TECHNICAL REPORT

HYDRO-ECOLOGICAL ANALYSIS OF THE PROPOSED BASIN PLAN – SOUTH AUSTRALIAN FLOODPLAIN

2012/11

Government of South Australia
Department for Water

HYDRO-ECOLOGICAL ANALYSIS OF THE PROPOSED BASIN PLAN – SOUTH AUSTRALIAN FLOODPLAIN

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FOREWORD

South Australia's Department for Water leads the management of our most valuable resource—water.

Water is fundamental to our health, our way of life and our environment. It underpins growth in population and our economy—and these are critical to South Australia's future prosperity.

High quality science and monitoring of our State's natural water resources is central to the work that we do. This will ensure we have a better understanding of our surface and groundwater resources so that there is sustainable allocation of water between communities, industry and the environment.

Department for Water scientific and technical staff continue to expand their knowledge of our water resources through undertaking investigations, technical reviews and resource modelling.

Scott Ashby
CHIEF EXECUTIVE
DEPARTMENT FOR WATER

ACKNOWLEDGEMENTS

Invaluable contribution was provided by the Murray-Darling Basin Authority in the form of data and briefings.

Members of the Goyder Institute for Water Research as well as a number of experts within South Australian Government have provided feedback on draft material and presentations from the analysis. This feedback has greatly improved the interpretation contained in the report.

This report has been peer reviewed by Mr Geoff Podger, Senior River System Modeller, CSIRO Land and Water and Kumar Savadamuthu, Principal Hydrologist, Department for Water. Internal review was also undertaken by the Policy and Strategy Division of the Department for Water. Input from the reviewers has greatly improved the content and conclusions of the report.

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EXECUTIVE SUMMARY

In November 2011, the Murray-Darling Basin Authority (MDBA) released the proposed Basin Plan for public consultation. The proposed Basin Plan includes a reduction in consumptive use across the Basin of 2750 GL. As part of development of the proposed Basin Plan, the MDBA has undertaken hydrological modelling of the Murray-Darling Basin to inform the determination of the Environmentally Sustainable Level of Take.

This report provides analysis and interpretation of the approach taken by the MDBA in modelling the water recovery scenarios for the proposed Basin Plan, analyses the MDBA's modelled outputs and describes the potential hydrological and ecological outcomes for South Australia and assists in assessing the implications of the proposed Basin Plan for South Australia. The report also explains how the current approach has differed from the approach used for the Guide to the Basin Plan (released in October 2010), as well as identifying any limitations or risks associated with the current approach. It is intended that this report will form a key element of the science analysis to support the South Australian Government's response to the proposed Basin Plan.

Analysis in this report is focussed on the South Australian River Murray floodplain between the South Australia / New South Wales / Victoria border and Wellington, South Australia.

The hydrological analysis has been undertaken using modelled outputs of River Murray flow and salinity from the MDBA's modelling of water recovery scenarios for the development of the proposed Basin Plan. The analysis has been used to determine if South Australia's targets, including salinity targets and specific environmental water requirements of the River Murray floodplain will be met by the 2750 GL scenario. A spatial analysis has also been undertaken, using the River Murray Floodplain Inundation Model, to determine the proportion of particular vegetation communities that would be inundated for a given flow (i.e. how frequently inundation occurs and the period of inundation). The proportion, frequency and duration of inundation for different vegetation communities under modelled hydrological regimes from the 2750 GL scenario has been used as the basis for the ecological interpretation. This interpretation describes the ecological outcomes that could be expected for the South Australian floodplain from the proposed Basin Plan compared to baseline conditions (similar to current conditions).

Outputs provided by the MDBA sensitivity runs, which modelled 2400 GL and 3200 GL water recovery scenarios, were also analysed to show the impact of different water recovery volumes on ecological outcomes.

The key findings and messages from the analysis are as follows:

- The 2750 GL water recovery scenario demonstrates an improvement in the delivery of flows to meet River Murray EWRs in South Australia when compared to baseline conditions.
- Improvements are evident both in the total annual volume delivered to South Australia, as well as the frequency of daily flow rates. Notably the median annual volume is predicted to increase by 2400 GL, an increase of approximately 50% compared to baseline.
- In the driest year over the modelled 114-year climate period the lowest annual volume nearly doubled from 1030 GL to 2000 GL.
- The median flow increased from 18 050 ML/day to 23 000 ML/day.

- The increased flows delivered under the 2750 GL scenario compared to baseline conditions improves the ability to meet salinity targets for the main river channel. In particular, the targets to not exceed 830 EC for 95% of the time and to remain below the 1400 EC trigger for critical human water needs are met by the 2750 GL scenario. However, it should be noted that current modelling does not account for additional salt load that may occur from increased frequency of floodplain inundation (under both managed and unregulated flow events).
- In terms of daily flow rate over the border the 2750 GL scenario resulted in an increase in the frequency of all flow rates up to approximately 80 000 ML/day. The frequency of high flow events (i.e. over 80 000 ML/day) remain similar to Baseline Conditions. These high flows are generally referred to as unregulated events and therefore considered natural flood events.
- While this analysis identifies potential for benefits to be achieved relative to the baseline under the 2750 GL scenario, the actual benefits delivered are fundamentally dependent on the way in which water is delivered and used. This includes, but is not restricted to, the way in which flows are prioritised, physical, operating and policy related delivery constraints, the portfolio of entitlements secured for environmental purposes (ie. mix of high and low security products) and rules relating to trading and carryover. As a result, the current benefits forecast represent only one possible outcome of the delivery of an additional 2750 GL on average per annum.
- Despite this improvement, very few Riverland–Chowilla EWRs defined by either the MDBA or South Australia are met under the 2750 GL scenario when assessed according to average frequency. MDBA targets are set across a range of risk levels and three of the seven MDBA targets are met at a high level of risk. The South Australian targets are set at a low level of risk and one out of the twenty SA targets is met.
- The improved hydrological conditions observed for the 2750 GL scenario are expected to achieve some ecological improvement compared to the baseline. Benefits are most likely to be observed in and around the main channel of the river. The habits most likely to experience benefit are in-channel habitats, some low lying temporary wetlands and some floodplain communities.
- The maximum time between particular flow events is considered to be more ecologically significant than the average frequency of events. As a result, using the maximum time between events is considered to reflect low ecological risk and using the average frequency is considered to reflect a higher level of ecological risk.
- Using the low risk approach, (i.e. the maximum interval and duration metrics are met) the 2750 GL scenario could potentially support 30% more red gum habitat and 39% more lignum habitat relative to the low risk baseline scenario. That is, under the 2750 GL scenario approximately 11% of total red gum habitat and approximately 3.2% of total lignum habitat will be supported compared to 8.4% and 2.3% respectively under baseline conditions. Using the higher risk approach (i.e. the average frequencies are met but maximum intervals may be breached) approximately 30% of total red gum habitat and 15% of total lignum habitat could be supported under the 2750 GL scenario compared to 24% and 7% respectively for the baseline scenario. This represents a 25% increase for red gum and a 114% increase for lignum under the 2750 GL scenario relative to the baseline scenario.
- A large percentage of the total floodplain, as defined by the 1956 flood line, remains at risk under the 2750 GL scenario, with either the frequency and/or the duration of flow events less than that required to support good condition.

- The EWRs described for the Riverland–Chowilla site mostly relate to overbank flows with high flow rates. Given the highly regulated condition of the Murray-Darling Basin delivery of these may be impacted by system constraints, including both physical and operational constraints. Examples include flow rate limits (under regulated conditions) to prevent overbank flows and excess losses, capacity limits on dam outlets, channel and bridge constraints to prevent inundation of roads and private property and water transfer rules. The MDBA has suggested that these constraints may create a ceiling for the delivery of environmental water.
- The sensitivity analysis undertaken by the MDBA (i.e. using the 2400 GL and 3200 GL scenarios to show impact of different water recovery volumes) demonstrated only subtle differences in outcomes for the Riverland–Chowilla floodplain. This analysis included the system constraints within the model and therefore potential benefits to the floodplain from additional water have likely been masked by these constraints.
- There may be opportunity to improve delivery of flows between 40 000 ML/day to 80 000 ML/day through changed operational arrangements and the removal or relaxation of some constraints. Better delivery of these flows could lead to significantly improved ecological benefits. Significant areas of floodplain vegetation communities become inundated with flows between 40 000 ML/day to 80 000 ML/day. For example, only 6% of the total lignum community is inundated at 40 000 ML/day whereas this increases to 76% of the total community at flows of 80 000 ML/day.
- A large percentage of the total floodplain, as defined by the 1956 flood line, remains at risk under the 2750 GL scenario, with either the frequency and/or the duration of flow events less than that required to support good condition.
- The ability to deliver South Australian and MDBA EWRs of 80 000 ML/day and above are typically unchanged by the 2750 GL scenario when compared to baseline conditions. These events are reliant on large unregulated flows (natural floods) and so little opportunity exists to increase their frequency. Therefore the proposed Basin Plan has very limited ability to influence the ecological outcomes on these higher parts of the floodplain.
- Technical differences in modelling approach mean that the results from the 2750 GL scenario and those presented in the Guide to the Basin Plan are not directly comparable. Modelling of the 3000, 3500 and 4000 GL scenarios using the current modelling approach would yield different outcomes to those previously reported.

1. INTRODUCTION

The Murray-Darling Basin Authority (MDBA) released the proposed Basin Plan for public consultation in November 2011. The Basin Plan offers a once in a lifetime opportunity to address over-allocation of water resources across the Basin, manage salinity issues and achieve enhanced environmental and water security outcomes.

The intent of the Basin Plan is to provide for the integrated and sustainable management of water resources in the Murray-Darling Basin, including enforceable sustainable diversion limits for the Basin's surface water and groundwater resources. It aims to ensure that water is available for the health of key environmental assets and functions across the entire Basin while supporting food production and river communities.

The Guide to the proposed Basin Plan (the Guide) was released by the MDBA in October 2010. At that time, the Goyder Institute for Water Research undertook a high-level independent scientific review of the water recovery scenarios outlined in the Guide, in collaboration with scientists, technical and policy staff from government agencies.

The review highlighted that the 3500 GL and 4000 GL scenarios proposed in the Guide were more likely to meet environmental water requirements of South Australia's key environmental assets and increased the likelihood of maintaining or improving the health of the River Murray, estuarine and floodplain environments.

Following the release of the Guide, State Government officers have continued to liaise with the MDBA during the development of the proposed Basin Plan. As part of this process, the MDBA progressively made information and data available during 2011. The proposed Basin Plan, released in November 2011, was accompanied by several MDBA-published reports describing the approach and assumptions used.

This report provides analysis and interpretation of the approach taken by the MDBA in modelling the water recovery scenarios for the proposed Basin Plan, analyses the MDBA's modelled outputs and describes the potential hydrological and ecological outcomes for South Australia and assists in assessing the implications of the proposed Basin Plan for South Australia. The report also explains how the current approach has differed from the approach used for the Guide, as well as identifying any limitation or risks associated with the current approach. It is intended that this report will form a key element of the science analysis to support the Government of South Australia's response to the proposed Basin Plan.

Analysis in this report is focussed on the South Australian River Murray floodplain between the South Australia–New South Wales–Victoria border and Wellington, South Australia. Analysis relating to the Coorong, Lower Lakes and Murray Mouth (CLLMM) is provided in the Department of Environment and Natural Resources Technical Report "*Review of the Basin Plan Water Recovery Scenarios for the Lower Lakes, South Australia: Hydrological and Ecological Consequences*" (Heneker and Higham, 2012, in preparation).

The hydrological analysis has been undertaken using modelled outputs of River Murray flow from the MDBA's modelling of water recovery scenarios for the development of the proposed Basin Plan. The analysis has been used to determine if the specified environmental water requirements of the River Murray floodplain have been met and to what extent flow events in the River Murray in South Australia have been influenced by the recovery and delivery of environmental water due to the Basin Plan. A spatial analysis has also been undertaken, based on areas of inundation at various river flow rates from the River Murray Floodplain Inundation Model, to determine the extent of various vegetation types impacted by the modelled flow regimes. The hydrological and spatial analyses have been used as the basis for an ecological interpretation which has described the ecological outcomes to the South Australia floodplain.

This report does not address the impact from the proposed Basin Plan water recovery scenarios on extractive users of the River Murray in South Australia.

This technical report has been informed by briefings, draft and published reports, data and MDBA model outputs received as at 28 February 2012.

2. DEFINITIONS AND MODELLING SCENARIOS

2.1. ENVIRONMENTALLY SUSTAINABLE LEVEL OF TAKE

The *Water Act 2007* (Cth) requires that the Basin Plan establish an Environmentally Sustainable Level of Take (ESLT), which is defined as the level at which water can be taken from a water resource which, if exceeded, would compromise:

- key environmental assets of the water resource; or
- key ecosystem functions of the water resource; or
- the productive base of the water resource; or
- key environmental outcomes for the water resource.

The MDBA has interpreted that the ESLT is influenced by three factors: environmental science, system constraints and social and economic factors (MDBA 2011b).

The MDBA has determined that the Basin's ESLT is 10,873 GL/yr (MDBA 2011b). This volume was estimated on the basis of optimising environmental, economic and social outcomes without compromising the key environmental assets and ecosystem functions, as well as meeting the requirements of the Water Act. Given that the MDBA has assessed the baseline[1] level of take to be 13 659 GL/yr, this represents a reduction in take of 2750 GL/yr. This comprises a reduction of 390 GL/yr from the northern Basin, 2289 GL/yr from the southern Basin and 71 GL/yr from the disconnected rivers.

2.2. SUSTAINABLE DIVERSION LIMIT

The Water Act describes the Sustainable Diversion Limit (SDL) as the maximum long-term annual average quantities of water that can be taken, on a sustainable basis, from the Basin water resources as a whole, or any particular part of it. The SDL must reflect an environmentally sustainable level of take.

2.3. ENVIRONMENTAL WATER REQUIREMENTS

Environmental water requirements (EWRs) describe the amount of water required to keep an environmental asset maintained in a desired condition. EWRs specify the water regime required to achieve particular ecological conditions or outcomes. In the proposed Basin Plan this is expressed as either a volume or flow rate, which is associated with a desired frequency as well as a duration for particular events. Several EWRs may exist for each asset, targeting different elements of the ecosystem. For floodplain assets, the river flow rate is directly related to the extent of inundation that is required.

The Riverland–Chowilla Floodplain is one of two key environmental asset hydrologic-indicator sites in South Australia used by the MDBA analysis and modelling for the proposed Basin Plan. The MDBA has

[1] Baseline conditions are similar to current conditions. Recent operational and water sharing changes may not be represented in baseline conditions.

stated the assumption that the Riverland–Chowilla Floodplain hydrologic indicator site represents the River Murray floodplain between its junction with the Darling River and Lower Lakes.

Environmental water requirements have been developed for the Riverland–Chowilla Floodplain by the MDBA. South Australia has provided additional advice to the MDBA on EWRs relevant to the Riverland–Chowilla site (DWLBC 2010) and these are referred to as the SA EWRs. Overall, both sets of EWRs are aimed at providing a range of flows that promote ecosystem functions and deliver inundation of wetlands and habitats. An explanation of the MDBA EWRs is contained in the MDBA report *The proposed "environmentally sustainable level of take" for surface water of the Murray-Darling Basin: Methods and outcomes* (MDBA 2011b), South Australian EWRs are described in the South Australian government report *Preliminary Review of the Murray-Darling Basin Authority Environmental Water Requirements set for South Australian sites* (DWLBC 2010), while the report prepared by the Goyder Institute for Water Research as part of their review of the Guide to the Basin Plan, *Analysis of South Australia's environmental water and water quality requirements and their delivery under the Guide to the proposed Basin Plan* (Pollino *et al* 2011) contains a description of both MDBA and South Australian EWRs. The Goyder Institute reviewed both the MDBA and the South Australian EWRs and considered the South Australian EWRs to be more representative (CSIRO 2011), due to their inclusion of additional assets and values such as bird breeding.

The MDBA EWRs have been used in the MDBA modelling process to develop an environmental water demand time series for the Riverland–Chowilla site. The MDBA have also developed a set of key ecosystem function targets for sites along the Murray in South Australia which are typically lower-flow targets, such as baseflows and freshes. Key ecosystem function targets have not been assessed in this report.

The targets and EWRs are made up of several components:

1. An objective or target – most objectives relate to a desired condition or outcome and are quantified in terms of proportion of habitat (e.g. red gum forest/woodland) to be maintained and/or improved, unless the objective relates to an ecosystem function (e.g. provide access to the floodplain for spawning). In general, targets that relate to habitat are to maintain and/or improve 80% of a particular vegetation community consistent with the Ramsar limits of acceptable change (Newall *et al* 2009).

2. The EWR metrics – generally specify required duration and frequency of inundation, timing and maximum interval between inundation events. Together these metrics describe the flow regime required by the taxa or habitat in order to support the desired condition or the hydrological conditions needed to trigger a function (e.g. spawning)

3. A flow rate – for the majority of the targets, the flow rate is a surrogate for a certain extent of inundation and relates to the proportion of habitat identified within the target. Exceptions to this statement are EWRs associated with floodplain functions and in-channel habitat.

A key assumption of the approach used for developing the SDL is that the environmental water requirements of the hydrologic indicator sites are representative of the water requirements of the whole reach; in this case, the water requirements of the Riverland–Chowilla indicator site are representative of the River Murray floodplain between the Darling River and Wellington.

2.4. MODELLING SCENARIOS

A range of water recovery and delivery scenarios have been modelled by the MDBA in the course of developing the proposed Basin Plan, These scenarios are detailed below, as described in MDBA (2012).

1. **Baseline conditions**
   Baseline conditions represents the Basin development, water use and water sharing arrangements as at June 2009. It is similar to current conditions and includes environmental water already recovered for The Living Murray and Water for Rivers for the Snowy Rivers. However, it doesn't include several other existing or proposed Commonwealth environmental water recovery programs. The modelled time series represents usage and water delivery patterns over 114 years of climate and catchment inflows if constant June-2009 development and water sharing arrangements had been in place for the whole time period.

2. **Without development conditions**
   The without development conditions models the Basin with all current diversions and development removed, such as dams and weirs. The modelled-flow time series is similar to natural conditions over the 114 years of climate and catchment inflows. However, the scenario does not take into account changes to land use and the consequent alteration of catchment runoff, so is not necessarily a true representation of natural conditions.

3. **Proposed Basin Plan 2750 GL scenario**
   The proposed Basin Plan 2750 GL scenario represents a reduction in current diversions of 2750 GL across the Basin, assuming current water sharing and operational arrangements. Of the 2750 GL, 400 GL has been recovered from the northern Basin (the Darling catchment upstream of Menindee Lakes), with the remaining 2350 GL recovered from the southern Basin. The proposed Basin Plan has specified volumes to be recovered for each region (described as in-valley reductions) as well as shared reductions across northern and southern connected systems. The models have had to incorporate assumptions regarding how the shared reduction will be distributed amongst regions, as well as the type of licence recovered. The Pick-a-Box tool has been used to schedule environmental flow delivery (described in Section 4.2.2).

4. **2400 GL and 3200 GL scenarios for sensitivity analysis**
   The proposed Basin Plan 2400 GL and 3200 GL scenarios were run by the MDBA to demonstrate the sensitivity of the model outputs to variations in the total amount of environmental water recovered. Similar to the 2750 GL scenario, the models assume current water sharing and operational arrangements. The Pick-a-Box tool was also used as part of the modelling process.

5. **2800 GL scenario**
   The 2800 GL scenario was modelled by the MDBA prior to the release of the proposed Basin Plan in November 2011. It is identical to the 2750 GL scenario, apart from the recovery of an extra 50 GL from the northern Basin. The environmental flow demands applied in Pick-a-Box are the same as the 2750 GL scenario. The impacts to South Australia of the change to the total recovered volume are discussed in Section 5.3.

6. **Guide to the Basin Plan 3000 GL, 3500 GL and 4000 GL scenarios**
   The Guide to the Basin Plan modelling scenarios were undertaken by the MDBA in late 2010. The modelling approach and assumptions used by the MDBA have been considerably modified subsequent to the modelling of the Guide scenarios, as described in Section 4. Outcomes from these scenarios are presented for information only and do not demonstrate the likely outcomes from the recovery of 3000 GL, 3500 GL or 4000 GL under the current modelling framework.

DEFINITIONS AND MODELLING SCENARIOS

Note that the analyses contained in this report relate to specific scenarios as described by MDBA model run numbers listed in Section 5.1. The MDBA may revise their modelling of these scenarios in the future which could produce different outcomes.

3. STUDY AREA

For the purposes of this analysis, the South Australian River Murray floodplain is defined as the area within the 1956 flood boundary minus permanent water, minus lower Murray irrigated pastures and covers a total area of 80,042 ha. The SA River Murray floodplain can be further divided based on geomorphology. In its 2225 km course from the Hume Dam to the Southern Ocean, the River Murray traverses five distinct geomorphic regions (Eastburn 1990 in MDBC 2005), three of which occur in South Australia:

- The Valley (or Mallee Trench) – extends from the Wakool junction in the Swan Hill region of Victoria for 850 river kilometres to Overland Corner in South Australia. It is characterised by a wide floodplain up to 10 km in width and a meandering river with many anabranches, wetlands and deflation basins.

- The Gorge – covers a river distance of about 280 km, from Overland Corner to Mannum. The river and floodplain are constrained to a 2–3 km wide corridor within a deep limestone gorge. The channel is characterised by long straight reaches and short angular sections. The section of floodplain between Mannum and Wellington is not included in this analysis since it has been highly modified, with the majority of the area isolated from the River by levee banks and converted to irrigated pasture. Very little natural floodplain habitat remains in this reach.

- The Lower Lakes and Coorong – incorporates Lakes Alexandrina and Albert, the Coorong and the Murray Mouth. The distance from Wellington to the Mouth is 73 km. The Lower Lakes, Coorong and Murray Mouth is a separate hydrological indicator site for the MDBA. It is the focus of a separate ecological assessment by Heneker and Higham (2012).

Hydraulic conditions and habitat vary between these regions as they are largely determined by the shape of the river channel and its interaction with geomorphic processes such as sediment erosion, transport and deposition. Variations in flow interact with geomorphology (e.g. elevation, sill levels) to control longitudinal and lateral connectivity, resulting in different areas being inundated and exposed at different times. The spatially and temporally dynamic habitats created maintain the biodiversity and ecosystem processes that are characteristic of the SA floodplain ecosystem (Wallace, 2011).

The Riverland–Chowilla indicator site recognised by the MDBA for the purpose of the Basin Plan incorporates the Chowilla floodplain and the Riverland Ramsar site. Areas outside of Chowilla that are part of the Riverland Ramsar site include the Calperum floodplain area, Ral Ral anabranch and Murtho floodplain area. The SA EWRs were developed based on data from Pike and Katarapko floodplains (see DWLBC, 2010) and applied to Riverland–Chowilla. Pike and Katarapko floodplains are frequently recognised priority floodplain assets within SA. They represent three of the largest and most diverse floodplain complexes within the region. All three are located within the valley geomorphic reach.

The primary spatial scale used for the ecological analysis was the entire SA RM floodplain. Where possible, comparisons between geomorphic reaches and against the Riverland–Chowilla indicator site were also undertaken. The Mannum to Wellington reach has not been separately analysed, although the remnant native vegetation fringing the irrigated pastures and the limited remaining natural wetland areas have been included in the figures for the broader SA RM floodplain.

The locations of the South Australia hydrologic indicator sites are shown in Figure 1.

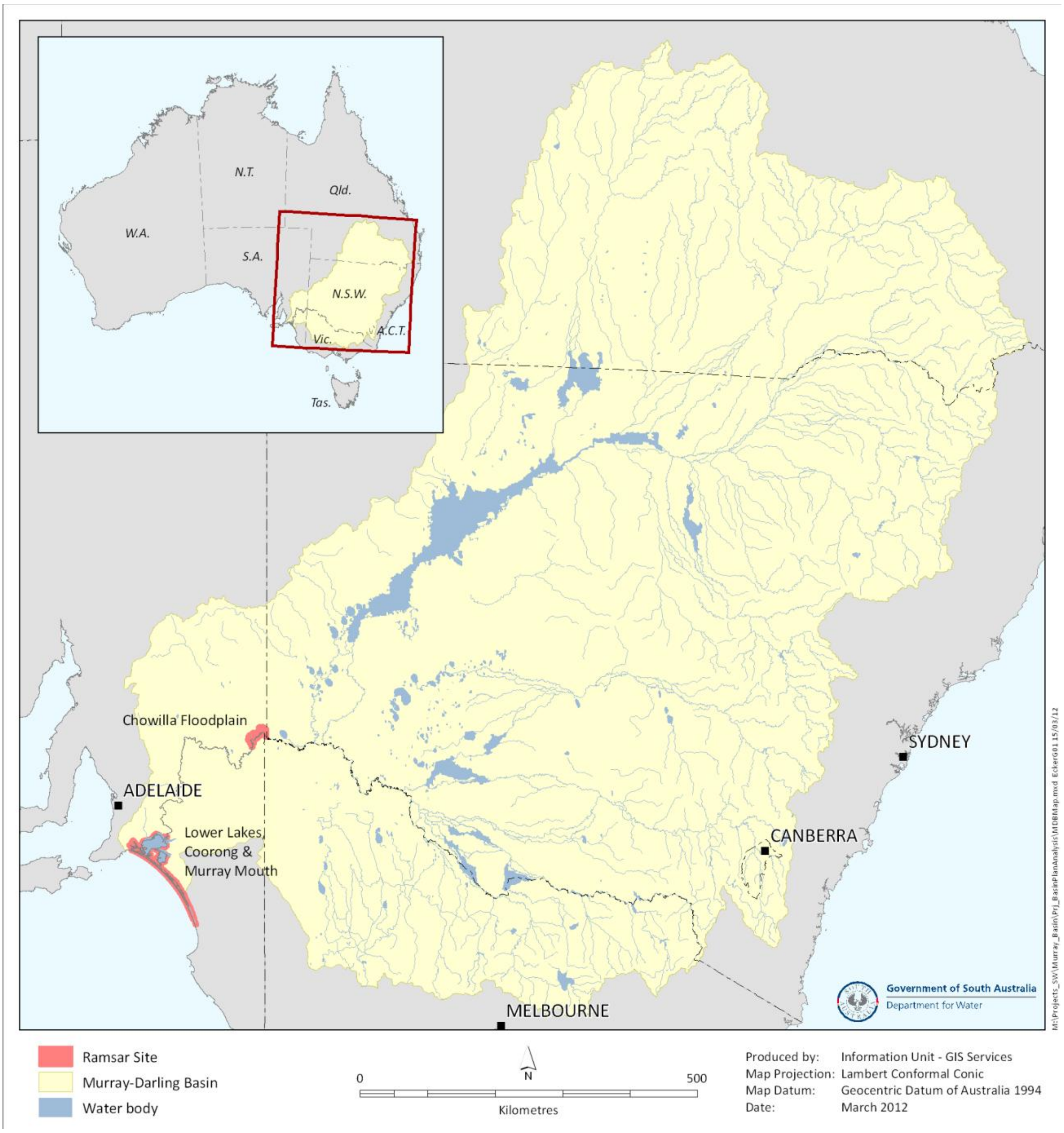

Figure 1. Location of South Australian hydrologic indicator sites

4. MDBA MODELLING APPROACH AND ASSUMPTIONS

4.1. THE GUIDE TO THE BASIN PLAN

4.1.1. DETERMINATION OF SUSTAINABLE DIVERSION LIMITS AND ENVIRONMENTALLY SUSTAINABLE LEVEL OF TAKE

The Guide to the Basin Plan was released in October 2010. The approach adopted by the MDBA in determining the SDL has been described in MDBA (2010b) and Pollino *et al* (2011). It is briefly summarised here to provide context for the analysis, as well as assisting in understanding how the modelling has been used, its limitations and what useful information it may provide.

As described in the Guide (MDBA 2010b), the MDBA used an analytical approach to calculate a volume of 7600 GL required to return the Basin to good environmental health. Good environmental health was considered to be achieved by returning end-of-system flows in the range of 60 to 80% of undeveloped flows. This is depicted in Figure 2.

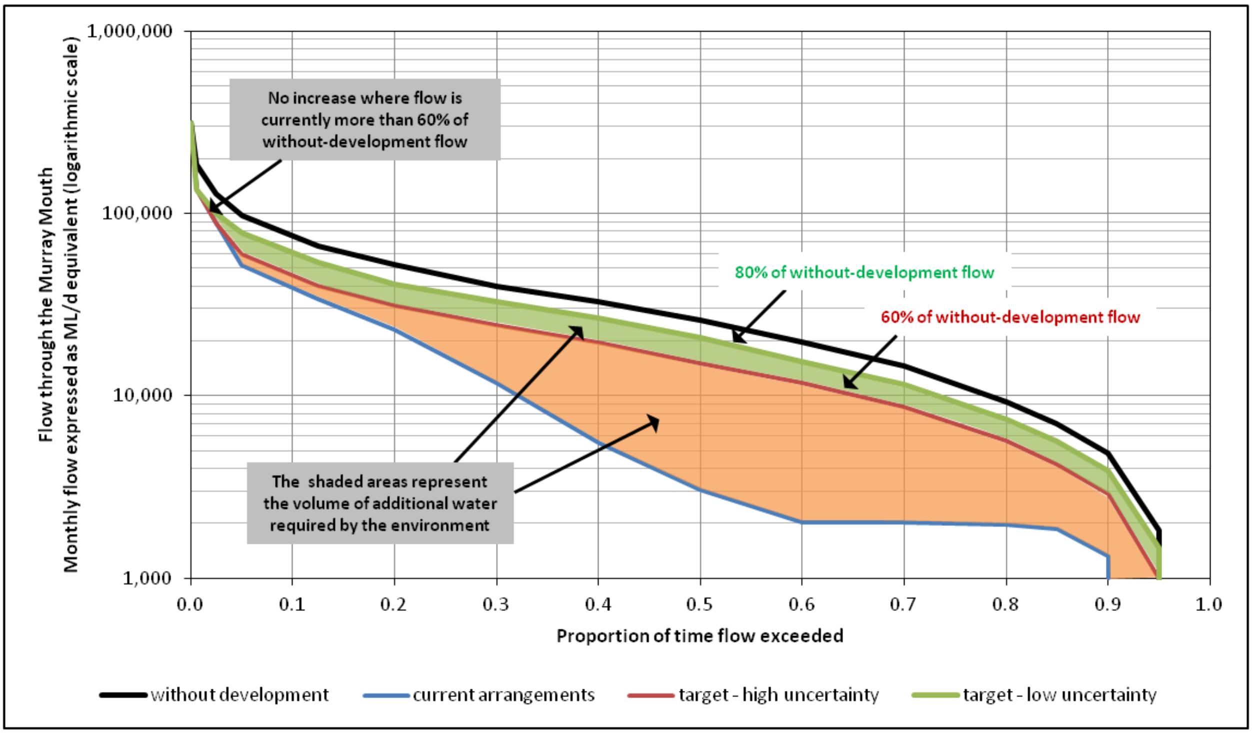

Figure 2. Analytical flow duration curve approach to determining the SDL (reproduced from MDBA 2010b, p. 111)

In consideration of the social and economic effects in the Basin, the Guide recommended a Sustainable Diversion Limit (SDL) with reductions ranging from 3000 GL to 4000 GL from current use. Using end-of-system flow analysis, this was concluded to improve the environmental health of all valleys in the Basin, although some, such as the Murray Valley, were still rated as poor under the 3000 GL scenario (MDBA 2010a).

4.1.2. MODELLING FOR THE GUIDE TO THE BASIN PLAN

SDLs proposed by the Guide were determined based on a simple end-of-system flow analysis across 19 locations in the Basin (MDBA 2011b). Hydrological models were in development at the time of the preparation of the Guide, however, due to technical and time limitations, SDLs were proposed without input from hydrological models (MDBA 2011b).

Modelling of the Guide scenarios was completed soon after the release of the Guide in early 2011. Modelling of the Basin was undertaken using the Integrated River System Modelling Framework (IRSMF) developed by CSIRO for the Murray-Darling Sustainable Yields Project. The IRSMF links together the twenty-four separate river system models of the Murray-Darling Basin into a consolidated modelling tool (see Figure 2). This framework was first developed by CSIRO through their Murray-Darling Sustainable Yields project (MDBA 2012).

Note that while the models are linked together in the IRSMF, there are still significant limitations in how the models work together. For example, the IRSMF isn’t able to supply demands for water in the Murray system by calling on water from tributaries such as the Murrumbidgee and Goulburn.

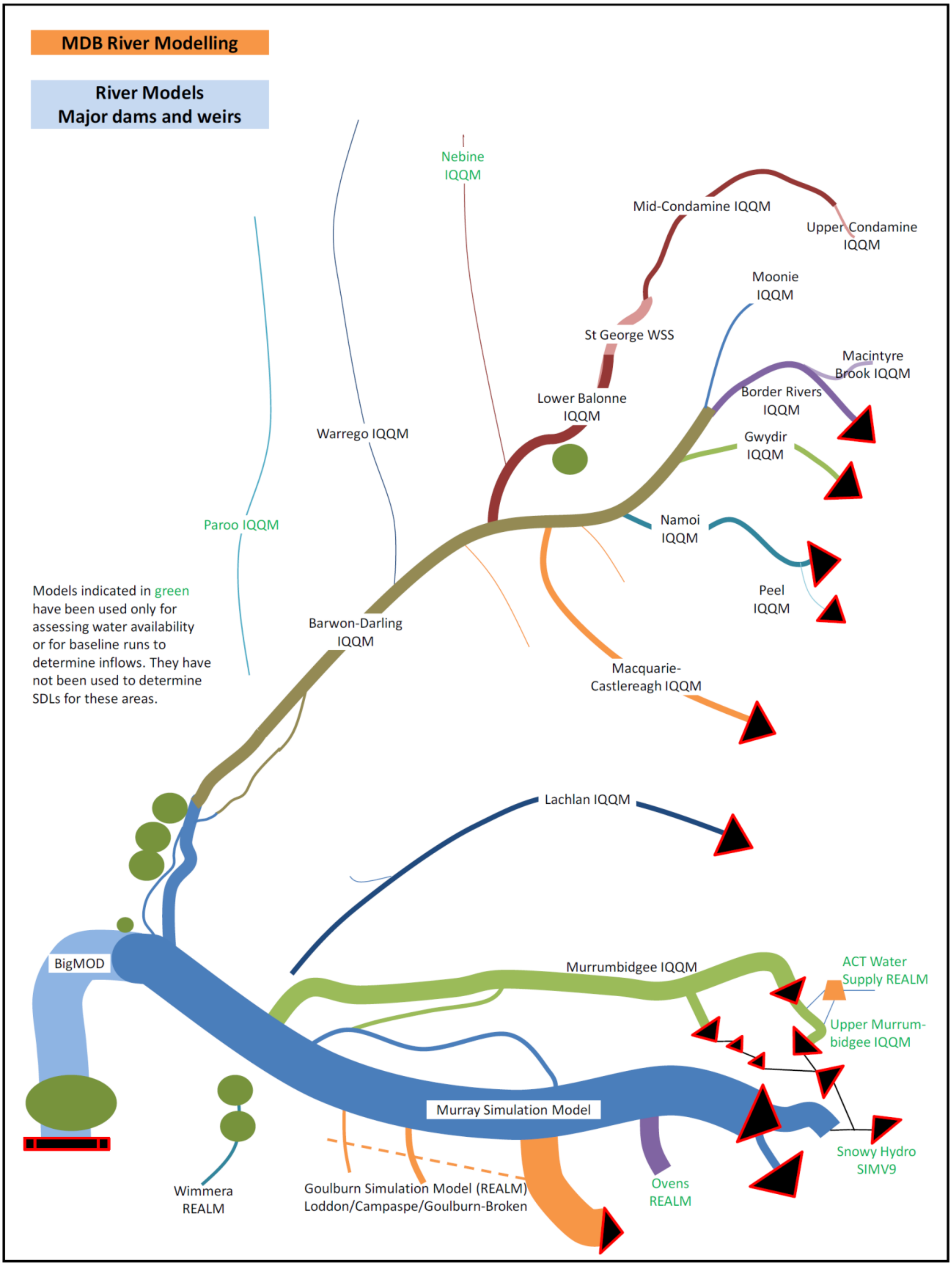

Figure 3. **Conceptual diagram of Integrated River System Modelling Framework of Murray-Darling Basin (MDBA 2012 p. 5)**

As described previously, it is important to note that the hydrological modelling did not directly inform the setting of the 3000, 3500, 4000 or 7600 GL water recovery volumes (these were developed using end-of-system flow analysis). Rather, the modelling was used to test how the recovered water might be delivered to key environmental assets and which of the environmental water requirements could be met. The MDBA has described this as the difference between 'Push and Pull' modelling (2011d), where 'Push' is modelling to inform the SDL and 'Pull' is modelling to assess what can be achieved with a given SDL. The hydrologic modelling for both the Guide and the proposed Basin Plan has utilised the 'Pull' approach.

4.2. THE PROPOSED BASIN PLAN

4.2.1. APPROACH

The Australian Government's commitment to 'Bridge the Gap' to achieve the SDLs set out in the Basin Plan through water purchase and infrastructure programs (MDBA 2011e) has impacted the way that environmental water is recovered and used in the Murray-Darling Basin. Considerable work has gone into revising the hydrological models since the release of the Guide to reflect these changes.

The two significant policy changes that affect hydrological modelling of proposed Basin Plan scenarios are (MDBA 2011d):

- The Australian Government's commitment to 'Bridge the Gap' through buying back entitlements from willing sellers in order to meet SDLs, in combination with infrastructure and efficiency programs. This means that recovered environmental water will now have the same characteristics as irrigation entitlements.
- A commitment by the Australian Government Minister for Water that remaining irrigator water access rights would not be compromised as a result of the Basin Plan. In other words, their existing reliability will be maintained.

While the 'Bridge the Gap' commitment describes both water purchases and water-saving infrastructure to meet the SDLs described in the proposed Basin Plan, the modelling approach to date appears to only simulate meeting the proposed SDLs through water recovery, that is, through water purchases.

The ESLT and SDLs in the proposed Basin Plan have been informed by hydrological modelling (MDBA 2011b). Similar to the Guide and the 'push' approach described previously, hydrological modelling of environmental demands has not been directly used to determine the magnitude of the SDL. The MDBA has described the approach as the indicator site method, which uses the hydrological modelling to test the environmental outcomes of a nominated SDL rather than being used to determine what is required. The MDBA has promoted this approach as being able to take into account not only the ecological targets and flow requirements of indicator sites, but also opportunities and constraints for environmental water delivery. This approach for determination of the SDL has also been described as being based on 'multiple lines of evidence', as it can include input from other environmental studies, as well as social and economic considerations (MDBA 2011b).

4.2.2. MODELLING FOR THE PROPOSED BASIN PLAN

Major changes to the modelling supporting the proposed Basin Plan are described below. While some reflect policy changes, others have been implemented due to additional time available to refine techniques.

1. Modelling of recovered water as Held Environmental Water

   The buyback announcement by the Australian Government has led to significant revisions to the hydrological models. Modelling undertaken for the Guide to the Basin Plan represented the recovered environmental water as planned[2] environmental water, which was prioritised over water held for entitlements. Following the policy changes, modifications were made so that the recovered water is represented as held[3] environmental water rather than planned environmental water. For many of the valley models, particularly the IQQM models in NSW, this has required makeshift changes to the models to incorporate an Environmental Water Account, since time limitations would not have allowed the model network to be significantly revised to represent the account properly. In theory, the recovered environmental water will have the same characteristics as irrigation entitlements, which is how it has been represented in the models.

2. Environmental Event Selection Tools

   Another major revision to the modelling by the MDBA is the introduction of Environmental Event Selection Tools, which include a semi-analytical spreadsheet-based tool referred to as Pick-a-Box (MDBA 2011f). These tools are designed to improve coordination and efficiency of watering events across multiple sites and valleys in the Basin and overcome some of the deficiencies of the IRSMF, such as passing demands upstream into valleys such as the Murrumbidgee and Goulburn. Use of the Environmental Event Selection Tools is an interactive process where the modeller manually selects and schedules which flow events to deliver to hydrologic indicator sites using available water from the environmental water account.

3. Modelling of additional environmental flow demands

   Revisions to the hydrological models have enabled additional environmental watering requirements (EWRs) to be included, such as base flows and freshes. However, certain high flow demands, such as the 100 000 ML/day and 125 000 ML/day demands for Chowilla and 120 000 ML/day and 150 000 ML/day demands for Hattah Lakes, are no longer present as demands in the model in recognition that these events are predominantly met by unregulated (flood) events with little operational control. These EWRs are still retained as targets and indicators of ecological health for these key environmental assets.

