The feasibility of relaxing constraints in Northern Victoria

VICTORIA State Government | Energy, Environment and Climate Action

Acknowledgements

The Department of Energy, Environment and Climate Action acknowledges the efforts of the Constraints Consultative Committee in its guidance and discussion on the technical information to advise the Department and the Victorian Minister for Water on the feasibility of relaxing constraints in Northern Victoria.

Photo credit

Reedy Swamp, Victoria (courtesy of Sequana Partners)

We acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, their unique ability to care for Country and deep spiritual connection to it.

We honour Elders past and present whose knowledge and wisdom has ensured the continuation of culture and traditional practices.

DEECA is committed to genuinely partnering with Victorian Traditional Owners and Victoria's Aboriginal community to progress their aspirations.

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Foreword

The communities of northern Victoria have developed and prospered because of river regulation. River regulation along the Goulburn and Murray Rivers has played a vital role in supporting agriculture, providing water security, and fostering economic development. However, we also acknowledge its environmental and cultural impacts, observing a considerable decline in the health of our river systems.

The Victorian Constraints Measures Program (Victorian CMP) explores how more natural river flows could be delivered while managing risks and impacts to public and private land, infrastructure, stock, crops and people. Over the term of its appointment, the Constraints Consultative Committee has given due consideration to the task set by the Victorian Minister for Water: to provide advice on the feasibility of delivering higher and more natural flow regimes in the Goulburn and Murray rivers.

Since April 2022 the Committee has brought together informed community members, environmental water managers, river operators, land managers and Traditional Owners to explore and discuss the benefits and risks of relaxing current flow limits in the Murray and Goulburn rivers. The technical work carried out by the project team has been robust and extensive and has incorporated Committee member feedback. Rigorous assessments and analyses have been conducted, providing a solid foundation upon which discussions and advice have been based.

A major flood event in 2022 added a unique dimension to our discussions. Although rising rivers provided important opportunities to gather real-life insights, we recognise that there were devastating consequences to many people, including members of the Committee, and there is a risk of communities confusing the scale of these floods with the flows that we have considered.

Recognising the complexities associated with the Victorian CMP, most Committee members recommend that the program move forward to develop a business case, but not at the expense of leaving the community behind. We support Victoria's staged delivery approach and the need to proceed at a pace that allows for meaningful community collaboration, engagement and understanding.

Victoria has been at the forefront of efforts to recover water for the environment, and it is the Committee's aim to ensure that this already available water for the environment is utilised to its greatest benefit, maximising positive outcomes for both the environment and the communities it sustains. While we have focused on what these flows may mean for Victoria, we recognise the need to consider the larger system scale and strongly encourage governments to assess and address the benefits and challenges of changing flow regimes that impact river systems and communities as a whole.

One of the hallmarks of our Committee's success has been the thorough and inclusive process to gather diverse perspectives and engage in robust discussions. We have ensured that every member has had the opportunity to contribute their views, fostering an environment of openness and shared understanding. This inclusive approach has been instrumental in producing this report that accurately reflects the valuable insights and diversity of views within our Committee.

I extend my gratitude to all members of the Constraints Consultative Committee for their valuable contributions. By embracing a collaborative approach and fostering widespread engagement, we can work towards a collective and sensible solution that maximises environmental outcomes while balancing the impacts on individual landowners.

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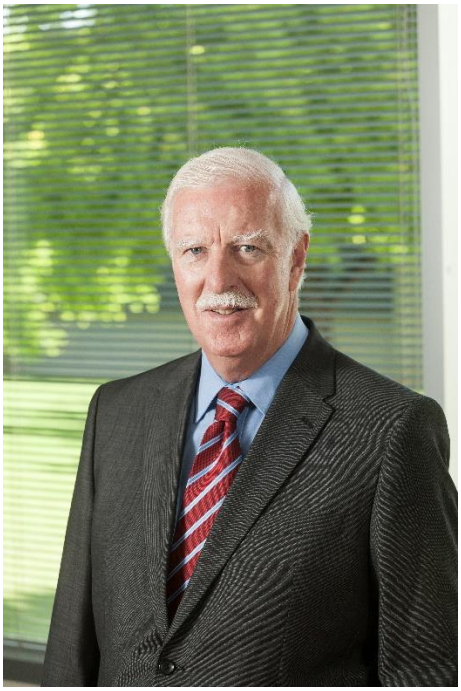


Hon. Patrick McNamara AM

Chair, Victorian Constraints Measures Program Consultative Committee

Executive Summary

The Victoria Constraints Measures Program (CMP) is a study investigating the feasibility of options to relax river operating rules (constraints) on the Murray and Goulburn Rivers to enable river operators to generate overbank flows below the minor flood level for the environment.

Current river operating rules prevent environmental water managers from using their existing water holdings to generate over bank flows to water low lying billabongs and wetlands. Unless there are flood easements in place or unless the flows are part of flood operations, it is not lawful for river operators to damage property by flooding land without the agreement of the property owners.

The CMP is being delivered in a staged approach. The aim of this first and current stage is to determine if there are viable options that could sensibly deliver enhanced natural river flows. A consultative committee participated and provided advice into this Feasibility Study. The Committee met regularly to discuss the technical work and its findings.

The Feasibility Study investigates options to allow flows up to minor flood level using existing environmental water allocations. Options included the notified flow rates in the Basin Plan. Flows that would cause moderate or major flooding were not included in the Basin Plan.

The majority of Consultative Committee members recommend proceeding to the next phase of the CMP which will involve the development of a detailed business case that includes a full assessment of the costs and benefits of the program.

What is constraints relaxation about?

Communities of Northern Victoria and the Murray-Darling Basin have developed and benefitted from river regulation. Weirs and dams were constructed along the river systems throughout the 1900s to regulate water flow and service irrigation areas. River regulation has played a vital role in supporting agriculture, enabling water security, fostering economic development and providing opportunities for recreation.

Reduced floodplain watering due to river regulation has resulted in the health of floodplain forests and wetland ecosystems decline over many decades. This has had negative impacts on native fish, waterbirds and other species that depend on the health of floodplain ecosystems.

River operating rules, also known as constraints, apply to all regulated releases from dams and weir storages including environmental flows. There has been extensive development on the floodplain, and constraints have helped provide certainty to those that live, work and play along our waterways. However, remnant native vegetation and wetlands still exist on the floodplain. With constraints this means that rivers connect to their floodplains less often than what's needed to maintain healthy river, wetland and floodplain ecosystems.

The Victorian Government, with the support of a Consultative Committee of key stakeholders, are investigating if these constraints could be relaxed or removed. With less constraints in place, river operators could deliver more water for the environment into the system and onto the floodplain – at times needed by the environment.

Under the Committee's direction, investigations looked beyond in-channel in the Goulburn. The Victorian CMP explores the potential to enhance environmental, recreational and cultural outcomes. It does this by looking at how the environmental water that is already available could be delivered more effectively to areas that need it.

The Victorian Government is investigating flows that are largely at or below the minor flood level. This means it won't affect dwellings, but could affect agricultural land, access roads, pumps, fencing, and other man-made structures.

Why do we need to water floodplains?

Floodplain inundation is a core part of a healthy, functioning ecosystem. Through long-term monitoring, we know floodplains are already stressed but there are still high value wetlands and remnant native vegetation that could be maintained with watering. River regulation has interrupted many of the natural river and wetland processes needed by native plants and animals to grow, reproduce, move and ultimately survive.

With climate change worsening conditions, high value floodplain ecosystems will continue to decline without intervention.

Some native floodplain vegetation, like black box trees, are located higher on the floodplain. These trees need watering less frequently and they generally only receive watering from major flooding. To protect and restore values higher on the floodplain, infrastructure can be used to shepherd water to where it is needed, so that the duration and extent of watering is similar to that of a natural larger flood event to meet the ecological objectives.

Relaxing constraints supports Victoria's long-standing position of making the best use of available water for the environment. Projects like the Living Murray have been in place for two decades and shown the importance and success of floodplain watering. Another example is the Victorian Murray Floodplain Restoration Project (VMFRP) which will water up to 14,000ha of high-value floodplain for the duration and to the extent needed to restore them.

The Living Murray, VMFRP and CMP are all part of the Murray Darling Basin Plan – Sustainable Diversion Limit Adjustment Mechanism (SDLAM), which aims to deliver water to where it is currently needed. Beyond their environmental and cultural benefits, they also help regional communities by reducing the need for further water recovery.

Constraints in context of the Murray Darling Basin Plan

The CMP is being funded by the Commonwealth as part of the Murray-Darling Basin Plan. It is a Sustainable Diversion Limit Adjustment Mechanism (SDLAM), or "offset" project, where better environmental outcomes can be achieved using less water. The Murray-Darling Basin Authority has determined that the water recovery target can be reduced by 605 GL through all SDLAM projects. It is estimated to generate 53 GL of offsets exclusive of any offsets generated by relaxing constraints on the Goulburn River. In 2018 it was recognised by the MDBA that the relaxation of constraints could also provide additional environmental benefits.

This study looks at the feasibility of relaxing constraints along the Victorian Murray River between Hume Dam and Wakool Junction and the Goulburn River between Lake Eildon and the Murray.

Assessing whether Constraints lifting is feasible

The environmental and associated benefits of a river being connected to its floodplain are well accepted. However, governments and communities must balance the environmental benefits of creating over bank flows with the risks, damage and costs caused by flooding private and public property.

The majority of the Consultative Committee believe constraints should only be relaxed if the benefits exceed the costs and compensation for inundation impacts is provided in a transparent and fair manner.

Previous constraints relaxation studies were of insufficient quality to allow governments to make informed judgements about the feasibility of relaxing constraints. In particular:

- river simulation models ran on a monthly time step when a daily time step is required to properly asses the magnitude, duration and frequency of environmental flows,
- inundation models were not capable of accurately projecting the areas that would be inundated with the relaxed constraints options, which meant that estimates of benefits and costs were unreliable,
- engagement with landholders and the broader community was limited,
- partnering with Traditional Owners was inadequate,
- regulatory approvals pathway was not considered, and
- critical policies were unresolved, including policies to offset costs to affected landowners, policies for creating flood easements, policies for managing assets required to mitigate flooding impacts and policies determining responsibility and accountability for delivering over bank environmental flows.

This Feasibility Study provides the data and analysis needed to progress the above matters in future program stages and determine whether and by how much constraints should be relaxed.

The technical modelling used the volume of presently available environmental water holdings without considering any potential additional water recovery measures, such as the 450GL outlined in the Basin Plan.

Most Committee members have strongly voiced concerns about the prospect of further water recovery through buybacks. These concerns stem from the observed adverse effects of previous buybacks within northern Victorian communities.

What are the major findings?

Technical investigations into hydrology, land and asset mapping and environmental benefits analysis have addressed significant data and modelling gaps and enabled meaningful and informed conversations.

While technically feasible and socially challenging, most of the Consultative Committee support further investigations into the benefits, risks, and costs of relaxing constraints to enable overbank flows up to minor flood level on the Goulburn and Murray River.

They strongly advised that key elements of the Feasibility Study should be discussed with community before a preferred relaxation option is adopted by government and discussions are held with all affected landholders.

Most Committee members recommend that relaxed constraints should only be used to provide greater flexibility to deliver already available water for the environment.

Consultative Committee and engagement

The Ministerial Council agreed that States take a community co-design approach to assessing in detail the feasibility of relaxing constraints. The Victorian Government has used a community co-design approach to prepare this feasibility study in accordance with the Murray Darling Basin Ministerial Council decision of 2019.

A Consultative Committee involving landholders, major water users, environmental agencies, Traditional Owners, local government and state and interstate agencies participated in preparing the Feasibility Study

The Committee provided various perspectives on the modelling outputs, options and issues included in the Feasibility Study. The Committee investigated flows up to the notified flow rates in the Basin Plan but also requested the option of allowing of overbank flows of 25,000 ML/d in the lower Goulburn River be analysed.

The involvement of the Consultative Committee should be considered as the start of the community co-design process. Future engagement should involve a wider range of stakeholders to comprehensively understand and document the level of support for relaxing constraints and the measures needed to offset impacts on affected landowners before individual landholders are approached.

Results of analysis

Improvements to our technical knowledge

The Feasibility Study has addressed significant data gaps enabling informed analysis and committee discussions about the benefits, costs, risks and the issues that need to be resolved.

With the Committee's input, computer models were developed and run to analyse the effects of options for relaxing constraints on the size, frequency and duration of environmental flows. This modelled flow data was then used to model the location and areas of private and public land that would be inundated. This information was then used to estimate environmental benefits and identify the assets that would be affected by each option.

Technical improvements include:

- Hydrological models have been upgraded from a monthly time step to a daily time step which is required to model environmental water deliveries which vary significantly over a week.
- For the first time, daily flow information from the Goulburn River hydrological model has been used to provide flow data to the daily Murray River hydrological model. This is the first step to integrate Goulburn, Murrumbidgee and Murray models to improve analysis of integrated system response to relaxed constraints.
- Hydraulic modelling used to map areas of inundation for each option have been upgraded to provide detailed inundation maps for individual properties and at-risk assets have been identified.

- Hydraulic model results have undergone rigorous validation using real-time flow data from periods where the rivers were running at the same levels as the modelled scenarios. This validation included on-site verification during critical flow events, as well as the use of drones, satellite imagery, and aerial photography.
- Ecological models have been developed using outputs from the hydrological and hydraulic modelling to analyse the environmental responses for each of the options.
- The above models have been used to investigate how climate change would influence the benefits of relaxing constraints.
- The network of streamflow and rainfall gauges in the Goulburn River catchment has been expanded and will provide river operators with real time data to reduce the risk of exceeding flow rules. The location of these gauges was developed with input from the Consultative Committee.
- While the technical analysis in the Feasibility Study provides a robust basis for assessing options, it is crucial that future stages of the program be informed by a thorough assessment of the impacts and costs at the local property level, this must include discussions with impacted individual landowners.

Environmental benefits – Victorian Murray and Goulburn

Currently there are a range of environmental flow requirements that cannot be achieved by environmental water managers due to constraints, including higher flows that reconnect rivers to floodplains. This limits the ability to maximise the benefits from available water for the environment. Because of these constraints, environmental water holders are managing water holdings through mechanisms such as carry-over and temporary trading of allocation.

Relaxing constraints provides environmental benefits. The greatest benefits relate to the ability to water low-lying riparian vegetation and billabongs and flood runner ecosystems more frequently. Environmental studies show that the frequency, duration, and timing of inundation as well as the area inundated are all important.

The ecological needs of the floodplain below the minor flood level cannot be fully met by relaxing constraints because the short duration of inundation. However environmental benefits are still realised.

Relaxing constraints to the notified flow rates would not benefit the large areas of higher floodplain red gum and black box forests that need moderate and major flood events to be watered. Environmental works such as The Living Murray and the environmental works proposed through the Victorian Murray Floodplain Restoration Project (VMFRP) are required to protect these sites, as these works alone can support inundation at the required durations needed to restore floodplains.

The modelling suggests that constraints relaxation would enable more frequent achievement of a larger range of environmental flow requirements along both rivers. As a result, environmental water holders would be able to achieve greater use and efficiency from their water portfolio. However, based on the range finding modelling conducted in this study, it's apparent the modelled constraint remains the limitation to full environmental water utilisation, not the available amount of water for the environment. Flow targets in excess of those modelled would be required to potentially increase the utilisation. There are also opportunities to further explore environmental water delivery strategies to enable more effective use of the available portfolio.

<u>Goulburn River</u>

Changes in river operating rules on the Goulburn River below Eildon, at Molesworth and at Shepparton were modelled and compared with operations under the current rules.

Adopting flows below Eildon of 13,700 ML/d, at Molesworth of 14,000 ML/d and at Shepparton of 25,000 ML/d would provide the greatest environmental benefits. A total of 6,064 ha of public land and 1,505 ha of private land (289 properties) would experience more frequent inundation.

The area of public land inundated upstream of Shepparton is relatively small compared to the area of private land. The reverse is true below Shepparton where the area of public land inundated is relatively large compared to the area of private land.

Material environmental benefits start to occur in the high environmental value lower Goulburn floodplain at 21,000 ML/d. These flows would water high value wetlands and start to inundate red gum and black box forests. This requires a flow of at least 12,000 ML/d at Molesworth in the Goulburn River below Lake Eildon.

Murray River

Adopting flows at Doctors Point of 40,000 ML/d and 45,000 ML/d at Yarrawonga would provide the greatest environmental benefits along the Murray. A total of 45,741 ha of public land and 3,576 ha of private land (170 properties) would experience more frequent inundation.

The area of public land inundated upstream of Yarrawonga is relatively small compared to the area of private land. The reverse is true below Yarrawonga where the area of public land inundated is relatively large compared to the area of private land.

Material environmental benefits in Victoria start to occur in the high environmental value wetland and red gum forests associated with flood runners and localised wetlands in the Yarrawonga to Wakool reach of the Murray River at flows of 30,000 ML/d at Yarrawonga.

Uncontrolled flooding

Modelling shows that relaxing constraints would enable more environmental water to be released from storages than under current operating rules. This would increase dam airspace enabling the dams to store more flood inflows and reduce the size of moderate floods. Releasing environmental water throughout the year can provide flood mitigation as a secondary benefit, depending on how the entitlement holders chose to use their water.

Climate change

Modelling of climate change projections indicate that the duration of flows at or above the constraint level decreases and that the interval between overbank flows increase. In the year 2070, under high climate change conditions, flows rarely reach or exceed environmental flow targets.

There is a significant risk that climate change will cause further ecosystem decline assuming current river operations. Resilience to climate change would be improved by relaxing constraints. However, under severe climate change and conditions like the Millennium Drought, the modelling suggests the benefits of relaxing constraints are far less.

Flows downstream of the Wakool junction and at the SA Border

While not formally part of the original Feasibility Study area, the Committee sought advice on the potential benefits and risks of the notified flow rates in the River Murray downstream of the Wakool Junction. Due to the physical nature of the river channel, the flows are likely to remain within the public land estate. Like the above reaches, the benefits are associated with flood runners and anabranches rather than wholescale floodplain inundation. An additional benefit is that there would be an increase to river channel capacity to deliver environmental water in times of potential channel capacity rationing.

The need for environmental works projects such as The Living Murray and the proposed VMFRP are more pronounced further downstream.

Modelling suggests the frequency of flows of 80,000 ML/day in the Murray River at the South Australian border are unlikely to increase under relaxed constraints. Flows of this magnitude are dependent upon significant unregulated flows throughout the system and are only possible in a narrow range of naturally driven scenarios.

Complementary measures

It is the Consultative Committee's view that complementary programs, including grazing management, revegetation, pest control, and monitoring, are necessary to maximise environmental outcomes. A program to address erosion of the Murray River is required even if constraints relaxation is not implemented. Addressing the deterioration of the riparian zone along the Goulburn and Murray rivers is critical to enhance the benefits of environmental watering.

There may also be further opportunities for minor infrastructure works such as the installation of culverts on raised tracks in key wetlands or floodplain sites to enhance environmental resilience and maximise the

outcomes from environmental water. These opportunities would be investigated as part of any future program stages.

Environmental risks of relaxing constraints

Environmental risks of relaxing constraints considered by the Feasibility Study include reducing the frequency of moderate flood events, increasing bank erosion, and increasing carp populations. Ecological response modelling and a review by an expert panel found only one of the four assessed risks to be material (i.e. reducing the frequency of moderate flood events) and concluded that the environmental benefits of relaxing constraints outweigh the environmental risks.

Modelling indicates that the increased utilisation of environmental water allocations enabled by relaxing constraints would decrease the frequency of the moderate flood events that water Blackbox communities on the higher floodplain.

Relaxing constraints is not expected to increase current rates of bank erosion which are thought to be caused by river operations to deliver irrigation water and in some river reaches by boat wake.

Spikes in carp populations have been observed after major flooding events. The short duration flow regimes under relaxed constraints are designed to not exceed minor flood levels and are not expected to increase the overall number of carp in the river system. However, further investigations and learnings from other environmental watering programs are to be undertaken in any future program stages to manage carp.

The timing and duration of environmental watering of wetland and low-lying floodplains enabled by relaxing constraints is considered to not change the occurrence or severity of hypoxic blackwater events. These events tend to be observed after major floods occurring in warmer months of the year.

Policy Issues

Traditional Owner engagement

Water is an integral part of Country. The Feasibility Study consultation approach supported Traditional Owner self-determination, enabling Traditional Owners to decide whether to participate and to guide the engagement process. The process included meetings on Country.

The majority of Traditional Owner Groups consulted supported further exploration of relaxing constraints to achieve environmental and cultural outcomes and gave in principle support to see the project go forward to the next stage of investigation. Some groups require further information to have a better understanding of the project before they determine their level of support.

Each Traditional Owner submission is presented as separate, stand-alone statement to the Victorian Minister for Water in accordance with the wishes of some groups.

It is proposed that there be continued partnerships and engagement with Traditional Owners for the next phase of the program, recognising their central role for healing Country and identifying areas of cultural value that can be watered by relaxing constraints. Additionally, the aim is to identify areas of key cultural value that need water but will not benefit from relaxing constraints.

Mitigation and compensation measures

The inundation modelling of the options to relax constraints would not impact any homes. The inundation of private property primarily affects stock grazing areas, river pumps, fencing, farm access routes and overall property management. The impacts on public land are mainly limited to local 2WD and 4WD tracks and some recreational facilities.

River operators require landowner agreements before they release environmental water from storages that inundate the landowner's land.

The Feasibility Study indicates that a large number of new assets are unnecessary to offset the effects of relaxing constraints. Where asset works are required, it is proposed that there be no change to the ownership of assets.

Private land

The Feasibility Study adopts the approach that compensation will be paid to landholders to offset lost production and the costs of clean up and reinstatement attributable to environmental watering events. The Committee recommends that compensation should encompass potential long-term recurring impacts resulting from inundation.

The Feasibility Study includes high level principles for calculating the compensation to be paid to each landholder. Detailed rules and processes to calculate the amount of the compensation package for each landholder would be developed as part of the next stage of the Project.

Compensation payments would only be made where the landholder enters into an enduring agreement allowing inundation of a defined part of their land. The creation of a flood easement on land titles is the recommended form of agreement.

Easements would need to be created for the area expected to be inundated and include an additional risk buffer for river operations. The extent of buffers would be further investigated in future project stages and will depend on the ability for the Enhancing Environmental Water Delivery project (EEWD) to provide appropriate forecasting tools.

Appropriate compensation offers would be required to ensure voluntary agreements from landholders. Past experience in creating flood easements suggests that some landholders will withhold their agreement.

Existing legislation enables Governments (State and Commonwealth) to create flood easements via compulsory powers without the agreement of the landowner. Unless otherwise advised by Government, any compensation approaches as part of future implementation must adhere to the *Victorian Government Land Transaction Policy 2022*.

The recommended approach is to use these Government powers as a last resort, after every effort has been made to create flood easements voluntarily and where there is an overwhelming community benefit in creating the easements.

Public land

The improved environmental values of public land would be a major outcome of relaxing constraints. Some capital expenditure may be required to assets on public land. It is proposed that these costs would be met as part of the implementation costs.

Relaxing constraints would result in a range of ongoing land and asset management activities that require appropriate planning and support by public land managers. The government, through its land managers would manage ongoing risks to public land using current funding arrangements. The project would not fund ongoing costs.

Relaxing constraints should not result in a material increase in local government costs. There should be no impact on rates.

System integration

While individual constraint projects need to be assessed for local benefits and impacts, further coordinated planning between states is needed to understand system-wide benefits and implications of relaxing constraints, including the feasibility of achieving flow objectives at the SA border.

River operating rules along the length of the Murray River must work together, upstream, rules should have regard to the downstream rules and vice versa. This is also the case for the operating rules in the Goulburn and Murrumbidgee rivers. These must also work with the rules for the Murray.

The relaxation of constraints along the Murray, Goulburn and Murrumbidgee Rivers needs to be integrated to ensure that the rules work together at the system scale. Integration requires a joined-up project that considers benefits, risks, engagement, and policies across borders.

There must be consistency in compensation and mitigation approaches across state borders to ensure that landowners on both sides of the river are treated fairly.

Regulatory approvals to implement the CMP may require approvals under Victorian, New South Wales and Commonwealth legislation. It is likely that this would be a very unwieldy, time consuming and costly process. It is proposed that a streamlined approval process suitable for assessing interjurisdictional environmental

enhancement projects like the CMP be developed by the Commonwealth Victorian and New South Wales regulators.

Operational considerations

River operators and environmental water managers have extensive experience in delivering environmental water and have developed detailed management processes and practices. These arrangements would provide a very strong basis for managing with relaxed constraints.

Risk workshops held with representatives from various organisations involved in river operations and environmental water management identified risks and explored mitigation options. Options included:

- The creation of buffers above designated flows to manage the residual risk of flows exceeding targets.
- Improved tools to provide short term predictions of unregulated flows caused by catchment rainfall.
- Using a staged approach to progressively increase flows up to the new relaxed operating rules and applying adaptive management principles.
- Government providing clarity on who is liable for any residual risks of unintentionally causing overbank flows that exceed agreed limits.
- Ensuring there is a clear statutory responsibilities and functions for delivering overbank environmental flows. This is being progressed by the Enhancing Environmental Water Delivery (EEWD) project.

Moving forward

Proceeding to the next phase is recommended.

River operating rules along the length of the Murray River must work together, upstream rules should have regard to the downstream rules and vice versa. This is also the case for the operating rules in the Goulburn and Murrumbidgee rivers.

Because of this interconnection it's critical that Basin States and the Commonwealth agree to proposed relaxed operating rules before initiating extensive community engagement. The establishment of system-wide parameters and governance is necessary to ensure efficient and transparent collaboration with affected communities.

Agreement is also necessary on the approach to determine the benefits and costs for both sides of the Murray River as well as the Goulburn and Murrumbidgee rivers. This should be completed as part of prudent whole of system Business Case development.

Relaxing constraints is a vital step to re-establish the connection between rivers and their low-lying wetlands and floodplains. However, the Feasibility Study and the diverse range of views expressed by the Consultative Committee underscore the need for additional investigations and wider engagement. There also remains the need to progress complementary projects such as the VMFRP and EEWD to further maximise environmental outcomes with available water for the environment.

Throughout the process the Consultative Committee was very clear – members wanted to see already available water for the environment to be used efficiently to generate local benefits, for people and the environment. The Committee strongly advised that Governments should publish rigorous system level costs and benefits of relaxing constraints and provide further information on how landowners and asset owners would be compensated.

The Committee also emphasised the importance of early and extensive engagement with landowners and the community to enhance participation. While there has been some input from various perspectives to inform this study, broader engagement with affected communities is still required.

It's crucial that communities and individual landowners have ample information and time to understand the impacts and implications of proposed new river operating rules and the compensation and mitigation approaches. This means that the Constraints Measures Program must continue to be developed using a community co-design approach, which puts those who will be affected by the project at the centre of discussions.

As the CMP progresses, DEECA will continue to partner with Traditional Owners in line with Pupangarli marnmarnepu. DEECA acknowledge Aboriginal Victorians have the right to make choices that best reflect them on their journey to self-determination and is committed to delivering real outcomes by following their lead.

1 Introduction

1.1 The Murray River and its tributaries

The Murray River is highly valued by the community for its significant role as a water source and for the environmental and recreational opportunities it offers. However, it is no longer a free-flowing natural river. Over time, the river has undergone substantial modifications to meet the water supply needs of towns, industries, irrigation, and more recently, to support environmental preservation efforts. Towns located outside the Murray Basin, including Adelaide and extending as far west as Whyalla, rely on the Murray River for their water supply.

The river has been altered with the construction of various infrastructure such as the two major storages - Hume Dam, completed in 1936, and Dartmouth Dam, completed in 1979. Additionally, there are 16 locks and weirs along its course that have transformed nearly 1,000 km of free-flowing river into a series of weir pools. Furthermore, the mouth of the river is obstructed from the sea by five barrages, which were built between 1940 and 1945 to mitigate tidal effects and prevent seawater intrusion into the Lower Lakes and the River Murray up to 250 km upstream during periods of low flow.

To augment water resources, an average of 570,000 ML (megalitres) of water is diverted annually from the Snowy River catchment into the Murray River.

The Murray is and will continue to be a vital working river rather than a near natural river, providing for human and natural values. Some environmental values have been lost due to intensive human use and modification however, many environmental values remain however are impacted by floodplain disconnection. In this context, 'environment' refers to the natural ecosystems, biodiversity, and ecological features supported by the river. These encompass the various elements of the landscape, such as flora, fauna, and

the intricate relationships between them. The term also encompasses the broader ecological functions that contribute to the health and sustainability of the region.

Figure 1: Cattle grazing on productive pasture along the Murray River floodplain between Hume and Yarrawonga. Photo taken in September 2022 (courtesy of Sequana Partners)

The construction of dams and weirs have significantly impacted the Murray's floodplains and wetlands. These changes have led to a decline in higher flows that naturally spill over the riverbanks, disrupting the river's natural behaviour. Over time, the river has been disconnected to the floodplain.

Before the construction of dams and weirs, the Murray River's flow or height was often described as a "pulse" or "heartbeat" (Figure 2). The river's natural rhythm involved a regular cycle of wetting (highs) and drying (lows). However, the construction of Lock 1 in 1922 and the Hume Dam in 1936 marked a turning point. These structures brought about a notable shift in the river's pulse, diminishing low flows and disrupting the natural flow pattern.

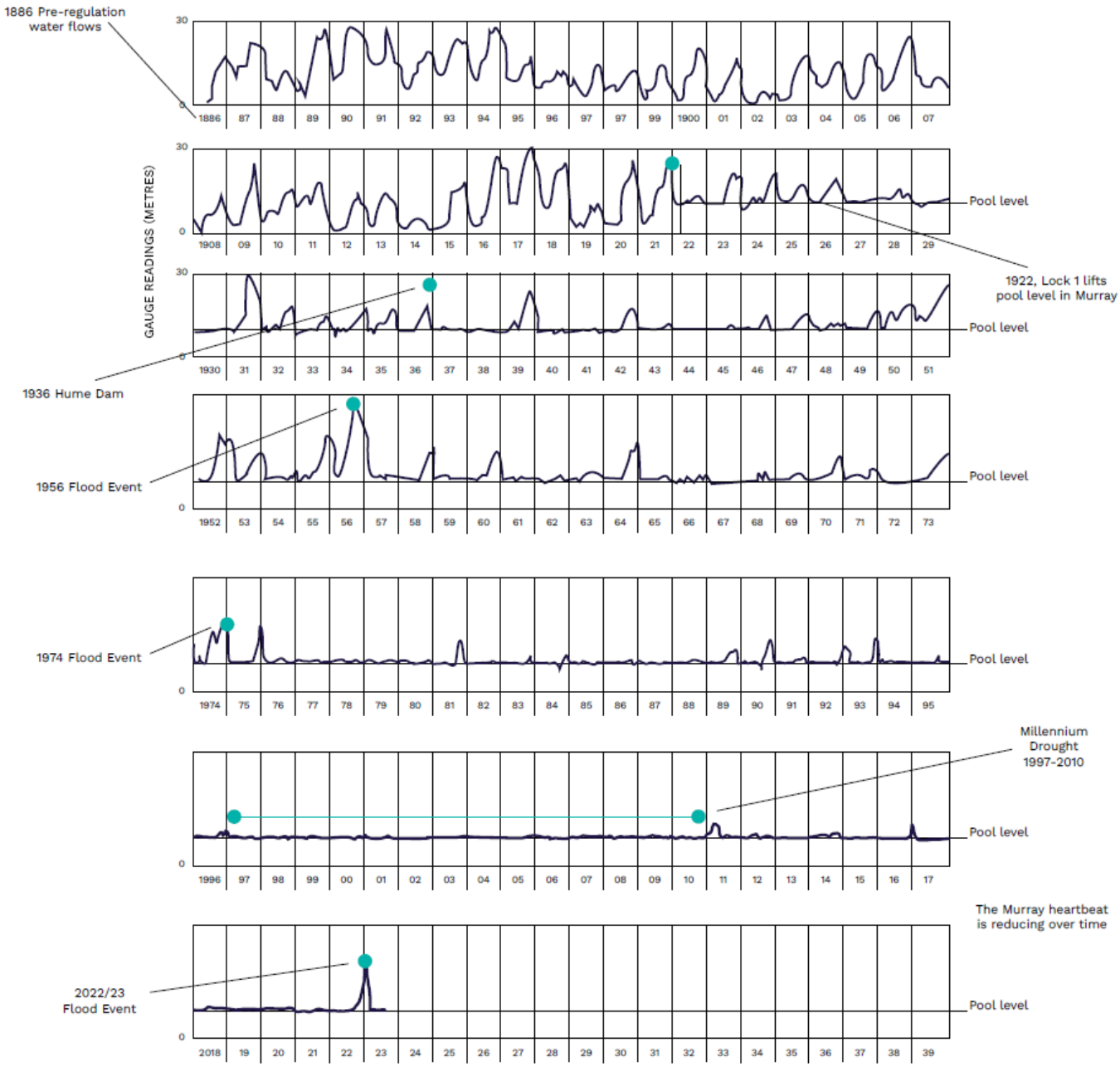


Figure 2: Mapping the Murray's heartbeat: 1886-2023 river heights at Lock 1 South Australia

One prominent example of this disruption is evident in the construction and operation of the locks and weirs artificially increasing river levels. Another is the occurrence of major floods. The once-regular major flood events have become infrequent.

