. Expected ecological outcomes from the proposed watering action

Issues to be considered will include:

- how well defined and realistic the objectives are for the proposed watering action;
- the consistency of these objectives with the overall CEWH ecological objectives for the current forecast water availability scenario;
- the current health of the asset(s);
- the improvement in health of the asset(s) expected from the watering action;
- the Basin-wide significance of the ecological response from the watering action;
- any secondary environmental effects expected to result from the watering action (e.g. connected system benefits); and
- the change in the health of the asset(s) expected if environmental water is not provided.

3. Potential risks of the proposed watering action at the site and at connected locations

Issues to be considered will include:

- how thoroughly the potential risks have been assessed for the proposed watering;
- the adequacy of measures proposed to minimise these risks; and
- the likelihood and consequence of variance from the expected ecological outcome (including negative impacts on biota and water quality).

4. Long-term sustainability of the asset(s) including appropriate management arrangements

Issues to be considered will include:

- the adequacy of long-term management and delivery arrangements;
- the existence of complementary natural resource management activities supporting the long-term management arrangements, including those that improve water quality; and
- the effectiveness of monitoring, evaluation and reporting arrangements for the watering activity including clear links to the defined objectives.

5. Cost effectiveness and operational feasibility of undertaking the watering

Issues to be considered will include:

- the amount of Commonwealth water and resources needed, including relative to the contribution of the State and delivery partner to (i) the watering event and (ii) subsequent monitoring of actions and outcomes;
- opportunity to supplement natural flows or other water releases; and
- the operational feasibility of undertaking the watering action (e.g. channel capacity, infrastructure constraints, etc).
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APPENDIX C Watering assessments

Contents:

1. Ecological significance of the asset(s)

Ecological significance

The Goulburn Broken catchment represents 2.1 per cent of the total area of the Murray-Darling Basin and generates approximately 11 per cent of the runoff within the Murray Darling Basin. Ecosystem values include[1]:

• The presence of intact native fish populations, including icon species such as Murray cod and golden perch.

• The intact and generally healthy riparian and floodplain areas, including river red gum and other ecological vegetation classes and complexes.

• Its connection with other important rivers and floodplain systems along the Murray River, providing habitat diversity and connection at landscape scales.

• The presence of a number of Ecological Vegetation Classes (EVCs) in the Murray Fans bioregion, including Riverine Grassy Woodland, Sedgy Riverine Forest and Floodplain Riparian Woodland, as well as protecting areas of endangered Plains Woodland and Riverine Chenopod Woodland along the Murray River.

Presence of threatened species and ecological communities, and listed migratory species

Several Commonwealth threatened species and communities and migratory species are associated with the lower Goulburn River, including:

- 15 vulnerable, endangered or critically endangered Commonwealth listed threatened fauna species including the endangered Macquarie perch and trout cod;
- 8 flora species;
- 13 migratory species; and
- 4 threatened ecological communities including the critically endangered White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland.

Listings / reserves[2]

- Commonwealth: the lower Goulburn River Floodplain (13,000 ha) is listed in the Directory of Important Wetlands Australia. The floodplain is regarded as a having a high ecological value, containing major areas of natural ecosystem within a large, intensively cleared irrigation and grazing region. Within the floodplain, there are a variety of permanent and temporary wetlands which provide extensive habitat for waterbirds and fish. The system also forms an important breeding area for waterbirds, including many colonial nesting species.
- State: Heritage River (Lake Eildon to The Murray River), *Heritage Rivers Act 1992 (Vic)*

[1] Cottingham et al. 2011a - "Water use delivery: Loddon River Catchment" Prepared for the Department of Sustainability, Environment, Water, Populations and Community by Peter Cottingham and Associates and SKM.
[2] *EPBC Act* Protected Matters Report, June 2011

- Two State Wildlife Reserves (Gemmill Swamp Wildlife Reserve: 173 ha and Reedy Swamp State Wildlife Reserve: 224 ha) and the Loch Garry Wildlife Management Co-operative Area (687 ha) are included within the floodplain: the wetlands of the floodplain have been grouped together in one entry because of their large number.
- Ramsar sites NSW Central Murray State Forests and Barmah forest are within 10km of the Goulburn River

2. Expected ecological outcomes from the proposed watering action

<u>Current health of asset</u>

Between August and December 2010 the Goulburn River received a number of spring freshes and two overbank flows. These floods and freshes supplied water to a system impacted by drought, and provided an input of nutrients, carbon and organic matter to the stream and an exchange of sediments and biota between the channel, floodplain and wetlands. The higher flows connected floodplains that have not been connected for 10 – 15 years and improved riparian vegetation health. The improved productivity on the floodplain appears to have resulted in the spawning of golden perch (*Macquaria ambigua*) in the Goulburn River for the first time in eight years.

There have also been some negative impacts including a blackwater event resulting in fish kills; continuous inundation on the lower parts of the river bank has killed many saplings and prevented germination of herbs and forbs. Germination may also have been inhibited due to deposition of sediment on the river banks (approximately 5cm) (Water Technology, 2011) inhibiting germination in the lower river banks; and some areas significant bank erosion.

The Sustainable River Audit Condition and Ecosystem Health assessments for valleys in the Murray-Darling Basin (2004–07) ranked the lower Goulburn River overall ecosystem health as very poor. The hydrology component was rated poor, whilst the fish and macroinvertebrates were rated as very poor and poor respectively. The Victorian Index of Stream Condition (2004) classified the overall condition of the lower Goulburn River as moderate to poor.

<u>Objectives</u>

The specific watering objectives are:

- Provide suitable in-channel habitat for all life stage of native fish including: deep water habitat for native fish and slow shallow habitat required for larvae/juvenile recruitment and adult habitat for small bodied fish.
- Submersion of snag habitat within the euphotic zone to provide habitat and food source for macro-invertebrates;
- Entrainment of litter packs available as food/habitat source for macroinvertebrates; and
- Maintenance of water quality suitable for macroinvertebrates.

Expected improvements / outcomes

The proposed priority flow components; increased minimum flows and freshes, are a significant improvement to the flow regimes that would otherwise occur. Hence they should significantly improve most elements of the in channel river environment, particularly fish and macroinvertebrates, and continue the ecological recovery started in 2010-11 after the prolonged drought years.[3]

Secondary environmental effects

Water from the Goulburn River discharges to the Murray River upstream of Gunbower Forest and contributes to the watering of this important Ramsar-listed site.

Consistency with CEWH ecological objectives

For a median to wet water availability scenario, the *Framework for determining Commonwealth environmental watering actions* identifies watering objectives of maintaining or improving ecological health and resilience. The associated management objectives and actions include enabling the growth, reproduction and small-scale recruitment of flora and fauna. These objectives are compatible with the specific objectives of this watering action.

