This business case was used to inform decision-making on sustainable diversion limit adjustment mechanism projects.

Detailed costings and personal information has been redacted from the original business case to protect privacy and future tenders that will be undertaken to deliver this project.

River Murray in South Australia Constraints Measure

Business Case

Prepared by Department of Environment, Water and Natural Resources and the Murray-Darling Basin Authority on behalf of the governments of Victoria, New South Wales and South Australia.

Version control

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20 July 2015	Penny Sullivan	Edits from RMC SC 4
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Executive Summary

Under the Murray-Darling Basin Plan, Basin State Governments and the Commonwealth committed to preparing and progressing the Constraints Management Strategy (**CMS**). The Commonwealth Government has set aside up to $200 million to address constraints in the Water for the Environment Special Account, which will be released following funding decisions by Basin State Ministers by 30 June 2016 as part of the sustainable diversion limit adjustment mechanism.

Defined as the physical and operational practices that restrict the volume of water and in particular environmental water that can be delivered through the system, the relaxation of constraints is an integral part of the commitment to restoring the health of the Basin. The Murray Darling Basin Authority (**MDBA**) released the Constraints Management Strategy in 2013. It identified seven key focus areas for which further investigation and consideration should follow throughout three key phases: prefeasibility, feasibility and planning and implementation to 2024.

In 2014 MDBA conducted prefeasibility technical assessments which was refined during feasibility analysis in 2015. Pursuant to the Constraints Management Strategy, Basin State Governments and MDBA have prepared a suite of business cases to assist Ministers in allocating the $200 million.

This business case relates to the River Murray in South Australia. It is part of an integrated package of business cases regarding the River Murray, with the Governments of New South Wales and Victoria preparing business cases for the Hume to Yarrawonga and Yarrawonga to Wakool Junction reaches.

The feasibility analysis (including costing and hydrological modelling) that is summarised in this business case has been prepared assuming various flow rates at upstream key focus areas. In particular this business case assumes that at the Yarrawonga to Wakool reach a flow rate range of between 50,000 to 65,000 ML/day will be coordinated with natural flows and higher flows in other reaches to achieve flows of up to 80,000 ML/day at the South Australian border. It is important to note that no final decisions on flow rates have been made and will part of Ministers' considerations as part of broader Basin Plan implementation.

The purpose of this business case is to demonstrate and provide details of the:

1. benefits to be gained from relaxing constraints;
2. proposed hydrological operating regime for river operators where constraints are relaxed;
3. proposed works and measures which will need to be undertaken to relax constraints; and
4. estimated costs required for those works.

This business case summarises the learnings to date gained from communities and stakeholders consulted since 2013. In June 2016, Basin State Ministers will decide how relaxing constraints forms part of the broader sustainable diversion limit adjustment mechanism before further planning and implementation of the CMS from 2016 to 2024.

Benefits of relaxing constraints

The River Murray is a highly regulated system delivering water throughout the Basin for consumptive, agricultural, irrigation and environmental uses. The delivery of water throughout the Basin and ultimately to the River Murray in South Australia occurs pursuant to planning and operating regimes that currently result in a mostly stable river system; where water is managed through various dams, storages, locks and weirs and delivered in ways to meet the various needs. This system has been influenced by drought cycles and prioritising economic and consumptive needs. However, it means that the flow of water throughout the Basin is vastly different and lacks the seasonal peaks and overbank flows that routinely

watered the upper and middle parts of the floodplain, flushed salts, maintained longitudinal connectivity and supported plant and animal communities. So much so that under current development conditions, the average annual flow to South Australia is modelled to have been reduced by 52% compared to "without development" conditions.

An important component of achieving the enhanced environmental outcomes defined under Schedule 5 of the Basin Plan is removing or easing constraints to provide opportunities for environmental watering of an additional 35,000 hectares (**ha**) of floodplain in South Australia, New South Wales and Victoria. The modelling conducted by the MDBA in 2012 indicated that addressing constraints is the key driver to pursue this enhanced environmental outcome.

Under the 2012 modelling scenario, flows to South Australia need to reach 80,000 megalitres per day (ML/day) occurring 18% of years for a total duration of 30 days (with a minimum duration of 7 consecutive days) between June and May to pursue the 35,000 ha of additional floodplain benefit. Removing or relaxing constraints across the Basin is critical to delivering this outcome. Having the capacity to deliver these flows to South Australia is dependent on the flow rates for relaxed constraints in upstream reaches.

These ecological outcomes are restated and further explored in the Basin-wide Environmental Watering Strategy, and refocused for environmental assets in the South Australian Long-Term Watering Plan.

The environmental benefits of delivering timed environmental releases to replicate pre-regulation seasonal overbank flows will be realised both in the South Australian reach, and Basin-wide. In South Australia the health and vitality of the Coorong, Lower Lakes and Murray Mouth are of critical importance and the area is recognised as a Living Murray Icon Site and a Ramsar Wetland of International Importance. Addressing constraints will assist this area by adjusting salinity, ground water, and moving organisms and sediments throughout the length of the river. These benefits also extend to the main River Murray channel and floodplain to promote longitudinal and lateral connectivity. Basin-wide, occasional watering of the floodplain will restore seasonal breeding cycles to floodplain and wetland depending flora and fauna and will restore river connectivity.

The socio-economic benefits include better risk management and increased community, agency and business capacity to plan, prepare, manage and respond to high flow events. Addressing constraints will also enable improved access to land and property during high flows and provide increased recreation and tourism opportunities. Other benefits include providing more flexibility for river operators and environmental water managers. These benefits will also be realised during natural high flow events that occur regardless of any environmental watering augmentations.

There is broad community support for the CMS in South Australia. Communities recognise that addressing constraints to allow higher flows will enable effective environmental watering in South Australia which will bring the above-mentioned socio-economic benefits, so long as the effects of inundation are appropriately managed.

Proposed hydrological operating regime

Hydrological modelling undertaken by the MDBA indicates that high flows of up to 80,000 ML/day can be delivered to the South Australian border. This represents the operational limit to which flows can be practically delivered to South Australia; however such delivery can only occur if upstream constraints are relaxed and water is delivered with coordinated releases from multiple storages and valleys. This operational limit is classified as a "high flow" for most parts of the River Murray in South Australia, and as a "minor flood" for shack areas downstream of Cadell.

The modelling suggests the most likely change to the operating regime is to increase the peak and duration of low to moderate flows during spring and early summer to follow natural seasonal flows. There are no changes to the frequency, duration and timing of natural high flow and flood events, which will continue to occur regardless of environmental water augmentations. Likewise, there is no suggestion or proposal that addressing constraints would return the river to the flow regimes that were experienced prior to the last century of regulation, or that flows to South Australia would be augmented to be greater than 80,000 ML/day at the border.

Flows will be managed in South Australia under existing arrangements subject to annual river operations and environmental water management plans to maximise environmental watering benefits to the floodplain and environmental assets.

An integral component of the proposed operating regime is that the implementation and operational delivery of high flows will proceed conservatively and incrementally, such that flows are augmented in a piecemeal fashion year on year (or event by event). Proceeding in this manner will best manage potential risks in that system processes will be tested and the effects of inundation can be confirmed with each increment which will in turn build trust and credibility with communities and stakeholders.

Proposed works and measures

Modelling conducted during the prefeasibility and feasibility phases of the CMS shows the likely inundation extent of flows at 80,000 ML/day at the South Australian border. This information has been refined and through separate engagements with independent consultants has been verified with a number of key stakeholders.

The main impact from these flows is the likely inundation of private land comprising mostly shack communities downstream of Morgan. The potential impacts are to grassed areas and private jetties on riverfront properties, with a small number of dwellings potentially inundated. For these impacts, the potential mitigation measures costed include, for example, negotiating and purchasing voluntary easements from landholders and constructing communal levees to minimise inundation on private land. Where some areas are identified as likely to experience interrupted access during higher flows, the mitigation measure proposed is raising and/or developing access tracks. With respect to private businesses, the proposed range of mitigation measures that have been costed includes, for example, compensating business losses, constructing levees to prevent high flows inundation and raising access tracks to maintain access during high flows.

With respect to public infrastructure, the extent of impacts is dependent on the infrastructure and the overall feasibility (in terms of cost, ownership and risk) of the mitigation measure. Where inundation of public roads is identified, the project recommends operational and maintenance responses including clean-up, repairs and restoration (as capital works were considered not practically feasible or too expensive). Alternatively, capital works upgrades were recommended to manage inundation to large scale public infrastructure such as banks, marinas and pontoons where operational response costs were considered not feasible or too expensive.

Levees around Renmark and the Lower Murray could be managed through operational responses such as repairing, restoring and replacing levees after a high flow event. There was also a very small risk of impacts associated with inundation to agricultural land for which land management arrangements were recommended.

Additional mitigation activities such as advance warnings, notifications, communications and awareness activities greatly complement the ultimate investment in capital-expense mitigation activities described above.

It is important to note that while consultants have costed and presented a range of mitigation options, the CMS is still at an early stage of concept and design and these options will need to be assessed further during Phase 3. The mitigation measures will be further refined with public and private business partners with respect to governance arrangements, ongoing operations and maintenance costs, ease of implementation.

Estimated costs of works and measures

It must be emphasised that this South Australian business case recognises that the delivery of 80,000 ML/day to the South Australian border is dependent on the upstream relaxation of constraints – hence the importance of this business case being considered in conjunction with the business cases for Hume to Yarrawonga and Yarrawonga to Wakool Junction.

The estimated costs of relaxing constraints in the South Australian reach presented in this business case is subject to confirmation of the expected relaxed constraints flow rates of upstream reaches and in particular downstream of Yarrawonga Weir. Consultants engaged by the MDBA have prepared two options for cost estimates with respect to mitigation options for specialist activities. Option 1 assumes that land management arrangements (in the form of easements and like agreements) would be pursued in preference to infrastructure works, whilst Option 2 assumes the reverse.

Taking Option 1, the cost estimate to address constraints in South Australia is between [redacted] (assuming mid-range contingencies) and [redacted] (assuming high-range contingencies).

Taking Option 2, the cost estimate to address constraints in South Australia is between [redacted] (assuming mid-range contingencies) and [redacted] (assuming high-range contingencies).

These cost estimate options are not prepared on an "either/or" basis and it is open to Basin States to ultimately pursue a combination of the two costings options. Both cost estimate options include administration and project management costs, design and approvals processes, contingency and cost escalation to account for and manage risks for costings uncertainty, and are for a range of flow rates between 50,000 and 65,000 ML/day delivered downstream of Yarrawonga Weir. A more detailed explanation of mid and high range cost estimates and contingencies is at sections 2.6 and 7.

Investment will result in:

- reinstatement activities following high flow events to approximately 11km of sealed roads, 43km of unsealed roads and 400km of tracks;
- capital response measures for up to 40km of private levees around Renmark and the Lower Murray;
- land management arrangements and infrastructure upgrades to 23 shack communities and seven private businesses;
- capital upgrades to approximately 42km of roads and specific public assets such as banks, walls, boating and marina infrastructure; and
- land management arrangements for almost 10,000 ha of agricultural land.

Phase 3 implementation

The final part of this business case outlines the key components for implementation, including the policy, governance and funding arrangements for the planning and implementation phase from 2016 to 2024.

Implementation of the Pre-requisite Policy Measures to protect environmental flows from extraction, delivering environmental water on top of other instream flows and using environmental water

throughout the length of the river are required to fully implement potential physical constraints investment.

The governance for the initial commencement of the next phase of CMS are proposed to continue through the existing governance arrangements for Basin Plan implementation. This will be reviewed in due course once issues related to ownership and other matters are finalised.

The funding arrangements are through the Water for the Environment Special Account administered by the Commonwealth Government Department of Agriculture and Water Resources. Principles are also included for potential co-contributions and ongoing asset ownership, operations and maintenance.

Communications and community engagement

The MDBA and the Department of Environment, Water and Natural Resources (**DEWNR**) engaged with local councils, peak irrigation bodies, indigenous nations and shack communities during 2013-14. These stakeholders understood the benefits of high flows and indicated that risks were manageable given appropriate notifications and the right investment.

DEWNR re-connected with local councils, state government asset managers and shack communities in 2015 to verify the potential impacts, assess the feasibility of mitigation options and refine cost estimates for the business case.

Effective communication and consultation with stakeholders will continue during further design and implementation to understand community issues at the regional and local level and to seek input on the development and implementation of constraints management measures.

1 Background

This section details how the health of the Murray-Darling Basin has declined and how the Commonwealth and Basin State governments recognise the importance of delivering environmental water throughout the length of the system to restore its ecological health and balance. It explains the Constraints Management Strategy and the purposes of this Business Case for investment, as well as outlining the critical dates for decision, planning and implementation. Finally, this section provides background information of the River Murray in South Australia.

1.1 Context

Over the last hundred years of development and regulation in the Murray-Darling Basin, the natural pattern of river flows has changed significantly. Historically, water would flow in seasonal peaks out of the main channels into surrounding creeks, flood runners, and onto the floodplains thereby inundating wetlands and lakes. These flows would move environmental debris through the length of the river, adjust soil salinity levels, replenish groundwater storages and inundate the floodplain and wetlands all of which is vital for creating breeding and feeding opportunities for water-dependant animals and flood-dependent vegetation.

As Australia's agricultural industry increased and towns and cities grew, it became necessary to physically control the flows through the Basin by increasing river regulation and operating water storage systems along the river to support consumptive, agricultural and industrial needs. The main focus of current river regulation is to capture the natural flows in dams, locks and weirs. Water is then released as constant flows during summer and autumn which is to the primary benefit of irrigators and recreational river users.

These practices have been instrumental in providing for critical human water and irrigation supply needs, especially during times of drought. However, the Commonwealth and Basin State governments recognise that over a century of development and regulation has been at the expense of the health of the river system, floodplains and dependent ecology.

Downstream of the main water storages, small overbank flows occur dramatically less frequently reaching a vastly smaller area of the floodplain and wetlands than before the Basin was regulated. Accordingly, where river regulation has kept flows in the main channel without periodic overflows and inundation of the floodplain, the natural and native ecosystems have been placed under great stress. Populations of native fish and waterbirds have greatly declined as has the size and health of the wetlands, floodplain forests and woodlands.

In recognition of this environmental degradation, in recent decades, governments, industry and communities have made significant in-roads and in-principle agreements to maintain and restore the environmental sustainability and ecological health of the Basin. Commonwealth and Basin State governments and the Murray-Darling Basin Authority (**MDBA**) recognise that this recent work can be built on and more can be done to improve the effectiveness of environmental watering practices.

In light of the above, Basin States asked MDBA to develop the Constraints Management Strategy (**CMS**) pursuant to the requirements of the Basin Plan (Clause 7.08).

1.2 The Constraints Management Strategy

The MDBA released the CMS in November 2013.

The CMS defines a constraint as a river management practice or structure that restricts the volume and timing of water that can be delivered through the river system. In particular, the CMS is concerned with

the delivery and timing of environmental water allocations and is separate to the delivery of consumptive and irrigation water allocations. That said, addressing the physical and operational constraints that limit the delivery of environmental water will improve the ability and effective delivery of other water allocations.

The ultimate aim of the CMS is to improve the availability and delivery of environmental water to achieve greater environmental outcomes. It builds on past achievements to restore a small part of the natural flow pattern while identifying and describing the current physical, operational and management constraints affecting environmental water delivery.

Importantly, it is acknowledged the Basin will never be restored to its original pre-development peaks and flows and this is not the intention of the CMS or this Business Case. The Basin Plan and the CMS recognise that ongoing regulation is critical to supporting agricultural, industrial and consumptive water needs; however, amending certain key physical structures and operational practices will restore a number of natural smaller overflows which is critical to the environment's ongoing health and resilience.

Following the release of the CMS in 2013, the MDBA commenced the first of the CMS's three phases: the pre-feasibility phase of technical analysis. The results of that work are contained in the first Annual Report released by the MDBA in November 2014, and the Reach Reports for each of the Key Priority Focus Areas identified for consideration in the Sustainable Diversion Limit Adjustment Mechanism.

1.3 Business Cases for Key Priority Focus Areas

As a result of the pre-feasibility phase of analysis, in 2014 Basin Ministers agreed to progress the CMS to the second phase, the feasibility phase, which includes developing business cases for each of the identified seven Key Priority Focus Areas, and asked that work should proceed as an integrated package for the three River Murray key focus areas – Hume to Yarrawonga, Yarrawonga to Wakool Junction and the River Murray in South Australia.

Together with input from Basin States, the MDBA has progressed the work conducted in 2014 to contribute towards this suite of business cases on behalf of the governments of New South Wales, Victoria and South Australia. These business cases will inform Commonwealth decisions regarding future investment in relaxing constraints. The work conducted in preparing these business cases will continue to assist Basin States in their continued application of the Basin Plan and decisions related to environmental watering.

As described throughout this document, the proposed measures will commence during the third phase of the CMS: planning and implementation phase, which is scheduled to commence after Commonwealth investment decisions are made in July 2016, and continue to complete implementation in 2024.

This business case describes the measure proposed to address constraints in the River Murray in South Australia including the costs, feasibility, stakeholders, impacts, and anticipated environmental outcomes. The status of the environment of the River Murray in South Australia is described including the environmental and ecological objectives and benefits of the measures proposed under the CMS for the floodplain, wetlands, Lower Lakes, Murray Mouth and Coorong, as well as for the whole of the Basin system.

As will be apparent in this Business Case, the health of the River Murray in South Australia is dependent on the relaxation of upstream constraints to enable higher flows to reach the South Australian border.

Within South Australia, the measure proposed primarily concerns addressing infrastructure and access issues that are affected by higher flows. As is described in Section 4 about the proposed operating regime, the intent of the CMS is to enable augmentation of natural flows to increase their peak and/or

duration for increased environmental benefits. This augmentation will not affect the occurrence of moderate or major floods, which will remain natural events.

This Business Case also includes further information about implementation planning, policy, legislation, governance arrangements, funding, stakeholder communications and risk management to support the case for investment.

1.4 River Murray in South Australia

This business case outlines the proposal to relax constraints in the River Murray in South Australia. It summarises the results of work conducted by the MDBA and the South Australian Department of Environment, Water and Natural Resources (**DEWNR**) during the feasibility phase and proposes a suite of works and mitigation measures that can be progressed with appropriate funding.

The Murray-Darling Basin in South Australia covers approximately 7% of the state and is its principal supply of water (Natural Resources, SAMDB, 2014). It is a complex system comprising the main river channel which extends from the South Australian border, includes an extensive floodplain (defined by the 1956 flood extent and including environmental assets, Chowilla, Pike and Katarapko Floodplains), temporary and permanent creeks and wetlands, swamps, the Lower Lakes (Lake Albert and Lake Alexandrina), the unique Coorong and estuarine Murray Mouth region (Murray-Darling Basin Authority, 2014b).

Economically, the River Murray is a vital asset to South Australia providing the majority of Adelaide's and other regional townships' water needs. It is the most productive agricultural region in South Australia with approximately 80% of the land engaged in primary production. It accounts for 22% of all agricultural workers in South Australia and 29% of all South Australian agricultural business (Primary Industries and Regions South Australia). In 2011-2012, the gross regional product for the South Australian portion of the Murray-Darling Basin was approximately $3.1 billion. Notably, the region contributes about $2.2 billion of the state's $15 billion gross food and wine product (RDA Murraylands & Riverland Roadmap 2013-2016).

Tourism, eco-tourism and holiday destinations are important sources of revenue contributing approximately $200 million each year to the Murraylands and Riverland. A high proportion of tourists to the area are from Adelaide staying in shacks, caravans, campsites and houseboats. Tourism is recognised as an area with significant growth potential, especially in light of the growing interest in and potential to capitalise on eco-tourism with, for example, Banrock Station Wetland and the Coorong and Murray Mouth.

The region attracts tourist and recreational activities along the river and in noted conservation areas such as the Murray River National Park. Many towns along the river are highly dependent on tourism and recreational river users. The river is also home to many shack communities that are located mostly downstream of Cadell. These riverfront properties contain a mix of permanent residents and holiday makers that enjoy the relaxed river lifestyle and recreational activities such as boating, fishing, water sports and camping.

Aboriginal people represent approximately 3.6% of the region's population (RDA Murraylands & Riverland Roadmap 2013-2016) and the River Murray, floodplains and wetlands are important to their life and culture. Traditional Owners and the South Australian Government have entered into agreements to improve consultation and opportunities for Aboriginal people to be involved in water resource planning and implementation (Natural Resources, SAMDB, 2014). The First Peoples of the River Murray and Mallee Region (FPRMM) and the Ngarrindjeri Regional Authority are two of the main indigenous representative bodies for the River Murray in South Australia.

2 Project details

This section describes the measure proposed to relax constraints in the River Murray in South Australia: to address, through a combination of capital works and a suite of mitigation measures, the physical impacts to local communities, businesses and stakeholders as a result of high flows and resulting inundation. This section also provides a high-level summary of the likely impacts, costs and mitigation measures investigated while highlighting that feasibility phase investigations will be further refined through the planning and implementation phase.

2.1 Description of the measure

The River Murray in South Australia has important environmental, social and economic values that react to and depend on flows: their seasonality, frequency and volume. The river environment is a complex and diverse system stretching from the border to the Coorong, Lower Lakes and Murray Mouth with hundreds of wetlands, floodplains, anabranches and creeks in between (Figure 1). The riverine environment is diverse and the large floodplain is divided into geomorphic reaches including the valleys and cliffs in the middle reaches before flattening out to the Lower Murray.

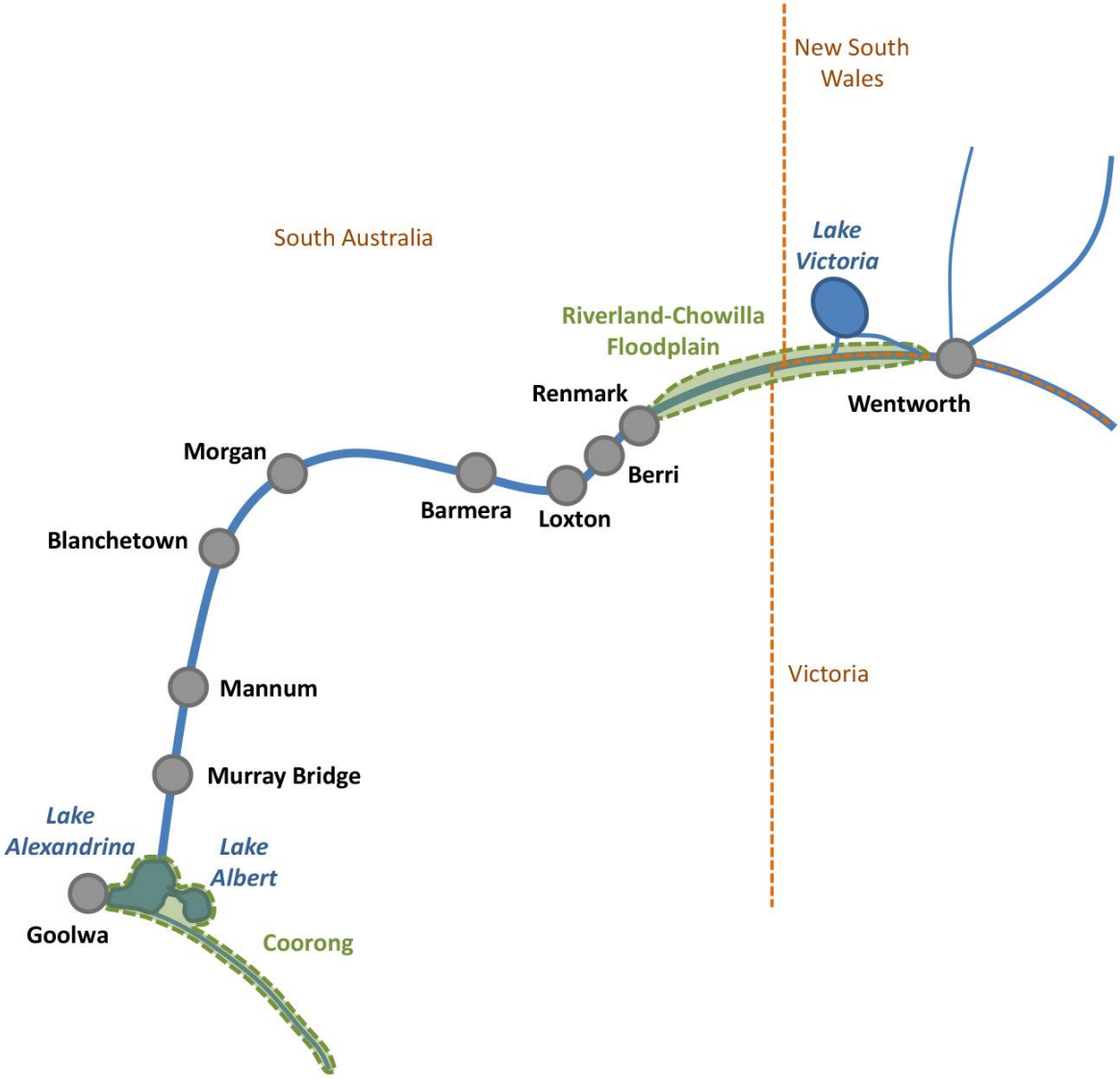

Figure 1: Schematic drawing of the River Murray in South Australia.

Under the Murray-Darling Basin Agreement, South Australia's annual entitlement flow of up to 1,850 gigalitres (**GL**) is delivered at the South Australian border at rates ranging from 3,000 megalitres per day (**ML/day**) to 7,000 ML/day, depending on the time of year under "normal" conditions (i.e. outside periods of extremely dry and wet years). Before the last century of development, hydrologists estimate the River Murray in South Australia would have received higher flows of 80,000 ML/day at the South Australian border approximately every 2 years compared to the current average of every 8 years (Cale, 2009). These natural seasonal high flows are responsible for controlling soil salinity, replenishing groundwater supplies, moving debris and food sources through the length of the channel, and inundating the floodplain and wetlands such that conditions for dependent flora and fauna would occasionally be ideal for reproduction and nutrition ensuring the viability of these species and the ongoing cyclical health of the floodplain, as detailed further in Section 3.

The health of the River Murray in South Australia is dependent on relaxing the physical and operational constraints upstream of the South Australian border to ensure the connectivity of the entire Basin and delivery of periodic high flows enhanced by environmental water. High flows are important for maintaining longitudinal connectivity as well as promoting lateral connectivity to deliver water to the wetlands, floodplains, creeks and anabranches connected to the main river channel.

The relaxation of upstream constraints is integral to the delivery of enhanced higher flows to South Australia. Accordingly, the measure proposed below must be considered in conjunction with the measures proposed in the business cases for upstream reaches. The relaxation of constraints must be achieved as a package of measures to ensure the connectivity of the Basin and the overall restoration of the River Murray's health.

The measure proposed in this business case is to address the infrastructure and access routes that may be negatively affected by flows up to 80,000 ML/day at the South Australian border. This will be achieved by a combination of capital works and other mitigation activities, including operational, policy, and various land management arrangements, as detailed in Section 5. Enhanced flows of this type will be delivered in a conservative, step-wise approach to manage risk, test the operational processes and build trust and credibility with the community and stakeholders.

By adopting the measures proposed in this business case, communities and businesses will be minimally affected by the augmented high flows in the River Murray in South Australia delivered by the CMS. This measure will, however, in turn benefit the same communities and businesses during naturally occurring moderate and major floods, which will occur regardless of environmental water augmentations.

It is important to recognise that the technical investigations, consultation and cost estimates that form part of this suite of business cases are at the feasibility phase of works. During the prefeasibility phase, the MDBA and the consultants it engaged performed high-level desktop technical analyses and preliminary consultation with key stakeholders to inform the conclusions and recommendations in the 2013-14 Annual Progress Report and Reach Reports. This current phase of work has refined those high level analyses with additional technical information and more extensive data-collection through a series of selected case studies. However, it should be recognised that this is still an early stage of the CMS and the potential impacts, costs and mitigation measures will be confirmed and further developed for the planning and implementation phase.

2.2 Objectives of the measure

The objectives of this measure are to:

- Relax priority physical constraints to environmental water delivery in upstream reaches to provide greater opportunities to increase flows to all downstream reaches, including the River Murray in South Australia; and
- Relax priority physical constraints for the River Murray in South Australia to enable environmental flows to be better managed and the effects of higher flows mitigated.

The benefits of the measure are:

- Environmental benefits for the broader Basin and the environmental assets, including the main river channel, wetlands, floodplains, creeks and anabranches and the Coorong, Lower Lakes and Murray Mouth;
- Socio-economic benefits through improved access to land and property during high flows, increased recreation and tourism opportunities and improved river operations and environmental water planning and risk management.

These benefits would also be realised for natural high flow events that are likely to occur regardless of any environmental water augmentations to improve the capacity and resilience of local communities and businesses that rely on the river for their lifestyle and livelihood.