4.2.3. KEY DIFFERENCES BETWEEN MODELLING FOR THE GUIDE TO THE BASIN PLAN AND THE PROPOSED BASIN PLAN

As described previously, policy changes since the release of the Guide have significantly changed the way in which it is expected that environmental water will be recovered and distributed within the Basin. Previous analysis relating to the delivery of EWRs undertaken for the Guide scenarios, such as that contained within the Goyder Institute '*Science review of the implications for South Australia of the Guide to the proposed Basin Plan*' (CSIRO, 2011), is not therefore directly comparable to the proposed Basin

2 Planned environmental water is water that is preserved for environmental purposes by a State law or instrument and is typically delivered according to certain rules and triggers. An example is the Barmah-Millewa Environmental Water Allocations (MDBA 2010b).

3 Held environmental water is water for environmental purposes that is made available under a water access, delivery or irrigation right.

Plan. The recovery and use of 2750 GL is very different to that of the Guide scenarios and much of the analysis and interpretation contained in CSIRO (2011) can be directly applied to support analysis of the proposed Basin Plan, for example, the impact of increased environmental water on delivery of EWRs and the role of operations and constraints.

The changed handling of recovered environmental water from planned to held, in combination with the requirement to have no effect on irrigator reliability, has changed the annual distribution of delivery of environmental water, as shown in Figure 4 (note that only the delivery of recovered environmental water is shown; the total volume delivered would also include unregulated flows). While this figure relates to the proposed Basin Plan 2400 GL scenario (the figure for the 2750 GL or 2800 GL scenarios was unavailable), it is expected that the overall pattern for the 2750 GL is similar.

In Figure 4, the upper graph demonstrates the delivery of environmental water as modelled by the Guide method, where the recovered water is categorised as planned environmental water. As planned water, the delivery is quite variable from year-to-year, ranging from zero in many years to greater than 9000 ML in a single year. (Note that only the delivery of recovered environmental water is shown; the total volume delivered to meet EWRs would also include unregulated flow which is not shown here). This is because planned water is able to be held in storage on an inter-annual basis and delivered according to the EWR demand sequence, which may not require water every year. In contrast, the lower graph demonstrates the delivery of recovered water as held environmental water as modelled for the proposed Basin Plan. It can be seen that the delivery of environmental water stays fairly constant across all years, despite the variable climate and environmental demands of the system. This indicates that as held environmental water, there is less flexibility to manage, store and distribute environmental water inter-annual to meet climatic variations in the Basin.

Modelling for the Guide scenarios did not include operational constraints, so delivery of higher flow EWRs were likely to have been over-represented. Also, Guide modelling prioritised environmental demands over entitlements, meaning that allocations would have been impacted, particularly in years of low water availability and the years immediately following these (when many demands would be sought). The Guide modelling was also only able to order and supply River Murray EWRs from River Murray storages, such as Hume and Dartmouth, since there were no mechanisms to supply demands from other valleys.

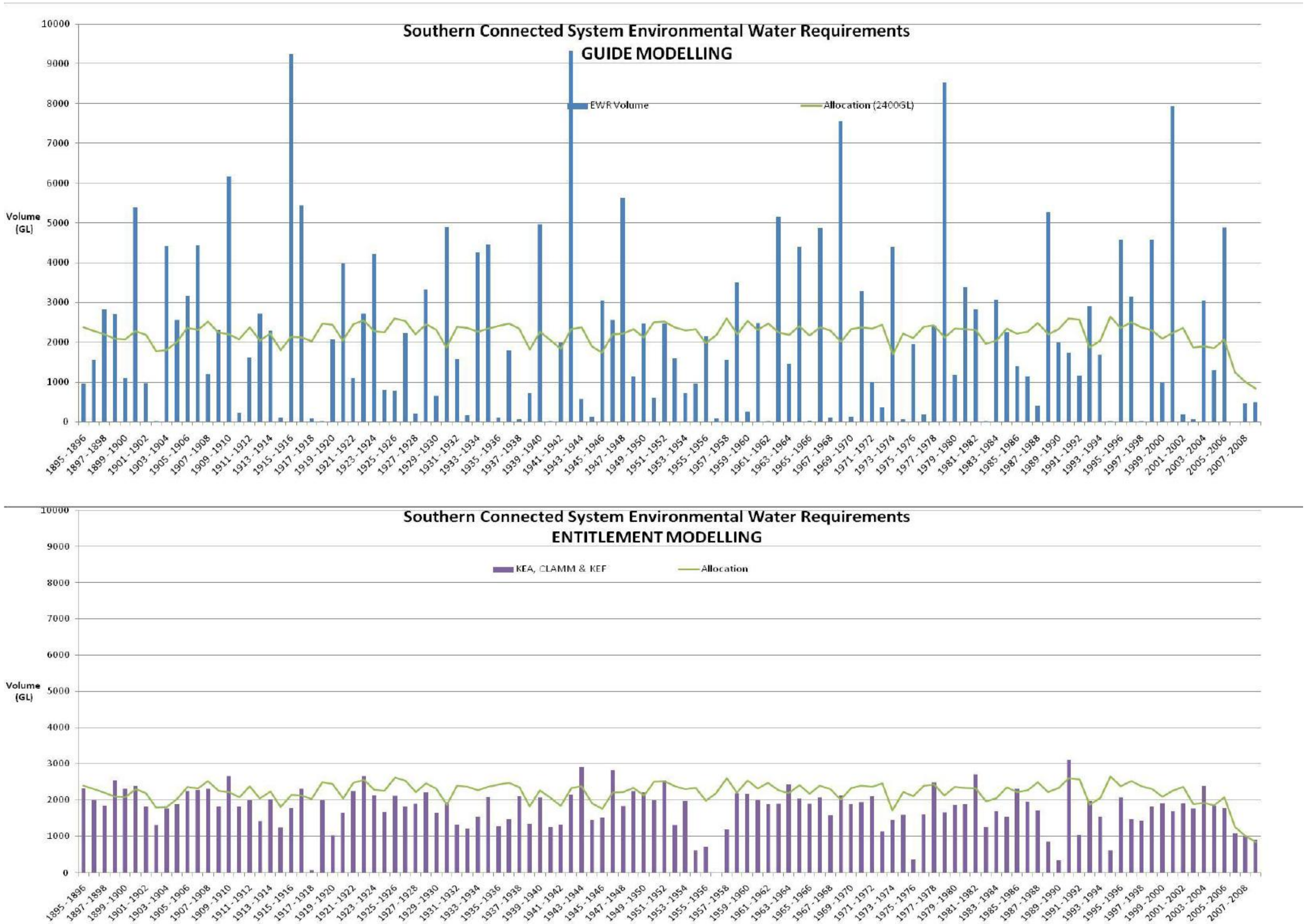

Figure 4. **Delivery of Environmental Water under 2400 GL Scenario (MDBA 2011d)**

5. WATER DELIVERY TO SOUTH AUSTRALIA BY BASIN PLAN SCENARIOS

5.1. DESCRIPTION OF DATA AND ANALYSIS METHODS

Modelling of the proposed Basin Plan scenarios has been undertaken by the MDBA using the IRSMF, a modelling tool that links together individual Murray-Darling Basin valley models developed by state agencies and the MDBA (MDBA 2012). The IRSMF, in conjunction with iterative analysis of environmental water delivery using the Environmental Event Selection Tools, enables the MDBA to undertake modelling of whole-of-Basin scenarios for the proposed Basin Plan. The IRSMF is run for the period 1 July 1895 to 30 June 2009 and consequently incorporates both extended dry periods (such as the Federation and Millennium Droughts) and wet periods (the floods of the 1950s and 1970s). This allows river management decisions to be tested against a range climatic conditions (MDBA 2012).

MSM-BIGMOD is the hydrologic model used to simulate flows and salinities in the Murray system from the Dartmouth Dam to the Barrages and Coorong in South Australia and including the Lower Darling downstream of Menindee Lakes (MDBC 2002). The model incorporates water resources infrastructure, policies, water sharing arrangements, diversions and river operations. Flow, water level and storage volume can be simulated for numerous river, reservoir and diversion locations within the model. In addition, salinity (expressed in units of electrical conductivity) can be calculated for the period 1 January 1975 to 30 June 2009.

The MDBA supplied DFW with MSM-BIGMOD outputs for the following scenarios on 6 December 2011:

- Baseline – Run #845
- 2750 GL – Run #865
- Without development – Run #844
- 2400 GL – Run #859
- 3200 GL – Run #863
- 2800 GL – Run #847

In addition, the Pick-a-Box spreadsheets for the southern connected system were provided for the 2400 GL, 2800 GL and 3200 GL scenarios. The 2800 GL Pick-a-Box spreadsheet is also relevant to the 2750 GL scenario since the same environmental demand sequences were used for both model runs.

DFW has previously obtained MSM-BIGMOD outputs for the Guide 3000 GL, 3500 GL and 4000 GL scenarios via the Goyder Institute for Water Research. These runs were provided by the MDBA on 22 January 2011, created using model Version – 1 November 2010 (run numbers were not provided to DFW).

The MSM-BIGMOD outputs provided were in the form of large text files which contained daily values (flow, level, storage, salinity) for the modelled period 1 July 1895 to 30 June 2009 (114 years in total). All analysis undertaken for this report (with the exception of salinity analysis in Section 9) has been based on daily outputs of river flow for the full modelled period of 1895–2009. No analysis was undertaken with monthly model outputs.

5.2. ANALYSIS OF FLOW AND VOLUME DELIVERED TO SA

River Murray flow entering South Australia at the South Australia–New South Wales–Victoria border is represented in MSM-BIGMOD by the output *Flow to SA*. Within South Australia, discharges from tributaries of the River Murray are typically minor in comparison to the mainstream River Murray flow. Consequently, *Flow to SA* is considered representative of the total water available for environmental flow and diversions. Statistics relating to *Flow to SA*, baseline and without development conditions are presented in Table 1. The statistics indicate that water delivered to South Australia is significantly increased under the 2750 GL scenario, with an additional average volume of 1816 GL per year compared to baseline conditions. This represents an increase from 52% to 66% of the without development volume. Flow rates entering South Australia are also improved across all measures, particularly in the lower flow range, represented by the 10th percentile statistic.

Table 1. Flow to SA statistics

Statistics	2750 GL Scenario	Baseline Conditions	Without Development Conditions
Annual Volume (GL)			
Mean	8408	6592	12 796
Median	7174	4762	11 624
Minimum	2005	1027	1531
Maximum	42 210	40 897	46 195
10th Percentile	3372	2382	6126
90th Percentile	13 377	11 298	19 294
Flow (ML/day)			
Mean	23 020	18 048	35 035
Median	13 404	9490	25 600
Minimum	765	724	7
Maximum	276 545	270 459	287 864
10th Percentile	5177	3975	6368
90th Percentile	53 525	44 093	73 690

The frequency distributions of annual volume and daily flow to South Australia are shown in Figure 5 and Figure 6, respectively. The annual volume of flow to South Australia is increased across all frequencies, most markedly in the middle range of volumes. For example, the median volume (50% chance of exceedance) under the 2750 GL scenario is 7174 GL, which under baseline conditions was only met in 32% of years. The daily frequency of *Flow to SA* is similarly increased across most flow bands, however, it can be seen that the frequencies converge for flows greater than approximately 80 000 ML/day, indicating that the 2750 GL scenario does not increase the occurrence of very high flows. The middle range of flows is also most affected by the 2750 GL scenario; the exceedance of 10 000 ML/day increases from 46% to 60% of days, while exceedance of 20 000 ML/day increases from 25% to 38% of days.

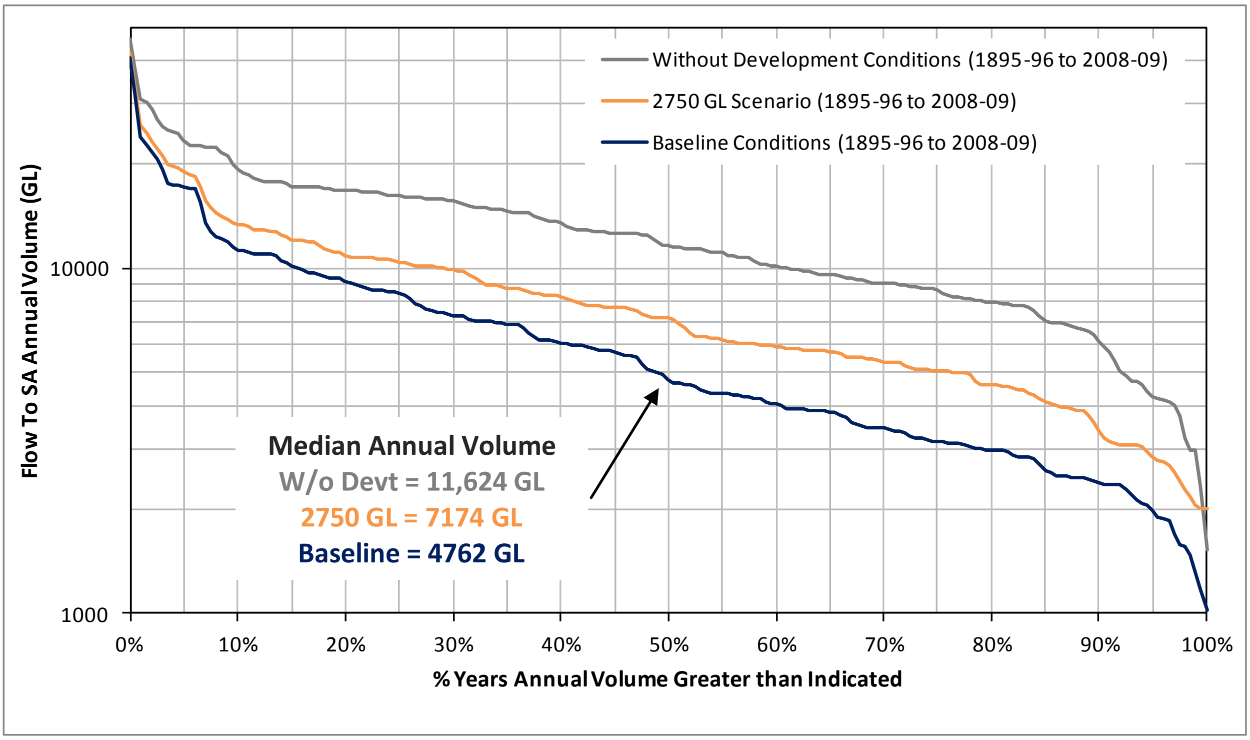

Figure 5. **Frequency Distribution of Annual Volume to South Australia – Baseline Conditions vs. 2750 GL scenario and Without Development Conditions (1895–96 to 2008–09)**

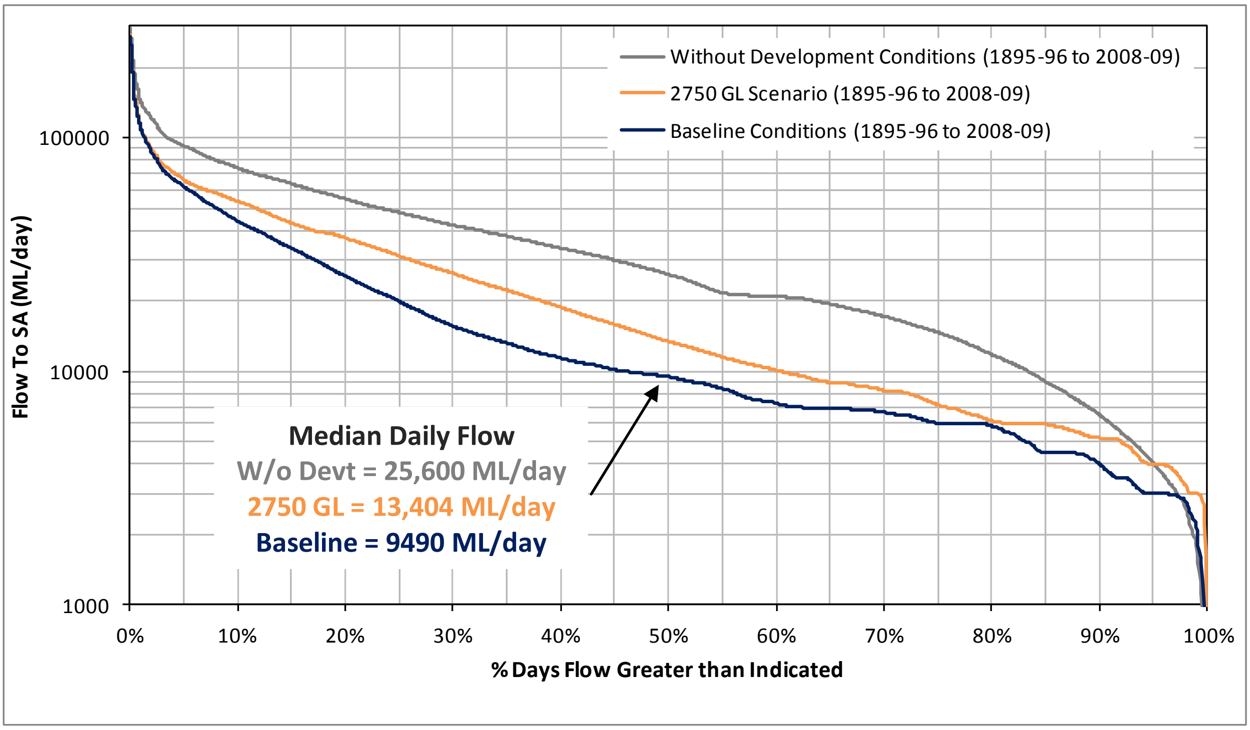

Figure 6. **Frequency Distribution of Daily Flow to South Australia – Baseline Conditions vs. 2750 GL scenario and Without Development Conditions (1895–96—2008–09)**

The additional volume delivered to South Australia over the modelled period of 1895 to 2009 is shown in Figure 7. The additional volume provided under the 2750 GL scenario is variable around a mean of 1816 GL, although reasonably consistent across all years, ranging from a minimum of 275 GL to a maximum of 3300 GL. In the drought years of 2006 to 2009, the additional volume delivered under the 2750 GL scenario is reduced to between 465 GL and 965 GL per year. This is due to a reduced amount of overall available water in the system, which reduces allocations and consequently the available volume of held environmental water. However, in relative terms, the amount is significant, representing an increase of 30% to 95% of baseline annual volume.

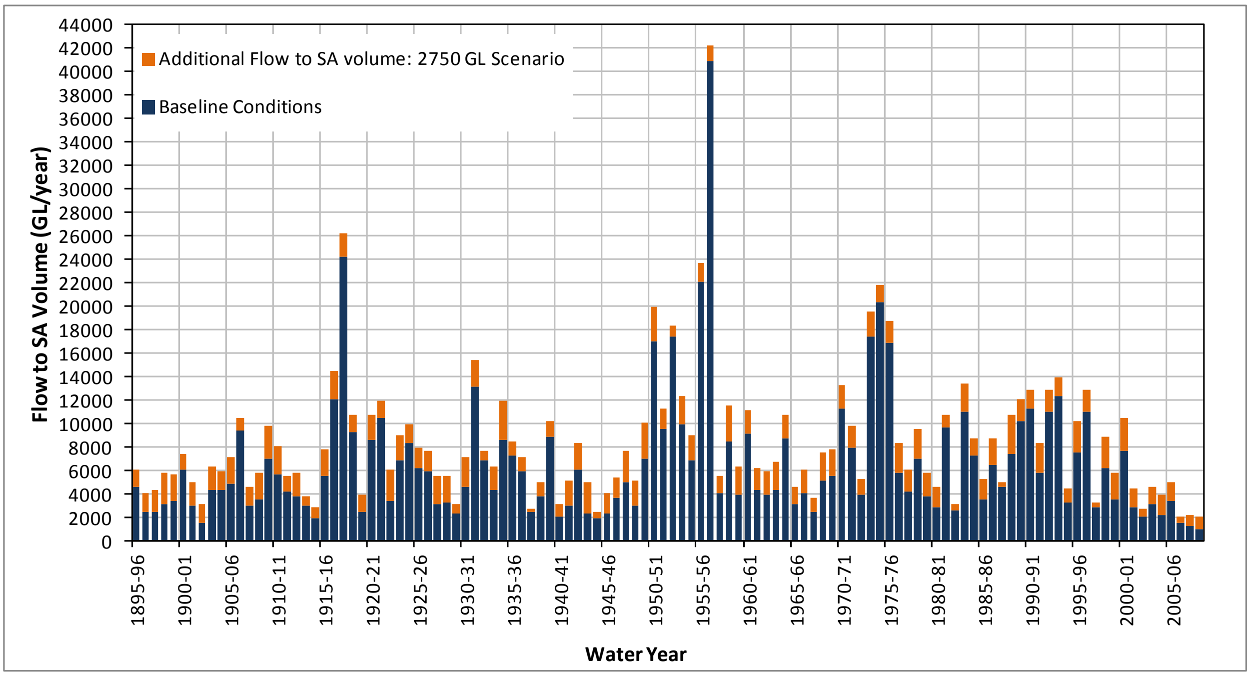

Figure 7. Additional Annual Flow to SA volume from 2750 GL scenario

In Figure 8, the frequency distributions for *Flow to SA* for the without development and the proposed Basin Plan 2750 GL scenarios have been plotted with curves representing 60% and 80% of without development flow, similar to the analytical approach for determining environmental water requirements used in the Guide (as shown in Figure 2). According to this method of analysis, it would appear that the shortfall in the volume of water for the environment occurs in the middle range of flow bands, that is, in the range of around 6000 ML/day to 25 000 ML/day. However, as demonstrated later in this report, environmental water requirements relating to higher flow bands are at risk under the proposed Basin Plan. This highlights the deficiencies of this simplistic approach for calculating SDLS, as used in the Guide.

At the lower end of the flow range, for flows less than 4000 ML/day, the proposed Basin Plan 2750 GL scenario exceeds both baseline and without development conditions. The increased provision of these lower flows is due to the focus by the MDBA on providing the full spectrum of environmental flows (baseflows, freshes and overbank), as well as improved delivery during drought years. While periods of zero flow were a natural occurrence for the undeveloped River Murray in South Australia, this is no longer viable from a water supply, industry or ecological perspective due to its current highly regulated state.

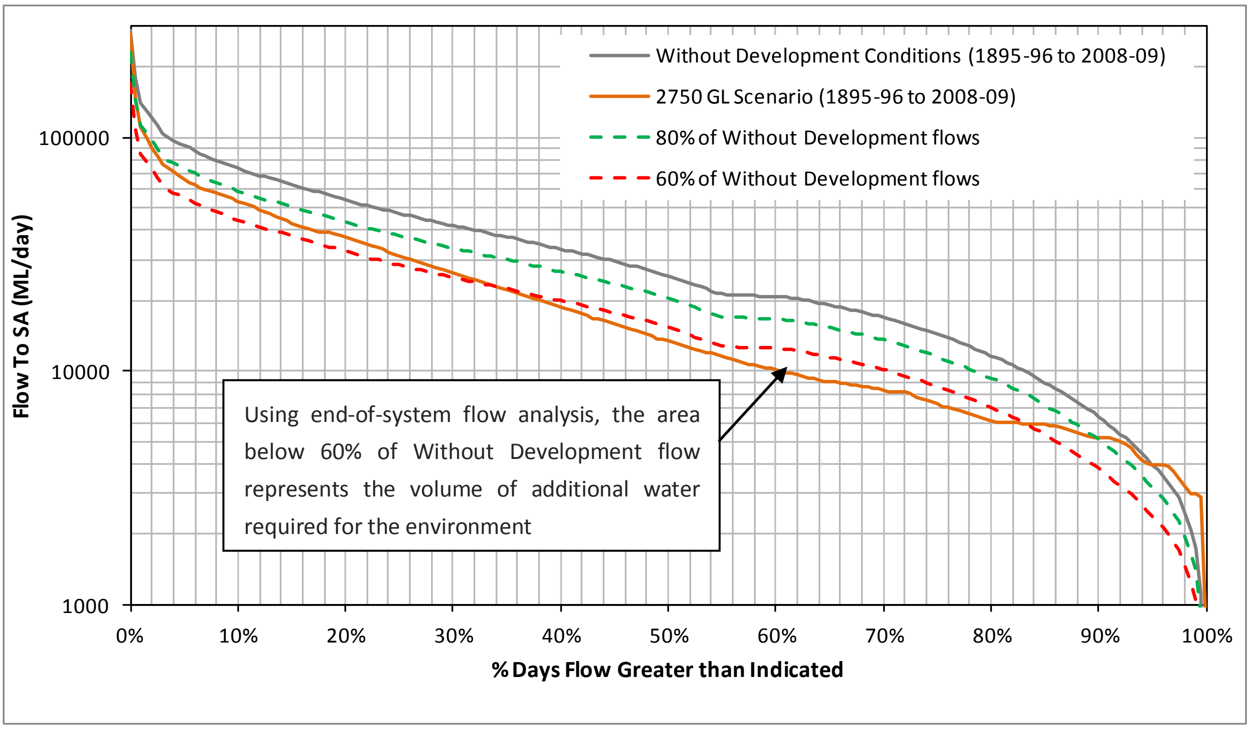

Figure 8. Frequency Distribution of Flow to SA plotted against 60% and 80% of Without Development Flow (1895-96—2008–09)

To demonstrate how events have been modelled and delivered, the last three decades of daily flow data for *Flow to SA* are shown in Figure 9, Figure 10 and Figure 11. The graphs illustrate how environmental water has been delivered to enhance both high and low flow events. In particular, it can be seen that there is an improvement in the minimum flow delivered to South Australia during the drought periods of 2006–09 compared to baseline conditions. Furthermore, there appears to be little improvement in delivery of events greater than around 80 000 ML/day, which is consistent with interpretations from the frequency distribution plot of daily flow.

In reality, the actual delivery of high flow events will be dependent on the operation of the Commonwealth Environmental Water Holder, State Environmental Watering Plans and Water Resource Plans and river operating rules and policies. These and other uncertainties are discussed further in Section 10.

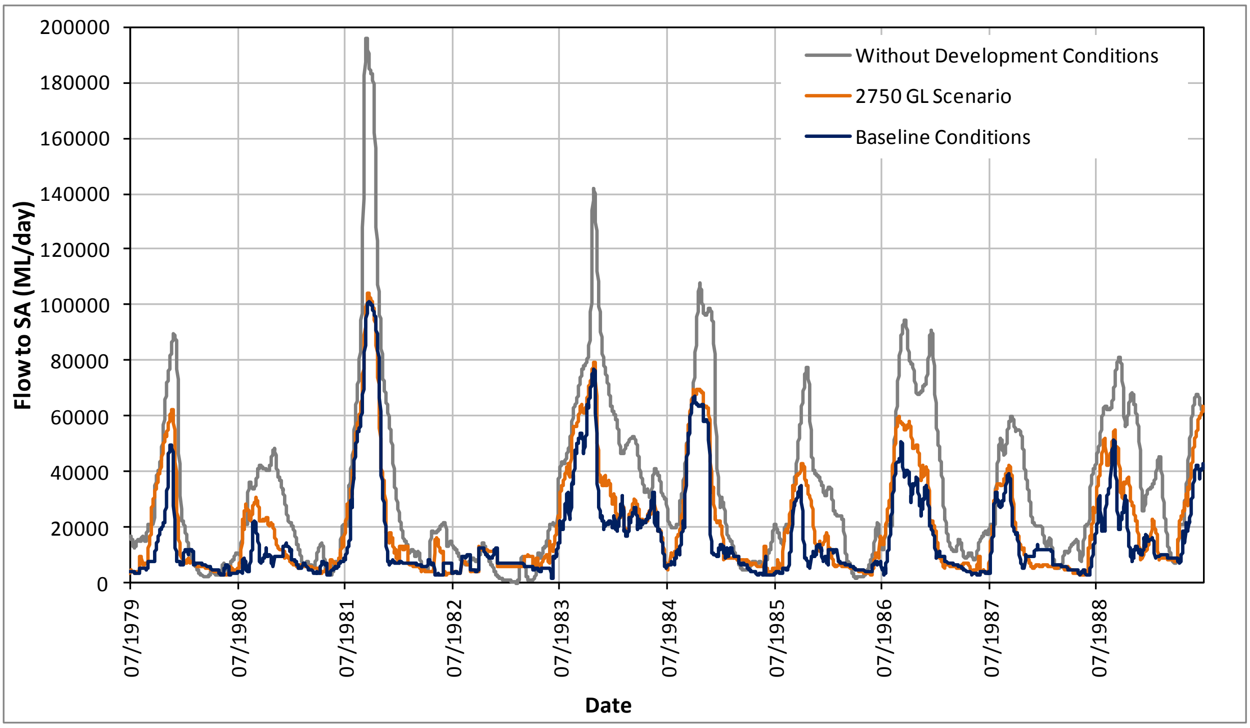

Figure 9. **Modelled flow to South Australia for Without Development Conditions, Baseline Conditions and 2750 GL scenario, 1979–89**

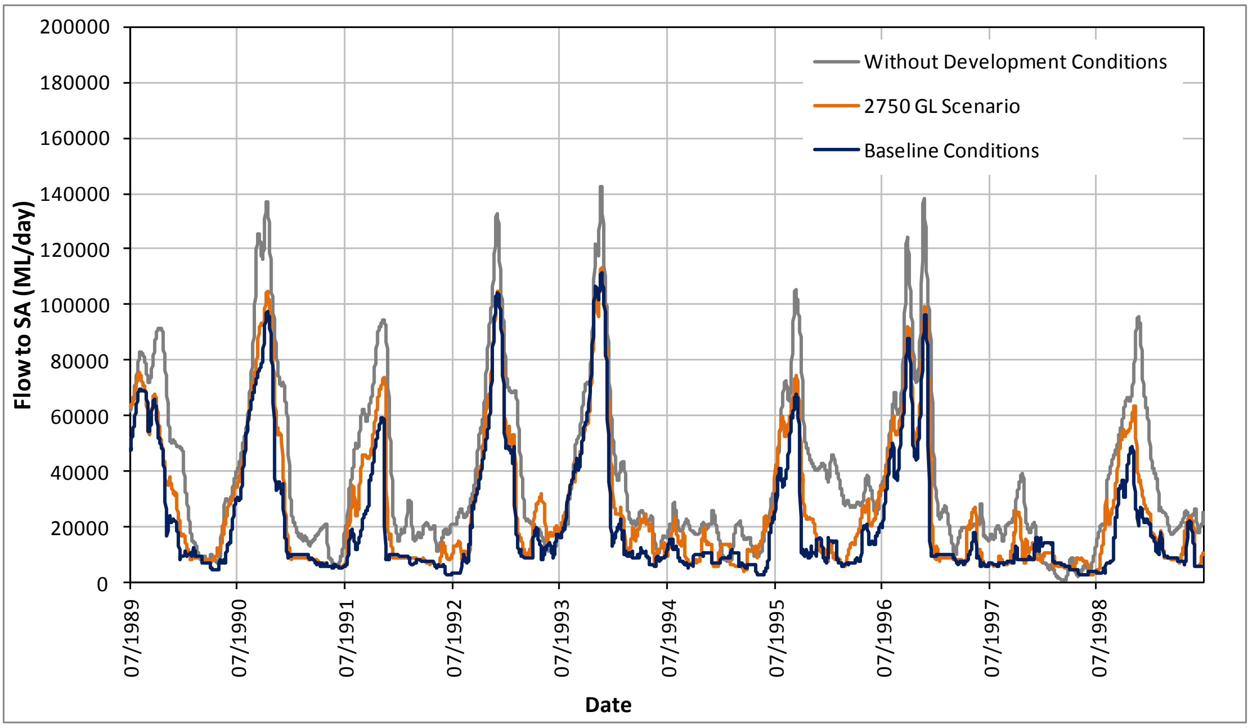

Figure 10. **Modelled flow to South Australia for Without Development Conditions, Baseline Conditions and 2750 GL scenario, 1989–99**

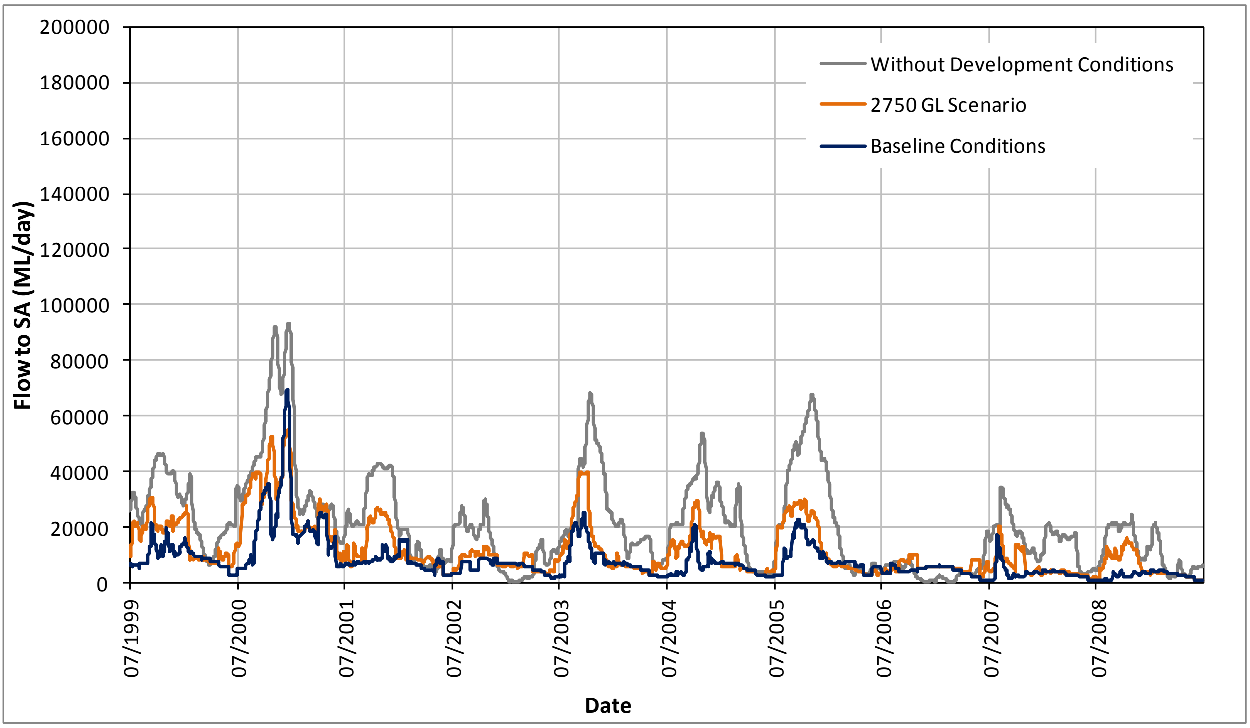

Figure 11. Modelled flow to South Australia for Without Development Conditions, Baseline Conditions and 2750 GL scenario, 1999–2009

5.3. FLOW AND VOLUME DELIVERED TO SA FROM 2400 GL AND 3200 GL SCENARIOS

The 2400 GL and 3200 GL scenarios were run to demonstrate the sensitivity of outcomes delivered by the proposed Basin Plan to variations in the amount of environmental water recovered. The scenarios were developed in a similar manner to the proposed Basin Plan 2750 GL scenario, using the Pick-a-Box tool to schedule flow delivery to environmental sites and retaining current operating rules and constraints.

Statistics for *Flow to SA* in terms of annual volume and daily flow for the 2400 GL and 3200 GL scenarios are shown in Table 2. The 2400 GL scenario delivers an average 275 GL less to South Australia than the proposed Basin Plan 2750 GL scenario (compared to 350 GL less recovered Basin-wide), while the 3200 GL scenario delivers an average of 303 GL more to South Australia compared to the 2750 GL scenario (compared to 450 GL more recovered Basin-wide).

Table 2. Flow to SA statistics for proposed Basin Plan sensitivity scenarios

Statistics	2750 GL scenario	2400 GL scenario	3200 GL scenario
Annual Volume (GL)			
Mean	8408	8133	8711
Median	7174	6916	7374
Minimum	2005	1547	2122
Maximum	42 210	41 988	42 432
10th Percentile	3372	3219	3551
90th Percentile	13 377	13 040	13 746
Flow (ML/day)			
Mean	23 020	22 268	23 848
Median	13 404	12 178	14 399
Minimum	765	765	765
Maximum	276 545	275 748	277 184
10th Percentile	5177	5244	5353
90th Percentile	53 525	52 988	55 443

The frequency distributions for annual volumes of *Flow to SA* for the proposed Basin Plan 2750 GL scenario and the sensitivity scenarios of 2400 GL and 3200 GL are shown in Figure 12. Differences between the scenarios are reasonably stable across the range of annual flow volumes delivered to South Australia. In relative terms, however, the impact of the sensitivity scenarios is greatest for the lower range of volumes. The potential impact of system constraints on these outcomes is discussed further in Section 10.

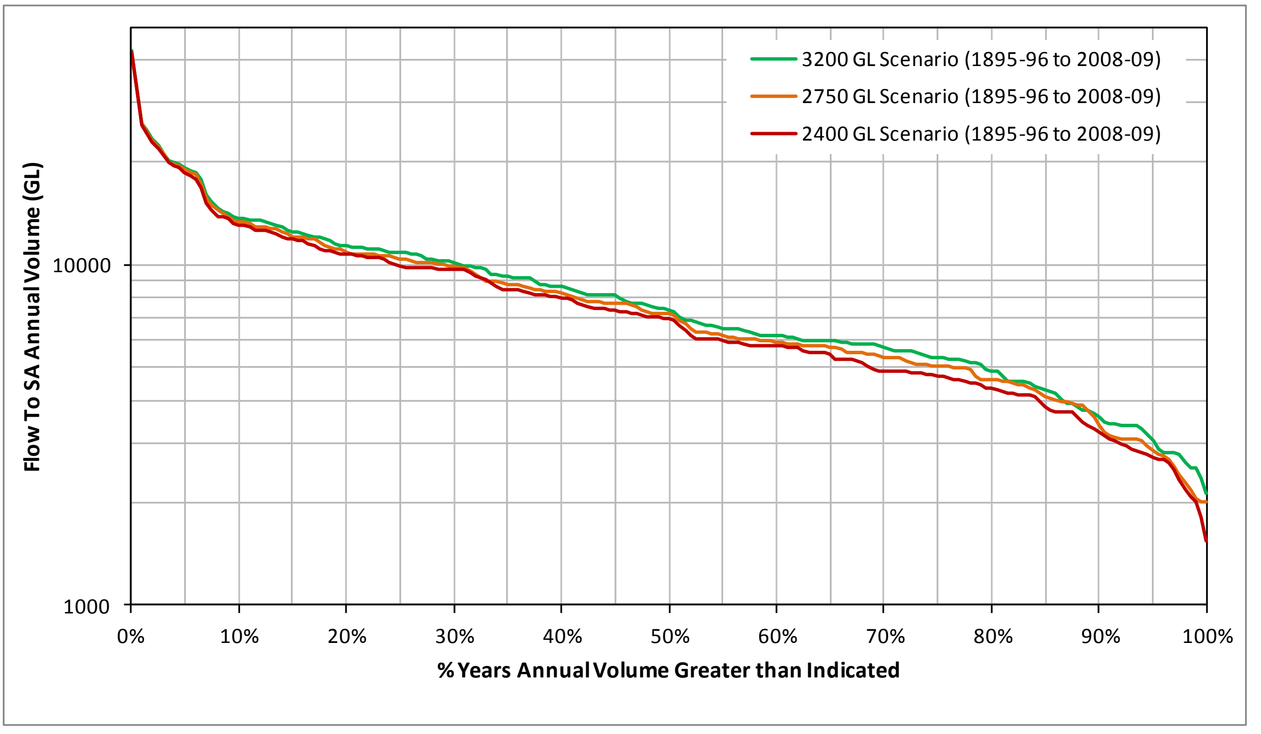

Figure 12. Frequency Distribution for Annual Volume to South Australia – 2750 GL Scenario vs. 2400 GL and 3200 GL Scenarios (1895–96—2008–09)

Annual differences in the volume delivered to South Australia between the 2750 GL scenario and the 2400 GL and 3200 GL scenarios are shown in Figure 13. It is apparent that there are larger inter-annual differences in volume between the scenarios, up to 1500 GL per year. This is thought to be due to differences in environmental flow scheduling using the Pick-a-Box tool. In years of high unregulated flow, for example, 1956–57 and 1973–74, the differences between the sensitivity scenarios and the 2750 GL scenario are similar to the long-term average. In other years, different decisions are made within Pick-a-Box regarding which environmental water requirements to deliver, which can vary both within and between environmental assets. The large inter-annual variability in the sensitivity scenarios reduces the ability to effectively compare the relative difference between scenarios, since the decision-making process regarding which targets are prioritised in Pick-a-Box is not rules-based and therefore not transparent or consistent.