Specifically, the frequency of small overbank flows has also been significantly reduced. In the Murray River, these flows, which used to happen approximately every second year, now occur much less frequently, with intervals of 6 to 8 years. The Goulburn River, too, has experienced a decline in flow frequency, shorter durations, and longer gaps between events compared to its natural state.

1.2 The importance of floodplain connectivity

Floodplain river ecosystems represent complex interdependent systems, where floodplains, wetlands, and channels work together. These systems encompass various components, such as flood-dependent vegetation like floodplain wetlands, redgum forests, and redgum and black box woodlands, all of which rely on flooding. This vegetation plays a crucial role in facilitating the movement of essential nutrients, carbon, and sediment between land and water environments. Moreover, it serves as vital habitat and food sources for diverse aquatic life, including fish, birds, invertebrates, as well as reptiles, amphibians, and mammals like rakali and platypus.

Beyond their ecological significance, floodplain river ecosystems offer a range of valuable services. These include soil creation, water purification, climate regulation, and various cultural, educational, and recreational opportunities. Recent research has revealed that healthy wetlands can store more carbon per unit area compared to forest ecosystems, contributing to carbon sequestration efforts.

Figure 3: Recreational activities on Yarran Creek (courtesy of NCCMA)

Emerging evidence underscores the critical connections between floodplains and main river channels. The movement of water, sediment, and carbon particles within the channels significantly affects floodplain productivity. In turn, floodplain-derived carbon is released into the channels during flooding events. This flood-derived carbon becomes a major contributor to the carbon content within the water, which in turn fuels aquatic productivity. This productivity extends to various organisms like benthic algae, phytoplankton, and submerged aquatic plants, which then form the basis of the food chain for creatures like macro invertebrates, fish, turtles, and platypus.

Numerous species have life cycles that necessitate access to both main river channels and wetland habitats. A prime example is the native catfish, which begins its life in wetlands before migrating to the river channels for further development and dispersal.

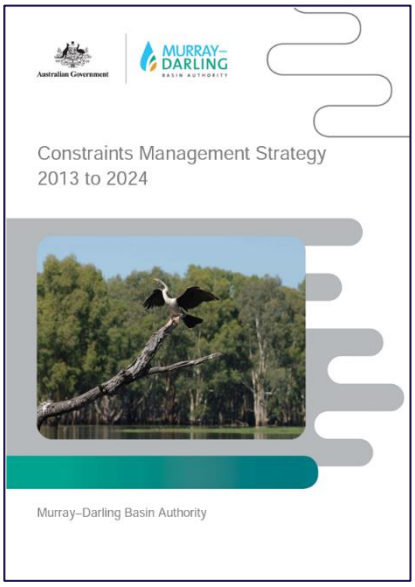
The regulation of rivers has significantly altered these natural features of lateral (side-to-side) and longitudinal (up-and-downstream) connections in the rivers under consideration. River regulation involves managing floodwaters for various uses, and this transformation of flow patterns primarily serves consumptive purposes. However, this alteration reduces the occurrence of natural flooding events, resulting in higher flow rates in the river channels. Consequently, the increased energy in the water leads to greater erosion along the riverbanks. River regulation has also affected specific habitats, including the river channels themselves.

1.3 What is the constraints measures program?

The change in flows due to river regulation and climate change have interrupted many of the natural river and wetland processes. These processes are needed by native plants and animals to survive. Water for the

environment is released into some of these rivers and wetlands to improve their health, however, due to physical and operational barriers, known as “constraints”, there are some low-lying floodplains that cannot be watered.

In 2013, the Murray Darling Basin Authority (MDBA) published the Constraints Management Strategy[1] to investigate how water could be provided to the floodplain and wetland habitats when needed, while avoiding or mitigating impacts to riparian landholders, communities and industries utilising the floodplains. By relaxing constraints through multiple rivers in the southern connected Basin, it aims to achieve significant environmental, cultural and social benefits from flows of up to 80,000 ML/day in the River Murray at the South Australian Border.



The Strategy proposes actions by New South Wales, Victoria and South Australia to relax river operating rules (constraints) to enable overbank flows to reconnect the floodplain to the River to enhance river and wetland environmental health. The Strategy proposed a range of relaxed constraint flows through State implementation of Constraints Management projects for six focus areas across the Southern Connected Basin.

- Hume to Yarrawonga (Upper Murray)
- Below Yarrawonga to Wakool Junction (Mid-Murray
- Goulburn
- Murrumbidgee
- Lower Darling
- Lower Murray (South Australia)

The constraints projects form part of the Sustainable Diversion Limit Adjustment Mechanism (SDLAM) which is a way to change the 2,750 gigalitres (GL) sustainable diversion limits target of the Murray Darling Basin Plan if a similar or even better environmental outcomes for the rivers, wetlands and birds and fish can be achieved using less water with lower socio-economic costs to regional communities. It’s a provision written into the 2012 Basin Plan and agreed by Basin States and the Commonwealth. The constraints projects are “offset projects” that mean better environmental outcomes can be achieved using less water. The Murray-Darling Basin Authority has determined that the water recovery target can be reduced by 605 GL through these projects.

The program's primary objective is to take practical actions aimed at improving the environmental condition of the Murray River. It is essential to recognise that the program's focus is not on restoring the Murray to its pre-European environmental conditions, but rather seeking environmental outcomes in the context of managing risks to landowners and asset owners.

Managers of environmental water would combine or ‘piggy-back’ on existing flows with releases from dams of water for the environment (Figure 4). This would create a more variable river flow regime including overbank flows. These overbank flows help connect the floodplains to the rivers, benefiting the overall ecosystem.

[1] https://www.mdba.gov.au/sites/default/files/pubs/Constraints-Management-Strategy.pdf

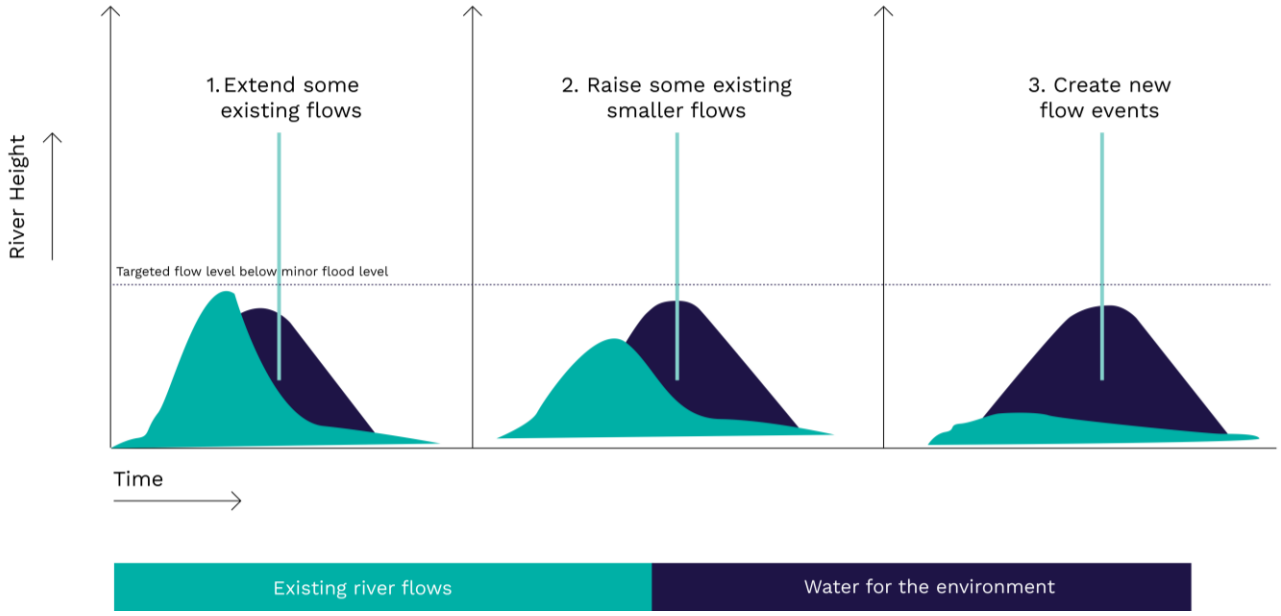


Figure 4: Using water for the environment combined with natural flows can either extend, raise or create flow events required to maintain and enhance the environment

1.4 Victorian Constraints Measures Program

The Victorian Constraints Measures Program (CMP) focuses on utilising the available water for the environment to provide overbank flows to reconnect the rivers to their low-lying floodplains up to the minor flood level. With funding provided by the Australian Government in 2021, Victoria, as part of its ongoing commitment to improving the health of its rivers has embarked on this feasibility study of the Victorian Constraints Measures Program (CMP). The primary objective is to assess the feasibility of relaxing the current flow limits, or constraints, in the Goulburn River and Murray River in Northern Victoria.

The aim is to improve waterway health by enhancing the connection between the Murray and Goulburn rivers to their low-lying floodplains. This also will also maintain and enhance the river environments that are valued by Victorian communities for social and recreational activities.

> *"Through this process we can water more area. It makes more efficient use of the water we can deliver."*
>
> Consultative Committee Member

However, restoring flows to below minor flood levels would have implications for private land, agricultural production, livestock, private access roads, and public infrastructure such as roads, bridges, and culverts. Ways to enhance natural river flows while effectively managing risks and minimising impacts to both public and private land and assets have been investigated.

> "*We want to see the Victorian benefit with the water that has already been recovered as well as preserving cultural benefits.*"
>
> Consultative Committee Member

This feasibility study has considered the balance between increasing the frequency and duration of overbank flow regimes while protecting the interests of land holders, asset owners and communities that would be affected by overbank flows. This approach was taken to ensure that the diverse needs and interests of stakeholders were considered while working towards improving the health the Murray and Goulburn rivers.

Previous investigations, including the development of earlier Business Cases, have been undertaken to explore how a more natural flow regime could be implemented in these rivers. However, these investigations were based on deficient information and data, relied on limited modelling, and failed to adequately consider community and Traditional Owner perspectives on a consistent basis.

This feasibility study has been undertaken using improved data, new superior hydrological models and updated, accurate hydraulic modelling. The modelling undertaken as part of this feasibility study is of a standard that would enable informed conversations with impacted landowners and managers. The establishment of a consultative committee has ensured that the stakeholders that would be affected by relaxing constraints are a central consideration.

1.5 Key objectives for program progression

The Victorian CMP is only one of the projects contributing to the broader strategy. The objective for changed river operations and relaxing constraints in Victoria is multi-faceted and encompasses several key considerations. Recognising the impacts river regulation has had on Victoria's floodplains and environment, the primary aim is to maximise the outcomes derived from the already available environmental water resources to benefit the health of the Murray and Goulburn rivers, as well as their associated floodplains. However, this objective is accompanied by a strong commitment to recognise and effectively manage the risks and minimise and address the impacts on landowners throughout the process.

Managing impacts on landholders is a critical consideration because under the *Water Act 1989* (Vic) river and storage operators (i.e. Goulburn Murray Water) are legally liable for any harm or damage caused by their actions during regulated flows that inundates private property[2] without the agreement of the land owner.

The following key objectives have been identified in the progression of the program:

- **The benefits from the existing environmental water resources need to be maximised:** There needs to be more effective use of and gain the greatest benefit from the already available environmental water.
- **The program needs to demonstrate value for money:** It is essential to ensure that the benefits resulting from the relaxation of constraints surpass the associated costs.
- **The program must deliver both local and broader environmental benefits:** relaxing constraints should achieve not only local environmental benefits within the Goulburn and Victorian Murray, but also broader environmental outcomes that depend on a healthy river and floodplain at a system level and in other states.
- **The program should consider more than environmental benefits:** there may be opportunities for additional benefits to be realised including social, cultural and recreational.
- **The program must receive broader regional support:** Obtaining social licence and regional support is crucial for relaxing constraints. This involves engaging with and gaining approval from the affected communities and stakeholders. Public acceptance and support are vital for the success of projects, particularly those with landowner, environmental and community impacts.
- **The program must actively ensure fair treatment of landowners:** Engaging with and listening to landowners' concerns and needs is essential when considering changes in river operations through relaxing constraints. It is recognised that some landowners would be disproportionately affected, and mitigation and compensation approaches must be fair, transparent, equitable and robust.
- **The program's implementation must be practical**: Straightforward and cost-effective solutions and strategies must be considered, including the complexities of river operations, interjurisdictional regulatory approval processes, and engaging with large numbers of landowners.
- **Water buybacks should be avoided**: The Victorian CMP is an "offset project" under the Murray Darling Plan and together with the other offset projects aims to reduce water recovery by 605 GL. Victorian irrigation communities have already done the heavy lifting to recover water under the Basin Plan and the Consultative Committee believe that further buybacks are unacceptable. By delivering the constraints

[2] Note that river operators are able to undertake releases in association with flood management activities and to protect the structural integrity of the dam.

project and making better use of already available water for the environment, further water recovery from Victoria can be avoided.

By upholding these objectives, the Victorian CMP would strike a balance between achieving positive environmental outcomes and addressing the needs and concerns of local communities, landowners, and the broader system.

1.6 Key focus areas

There are three key focus areas being investigated as part of the CMP as outlined below and depicted in Figure 5.

- **Hume Dam to Yarrawonga Weir:** This section covers approximately 210 km from Hume Dam to Yarrawonga Weir and involves a joint proposal by the Victorian and New South Wales Governments. The Murray River in this reach is a meandering system with a well-defined floodplain and some key conservation areas including Ryans Lagoon, Moodemere nature conservation reserve and the Lower Ovens wildlife reserve.
- **Yarrawonga Weir to Wakool Junction:** Led by the New South Wales Government, this section spanning around 670 km would focus on overbank flows occurring predominantly in NSW. This stretch of the river features a flat floodplain that connects various anabranches, flood runners, and creeks. It is home to important wetland systems, including the Barmah-Millewa Forest and the Gunbower-Perricoota-Koondrook Forest. Victoria would evaluate the possibility of relaxing constraints from the Yarrawonga Weir to the Wakool Junction.
- **The Goulburn River:** This area covers the extent of the Goulburn River, which stretches approximately 430 km from Lake Eildon to the Murray River. This project is divided into two sections:
  - Mid Goulburn: From Lake Eildon to Goulburn Weir.

    Below Lake Eildon, the catchment is characterised by relatively steep foothills. Most of the floodplain has been cleared for agriculture, being predominantly dryland (e.g., livestock grazing) but with some irrigated agriculture. This reach contains high ecological wetland systems such as Tahbilk Lagoon and Horseshoe Bend.
  - Lower Goulburn: From Goulburn Weir to the Murray River.

    The Lower Goulburn floodplain has been extensively modified with clearing for agriculture and grazing on both sides of the river. The priority environmental flow reaches in the Goulburn River are downstream of Goulburn Weir and Gemmill's Swamp and the Lower Goulburn National Park represent notable environmental features of the Lower Goulburn Floodplain.

Although not explicitly included in all technical modelling, consideration has been given to the reach of the Murray River downstream of Wakool Junction to the South Australian, with Traditional Owner consultation undertaken and a desktop assessment of enhanced wetland benefits undertaken in conjunction with the Mallee Catchment Management Authority.

Figure 5: Victorian CMP key focus areas

1.7 Feasibility study development

The Victorian CMP Consultative Committee (the Committee) was established to facilitate a community-centred approach to explore the feasibility of relaxing constraints within the Goulburn and Murray Rivers.

Chaired by Hon. Patrick McNamara AM, the Committee brings together landowners, environmental water managers, river operators, land managers, and Traditional Owners.

Throughout 2022 and 2023, the Committee regularly convened to explore the benefits, risks, and concerns associated with lifting current river flow limits. The Committee's discussions also involved observers from the NSW Reconnecting River Country project, the MDBA, and Australian government representatives from the Department of Climate Change, Energy, the Environment, and Water (DCCEEW).

This report presents a summary of key technical approaches, outcomes, and insights from the Committee, providing advice to the Victorian Minister for Water on the feasibility of changing river operations in the Murray and Goulburn Rivers to enhance environmental outcomes.

2 Consultative Committee and engagement

- The Constraints Consultative Committee was established to provide informed advice on the way forward for the Victorian Constraints Measures Program.
- The matters for consideration within the terms of the Committee's engagement included the approach to community co-design and engagement for any future project phases; changes to physical and operational constraints; impacts, benefits, and cost compensation and mitigation frameworks; and risk management.
- Through open discussions and sharing different perspectives, the Committee fostered an understanding of the project and constraint relaxation requirements.
- The Committee was pivotal in avoiding unnecessary costs or concerns in engaging the community more extensively, especially if the project was considered unfeasible.
- The Committee consisted of local landowners along the Goulburn and Murray Rivers, environmental water managers, representatives from Traditional Owner groups, local governments and agencies.
- Representatives from the MDBA, NSW Reconnecting Country Project and the Australian Government were observers at Committee meetings, associated risk workshops and technical meetings. This ensured transparency in project progress, information, and discussions.
- Engaging a Consultative Committee is the start of implementing community co-design. Future stages should involve a wider range of stakeholders and further engagement. Broadly engaging with the community is needed to comprehensively understand and document the impacts of the program, before individual landholders are approached.

2.1 The importance of a community co-design approach

The Murray-Darling Basin Ministerial Council (MinCo) consists of Ministers responsible for water from each state within the Basin and the Australian Government. During the MinCo meeting held in August 2019, the Ministers agreed on the importance of consultation and engagement for the Constraints Measures Program.

The *MDBA Constraints Management Strategy (2013)* also highlights that affected communities, including landholders and land managers, water entitlement holders, Traditional Owners, management agencies and local government need to be involved from the beginning to identify potential impacts and solutions.

> '*Ministers noted that successful implementation of the constraints program will require close engagement with landholders and local communities…*'
>
> Murray-Darling Ministerial Council 4 August 2019

While there may be ecological benefits of reinstating environmental water to lower floodplains and wetlands, Basin communities have previously raised valid concerns about the impacts on public and private assets and the scope and accuracy of technical information that exists across the program in the Southern Basin.

2.2 Community support in shaping this study

In line with the MinCo commitment, DEECA established the Constraints Consultative Committee to facilitate this community-centred approach. This places potentially impacted community members and stakeholders at the centre of the program. The Committee was given the task of giving informed advice on the way forward, considering the importance of avoiding unnecessary costs or concerns in engaging the community more extensively, especially if the project was considered unfeasible. Independently chaired by the Hon. Patrick McNamara AM, the Committee leveraged the combined experience, knowledge and opinions of members. The role of the Committee was not to reach a consensus, as decisions about the Victorian CMP are the responsibility of the Victorian Government. The Committee provided an advisory forum for members to provide comments and input on the design and feasibility of the program. They also provided input and views for the Minister.

The Consultative Committee comprised members from:

- Registered Aboriginal Parties (RAPs)
- local landholders
- irrigators
- community members
- river operators
- council representation
- Catchment Management Authorities
- Victorian Environmental Water Holder
- land managers
- representative bodies and impacted agencies.

DEECA engaged with agencies to identify community members with experience and knowledge of water-based issues who reside in all sections of the Goulburn and Murray Rivers as part of this study, both in the upper and lower reaches.

Figure 6: Victorian Constraints Consultative Committee (Photo courtesy of Geoff Adams)

Throughout 2022 and 2023, a diverse range of views and perspectives have been shared through Committee meetings and associated forums, surveys, and correspondence received by the Committee Chair. These perspectives have been gathered within this report with all Committee members agreeing that the feasibility report must fairly represent all Committee members' divergent and shared perspectives. The Committee members have all been provided with the opportunity to review and comment on this report to ensure that critical aspects of what was heard are incorporated.

Under the terms of their appointment, the Committee members considered the range of information for relaxed constraints scenarios and provided comments on the merit of proceeding to future stages of investigation under the Victorian CMP. The matters for consideration within the terms of engagement included:

- Approach to community co-design and engagement for any future project phases.
- Changes to physical and operational constraints.
- Impacts, benefits, and cost compensation and mitigation frameworks.
- Risk management.

The Committee has been instrumental in shaping the direction for thorough technical investigations and policy frameworks. By facilitating open discussions and sharing different perspectives, the Committee has fostered an understanding of the project and constraint relaxation requirements. Committee members recognised the complexities of the Victorian CMP and expressed a range of opinions on the benefits, impacts, and feasibility of advancing to subsequent stages. This information would enable informed conversations with affected landowners and the wider community in the future stages of the program.

2.3 Additional Committee actions completed

The Committee discussed the outcomes of technical work and has been instrumental in its design. Committee discussions and input have driven the technical investigation approach of this feasibility study, suggesting:

- additional flow scenarios for modelling
- identifying the need for drone imagery in key sites
- requesting additional studies into riverbank erosion
- suggesting additional locations to install streamflow and rainfall gauges
- requesting additional investigations into the recreational benefits and impacts of changed flow regimes.

2.4 Partnership with Traditional Owners

As well as being on the Committee, DEECA partnered with Traditional Owners via targeted consultation. The pivotal role First Peoples play in this system is recognised, due to their enduring connection to Country and interest in water resource management. In line with Pupangarli Marnmarnepu, DEECA is committed to honouring the rights and dignity of Traditional Owners and Aboriginal Victorians through self-determination. Through partnership with First Peoples, the importance around Aboriginal people being at the centre of decision-making around the issues that affect their lives is recognised.

Traditional Owners were engaged in open dialogue to understand perspectives on the benefits and risks of relaxing constraints in the project area. This program offered the opportunity for dedicated consultation with each of the 21 individual Traditional Owner groups. These conversations allowed them to express their aspirations, concerns, and provide advice on future involvement should the project progress. The potential for floodplain inundation downstream of the study area and consideration of the influence to the Victoria/South Australia border was investigated, but in less detail.

2.5 Additional consultation

In addition, the Committee organised five informal 'kitchen table' meetings with landowners along the Goulburn and Murray Rivers within the area of the study. These meetings served as a platform for additional community members to share their local experiences and perspectives on the likely impacts on private properties and the surrounding environment. By including a diverse range of views, these meetings provided valuable information that enhanced the feasibility assessment of the program.

Additional views were also provided to the Committee using Focus Groups with parties interested in the Victorian CMP. Interviews were held with representatives from:

- the Wentworth Group of concerned scientists
- BirdLife Murray Goulburn
- Trust for Nature.

The outcomes of these focus groups were provided to the Committee to inform discussions.

3 Technical approach

- Technical and modelling studies were the basis of this feasibility study. However, future stages of the program need to include a thorough assessment of the impacts and costs at the local property level, including discussions with impacted individual landowners.
- The project has expanded the network of streamflow and rainfall gauges in the Goulburn River catchment. The locations of these gauges were developed with input from the Consultative Committee and expansion of the network will support river operators in managing river conditions and aid in unregulated flood management.
- To better reflect river operations and water delivery, the hydrological models have been improved by transitioning from a monthly time step to a daily time step.
- For the first time, daily flow information from the Goulburn River hydrological model has been used to inform tributary inflows into the Murray River hydrological model. This is the first step to investigating how the broader system may respond to relaxed constraints.
- Work undertaken for this feasibility study has enhanced the hydraulic modelling capabilities across both the Goulburn and Murray rivers. This work has resulted in detailed inundation maps for both the Goulburn and Murray rivers, from Lake Hume to the Wakool junction, which aligns with modelling undertaken in NSW. Inundation of individual properties can be estimated, and at-risk assets identified for a range of flow scenarios. Detailed inundation maps will inform individual landowner discussions in future stages of the program.

3.1 Aligning with environmental flow requirements

The technical approach looks at what may happen if existing river constraints were relaxed to maximise the outcomes from already available environmental water.

It's not simply the amount of water flowing in a river that's important. Environmental flows aim to mimic the natural flow regime including the volume, timing, duration, frequency and quality of flows that are provided. Like the natural flow of rivers, different combinations of flow components provide a range of benefits for ecosystems. The roles of these different flow components are shown in Figure 7.

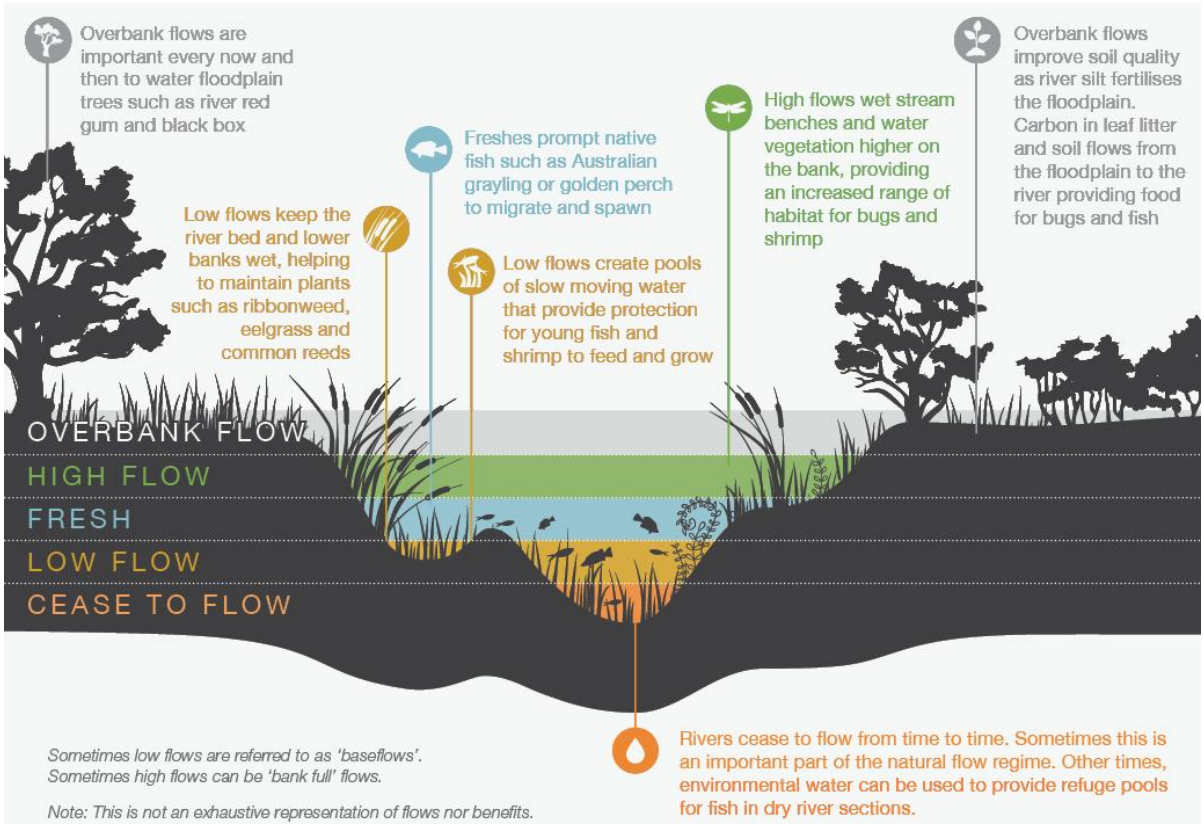


Figure 7: The role of different environmental flow components[3]

Environmental water requirement (EWR) considers these flow components to establish the amount, frequency and duration of water required to maintain and preserve aquatic ecosystems, with a minimum risk of degradation.

Developing environmental flow and watering recommendations is a complex scientific task that uses information on the hydrology, geomorphology, and ecology of the river system. The method follows a process to establish specific environmental objectives that depend on water flows and determine the flow regime necessary to achieve those objectives. The hydrologic models in this study aim to deliver environmental flows and watering regimes in line with the recommendations for each of the river reaches[4,5,6].

The inputs to the model best represented how environmental water may be ordered in line with the Goulburn River environmental flow requirements and river operations. The DEECA modelling team worked closely with Goulburn-Murray Water and environmental water managers. Their expertise and knowledge were crucial in clarifying the assumptions and inputs used in the modelling process. All assumptions and inputs were extensively workshopped with Goulburn Broken Catchment Management Authority, Goulburn-Murray Water and the Victorian Environmental Water Holder (VEWH).

The EWR incorporated into the model were developed to deliver both instream flow events that support fish breeding and overbank flows up to minor flood levels to water lower parts of the floodplain. Although the modelled flows were based on the flow recommendations, the actual environmental water able to be delivered at any time would be dependent upon many factors including water availability, catchment conditions, tributary inflows and environmental needs.

Environmental water deliveries require planning that considers various climatic conditions. The established environmental flow recommendations set the desired flow regime (timing, duration, frequency) to achieve flow-dependent environmental objectives. This provides a range of flow

[3] Source: VEWH, https://www.vewh.vic.gov.au/news-and-publications/stories/understanding-flows-some-terminology-explained

[4] Department Of Planning, Industry & Environment DPIE. (2020). Murray–Lower Darling Long Term Water Plan Part A: Murray–Lower Darling catchment.

[5] GBCMA (2014) Mid Goulburn River FLOWS study- Final report: Flow recommendations.

6 University of Melbourne (2020) Kaiela (Lower Goulburn River) Environmental Flows Study

recommendations for desired flow frequency, timing and duration. However, it is essential to understand that achieving these flows may not always be feasible due to prevailing climatic conditions and water availability.

This project does not attempt to reinstate the full range of environmental flow recommendations as some of these flow magnitudes would require man-made flows equivalent to moderate and major flooding. Constraints is only targeting flows up to the minor flood level so as not to create severe impacts on regional communities.

Overbank flows are of the greatest interest to landowners, as opposed to the in-channel flows of varying levels that are also considered as part of the flow requirements. The overbank flow recommendations for each river reach and flow scenario are presented in Appendix 2: Environmental Flow Requirements.

3.2 Current operating constraints in the Goulburn and Murray Rivers

River operators manage flows in the Goulburn and Murray Rivers in accordance with operating rules that are designed to minimise conveyance losses and avoid overbank flows that inundate private property. These operating rules or 'constraints' are effective for the delivery of consumptive water but prevent environmental managers from ordering environmental water releases to create overbank flows to water environmentally valuable floodplains. This means that the full potential of environmental outcomes from existing water holdings are not achieved and environmental water is not being used as efficiently as it could be.

In the Murray River and Goulburn River, operating rules for regulated flows are specified downstream of major dams and weir storages at locations where overbank flows first occur or at gauging stations that are indicative of downstream overbank flows. The locations of current river operating flow limits within the areas of this study are provided in Table 1 and are shown in Figure 8. These flow limits aim to strike a balance between water management needs and safeguarding private properties from water flow.

Table 1: Current river operating flow limits

Location	Current constraint (ML/d)	Current constraint (river height m)	Minor flood level (m)
Murray River at Doctors Point (downstream of Hume Dam)[a]	25,000	3.7	4.3
Murray River at Yarrawonga Weir (downstream of Lake Mulwala	15,000	2.4	6.4
Goulburn River at Molesworth[b] (downstream of Lake Eildon)	10,000	-	-
Goulburn River at Shepparton (downstream of Goulburn Weir)	9,500	5.52	9.0

a. The operational constraint at Doctors Point is 17,000 ML/d however agreements have been reached with many (not all) landowners to allow operational flows of 25,000 ML/d. The minor flood level presented is that at Albury

b. Note: The current constraint at Molesworth is notional. Water released from Eildon Dam is currently limited to a maximum of 9,500 ML/d to stay below the notional constraint at Molesworth as no gauge currently exists. As such there is no associated constraint river height or minor flood level established at Molesworth.

Figure 8: Key current operating constraints in the areas of study along the Goulburn and Murray Rivers

3.3 Flow scenarios investigated

As part of the study, various flow scenarios up to the minor flood level were selected so modelling could be done.

All modelled flow scenarios were analysed based on the volume of presently available environmental water holdings, without considering any potential additional water recovery measures, such as the 450GL outlined in the Basin Plan. Most Committee members strongly voiced concerns about the prospect of further water recovery through buybacks. These concerns stem from the observed adverse effects of previous buybacks within northern Victorian communities.

A baseline for considering the relaxation of flow constraints is established by the flow rates specified in the Basin Plan SDLAM program. Notified flow rates are the maximum flow rates proposed to be targeted for environmental flows as part of constraint measure projects. The flow rates were notified in concept business cases prepared as part of the Basin Plan's Sustainable Diversion Limit Adjustment Mechanism process. These notified flow rates were based on scientific studies which aimed to maximise ecological outcomes, were agreed upon by the Murray-Darling Ministerial Council in 2017[7] and form the scope of the Victorian CMP, are as follows:

- **Hume to Yarrawonga key focus area:** Relax constraints on regulated environmental flows up to 40,000 ML/day at the Doctors Point gauging station below Hume Dam on the Murray River.