3. Potential risks of the proposed watering action at the site and at connected locations

The key identified risks are summarized below:

- Water quality (low risk): as the proposed flows will be wholly within channel, and as such will not mobilise new sources of carbon, there is minimal risks of negative water quality outcomes, with improvements the most likely option.
- Water loss (low risk): G-M Water undertakes compliance activity to identify any unauthorised diversions .
- Flooding of private land/personal injury (low risk): These risks are viewed as low due to the size of the water share delivered relative to the flows within the system and the capacity of the river channels, as well as specific requirement to cease the release of Commonwealth environmental water if unregulated flows are meeting the environmental objectives

4. Long-term sustainability of the asset(s) including appropriate management arrangements

Long-term management and delivery arrangements

The Goulburn River is covered by the *Goulburn Broken Regional River Health Strategy* 2005, a long term plan to improve the health of the waterway. The objectives of the strategy are based on managing and improving flow regimes; water quality; riparian lands; in-stream biota; threatened species and communities; floodplain, wetlands and groundwater; adaptive management, monitoring and education; and strategic planning. The *Northern Regional Sustainable Water Strategy* also provides a framework for long-term water resource planning, aiming to protect and where possible, improve the health of rivers, wetlands and aquifers from the impacts of drought, climate change and variability and other risks. Flow requirements in the Goulburn River are well documented through a range of studies and plans including an annual watering plan prepared by the GBCMA.

[3] GBCMA. May 2011. Goulburn River seasonal watering proposal for 2011-12.

The newly established Victorian environmental water planning framework, including the appointment of the Victorian Environmental Water Holder (VEWH) on 1 July 2011, will include an environmental water management plan for the use of Victorian held water in the catchment. This will form the basis of future seasonal watering proposals, describing priority water use in the coming year under a range of climatic scenarios and a multi-year rolling outlook.

Complementary NRM activities

The Lower Goulburn River is covered by the Goulburn-Broken River Health Strategy, a long term plan to improve the health of the waterway. This includes the management of riparian zones, floodplain management, as well as in-stream issues.

Flows requirements in the Lower Goulburn are well documented through a range of studies (including Cottingham *et al.* 2007). The Goulburn River also has significant water recovery targets identified through both the Northern Victorian Sustainable Water Strategy and the Guide to the Basin Plan. Whilst neither target is assured of being met, it does indicate the ongoing priority of the Goulburn River for water recovery.

The GBCMA has developed a seasonal watering proposal for 2011-12.

Operational monitoring: Victoria (VEWH and the GBCMA) will provide an operational report following completion of this watering event. Victoria will also report weekly to the Commonwealth on the use of environmental water and water quality. Victoria would consult with the Commonwealth on any changes to an agreed watering action. These activities meet the Commonwealth's requirement for operational monitoring.

River Health Monitoring: The Goulburn River is part of the integrated Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP). VEFMAP is a long term monitoring program designed to detail the benefits of environmental flows and includes water quality, fish, vegetation and geomorphic monitoring.
Water Quality: Water quality monitoring is undertaken regularly at various locations by the GBCMA.
Observational Monitoring: As part of weekly reports, observations and photographs of the response to the flow will be provided. A more detailed report will be provided once a fortnight (based on reporting requirements to the Victorian minister).

5. Cost effectiveness and operational feasibility of undertaking the watering

The focus of the 2011/12 option for environmental watering is therefore to continue the ecological recovery, particularly focussed on the winter/spring flows which were so absent during the drought years. This involves providing increase minimum flows up to 830 ML per dayay at Murchison and a good spring fresh between 5,600 and 9,000 ML per dayay at Murchison (and desirably another winter/spring fresh)[4].

Cost effectiveness

The delivery of the water to the Lower Goulburn is both cost effective (minimal to no costs) and feasible (no delivery constraints, including impacts from unregulated flows).

Delivery arrangements

Delivery would be managed by the VEWH, GBCMA and G-MW.

[4] GBCMA 2011

Operational feasibility

The option is operationally feasible.

1. Ecological significance of the asset(s)

The Campaspe River is considered a high priority under the *North Central River Health Strategy* (RHS) (NCCMA 2005). A major objective of the RHS is to focus on the high values within reaches considered to be at high risk and implement mitigation actions. Reach 4 downstream of Campaspe Siphon is a priority under the RHS in order to:

- Minimise the risks to connected high value assets (Murray River). The lower Campaspe River can significantly influence the health of the Murray River. It has a direct influence on the health of the Murray River, including salinity, flows and exchange of aquatic species, such as native migratory fish; and
- Protect and enhance reaches at high risk from human impacts – this reach is ranked in the top 20 high risk reaches in the RHS.

The Campaspe River supports flora and fauna of national, regional and local conservation significance[5 6 7]. For example, 11 fish species, including five of significant conservation status, have been recorded in the Campaspe River below Lake Eppalock over the past 30 years[8]. Two threatened plant species have been recorded among the 11 significant Ecological Vegetation Classes (EVCs) along Reach 4[9] (NC CMA 2009). Features such as pools (including weir pools such as Campaspe Weir and The Siphon) serve as important refugia for the survival of organisms that can recolonise reaches following periods of drought. Protecting and then connecting in-channel habitat is important for the recovery of the river following periods of cease to flow.

<u>Threatened species and ecological communities, and listed migratory species</u>

Significant species identified at the site are the golden perch (*Macquaria ambigua*: Victoria vulnerable), Murray cod (*Maccullochella peellii peelii*: Commonwealth vulnerable, Victoria endangered), silver perch (*Bidyanus bidyanus*: Victoria critically endangered) and the trout cod (*Maccullochella macquariensis* Commonwealth endangered; Victoria critically endangered), and the brown treecreeper (*Climacteris picumnus:* Victoria near threatened). Flora at the site includes the Pale Flax-lily (*Dianella sp. aff. longifolia* (Riverina): Victoria vulnerable).

In summary, Commonwealth threatened and migratory species and communities associated with the Campaspe River include:

- 14 fauna species;
- 5 flora species;
- 12 migratory species; and
- 4 communities.

<u>Listings / reserves</u>

There are no internationally or nationally important wetlands or reserves along this river reach.

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[5] SKM (2006b). Campaspe River environmental flows assessment: Issues paper. Sinclair Knight Merz, Melbourne.
[6] NCCMA (2005). North Central river health strategy. North Central Catchment Management Authority, Huntly
[7] NCCMA (2010). 2010-2011 Annual Watering Plan Campaspe River System. North Central Catchment Management Authority.
[8] SKM (2006b). Campaspe River environmental flows assessment: Issues paper. Sinclair Knight Merz, Melbourne.
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2. Expected ecological outcomes from the proposed watering action

Current health of asset

The Campaspe River lowland zone (downstream of Lake Eppalock) ecosystem was in very poor health when rated by the Sustainable Rivers Audit 2008. In this zone the river was rated as extremely poor for fish health, poor for macroinvertebrate health and poor to moderate for hydrological condition. The Victorian Index of Stream Condition (2004) ranked the overall condition of the Campaspe River from Lake Eppalock to the Murray River as poor to moderate.

