



Australian Government



Assessment of environmental water requirements for the proposed Basin Plan: **Lower Goulburn River Floodplain**

Published by Murray-Darling Basin Authority
Postal Address GPO Box 1801, Canberra ACT 2601
Office location Level 4, 51 Allara Street, Canberra City
Australian Capital Territory
For further information contact the Murray-Darling Basin Authority office
Telephone (02) 6279 0100 international + 61 2 6279 0100
Facsimile (02) 6248 8053 international + 61 2 6248 8053
E-Mail info@mdba.gov.au
Internet <http://www.mdba.gov.au>

MDBA Publication No: 31/12

ISBN: 978-1-922068-39-2 (online)

© Murray–Darling Basin Authority for and on behalf of the Commonwealth of Australia, 2012.

With the exception of the Commonwealth Coat of Arms, the MDBA logo, all photographs, graphics and trademarks, this publication is provided under a Creative Commons Attribution 3.0 Australia Licence.



<http://creativecommons.org/licenses/by/3.0/au>

The MDBA's preference is that you attribute this publication (and any material sourced from it) using the following wording:

Title: Assessment of environmental water requirements for the proposed Basin Plan:
 Lower Goulburn River Floodplain

Source: Licensed from the Murray–Darling Basin Authority, under a Creative Commons
 Attribution 3.0 Australia Licence.

The MDBA provides this information in good faith but to the extent permitted by law, the MDBA and the Commonwealth exclude all liability for adverse consequences arising directly or indirectly from using any information or material contained within this publication.

Australian Government Departments and Agencies are required by the *Disability Discrimination Act* 1992 (Cth) to ensure that information and services can be accessed by people with disabilities. If you encounter accessibility difficulties or the information you require is in a format that you cannot access, please contact us

Goulburn–Broken Region

Assessment of Lower Goulburn River Floodplain environmental water requirements

1. Introduction

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

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

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

1.1. Method to determine site-specific flow indicators

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

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

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

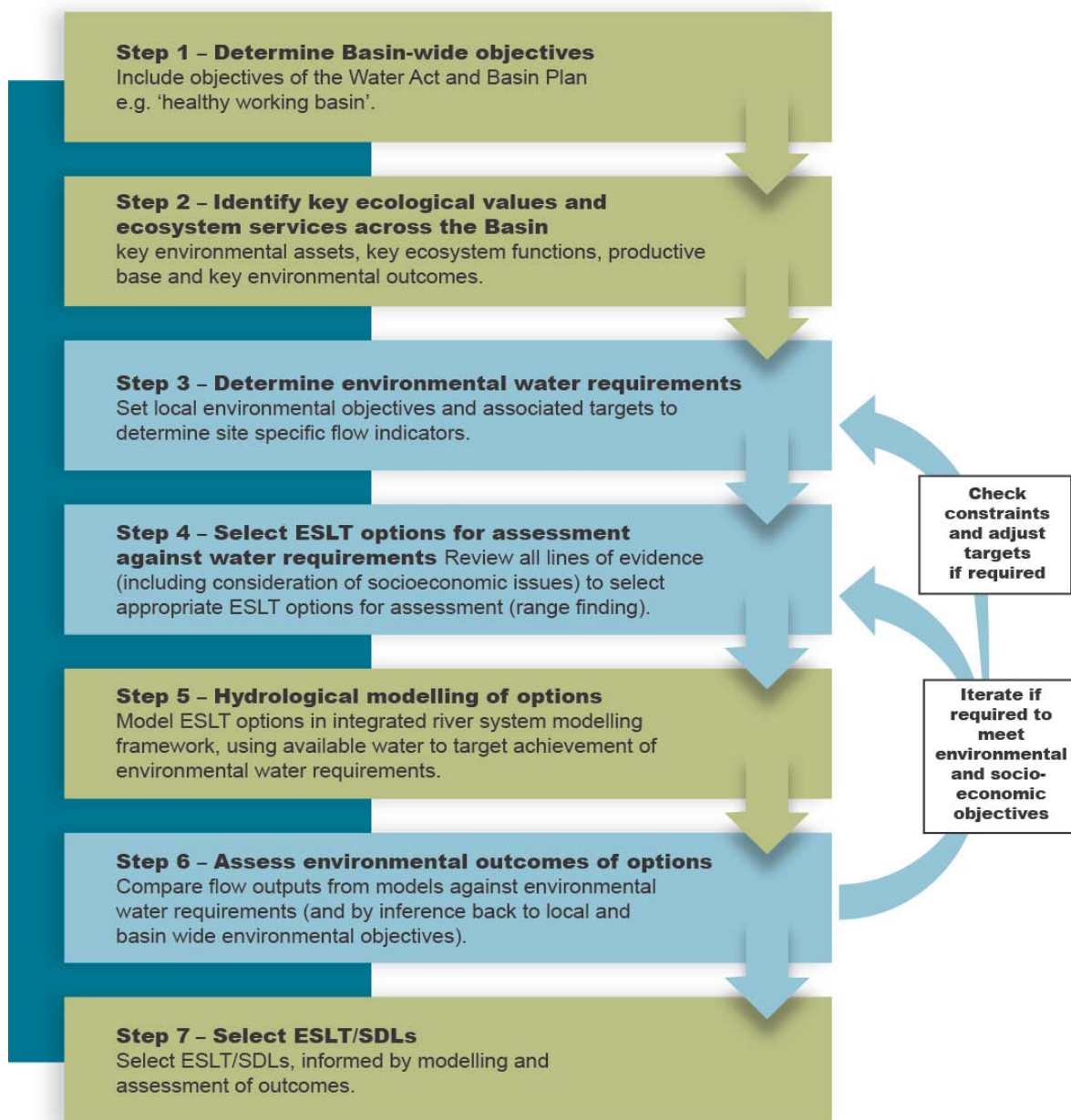


Figure 1: Outline of method used to determine an Environmentally Sustainable Level of Take (Source: MDBA 2011).

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

This report provides a description of the detailed eco-hydrological assessment of environmental water requirements for the Lower Goulburn River Floodplain including information supporting the development of site-specific flow indicators for the site (with reference to flows gauged on the Goulburn River at Shepparton). More information on how the site-specific flow indicators for the Lower Goulburn River Floodplain were used within the Basin-wide modelling process to inform the

ESLT (i.e. Step 5 and 6 in Figure 1) can be found in the report '*Hydrologic modelling to inform the proposed Basin Plan: Methods and results*' (MDBA 2012).

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

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

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

This approach is consistent with the original intent of the overbank flow recommendations as described in the Victorian Department of Sustainability and Environment (2011) report. This report was to be used as a guide to the intended overbank flow regime however the environmental flow operations should intentionally incorporate variability in peak magnitude when delivering flows in the recommended range (Victorian Department of Sustainability and Environment 2011).

2. Site location and extent

The Lower Goulburn River Floodplain hydrologic indicator site extends from the Goulburn River's junction with the River Murray upstream toward Shepparton, covering an area of about 13,000 ha (Figure 2). The Lower Goulburn River Floodplain is listed as a wetland of national importance (Department of the Environment, Water, Heritage and the Arts 2009) and is set within the broader floodplain of the Lower Goulburn.

The boundary and extent of the Lower Goulburn River Floodplain hydrologic indicator site has been defined using the Collaborative Australian Protected Areas database and data from *A directory of important wetlands in Australia*. Spatial data used in Figure 2 are listed in Appendix A. The boundary of the hydrologic indicator site described below corresponds to the areas of floodplain downstream of Shepparton confined within the levee system. The site incorporates the majority of the extent of the Lower Goulburn National Park.