It is interesting to note that there are thirteen years in which both the 2400 GL and 3200 GL scenarios deliver a greater volume to South Australia than the 2750 GL scenario, while both scenarios deliver less volume for nine years. In one year (1990–91), the 2400 GL scenario delivers more than 2750 GL scenario while the 3200 GL scenario delivers less. These apparent inconsistencies illustrate the uncertainties associated with comparing modelling results between scenarios at the statistical level. It is difficult to assess the reasons and decision-making processes responsible for these variations, which would require in-depth scrutiny of annual priorities within Pick-a-box, but it does highlight the difficulty in comparing scenarios when there are such significant interannual variations.

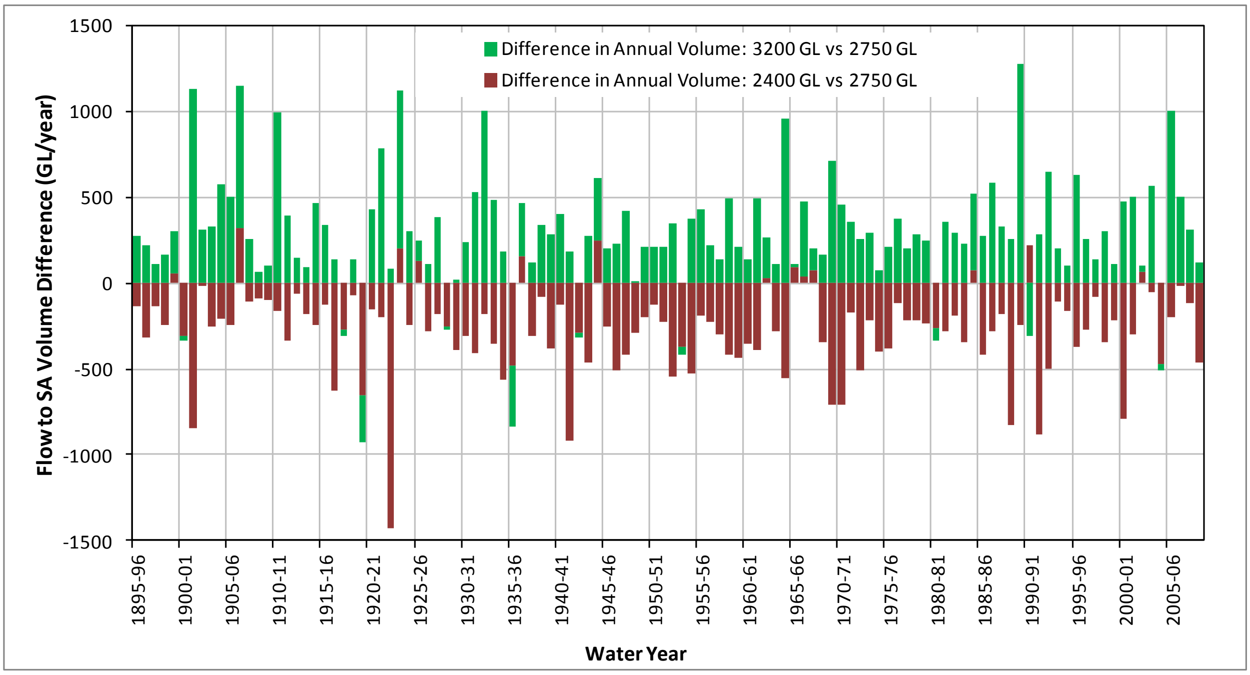

Figure 13. Flow to SA volume difference for 2400 GL and 3200 GL scenarios

The frequency distributions of daily *Flow to SA* for the proposed Basin Plan 2750 GL scenario and the sensitivity scenarios of 2400 GL and 3200 GL are shown in Figure 14. The graph demonstrates that the differences between the events across most flow bands are subtle. The curves tend to converge for high flow bands, indicating that flows in excess of around 80 000 ML/day occur are less dependent by the total volume of environmental water recovered. This is potentially influenced by the impact of system constraints preventing or inhibiting the delivery of higher flows events.

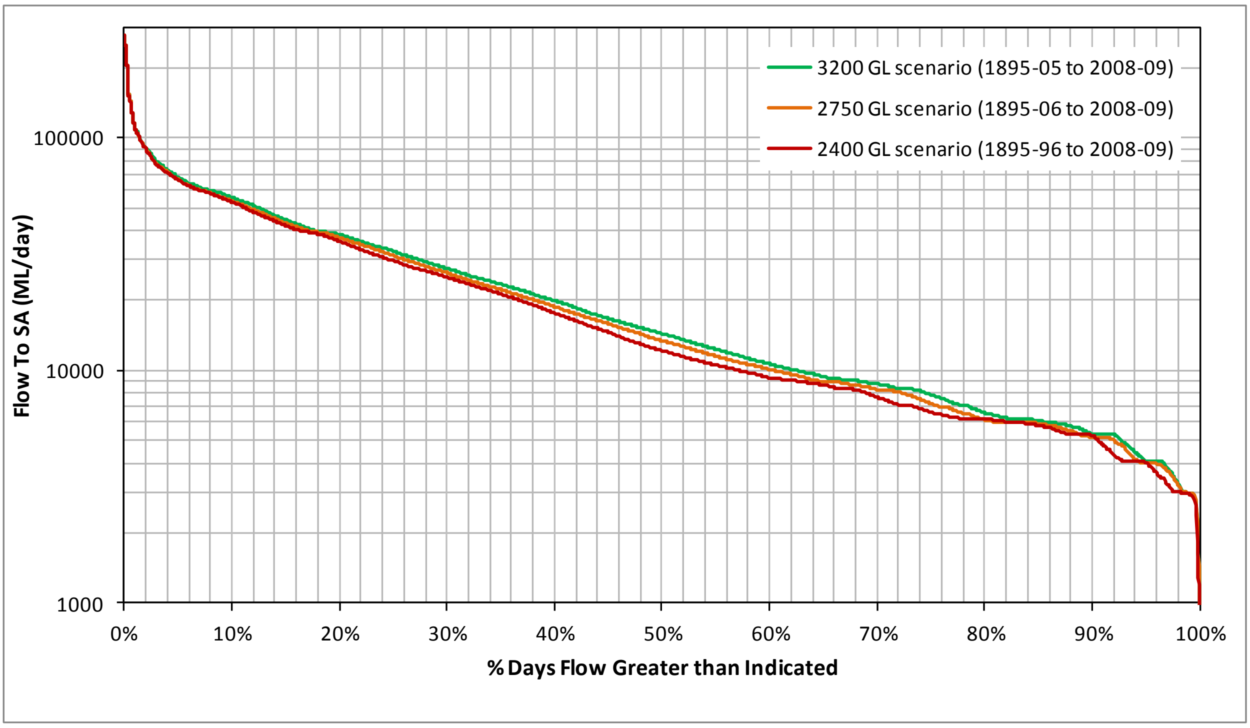

Figure 14. Frequency Distribution of Daily Flow to South Australia – 2750 GL Scenario vs. 2400 GL and 3200 GL Scenarios (1895–96—2008–09)

5.4. DIFFERENCE BETWEEN 2750 GL AND 2800 GL SCENARIOS

The MDBA undertook modelling of a water recovery scenario of 2800 GL in mid-2011, which was provided to DFW in September 2011. A decision was made shortly prior to the release of the proposed Basin Plan in November 2011 to revise the total volume of recovery downwards to 2750 GL. The 50 GL difference was due to reduced recovery in the northern Basin, upstream of Menindee Lakes. The 2750 GL scenario was subsequently modelled by the MDBA; however, environmental demand sequences for delivering water to key environmental assets in the southern Basin remained the same as those determined for the 2800 GL scenario. The poor connection of the northern Basin to South Australia (due to large transmission losses in the Darling system), the attenuating effect of the Menindee Lakes system and the unchanged environmental delivery patterns, generally means that the reduced recovery of environmental water has a small impact on volume and flow rates delivered to South Australia. Statistics comparing the annual volume and daily flow to South Australia for the proposed Basin Plan 2750 GL and 2800 GL scenarios are shown in Table 3.

Table 3. Comparison of Flow to SA statistics for 2800 GL and 2750 GL scenarios

Statistics	2750 GL scenario	2800 GL scenario
Annual Volume (GL)		
Mean	8408	8415
Median	7174	7169
Minimum	2005	2080
Maximum	42 210	42 236
10th Percentile	3372	3372
90th Percentile	13 377	13 387
Flow (ML/day)		
Mean	23 020	23 038
Median	13 404	13 407
Minimum	765	765
Maximum	276 545	276 551
10th Percentile	5177	5177
90th Percentile	53 525	53 583

The statistics for daily *Flow to SA* is minimally affected by the additional 50 GL in recovered water. Similarly, the mean volume delivered by the 2800 GL scenario is only 7 GL per year more than the 2750 GL scenario. However, there is a difference in the minimum annual volume delivered of 75 GL. A closer inspection of the modelled outputs reveals that there are some years in which the variation in outflow from Menindee Lakes is far greater than the variation of the inflow, suggesting that the changed inflow volume triggered different operating conditions for Menindee Lakes for that year, for example, by passing into MDBA control due to reduced storage volume.

The variations in annual inflow and outflow from Menindee Lakes due to the reduced recovery of 50 GL in the northern Basin are shown in Figure 15 and Figure 16. The average reduction in inflow to

Menindee Lakes is 11 GL per year for 2750 GL compared to 2800 GL, while the average reduction in outflow is 8 GL.

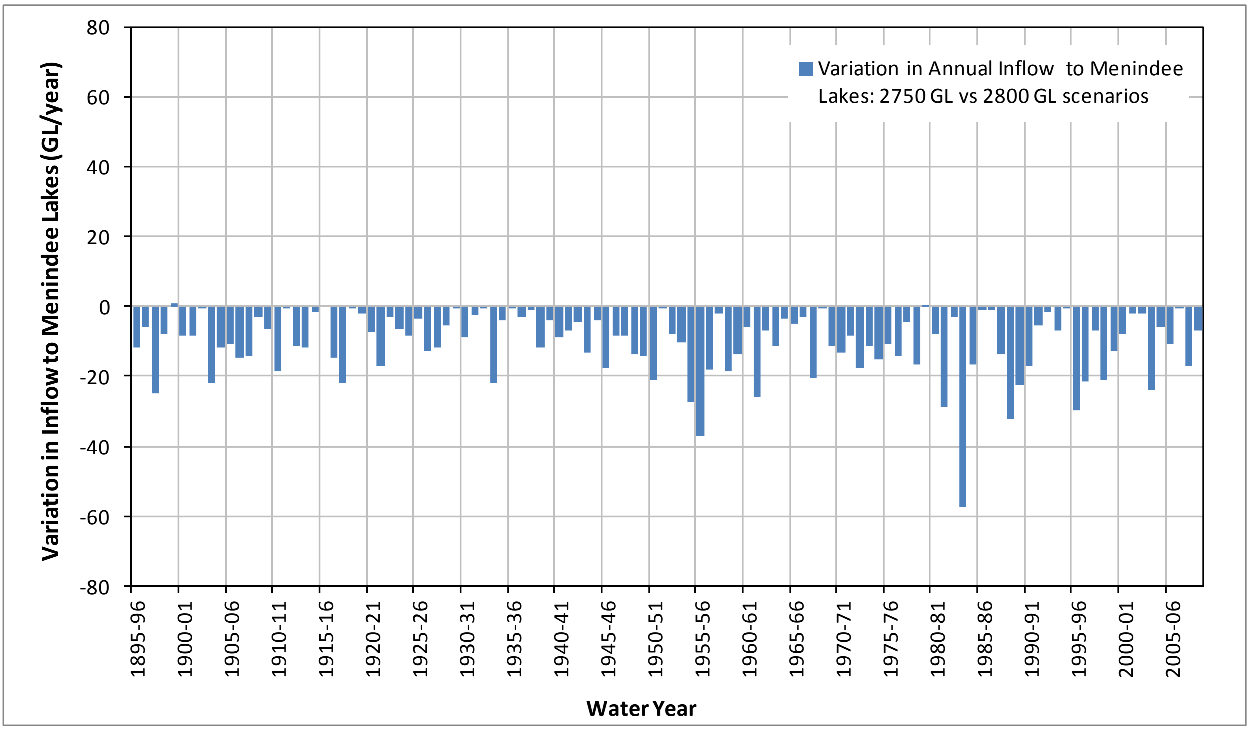

Figure 15. Variations in Annual Inflow Volume to Menindee Lakes due to 50 GL Reduction of Water Recovery in Northern Basin

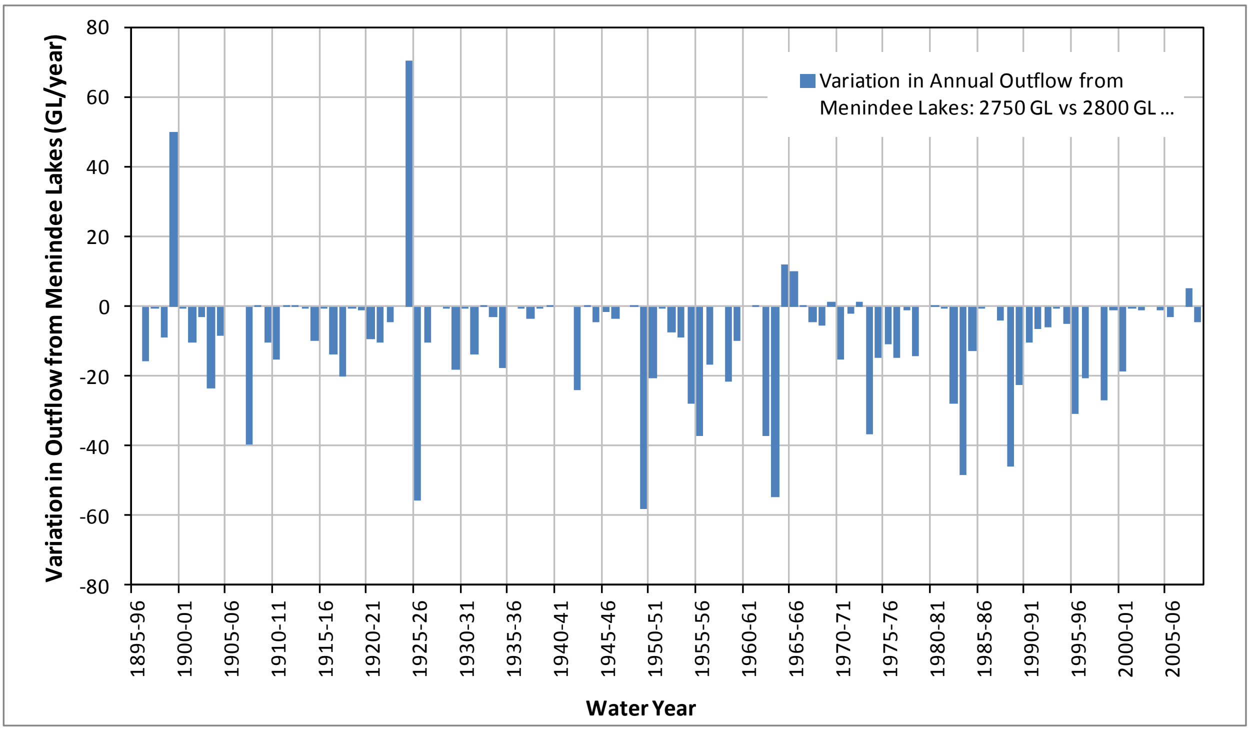

Figure 16. Variations in Annual Outflow Volume from Menindee Lakes due to 50 GL Reduction of Water Recovery in Northern Basin

The figures indicate that despite the average differences in inflow and outflow volume from Menindee Lakes being small, there is some variation to water delivery to South Australia, particularly in times of lower water availability.

5.5. DIFFERENCES IN FLOW DELIVERY UNDER THE GUIDE TO THE BASIN PLAN SCENARIOS

Statistics relating to the Guide to the Basin Plan 3000 GL, 3500 GL and 4000 GL scenarios are shown in Table 4. Mean and median volumes delivered by the Guide scenarios are consistent with the 2750 GL scenario. However, a key difference is the reduced provision of lower range flows with Guide scenarios. This is indicated by the lower 90th percentile daily flow and the lower minimum annual volume under the Guide scenarios. The modelling approach and assumptions used for the Guide to the Basin Plan were not able to deliver to South Australia its minimum entitlement of 1850 GL per year across the modelled period, indicating increased risk during drought periods compared to the proposed Basin Plan approach.

Table 4. Flow to SA statistics of Guide to the Basin Plan scenarios

Statistics	Proposed Basin Plan 2750 GL	Guide to the Basin Plan		
		3000 GL	3500 GL	4000 GL
Annual Volume (GL)				
Mean	8408	8368	8644	8958
Median	7174	7323	7686	8108
Minimum	2005	1179	1255	1253
Maximum	42 210	42 199	42 449	42 769
10th Percentile	3372	3189	3268	3598
90th Percentile	13 377	13 512	13 963	13 713
Flow (ML/day)				
Mean	23 020	22 911	23 665	24 526
Median	13 404	11 041	11 973	12 830
Minimum	765	776	1175	862
Maximum	276 545	273 800	273 958	274 101
10th Percentile	5177	4152	4229	4161
90th Percentile	53 525	57 619	58 542	59 618

The flow frequency curves for *Flow to SA* for the proposed Basin Plan 2750 GL scenario and the Guide to the Basin Plan 3000 GL, 3500 GL and 4000 GL scenarios are shown in Figure 17. The curves show that the proposed Basin Plan 2750 GL scenario provides flows in the range up to 15 000 ML/day more often compared to the Guide scenarios. However, flows in the range of 25 000 ML/day to 100 000 ML/day occur more frequently with the Guide scenarios. Above 100 000 ML/day, both Guide and proposed Basin Plan scenarios deliver similar outcomes.

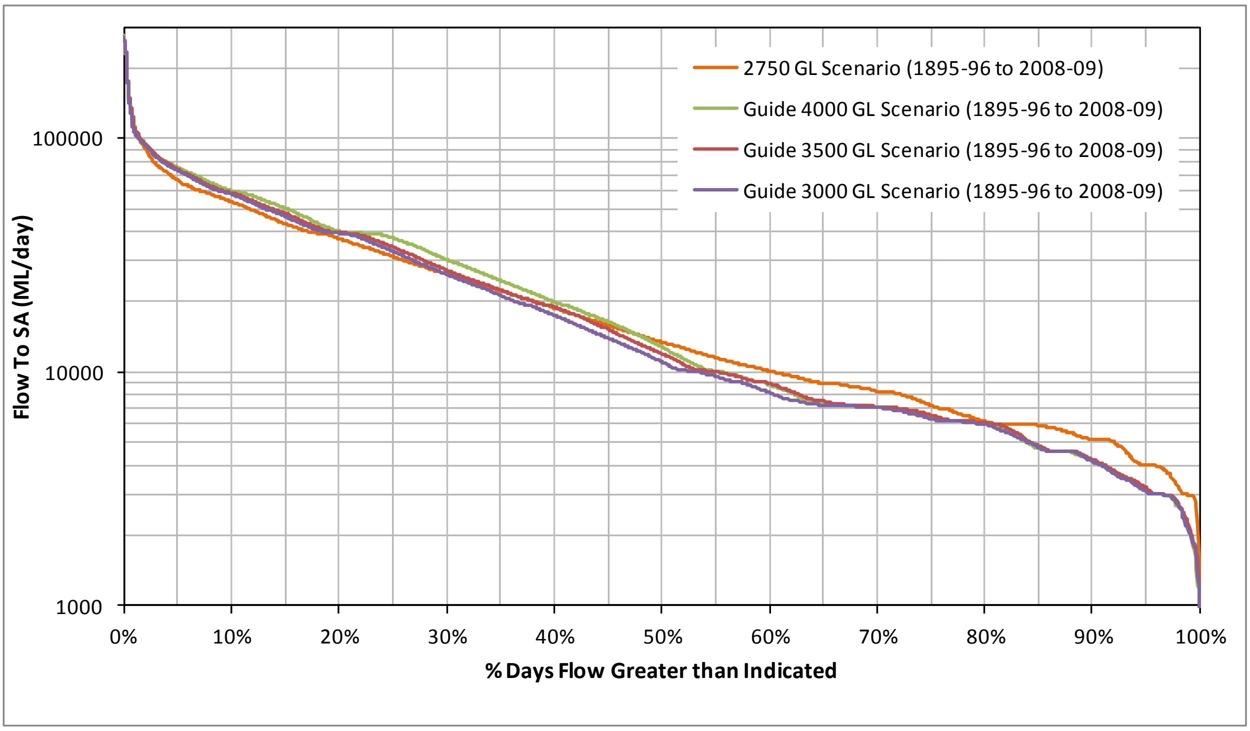

Figure 17. Flow Distribution of Daily Flow to South Australia – 2750 GL Scenario vs. Guide 3000 GL, 3500 GL and 4000 GL Scenarios (1895–96—2008–09)

A critical modelling assumption that improved the ability of the Guide scenarios to deliver a greater proportion of flows in the 25 000 ML/day to 100 000 ML/day range was the 'turning off' of constraints in the Guide modelling. For example, maximum flow limits at river locations in the model that reflect current operating rules were deactivated. Delivery of higher flows was also enhanced by the ability to significantly vary flow delivered to environmental demands between years, effectively storing environmental water over two or more years to supplement high flows. This is not possible under the current operating rules and assumptions as they appear in the current models (i.e. the 2750 GL scenario).

To further demonstrate the difference in flow delivery patterns under different modelling approaches between Guide and proposed Basin Plan scenarios, the daily flow time series for 'Flow to SA' for the Guide to the Basin Plan 3000 GL scenario and the proposed Basin Plan 2750 GL scenario for the period 1979–2009 are shown in Figure 18, Figure 19 and Figure 20.

In general, the Guide modelling delivers high peaks to South Australia, although this is variable across events. This is particularly the case during the drier years occurring post-2000, which, in addition to the lack of constraints as described previously, would be influenced by the modelling approach for the Guide which enabled a greater call on environmental water in drier years to meet environmental demands in preference to entitlements.

Conversely, the proposed Basin Plan 2750 GL scenario delivers more smaller events and variability in the flow band less than 20 000 ML/day. This is due to the addition of a range of lower-flow environmental water requirements, such as baseflows and freshes, into the demand sequences in the modelling for the proposed Basin Plan 2750 GL scenario. The ability of the proposed Basin Plan modelling approach to call on water from most of the tributaries in the southern connected Basin and not just the Murray, provides greater flexibility to create and/or enhance environmental-flow delivery events compared to the Guide approach.

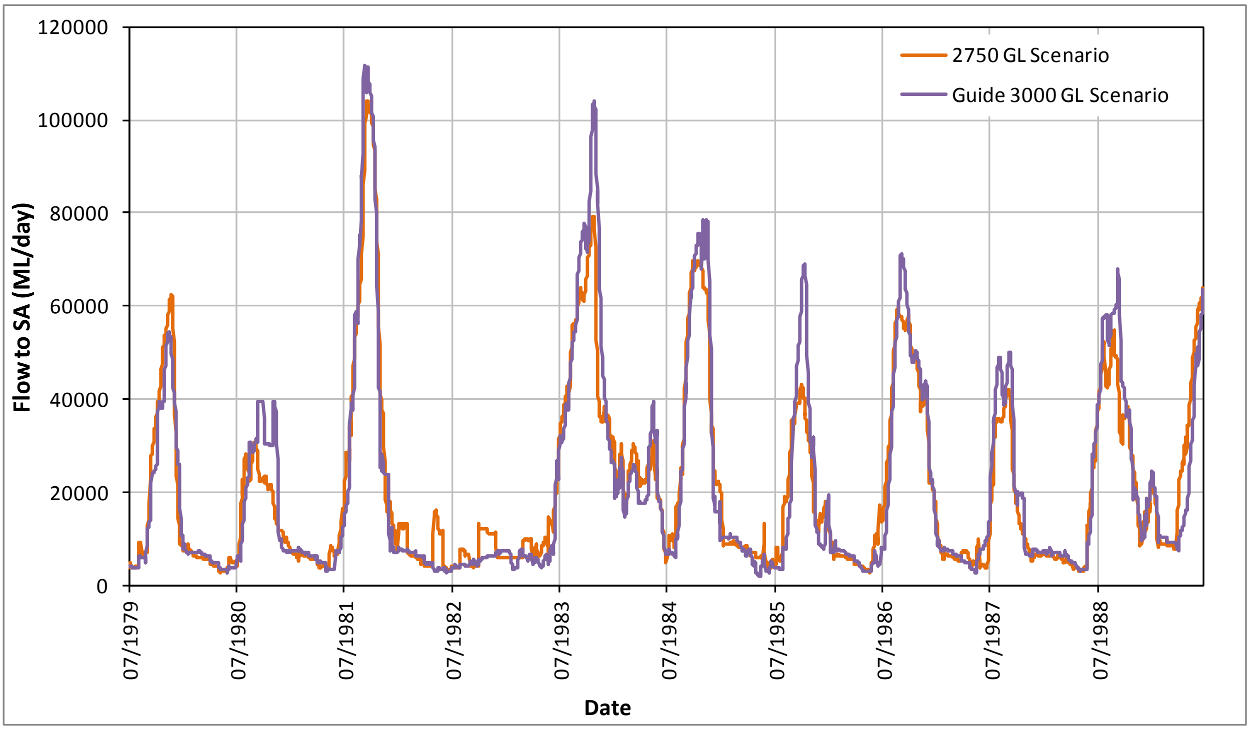

Figure 18. Modelled Flow to SA for 2750 GL and Guide 3000 GL Scenarios, 1979–89

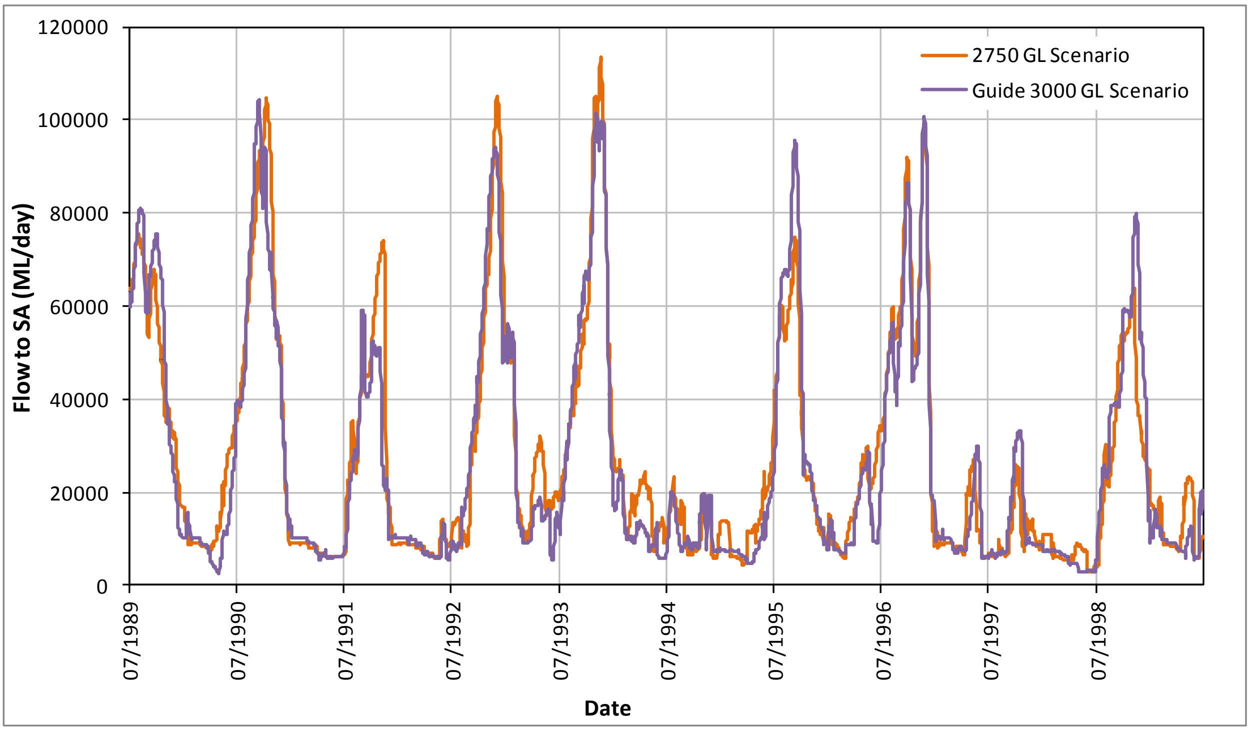

Figure 19. Modelled Flow to SA for 2750 GL and Guide 3000 GL Scenarios, 1989–99

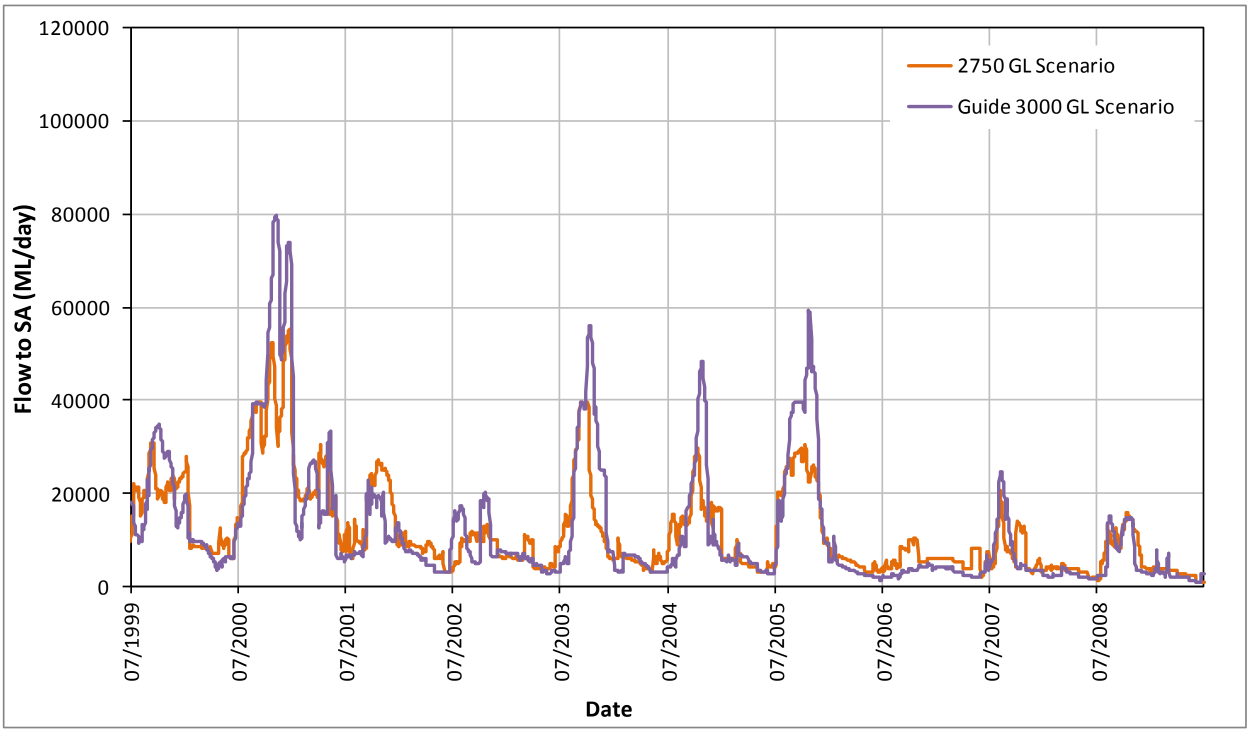

Figure 20. **Modelled Flow to SA for 2750 GL and Guide 3000 GL Scenarios, 1999–2009**

6. HYDROLOGICAL ANALYSIS FOR THE SOUTH AUSTRALIAN FLOODPLAIN

6.1. INTRODUCTION

The hydrological analysis presents an assessment of the delivery of South Australian and MDBA EWRs using the modelled outputs from the IRMSF. Specifically, BIGMOD daily flows determined for 'Flow to SA' have been analysed to check whether they meet the EWRs set by South Australia and the MDBA in terms of flow, duration and frequency. Note that the MDBA made available to South Australia only the MSM-BIGMOD and Pick-a-Box components of the IRMSF; models relating to other valleys were not provided.

There are few tributaries between the Darling River and the Lower Lakes, none of which are able to significantly contribute to the total flow in the River Murray. Consequently, for the purposes of this analysis, which only considers flows of 20 000 ML/day and above, the River Murray flow at the South Australia–Victoria–New South Wales Border ('Flow to SA') is said to be representative of the flow for the entire length of the river in South Australia.

The MDBA has consistently stressed that model runs represent only one way in which to deliver the water and hence, do not necessarily represent the outcomes that will be achieved. Consequently, this analysis should be considered as indicative only of the outcomes that could be achieved and should not be used for specific or in-depth comparisons.

6.2. HYDROLOGICAL ANALYSIS OF ENVIRONMENTAL WATER REQUIREMENTS

An assessment of the EWRs developed by the MDBA and South Australia is shown in Table 5 and Table 6 for the proposed Basin Plan 2750 GL scenario. The frequency of events has been presented as the average recurrence interval in years. An event with an average recurrence interval of five years would be expected to occur on average once in every five years. In their reports, the MDBA has reported the frequencies of EWRs in percentage terms. For example, a frequency of 20% means that the event occurs on average 1 in 5 years (this can be determined by calculating 100 ÷ frequency).

The EWR assessment presented in Table 5 and Table 6 was provided to the Goyder Institute for Water Research in February 2012, prior to the publication of this report. Minor amendments were subsequently made to the formatting and presentation of the tables for their inclusion in this report. The original tables, as provided to the Goyder Institute are contained in Appendix D.

HYDROLOGICAL ANALYSIS FOR THE SOUTH AUSTRALIAN FLOODPLAIN

In this section, each EWR has been coloured to denote whether the target has been met in the following manner:

EWR target is met under scenario*
EWR target is not met under scenario, but occurs at an increased frequency compared to baseline conditions
EWR target is not met under scenario, with a frequency that is less than or the same as under baseline conditions

*includes meeting high uncertainty targets

Note that other colouring schemes are used in the following section.

Table 5. Assessment of MDBA Riverland–Chowilla floodplain EWRs

No.	Target	Environmental Water Requirement		Notes About Requirement		Baseline Frequency (1 in .. years)	Without Develop-ment Frequency (1 in .. years)	Target Frequency (1 in .. years)		2750 GL Scenario Frequency (1 in .. years)
		Flow (ML/d)	Duration (days)	Timing (season)	Min. Duration (days)			Low Uncertainty	High Uncertain ty	
MDBA 1	Freshes	20 000	60	–	Longest single continuous	2.2	1.1	1.25	1.4	1.3
MDBA 2	Maintain 80% of the current extent of wetlands in good condition Maintain 80% of river red gum in good conditions	40 000	30	Jun–Dec	7	2.7	1.2	1.4	1.7–2	1.9
MDBA 3	Maintain 80% of the current extent of red gum forest in good condition Maintain 80% of river red gum in good conditions	40 000	90	Jun–Dec	7	4.4	1.6	2	3	2.9
MDBA 4	Maintain 80% of the current extent of red gum forest in good condition Maintain 80% of river red gum in good conditions	60 000	60	Jun–Dec	7	8.1	2.3	3	4	5.4

No.	Target	Environmental Water Requirement		Notes About Requirement		Baseline Frequency (1 in .. years)	Without Develop-ment Frequency (1 in .. years)	Target Frequency (1 in .. years)		2750 GL Scenario Frequency (1 in .. years)
		Flow (ML/d)	Duration (days)	Timing (season)	Min. Duration (days)			Low Uncertainty	High Uncertain ty	
MDBA 5	Maintain 80% of the current extent of red gum forest in good condition, maintain 80% of the current extent of red gum woodland in good condition	80 000	30	Pref. winter/ spring but timing not constrained	7	10	2.9	4	6	9.5
MDBA 6	Maintain 80% of the current extent of black box woodland in good condition	100 000	21	Pref. winter/ spring but timing not constrained	1	16	5	6	8	19
MDBA 7	Maintain 80% of the current extent of black box woodland in good condition	125 000	7	Pref. winter/ spring but timing not constrained	1	23	6	8	10	23

Table 6. Assessment of South Australian Riverland–Chowilla floodplain EWRs

Source and #	Target	Environmental Water Requirement			Baseline Frequency (1 in .. years)	Without Development Frequency (1 in .. years)	Target Frequency (1 in .. years)	2750 GL Scenario Frequency (1 in .. years)
		Flow (ML/d)	Duration (days)	Timing				
BBr1	Successful recruitment of cohorts of black box at lower elevations	85 000	20	spring or early summer	9.5	2.9	10 (+ successive years[4])	8.8
BBr2	Successful recruitment of cohorts of black box at higher elevations	>100 000	20	spring or early summer	16	5	10 (+ successive years[5])	19
BB1	Maintain and improve the health of 80% of the black box woodlands	>100 000	20	spring or summer	16	5	6 (max. interval 8 years)	19
BB2	Maintain and improve the health of ~60% of the black box woodlands	100 000	20	spring or summer	16	5	5 (max. interval 8 years)	19
BB3	Maintain and improve the health of ~50% of the black box woodlands	85 000	30	spring or summer	11	3.4	5 (max. interval 8 years)	9.5
RGr	Successful recruitment of cohorts of river red gums	80 000	60	Aug–Oct	16	5	5[6] (+ successive years)	16

[4] EWR for black box and red gum recruitment includes the need for flooding in successive years, i.e. floods must occur in at least 2 consecutive years for successful recruitment

[5] EWR for black box and red gum recruitment includes the need for flooding in successive years, i.e. floods must occur in at least 2 consecutive years for successful recruitment

[6] EWR for red gum recruitment in DWLBC 2010 did not specify preferred frequency, however to enable analysis the frequency provided within EA 2010 was used

Source and #	Target	Environmental Water Requirement			Baseline Frequency (1 in .. years)	Without Development Frequency (1 in .. years)	Target Frequency (1 in .. years)	2750 GL Scenario Frequency (1 in .. years)
		Flow (ML/d)	Duration (days)	Timing				
RG	Maintain and improve the health of 80% of the river red gum woodlands and forests (adult tree survival)	80 000 to 90 000	>30	Jun - Dec	10	2.9	3.3– 4 (max. interval 5 yrs)	9.5
Lig1	Maintain and improve the health of ~50% of the lignum	70 000	30	spring or early summer	8.1	2.3	3 (max. interval 5 years)	6
Lig2	Maintain and improve the health of 80% of the lignum	80 000	30	spring or early summer	10	2.9	5 (max. interval 8 years)	9.5
Ligr	Lignum recruitment - 66% of community maintained [7]	70 000	120	-	29	10	5	29
Mos1	Provide mosaic of habitats (i.e. larger proportions of various habitat types are inundated)	90 000	30	spring or early summer	14	4.1	5 (max. interval 6 years)	13
Mos2	Provide mosaic of habitats (i.e. larger proportions of various habitat types are inundated)	80 000	>30	spring or early summer	10	2.9	4 (max. interval 5 years)	9.5

[7] An EWR for lignum recruitment was not provided in DWLBC 2010, however the Goyder Institute recommends the inclusion of a lignum recruitment target. This EWR has been developed from information provided in EA 2010

Source and #	Target	Environmental Water Requirement			Baseline Frequency (1 in .. years)	Without Development Frequency (1 in .. years)	Target Frequency (1 in .. years)	2750 GL Scenario Frequency (1 in .. years)
		Flow (ML/d)	Duration (days)	Timing				
Mos3	Provide mosaic of habitats (i.e. larger proportions of various habitat types are inundated)	70 000	60	spring or early summer	14	3	4 (max. interval 6 years)	13
Mos4	Provide mosaic of habitats (i.e. larger proportions of various habitat types are inundated)	60 000	60	spring or early summer	11	2.5	3 (max. interval 4 years)	9.5
WB1	Maintain lignum inundation for waterbird breeding events	70 000	60	Aug–Oct	14	3	4 (max. interval 6 years)	13
WB2	Provide habitat (river red gum communities) for waterbird breeding events	70 000	60	Aug–Oct	14	3	4 (max. interval 6 years)	13
FP	Stimulate spawning, provide access to the floodplain and provide nutrients and resources	80 000	>30	Jun–Dec	10	2.9	4 (max. interval 5 years)	9.5
TW1	Inundation of (~80%) temporary wetlands for large scale bird and fish breeding events	80 000	>30	Jun–Dec	10	2.9	4 (max. interval 5 years)	9.5

Source and #	Target	Environmental Water Requirement			Baseline Frequency (1 in .. years)	Without Development Frequency (1 in .. years)	Target Frequency (1 in .. years)	2750 GL Scenario Frequency (1 in .. years)
		Flow (ML/d)	Duration (days)	Timing				
TW2	Maintain and improve majority of lower elevation (~20%) temporary wetlands in healthy condition; and Inundation of lower elevation temporary wetlands for small scale bird and fish breeding events, and microbial decay/export of organic matter	40 000	90	Aug–Jan	4.4	1.6	2 (max. interval 3 years)	2.9
FV	Provide variability in flow regimes at lower flow levels	Pool to 40 000[8]	Variable		4.4	1.6	1.25 (max. interval 2 years)	2.9

[8] While no specific flow is defined, this EWR has been assessed as the percentage of years in which 40,000 ML/day is reached with 1 day minimum duration

With respect to the MDBA EWRs, those specifying lower flow magnitudes are met by the 2750 GL scenario, up to 40 000 ML/day and only for high uncertainty targets. In the range 40 000 ML/day to 80 000 ML/day the EWRs are not met; however, the 2750 GL scenario is an improvement on average frequency when compared to baseline conditions. Above 80 000 ML/day the outcomes remain essentially the same as baseline (current) conditions. The colouring in the table shows some slight worsening for the 100 000 and 125 000 ML/day EWRs, but a closer review of these data demonstrates that the difference is very minimal. The average frequency of flows above 80 000 ML/day is effectively unchanged with the 2750 GL scenario.