Prior to September 2010, years of drought have put the Campaspe under ecological stress. Reach 3 (Campaspe Weir to the Campaspe Siphon) experienced extended periods of no flow. Reach 4 (downstream of Campaspe Siphon)[10] received summer flows via the Inter Valley Transfer, however it also experienced periods of cease to flow in winter. The Campaspe catchment has received significant rainfall since September 2010 which has resulted in significant natural flows. Anecdotal observations (personal communication with Darren White, NCCMA) of benefits from these flows include a reduction in extensive reed beds within the channel, scouring of pools to re-create deep-water habitat, elimination of woody vegetation from within the river channel and high rates of germination of river red gum on the floodplain.

Expected improvements / outcomes

Provision of winter and spring base flows is expected to build on the benefits from earlier flows such as facilitating the recruitment of native riparian species, reducing encroachment of terrestrial vegetation, improving water quality, especially reduce salinity and increase dissolved oxygen by maintaining permanent connecting flow. The provision of spring high flows/freshes are expected to inundate additional snag habitats, and will facilitate wetting and drying of biofilms; flush sediment from biofilms and therefore increase food availability for macroinvertebrates which are a food source for fish, and play a key primary role in the food chain feeding on and breaking down organic matter; provide cues for fish movement and recruitment; and flush organic material into the river to reduce the organic load from the riparian zone, and recharge carbon and other nutrient levels in the river to support the food chain in-stream.

A significant secondary environmental effect is that outflows from the Campaspe River will contribute to stream flows in the Murray River downstream of Echuca and thus may contribute to flow events at downstream sites.

Watering objectives

Winter and spring flows have already been approved. If additional water becomes available after spring, it will be used to:

Top up summer base flows to 20 ML per day to maintain aquatic vegetation, habitat for fish, constant flow to reduce salinity and preserve oxygen levels and macroinvertebrate habitat.

Provide summer freshes after 1 February to maintain riparian and in-channel vegetation and support recruitment; provide longitudinal connectivity and cue fish movement from the Murray River, flush and mix river pools to reduce salinity and improve oxygenation levels; and inundate additional snags and wash sediments off biofilms for macroinvertebrates.

[10] NCCMA (2009). The Campaspe River Interim Environmental Watering Plan. Report prepared for NVIRP. North Central Catchment Management Authority, Huntly.

These objectives and actions are compatible with objectives of the *Framework for determining Commonwealth environmental watering actions*.

3. Potential risks of the proposed watering action at the site and at connected locations

The key identified risks are summarized below:

- Water quality (low risk): as the proposed flows will be wholly within channel, and as such will not mobilise new sources of organic carbon, there is minimal risks of negative water quality outcomes, with improvements the most likely outcome.
- Water loss (low risk): there are minimal diverters in the lower Campaspe River and Goulburn-Murray Water has committed to accounting for the water to ensure any diversions are not from environmental releases.
- Flooding of private land/personal injury (low risk): these risks are considered as low due to the size of the water share delivered relative to the flows within the system and the capacity of the river channels, as well as specific requirement to cease the release of Commonwealth environmental water if unregulated flows are meeting the environmental objectives.

4. Long-term sustainability of the asset(s) including appropriate management arrangements

<u>Complementary NRM activities</u>

The Campaspe River is covered by the *North Central River Health Strategy* 2005, a long term plan to improve the health of the waterway. The objectives of the strategy are based on flow regimes; water quality; riparian lands; in-stream biota; threatened species and communities; floodplain, wetlands and groundwater; adaptive management, monitoring and education; and strategic planning.

<u>Long-term management and delivery arrangements</u>

The newly established Victorian environmental water planning framework, including the appointment of the Victorian Environmental Water Holder on 1 July 2011, will include an environmental water management plan for the use of Victorian held water in the catchment. This will form the basis of future seasonal watering proposals, describing priority water use in the coming year under a range of climatic scenarios and a multi-year rolling outlook.

The Campaspe Irrigation District is due to be decommissioned as part of the Northern Victorian Irrigation Renewal Project (NVIRP), which could change river operation in the Campaspe River. As a result, up to 12,000 ML may be returned to the river as environmental flows.

<u>Effectiveness of monitoring, evaluation and reporting arrangements</u>

The Victorian Environment Water Holder (VEWH) and the NCCMA will provide an operational report following completion of this watering event. The DSE and NCCMA will report weekly to the Commonwealth on the use of environmental water and water quality, and fortnightly on any incidental observations of ecological responses (including photographs). DSE and NCCMA would consult with the Commonwealth on any changes to the watering action. These activities meet the Commonwealth's requirement for operational monitoring.

There will be no targeted intervention monitoring for the proposed action. However, the Commonwealth's monitoring and evaluation framework acknowledges that intervention monitoring will not be undertaken for all watering actions. While there are no direct surveys of the ecological responses from the watering action, DSE will report on longer-term ecological outcomes through the Victorian Environmental Flows Monitoring and Assessment Program. These reports will be provided to the Commonwealth when available, expected to be in three years' time. Results from these studies may inform future environmental watering activities.

5. Cost effectiveness and operational feasibility of undertaking the watering

Cost effectiveness

There are no delivery charges associated with the watering action. The environmental water flows will also capitalise on the natural flows to the system and higher rainfall during the 2010-11 season. The Commonwealth environmental water will supplement "passing flows" and may also be supplemented by the release of TLM water.

Monitoring activities are also included as part of pre-existing programs, and would constitute a contribution to the watering option by Victoria.

Any water delivered via the Waranga Western Channel from the Goulburn system would attract fees.

Operational feasibility and potential constraints

The option is operationally feasible and would be managed by the NCCMA and Goulburn Murray Water.

1. Ecological significance of the asset(s)

Ecological significance

The Loddon River is considered a high priority under the *North Central River Health Strategy* (RHS 2005).

The Loddon River and Twelve Mile Creek have been identified as Key Environmental Assets in the Murray-Darling Basin Authority's Guide to the Basin Plan. Both are recognised as capable of supporting species listed in relevant international agreements, provide vital habitats, support Commonwealth and state listed threatened species and endangered ecological communities and support or are capable of supporting significant biodiversity. There are no internationally or nationally listed areas situated directly along the Loddon River. However, the Kerang Wetlands Ramsar site is located at the junction of three major floodplains, associated with the Avoca, Loddon and Murray Rivers, and is hydrologically linked to the Loddon River.