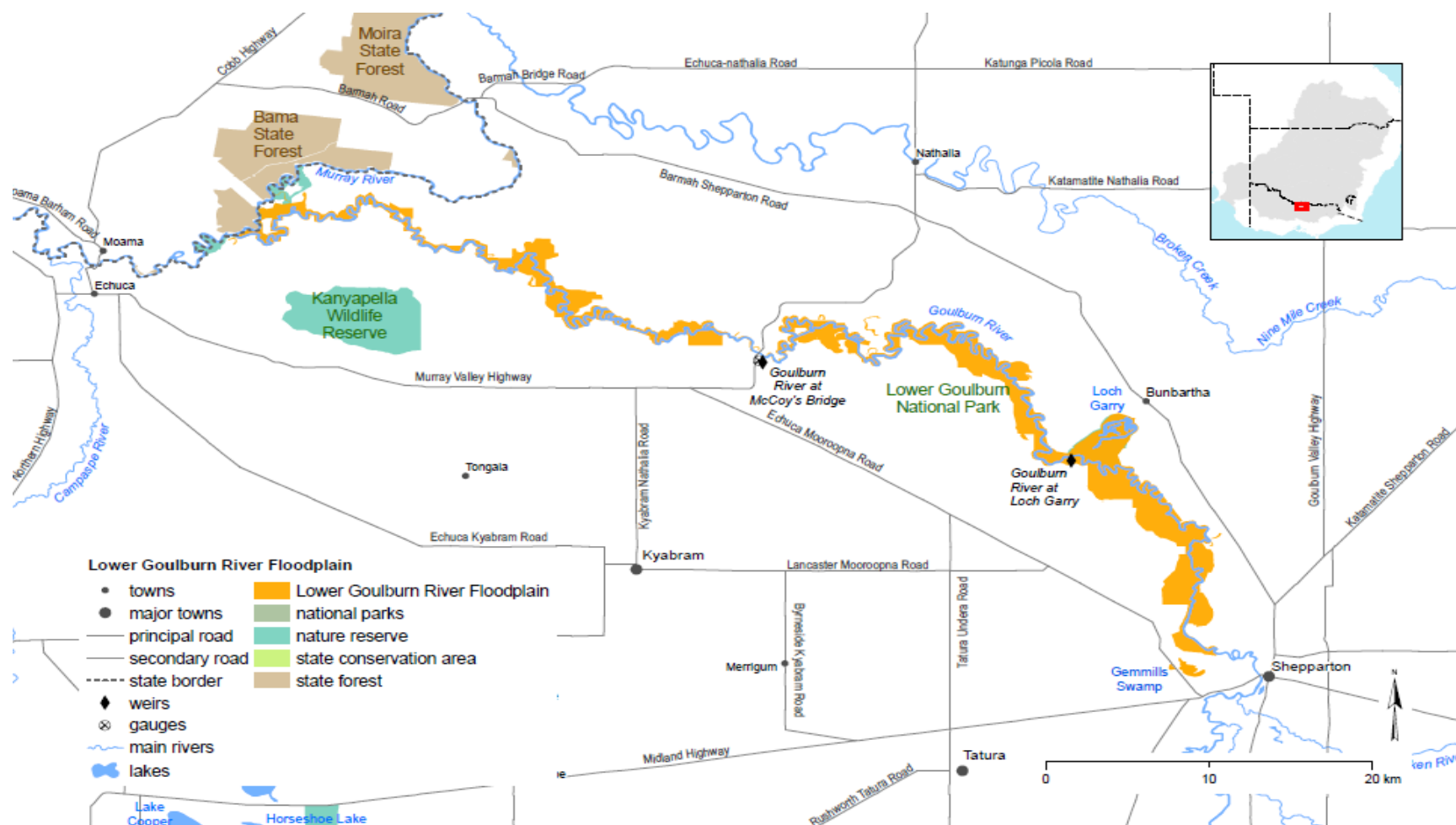


Figure 2 Location and extent of the Lower Goulburn River Floodplain key environmental asset. Flow indicators are specified at Shepparton on the Goulburn River.

3. Ecological Values

The Lower Goulburn River Floodplain supports a range of flood-dependant vegetation communities including river red gum (*Eucalyptus camaldulensis*) open forest woodland. Smaller areas of grey box (*E. moluccana*) open forest woodland with associated yellow box (*E. melliodora*), white box (*E. albens*) and black box (*E. largiflorens*) occur on higher parts of the floodplain (Department of the Environment, Water, Heritage and the Arts 2009).

The Lower Goulburn River Floodplain provide a variety of key habitats including a network of ‘flood runner’ watercourses and 70 separate wetland sites (Victorian Department of Natural Resources and Environment 1995). Both permanent and temporary wetlands are found within the floodplain such as billabongs, sloughs, marginal swamps, scroll swales, anabranches and cut-off loops (Department of the Environment, Water, Heritage and the Arts 2009). Key wetlands include Gemmills Swamp and Reedy Swamp state wildlife reserves and Loch Garry Wildlife Management Cooperative Area (Department of the Environment, Water, Heritage and the Arts 2009).

These ecosystems support important species and habitats that are listed in international agreements such as Ramsar, and include vulnerable and endangered species. Appendix B provides a summary of the conservationally significant species recorded at the floodplain.

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

Based on the ecological values identified at Lower Goulburn River Floodplain, the site meets three of the five key environmental asset criteria (Table 1).

The assessment of key environmental asset criteria is largely informed by the Australian Wetlands database (Department of the Environment, Water, Heritage and the Arts 2009). Less data are available on the values of the Lower Goulburn River Floodplain compared to nearby hydrologic indicator sites on the River Murray (such as Barmah–Millewa Forest and Gunbower–Koondrook–Perricoota Forest).

Table 1 Assessment of the Lower Goulburn River Floodplain against MDBA key environmental asset criteria.

Criterion	Ecological values that support the criterion
1. The water-dependent ecosystem is formally recognised in international agreements or, with environmental watering, is capable of supporting species listed in those agreements	The Lower Goulburn River Floodplain is formally recognised in, or is capable of supporting species listed in the Japan–Australia Migratory Bird Agreement, the China–Australia Migratory Bird Agreement or the Republic of Korea–Australia Migratory Bird Agreement. For a full list of species listed under Commonwealth legislation that have been recorded at the Lower Goulburn River Floodplain refer to Appendix B.
3. The water-dependent ecosystem provides vital habitat	<p>The Lower Goulburn River Floodplain's ecological values 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 2009).</p> <p>A total of 34 bird species have been recorded breeding at Gemmills Swamp, including Australian white ibis (<i>Threskiornis molucca</i>), royal spoonbill (<i>Platalea regia</i>), yellow-billed spoonbill (<i>P. flavipes</i>), black swan (<i>Cygnus atratus</i>), Pacific black duck (<i>Anas superciliosa</i>), grey teal (<i>Anas gracilis</i>), musk duck (<i>Biziura lobata</i>), dusky moorhen (<i>Gallinula tenebrosa</i>), purple swamphen (<i>Porphyrio porphyrio</i>), Eurasian coot (<i>Fulica atra</i>), and masked lapwing (<i>Vanellus miles</i>) (Department of the Environment, Water, Heritage and the Arts 2009).</p> <p>The Lower Goulburn River has a diverse native fish population, which includes several species of recreational angling value and/or conservation significance (Koster et al. 2009). Conservationally significant species include the Murray cod and Trout cod, which are listed nationally under the Environmental Protection and Biodiversity Conservation Act 1999 and Silver perch which are listed as critically endangered under the Victorian Flora and Fauna Guarantee Act 1999.</p>
4. Water-dependent ecosystems that support Commonwealth, State or Territory listed threatened species or communities	Species and communities listed as threatened under both Commonwealth and state legislation that have been recorded at the site are in Appendix B.