2.3 Sustainable Diversion Limit resource units affected

This measure will involve works in the following Sustainable Diversion Limit resource units:

- South Australian Murray (SS11).

When combined with the Hume-Yarrawonga and Yarrawonga-Wakool constraint measures, it will also involve:

- Victorian Murray (SS2); and
- New South Wales Murray (SS14).

2.4 Proponent

The Government of South Australia is proposing this measure through DEWNR. This measure is being proposed as a physical constraint measure.

2.5 Impacts and mitigation activities

The main impacts and mitigation activities of the proposed operating regime include:

- Impacts on public infrastructure assets, which can be addressed by a combination of reinstatement works and capital works in some locations;
- Impacts on river shacks on the River Murray, which can be addressed by a combination of various land management agreements regarding affected land, and capital works in some locations;
- The potential for works on levees to ensure they can withstand the proposed operating regime.

There would also be some smaller scale inundation of agricultural land, which can be mitigated through land management arrangements.

The potential impacts and mitigation activities of flows up to 80,000 ML/day at the South Australian border are described in more detail in Section 5.

2.6 Summary of estimated costs

A summary of the estimated costs for mitigation activities is presented in Table 1. The costs comprise the following:

- Costs of mitigation measures;
- Infrastructure implementation costs; and
- Program management costs.

Independent consultants have estimated the cost of mitigation measures for the River Murray in South Australia under two scenarios: "YAR 65" and "YAR 50". These two scenarios represent the managed flows delivered downstream of Yarrawonga Weir: 65,000ML/day or 50,000ML/day, respectively.

Table 1: Summary of estimated costs of mitigation measures for the River Murray in South Australia.

Component	YAR 65 Cost estimate (million)		YAR 50 Cost estimate (million)	
Proposed mitigation measures	***Mid***	***High***	***Mid***	***High***
Land management arrangements for agricultural land (including private infrastructure)	[redacted]			
Operational response for public infrastructure				
Reinstatement works for public infrastructure				
Capital works on public infrastructure				
Land management-focused **arrangements for specialist activities (option 1)**				
Infrastructure-focused arrangements **for specialist activities (option 2)**				
Capital works on levees				
Implementation costs for option 1				
Implementation costs for option 2				
Program management costs				
Total costs (option 1)				
Total costs (option 2)				

For each mitigation measure, the project consultants provided estimated base costs of undertaking the measure. For each project the consultants included a factor for contingency which was calculated depending on a number of assumptions and level of risk identified for each project. In many cases the consultants provided two sets of estimates: "moderate" which included a lower level of contingency, and "high" which included a higher level of contingency. The specific issues taken into account in forming these base costs and contingencies are described in Appendix 6 and in the project reports.

For completeness, it should be noted that the nature of the hydrological assumptions means that cost estimates are likely to be over-estimates regardless of considering further contingencies.

The broad high cost estimate for the River Murray in South Australia is, depending on whether option 1 or 2 is pursued, between [redacted] (option 1) and [redacted] (option 2), dependent on the upstream flow rates, for a mix of infrastructure works, operational responses and land management arrangements for public and private land, agencies and businesses. The higher estimated costs under the YAR 50 scenario reflect the outcomes of the hydrological modelling, which predict a slightly increased frequency of flow events with shorter duration compared to the YAR 65 scenario.

The costs of mitigation activities are described in more detail in Section 7, including the assumptions, contingencies, infrastructure implementation and program management costs.

The proposed schedule attached at Appendix 3 details planning and implementation from 2016 to 2024 and includes broad stages of confirming governance arrangements, verifying information requirements, scoping private and public mitigations measures, conducting operational trials and delivery of relaxed constraint flows.

2.7 Confirmation that the measure is consistent with the CMS

The measure proposed is consistent with the CMS, in that it relaxes a constraint in one of the identified priority key focus areas. It is also consistent with the principles of the CMS, in that:

- it will help maximise environmental outcomes that can be obtained from managing all water available for environmental use (and managing water for other purposes en route) (Section 3);
- affected communities, including land holders and managers, water entitlement holders, Traditional Owners, management agencies and local government are being involved from the beginning to identify potential impacts and solutions (Section 5.2 and Appendix 4);
- in pursuing environmental outcomes through the relaxation or removal of constraints, this measure includes solutions that:
    - recognise and respect the property rights of landholders and water entitlements holders (Section 5);
    - do not create any new risks to the reliability of entitlements (Section 5);
    - have been identified in consultation with affected parties to determine if impacts can be appropriately addressed and mitigated to enable changes to proceed (Section 5.2 and Appendix 4);
    - identify and aim to achieve net positive impacts wherever possible (Section 2.2);
    - will be worked through in a fair and transparent/equitable way (Section 5 and Appendix 4); and
    - work within the boundaries defined by the *Water Act 2007* (Cth), the Basin Plan and relevant state water access and planning systems (Section 8).
- it enables all water holders, whether existing consumptive users or environmental water holders, to use their water efficiently to meet the needs of that use, while not adversely affecting other entitlements (Section 4);
- potential changes are being worked through with relevant Basin State governments and relevant stakeholders to resolve issues before changes to on-ground arrangements are made (Section 8);
- decisions to proceed with removing constraints will be made by Basin State governments with investment being decided by the Commonwealth on the collective advice of governments (Section 8); and
- investing in this constraint measure will:
    - provide optimal Basin-wide environmental outcomes, taking into account economic and social considerations (Section 5);
    - include lasting solutions to provide certainty and protection to stakeholders over time (Section 5); and
    - avoid or address impacts to third parties (Section 5).

(Murray-Darling Basin Authority, 2013a).

3 Environmental benefits

This section describes the ecological values and benefits from the relaxation of constraints for the whole of the Murray-Darling Basin and specific priority environmental assets within South Australia. It describes the enhanced environmental outcomes set out in Schedule 5 of the Basin Plan, the Basin-wide Environmental Watering Strategy and the South Australian objectives with respect to the South Australian Long Term Watering Plan. Finally, this section outlines the current hydrology of the River Murray in South Australia and the Environmental Watering Requirements for the priority environmental assets.

3.1 Ecological values

Achieving enhanced environmental water flows across the Basin will lead to Basin-wide improved environmental outcomes including beneficial outcomes for native fish abundance, increased numbers of waterbirds and improved condition of water-dependent vegetation communities such as river red gums.

As will be described in Section 4, the purpose of the CMS is to address constraints that currently limit the capacity to augment naturally occurring flows and in particular the peak and/or duration. These aims will be subject to annual river operator plans, and will not augment moderate or major flooding. The Basin Plan and the CMS do not aim to restore the pre-development state of the river, but rather augment natural flows' peaks and/or durations to improve the hydrological regime to provide more favourable conditions for the SA River Murray ecosystem: in particular, seasonal overbank flows of the main river channel and the subsequent inundation of adjacent floodplains, wetlands, creeks and flood runners.

This will achieve a number whole-of-system benefits described in greater detail in Section 3.3.1 below including for the following habitat areas outlined in Table 2 below.

Table 2: Summary of expected environmental outcomes for whole of Basin for habitat areas.

Habitat areas	Outcome across whole of Basin
Riparian or 'streamside' habitats	The ability to reinstate more frequent and variable 'bank full' events which will maintain healthy streamside vegetation such as river red gums and river cooba.
Permanent and semipermanent wetland habitats close to the major rivers	The ability to reinstate more frequent and variable flow regimes to provide healthy wetland habitats and support the role that these systems play in the productivity of the river system more broadly - for example providing breeding and feeding habitats for birds and fish, and carbon/nutrient inputs to support in stream productivity.
Low level floodplain habitats	The ability to reinstate more frequent and variable flow regimes to water low level floodplain vegetation communities such as red gum forests and woodlands, to maintain the health of these communities and the important role they play in the broader productivity of the Basin's rivers.

Mid and high level floodplain habitats	Inundation of these habitats requires medium to large unregulated flow events that are generally outside the ability for river operators to influence and manage with current river operating constraints (such as the inundation of private land). Flows for these habitats will continue to occur in response to large rainfall events in relatively wet years (such as 2010-11). In some parts of the Basin these habitats are in declining health and transitioning to more flood tolerant vegetation communities (as compared to flood dependent vegetation). There may be opportunities for works and measures to overcome delivery constraints, and provide other outcomes that improve the ability to manage these areas in the future. These actions could deliver substantial benefits to these habitats, but further cost benefit analysis and consultation with stakeholders and communities is required.

(Murray-Darling Basin Authority, 2011)

As will be described in Section 3.2 below, the environmental objectives of the CMS are stated in the Basin Plan, which are then refined in the Basin-wide Environmental Watering Strategy (**EWS**). These objectives are then specified with respect to South Australia's Priority Environmental Assets (**PEA**) in the South Australian Long Term Watering Plan (**SA LTWP**) and the ecological values of these assets are summarised below.

The Basin Plan requires long term watering plans not be inconsistent with relevant international agreements (Section 8.20(5)). Applicable are the Ramsar Convention, the Bonn Convention, Japan-Australia Migratory Bird Agreement, China-Australia Migratory Bird Agreement and Republic of Korea-Australia Migratory Bird Agreement.

Within the South Australian River Murray Water Resource Plan Area, there are three wetland and floodplain complexes that are included in the Ramsar List of Wetlands of International Importance, including the Riverland Ramsar site (an area of 30,600 hectares (**ha**) that includes the South Australian portion of the Chowilla Floodplain, and wetland and floodplain areas downstream to Renmark); the Banrock Station Ramsar site near Kingston on the Murray (1,068 ha); and the Coorong, and Lakes Alexandrina and Albert (142,530 ha). The inclusion of these sites in the Ramsar Convention means that there is a commitment to maintain the ecological characters of the site including the ecosystem components, processes and benefits of the wetland.

The three bilateral migratory bird agreements and the Bonn Convention aim to conserve the terrestrial, aquatic and avian migratory species included. The identified bird species must be included in Commonwealth legislation[1] to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places. Further the habitat and breeding requirements of these migratory bird species have been considered in the development of ecological objectives and targets for the priority environmental assets of the South Australian River Murray Water Resource Plan Area.

The SA LTWP identifies three South Australian PEA:

1. The South Australian River Murray Floodplain (the Floodplain);
2. The South Australian River Murray Channel (the Channel); and
3. The Coorong, Lower Lakes & Murray Mouth (**CLLMM**).

Each of the above PEA meets the criteria as an environmental asset set out in Schedule 8 of the Basin Plan.

[1] *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

The River Murray in South Australia is described generally in Section 1.4 above and an overview of each of the South Australian PEA follows.

3.1.1 The River Murray Floodplain

In South Australia, the full extent of the floodplain is defined by the 1956 flood level. As is outlined in Section 4, augmented flows above 80,000ML/day will not be pursued by CMS. As a result the Floodplain is defined for the purpose of the SA LTWP as approximately 60% of the full floodplain, or the portion which current modelling indicates would be inundated by flows up to and including the maximum contemplated flows of 80,000 ML/day at the South Australian border. Whilst the upper reaches of the full floodplain have ecological importance, those areas cannot be actively managed with environmental water and hence cannot be included in this measure and the SA LTWP.

The Floodplain runs immediately adjacent to the Channel and does not contain any areas of permanent water. The Floodplain has 40 plant species listed as Endangered, Vulnerable or Rare,[2] and 50 protected fauna species of which two are nationally threatened.[3]

There are three large-scale floodplains being the Chowilla (a TLM Icon Site), Pike and Katarapko Floodplains that straddle Locks 6, 5 and 4 respectively. The water head difference across the locks provides opportunities to manage levels in the anabranch creeks that run around the locks enabling inundation across the floodplain that would otherwise only receive water during higher flows. Active management through targeted infrastructure investment has occurred, and continues to occur, through numerous programs to improve the ecological health and resilience of these priority floodplains.

Specific details of flora and fauna, habitats and ecological functions are contained in the referenced reports, including management plans, studies, reports and databases. The broad conceptual framework is that high flows provide water for vegetation that provides habitat for invertebrates, fish, frogs, birds and mammals. This enables dispersal, migration and movement, supports feeding and breeding events, and provides refuges during dry periods.

3.1.2 The River Murray Channel

The Channel covers approximately 28,800 ha and extends longitudinally from the South Australian border to the Lower Lakes south of Wellington, or approximately 560 river kilometres. Laterally the Channel is defined as the area inundated at flows up to 40,000 ML/day at the South Australian border under normal river operations. Furthermore, the Channel includes other areas such as permanently inundated wetlands and anabranches.

Records include 54 plant species which are listed as Endangered, Vulnerable or Rare, and 64 protected fauna species of which two are nationally threatened. The Channel is also a The Living Murray (**TLM**) Icon Site and encompasses part of the Riverland Ramsar and Banrock Station Ramsar Wetlands.

Over the last decade, several of the wetlands, backwaters, anabranches and creeks have been actively managed through construction and operation of environmental regulators. These have been installed to allow the re-instatement of wetting and drying cycles and flow improvement to mimic natural water level variations and flow conditions to enhance the ecological health and resilience of these ecosystems. These wetlands have also received large volumes of environmental water *en route* to the CLLMM, including creating pulses to promote fish outcomes. There have also been pumping projects to wetland basins higher up on the floodplain to address problems arising from extended dry conditions. Weir pool

[2] *National Parks & Wildlife Act 1972* (SA).
[3] *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

manipulation trial events during spring have also been conducted recently to promote larger scale floodplain benefits, including vegetation responses.

3.1.3 Coorong, Lower Lakes and Murray Mouth

The Coorong, Lower Lakes and Murray Mouth is recognised as a Living Murray Icon Site and a Ramsar Wetland of International Importance. The make-up of the area is extremely complex consisting of 142,530 ha including Lake Albert and Lake Alexandrina, which are shallow permanent lakes fringed by ephemeral wetlands; the lower reaches of the Eastern Mount Lofty Ranges tributaries; the Murray Mouth estuary; and the Coorong, an approximately 14 km long narrow shallow lagoon.

The Lower Lakes are physically separated from the Murray Mouth and Coorong by a complex of islands, channels and five barrages. The barrages were constructed in the 1930s to manage and reduce the impacts from the intrusion of seawater to the Lower Lakes and up to 250km upstream of the Mouth.

The salinity of the Coorong is dependent on freshwater flows and coastal conditions. Freshwater outflows are crucial to keep the Murray Mouth open. At times and due to the impacts of River regulation and extraction, the Murray Mouth has constricted and closed and dredging has been required to keep the Mouth open.

On average, flow through the system to the Murray Mouth has been reduced by 75% and the wetlands throughout the lower reaches of the system experience man-made droughts in 60% of years (compared to an estimated 5% pre-development) (Murray-Darling Basin Authority, 2014c).

The CLLMM has high conservation, ecological and cultural significance, with 34 plant species listed as Endangered, Vulnerable or Rare, and 93 protected fauna species of which two are nationally threatened.

The significance of the CLLMM is reflected in the Basin Plan as three of the overall environmental objectives "*to protect and restore connectivity within and between water-dependant ecosystems*" relating to this area (Section 8.06(3)) including, for example, keeping the Murray Mouth open, ensuring the water quality of the Coorong is maintained within ecosystem tolerances, and maintaining minimum levels for the Lower Lakes.

The CLLMM has been through a period of active management through several programs, including vegetation planting, Ruppia translocations, installation of fish ways and community ownership and awareness initiatives to improve the management of the system, and large volumes of environmental water have been prioritised for the site for many years. A strong partnership with the Ngarrindjeri has also been established with formal agreements now in place.

3.2 Ecological objectives and outcomes

The ecological objectives and targets for the three PEA in South Australia are consistent with the objectives stated in the Basin Plan, by the Basin-wide Environmental Watering Strategy (EWS) and the SA LTWP.

By section 7.09(e) of the Basin Plan, the easing or removal of constraints and the addition of environmental water above the benchmark conditions of development must allow the enhanced environmental outcomes set out in Schedule 5 to the Basin Plan to be pursued as compared the benchmark environmental outcomes.

The prescribed enhanced environmental outcomes that are the primary focus of CMS include:

- providing opportunities for environmental watering of an additional 35,000 ha of floodplain in South Australia, New South Wales and Victoria to improve the health of forests, fish and bird habitat, improve the connection to the river and replenish groundwater; and

- achieving in-stream outcomes and improved connections with low to middle level floodplain and habitats adjacent to rivers in the south Murray-Darling basin.

The remaining enhanced environmental outcomes include:

- further reducing salinity levels in the Coorong and Lower Lakes;
- keeping water levels in the Lower Lakes above prescribed levels at greater than 0.4m AHD 95% of the time and above 0.0m AHD 100% of the time;
- ensuring the Murray Mouth remains open without dredging at least 95% of years;
- exporting salt from the Basin through the Murray Mouth; and
- increasing flows through the barrages to the Coorong.

The environmental objectives set out by the Basin Plan may be summarised as follows:

1. Protect and restore water-dependant ecosystems;
2. Protect and restore the ecosystem functions of water-dependent ecosystems; and
3. Ensure that water-dependent ecosystems are resilient to climate change and other risks and threats.

The EWS was released by the MDBA in November 2014 as required by Section 8.13 of the Basin Plan. It elaborates on the overall environmental objectives by describing the expected outcomes for four ecological components of the river system: river flows and connectivity; native vegetation; waterbirds; and native fish.

The expected environmental outcomes described in the EWS focus in particular on its main goal: to partially reinstate or protect some ecologically-important flows. However, the EWS notes that the particular outcomes from environmental watering will change annually depending on a range of factors including the condition of the environment and climatic conditions, as well as annual environmental water and river operations plans. The EWS further notes that managed environmental watering events alone will not achieve the expected outcomes as natural events and other flows in the river will affect the outcome.

The expected environmental outcomes as extracted from the EWS are summarised in Table 3 below.

Table 3: Expected environmental outcomes from the EWS.

River Flows and Connectivity
Longitudinal connectivity
• Keep base flows at 60% of the natural level. • 10% overall increase in flows in the Barwon-Darling: from increased tributary contributions from the Condamine-Balonne, Border Rivers, Gwydir, Namoi and Macquarie-Castlereagh catchments collectively. • 30% overall increase in flows in the River Murray: from increased tributary contributions from the Murrumbidgee, Goulburn, Campaspe, Loddon and Lower Darling catchments collectively. • 30 to 40% increase in flows to the Murray Mouth.
Lateral connectivity
• 30-60% increased frequency of freshes, bank-full and lowland floodplain flows in the Murray, Murrumbidgee, Goulburn-Broken and Condamine-Balonne catchments. • 10- 20% increased freshes and bank-full events in the Border Rivers, Gwydir, Namoi, Macquarie-Castlereagh, Barwon-Darling, Lachlan, Campaspe, Loddon and Wimmera catchments. • Maintain current connectivity levels in the Paroo, Moodie, Nebine, Ovens and Warrego catchments.
End-of-basin flows
• Improved flows and connectivity of the river to its estuary (the Coorong) and to the sea. • Barrage flows greater than 2,000 GL/year on a three-year rolling average basis for 95% of the time, with a two year minimum of 600GL at any time. • Water levels in the Lower Lakes are maintained above sea level (0m AHD); and above 0.4m AHD 95% of the time to allow for barrage releases.

- Salinity in the Coorong and Lower Lakes remains below critical thresholds for key flora and fauna including:
  - Salinity in Lake Alexandrina is lower than 1,000 EC 95% of the time and less than 1,500 EC all the time; and
  - Salinity in the Coorong's south lagoon in less than 100 grams per litre 95% of the time.
- Murray mouth is open 90% of the time to an average annual depth of one metre.

Water-dependent vegetation

Forests and woodlands

- Maintain the current extent of forest and woodland vegetation including approximately: 360,000 ha of river red gum; 409,000 ha of black box; and 310,000 ha of coolabah.
- No decline in the condition of river red gum, black box and coolibah across the Basin.
- By 2024, improved condition of river red gum in the Lachlan, Murrumbidgee, Lower Darling, Murray, Goulbourn-Broken and Wimmera-Avoca.
- By 2024, improved recruitment of trees within river red gum, black box and coolibah communities – in the long term achieving a greater range of tree ages.

Shrublands

- Maintain the current extent of extensive lignum shrubland areas within the Basin.
- By 2024, improvement in the condition of lignum shrublands.

Non-woody vegetation

- Maintain the current extent of non-woody vegetation.
- By 2024, increased periods of growth for communities that:
  - closely fringe or occur within the main river corridors; and
  - form extensive stands within wetlands and low-lying floodplains including Moira grasslands in Barmah-Millewa Forest; common reed and cumbungi in the Great Cumbung Swamp and Macquarie Marshes; water couch on the floodplains of the Macquarie Marshes and Gwydir Rivers; and marsh-club-rush sedgelands in the Gwydir.
- Sustained and adequate population of *Ruppia terosa* in the south lagoon of the Coorong, including:
  - By 2019, R. tuberosa to occur in at least 80% of sites across at least a 50km extent; and
  - By 2029, the seed bank to be sufficient for the population to be resilient to major disturbances.

Waterbirds

- The expected outcomes for waterbirds are increased abundance and the maintenance of current species diversity. From 2024 onwards, the expected outcomes are:
  - The number and type of waterbird species present in the Basin will not fall below current observations;
  - A significant improvement in waterbird populations in the order of 20-25% over the baseline scenario, with increases in all waterbird functional groups;
  - Breeding events of colonial nesting waterbirds to increase by up to 50% compared to the baseline scenario; and
  - Breeding abundance (nests and brooks for all of the other functional groups) to increase by 30-40% compared to the baseline scenario, especially in locations where the Basin Plan improves over-bank flows.
- Because of the importance for migratory shorebirds, for the Coorong, Lakes Albert and Alexandrina the expected outcomes by 2019 are at a minimum to maintain populations of the following four key species: curlew sandpiper, greenshank, red-necked stint and sharp-tailed sandpiper, at the levels recorded between 2000 and 2014.

Native Fish

The following broad outcomes are expected by 2024:

- No loss of native species currently present within the Basin.
- Improved population structure of key species through regular recruitment.
- Increased movement of key species.
- Expanded distribution of key species and populations in the northern and southern Basin.

The following outcomes are expected:

- For short-lived species: restored distribution and abundance to levels recorded pre-2007 (prior to major losses caused by extreme doubt). This will require annual or biennial recruitment events depending on the species.
- For moderate to long-lived species:
  - Improved population structure (ie a range of size-age classes for all species and stable sex ratios where relevant) in key sites. This will require annual recruitment events in at least eight of 10 years at 80% of key sites, with at least four of these being 'strong' recruitment events.
  - A 10 to 15% increase of mature fish (of legal take size) for recreational target species (Murray cod and golden perch) in key populations.
  - Annual detection of species and life stages representative of the whole fish community through key fish passages; with an increase in passage of Murray cod, trout cod, golden perch, silver perch, Hyrtl's tandan, congollis, short-headed lamprey and pouched lamprey through key fish passages to be detected in 2019-2024; compared to passage rates detected in 2014-2019.
- For estuarine species – additional outcomes are:
  - Detection of all estuarine-dependant fish families throughout 2014-2024.

  - Maintenance of annual population abundance (Catch Per Unit Effort – CPUE) of key estuarine prey species (sandy sprat and small-mouthed hardyhead) throughout the Coorong.
  - Detection of a broad spatial distribution of black bream and greenback flounder; with adult black bream and all life stages of greenback flounder present across >50% of the Coorong in eight out of 10 years.
  - Detection in nine out of 10 years of bi-directional seasonal movements of diadromous species through the barrages and fishways between the Lower Lakes and Coorong.
  - Increased rates of native fish passage in 2019-2024 compared to 2014-2019.
  - Improved population structure of mulloway, including spawning aggregations at the Murray mouth in six out of 10 years and recruitment in at least five out of 10 years.
- Expanded distributions of key fish species are expected by 2024 including:
  - A doubling of the current (mostly restricted distributions of key species in the northern Basin.
  - Significant increases in the distributions of key species in the southern Basin.

(Murray-Darling Basin Authority, 2014c)

DEWNR has developed a long-term watering plan for the South Australian River Murray Water Resource Plan Area in accordance with the environmental management framework within the Basin Plan. It describes the South Australian hydrological regimes needed to support a healthy, functioning South Australian River Murray ecosystem. It provides consolidated ecological information to facilitate annual environmental watering planning for the three priority environmental assets in the River Murray in South Australia described above.

With respect to the CLLMM PEA, the SA LTWP identifies eight ecological objectives and 30 nested ecological targets. The ecological attributes include ecosystem processes and physio-chemical conditions, vegetation, macro invertebrates, fish and waterbirds.

With respect to the Channel PEA, the SA LTWP identifies 16 ecological objectives and 29 nested ecological targets. These focus on abiotic processes, water quality, biofilms, vegetation, wetlands, groundwater and fish.

The ecological components of the Floodplain PEA largely overlap those of the Channel, the main difference being the effect that elevation of the Floodplain has on hydrology. With that in mind, the SA LTWP contains 21 ecological objectives and 40 nested ecological targets for the Floodplain. These focus on nutrients, carbon, biofilms and microbes, microfauna, vegetation, macro invertebrates, frogs, fish and waterbirds.

The ecological objectives and nested ecological targets are highly technical with ecological specificity and are contained in the SA LTWP.

3.3 Anticipated ecological outcomes from CMS

3.3.1 Anticipated ecological benefits — within reach

The hydrological regime (in the form of environmental water requirements or EWRs) for a healthy, functioning River Murray in South Australia is described in the SA LTWP as described above. The SARM LTWP and four key background technical reports contain significant technical ecological detail regarding the targets.

As will be described in Section 4 below, benefits (in particular delivering the EWRs) for the River Murray in South Australia will be experienced where higher flows are received at the South Australian border, which is entirely dependent on the relaxation of upstream constraints and the coordinated delivery of water from multiple valleys and storages.

Hydro-ecological conceptual modelling has detailed the likely ecological benefits to:

1. the “lower River Murray channel and floodplain” which includes all habitats below the 1956 flood level (and hence is a more extensive area than the Floodplain PEA); and

2. the “Lower Lakes and Coorong” measured from Wellington to the Murray Mouth including the Coorong lagoons.

The conceptual model comprises a range of different proposed flow bands up to 80,000 ML/day at the South Australian border. The conceptual models contain statements on ecological patterns and processes expected from biotic/abiotic components based on relevant hydrological data. Those statements are assigned a measure of certainty and the conceptual model statements were then synthesised into a simplified conceptual diagram presenting the key ecological patterns and processes.

A selection of the findings demonstrating the increased benefits at both 40,000 ML/day and 80,000ML/day are reproduced in Table 4 and Table 5 below.

Table 4: Selected increased benefits modelled for the Lower River Murray Channel and Floodplain where 40,000 ML/day and 80,000 ML/day flows are received at the South Australian border.

Asset	40,000 ML/day	80,000 ML/day
Fish	Foraging generalists present in low abundance in river channel. Present in connected wetlands and floodplain. Circa-annual spawning nesting species present in anabranch and river channel habitats, where habitat availability is enhanced. A proportion will undertake small to large scale longitudinal movements. Recruitment to Young Of Year may occur.	Foraging generalists present in connected wetlands and floodplain; spawning and recruitment likely. Circa-annual spawning nesting species present in anabranch and river channel habitats, where habitat availability is enhanced. A proportion will undertake small to large scale longitudinal movements. Enhanced recruitment to Young Of Year.
Microbiota	Inhibition of reproduction. More diverse and abundant communities than river channel. Increased abundance of group C-E species (ie species characterised by short maturation time and low dispersal abilities (C), obligate aquatic life stages and medium to high salinity tolerance (D), and constant water requirement, no terrestrial phase and medium salinity tolerance (E)). Populations of group A and B species maintained (ie species characterised by aquatic eggs requiring full submersion for development, medium to low tolerance on increased salinity (A), low tolerance to salinity, low dispersal ability and short terrestrial phase (B)).	Increased habitat availability for littoral microbiota. More diverse and abundant communities than river channel. Increased abundance of group A-D species. Decreased abundance of group E species. A proportion of floodplain community will be flushed into river channel. Generally increased diversity, abundance and biomass.
Vegetation	Amphibious fluctuation of tolerator-woody vegetation condition will improve in temporary wetlands and be maintained on the edges of permanent water, and where groundwater is being freshened. Terrestrial damp and amphibious fluctuation tolerant (emergent, plastic and low-growing) vegetation recruitment in temporary wetlands and floodplain.	Amphibious fluctuation of tolerator-woody vegetation condition will improve on the edges of permanent water, in temporary wetlands and on the floodplain, where recruitment will occur. Terrestrial damp, floodplain, amphibious fluctuation tolerant (emergent, plastic and low-growing) and emergent vegetation recruitment in temporary wetlands and floodplain.
Waterbirds	Inundation increases spatial overlap of nesting and foraging habitat, benefitting reed-dependent species. Increased breeding opportunities for nomadic and regional species.	Increased habitat and breeding opportunities for nomadic and regional waterbirds, as well as improved habitat condition for terrestrial species.
Frogs	Increase in preferred breeding habitat and recruitment with inundation of river red gum, riparian vegetation and temporary wetlands, if hydroperiod sufficient for tadpole metamorphosis. Littoral zones provide protection for tadpoles from fish predation.	Increased inundation results in increased habitat availability, prey resources and dispersal of most species.
Carbon and nutrients	Decreased autotrophic activity, increase heterotrophic activity. Increased mobilisation of Filterable Reactive Phosphorus and Dissolved Organic Carbon.	Decreased autotrophic activity, increase heterotrophic activity. Organic material flushed into river and downstream to Lower Lakes, Coorong and Southern Ocean. Increases in available Natural Organic Matter with increased inundation of black box and river red gum.