Presence of threatened species and ecological communities, and listed migratory species

The Loddon River downstream of Laanecoorie Reservoir potentially provides habitat for several Commonwealth threatened and migratory species (*EPBC Act 1999*), including:

- 22 threatened species;
- 12 migratory species; and
- three ecological communities including the critically endangered White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland.

Listings and Reserves

There are no internationally or nationally important wetlands or reserves along this river reach.

2. Expected ecological outcomes from the proposed watering action

Current health of the asset

In-stream and overbank flows which occurred during spring and summer 2010-11 have met key ecological objectives as specified the *Loddon Environmental Flow Study* (SKM 2010). The reach of river downstream of Loddon Weir had been completely dry since 2007; however, recent observations (pers. comm. Phil Slessar, NCCMA) indicate that fish have returned to this part of the river. Other positive impacts of the recent flows including the scouring of pools, entrainment of organic material from the channel, benches and floodplain, and removal of terrestrial plants from within the river channel.

The Loddon River ecosystem was in very poor health when rated by the Sustainable Rivers Audit 2008. The river in the lowland zone (reach below Laanecoorie Reservoir) was rated as extremely poor for fish health, poor for macroinvertebrate health and moderate for hydrological condition. The Victorian Index of Stream Condition (2004) ranked the overall condition of the Loddon River from Laanecoorie Reservoir to the Murray River as very poor to moderate.

Watering objectives

Winter and spring flows have already been approved. If additional water becomes available after spring, it will be used to:

1. Top up summer base flows maintain in-stream vegetation and maintain water quality.
2. Provide summer freshes to maintain riparian and in-channel vegetation recruits; provide longitudinal connectivity and cue fish movement from the river Murray, flush and mix river pools to reduce salinity and improve oxygenation levels; and inundate additional snags and wash sediments off biofilms for macroinvertebrates.

Consistency with current CEWH objectives

The objectives of the environmental watering action are to support maintenance of the extent, diversity, and continuity of aquatic and river bank vegetation; maintenance of dynamic, diverse food webs that support higher organisms and contribute to river health; and maintenance of suitable in-channel habitat and flow continuity for all life stages of native fish. These objectives and actions are compatible with objectives of the *Framework for determining Commonwealth environmental watering actions*.

Expected improvement

- The Loddon River is connected to the Murray River and maintaining baseflows and introducing freshes may promote and facilitate fish migration, and so increase abundance and diversity of the fish population in the lower reaches of the Loddon River.
- Periodic freshes will provide benefits by flushing organic material from low lying benches, recharging carbon and other nutrient levels in the river channel, supporting the food chain in-stream, inundate additional snag habitats that may be temporarily used by some species and will facilitate wetting and drying of biofilms, and will flush sediment from biofilms and therefore increase food availability for macroinvertebrates.
- Permanent connecting flow is expected to improve water quality, especially reduce salinity and increase dissolved oxygen, and reduce the negative impacts associated with acid sulphate soils.
- Base flows will prevent expansion and future colonisation by semi-terrestrial plants within the channel, and promote regeneration of existing riparian vegetation, including key species, river red gum, which provide structural habitat for many other species.

Secondary environmental and connected system benefits

Outflows from the Loddon River will contribute to stream flows in the Murray River. The Loddon River directly influences the health of the Murray River including salinity, flows, and the exchange of aquatic species. The Loddon River system is also hydraulically connected to the Boort wetlands, and Kerang Lakes system, thus influencing the ecological health of these environments.

Whilst the majority of the flows will travel along the Loddon River, a small proportion of the water may go into the Twelve Mile Creek distributary because the regulator at this junction is in partial disrepair. Twelve Mile Creek is hydraulically more efficient than the parallel section of the Loddon River, and has an important anastomosing section that flows through an area of protected riparian vegetation[11].

[11] SKM (2010). Review of environmental flow requirements for the Lower Loddon River System. Flow recommendations. Sinclair Knight Merz, Melbourne.

3. Potential risks of the proposed watering action at the site and at connected locations

The key identified risks are summarized below:

- Water quality (low risk): As the proposed flows will be wholly within channel, and as such will not mobilise new sources of carbon, there is minimal risks of negative water quality outcomes, with improvements the most likely outcome.
- Water loss (low risk): G-M Water undertakes compliance activities to identify unauthorised diversions.
- Flooding of private land/personal injury (low risk): These risks are viewed as low due to the size of the water share delivered relative to the flows within the system and the capacity of the river channels, as well as specific requirement to cease the release of Commonwealth environmental water if unregulated flows are meeting the environmental objectives

4. Long-term sustainability of the asset(s) including appropriate management arrangements

Long-term management and delivery arrangements

The Loddon River is covered by the *North Central River Health Strategy* 2005, a long term plan to improve the health of the waterway. The objectives of the strategy are based on managing and improving flow regimes; water quality; riparian lands; in-stream biota; threatened species and communities; floodplain, wetlands and groundwater; adaptive management, monitoring and education; and strategic planning. The *Northern Regional Sustainable Water Strategy* also provides a framework for long-term water resource planning, aiming to protect and where possible, improve the health of rivers, wetlands and aquifers from the impacts of drought, climate change and variability and other risks. Flow requirements in the Loddon River are well documented through a range of studies and plans including an annual watering plan prepared by the NCCMA.

The newly established Victorian environmental water planning framework, including the appointment of the Victorian Environmental Water Holder on 1 July 2011, will include an environmental water management plan for the use of Victorian held water in the catchment. This will form the basis of future seasonal watering proposals, describing priority water use in the coming year under a range of climatic scenarios and a multi-year rolling outlook.

Complementary natural resource management activities

The Loddon Stressed River project is a large scale project designed to complement the delivery of environmental flows for the Loddon River downstream of Cairn Curran and Tullaroop reservoirs. The project has a focus on protection and rehabilitation of riverside (or riparian) areas, community involvement and improving conditions and migration paths for native fish. The NCCMA is the lead agency in north central Victoria coordinating and monitoring natural resource management programs for the region.

Effectiveness of monitoring, evaluation and reporting arrangements

The Victorian Department of Sustainability and Environment (DSE) and the NCCMA will provide an operational report following completion of this watering event. In addition, DSE will report weekly to the Commonwealth on the use of that water and on water quality (operational monitoring) and fortnightly on any observations of ecological responses, such as presence of native fish, (including photographs). These activities meet the Commonwealth's requirement for operational monitoring.

There will be no targeted intervention monitoring for the proposed action. However, the Commonwealth's monitoring and evaluation framework acknowledges that intervention monitoring will not be undertaken for all watering actions. Other monitoring programs are being undertaken in the Loddon River, including the Victorian Environmental Flow Monitoring Assessment Program and the Sustainable River Audit which draws on data from the Victorian Index of Stream condition (ISC). Results from these studies may inform future environmental watering activities.