4. Hydrology

The hydrology of the Lower Goulburn River Floodplain is driven by flows in the Goulburn River, via Goulburn Weir diversions as well as a number of effluent channels (CSIRO 2008). Compared to the adjacent River Murray, flows are much 'flashier', with large flows often persisting for only a few days or weeks, compared to weeks or months in adjacent reaches of the River Murray. As the Goulburn River is ecologically and hydrologically linked to the River Murray, integrated management of both rivers is a highly desirable outcome (Water Technology 2010). The Living Murray program recognises that flooding of Gunbower Forest, in particular, could be highly dependent on flows from the Goulburn River, given the limited ability to move water from the upper Murray through the Barmah Choke (Water Technology 2010).

The flooding behaviour and inundation characteristics of the Goulburn River were assessed by Water Technology (2010). This assessment found that the reach between Kialla to Bunbartha is characterised by flows of 20,000 ML/d, generally confined to the river channel. Flows in excess of 30,000 ML/d result in extensive areas of overbank floodplain inundation in adjacent riparian areas, including complete inundation of Gemmills Swamp. This is supported by anecdotal reports which indicate that volumes exceeding 24,000 ML/d result in out-of-channel flows (Cottingham et al. 2007).

With flows of 20,000 ML/d, the Lower Goulburn River between Bunbartha and the River Murray confluence is characterised by limited floodplain inundation and anabranch flow adjacent to Loch Garry (Water Technology 2010). However, when flows exceed 30,000 ML/d, extensive areas of floodplain within the levees are inundated, with limited outflow to Deep, Wakiti and Hancocks creeks (Water Technology 2010).

The Goulburn River floodplain downstream of Shepparton is largely contained within a network of levees that limit the inundation extent of overbank flows and thereby increase the proportion of overbank flow which returns to the Goulburn River (Victorian Department of Sustainability and Environment 2011). Chee et al. (2009) report that block banks and levee construction along the length of the Goulburn River reduce connectivity between the channel and its floodplain. This, combined with flow regulation and flood control works, has resulted in a substantial reduction in the frequency and area of floodplain and wetland inundated.

One of the major impacts of flow regulation on the Goulburn River has been to alter the frequency and duration of regular flooding. The CSIRO Sustainable Yields Project reported that flooding in the Lower Goulburn River has been significantly reduced, which is largely due to water resource development in the Goulburn River. Under without development conditions, flows that inundated the Lower Goulburn River Floodplain were relatively common — occurring every 2.5 years on average and never more than about a decade between events (CSIRO 2008). However, there is now an average of 11 years between flooding events, and the maximum period between events is 37 years (CSIRO 2008). Similarly, Victorian Department of Sustainability and Environment (2011) report a change in the frequency, duration and maximum period between overbank flow events under current conditions. This is likely to have changed the filling and drying pattern of floodplain billabongs and anabranches, clearly important habitats associated with the Goulburn River (Cottingham et al. 2003a).

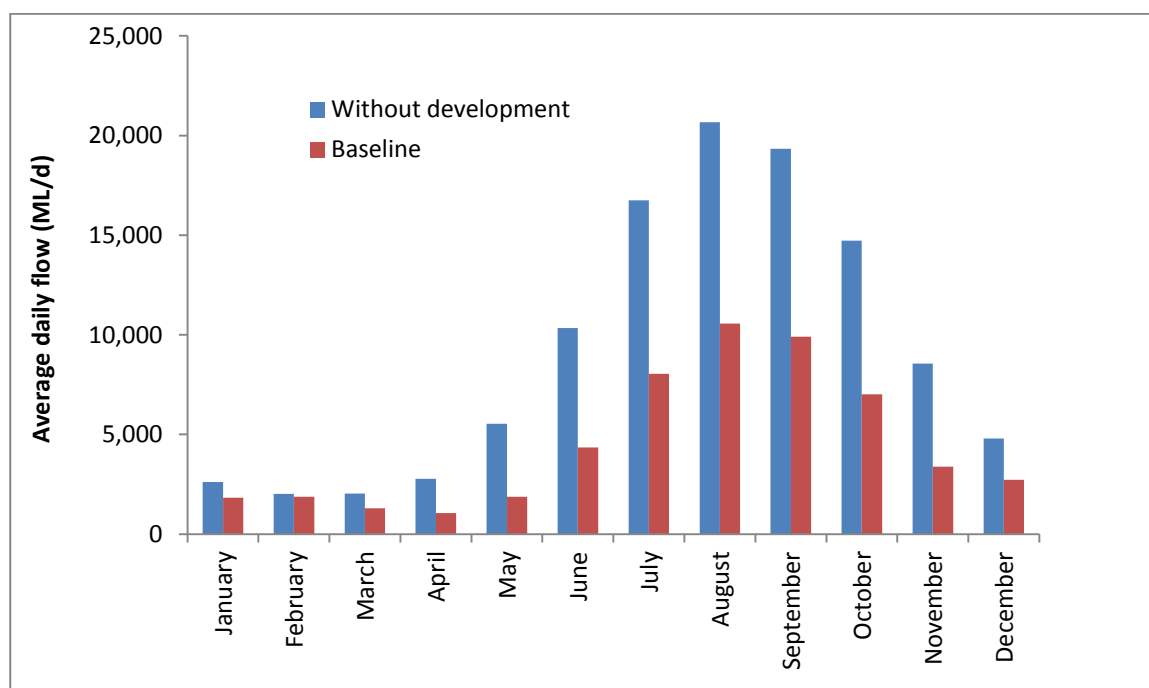


Figure 3 Modelled mean monthly flow at McCoys Bridge, Lower Goulburn River (Source: MDBA analysis).

5. Determining the site-specific flow indicators for the Lower Goulburn River Floodplain

5.1. Setting site-specific ecological targets

The objective setting framework used to determine the ESLT is outlined in the report *‘The proposed “environmentally sustainable level of take” for surface water of the Murray-Darling Basin: Method and Outcomes’* (MDBA 2011). In summary, the MDBA developed a set of Basin-wide environmental objectives and ecological targets, which were then applied at a finer scale to develop site-specific objectives for individual key environmental assets. Using these site-specific objectives, ecological targets that relate specifically to the Lower Goulburn River Floodplain were developed (Table 2). Information underpinning site-specific ecological targets is shown in Table 2.

Site-specific ecological targets formed the basis of an assessment of environmental water requirements and the subsequent determination of site-specific flow indicators for the Lower Goulburn River Floodplain, as described below.

The MDBA’s site-specific ecological targets for the Lower Goulburn River are broadly consistent with environmental objectives previously specified during assessment of floodplain environmental water requirements (Table 2; Victorian Department of Sustainability and Environment 2011). The MDBA has relied upon environmental flow studies undertaken by Victorian to inform environmental water requirements for the Lower Goulburn River Floodplain described within this document and it is therefore important that environmental objectives and targets are comparable. Environmental flow studies underpinned water recovery targets proposed within the Northern Region Sustainability Water Strategy (Victorian Department of Sustainability and Environment 2009c) which have been adopted by the MDBA as the proposed Sustainable Diversion Limit for the Goulburn-Broken region.

Table 2 Site-specific ecological targets for the Lower Goulburn River Floodplain.