Only one of the South Australian EWRs is met by the 2750 GL scenario, although the frequency of the majority of EWR events is increased (improved) compared to baseline conditions. Similar to the analysis for the MDBA EWRs, the events that are not improved by the 2750 GL scenario relate to higher flow requirements, that is, 80 000 ML/day and above.

Generally, South Australia's EWRs are higher and more frequent than those defined by the MDBA. The MDBA also has a range of target values (low uncertainty to high uncertainty) which further broadens the difference from South Australian targets. When assessed against low uncertainty targets only, none of the MDBA targets are met.

6.3. ANALYSIS OF PARTIAL DELIVERY OF EWRS

In order to further demonstrate the extent to which EWRs are being met by baseline and the 2750 GL scenario, these have been plotted on flow-frequency curves (as shown in Figure 21 to Figure 25). EWRs have been shown on separate graphs for each duration sought. These graphs demonstrate the convergence of baseline conditions and the 2750 GL scenario for flows around 80 000 ML/day and above.

The flow-frequency curves are also useful for assessing what could be successfully delivered by the modelled scenarios and consequently, the extent of floodplain impact. Consider the second temporary wetland South Australian EWR as an example (TW2), which is designed to maintain and improve the condition of temporary wetlands to support small scale breeding events (refer to Figure 21 for illustration). The TW2 requirement is 40 000 ML/day for 90 days, occurring once every two years on average. As shown in Figure 21, this EWR can not be met by the 2750 GL scenario; however, the target frequency could be met in those wetlands inundated by a flow of 30 000 ML/day. The model results provided in Figure 21 to Figure 25 have been used to support an ecological interpretation that estimates the potential reduced extent of healthy floodplain based on flows that achieve the EWR frequency and duration. It has also been used to identify floodplain areas potentially at increased risk (Sect. 7).

For the graphs and the tables that follow, the frequency of events is presented in terms of percentage, rather than average recurrence interval.

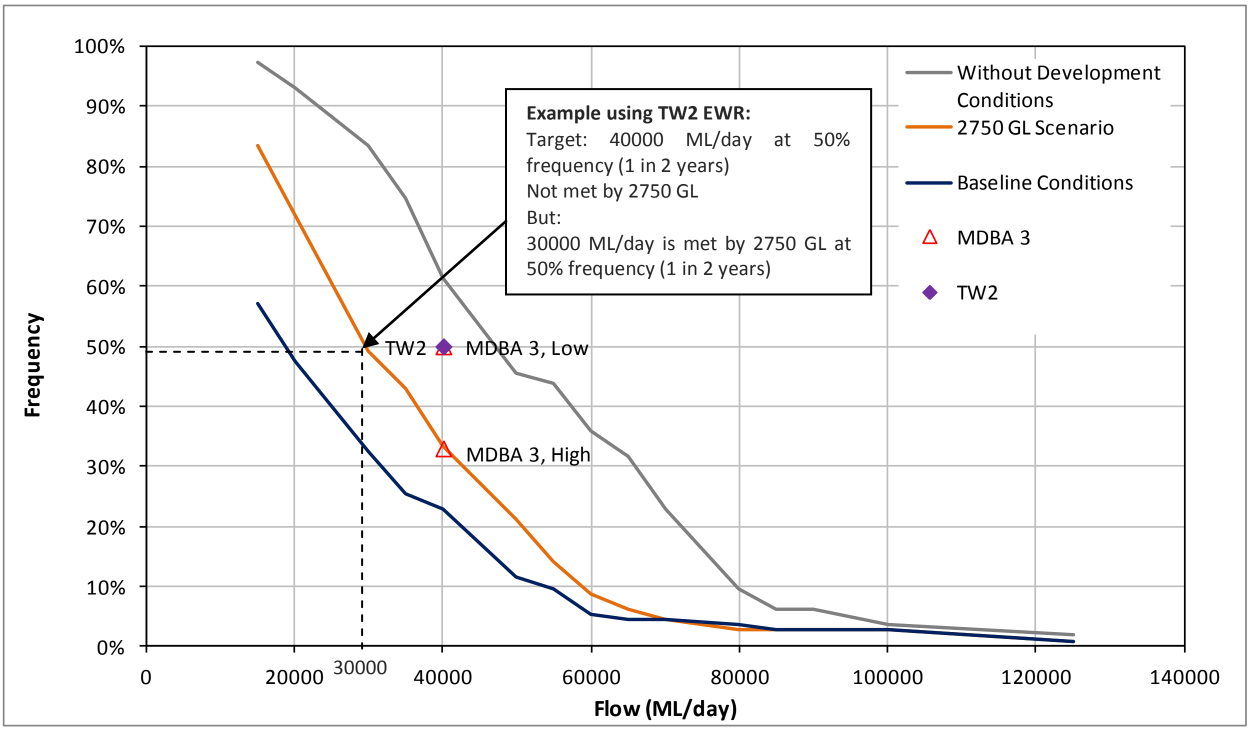

Figure 21. Flow-frequency curve for 90 day duration EWR for Riverland–Chowilla

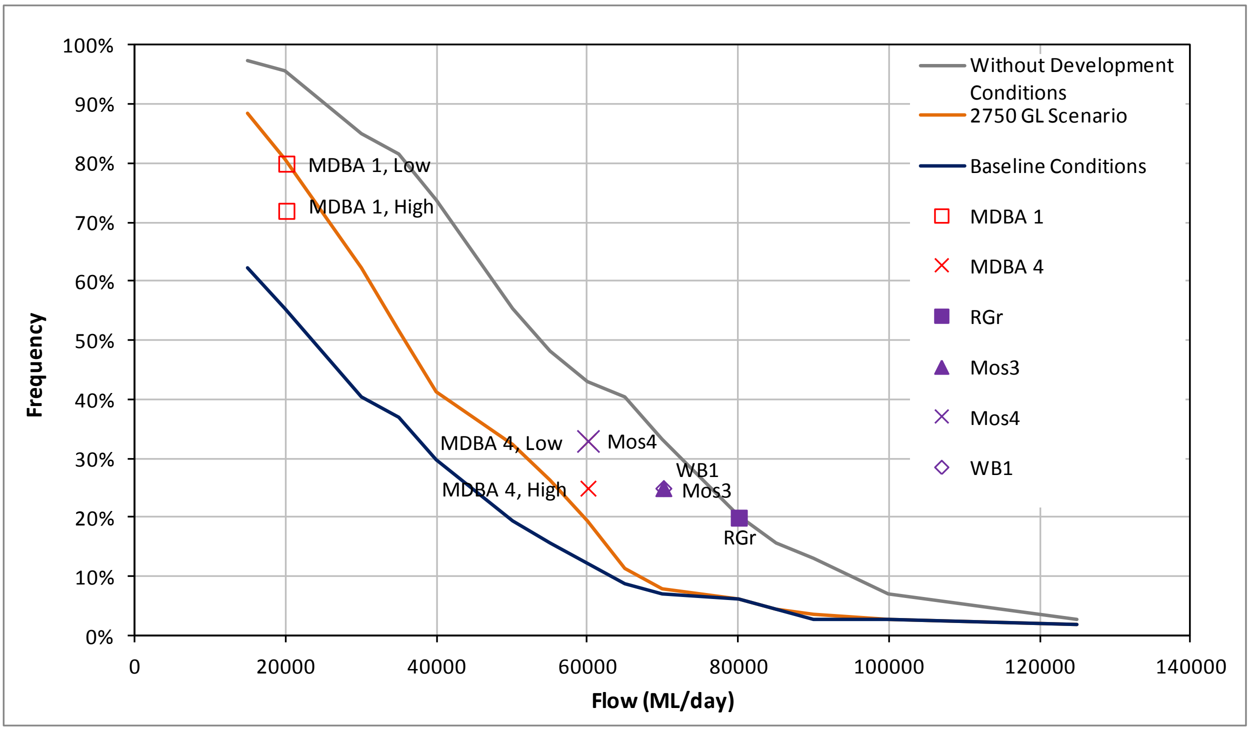

Figure 22. Flow-frequency curve for 60 day duration EWR for Riverland–Chowilla

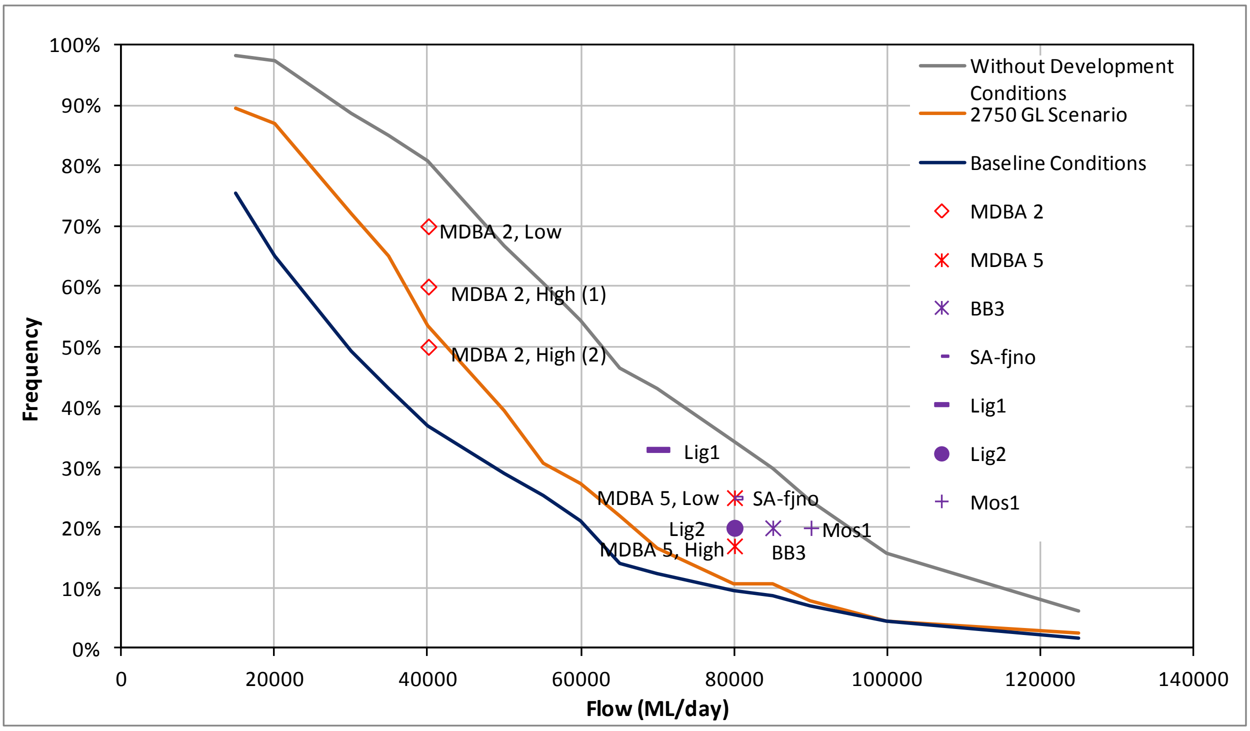

Figure 23. **Flow-frequency curve for 30 day duration EWR for Riverland–Chowilla**

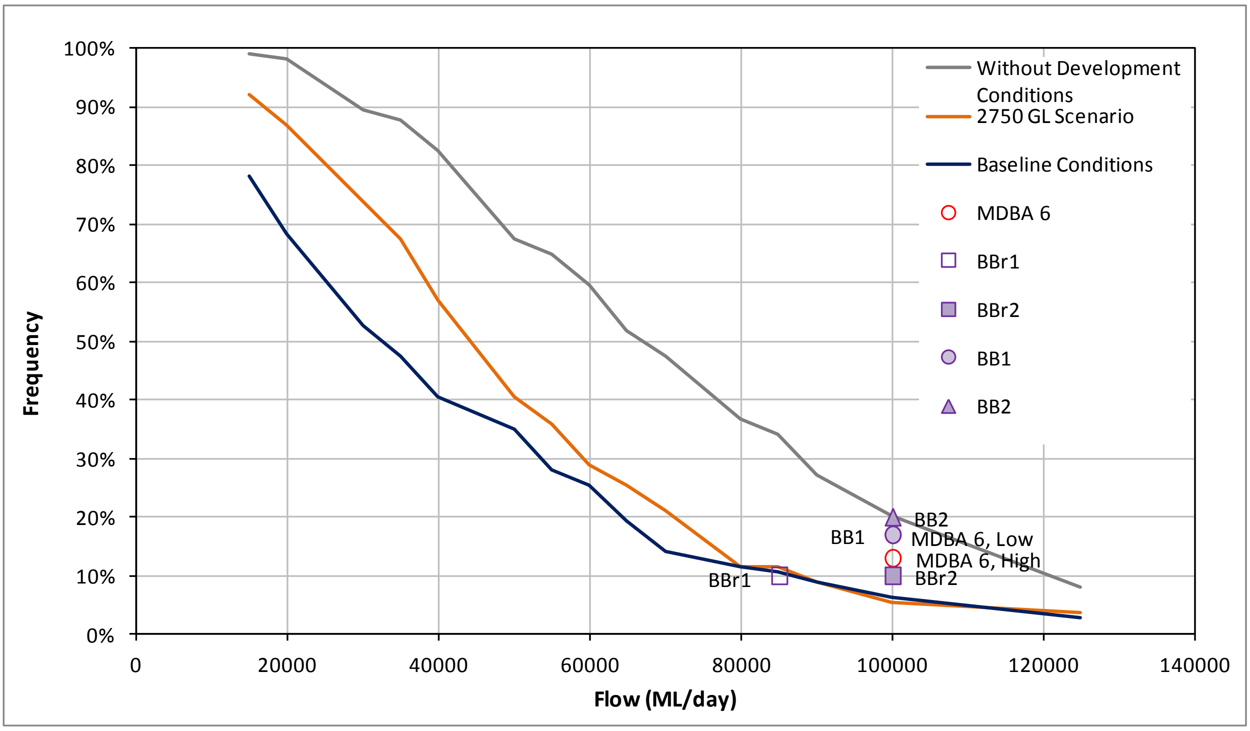

Figure 24. **Flow-frequency curve for 20 day duration EWR for Riverland–Chowilla**

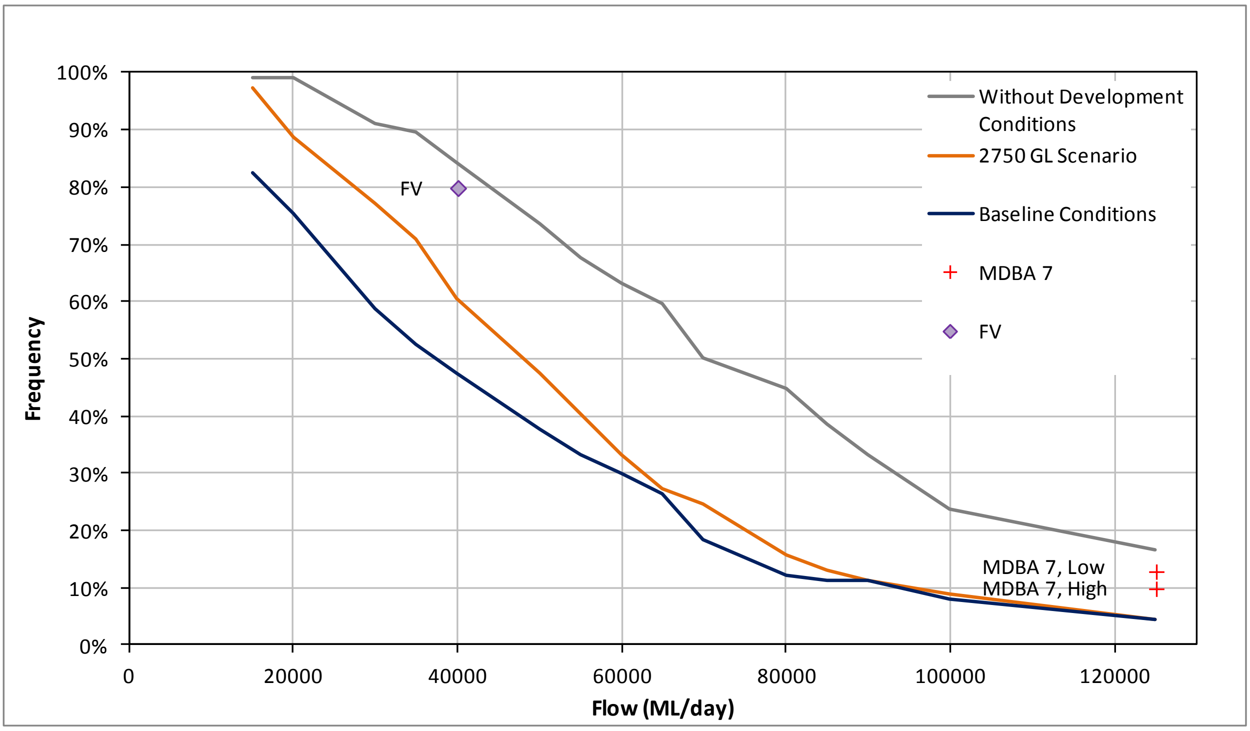

Figure 25. Flow-frequency curve for 7 day duration EWR for Riverland–Chowilla

6.4. ANALYSIS OF INTERVALS BETWEEN EVENTS

Assessment of the EWRs in Table 5 and Table 6 focuses on the average frequency of events over the modelled period of 114 years. Further analysis was undertaken to investigate the distribution of watering events over the modelled period, particularly the maximum time between events.

Maximum interval statistics relating to the MDBA and SA EWRs are shown in Table 7 (average intervals are shown for comparison and are reproduced from Table 5 and Table 6). Note that the modelled period ends on 30 June 2009, which was when the Murray-Darling Basin was still experiencing drought. Note that for some flow events, the maximum interval between events occurs at the end of the modelled period. For these events, the maximum interval would be even greater if the modelled period was extended beyond 2009.

Table 7. Interval Analysis of Riverland–Chowilla EWRs

Target No.	Environmental Water Requirement	Target Average Interval (years)	Target Maximum Interval (years)	2750 GL Scenario Average Interval (years)	2750 GL Scenario Maximum Interval (years)	Without Development Scenario Maximum Interval (years)
MDBA EWRs						
MDBA 1	20 000 ML/day for 60 days	1.25 – 1.4	-	1.3	4	2
MDBA 2	40 000 ML/day for 30 days	1.4 - 2	-	1.9	9	4
MDBA 3	40 000 ML/day for 90 days	2 - 3	-	2.9	13	6
MDBA 4	60 000 ML/day for 60 days	3 - 4	-	5.4	23	9
MDBA 5	80 000 ML/day for 30 days	4 – 5.9	-	9.5	23	12
MDBA 6	100 000 ML/day for 21 days	5.9 – 7.7	-	19	38	13
MDBA 7	125 000 ML/day for 7 days	7.7 - 10	-	23	38	13
SA EWRs						
BBr1	85 000 ML/day for 20 days	10	Requires successive years	8.8	23	12
BBr2	100 000 ML/day for 20 days	10	Requires successive years	19	38	13

Target No.	Environmental Water Requirement	Target Average Interval (years)	Target Maximum Interval (years)	2750 GL Scenario Average Interval (years)	2750 GL Scenario Maximum Interval (years)	Without Development Scenario Maximum Interval (years)
BB1	100 000 ML/day for 20 days	6	8	19	38	13
BB2	100 000 ML/day for 20 days	5	8	19	38	13
BB3	85 000 ML/day for 30 days	5	8	9.5	23	12
RGr	80 000 ML/day for 60 days	5	Requires successive years	16	34	13
RG	80 000 to 90 000 ML/day for 30 days	3.3-4	5	9.5	23	12
Lig1	70 000 ML/day for 30 days	3	5	6	23	9
Lig2	80 000 ML/day for 30 days	5	8	9.5	23	12
Ligr	70 000 ML/day for 120 days	5	-	29	35	34
Mos1	90 000 ML/day for 30 days	5	6	13	24	13
Mos2	80 000 ML/day for 30 days	4	5	9.5	23	12
Mos3	70 000 ML/day for 60 days	4	6	13	23	9
Mos4	60 000 ML/day for 60 days	3	4	9.5	23	9
WB1	70 000 ML/day for 60 days	4	6	13	23	9
WB2	80 000 ML/day for 30 days	4	5	13	23	12
TW1	80 000 ML/day for 30 days	4	5	9.5	23	12
TW2	40 000 ML/day for 90 days	2	3	2.9	13	6
FV	Up to 40 000 ML/day	1.25	2	2.9	9	4

It can be seen that for many flow events, the maximum time between events far exceeds the average interval. This is because over the modelled time period, large flow events frequently occur in successive wet years, for example, 1955–56 and 1973–74, with lengthy dry periods in between. Consequently, the average interval often presents an optimistic view of the time period between events.

It is recognised that for many ecological communities, the maximum length of a dry spell is often more critical than the average frequency of events. It can be seen that for the majority of EWRs, the maximum interval specified by the EWR exceeds that calculated from the without development time series. However, what is not revealed by these statistics is the distribution of these dry spells. For example, the without development time series may only have one extended dry spell in the length of record with the majority of spells being much shorter, whereas a developed scenario may have a much higher incidence of extended dry periods. The health of the community at the onset of an extended dry period also has a bearing on its resilience.

7. ECOLOGICAL INTERPRETATION OF HYDROLOGICAL ANALYSIS FOR THE SOUTH AUSTRALIAN FLOODPLAIN

7.1. SCOPE

The hydrological analysis of average frequency shows that one of the twenty SA EWR targets are met and three of the seven MDBA EWR targets are met under the 2750 GL scenario. The analysis has indicated potential improvement over baseline conditions (Table 5 and Table 6) however, further analysis is required to determine whether the improved hydrological conditions translates into ecological benefit. This component of the analysis aims to further explore the nature of any potential benefits to the floodplain in South Australia, as well as potential consequences of not delivering the full EWR targets. The area of interest for this interpretation of potential ecological consequences is the South Australian River Murray floodplain (SA RM floodplain) between the SA–NSW–Victoria border and Wellington.

This ecological interpretation is limited to an assessment of the SA EWRs (DWLBC 2010). The Goyder Institute's science review of the Guide to the proposed Basin Plan found the MDBA EWRs and the SA EWRs to be 'similar but not coincident' and considered the SA EWRs to be the most appropriate and comprehensive in describing ecological objectives for Riverland–Chowilla and more representative of the ecological character of the site (CSIRO 2011). The South Australian EWRs also consider additional floodplain ecological communities and include recruitment targets for key species and therefore are considered more appropriate for understanding ecological implications and outcomes expected under the Basin Plan. There are also issues regarding the specification of the MDBA targets for the Riverland–Chowilla site, which makes it unclear how some of the MDBA targets should be interpreted. For example 'Maintain 80% of the current extent of red gum forest in good condition' is addressed by three separate EWRs that vary in duration, frequency and flow rate and it is not clear how this information would be incorporated into the ecological interpretation performed in the section of the report.

It should be noted that the South Australian EWR focus on vegetation communities and it is assumed that these communities provide habitat and therefore act as a surrogate for a number of other biotic groups. The complementary report completed by the Goyder Institute (2012) uses the information presented in this report to explore a broader range of potential ecological outcomes.

The key questions to be addressed through this ecological interpretation are:

1. Can we expect ecological benefits to the South Australian floodplain from the Basin Plan – i.e. the 2750 GL water recovery scenario?

2. Are there parts of the South Australian floodplain that will continue to be at risk under the Basin Plan 2750 GL water recovery scenario?

Note that much of the ecological interpretation work was undertaken using outputs from the 2800 GL scenario, prior to receipt of the 2750 GL scenario. Consequently, some text or figures may refer to the 2800 GL scenario. As demonstrated previously (Sect. 5.4), this has limited implication for the outcomes as there is no discernable difference between the two scenarios for the Riverland–Chowilla site for flows above 20 000 ML/day.

7.2. METHODS

The primary information supporting this ecological analysis was the extent of floodplain habitats inundated at increasing flow bands. This information was generated using the River Murray Flood Inundation Model Version 4 (Overton *et al* 2006; hereafter FIM) and the vegetation spatial layer held within the Department of Environment and Natural Resources' Environmental GIS. A detailed description of the spatial analysis (including the GIS layers used) is provided in Appendix A.

The maps that supported the analysis, including vegetation layers (Map B1), inundation extents (Map B2) and vegetation inundated at flow rates of 40 000 ML/day (Map B3), 60 000 ML/day (Map B4), 80 000 ML/day (Map B5) and 100 000 ML/day (Map B6) are provided in Appendix B.

Vegetation on the SA RM floodplain was divided into eight major vegetation groups based on the functional groups identified within Rogers and Ralph 2011, with the three key SA RM floodplain species (black box, red gum and lignum) considered separately. The eight vegetation groups used were:

1. Black Box woodlands
2. Red Gum forests and woodlands
3. Forblands
4. Grasslands
5. Lignum
6. Other Shrublands (excluding lignum)
7. Other Woodlands/Forests (excluding red gum and black box)
8. Sedgelands

Details of the vegetation communities within each group are provided in Appendix A.

The extent of temporary wetlands was considered separately from the vegetation groups, as a sensitivity analysis revealed approximately 6000 ha of native vegetation fell within mapped temporary wetland basins. Wetland polygons generated through the SA River Murray wetland prioritisation project were used to define temporary wetland areas.

For the purpose of this analysis temporary wetlands includes those pool-level wetlands that have the ability to be actively managed, i.e. those wetlands that have a flow regulator that can be used to implement a wetting and drying regime. Therefore, the estimated areas of temporary wetland could be considered an overestimate as these managed pool-level wetlands would be permanently inundated were it not for the infrastructure. However, they have been included in the calculation for temporary wetlands as the ecological outcomes desired from these systems are more aligned to other temporary wetlands than non-managed pool-level wetlands.

The remaining natural floodplain located between Mannum and Wellington was included in this analysis, as when combined with data from the gorge and the valley, it will make up the total SA River Murray floodplain.

7.3. RIVERLAND–CHOWILLA AS AN INDICATOR SITE FOR THE SOUTH AUSTRALIAN FLOODPLAIN

Approximately 130 South Australian key environmental assets (KEAs) are listed in the Guide to the proposed Basin Plan (MDBA 2010b, p. 455), nine of which are located on the Chowilla, Pike or Katarapko floodplains and many located within the gorge geomorphic reach. The MDBA (2010) has stated that “by determining the EWRs at a subset of locations in the Basin, selected either for functions or assets, this methodology ensured that functions in all parts of the Basin and all key environmental assets would receive adequate environmental water” (p. 69). The subset of locations included 18 hydrologic indicator sites for key environmental assets, of which two are located in South Australia; Riverland–Chowilla and the Lower Lakes, Coorong, Murray Mouth. The MDBA have stated the assumption that if the EWRs for Riverland–Chowilla and Lower Lakes, Coorong, Murray Mouth are met then there will also be sufficient environmental water provided for the river between these two sites.

In order to explore this statement, the areas of key vegetation communities and habitats (as described by the SA targets) inundated under different flow rates were modelled at three nested spatial scales as described in Section 3, using the FIM and DENR vegetation layers. The spatial scales considered were:

1. Broader SA River Murray floodplain (incorporates gorge and valley geomorphic reach plus remnant floodplain habitat located between Mannum and Wellington)
2. Gorge geomorphic reach
3. Valley geomorphic reach (incorporates Riverland–Chowilla indicator site)
4. Riverland–Chowilla indicator site.

The proportion of each vegetation community or habitat that would be inundated under the targeted flow rates (specified by the SA EWRs) was determined. This was calculated at each spatial scale and represents how much of each vegetation community would be inundated on the floodplain if the target flows were delivered. In general, a lesser proportion of habitat is inundated in the gorge geomorphic reach at a given flow rate compared to the Riverland–Chowilla site or the valley geomorphic reach. This means that higher flows are required to inundate a similar proportion of floodplain habitat in the gorge reach than in the valley reach. As the results for the broader SA River Murray floodplain combine results from the gorge and the valley reaches, the proportion of habitat inundated at the whole of floodplain scale generally falls somewhere between the two individual reaches. There is 40% less red gum and 20–30% less lignum inundated in the gorge compared to Riverland–Chowilla, however, there is approximately 25% more temporary wetlands in the gorge compared to Riverland–Chowilla.

It is not clear what is driving this difference between the valley and the gorge reaches. Hydrology is considered a key driver of habitat structure (e.g. Bunn and Arthington 2002), however the suggestion that higher flows are required in the gorge to inundate the same proportion of a given habitat type as in the valley indicates that other drivers may also be important. Other drivers that may be influencing this result include:

- Possible differences in soil type resulting in greater lateral infiltration and aquifer recharge within the gorge reach enabling vegetation to establish and survive at higher elevations
- Shallower and/or fresher aquifers occur in the gorge reach and support vegetation growth
- Rainfall runoff from the cliffs in the gorge reach provide an additional water source to vegetation located on the outer limits of the floodplain
- The accuracy of FIM outputs may vary between these reaches.

Results are presented in Table 8 at three nested hierarchical spatial scales: SA floodplain, incorporating all floodplain areas; Reach scale (Gorge and Valley reaches) and Sub-reach scale an area within the Valley reach incorporating the Riverland Ramsar site and the South Australian section of the Chowilla Icon Site.

Table 8. Proportion of target taxa/habitat inundated under targeted flow rate at different spatial scales

Target				Proportion of targeted taxa/habitat inundated at target flow rate[9] (number in brackets indicates flow rate needed to inundate % target for the relevant vegetation community)			
#	Targeted taxa/function	%[10]	Flow rate (ML/day)[11]	SA RM floodplain	Gorge reach	Valley reach	Riverland–Chowilla
BBr1	Black box recruitment - lower elevations	50%	85 000	35.7 (>100 000)	24.5 (>100 000)	38.7 (>100 000)	30.4 (>100 000)
BBr2	Black box recruitment - higher elevations	80%	>100 000	100.0	100.0	100.0	100.0
BB1	Black box woodlands	80%	>100 000	100.0	100.0	100.0	100.0
BB2	Black box woodlands	60%	100 000	45.7 (>100 000)	41.0 (>100 000)	39.7 (>100 000)	53.4 (>100 000)
BB3	Black box woodlands	50%	85 000	35.7 (>100 000)	24.5 (>100 000)	38.7 (>100 000)	30.4 (>100 000)
RGr	River red gum recruitment	75%	80 000	35.7 (100 000)	24.5 (>100 000)	38.7 (85 000)	30.4 (85 000)

9 Flows are considered in 5000 ML/day increments

10 Where no target % has been specified, a value has been derived through comparison with other targets for the same species/community and with data provided in DWLBC 2010

11 FIM only models inundation extent up to 102 000 ML/day therefore 100 000 ML/day is the maximum flow rate where % inundation can be estimated

Target				Proportion of targeted taxa/habitat inundated at target flow rate[9] (number in brackets indicates flow rate needed to inundate % target for the relevant vegetation community)			
#	Targeted taxa/function	%[10]	Flow rate (ML/day)[11]	SA RM floodplain	Gorge reach	Valley reach	Riverland–Chowilla
RG	River red gum woodlands and forests	80%	80 000	62.0 (>100 000)	35.6 (>100 000)	74.8 (85 000)	73.9 (90 000)
		80%	90 000	69.1 (>100 000)	40.4 (>100 000)	83.1 (85 000)	80.8 (90 000)
Lig1	Lignum	50%	70 000	49.3 (75 000)	34.5 (85 000)	54.4 (70 000)	56.0 (70 000)
Lig2	Lignum	80%	80 000	76.0 (85 000)	49.8 (>100 000)	85.0 (80 000)	81.7 (80 000)
Ligr	Lignum recruitment[12]	66%	70 000	49.3 (80 000)	34.5 (95 000)	54.4 (75 000)	56.0 (75 000)
Mos1	Mosaic of habitats[13]	n/a	90 000	62.0	43.4	67.7	61.7

12 A target relating to lignum recruitment was not provided in DWLBC 2010, however the Goyder Institute recommends the inclusion of a lignum recruitment target. This EWR has been developed from information provided in EA 2010

13 Results represent % vegetated area (regardless of type) inundated at given flow rate

Target				Proportion of targeted taxa/habitat inundated at target flow rate[9] (number in brackets indicates flow rate needed to inundate % target for the relevant vegetation community)			
#	**Targeted taxa/function**	**%[10]**	**Flow rate (ML/day)[11]**	**SA RM floodplain**	**Gorge reach**	**Valley reach**	**Riverland–Chowilla**
Mos2	Mosaic of habitats	n/a	80 000	52.7	38.1	57.3	53.4
Mos3	Mosaic of habitats	n/a	70 000	33.6	29.3	35.0	35.4
Mos4	Mosaic of habitats	n/a	60 000	20.1	25.2	18.6	17.9
WB1	Waterbird breeding - lignum inundation	50%	70 000	49.3 (80 000)	34.5 (95 000)	54.4 (75 000)	56.0 (75 000)
WB2	Waterbird breeding – river red gum inundation	50%	70 000	44.9 (75 000)	30.9 (95 000)	51.7 (70 000)	53.9 (70 000)
FP	Stimulate spawning/floodplain access[14]	n/a	80 000	52.3	38.9	57.1	54.6
TW1	Temporary wetlands – higher elevations	80%	80 000	87.7 (75 000)	83.6 (75 000)	90.9 (75 000)	91.4 (75 000)

[14] Results represent the % area of floodplain (including non-vegetated areas) that are inundated at a given flow rate

Target				**Proportion of targeted taxa/habitat inundated at target flow rate[9] (number in brackets indicates flow rate needed to inundate % target for the relevant vegetation community)**			
#	**Targeted taxa/function**	**%[10]**	**Flow rate (ML/day)[11]**	**SA RM floodplain**	**Gorge reach**	**Valley reach**	**Riverland–Chowilla**
TW2	Temporary wetlands - lower elevations	20%	40 000	50.0 (<20 000)	62.7 (<20 000)	45.0 (<20 000)	38.3 (<20 000)
FV	Provide variability in flow regimes at lower flow levels	n/a	Pool to 40 000	n/a – target relates to in-channel flows			

A preliminary analysis was also undertaken to determine the percentage floodplain habitat found in the gorge versus the valley reach and whether the structure of the floodplain habitat varied between these reaches. An assessment of the proportion of the floodplain within each reach that was covered by each vegetation community was also undertaken, i.e. within a given reach, what proportion of habitat is red gum forest and woodland?

The valley reach constitutes a much larger proportion of the total floodplain area than the other reaches, therefore, a much greater proportion of any given vegetation type is found within the valley reach than in the gorge (Figure **26**). The degree of difference varies depending on the vegetation community but ranged from 99.4% more forblands in the valley to 34.8% more grasslands in the valley.

The same four vegetation communities, red gum woodlands and forests, black box woodlands, lignum and other shrublands, dominate both the valley and the gorge reach and collectively they account for approximately 80% of the total floodplain area within each reach. The dominant vegetation community within the gorge reach was “red gums’ whereas ‘other shrublands’ dominate the valley reach (Figure **27**).

This analysis indicates that there are distinct differences between the valley and gorge reaches and that the EWRs based on ecological assets in the valley reach may not be directly applicable to assets in the gorge reach. This challenges the validity of the assumption made by the MDBA that the Riverland–Chowilla indicator site is sufficiently representative of the broader South Australian floodplain, in particular those parts of the floodplain within the gorge geomorphic reach, which is unique at the Basin scale.

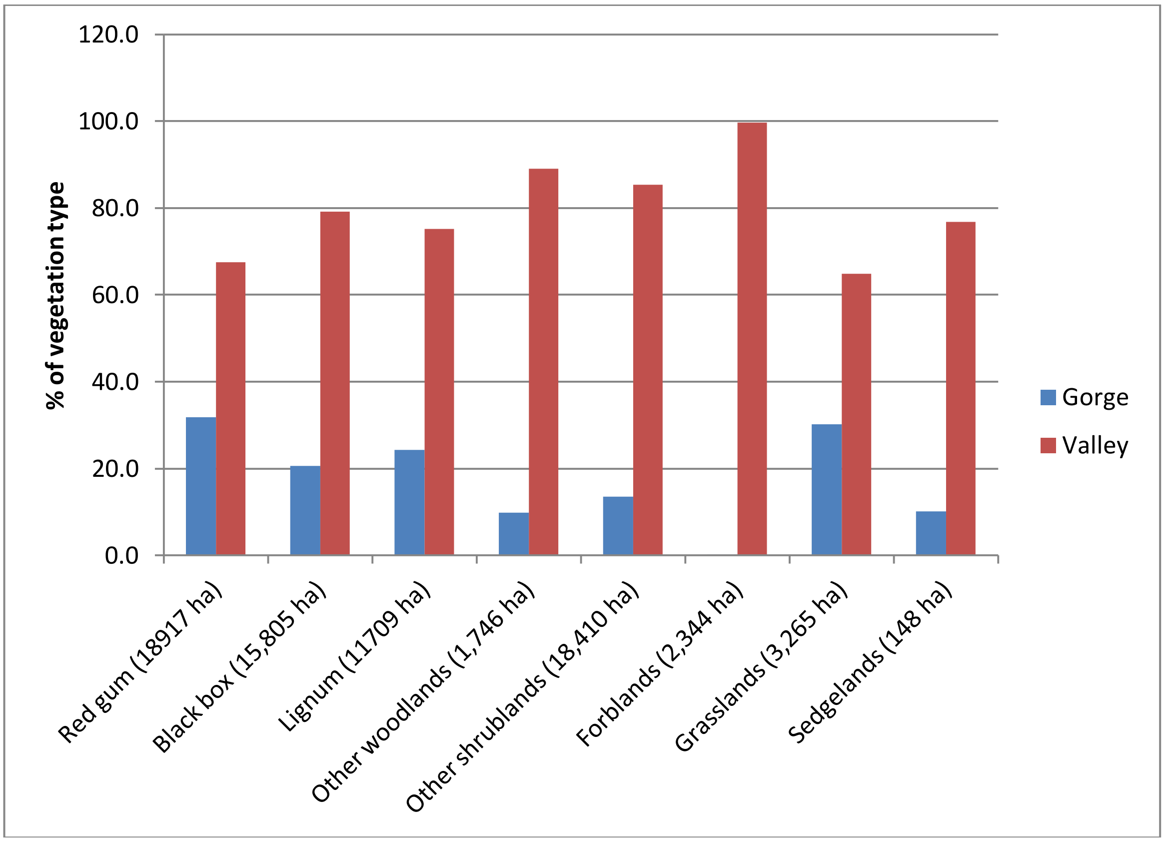

Figure 26. For a range of key vegetation communities, the proportion of that vegetation type that is found within the valley and the proportion found within the gorge geomorphic reaches

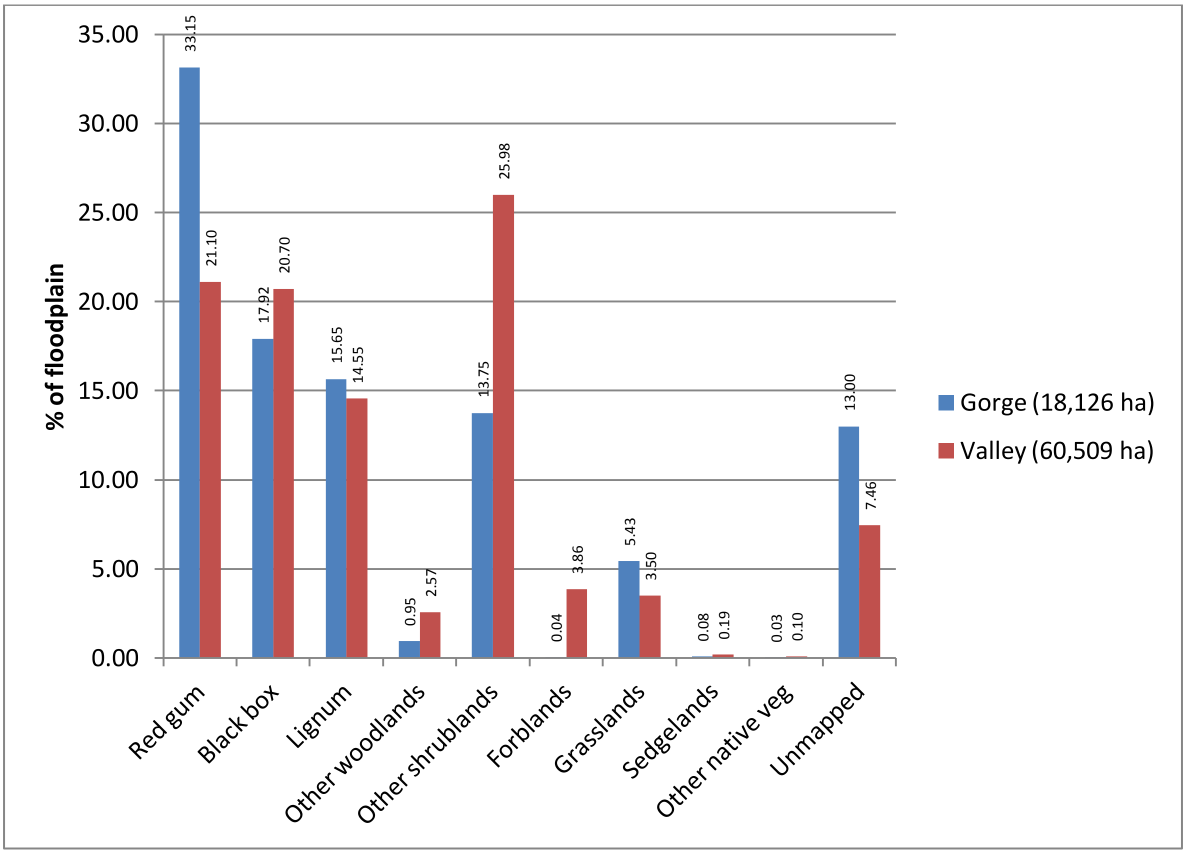

Figure 27. **For the two key geomorphic reaches, the proportion of total floodplain represented by each of the key vegetation types**

7.4. THE POTENTIAL ECOLOGICAL BENEFITS AND IMPLICATIONS OF THE 2750 GL WATER RECOVERY SCENARIO

The hydrological analysis above (Section 6.2) demonstrated that flows delivered under the 2750 GL scenario would meet one out of 20 SA EWR targets, however it did suggest a hydrological improvement compared to baseline for most of the EWRs. The following ecological interpretation was undertaken to assess the extent to which the observed improvement in hydrological conditions represents an improvement in ecological outcomes. It is anticipated that the delivery of additional environmental water would provide ecological benefit. Although the flow regime may not be sufficient to deliver water at the desired frequency and duration to all the targeted areas of the floodplain, an ecologically appropriate flow regime will be delivered to more of the floodplain and associated vegetation communities than under the baseline conditions.