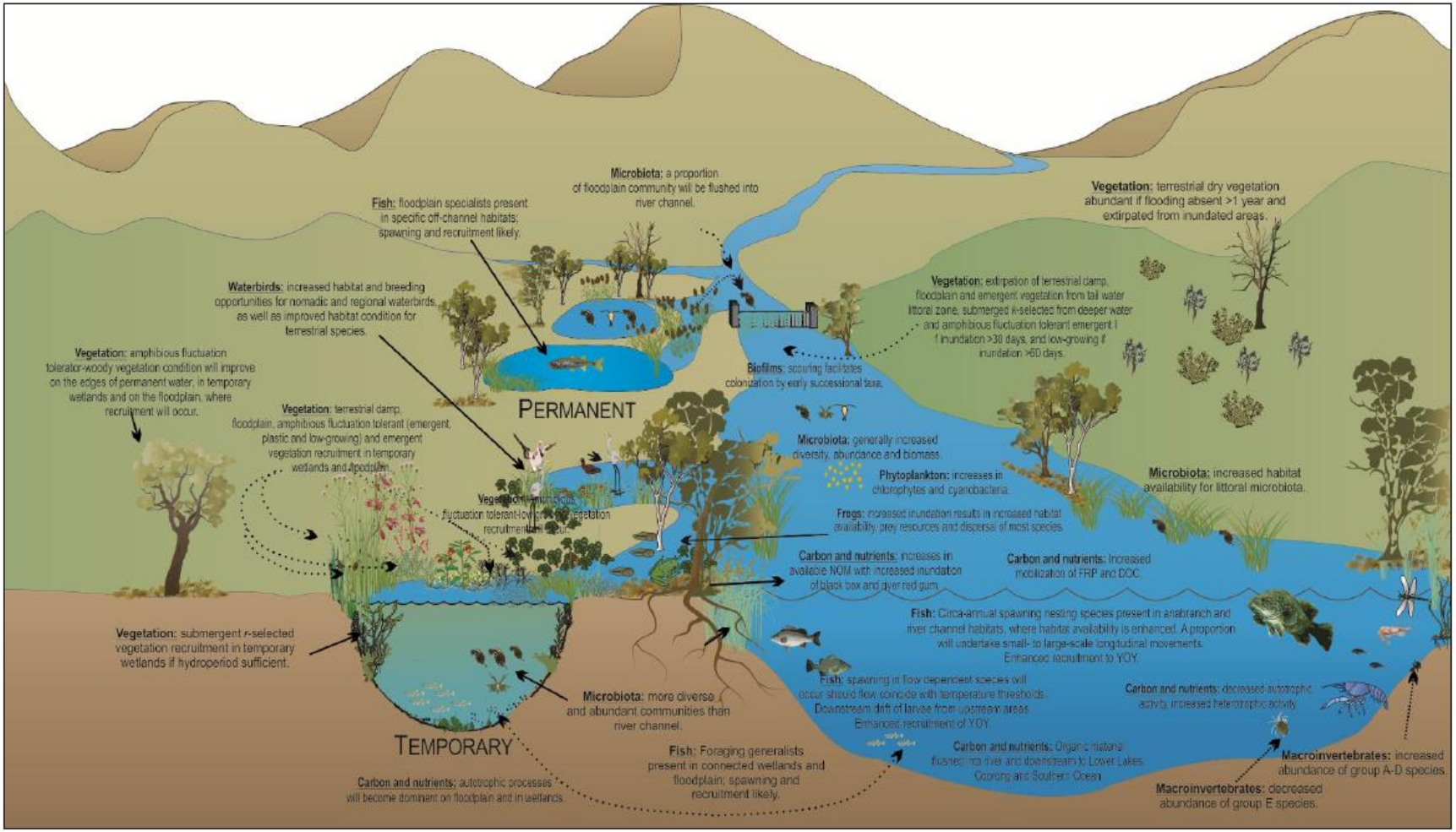

Figure 10-9. Synthesis diagram of hydro-ecological models for flows of 80,000 ML.day^{-1} in the 'lower River Murray channel and floodplain'. Select vegetation symbols courtesy of the Integration and Application Network (ian.umces.edu/symbols).

Figure 2: Conceptual diagram of key ecological patterns and processes in the Lower River Murray Channel and Floodplain at 80,000ML/day QSA (Bice, et al., 2014).

Table 5: Selected increased benefits modelled for the Lower Lakes and Coorong where 40,000ML/day and 80,000ML/day are received at the South Australian border.

Asset	40,000 ML/day	80,000 ML/day
Fish	Foraging generalists widespread and abundant in lakes and Coorong. Diadromous species present. Abundance reliant on connectivity/recruitment in preceding years. Certain marine species present in Coorong, within vicinity of Murray Mouth. Estuarine dependent species widespread and abundant in Coorong, from Murray estuary through North Lagoon. Flow dependent specialists common in lakes and recruitment will occur. Present in Coorong in low abundance. Circa-annual spawning nesting species rare. Spawning may occur. Small-bodied estuarine species present in low abundance.	Foraging generalists widespread and abundant in lakes and Coorong. Diadromous species present in lakes and Coorong. Certain marine species present in Coorong, within vicinity of Murray Mouth. Estuarine dependent species widespread and abundant in Coorong, from Murray estuary through North Lagoon and potentially South Lagoon. Flow dependent specialists common in lakes and recruitment will occur. Present in Coorong in low abundance. Circa-annual spawning nesting species rare. Spawning may occur. Small-bodied estuarine species present in low abundance.
Microbiota	Estuarine micro crustacean assemblage. Freshwater limnetic assemblage.	Increased diversity. Increased prevalence of freshwater rotifers. Lake Albert assemblage dominated by freshwater rotifers.
Vegetation	Emergent vegetation present between 0 and +0.9m AHD. Emergent and plastic amphibious fluctuation tolerator vegetation present between +0.2m and +0.8m AHD. Low growing amphibious fluctuation tolerant vegetation present between +0.6 and +0.8m AHD. Submergent k-selected vegetation present between -0.2 and+0.5m AHD. Submergent r-selected vegetation present in temporary wetlands in winter/spring. Terrestrial dry and damp vegetation restricted to >+0.9m AHD. *Ruppia tuberosa* will germinate in late autumn with raised water levels in South Lagoon. Propagule bank replenished if flows persist until spring/summer.	Emergent vegetation present between 0 and +0.9m AHD. Emergent and plastic amphibious fluctuation tolerator vegetation present between +0.2m and +0.8m AHD. Low growing amphibious fluctuation tolerant vegetation present between +0.6 and +0.8m AHD. Submergent k-selected vegetation present between -0.2 and+0.5m AHD. Submergent r-selected vegetation present in temporary wetlands in winter/spring. Terrestrial dry and damp vegetation restricted to >+0.9m AHD. *Ruppia tuberosa* will germinate in late autumn with raised water levels in South Lagoon. Propagule bank replenished if flows persist until spring/summer.
Phytoplankton	Occurrences cyanobacteria blooms. Freshwater species present but will decline in diversity and biomass with increasing distance from discharge.	Community dominated by riverine species with low cell concentrations due to turbidity mixing and flushing. Increased prevalence of freshwater species in North and South Lagoons.
Salinity	Salinities reduced and gradient weakened.	Salinities reduced and gradient weakened.

Table 6 below shows the extent of vegetation and Australian National Aquatic Ecosystem wetlands that could be inundated in the lower River Murray in South Australia at three different flow rates.

Table 6: Extent of vegetation and wetlands inundated for the River Murray in South Australia for different flows at the South Australian border.

	Total inundated vegetation				
Flow rate (ML/day)	**Red gum woodlands (ha)**	**Red gum forests (ha)**	**Black box (ha)**	**Shrublands (ha)**	**ANAE wetlands (ha)**
40,000	271	1250	2769	2772	38333
60,000	964	2426	8244	9254	42652
80,000	1995	4009	26896	29159	48801

ANAE = Australian National Aquatic Ecosystem

(Murray Darling Basin Authority, 2014)

Table 6 above shows that, by extending the area of inundation, there are likely to be benefits to floodplain vegetation and wetlands and the many flora and fauna species they support within the River Murray in South Australia.

Importantly, the areas given in Table 6 are the total area of vegetation inundated; the area of land for which easements and other mitigation measures would be needed is significantly smaller.

Monitoring and evaluation will be conducted in accordance with planning pursuant to the SA LTWP and broader Basin Plan implementation.

3.3.2 Anticipated ecological benefits – whole of system

This business case proposes relaxing constraints for the River Murray in South Australia, together with the relaxation of constraints in upstream reaches that facilitate higher flows and provide benefits across the Basin. Key environmental assets upstream that would benefit from increased flows include the Barmah–Millewa Forest, Werai Forest, Gunbower–Koondrook–Perricoota forests, and Hattah Lakes. Other significant areas include various wetlands along the River Murray channel and the Wakool River system (Green & Alexander, 2006) (Murray-Darling Basin Authority, 2014d).

In conjunction with constraints relaxation in the Hume to Yarrawonga and Yarrawonga to Wakool Junction key focus areas, the improved capacity to deliver overbank watering events created through this measure would assist in helping to achieve the Basin-wide outcomes in Table 3 above. Relaxing constraints in all three key focus areas of the River Murray (Hume to Yarrawonga, Yarrawonga to Wakool and Lower River Murray) is important for achieving environmental flows and outcomes in the downstream reaches between the source and the destination as well as benefits within the reaches themselves.

3.3.3 Potential adverse environmental outcomes – within reach and whole of system

A high level assessment of the potential adverse environmental outcomes, including some which are also associated with normal environmental watering, is presented in Appendix 2. The key risks are to salinity, water quality, pests, species, ecological function and connectivity, and other cumulative impacts. These risks and issues are considered for all environmental watering events, but are especially important to consider for overbank events as higher flows could exacerbate some of these risks. Generally the risks are within the scope of risks that are managed by current controls and the environmental benefits also work

to reduce and compensate for these risks over the longer term. In other words, increased high flow events help to mitigate any risks that may arise from a single event and will be outweighed by the broader ecological benefits.

The risk assessment is consistent with the Commonwealth Environmental Water Holder (**CEWH**) Framework for Determining Commonwealth Environmental Water Use. Under the framework environmental watering should have regard to the potential environmental risks, including downstream environmental risks, that may result from applying environmental water and measures that may be taken to minimise those risks (Commomwealth Environmental Water Office, 2013).

3.4 Hydrology of the area and environmental water requirements

South Australia's annual entitlement flow of up to 1,850 GL is delivered at the South Australia border at rates ranging from 3,000 ML/day to 7,000 ML/day, depending on the time of year and trade adjustments under regulated conditions (i.e. outside of extreme dry or wet periods). Annual flows have dropped below entitlement during extreme drought, as occurred during the recent millennium drought, and in some years where there has been insufficient inflows into controlled storages.

As described above, river regulation has significantly reduced the occurrence and magnitude of medium and small flows to South Australia (Murray-Darling Basin Authority, 2012). Modelling results have shown that under current development conditions in the Murray–Darling Basin the average annual flow to South Australia has been reduced by 52% compared to without development conditions (CSIRO, 2008). Flows of 80,000 ML/d occurred under without development conditions approximately 34% of years, but under baseline (i.e. pre-Basin Plan) conditions occurs approximately 10% of years (Murray-Darling Basin Authority, 2012).

The CSIRO found that as a result of water resource development, the average period between beneficial spring-summer overbank flows has more than tripled from 2.4 years to 9.3 years (CSIRO, 2008). Similarly, the maximum period between events under current conditions is five times the maximum period experienced under without development conditions from 5.7 years to 28.7 years. Flow volumes have also been greatly reduced, such that the average annual flow volume is now less than half of the volume compared to without development conditions (i.e. down from 2431 GL to 947 GL) (Murray-Darling Basin Authority, 2014a).

In times when flows are at entitlement rates, environmental water may be used to increase flow rates to trigger biological processes such as fish spawning. When there is more water in the river and the flow rates are higher, environmental water can be used to add to the flow to increase the area of floodplain and wetlands that are inundated, which helps drive biological processes, improves water quality, and assists with the removal of salt out of the system and sand out of the Murray Mouth (Murray-Darling Basin Authority, 2014a).

The flow inundation modelling is described in Appendix 8 and includes information on the relationships between flow, area, volume and height, as well as the modelling assumptions and calibrations.

The Environmental Water Requirements of the PEAs are described briefly below, with greater detail provided in the SA LTWP:

- There are seven EWRs identified for the Channel PEA, the metrics of which include discharge, duration, timing and frequency;
- There are five EWRs identified for the Floodplain PEA, the metrics of which include discharge, duration, timing, frequency, and rate of rise and fall; and

- There are four EWRs identified in the CLLMM PEA, which are required to maintain the requisite salinities in the Lower Lakes but also to incorporate other factors related to the desired hydrological regime for the site. The metrics include annual barrage flow, average return interval, maximum interval, timing, lake water level range, lake water level timing, Coorong South Lagoon water level, Coorong South Lagoon water timing and Coorong South Lagoon duration.

During development of the Basin Plan, MDBA established environmental flow indicators which are linked to the objectives of the Basin Plan. These are outlined in the report *The proposed "environmentally sustainable level of take" for surface water of the Murray-Darling Basin: Methods and outcomes*. (Murray-Darling Basin Authority, 2011).

4 Proposed operating regime

Section 3.4 above outlines the current hydrology of the River Murray in South Australia and the Environmental Watering Requirements. This section discusses the proposed changes to hydrology noting that the operational limit of flows that can be delivered to South Australia due to relaxing constraints is 80,000 ML/day. Further, the delivery of this will occur pursuant to annual planning that will gradually augments flows with an incremental delivery. Finally, this section identifies how the Prerequisite Policy Measures will assist the delivery of operational changes.

4.1 Proposed changes to hydrology

As part of the feasibility phase of the CMS, hydrological modelling undertaken by the MDBA shows that the upper threshold and operational limit to the range of flows that can be practically delivered to South Australia is 80,000 ML/day. A hydrological model was used to define a "relaxed constraints" flow regime, which shows what is hydrologically feasible with one possible method of water delivery with the specified volume of environmental water recovered annually under the Basin Plan. The modelling does not prescribe a future flow regime, but provides an upper limit for how many times any new capacity created by relaxing constraints could be used in order to ensure the cost estimates adequately cover the costs associated with mitigating the effects of addressing constraints. It shows the upper limit can be achieved by relaxing priority physical constraints upstream and from coordinated releases from multiple upstream storages and valleys. Relaxing constraints within South Australia will enable all flows up to and including this amount to be better received and managed. The hydrological modelling is summarised in Appendix 7.

For the purposes of this business case, the "relaxed constraints" modelling assumes two different regulated flow limits at Yarrawonga as investigated throughout the course of Phase 2: 50,000 ML/day (YAR50) and 65,000 ML/day (YAR65). The ultimate flow rates implemented in the upstream reaches, together with the coordinated delivery of increased flows and natural flows, will result in a greater frequency and/or duration of 80,000 ML/day events at the South Australian border.

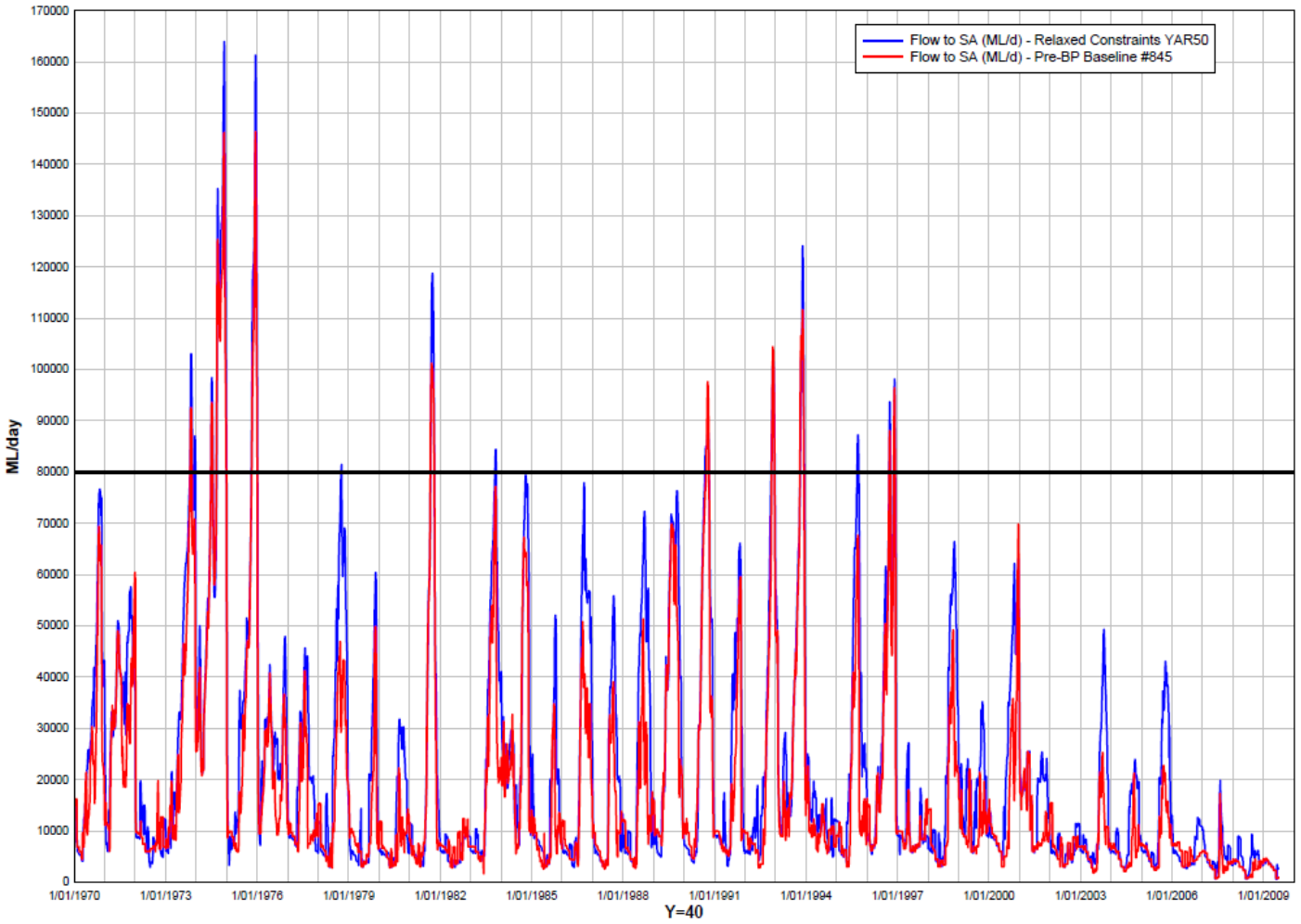

Figure 3: Hydrographs from the MDBA hydrological modelling comparing the flows to South Australia under a relaxed constraints scenario and the pre-Basin Plan baseline scenario between 1970 and 2010.

Figure 3 above compares two sets of hydrological modelled flows to South Australia for the period from 1970 and 2010, being: baseline modelled flows (i.e. those received by South Australia pre-Basin Plan) compared to flows modelled under one relaxed constraints scenario (YAR50). The relaxed constraints scenario demonstrates what is hydrologically feasible pursuant to one method of environmental water delivery; in particular, augmentation of the baseline flow where upstream constraints are addressed as proposed in this business case, before taking into account individual river operations practices and policy limits (which would likely limit the scale of augmentation, as described below).

Pursuant to Figure 3, the following observations can be made about the baseline modelled flow (i.e. before constraints are relaxed):

- the flows greater than 80,000 ML/day occurs 12 times in the 40 year modelling period;
- flows greater than 80,000ML/day did not occur during periods of low flow such as during the Millennium Drought; and
- flows greater than 80,000 ML/day generally occur during periods of natural high flows in both the baseline modelled flow and the relaxed constraints scenario.

Under the relaxed constraints scenario:

- the peak and duration of low to moderate flows are increased; and
- flows at or greater than 80,000 ML/day could occur on average once more per decade where natural high flow events are "topped up".

And generally:

- depending on flow conditions and river environment, the duration of events is between several weeks and a few months; and
- flow events are most likely between June and November each year which is when natural tributary flow events occur pursuant to natural seasonal flow patterns, noting that flows may be delivered in late spring and early summer given upstream travel times.

In ideal circumstances, the occurrence of higher flows between June and November poses the least risk to recreation and tourism activities (as identified in Section 5.2) and is the most beneficial to wetlands and floodplains in advance of the drier seasons. This timing would also minimise competition for upstream channel capacity by avoiding the peak irrigation demands typically in late spring and summer. However in practice the timing of delivery will be subject to upstream travel times, individual river operators' practices and natural rainfall events.

There are no proposed changes to hydrology or current operational practices during extreme flooding events. These events will occur regardless of physical constraints relaxation.

4.2 How flow rates would be delivered operationally

There are two elements in considering how higher flow rates would be delivered operationally to the River Murray in South Australia: the first is in the supply of water to the border, and the second is management of the flows in South Australia.

Prefeasibility phase modelling indicated that flows of up to 80,000 ML/day could be delivered to South Australia pursuant to coordinated releases of water from multiple valleys and storages to achieve a single event outcome. This outcome will rely on coordinated delivery and travel times to create the event. In some river systems such as the Murrumbidgee River the travel times can be quite long, exceeding six weeks from the headwater storages to the Murrumbidgee – River Murray junction. For example, high flows between 50,000 ML/day and 80,000 ML/day in the Lower Murray could be delivered through

coordinating releases from storages such as the Hume Dam, Lake Eildon and the Menindee Lakes, combined with unregulated flows entering the River Murray from tributaries such as the Kiewa, Murrumbidgee or Ovens rivers during winter or early spring (Murray-Darling Basin Authority, 2013c).

Figure 4 below conceptually demonstrates how contributions from upstream reaches result in increased flows at the South Australian border. It is important to note that these contributions also provide flows to the rivers and streams in between their source and South Australia, contributing to the wider environmental benefits outlined in Section 3.3 above.

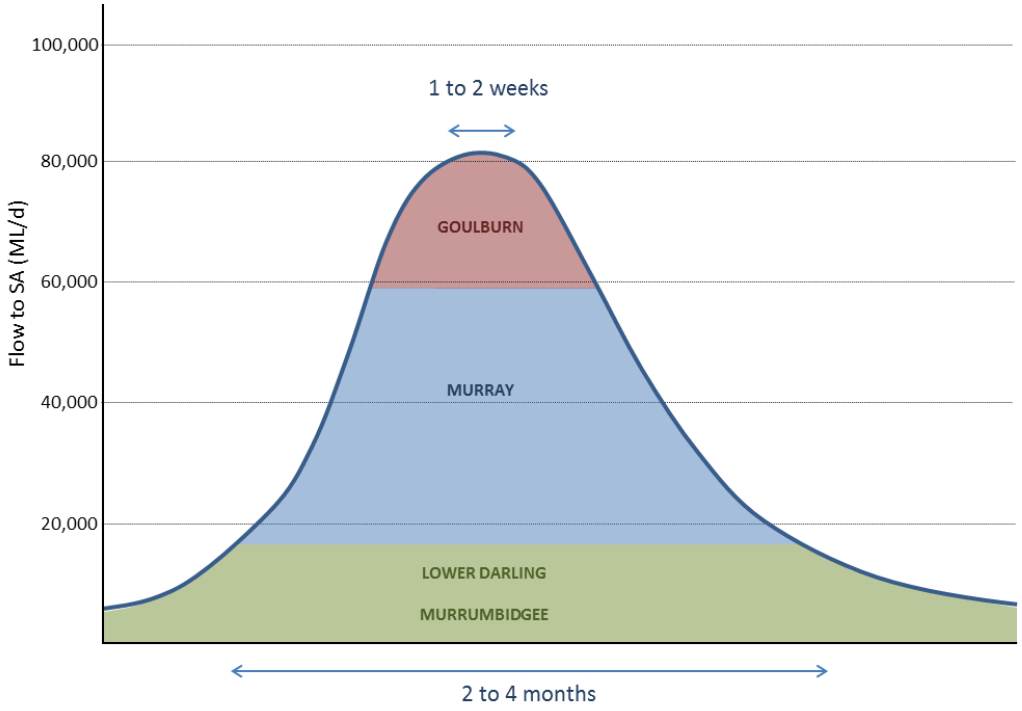

Figure 4: Indicative contribution (typical peak and flow duration) from each of the four regions to building an 80,000ML/day event at the SA border.

Flows will be managed in South Australia through the current normal River Murray operations by the South Australian Government. Additional flows will be diverted and temporarily captured and used to meet the environmental water demands of environmental assets discussed in Section 3. For instance, environmental water can be delivered and managed via environmental regulators recently constructed (and planned to be built) on the Chowilla, Pike and Katarapko Floodplains and managed wetlands, as well as delivered to the Coorong, Lower Lakes and Murray Mouth.

These decisions will be made within existing frameworks consistent with the SA LTWP and annual plans managed by river operators and environmental water managers. Relaxing constraints will provide river operators and environmental water managers with flexibility and ability to take advantage of environmental watering opportunities.

The final consideration for river operations with respect to additional flows regards managing inundation risk. Currently all higher flows are managed and regulated to the extent possible with existing tools and warning systems to minimise risk to landholders and communities. The delivery of higher flows will be subject to these already established practices.

The South Australian Government has a classification system describing the implications of different flow rates measured at the South Australian border. From this, advice and warnings can be provided to

communities approximately four to six weeks in advance of receiving the predicted flows, due to the travel time of water from upstream storages and tributaries to South Australia.

Flows at 80,000 ML/day are classified as high flow for the main part of the River Murray in South Australia. This recognises that although some floodplain inundation occurs, the associated effects are considered minor.

Where flows are above 60,000 ML/day, a minor flood warning is issued for shack areas downstream of Cadell excluding River Murray towns. Some impacts are felt at this flow rate as reported by local experience after the high flow event of 2011-12 that peaked at 94,000 ML/day.

4.2.1 Implementing flows incrementally

In developing these business cases, Basin States and the MDBA have committed to the principle that delivering additional environmental flows will occur pursuant to a conservative, step-wise approach.

For example, additional flows will be delivered over time with initial smaller, timed releases followed by increases that incrementally impact the peak and/or duration of flow events. This approach will best manage risks, enable real-time testing of river operations and processes, monitor potential impacts and build trust and credibility with the community and stakeholders.

Constraints measures are expected to enter into operation towards 2024 when all mitigation arrangements along the length of the river are in place. At the commencement of the new flow capacity, environmental flows should be implemented in a staged and incremental manner to test for effects on the ground and on communities before larger flows are implemented. This objective is compatible with key principles that guide river operations.

These key principles include adaptive management techniques to find better ways to operate the River Murray system and to avoid unnecessary large-scale changes to river conditions. Generally speaking and where possible, time should be taken to carefully consider the potential for any interactions, dependencies and implications, for example as a result of large releases from storages. Implementing the CMS will lead to large scale changes to normal river operations as there will be a decision to inundate downstream areas, whereas traditionally operations have been undertaken to minimise the impacts of inundation on downstream communities.

The principle of implementing flows in a staged and incremental manner is also consistent with the concept of commissioning structures in stages rather than operating at full capacity on the initial event. This principle has been applied in the commissioning of environmental works and measures under other environmental works and measures programs.

4.3 Principles for river operations

River Murray system operators apply a set of guiding principles which involve exercising judgement and consideration of numerous opportunities, risks, uncertainties and options while maintaining the flexibility to effectively respond to conditions and system drivers. The following guiding principles provide the foundation for operations in the River Murray system:

- Apply adaptive management to find better ways to operate the River Murray system. Applying adaptive management gives a framework for evaluating and documenting lessons learnt, so that they can be applied in the future. The Independent River Operations Review Group (IRORG) process is a key part of the adaptive management framework along with the MDBA's River Operations Improvement Program.