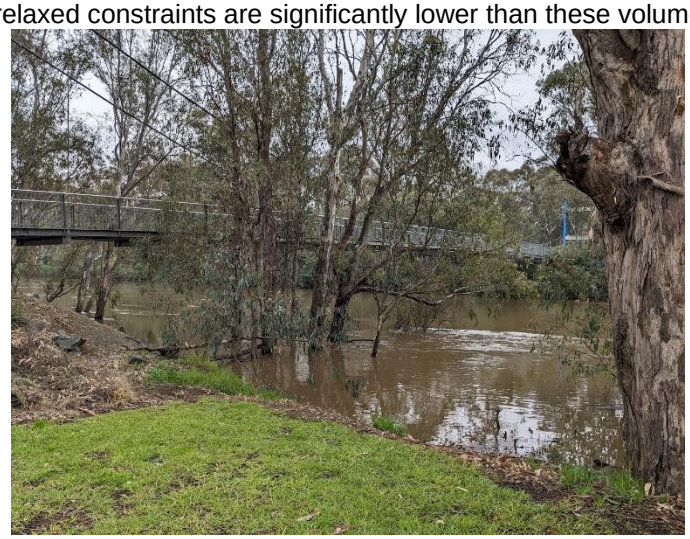
[7] Package of supply, constraint and efficiency measures agreed by the Murray Darling Basin Ministerial Council on 16 June 2017, https://www.mdba.gov.au/sites/default/files/docs/Package-constraint-supply-efficiency-measures.pdf

- **Yarrawonga to Wakool Junction key focus area:** Relax constraints on regulated environmental flows up to 30,000 ML/day at Yarrawonga Weir on the Murray River. Additionally, a risk buffer is included to accommodate flows up to 50,000 ML/day.
- **New Goulburn key focus area (nominated as a constraint measure only):** Relax constraints on regulated environmental flows up to 17,000 ML/day with a risk buffer to 20,000 ML/day at Shepparton. It is important to note that originally, when the Basin Plan was settled, the proposed constraints relaxation for the Goulburn was up to 40,000 ML/day. However, the State decided to modify the notified flow rate to 20,000 ML/day to prevent the inundation of the lower-Goulburn floodplain while still allowing bank full and high in-channel flow rates. This modification was also in response to community concerns about the impacts of larger flows.

The Committee used these flow rates and boundary parameters as a starting point for their discussions on relaxing flow constraints in the study areas of the Murray and Goulburn Rivers. These parameters align with the Victorian government's position that the Goulburn reach should focus on flows within the river channel only and that overbank flows should not be considered.

Opinions within the Committee varied when it came to the proposed flow ranges for modelling on the Goulburn River. Some members expressed concerns that these flows might not bring sufficient environmental benefits. They suggested exploring higher flows, including overbank flows, to fully understand the advantages and impacts of relaxing constraints. They wanted to ensure that the feasibility study was robust and credible by investigating the benefits and impacts associated with these higher flows. On the other hand, some members argued against changing the established parameters and believed that the focus should solely be on flows within the river channel.

During the discussions, the Committee recognised the presence of levees in the lower-Goulburn, which protect private land but leave public land more vulnerable to the potential impacts of relaxed constraints. The development of this levee system commenced in the late 19th century, providing flood protection from flows of up to 40,000 - 50,000 ML/day for the adjacent agricultural land. As the flows being considered under relaxed constraints are significantly lower than these volumes, there are not expected to be material impacts on the structures.



Some Committee members proposed that if higher flows, even up to the minor flood level, were considered in the lower-Goulburn, it would be beneficial to also assess the benefits and impacts of similar scenarios in the mid-Goulburn. They highlighted environmental values in the stretch from Eildon to Nagambie that could potentially benefit from increased flows. Concerns were raised about the potential negative consequences on properties and businesses around the Molesworth area if flows were increased, as the current releases from Lake Eildon are designed to manage inundation at Molesworth.

Figure 9: Bank full flows in the Goulburn River at Shepparton

The Committee highlighted the need for a thorough feasibility study that examines the benefits and impacts of larger flows along the entire Goulburn River, including flows up to the minor flood levels with an extra buffer for risk mitigation. Buffers enable river operators to have a risk allowance in their operations when targeting flows. The need for appropriate buffers to be defined and be in place if relaxed constraints are to be implemented has been highlighted by river operators as part of the river operation risk assessments undertaken as part of this project. The actual buffers required are currently undefined and would depend on a range of factors including the constraint scenario, the sophistication of flow management tools available to operators and the coverage of data systems. Compensation and mitigation framework measures would be based on the potential impacts at the targeted flow plus the buffer (ie buffers are on top of target flows) (Figure 10). Committee members acknowledged that as flow scenarios increase, the buffer should be adjusted appropriately to ensure effective mitigation against unintended inundation.

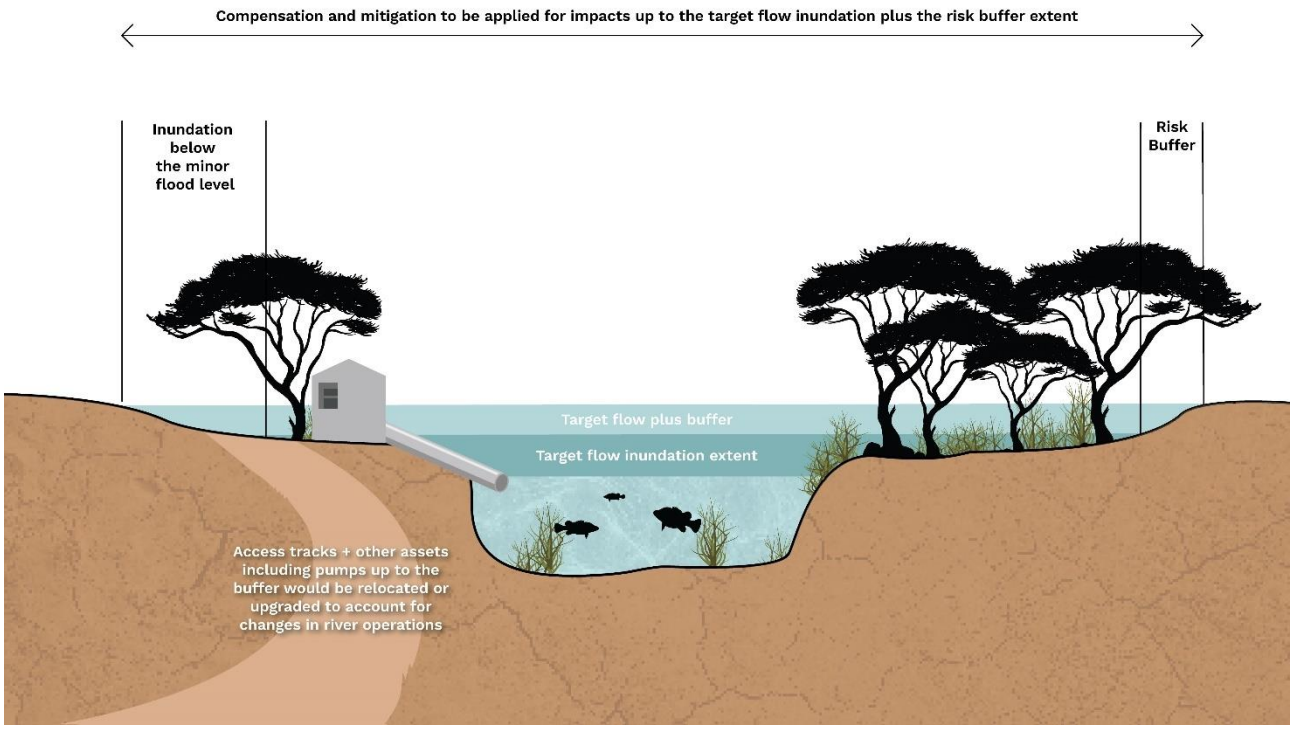


Figure 10: Relaxed constraint flow target and risk buffers

To explore the various possibilities for constraint relaxation in the mid and lower Goulburn River, the University of Melbourne's Stochastic Goulburn Environmental Flow Model (SGEFM) was employed. This model was chosen for its flexibility and ability to quickly evaluate multiple constraint scenarios to provide the greatest insights. Prior to this analysis, the SGEFM underwent several updates to ensure its outputs were well-suited for investigating constraint relaxation.

The modelling, known as the "range-finding" exercise, identified four combinations of operational constraint options for the Goulburn River that were worth undertaking an analysis of their benefits and risks and exploring further with the Committee. These options were assessed based on the expected improvements in important measures like the reliability of water allocations, reducing environmental water shortages, and decreasing the amount of allocated environmental water that can't be delivered efficiently due to constraints. Each Goulburn flow scenario was also evaluated using twelve ecological models that represent the specific objectives for environmental water in the lower Goulburn River. These assessments provide valuable information about the potential outcomes of each constraint relaxation option and were endorsed by the Committee for further modelling.

The relaxed constraints scenarios modelled for the Goulburn River are shown in Table 2 and are represented in Figure 11. All flow scenarios are below the minor flood level (where defined) with the minor flood level in Shepparton being 30,800 ML/day.

Table 2: Goulburn River relaxed constraint scenarios

Constraint location	Current constraint (ML/d)	Relaxed constraint scenario (ML/d)			
		M10L17	M10L21	M12L21	M14L25
Molesworth (Mid Goulburn)	10,000 (notional)	10,000[a]	10,000	12,000	14,000
Shepparton (Lower Goulburn)	9,500	17,000[a]	21,000	21,000	25,000

a In-channel constraint scenario originally considered as part of the assessment. Scenarios greater than this were requested by the Committee for broader consideration.

The naming convention used to describe the flow scenarios, as outlined in Table 2, is:

- M = Mid Goulburn constraint as managed at Molesworth (flow in ML/d)
- L = Lower Goulburn constraint as measured at Shepparton (flow in ML/d)

For example, the scenario M14L25, is the combined relaxation of constraints in both lengths of the Goulburn River. The M14L25 naming convention represents relaxing constraints to:

- Mid Goulburn: 14,000 ML/d, as managed at Molesworth.
- Lower Goulburn: 25,000 ML/d, as measured at Shepparton.

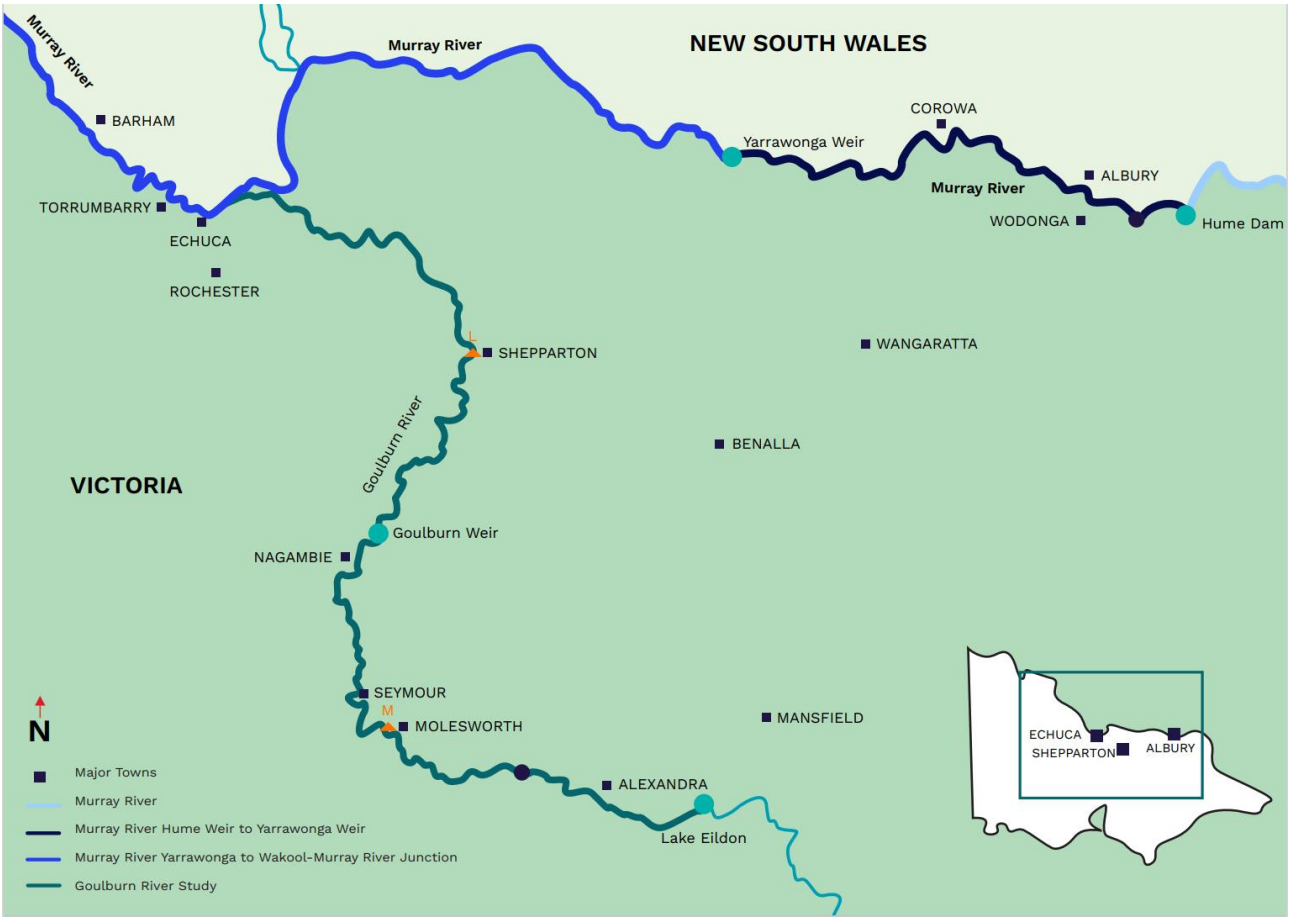


Figure 11: Location of the modelled Goulburn constraints at Molesworth and Shepparton

Like the Goulburn River relaxed constraint flow scenarios, members of the Consultative Committee supported testing a range of relaxed constraints flow rates in the study areas on the Murray River above (up to the minor flood level, inclusive of a risk buffer) and below the notified flow rates. This was done to understand the impacts on the expected levels of benefits and the resulting acceptability to stakeholders.

The Committee determined that the proposed baseline flows for modelling in the Murray River were suitable. The Committee also recognised that coordination and communication with the complementary floodplain restoration projects and the New South Wales constraints program equivalent, Reconnecting River Country Program (NSW RRCP), would be necessary.

Table 3 below summarises the scenarios investigated by the Victorian CMP for the Murray River at the constraint locations shown in Figure 12. The flow scenarios for the study areas on the Murray River align with the relaxed constraints flow rates assessed by the NSW RRCP in the Murray River.

Table 3: Murray River relaxed constraint scenarios

Constraint location	Current constraint (ML/d)	Relaxed constraint scenario (ML/d)			
		Y25D25	Y30D30	Y40D40	Y45D40
Doctors Point (Hume to Yarrawonga)	25,000	25,000	30,000	40,000	40,000
Yarrawonga Weir (Yarrawonga to Wakool)	15,000	25,000	30,000	40,000	45,000

The naming convention used to describe the flow scenarios, as outlined in Table 3 is:

- Y = Yarrawonga weir downstream constraint (flow in ML/d)
- D = Doctors Point river gauge constraint (Flow in ML/d). Doctors Point is located approximately 5 km downstream of Albury-Wodonga.

For example, the scenario Y45D40, is the combined relaxation of constraints in both study lengths of the Murray River. This scenario represents relaxing constraints to:

- Hume to Yarrawonga: 40,000 ML/d, as measured at Doctors Point.
- Yarrawonga to Wakool: 45,000 ML/d, as measured at Yarrawonga Weir.

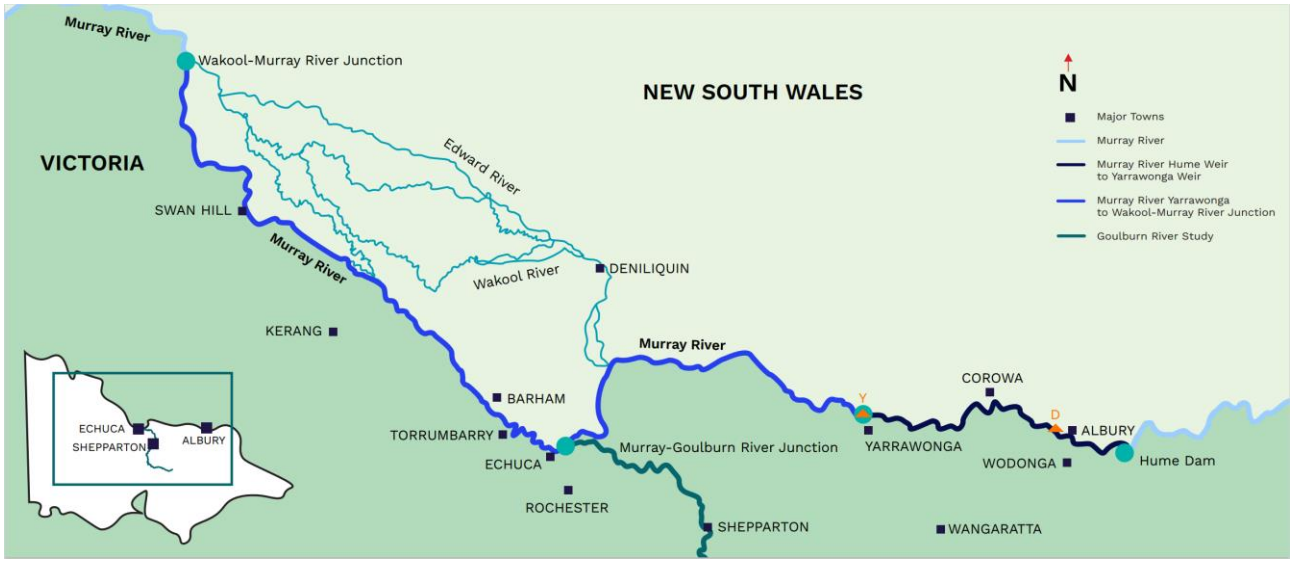


Figure 12: Location of the modelled Murray River constraints at Doctors Point and downstream of Yarrawonga Weir

These scenarios for the Goulburn and Murray Rivers were used within the technical modelling and were further discussed by the Committee.

3.4 Modelling approach

Three types of models were used to understand water in the landscape under different relaxed constraint scenarios: hydrologic, hydraulic and environmental.

- **Hydrologic modelling** was used to investigate the differences in water availability and river flow that would impact the surrounding land including the frequency (how often), duration (how long), timing (what time of year) and size (how big) of river flows.

- **Hydraulic modelling** was used to prepare maps that show the potential land that may be under water under the different flow scenarios. It showed the extent (area covered), depth (how deep) and velocity (how fast) of water flows.
- **Environmental modelling** was used to study how the environment would react to changes in how often, how long, and where floodplains get inundated. This was looked at based on historical climate conditions as well as where river flows were reduced due to climate change.

Hydraulics explains where the water goes in the landscape.

Hydrology explains river flow behaviour (timing, frequency, duration and river height).

These models were used to investigate options for relaxing constraints in the Goulburn and the study areas of the Murray River (Figure 13).

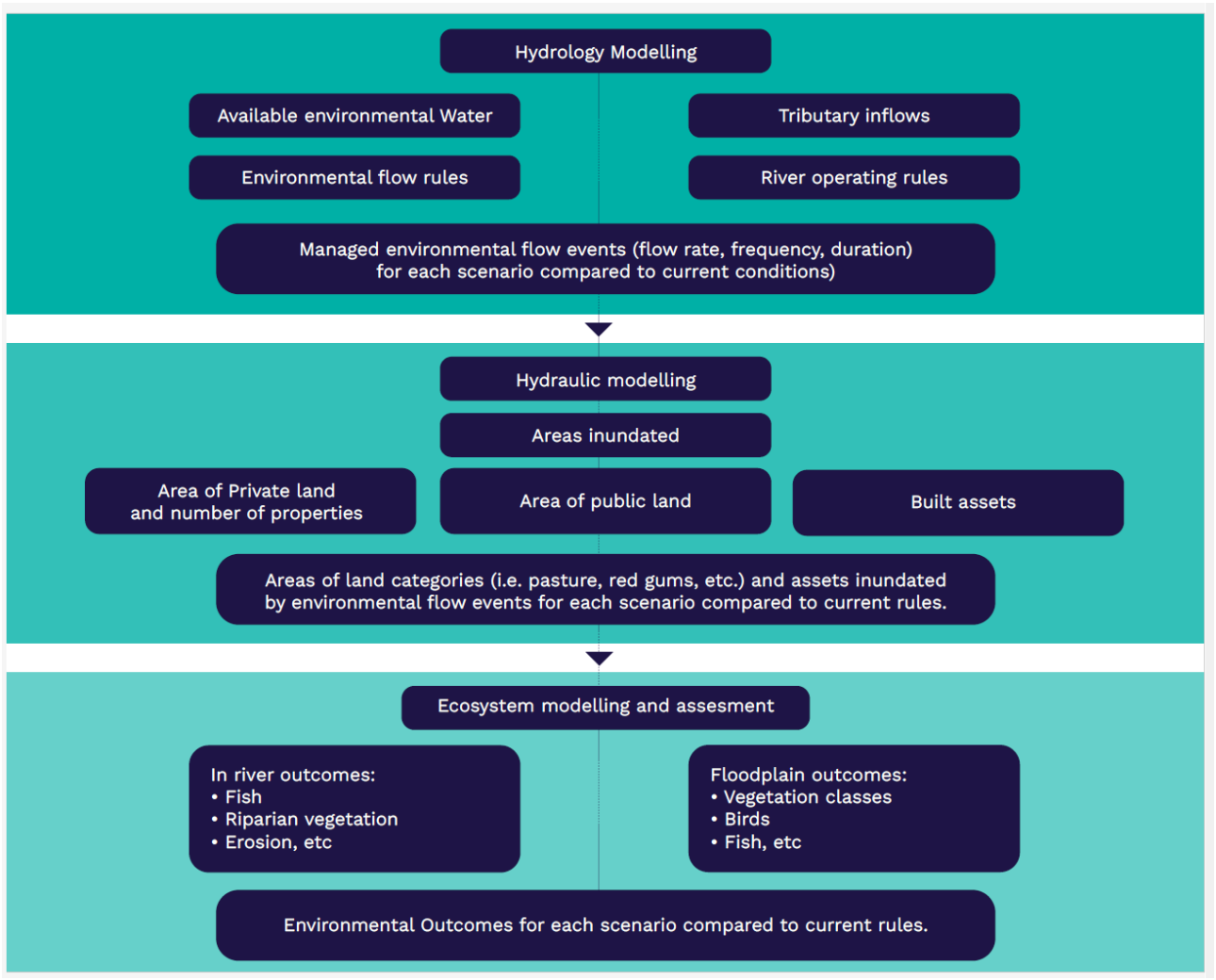


Figure 13: Feasibility study analysis approach

3.5 Improvements in data and models

Past investigations and business cases were conducted to explore options for addressing constraints on the Murray and Goulburn Rivers. However, these studies were based on limited information and data. Concerns were also raised by community members around the adequacy of this previous work. Recognising these limitations, Victoria and NSW commissioned an independent review of the previous modelling, which

concluded that the existing approach was not suitable for a project like constraints relaxation[8]. A key finding from this review was that the modelling done was *not suitable for assessing and communicating the third-party risks. The modelling has been undertaken at an aggregate scale for planning purposes…. The available modelling does not produce the information required to access and communicate risks to landholders, local governments, and infrastructure managers at 80,000 ML/d at the South Australian border*.

The key previous model limitations identified by the Independent Expert Panel are shown in Table 4. This also demonstrates how these concerns have been addressed as part of the feasibility study technical work.

Table 4: How Independent Expert Panel concerns were addressed

Independent Expert Panel concern	How this feasibility study has addressed these concerns
The available modelling did not produce the information required to assess and communicate risks to landholders, local governments, and infrastructure managers at that scale.	Property level mapping has now been undertaken with a 2m grid cell compared to the 10m grid cell previously used. This provides a greater level of detail for landowners and land managers as to what inundation extents may occur at different flow scenarios.
The extent to which the use of the environmental portfolio (of water allocations) relies on implementation of constraints measures was partially assessed.	A key indicator used for this feasibility study was the efficiency of use of the already available portfolio of water for the environment. This was compared to current operating conditions as well as a range of future climates for flow scenarios.
Changes in the area, frequency, and duration of inundation of compared to a 'do nothing' case were not presented.	This study has presented analysis of the areas, frequency, and duration of land under current operating conditions as well as a range of flow scenarios.
River operators have identified that investment in additional rainfall and stream gauging is required at various locations to enable better informed decisions about regulating overbank flows	Additional rainfall and streamflow gauges have been installed as part of this program to increase the coverage of the hydrometric network. This will provide river operators with greater real time information to assist in river operations.
This modelling should also investigate the effects of low, median, and high climate change scenarios on environmental water availability, flooding characteristics and environmental outcomes.	Climate change scenarios have been included in the modelling approach for this feasibility study so that the range of flow scenarios and resulting ecological impact can be compared under a range of future climates.

This feasibility study has specifically addressed these data and modelling gaps. This ensures that meaningful conversations and informed decisions have taken place within the Committee and with the wider community.

Hydrological modelling is used to determine the frequency, duration, timing, and size of river flows. This study uses the latest models that operate on a daily time-step, compared to the monthly time-step used in previous investigations. These updated models also include operating rules for using environmental water that were developed catchment management authorities in consultation with specialist ecologists.

In addition, advances were made in modelling how environmental water holdings in the Goulburn River could be used to contribute to environmental water demands in the Murray River.

Work to support environmental watering regimes in the Murray, Goulburn and Murrumbidgee rivers is underway. The integration of the modelling outcomes from the Goulburn and Murray systems is an important advance.

River morphology changes over time and can change after flood events. Extensive bathymetry surveys (measurements of the river's depth and the shape of its bed and banks) have been completed for the mid

[8] Murray Darling Basin Constraints Modelling – Report by the NSW and Victorian Ministers Independent Expert Panel, 16 December 2019

Goulburn which is crucial for accurate hydraulic modelling to identify where the floodplain is inundated at different river flow rates/water levels. Over 190 kilometres of the mid Goulburn River was surveyed using advanced echo sounder technologies (Figure 14). Land-based survey techniques were also used to establish river cross sections at 30 locations.

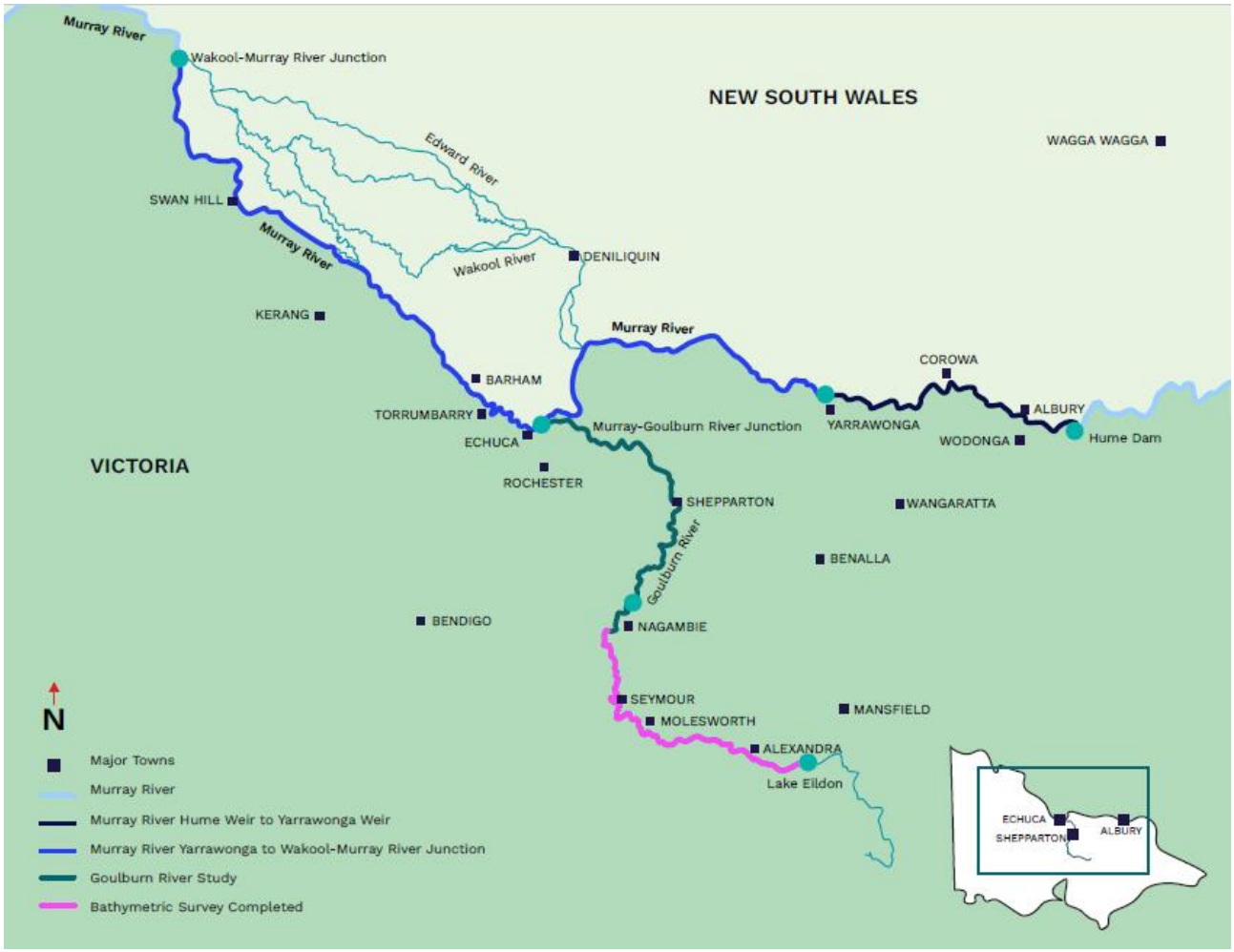


Figure 14: Extent of new bathymetric survey on the Goulburn River

Aerial photography of overbank flow events in 2010 and 2017 were used to ensure the accuracy of the hydraulic models.

The updated Goulburn hydraulic model provides water depth estimates at a much finer resolution, with information available at 2-meter grid cells (Figure 16), compared to the previous models' 10-meter grid cells (Figure 15). This means that the information generated is more meaningful and useful for property owners and public land managers, as it provides a clearer understanding of where water may go on their properties at the scales that are most relevant to them.

Figure 15: Representation of modelled 25,000 ML/d flows in the Lower Goulburn in previous modelling (2016). Inundation extents are 'blocky' due to the 10m cell resolution and the depth of water across the floodplain is not represented.

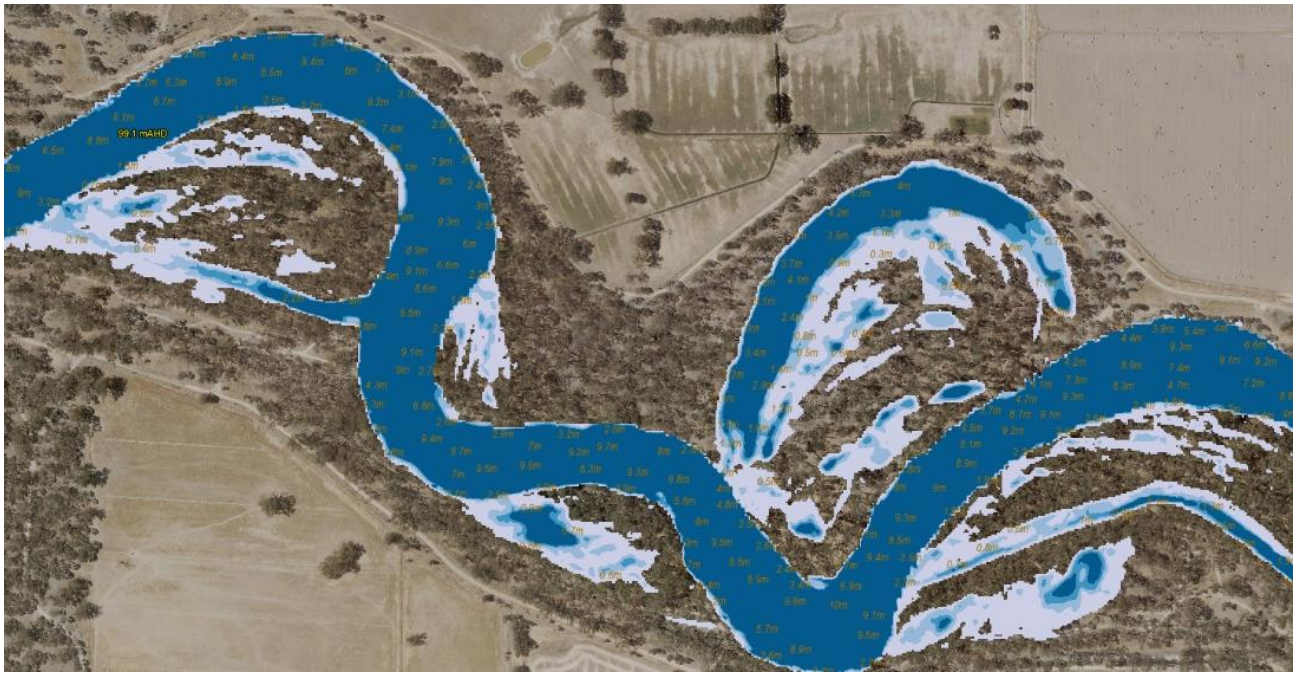


Figure 16: Representation of 25,000 ML/d flows in the Lower Goulburn for modelling undertaken as part of this feasibility study (HARC, 2022). Results are more refined with 2m cell grids and the depth of water across the floodplain is presented. The darker the blue colour the deeper the water.