Site-specific ecological targets	Justification of targets
<ul style="list-style-type: none"> • Provide a flow regime which ensures the current extent of native vegetation of the riparian, floodplain and wetland communities is sustained in a healthy, dynamic and resilient condition • Provide a flow regime which supports the habitat requirements of waterbirds and is conducive to successful breeding of waterbirds • Provide a flow regime which supports recruitment opportunities for a range of native aquatic species (e.g. fish, frogs, turtles and invertebrates) • Provide a flow regime which supports key ecosystem functions, particularly those related to connectivity between the river and the floodplain 	<p>The Lower Goulburn River Floodplain supports a variety of wetland habitats and flood dependent vegetation communities.</p> <p>The Lower Goulburn River Floodplain has been impacted by development for agriculture with parts of the floodplain cleared and/or disconnected from the river by levees. The current extent of native vegetation refers to the remaining intact floodplain comprising state forest, other public land reserves and private land. The major wetlands and floodplain forests of the lower Goulburn River are located within the confined areas of the floodplain (Victorian Department of Sustainability and Environment 2011). Ecological targets for the Lower Goulburn River Floodplain propose to ensure the current extent of native vegetation communities is sustained in recognition that only a portion of the floodplain remains intact. Analogous environmental objectives specified by Victorian Department of Sustainability and Environment (2011) include: increase the extent and diversity of aquatic vegetation; connection of floodplain ecosystem components, including grasslands, woodlands, permanent and temporary wetlands; and, dynamic food webs maintaining wetland diversity and productivity.</p> <p>Waterbird breeding has been recorded within wetlands of the Lower Goulburn River Floodplain. Victorian Department of Sustainability and Environment (2011) analogous objectives in relation to waterbirds are to increase abundance of waterfowl and colonial nesting waterbirds by improving recruitment conditions; and, to achieve successful recruitment of waterfowl and colonial nesting waterbirds in as many years as possible.</p> <p>The site supports important habitat and species and include vulnerable and endangered species such as Murray cod (<i>Maccullochella peelii peelii</i>) and Trout Cod (<i>Maccullochella macquariensis</i>). Achieving the targets for floodplain wetlands and waterbirds will ensure inundation of breeding and feeding habitats considered key for a range of fish, amphibian and water-dependent reptile and invertebrate species. Analogous environmental objectives specified by Victorian Department of Sustainability and Environment (2011) include: diverse, resilient macro-invertebrate communities within wetlands; suitable off-channel habitat for all life stages of fish; access to floodplain and off-channel habitats for fish spawning and/or larval rearing; and, increase the diversity and distribution of amphibian species.</p> <p>Key ecosystem functions support fish, birds and invertebrates through habitat maintenance, energy transfer and facilitating connections between rivers and floodplains. Overbank flows supply the floodplains with nutrients and sediments from the river, accelerate the breakdown of organic matter and supply water to disconnected wetlands, billabongs and oxbow lakes. As the floodwaters recede, the floodplains provide the main river channel with organic matter.</p> <p>The hydrological connection between watercourses and their associated floodplain provides for the exchange of carbon and nutrients (Thoms 2003). These connections are considered essential for the functioning and integrity of floodplain-river ecosystems. Analogous environmental objectives specified by Victorian Department of Sustainability and Environment (2011) include: flood regime has all the elements of a natural floodplain; increase contribution of wetlands and floodplain to processes such as river productivity; maintain an open exchange between the river and the floodplain for propagules, carbon, nutrients and biota; and, floodplain inundation for exchange of food and organic material between floodplain and channel</p>

The MDBA (2011) report *'The proposed "environmentally sustainable level of take" for surface water of the Murray-Darling Basin: Method and Outcomes'* provides further description of MDBA's use of the Northern Region SWS as a key line of evidence that has informed the within catchment SDLs proposed for the Goulburn River in the draft Basin Plan.

5.2. Determining site-specific flow indicators

There have been numerous studies assessing the environmental water requirements of the Lower Goulburn River Floodplain and the understanding of its requirements has evolved over time. Environmental water requirements described herein have been based primarily on the Victorian Department of Sustainability and Environment (2011) report *Overbank flow recommendations for the Lower Goulburn River*. In this study, flow recommendations were developed that would meet requirements of flood dependent vegetation of the Lower Goulburn River Floodplain using up-to-date hydraulic and hydrologic tools to assess flood characteristics. The Victorian Department of Sustainability and Environment (2011) report was not completed prior to release of the Guide to the Basin Plan. Accordingly, environmental water requirements of the Lower Goulburn River Floodplain described within Volume 2 Part II of the Guide to the proposed Basin Plan were based upon best available information at the time, particularly, Cottingham et al. (2003b), Cottingham et al. (2007) and Water Technology (2010), see MDBA (2010) for further detail. Environmental water requirements as described below represents an improved method compared to previous assessments.

5.2.1. Vegetation

The development of site-specific flow indicators to achieve the site specific ecological targets focused on assessment of the bankfull and overbank elements of the flow regime necessary to maintain flood dependent vegetation communities. To inform this assessment information on the relationship between flow and floodplain/wetland inundation is needed. Recent analysis completed by Water Technology (2010) and Victorian Department of Sustainability and Environment (2011) used hydraulic and hydrologic tools to assess the relationship between flow and inundation of high value wetlands and also between flow and inundation of flood dependent vegetation communities.

In terms of wetland and broader floodplain inundation, Water Technology (2010) hydraulic modeling provides information regarding the area of wetlands and floodplain inundated at flows between 20,000 and 60,000 ML/d in different reaches of river. Figure 4 shows this relationship for the Lower Goulburn River, from upstream of Shepparton to the River Murray junction. This modeling indicates that flows of 60,000 ML/d inundates practically the entire confined floodplain (i.e. the area of the hydrologic indicator site) as well as areas outside of the levee network including agricultural and urban land. Victorian Department of Sustainability and Environment (2011) suggest flows of 60,000 ML/d are considered to represent the maximum inundation required as it effectively covers all of the environmental assets within the floodplain. Flows up to 40,000 ML/d inundate approximately 70% of the floodplain area but 90% of the flood dependent vegetation communities (Figure 4). This modeling also suggests only relatively small increases in wetland inundation occurs between flows of 30,000 to 60,000 ML/d magnitudes (Figure 4; Water Technology 2010). Victorian Department of Sustainability and Environment (2011) analysis of the inundation characteristics of high value wetlands within the Lower Goulburn provides further support to findings of Water Technology (2010). Twelve high value floodplain wetlands were identified and their inundation characteristics were assessed using outputs from the Goulburn River

hydraulic model. Based on this analysis, flows in the range of 30,000 to 40,000 ML/d will achieve almost complete inundation at all wetlands and flows greater than 40,000 ML/d provide marginal benefit for inundation of high value wetlands in the Lower Goulburn (Victorian Department of Sustainability and Environment 2011). Specifically, 3 high value wetlands are inundated almost completely at flows of 20,000 ML/d, a further 7 wetlands are inundated at flows of 30,000 ML/d and the remaining 2 of the 12 high values wetlands are inundated at flows of 40,000 ML/d.