- Contribute to environmental outcomes. This principle applies to demand driven system conditions, however it may become increasingly relevant to inflow driven conditions in the future as operational constraints to managing higher flows are relieved or resolved. River regulation has had significant impacts on both the in-stream, riparian and floodplain environment in the River Murray System. River operations have been changing over time to try and reduce these impacts. These changes are supported by major reforms, such as The Living Murray program, the Basin Plan and the recovery of water for the environment. River operations in the River Murray system contribute to environmental water management and delivery in a range of ways, such as providing information to help inform annual environmental watering priorities and helping to identify opportunities to coordinate environmental watering.
- Coordination of River Murray System storage operations with tributary inflows. This principle supports the achievement of the general objectives and outcomes for water storage and delivery and accounting. It applies in both demand and inflow driven conditions. Coordinating River Murray System operations with tributary inflows provides for efficient and effective operation of the River Murray system by conserving water and minimising undesirable losses or unnecessary transfers between storages while maximising water available to the States.
- Meet water orders, as far as possible. This principle applies during demand driven conditions. This principle requires water orders and water entitlements along the River Murray system to be met, as far as possible, by river operators making appropriate storage releases. A water order may be for consumptive or environmental water use.
- Other principles. Other principles that guide River Murray operations include: passing flows safely; anticipating problems and exercise judgment; releasing water from downstream storages first; avoiding unnecessary big changes to river conditions; using historic data, information and modelling to guide operations; monitoring and considering relevant climate outlooks and weather forecasts; and maintaining open communications.

4.4 Policy or operational changes required

In order to deliver the flows proposed in this business case, the Pre-requisite Policy Measures (PPMs) identified in Section 7.15 of the Basin Plan will need to be implemented. In 2013, the CMS identified nine operational and management constraints to the delivery of higher flows in the River Murray. Of those, the following three PPMs were identified by the CMS Annual Progress Report 2013-14 as a priority together with developing an equitable and transparent arrangement for channel capacity sharing:

- protecting environmental flows from extraction;
- delivering environmental water on top of other in stream flows; and
- using environmental water throughout the length of the river.

The PPM Implementation Plans are currently being developed by MDBA and Basin States to address the operational and management constraints to the delivery of higher flows in the River Murray. These will be delivered prior to 2019.

5 Third Party impacts and mitigation measures

During the feasibility stage of CMS, MDBA contracted specialist independent consultants to verify, assess and provide broad costings with respect to the potential impacts to stakeholders as a result of augmenting environmental flows. The broad categories of potential impacts considered were to public and private land, infrastructure and levees as well as private businesses and agricultural land. This section contains a summary of the findings including the extent of potential impacts and a summary of potential mitigation options. A summary of the mitigation costings including contingencies and assumptions is in Section 7.

5.1 Assessment of impacts, mitigation measures and costs

During the feasibility stage of CMS, MDBA commissioned independent consultants to determine the range and cost of potential impacts and mitigation measures with respect to five discrete impact classes:

- levees;
- agricultural land;
- public infrastructure;
- specialist activities such as shacks, caravan parks, golf courses, etc; and
- implementation and approvals.

These projects built on prefeasibility phase desktop assessments conducted during 2013-14. Each project was informed by flow inundation modelling and assumptions which included managed flows up to 80,000ML/day for the River Murray in South Australia.

Across all the projects, the consultants undertook a number of case studies to highlight and verify impacts to representative assets or business types and engaged with key stakeholder groups to verify the modelled impacts, gauge the feasibility of the mitigation options and estimate the likely costs of mitigation. A summary of the scope, approach and assumptions of these projects is at Appendix 6 and full reports are available upon request.

Table 7 below summarises the nature and extent of potential impacts and mitigation measures identified and costed by the independent consultants. Details of the estimated costs of the proposed operating regime for the River Murray in South Australia, including the identified mitigation measures, are included at Section 7 and Appendix 6.

Table 7: A summary of the potential impacts and mitigation measures of the proposed operating regime.

Nature of potential impact		Extent of potential impact	Recommended mitigation activity
Inundation of agricultural land	Horticulture	5 ha	Land management arrangements
	Tolerant pasture	9,369 ha	
	Total area	9,374 ha	
Reinstatement of public infrastructure[4]	Sealed roads	10,987 m	Reinstatement activities
	Unsealed roads	42,786 m	
	Tracks	399,822 m	
	Landscaping	8 ha	
Impacts on specific public infrastructure assets	Isolated property access road upgrades	42,786 m	Road upgrades
	Loxton Bank stabilisation works		Capital response measures
	Berri Marina boat ramp upgrade		
	Berri reinforcing wall upgrade		
	Berri boating pontoons		
	Draper Road upgrade		
	Concrete Stairs		
	SA Water Salt Interception Scheme		
Impacts on specialist activities	Shack communities	23	Land management arrangements and infrastructure upgrades
	Caravan park	1	Land management arrangements and infrastructure upgrades
	Factory	1	Land management arrangements
	Forestry	1	No mitigation recommended by consultants
	Golf course	1	Land management arrangements
	Marina / marina slipway	2	Land management arrangements and infrastructure upgrades
	Quarry	1	Land management arrangements
	Residential	6	Land management arrangements and infrastructure upgrades
Impacts to overtopped levees	Earthen	10,600 m	Capital response measures (see Appendix 6)
	Unsealed road / track	9,900 m	
	Sealed road	800 m	
Impacts to flood control levees	Earthen levees	9,800 m	
	Unsealed road / track	5,900 m	
	Sealed road	2,200 m	

With respect to the specialist activities project, the main impact from the proposed operating regime is the inundation of private land comprising mostly shack communities downstream of Morgan. This comprises potential impacts to grassed areas and private jetties on riverfront properties, with a small number of dwellings potentially inundated. For these impacts, the potential mitigation measures costed include, for example, negotiating land management arrangements with landholders and constructing communal levees to minimise inundation on private land. Where some areas are identified as likely to experience interrupted access during higher flows, the mitigation measure proposed by the consultants is raising and/or developing access tracks. With respect to private businesses, the project proposes a range

[4] Includes impacts to roads above crossings (e.g. culverts and bridges).

of mitigation measures for consideration including compensation for business losses, constructing levees to prevent high flows inundation and raising access tracks to maintain access during high flows.

With respect to public infrastructure, the extent of impacts is dependent on the infrastructure and the overall feasibility (in terms of cost, ownership and risk) of the mitigation measure. Where inundation of public roads is identified, recommendations include operational responses to bridges, roads and culverts including clean-up, repairs and restoration (as capital works were considered not practically feasible or too expensive). Alternatively, capital works upgrades were recommended to manage inundation to specific public infrastructure such as banks, marinas and pontoons where operational response costs were considered not feasible or too expensive.

The mitigation measures to address the potential impacts of higher flows on salt interception schemes considered include: temporary decommissioning of floodplain bores and disconnection of electricity in advance of high flow events, followed by recommissioning once events are over; raising of floodplain bores on platforms to accommodate higher flow events (noting that some bores already have this capability); and potential infrastructure solutions (e.g. levees).

The levees around Renmark and the Lower Murray could be managed through capital response measures to ensure that levees can better withstand proposed high flows. There was also a risk of inundation to some low lying agricultural land. This land is characterised by dry, semi-arid climatic conditions and the dominant land use type has been assessed as native pasture which is tolerant of inundation. The consultants suggested that increased environmental flows in this semi-arid environment may create a benefit from pasture rejuvenation. While this benefit would be offset to some degree by some clean-up costs (e.g. fence repairs) it is expected that overall there may be a net benefit. It has been assumed for the purpose of this business case that land management arrangements may be required to mitigate any potential impacts.

Other mitigation measures such as advance warnings, notifications, communications and awareness activities have broadly been considered by the consultants' projects and will greatly complement the ultimate investment in tangible mitigation activities described above. The suite of non-capital mitigation measures are discussed in section 8.3.

A detailed risk assessment and strategy has been prepared for the project development and delivery component at Appendix 5, which includes the key risks to the assumptions and limitations discussed above. A detailed risk assessment and strategy for the operating regime[5] is not appropriate at this stage of the business case development given the broad scale and nature of the potential impacts, mitigation measures and costing estimates. Instead, the broad risks of the operating regime have been described and addressed quantitatively and qualitatively above.

5.2 Stakeholder comments

As the assessment of risks in section 5.1 influences a number of public agencies and private landholders and businesses, a number of key stakeholder groups were engaged to inform the assessment of potential impacts, mitigation measures and costs. Feedback received from these groups on the proposed operating regime and how impacts can best be managed was important to gain insights into how river operations interact with businesses and communities that use the river for their livelihood and lifestyle. Further building and maintaining strong stakeholder relationships will be crucial for the implementation phase from 2016 to 2024.

[5] Required by the Phase 2 Assessment Guidelines, section 4.7

In 2013 and 2014, MDBA and the South Australian Government consulted with representatives from river communities along the South Australian River Murray about the implications for various stakeholders of flows of 60,000 ML/day and 80,000 ML/day at the South Australian border. Consultation has mostly drawn from stakeholders' recent experience in the 2011-12 high flow events, which peaked at 94,000 ML/day at the South Australian border and which exceeds the range of flows expected to be delivered under the CMS.

On the whole, feedback from stakeholders has been positive especially where the CMS is understood as capitalising on natural events and restoring the natural seasonal cycle of river flows. This is particularly understood and appreciated by local river communities for whom memories of the drought years and positive effects of 2010-12 high flows is recent.

The majority of feedback received from local councils, peak irrigation bodies and indigenous nations was that advance notification procedures would assist in effective management and mitigating against the majority of adverse effects of higher flows. For the most part, this would be relatively easy to achieve given that South Australia has the ability to be aware of high flows approximately four weeks in advance due to the delay in transmitting water from upstream storages.

The main concerns from tourism operators, including local councils, business and shack communities, relate to the timing of high flow events, noting that summer months are peak tourism periods and high flows prevents or modifies the availability of houseboats and recreational river use. It was recommended that high flows during these periods should be minimised.

In 2015, DEWNR re-engaged with a number of representatives initially consulted regarding the CMS and the Basin Plan. The purpose of recent consultation has been to:

- inform key stakeholders of the progress of CMS through pre-feasibility and feasibility analyses;
- verify findings by consultants engaged by MDBA regarding impacts to public and private land and infrastructure;
- contribute high-level opinions about the suitability of various mitigation options being costed; and
- maintain relationships with priority communities, businesses and public agencies to prepare for the CMS Planning and Implementation Phase from 2016 to 2024.

In particular, through the development of this business case, DEWNR has re-engaged with local councils, public infrastructure operators, peak irrigation bodies and shack associations.

Recent consultation has confirmed earlier feedback that reactions to CMS continue to be generally positive, especially where it is understood that natural flows will be augmented to high flows as opposed to artificially creating moderate or major flooding. Engagement showed that these groups understood the environmental, economic and social benefits of higher environmental flows and thought that potential impacts could be adequately managed with the appropriate notifications and suitable investment.

Specific feedback from stakeholders includes:

- the environmental benefits of high flows increase the health and resilience of wetlands, floodplains, backwaters and anabranches;
- high flows provide social and economic benefits through enhanced opportunities for recreation and tourism;
- addressing priority physical constraints will provide other benefits such as better access to land and property during naturally occurring high flows;

- the timing of augmented high flows should be considered particularly with respect to peak tourism activities, especially during the summer months and holiday periods;
- community education regarding high flows would be beneficial, particularly where media report "high flows" as "flooding", which can detrimentally impact on tourism;
- advance notification is crucial as many impacts can be managed with appropriate preparation prior to a high flow event;
- the extent of impacts depends on the frequency, duration and timing of high flow events, including the rate that water levels rise and fall before and after an event;
- the majority of impacts concern clean-up and minor repair and operational management responses following a high flow event;
- there were specific infrastructure identified that would benefit from capital works to prevent damage during high flow events;
- other capital works were not feasible due to the large construction footprint and hence expensive cost;
- where inundation affects access roads this often coincides with water reaching the desired floodplain and wetlands, hence raising roads in some cases might be counter-productive to achieving improved environmental outcomes; and
- some shack communities have indicated preferences for managed high flow events to be delivered at rates lower than the operational limit to minimise disruption and potential impacts.

These stakeholder groups drew upon recent experiences during the 2010-12 natural high flows, which was beneficial in verifying the nature and extent of potential impacts, evaluating the effectiveness of various mitigation measures and estimating actual costs, especially for operational management responses. This feedback has been reflected in the operating regime in Section 4 and the assessment of potential impacts, mitigation measures and estimated costs in Section 5.1.

The key findings of the CMS consultation were consistent with recent South Australian Government stakeholder engagement on other Basin Plan initiatives such as the SA LTWP and weir pool manipulation trial events under the Riverine Recovery Project. The common themes were that community and stakeholders understood the benefits of environmental water management and thought that risks were manageable with appropriate notification, monitoring and engagement.

Appendix 4 is a stakeholder engagement strategy detailing community engagement and stakeholder involvement and participation during the planning and implementation phase.

5.3 Technical feasibility and fitness for purpose of mitigation options

5.3.1 Details of mitigation activities

The proposed mitigation activities outlined in section 5.1 can be broadly categorised as follows:

- prevention: an active measure that permanently seeks to prevent inundation of land or infrastructure from high flows, including capital infrastructure works to either upgrade existing infrastructure to withstand high flows (e.g. raise access tracks) or construct new infrastructure to prevent high flows inundation (e.g. build levees);
- compensation: an acknowledgement that inundation may cause temporary minor damage to land or businesses losses that can be compensated through land management arrangements (e.g. easements) or payments for business losses (e.g. capitalised at net present value), noting that inundation will not be prevented under these mitigation activities;

- response: a passive operational and maintenance response to inundation after a high flow event, including repairing and restoring levees, grading tracks, cleaning assets and re-seeding grassed areas; and
- notification: advance warnings of high flow events to advise landholders and businesses to be prepared to take courses of action to prevent damage or loss.

Due to the large scale of influence of the proposed operating regime (i.e. length of the River Murray from the South Australian border to the Murray Mouth, including the main river channel, backwaters, anabranches, wetlands and floodplains) and wide range of potential impacts and mitigation measures, detailed assessments of mitigation options have not been conducted. Instead, high level design criteria and maps showing the broad location, access routes and footprint area for each project is contained within the full consultants' reports. Likewise, the CMS Feasibility Phase has not progressed to the concept design, detailed design and geotechnical investigations stages and these will be conducted during the CMS Planning and Implementation Phase during 2016 to 2024 should investment be approved. The consultants' reports provide sufficient information to enable broad investment decisions to be made based on the feasibility investigations conducted to inform this business case.

5.3.2 Principles/process for determining mitigation options

The project reports summarised in this section provide a variety of, but not necessarily the full range of, mitigation options for addressing impacts. The options proposed by individual consultants are necessarily limited to those which can be costed and, due to the early stage of design and process, have not been considered in conjunction with other mitigation options and overarching policy decisions.

During the planning and implementation phase, the key principles that will be adopted to assess and determine the appropriate mitigation measures that will be engaged to address potential impacts include:

- the effectiveness of the risk mitigation strategy: does the measure prevent the potential impact from occurring or appropriately compensate potential damage or loss?;
- cost and feasibility;
- the effectiveness of the mitigation measure to limit liability;
- whether the arrangements provide an enduring and ongoing solution as opposed to a temporary measure;
- avoidance of unintended environmental impacts: i.e. raising an access track may prevent environmental water from reaching parts of the floodplain which is counter-productive to the ultimate goals of the project;
- the nature of voluntary agreements and degree of support required from landholders, businesses and public agencies to implement the mitigation measure;
- the necessary policy and legal frameworks to enable mitigation implementation; and
- the nature of asset ownership and ongoing operational and maintenance costs.

Discussions with landholders, businesses and public agencies are ongoing and will play an important role in determining the appropriate mitigation measure to address a potential impact, as detailed in the engagement strategy attached at Appendix 4.

Other complementary mitigation measures are discussed in Sections 6 and Section 8.3, and governance and funding arrangements are addressed in Sections 7 and Section 8.3.

6 Complementary actions and dependencies

This section considers the interaction of constraint measures in the River Murray in South Australia with the other two parts of the River Murray main channel: Hume to Yarrawonga and Yarrawonga to Wakool, as well as a high level synopsis of the interaction with other policies, projects and supply measures under the Basin Plan.

6.1 Interactions with other constraint measures

The three parts of the River Murray — Hume to Yarrawonga, Yarrawonga to Wakool Junction and the River Murray in South Australia — are considered as a single package for the purposes of these business cases due to their inter-dependencies. Without relaxing constraints in all three key focus areas, as has been stated throughout this document, it will not be possible to take advantage of relaxed constraints in just one part of the River Murray.

The River Murray contains important environmental assets throughout each of the three River Murray constraint areas. Relaxing constraints along the main channel of the River Murray can provide some of the greatest environmental outcomes, particularly if regulated releases can be timed, based on natural cues, to combine with unregulated flows from the Kiewa, Ovens, Goulburn and/or Murrumbidgee rivers to build flows up to 80,000 ML/day at the South Australian border. For example flows from Hume Dam can be used to connect with tributary flows downstream to increase the size of the peak event and water more floodplain, or to extend the duration of a natural flow event to keep water on the floodplain for longer. Without relaxing constraints in the River Murray, relaxed constraints in the Goulburn and Murrumbidgee will be limited to in-valley benefits only (Murray-Darling Basin Authority, 2014b).

The majority of flows into the lower River Murray system come from the Upper River Murray (including the Kiewa and Ovens Rivers), Goulburn, Murrumbidgee and Darling Rivers. The Upper River Murray is usually the dominant contributor to a target event in the Lower River Murray and therefore the characteristics of flows in the Lower River Murray can usually be directly correlated with those in the upper Murray. An increase in upstream flow leads to a linear increase in the probability of a successful watering event downstream.

As a result of the high level of hydrologic connectivity the three River Murray constraints are inherently interrelated. A coordinated and integrated approach to these measures is required to enable system-wide benefits along the length of the River Murray. Recognising this, Ministers requested that, as a priority, work should proceed as an integrated package for the three River Murray key focus areas following their decision in December 2014.

6.2 Interactions with Prerequisite Policy Measures

Protecting environmental flows from extraction, delivering environmental water on top of other in-stream flows and using environmental water throughout the length of the river are important for achieving environmental outcomes. The policy and operational measures were discussed in section 4.3.

6.3 Interactions with other supply measures

Some supply measures will benefit from constraints in the River Murray being relaxed. Supply measures with such potential interactions in the River Murray include:

- Hume Dam airspace (this supports the operators' flexibility and adaptability by improving the airspace rules and management options regarding change spill behaviour which may increase the risk of inundating public and private land. This constraints measure would significantly help to address the impacts on landholders and potential liabilities for governments);

- Menindee Lakes Water Savings Project (if the outlet capacity is to be increased and higher flows are released in the Lower Darling);
- Modification of Locks 8 and 9 weir pool raising and lowering (if there are impacts on private property); and
- The Living Murray works and measures (to maximise the efficiency of operation of The Living Murray works and measures, icon sites would benefit from being able to deliver water to and operate structures at higher flow rates).

The CMS also interacts with other environmental works and measures projects in South Australia, including:

- wetland management and weir pool manipulation as part of the Riverine Recovery Project;
- infrastructure investment at the Pike and Katarapko Floodplains and salinity management under the South Australian Riverland Floodplain Integrated Infrastructure Program;
- works and activities for the Coorong, Lower Lakes and Murray Mouth Recovery Project and The Living Murray Project; and
- infrastructure operations on the Chowilla Floodplain as part of The Living Murray.

7 Costs and funding arrangements

Section 5 detailed the findings of independent consultants' projects on the likely impacts of inundation at the operational limit of high flows. As part of that assessment the consultants costed a range of mitigation measures that are detailed in this section. There is a discussion of the ongoing funding arrangements for the implementation phase of CMS, whether co-contributions will be sourced and how operations and maintenance costs will be treated.

7.1 Estimation of the total costs for the measure and factors considered in determining costs

This business case for the River Murray in South Australia is being considered as part of relaxing constraints for the entire River Murray system. The magnitude of flows that can be delivered to the South Australian border is dependent on proposed changes to operating regimes in the upstream reaches being Hume to Yarrawonga and Yarrawonga to Wakool Junction. At the time of preparing this Business Case, the extent of the proposed operating regime changes in the Yarrawonga to Wakool Junction were still being considered. The cost estimates below reflect flows of 65,000 ML/day (YAR 65) and 50,000 ML/day (YAR 50) downstream of Yarrawonga Weir as investigated by the project consultants.

The estimated costs of the mitigation measures considered in Section 5 are summarised in Table 8 below.

As described in Section 2, for each mitigation measure, the project consultants provided estimated base costs of undertaking the measure. For each project the consultants also included a factor for contingency, which was calculated depending on the number of assumptions and level of risk identified for each project. In many cases the consultants provided two sets of estimates: "moderate" estimates, which included a lower level of contingency, and "high" estimates, which included a higher level of contingency. Table 8 presents "high" estimates as provided by the consultants to reflect the current early stage of design and scoping of mitigation measures. The specific issues taken into account in forming these base costs and contingencies are described in Appendix 6 and in the project reports.

Costs were escalated at 2.68% per year for each year from 2014-15 to project implementation in accordance with cost escalation advice received from the then Commonwealth Department of the Environment for supply and constraint measure project business cases.

Next, administration and management costs were considered and this is further described in Appendix 6. These include potential costs associated with engineering design, approvals and construction associated with capital works on public infrastructure, specialist activities and levees, in addition to those already identified under each project. In estimating these costs it has been assumed that there will be some degree of cost saving through bundling of similar packages of capital works measures.

The program management costs based on the implementation plan at Appendix 3 is estimated at [redacted] for 2016 to 2024 and is expected to be the same for both the YAR 65 and YAR 50 flow scenarios.

As is demonstrated in Table 8, once all of these costs and factors are considered, the total costs for proposed mitigation measures for the River Murray in South Australia is currently estimated at $38-40 million to $66-68 million depending on the mix of land management arrangements and infrastructure works and the extent of constraints relaxation flow rates for upstream reaches.

Note that Table 8 presents two sets of mitigation options for specialist activities. Option 1 assumes that land management arrangements (in the form of easements and like agreements) would be pursued in preference to infrastructure works, whilst Option 2 assumes the reverse. At this stage of assessment,

Option 2 is the more costly of the options, with capital infrastructure works only preferred where the cost to do so is justifiable with respect to the cost of the subject land management arrangement. In particular, infrastructure works on private infrastructure was proposed by the consultants on the basis of necessity to maintain access to areas of land that would suffer from interrupted access caused by higher flows. However, these cost estimates do not require Basin state governments to decide an “either/or” approach at this stage but are prepared to demonstrate the differences from approach.

Table 8: A summary of the estimated costs of mitigation measures.

Recommended mitigation activity for potential impact	Key issues considered	Estimated cost ($m)			
		YAR 65		YAR 50	
		Mid-range	High estimate	Mid-range	High estimate
Land management arrangements for agricultural land	Inundation impacts on tolerant pastures. Inundation impacts on horticulture. Farm management costs, including clean-up, fencing and pumps.	[redacted]			
Operational response for public infrastructure	Public asset managers would incur additional resourcing costs associated with high flow preparations. Enacting mitigation controls (such as road management/closing and shutting off backflow prevention valves) was a common cost, not captured by asset costing.				
Reinstatement works for public infrastructure	Rehabilitation of roads (potholes, pavements, regrading). Maintenance of tracks. Replacement or reinstatement of culverts. Grading and removal of debris in fords. Impacts on landscaped areas.				
Capital works on specific public infrastructure assets	Isolated property access road upgrades				
	Loxton Bank stabilisation works				
	Berri Marina boat ramp upgrade				
	Berri reinforcing wall upgrade				
	Berri boating pontoons				
	Draper Road upgrade				
	Concrete Stairs				
	SA Water Salt Interception Schemes				
Capital works on levees	Management response measures including levee repair, widening, restoration, replacement and vegetation removal				
Land management-focused arrangements for specialist activities (option 1)	Land management arrangements for private specialist activities				
	Infrastructure works for specialist activities				
Infrastructure-focused arrangements for specialist activities (option 2)	Land management arrangements for private specialist activities				

	Infrastructure works for specialist activities	[redacted]
Implementation costs for land management-focused arrangements (option 1)	It is assumed that there will be bundling of similar packages of capital works measures	
Implementation costs for infrastructure-focused arrangements (option 2)	It is assumed that there will be bundling of similar packages of capital works measures	
Program management costs	Project management, administration and governance	
Total costs	**Land management arrangements for specialist activities (option 1)**	
	Capital works for specialist activities (option 2)	

These costs have been refined and developed from those provided during the prefeasibility phase, which broadly and narrowly estimated a total cost of $5 million: $2 million for land management arrangements and $3 million for roads. The increase from prefeasibility phase to the current costing estimates can be attributed to a number of factors including:

- new considerations such as a new cost for levees management responses and an additional cost for agricultural land management arrangements;
- increases in the number, scope and scale of infrastructure and assets from previous estimates which increases the mitigation costs for public infrastructure; and
- refined estimated mitigation costs for private land and businesses which were not considered in earlier assessments.

At this stage of feasibility work, the projects described in this section contain a number of assumptions and limitations affecting the assessment of potential impacts, mitigation measures and cost estimates. These cost estimates are subject to a number of assumptions detailed in Appendix 6, the consultants' reports and include:

- hydrological modelling assumptions both for the delivery of the proposed operating regime flows to South Australian border as well as the flow inundation mapping for the River Murray in South Australia to assess potential impacts;
- GIS datasets and desktop information for the private and public land, infrastructure and levees to assess potential impacts;
- cost estimates using the methodologies adopted by the professional consultants, including land values and gross margins, the net present value calculations for future capitalised operations and maintenance costs, contingency and escalation;
- desktop assessments used to provide broad costings at the regional scale where more detailed data and information was limited;
- case studies used to extrapolate costs from the local scale to the regional scale where time and budget were limited;
- infrastructure design, approvals, project management and implementation processes and associated additional cost; and
- mitigation measures are preferable, feasible and implementable.

These assumptions create uncertainty in the estimates resulting in a number of risk management approaches applied to reduce this uncertainty and provide accurate costs for the business case. These risk management approaches included:

- hydrological modelling and GIS analysis was conducted by technical experts from MDBA and DEWNR and verified by river flow and height gauges where possible;
- MDBA engaged external professional consultants with experience and expertise in determining potential impacts, recommending mitigation measures and estimating costs of high flows on the River Murray;
- engagement with key stakeholders and the community with knowledge of local conditions to verify potential impacts, mitigation measures and estimated costs;
- clarifying assumptions to the extent possible and understanding the extent to which the assumptions define project uncertainty, risk, scope and investment potential; and
- incorporation of contingency and cost escalation calculations to account for uncertainties.

These assumptions, and consequential uncertainty and risk to project scope, have been managed through using adequate contingency and cost escalation calculations. This ensures that cost estimates are reflective of the project risk profile during the current feasibility phase, in particular that the project is at an extremely early phase of scoping and design, and are fit for purpose in providing a sufficient advice to make investment decisions regarding the implementation phase of CMS. During the implementation phase, these cost estimates will be further refined through concept and detailed design processes, as provided in Appendix 3.

Further detail on the assumptions and implications for the costs estimates is at Appendix 6.

For this section, the Phase 2 Assessment Guidelines also require a discussion on the environmental benefits and risks, which are described in Section 3 and Appendix 2 respectively. The social and economic benefits and risks are described in section 2.2 and section 5.1 respectively.

7.2 Proposed funding arrangements

The proponents are seeking Commonwealth Constraint Measure Funding from the Water for the Environment Special Account. The proposal meets the purposes of this Account, including:

- improving or modifying any infrastructure (including bridges and roads) that constrains the delivery of environmental water to the environmental assets of the Murray-Darling Basin in order to ease or remove those constraints;
- increasing the capacity of dams and storages to deliver environmental water to the environmental assets of the Murray-Darling Basin;
- entering agreements to acquire an interest in, or in relation to land (including easements) to facilitate environmental watering of the environmental assets of the Murray-Darling Basin; and
- improving the rules, policies, practices and procedures in relation to the use and management of the Basin water resources.

7.2.1 Co-contributions

For the purposes of this business case, it has been assumed that all costs would be met by Commonwealth Constraint Measure Funding under the Water for the Environment Special Account.

Any opportunities for potential co-contributions from prospective business partners will be considered during the CMS Planning and Implementation Phase form 2016 to 2024. Key principles for any potential co-contributions include:

- asset ownership, operations and maintenance arrangements for both upgrades to existing infrastructure and construction of new infrastructure;
- opportunities to leverage other funding sources to complement potential CMS investment;
- taking advantage of opportunities where potential business partners may wish to make voluntary contributions above and beyond initial CMS investment; and
- capacity to enter into secure and enduring business partnerships for mutually beneficial long-term outcomes.

7.2.2 Arrangements for ongoing ownership and maintenance of infrastructure

The primary funding arrangements proposed under this business case under the Water for the Environment Special Account does not explicitly enable funding for ongoing operations and maintenance costs. Therefore, arrangements for ongoing asset ownership and operations and maintenance of infrastructure will need to be negotiated. This will depend on factors such as whether potential CMS investment is proposing to upgrade existing infrastructure or construct new infrastructure, existing arrangements and future risk management.