These improvements mean that the hydraulic modelling results used for this assessment are more robust and address the comments of the independent review of the previous modelling. This modelling found that potential inundation risks needed to be more detailed and presented at smaller scales to enable meaningful consultation with the community about constraint relaxation.

The improved data and modelling significantly improve the accuracy and reliability of the analysis undertaken by this study. Consideration will need to be made in any future stages regarding how the river morphology has changed following the 2022 flood event. The Committee advised that the analysis provided is fit for the purposes of this feasibility study.

3.6 Improvements in gauge network for real-time data

To effectively plan and manage enhanced environmental watering and the associated river operations, it is crucial to have reliable data on rainfall and stream flows. Gaps had previously identified in the stream flow and rainfall monitoring networks in the mid-Goulburn catchment, which contributes approximately one half of the flow in the Goulburn River. Murray River gauging within the area of study was considered adequate.

> *"It would be good to get the extra rainfall and streamflow stations to help in operating the river. Having access to the technology can help mitigate the risk."*
>
> Consultative Committee Member

To address gaps, an assessment was conducted on the existing monitoring network, and the suitability of new sites for gauges was evaluated. Key stakeholders were consulted including GMW, GBCMA, DEECA and BoM (Bureau of Meteorology) and Consultative Committee members. The assessment also included thorough field investigations.

The final sites for new gauges is shown in Table 5 and Figure 17 below.

Table 5: New rainfall and streamflow gauges to be installed as part of the Victorian CMP.

No	Site	Type	Latitude	Longitude
1	Goulburn River at Molesworth	Streamflow & Rainfall Gauge	-37.1651	145.5438
2	Yea River confluence with Goulburn River	Streamflow & Rainfall Gauge	-37.2101	145.4130
3	King Parrot Creek confluence with the Goulburn River	Streamflow & Rainfall Gauge	-37.1731	145.2523
4	Major Creek upper catchment	Rainfall Gauge	-36.9708	144.7946
5	Dabyminga Creek & King Parrot Creek - Upper Catchment	Rainfall Gauge	-37.2694	145.2108
6	Acheron River & Murrindindi Rivers – Upper Catchment	Rainfall Gauge	-37.3766	145.6213
7	Rubicon River upper catchment	Rainfall Gauge	-37.3739	145.8653
8	Rubicon River lower catchment	Rainfall Gauge[1]	-37.2906	145.8275
9	Spring Creek upper catchment	Rainfall Gauge	-37.0777	145.7181
10	Murrindindi upper catchment	Rainfall Gauge	-37.4722	145.5661
11	Murrindindi River at Murrindindi	Telemetry Only	-37.397	145.564

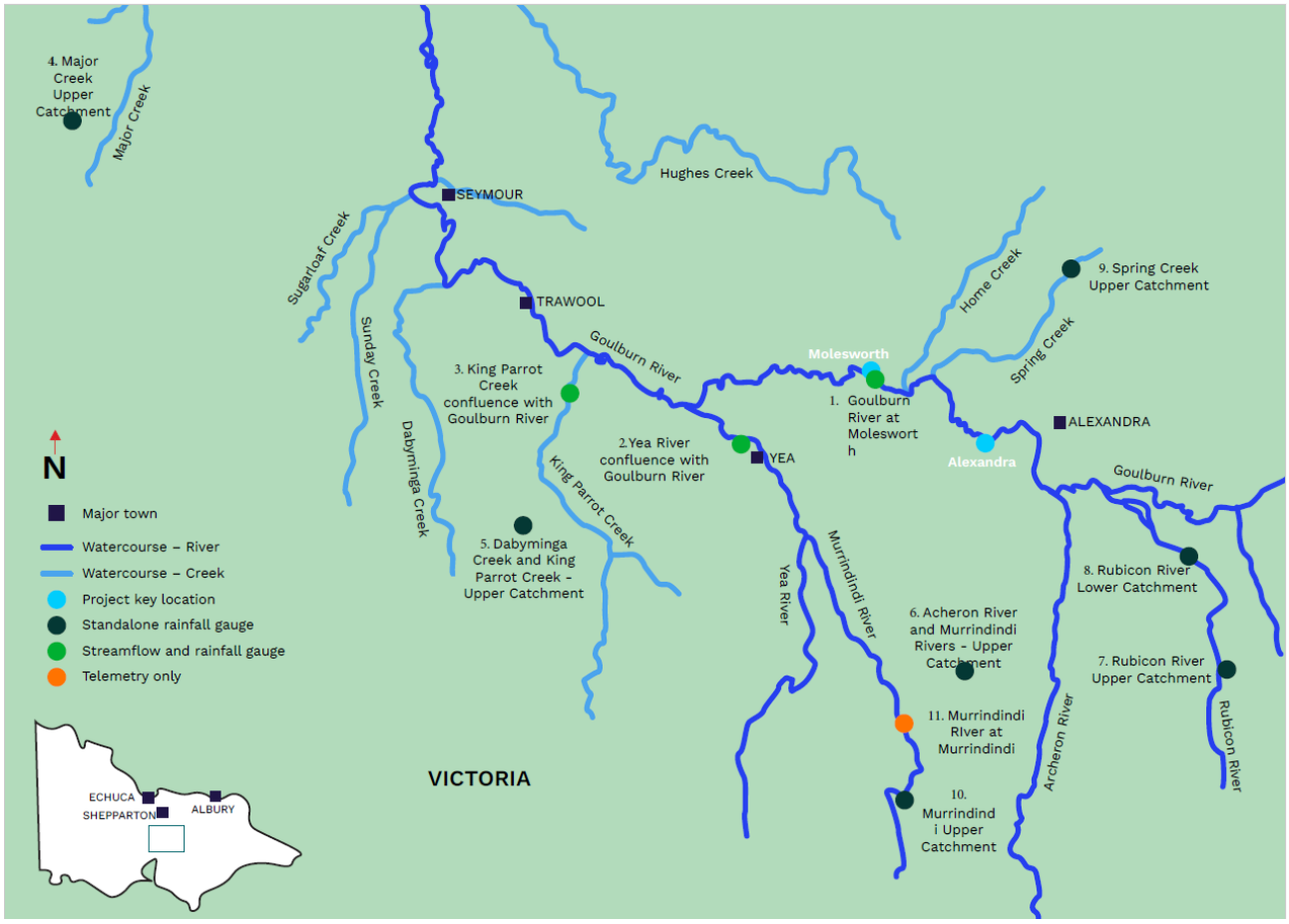


Figure 17: Overview map of installed streamflow and rainfall gauging sites

The Committee supported construction of additional gauges as part of this stage of the project. Among the proposed sites, the Committee recognised the new streamflow gauges at Yea and Molesworth as particularly beneficial.

Installation and operation of all newly identified sites is expected to be completed by the end of 2023 subject to the necessary approvals.

> *"A new gauge at Yea will make a big difference"*
>
> Consultative Committee Member

Improving the rainfall network coverage and availability of streamflow gauging data in these areas would support better decision-making for river operations. By expanding the monitoring network, it would be possible to gather more comprehensive and accurate real-time data on stream flows and rainfall, which would be vital for informing environmental flows under relaxed constraints.

Figure 18: Rainfall gauge installed in Murrindindi upper catchment (site 10)

3.7 Understanding flow heights, frequency, timing and duration

Hydrological models of the Goulburn and Murray rivers were used to simulate flows in the river system using both historic climate data and projected climate change data for each of the relaxed constraints scenarios. The models were configured to consider both consumptive and environmental water entitlements. The models provide daily data on seasonal water allocations, the amount of water carried over, the amount of water used by both consumptive water entitlement holders and environmental water holders and river flows.

The daily river flow data is used to generate statistics about the frequency of flow rates (and river heights), the duration of flow events of interest to environmental managers, and the length of time between the flow events of interest. These data are important inputs for determining the extent and frequency of inundation of floodplains which in turn is required to investigate environmental outcomes.

The Goulburn and Murray hydrological models targeted the environmental flow demands, including the overbank flows listed in Appendix 2, and simulated the relaxed constraint scenarios using historical climate data from the 1890s to June 2020. Additionally, the models were run for post-1975 conditions and projected climate conditions for the year 2070 to understand how relaxing constraints would meet environmental water demands under future climate scenarios. This analysis helped us assess the effectiveness of constraint relaxation in meeting environmental needs in the face of potential climate changes.

The purpose of the hydrologic modelling in this stage of the Victorian VCMP was to investigate the relaxation scenarios investigated by the Committee. The anticipated environmental, cultural, and social impacts of relaxing constraints were analysed by combining the results of the hydrological modelling with the predicted extent of inundation from hydraulic models and ecosystem modelling. This enabled the Committee to compare the projected outcomes with the current conditions, giving them a clearer idea of the potential changes and enabling them to provide informed input on the feasibility of the project.

The University of Melbourne, DEECA, and MDBA conducted the hydrologic modelling for this feasibility study. These models considered the current water demands, infrastructure, and operational rules. The purpose was to evaluate how well the desired environmental flow recommendations could be achieved under different scenarios where constraints were relaxed.

This study is the first time such modelling has been done using the daily-time step DEECA Goulburn, Broken, Campaspe, Coliban, and Loddon (GBCCL) Source Model and the MDBA Source Murray Model (SMM). These models improve significantly on previous modelling and is the first time that the impact of constraint relaxation in the Goulburn and Murray systems has been modelled in a connected way. While the hydrology models for the Goulburn and Murray systems are not directly connected, they have been created using the same software (Source). This means that although the models cannot automatically transfer water from the Goulburn model to the Murray model to meet environmental or irrigator demands, the outputs from the Goulburn model can be easily converted into input files for the Murray model. This allows the simulation of relaxed constraint scenario flows at the end of the Goulburn River and their impact on the Murray River.

It is important to note that the hydrology modelling presented in this study is based on certain assumptions regarding how environmental water managers order and manage environmental water. These modelling assumptions cannot optimise deliveries and fully incorporate the real-life flexibility in decision-making that environmental water holders actually have, however they impact the predictions of the timing, duration and frequency of bankfull and low overbank flows under relaxed constraints. If environmental water managers and river operators work to better coordinate the environmental water flows between the Murray and Goulburn rivers, even more improvements can be expected. The potential benefits and impacts of more closely aligning the use of environmental water in the rivers that comprise the southern connected Murray-Darling Basin is being considered as part of the Enhanced Environmental Water Delivery (EEWD) project.

The Committee highlighted the crucial influence of flow frequency, duration, and timing of higher flows on landowners, particularly in terms of land management. Some members expressed that prolonged inundation exceeding one week could result in significant damage and loss of productive pastures, leading to substantial re-establishment costs. Victorian research into inundation impacts on productive pastures indicates that prolonged water cover for 5 days or more can cause significant long-term damage[9]. Rising expenses for fertilisers, seeds, and other materials further exacerbate the financial burden faced by affected landowners.

[9] Department of Primary Industries (2011) Recovery of pastures after floods – fact sheet

Feedback from the Committee included a preference for a single significant inundation event rather than multiple smaller height and longer duration events, as the latter would have a more severe impact on their business through multiple clean-ups and reinstatements. **Therefore, it is essential to provide clear information on targeted flows and outcomes from the modelling in future communications with potentially affected landowners**. This information should not only include inundation extents but also details on the proposed timing, duration, and frequency of flows under relaxed constraints. Such clarity would enable landowners to assess the potential impact on their operations effectively.

> *"Floods that come quickly and get away quickly are easier to manage."*
>
> Consultative Committee Member

The adequacy of using a daily time-step model was discussed by the Committee and whether the feasibility study needed sub-daily models to capture the rapid fluctuations in flows in small tributaries like the Yea River.

Flows in the large rivers like the Goulburn and Murray River respond much more slowly to rainfall than small tributaries in steep catchments like the Yea river where flow can rise and fall within a single day in response to heavy rain.

> *"Under flows of 7-21 days, all of our flooded productive pasture will be dead when the water goes down and it would take 18 months to come back to full production.*
>
> Consultative Committee Member

The daily time-step models used for the Goulburn and Murray rivers are appropriate for investigating high flow events which typically extend over weeks rather than within a day. This model captures the overall trends and impacts of different management scenarios.

River operators do not use these models for operational decisions. Goulburn-Murray Water currently uses real time flow and rainfall data recorded every 15 minutes to inform their storage release decisions. Real time information would continue to be used by river operators if constraints are relaxed. Additional rainfall and streamflow gauges have been installed to improve data required for real time river operations.

The Committee concluded that the hydrology models were fit for purpose.

3.8 Understanding potential inundation extents

Hydraulic modelling was used to map the areas on the floodplain that are likely to be covered by changed river flows and determine the corresponding water depth.

The hydraulic modelling for the feasibility study was undertaken by consultants HARC for the Goulburn River, Manly Hydraulic Laboratory (NSW Department of Planning and Environment) for the Murray River Barmah to Torrumbarry (Zone 9), and the MDBA for the remaining Murray River hydraulic model zones.

The Committee wanted to ensure that modelling results accurately represented what may happen under the changed river operations. Models were carefully calibrated to ensure they were accurate and fit for purpose for the flow scenarios being investigated.

The models undergo a calibration and validation process using data from existing flow gauges along the river to ensure their accuracy and reliability. During calibration, the model parameters were adjusted to match the historical flow records at the gauged locations. Once calibrated, the model accurately simulated flows at other locations within the river system, even where gauges may not be present.

Calibration data comparing modelled and recorded data were presented to the Committee. Figure 19 provides an example of the modelled data for the Goulburn River at Seymour compared to the observed data. It shows the relationship between the depth of water in the river at a streamflow gauge and corresponding river flow volume. The blue modelled output at the flows being considered strongly aligns with the official rating curve and the orange measured flow records. The blue output is on or very close to the official rating curve as shown in Figure 19. The strong correlation between the modelled and observed data is also evident for all other gauges along the Goulburn River. The calibration process demonstrates the model's ability to predict river heights accurately at intermediate locations and confidence that it is fit for purpose.

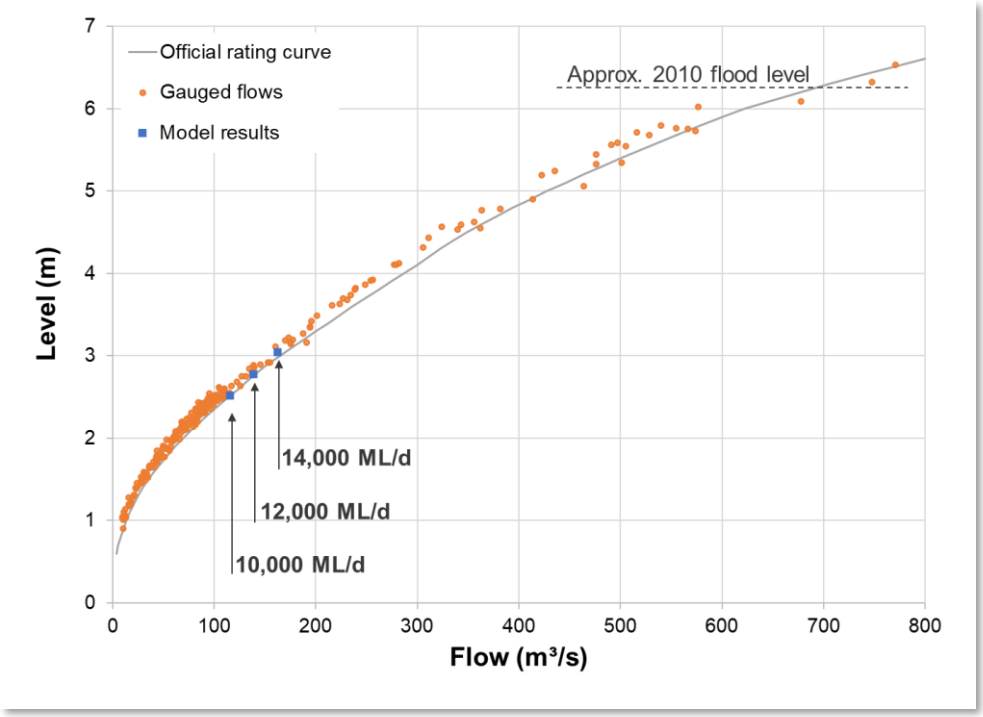


Figure 19: Hydraulic model results (blue) at Seymour on the Goulburn River against the official rating curve (grey) and gauged/measured flows (orange) (HARC Goulburn modelling 2022).

The hydraulic models have been used to generate the 'inundation area' for both the current conditions and the relaxed constraint flow scenarios along the Goulburn and study areas of the Murray River as presented in Table 2 and Table 3. An example of the inundation modelling is demonstrated in the following figures for the Molesworth Recreation Reserve and Caravan and Camping Park along the Goulburn River. The modelled inundation area is shown on maps by a gradient of blue colours. The darker the blue, the deeper the water.

The lighter the blue, the shallower the water as shown in Figure 20 below. This figure demonstrates that there are already low-lying areas of the landscape that are currently already inundated under the current constraint conditions.

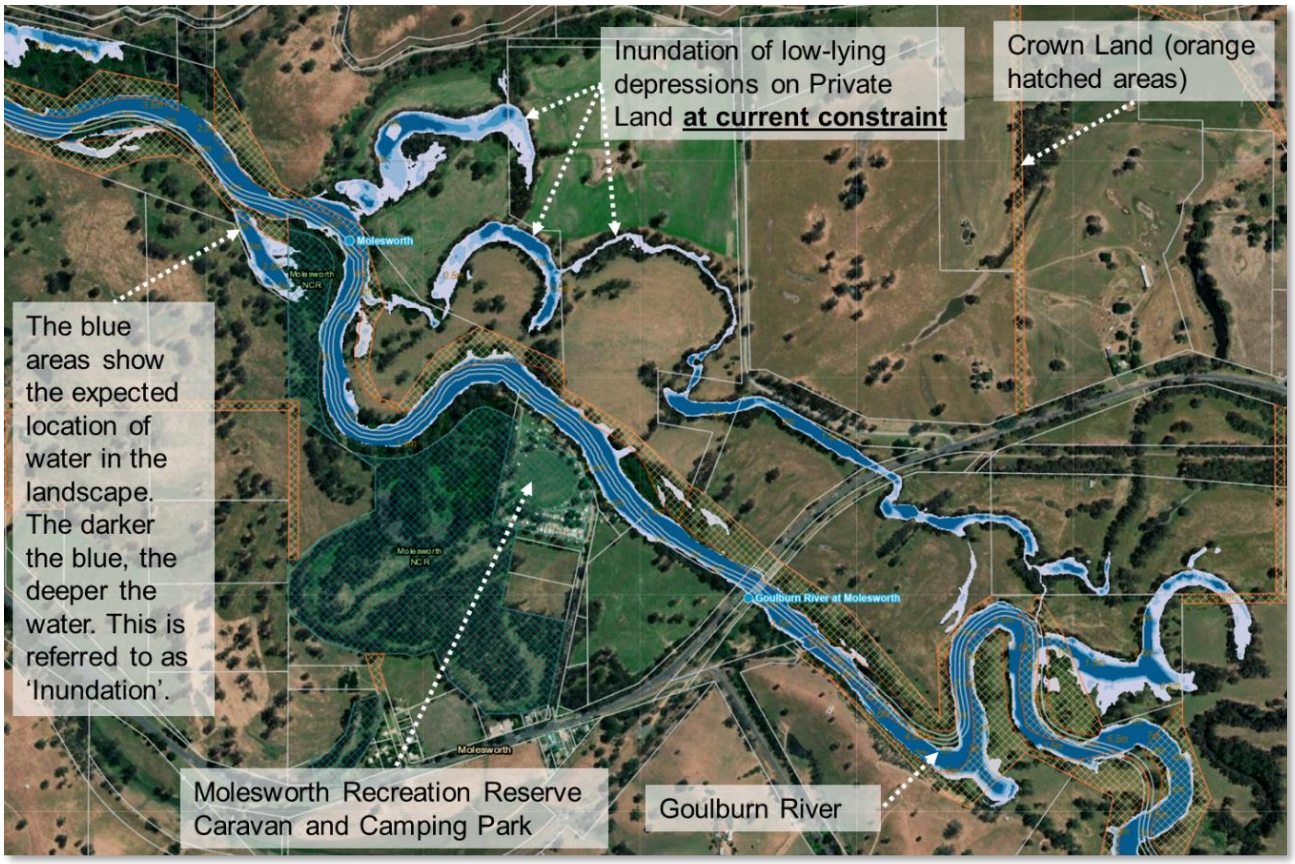


Figure 20: Mid Goulburn, Goulburn River - Molesworth Recreation Reserve Caravan and Camping Park, showing the flow footprint of the 10,000 ML/d current constraint conditions as measured at Molesworth

As the flow scenario increases, the area of inundation of the surrounding land also increases, filling low areas of the floodplain including heavily vegetated oxbows or billabongs (Figure 23). Oxbows or billabongs are created when a river's wide bend is separated, forming a U-shaped body of water. Figure 21 shows the additional areas that would be inundated at Molesworth if the current constraint limit of 10,000 ML/d is increased to 12,000 ML/d. The newly inundated areas compared to under current constraint conditions are circled in red.

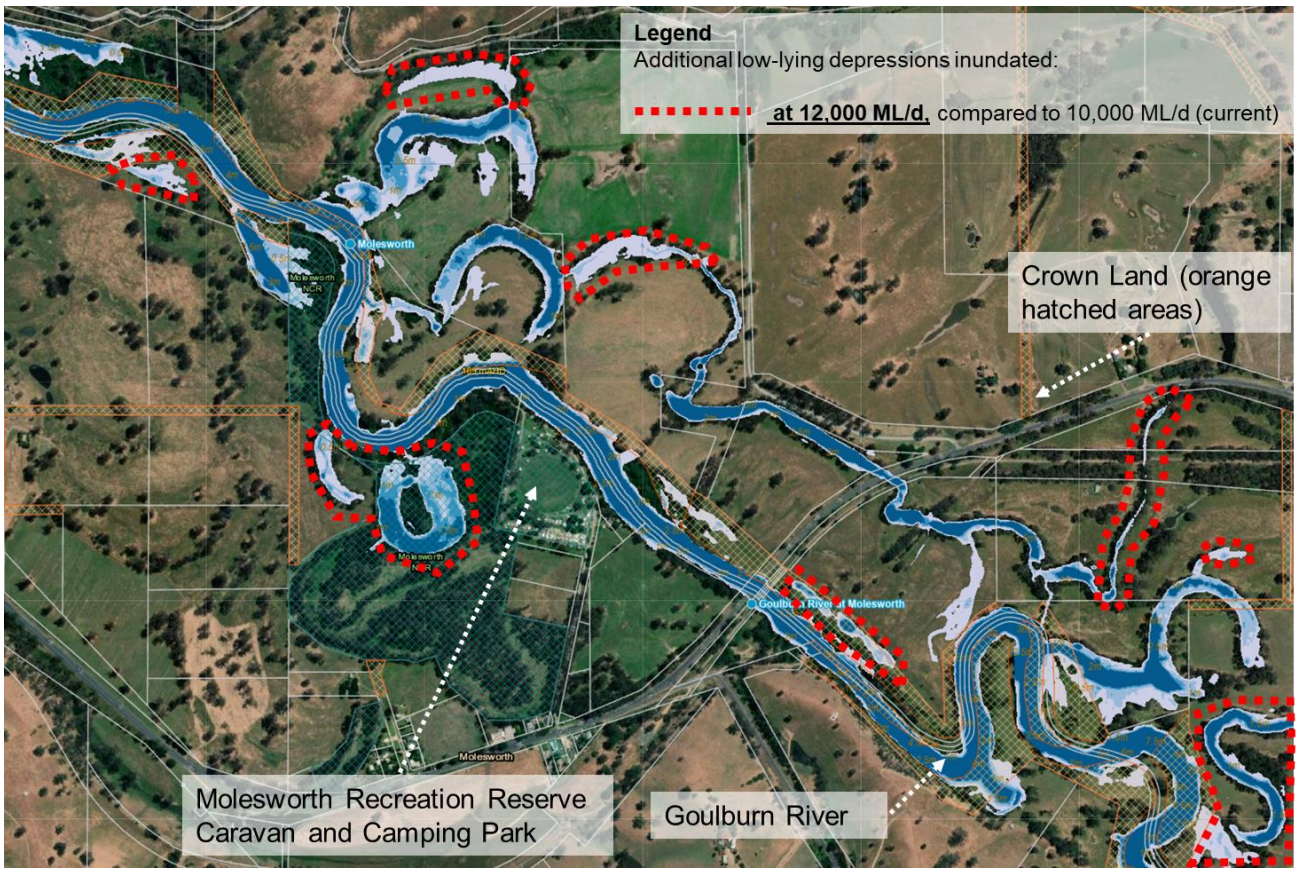


Figure 21: Mid Goulburn, Goulburn River - Molesworth Recreation Reserve Caravan and Camping Park, showing 12,000 ML/d as measured at Molesworth. The areas in red are newly inundated under flows of 12,000 ML/day compared to the current constraint

As the constraint continues to be relaxed, corresponding river heights would increase and so would the area of low-lying floodplain inundated. Figure 22 shows the additional area of land around Molesworth that would be inundated as the constraint is further relaxed from 12,000 ML/d to 14,000 ML/d. The additional areas inundated are shown in yellow compared to the areas that are inundated under flows of 12,000 ML/d.

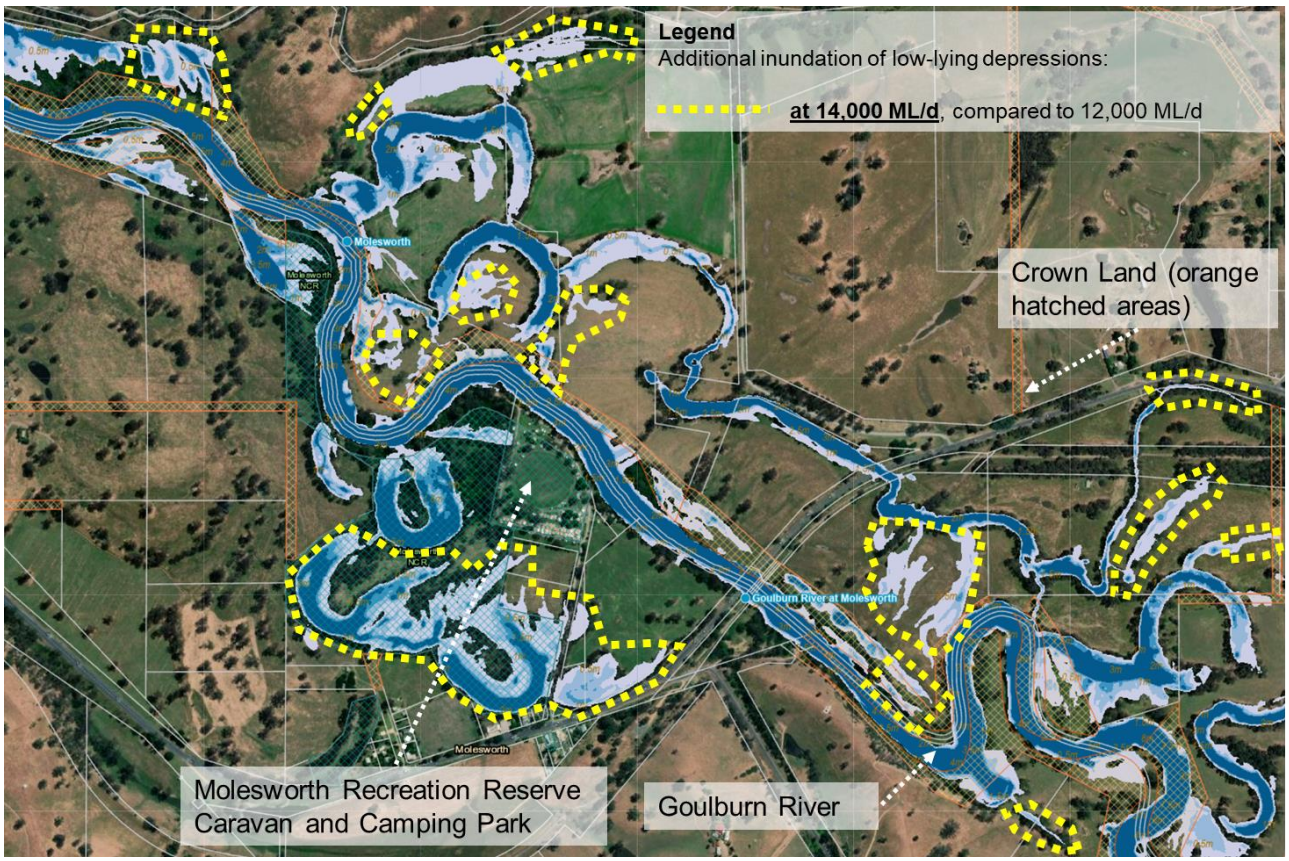


Figure 22: Mid Goulburn, Goulburn River – Molesworth Recreation Reserve Caravan and Camping Park, showing 14,000 ML/d as measured at Molesworth, with areas in yellow newly inundated compared to flows of 12,000 ML/d

Figure 23 below shows the full inundation of the Molesworth Recreation Reserve area at flows of 14,000 ML/d. Areas within the yellow and red are inundated at these flows compared to under the current constraints. This shows that at flows of 14,000 ML/d there is no impact to the Molesworth caravan park or entrance track.

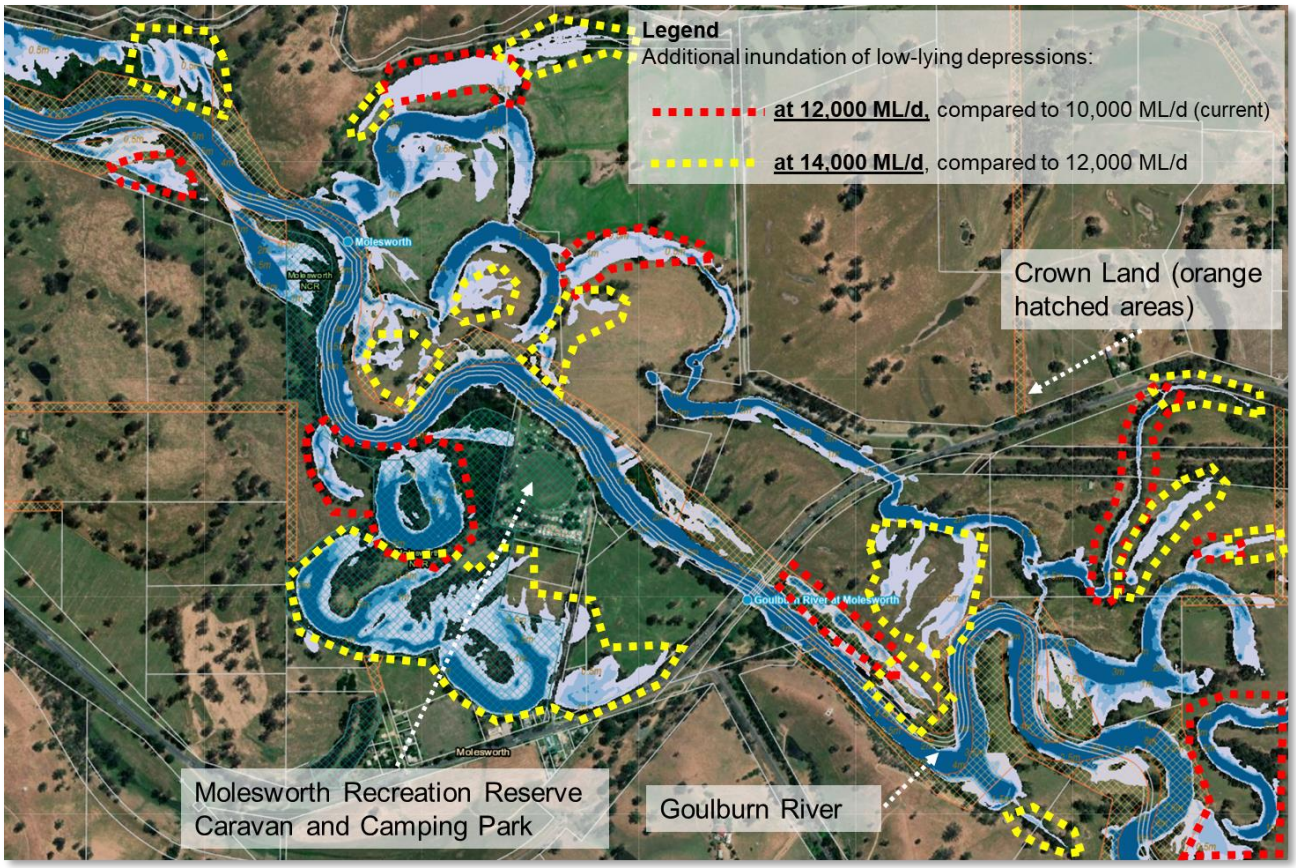


Figure 23: Mid Goulburn, Goulburn River - Molesworth Recreation Reserve Caravan and Camping Park, showing 14,000 ML/d as measured at Molesworth, with annotations for flows of 12,000 ML/d. The highest flows considered by the Committee are 14,000 ML/d

Similar impacts can be seen along the study areas of the Murray River as constraints are relaxed and flows increase for each of the modelled scenarios. Flows of the current constraint of 25,000 ML/d in the Hume to Yarrawonga extend into low-lying depressions adjacent the Murray River on both private and public land as shown in Figure 24 below at an example location at Brimin.