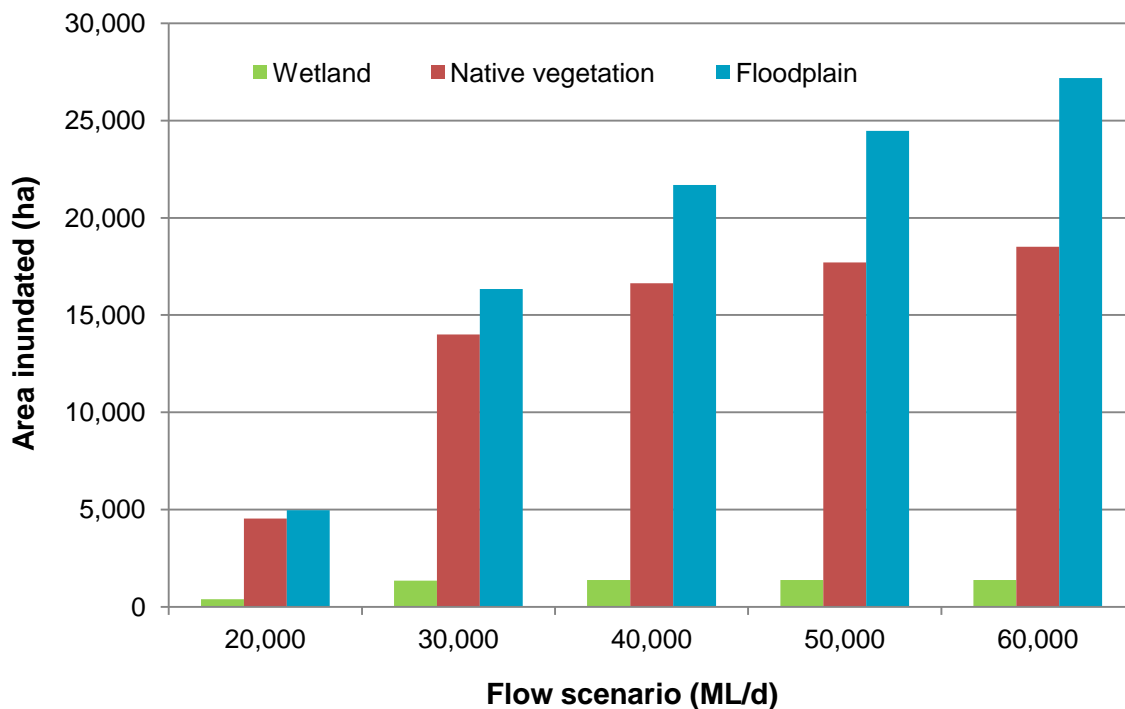


Figure 4 Relationship between flows and wetland, native vegetation and floodplain inundation for the Lower Goulburn River. Note: wetland inundation is not determined for the reach between Bunbartha to River Murray junction (Source: MDBA analysis of data in Water Technology 2010).

Figure 4 also shows inundation of native vegetation communities within the Lower Goulburn River floodplain which indicates a modest increase in native vegetation inundation occurs between flows of 40,000 to 60,000 ML/d. Based on this evidence Water Technology (2010) suggests that flows of 40,000 ML/d may provide the most environmental benefit in terms of floodplain vegetation and wetland inundation for the Lower Goulburn River for the least economic cost.

Information on the relationship between flows and inundation of vegetation communities of the Lower Goulburn River Floodplain was further assessed as part of the recently completed review of the overbank flow recommendations for the Lower Goulburn River (Victorian Department of Sustainability and Environment 2011). Ecological Vegetation Classes (EVCs) were utilised as a holistic, floodplain wide approach to analyse flood dependencies and water requirements of floodplain vegetation communities. Information on the spatial extent of flood dependent vegetation communities in the Lower Goulburn River are shown in Table 3. It should be noted that areas inundated at flows 60,000 ML/d as shown in Table 3 cover a larger area of the broader lower

Goulburn River downstream of Lake Eildon compared to the Lower Goulburn River Floodplain hydrologic indicator site and is provided to give an indication of the relative proportion of different flood dependent vegetation communities. Information on the desirable inundation frequency, duration and interval between flooding events for each of the different EVCs of the Goulburn River Floodplain are also presented in Table 3.

Table 3 Area and water requirements of flood dependent vegetation communities of the Goulburn River Floodplain (not in the Lower Goulburn River HIS) (Source: Victorian Department of Sustainability and Environment 2011).

Vegetation community – Ecological Vegetation Class	Inundated area (ha) at flow of 60,000 ML/d	Optimal Flood frequency (years in 10)	Optimal inundation duration (months)	Maximum tolerable interval between flooding (years)
Tall Marsh / Open Water Mosaic	120.4	8 – 10	8 – 12	2
Rushy Riverine Swamp	139.6	7 – 10	8 - 11	3
Spike-sedge Wetland / Tall Marsh Mosaic	49.7	7 – 9	6 – 10	3
Floodway Pond Herbland	0.4	6 – 10	4 – 6	4
Drainage-line Aggregate	446.6	6 – 10	2 – 3	3
Riverine Swamp Forest	832.8	3 – 8	1 – 6	3
Billabong Wetland Aggregate	416.6	5 – 10	8 – 11	3
Floodplain Wetlands Aggregate	156.1	3 – 7	< 1 – 4	4
Sedgy Riverine Forest	3545.4	3 – 5	1 – 2	4
Floodplain Riparian Woodland	3205.0	3 – 5	< 1 - 2	4
Riverine Grassy Woodland	6093.6	2 – 6	< 1 – 2	5
Riverine Swampy Woodland	1344.1	2 – 6	< 1 - 2	5
Creekline Grassy Woodland	109.4	2 - 4	2 - 3	5

Analysis of the relationship between flows and inundation of each of the flood dependent vegetation communities suggests that different vegetation communities are distributed across the floodplain independent of flows i.e. the floodplain is a mosaic of the different EVCs and particular flows will not target specific vegetation communities (Victorian Department of Sustainability and Environment 2011). Given there is not a strong relationship between distribution of EVCs across the floodplain and flow, Victorian Department of Sustainability and Environment (2011) state it is not necessary to develop flow recommendations for individual groups of EVCs and instead a single relationship between flow and inundation of all of the flood dependent vegetation communities was developed (Figure 5). This demonstrates a similar relationship between flow and native vegetation inundation to the relationship identified by Water Technology (2010) whereby a

significant increase in proportion inundated occurs between flows of 20,000 ML/d and 30,000 ML/d. Approximately 90% of flood dependent vegetation communities are inundated at flows of 40,000 ML/d with only relatively small incremental increases in proportion inundated up to flow of 60,000 ML/d.

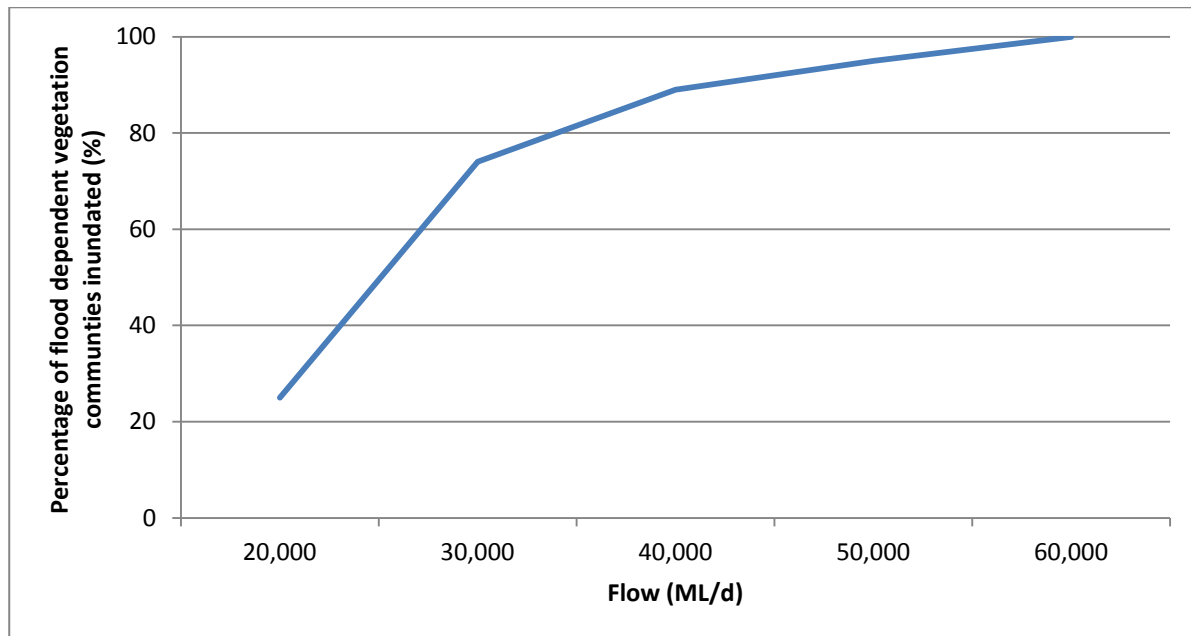


Figure 5 Relationship between flows and inundation of flood dependent Ecological Vegetation Classes (Source: Victorian Department of Sustainability and Environment 2011).