It is important to note that this is different to operational management responses as a mitigation measure to prepare and respond to high flow events. For the purposes of this business case, these costs are considered to be within scope as they have been capitalised operational management costs with net present value calculations to account for future liabilities.

8 Project governance and management arrangements

This section outlines how the CMS measures proposed in these business cases will be delivered for the planning and implementation phase. The third phase of CMS will initially likely continue various interim arrangements so that final decisions can be made with respect to governance and funding matters. In order to progress to the next stage, a risk management strategy has been prepared as has a project plan for continued stakeholder consultation. This section outlines policy and legal issues that will need to be considered as CMS continues to progress through the planning and implementation phase.

8.1 Implementation Plan

Due to the interaction of the three River Murray constraint measure business cases, the measures will be implemented in a coordinated manner. A broad Implementation Plan for the River Murray constraints measures has been included in Appendix 3.

The Implementation Plan outlines six key phases:

- governance arrangements;
- information refinement;
- private tenure mitigation options;
- public tenure mitigation options;
- operational trials; and
- delivery of relaxed constraint flows.

Appendix 3 explores these six phases and identifies key tasks and dependencies required within each. The Implementation Plan is subject to future amendment following final investment decisions and the progression of CMS to the planning and implementation phase.

Figure 5 below conceptually demonstrates the Implementation Plan.

The delivery of relaxed constraint flows (augmented environmental flows) will commence once mitigation measures have been implemented. As is described in Section 5 above, the delivery of increased flows will then be an incremental process with flows supplemented in increasing levels toward the operational limit of 80,000 ML/day at the South Australian border.

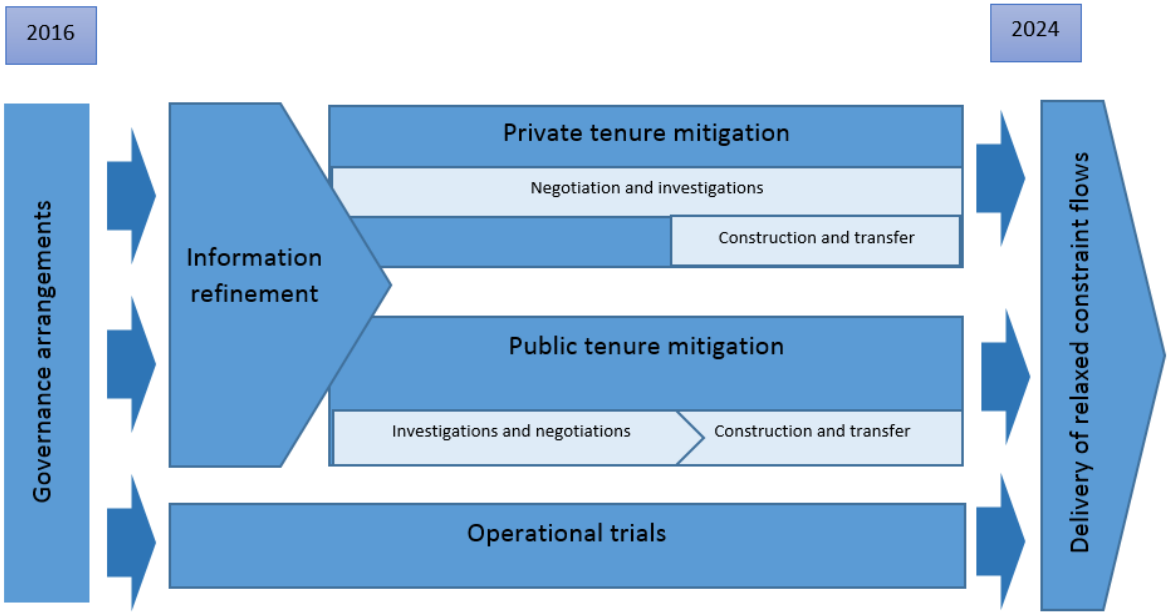

Figure 5: Relationship between key phases of constraints measure implementation

8.2 Stakeholder engagement strategy

Landholder and community support is critical for the effective implementation of constraints management works and measures. Feedback gathered to date indicates broad community support for the strategy and the delivery of higher flows in South Australia from local councils, peak irrigation bodies, indigenous nations and shack communities. More information on the key findings from the broad consultation undertaken on the CMS to date is at section 5.2.

Effective communication and consultation with stakeholders will continue during further design and implementation to understand community issues at the regional and local level and to seek input on the development and implementation of constraints management measures. The focus of community engagement will transition from informing and consulting to involving and collaborating as the priorities shift from business case development to planning and implementation. More information on the stakeholder engagement strategy is at Appendix 4.

8.3 Legal and Policy issues to be addressed

The implementation of CMS will be pursuant to a multi-jurisdictional framework including the *Water Act 2007* (Cth), the Murray-Darling Basin Agreement, the Basin Plan, and individual state Acts regulating use of the main channel and tributaries, including statutes managing river operators. Each river operator, Basin State and the MDBA, together with the CEWH, will need to be confident that these inter-related Acts and agreements provide sufficient authorisation for the operation of CMS and this will be progressed as part of the implementation phase of CMS.

At a high level of generality, legal and policy issues to be reviewed and confirmed during planning and implementation include:

- confirming the requirements of the multi-jurisdictional framework;
- administrative policy and procedural arrangements to ensure best practice, procedural fairness and relevant considerations are taken into account;
- principles for negotiating or renegotiating voluntary land management agreements including for example easements;

- ownership of and internal arrangements and coordination with respect to implementing a range of additional non-capital mitigation measures: for example, appropriate notification procedures; and
- review of applicable legislation.

The ongoing management of legal, policy, and other risks are included in the risk management plan included at Appendix 5.

A desktop cultural heritage assessment was conducted by independent consultants to inform the business case. The main finding was that DEWNR will work with indigenous nations to conduct cultural heritage assessments to manage risks and preserve and protect sites of indigenous cultural significance. These will be conducted as part of the design, construction and delivery phases of implementation to manage risks at each stage of project delivery. Other regulatory approvals such as native vegetation and environmental approvals are detailed in Appendix 6.

8.4 Proposed governance and project management arrangements

During the feasibility phase, governance and project management has been coordinated between the Commonwealth Department of Agriculture and Water Resources (**DAWR**), MDBA and Basin States as described below.

In February 2013, the Australian Parliament made a special appropriation of $1.77 billion to the Water for the Environment Special Account established under section 86AB(1) of the Water Act for a ten-year period from 2014-2015. The funds have been allocated in two main streams: first to efficiency measure projects to deliver 450 GL of additional environmental water (approximately $1.5 billion allocated); and second to easing or removing constraints on the ability to deliver environmental water to the environmental assets of the Murray-Darling Basin. There has been $200 million allocated for constraints work including up to $5 million for Basin states to develop these business cases.

Pursuant to the special appropriation, DAWR provided funding to each of the Basin States who in turn provided a portion of those funds to MDBA for the purpose of progressing technical feasibility analyses and preparing these business cases. MDBA have in turn engaged various sub-contractors to progress discrete technical and/or case study analyses whose works have informed and form appendices to these business cases.

With respect to the development of this business case for the River Murray in South Australia, DEWNR directly assisted and/or led specific investigations, communication and preparation of this business case.

Representatives from the MDBA, Basin States and observers from DAWR and CEWH met frequently to ensure continued inter-governmental cooperation and consensus during the feasibility stage and development of these business cases.

Taking into account the rules of the Water for the Environment Special Account, it is anticipated that the governance arrangements in place during the feasibility phase remain in place during the early part of the planning and implementation phase such that an appropriate future pathway can be agreed upon once funding and ownership matters are decided upon. This is detailed in Appendix 3.

8.5 High level risk assessment

A high level risk assessment is provided at Appendix 5 for the planning and implementation phase.

The risks will be owned by the project proponents and risks will be monitored and reviewed every six months. Any risks with a residual risk rating of moderate and below will be accepted and monitored to ensure the risk rating does not escalate during implementation. Risks with a residual risk rating of

significant and above will be actively managed and monitored throughout project delivery. At this stage of the CMS these risks have been highlighted for consideration and further pathways will be put into place to address them prior to investment decisions. Many of these identified risks reflect the scale and complexity of the CMS project in developing mitigation strategies to manage high flows delivery and their rating and strategy are considered reasonable and manageable with respect to the current early stage of the business case development.

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Appendix 1: Phase 2 Guidelines Eligibility Criteria

The Key Evaluation Criteria specified in the Phase 2 Assessment Guidelines for Supply and Constraint Measure Business Cases have been addressed in this business case as referenced in Table 9.

Table 9: Phase 2 Assessment Guidelines and relevant sections of this Business Case

Section of Guidelines		Relevant section of Business Case
4.1	Project details	Section 2
4.2	Ecological values of the site	Section 3.1
4.3	Ecological objectives and targets	Section 3.2
4.4.1	Anticipated ecological benefits	Section 3.3.1 Section 3.3.2
4.4.2	Potential adverse ecological impacts	Section 3.3.3 Appendix 2
4.5.1	Current hydrology and proposed changes to the hydrology	Section 3.4
4.5.2	Environmental water requirements	Section 3.4
4.6	Operating Regime	Section 4
4.7	Assessment of risks and impacts of the operation of the measure	Section 5.1
4.8	Technical feasibility and fitness for purpose	Section 5.3
4.9	Complementary actions and interdependencies	Section 6
4.10.1	Costs, Benefits and Funding Arrangements for new unfunded projects seeking Commonwealth Supply or Constraint Measure Funding	Section 7.1 Section 7.2
4.11	Project Governance & Project Management Arrangements	Section 8 Appendix 3 Appendix 4 Appendix 5
4.11.1	Stakeholder Management Strategy	Section 8.2 Appendix 4
4.11.2	Legal and regulatory requirements	Section 8.3
4.11.3	Governance and project management	Section 8.1 Section 8.4 Appendix 3
4.11.4	Risk Assessment of Project Development and Delivery	Section 8.5 Appendix 5

Appendix 2: Assessment of potential adverse environmental outcomes

The potential adverse environmental outcomes identified for the measure in Table 10.

Table 10: Potential adverse environmental outcomes or risks associated with relaxed constraints water delivery in the River Murray

Risk	Geographical scope	Description	Mitigation/control
Blue-green algae	Whole of system depending on conditions	Blooms that may occur at the same time as environmental watering events cannot be attributed solely to river flows and environmental watering is not considered to amplify most of the individual risk factors, but without controls it could potentially help create stable water levels through the use of weir pool lowering, which could amplify the risk of blooms under certain conditions.	Watering may be designed with specific flow variability provisions to avoid stable water levels for prolonged durations: for example, while the weir pool is lowered the water levels are fluctuated around a mean to prevent stratification. A follow-up flow may be incorporated to encourage mixing of water layers following weir pool lowering and provide flushing to reduce potential impacts associated with blue-green algae.
Geomorphic impacts	Whole of system	By providing more variable and overbank flows, the measure should help mitigate the risk factors that contribute to scouring, notching and other erosion impacts in the long term. However, without controls, higher environmental flows could potentially contribute to individual cases of accelerated erosion that might have localised impact in both the short and long term. Also, river banks are more susceptible to erosion under current conditions so unless the rates of recession associated with flow events are managed, environmental watering may amplify the risk of bank slumping as well as associated turbidity impacts.	Manage the rate of recession of the flow tail to most effectively manage the risk of erosion and bank slumping. Ongoing monitoring and a commitment to help address potential impacts.
Hypoxic blackwater	Whole of system	Given that the measure intends to increase the frequency of overbank flows, this should reduce both the frequency and severity of blackwater events over time. However, without considering program controls, blackwater events could still occur in the short-term given that organic matter can build up over only one season.	Watering may be designed to specifically avoid high risk periods, such as warm weather in late spring and summer, in order to reduce the potential for hypoxic blackwater. Where possible and where natural dilution flows are not available, dilution flows may be provided to provide aquatic refuge habitat in the main river channel during blackwater events and provide localised dilution of incoming blackwater from the floodplain. Additional monitoring activities may include testing of dissolved oxygen levels to assist in the active management of the watering action and for adaptive management.

Salinity and groundwater recharge	Whole of system	If spikes in salt concentrations associated with individual watering events are not mitigated by the provision of dilution flows, environmental watering could potentially amplify the risk of salinity spikes during watering actions on a short-term basis. In addition, given that post-watering spikes are a product of multiple factors that affect groundwater salinity, by providing additional river flows and weir pool manipulations environmental watering may amplify the risk of post-watering salinity spikes.	Application of the The Living Murray framework for salinity spike management to help ensure that environmental watering is undertaken with regard to the Basin Plan salinity targets. Dilution flows may be provided, where possible and where natural dilution flows are not available, to reduce the concentration of mobilised salt. Communication materials may be provided to affected communities where relevant. This includes media releases by the delivery partner/s and river operators.
Spread of disease (particularly chytrid fungus)	Whole of system	Environmental watering is likely to reduce the overall risk of mosquitoes by changing the seasonality and variability of flow events. Psittacine Circoviral disease is not water-borne and water flows are only one of a number of factors that may contribute to the spread of infected parrot species. River flows are only one of a number of factors that can spread root-rot fungus. However, by increasing the frequency of small to medium flows that promote hydrologic connectivity, the measure may increase the frequency with which frog species are exposed to the chytrid fungus.	The peak flow of the watering action will be designed to most effectively manage inundation of risk areas. This may include avoidance of the area altogether (where possible and appropriate).
Spread of pest flora species	Whole of system	By increasing the frequency of small to medium flows that promote hydrologic connectivity and seeking to provide flows during potential risk periods such as spring, the measure may amplify the risk of spread or population increase of pest flora spread by flows. A more natural flow regime would also help to benefit establishment of native species and provide non-beneficial conditions for the spread of some non-native species.	As this is an exacerbation of an existing risk, existing weed control programs may help to manage it. Easement agreements may also include a recognition of the greater need for weed management to help supplement existing weed management on private land.
Spread or population increase of pest fauna species	Whole of system	By increasing the frequency of small to medium flows that promote hydrologic connectivity and seeking to provide flows during potential risk periods such as spring, the measure may amplify the risk of spread or population increase of aquatic and amphibious pest fauna.	Site managers may be requested to use existing exclusion devices, such as carp screens, to minimise the additional contribution to the spread of pest fauna. Regulatory structures may be used to complement the watering action and help mitigate pest fauna impacts. For example, a wetland system may be watered to support vegetation outcomes and once watering has concluded regulating structures may be closed to prevent further inflows. This allows the wetland to be dried out to kill invasive fauna, while vegetation condition is maintained

			through soil moisture as a result of the watering action.*

Appendix 3: Implementation Plan

The implementation of the three River Murray constraint measure business cases: Hume to Yarrawonga, Yarrawonga to Wakool Junction and the River Murray in South Australia will be implemented as an integrated package.

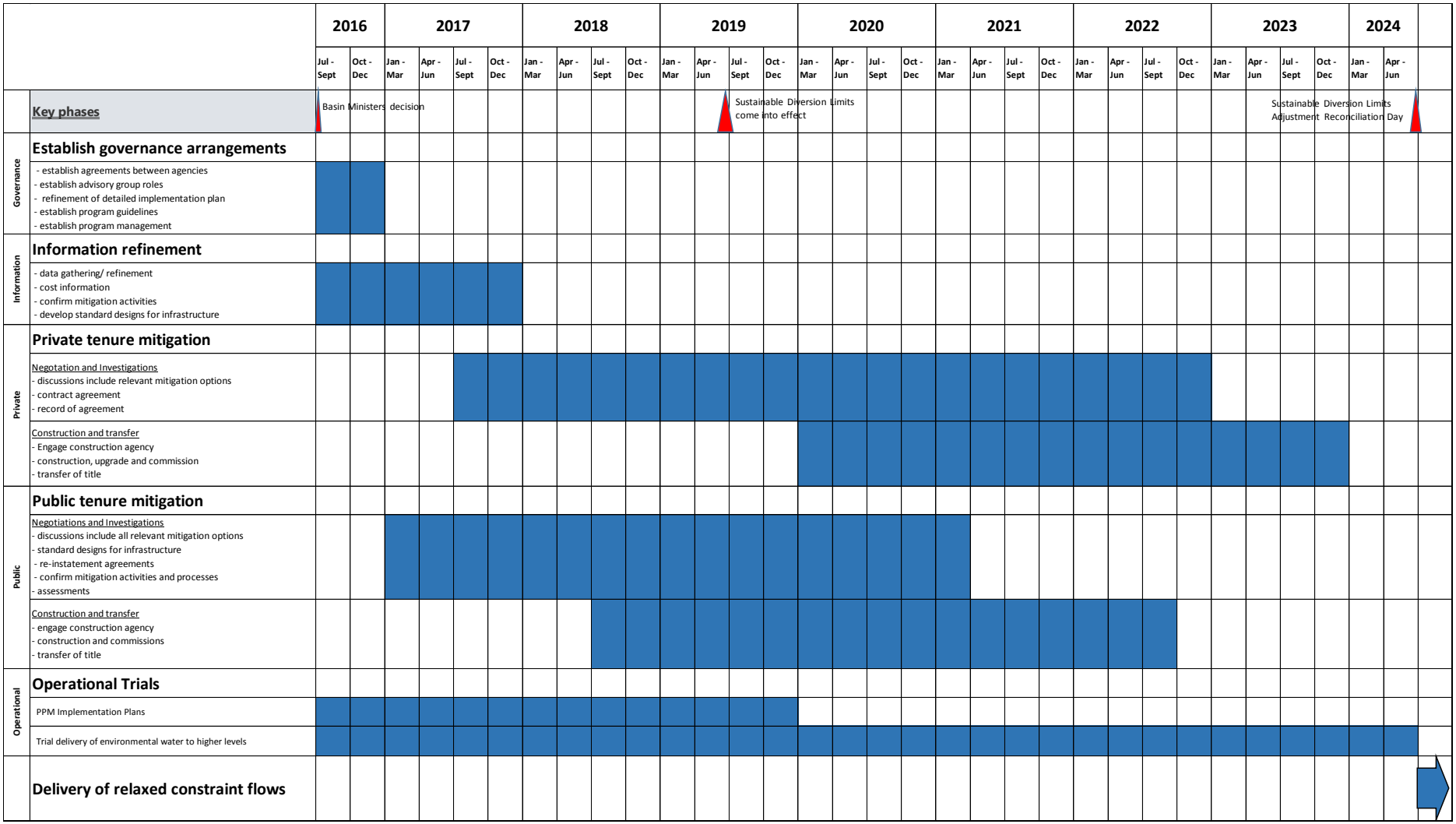
This Implementation Plan outlines the key phases, estimated times, key tasks and dependencies that will be required for implementation. The six key phases identified and discussed in this Implementation Plan are:

- governance arrangements
- information refinement
- private tenure mitigation options
- public tenure mitigation options
- operational trials, and
- delivery of relaxed constraint flows.

Figure 1 identifies the relationship between the broad phases in the Implementation Plan and the timelines for implementation.

The Implementation Plan will require further development in the first year of implementation during 2016-17 should funding be approved.

Figure 6: Constraints measures estimated implementation timeline.



Governance arrangements

July 2016 – December 2016

If Ministers agree to implement the proposed River Murray constraint measures, governance arrangements will need to be formally established to ensure the long-term continuity and success of the program.

Key tasks

Key tasks for the governance arrangements phase include:

- establishing **agreements between jurisdictions (and associated agencies)** on the responsibilities, roles and functions of the State and Commonwealth governments;
- establishing **program structures in agencies** expected to implement the constraints business measures, their roles, inter-agency liaison routes and how they will incorporate any new information into negotiations;
- establishing **program guidelines** for the implementation of the constraint measures for the River Murray;
- defining coordinated **program management approach** in order to oversee the work allocation, resourcing, budgeting, progress of implementing constraints measures, initial activities for the program management group will include:
    - finalisation of a **detailed Implementation Plan** and distribute between the implementing organisations; oversee the **stakeholder engagement strategy**, including confirmation of roles and establishment of advisory groups (where appropriate). The role of an existing or a new group in regards to implementing constraints measures must be clearly identified and incorporated into the groups' Terms of Reference; and
    - establishing **supporting mechanisms** for stakeholders to access independent advice on any technical, legal or engineering issues.

Key dependencies

Dependencies that have been identified include:

- clarification of managerial and financial delegation of the mitigation measures proposed in each reach;
- clarification of the consent (approval) authorities;
- the role and capacity of the community advisory group (or similar) to coordinate technical and community information; and
- funding arrangements for funding mitigation works are agreed, including resourcing.

Program Management and Resourcing

The Program Management approach is subject to the decision of the long-term governance arrangements. However, regardless of what governance arrangements are agreed, appropriate resourcing will be required for mitigation responses to third-party impacts (e.g. easements and infrastructure upgrades) and program management. Effective program management will be required to ensure accountability under the relevant public administration legislation, and for effective stakeholder engagement, negotiation and approvals processes in implementing constraints measures.

A key issue will be resourcing working with landholders at a detailed one-on-one level working towards negotiating property level agreements. For the River Murray in South Australia constraints this means landholders and communities that stretch from the South Australian border to Coorong, Lower Lakes and

Murray Mouth. Public and private infrastructure works also requires working with local councils, riverbank landholders and multiple regional authorities and river user groups.

Possible Resourcing Approach

Effective program management would require a program management group as summarised in Table 11.

Table 11: Indicative resourcing required for program management group for the River Murray in South Australia)

FTE	Role	Tasks
1.0	Team supervisor	Responsible for planning, coordinating and team management
1.0	Team admin support	Secretariat support for various steering committees and project control board, team administration and logistics, reporting, and developing communications material for the project
1.0	Riparian landholder project officer	One-on-one meetings, property ground- truthing surveys, development of landholder specific maps, inclusion of local knowledge, field days, community meetings (note need a minimum of 2 people for Work, Health and Safety requirements)
1.0	Public infrastructure project officer	Public infrastructure project management, site visits and inspections, reporting, council briefings, field days, community meetings.
1.0	Legal officer	Responsible for providing legal advice to project team regarding easement acquisition and other issues as they arise

Potential additional resources for Infrastructure Implementation

Assumptions for costing Infrastructure Implementation have been developed by independent consultants and are outlined in Appendix 6.

The consultants recommended bundling of small infrastructure works (particularly on private land) into a package of works would be beneficial to achieve the greater scale needed to provide efficiencies and cost savings for design, approval and contracting/supervision of infrastructure works.

Bundling small work packages together will also be more efficient and cost effective, attracting contractors with the required processes, practices and systems for these types of works.

Resourcing for Public Asset Mitigation

It is likely that local asset managers generally have the in-house expertise to undertake public reinstatement works after events. The project delivery team will work with local asset managers to manage the additional public capital works detailed in Section 5.

Skills required to implement the measure

The personnel / agencies managing the program should have skills in contract management, legal, technical, scientific and stakeholder liaison / engagement.

A summary of the respective skills required for implementation of the Program is summarised in Table 12.

Table 12: Resourcing requirements for each phase of implementation

Resourcing skill/requirement	Information refinement	Private Tenure Mitigation	Public Asset Mitigation	Operational Trials
Community liaison	Required	Using local engagement teams to negotiate easement or other mitigation measures may assist in the negotiation process	Using local engagement teams to negotiate easement or other mitigation measures may assist in the negotiation process	Required
Costing analysis	Final appraisal, easement agreements, number of options and locations	final appraisal, easement agreement, number of options and location	final appraisal, including agreement to facilitate asset reinstatement issues	
Legal advice	Contractual, land acquisition, State and Commonwealth	contractual, land acquisition, state and Commonwealth	contractual, land acquisition, state and Commonwealth	
Technical analysis	Engineering, scientific, technical, data analysis	engineering, scientific, technical, data analysis	engineering, scientific, technical, data analysis	
Construction		labour, earthworks, etc.	existing Council teams	
Engineering		design, project management, environmental assessments, applications, approvals	existing Council teams	
River operators	Operational knowledge, site impacts, coordination of investigations			State, MDBA
Environmental water holders				Required
Environmental Assessments			for processing regulatory approvals	

Information refinement phase

July 2016 – December 2017

This phase ensures critical data and costing information is refined or updated, to ensure that all information is available, and governance arrangement agreed to begin negotiations with individual stakeholders.

As outlined in the RMCSC Feasibility Phase work plan, following handover of constraints Business Cases to State Governments (November 2015), the MDBA Constraints Management Branch will continue to refine feasibility phase analysis until June 2016. This includes the preparation of final public reports for the Costings Projects. The MDBA will also assist governments in advice on Implementation Decisions (including development of draft program guidelines).

Key tasks

The key tasks of this phase will include:

- obtain or refine data for:
    - improved inundation Mapping- (new LiDar mapping, and aerial photography of high flow events);
    - Hydrodynamic Modelling, and further refine how water moves through the system;
    - development of draft landholder agreements ;
    - surveys – property ground- truthing surveys, development of landholder specific maps, site visits or inspections, inclusion of local knowledge;
    - verification – confirmation of landholder ownership;
    - finalise qualification of inundation risk and appropriate method(s) to reduce risk;
- refine any remaining or identified costing information on easements, infrastructure or specialist activities;
- establish liaison with stakeholders establish the liaison channel with the community advisory group or stakeholder, as identified per the engagement strategy; and
- jurisdictions work with representative stakeholder groups to develop principles on which to base negotiations for individual land tenure agreements.

Key dependencies

Dependencies that have been identified include:

- information required to be used as part of the negotiation process, for example identification of affected land, supporting maps, data and costs; and
- agreement of the program guidelines by governments.

Private tenure mitigation

June 2017 – January 2023

In collaboration with landholders and communities, the program management group will develop a fair and transparent process to implement mitigation measures.

The infrastructure implementation costs have been broadly quantified through costings work undertaken by Jacobs (JACOBS, unpublished (a)).

Negotiations and investigations

June 2017 – January 2023

This phase aims to reach a resolution with the affected private landholder(s) on suitable ways to mitigate or offset third party impacts, mostly through land management arrangements and infrastructure upgrades.

Negotiations will need to be done in a coordinated manner, addressing all mitigation activities proposed for the land holder as one package, and will require a formal agreement to be established. If negotiations with stakeholders are still not settled by December 2022, advice will need to be sought by the overseeing agency in accordance with the Program Guidelines.

Key tasks

The key tasks of this phase will include:

- negotiating mitigation options with effected stakeholders;

- refine draft landholder agreements with stakeholders, this process is likely to include lengthy periods of statutory consultation and review; and
- agree private mitigation options with stakeholders.

Key dependencies

Dependencies that have been identified include:

- clear communication and clarity of the negotiation process for affected parties;
- liaison with the private land holder; and
- access to requested information.

Construction and transfer of private infrastructure

June 2017 – December 2022

The key tasks required to plan, design and construct, maintain or upgrade the affected infrastructure are detailed in Figure 7.

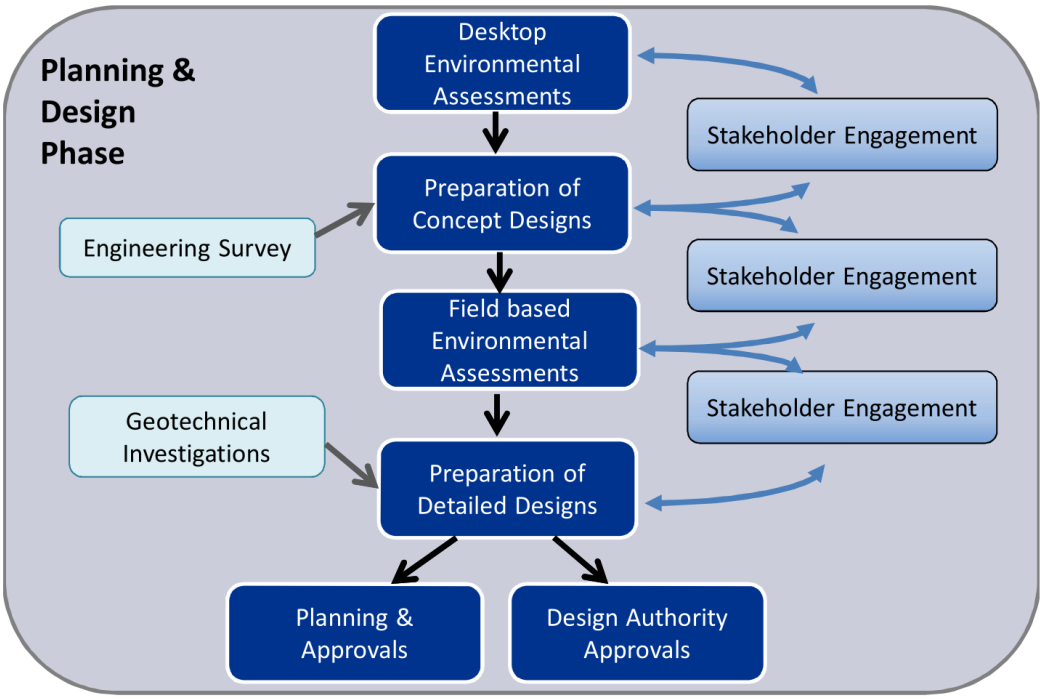


Figure 7: Flow chart demonstrating overall processes for project delivery (JACOBS, unpublished (a))

Key dependencies

This phase will be largely dependent on how the negotiation process occurs and jurisdictional processes, such as approvals which may include additional statutory community consultation and appeal processes.