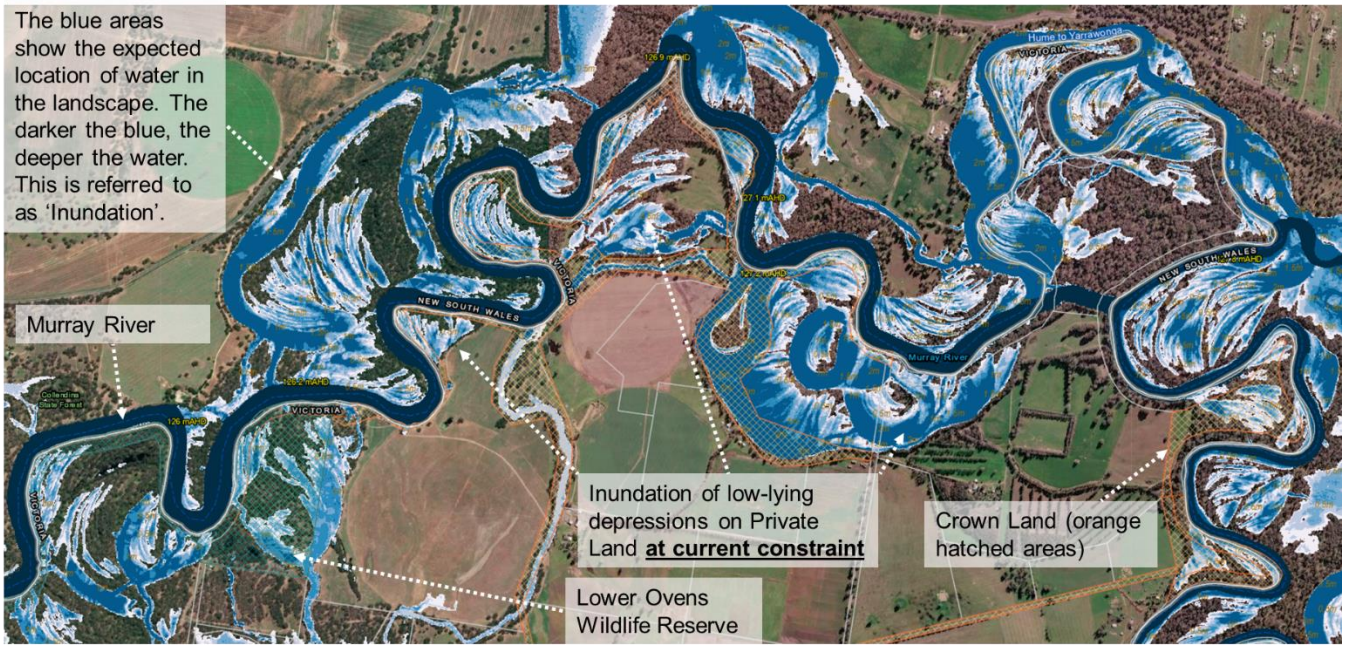


Figure 24: Hume to Yarrawonga reach Murray River - Area around Brimin, showing the modelled inundation extent at the current flow constraint of 25,000 ML/d

As the constraint at Doctors Point is relaxed, and flows increase to 30,000 ML/d, further extents of the low-lying floodplain are inundated. These additional areas at this flow at Brimin on the Murray River are shown in the red dashed lines in Figure 25.

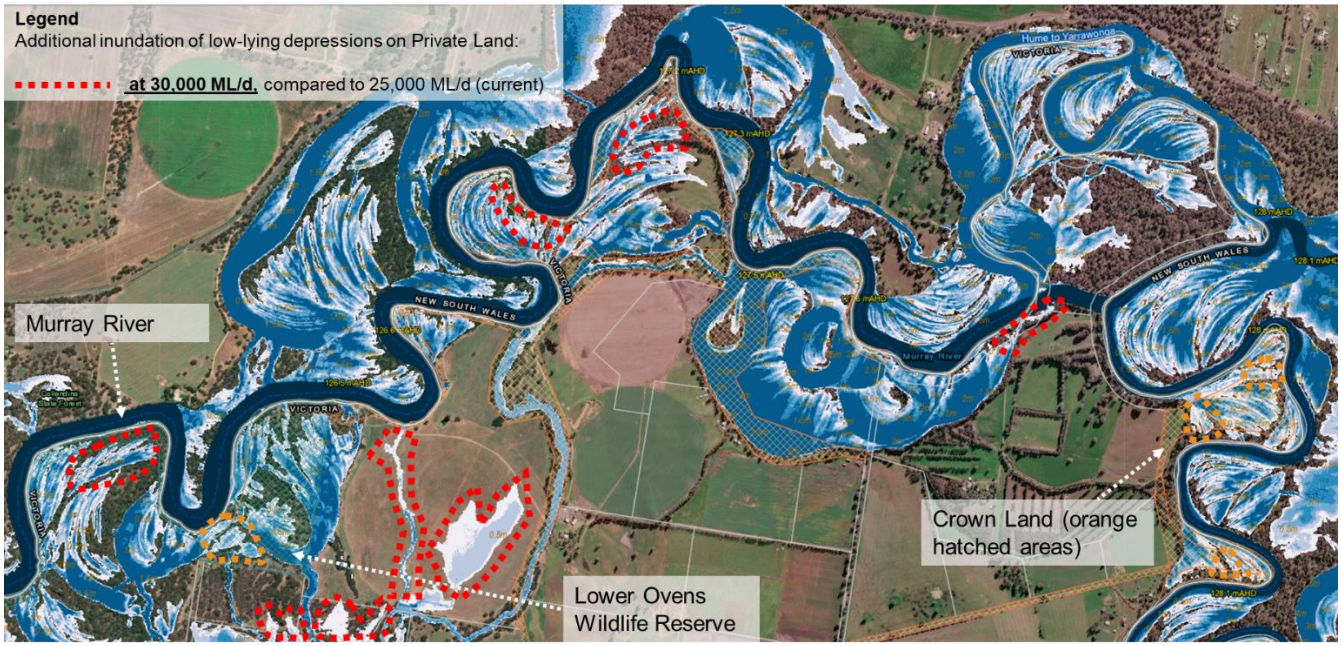


Figure 25: Hume to Yarrawonga reach on the Murray River - Area around Brimin showing the modelled inundation extent at 30,000 ML/day. The areas in red are newly inundated under flows of 30,000 ML/day compared to the current constraint of 25,000 ML/day

Relaxing the constraint at Doctors Point further to 40,000 ML/d, increases the depth of inundation over area and increases the connection to the floodplain even further. The additional areas of the floodplain engaged around Brimin at flows of 40,000 ML/d compared to 30,000 ML/d are shown in the yellow dashed lines below (Figure 26). Existing levees at this site continue to protect adjacent private property at modelled flows of 40,000 ML/d.

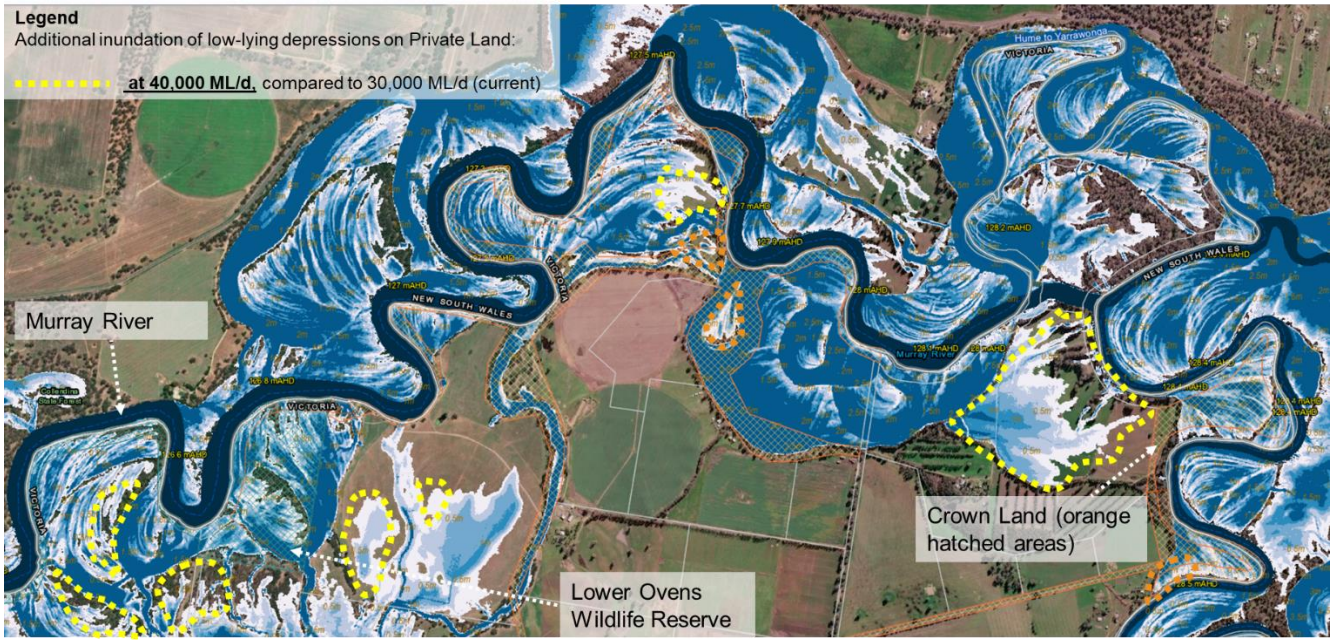


Figure 26: Hume to Yarrawonga reach on the Murray River - Area around Brimin showing the modelled extent at 40,000 ML/day with areas in yellow newly inundated compared to flows of 30,000 ML/day

Figure 27 below shows the full inundation of the floodplain at Brimin at flows of 40,000 ML/d. Areas within the yellow and red are inundated at these flows compared to under the current constraints.

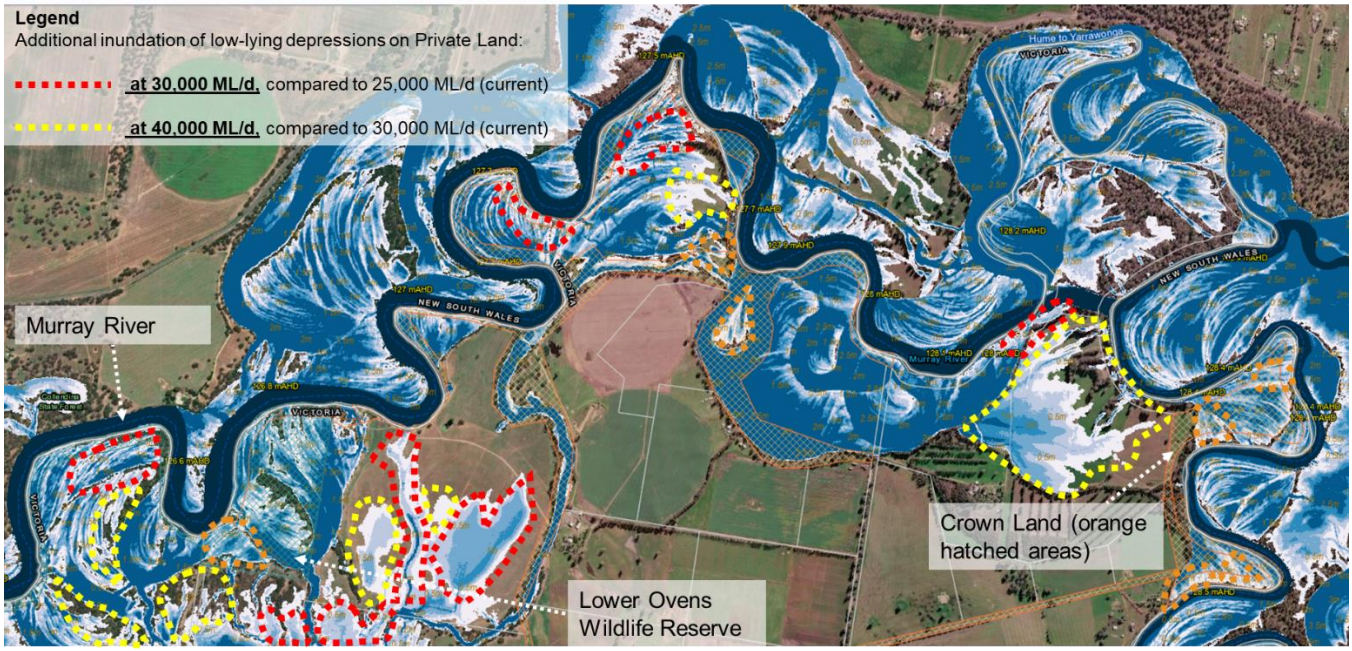


Figure 27: Hume to Yarrawonga reach on the Murray River - Area around Brimin showing the modelled extent at 40,000 ML/day with annotations for flows of 30,000 ML/day. The highest flows considered by the Committee for this reach are 40,000 ML/d.

The Committee investigated whether raising river levels in the Goulburn and Murray Rivers by relaxing constraints caused water levels to rise in their tributaries. The effect of creating higher flows in the Goulburn River on flooding in the lower Yea River was investigated because of concerns that it was "*unable to drain as quickly*". Local landowners have observed this phenomenon, which they refer to as "backing up" of water, leading to localised flooding. Similar concerns were raised about water "backing up" Murry River tributaries including the Loddon and Ovens rivers.

> *"Flood water doesn't get away easily when the Goulburn is high."*
>
> Consultative Committee Member

The modelling results indicated that while there is some inundation of properties at the confluence of the Goulburn and Yea Rivers during flows of interest in the Goulburn, the river responses in the Yea River were primarily driven by localised rainfall and runoff from its steep catchment, rather than being influenced by high flows in the Goulburn River.

Committee members also expressed concerns about the flows from the tributaries of the Ovens and Loddon rivers into the Murray River, highlighting previous major flood events on the Murray and Loddon rivers that caused major damage to farms. One specific example highlighted was the major flood in 2011, where the Loddon River's backing up led to a property being inundated for a period of 16 weeks.

The Committee acknowledged that the experiences of landowners during previous major flood events, can significantly influence their perceptions of the potential impacts of relaxed constraints on their properties even though flow rates enabled by relaxing constraints would be much lower, generally not exceeding minor flood levels. The Committee recognised the importance of effective communication to address any concerns and provide accurate information regarding the modelled outcomes from relaxing constraints.

Committee members requested additional validation of the accuracy of the modelled inundation areas. This was necessary due to concerns raised in previous investigations of the Goulburn and Murray rivers between 2013 and 2017, which prompted the need for ground-truthing.

> *"I think the issue of ground-truthing the model is very important."*
>
> Consultative Committee Member

The model outcomes were also subjected to further testing by representatives from the Catchment Management Authority (CMA), Traditional Owners, Goulburn-Murray Water, select Committee members, and individual private landowners along the Goulburn River. This testing allowed for a comparison between the predicted extent of inundation from the model outputs and the observed inundation on the ground. The results demonstrated a strong correlation between the modelled outputs and the actual water levels observed, providing validation for the accuracy of the models.

During the Committee's tenure, both rivers experienced a significant major flood event. Although the actual flows during the flood surpassed the flow rates considered by the Committee for relaxed constraints, the rising water provided an opportunity to conduct site visits, use drones, and capture aerial and satellite imagery to accurately map the extent of flooding caused by the flow rates being modelled for the different scenarios. The observed levels of inundation were compared with the extent of inundation predicted by the models.

The ‘A’ and ‘B’ in the aerial image and plan in Figure 28 below show approximately the same locations in the landscape at Bunyarra on the Murray River in the Hume to Yarrawonga reach. The dark yellow circle shows the approximate location of the drone and the dashed lines the ‘field of vision’. The shape of the water on the landscape in the photo of a natural flood event of approximately 40,000 ML/d strongly matches the shape of the modelled inundation extent at modelled flows of 40,000 ML/d as it ‘fans’ out into the floodplain. On both the photo and the model output, the water is crossing the same point in the landscape at the A and B locations.

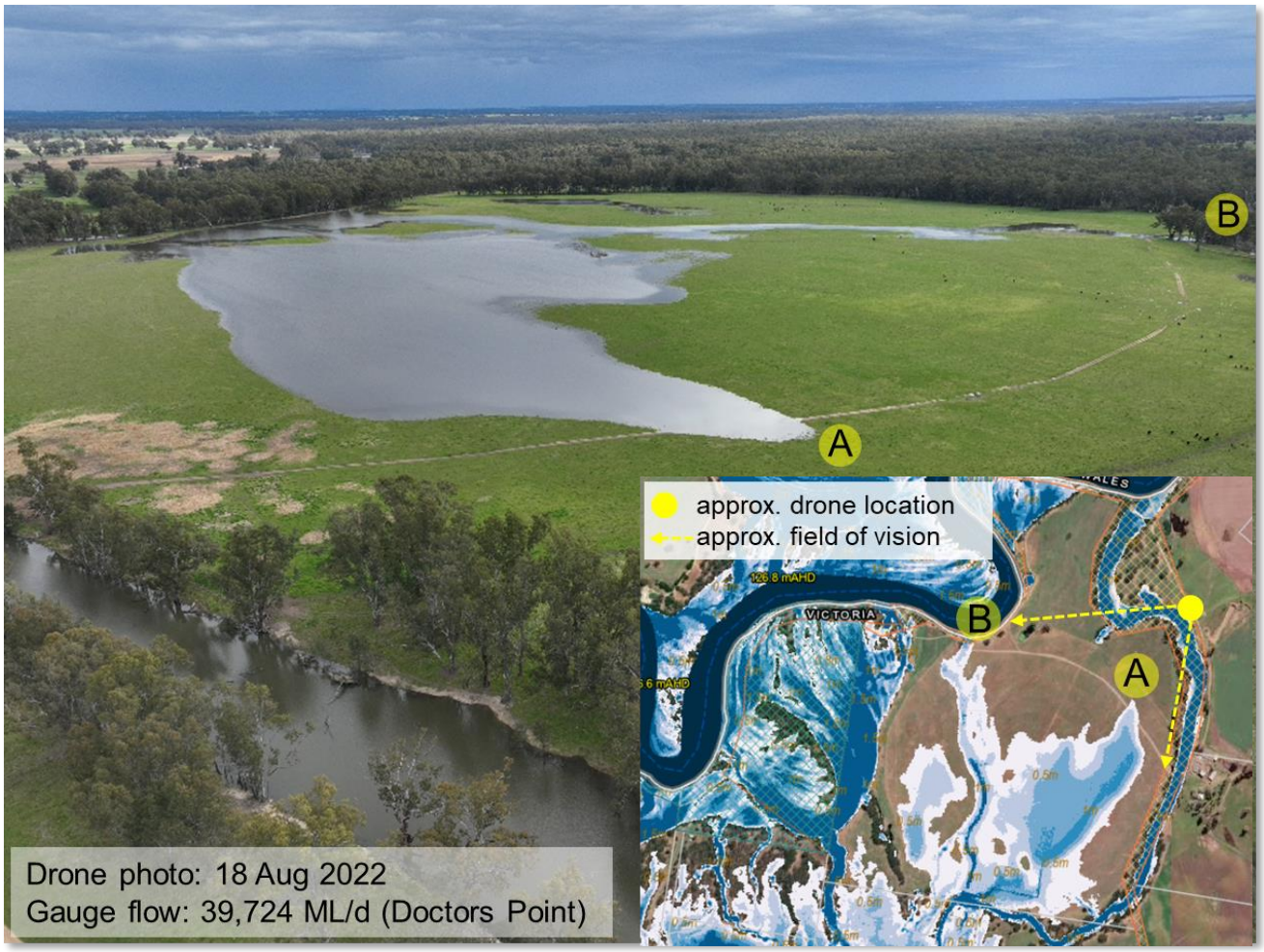


Figure 28: Drone photo taken at Bunyarra with unregulated river flows measuring 39,724 ML/d at Doctors Point (Murray River) on 18 August 2022 and modelled inundation at Bunyarra at flows of 40,000 ML/d

Sentinel Hub satellite imagery was also used to compare the modelled flows with the observed flows on the ground as the river rose. Sentinel Hub is a cloud-based geospatial platform that provides access to a wide range of satellite imagery data, including data from the European Space Agency's Sentinel satellites. It is designed to simplify and streamline the process of accessing and analysing satellite imagery for various applications, such as environmental monitoring, agriculture and urban planning. As the Sentinel Hub imagery

captures all water within the landscape, it also shows water in the landscape from rain events, existing permanent water bodies as well as floodplain inundation because of higher river levels. As demonstrated in Figure 29 below, there is a similarity between the blue areas representing modelled flows around Gemmill Swamp at Shepparton (left) and the darker areas indicating water observed by the satellite when the Goulburn River was flowing at equivalent streamflow rates (right).

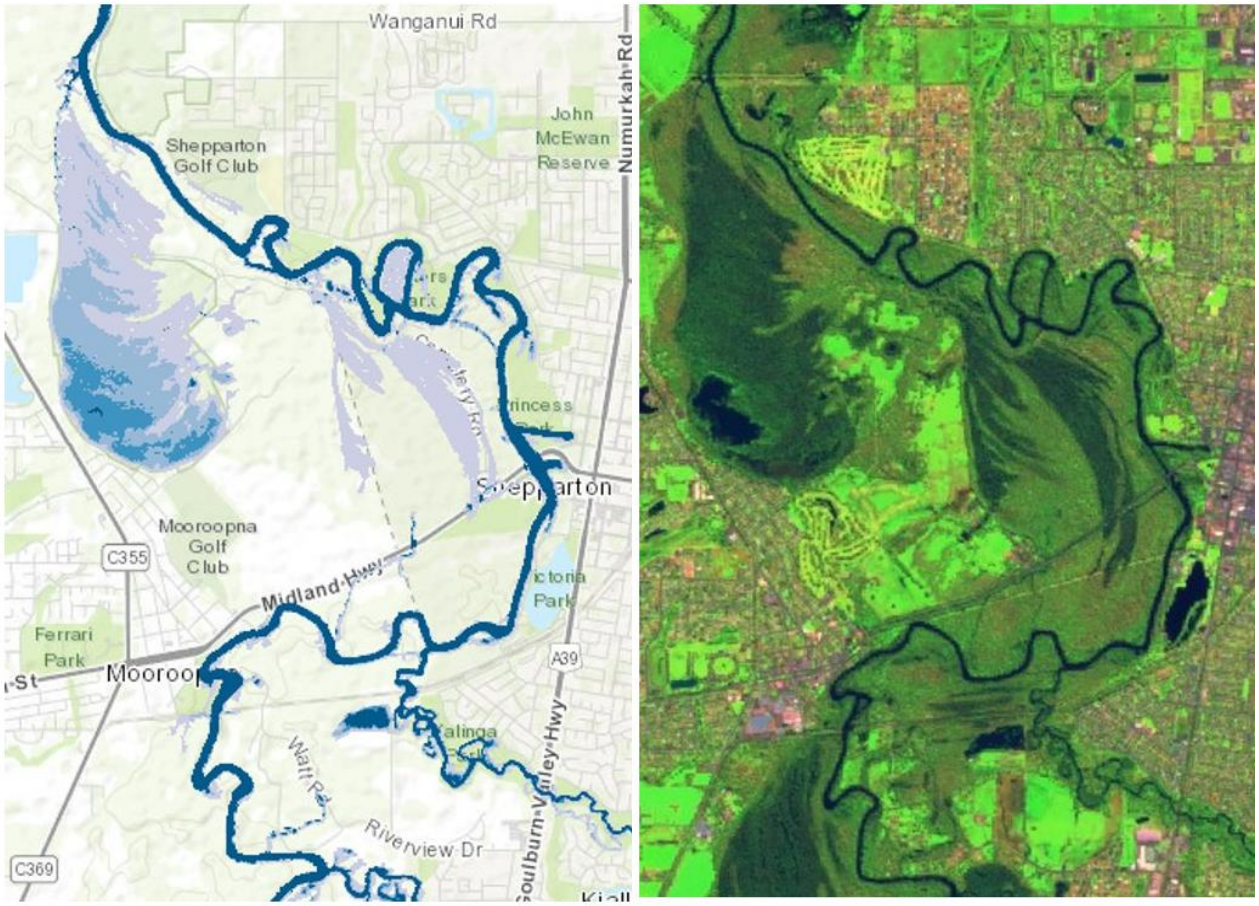


Figure 29: Comparison of 25,000 ML/d modelled flows of the Goulburn River at Gemmill Swamp (lower-Goulburn) left, and Sentinel Hub imagery for 13 October 2022 with an average daily flow rate of 26,000 ML/d at Shepparton on the right

Committee members expressed specific concerns regarding the potential impacts of relaxing constraints in the mid-Goulburn on the low-lying areas of Molesworth, particularly around the recreational reserve and caravan park. To provide real-time data to inform river operation decisions, a new stream gauge is being installed by the end of 2023 at the choke point in Molesworth as part of this Feasibility Study. Since there was no existing measuring device at this location, the project team used a combination of aerial imagery and in-field stream measurements to accurately gauge the flows and observe the corresponding extent of inundation. This approach allowed for a comprehensive understanding of the actual water levels and their impact on the area.

Modelling of the highest flow scenario of 14,000 ML/d suggest that there is no inundation of the Molesworth caravan park at these levels. This is supported by field observations with the field team recording a streamflow reading of 17,249 ML/d at Molesworth on 24 September 2022, with water at the time observed rising over the entrance to the Molesworth Caravan Park (Figure 30).

Figure 30: Water over the road preventing access to the Molesworth Caravan Park entry - 25 September 2022. Flows measured in the Goulburn River at Molesworth at approximately 17,200 ML/d

Despite the recorded flow levels at Molesworth being higher than the expected flows under relaxed constraints, this presented valuable opportunities for the Committee to gain insights into the potential impact of higher flows on the surrounding areas. To facilitate a thorough analysis, additional hydraulic modelling was conducted for flows of 17,000 ML/d in the mid-Goulburn. This allowed for a comparison between the model outputs and imagery captured during the event, providing a comprehensive understanding of the implications of such flows on the landscape and a further validation of model outputs.

Figure 33 below shows the aerial imagery of water in the floodplain on 3 October 2022 at the Molesworth Recreational Reserve. Water over the road at the entrance to the caravan park (Figure 30) can also be seen in Figure 31.

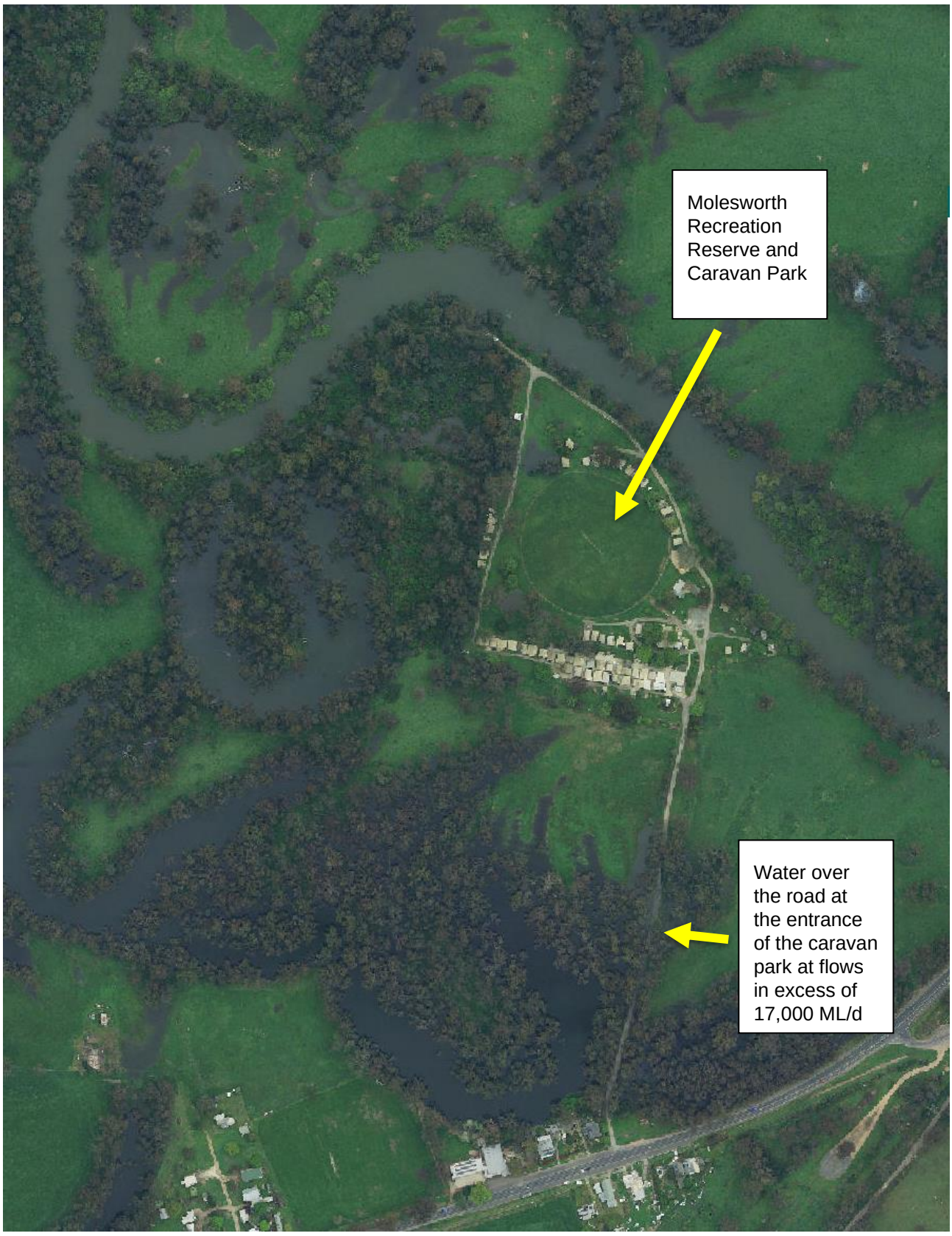


Figure 31: Aerial imagery taken showing inundation at the Molesworth Recreation Reserve 3 October 2022. Flows were measured in the Goulburn River at Molesworth in the vicinity of 17,000 ML/d which is higher than scenarios investigated for constraints relaxation

Digitisation of the imagery of water extent from the high flows during Spring 2022 was completed to identify those areas on the floodplain that are inundated from the main river (blue), connected to the river (green) or disconnected and most likely due to rainfall runoff pooling in isolated depressions (red). This is shown in Figure 32 below.

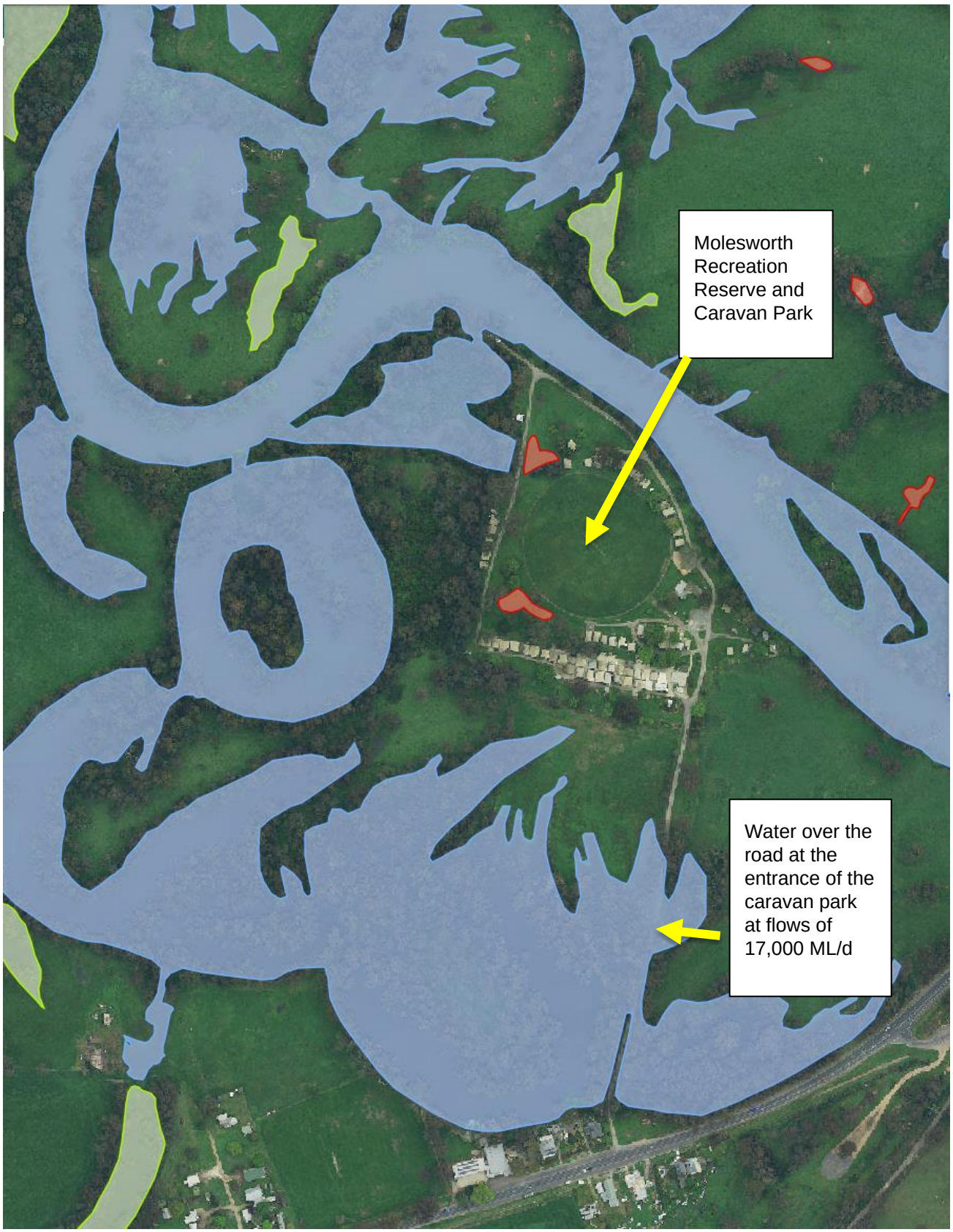


Figure 32: Digitised inundation footprint from flows in the vicinity of 17,000 ML/d at Molesworth 3 October 2022.