5. Cost effectiveness and operational feasibility of undertaking the watering

Allocations for winter/spring 2011 have already been committed and approved for use. Additional water may be available via trade, transfer or late-season allocations.

The volumes required in an "average" or "median" scenario would be 8,666 ML for a spring fresh and 3,088 ML for a summer fresh.

The delivery of the water from headworks is cost-effective. There is no charge for delivery of environmental water in natural waterways in Victoria's Northern Regional Sustainable Water Strategy.

Monitoring activities and associated costs are also included as part of pre-existing programs, and therefore constitute a contribution to the watering options by Victoria. Any water delivered via the Waranga Western Channel from the Goulburn system would attract fees.

Releases would be managed by the VEWH, NCCMA and G-MW.

The option is operationally feasible. Releases would be managed by the NCCMA and G-MW.

1. Ecological significance of the asset(s)

The Boort Wetlands are regionally-important wetlands with high environmental values (Hydro Environmental 2009).

The Boort Wetlands are a series of wetlands located to the west of the Loddon River and north of Loddon Weir and include Lake Boort, Lake Meran, Little Lake Meran, Lake Yando, and Lake Leagher. They are considered to be bioregionally important. Shallow freshwater marshes, such as Lake Yando, Lake Leaghur and Lake Boort support diverse vegetation such as reeds, river red gum, water couch, water milfoils and water ribbons (*Triglochin spp.)*. These provide habitat for a variety of biota such as waterbirds, waterfowl and frogs.

Collectively, the Boort Wetlands provide important breeding, feeding and refuge habitat for waterbirds (Parks Victoria 2003, NCCMA 2010a, b, c, d). At the landscape scale, the wetlands provide a great diversity of habitat types and drought refuges in a heavily modified landscape. The wetlands are visited by waterbird species (including those listed under JAMBA, CAMBA, ROKAMBA) such as Caspian tern, whiskered tern, great egret, Australasian shoveller, freckled duck, hardhead and blue-billed duck. The wetlands also support a variety of vegetation assemblages, including ecological vegetation classes such as River red gum swamp, Black box woodland, Tall marsh and Lignum swamp

Lake Boort - Waterbirds including the following: whiskered tern (*Chlidonias hybridus)*; great egret (*Ardea alba*; EPBC migratory); Australasian shoveler (*Anas rhynchotis*; SA rare); freckled duck (*Stictonetta naevosa:*Vic endangered); hardhead (*Aythya australis)* and blue-billed duck (*Oxyura australis:* Vic endangered).

Other species listed on the site asset register are the southern bell frog (*Litoria raniformis*, vulnerable) and the Murray cod (*Maccullochella peelii peelii*, vunerable).

2. Expected ecological outcomes from the proposed watering action

Water delivery may be considered to Lake Boort in order to ensure it remains inundated and thus assist in the control of annual weed species which have previously dominated the lakebed.

Watering any of these wetlands would increase the habitat available for water bird species (drought refuge) and improve the condition of the vegetation of the wetland ensuring further decline does not occur. Similar response to water events during 2009-10 can be found in the draft Loddon 2010-11 annual watering plan (NCCMA 2010). The final plan is expected to be completed soon, following statutory approvals by the Victorian Minister for the Environment.

Consistency with current CEWH objectives

The objectives under a median to wet water availability scenario are to maintain or improve ecological health and resilience. The management objectives and actions under these scenarios include enabling the growth, reproduction and small-scale recruitment of flora and fauna, as per the *Framework for determining Commonwealth environmental watering actions*. These objectives are compatible with the specific objectives of this watering action.

3. Potential risks of the proposed watering action at the site and at connected locations

The key identified risks are summarised below:

Diverters exist on some wetlands, which may use water for stock and domestic purposes. Further investigation to minimise this risk would need to be undertaken in association with the water corporation. Delivery may be constrained by the capacity and availability of irrigation channels, however delivery during spring or late autumn should be feasible. Potential impacts may result from the potential for overflow into private land and damage to infrastructure should high unregulated flows occur during 2011-12.

4. Long-term sustainability of the asset(s) including appropriate management arrangements

The Boort Wetlands have access to water from a range of sources, including a dedicated environmental entitlement and access to unregulated flows from the Loddon River during times of flood. There are a range of existing plans and strategies that provide for the protection and enhancement of the natural values of the Boort Wetlands, including environmental watering plans prepared for the northern Victoria irrigation renewal project for Lakes Leaghur, Yando, Little Lake Boort and Meran; and the Loddon River Watering Options Plan (Cottingham *et al.* 2011c). The NCCMA has prepared a Loddon River seasonal watering proposal for 2011-12, which also addresses the Boort wetlands.

The newly established Victorian environmental water planning framework, including the appointment of the Victorian Environmental Water Holder on 1 July 2011, will include an environmental water management plan for the use of Victorian held water in the catchment. This will form the basis of future seasonal watering proposals, describing priority water use in the coming year under a range of climatic scenarios and a multi-year rolling outlook.

The NCCMA are prepared to monitor water levels and delivery. Additional monitoring such as waterbird monitoring will be considered on a case-by-case basis.

5. Cost effectiveness and operational feasibility of undertaking the watering

The watering actions are cost-effective and operationally feasible.

The water would be delivered through existing irrigation channels managed by Goulburn-Murray Water. The charge per megalitre may be at a reduced rate as it is deemed an interruptible supply, however given deliveries would occur outside peak irrigation times this should not be an issue. Future policies on pricing the delivery of environmental water in Victoria could become more affordable (proposed future charges would only be out of pocket expenses).

Any water delivered via the Waranga Western Channel from the Goulburn or Campaspe systems would attract additional fees.

1. Ecological significance of the asset(s)

The Broken Creek system is recognised for locally and regionally significant environmental values including:

- The presence of Victorian and nationally threatened flora and fauna species dependent on the aquatic ecosystem including the nationally Vulnerable Murray cod (*Maccullochella peelii peelii)*and the State Vulnerable golden perch *(Maquaria ambigu);*
- The presence of significant wetlands, with Broken Creek listed in the Directory of Important Wetlands in Australia and the Ramsar listed Barmah Forest on the Murray River at the downstream end of Broken Creek;
- The Broken-Boosey State Park system covering approximately 60% of the stream frontage downstream of Katamatite. The park system provides habitat for a range of threatened flora and fauna, contains stands of threatened Ecological Vegetation Classes and provides an important vegetated linear corridor across a generally cleared agricultural landscape.

Several Commonwealth (EPBC Act) and state (Fauna and Flora Guarantee Act) threatened species, migratory species and communities are associated with the lower Broken Creek including:

- 10 vulnerable, endangered or critically endangered Commonwealth fauna species;
- 9 migratory species;
- 16 state listed fauna species;
- 5 vulnerable Commonwealth flora species;
- 1 state flora species; and

4 Commonwealth communities including the critically endangered White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland. Fishways have been established at all weirs along Lower Broken Creek between Nathalia and the Murray River and at the 2 weirs at Katandra. Fish populations along the creek have been monitored for a number of years to assess the effectiveness of the fishways in allowing movement, as well as the changes to the distribution of fish as a result (O'Connor and Amtstaetter 2008).