Other factors

The volume of infrastructure work required may directly impact on the resourcing available within the local region. Some regions may already have capacity to manage and build the infrastructure, and other areas may need to access skills and expertise from outside the region depending on local capacity and capability.

Public asset mitigation

January 2017 – October 2022

The key finding of the Public Infrastructure consultancy (by AECOM) is that the preferred mitigation approach for public asset managers (including local councils) is the negotiation of mechanisms to provide asset owners additional resourcing to reinstate public assets (roads, parks, crossings and civil infrastructure) after CMS flows.

Negotiations and investigations

January 2017 – March 2021

Key tasks

In the public forum there are set processes to follow when funding asset management arrangements between governments and Councils. These existing processes can assist in making the negotiations, investigations, construction and contractual obligations streamlined and are likely to be in place earlier than private mitigation.

Key dependencies

- clear communication and clarity of the negotiation process for affected asset manager and
- liaison with the public land holders potential affected by impacts to public assets
- legal issues to be addressed through State and Commonwealth frameworks, such as the use of the funding of asset reinstatement works, and
- Jurisdictional processes for negotiations, investigations and other assessments.

This phase will be largely dependent on how the negotiation process occurs and associated jurisdictional processes.

Operational trials undertaken by environmental water holders

June 2016 – June 2024

It is recommended that governments conduct 'operational trials' through existing river management processes. This phase recognises that if higher flows were to be trialled, or natural flows were to occur at rates similar to those proposed in the three River Murray Constraints Measure Business Cases, these events would provide valuable opportunities to refine the knowledge base to inform negotiations and mitigation options for the future delivery of relaxed constraints flows.

Delivery of relaxed constraint flows

From June 2024

By 2024, it is anticipated that all required mitigation options will be in place.

Maximum regulated heights will only be delivered if:

- there is full mitigation for the target flow;
- there is an enduring Governance structure to support the flow;
- there is environmental water available;
- there are suitable climatic conditions; and
- river operators are comfortable that during delivery, the risk of exceeding the maximum regulated height is negligible.

The delivery of environmental flows under a relaxed constraint scenario will be largely dependent on climatic conditions. Delivery of increased flows will be an incremental process, slowly working towards maximum flow rates over several seasons.

Appendix 4: Stakeholder Engagement Strategy

Purpose

This communication and engagement plan will scope key elements for the delivery of Phase 3 of the CMS for the River Murray in South Australia from 2016 to 2024.

Stakeholder identification

A summary of key stakeholder groups that have some degree of interest in, or are affected by, the CMS is at Table 1 with a comprehensive list of stakeholders at Attachment A.

Table 13: Stakeholder identification

DEWNR	**SA Government**	**Commonwealth**	**Local Government**	**Other government**
• Executive • MDBCC • Water and Climate Change • River Murray Operations and Major Projects • Hazards Team	• SA MDB NRM Board • SA Water • DPTI • PIRSA • EPA • Dept of Health • Tourism SA • SAFECOM • SES • SAPOL • Murray and Mallee Zone Emergency Management Committee	• MDBA • DAWR • DoE • CEWO	• Local councils • Local Government Association • Murray Mallee LGA	• State Governments • Opposition • SA Power Networks • RDA Murraylands and Riverland • River Murray Advisory Committee • Murray-Darling Association (Regions 5 and 6) • MDBA Basin Community Committee
External consultants • External professional consultants	**Primary producers and industry groups** • Peak industry groups • Floodplain landholders	**Irrigators** • Individual irrigators • RIT/CIT • Irrigation trusts • Private pump owners	**Landholders** • Shack associations • Individual shack owners • Individual landholders	**Indigenous** • Indigenous nations • Traditional Owners/groups

Environmental groups	**Advocacy groups**	**Tourism**	**Communities**	**Media**
• Local Action Planning (LAP) officers • NRM groups • Community organisations • NGOs	• Business associations	• Houseboats • Recreational boaters • Recreational fishers • Caravan park owners/operators • Accommodation	• River Murray towns • Tourists/visitors • Community clubs • Broader SA community	• Local media • The Advertiser • ABC

Foundations and Principles

One of the key principles underpinning the CMS is that "Affected communities, including landholders and managers, water entitlement holders, Traditional Owners, management agencies and local government need to be involved from the beginning to identify potential impacts and solutions".

This principle has underpinned the public participation approach that DEWNR and MDBA have undertaken to date, conducting several meetings with stakeholders and communities to build understanding, identify and refine options and collect and report on community information and issues.

It is recognised that effective community engagement improves decisions by identifying critical issues early, promoting opportunities for increased awareness and understanding and providing a balanced review of the problem or opportunity by incorporating a diverse range of perspectives. It is also recognised that the effectiveness and sustainability of decisions are more enduring when factors such as local knowledge and perspectives and sensitivity to community context are also part of the decision-making equation (International Association for Public Participation 2006).

However community engagement is not just about input into decision making, engagement also has an important role in building community capacity and relationships and helping individuals and communities to move through the process of change. This is particularly important in the context of constraints management, where governments are essentially seeking new ways to manage rivers, requiring a significant period of adjustment for many landholders who have built lifestyles and businesses around expectations of regulated river behaviour.

There are seven professional standards and best practices (International Association for Public Participation 2006) that were originally developed over two years of broad international participation to identify those aspects of public participation that transcend national and cultural boundaries. The Core Values are used around the world to guide the development, implementation and evaluation of public participation processes. These practices listed below will continue to be used to guide engagement during the planning an implementation of the Constraints Management Strategy.

- The public should have a say in decisions about actions that could affect their lives.
- Public participation includes the promise that the public's contribution will influence the decision.
- Public participation promotes sustainable decisions by recognising and communicating the needs and interests of all participants, including decision makers.
- Public participation seeks out and facilitates the involvement of those potentially affected by or interested in a decision.
- Public participation seeks input from participants in designing how they participate.
- Public participation provides participants with the information they need to participate in a meaningful way.

- Public participation communicates to participants how their input affected the decision.

This communications and engagement plan has been scoped with the expectation that community input will continue at the levels of inform and consult, with some component projects such as landholder agreements and infrastructure construction extending to involve and collaborate (IAP2 Spectrum 2006). The stakeholder goals and promises are summarised in Table 14.

Table 14: Stakeholder goals and promises for each level of stakeholder impact.

Stakeholder impact level	Stakeholder engagement goal	Promise to stakeholders
Inform	To provide balanced, objective, accurate and consistent information to assist stakeholders to understand the problem, alternatives, opportunities and/or solutions	We will keep you informed
Consult	To obtain feedback from stakeholders on analysis, alternatives and/or outcomes	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how stakeholder input influenced the outcome
Involve	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the outcome
Collaborate	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	We will look to you for advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.

Issues and sensitivities

It is extremely important to set accurate community expectations about the scope (purpose and scale) of engagement being undertaken during different stages of the project, given this is an eight-year proposition of significant complexity. Based on feedback received so far, the main issues and sensitivities are:

- asset management and ongoing funding for operational and management measures to prepare for and respond to high flow events;
- opportunities to leverage co-contributions for potential mitigation measures with prospective business partners;
- the degree to which implementation of mitigation measures effectively manages risk for governments, landholders, agencies and businesses;
- lack of exposure to CMS processes, especially explanation of the benefits of high flows; and
- Basin Plan implementation reaches a critical stage of delivery, especially following a significant period of change with the recent drought and high flows.

Discussions with the agencies, communities and businesses likely to be affected by high flows have commenced and will continue during the planning and implementation phase to reach solutions on these issues and sensitivities. To address these issues and sensitivities, engagement priorities are:

- engagement needs to be very clear about what people can influence, with significant early and continuing input into expectation management;
- issues and sensitivities means that there should be a commitment across the project to providing accurate information to demonstrate transparency;

- people may need to be able to access independent advice as part of the process, and this should be built into those parts of the project where individual negotiations are likely to occur;
- need efforts to get down to the individual property level as soon as possible to provide accurate information about the process, establish relationships that need to be sustained over the long term, and start fostering a constructive process where people can start to adapt to change;
- establish ways to support community members getting involved and staying informed about sub-components of the project that require significant development and design over time;
- establish processes for community members to get involved with verifying and improving the accuracy of developing technical work; and
- if possible, aside from the focus on 'direct impact' engagement work, include scope for community wellbeing and resilience engagement, allowing those indirectly touched to adapt to change around them.

Work plan for 2016-2024

The eight year planning and implementation phase has been broken down into a number of phases to better reflect project development as well as provide points in time to evaluate project progress, risks and any need for modification. Similarly a complex project involving public and private land and infrastructure from the South Australian border to the Coorong, Lower Lakes and Murray Mouth needs to be broken down into a number of work themes.

The structure provided in the Appendix 3- Implementation Plan outlines the broad phases of work that need to be completed to address constraints as follows:

- governance arrangements;
- information refinement;
- private tenure mitigation options;
- public tenure mitigation options; and
- delivery of increased flows.

By considering the information provision and feedback needs at each of these phases it is possible to broadly map out an approach to communications and engagement with directly affected stakeholders. Table 3 'Key engagement tasks and methods for directly affected stakeholders' provides some details on important implementation tasks that require communication and feedback from stakeholders directly affected by the implementation work. The party responsible for leading engagement activities has not yet been included, but should be confirmed when states have finalised their preferred governance arrangements should funding be secured.

The participation tactics are provided in Table 15 and range from broad activities such as media and website communications to inform and consult to briefings and meetings to involve and collaborate with community and stakeholders. Using a range of participation tactics will enable different ways of gathering feedback and will provide opportunities to identify and record key issues and sensitivities and develop pathways to acknowledge and address any outstanding concerns.

The main assumptions are:

- fundamentally, the CMS will proceed beyond the Feasibility Phase;
- flow bands investigated under the CMS to assess potential third party impacts will be the same as those agreed for investment purposes; and
- communities and stakeholders are aware of the CMS process and outcomes as engagement is required to verify the potential impacts, provide a high degree of confidence in costings, and assist with smooth transitions during planning and implementation phases.

The main constraints are:

- budget limits the scope, nature and amount of engagement that can be achieved so activities and outputs will be prioritised accordingly; and
- the need for dedicated communications resources to undertake comprehensive and thorough community engagement and consultation during planning and implementation.

Table 15: Key engagement tasks and methods for directly affected stakeholders

Phase	Task	Engagement aim	Stakeholders involved	Method
Governance arrangements	Establish any working groups, advisory groups or subcommittees with clear terms of reference.	Members of these groups are aware of their roles and responsibilities with respect to progressing constraints work.	Representatives from councils, riparian landholders, state government agencies, etc.	Meetings.
	Establish supporting mechanisms for stakeholders to access independent advice on any technical, legal or engineering issues.	Riparian landholders are confident that they have access to advice to represent their collective interests in understanding the process and outcomes of negotiations about easements.	Riparian landholders as represented by these groups.	Meetings.
Information refinement	Use aerial photography to capture images of a natural (or trial) flow of around 80,000ML/day at SA border to further refine the inundation mapping.	Riparian landholders are confident that the inundation mapping to be used to establish easement boundaries will adequately reflect the extent of inundation.	Riparian landholders.	Website, emails, letters.
	Share the finalised inundation risk study and plans for mitigating risk.	All stakeholders are confident that risk of inundation has been mitigated to an acceptable level.	All affected stakeholders.	Meetings.
	Refine any remaining or identified costing information in infrastructure, specialist businesses.	All specialist business/activity stakeholders have been consulted with and are confident that the impact on specialist activities can be mitigated.	Specialist business/activity owner/operators and councils or other infrastructure owners where public infrastructure is involved in the mitigation solution.	One-on-one meetings.
	Confirmation of landholder ownership.	The lead agency has confirmation of property ownership for negotiations.	All riparian landholders.	Letters.

	Surveys – property verification surveys, development of landholder specific maps, site visits or inspections, inclusion of local knowledge.	Landholders are confident that the area subject to an easement agreement has been accurately mapped out and all on-farm activities that will be affected by higher flows have been considered in the proposed mitigation solutions.	Riparian landholders.	One-on-one meetings.
	Jurisdictions to work with representative stakeholder groups to develop principles on which to base negotiations for individual land tenure agreements.	A model for engagement and negotiation is proposed that riparian landholders are willing to sign up to.	Riparian landholders.	Meetings.
	Confirm the mitigation actions required with individual landholders.	Landholders willing to execute agreements.	Individual riparian landholders.	One-on-one meetings with landholders.
Land tenure based mitigation options	Confirm clear communication points and clarity of process for affected parties.	Affected parties (councils, businesses and riparian landholders) know where to go for information and who to talk to if they need clarification of where work is up to or if they have any concerns.	All affected stakeholders.	Meetings, website, local media.
	Legal items – drafting of contracts (including the inclusion of all mandatory requirements, maintenance if relevant and that all relevant parties are listed as beneficiaries), land is acquired according to the relevant legislation (and registration), clarity of package – either access to land, clean – up costs.	Provide all landholders and businesses with draft contracts and associated fact sheets to enhance understanding and uptake.	Riparian landholders and private businesses.	Draft contracts provided by letter Some information sessions on the process could be held prior to sending out draft contracts.

Infrastructure based mitigation options- private landholders	Surveys – property verification surveys, development of landholding specific maps for location of new infrastructure/upgrading infrastructure.	All landholders (riparian and businesses) are aware of the process for location and type of infrastructure.	Riparian landholders private businesses.	Meetings.
	Confirm structure with stakeholder, provide a draft of contract including proposed operation and maintenance schedule and diagrams of indicative structures.	Landholder has confidence in the process and will agree to the proposed infrastructure solution.	Affected riparian landholders where infrastructure is part of the mitigation.	One-on-one meetings.
Public tenure (infrastructure)	In –principle agreement with landholders for land management arrangements.	Council or agency has confidence in the process for land management arrangements.	Council/agency with affected infrastructure.	Meetings.
	Pre-Acquisition declaration published in gazette and local newspaper.	Persons affected know they have the opportunity to apply for reconsideration of declaration before the Pre-Acquisition declaration becomes absolute and relevant Minister authorises acquisition of easement.	General community.	Local media and gazette.
	Establish standard infrastructure diagrams for bridges, low-lying crossings, culverts, etc.	Councils (or other infrastructure owners) have an opportunity to provide input to the infrastructure design.	Infrastructure owners.	Email, meetings.
	Confirm structures with stakeholders, provide a draft of contract including the easement arrangements.	Councils (or other infrastructure owners) agree to the structures including the proposed operation and maintenance schedules and easement agreement.	Infrastructure owners.	Email, meetings.
	Agency and landholder enter into agreement in the relevant forms and monies are exchanged.	All parties are clear on their roles and responsibilities going forward.	Infrastructure owners.	Meetings.

Delivery of relaxed constraint flows	Confirmation that adequate mitigation activities have been undertaken to allow the delivery of higher environmental flows.	All affected stakeholders are aware that higher environmental flows are possible.	All affected stakeholders.	Local media, notifications.
	Develop process for alerting affected stakeholders that a high environmental flow is likely/imminent.	All affected stakeholders are aware that higher environmental flows are likely and are clear of the timeframes for delivery.	All affected stakeholders.	Website, meetings, local radio, notifications.
	Provide advice of imminent environmental flows to affected stakeholders.	All affected stakeholders are aware of an imminent environmental flows.	All affected stakeholders.	Notifications.
	Confirm extent of flow events with riparian stakeholders.	Continue to gain the confidence of riparian landholders by confirming the inundation extent reflects the easement footprints.	Volunteer riparian landholders.	Meetings.

Attachment A: Comprehensive list of stakeholders

Stakeholder category	Organisation	Interest/input/relevance
DEWNR	Executive	Endorsement of business case
	Murray-Darling Basin Coordinating Committee	Endorsement of business case
	Water and Climate Change Branch	Basin Plan implementation
	River Murray Operations and Major Projects	River Murray operations and infrastructure; environmental watering projects
	Hazards Team	Flood hazard leader, other flood work
SA Government	SA Murray-Darling Basin Natural Resources Management Board	Community interface
	SA Water	Impact on SA Water assets, operations
	Department of Planning, Transport and Infrastructure	Infrastructure (boat ramps, ferries etc); planning and development laws, land boundaries
	Department of Primary Industries and Regions SA	Irrigators
	Environment Protection Authority	Water quality
	Department of Health	Water quality, public health during high flows
	Tourism SA	Tourism
	SA Fire and Emergency Services Commission	Emergency management
	SA Police	Emergency management
	State Emergency Service	Emergency management
	Murray and Mallee Zone Emergency Management Committee	Emergency management arrangements, policies etc
Commonwealth Government	Murray-Darling Basin Authority	Lead development of business case
	Department of Agriculture and Water Resources	Business case funding
	Department of the Environment (previous)	
	Commonwealth Environmental Water Office	Provision of environmental water
Local Government	Renmark Paringa Council	Understand impacts, opportunities, mitigation options
	Berri Barmera Council	
	District Council of Loxton Waikerie	
	Mid Murray Council	
	Rural City of Murray Bridge	
	Alexandrina Council	
	Coorong District Council	
	District Council of Karoonda East Murray	
	Local Government Association	
	Murray Mallee Local Government Association	
Other Government	Victorian Government Department of Environment, Land, Water and Planning	Prepare business cases with MDBA through RMC SC
	New South Wales Government Department of Primary Industries Office for Water	
	The Hon Michelle Lensink MLC	Opposition spokesperson for the environment

	SA Power Networks	Potential impact on assets
	Regional Development Australia Murraylands and Riverland	Community perspective
	River Murray Advisory Committee	Community awareness (water reform generally)
	Murray-Darling Association (Regions 5 and 6)	
	MDBA Basin Community Committee	
External professional consultants	GHD	Undertake projects to inform business case
	Jacobs	
	AECOM	
Primary producers and industry groups	Lower Murray Irrigators Association	Representative views of impacts, mitigation options and general awareness-raising
	Primary Producers SA (NRM Committee)	
	SA River Communities (SARC)	
	SA Murray Irrigators Incorporated	
	Irrigation Association of SA	
	Citrus Growers of SA	
	SA Citrus Board	
	SA Citrus Industry Development Board	
	Riverland Grape Group Association	
	Riverland Wine Grape Growers' Association	
	Riverland Wine Industry Development Council	
	SA Wine Industry Council	
	SA Dairy Farmers Association	
	Meningie-Narrung Irrigators Association	
	Floodplain landholders	Location, nature and extent of inundation, possible mitigation options, environmental benefits, awareness-raising
Irrigators	Individual irrigators	Impacts, mitigation options, awareness-raising
	Renmark Irrigation Trust	Impacts, mitigation options, representative views of customers, awareness-raising
	Central Irrigation Trust	
	Woodlane Irrigation Trust	Impacts, mitigation options, representative views of customers, awareness-raising
	Pyap Irrigation Trust	
	Golden Heights Irrigation Trust (Ramco)	
	Irrigation Trust of SA	
	Sunlands Irrigation Trust	
	Jervois Irrigation District Trust	
	Pike Mundic Irrigation Association	
	Smith Family Trust	
	Haslett Holdings Pty Ltd	
	Greenways Irrigation Trust Inc	
	Private pump owners	Impacts, mitigation options, awareness-raising
Shackowners	Paisley Island Shack Community (Blanchetown)	Impacts, mitigation options, awareness-raising
	Port Milang Shack Owners association	
	Coorong Shack Owners Association	
	Blanchetown Shack Owners Association	
	South Punyelroo Progress Association	
	Teal Flat Holiday Homes Association	
	Walker Flat Holiday Homes Association	
	Greenways Landing Shack Area	

	Big Bend Holiday Home Owners Association	
	Five Mile Shack Owners Association	
	Marks Landing Progress Association	
	Langs landing association INC	
	Scotts Creek Inc	
	Bolto Reserve Progress Association Inc	
	Bowhill Holiday Homes Association Inc	
	Blanchetown Progress Association	
	McBeans Pound Committee	
	Idyll Acres Leaseholders Association	
	Brenda Park Leaseholders Association	
	Pelican Point Association	
	Old Teal Flat (rep)	
	Scrubby Flat Group	
	Caloote Landing Progress Association	
	North Punyelroo Association	
	Caurnamont Progress Association	
	Young Husband Holdings Pty Ltd	
	Individual shack owners	Impacts, mitigation options, awareness-raising
Landholders	Individual landholders	Impacts, mitigation options, awareness-raising
Indigenous	First Peoples of the River Murray and Mallee Region	Representative views of impacts, environmental benefits, mitigation options, awareness-raising
	Ngarrindjeri Regional Authority	
	Murray-Lower Darling Rivers Indigenous Nations	
	River Murray and Mallee Aboriginal Corporation	
	Mannum Aboriginal Community Association	
	Gerard Aboriginal Community	
	Aboriginal Lands Trust	
	Aboriginal Heritage Board	
Environmental groups	Mid Murray LAP Committee (Cambrai)	Environmental benefits, possible impacts experienced by others, awareness-raising
	Riverland West LAP	
	Murray Mallee LAP	
	Renmark to the Border LAP (Renmark)	
	Loxton to Bookpurnong LAP (Berri)	
	Berri Barmera LAP (Berri)	
	Mannum to Wellington LAP	
	Goolwa to Wellington LAP	
	Mallee and Coorong NRM group	Environmental benefits, possible impacts experienced by others, awareness-raising
	Rangelands NRM group	
	Ranges to River NRM group	
	Riverland NRM group	
	Coorong Lower Lakes and Murray Mouth Community Advisory Panel	Environmental benefits, possible impacts experienced by others, awareness-raising
	Lower River Murray Reference Group	
	Conservation Council of SA	
	Wetland Care Australia	
	The Wilderness Society	
	Green Australia SA	
	Nature Conservation Society of SA	
	Nature Foundation of SA	
	Australian Conservation Foundation	

	Australian Landscape Trust (Calperum Station)	
	Murraypeena Heritage Association Inc	
	Friends of the River Inc (Murray Watch)	
	Friends of Riverland Parks	
	Friends of Coorong National Parks	
	Friends of Long Island	
	Bookmark Supporters	
	Banrock Station RAMSAR Wetlands Management Advisory Group	
	Brenda park/Scotts Creek Wetland Group	
	Bolto Residents Community Group	
	Murpbook Lagoon Community Group	
	Riverland Natural Resource Management Group	
	South Australian Rivers Community Group	
	Southern Alexandrina Business Association	
	Lower lakes and Coorong Infrastructure Committee	
	River Lakes Coorong Action Group	
	MurrayCare	
	Hydrological Society of SA	
	Chowilla Floodplain Community Reference Committee	
	Birds SA	
	Community Action for the Rural Environment Team (CARE)	
Advocacy groups	Business associations (TBC)	Representative views of impacts, mitigation options and general awareness-raising
Tourism	South Australian Boating Facility Advisory Committee	Implications for boat ramps, marinas
	Boating Industry Association of SA	Impacts, mitigation options, awareness-raising
	River Murray Boat Owners Association	
	Houseboat Hirers Association	
	Inland Recreational Fishing Committee	Impacts, mitigation options, awareness-raising
	Murraylands Regional Tourist Association	Representative views of impacts, mitigation options, awareness-raising
	Canoe SA	Impacts, mitigation options, awareness-raising
	Riverland Leisure Canoe Tours	
	The Marina Hindmarsh Island	
	Blanchetown Riverside Holiday Park	Impacts, mitigation options, awareness-raising
	Berri Riverside Caravan Park	
	Greenwood Park Caravan Park	
	Kingston-on-the-Murray Caravan Park	
	Cobdogla Station Caravan Park	
	Discovery Holiday Park – Lake Bonney	
	Lake Bonney Caravan Reserve	
	Loxton Riverfront Caravan Park	
	Morgan Riverside Caravan Park	
	Renmark Riverfront Holiday Park	
	Riverbend Caravan Park (Renmark)	
	Waikerie Caravan Park	
	Punyelroo Caravan Park	

	Riverbush Cottages (Berri)	Impacts, mitigation options, awareness-raising
	17 QED Lakeside Barmera	
	Gilgens Country River Retreat	
	Aruma Ski Resort, Walker Flat	
	River Shack Rentals	
	Pompoota Homestead	
Communities	River Murray towns	Awareness-raising
	Tourists/visitors	
	Community clubs	
Media	Local media	Awareness-raising, environmental benefits, seek community engagement
	Murray Pioneer (Renmark)	
	Murray Valley Standard	
	The Advertiser	
	ABC	
	DEWNR website	
	Yoursay.sa.gov.au	

Appendix 5: Risk Assessment

A high level assessment of the risks to implementation of the measure is presented in Table 16. Risks have been assessed according to the risk assessment framework presented at Section 8.5.