The South Australia State NRM Plan (2006) defines environmental water requirements as “the water regime needed to sustain the ecological values or aquatic ecosystems, including their processes and biological diversity, at a low level of risk …”. In line with this definition, for this purposes of this assessment, floodplain vegetation and communities will be considered to be at low level of risk if the full complement of EWR metrics are met. This provides a way of identifying those areas of the floodplain where there can be a degree of confidence in achieving ecological outcomes (i.e. those at a low level of risk). Those parts of the floodplain, where the full complement of EWR metrics are not met, can be considered to be at some level of elevated risk.

For the purpose of this analysis, it is assumed that the maximum time between particular flow events is more ecologically significant than the average frequency of events. This is based on the assumption that the maximum interval metric represents an ecological threshold and that exceeding the threshold may have significant ecological impacts. A given flow sequence may achieve the average frequency metrics, but exceed the maximum interval metrics.

The following analysis has used average frequency and maximum interval metrics data from Table 7 to assess the portion of the floodplain where it is expected an ecologically-appropriate flow regime will be delivered under baseline conditions and the 2750 GL scenario. The criteria for this assessment are as follows:

- Maximum interval and duration metrics met = low level of ecological risk
- Average frequency and duration metrics met = elevated level of ecological risk
- Neither frequency or duration metrics met = highest level of ecological risk.

The flow-rate where the frequency and duration metrics are met as prescribed by the EWR under the baseline and the 2750 GL scenarios is expressed in Table 9. This flow-rate equates to a floodplain extent or area where an appropriate water regime will be delivered. The 2750 GL scenario does not provide the area of suitable habitat for each vegetation community specified by EWR target, however, it does provides some increase in potential habitat compared to baseline conditions. For example, the 2750 GL scenario could potentially support red gums at a low level of risk (i.e. maximum interval and duration metrics met) in an area equivalent to 35 000 ML/day extent, compared to an area equivalent to 20 000 ML/day flow under baseline conditions. Using the high risk criteria (i.e. average frequency and duration metrics met), the 2750 GL scenario could support red gums in an area equivalent to 60 000 ML/day compared to 55 000 ML/day under baseline conditions.

The proportion of each habitat or vegetation community that currently exists in those areas of the floodplain identified as 'suitable' were calculated by combining the current vegetation distribution with the flow rates described in Table 9. Figure 28 presents the proportion of vegetation communities considered to be at a low level of risk under the 2750 GL scenario and baseline conditions (also presented in Appendix C2). Figure 29 presents the proportion of vegetation communities that are considered to be at an elevated level of risk (average frequency and duration metric are met) under the 2750 GL scenario and baseline conditions (also presented in Appendix C1).

Generally there are small improvements observed between baseline conditions and the 2750 GL scenario. The increase in the proportion of vegetation communities supported from the 2750 GL scenario relative to baseline is greater when you accept a higher degree of ecological risk. Using the low risk criterion (i.e. maximum interval and duration), approximately 11% of total red gum habitat and approximately 3.2% of total lignum habitat will be supported compared to 8.4% and 2.3% respectively under the baseline conditions. Although the absolute increase is relatively small, the increase from the 2750 GL scenario relative to baseline is 30% for red gum habitat and 39% for lignum habitat. Using the higher risk criterion (i.e. the average frequencies are met) approximately 30% of total red gum habitat and 15% of total lignum habitat could be supported under the 2750 GL scenario.

Table 9. Comparison of targeted flow rate (ML/day) to flow rates that meet EWR metrics under Baseline Conditions and 2750 GL scenario

Target/EWR			Results under Baseline Conditions		Results under 2750 GL scenario	
#	Taxa/Function	Flow rate (ML/day)	Flow rate (ML/day) that meets frequency and duration metrics of EWR	Flow rate (ML/day) that meets duration and maximum interval metrics of EWR	Flow rate (ML/day) that meets frequency and duration metrics of EWR	Flow rate (ML/day) that meets duration and maximum interval metrics of EWR
BBr1	Black box (recruitment – lower elevations)	85 000	85 000	Unable to assess	85 000	Unable to assess
BBr2	Black box (recruitment – higher elevations)	>100 000	85 000	Unable to assess	85 000	Unable to assess
BB1	Black box woodlands	>100 000	65 000	40 000	70 000	50 000
BB2	Black box woodlands	100 000	65 000	40 000	70 000	50 000
BB3	Black box woodlands	85 000	60 000	35 000	65 000	50 000
RGr	River red gums (recruitment)	80 000	50 000	Unable to assess	55 000	Unable to assess
RG	River red gum woodlands and forests	80 000 to 90 000	55 000	20 000	60 000	35 000
Lig1	Lignum	70 000	45 000	20 000	55 000	35 000
Lig2	Lignum	80 000	60 000	35 000	65 000	50 000
Ligr	Lignum (recruitment)	70 000	Unable to assess			
Mos1	Mosaic of habitats	90 000	60 000	20 000	65 000	35 000
Mos2	Mosaic of habitats	80 000	55 000	20 000	60 000	35 000

Target/EWR			Results under Baseline Conditions		Results under 2750 GL scenario	
#	Taxa/Function	Flow rate (ML/day)	Flow rate (ML/day) that meets frequency and duration metrics of EWR	Flow rate (ML/day) that meets duration and maximum interval metrics of EWR	Flow rate (ML/day) that meets frequency and duration metrics of EWR	Flow rate (ML/day) that meets duration and maximum interval metrics of EWR
Mos3	Mosaic of habitats	70 000	45 000	15 000	55 000	20 000
Mos4	Mosaic of habitats	60 000	35 000	<15 000	45 000	20 000
WB1	Waterbird breeding (lignum)	70 000	45 000	15 000	45 000	20 000
WB2	Waterbird breeding (river red gum)	70 000	45 000	15 000	45 000	20 000
FP	Spawning/floodplain access	80 000	55 000	20 000	60 000	35 000
TW1	Temporary wetlands (higher elevations)	80 000	55 000	20 000	60 000	35 000
TW2	Temporary wetlands (lower elevations)	40 000	<20 000	<15 000	30 000	15 000
FV	Flow variability	Pool to 40 000	Unable to assess			

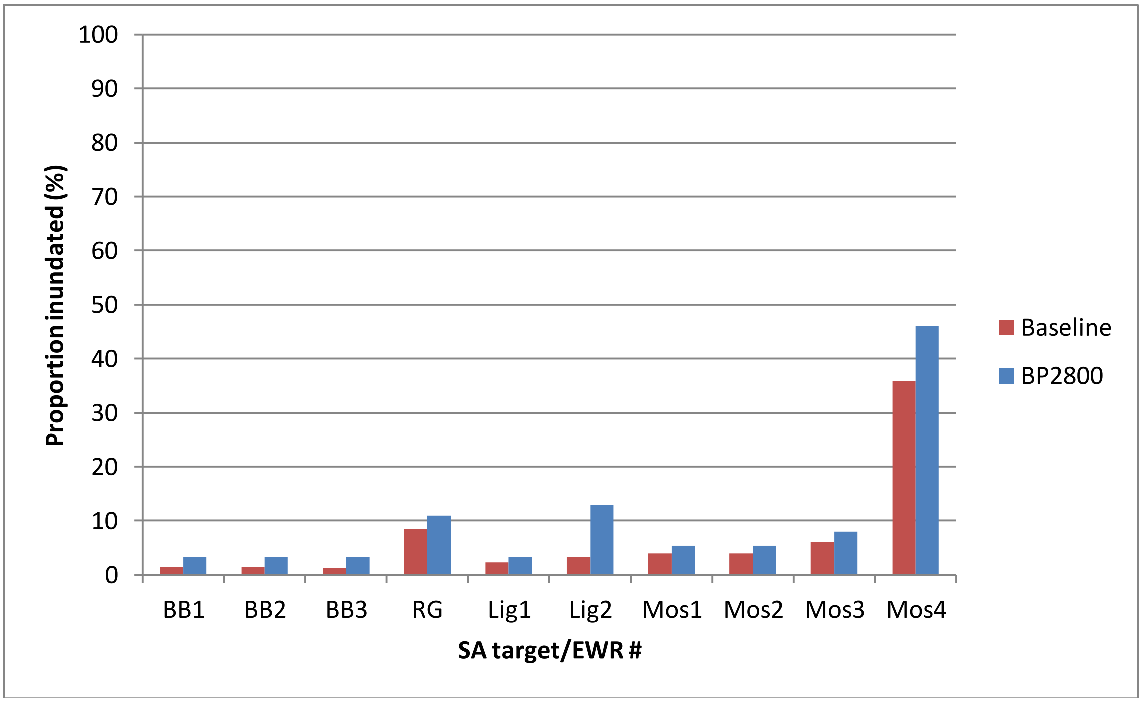

Figure 28. **Proportion of targeted habitat/taxa inundated at flow rate that meets duration and maximum interval metrics of EWR under Baseline and 2800 GL scenario**

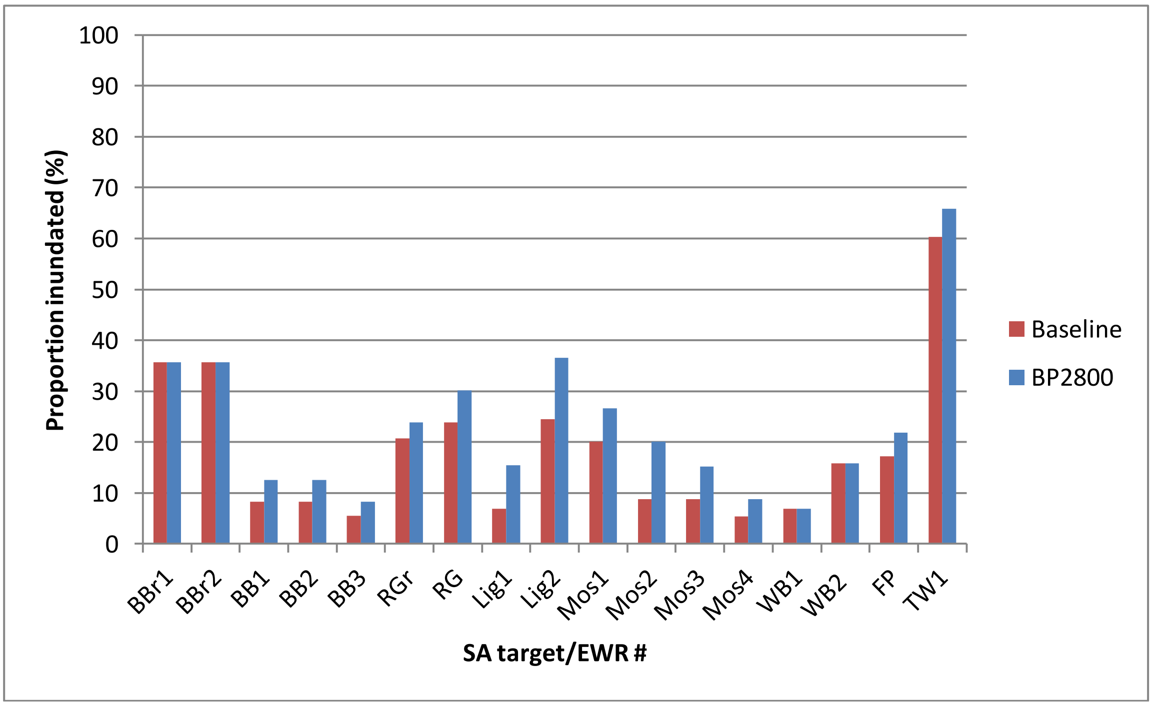

Figure 29. **Proportion of targeted habitat/taxa inundated at flow rate that meets average frequency and duration metrics of EWR under Baseline and 2800 GL scenario**

The spatial distribution of red gum forests and woodlands, black box woodlands and lignum for which all EWR metrics are met are presented in the three attached maps in Appendix B (Maps B7, B8 and B9). These maps could be used as the basis for a qualitative assessment of the ecological consequences to the floodplain vegetation communities due to patch size, proximity and connectivity under the 2750 GL scenario.

The cumulative percentage of habitat inundated across the South Australian floodplain at increasing flow rates was plotted for the major habitat types; red gum, black box, lignum and temporary wetlands (Figure 32 to Figure 33, using data from Appendix C1 and Appendix C2). These plots also incorporate the risk criteria presented above, displaying the proportion of each habitat type at low level of risk (i.e. maximum interval and duration metric met, displayed in green), an elevated level of risk (average frequency and duration metric met, displayed in orange) and the highest category of risk (i.e. no EWR metrics met, displayed in red). These results further demonstrate that the 2750 GL scenario supports a small percentage of the each habitat types at a low level of risk and that the proportion of habitat supported is increased if you accept a higher degree of ecological risk.

The results for different floodplain habitats (red gum forests and woodlands, black box woodlands, lignum, temporary wetlands and mosaic of habitats) are discussed below.

The maximum interval metric for adult red gum is five years (Figure 7). These events must be a minimum of 30-days duration to meet the red gum water requirements. The hydrological analysis of the 2750 GL scenario indicates that the maximum flow at which this five-year interval is not exceeded (for 30-day duration events) is 35 000 ML/day. At flows of 35 000 ML/day, only 11.0% of existing red gum woodlands and forests on the SA River Murray floodplain will be inundated (Figure 32).

Under the 2750 GL scenario, 11% of the total area of red gum woodlands and forests will be expected to receive a flow regime as specified in the EWR. Therefore with the current delivery assumptions, the 2750 GL scenario has the potential to support 11% of the total red gum habitat on the floodplain at low level of risk.

The flow frequency curves (Sect. 6.3) indicate that, under the 2750 GL scenario, the maximum flow rate that will meet the average frequency and duration requirements for adult red gum health maintenance and/or improvement (as per the SA EWR) is 60 000 ML/day. At flows of 60 000 ML/day, up to 30.1% of existing red gum woodlands and forests on the SA River Murray floodplain could potentially be supported. While this is considered to be an improvement on the current situation there are still significant risks to acheiving outcomes. The remainder of the red gum habitat where no EWRs are met will continue to be at the highest levels of risk to achieving outcomes for red gums (Figure 32).

7.4.1. BLACK BOX

There are three SA targets and EWRs relating to adult tree survival for black box woodlands (see targets BB1, BB2 and BB3 in Table 6). These targets vary in terms of the proportion of black box to be improved and/or maintained and hence, the flow rate of the EWR also changes as it relates directly to area of inundation. Event frequency and duration also varies between the black box EWRs as a representation of the different water requirements of trees located at different elevations and hence their history of inundation.

All three black box adult-tree survival targets specify a maximum interval of eight years, with an event duration of 20 or 30 days (depending on the target). Under the 2750 GL scenario, the maximum flow at which this eight-year interval is not exceeded is 50 000 ML/day. This threshold applies for both 20-day and 30-day duration events. At flows of 50 000 ML/day, only 3.2% of existing black box woodlands on the SA River Murray floodplain are inundated (Figure 30).

Under the 2750 GL scenario, 3.2% of the total area of black box woodlands will be expected to receive a flow regime that meets both the maximum interval and duration metrics. Therefore with the current delivery assumptions, the 2750 GL scenario has the potential to support 3.2% of the total black box habitat on the floodplain at a low level of risk.

Under the 2750 GL scenario, the maximum flow at which the average frequency and duration metrics of BB1 and BB2 are satisfied is 70 000 ML/day. At flows of 70 000 ML/day, 12.6% of existing black box woodlands on the SA River Murray floodplain are inundated (Figure 30). However, these are the EWR metrics for the black box trees located at higher elevations (85 000 to >100 000 ML/day), which specify a shorter event duration and lower frequency and trees at lower elevations may require water for longer or more frequently to survive (as implied by the EWR for BB3). The maximum flow rate that meets the inundation frequency and duration requirements for adult black box trees at lower elevations is 65 000 ML/day. At flows of 65 000 ML/day, 8.3% of existing black box woodlands on the SA River Murray floodplain could potentially be supported. While it is considered this may be an improvement on the current situation, there are still significant risks to achieving outcomes. The remainder of the black box habitat, where no EWRs are met, will continue to be at the highest level of risk of achieving outcomes for black box (Figure 30).

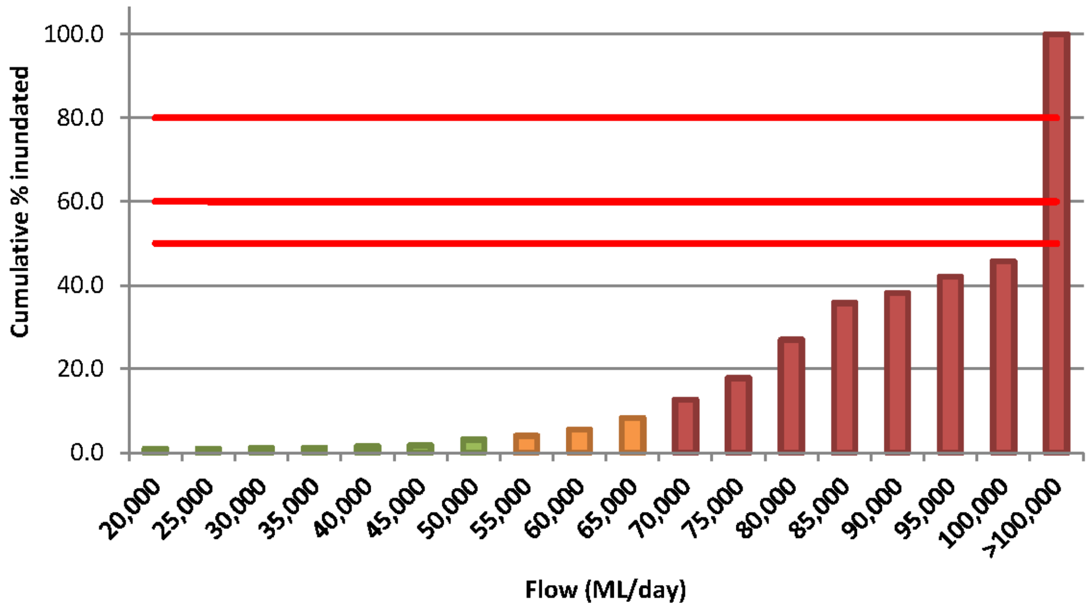

Figure 30. Proportion of black box habitat inundated on the SA RM floodplain at 5000 ML/day flow increments

Green bars indicate all metrics of the SA EWR are met under 2750 GL scenario

Orange bars indicate the frequency and duration metrics are met but not maximum interval metric

Red bars indicate the frequency/duration metrics are not met

Red lines indicates the targeted proportion of black box (50%, 60% and 80%)

7.4.2. LIGNUM

Similar to black box, there are two targets and EWRs relating to the maintenance and/or improvement of lignum. The Lig 1 target is for a smaller proportion of the lignum community, located at lower elevation and therefore in inundated at a lower flow rate and is assumed to require a higher frequency of inundation than Lig 2. This implies that lignum at higher elevations on the floodplain (Lig 2) has adapted to less frequent flooding than that at lower elevations.

EWRs for SA targets Lig 1 and Lig 2 specify a maximum event interval of five and eight years, respectively and both, require an event duration of 30-days. Under the 2750 GL scenario, the maximum flow rate at which these maximum intervals are not exceeded (for 30-day duration events) is 50 000 ML/day for eight-years and 35 000 ML/day for five years.

However, the EWR for Lig1 indicates that the Lignum at lower elevations (<70 000 ML/day) has a maximum interval requirement of five years and therefore, the duration and maximum interval metrics are only met at flows of 35 000 ML/day, where only 3.2% of existing lignum on the SA River Murray floodplain is inundated (Figure 31).

Under the 2750 GL scenario, 3.2% of the total area of lignum will be expected to receive a flow regime that meets both the maximum interval and duration metrics. Therefore, with the current delivery assumptions, the 2750 GL scenario has the potential to maintain and/or improve 3.2% of the total lignum habitat on the floodplain at a low level of risk.

The maximum flow rate that meets the average frequency and duration metrics of Lig2 under the 2750 GL scenario is 65 000 ML/day (Figure 31). Approximately 36.5% of existing lignum on the SA River Murray floodplain is inundated at flows of 65 000 ML/day. However, the EWR for Lig1 indicates that lignum located at elevations at or below 70 000 ML/day need to be inundated more frequently. Under the 2750 GL scenario, the maximum flow rate that meets the Lig1 frequency and duration metrics is 55 000 ML/day. At flows of 55 000 ML/day, 15.4% of existing lignum on the SA River Murray floodplain could potentially be supported, but there is an elevated degree of risk. While it is considered this may be an improvement on the current situation, there are still significant risks to achieving outcomes. The remainder of the lignum habitat, where no EWRs are met, will continue to be at the highest level of risk of achieving outcomes for lignum (Figure 31).

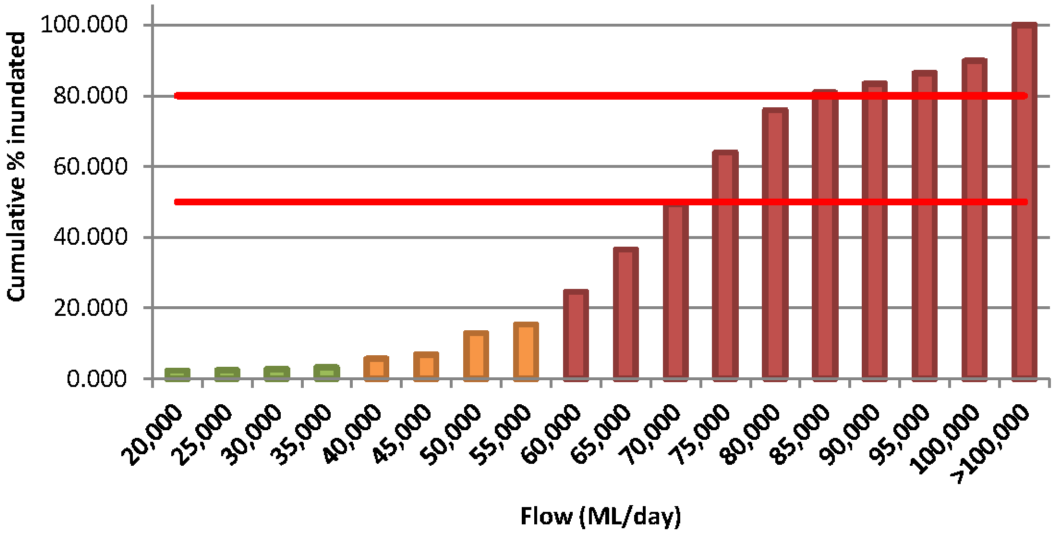

Figure 31. Proportion of lignum habitat inundated on the SA RM floodplain at 5000 ML/day flow increments

Green bars indicate all metrics of the SA EWR are met under 2750 GL scenario

Orange bars indicate the frequency and duration metrics are met but not maximum interval metric

Red bars indicate the frequency/duration metrics are not met

Red lines indicates the targeted proportion of lignum (50% and 80%)

7.4.3. RECRUITMENT OF KEY VEGETATION COMMUNITIES

The analysis has already shown that a large proportion of the three key floodplain vegetation species (red gums, black box and lignum) remain at risk under the 2750 GL scenario due to only small areas receiving an appropriate flow regime to support adult tree survival. For self-sustaining populations to persist, germination and recruitment to the adult population is also required.

There are separate targets and EWRs relating to red gum, black box and lignum recruitment (see RGr, BBr1, BBr2, Ligr in Table 6. An assessment was undertaken to determine the flow rates under the 2750 GL scenario that meet the EWR metrics for red gum and black box recruitment and the proportion of the current extent of each vegetation type inundated at these flow rates. As adult trees will need to be present to provide propagules, these are considered the areas where successful recruitment will most likely occur. The lignum recruitment target and EWR could not be assessed using the hydrological data available.

Under the 2750 GL scenario, the maximum flow rate that will meet the inundation frequency and duration requirements for red gum recruitment (as per the SA EWR) is 55 000 ML/day. At flows of 55 000 ML/day, 23.9% of red gums on the SA River Murray floodplain are inundated, which indicates that successful recruitment could occur within 23.9% of the current extent of red gum woodlands and forests.

The EWR also specifies that red gum recruitment requires 60-day duration flood events in successive years (or serial floods). The interval analysis provided in Section 6 shows the number of times that 60-day events occur with an interval of only one year, i.e. the number of times the appropriate conditions for red gum recruitment will occur. This analysis indicates that, under the 2750 GL scenario, there would potentially be eight successful recruitment events in the modelled 114-year period.

There are two targets and EWRs relating to black box recruitment. BBr1 is for black box recruitment at lower elevations and hence specifies a lower targeted flow rate, while BBr2 relates to black box recruitment at higher elevations and specifies a higher flow rate. There is no difference in the frequency and duration metrics of BBr1 and BBr2.

The maximum flow rate under 2750 GL scenario that meets the frequency and duration metrics for black box recruitment (as per the SA EWR) is 85 000 ML/day. At flows of 85 000 ML/day, 35.7% of black box on the SA River Murray floodplain is inundated, which indicates that successful recruitment could occur within 35.7% of the current extent of black box woodlands.

Like red gums, black box are believed to require serial floods for successful recruitment and the EWRs specify 20-day duration events in successive years are needed. No interval analysis for 85 000 ML/day events of 20-days duration is available. However, it does show that consecutive 80 000 ML/day events of 30-days duration occur three times in the 114-year modelled period and 100 000 ML/day events of 21-days duration occur twice in the 114-year period. These results indicate that two to three black box recruitment events could potentially occur in the modelled 114-year period.

7.4.4. TEMPORARY WETLANDS

There are two targets for temporary wetlands. TW2 is for a lesser proportion of temporary wetlands compared to TW2 and has a lower flow rate, longer duration, higher frequency and shorter maximum interval, implying a need for longer, more frequent floods in wetlands located at lower elevations. The EWRs for temporary wetlands were developed to support bird and fish breeding, microbial decay and the export of organic matter as well as wetland condition.

The EWR for TW1 specifies a maximum interval metric of five years (for 30-day duration events), which is met at flows of 35 000 ML/day under the 2750 GL scenario and inundates 46% of temporary wetlands. However, the EWR for TW2 specifies a shorter maximum interval for temporary wetlands located at lower elevations (<40 000 ML/day) of three years but also a longer event duration (90 days). These requirements were met at flows of 15 000 ML/day under 2750 GL scenario. The FIM analysis was only undertaken for flow bands of 20 000 ML/day and above. At flows of 20 000 ML/day, 35.8% of temporary wetlands are supported at a low level of risk. Although the flow rate specified by the TW2 EWR was not met under the 2750 GL scenario, it is likely that a greater area of temporary wetlands will be maintained than targeted (20%).

Under the 2750 GL scenario, the maximum flow rate that meets the average frequency and duration metrics of TW1 (higher elevation wetlands) is 60 000 ML/day, where 65.8% of temporary wetlands are inundated. The EWR for TW2 indicates that wetlands located at elevations at or below 40 000 ML/day need to be inundated longer and more often. The frequency and duration metrics of TW2 are met by flows of 30 000 ML/day under the 2750 GL scenario. At flows of 30 000 ML/day, 43.7% of temporary wetlands on the SA River Murray floodplain will be inundated (Figure 33), which exceeds the target of 20%.

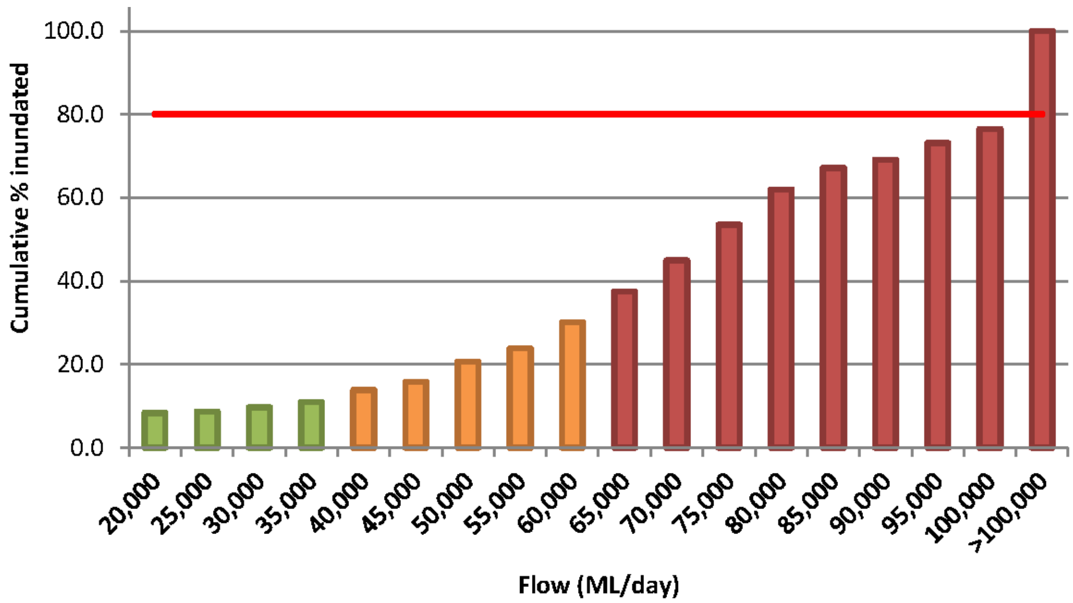

Figure 32. Proportion of red gum habitat inundated on the SA RM floodplain at 5000 ML/day flow increments

Green bars indicate all metrics of the SA EWR are met under 2750 GL scenario

Orange bars indicate the frequency and duration metrics are met but not maximum interval metric

Red bars indicate the frequency/duration metrics are not met

Red line indicates the targeted proportion of red gums (80%)

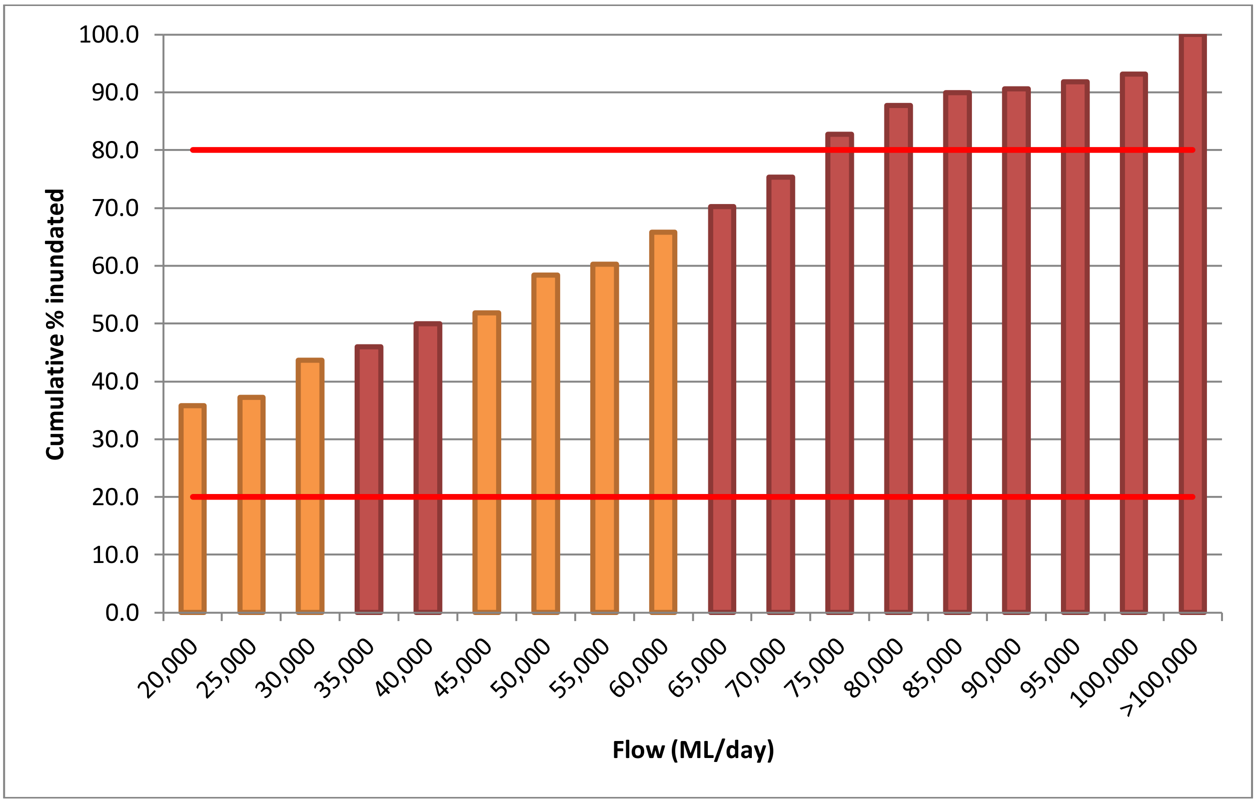

Figure 33. Proportion of temporary wetlands inundated on the SA RM floodplain at 5000 ML/day flow increments

Orange bars indicate the frequency and duration metrics are met but not maximum interval metric
Red bars indicate the frequency/duration metrics are not met
Red lines indicates the targeted proportion of temporary wetlands (20% and 80%)

7.4.5. MOSAIC OF HABITATS

There are four EWRs for the target 'provide mosaic of habitats' (see Mos1, Mos2, Mos3 and Mos4 in Table 6), which were established by using the FIM to determine the flows at which the largest percentages (non-cumulative) of eight habitat types are inundated (DWLBC 2010). There were slight differences in the habitat types used to develop the EWRs and those used for this analysis. In developing the EWRs, DWLBC (2010) considered temporary wetlands, lignums, samphire, sporobulus, chenopod, reedbed, black box woodland and red gum forests and woodlands. The analysis for this report used the vegetation groups from the DENR mapping of woodlands and forests, shrublands, forblands, grasslands and sedgelands, which are similar to the functional groups identified in Rogers and Ralph 2011. Data for the three dominant floodplain vegetation species (lignums, black box woodlands and red gum forests and woodlands) were separated out. Temporary wetlands were not considered separately for this analysis as the DENR vegetation mapping included vegetation that fell within the mapped temporary wetland polygons. Despite these differences, the target can still be assessed as it relates to a mosaic of habitats rather than specific habitat types. The target specifies inundation of a 'large proportion of various habitats' but does not give a specific proportion or habitat type therefore a more qualitative assessment was undertaken for Mos1, Mos2 Mos3 and Mos4.

The four EWRs for the target 'provide mosaic of habitats' differ, with those specifying a lower flow rate generally having a longer duration, higher frequency and shorter maximum interval. It is assumed that these EWRs take into account the potential for vegetation at higher elevations to have adapted to require water less often to survive.

The targeted flow rate ranged from 60 000 ML/day for Mos4 to 90 000 ML/day for Mos1. The flow rate that meets the frequency and duration metrics of the EWRs under the 2750 GL scenario ranges from 45 000 ML/day for Mos4 to 60 000 ML/day for Mos1 (Table 9). The flow rate that meets the duration and maximum interval metrics of the EWRs under the 2750 GL scenario ranges from 20 000 ML/day for Mos4 to 35 000 ML/day for Mos2[15] (Table 9).

Figure 34 shows the proportion of each habitat type inundated at 10 000 ML/day increments on the SA RM floodplain. At flows of 20 000 ML/day and 35 000 ML/day, less than 20% of all habitat types are inundated, except for sedgelands. It is not until flow rates of over 70 000 ML/day that more than 50% each of lignum, grasslands, red gum and other shrublands inundation occurs. For black box, other woodlands and forblands, flows of greater than 100 000 ML/day are required to inundate 50% of the habitat.

The analysis indicated that the area of lower-elevation temporary wetland that will receive an appropriate flow regime (as per TW2 EWR) will exceed the target. Taxa that rely on lower-elevation temporary wetlands for habitat and breeding are therefore potentially at a low level of risk under the 2750 GL scenario. This may include frog species such as the nationally-threatened southern bell frog (*Litoria raniformis*) and native fish species that are considered low flow and wetland specialists. Native fish species that fall within this functional group include the Murray hardyhead (*Craterocephalus fluviatilis*) and purple-spotted gudgeon (*Morgurnda adspersa*), both of which are listed as threatened species.

A quantitative assessment of target FV is not possible due to the nature of the EWR metrics, which describe annual variability of flows between entitlement and 40 000 ML/day (the threshold for in-channel flows). The hydrological assessment indicates that under 2750 GL scenario there will be an improvement in within-channel flows including the creation of freshes. These improvements may benefit taxa that benefit from increases in flow velocity including large-bodied native fish, particularly flow-cued spawners such as callop (*Macquaria ambigua*) and silver perch (*Bidyanus bidyanus*).

Data from the assessment of the target for the provision of a mosaic of habitats indicate that sedgelands may also be at a low level of risk due to a high proportion being inundated at lower flow rates. Fauna that rely on sedgelands for habitat could also therefore be at a low level of risk.

Data from the assessment of the target for the provision of a mosaic of habitats indicate that only small proportions of most other vegetation groups are inundated at lower flow rates, particularly other woodlands and forblands. Fauna that rely on floodplain vegetation for habitat, particularly those using woodlands and forblands, may therefore may continue to be at risk.

There are two targets and EWRs specifically relating to waterbird breeding, one focussed on the inundation of lignum (WB1) and the other on the inundation of red gums (WB2). The frequency, duration and maximum interval metrics of WB1 and WB2 are the same.