Although flows during this time were above the constraint scenarios for the Goulburn River, a model run was completed for flows of 17,000 ML/d to compare modelled output with the observed aerial imagery. The modelled inundation footprint for flows of 17,000 ML/d at Molesworth is shown below in Figure 33. These

figures show a strong correlation between the inundation footprint/shape of the modelled scenario compared to that observed during the high flow events in September/October 2022.

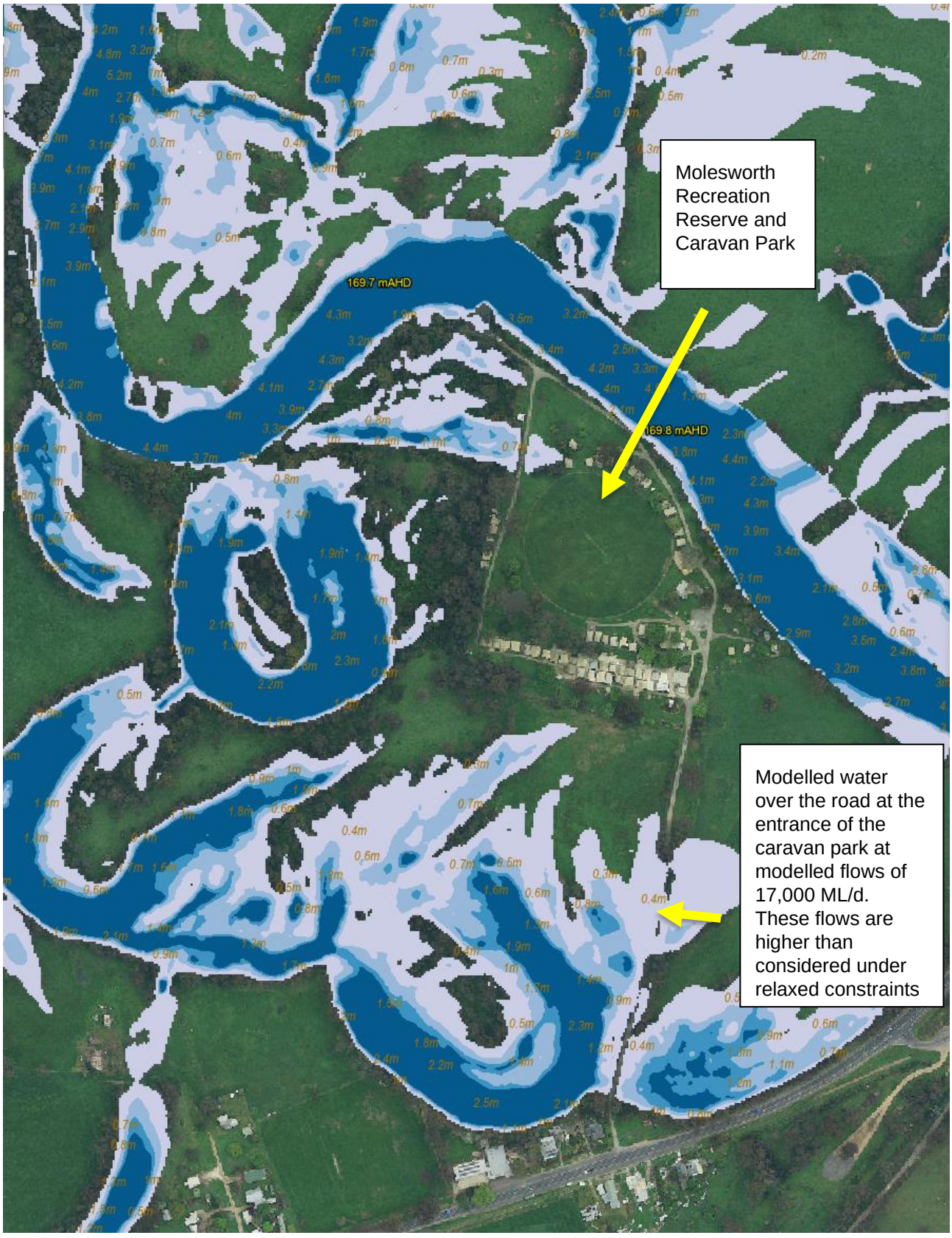


Figure 33: Modelled inundation extent of Molesworth at approximately 17,000 ML/d. These flows are higher than being considered for target flows under relaxed constraints.

> *"The data that has been provided is extraordinary. Whenever we asked for more detail, it was provided."*
>
> Consultative Committee Member

The Committee perceived the hydraulic modelling inundation results as high-quality, noting a clear correlation between the model outputs and the actual observations on the ground during the 2022 event. Riparian landowner Committee members specifically noted the accuracy of the modelled inundation extents compared to the impacts on their own properties. The Committee acknowledged the complexity of the program and the challenges in effectively communicating the impacts and benefits associated with each flow scenario to landowners. To address this, the Committee supports further discussions and verification of the model outputs through one-on-one engagements in future program stages. These engagements would be enhanced using aerial and satellite imagery obtained during the higher flow event in Spring 2022.

It is important to recognise that there is a risk of confusion between the flows considered for relaxed constraints and the flows experienced during the 2022 floods. The Committee considers the captured imagery to be a valuable and impactful communication tool for addressing this concern and facilitating better understanding by individual landowners and within the wider community.

3.9 Understanding ecological responses to changed river operations

In this feasibility study, ecological response models were employed to simulate the behaviour of floodplain and riverine ecosystems and assess the potential impacts on species that rely on floods for their abundance and well-being. These models were developed by experts who specialise in this field and have been used in previous projects such as the Environmental Flow Assessment for the Goulburn River and the NSW Reconnecting River Country Program. The ecological response models drew upon extensive data, research, and years of monitoring of Australian ecosystems. They considered how these ecosystems behave and respond to different factors, including flood events, the delivery of environmental water, and the time between events, such as drought periods. They have been built based on real-life observations of how ecosystems have responded to watering events.

These models enabled changes to flood-dependent species to be evaluated including overall abundance and condition resulting from relaxed constraints to be evaluated. This information is crucial for understanding the potential environmental benefits and risks of each constraint relaxation options for historic and climate change conditions.

The assessment considered the following themes for evaluating the benefits and risks of relaxed constraints:

- **Floodplain vegetation:** The impact on vegetation that grows in floodplain areas.

- **Instream productivity:** The effects on the productivity of organisms within the river, such as algae and aquatic plants.

- **Instream water quality:** The quality of the water within the river, including factors like oxygen levels and nutrient concentrations.

- **Instream macroinvertebrates:** The well-being of small organisms living in the river, such as insects and worms.

- **River and floodplain dependent fish:** The impact on fish species that rely on both the river and floodplain habitats.

- **Waterbirds:** The influence on bird species that inhabit or rely on water environments.
- **Platypus and turtles:** The well-being and habitat requirements of these specific aquatic species.
- **Channel geomorphology/erosion rates:** The changes in the shape and structure of the river channel and the erosion processes occurring.

This approach enabled the environmental outcomes of each constraint relaxation option to be evaluated and compared at both the reach scale (specific sections of the river) and across the multiple reaches. The assessment methods followed a bottom-up approach, relying on the expertise of specialists who understand the specific water requirements of different species and ecological processes within the identified themes.

Existing ecological response models were used whenever possible. These models had been previously developed for related projects and were adapted to suit the specific requirements of the Victorian CMP. No new ecological response modelling approaches were created for this assessment, but existing models were modified as needed.

The assessment process incorporated quantitative modelling techniques that were originally developed for the New South Wales Reconnecting River Country Program (NSW RRCP). The investigation consisted of two main components:

- Review of the NSW RRCP assessment methods and results for the Murray River, specifically for Victoria's purposes.
- Application of the NSW RRCP approach to assess the impacts on vegetation and birds in the Goulburn River.

The assessment of the Goulburn River also included the use of stochastic ecological modelling developed by the University of Melbourne and used within the scenario ‘range finding’ exercise. This additional modelling provided another valuable line of evidence to enhance the assessment process. Incorporating the results from both the stochastic ecological modelling and the previously mentioned assessment methods, resulted in a comprehensive evaluation of the potential impacts and outcomes in the Goulburn River system.

The use of multiple lines of evidence strengthens the robustness of the assessment, ensuring a more comprehensive understanding of the ecological implications of relaxing constraints in the Goulburn River.

Figure 34: Environmental watering at Yarran Track (photo courtesy of NCCMA)

3.10 Understanding how landowners and land managers may be impacted

Restoring overbank flows up to minor flood levels would have implications for various aspects of private land, agricultural activities, property management, livestock, assets, private access roads, and public infrastructure like roads, bridges, and culverts.

The land and asset impact assessment conducted as part of this study examined the potential impacts of different constraint relaxation scenarios and identifies the number of affected parties who may require mitigations. This assessment aims to understand the nature of the impacts that may arise from the changes in flow conditions.

A project Geographic Information System (GIS) was created to incorporate various maps and datasets related to floodplain land use, cadastral boundaries, property information, and transportation networks. These datasets were obtained from the Victorian Government Data Directory.

The GIS database was essential for performing spatial analyses to evaluate how land use and assets would be affected by various flow rate scenarios caused by the relaxation of constraints. By utilising the GIS technology, the project team was able to visualise and analyse the spatial relationships between the proposed changes in flow conditions and the associated effects on land use and assets. Assets considered included buildings and structures, river diversion pumps, roads and tracks, sites of European heritage and bridges.

Figure 35: Private pump stations located along the rivers may be impacted by higher river flows under relaxed constraints. Works would be required to mitigate these impacts.

The assessment method involved several steps to accurately identify the impacts on land and assets within the modelled inundation areas:

- **Desktop queries**: This involved using the project's GIS (Geographic Information System) to query and analyse different datasets related to land and assets. Additionally, hydraulic model shape files representing the extent and depth of inundation for each scenario were used. This allowed for the identification of land and assets along the rivers that fell within the inundated areas.
- **Title searches**: To obtain more accurate information about the potentially affected landowners, the required legal agreements, and any obstacles related to creating inundation easements on titles, title searches were conducted for private properties anticipated to be impacted by the inundation extent.
- **Site visits:** In cases where the impacts on infrastructure, especially public assets, were inconclusive through desktop assessment alone, site visits were conducted to validate and ground-truth the assessment results.
- **"Kitchen table" meetings:** Consultative Committee members and local landowners participated in meetings held in each river reach. These informal discussions provided valuable insights into the potential impacts on private properties based on local knowledge and experiences.
- **Exclusion of river areas**: When quantifying the impacts of inundation, the land area occupied by rivers (such as shown in Figure 36 below) was excluded from the analysis. To define and exclude these river areas, specific datasets such as VicMap Hydro - Water Area (polygon) 1:25,000 were used for the Goulburn River. For the study areas on the Murray River, the southern edge of the river coincided with the Victorian state boundary.

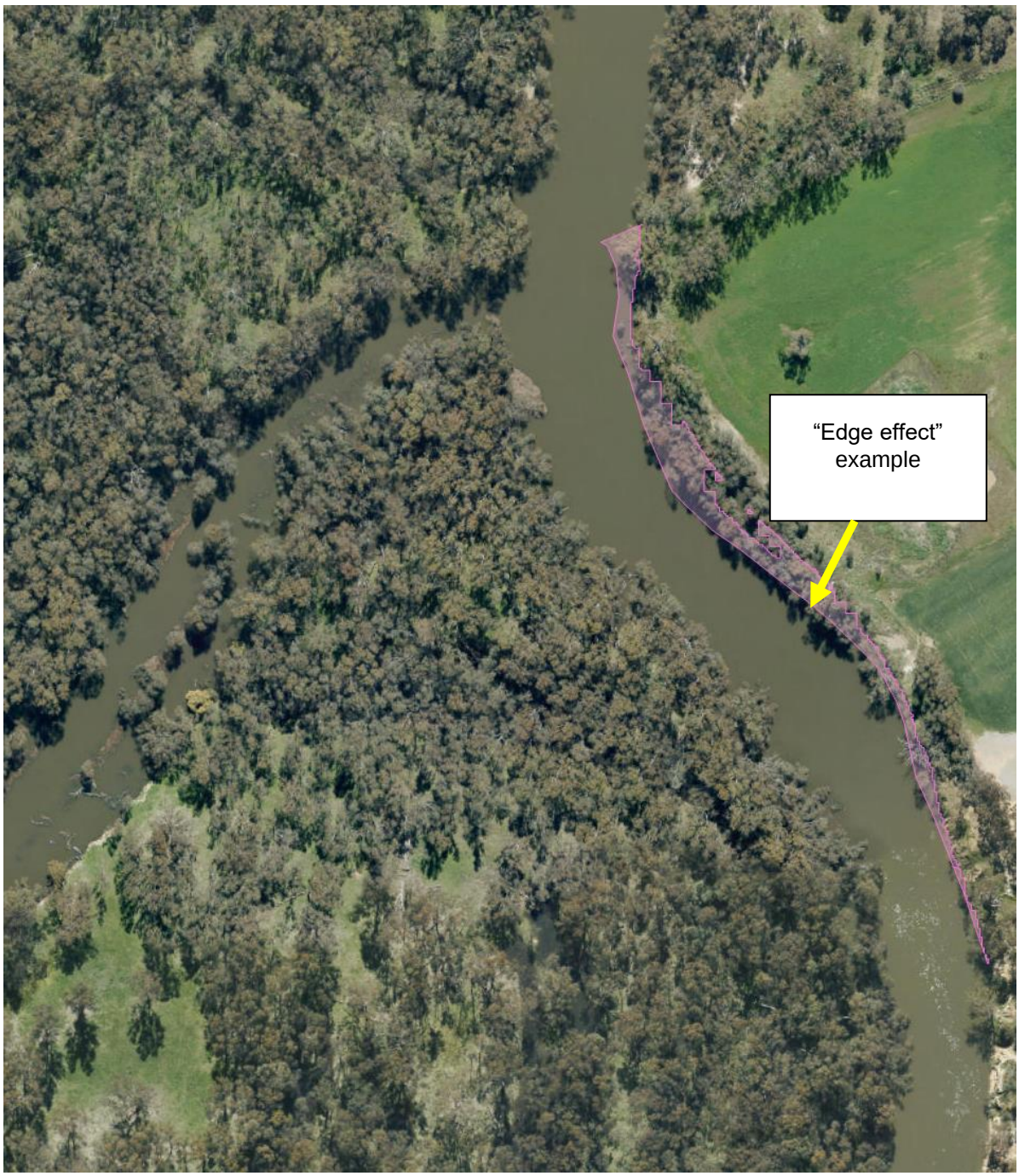


Figure 36: “Edge effect” examples along the Murray (pink areas show private land inundation GIS query results)

The impact assessment conducted in this stage of the Constraints Measures Program has certain limitations, including:

- Potential gaps or inaccuracies in the land and assets datasets used in the project's Geographic Information System (GIS).
- Inherent limitations in the accuracy of the hydraulic modelling, although accuracy has improved through ground-truthing and correlation with aerial imagery obtained across the rivers during the high flows in Spring 2022.
- Limited GIS data available for infrastructure on private land, including private access tracks and driveways. The Committee agrees this limitation must be addressed by engaging with potentially affected parties in subsequent stages of the Victorian CMP. The Committee advises this is particularly important to identify where access and broader property management may be impeded across the property under higher flows.

- The hydraulic model used in the assessment represents a steady-state condition rather than the dynamic reality of a river system. In reality, the flow would vary along the river, whereas the model provides a single water level for a given flow magnitude at any location along the river reach. The assessment is based on steady-state inundation footprints which is suitable for an assessment of this type.
- The assessment does not currently include considerations for cultural heritage impacts. Discussions regarding cultural heritage impacts are ongoing with individual Traditional Owner groups and should be incorporated into future assessments.

Recognising the importance of understanding the full extent of impacts and benefits at a property level, the Committee emphasised the need for direct engagement with affected landowners (including leaseholders) and land managers in future stages. This direct communication would enable a thorough evaluation of flow scenarios and their specific effects on each property. Additionally, the cost of mitigation and compensation for these impacts should be determined to facilitate a comprehensive cost-benefit analysis.

3.11 Inclusion of climate change modelling

Climate change modelling was included to assess whether relaxing constraints can provide potential environmental outcomes under future climate scenarios. All constraints study reaches are predicted to experience a warmer and drier future climate, with increased likelihood of extreme droughts and floods. Such changes are predicted to negatively impact on hydrological conditions in both rivers, causing substantial decreases in mean annual flows, overbank events, and freshes and increases in cease-to-flow events.

The Committee also identified the importance of considering climate change scenarios to help identify the benefits, risks, and likelihood of achieving the environmental outcomes under a future climate regime.

Climate change represents significant risks for ecological outcomes with the condition of ecological values expected to decline as the climate warms and dries. Environmental water shortfall volumes are also expected to increase under climate change as tributary flows and entitlements decrease. To assess how constraints relaxation may be used to assist ecological resilience under climate change, this feasibility study has included modelling of different constraint scenarios under a range of climates.

Modelling was undertaken to simulate the current constraints and river operating scenario under 3 different climate conditions:

- Post-1975 climate conditions
- Projected conditions for the year 2070:
  - Medium climate change scenario
  - High climate change scenario

Not all flow scenarios were modelled under the 3 different climate conditions. The scenarios included in the modelling are shown in Table 6.

Table 6: Relaxed constraint scenarios modelled with alternative climate conditions

River	Constraint location	Constraint modelled under potential climate conditions
Goulburn	Mid-Goulburn	10,000 ML/d
	Shepparton	17,000 ML/d
Murray	Doctors Point	40,000 ML/d
	D/S of Yarrawonga	40,000 ML/d

4 Goulburn River outcomes

- Relaxing constraints in the Goulburn River can enhance the efficient use of existing environmental water holdings, especially during planned environmental flow events from July to October. The benefits increase as constraints are further relaxed and floodplain inundation increases.
- The Lower Goulburn experiences the greatest floodplain benefits when constraints are relaxed, allowing for the inundation of larger areas of environmentally valuable public land.
- Compared to the Lower Goulburn, the Mid Goulburn sees minimal ecological improvement from relaxed constraints, emphasising the need to consider broader whole of river benefits, particularly in the Lower Goulburn, to assess overall advantages for the Goulburn River.
- Relaxing constraints in the mid-Goulburn directly impacts environmental outcomes in the lower Goulburn and downstream in the Murray River. Achieving environmental flow recommendations in the lower Goulburn improves as constraints in the mid-Goulburn are further relaxed, leading to enhanced vegetation quality in the lower Goulburn.
- In the Goulburn River, relaxing constraints enables the inundation of two and a half times more water-dependent vegetation communities with environmental water. Inundation levels range from approximately 5,000 hectares to over 13,000 hectares, depending on the constraint scenario.
- The highest modelled scenario could potentially reconnect an additional 4,855 hectares of public land in the lower Goulburn to the river, though this requires inundating 1,107 hectares of additional private land along the Goulburn River.
- Private property in the mid-Goulburn is disproportionately affected compared to the lower Goulburn, where environmental benefits are greater. Concerns have been raised by landowners about the impacts of higher flows on individual enterprises and particularly productive pastures.
- In the mid-Goulburn, an additional 514 hectares of private property, including productive pastures, would be impacted at the highest modelled constraint scenario. This affects 43 more properties compared to current conditions.
- No dwellings or major assets are impacted at the modelled flow rates, but river pumps and tracks, especially through public land in the lower Goulburn, would be affected. Discussions with individual property owners are necessary to fully determine the extent of impacts at these flow rates, especially for impacts beyond the directly inundated area such as impeded access.
- Modelling suggests annual impacts on land in the mid-Goulburn at the constraint limit. However, achieving flows at the modelled constraint in the Lower Goulburn depends on ‘piggy backing’ on unregulated tributary inflows. Flow targets in the lower reach cannot be achieved by dam releases alone.
- Overbank flows in the lower Goulburn of 21,000 ML/d, start to reconnect key environmental and cultural areas such as Gemmill Swamp.
- Modelling of Goulburn inflows to the Murray River indicates improved environmental Murray outcomes by relaxing constraints in the Goulburn River.
- All constraint scenarios' modelling shows that the reliability of Goulburn water entitlements would not be reduced.
- Relaxing constraints would enable more environmental water to be released from storages than under current rules, increasing dam airspace and reducing the size of moderate floods. Releasing environmental water throughout the year can provide flood mitigation as a secondary benefit, depending on how the entitlement holders chose to use their water. Furthermore, floodplain landowners would benefit from mitigation works up to constraint flow levels and a risk buffer, whereas they are currently directly affected by natural flood impacts.
- Exploring additional scenarios, such as M12L25 and M14L21, is recommended to assess different combinations of relaxed constraints and potential environmental benefits.
- Except for the most severe climate scenario, where water availability is the major limiting factor, relaxing constraints can serve as a valuable tool for Goulburn environmental water managers to adapt to a drying

climate. It's crucial to recognise that in such an environment, river management would need to significantly differ from current practices.

4.1 Goulburn modelled scenarios

A range of outcomes are presented for both the mid-Goulburn, lower Goulburn and overall Goulburn study area for each of the modelled scenarios as per Table 7.

Table 7: Goulburn River constraint scenarios modelled as part of the feasibility study

Constraint Location	Current Constraint (ML/d)	Relaxed constraint scenario			
		M10L17	M10L21	M12L21	M14L25
Eildon Release	9,500	9,500	9,500	12,000	13,700
Molesworth (Mid-Goulburn)	10,000 (nominal)	10,000	10,000	12,000	14,000
Shepparton (Lower Goulburn)	9,500	17,000	21,000	21,000	25,000

4.2 Land potentially inundated

The direct costs of relaxing constraints are represented by changes in the area and frequency of inundation of private land and assets. Increased inundation can impact property management, reduce production during and immediately after each inundation event and/or require additional expenditure to restore production after each event.

As the constraint is further relaxed and the river flow increases, the area of inundation increases. The area of both public and private land inundated for each of the reaches is shown in the following graphs.

Only two scenarios were investigated that change the constraint in the mid-Goulburn, namely M12L21 and M14L25. As such any assessment of M10L17 and M10L21 will show no change from current constraint conditions as this scenario maintains the current in-channel operating arrangements at Molesworth. A greater extent of private land may be inundated at the highest constraint relaxation scenario in the Mid-Goulburn (Figure 37).

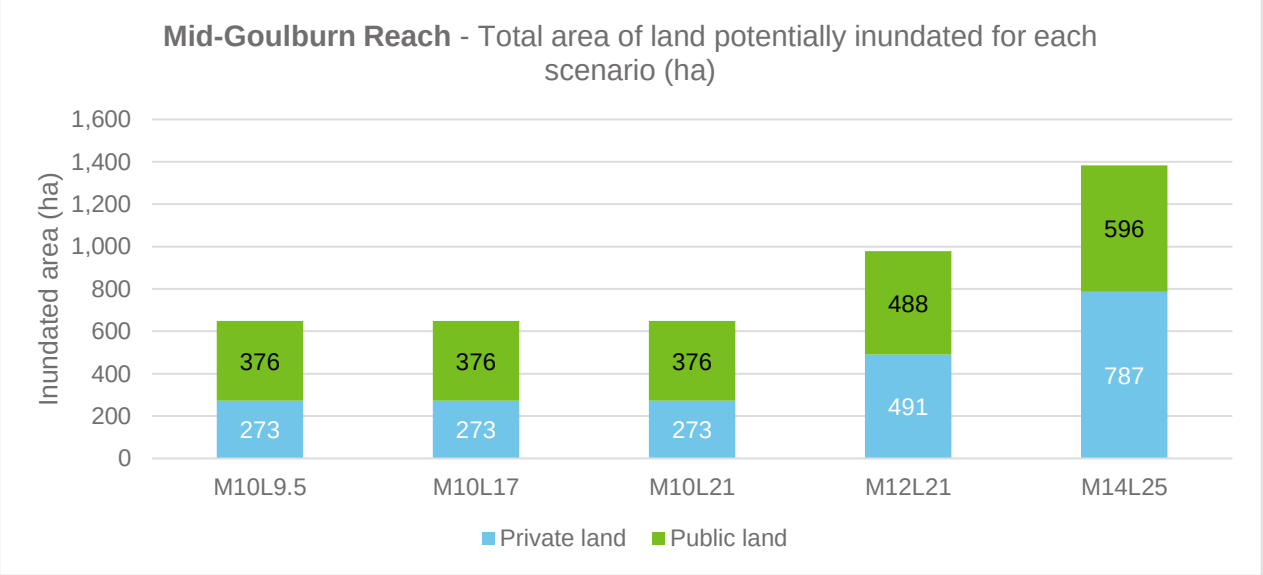


Figure 37: Total area of land potentially inundated for each scenario (ha) for the mid-Goulburn

However as constraint scenarios are relaxed in the lower Goulburn, a greater area of public land through the lower Goulburn National Park and surrounding reserves is inundated compared to private land. Over 7.5 times the area of public floodplain has the potential to be watered compared to private land in the Lower Goulburn under the highest constraint relaxation scenario (Figure 38).

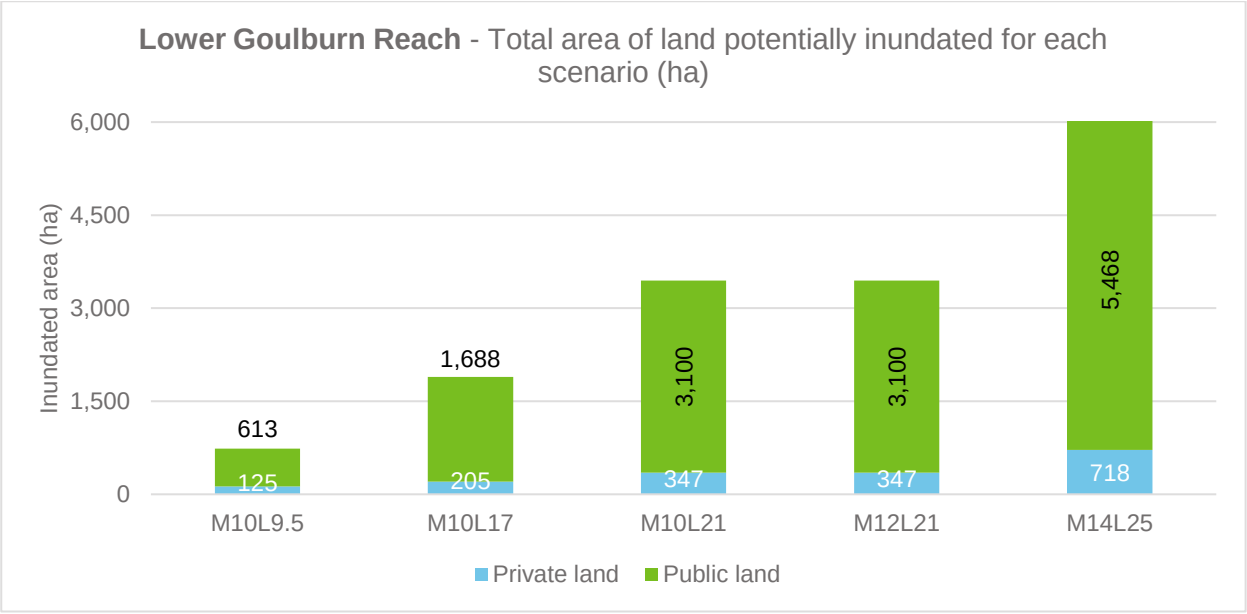


Figure 38: Total area of land potentially inundated for each scenario (ha) for the lower-Goulburn River

Relaxing constraints along both reaches of the Goulburn River has the potential to water four times the area of public land compared to private land (Figure 39).

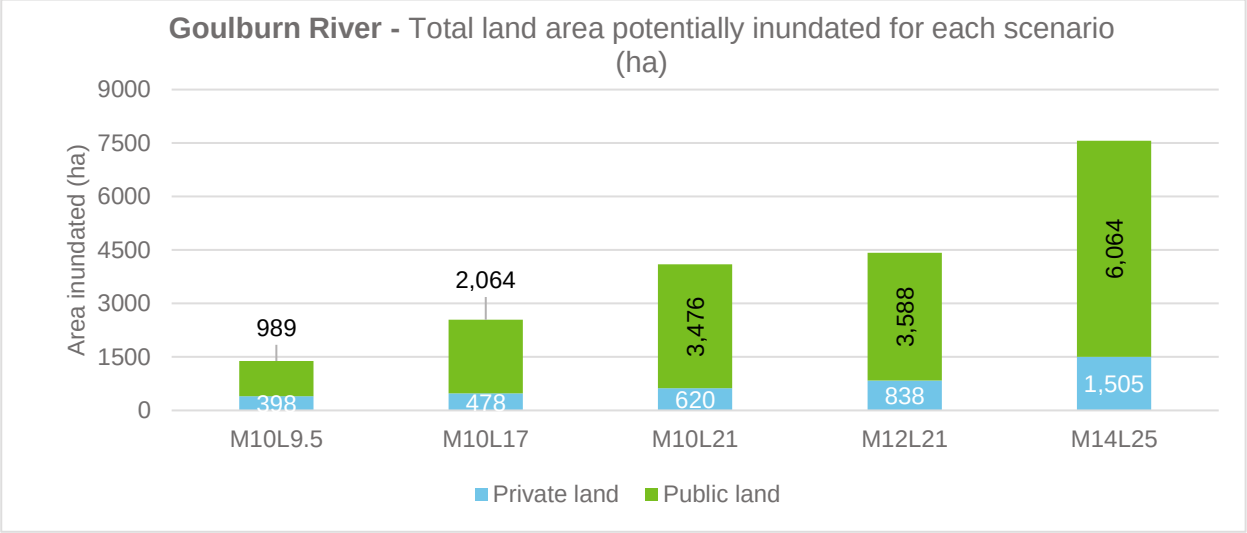


Figure 39: Total area of land potentially inundated for each scenario (ha) along the Goulburn River

4.3 Properties potentially impacted

At current constraint levels there are properties along the Goulburn River that experience some level of inundation. This is predominantly due to the 'edge effects' previously discussed (Section 3.10) and how the land title has been established in relation to the river. A key aspect of consideration is the number of private properties impacted under each scenario compared to under current river operations. Up to an additional 289 private properties are potentially inundated along the Goulburn River at the greatest relaxed constraint scenario compared to current conditions (Figure 40).