Based on the information presented above flow thresholds of 25,000 and 40,000 ML/d were recommended as the lower and upper bounds (Victorian Department of Sustainability and Environment 2011). More specifically, a 25,000 ML/d flow event was selected for wetlands and vegetation communities that require more frequent flooding than provided by the upper bound recommendation. The 40,000 ML/d event was selected as it inundates almost the full extent of flood dependent vegetation and the high value wetlands while avoiding the major risks and liabilities that would be associated with higher flows that causes inundation outside of the levee network (Water Technology 2010; Victorian Department of Sustainability and Environment 2011).

5.2.1. Other biota

The 2011 overbank flow recommendations developed by Victorian Department of Sustainability and Environment (2011) and adopted by MDBA were devised primarily from the water requirements of flood dependent vegetation communities as it was considered that the implications of an altered overbank flow regime were best understood for floodplain wetland vegetation (Victorian Department of Sustainability and Environment 2011). Subsequent assessments undertaken by Victorian Department of Sustainability and Environment (2011) confirmed that these water requirements are appropriate to ensure inundation of high value wetlands and achieve objectives for a range of biota including macro-invertebrate communities, native fish, waterbirds and woodland birds and frogs.

At the larger valley or regional scale the 2004-2007 Sustainable Rivers Audit (SRA) assessed the condition of native fish populations within the Goulburn River is degraded with a fish condition

indice of “extremely poor” at the valley scale (Davies et al. 2008). At a local scale, a detailed assessment of the fish communities of the lower Goulburn River from Goulburn Weir downstream to the River Murray junction reported diverse native fish population, which includes several species of recreational angling value and/or conservation significance (Koster et al. 2009). Conservationally significant species include the Murray cod and Trout cod, which are listed nationally under the Environmental Protection and Biodiversity Conservation Act 1999 and Silver perch which are listed as critically endangered under the Victorian Flora and Fauna Guarantee Act 1999. Importantly Murray cod are the most abundant large-bodied native species in the lower Goulburn River and there is evidence that Murray cod spawn regularly in the lower Goulburn River. In addition, the lower Goulburn River (between Goulburn Weir and Shepparton) is believed to support a breeding population of the nationally endangered Trout cod and recreationally significant Golden perch (Koster et al. 2009; Koster pers. comm. 2011).

The Department of Sustainability and Environment (2011) indicate that native fish objectives are expected to be met by the recommended events. Benefits for native fish populations will occur by inundation of the broader floodplain providing a source of organic matter for the fish and providing opportunities for fish to move between wetlands and the main channel. The proposed flows will also provide breeding cues for flood spawners

Additional flow indicators developed by MDBA for the Lower Goulburn River for the in-channel fresh element of the flow regime (separate report in preparation) are intended to complement flow indicators specified in this report. The aim of the in-channel fresh indicators is to inundate key habitat features and maintain healthy populations of native fish species.

5.2.2. Proposed flow indicators

The site-specific flow indicators for Lower Goulburn River Floodplain set out in Table 4 have been based on the work of Victorian Department of Sustainability and Environment (2011) which represents an amalgam of information from existing literature and hydraulic and hydrologic modelling data. The rationale for these indicators is explained in the earlier parts of Section 5.2. Site-specific flow indicators are expressed at Shepparton on the Goulburn River. The site-specific flow indicators needed to achieve ecological targets for Lower Goulburn River Floodplain should be read in their entirety to understand the environmental water requirements as both flow indicators will contribute to achieving ecological targets.

The site-specific flow indicator thresholds are based on inundation of high value wetlands and flood dependent vegetation communities. The recommended frequency of events and maximum period between events were derived from an understanding of the key vegetation communities watering requirements as set out in Table 3. The duration of events recommended were derived based on analysis of the median duration of high flow events under without development conditions with the assumption that water will be retained on the floodplain for sufficient duration to achieve ecological targets e.g. maintain vegetation communities and ensure successful waterbird breeding. Flow indicators as specified for the bankfull and overbank elements of the flow regime attempt to strike a balance between desirable flow threshold, duration and timing with desirable frequency (as described in Table 3) and represent a variable flow regime that is consistent with the “without development” hydrology of the site.

Generally, the flow indicator metric with the greatest level of uncertainty across the Basin is the definition of the desirable frequency of inundation, expressed as the proportion of years an event is

required. This uncertainty is due to a number of reasons. Firstly, it is likely that there are thresholds for many plants and animals beyond which their survival or ability to reproduce is lost, but the precise details of those thresholds are mostly unknown or where there is information (for instance river red gum communities) our knowledge is evolving. Secondly, vegetation communities are located across the floodplain and would have experienced significant variability in their inundation frequency under pre-development conditions which subsequently makes specification of a single frequency metric deceptively certain. For many species and ecological communities the relationship between water provisions and environmental outcomes may not be threshold based, rather there could be a linear relationship between flow and the extent of environmental outcomes or the condition of a particular ecological species/community.

Recognising the degree of confidence in specifying a desirable frequency, 'low-uncertainty' and 'high-uncertainty' frequency of flow events have been specified (Table 5). For the low-uncertainty frequency, there is a high likelihood that the environmental objectives and targets will be achieved. The lower boundary of the desired range is referred to here as the high uncertainty frequency which is effectively the best estimate of the threshold, based on current scientific understanding, which, if not met, may lead to the loss of health or resilience of ecological communities, or the inability of species to reproduce frequently enough to sustain populations. The high uncertainty frequencies attempt to define critical ecological thresholds. The high uncertainty frequency is considered to indicate a level beyond which the ecological targets may not be achieved.

The Victoria Department of Sustainability and Environment (2011) report presents the desired frequency in three different formats:

- mean number of events per 10 years;
- mean number of event *years* per 10 years; and
- mean number of events in an event year.

The mean number of event years per 10 years was highlighted as the frequency component with the best available scientific knowledge and accordingly is used as the primary assessment of frequency. The mean number of event years per 10 years has been expressed by MDBA as the proportion of years an event is required in Table 4 to ensure it is a consistent format with other hydrologic indicator sites throughout the Basin. Modelled flow data was used to verify if recommended frequencies were achievable and not greater than without development flows.

The Victoria Department of Sustainability and Environment (2011) report documents express the desired frequency as a range, with desired frequencies increasing from lower to optimal to upper. The high and low uncertainty frequency flow indicator metrics in Table 4 attempt to encapsulate the broad water requirements represented by this range. MDBA's independent analysis of modeled without development flows indicates that the desired upper frequency for 25,000 ML/d flows recommended by Victorian Department of Sustainability and Environment (2011) exceeded without development conditions and therefore the MDBA has selected the optimal frequency, specified by DSE (2011) as its low uncertainty value.