2. Expected ecological outcomes from the proposed watering action

The Broken Creek ecosystem was in very poor health when rated by the *Sustainable Rivers Audit 2008.* The Victorian Index of Stream Condition (2004) classified the overall condition of the lower Broken Creek as moderate.

<u>Objective</u>

The objectives for environmental watering of the lower Broken Creek system focus on native fish:

- Improving native fish habitat and passage;
- ensuring persistence of aquatic habitats during migration and breeding seasons, particularly for Murray Cod;
- supplying sufficient flow to operate the fishways and providing fish access to appropriate habitat all year (Water Technology 2010);

These objectives and actions are compatible with objectives of the *Framework for determining Commonwealth environmental watering actions*.

3. Potential risks of the proposed watering action at the site and at connected locations

Key identified risks are summarised below:

- Water Quality (low risk): as the proposed flows will be wholly within channel, and as such will not mobilise new sources of carbon, there is minimal risks of negative water quality outcomes, with improvements the most likely outcome;
- Water Loss (low risk): G-M Water undertakes compliance activities to identify unauthorised diversions; and
- Flooding of private land/personal injury (low risk): these risks are viewed as low due to the size of the water share delivered relative to the flows within the system and the capacity of the river channels, as well as specific requirement to cease the release of Commonwealth environmental water if unregulated flows are meeting the environmental objectives.

4. Long-term sustainability of the asset(s) including appropriate management arrangements

There are a range of existing plans and strategies that provide for the protection and enhancement of the natural values of Broken Creek, including Goulburn Broken Regional River Health Strategy (2005-2015); Biodiversity Action Plan – Dookie Landscape zone; and Broken-Boosey State Park and Nathalia, Numurkah, Tungamah and Youarang Natural Features Reserves Management Plan.

The Lower Broken Creek is covered by the *Goulburn Broken Regional River Health Strategy 2005*, a long term plan to improve the health of the waterway. The objectives of the strategy are based on managing and improving flow regimes; water quality; riparian lands; in-stream biota; threatened species and communities; floodplain, wetlands and groundwater; adaptive management, monitoring and education; and strategic planning. The *Northern Regional Sustainable Water Strategy* also provides a framework for long-term water resource planning, aiming to protect and where possible, improve the health of rivers, wetlands and aquifers from the impacts of drought, climate change and variability and other risks. Flow requirements in the Goulburn River are well documented through a range of studies and plans including an annual watering plan prepared by the GBCMA.

The newly established Victorian environmental water planning framework, including the appointment of the Victorian Environmental Water Holder (VEWH) on 1 July 2011, will include an environmental water management plan for the use of Victorian held water in the catchment. This will form the basis of future seasonal watering proposals, describing priority water use in the coming year under a range of climatic scenarios and a multi-year rolling outlook

The long term sustainability of Lower Broken Creek is supported by water management activities of GBCMA and GM-W. The GBCMA and G-MW monitor DO conditions and respond to low DO by increasing flows from the Murray River via the Murray Valley irrigation area, or from the Goulburn River via the East Goulburn Main Channel, use of the water quality reserve.

The impact of Northern Victoria Irrigation Renewal Program (NVIRP)[12] on Broken Creek has been assessed and an environmental watering plan developed (Water Technology, 2010). While the plan found that the changes under NVIRP are not expected to impact on the high value environmental assets of the Lower Broken Creek, it recommended that the effect of NVIRP on environmental water demands and deliveries to the Lower Broken Creek be investigated further if the Commonwealth wants to pursue this Lower Broken Creek as a watering option.

5. Cost effectiveness and operational feasibility of undertaking the watering

[12] GBCMA. 2010. Lower Broken Creek and Nine Mile Creek Environmental Watering Plan

Watering actions are operationally feasible, as water can be directed into the creek via the Murray and the Goulburn via irrigation channels. However, the delivery water through the channels will cost between $5 and $10 per ML, which is below the cost of pumping water to wetlands.

Water delivery, monitoring and reporting would be undertaken by the Goulburn Broken CMA. Water quality and quantity is monitored as part of the Victorian Water Quality Monitoring Network.

1. Ecological significance of the asset(s)

Listings and reserves

The lower Broken River downstream of Casey's Weir has DIWA listed wetlands (1268 ha, between 8 km NNW of Benalla & Shepparton), and meanders for over 63 km through plains country before reaching the Goulburn River at Shepparton. The two DIWA criteria for inclusion are (1) 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; and (2) the wetlands are of outstanding historical or cultural significance.

Habitat values

The river and its associated riparian and wetland habitats are a stronghold for native flora and fauna in the region including the *Flora and Fauna Guarantee Act (Vic)* listed Brolga, bush stone-curlew, regent honeyeater, squirrel glider, and eastern great egret. In addition, they support an array of native flora species including river swamp wallaby-grass (*Amphibromus fluitans*), which is listed as vulnerable under the *EPBC Act 1999*.

Although the Broken River system, which includes both the Broken Creek and Broken River, is a highly modified system, it supports a diverse native fish community. Some of the native fish species present in this system include the nationally threatened Murray cod (*Maccullochella peelii peelii*) and Macquarie perch (*Macquaria australasica*) while golden perch (*Macquaria ambigua*), silver perch (*Bidyanus bidyanus*) and Murray Darling rainbowfish (*Melanotaenia fluviatilis*) are listed as threatened in Victoria (O'Connor Frank Amtstaetter 2008).

Presence of threatened species and ecological communities, and listed migratory species

Several Commonwealth (EPBC Act) and state (Fauna and Flora Guarantee Act) threatened species, migratory species and communities are associated with the lower Broken River including:

- 14 vulnerable, endangered or critically endangered Commonwealth fauna species;
- 11 migratory species;
- 25 state listed fauna species;
- five Commonwealth flora species including the critically endangered, Plains Riceflower (*Pimelea spinescens subsp. Spinescens);*
- seven state flora species; and
- three Commonwealth communities including the critically endangered White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland.

2. Expected ecological outcomes from the proposed watering action

The Broken River has a largely natural flow pattern characterised by winter flooding and low summer flows. Regulation of the Broken River has reduced the variability of flows, decreased median flows in winter and increased median flows in summer, particularly in its upper reaches (Cottingham et. al. 2001). However the decommissioning of Lake Mokoan in 2009 has resulted in a reduction of the volume of water harvested in the catchment from approximately 30 per cent to 13 per cent and this has enhanced the natural flow patterns of the lower reaches of the river by increasing winter median flows and reducing summer median flows.