Under the 2750 GL scenario, the maximum flow rate that meets the frequency and duration metrics of WB1 and WB2 is 45 000 ML/day and the maximum flow rate that meets the duration and maximum interval metrics is 20 000 ML/day. At flows of 20 000 ML/day, 2.3% of existing lignum on the SA RM floodplain and 8.4% of existing red gum forests and woodlands are inundated. Waterbirds that rely on inundated red gum and lignum for breeding could potentially be at risk due to a lack of available breeding habitat, although an assessment at the individual species level should be undertaken due to differences in requirements between species.

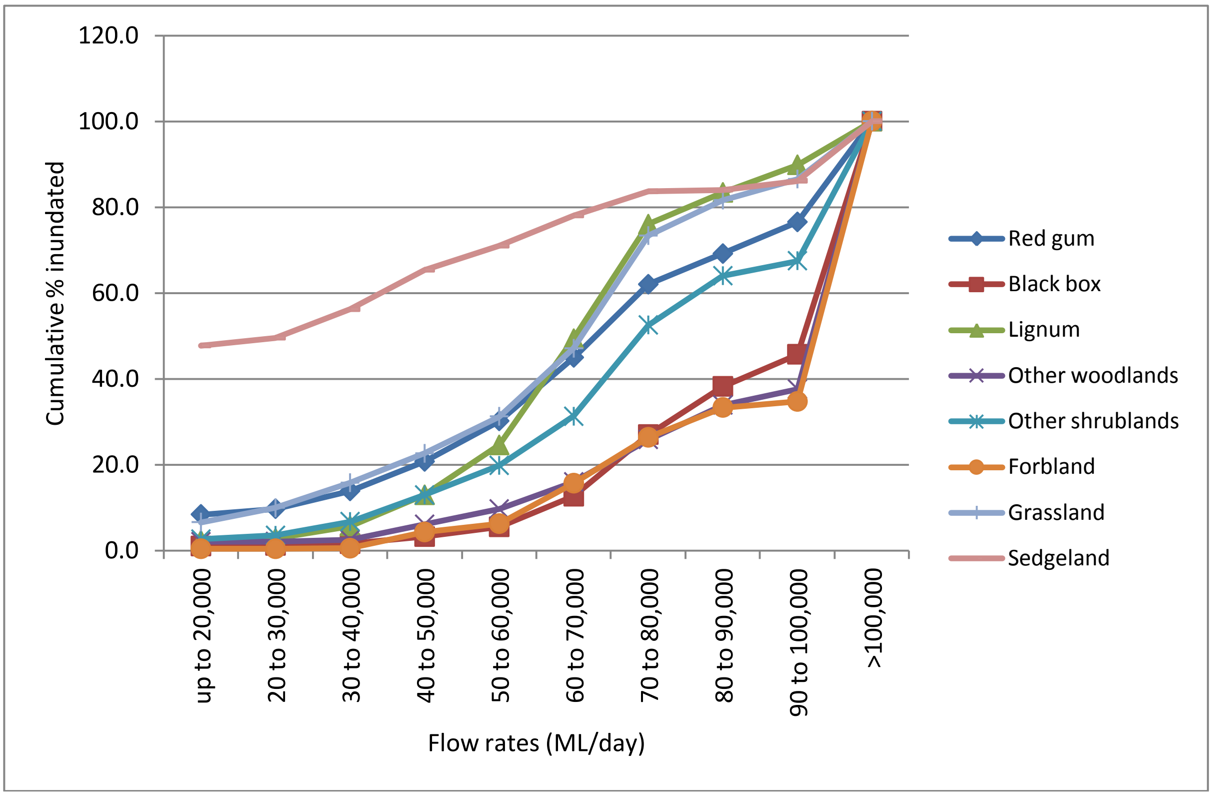

Figure 34. Proportion of each major vegetation group inundated at 10 000 ML/day flow increments on the SA River Murray floodplain

The proportion of each habitat type inundated at 10 000 ML/day increments for the SA floodplain was calculated (Figure 34). At flows of approximately 30 000 ML/day less than 20% of all habitat types are inundated, except for sedgelands. It is not until flow rates reach 70 000 ML/day that more than 50% of lignum, grasslands, red gums and other shrublands are inundated. For black box, other woodlands and forbes, flows of greater than 100 000 ML/day are required to inundate 50% of the habitat. Habitat types such as lignum, grasslands and 'other shrublands' show the greatest increase in the percentage of inundation between flow bands of 40 000 and 80 000 ML/day with lignum showing an increase of cumulative inundation of approximately 6% at 40 000 ML/day to approximately 76% at 80 000 ML/day. This suggests that further improvement in the delivery of flows between the 40 000 ML/day and 80 000 ML/day could achieve significant ecological improvement for some habitat types.

7.5. INFORMATION TO SUPPORT FURTHER ECOLOGICAL ANALYSIS

The short and long-term consequences to the floodplain of only partially meeting the EWR are unclear and require further ecological interpretation.

There may be some tolerance within the EWRs, with vegetation able to survive, but not necessarily thrive and reproduce under a reduced duration and frequency of flooding. Duration of events can be important to ensure ecological processes and functions, such as breeding cycles, have sufficient time to fully complete. The frequency of events is important for ensuring key functions and processes occur often enough to sustain populations and communities. However, it is likely that exceeding maximum interval thresholds is ecologically more significant than not meeting the average frequency or duration metrics. However, the SA EWR have been developed from vegetation currently growing at higher elevations on the floodplain that have adapted to and/or require less frequent flooding and therefore may have different maximum thresholds for intervals between events. For example the EWR for lignum at lower elevations has a maximum return interval of five years, whereas the equivalent EWR for higher elevations has an eight year maximum interval. This suggests that lignum communities have the ability to adapt and survive with longer periods between flood events. It is not clear however, whether lignum that has recruited and established under a wetter regime can adapt to a drier regime or whether only those that recruit and establish under a dry regime are tolerant.

Understanding these tolerances and thresholds will be important for managing the floodplain through the implementation of the Basin Plan. For example if it is assumed that lignum could recruit and establish at the lower elevations of the floodplain under and adapt to a frequency of flooding similar to that currently at higher elevations (Lig2 EWR metrics) then the 2750 GL scenario could provide suitable hydrological conditions and support a much larger area of lignum than has been currently presented.

Future ecological research and investigation needs to focus on improving our understanding of floodplain responses and enable manages to optimise delivery of environmental water for maximum ecological benefit.

There is a distinct grouping of targets within Table 6 and reference back to the EWRs indicates that the reinstatement of 1-in-4 year events of 80 000 ML/day for 30 days and 70 000 ML/day for 60 days would benefit several habitats and functions, including adult red gum survival, mosaic of habitats, waterbird breeding, floodplain access for spawning and large-scale fish, frog and bird breeding.

7.6. SUMMARY OF THE ECOLOGICAL INTERPRETATION

- There are distinct differences between the valley and gorge geomorphic reaches and that the EWR based on the ecological assets of the valley reach may not be directly applicable to assets in the gorge reach.
- The improved hydrological conditions observed for the 2750 GL scenario are expected to achieve some ecological improvement compared to baseline conditions. Benefits are most likely to be observed in and around the main channel of the River. The habitats most likely to experience benefit are the in-channel habitats, some low lying temporary wetlands and some floodplain communities.

- Using the low-risk approach, the 2750 GL scenario could potentially support 30% more red gum habitat and 39% more lignum habitat relative to the low-risk baseline conditions (i.e. under the 2750 GL scenario, approximately 11% of total red gum habitat and approximately 3.2% of total lignum habitat will be supported compared to 8.4% and 2.3% respectively under baseline conditions). Using the higher risk approach (i.e. the average frequencies are met) approximately 30% of total red gum habitat and 15% of total lignum habitat could be supported under the 2750 GL scenario compared to 24% and 7% respectively for the baseline scenario. This represents a 25% increase for red gum and a 114% increase for lignum under the 2750 GL scenario relative to the baseline scenario.
- A large percentage of the total floodplain, as defined by the 1956 flood line, remains at risk under the 2750 GL scenario, with either the frequency and/or the duration of flow events less than that required to support good condition.
- Significant area of floodplain vegetation communities become inundated with flows between 40 000 ML/day to 80 000 ML/day. For example, only 6% of the total lignum community is inundated at 40 000 ML/day whereas this increases to 76% of the total community at flows of 80 000 ML/day.

8. ANALYSIS OF SENSITIVITY SCENARIOS

An assessment of EWRs met under the 2400 GL and 3200 GL sensitivity scenarios for South Australian and MDBA EWRs is shown in Table 10. For the most part, the modelled results show only minor differences in outcomes for the 2400 GL and 3200 GL scenarios. Improvement is seen for the EWRs MDBA 6, BBr2, BB1 and BB2, however, these all relate to essentially the same flow and duration requirement of 100 000 ML/day for 20 days, so the overall impact is possibly exaggerated due to there being multiple EWRs with the same requirement. The small impact from the sensitivity cases has been explained by the MDBA as being due to the relatively small scale of change (400 GL represents +/- 5% of the median annual flow to South Australia under baseline conditions) and the impact of constraints which restricts the delivery of high overbank flows to the floodplain (MDBA 2011b). However, analysis by DFW of model results made available by the MDBA has been unable to confirm that constraints, rather than water availability, have restricted the delivery of additional events under the 3200 GL scenario. This is discussed further in Section 10.

Table 10. Assessment of EWRs for 2400 GL, 2750 GL and 3200 GL Sensitivity Scenarios

EWR	Target Average Recurrence Interval	Modelled Average Recurrence Interval (years)				
		Baseline	Without Development	2400 GL scenario	2750 GL scenario	3200 GL scenario
MDBA EWRs						
MDBA 1	1.25–1.4	2.2	1.1	1.3	1.3	1.3
MDBA 2	1.4–2	2.7	1.2	2	1.9	1.8
MDBA 3	2–3	4.4	1.6	3	2.9	2.9
MDBA 4	3–4	8.1	2.3	5.2	5.4	4.8
MDBA 5	4–6	10.4	2.9	8.8	9.5	8.8
MDBA 6	6–8	16	5	16	19	14
MDBA 7	8–10	23	6	23	23	23
South Australian EWRS						
BBr1	10	9.5	2.9	8.8	8.8	8.1
BBr2	10	16	5	16	19	14
BB1	6	16	5	16	19	14
BB2	5	16	5	16	19	14
BB3	5	11	3.4	10	9.5	10
RGr	5	16	5	19	16	16
RG	4	10	2.9	8.8	9.5	8.8
Lig1	3	8.1	2.3	6.3	6	5.4
Lig2	5	10	2.9	8.8	9.5	8.8
Ligr	5	29	10	29	29	29

EWR	Target Average Recurrence Interval	Modelled Average Recurrence Interval (years)				
		Baseline	Without Development	2400 GL scenario	2750 GL scenario	3200 GL scenario
Mos1	5	14	4.1	11	13	13
Mos2	4	10	2.9	8.8	9.5	8.8
Mos3	4	14	3	11	13	9.5
Mos4	3	11	2.5	9.5	9.5	7.6
WB	4	14	3	11	13	9.5
FP	4	10	2.9	8.8	9.5	8.8
TW1	4	10	2.9	8.8	9.5	8.8
TW2	2	4.4	1.6	3	2.9	2.9
FV	1.3	4.4	1.6	3	2.9	2.9

Note: Green denotes EWR achieved, orange denotes EWR not achieved but improved from baseline, red denotes worse than or the same as baseline

The difficulty with making meaningful comparisons between the scenarios at the statistical level is demonstrated by comparing the frequencies for the MDBA EWRs for flows of 60 000 ML/day to 100 000 ML/day and the South Australian EWRs for flows of 70 000 ML/day to 100 000 ML/day, as shown in Table 10. For these EWRs the frequency of events for the 2750 GL scenario is less than both the 2400 GL and 3200 GL scenarios, which confirms that the results are influenced by factors other than the total volume of environmental water. It also highlights the considerable uncertainty with using these modelling results for comparing outcomes between scenarios at the statistical level.

In order to investigate these differences between modelling results further, the durations of individual events meeting various flow criteria were plotted. These are shown in Figure 35, Figure 36 and Figure 37. The durations of events exceeding 70 000 ML/day is shown in Figure 35. It can be seen that for the majority of events, the Basin Plan scenarios deliver 70 000 ML/day for similar durations, but typically increasing with the volume of water recovered. However, there are some notable exceptions where the Basin Plan scenarios deliver events differently, as highlighted in the figure. In the particular case of the South Australian EWR ‘Mos3’, which has a requirement of 70 000 ML/day for 60 days, the Basin Plan scenarios are similar across all events except for 1921 and 1993. In 1921, the EWR is only met by the 3200 GL scenario. The 1993 event, however, is interesting because the EWR is met by the 2400 GL and 3200 GL scenario, but not the 2750 GL scenario. The difference in durations between the scenarios is small (57 days for the 2750 GL scenario compared to 60 days for both the 2400 GL and 3200 GL scenarios), yet the ‘failure’ of this single 2750 GL event affects the reported statistics to imply that the 2750 GL scenario delivers worse outcomes than the other two scenarios. This demonstrates that caution needs to be applied when interpreting the statistics, as the success or failure of certain events may disproportionately skew the metrics that are reported.

A similar situation exists for the 80 000 ML/day EWRs, as shown in Figure 36. Average interval statistics indicate that the EWR of MDBA 5 (80 000 ML/day for 30 days) occurs more frequently for the 2400 GL scenario than for 2750 GL. However, inspection of the durations of individual events shows that this is due to the delivery of a single additional event in 1973. This is also the case for the 100 000 ML/day EWRs, which demonstrate a discrepancy for the 1981 event.

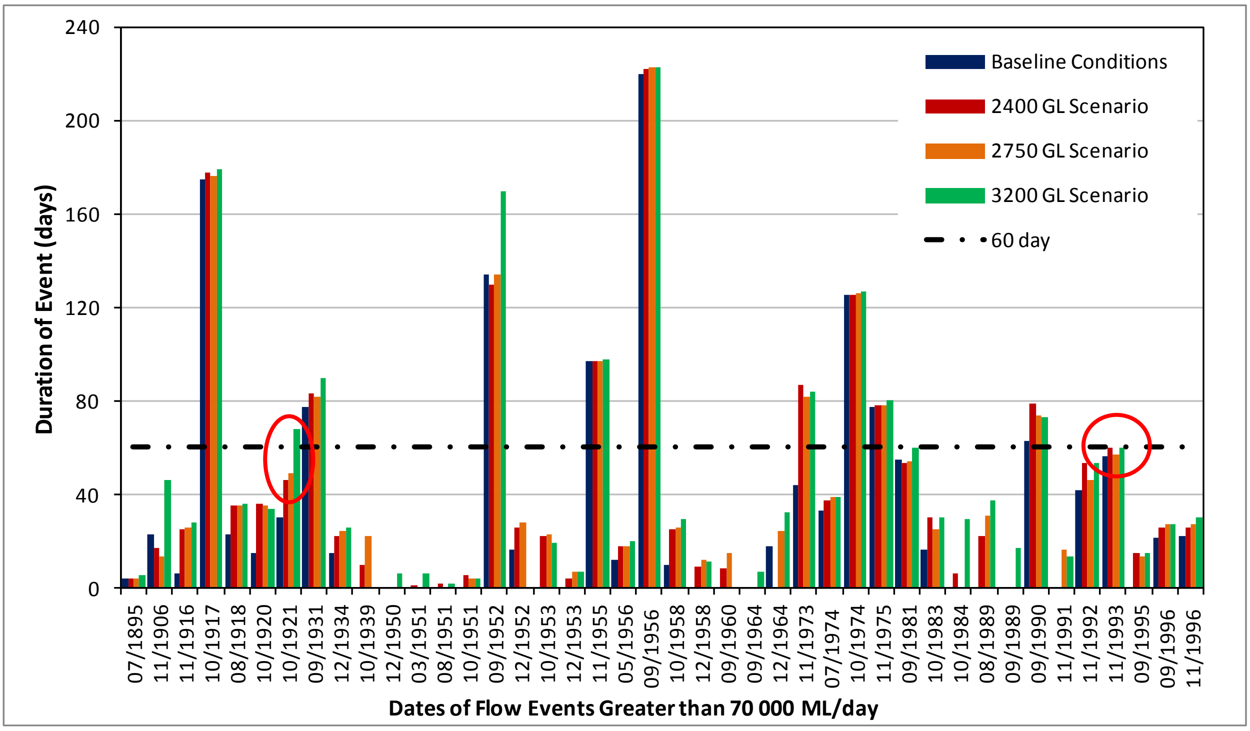

Figure 35. Duration of events exceeding 70 000 ML/day

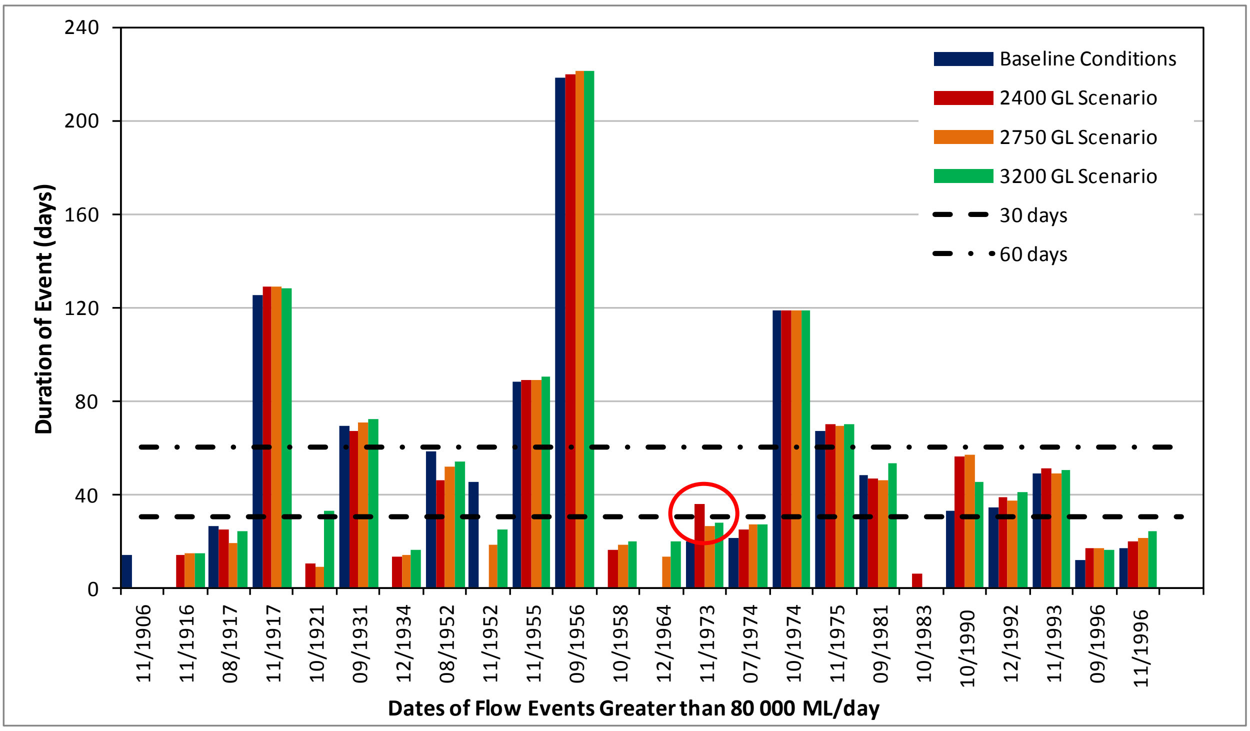

Figure 36. Duration of events exceeding 80 000 ML/day

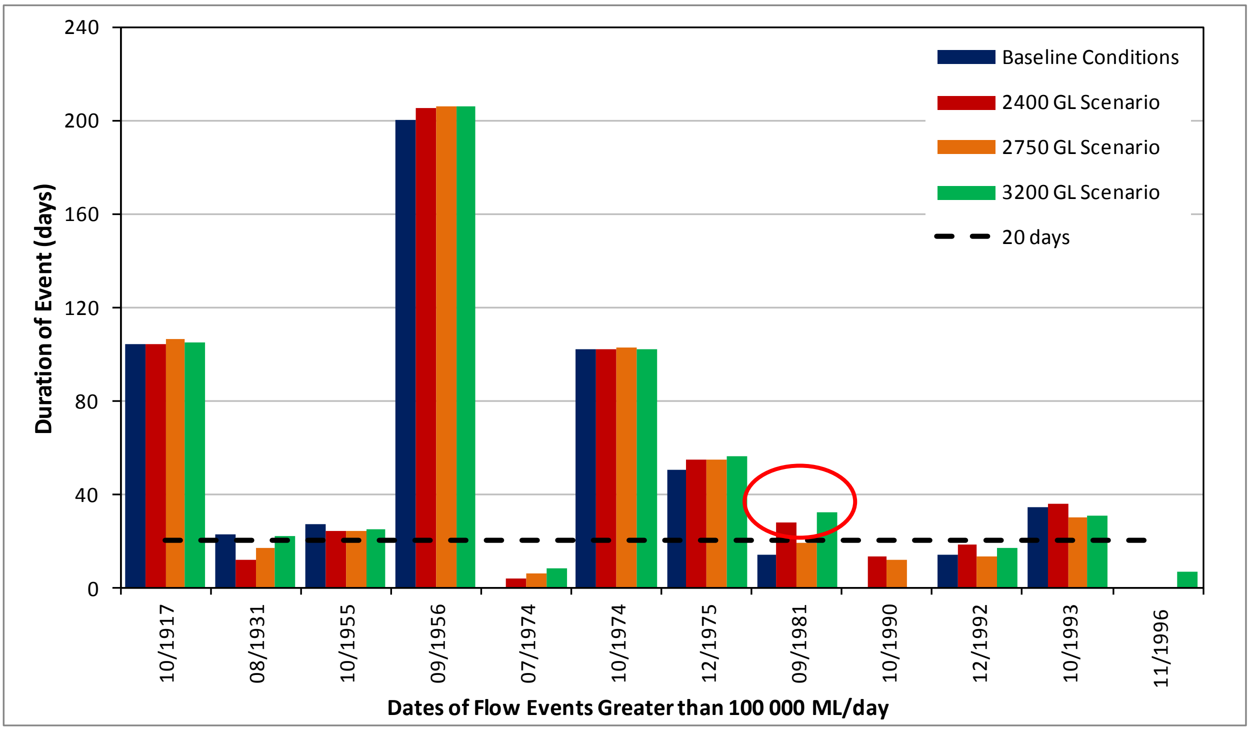

Figure 37. Duration of events exceeding 100 000 ML/day

The analysis of maximum dry periods for MDBA and South Australian EWRs is shown in Table 11. It can be seen that the 3200 GL scenario does have an appreciable impact on reducing the maximum dry period for some events, but generally the difference is small.

Table 11. Maximum Dry Interval for South Australian EWRs

	Environmental Water Requirement	2400 GL Scenario Maximum Interval (years)	2750 GL Scenario Maximum Interval (years)	3200 GL Scenario Maximum Interval (years)
MDBA EWRs				
MDBA 1	20 000 ML/day for 60 days	4	4	4
MDBA 2	40 000 ML/day for 30 days	9	9	9
MDBA 3	40 000 ML/day for 90 days	13	13	13
MDBA 4	60 000 ML/day for 60 days	23	23	22
MDBA 5	80 000 ML/day for 30 days	23	23	23
MDBA 6	100 000 ML/day for 21 days	38	38	24

	Environmental Water Requirement	2400 GL Scenario Maximum Interval (years)	2750 GL Scenario Maximum Interval (years)	3200 GL Scenario Maximum Interval (years)
MDBA 7	125 000 ML/day for 7 days	38	38	38
South Australian EWRS				
BBr1	85 000 ML/day for 20 days	23	23	23
BBr2	100 000 ML/day for 20 days	38	38	24
BB1	100 000 ML/day for 20 days	38	38	24
BB2	100 000 ML/day for 20 days	38	38	24
BB3	85 000 ML/day for 30 days	23	23	23
RGr	80 000 ML/day for 60 days	34	34	34
RG	80 000 to 90 000 ML/day for 30 days	23	23	23
Lig1	70 000 ML/day for 30 days	23	23	21
Lig2	80 000 ML/day for 30 days	23	23	23
Ligr	70 000 ML/day for 120 days	35	35	35
Mos1	90 000 ML/day for 30 days	24	24	24
Mos2	80 000 ML/day for 30 days	23	23	23
Mos3	70 000 ML/day for 60 days	23	23	23
WB1	60 000 ML/day for 60 days	23	23	22
WB2	70 000 ML/day for 60 days	23	23	23
FP	80 000 ML/day for 30 days	23	23	23
TW1	80 000 ML/day for 30 days	23	23	23
TW2	40 000 ML/day for 90 days	13	13	13

	Environmental Water Requirement	2400 GL Scenario Maximum Interval (years)	2750 GL Scenario Maximum Interval (years)	3200 GL Scenario Maximum Interval (years)
FV	Up to 40 000 ML/day	9	9	9

From the data presented in Table 11 it appears that there is no significant difference between the maximum dry periods between the 2400 GL and 2750 GL scenarios. The 3200 GL scenario reduces the maximum interval for a small number of EWRs compared to the 2750 GL scenario, but only those relating to 100 000 ML/day flows.

The maximum interval results presented in Table 11 above for the MDBA EWRs are also graphed in Figure 38, along with baseline and without development results. For the lower flow EWRs (20 000 ML/day to 40 000 ML/day), there is no difference in maximum interval between events when comparing the sensitivity scenarios, although there is a marked improvement (reduction in maximum interval) when compared to baseline conditions. Maximum intervals are similar across sensitivity scenarios and baseline conditions for the higher flow EWRS (60 000 ML/day and above), with the exception of the EWR for 100 000 ML/day, which demonstrates an increase in maximum interval for the 2400 GL and 2750 GL scenarios compared to baseline. Figure 38 reiterates the observations from Table 11 that only the statistics relating to the 100 000 ML/day EWR show an improvement in maximum interval between events when comparing the 3200 GL scenario to the 2750 GL scenario. Despite the improvement compared to the 2750 GL scenario, it does not represent an improvement from baseline conditions.

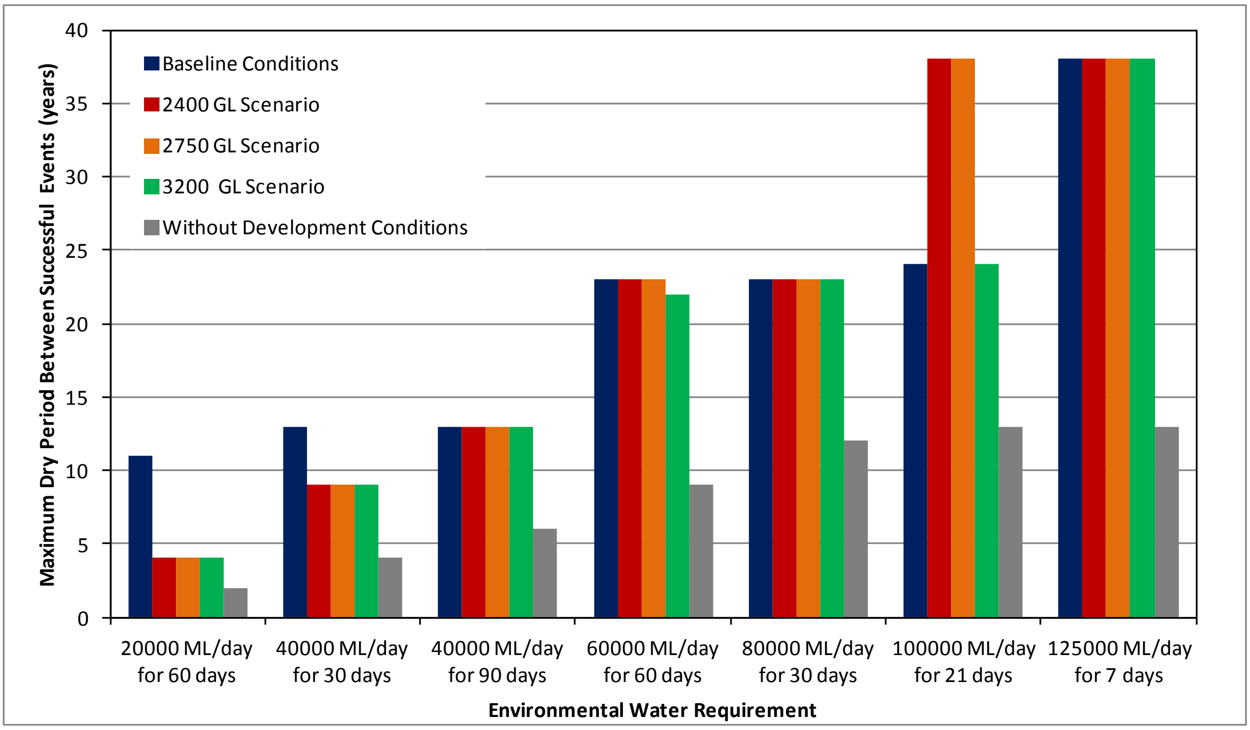

Figure 38. Maximum Interval Between Successful Events for MDBA EWRs, 2750 GL Scenario vs. Baseline Conditions, 2400 and 3200 GL Scenarios and Without Development Conditions

ANALYSIS OF SENSITIVITY SCENARIOS

Based on the analysis presented in this section, it is difficult to assess whether the sensitivity scenarios make a significant difference to the delivery of Riverland–Chowilla EWRs, particularly for EWRs with higher flow requirements. For higher flow events, the differences between the Basin Plan sensitivity scenarios in terms of event delivery and duration appears to be small across most events, with significant alteration or enhancement limited to only a few events over the modelled period. Similarly, when the maximum interval between events is analysed, significant improvements are only evident for EWRs relating to a flows of 100 000 ML/day. Nonetheless, it is recognised that this analysis is based upon modelling which retains existing system constraints, which is likely to limit the outcomes achievable.

9. WATER AVAILABILITY TO MEET WATER QUALITY REQUIREMENTS

Salinity is the main parameter for which an assessment can be made regarding the water quality impacts of the proposed Basin Plan. MSM-BIGMOD calculates salinity for the River Murray and Lower Lakes for only a portion of the total climate modelling period—since 1st January 1975, a period of 34 years. However, there remains considerable uncertainty as to the ability of the model to represent and predict the salinity impacts of the changed distribution of water under the proposed Basin Plan. In particular, the salinity impact of environmental water management on the River Murray floodplain is not yet well quantified and consequently not explicitly represented in the model. Nonetheless, the model is considered to provide some useful insights into water quality trends.

A comprehensive assessment of salinity in the Lower Lakes is included in Heneker and Higham (2012).

The proposed Basin Plan (MDBA 2011a) sets out salinity targets and triggers for the River Murray in South Australia based on requirements for human consumption, irrigation, recreation, salinity management and the environment. The Murray-Darling Basin Agreement (Schedule 1 to the Water Act) also prescribes a Basin Salinity Target. An assessment of compliance to targets and triggers relating to South Australia has been undertaken based on modelled salinity outputs generated by MSM-BIGMOD, shown in Table 12.

Table 12. Compliance with Salinity Targets and Triggers

Salinity Target or Trigger	Reporting site[16]	Target value (mg/L)	Target value, EC (µS/cm)	Compliance[17] with target over modelled period (1/1/1975–30/6/2009	
				Baseline Conditions	2750 GL Scenario
Water quality targets for raw water for treatment for human consumption (MDBA 2011a, S.8.13)	Tailem Bend	500	830	95%	97%
Water quality targets for irrigation water – Southern Basin, Murray River and Tributaries (MDBA 2011a, S.8.14)	Tailem Bend	500 95% of the time	830 95% of the time	95%	97%
Salinity Operational Target (MDBA 2011a, S.8.18)	Murray Bridge	500 95% of the time	830 95% of the time	96%	97%
	Morgan	500 95% of the time	830	97%	99%
Salinity trigger point at which water in the River Murray System becomes unsuitable for meeting critical human water needs (MDBA 2011a, S.10.05)	Tailem Bend	840	1400	100%	100%
Basin Salinity Target (Schedule B to the Murray-Darling Basin Agreement, Water Act)	Morgan	-	800 for 95% of time during Benchmark Period (1/5/75 to 30/4/00)	96% (96% during Benchmark Period)	98% (99% during Benchmark Period)

For the locations assessed in South Australia, the proposed Basin Plan scenario leads to an improvement in salinity according to the modelled outputs. The maximum period of exceedance of the 500 mg/L target value is also improved by the 2750 GL scenario, reducing to 92 days compared to a maximum period of exceedance of 124 days under baseline conditions. The improvements are thought to be due

[16] Where no reporting site has been specified, targets have been assessed at Tailem Bend since this is the most downstream site for water extractions (excluding the Lower Lakes) for which salinity is modelled by MSM-BIGMOD

[17] Percentage of days less than or equal to target value

to increases in lower-range flows which provide additional dilution of salt inflows. Increased frequency of low flow ranges is also likely to reduce the likelihood of algal blooms, although this hasn't been quantitatively assessed. These downward trends in salinity should be viewed as indicative only, as they are dependent on many factors which cannot be modelled at this stage, such as changed flooding regimes of floodplains and wetlands, both natural and managed.

Human consumption, irrigation and operational targets are met for all sites in South Australia. Further clarification is required from the MDBA regarding what is specifically meant by "95% of time", for example, if it refers to an annual rolling period or some shorter or longer length of time, as this will affect maximum longest period for which the target may be exceeded. Schedule 10 of MDBA 2011a specifies that water quality and salinity targets are to be reported against every five years. It is not clear if this is the period against which the criteria "95% of time" is measured.

10. DISCUSSION

This report has provided a hydrological analysis of the modelling outputs and other material generated by the MDBA for the development of the proposed Basin Plan. It has focused on assessing the flows that South Australia can expect to receive under the proposed Basin Plan and whether these flows would be sufficient to deliver on specified environmental and water quality targets. The analysis was used as the basis of an ecological interpretation which has described the potential ecological outcomes and consequences to the South Australian floodplain of the proposed water recovery scenario.

Key findings from the hydrological analysis include:

- The 2750 GL water recovery scenario demonstrates an improvement in the delivery of flows to meet River Murray EWRs in South Australia when compared to baseline conditions.
- Improvements are evident both in the total annual volume delivered to South Australia as well as the frequency of daily flow rates. Notably, the median annual volume is predicted to increase by 2400 GL an increase of approximately 50% compared to baseline.
- In the driest year over the modelled 114-year climate period the lowest annual volume nearly doubled from 1030 GL to 2000 GL.
- The median flow increased from 18 050 ML/day to 23 000 ML/day.
- In terms of daily flow rate over the border the 2750 GL scenario resulted in an increase in the frequency of all flow rates up to approximately 80 000 ML/day. The frequency of high flow events (i.e. over 80 000 ML/day) remain similar to baseline conditions. These high flows are generally referred to as unregulated events and are therefore beyond the reasonable control of river management actions.
- Despite this improvement very few Riverland–Chowilla EWRs defined by either the MDBA or South Australia are met under the 2750 GL scenario when assessed according to average frequency. MDBA targets are set across a range of risk levels and three of the seven MDBA targets are met at a high level of risk. The South Australian targets are set at a low level of risk and one out of the twenty SA targets is met.
- Modelled outputs for salinity were improved by the 2750 GL scenario compared to baseline. Targets for drinking water quality, irrigation and environment which require salinity to be below 500 mg/L (830 EC) for 95% of the time are met by the 2850 GL scenario. The modelled salinity also remains below 1400 EC for 100% of the time, thus meeting the requirement for critical human water needs.

Key findings from the ecological interpretation include:

- There are distinct differences between the valley and gorge geomorphic reaches and that the EWR based on the ecological assets of the valley reach may not be directly applicable to assets in the gorge reach.
- The improved hydrological conditions observed for the 2750 GL scenario are expected to achieve some ecological improvement compared to baseline conditions. Benefits are most likely to be observed in and around the main channel of the River. The habitats most likely to experience

benefit are the in-channel habitats some low lying temporary wetlands and a portion of the floodplain communities such as red gum and lignum.

- Using the low risk approach, (i.e. the maximum interval and duration metrics are met) the 2750 GL scenario could potentially support 30% more red gum habitat and 39% more lignum habitat relative to the low risk baseline scenario. That is, under the 2750 GL scenario approximately 11% of total red gum habitat and approximately 3.2% of total lignum habitat will be supported compared to 8.4% and 2.3% respectively under baseline conditions. Using the higher risk approach (i.e. the average frequencies are met but maximum intervals may be breached) approximately 30% of total red gum habitat and 15% of total lignum habitat could be supported under the 2750 GL scenario compared to 24% and 7% respectively for the baseline scenario. This represents a 25% increase for red gum and a 114% increase for lignum under the 2750 GL scenario relative to the baseline scenario.
- A large percentage of the total floodplain as defined by the 1956 flood line remains at risk under the 2750 GL scenario with either the frequency and/or the duration of flow events less than that required to support good condition.
- Significant areas of floodplain vegetation communities become inundated with flows between 40 000 ML/day to 80 000 ML/day. For example, only 6% of the total lignum community is inundated at 40 000 ML/day whereas this increases to 76% of the total community at flows of 80 000 ML/day. Similarly, the area of red gum inundated increases from 14% at 40 000 ML/day to 62% at 80 000 ML/day.

It is important that the key assumptions and limitations of the approach (both of the MDBA modelling as well as this current analysis) are recognised and it is highlighted how these might impact on the conclusions and findings of this analysis. Discussion of these assumptions and limitations has been informed by the analysis presented in this report as well as material provided by the MDBA in the form of reports briefing sessions and other communications.

One of the key limitations of the modelling approach is that the model outputs are only one of many possible representations. That is, the outputs only represent one way in which the recovered environmental water could be delivered and there are numerous possible variations.

The hydrological modelling undertaken to date by the MDBA uses various assumptions for the way environmental water is secured and delivered. As the Basin Plan is implemented the patterns of acquisition and delivery for environmental water may be different to those assumptions and therefore, the actual patterns of water delivery may differ from the modelled results. This means that the hydrological and ecological outcomes achieved by the recovered volume could be different to those presented in this report. Key assumptions incorporated in the modelling that could vary upon implementation of the Basin Plan include:

- The final portfolio of the environmental water portfolio (i.e. the relative proportion of general and high security licences)
- Particular rules for trade and carryover

- Modelled patterns of use and consumption. These have been based on historic patterns of use and may differ in the future as usage includes a greater proportion of environmental water which may require a different seasonal pattern.

- The amount of works and measures used as an offset to achieve the SDL as an alternative to market purchase. This may influence the pattern of delivery.

- The delivery of environmental water. Delivery via multiple environmental water holders may alter the pattern of delivery compared to the modelled results.

- The prioritisation and decision-making processes that will be used to deliver water (i.e. the Environmental Watering Plans). These may be different to those used in the current MDBA model and this will influence the ecological outcomes that can be achieved.

System constraints are an important issue that can influence the delivery of environmental water to South Australia, particularly for high flow events. There is little ability to deliver (or enhance) flows that deliver water to high parts of the floodplain, as these are beyond the operational capacity of river management infrastructure and/or would result in unacceptable flooding risks to private land (MDBA 2011b). For South Australia, a flow of around 80 000 ML/day is considered to be the upper limit beyond which river management is unable to reasonably influence the delivery of flow events (informed by MDBA 2011b MDBA 2011c and MDBA 2011g). Flows of this magnitude and greater are reliant on unregulated flows generated by large rainfall events. For events smaller than these (e.g. in the 40 000 to 80 000 ML/day range) there may be scope for better delivery of watering events if constraints were addressed. System constraints and potential management options are discussed in the MDBA report *River management – challenges and opportunities* (MDBA 2011c). This report describes constraints that could potentially be addressed to improve delivery of water to higher parts of the floodplain in South Australia. They include relaxing flow restrictions downstream of Hume Dam, at Menindee Lakes and within the Goulburn Valley. Further modelling and analysis is required from the MDBA to assess the impact on flow delivery through addressing constraints.

The ability to better deliver flows between 40 000 ML/day to 80 000 ML/day through changed operational arrangements and the removal or relaxation of some constraints could lead to significantly improved ecological benefits. Significant areas of floodplain vegetation communities become inundated with flows between 40 000 ML/day to 80 000 ML/day. As mentioned above, up to 62% of the red gum community and 78% of the lignum (which is critical breeding habitat for birds) becomes inundated at 80 000 ML/day. The ability to deliver South Australian and MDBA EWRs above 80 000 ML/day are typically unchanged by the 2750 GL scenario when compared to baseline conditions. These events are reliant on large unregulated flows (natural floods) and so little opportunity exists to increase their frequency. Therefore, the proposed Basin Plan has very limited ability to influence the ecological outcomes on these higher parts of the floodplain.