Table 4 Site-specific ecological targets and associated flow indicators for the Lower Goulburn River Floodplain

Site-Specific Ecological Targets	Site-Specific Flow Indicators						Without development and baseline event frequencies	
	Flow required (measured at Shepparton; ML/day	Duration (median; days)	Timing	Frequency ^a – proportion of years event required		Maximum period between events (years)	Proportion of years event occurred under modelled without development conditions (%)	Proportion of years event occurred under modelled baseline conditions (%)
				Low uncertainty (%)	High uncertainty (%)			
<p>Provide a flow regime which ensures the current extent of native vegetation of the riparian, floodplain and wetland communities is sustained in a healthy, dynamic and resilient condition</p> <p>Provide a flow regime which supports the habitat requirements of waterbirds and is conducive to successful breeding of waterbirds</p>	25,000	≥5	June to November	80	70	3	90	57
<p>Provide a flow regime which supports recruitment opportunities for a range of native aquatic species (e.g. fish, frogs, turtles and invertebrates)</p> <p>Provide a flow regime which supports key ecosystem functions, particularly those related to connectivity between the river and the floodplain</p>	40,000	≥4		60	40	5	72	38

^a Victoria Department of Sustainability and Environment (2011) express desired frequency in 3 different formats. The proportion of years with an event has been used as the primary assessment of frequency as it has the best scientific knowledge to support setting of a target. The number of events in an event year and number of events per 10 years are used as secondary performance indicators of overbank flow frequency.

Note: Multiplication of the flow rate by the duration and frequency (proportion of years event required) does not translate into the additional volume of water the site needs to be environmentally sustainable. This is because part of the required flow is already provided under baseline conditions. Additional environmental water required is the amount over and above the baseline flows.

It is recognised that periods between inundation events are an important consideration when trying to determine ecosystem resilience or thresholds of irreversible change. The Lower Goulburn River Floodplain is one of the few sites across the Basin where the MDBA has proposed a maximum dry period consistent with recommendations of Victorian Department of Sustainability and Environment (2011). Maximum dry periods between successful events is reported for hydrological modelling associated with the Lower Goulburn River Floodplain hydrologic indicator site in MDBA 2012.

6. Flow Delivery Constraints

Basin-wide environmental objectives have been developed within the context of being deliverable in a working river system that contains public and private storages and developed floodplains. To understand and assess the implications of key constraints on the ability to achieve flow indicators specified for the Lower Goulburn River Floodplain, MDBA has drawn upon a combination of existing information (e.g. Water Sharing Plans, operating rules of water agencies, flood warning levels) and practical knowledge of river operators supported by testing using hydrological modelling.

Flows downstream of Lake Eildon are typically limited to 12,000 or 18,000 ML/d under regulated flow conditions at Seymour and Trawool respectively to avoid flooding of private land around these areas. In addition, delivery constraints also exist in the lower sections of the Goulburn River around Shepparton and areas further downstream to avoid flooding of private land and minor roads not protected by existing levees. These constraints will at times prevent the release of flows, or adding water to augment natural flows to achieve flow indicators specified for Lower Goulburn River Floodplain.

The MDBA has a vision of a healthy working Basin that has vibrant communities, productive and resilient industries, and healthy and diverse ecosystems. The delivery of environmental flows as a managed watering event within a healthy working Basin is highly dependent on existing system constraints, accordingly the site-specific flow indicators have been classified into three broad types (Table 6). Consistent with this rationale, within the hydrological modelling process used by the MDBA to assess the achievement of site-specific flow indicators orders for environmental flows have been limited to be within the constraints represented by the baseline model. This limits the delivery of regulated flows to the Lower Goulburn River Floodplain.

Based on the information above, achievement of the 25,000 ML/d and 40,000 ML/d site-specific flow indicators at Shepparton will be difficult to support with only regulated releases from dams. Achieving these higher threshold flows will be reliant on supplementing tributary inflows with regulated release from storage and their duration will be limited to the duration of the tributary inflow.

The Victorian Department of Sustainability and Environment (2011) suggest based on their analysis that flows up to 40,000 ML/d at Shepparton are achievable within existing physical constraints and avoids major risks and liabilities that would be associated with managed environmental flow releases that exceeded this flow rate (e.g. flooding of private rural and urban land, damage to the existing levees, impacts on water resource reliability and the ability to deliver an event).

Hydrological modelling undertaken by the MDBA to inform the proposed draft Basin Plan (MDBA 2012) confirms that the flow indicators as specified can generally be delivered through a combination of augmenting of tributary inflows with regulated release from storage and storage spills. However, modelling analysis presented in MDBA (2012) also indicates that in some years flood constraints

downstream of Lake Eildon may limit the ability to augment tributary inflows and hence impede the ability to achieve the desired flow indicators (specifically the maximum period between events).

Table 6 Site-specific flow indicators for the Lower Goulburn River Floodplain and the effect of system constraints

Site-specific ecological targets	Site-specific flow indicators
Provide a flow regime which ensures the current extent of native vegetation of the riparian, floodplain and wetland communities is sustained in a healthy, dynamic and resilient condition	25,000 ML/d for a median duration of 5 days between June & November for 70% of years
Provide a flow regime which supports the habitat requirements of waterbirds and is conducive to successful breeding of waterbirds	40,000 ML/d for a median duration of 4 days between June & November for 40% of years
Provide a flow regime which supports recruitment opportunities for a range of native aquatic species (e.g. fish, frogs, turtles, invertebrates)	
Provide a flow regime which supports key ecosystem functions, particularly those related to connectivity between the river and the floodplain	

Key

	Achievable under current operating conditions Flow indicators highlighted in blue are considered deliverable as mostly regulated flows under current operating conditions.
	Achievable under some conditions (constraints limit delivery at some times) Flow indicators highlighted in yellow are considered achievable when delivered in combination with tributary inflows and/or unregulated flow events. They may not be achievable in every year or in some circumstances, and the duration of flows may be limited to the duration of tributary inflows.
	Difficult to influence achievement under most conditions (constraints limit delivery at most times) Flow indicators highlighted in brown require large flows that cannot be regulated by dams and it is not expected that these flows can currently be influenced by river operators due to the river operating constraints outlined above.

7. Summary and conclusion

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

The flow indicators in this report are used to assess potential Basin Plan scenarios. MDBA (2012) summarises how the proposed draft Basin Plan released in November 2011 performs against flow indicators for the Lower Goulburn River Floodplain. Specifically, modelling of the water recovery targets as proposed within the Northern Region Sustainability Water Strategy (Victorian Department of Sustainability and Environment 2009c) and adopted by the MDBA as the proposed Sustainable Diversion Limit for the Goulburn-Broken region is presented.