Table 16: Risk assessment for implementing the South Australian River Murray constraints measure

Risk ID	Risk Description	Risk Category	Raw Risk Likelihood	Raw Risk Consequence	Raw Risk Rating	Mitigation strategies	Risk Treatment	Residual Risk Likelihood	Residual Risk Consequence	Residual Risk Rating
Project development and delivery										
Design Risk										
1	Structural failure during commissioning or operation of infrastructure.	Reputation	Possible	Moderate	Significant	Engage experienced contractors to design capital works and review prefeasibility and feasibility studies. Engage technical consultants as appropriate for further studies about conditions and structural integrity. Employ project management arrangements to ensure construction is to a suitable standard. Commission all new works gradually with stepped approach to progressively test new and/or upgraded infrastructure.	Reduction	Unlikely	Moderate	Moderate
Risk to project completion on time										
2	Delays in building approvals or contractual arrangements leading to significant project delays.	Reputation	Possible	Minor	Moderate	Clearly define approvals processes during Feasibility Phase. Assign ownership to agencies with experience developing these works and with strong procurement, contract and project management protocols. Include clear roles and responsibilities in implementation plan in business case. Monitoring and evaluation process to evaluate progress.	Reduction	Unlikely	Minor	Low
3	Natural high flow or flooding events delay construction of infrastructure on floodplains.	Reputation	Possible	Moderate	Significant	Plan to undertake construction during summer dry period. Use contractors who are experienced with building on floodplain. Normal project management arrangements to monitor delays.	Reduction	Possible	Minor	Moderate
Risk of Project Failure										
4	CMS does not proceed to the Planning and Implementation Phase for 2016 to 2024.	Reputation	Unlikely	Major	Moderate	River Murray Constraints Steering Committee and other multijurisdictional committees to meet regularly to review progress of business cases and Feasibility stage of CMS to meet Phase 2 Guidelines and funding partner requirements to implement Basin Plan. Regularly brief and update other MDB committees through the governance framework to resolve any issues as they arise.	Reduction	Rare	Major	Moderate

Inability to deliver the project within budget										
5	Inadequate cost assumptions for potential mitigation strategies.	Financial	Likely	Major	Significant	MDBA to use external professional consultants with experience and expertise in estimating costs of potential mitigation strategies on the River Murray. Consult further with technical experts during Planning and Implementation stages to verify any outstanding issues. Seek clarity on assumptions and how this translates to defining project uncertainty, risk, scope and investment. Include defined contingency for investment decisions to account for costings uncertainty. Verify costings of potential mitigation strategies with impacted parties. Build in more detailed planning and assessments for next phase of the project to refine cost estimates.	Reduction	Possible	Major	Significant
Legal and Landholder risks										
Risks associated with gaining landholder agreements										
6	Lack of landholder participation in and/or support for landholder agreements.	Stakeholders	Likely	Major	Significant	Continue communications and stakeholder engagement to involve local community in the process. Engage with effected landholders during planning and implementation phase to ensure appropriate mitigation option selected. Prepare communication principles and maintain consultation register. Develop principles for negotiating and costing voluntary processes. Engage legal advice/assistance to prepare principles and commence negotiations. Extensive engagement of landholders in proposal design and implementation.	Reduction	Possible	Moderate	Significant
7	Residual litigation risk after implementing voluntary landholder management arrangements.	Stakeholders	Possible	Major	Significant	MDBA and Basin States seek legal advice on legislative provisions and potential risks of litigation and mitigation strategies. Undertake legal assessment to identify possible legislation approaches and suite of mitigation strategies. Prepare and implement detailed communications and community engagement strategy with landholders. Increase awareness of river operators and other relevant parties of potential legal and litigation risks of environmental water policies and projects and ensure consistent approaches are implemented.	Reduction	Unlikely	Major	Moderate

Risks of impacts to landholders										
8	Extent of potential mitigation strategies does not adequately address physical constraints leading to exposure to risk during high flow delivery.	Stakeholders	Possible	Major	Significant	Engage external professional consultants with experience and expertise in defining potential impacts and mitigation strategies on the River Murray. Consult other technical experts to verify any outstanding issues. Benchmark potential impacts and mitigation strategies with other areas of the Basin. Seek clarity on assumptions and how this translates to defining project uncertainty, risk, scope and investment. Build in more detailed planning and assessments for next phase of the project to refine cost estimates. Include "buffer" in calculation of flow inundation levels for purposes of mitigation measures (Eg easements, infrastructure placement). Implement new operating regime with stepped approach to monitor flow impacts.	Reduction	Unlikely	Moderate	Moderate
Risks associated with gaining statutory approvals, changes to legislation and/or delays due to parliamentary processes										
9	Potential legal challenge by landholders or third parties (including native title claims, etc) to proposed legislative changes or mitigation strategies.	Reputation	Possible	Major	Significant	Ensure all relevant statutory development approvals have been sought and granted. Seek legal clarification on outstanding litigation risks from legal advice. Seek more detailed legal advice on specific issues as required. Include legal principles in the business case to identify possible legislation approaches and suite of mitigation strategies.	Reduction	Unlikely	Moderate	Moderate
Cumulative Impacts										
Risks associated with flow-on effects of implementing the project and the collective impacts of interactive measures										
10	Exacerbated flood risk of unexpected rainfall events during or following the delivery of high flow events resulting from relaxing physical constraints.	Reputation	Unlikely	Moderate	Moderate	Continue multijurisdictional governance arrangements to oversee the development of consistent policy approaches to address exacerbated flood risk of high flow events from relaxing physical constraints. Ensure policy approaches are consistent with flood hazard warning approaches for Basin States. Implement operating regime with stepped approach and ongoing monitoring and evaluation to assess changing flood risk. Continue to engage technical consultants in the delivery of infrastructure assessed against updated modelling and inundation layer maps.	Reduction	Rare	Moderate	Low

11	Physical constraints relaxation is not maximised thereby preventing full use of environmental water due to headwater storage release limits, timed release limitations, river operator actions.	Environmental	Possible	Moderate	Significant	Involve operators and CEWO through proposal development. Support changes to provide operators with better coverage. Enhanced rainfall and stream-flow gauging networks to improve rainfall-runoff models and improve understanding of system responses, especially in unregulated rivers. Commit to pre-requisite policy measures implementation plans in business case. Continue participation in multijurisdictional governance committees to identify options and processes to address channel capacity sharing.	Reduction	Unlikely	Moderate	Moderate
Environmental/Ecological risks										
See Appendix 2 for detailed assessment & management plan of ecological risks										
Salinity & Water quality										
See Appendix 2 for detailed assessment & management plan of ecological risks										
Cultural Heritage										
Ongoing and once-off implications for significant sites										
12	Potential impacts to indigenous cultural heritage from high flows resulting from relaxing physical constraints.	Stakeholders	Possible	Major	Significant	MDBA to use external professional consultants with experience and expertise in assessing potential impacts to indigenous cultural heritage on the River Murray. Consult other technical experts within SA government to verify any outstanding issues. Build in more detailed planning and assessments for next phase of the project. Ensure communications and engagement plan includes pro-active consultation with native title holders and groups impacted by cultural heritage. Conduct cultural heritage assessment and identify key stakeholders.	Reduction	Unlikely	Moderate	Moderate
Social & Economic										
Stakeholder acceptance risks; downstream third party impacts, access to parks for public use and pumping duration risks										
13	Large natural flood during implementation phase causes increased community/stakeholder concern about damaging floods	Reputation	Possible	Moderate	Significant	Continue to implement communications and engagement plans to include community and landholders in proposal design. Engagement and communications strategy to communicate the lower level of flows being proposed. Take advantage of opportunities to verify flow inundation modelling to increase confidence in assessment of potential impacts and mitigation strategies.	Reduction	Possible	Minor	Moderate

Modelling										
Risks associated with the modelling (assumptions, accuracy of model, accuracy of input data, interpretation of modelling outcomes)										
14	Incorrect flow inundation modelling leads to poor assessments of the scale of potential impacts.	Reputation	Likely	Moderate	Significant	Modelling and GIS analysis conducted by technical experts from the MDBA. Include adequate physical buffer area for assessing scale of potential impacts. Use most up-to-date datasets on infrastructure and land tenure through technical investigations. Verify spatial data with available satellite imagery. Consult other technical experts to verify any outstanding issues. Seek clarity on assumptions and how this translates to defining project uncertainty, risk, scope and investment. Include defined contingency for investment decisions to account for modelling uncertainty. Verify scale of potential impacts with historical accounts of landholders. Build in more detailed planning and assessments for next phase of the project.	Reduction	Possible	Minor	Moderate
Operation, Maintenance & Management										
Risks re operation and management of the measure post completion/commissions that may affect the enduring benefits of the measure including any risks to projects that require future regulatory change. This should include ongoing monitoring, evaluation and reporting around the operation and ecological outcomes associated with the project.										
15	Lack of clearly defined roles and responsibilities for operation and maintenance of potential new and upgraded infrastructure.	Financial	Likely	Major	Significant	Clearly define roles and responsibilities for operations and maintenance of potential new and upgraded infrastructure with business partners during business case development and implementation. Leverage capital works during negotiations with business partners to offset operations and maintenance costs. Implement communications and engagement strategy.	Reduction	Possible	Major	Significant
Security of Funds										
Risks that may affect the security of funds sources for the project to support project implementation into the future										
16	Inability to use Water for the Environment Special Account to fund operations and maintenance costs for physical constraints.	Financial	Likely	Major	Significant	Leverage other funding sources with business partners to fund operations and maintenance costs for potential new and upgraded infrastructure. Explore other opportunities to fund operations and maintenance costs.	Reduction	Possible	Major	Significant

Appendix 6: Projects Commissioned

Independent consultants were engaged to undertake five projects to assess impacts, mitigation measures and costs. These projects are summarised in Table 17.

Table 17: Projects commissioned under the Constraints Management Strategy

Project	Consultant(s)	Tasks	Sub-tasks	Methods used
Levee works	AECOM	Assess levee works required in the Yarrawonga-Wakool, Murrumbidgee and South Australia key focus areas and associated costs	Collate data on characteristics of the levee network Review publicly available information relating to levee condition Assess potential impacts and response measures Prepare cost estimates for proposed response works	Expert analysis
Agricultural land	GHD	Undertake assessment of impacts and benefits on agriculture, and the costs of easements that may be required over the land in light of those impacts or benefits	Define key economic assumptions, e.g. land use, land value, impacts Define hydrological assumptions, i.e. frequency/timing/duration of flows Calculate costs	Primarily desktop based, supplemented by consultation with informed stakeholders (e.g. agricultural experts) Draw on modelling undertaken by MDBA (refer to Appendix 7)
Public infrastructure	AECOM	Refine assessment of public infrastructure (e.g. roads, crossings, bridges, stormwater), how it might be affected by changes in flows, and mitigation options and costs.	Reassess and refine existing GIS-based datasets Consult with regional stakeholders to refine understanding of impacts on specific infrastructure items, and works required Estimate costs of infrastructure works	Expert analysis Consult with regional stakeholders Expert analysis

Implementation costs	Jacobs	Assess what processes would be required to implement mitigation measures, and estimate costs of those processes	Stocktake of approval and management requirements relevant to implementing mitigation measures Estimate costs of processes Prepare advice on implications on potential governance options on CMS infrastructure implementation.	Expert analysis
Specialist activities	Jacobs	Consider specialist activities (e.g. caravan parks, golf courses, quarries and Murray Shacks), how they might be affected by changes in flows, and mitigation measures and costs	Identify specialist activities which would be affected, and develop methodology for identifying potential impacts and appropriate mitigation measures. Engage with potentially affected businesses and develop story about how affected Develop indicative estimates of costs	Expert analysis Consult with regional stakeholders Expert analysis

The main assumptions for the costs estimates are at Table 18.

Table 18: Assumptions and caveats associated with the cost estimates

Issue	Assumption/caveat	Implications for cost estimates
Hydrology	Cost estimates are based on very specific hydrological assumptions (refer to description of modelling in Appendix 7). For costing purposes, it has been assumed that the outcomes of that hydrological modelling represent an outer envelope of what is hydrologically feasible, if constraints were relaxed.	Expected to result in overestimate rather than underestimate
Land management arrangements over agricultural land	Assume that land values, agricultural gross margins and impacts of higher flows can be generalised in a model. Model assumptions have been "ground truthed" through consultation with relevant local experts, but by necessity they are still average values. In reality they would vary from property from property.	Estimates are considered fit for purpose at regional level but not at a more local scale. A contingency of 10% has been built into the land management arrangements costs.
Land management arrangements – administrative costs	A $5,000 "administration" cost has been assumed per property. These costs include establishing the criteria for calculation of the level of compensation, site inspections and negotiations with land owners and legal costs to include easements on land titles. Based on previous experience in negotiating easements along the Hume-Yarrawonga and Mitta-Mitta regions.	Estimate may be too low if stakeholders require a different level of administrative cost to what was required in Hume-Yarrawonga.

Infrastructure on agricultural land	Broad assumptions have been made regarding the nature of infrastructure works required on agricultural land, and the number of properties affected	Estimated costs are small (less than $1 million) and therefore not highly material to overall cost estimates. Assumptions are considered appropriate for feasibility assessment.
Capital works on public infrastructure	These assets were identified by stakeholders (e.g. councils) and reviewed by engineering experts (AECOM). However, there were practical limitations to the level of detail to which cost estimates could be made for these works.	Cost estimates are considered "prefeasibility" in terms of accuracy. A contingency of 15 to 60 percent has been built in to base cost estimates. A further 12 to 160 percent contingency has been added to cover potential additional implementation costs. Estimates are considered more likely to be overestimates than underestimates.
Reinstatement works on public infrastructure	Identified through a desktop analysis, supplemented by consultation with stakeholders (e.g. councils). However, there were practical limitations to the level of detail to which the consultation process could consider individual infrastructure items.	Estimates are considered fit for purpose at LGA level but not at a more local scale
Works on levees	Desktop assessment only. Insufficient data and time meant it was not feasible to consider levees through a detailed on-ground assessment.	Cost estimates are considered "prefeasibility" in terms of accuracy. A contingency of 40 to 120 percent has been built in to base cost estimates. A further 12 to 17 percent contingency has been added to cover potential additional implementation costs. This range represents the relative uncertainty relating to certain levee types. Estimates are considered more likely to be overestimates than underestimates.
Specialist activities	Identified through a desktop analysis, supplemented by selected "case studies" from which costs have been extrapolated.	Estimates are considered fit for purpose at regional level but not at a more local scale, or for individual activities (or categories of activity). A contingency of 100 percent has been built into base cost estimates. A further 30 to 100 percent contingency has been added to cover potential additional implementation costs. Estimates are considered more likely to be overestimates than underestimates.

A sensitivity analysis was also conducted as is presented in Table 19.

Table 19: Outcomes of sensitivity analysis

Impact	Key uncertainties considered	Analyses undertaken	Implications for cost estimates
Impacts on public infrastructure	Test key assumptions underlying the cost estimates, and assess the implications of varying these	Sealed roads (*inundation length* change by 20 percent; and *quantities* reduced by 10 percent) Unsealed roads (*quantities* increased by 20 percent)	The variables with the greatest cost impact are: on the PV for the South Australia Murray Reach are:

	assumptions for the estimated reinstatement cost	Tracks *(quantities* doubled) Shared Path/Walking Track (increase *repair intervals* from 50m every 20m) Culverts (*replacement quantities* doubled, and *end wall reinstatement* quantities doubled) Culverts (applied *clean up only* costs to 2/3 of events) Bridge (applied *clean up only* costs to 2/3 of events) Landscaped Area (+-2% change in quantity allowance) Landscaped Area (uncapped) Landscaped Area (assume $10,000/shire only) Total Cost (activate response 90% of events only)	• Operation Response cost to 90% of events only -10% • Change in quantity of unsealed roads impacted +7% • Change in the repair cost of tracks +5%
Impacts on specialist activities	Test key assumptions underlying the cost estimates, and assess the implications of varying these assumptions for the estimated mitigation costs	Twenty sources of uncertainty were included in the analysis (see JACOBS unpublished, 2015(6)). A Monte-Carlo analysis method was used to develop distribution ranges for key outputs by varying inputs according to the limits set by the uncertainty data. Two types of distribution were applied; even distributions where the uncertain parameter could take on any value within the specified bounds with equal probability, or triangular whereby the uncertain parameter would take on central values more often than extreme values.	The Monte Carlo analysis produced a probability distribution of estimated costs. The P50 and P90 costs were reported as the "moderate" and "high" estimates by the study. It is expected that the 100 percent contingency would be sufficient to cover potential cost factors identified in the Monte Carlo Analysis.
Levee works	Not tested		

Levee works

Context and scope

Potential works on levees were identified as an issue during the 2014 prefeasibility phase, but not assessed. It was therefore necessary to consider levee works in more detail in the 2015 feasibility phase.

AECOM was engaged to assess potential implications of relaxing constraints for levees in the Yarrawonga-Wakool, Murrumbidgee and South Australia.

AECOM did not consider levee works in the Goulburn as these were assessed through separate projects commissioned by the Victorian Government.

Approach to assessing impacts and mitigation options

AECOM's study aimed to improve knowledge of:

- the location and representation of levees in the key focus areas;
- the potential impact of flows on the located levees; and
- the identification and prioritisation of mitigation options.

AECOM undertook a levee desktop assessment which included:

- collating and review of current publically available data and data provided by MDBA;
- topographic assessment of LiDAR data to identify potential levee locations;
- create a GIS layer for levees, utilising data quality flags to highlight uncertainty on the location of the levee;

- identify levee information gaps;
- create infilled levee data through the development of an automated GIS script;
- undertake an assessment on the location of the levees compared to specified inundation extents to determine if any levees are within or adjacent to the predicted inundation extent; and
- estimate the length of levee within each inundation extent.

AECOM initially undertook the above desktop assessment for the Yarrawonga-Wakool reach, for inundation extents of 50,000 and 65,000 ML/day. After the methodology had been tested, they then applied it to the Murrumbidgee and South Australian reaches.

AECOM identified impacts and developed mitigation options and costs by:

- reviewing publicly available information and liaising with MDBA personnel to determine if any levee condition assessments had been undertaken for the identified lengths;
- for levees that were assessed as potentially affected by increased flows, costing mitigation responses as detailed in Table 20.

Table 20: Rule of Thumb for levee costings

Levee failure Mechanism	Response	Criteria	Allowance for flow events <7 days	Allowance for flow events >7 days
Crown depression	Crown depression repair	Overtopped levees	Removing the existing surface and strip the top layer 100mm. Backfilling levee material 200mm.	**As per <7 days allowance**
Minor erosion of water side slope and toe	Levee widening	Flood controlled levees	Widen levee bank material by 0.3m and key toe into in situ material.	Re-establish pre-erosion slope by compacting embankment material as well as armouring slope with rock.
Major erosion of water side slope and toe	Water side slope restoration	Flood controlled levees	Replace embankment material in the eroded portion of slope. Include a 150mm bedding layer and place a 400mm thick layer of angled rock.	**As per <7 days allowance**
Erosion of land side slope and toe	Land side slope restoration	Overtopped levees	Replace embankment material in the eroded portion of slope.	**As per <7 days allowance**

Levee Failure Mechanism	Response	Criteria	Allowance for <7 days	Allowance for >7 days
Seepage/Piping	Undrained toe berm	Overtopped levees and Flood controlled levees	Construct undrained toe berm. Place and compact soil in lifts to achieve minimum height (1/3 of the levee height) and width (two times the berm height).	Construct drained toe berm. Drainage system includes a 300mm filter layer and 300mm drainage rock layer. A geotextile is placed between the drainage rock and overburden soil,
Saturation	Levee replacement	Flood controlled levees	Re-build levee and key into existing structure (core/cut off trench/surfacing) 50%	Re-build levee and key into existing structure (core/cut off trench/surfacing) 100%
Desiccation cracks	Surface repair	Overtopped levees and Flood controlled levees	Strip top layer of levee material 100mm and backfill levee material to match design elevations and slopes.	As per <7 days allowance
Animal burrowing	Slope restoration	Overtopped levees and Flood controlled levees	Replace embankment material in the eroded burrow to restore the	As per <7 days allowance

			levee slope to the slope of the adjacent undamaged levee or flatter.	
Tree and shrub roots	Vegetation removal	Overtopped levees and Flood controlled levees	Remove tree and shrub roots and reinstate the surface by placing and compacting embankment material in the exposed portion to restore the levee slope to the slope of the adjacent levee.	As per <7 days allowance
Land side slope instability			Replace embankment material in the eroded portion of slope. Include a 150mm bedding layer and place a 400mm thick layer of angled rock.	As per <7 days allowance
Water side slope instability	Partial levee replacement.	Overtopped levees	Replace embankment material in the eroded portion of slope. Include a 150mm bedding layer and place a 400mm thick layer of angled rock.	Remove loose debris and excavate existing levee embankment and foundation. Prepare the subgrade and the remaining slope face for embankment construction. Place and compact soil in lifts to achieve required height and width. 50%

What was taken into account in cost estimates

Cost rates and estimates were prepared and verified by qualified Quantity Surveyors with experience in flood recovery works. Cost estimates were prepared based upon the rectification works that may be required post an inundation event of identified levees within the subject area. The estimates were based upon the specific type of levees that will be inundated, and were prepared based upon an indicative first principles estimate build-up. Generally, the rates for the earthen levees are based upon the following:

- trapezoidal levee with 3m crest width, 1m high, 1 in 3 batter slopes;
- earthworks rates sourced from recent projects in the region;
- quotations from local soil suppliers and quarries for materials delivered to site; locations not exceeding 75km from the source, including culvert structure and fill material
- a 2% allowance for minor works to facilitate drainage of adjacent land (e.g. drainage outlets including regulators/syphons);
- allowance for the construction of an access track of 4.5m for levee repair works and farm reinstatement works to allow drainage of farmland (for levees located on private land);
- 50% of locally sourced suitable earth fill (within approximately 10km); and
- 50% contingency.

Life Cycle of Levees

The consultants have advised that Levees in this region typically have a 100 year life cycle. Most of the levees affected are between 50 and 80 years through their life cycle. Consequently the consultants have costed mitigation measure over a 30 year timeframe (i.e. remaining timeframe in the levees life cycle). Levee reinstatement costs identified in this report were estimated for a 30 year period. This period is consistent with the anticipated remaining life of the oldest levees in the catchment and is also a typical timeframe for the evaluation of infrastructure, used by Infrastructure Australia and other infrastructure funding agencies.

It was assumed that response measures would be required for 1m in every 30m of levees affected by an event. This factor is consistent with the approach taken in Victoria for the North Central Catchment Management Authority (NCCMA) and Goulbourn Broken Catchment Management Authorities (GBCMA). Engineering judgment was applied to increase this factor to 1m every 15m for inundation events greater than a 7 day duration.

AECOM used the following information/ data to assess impact and mitigation options and costs for this project:

- Maunsell Australia Pty Ltd (April 2009) Floodplain Risk Management Study –Edward, Wakool & Niemur Rivers –Stages 1, 2 and 3;
- SMEC in conjunction with Brian Mitsch and Associates (Feb 2003). Edward/Wakool Rivers – Stages 1, 2, 3 – Rural Floodplain Management Plan – Phase A Compendium of Data;
- SMEC in conjunction with Brian Mitsch and Associates (May 2004). Edward/Wakool Rivers – Stages 1, 2, 3 – Rural Floodplain Management Plan – Phase A Flood Study;
- Environment, Climate Change & Water (January 2011) Floodplain Management Plan, Edward and Wakool Rivers Stage 1 Deniliquin to Moama-Moulamein Railway;
- Water Technology (January 2013) Rural Levees Assessment Final Report;
- ID&A (March 2002) Tuppal and Bullatale Creeks – Data Collection and Flood Study – Flood Study Report;
- ID&A (March 2002) Tuppal and Bullatale Creeks – Data Collection and Flood Study – Compendium of Data Report;
- NSW Government Department of natural Resource (May 2004) Tuppal and Bullatale Creeks Floodplain Management Plan maps;
- Victoria Department of Water, Land and Biodiversity Conservation (DELWP) 2014, General Layers (including crown public land, land parcels, roads, streams, and water network);
- Rural Levees Assessment 2012, North Central Catchment Management Authority (CMA);
- NSW Floodworks, NSW Department of Primary Industries (DPI);
- SA Levee Bank Management Strategy2015, Department of Environment, Water and Natural Resources (DEWNR);
- SA Levee Banks 2011, DEWNR;
- NSW Land and Property Information (LPI) Digital Topographic Database, 2014.

Agricultural land

Context and scope

During the CMS prefeasibility phase, GHD was engaged to investigate and estimate the likely costs associated with ensuring passage of environmental flows over agricultural land. The prefeasibility study focused primarily on the purchase of easements from landholders, but also looked at other potential arrangements. The principal output of the study was a desktop-based model to calculate the likely

magnitude of costs associated with the purchase of easements. The model provides an estimate of how changes to the flow regime might have implications for the *worth of the affected land*[6] as a function of impacts on agricultural activity. The model was applied to a set of different flow scenarios in order to enable comparison between options.

This model was not applied to South Australia for the prefeasibility phase, on the basis that it was expected that any impacts in South Australia would be minor, as affected land would predominantly consist of lower-value native pastures.

Approach to assessing impacts and mitigation options (feasibility phase)

For the feasibility phase, GHD was engaged to undertake further work.

In South Australia, GHD undertook modelling to develop an indicative estimate of the possible costs of easements for affected agricultural land in South Australia. For the purposes of this assessment, GHD built on their existing model for the Lower Darling by:

1. using ACLUM land use classifications, refined through further checking against satellite imagery;
2. using livestock gross margins for grazing tolerant pastures for the Lower Darling, which were assumed to apply in the region of South Australia affected;
3. providing estimates to the South Australian Department of Environmental, Water and Natural Resources (DEWNR) for review;
4. updating hydrology assumptions to reflect modelling work undertaken during 2015. The hydrological assumptions used are summarised in Appendix 7.

GHD's work in South Australia was purely desktop based. Unlike in other reaches (Hume-Yarrawonga and Yarrawonga-Wakool) GHD did not undertake landholder visits or case studies in South Australia. This was considered appropriate given the very low cost estimates.

What was taken into account in cost estimates

GHD considered impacts and mitigation options on inundated land for the following land use types:

- grazing tolerant pastures; and
- horticulture

In 2014, GHD assessed that the inundation of tolerant pastures along the Lower Darling reach would result in pasture rejuvenation given the underlying semi-arid climatic conditions. GHD has similarly assessed that inundation on tolerant pastures would promote pasture rejuvenation on affected land in South Australia. This impact of inundation could be considered a direct benefit.

In addition to the benefit of pasture rejuvenation, GHD recognised that inundation would potentially result in other costs, including those associated with foregone grazing and clean-up.

Impacts and costs as a result of interrupted access were considered to be negligible. This was due to the relatively flat topography and the general absence of flood runners that could otherwise restrict access to livestock for management purposes. As a result, the costs associated with interrupted access were calculated as zero.

[6] "*Worth of affected land"* is calculated as a function of "*agricultural land worth"*.

Public infrastructure

Context and scope

During the CMS prefeasibility phase, URS engineering consultants were engaged to investigate the costs associated with potential infrastructure works to mitigate the impacts of higher environmental flows – for example, works on roads or river crossings.

URS developed a desktop-based model which assumed that "unit rates" could be used to estimate the costs of infrastructure work. Desktop-based GIS analysis was used to identify what infrastructure would potentially be affected, through assessment of the intersections between GIS-based infrastructure datasets, and modelled inundation maps at different flow rates. URS also assessed the costs associated with a small selection of specified larger infrastructure items.

In 2015 AECOM was engaged to undertake work during the CMS feasibility phase, to build on and refine the assessment undertaken by URS in 2014. AECOM undertook this work in the following key focus areas: Hume-Yarrawonga, Yarrawonga- Wakool, River Murray in South Australia, Murrumbidgee, and Goulburn.

Note that AECOM considered only public[7] infrastructure. Infrastructure on agricultural land was considered separately by GHD through the private agriculture project.

Approach to assessing impacts and mitigation options

AECOM refined the prefeasibility costing work by:

- creating a spatial (GIS) database of available information;
- identifying assets at risk, in consultation with regional stakeholders;
- developing responses/treatments for assets at risk;
- preparing an estimate of probable cost for response/treatment measures; and
- undertaking an assessment of the total cost for each reach.

A key element of the project was working with on-ground stakeholders to ground truth assumptions and modelled inundation outcomes of infrastructure that would be affected at the specified flow rates. AECOM engaged with asset managers from local councils and state government through a combination of regional meetings and teleconferences:

What was taken into account in cost estimates

During their consultations with local councils and other public asset managers, AECOM found that:

[7] For the purposes of this project "public infrastructure" included:

- transport infrastructure (e.g. roads, crossings, bridges) which is owned or maintained by governments (e.g. local councils);
- stormwater and sewerage infrastructure which is owned or maintained by local councils;
- levees which are owned or maintained by local councils and which are used to help manage the effects of higher river levels and/or significant rainfall events;
- river operation infrastructure (e.g. locks, weirs, floodgates, regulators) which are publicly owned or maintained;
- irrigation infrastructure (e.g. irrigation channels, drainage canals) which is owned or maintained by corporate entities (e.g. irrigation companies), even where those corporate entities are privately owned and operated (e.g. Murray Irrigation Limited).

Similar infrastructure which is owned or maintained on agricultural land (e.g. roads, crossings, bridges, levees on agricultural land, private irrigation pumps) was outside the scope of this project.

- substantial capital upgrade works would not be typically required to mitigate against environmental flows. Council's identified that the most efficient approach to mitigate environmental flows is to proactively manage, or directly respond to the impacts of the events. A small number of exceptions for assets requiring upgrade were identified and recorded;
- very few culverts or bridges require physical repair/replacement after flow events. The typical response was clean up of silt and debris and reinstatement of beaching where materials had been washed away;
- roads subject to inundation or even water to the road shoulder would not necessarily require works, but experienced greater rates of deterioration in the months after flows;
- operational costs to enact mitigation controls (such as road management/closing and shutting off backflow prevention valves) was a common cost, not captured by asset costing;
- duration of inundation extending beyond seven days has an amplified impact on damage and costs. The impacts of this have been considered in proposed treatment measures and associated costs, and separate calculations prepared for each outcome;
- landscaped areas (including manicured grassed parks and sports fields) require rectification; and
- waterside infrastructure (such as jetties, pontoons, boardwalks) often require maintenance and repair.

AECOM considered the following mitigation responses in developing cost estimates as outlined in Table 21.