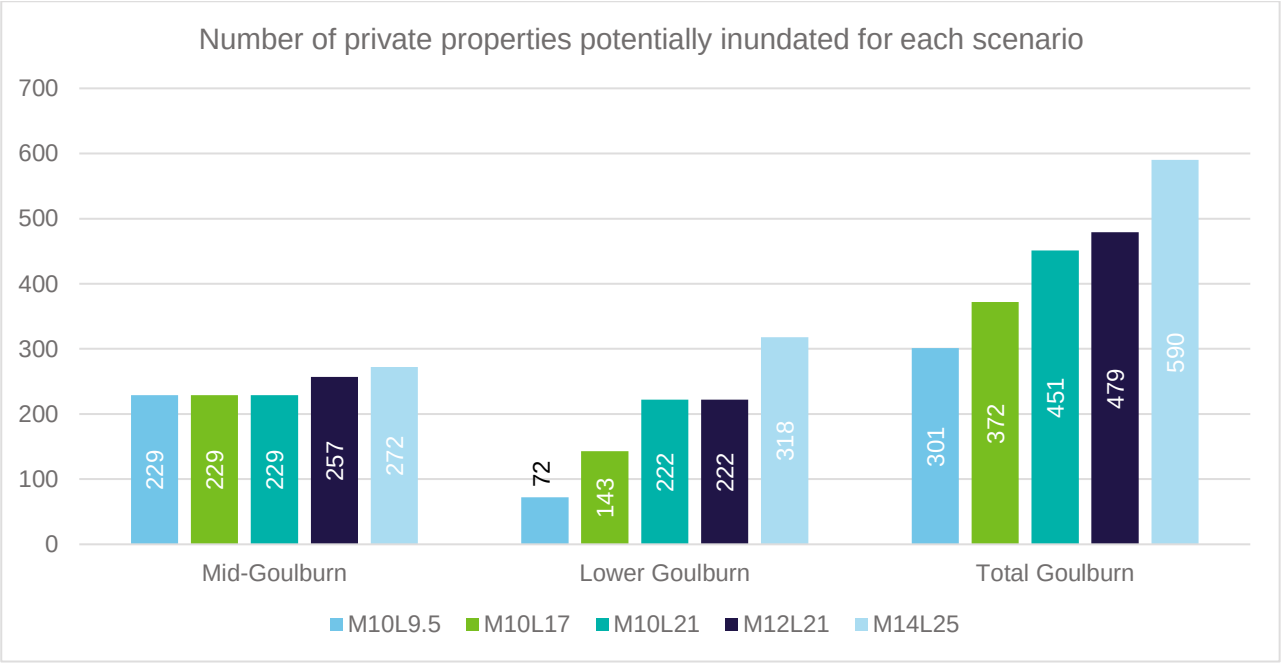


Figure 40: Number of private properties potentially inundated for each scenario along the Goulburn River

As constraints are relaxed in the mid and lower Goulburn, further private properties are impacted. In the Mid-Goulburn, there are up to an additional 43 properties that will experience some level of inundation at the highest modelled flow scenario of 14,000 ML/d compared to current operating practices (Table 8).

Table 8: Impacts of different constraint scenarios on the inundation on private land for the Mid-Goulburn River

	Mid-Goulburn			
Scenario	**Area of private land inundated (ha)**	**Change from current (ha)**	**No of private properties impacted**	**Change from current**
M10L9.5	273	0	229	0
M10L17	273	0	229	0
M10L21	273	0	229	0
M12L21	491	217	257	28
M14L25	787	513	272	43

Modelling suggests that at the highest flow scenario, there will be a larger number of newly impacted properties in the lower Goulburn reach compared to the mid-Goulburn reach. At the highest modelled flow scenario of 25,000 ML/d at Shepparton, an additional 246 private properties are anticipated to be impacted (Table 9).

Table 9: Impacts of different constraint scenarios on the inundation on private land for the Lower-Goulburn River

	Lower-Goulburn			
Scenario	**Area of private land inundated (ha)**	**Change from current (ha)**	**No of private properties impacted**	**Change from current**
M10L9.5	125	0	72	0
M10L17	205	80	143	71
M10L21	347	222	222	150
M12L21	347	222	222	150
M14L25	718	593	318	246

Relaxing constraints is shown to inundate more private properties in the Lower Goulburn than the Mid-Goulburn compared to current constraints.

Analysis has been undertaken as to the extent of inundation of all privately held land parcels, noting that a property may be made up of one or many parcels. Within the mid-Goulburn reach at flows of 14,000 ML/d, 284 parcels (58%) are impacted by less than 1ha with 406 parcels (89%) inundated up to 5ha (Figure 41).

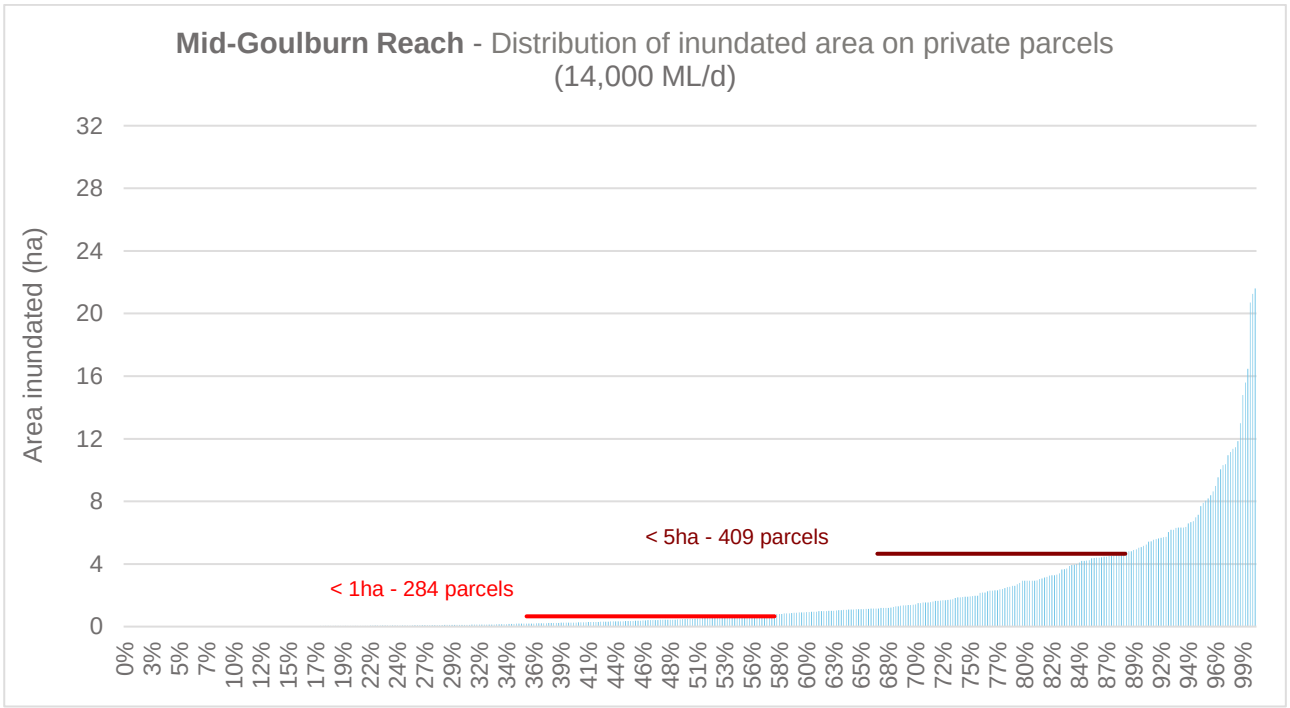


Figure 41: Distribution of potentially inundated area on private parcels at the highest constraint relaxation scenario of 14,000 ML/d along the mid-Goulburn River reach

A similar analysis was undertaken to determine the extent of inundation across private land parcels in the lower Goulburn. At flow rates at the highest constraint scenario of 25,000 ML/d at Shepparton, 349 parcels (63%) are inundated by up to 1ha. A total of 439 private parcels (91%) are inundated by up to 5ha.

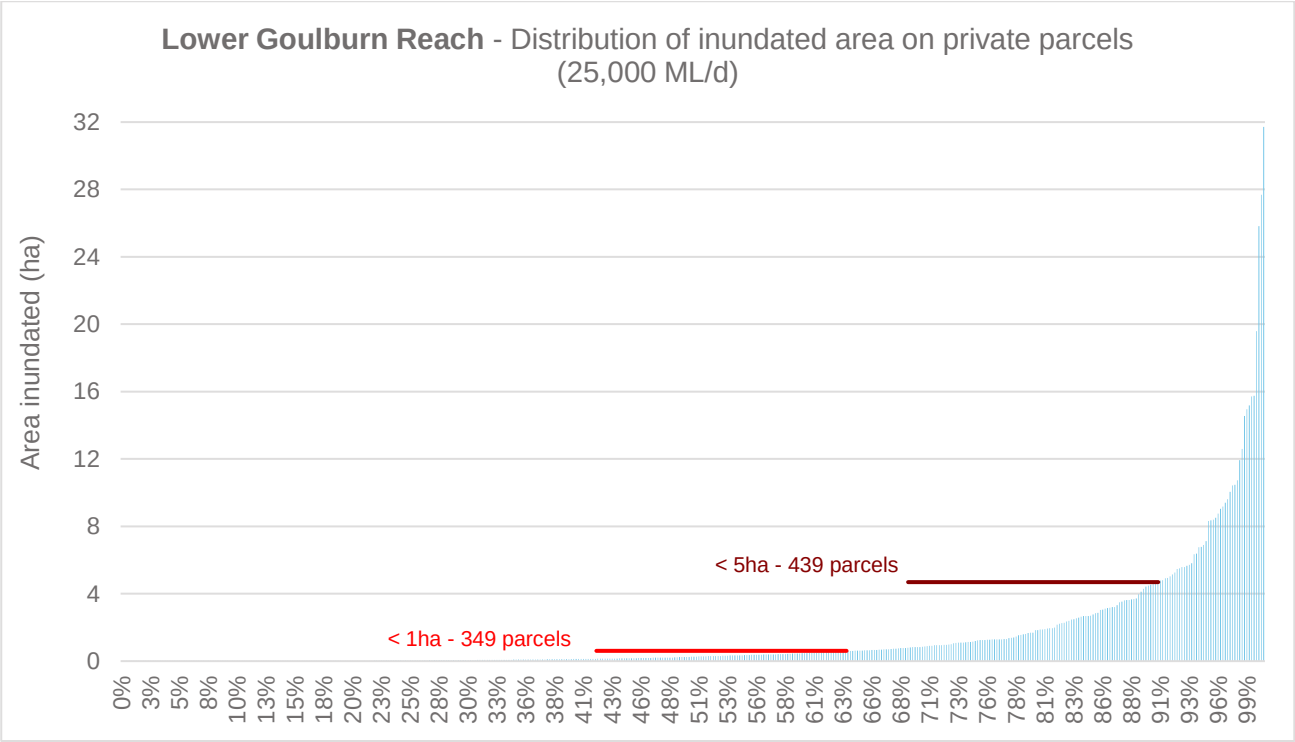


Figure 42: Distribution of potentially inundated area on private parcels at the highest constraint relaxation scenario of 25,000 ML/d along the lower-Goulburn River reach

Table 10: Average area of private land potentially inundated (ha and %) for each scenario in the Mid-Goulburn reach of the Goulburn River.

Mid-Goulburn				
Scenario	**Average area of private land inundated (ha)**	**Change from current (ha)**	**Average % of property inundated**	**Change from current**
M10L9.5	0.8	0	5%	0%
M10L17	0.8	0	5%	0%
M10L21	0.8	0	5%	0%
M12L21	1.2	0.4	7%	2%
M14L25	1.7	0.9	9%	4%

Table 11: Average area of private land potentially inundated (ha and %) for each scenario in the lower-Goulburn reach of the Goulburn River.

Lower-Goulburn				
Scenario	**Average area of private land inundated (ha)**	**Change from current (ha)**	**Average % of property inundated**	**Change from current**
M10L9.5	1.0	0	3%	0%
M10L17	0.9	-0.1	4%	0%
M10L21	1.1	0.1	5%	2%
M12L21	1.1	0.1	5%	2%
M14L25	1.5	0.5	9%	6%

4.4 Potential inundation of existing assets

The desktop assessment of the impact of higher flow scenarios on existing infrastructure shows that a range of assets are impacted, predominantly river pumps and tracks and roads. No dwellings are impacted under any of the scenarios as the flows target areas below the minor flood level. On-ground assessment would be required in any future potential stages to further investigate the potential impacts of changed flow scenarios. This is particularly important to determine the impact of inundation on property management and private access tracks as this information is not currently available in spatial datasets.

Table 12: Extent of potentially impacted assets along the Goulburn River at different constraint relaxation scenarios

Relaxed constraint scenario	Roads (km)	2WD & 4WD Tracks[10] (km)	Structures	Pumps		Dwellings
				Irrigation	Stock and Domestic	
M10L17	2.3	9	4	87	108	0
M14L25	10.5	56	9	94	122	0

The number of pumps located within the modelled inundation footprint and potentially inundated is high due to being located on or close to the riverbank. A higher relaxed constraint flow rate does not produce a significant change on the number pumps within the inundation extent.

The large number of existing tracks, predominantly in the floodplain forests of the lower Goulburn are increasingly impacted as flow scenarios increase. This is demonstrated with up to 56 km of tracks potentially impacted at the maximum relaxed constraint scenario and flows of 25,000 ML/d at Shepparton. The tracks are largely through bushland in the Lower-Goulburn. These track networks within public land are currently the subject of rationalisation.

Figure 43 to Figure 45 below show the increasing extent of the forest track network impacted around Shepparton as flows increase. These are gravel and dirt tracks that extend through the forest areas, used by management agencies, recreational users and bushwalkers. Relaxing constraints to 17,000 ML/d has minimal impact on tracks through the forested areas near Shepparton (Figure 43) with not many tracks being identified as inundated at these flows.

[10] The desktop assessment is limited by data available within public spatial datasets. It is acknowledged there are privately owned access tracks not captured within this dataset and therefore not included in this assessment. In any future stages of investigation, further assessment is required to quantify the impacts at a property level.

Figure 43: Minimal extent of impacted tracks in the floodplain forest along the Goulburn River at Shepparton from flows of 17,000 ML/d. The colours of the tracks indicate the depth of inundation at that flow.

As the flows increase, a greater extent of the track network in this area is subject to inundation. Figure 44 shows the impacted extents when flows are increased to 21,000 ML/d.

Figure 44: Extent of impacted tracks in the floodplain forest along the Goulburn River at Shepparton from flows of 21,000 ML/d. The colours of the tracks indicate the depth of inundation at that flow.

As the constraint is further relaxed to 25,000 ML/d in the lower Goulburn, the number of impacted tracks increases further (Figure 45). Discussions with relevant agencies will be required in any future stage to identify mitigation approaches for these impacted assets.

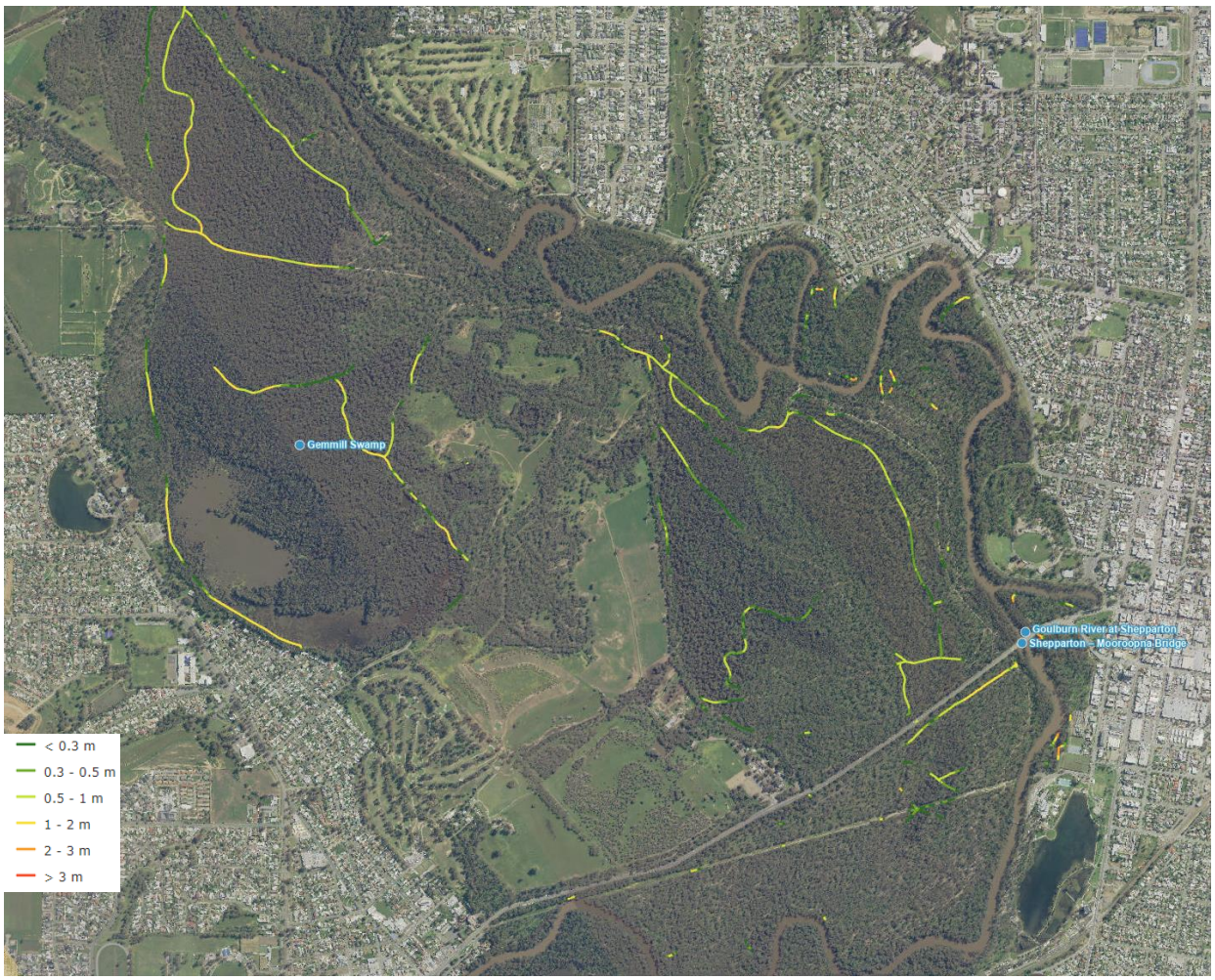


Figure 45: Extent of impacted tracks in the floodplain forest along the Goulburn River at Shepparton from flows of 25,000 ML/d. The colours of the tracks indicate the depth of inundation at that flow.

4.5 Flow timing, frequency and duration

The flow behaviour is extremely important to understand when assessing the potential benefits and impacts from different scenarios. Each of the scenarios would enable more efficient use of existing environmental water holdings, benefitting planned environmental flow events, particularly from July to October with environmental benefits increasing as the more constraints are relaxed and the areas of floodplain inundated increases.

The flow behaviour targets for the Goulburn River are outlined in Table 13. The flow behaviour is described in terms of the timing, frequency and duration of flow scenarios.

Table 13: Target flow behaviour to meet Goulburn environmental flow recommendations (summarised from Appendix 2 - Table 26)

Flow behaviour	Target
Timing	• July to October (winter and spring)
Frequency	• Overbank environmental flow deliveries preferred once a year • In dry/drought years (around 1 in 4) this changes to in channel only • Therefore, one overbank event is preferred around 7 years in 10 • Managed overbank events would not be planned if a natural event has achieved the target that year

Flow behaviour	Target
Duration	• 5 days at peak flow • Rise length around 6 days, fall beginning around 11 days

The Committee highlighted the crucial influence of flow frequency, duration, and timing of higher flows on landowners, particularly in terms of land management. Some members expressed that prolonged inundation exceeding one week could result in significant damage and loss of productive pastures, leading to substantial re-establishment costs.

Figure 46 shows how often 5 or more days of winter/spring flow are achieved at key locations for different flows (i.e. 10,000 ML/d or more, 12,000 ML/d or more etc.). This is for any 5 days in the period, not 5 consecutive days.

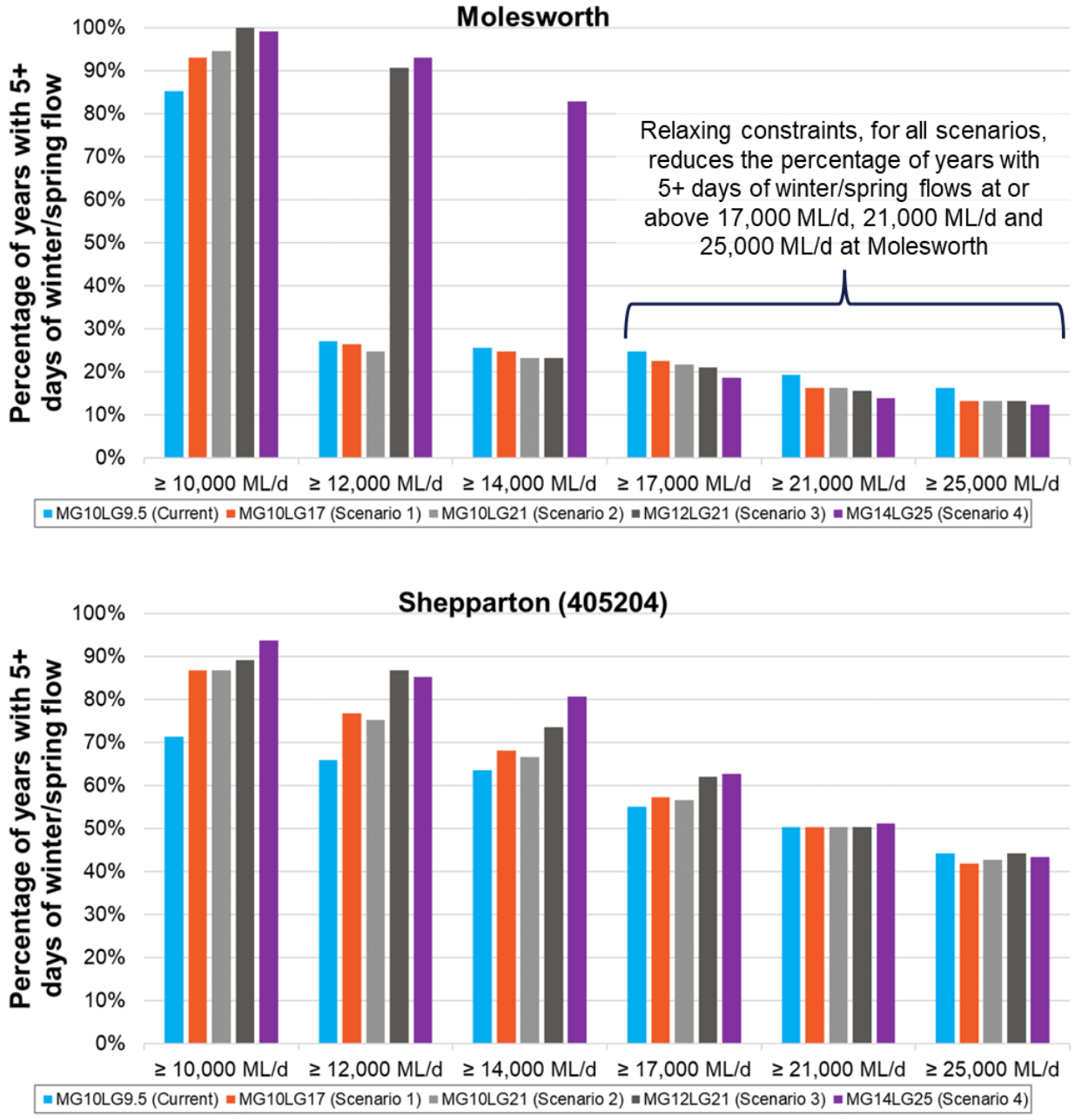


Figure 46: Proportion of years (1891-2020) with at least 5 days of winter/spring flow exceeding defined flow rates for the relaxed constraint scenarios at Molesworth (top) and Shepparton (Bottom)

Figure 47 shows the modelled flow levels at Molesworth and Shepparton under the highest constraint relaxation scenario (M14L25). For the mid-Goulburn, the flow limit is achieved by relaxing constraints in line with the model targets. This is due to the ability to deliver water to the mid-Goulburn directly from Eildon.

For the Lower Goulburn, relaxing constraints does not increase the times that the new flow limit is achieved (orange line does not reach the dashed grey line any more than the blue does).

Where the orange line is higher than the blue line, the flow of the event is increased by relaxing constraints. Figure 47 also suggests large flow events may also be reduced.

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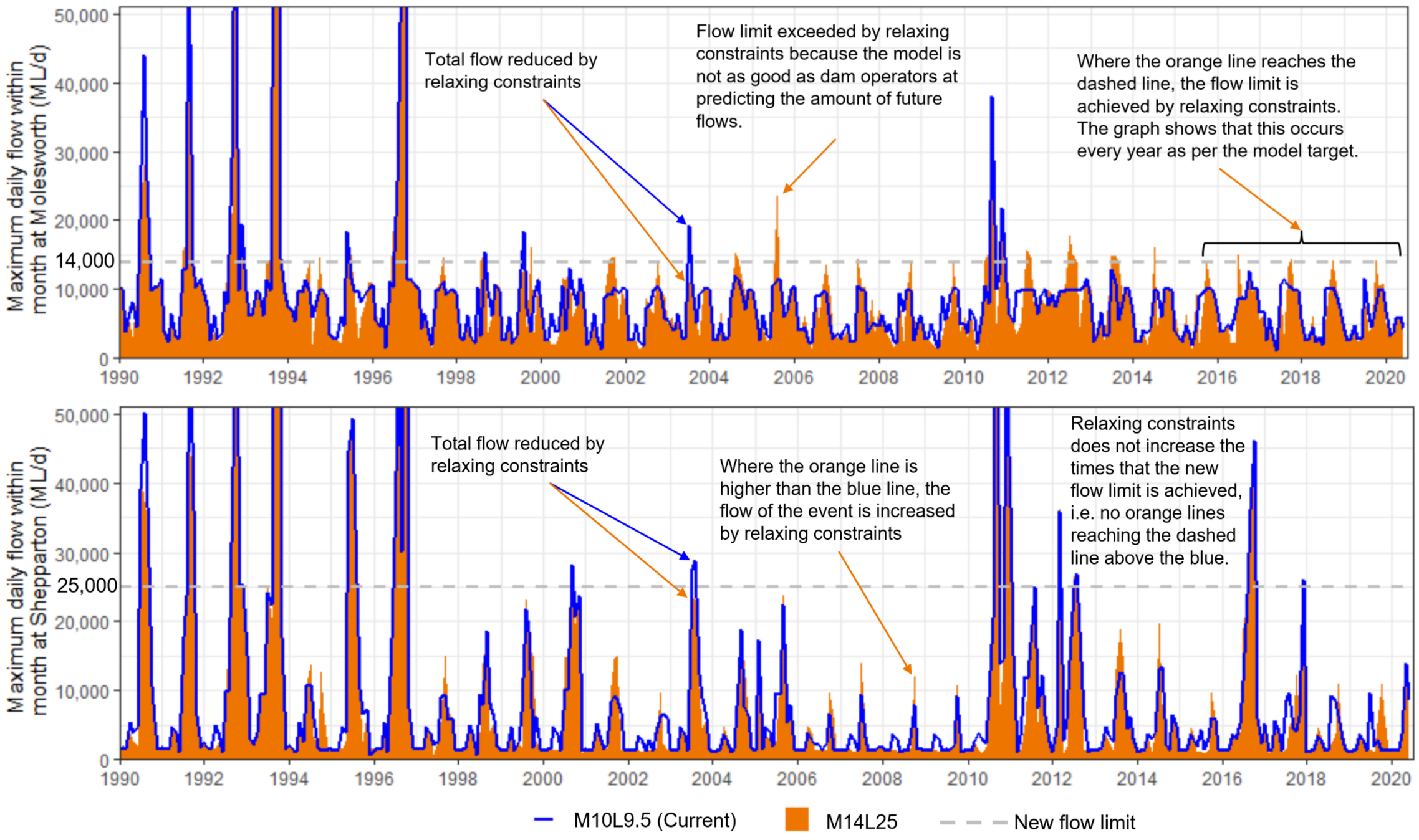


Figure 47: The modelled maximum daily flow at Molesworth (top) and Shepparton (bottom) within each month from 1990 to 2020 under current constraints and M14L25

The key observations for the Mid Goulburn are:

- flows can be achieved most year at the constraint level in the Mid-Goulburn
- relaxing constraints increases the number of years with 5 or more days of winter/spring flow at Molesworth for flows at or below 14,000 ML/d.
- relaxing constraints reduces the number of years with 5 or more days of winter/spring flow at Molesworth for flows at or above 17,000 ML/d, 21,000 ML/d and 25,000 ML/d. This would be attributed to the reduction in spills from storage dams.

The key observations for the Lower Goulburn are:

- flows at the targeted constraints level at Shepparton are not being achieved, however despite this, the modelled flows are still providing environmental benefits.
- the effect of relaxing the Mid Goulburn constraint to 14,000 ML/d is evident by the largest increase in the proportion of years with 5 or more days of winter/spring flow at Shepparton for flows up to 17,000 ML/d.
- there is marginal improvement in occurrence of flow reaching 21,000 ML/d or more at Shepparton for the M14L25 scenario.
- the number of years that have 5 or more days of winter/spring flows of 25,000 ML/d or more at Shepparton decreases by relaxing constraints to M14L25 compared to current constraints.
- achieving the relaxed constraint flow targets in the Lower Goulburn requires both relaxing upstream constraints and ‘piggybacking’ on unregulated tributary inflows.
- Further optimisation of flow events would be required to achieve targeted flows.

4.5.1 Climate change implications on flows

Hydrological modelling was conducted for the Goulburn and Murray Rivers under existing constraint conditions. This modelling considered three climate change scenarios: post-1975, 2070 with medium climate change, and 2070 with high climate change (please see Section 3.11 for details).

Figure 48 provides an example of how flows at Shepparton and Molesworth may change under each of these climate scenarios while maintaining the current constraint levels at both Molesworth (top) and Shepparton (bottom). For reference, the historical conditions match the post-1975 conditions for these three years. The figure illustrates a notable reduction in flows under the most extreme climate change scenario (indicated by the green line).

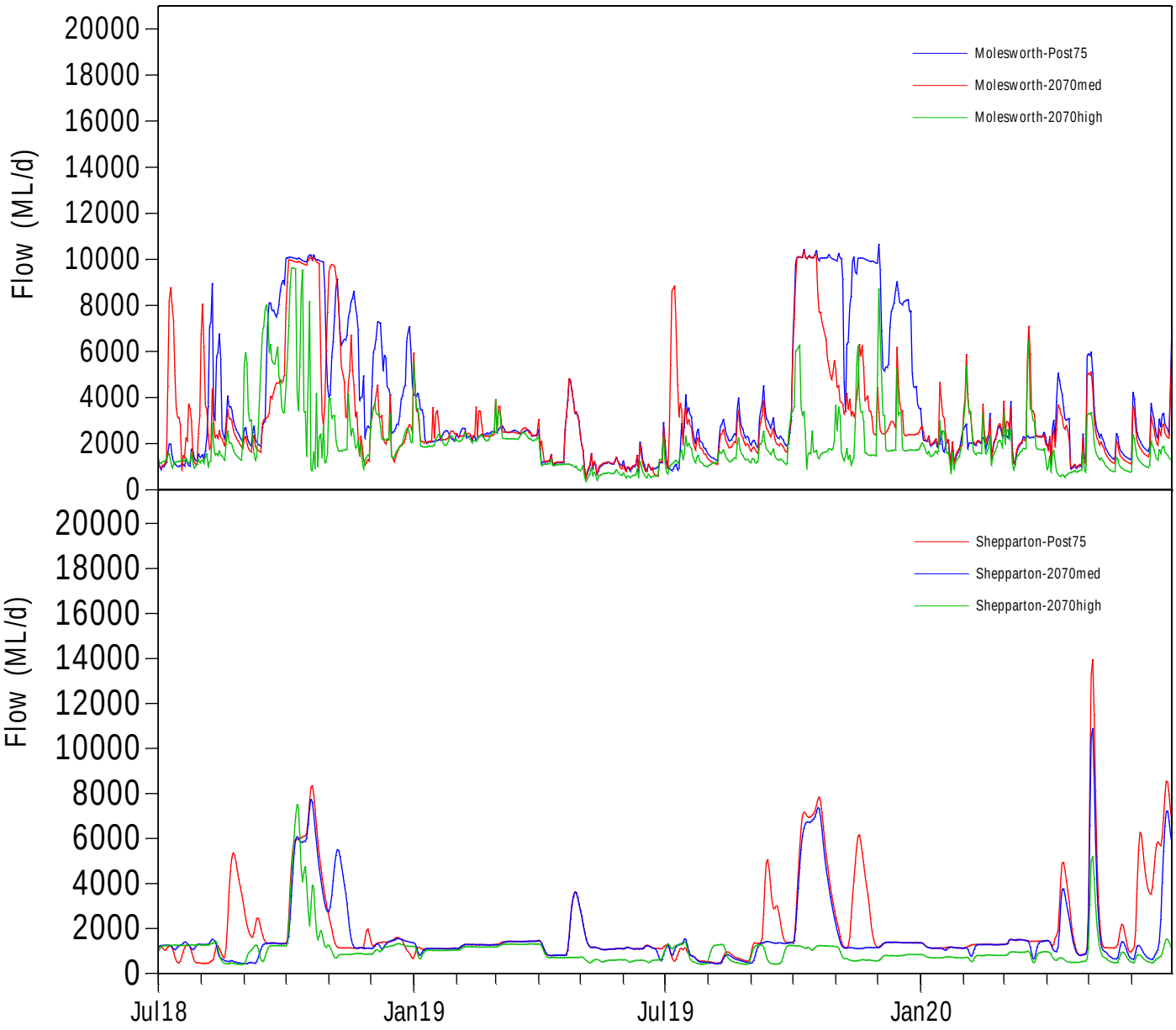


Figure 48: Example time-series of daily Goulburn River flow modelled for Molesworth and Shepparton for current constraints (M10L9.5) from July 2018 to June 2020 for post-1975 conditions and year 2070 conditions under medium and high climate change. Historic conditions are the same as post-1975 conditions for these three years.