The Broken River catchment has received significant rainfalls since September 2010. Lake Nillahcootie has been at around 100 per cent capacity since that time which has led to extensive unregulated flows over the last six months, and in turn likely to have contributed to an improvement in the condition of the riparian environment.

The Broken River ecosystem was in very poor health when rated by the *Sustainable Rivers Audit 2008*. The river in the lowland zone (reach below Lake Nillahcootie) was rated as very poor condition for fish health, poor condition for macroinvertebrate health and moderate to good for hydrological condition.

The Victorian Index of Stream Condition (2004) classified the overall condition of the lower Broken River as moderate.

Turbidity, total nitrogen and total phosphorous were all significantly higher within the Broken River downstream of Lake Mokoan, prior to decommissioning. Since the decommissioning during the 2008-09 summer, turbidity has significantly declined within the downstream reach, such that turbidity levels within the reaches upstream and downstream of Casey’s Weir are indistinguishable.

Objective

The objectives of the environmental watering action are to support maintenance of the extent, diversity, and continuity of aquatic and river bank vegetation; maintenance of dynamic, diverse food webs that support higher organisms and contribute to river health; and maintenance of suitable in-channel habitat and flow continuity for all life stages of native fish. These objectives and actions are compatible with objectives of the *Framework for determining Commonwealth environmental watering actions*.

3. Potential risks of the proposed watering action at the site and at connected locations

Key identified risks are summarised below:

- Water Quality (low risk): as the proposed flows will be wholly within channel, and as such will not mobilise new sources of carbon, there is minimal risks of negative water quality outcomes, with improvements the most likely outcome;
- Water Loss (low risk): G-M Water undertakes compliance activities to identify any unauthorised diversions; and
- Flooding of private land/personal injury (low risk): these risks are viewed as low due to the size of the water share delivered relative to the flows within the system and the capacity of the river channels, as well as specific requirement to cease the release of Commonwealth environmental water if unregulated flows are meeting the environmental objectives.

4. Long-term sustainability of the asset(s) including appropriate management arrangements

There are a range of existing plans and strategies that provide for the protection and enhancement of the natural values of Broken River, including Goulburn Broken Regional River Health Strategy (2005-2015); Biodiversity Action Plan – Dookie Landscape zone; and Biodiversity Action Plan - Violet Town.

Complementary NRM activities

The decommissioning of Lake Mokoan in 2009 has led to an improvement of the Broken River water quality below Casey’s Weir. This, combined with a re-adjustment to the flow regime towards natural conditions will generate waterway health benefits.

For more than 15 years, the Murray–Darling Freshwater Research Centre (MDFRC) has been conducting research on the Broken River and substantial increases in turbidity below Casey’s Weir (from Lake Mokoan outflows) have been noted throughout this period. The decommissioning of Lake Mokoan has created a unique opportunity to determine how decreasing the turbidity of the Broken River may affect freshwater fishes.

5. Cost effectiveness and operational feasibility of undertaking the watering

The watering option proposes to use the entire allocation (up to 51.2 ML) of Commonwealth environmental water to contribute to base flows or a fresh during summer.

Cost effectiveness and operational feasibility

No delivery costs are associated with this action. The option is operationally feasible and would be managed by the NECMA and Goulburn Murray Water.

The water cannot be transferred downstream for use in the southern connected part of the Murray Darling Basin, nor can water be transferred in from other trading zones.

1. Ecological significance of the asset(s)

The Ovens catchment represents 0.7 per cent of the total area of the Murray-Darling Basin and generates approximately 6 per cent of the runoff within the Murray Darling Basin. The Ovens River system has several significant environmental attributes which include:

- high level of naturalness of flows;
- relative intactness of the vegetation of the entire river system; and
- significance for larger connected systems.

Listings and reserves

- Commonwealth: Directory of Important Wetlands Australia (Ovens River from Killawarra to Lake Mulwala); and
- State: Representative Lowland River, Victoria and Heritage River (Ovens River from Killawarra to Lake Mulwala *Heritage Rivers Act 1992 (Vic)).*

Major reserves

- Warby-Ovens National Park - *Ovens River Section* (1,098 ha) - located downstream of Wangaratta. Warby-Ovens National Park links the lower Ovens to the mountains and the Ovens River section is one of the four new river red gum forests recently established in Victoria.
- Lower Ovens Wildlife Reserve (1,305 ha) is located at the confluence with the Murray River.

Habitat values

The Ovens River (downstream of Wangaratta Weir to the high water mark of Lake Mulwala) environmental values include:

- areas with river red gum open forests, woodlands with an intact understorey, occurrences of river red gum with a shrub understorey of river bottlebrush, silver wattle and rough barked honey myrtle (*Melaleuca parvistaminea)* and native grasslands;
- riparian areas providing habitat for the large-footed myotis;
- native fish nursery and refuge habitats;
- largely intact native fish habitat in the lower reaches – including self sustaining populations of Trout Cod and Murray Cod;
- habitat for the three species of tortoise; and
- floodplain wetlands and associated water bird habitats.

Species and communities

Numerous Commonwealth (*EPBC Act 1999*) and state (*Fauna and Flora Guarantee (Vic) Act*) listed species and communities are associated with the lower Ovens, Buffalo and King rivers, including:

- 14 vulnerable or endangered Commonwealth fauna species;
- 12 migratory species;
- 25 State listed fauna species;
- five Commonwealth flora species;
- four state flora species;

- three Commonwealth communities including the critically endangered White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland; and
- 10 depleted, vulnerable or endangered state-listed communities.

2. Expected ecological outcomes from the proposed watering action

Objectives

The objective is to support in-stream values of lower Ovens, King and Buffalo rivers. The objectives of the environmental watering action are to support maintenance of the extent, diversity, and continuity of aquatic and river bank vegetation; maintenance of dynamic, diverse food webs that support higher organisms and contribute to river health; and maintenance of suitable in-channel habitat and flow continuity for all life stages of native fish. These objectives and actions are compatible with objectives of the *Framework for determining Commonwealth environmental watering actions*.

Current health

The 2010-11 water year in the Ovens System was unusually wet (Matt O'Connell pers. comm.):

- the December-March inflows in the Ovens System have been the highest on record;
- a major flood occurred in September and December 2010 and significant inflows also occurred in February 2011;
- the storages within the system have remained in a spilling phase all summer and are likely to continue doing so into spring 2011; and
- currently all inflows to Lake Buffalo and Lake William Hovell are being passed through the storages, and consumptive demand is low. The environment is getting all the water it needs to meet the environmental watering objectives. In addition as the flow regime in the Buffalo, King and Ovens Rivers has been in a near natural pattern it is unlikely that a release of water above normal operating requirements, or an artificial wetting of the in-stream environment, would provide any significant benefit to the in-stream flow dependant ecology.