Modelling of the 3200 GL scenario was undertaken by the MDBA to test the ability of meeting a greater number ecological targets due to an additional 400 GL of recovered water. It was reported that the additional volume of recovered water provided few additional benefits relative to the 2800 GL scenario with system constraints considered to be a limiting factor in the range of improvement achievable from additional water (MDBA 2011b). Based on the information provided (MSM-BIGMOD and Pick-a-Box spreadsheets) to DFW, it is difficult to quantitatively assess the relative influence of recovered water volumes and system constraints on the delivery of EWRs in the of 40 000 ML/day and above flow range. Further modelling is required by the MDBA to clarify this issue.

A range of further work is required to assist in better understanding the impact of the proposed Basin Plan on the ecological communities in South Australia and how to optimise the achievement of specific targets. This includes:

- The development of ecological risk profiles for the Riverland–Chowilla Floodplain so that an assessment of outcomes under partial delivery of EWRs could be made
- Additional modelling of Basin Plan scenarios incorporating the removal or relaxation of constraints (within realistic limits) by the MDBA to determine the potential improvement in mid to high flow events and hence, environmental outcomes that may be obtained.

11. CONCLUSIONS AND KEY MESSAGES

The purpose of this report was to present the results of a hydrological and ecological analysis of the approach and modelling outputs of the proposed Basin Plan 2750 GL water recovery scenario. This report has assessed the hydrological and ecological outcomes relevant to the South Australian River Murray floodplain and in-channel water quality and has not included any assessment pertaining to the Lower Lakes Murray Mouth or Coorong. The analysis focuses on the EWRs defined for the key environmental asset of Riverland–Chowilla, but also extends the ecological interpretation to include the wider South Australian River Murray floodplain.

The modelling approach that has been used by the MDBA is considered robust in what could indicatively be achieved if 2750 GL was recovered using a pro-rata portfolio recovery approach. However, as the model is not rules based, the outputs represent just one potential set of outcomes from the recovery of 2750 GL and therefore should not be used as an absolute representation of “what will happen with 2750 GL water recovery”. The final outcome in terms of environmental benefits will be significantly dependent on how the CEWH and other environmental water holders and managers manage and prioritise the water recovered. As a result, the results should be considered as indicative.

The following presents conclusions and key messages from the analysis undertaken:

- The 2750 GL water recovery scenario demonstrates an improvement in the delivery of flows to meet River Murray EWRs in South Australia when compared to baseline conditions.
- Improvements are evident both in the total annual volume delivered to South Australia as well as the frequency of daily flow rates. Notably the median annual volume is predicted to increase by 2400 GL—an increase of approximately 50% compared to baseline.
- In the driest year over the modelled 114-year climate period the lowest annual volume nearly doubled from 1030 GL to 2000 GL.
- The median flow increased from 18 050 ML/day to 23 000 ML/day.
- The increased flows delivered under the 2750 GL scenario compared to baseline conditions improves the ability to meet salinity targets for the main river channel. In particular, the targets to not exceed 830 EC for 95% of the time and to remain below the 1400 EC trigger for critical human water needs are met by the 2750 GL scenario. However, it should be noted that current modelling does not account for any additional salt load that may occur from increased frequency of floodplain inundation (under both managed and unregulated flow events).
- In terms of daily flow rate over the border, the 2750 GL scenario resulted in an increase in the frequency of all flow rates up to approximately 80 000 ML/day. The frequency of high flow events (i.e. over 80 000 ML/day) remain similar to baseline conditions. These high flows are generally referred to as unregulated events and therefore considered natural flood events.
- Despite this improvement, very few Riverland–Chowilla EWRs defined by either the MDBA or South Australia are met under the 2750 GL scenario when assessed according to average frequency. MDBA targets are set across a range of risk levels and three of the seven MDBA targets are met at a high level of risk. The South Australian targets are set at a low level of risk and one out of the twenty SA targets is met.

CONCLUSIONS AND KEY MESSAGES

- The improved hydrological conditions observed for the 2750 GL scenario are expected to achieve some ecological improvement compared to baseline conditions. Benefits are most likely to be observed in and around the main channel of the River. The habits most likely to experience benefit are in-channel habitats, some low lying temporary wetlands and some floodplain communities.
- Using the low risk approach, (i.e. the maximum interval and duration metrics are met) the 2750 GL scenario could potentially support 30% more red gum habitat and 39% more lignum habitat relative to the low risk baseline scenario. That is, under the 2750 GL scenario approximately 11% of total red gum habitat and approximately 3.2% of total lignum habitat will be supported compared to 8.4% and 2.3% respectively under baseline conditions. Using the higher risk approach (i.e. the average frequencies are met but maximum intervals may be breached) approximately 30% of total red gum habitat and 15% of total lignum habitat could be supported under the 2750 GL scenario compared to 24% and 7% respectively for the baseline scenario. This represents a 25% increase for red gum and a 114% increase for lignum under the 2750 GL scenario relative to the baseline scenario.
- A large percentage of the total floodplain, as defined by the 1956 flood line, remains at risk under the 2750 GL scenario with either the frequency and/or the duration of flow events less than that required to support good condition.
- The EWRs described for the Riverland–Chowilla site mostly relate to overbank flows with high flow rates. Given the highly regulated condition of the Murray-Darling Basin delivery of these may be impacted by system constraints, including both physical and operational constraints. Examples include flow rate limits (under regulated conditions) to prevent overbank flows and excess losses, capacity limits on dam outlets, channel and bridge constraints to prevent inundation of roads and private property and water transfer rules. The MDBA has suggested that these constraints may create a ceiling for the delivery of environmental water.
- The sensitivity analysis undertaken by the MDBA (i.e. using the 2400 GL and 3200 GL scenarios to show impact of different water recovery volumes) demonstrated only subtle differences in outcomes for the Riverland–Chowilla floodplain. This analysis had the system constraints within the model and therefore potential benefits to the floodplain from additional water have likely been masked by these constraints.
- There may be opportunity to improve delivery of flows between 40 000 ML/day to 80 000 ML/day through changed operational arrangements and the removal or relaxation of some constraints. Better delivery of these flows could lead to significantly improved ecological benefits. Significant area of floodplain vegetation communities become inundated with flows between 40 000 ML/day to 80 000 ML/day. For example, only 6% of the total lignum community is inundated at 40 000 ML/day, whereas this increases to 76% of the total community at flows of 80 000 ML/day. The ability to deliver South Australian and MDBA EWRs of 80 000 ML/day and above are typically unchanged by the 2750 GL scenario when compared to baseline conditions. These events are reliant on large unregulated flows (natural floods) and so little opportunity exists to increase their frequency. Therefore the proposed Basin Plan has very limited ability to influence the ecological outcomes on these higher parts of the floodplain.

- Technical differences in modelling approach mean that the results from the 2750 GL scenario and those presented in the Guide to the Basin Plan are not directly comparable.

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UNITS OF MEASUREMENT

Units of measurement (SI and non-SI Australian legal)

Name of unit	Symbol
day	d
gigalitre	GL
hectare	ha
kilometre	km
megalitre	ML
microSiemens per centimetre	µS/cm
year	yr

GLOSSARY

Anabranch — A branch of a river that leaves the main channel

Aquatic ecosystem — The stream channel lake or estuary bed water and/or biotic communities and the habitat features that occur therein

Aquatic habitat — Environments characterised by the presence of standing or flowing water

Barrage — Specifically any of the five low weirs at the mouth of the River Murray constructed to exclude seawater from the Lower Lakes

Baseflow — The water in a stream that results from groundwater discharge to the stream; often maintains flows during seasonal dry periods and has important ecological functions

Basin — The area drained by a major river and its tributaries

Catchment — That area of land determined by topographic features within which rainfall will contribute to run-off at a particular point

CSIRO — Commonwealth Scientific and Industrial Research Organisation

Deflation basin — A hollow formed by the removal of particles by wind

DEH — Department for Environment and Heritage (Government of South Australia)

DENR — Department of Environment and Natural Resources (Government of South Australia)

DFW — Department for Water (Government of South Australia)

DWLBC — Department of Water Land and Biodiversity Conservation (Government of South Australia)

EC — Electrical conductivity; 1 EC unit = 1 micro-Siemen per centimetre (µS/cm) measured at 25°C; commonly used as a measure of water salinity as it is quicker and easier than measurement by TDS

Ecological indicators — Plant or animal species communities or special habitats with a narrow range of ecological tolerance; for example in forest areas such indicators may be selected for emphasis and monitored during forest plan implementation because their presence and abundance serve as a barometer of ecological conditions within a management unit

Ecological processes — All biological physical or chemical processes that maintain an ecosystem

Ecological values — The habitats natural ecological processes and biodiversity of ecosystems

Ecology — The study of the relationships between living organisms and their environment

Ecosystem — Any system in which there is an interdependence upon and interaction between living organisms and their immediate physical chemical and biological environment

Electrical Conductivity (EC) – Electrical conductivity is a measure of the water's ability to conduct an electrical current. Electrical conductivity (measured at 25^{o}C in units of mS cm^{-1} or µS cm^{-1}) can be used to estimate salinity because a relationship exists between the levels of dissolved salts in a water body and its conductivity.

Entitlement flow — Maximum monthly River Murray flow to South Australia agreed in to the Murray-Darling Basin Agreement 2008

Environmental values — The uses of the environment that are recognised as being of value to the community. This concept is used in setting water quality objectives under the Environment Protection (Water Quality) Policy which recognises five environmental values — protection of aquatic ecosystems recreational water use and aesthetics potable (drinking water) use agricultural and aquaculture use and industrial use. It is not the same as ecological values which are about the elements and functions of ecosystems.

Environmental water requirements — The water regimes needed to sustain the ecological values of aquatic ecosystems including their processes and biological diversity at a low level of risk

Ephemeral streams or wetlands — Those streams or wetlands that usually contain water only on an occasional basis after rainfall events. Many arid zone streams and wetlands are ephemeral.

Estuaries — Semi-enclosed water bodies at the lower end of a freshwater stream that are subject to marine freshwater and terrestrial influences and experience periodic fluctuations and gradients in salinity

EWR — Environmental Water Requirement

Floodplain — Of a watercourse means: (1) floodplain (if any) of the watercourse identified in a catchment water management plan or a local water management plan; adopted under the Act; or (2) where (1) does not apply — the floodplain (if any) of the watercourse identified in a development plan under the *Development (SA) Act 1993*; or (3) where neither (1) nor (2) applies — the land adjoining the watercourse that is periodically subject to flooding from the watercourse

Flow bands — Flows of different frequency volume and duration

Flow regime — The character of the timing and amount of flow in a stream

Groundwater — Water occurring naturally below ground level or water pumped diverted and released into a well for storage underground; see also 'underground water'

Infrastructure — Artificial lakes; dams or reservoirs; embankments walls channels or other works; buildings or structures; or pipes machinery or other equipment

Irrigation — Watering land by any means for the purpose of growing plants

Irrigation season — The period in which major irrigation diversions occur usually starting in August–September and ending in April–May

Lake — A natural lake pond lagoon wetland or spring (whether modified or not) that includes part of a lake and a body of water declared by regulation to be a lake. A reference to a lake is a reference to either the bed banks and shores of the lake or the water for the time being held by the bed banks and shores of the lake or both depending on the context.

Land — Whether under water or not and includes an interest in land and any building or structure fixed to the land

Licence — A licence to take water in accordance with the Act; see also 'water licence'

Licensee — A person who holds a water licence

MDBA — Murray–Darling Basin Authority

MDBC — Murray–Darling Basin Commission

Model — A conceptual or mathematical means of understanding elements of the real world that allows for predictions of outcomes given certain conditions. Examples include estimating storm run-off assessing the impacts of dams or predicting ecological response to environmental change

Monitoring — (1) The repeated measurement of parameters to assess the current status and changes over time of the parameters measured (2) Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans animals and other living things

Percentile — A way of describing sets of data by ranking the dataset and establishing the value for each percentage of the total number of data records. The 90th percentile of the distribution is the value such that 90% of the observations fall at or below it.

Ramsar Convention — This is an international treaty on wetlands titled *The Convention on Wetlands of International Importance Especially as Waterfowl Habitat*. It is administered by the International Union for Conservation of Nature and Natural Resources. It was signed in the town of Ramsar Iran in 1971 hence its common name. The convention includes a list of wetlands of international importance and protocols regarding the management of these wetlands. Australia became a signatory in 1974.

SDL – Sustainable Diversion Limit

Surface water — (a) water flowing over land (except in a watercourse), (i) after having fallen as rain or hail or having precipitated in any another manner (ii) or after rising to the surface naturally from underground; (b) water of the kind referred to in paragraph (a) that has been collected in a dam or reservoir

Threshold – a point at which a change in conditions (e.g. change in a quality property or phenomenon) produces a response/shift. For an example a decline in water level to a point where a shift in the ecological community is observed.

Tributary — A river or creek that flows into a larger river

Water allocation — (1) In respect of a water licence means the quantity of water that the licensee is entitled to take and use pursuant to the licence. (2) In respect of water taken pursuant to an authorisation under s.11 means the maximum quantity of water that can be taken and used pursuant to the authorisation

Water body — Includes watercourses riparian zones floodplains wetlands estuaries lakes and groundwater aquifers

Watercourse — A river creek or other natural watercourse (whether modified or not) and includes: a dam or reservoir that collects water flowing in a watercourse; a lake through which water flows; a channel (but not a channel declared by regulation to be excluded from the this definition) into which the water of a watercourse has been diverted; and part of a watercourse

Water-dependent ecosystems — Those parts of the environment the species composition and natural ecological processes that are determined by the permanent or temporary presence of flowing or standing water above or below ground; the in-stream areas of rivers riparian vegetation springs wetlands floodplains estuaries and lakes are all water-dependent ecosystems

Water-use year: South Australia — The period between 1 July in any given calendar year and 30 June the following calendar year; also called a licensing year

Water-use year: Murray-Darling Basin Authority — The period between 1 June in any given calendar year and 31 May the following calendar year

Wetlands — Defined by the Act as a swamp or marsh and includes any land that is seasonally inundated with water. This definition encompasses a number of concepts that are more specifically described in the definition used in the Ramsar Convention on Wetlands of International Importance. This describes wetlands as areas of permanent or periodic to intermittent inundation whether natural or artificial permanent or temporary with water that is static or flowing fresh brackish or salt including areas of marine water the depth of which at low tides does not exceed six metres.

APPENDIXES

A. BASIN PLAN GIS ANALYSIS – RIVER MURRAY SOUTH AUSTRALIA

Area figures for the inundation of vegetation on the River Murray floodplain.

Prepared and undertaken by Gaby Eckert SMI Division DFW

Spatial layers used in analysis:

- VEG.SAVegetation (Vegetation spatial layer held within DENR's Environmental GIS)
- Wetlands_2010 (Wetland Prioritisation Mapping provided by T Steggles)
- FIM III Model Outputs - 20 000 ML to 100 000 ML (5 000 ML/day flow increments) (CSIRO)
- TOPO.MurrayFlood1956 (Floodplain spatial layer held within DENR's Environmental GIS)
- Land and Water Management Plan Areas (includes Lower Murray swamp areas - provided by B Turner as LWMP_Merge.shp)
- SAMRIC 2006 River Murray Irrigated crops (provided by L Vears as SAMRIC_Crops2006.shp)

Methodology:

1. Preparation of the vegetation spatial layer (copy of the Vegetation spatial layer held within DENR's Environmental GIS)

    a. Join 'VEG.SAVEGETATION_LUT' to 'VEG.SAVegetation' spatial layer and export the join as a new layer.

        i. 'VEG.SAVEGETATION_LUT' (look-up table containing vegetation type information).

        ii. Look-up table joined to 'VEG.SAVegetation' by "SA_VEG_ID*/ SA_VEG_ID1*" fields. Field with vegetation type information = "DOMSPECIES_STRATUM".

    b. Add a new field to the 'VEG.SAVegetation_withLUT' layer and group the "DOMSPECIES_STRATUM" vegetation types into the following key species groups; black box red gum forbland grassland lignum other shrubland (excluding lignum), other woodland/forest (excluding red gum and black box) and sedgeland. Refer to Attachment 1 for the list of major floodplain vegetation groups and corresponding "DOMSPECIES_STRATUM" vegetation types.

        i. "DOMSPECIES_STRATUM" Description = Dominant or co-dominant species of the dominant stratum with a broad structural formation description. Mixed refers to the indication that dominant species listed is really the first and the group is a bit of a mix of more than 2 co-dominant species. Field alias = DOMSP_GENST).

2. Preparation of the wetlands spatial layer (copy of Wetland Prioritisation Mapping provided by T Steggles)

a. Join 'Prio_enter_RM_LL_Final_2010' to 'Wetlands_2010' spatial layer and export the join as a new layer.

   i. 'Prio_enter_RM_LL_Final_2010' (look-up table containing permanent/temporary water body information)
   ii. Look-up table joined to 'Wetlands_2010' by "AUS_WETNR* / AUS_WETNR*" fields. Field with permanent/temporary water body information = "WATER_BODY".

b. As the "WATER_BODY" field contains several descriptions pertaining to 'temporary' conditions the following terms were grouped under 'temporary'; ephemeral intermittent permanent/intermittent and seasonal. Permanent and permanent are grouped under 'permanent'. A new field is created that reflects these groupings.

3. Preparation of the floodplain spatial layer (copy of TOPO.MurrayFlood1956 spatial layer held within DENR's Environmental GIS)

   a. The 'TOPO.MurrayFlood1956' floodplain was divided into four regions using the cut tool;

      i. Chowilla/Riverland Ramsar
      ii. Valley (from Ramsar region to Lock 3)
      iii. Gorge (Lock 3 to Mannum)
      iv. Lower Murray Swamps (Mannum to Wellington)

   b. Permanent water bodies (detailed in the 'Wetlands_2010' spatial layer), floodplain irrigation areas (detailed in LWMP_Merge.shp), remaining irrigated crops (detailed in SAMRIC_Crops2006.shp) and highland areas ("AS2482" = 0) are removed from the 'TOPO.MurrayFlood1956' floodplain spatial extent using the erase tool.

   c. Union the edited TOPO.MurrayFlood1956 with VEG.SAVegetation_withLUT layer. This ensures that only vegetation within the edited floodplain spatial layer is included in the analysis.

4. Run FIM model (with the following parameters) and 5 000 ML/day intervals and export outputs to geodatabase.

   a. Flow of 20 000 to 100 000 ML/day at the South Australian Border Month of Year = September Predict Region = All Weir Height = Level

      i. Run FIM model across all reaches for September/spring flow conditions. This reduces the flow variation from the state border to Wellington (5 000 ML difference in January compared to 3 000 ML difference in September).

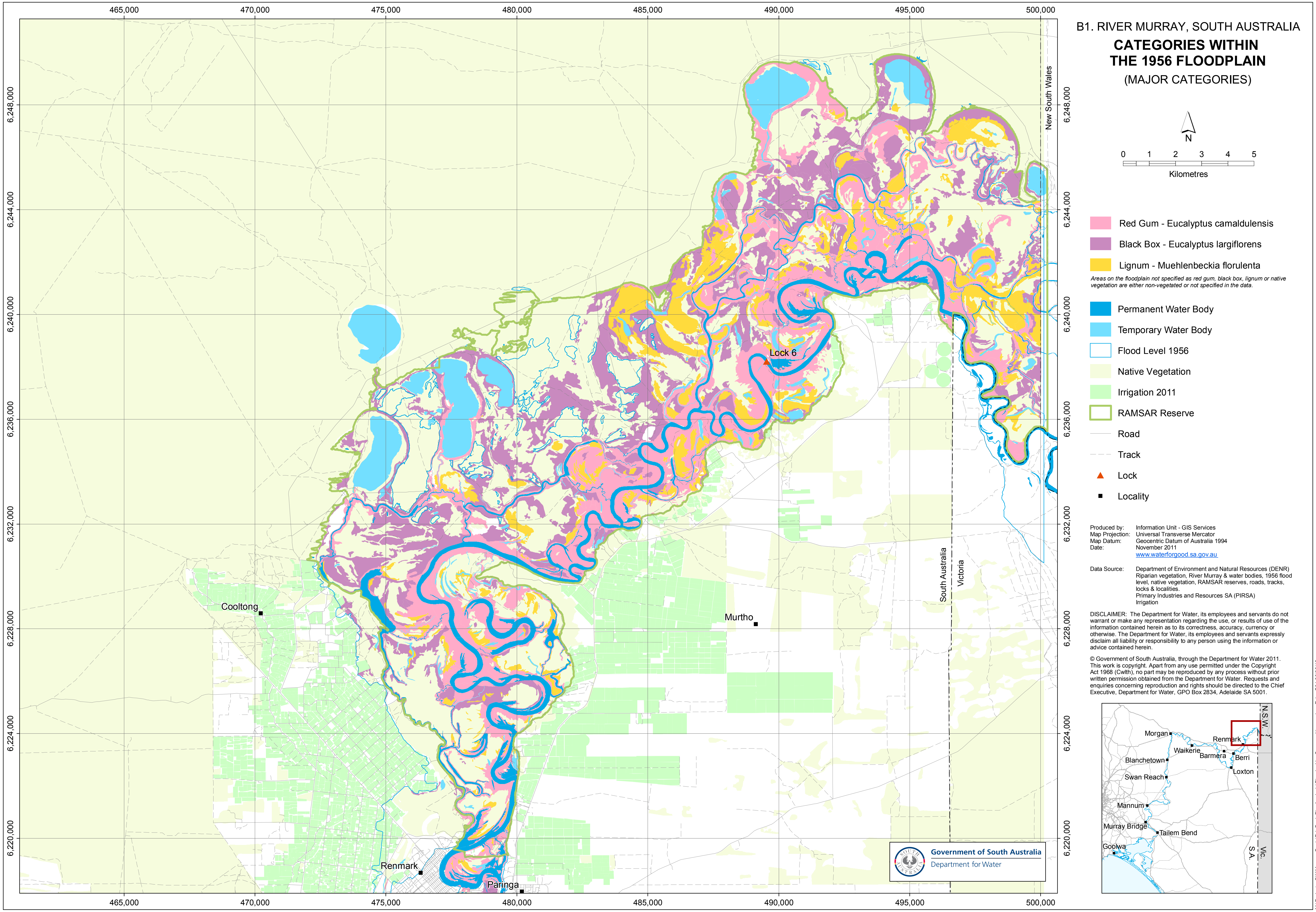
   b. Remove duplicate polygons from FIM outputs using ArcGIS topology tool. Duplicates will increase the area figures.

   c. Union each edited FIM output with the output from point 3.c. This results in 17 new outputs that can be analysed and have inundation area information extracted.

5. Perform spatial queries on each dataset and use the summary tool to extract the area of each vegetation type inundated at each flow within the four floodplain regions.

B. MAPS OF VEGETATION AND INUNDATION EXTENT

APPENDIXES



B1. RIVER MURRAY, SOUTH AUSTRALIA
CATEGORIES WITHIN THE 1956 FLOODPLAIN
(MAJOR CATEGORIES)
N
0 1 2 3 4 5
Kilometres
Red Gum - Eucalyptus camaldulensis
Black Box - Eucalyptus largiflorens
Lignum - Muehlenbeckia florulenta
Areas on the floodplain not specified as red gum, black box, lignum or native vegetation are either non-vegetated or not specified in the data.
Permanent Water Body
Temporary Water Body
Flood Level 1956
Native Vegetation
Irrigation 2011
RAMSAR Reserve
Road
Track
Lock
Locality
Produced by: Information Unit - GIS Services
Map Projection: Universal Transverse Mercator
Map Datum: Geocentric Datum of Australia 1994
Date: November 2011
www.waterforgood.sa.gov.au
Data Source: Department of Environment and Natural Resources (DENR) Riparian vegetation, River Murray & water bodies, 1956 flood level, native vegetation, RAMSAR reserves, roads, tracks, locks & localities. Primary Industries and Resources SA (PIRSA) Irrigation
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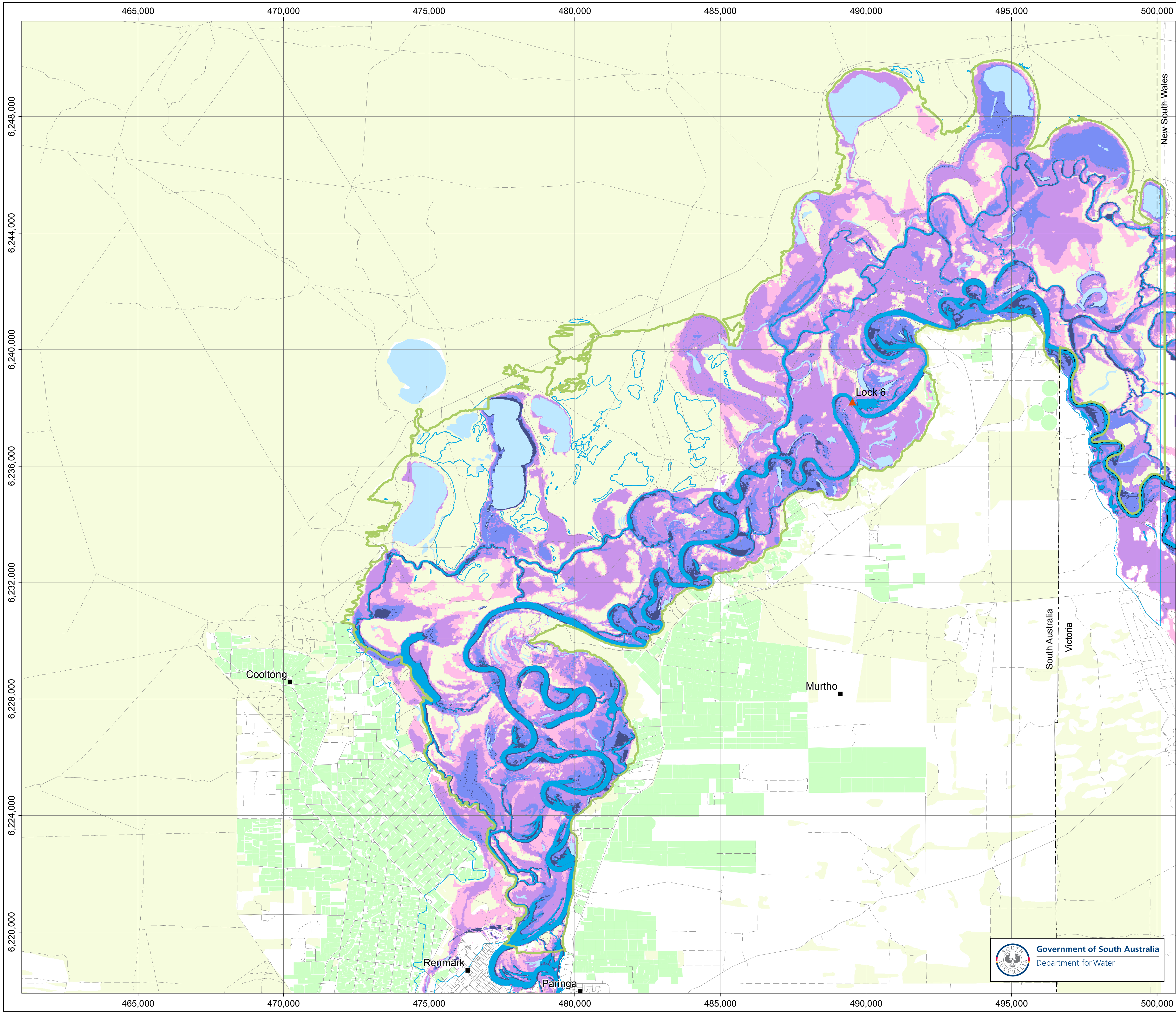
Government of South Australia
Department for Water
Lock 6
Cooltong
Murtho
Renmark
Paringa
New South Wales
South Australia
Victoria
Morgan
Renmark
Waikerie
Barmera
Berri
Blanchetown
Loxton
Swan Reach
Mannum
Murray Bridge
Tailem Bend
Goolwa
N.S.W.
S.A.
Vic.
465,000
470,000
475,000
480,000
485,000
490,000
495,000
500,000
6,248,000
6,244,000
6,240,000
6,236,000
6,232,000
6,228,000
6,224,000
6,220,000
EckerG01 29/03/12



B2. RIVER MURRAY, SOUTH AUSTRALIA

INUNDATION LEVELS

N

0 1 2 3 4 5

Kilometres

- 40,000ML/day
- 60,000ML/day
- 80,000ML/day
- 100,000 ML/day
- Permanent Water Body
- Temporary Water Body
- Flood Level 1956
- Native Vegetation
- Irrigation 2011
- RAMSAR Reserve
- Road
- Track
- Lock
- Locality

Produced by: Information Unit - GIS Services
Map Projection: Universal Transverse Mercator
Map Datum: Geocentric Datum of Australia 1994
Date: November 2011
www.waterforgood.sa.gov.au

Data Source: Department of Environment and Natural Resources (DENR)
Riparian vegetation, River Murray & water bodies, 1956 flood level, native vegetation, RAMSAR reserves, roads, tracks, locks & localities.
Primary Industries and Resources SA (PIRSA)
Irrigation
Inundation extents provided by the CSIRO River Murray Floodplain Inundation Model (RiM-FIM) (Version IV, 2006).

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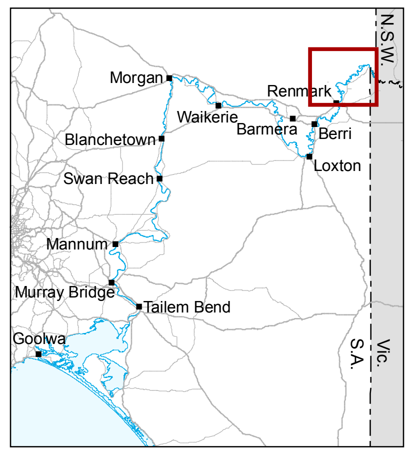

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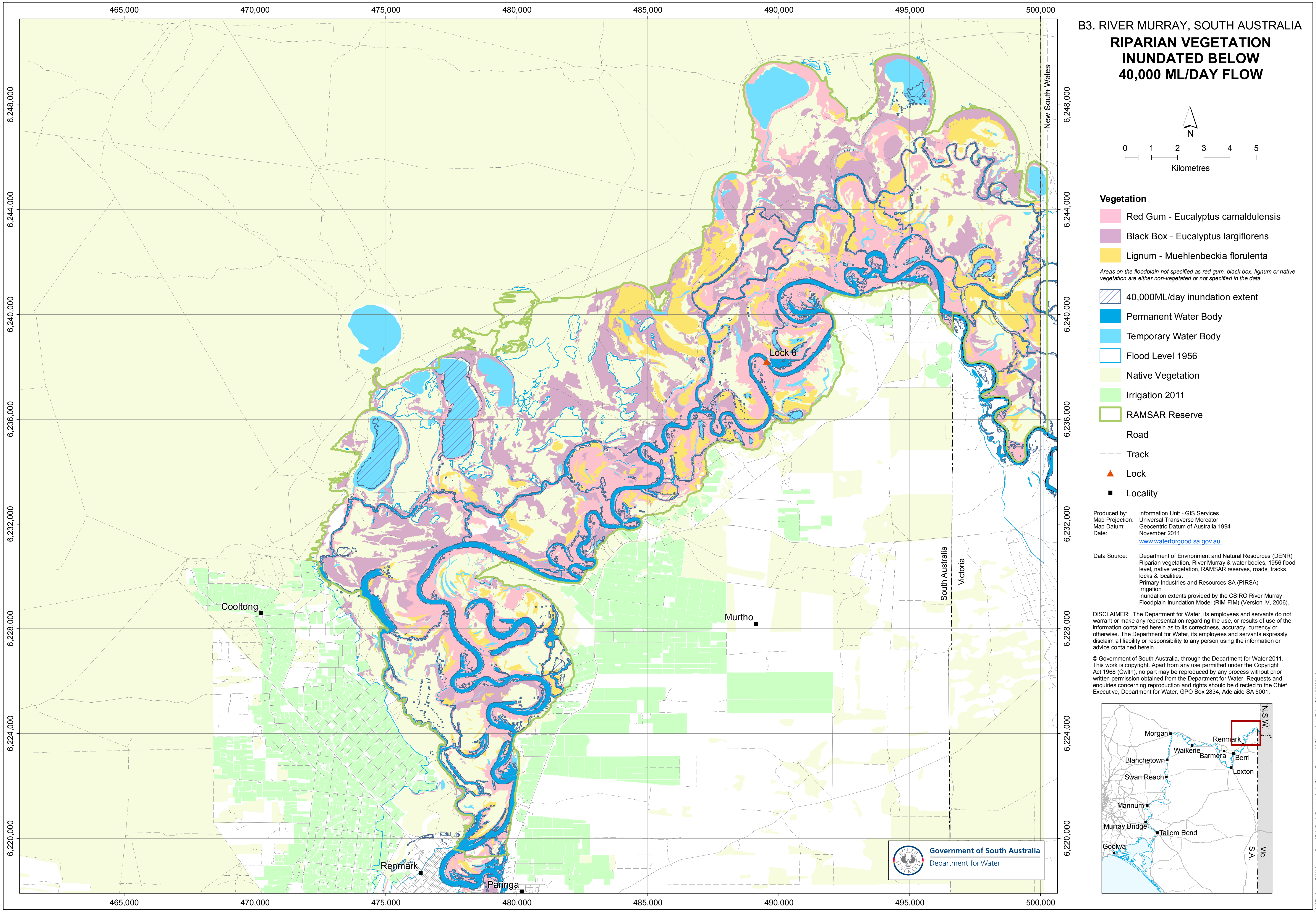

B3. RIVER MURRAY, SOUTH AUSTRALIA
RIPARIAN VEGETATION INUNDATED BELOW 40,000 ML/DAY FLOW
N
0 1 2 3 4 5
Kilometres
Vegetation
Red Gum - Eucalyptus camaldulensis
Black Box - Eucalyptus largiflorens
Lignum - Muehlenbeckia florulenta
Areas on the floodplain not specified as red gum, black box, lignum or native vegetation are either non-vegetated or not specified in the data.
40,000ML/day inundation extent
Permanent Water Body
Temporary Water Body
Flood Level 1956
Native Vegetation
Irrigation 2011
RAMSAR Reserve
Road
Track
Lock
Locality
Produced by: Information Unit - GIS Services
Map Projection: Universal Transverse Mercator
Map Datum: Geocentric Datum of Australia 1994
Date: November 2011
www.waterforgood.sa.gov.au
Data Source: Department of Environment and Natural Resources (DENR) Riparian vegetation, River Murray & water bodies, 1956 flood level, native vegetation, RAMSAR reserves, roads, tracks, locks & localities. Primary Industries and Resources SA (PIRSA) Irrigation Inundation extents provided by the CSIRO River Murray Floodplain Inundation Model (RiM-FIM) (Version IV, 2006).
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Government of South Australia
Department for Water
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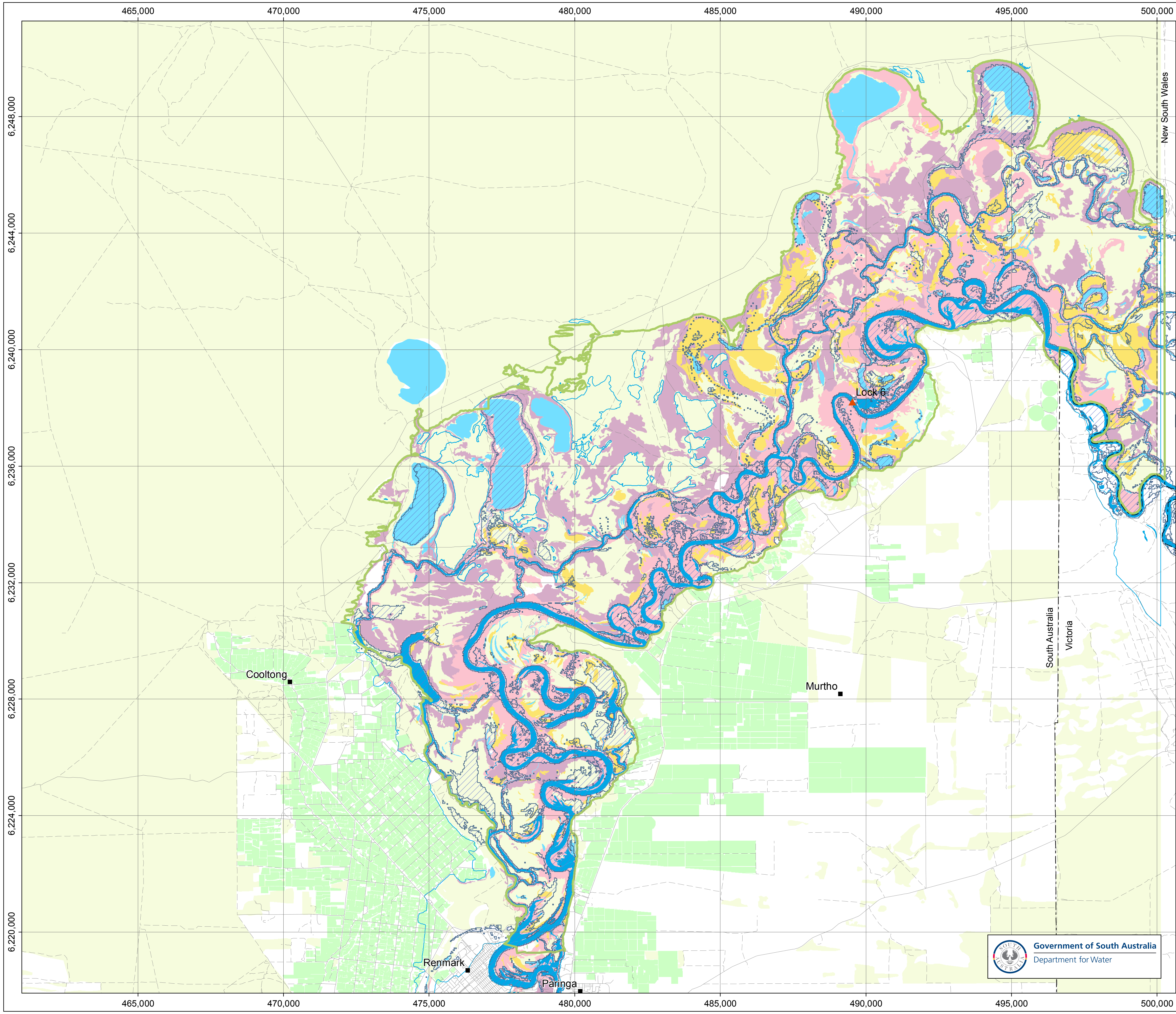
New South Wales
South Australia
Victoria
Lock 6
Cooltong
Murtho
Renmark
Paringa
Morgan
Waikerie
Barmera
Renmark
Berri
Loxton
Blanchetown
Swan Reach
Mannum
Murray Bridge
Tailem Bend
Goolwa
N.S.W.
Vic.
S.A.
EckerG01 29/03/12

B4. RIVER MURRAY, SOUTH AUSTRALIA

RIPARIAN VEGETATION INUNDATED BELOW 60,000 ML/DAY FLOW



N

0 1 2 3 4 5
Kilometres

Vegetation

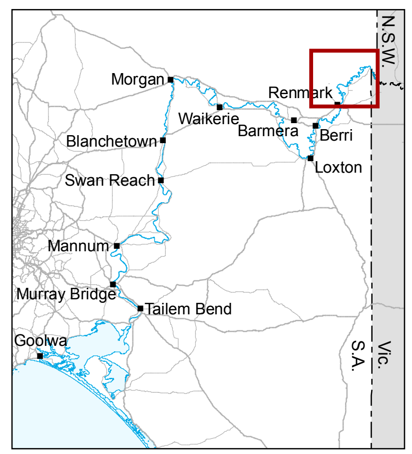
- Red Gum - Eucalyptus camaldulensis
- Black Box - Eucalyptus largiflorens
- Lignum - Muehlenbeckia florulenta

Areas on the floodplain not specified as red gum, black box, lignum or native vegetation are either non-vegetated or not specified in the data.

- 60,000ML/day inundation extent
- Permanent Water Body
- Temporary Water Body
- Flood Level 1956
- Native Vegetation
- Irrigation 2011
- RAMSAR Reserve
- Road
- Track
- Lock
- Locality

Produced by: Information Unit - GIS Services
Map Projection: Universal Transverse Mercator
Map Datum: Geocentric Datum of Australia 1994
Date: November 2011
www.waterforgood.sa.gov.au

Data Source: Department of Environment and Natural Resources (DENR) Riparian vegetation, River Murray & water bodies, 1956 flood level, native vegetation, RAMSAR reserves, roads, tracks, locks & localities.
Primary Industries and Resources SA (PIRSA) Irrigation
Inundation extents provided by the CSIRO River Murray Floodplain Inundation Model (RiM-FIM) (Version IV, 2006).