References

- Chee, YE, Webb, JA, Stewardson, M & Cottingham, P 2009, *Victorian environmental flows monitoring and assessment program: monitoring and evaluation of environmental flow releases in the Goulburn River*, report for Goulburn Broken Catchment Management Authority and the Victorian Department of Sustainability and Environment, eWater Cooperative Research Centre, Canberra.
- Cottingham, P, Stewardson, M, Crook, D, Hillman, T, Roberts, J & Rutherford, I 2003a, *Flow-related environmental issues associated with the Goulburn River below Lake Eildon*, report to Victorian Department of Sustainability and Environment and Murray–Darling Basin Commission, Cooperative Research Centre for Freshwater Ecology, Canberra.
- Cottingham, P, Stewardson, M, Crook, D, Hillman, T, Roberts, J & Rutherford, I 2003b, *Environmental flow recommendations for the Goulburn River below Lake Eildon*, technical report 01/2003, Cooperative Research Centre for Freshwater Ecology, Canberra.
- Cottingham, P, Stewardson, M, Crook, D, Hillman, T, Roberts, J, Rutherford, I & Oliver, R 2007, *Evaluation of summer inter-valley water transfers from the Goulburn River*, report to Goulburn Broken Catchment Management Authority, Shepparton, Victoria.
- CSIRO 2008, *Water availability in the Goulburn–Broken*, a report to the Australian Government from the CSIRO Murray–Darling Basin Sustainable Yields Project, CSIRO, Australia.
- Davies, PE, Harris, JH, Hillman, TJ & Walker, KF 2008, *SRA report 1: a report on the ecological health of rivers in the Murray–Darling Basin, 2004–2007*, report by the Independent Sustainable Rivers Audit Group for the Murray–Darling Basin Ministerial Council, Canberra.
- Department of the Environment, Water, Heritage and the Arts 2008, National framework and guidance for describing the ecological character of Australian Ramsar wetlands, module 2 of the national guidelines for Ramsar wetlands — implementing the Ramsar Convention in Australia, viewed 5 January 2010, <www.environment.gov.au/water/publications/environmental/wetlands/module-2-framework.htm>
- Department of the Environment, Water, Heritage and the Arts 2009, *Directory of important wetlands in Australia — information sheet: Lower Goulburn River Floodplain — VIC052*, viewed 9 November 2009, <www.environment.gov.au/cgi-bin/wetlands/search.pl?smode=DOIW>.
- Koster, W, Crook, D & Dawson, D 2009, *Lower Goulburn Fish Communities Project – 2009 Annual Report*. Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg.
- MDBA (Murray-Darling Basin Authority) 2010, *Guide to the proposed Basin Plan: Technical background Volume 2 Part II of III*. Murray-Darling Basin Authority, Canberra.
- MDBA (Murray-Darling Basin Authority) 2011, *The proposed “environmentally sustainable level of take” for surface water of the Murray-Darling Basin: Method and Outcomes*. Murray-Darling Basin Authority, Canberra.
- MDBA (Murray-Darling Basin Authority) 2012, *Hydrologic modelling to inform the proposed Basin Plan: Methods and results*. Murray-Darling Basin Authority, Canberra.

SKM 2007, *High Conservation Value Aquatic Ecosystems project - identifying, categorising and managing HCVAE*, Final report, Department of the Environment and Water Resources, 16 March 2007.
www.environment.gov.au/water/publications/environmental/ecosystems/hcvae.html

Thoms, M 2003 *Floodplain-river ecosystems: lateral connections and the implications of human interference*. *Geomorphology* 56: pp. 335–349.

Victorian Department of Natural Resources and Environment 1995, *Wetland database*, Parks, Flora and Fauna Division, Victorian Department of Natural Resources and Environment, East Melbourne.

Victorian Department of Primary Industry 2010, *A guide to the inland angling waters of Victoria — Goulburn River catchment*, viewed 14 April 2010, <www.nre.vic.gov.au/angling/05-Goulburn/Basin%205%20Goulburn%20River%20ED21Jan-worked.htm>.

Victorian Department of Sustainability and Environment 2009a, *Flora and/or fauna distribution data*, Victorian Department of Sustainability and Environment, Melbourne.

Victorian Department of Sustainability and Environment 2009b, 'Justification for key environmental assets', unpublished report, Victorian Department Sustainability and Environment, Melbourne.

Victorian Department of Sustainability and Environment 2009c, *Northern Region Sustainable Water Strategy*, Victorian Department of Sustainability and Environment, Melbourne.

Victorian Department of Sustainability and Environment 2011, *Overbank flow recommendations for the lower Goulburn River*, Victorian Department of Sustainability and Environment, Melbourne.

Water Technology 2010, *Goulburn River environmental flows hydraulics study*, report for the Goulburn–Broken Catchment Management Authority, Melbourne.

Appendix A

Data used in producing hydrologic indicator site maps

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

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

Appendix B

Species relevant to criteria 1 and 4: Lower Goulburn River Floodplain

Species	Recognised in international agreement(s) ¹	Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)	Flora and Fauna Guarantee Act 1998 (VIC)
Amphibians and reptiles			
Lace goanna (<i>Varanus varius</i>) ⁴			V
Brown toadlet (<i>Pseudophryne bibronii</i>) ⁴			E
Southern bell or growling grass frog (<i>Litoria raniformis</i>) ⁴		V	E
Birds			
Australasian bittern (<i>Botaurus poiciloptilus</i>) ^{2, 3}			E
Australasian shoveler (<i>Anas rhynchotis</i>) ⁴			V
Baillon's crake (<i>Porzana pusilla</i>) ^{2, 3}			V
Barking owl (<i>Ninox connivens</i>) ^{2, 3}			E
Bush stone-curlew (<i>Burhinus grallarius</i>) ^{2, 3}			E
Diamond firetail (<i>Stagonopleura guttata</i>) ⁴			NT
Eastern great egret (<i>Ardea modesta</i>) ^{2, 3}	✓		V
Freckled duck (<i>Stictonetta naevosa</i>) ⁴			E
Grey-crown babbler (<i>Pomatostomus temporalis temporalis</i>) ^{2, 3}			E
Ground cuckoo-shrike (<i>Coracina maxima</i>) ^{2, 3}			V
Intermediate egret (<i>Ardea intermedia</i>) ⁴			CE
Latham's snipe (<i>Gallinago hardwickii</i>) ^{2, 3}	✓		
Lewin's rail (<i>Lewinia pectoralis</i>) ^{2, 3}			V
Little bittern (<i>Ixobrychus dubius</i>) ^{2, 3}			E
Magpie goose (<i>Anseranas semipalmata</i>) ^{2, 3}			NT
Musk duck (<i>Biziura lobata</i>) ⁴			V
Painted honeyeater (<i>Grantiella picta</i>) ^{2, 3}			V
Royal spoonbill (<i>Platalea regia</i>) ⁴			V
Superb parrot (<i>Polytelis swainsonii</i>) ^{2, 3}		V	E
Swift parrot (<i>Lathamus discolor</i>) ^{2, 3}		E	E
Turquoise parrot (<i>Neophema pulchella</i>) ^{2, 3}			NT
White-bellied sea eagle (<i>Haliaeetus leucogaster</i>) ^{2, 3}	✓		V

Species	Recognised in international agreement(s)¹	Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)	Flora and Fauna Guarantee Act 1998 (VIC)
Fish			
Barred galaxias (<i>Galaxias fuscus</i>) ^{2, 3}		E	CE
Flat-headed galaxias (<i>Galaxias rostratus</i>) ⁴			V
Freshwater catfish (<i>Tandanus tandanus</i>) ^{2, 3}			E
Hardhead (<i>Aythya australis</i>) ⁴			V
Macquarie perch (<i>Macquaria australasica</i>) ^{2, 3}		E	E
Murray cod (<i>Maccullochella peelii peelii</i>) ^{2, 3}		V	E
Murray–Darling rainbowfish (<i>Melanotaenia fluviatilis</i>) ^{2, 3}			DD
Silver perch (<i>Bidyanus bidyanus</i>) ^{2, 3}			CE
Trout cod (<i>Maccullochella macquariensis</i>) ^{2, 3}		E	CE
Unspecked hardyhead (<i>Craterocephalus stercusmuscarum fulvus</i>) ^{2, 3}			DD
Mammals			
Squirrel glider (<i>Petaurus norfolcensis</i>) ^{2, 3}			E
Brush-tailed phascogale (<i>Phascogale tapoatafa</i>) ^{2, 3}			V
Plants			
Grey billy-buttons (<i>Craspedia canens</i>) ⁴			E
Jericho wire-grass (<i>Aristida jerichoensis</i> var. <i>subspinulifera</i>) ⁴			E
Western water-starwort (<i>Callitriche cyclocarpa</i>) ⁴			V
Communities			
Lowland Riverine fish community of the southern Murray–Darling Basin ²			L

CE = critically endangered DD = data deficient E = endangered L = listed NT = near threatened V = vulnerable

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

2 Victorian Department of Primary Industries (2010)

3 Department of the Environment, Water, Heritage and the Arts (2009)

4 Victorian Department of Sustainability and Environment (2009a,b)