Table 21: Public infrastructure impacts and mitigation responses

Asset Class	Definition / Description	Response	
		Allowance for <7 days	Allowance for >7days
Sealed Road	Sealed roads are typically any roads that have a bound surface finish; primarily asphalt but may also include concrete. Local Government Authorities: Any sealed road with Arterial, Sub-arterial, or Local classification that are owned or maintained by a Local Government Authority. Other Public Asset Owners: Road classes with a Major (assumed Freeway or Highway which are State owned) classification and sealed surface. Any sealed road that are within National or State Forests, or reserves that are not owned or maintained by a Local Government Authority.	Intermittent pothole rectification Allowance: Applied to 100% of the identified impacted sealed roads. Scope: 1 x 1 sqm pothole rectification every 20 m length of affected pavement	Intermittent pothole rectification Allowance: Applied to 90% of the identified impacted sealed roads. Scope: 1 x 1 sqm pothole rectification every 10 m length of affected pavement. Pavement Rehabilitation Allowance: Applied to 10% of the identified impacted sealed roads. Scope: Scarify and overlay 150 mm unbound granular road base with 7 mm to 14 mm 2-coat spray seal.
Unsealed Road	Unsealed roads are typically roads that are used for regular access to properties or assets, which have a formed earth material pavement (typically crushed rock or other compacted granular material) to a defined engineering standard. Local Government Authorities: Any unsealed road with Arterial, Sub-arterial, or Local classification that are owned or maintained by a Local Government Authority. Other Public Asset Owners: Any unsealed road with Arterial, Sub-arterial, or Local classification that are within National or State Forests, or reserves that are not owned or maintained by a Local Government Authority.	Road regraded Allowance: Applied to 100% of the identified impacted unsealed roads. Scope: Regrading of 8 m wide section without crushed rock supplement.	Road regraded Allowance: Applied to 100% of the identified impacted unsealed roads. Scope: Regrade 8 m wide section with 30 mm average crushed rock supplement.
Track	Tracks are typically assets which are used for infrequent access to sites or for recreational use (i.e. 4WD tracks), which are of suitable dimensions for vehicle access but possibly not constructed to a defined engineering standard. Local Government Authorities: Any road with a Track classification that is owned or maintained by a Local Government Authority. Other Public Asset Owners: Any road with a Track classification that are within National or State Forests, or	Ad-hoc maintenance allowance Allowance: Applied to 100% of the identified impacted tracks. Where the value of impacted tracks within a Local Government Authority area is less than $1,000, then no costs are allocated. Scope: [redacted] of inundated	Ad-hoc maintenance allowance Allowance: Applied to 100% of the identified impacted tracks. Where the value of impacted tracks within a Local Government Authority area is less than $1,000, then $1,000 of cost is allocated. Scope: [redacted] of inundated track. This does not equate to [redacted] cents per metre length of inundated track. The cost allocation, for example, may rectify a number of small defects over a 10 km length of track.

	reserves that are not owned or maintained by a Local Government Authority.	track.This does not equate to [redacted] cents per metre length of inundated track. The cost allocation, for example, may rectify a number of small defects over a 10 km length of track.	
Shared Path / Walking Track	Shared user paths are walking or cycle paths. These are typically defined paths that are for recreational use and have not been designed for vehicle access. Local Government Authorities: Any road with a Recreational classification that is owned or maintained by a Local Government Authority. Other Public Asset Owners: Any road with a Recreational classification that are within National or State Forests, or reserves that are not owned or maintained by a Local Government Authority.	Surface repair Allowance: Applied to 100% of the identified impacted tracks. Scope: 2 sqm crushed rock reinstatement every 50 m of inundated length.	
Bridge	Bridges provide road access over a river or floodplain. They may be associated with Local Government Authorities and Other Public Asset Owner roads.	Silt/debris removal and rock abutment reinstatement Allowance: Applied to 100% of the identified impacted bridges. Scope: Clean up bridge columns from gross pollutants (i.e. branches, litter etc) and reinstate 60 sqm of 300 mm rock rip-rap abutment lining.	
Culverts	Culverts are typically a pipe structure that allows water to flow under a road. They generally consist of four main components - a pipe, two headwalls, beaching at each headwall and the road over the pipe. It may be associated with Local Government Authorities and Other Public Asset Owner roads.	Silt/debris removal and rock beaching reinstatement Allowance: Applied to 100% of the identified impacted culverts. Scope: Pressure wash culvert and reinstate 10 sqm rock beaching at each headwall.	Culvert replacement Allowance: Applied to 1% of the identified impacted culverts. Scope: Replace 1 x 12 m long by 600 mm diameter culvert including headwalls and reinstate of pavement above. End wall reinstatement Allowance: Applied to 4% of the identified impacted culverts. Scope: Reinstate headwalls (2 no. off) for 1 x 600 mm diameter culvert with 10 sqm rock beaching at each headwall. Silt/debris removal and rock beaching reinstatement Allowance: Applied to 95% of the identified impacted culverts. Scope: Pressure wash culvert and reinstate 10 sqm rock beaching at each headwall.
Fords	Fords are a low area along a river or stream that is used as a road crossing, but designed for inundation/overspill in high flow events.	No asset reinstatement response applied. The cost of reinstatement of fords is considered to be included within the unsealed road maintenance allowance.	

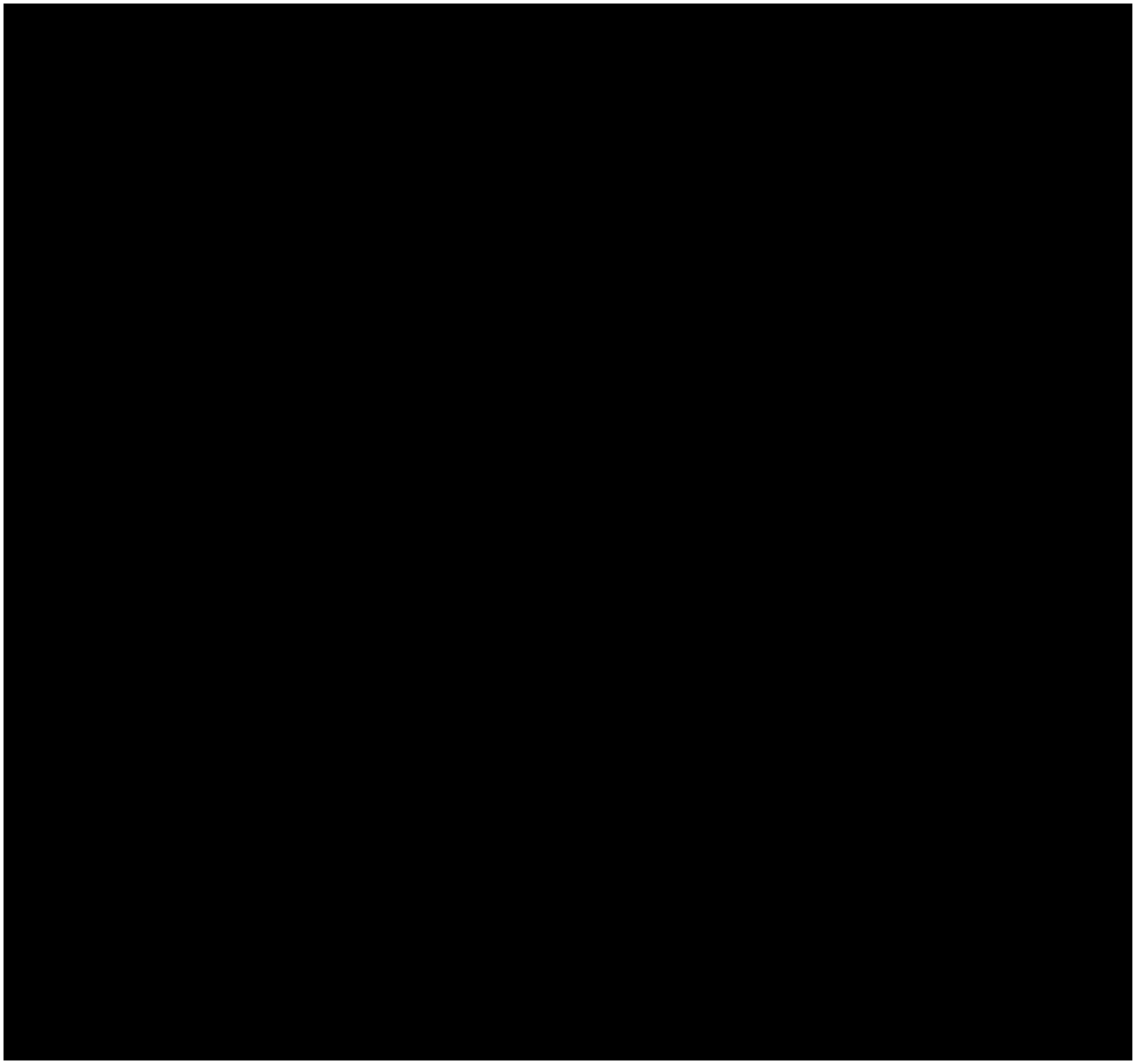
	It may be associated with Local Government Authorities and Other Public Asset Owned roads.		
Landscaped Area	Landscaped areas are grassed areas such as parks and sports fields which require rehabilitation after periods of inundation. These were identified using the land use planning zones which are generally referred to as: PPRZ, Public Park and Recreation Zone (Victoria and NSW); RE1, Public Recreation (NSW); Open Space (SA). These zones are referred to as 'Open Space' for consistency. Response measures would be applied to manicured (regularly mowed and actively used) landscape areas only.	Silt/debris removal only and Silt/debris removal and re-seeding Allowance: 1% of identified Open Space within Local Government Authority areas. If the value of reinstatement of Open Space was less than $10,000; $10,000 was allocated to the Local Government Authority area. If the value of reinstatement of Open Space was greater than $250,000; $250,000 was allocated to the Local Government Authority area. Scope: Two asset reinstatement measures were applied to impacted Open Space for events <7 days: 80% has silt/debris removal only – based on a hectare rate for scraping 50 mm silt and removing to suitable fill area within 10 km 20% has silt/debris removal and re-seeding	Silt/debris removal and re-seeding Allowance: 1% of identified Open Space within Local Government Authority areas. If the value of reinstatement of Open Space was less than $10,000; $10,000 was allocated to the Local Government Authority area. If the value of reinstatement of Open Space was greater than $250,000; $250,000 was allocated to the Local Government Authority area. Scope: Hectare rate for scraping 50 mm silt and removing to suitable fill area within 10 km and hydro-seeding.
Operational Costs	Asset Managers (Councils) have incurred additional resourcing costs associated with preparations.	Enacting mitigation controls (such as road management/closing and shutting off backflow prevention valves) was a common cost, not captured by asset costing.	

AECOM also considered a number of potential infrastructure items which would require capital works, which were identified during the stakeholder consultations and expert analysis. These items are detailed in Table 21.

AECOM utilised a number of datasets as part of their analysis:

- Collaboration between CSIRO & Murray–Darling Basin Authority (MDBA) 2015, Flow inundation modelling (65K, upper limit extent);
- Collaboration between CSIRO & MDBA 2014, Flow inundation modelling (20K, 35K, and 50K extents);
- Digitised Point crossings, NSW LPI Digital Topographic Database, 2014;
- Point Crossings, VICMAP, 2014;
- Roads on private land and public land, NSW LPI, 2014;
- Roads on private land and public land, Victoria DELWP, 2014;
- NSW LPI 2014 Cadastre of Public land;
- VICMAP 2014 Crown land Public Land Management (PLM25), Victoria DELWP;
- River Murray Water Main Structures and Hydrologic Indicators sites, MDBA 2008.

Implementation costs



Works on riparian and floodplain areas: The vast majority of the works proposed to be implemented under the CMS will be located in riparian and floodplain areas that are regularly subjected to flooding. An acknowledgement of this risk will need to be built into the proposed implementation strategies and a consistent approach to the management of this risk should be developed to ensure that project implementation is not unduly impacted by the inevitable inundation events.

Works on private land: The current program of works for the CMS includes significant numbers of works items that will be constructed on private land on behalf of private landholders. Works completed on private land will be inherently more complex as a result of the need to engage with a diverse range of individual landholders who have varying acceptance of the program.

Approvals Considerations

Planning application and approvals process: An integrated approach to design, application, stakeholder consultation and approvals is required for the proposed CMS infrastructure works programs. This will ensure that the implications of any change to the proposed works package are well understood and that there are no surprises as the proposed works are developed. It will also drive cost savings in undertaking planning and environmental assessments.

Flood prone areas of land are in many instances subject to a wide range of planning and environmental protection controls. The application and approvals process for many of the works associated with the CMS will therefore be complex. Specifically, works to be undertaken in riparian and floodplain areas typically retain a range of environmental and heritage values that will require consideration. Consequently the Approvals and Design Phases of the CMS may take several years to complete (see Table 25).

EPBC Act: It will be necessary to gain approval for implementation of the CMS under the Commonwealth *Environment Protection and Biodiversity Conservation* (EPBC) Act, 1999. A preferred approach to approval under this legislation will need to be developed that considers both construction and operational impacts of CMS implementation. The preparation of referrals for "bundles" of works may be a suitable approach. Determining the extent of "bundling" and hence the scale of any referral will be crucial to maximise efficiencies. A consistent consultation approach will need to be agreed and developed. It is envisaged to sit across all works in all jurisdictions to ensure that there is transparency and equity in interactions with all stakeholders, regardless of jurisdiction and the sub-program.

Table 25: Information requirements for applications and approvals across Victoria, South Australia and New South Wales

Issue	Information requirement	Scale of duration
Ecological assessment	A review of potential impacts on flora and fauna is required to determine potential impacts on, aquatic environment, native vegetation and other State and National listed species. This assessment may also manages issues associated with obtaining native vegetation offsets. Note: If seasonal surveys are required for particular species this could take up to a year.	2-12 months
Geomorphology assessment	Where works are being undertaken in and along waterways an assessment of the impacts on the stream geomorphology make be needed.	2 months
Aboriginal heritage	Consultation with the relevant Aboriginal groups is recommended and the completion of a cultural heritage survey may also be required depending on the location and extent of works.	2-6 months
European Heritage	A European heritage study may also be required depending on the age and significance of existing assets that may be impacted or replaced.	1-2 months
Surface water/inundation	Studies are required to determine the impact to third party property from inundation, and to manage potential pollution and stormwater runoff appropriately during construction and operation.	1-3 months
Traffic and transportation	Construction may generate significant volumes of traffic. A traffic management plan and route assessment may be required to ensure safe and efficient vehicle movement.	1-2 months.
Land division	A survey for land division purposes identifying the location of any easements.	1 month
Stakeholder / community engagement	Undertake meetings to gain feedback on the project, to confirm key risks and determine an approvals strategy. This duration could increase significantly if the works are to be located on private property	See Appendix 4 – Stakeholder Engagement

Governance Considerations

Complex scope of works: An extremely diverse range of works are currently proposed as part of the CMS. Via the State Constructing Authorities the MDBA has an existing operational model for the delivery, operation and maintenance of water infrastructure. However many of the works types proposed as part of the Constraints Management Strategy are atypical of works delivered via the current arrangements (e.g. roads, bridges, etc). Consideration should be made in relation to the use of alternate delivery agencies that have the relevant capability and the necessary capacity to undertake the work. Regardless of what model is chosen for implementation, given the scale and complexity of the likely final works program there needs to be a high level program management approach developed to ensure that there is consistency and transparency across all works categories and jurisdictions.

Specialist activities

Context and scope

During the CMS prefeasibility phase, some potential costs were not estimated. This included potential costs associated with mitigating impacts on Specialist Activities.[8] Instead, the nature of these impacts was assessed qualitatively (refer to Table 7 of the 2014 Cost Estimates report).

The CMS prefeasibility phase considered the potential impacts on river shacks in South Australia through a separate exercise undertaken by GHD.

Jacobs and RMCG (hereafter referred to as Jacobs) were engaged to inform the CMS feasibility phase by undertaking a more detailed assessment of potential impacts on specialist activities (including river shacks). Jacobs undertook this work in the Hume-Yarrawonga, Yarrawonga-Wakool, River Murray in South Australia, Murrumbidgee and Goulburn reaches (Table 26).

Table 26: Scope of Specialist Activities

Activity	Activity type	In/Out of Scope
Residential Activity (including River shacks)	Residential activity	In scope
Tourist cabins	Tourism activity	In scope
Caravan park	Tourism activity	In scope
Holiday accommodation	Tourism activity	In scope
Golf course	Recreation activity	In scope
Public park	Recreation activity	Out of scope (considered through separate public infrastructure project undertaken by AECOM)
Wineries	Other Primary Industry	In scope
Orchard (*Irrigated modified pastures, perennial tree fruits, perennial vine fruits*)	Other Primary Industry	Out of scope (considered through separate private agriculture project undertaken by GHD)
Turf farms	Other Primary Industry	In scope
Dairies	Other Primary Industry	Out of scope (considered through separate private agriculture project undertaken by GHD)
Nurseries	Other Primary Industry	In scope
Quarries	Other Primary Industry	In scope
Aquaculture	Other Primary Industry	In scope
Forestry	Other Primary Industry	In scope
House boat operators	River based business activities	In scope
Outdoor adventure tourist operators	River based business activities	In scope where CMS impacts on fixed assets

Approach to assessing impacts and mitigation options

Jacobs created a spatial (GIS) data base of available information to identify the type, number and location of affected specialist activities in the reach.

Jacobs assessed impacts, mitigation options and costs through two complementary processes of case studies and cost assessment and extrapolation.

[8] Broadly defined as land-uses and activities that are not related to broad-scale agriculture or major public infrastructure.

Case Studies

Jacobs worked with stakeholders through selected case studies, to "ground truth" assumptions and modelled inundation outcomes (Table 27). The consultants engaged through a combination of phone calls and regional visits to:

- discuss possible impacts from the anticipated flow events;
- obtain business data with which to build business cost models;
- discuss other similar businesses in the region, and whether the landholder being interviewed thought they would be impacted to a similar degree;
- explore possible mitigation options; and
- view the site, and refine mitigation option concepts.

Table 27: List of Specialist Activities Case Study Sites

Reach	Case Studies
Yarrawonga Wakool	Golf course, NSW
	Caravan park, NSW
	Forestry Operation, NSW
Murrumbidgee	Quarry, NSW
Hume to Yarrawonga	Visitors Centre, NSW
Goulburn	Caravan park (mid Goulburn), Victoria
	Aquaculture business, Victoria
	Caravan park (lower Goulburn), Victoria
South Australia	River Murray Shacks, South Australia

Cost Assessment and Extrapolation

Daily rate business losses were estimated based on case study data. Where available, data was used from case study sites visited during the community engagement phase of the project. Where sites were of an activity type that differed from the visited sites, desktop case studies were conducted. Desktop case studies included phone calls and searches of the internet for publically available data such as annual reports.

The metrics were selected so that they could be applied by reference to aerial imagery. For instance for caravan parks:

- the loss per day in the event of a total closure of the park, for example if the access road were inundated; and
- the loss in the event of a partial closure, measured in $/cabin per day or $/campsite per day.

In each case, impacts were calculated per day that the asset was unavailable, so that changes in average inundation event length would result in changes to the loss calculations.

The number of days for business to resume after inundation was assumed to vary by site. Default durations applied were:

- quarries 60 days, due to groundwater issues;
- caravan parks 7 days, assuming cabins are not damaged;
- abattoir/factory 3 days, based on minor level of inundation;
- club (football) 7 days, assuming fairly bare club houses, and oval ok after flooding;
- turf farm 0 days, as damaged turf was assumed to be scrapped and compensated;
- cellar door 21 days, as indoor areas and decorations may need tradespeople availability;

- shacks 21 days, as owners typically are offsite, and will take time to arrange repairs;
- forestry 90 days, as waterlogged floodplain is expected to impede heavy vehicle access from Spring – Summer;
- houseboat marina and slipway 7 days, as access should be restored once the river recedes, but it may take a few days for tourists or boat users to check current information; and
- residential 21 days, as indoor areas and decorations may need tradespeople availability.

In each case, sites which would experience greater or lesser inundation impacts were assumed to have longer or shorter recovery periods. For example, a quarry site experiencing only a cut access road would be expected to be operating within a week of inundation subsiding (assuming the road did not require rebuilding).

Jacobs considered mitigation measures in the context of two scenarios: an "easement focused" scenario, and an "infrastructure focused" scenario.

Table 28: Description of easement focussed and infrastructure focussed scenarios

Option	Description
Easement focus	In this scenario, the cheapest mitigation option was selected for each site. This scenario favoured easements as the primary method of mitigating impacts.
Infrastructure focus	In this scenario, infrastructure options were selected if available, in an attempt to minimise the number of easements. Total costs were higher for this scenario than for the easement focus scenario. A number of sites still required easements in this scenario as infrastructure was not suitable for mitigating all impacts. Examples include river shacks build directly on river banks where there is no room to construct a levee.

In assessing the costs associated with an easement focused scenario, Jacobs considered business impacts and a range of other impacts.

Table 29: Common factors considered in easement price

Mitigation Option	Description
Repair of quarry levees	Levees assumed to be in place but constructed from local materials by quarry operators rather than engineered levees constructed from imported material, and so easily damaged in large flow events
Clean up of inundated buildings	Included only when evidence existed that the building was not raised on stilts, as most floodplain construction is raised
Outdoor clean up	Applied to all sites which would experience inundation of part of the property, other than in undeveloped scrub or forest
Turf repair	Applied to activities which have clean lawn areas, where that lawn is likely to be important to the operation of the activity
Repair access track	Applied to dirt access tracks, assuming that a portion of tracks will require regrading after inundation
Repair of quarry levees	Levees assumed to be in place but constructed from local materials by quarry operators rather than engineered levees constructed from imported material, and so easily damaged in large flow events
Business Losses	Interruption of usual business activities

In assessing the costs associated with an infrastructure focused scenario, Jacobs considered the following possible infrastructure mitigation measures.

Table 30: Common Infrastructure Mitigation Options for Specialist Activities

Mitigation Option	Description
Construction of new levees	Appropriate where water spills onto the site through one side of the site, and infrastructure is not directly on the river bank. In some cases levee construction would require installation of stormwater drainage systems to release stormwater form the leveed area.
Armouring existing quarry levees with geofabric material	Tying down existing materials to prevent embankment toe erosion, rather than rebuilding the whole levee.
Raising access tracks / roads	Where existing tracks will be inundated, these could be raised above the water height, allowing access to property. Tracks were assumed to remain constructed of the current materials, whether dirt, or bitumen. Where necessary, bridge construction was included.
Unique solutions for individual sites	Such as moving a shed out of the potentially inundated area, installing pumps for aquaculture pond aeration, purchase of additional tree harvesters to allow stockpiling of material, or lifting a weatherboard house onto stilts

What was taken into account in cost estimates

Jacobs used the following information/ data to assess impact and mitigation options and costs for this project.

- modelled flow and inundation extents provided by the MDBA, and State authorities;
- aerial imagery;
- property boundary data sourced from various State authorities;
- unit rate construction costs obtained from Rawlinson's Australian Construction Handbook 2014 (Rawlinsons);
- refined unit rate for construction costs were identified at specific case study sites and applied to extrapolations (only where appropriate);
- business profit and turnover data obtained from case study landholders; and
- ABS business statistics.

Appendix 7: Hydrological Modelling

Summary of modelling approach

MDBA modellers undertook the hydrological modelling which informed this business case. The MDBA has long-established hydrological modelling capacity and has been developing models since the 1980s to inform water sharing arrangements in the River Murray System.

The constraints modelling was built on the existing Basin Plan modelling framework. The MDBA's MSM-BigMod platform was used for the River Murray, and NSW's IQQM and Victoria's REALM platforms used for the Murrumbidgee and Goulburn System respectively. These are established modelling platforms and accepted as industry best practice for the Southern Connected System, and were used to inform the Basin Plan in 2011-12.

State hydrological experts provided advice to inform the assumptions used in the modelling.

Hydrological modelling method

The modelling approach considered the Southern connected system (i.e. the River Murray System, Goulburn and Murrumbidgee) as an inter-connected single hydrologic unit. For the Albury-Yarrawonga reach, flows of up to 40,000 ML/day at Doctor's Point were modelled. For the Yarrawonga-Wakool Junction Reach, flows of up to 65,000ML/day downstream of Yarrawonga Weir were modelled with an alternative scenario of up to 50,000ML/day.

The method applied in the modelling aims to mimic natural flow cues and uses a probability-based approach to calculate environmental demands.

The model uses historical inflow data to determine environmental water delivery based on natural flow cues that reflect dry and wet cycles and natural variability. For the purposes of the model, environmental flow demands for winter and spring seasons are placed at locations throughout the system. The locations are specified based on the delivery patterns to meet the environmental water requirements used to inform the SDLs in the Basin Plan. The contribution of regulated flows is capped at a maximum limit for the delivery of flows within the Southern connected system. These demands trigger water to be released from storages to meet environmental demands, which are limited as in Table 1. The limit provided in the table is an absolute upper limit and is likely to be effectively utilised only during very wet years. For relatively dryer years, this limit is much lower as determined by limit-curve based on percentiles of monthly cumulative natural flows.

The model assumes environmental flows are limited by channel capacity (also set out in Table 1); the maximum allowable limit for each location; environmental water allocation; and other operational constraints.

Environmental demands are then estimated as a fraction of natural (without development) flows at each location. The fraction that is applied is calculated monthly based on percentiles of monthly cumulative natural flow data for the June to May water year. The fractions are relatively higher for the Winter-Spring months in the wetter years than for those months in the relatively drier years. The wetter years and drier years are identified based on monthly cumulative inflows to headwater storages, such as Hume dam in the upper Murray, and Burrinjuck dam in the upper Murrumbidgee. During extremely wet and dry years, particularly the wettest 10% of the years and driest 10-30% of years on record, environmental demands are not applied. The environmental demands are then used as inputs to the model.

The model produces daily estimates of environmental releases from storages, over a modelled 114-year period from 1895 to 2009. The 114-year sequence of daily model outputs was used to inform the business cases through:

- analysis of statistics of specified types of flow events (e.g. numbers of flow events lasting less than 7 days in length, or more than 7 days in length, in specified time periods). Such statistics informed analysis by GHD, AECOM and Jacobs on the impacts of relaxed constraints for agriculture, public infrastructure and specialist activities; and
- hydrographs created from the model outputs. These hydrographs informed the sections of the business cases on proposed changes to hydrology and the operating regime.

Table 31: Physical constraints and limits applied to environmental demand (ML/d)

Location	Assumed channel capacity when constraints are relaxed	Limit applied to environmental demand
River Murray		
Doctor's Point	40,000	
Yarrawonga	50,000 or 65,000	50,000 or 65,000
Torrumbarry		40,000
Euston		85,000
SA border		80,000
Lower Darling		
Weir 32	9,300	
Burtundy		17,000
Goulburn		
Eildon	15,000	
Molesworth	15,000	
Seymour	30,000	
Shepparton	40,000	40,000
Murrumbidgee		
Gundagai	33,000	
Narrandera		44,000
Maude		20,000
Balranald		12,000

Note that this maximum environmental demand limit is generally applied to the wet years. For dryer years, the maximum environmental demand is capped by limit curve and is much lower.

Assumed flow regime changes

To inform cost estimates, it was necessary to define a "baseline" flow regime, and a "post-CMS" flow regime, as inputs to the costing methods.

The "baseline" flow regime was assumed to be represented by modelling outputs from the MDBA's "baseline diversion limit" (BDL) model run. The "BDL" flow regime represents pre-Basin Plan water recovery condition and is a modelled representation of flows in the Basin, taking into account a 114-year climate sequence from 1895 to 2009, and assuming a level of development as per 2009. Refer to MDBA (February 2012) Hydrologic modelling to inform the proposed Basin Plan: methods and results, section 3.3.

The "post-CMS" flow regime represents post-Basin Plan water recovery condition and delivery of environmental water by relaxing channel capacity constraints, and was assumed to be represented by modelling outputs from the MDBA's "relaxed constraints" model run (described in the previous section of this document).

The “BDL” flow regime represents the most appropriate baseline for cost estimates, noting that:

- the costs that will be incurred in implementing mitigation options (e.g. easements or infrastructure works) would reflect the outcomes of negotiations with stakeholders, who will need to agree to those options, and associated funding, before they can be implemented;
- if mitigation options (e.g. easements and/or infrastructure works) were to be pursued, negotiations over costs would need to be with reference to a “baseline” which stakeholders can relate to (i.e. represents their recent lived experiences); and
- the “BDL” flow regime is an appropriate representation of this baseline. A non-modelled baseline (e.g. actual flows) would not be appropriate as it would not be possible to compare it to the “relaxed constraints” modelled 114-year flow regime.

Appendix 8: Flow Inundation Mapping

In order to inform the assessment of impacts, mitigation options and costs it was necessary to estimate spatially how higher managed flows would inundate areas of land. This section describes how inundation maps were produced.

CMS Pre-feasibility Phase (2014)

During the CMS pre-feasibility phase *hydraulic models* and *GIS processing* were used to generate inundation extent maps. For the River Murray in South Australia, MIKE-21 with FlexiMesh was used to model the extent of inundation (i.e. derive an "inundation footprint").

The inundation extent was captured and presented spatially using GIS tools (e.g. raster format transformed to polygon shapes). The use of GIS has two key advantages: access to geo-spatial analytical techniques (for example to identify location, size, and type of tenure or land use for affected properties), and the relative ease of presenting flow rate implications in the form of maps (for example for discussions with stakeholders).

In order to provide a reference point for analysis, and consultations with stakeholders, each inundation extent was related to a specified flow rate at a reference gauge or location. Further details of the methodology is described in the technical report "Flow inundation mapping & impact analysis[9] (MDBA, 2014).

CMS Feasibility Phase (2014-15)

Inundation maps were updated to take into account further modelling undertaken by the Department of Environment, Water and Natural Resources (SA) using the same model as for pre-feasibility, but with the addition of FlexiMesh in some areas (between Lock 3 and Wellington). Known flows at surface water gauges were used to verify the modelled areas of inundation.

Application of flow inundation mapping to impact, mitigation options and cost analysis

Consultants used the flow inundation extents, overlaid with other geo-spatial information, such as landuse, roads, crossings, tenure, to identify infrastructure and land that would be affected by different CMS flow options. The information served as a basis for identifying and costing the impacts and potential mitigation options.

The inundation extents were considered fit-for-purpose to assess impacts and estimate costs at a regional scale, and as a starting point for discussions with local stakeholders.

For CMS implementation the existing flow inundation mapping would function as a starting point for identifying and contacting property owners who may be directly affected, and for discussions and negotiations. It would also be necessary to update the inundation maps through improved modelling, further analysis of aerial photography, and/or further consultations with stakeholders regarding details of inundation in specific locations.

[9] For further details, see above report.