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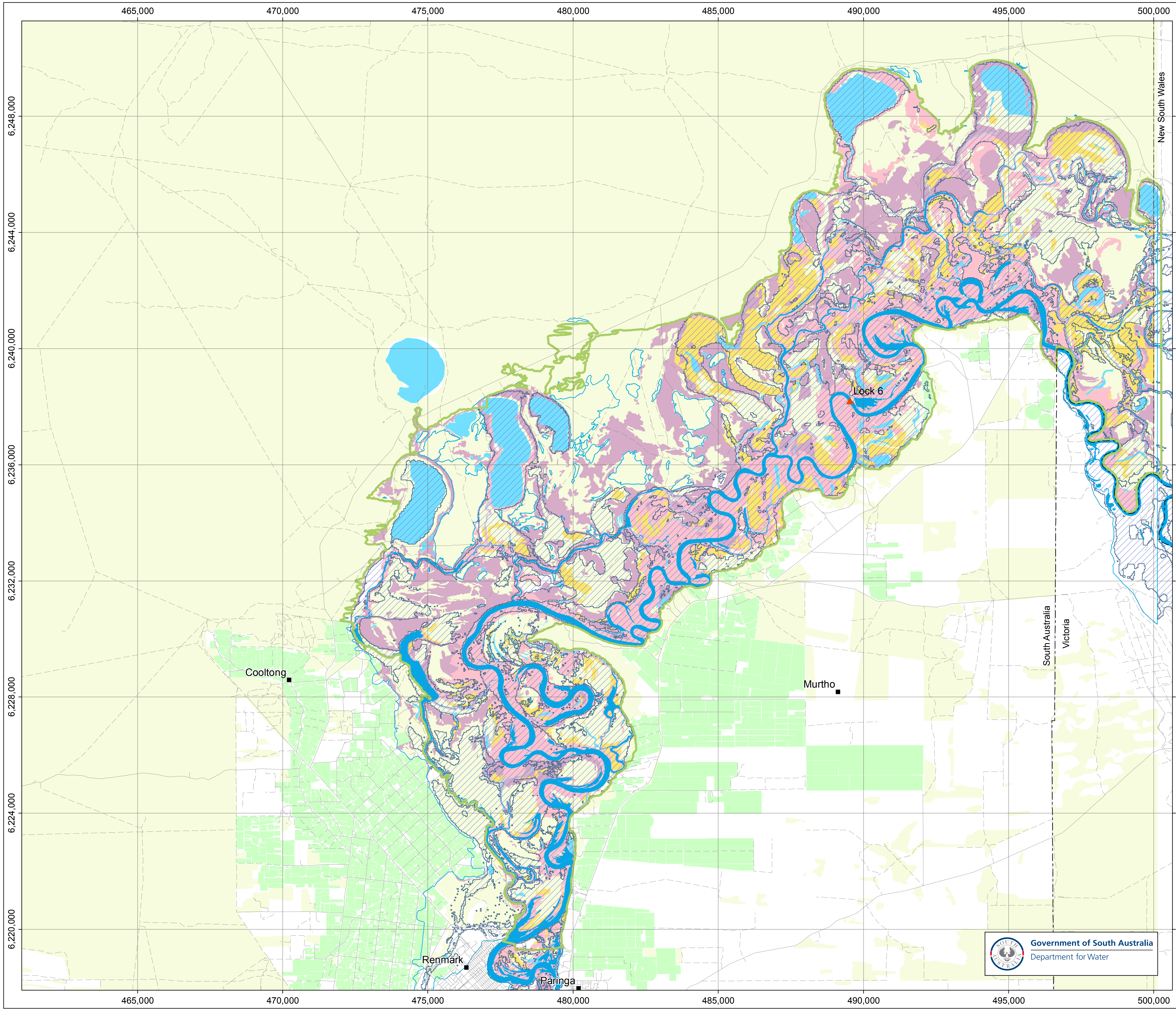

B5. RIVER MURRAY, SOUTH AUSTRALIA

RIPARIAN VEGETATION INUNDATED BELOW 80,000 ML/DAY FLOW

N

0 1 2 3 4 5

Kilometres

Vegetation

- Red Gum - Eucalyptus camaldulensis
- Black Box - Eucalyptus largiflorens
- Lignum - Muehlenbeckia florulenta

Areas on the floodplain not specified as red gum, black box, lignum or native vegetation are either non-vegetated or not specified in the data.

- 80,000ML/day inundation extent
- Permanent Water Body
- Temporary Water Body
- Flood Level 1956
- Native Vegetation
- Irrigation 2011
- RAMSAR Reserve
- Road
- Track
- Lock
- Locality

Produced by:	Information Unit - GIS Services
Map Projection:	Universal Transverse Mercator
Map Datum:	Geocentric Datum of Australia 1994
Date:	November 2011
	www.waterforgood.sa.gov.au
Data Source:	Department of Environment and Natural Resources (DENR) Riparian vegetation, River Murray & water bodies, 1956 flood level, native vegetation, RAMSAR reserves, roads, tracks, locks & localities. Primary Industries and Resources SA (PIRSA) Irrigation Inundation extents provided by the CSIRO River Murray Floodplain Inundation Model (RiM-FIM) (Version IV, 2006).

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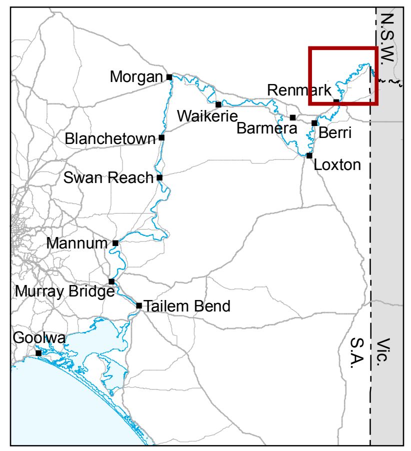

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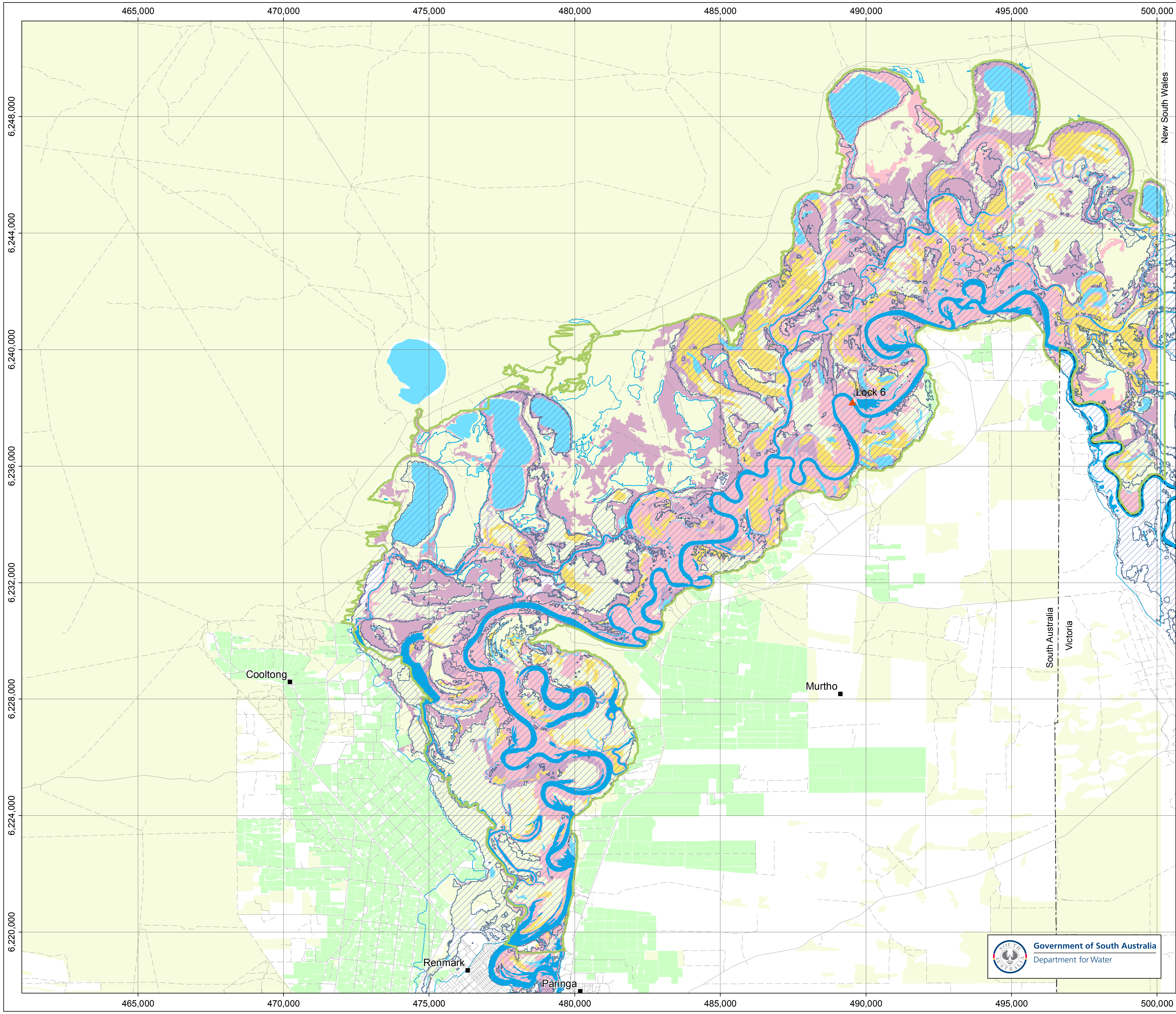

B6. RIVER MURRAY, SOUTH AUSTRALIA

RIPARIAN VEGETATION INUNDATED BELOW 100,000 ML/DAY FLOW

N

0 1 2 3 4 5

Kilometres

Vegetation

- Red Gum - Eucalyptus camaldulensis
- Black Box - Eucalyptus largiflorens
- Lignum - Muehlenbeckia florulenta

Areas on the floodplain not specified as red gum, black box, lignum or native vegetation are either non-vegetated or not specified in the data.

- 100,000ML/day inundation extent
- Permanent Water Body
- Temporary Water Body
- Flood Level 1956
- Native Vegetation
- Irrigation 2011
- RAMSAR Reserve
- Road
- Track
- Lock
- Locality

Produced by: Information Unit - GIS Services
Map Projection: Universal Transverse Mercator
Map Datum: Geocentric Datum of Australia 1994
Date: November 2011
www.waterforgood.sa.gov.au

Data Source: Department of Environment and Natural Resources (DENR) Riparian vegetation, River Murray & water bodies, 1956 flood level, native vegetation, RAMSAR reserves, roads, tracks, locks & localities.
Primary Industries and Resources SA (PIRSA) Irrigation
Inundation extents provided by the CSIRO River Murray Floodplain Inundation Model (RiM-FIM) (Version IV, 2006).

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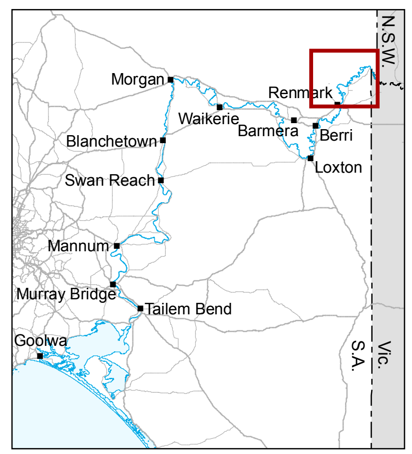

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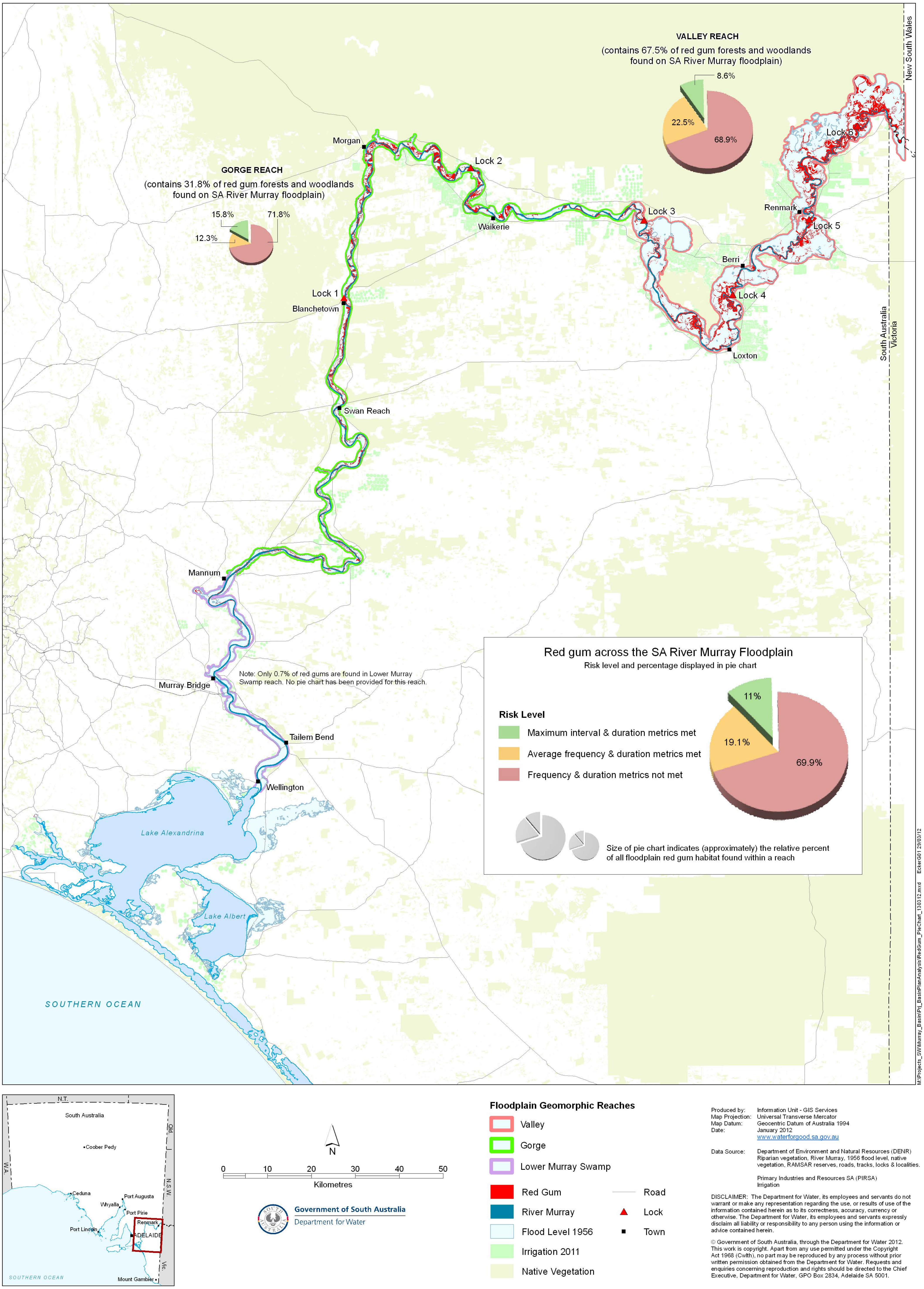
B7. GEOMORPHIC REACHES OF THE SOUTH AUSTRALIAN RIVER MURRAY FLOODPLAIN AND INDICATION OF THE DISTRIBUTION OF RED GUM FORESTS AND WOODLANDS WHERE EWR METRICS ARE AND ARE NOT MET



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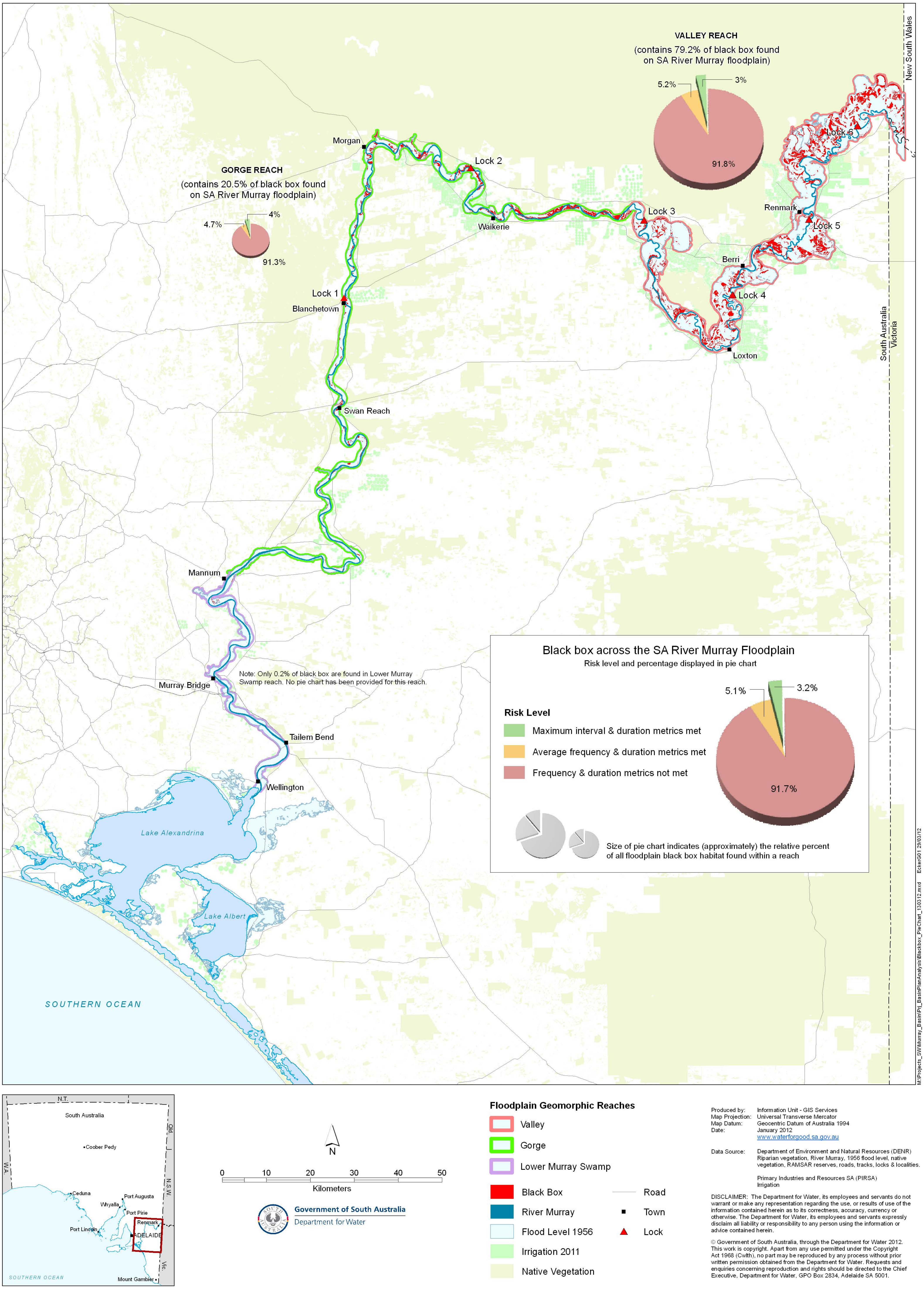
Produced by: Information Unit - GIS Services
Map Projection: Universal Transverse Mercator
Map Datum: Geocentric Datum of Australia 1994
Date: January 2012
www.waterforgood.sa.gov.au

Data Source: Department of Environment and Natural Resources (DENR) Riparian vegetation, River Murray, 1956 flood level, native vegetation, RAMSAR reserves, roads, tracks, locks & localities.

Primary Industries and Resources SA (PIRSA) Irrigation

B8. GEOMORPHIC REACHES OF THE SOUTH AUSTRALIAN RIVER MURRAY FLOODPLAIN AND INDICATION OF THE DISTRIBUTION OF BLACK BOX WHERE EWR METRICS ARE AND ARE NOT MET



Produced by: Information Unit - GIS Services
Map Projection: Universal Transverse Mercator
Map Datum: Geocentric Datum of Australia 1994
Date: January 2012
www.waterforgood.sa.gov.au

Data Source: Department of Environment and Natural Resources (DENR) Riparian vegetation, River Murray, 1956 flood level, native vegetation, RAMSAR reserves, roads, tracks, locks & localities.

Primary Industries and Resources SA (PIRSA) Irrigation

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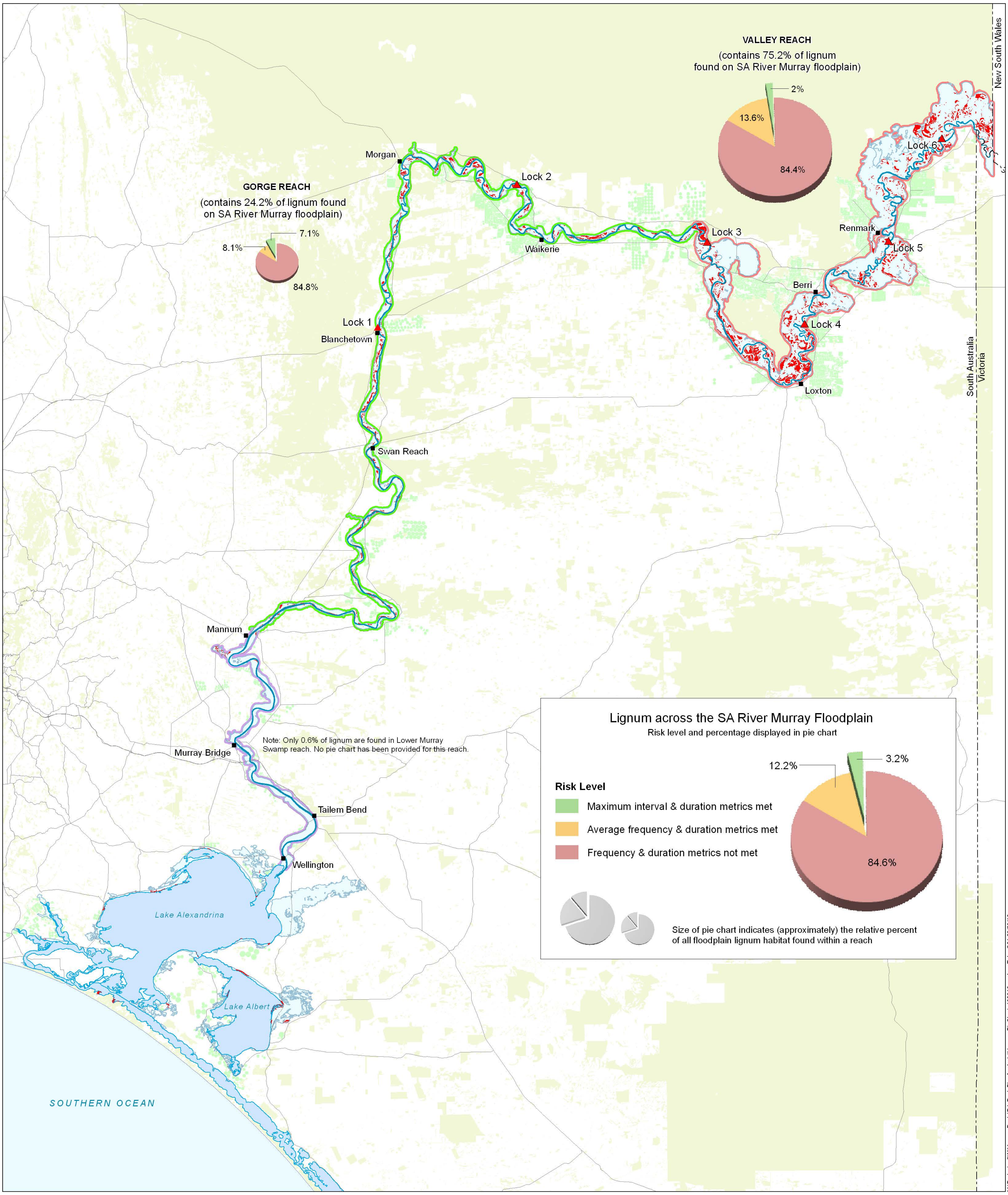
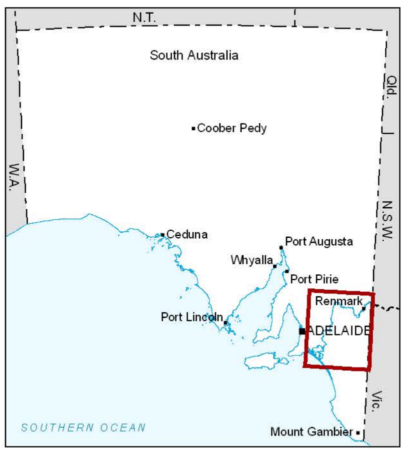
B9. GEOMORPHIC REACHES OF THE SOUTH AUSTRALIAN RIVER MURRAY FLOODPLAIN AND INDICATION OF THE DISTRIBUTION OF LIGNUM WHERE EWR METRICS ARE AND ARE NOT MET





N

0 10 20 30 40 50

Kilometres

Government of South Australia
Department for Water

Floodplain Geomorphic Reaches

- Valley
- Gorge
- Lower Murray Swamp
- Lignum
- River Murray
- Flood Level 1956
- Irrigation 2011
- Native Vegetation
- Road
- Lock
- Town

Produced by: Information Unit - GIS Services
Map Projection: Universal Transverse Mercator
Map Datum: Geocentric Datum of Australia 1994
Date: January 2012
www.waterforgood.sa.gov.au

Data Source: Department of Environment and Natural Resources (DENR) Riparian vegetation, River Murray, 1956 flood level, native vegetation, RAMSAR reserves, roads, tracks, locks & localities.

Primary Industries and Resources SA (PIRSA) Irrigation

C. SUPPORTING ECOLOGICAL ASSESSMENT

Table C1. Comparison of proportion of targeted taxa/habitats inundated at flow rates that meet the average frequency and duration metrics of the EWR under Baseline conditions and the 2750 GL scenario

Results are presented at four spatial scales with SA floodplain incorporating floodplain areas within the gorge and valley reaches as well as remnant floodplain habitat located between Mannum and Wellington; the gorge reach covering the floodplain located between Overland Corner and Mannum; the valley reach covering the floodplain between the border and Overland Corner including Riverland–Chowilla; Riverland–Chowilla incorporating the Riverland Ramsar site and the South Australian section of the Chowilla Icon Site.

Figures provided are the % of the total area of the targeted habitat/taxa found at the given spatial scale

Cells highlighted in green indicate the three greatest increases under the 2750 GL scenario when compared to baseline within each spatial scale

Target/EWR			Proportion of targeted habitat/taxa inundated at flow rate that meets average frequency and duration metrics of EWR							
#	Targeted taxa/function	Target %	Results under Baseline conditions				Results under 2750 GL scenario			
			SA floodplain	Gorge reach	Valley reach	Riverland–Chowilla	SA floodplain	Gorge reach	Valley reach	Riverland–Chowilla
BBr1	Black box (recruitment – lower elevations)	50%[18]	35.7	24.5	38.7	30.4	35.7	24.5	38.7	30.4
BBr2	Black box (recruitment – higher elevations)	80%	35.7	24.5	38.7	30.4	35.7	24.5	38.7	30.4
BB1	Black box woodlands	80%	8.3	8.7	8.2	8.8	12.6	11.8	12.8	14.3

[18] Where possible. For targets where no % was explicitly stated, a value was derived through comparison with other target %'s and flow rates for the same taxa/habitat and using data provided in DWLBC 2010

Target/EWR			Proportion of targeted habitat/taxa inundated at flow rate that meets average frequency and duration metrics of EWR							
#	Targeted taxa/function	Target %	Results under Baseline conditions				Results under 2750 GL scenario			
			SA floodplain	Gorge reach	Valley reach	Riverland–Chowilla	SA floodplain	Gorge reach	Valley reach	Riverland–Chowilla
BB2	Black box woodlands	60%	8.3	8.7	8.2	8.8	12.6	11.8	12.8	14.3
BB3	Black box woodlands	50%	5.5	7.3	5.0	5.6	8.3	8.7	8.2	8.8
RGr	River red gums (recruitment)	75%	20.7	23.1	19.5	19.4	23.9	21.6	24.9	25.5
RG	River red gum woodlands and forests	80%	23.9	21.6	24.9	25.5	30.1	28.2	31.1	32.3
Lig1	Lignum	50%	6.9	12.6	5.1	2.8	15.4	15.2	15.6	12.7
Lig2	Lignum	80%	24.5	27.3	23.8	19.6	36.5	29.6	39.0	34.2
Ligr	Lignum (recruitment)	66%	Unable to assess				Unable to assess			
Mos1	Mosaic of habitats [19]	n/a	20.1	25.2	18.6	17.9	26.6	26.6	26.7	25.5
Mos2	Mosaic of habitats	n/a	8.8	15.1	6.9	6.6	20.1	25.2	18.6	17.9
Mos3	Mosaic of habitats	n/a	8.8	15.1	6.9	6.6	15.2	17.9	14.5	14.3

[19] Results for targets relating to mosaic of habitats represent the % of total vegetated area (regardless of type) inundated at a given flow rate

Target/EWR			Proportion of targeted habitat/taxa inundated at flow rate that meets average frequency and duration metrics of EWR							
#	Targeted taxa/function	Target %	Results under Baseline conditions				Results under 2750 GL scenario			
			SA floodplain	Gorge reach	Valley reach	Riverland–Chowilla	SA floodplain	Gorge reach	Valley reach	Riverland–Chowilla
Mos4	Mosaic of habitats	n/a	5.4	11.2	3.7	3.1	8.8	15.1	6.9	6.6
WB1	Waterbird breeding (lignum)	50%	6.9	12.6	5.1	2.8	6.9	12.6	5.1	2.8
WB2	Waterbird breeding (river red gum)	50%	15.8	19.1	14.2	14.9	15.8	19.1	14.2	14.9
FP	Spawning/floodplain access [20]	n/a	17.2	20.4	16.4	16.3	21.9	27.2	20.4	19.8
TW1	Temporary wetlands (higher elevations)	80%	60.3	69.0	57.3	53.2	65.8	77.2	61.5	56.0
TW2	Temporary wetlands (lower elevations)	20%	Unable to assess				43.7	51.7	40.8	36.1
FV	Flow variability	n/a	Unable to assess				Unable to assess			

20 Results relating to floodplain access represent the % area of floodplain (including non-vegetated areas) inundated at a given flow rate

Table C2. Comparison of proportion of targeted taxa/habitat inundated at flow rate that meets the duration and maximum interval metrics of the EWR under the Baseline Conditions and the 2750 GL scenario

Results are presented at four spatial scales with SA floodplain incorporating floodplain areas within the gorge and valley reaches as well as remnant floodplain habitat located between Mannum and Wellington; the gorge reach covering the floodplain located between Overland Corner and Mannum; the valley reach covering the floodplain between the border and Overland Corner including Riverland–Chowilla; Riverland–Chowilla incorporating the Riverland Ramsar site and the South Australian section of the Chowilla Icon Site.

Figures provided are the % of the total area of the targeted habitat/taxa found at the given spatial scale

Cells highlighted in green indicate the three greatest increases under the 2750 GL scenario when compared to baseline within each spatial scale

Target/EWR			Proportion of targeted habitat/taxa inundated at flow rate that meets duration and maximum interval metrics of EWR							
#	Taxa/Function	%	Results under Baseline Conditions				Results under 2750 GL scenario			
			SA RM floodplain	Gorge reach	Valley reach	Riverland–Chowilla	SA RM floodplain	Gorge reach	Valley reach	Riverland–Chowilla
BBr1	Black box (recruitment – lower elevations)	50%	Unable to assess				Unable to assess			
BBr2	Black box (recruitment – higher elevations)	80%	Unable to assess				Unable to assess			
BB1	Black box woodlands	80%	1.5	3.1	1.1	1.1	3.2	4.0	3.0	3.9
BB2	Black box woodlands	60%	1.5	3.1	1.1	1.1	3.2	4.0	3.0	3.9
BB3	Black box woodlands	50%	1.2	2.5	0.9	0.8	3.2	4.0	3.0	3.9
RGr	River red gums	75%	Unable to assess				Unable to assess			

Target/EWR			Proportion of targeted habitat/taxa inundated at flow rate that meets duration and maximum interval metrics of EWR							
#	Taxa/Function	%	Results under Baseline Conditions				Results under 2750 GL scenario			
			SA RM floodplain	Gorge reach	Valley reach	Riverland–Chowilla	SA RM floodplain	Gorge reach	Valley reach	Riverland–Chowilla
	(recruitment)									
RG	River red gum woodlands and forests	80%	8.4	14.9	5.2	4.1	11.0	15.8	8.6	7.7
Lig1	Lignum shrubland	50%	2.3	4.7	1.6	0.7	3.2	7.1	2.0	1.1
Lig2	Lignum shrubland	80%	3.2	7.1	2.0	1.1	12.9	18.4	11.2	9.5
Ligr	Lignum (recruitment)	66%	Unable to assess				Unable to assess			
Mos1	Mosaic of habitats	n/a	3.9	8.8	2.4	1.6	5.4	11.2	3.7	3.1
Mos2	Mosaic of habitats	n/a	3.9	8.8	2.4	1.6	5.4	11.2	3.7	3.1
Mos3		n/a	Data not available				3.9	8.8	2.4	1.6
Mos4	Mosaic of habitats	n/a	Data not available				3.9	8.8	2.4	1.6
WB1	Waterbird breeding (lignum)	50%	Data not available				2.3	4.7	1.6	0.7
WB2	Waterbird breeding (river red gum)	50%	Data not available				8.4	14.9	5.2	4.1
FP	Spawning/floodplain access	n/a	6.1	11.6	4.4	3.0	8.0	14.1	6.1	5.2
TW1	Temporary wetlands (higher elevations)	80%	35.8	41.0	33.9	22.7	46.0	55.1	42.6	36.5
TW2	Temporary wetlands (lower elevations)	20%	Data not available				Unable to assess			
FV	Flow variability	n/a	Unable to assess				Unable to assess			

APPENDIXES

D. EWR ASSESSMENT TABLES SUPPLIED TO GOYDER INSTITUTE FOR WATER RESEARCH

EWR Assessment Tables provided to Goyder Institute for Water Research Expert Reference Panel convened on 10 February 2012.

Table D1. Assessment of MDBA Riverland–Chowilla EWRs

No.	Target	Environmental Water Requirement		Notes About Requirement		Baseline Frequency	Without Develop-ment Frequency	Target Frequency		BP2800 Scenario Frequency
		Flow (ML/d)	Duration (days)	Timing (season)	Min Duration (days)			Low Uncertainty	High Uncertainty	
MDBA 1	Freshes	20 000	60	–	Longest single continuous	46%	93%	80%	72%	77%
MDBA 2	Maintain 80% of the current extent of wetlands in good condition	40 000	30	Jun–Dec	7	37%	81%	70%	50–60%	54%
MDBA 3	Maintain 80% of the current extent of red gum forest in good condition	40 000	90	Jun–Dec	7	23%	61%	50%	33%	33%
MDBA 4	Maintain 80% of the current extent of red gum forest in good condition	60 000	60	Jun–Dec	7	12%	43%	33%	25%	19%
MDBA 5	Maintain 80% of the current extent of red gum forest in good condition maintain 80% of the current extent of red gum woodland in good condition	80 000	30	Pref. winter/spring but timing not constrained	7	10%	33%	25%	17%	11%
MDBA 6	Maintain 80% of the current extent of black box woodland in good condition	100 000	21	Pref. winter/spring but timing not constrained	1	6%	20%	17%	13%	5%
MDBA 7	Maintain 80% of the current extent of black box woodland in good condition	125 000	7	Pref. winter/spring but timing not constrained	1	4%	17%	13%	10%	4%

Table D2 Assessment of SA Riverland–Chowilla EWRs

Source and #	Target	Environmental Water Requirement			Baseline Frequency	Without Development Frequency	Target Frequency	BP2800 Scenario Frequency
		Flow (ML/d)	Duration (days)	Timing				
SA-a1 (BBr1)	Successful recruitment of cohorts of black box at lower elevations	85 000	20	spring or early summer	11%	34%	10% (+ successive years[21])	11%
SA-a2 (BBr2)	Successful recruitment of cohorts of black box at higher elevations	>100 000	20	spring or early summer	6%	20%	10% (+ successive years[22])	5%
SA-b (BB1)	Maintain and improve the health of 80% of the black box woodlands	>100 000	20	spring or summer	6%	20%	17% (max. interval 8 years)	5%
SA-c (BB2)	Maintain and improve the health of ~60% of the black box woodlands	100 000	20	spring or summer	6%	20%	20% (max. interval 8 years)	5%
SA-d (BB3)	Maintain and improve the health of ~50% of the black box woodlands	85 000	30	spring or summer	9%	30%	20% (max. interval 8 years)	11%
SA-e (RGr)	Successful recruitment of cohorts of river red gums	80 000	60	Aug–Oct	6%	20%	20%[23] (+ successive years)	6%
SA-f (RG)	Maintain and improve the health of 80% of the river red gum woodlands and forests (adult tree survival)	80 000 to 90 000	>30	Jun–Dec	10%	34%	25% to 30% (max. interval 5 years)	11%

[21] EWR for black box and red gum recruitment includes the need for flooding in successive years, i.e. floods must occur in at least 2 consecutive years for successful recruitment. Successive year requirement is not addressed in this hydrological assessment.

[22] EWR for black box and red gum recruitment includes the need for flooding in successive years, i.e. floods must occur in at least 2 consecutive years for successful recruitment. Successive year requirement is not addressed in this hydrological assessment.

[23] EWR for red gum recruitment in DWLBC 2010 did not specify preferred frequency, however to enable analysis the frequency provided within EA 2010 was used

Source and #	Target	Environmental Water Requirement			Baseline Frequency	Without Development Frequency	Target Frequency	BP2800 Scenario Frequency
		Flow (ML/d)	Duration (days)	Timing				
SA-g (Lig1)	Maintain and improve the health of ~50% of the lignum shrubland	70 000	30	spring or early summer	12%	43%	33% (max. interval 5 years)	17%
SA-g (Lig2)	Maintain and improve the health of 80% of the lignum shrubland	80 000	30	spring or early summer	10%	34%	20% (max. interval 8 years)	11%
SA-h (Ligr)	Lignum shrubland recruitment - 66% of community maintained [24]	70 000	120	–	4%	10%	20%	4%
SA-i (Mos1)	Provide mosaic of habitats (i.e. larger proportions of various habitat types are inundated)	90 000	30	spring or early summer	7%	25%	20% (max. interval 6 years)	8%
SA-j (Mos2)	Provide mosaic of habitats (i.e. larger proportions of various habitat types are inundated)	80 000	>30	spring or early summer	10%	34%	25% (max. interval 5 years)	11%
SA-k (Mos3)	Provide mosaic of habitats (i.e. larger proportions of various habitat types are inundated)	70 000	60	spring or early summer	7%	33%	25% (max. interval 6 years)	8%
SA-l (Mos4)	Provide mosaic of habitats (i.e. larger proportions of various habitat types are inundated)	60 000	60	spring or early summer	12%	43%	33% (max. interval 4 years)	19%
SA-m (WB1)	Maintain lignum inundation for waterbird breeding events	70 000	60	Aug–Oct	7%	33%	25% (max. interval 6 years)	8%
SA-m (WB2)	Provide habitat (river red gum communities) for waterbird breeding events	70 000	60	Aug–Oct	7%	33%	25% (max. interval 6 years)	8%

[24] An EWR for lignum recruitment was not provided in DWLBC 2010, however the Goyder Institute recommends the inclusion of a lignum recruitment target. This EWR has been developed from information provided in EA 2010

Source and #	Target	Environmental Water Requirement			Baseline Frequency	Without Development Frequency	Target Frequency	BP2800 Scenario Frequency
		Flow (ML/d)	Duration (days)	Timing				
SA-n (FP)	Stimulate spawning provide access to the floodplain and provide nutrients and resources	80 000	>30	Jun–Dec	10%	34%	25% (max. interval 5 years)	11%
SA-o (TW1)	Inundation of (~80%) temporary wetlands for large scale bird and fish breeding events	80 000	>30	Jun–Dec	10%	34%	25% (max. interval 5 years)	11%
SA-p (TW2)	Maintain and improve majority of lower elevation (~20%) temporary wetlands in healthy condition; and Inundation of lower elevation temporary wetlands for small scale bird and fish breeding events and microbial decay/export of organic matter	40 000	90	Aug–Jan	23%	61%	50% (max. interval 3 years)	33%
SA-q (FV)	Provide variability in flow regimes at lower flow levels	Pool to 40 000[25]	Variable		47%	84%	80% (max. interval 2 years)	61%

[25] While specific flow is defined, this EWR has been assessed as the percentage of years in which 40 000 ML/day is reached with one day minimum duration