The Sustainable River Audit Condition and Ecosystem Health assessments for valleys in the Murray-Darling Basin (2004–07) ranked the Ovens valley overall ecosystem health as poor. The hydrology component was rated good, whilst the fish and macroinvertebrates were both rated as poor. The Victorian Index of Stream Condition (2004) classified the overall condition of the Ovens River as moderate.

Consistency with current CEWH objectives

The objectives under a median to wet water availability scenario are to maintain or improve ecological health and resilience. The management objectives and actions under these scenarios include enabling the growth, reproduction and small-scale recruitment of flora and fauna, as per the *Framework for determining Commonwealth environmental watering actions*. These objectives are compatible with the specific objectives of this watering action.

3. Potential risks of the proposed watering action at the site and at connected locations

The key identified risks are summarized below:

- Water Quality (low risk): As the proposed flows will be wholly within channel, and as such will not mobilise new sources of carbon, there is minimal risks of negative water quality outcomes such as a black water event.

- Flooding of private land/personal injury (low risk): These risks are viewed as low due to the size of the water share delivered relative to the flows within the system and the capacity of the river channels, as well as specific requirement to cease the release of Commonwealth environmental water if unregulated flows are meeting the environmental objectives.

4. Long-term sustainability of the asset(s) including appropriate management arrangements

The environmental water objectives and underlying principles are primarily contained within Cottingham *et al.* (2008) *Lower Ovens Environmental Flows Project: Environmental flow recommendations*.

The river health asset risk assessment and strategic guidance on management interventions is contained within the North East Regional River Health Strategy (NECMA 2006).

Delivery arrangements
The asset is connected to the surface system and future water requirements can be met through natural flows. Environmental watering actions are based on the best available information and capture on-ground expertise, and that any delivery of Commonwealth environmental water continues to occur with strong cooperation between jurisdictions and regional agencies.

Complementary NRM activities
The Ovens River is a priority for river health works. Numerous state and Australian Government funded management activities and interventions occur with the Ovens system. All of these are guided by the North East Regional River Health Strategy. Recent Australian Government programs include:

- support of the Ovens River native fish demonstration reach around Wangaratta; and
- the pest plant and animal activities occurring under the *Caring for Our Country* high conservation value aquatic ecosystem - Lower Ovens River System project

5. Cost effectiveness and operational feasibility of undertaking the watering

Volumes
The watering option is to use 70 ML Commonwealth environmental water to contribute either to base flows or a fresh during summer.
Cost effectiveness and operational feasibility
No delivery costs are associated with this action. The option is operationally feasible and would be managed by the NECMA and Goulburn Murray Water. The water cannot be transferred downstream for use in the southern connected part of the Murray Darling Basin, nor can water be transferred in from other trading zones.

1. Ecological significance of the asset(s)

Listings and reserves

The lower Coliban River is considered to be a "working river" and has no international or national reserves or listings. There are several state reserves which occur along the Coliban River which include Taradale Streamside and Nature Conservation Reserves (202.1ha), Metcalfe Streamside Reserve (1.7ha), and Coliban Falls Geological Reserve (11.9ha).

The MDBA has identified the lower Coliban River as a key environmental asset, meeting two of the five criteria, namely supporting Commonwealth or state listed threatened species and/or ecological communities, and supporting, or capable of supporting, significant biodiversity.

Listed threatened species and communities

Several Commonwealth (*EPBC Act 1999*) and state (Fauna and Flora Guarantee Act) listed threatened species and communities are associated with the lower Coliban River including:

- 11 vulnerable, endangered or critically endangered Commonwealth fauna species;
- 11 migratory species;
- 20 state listed threatened fauna species;
- five Commonwealth flora species including the critically endangered plains riceflower (*Pimelea spinescens subsp. Spinescens)*;
- four state flora species;
- two Commonwealth communities including the critically endangered White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland; and
- three depleted, vulnerable or endangered State EVCs.

2. Expected ecological outcomes from the proposed watering action

Current condition

The Sustainable Rivers Audit assessment combines the lower Coliban River and middle reach of the Campaspe River immediately upstream of Lake Eppalock into the "slopes zone". The assessments for this zone are: ecosystem health extremely poor, macroinvertebrates very poor, fish extremely poor and hydrology moderate.

The Victorian Index of Stream Condition (2004) classified the overall condition as moderate.

The NCCMA's quarterly environmental report (September 2010) notes that the Coliban River has received substantial inflows due to above average rainfall since July 2010. The lower reaches of the river benefited most from this flow and water quality has generally been within acceptable standards, although the elevated nutrient loads remain a concern.

The average daily flow rates in each month, which have been significantly higher in the second half of 2010 compared to the same time frame in the three years prior.

The objectives of the environmental watering action are to support maintenance of the extent, diversity, and continuity of aquatic and river bank vegetation; maintenance of dynamic, diverse food webs that support higher organisms and contribute to river health; and maintenance of suitable in-channel habitat and flow continuity for all life stages of native fish. These objectives and actions are compatible with objectives of the *Framework for determining Commonwealth environmental watering actions*.

Water quality is monitored physio-chemical monitoring data collected by continuous monitoring probes constructed in the river. Data includes dissolved oxygen (at surface and at depth), temperature (at surface and at depth), salinity and pH.

Nutrient spot monitoring on a monthly basis, including turbidity, total phosphorus, total nitrogen, nitrates/nitrites and algal counts.

3. Potential risks of the proposed watering action at the site and at connected locations

A comprehensive risk assessment including control measures, will be submitted with the approvals minute. The key identified risks are summarised below:

- Water quality (low risk): as the proposed flows will be wholly within channel, and as such will not mobilise new sources of carbon, there is minimal risks of negative water quality outcomes, with improvements the most likely outcome.
- Flooding of private land/personal injury (low risk): these risks are viewed as low due to the size of the water share delivered relative to the flows within the system and the capacity of the river channels, as well as specific requirement to cease the release of Commonwealth environmental water if unregulated flows are meeting the environmental objectives.

4. Long-term sustainability of the asset(s) including appropriate management arrangements

There is no separate environmental water reserve bulk entitlement. The water for the Coliban is defined as "passing flows" and is contained within the Coliban Water's bulk entitlement. Coliban Water is required to release 8 ML per day or natural inflow (whichever is less). There are no natural resource management plans currently being implemented in the lower Coliban River.
Environmental watering actions are based on the best available information and capture on-ground expertise, ensuring that any delivery of Commonwealth water to the environment continues to occur with strong cooperation between jurisdictions and regional agencies.

5. Cost effectiveness and operational feasibility of undertaking the watering

The cost of water in the Coliban comprises a fixed annual cost of an annual service fee ($704.38) and an annual capacity charge ($137.68/ML), and a usage charge is $147.86/ML.