Hydrological modelling was employed to simulate the current constraints scenario for the Goulburn River system under both post-1975 conditions and projected conditions for the year 2070, accounting for medium and high climate change scenarios.

As indicated in Table 14, all proposed constraint options provide benefits that are relevant across a wide range of climate models and scenarios. However, in extremely dry future climates characterised by significant reductions in precipitation (20% or more), the advantages of relaxing constraints become less evident.

This implies that, except for the most severe climate scenario where water availability is the major limiting factor, relaxing constraints can serve as a valuable tool for environmental water managers to adapt to a drying climate. It's important to recognise that in such an environment, river management would need to significantly differ from what we are familiar with today.

Table 14: Goulburn constraint scenarios and outcomes under future climate conditions

Constraint Scenario	Outcomes under climate scenarios compared to current
M10L17 Molesworth 10,000 ML/d Shepparton 17,000 ML/d	Relaxing constraints to 17,000 ML/d in the lower Goulburn delivers consistent benefits across a range of future climates. Environmental water shortfall reductions are strongest under a moderately dry future climate. This suggests that this constraint option will deliver even greater benefits under a drier future climate. However, the total environmental water shortfall may still remain high.
M10L21 Molesworth 10,000 ML/d Shepparton 21,000 ML/d	This delivers similar benefits to M10L17 across the variable climate, with slightly better outcomes.
M12L21 Molesworth 12,000 ML/d Shepparton 21,000 ML/d	This scenario delivers consistent benefits under a range of future climates. There is a notable stronger response in benefits compared to maintaining the 10,000 ML/d constraint at Molesworth, especially for environmental water shortfall reductions.
M14L25 Molesworth 14,000 ML/d Shepparton 25,000 ML/d	Shows the largest benefits across the range of climate scenarios.

The modelling results indicate that under post-1975 and 2070 medium climate change conditions, the relaxation of constraints will lead to increased utilisation of environmental water holdings. However, under the more severe 2070 high climate change conditions, relaxing constraints will have a far smaller impact on environmental water use.

The following key conclusions can be drawn from the modelled climate change scenarios:

- Relaxing the lower-Goulburn constraint allows for greater utilisation of the environmental water portfolio to address the environmental needs in the lower-Goulburn region.
- The relaxation of the mid-Goulburn constraint enhances the ability to meet larger flow targets in the lower-Goulburn, especially in the context of climate change scenarios.
- As climate conditions become drier, the duration of flows at or above the constraints decreases, with longer intervals between such flow events.
- In the year 2070, under high climate change conditions, flows rarely reach or exceed these constraints.
- This implies that additional benefits from relaxing constraints beyond 10,000 ML/d in the mid-Goulburn and 17,000 ML/d in the lower-Goulburn can be expected under somewhat drier conditions (post-1975 and 2070 with medium climate change) but not under much drier conditions (2070 with high climate change).

In future stages of the CMP, further exploration of this observation can be carried out by employing the model to simulate other constraint relaxation scenarios (M10L21, M12L21, and M1425) under potential future climate conditions.

Figure 49: River Red Gum with environmental watering – courtesy of GBCMA

4.6 Potential vegetation benefits and impacts

4.6.1 Potential extent of vegetation inundated

The hydraulic modelling provides an indication of the extent of vegetation that has the potential to be inundated at the relaxed constraint conditions. Along the Goulburn River, a large portion of area potentially inundated on private property is mapped as native vegetation (Ecological Vegetation Class) (Figure 50). This is characteristic of the low-lying floodplain.

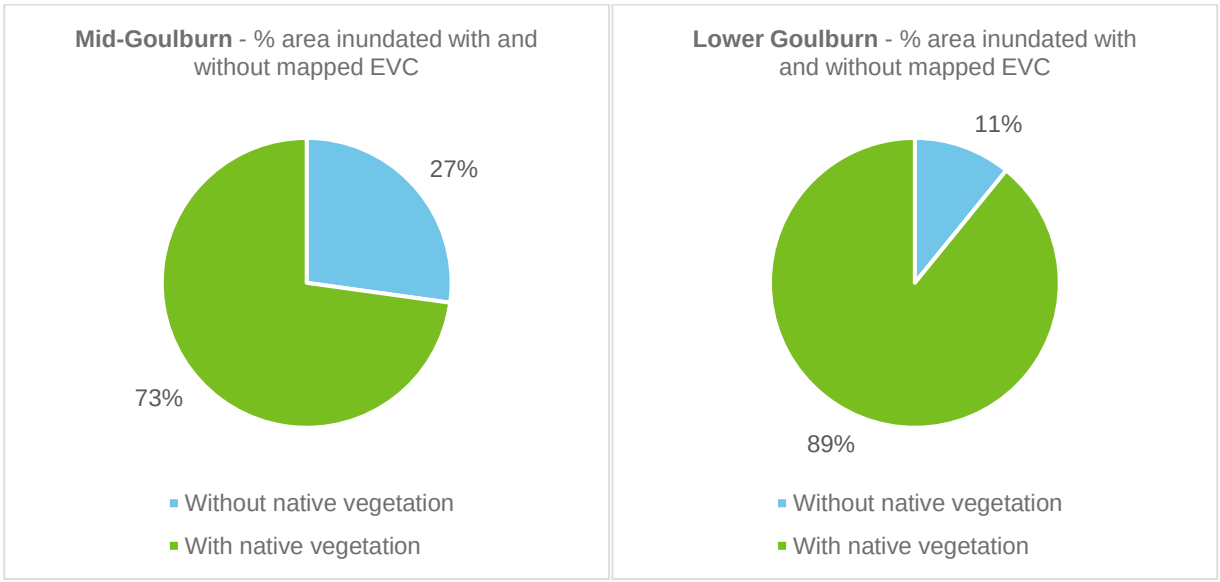


Figure 50: Distribution of native vegetation in the potentially inundated areas at the highest constraint relaxation scenario on the Goulburn River (14,000 ML/d in the mid-Goulburn and 25,000 ML/d in the lower Goulburn)

Vegetation watered within the Mid-Goulburn is largely flood-adapted terrestrial which is mainly characterised by River Red Gums (Figure 51).

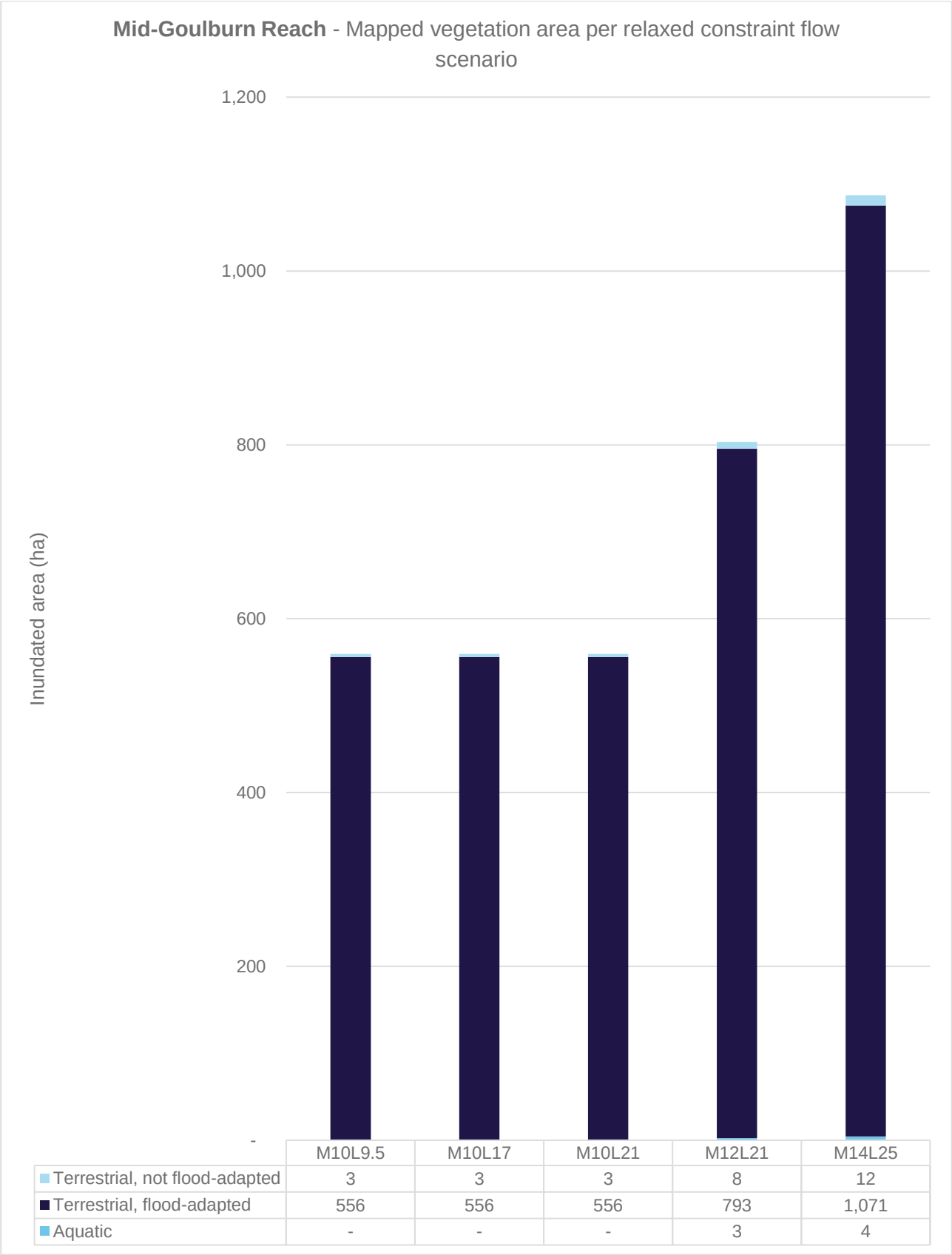
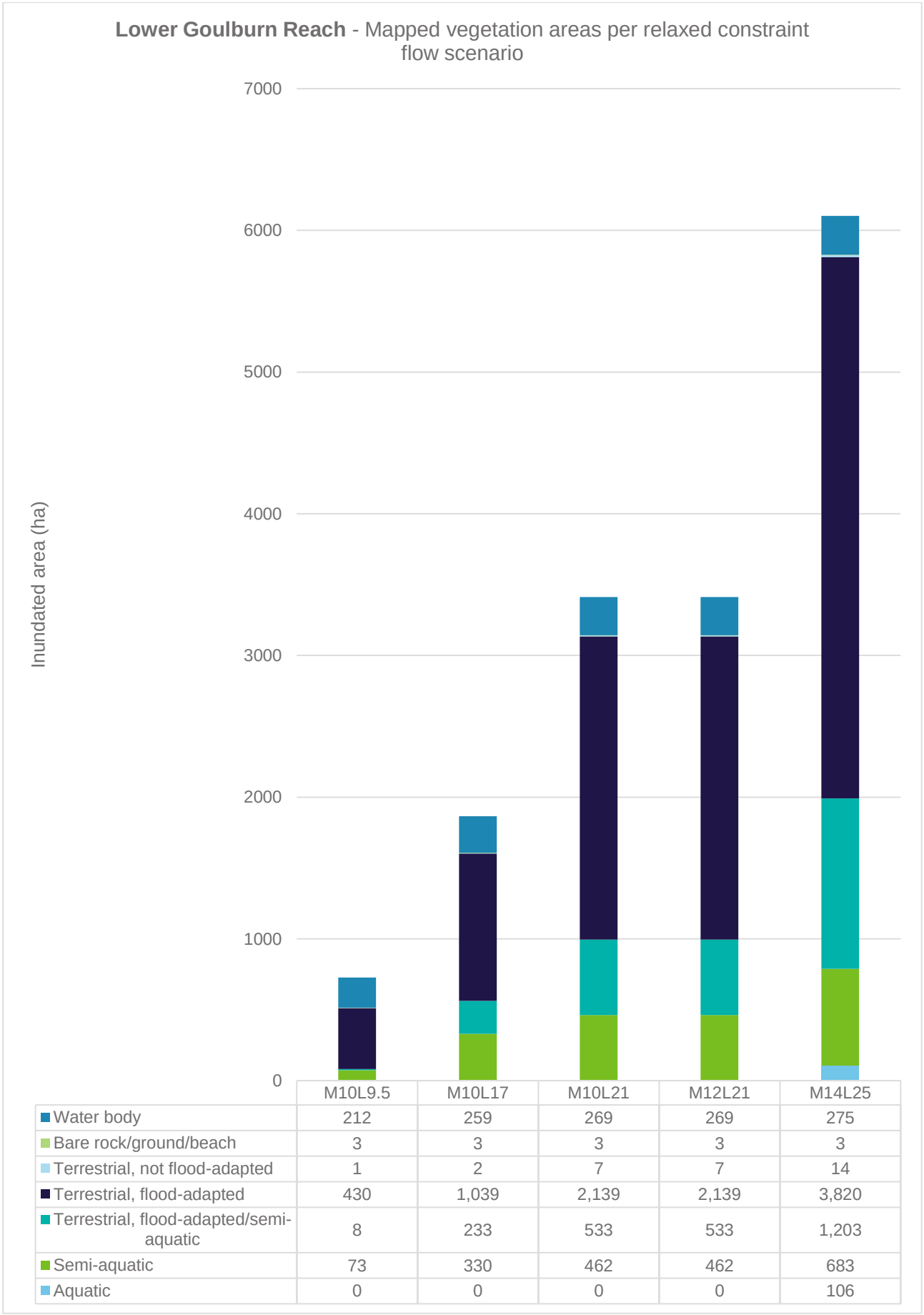


Figure 51: Mapped vegetation areas (ha) for each flow scenario along the Mid-Goulburn reach

A wider range of vegetation classifications are watered in the Lower Goulburn than in the Mid-Goulburn (Figure 52). The Lower Goulburn is mainly characterised by River Red Gums and Blackbox Woodlands.

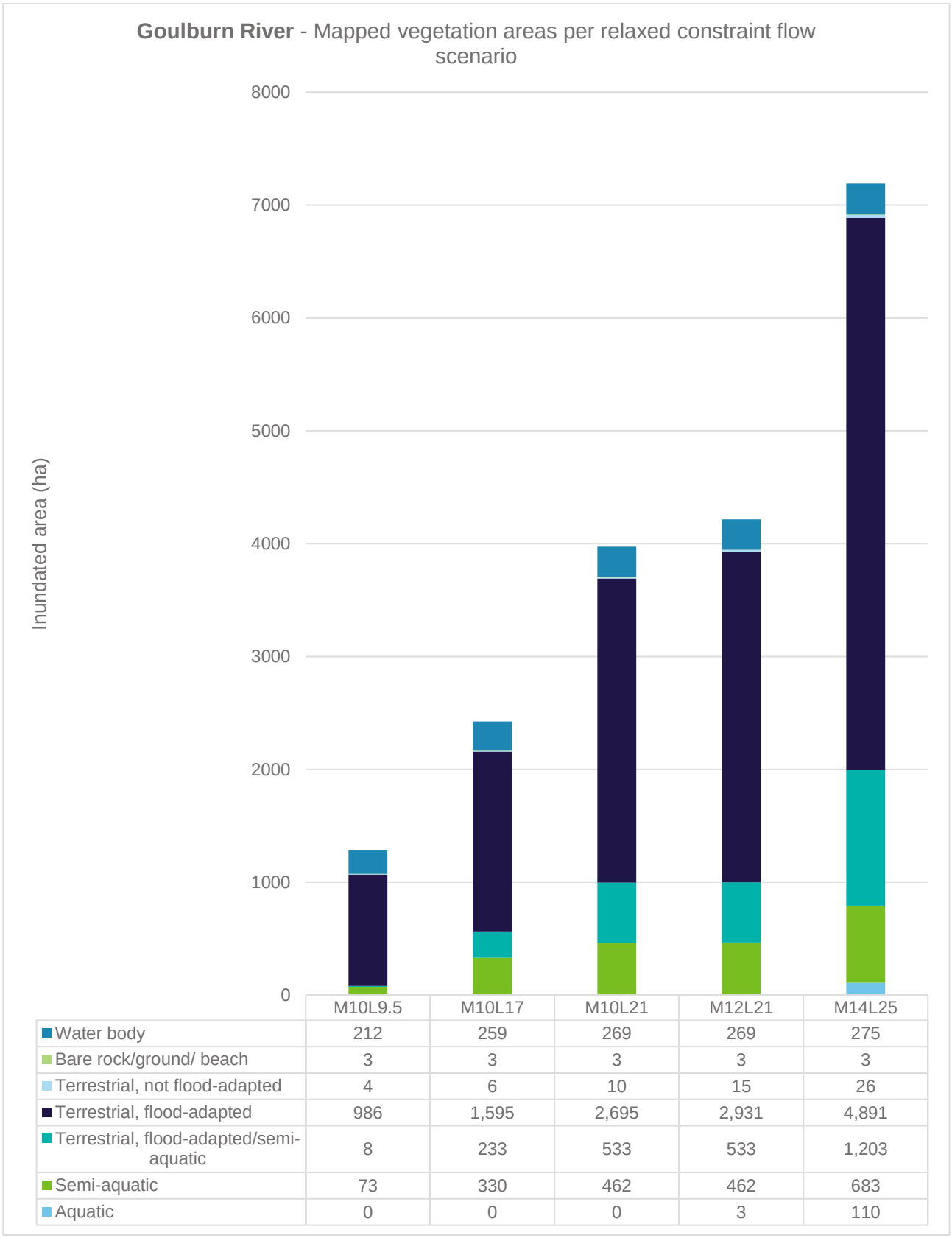


	M10L9.5	M10L17	M10L21	M12L21	M14L25
Water body	212	259	269	269	275
Bare rock/ground/beach	3	3	3	3	3
Terrestrial, not flood-adapted	1	2	7	7	14
Terrestrial, flood-adapted	430	1,039	2,139	2,139	3,820
Terrestrial, flood-adapted/semi-aquatic	8	233	533	533	1,203
Semi-aquatic	73	330	462	462	683
Aquatic	0	0	0	0	106

Figure 52: Mapped vegetation areas (ha) for each flow scenario along the Lower-Goulburn reach

Relaxing constraints to the highest scenario has the potential to water over 4 times the area of vegetation compared to current constraints to achieve environmental outcomes (Figure 53)

A significant portion of private land inundated occurs over areas with mapped EVC that may hold environmental value.



	M10L9.5	M10L17	M10L21	M12L21	M14L25
Water body	212	259	269	269	275
Bare rock/ground/ beach	3	3	3	3	3
Terrestrial, not flood-adapted	4	6	10	15	26
Terrestrial, flood-adapted	986	1,595	2,695	2,931	4,891
Terrestrial, flood-adapted/semi-aquatic	8	233	533	533	1,203
Semi-aquatic	73	330	462	462	683
Aquatic	0	0	0	3	110

Figure 53: Mapped vegetation areas (ha) for each flow scenario along the entire Goulburn River study area

4.6.2 Vegetation condition response

Relaxing constraints will significantly expand the area of water-dependent communities that can be inundated, providing enhanced protection for these vital ecosystems. The modelling undertaken is based on the area of existing vegetation, the hydraulic modelling that shows the extent that the floodplain may be watered under the different flow scenarios, and the hydrological modelling outcomes that shows the timing, frequency and duration of events.

Although environmental watering events target the environmental flow requirements for each reach, the hydrological modelling undertaken and presented in this report shows that the full range of environmental flow requirements cannot be achieved in all years. The achievement of these flow requirements is highly dependent upon rainfall and natural inflow events. As such, the vegetation response model reflects the outcomes of the hydrological modelling, rather than the desired outcome if all flow requirements could be achieved.

The vegetation response model uses five states of vegetation living health, plus dead state, to show the potential condition of vegetation in response to the various constraint relaxation scenarios.

The modelling uses the hydrological modelling results to determine periods of wet or dry which allow the vegetation to transition to another state. Only inundation events of 30 days or more will improve the condition (state) of Blackbox woodland and River Redgum forests and woodland. However, inundation of any duration, within the drying spell time, will prevent a decline in condition of these forests and woodlands to the next state.

It is important to note that the 30-day duration of events necessary to improve condition is longer than the target length of constraints relaxation flow events (5+ and 12+ days). As a result, based on the state transition modelling undertaken, the flow events currently modelled under the constraints relaxation scenarios assessed will be effective at enhancing vegetation resilience and reducing a decline in condition (state) but will have limited role in improving the condition of the vegetation communities. Essentially, this helps prevent these communities from slipping into a critical condition, often referred to as being 'near death,' and boosts their chances of surviving extended droughts.

The outcomes of this modelling effort revealed that at the end of the model run, under the 'do nothing more' scenario, approximately 75% of the river red gum vegetation community, amounting to around 15,000 hectares, in the Goulburn River system would be at risk of loss (Figure 54).

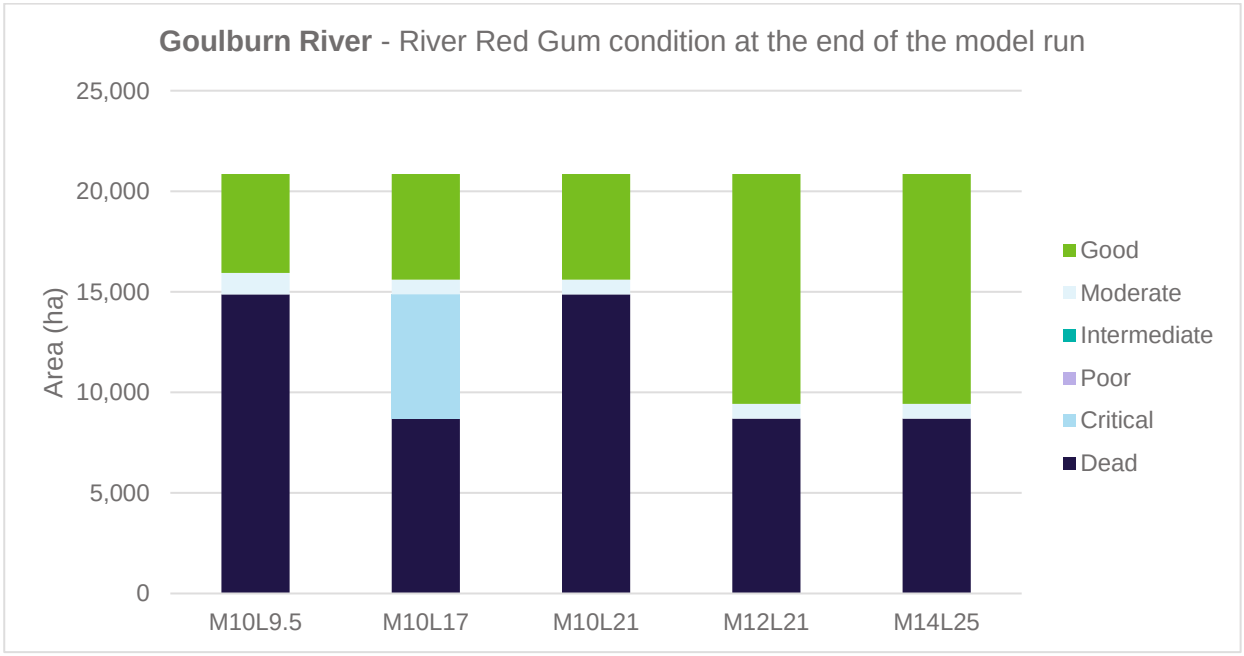


Figure 54: Modelled area and condition of River Redgum (RRG) along the Goulburn River under each modelled flow scenario

However, by relaxing constraints and increasing the connection of the river to the floodplain, it is possible to reduce this loss to less than 9,000 hectares, protecting over 6,000 hectares of river red gum vegetation.

Relaxation of constraints is required in both the Mid-Goulburn and Lower-Goulburn to generate vegetation quality benefits. The most significant improvements for River Red Gum vegetation quality is from the M12L21 and M12L25 scenarios.

The M10L17 and M10L21 provide a slight improvement to vegetation condition by pulling River Red Gums out of critical condition during the model run, if only for a short time, but were lost when a drought occurred. The M10L17 scenario provides more opportunities for the River Red Gum to recover and pull trees out of the critical phase over the period. For M10L21 this was not the case, where higher deliveries reduce the frequency of spills without further improving the condition.

While the relaxation of constraints to the extent modelled in this feasibility study offers significant benefits for vegetation communities in the low-lying areas of the floodplain, it's important to acknowledge that these benefits may not extend to all areas, especially those at higher elevations within the floodplain. Specifically, some areas dominated by vegetation like black box trees would not receive the required environmental water under any of the constraint relaxation scenarios assessed.

In the Goulburn River, the modelling revealed that these vegetation communities were historically sustained by uncontrolled spills originating from various sources such as environmental water entitlements retained in Lake Eildon, natural rainfall, and groundwater. However, the investigation suggests that under the highest levels of constraint relaxation, uncontrolled spills would become less frequent due to more targeted and efficient releases of environmental water.

It is likely that mature trees within these areas might persist without these spills. However, there's a substantial long-term risk to the overall viability of these communities beyond the reach of environmental watering. This risk stems from the critical role that inundation and floods play in facilitating the recruitment of new trees.

Figure 55 below provides a visual representation of the ecological modelling conducted for this project, focusing on black box communities in the Goulburn River. This figure illustrates the expected positive condition of black box vegetation under relaxed constraints and, conversely, the loss of vegetation that would accompany a reduction in spill events.

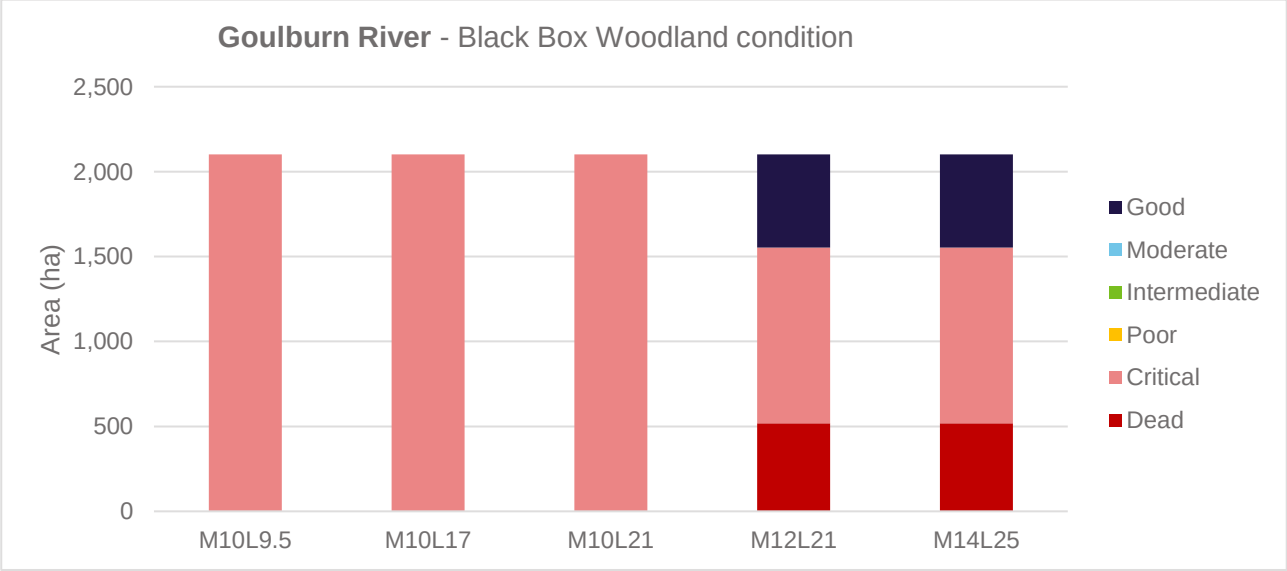


Figure 55: End state condition of the modelling for Goulburn River Black Box Communities (ha) under modelled relaxed constraint scenarios

The reduction of natural flow peaks with increasing relaxed constraint scenario is likely to mean that there would be areas of Black Box woodland that would not receive the required watering requirements, resulting in a loss of vegetation (Figure 55). However of the areas that remain within the inundation extent of relaxed constraints are shown to be in a better condition than the current constraint scenario.

For the M10L17 and M10L21 scenarios during the model run, areas that were in critical condition prior to droughts resulted in a loss of the Black Box woodland population.

While there are some risks for vegetation at higher elevations on the floodplain, the relaxation of constraints would provide a real and significant benefit to vegetation communities.

Figure 56 overlays the potential area of EVC inundated (on both public and private land), and the vegetation quality results presented for the Mid Goulburn and Lower Goulburn. This holistic view of the Goulburn River brings together the hydrology (as indicated by vegetation quality) and hydraulics (as indicated by the potential area inundated).

The analysis completed to inform the feasibility study shows:

- Constraints need to be relaxed to 12,000 ML/d at Molesworth and 21,000 ML/d at Shepparton (M12L21) as a minimum to generate significant vegetation quality outcomes for the potential area of EVC inundated.
- There is no difference in vegetation quality between the M12L21 and M14L25 scenarios, even though the potential area of EVC inundation increases. This shows that the hydrology (achieved area of inundation, duration and frequency) is not extending to the edges of the potential area of inundation (as shown by the inundation maps).

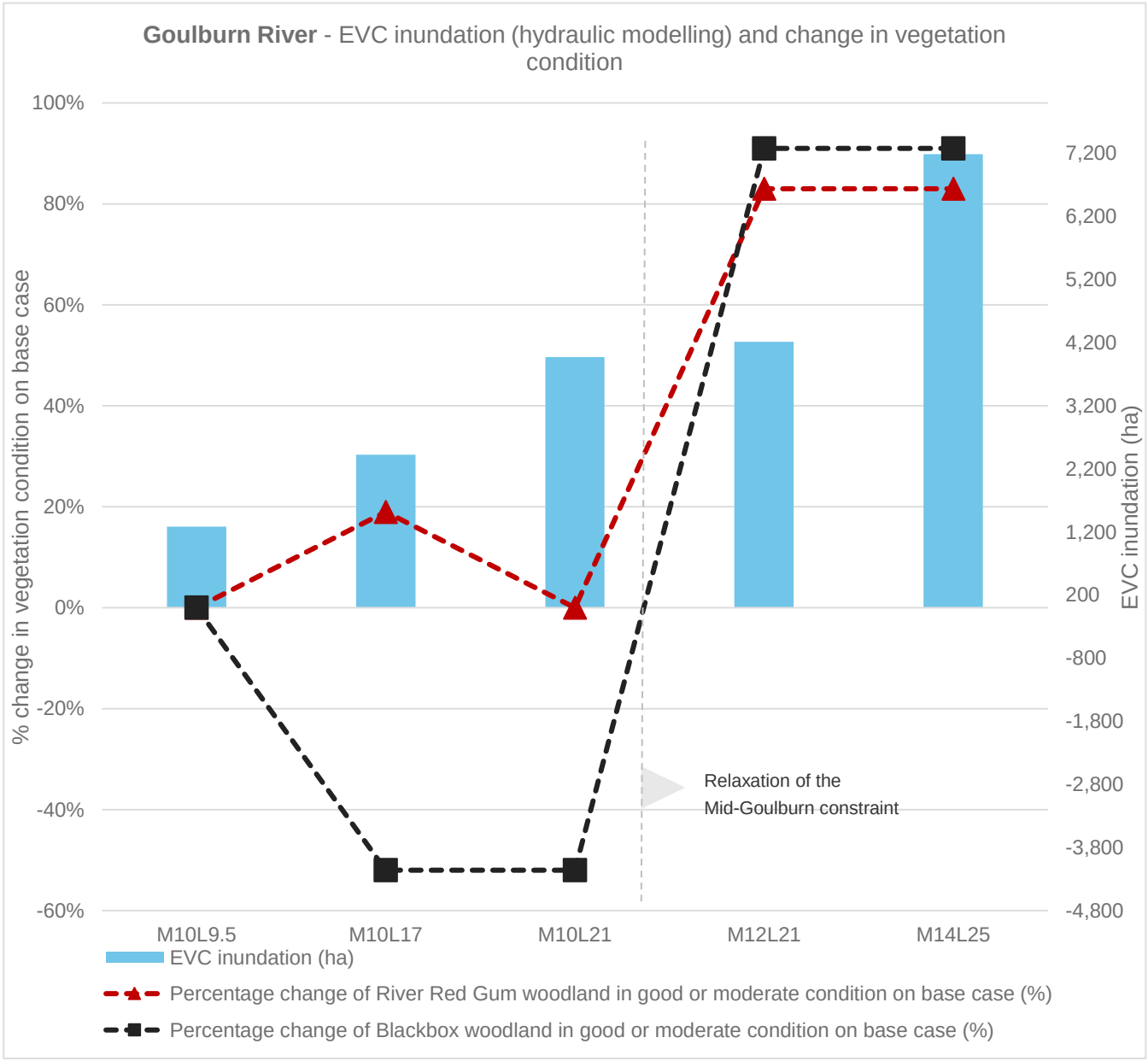


Figure 56: Ecological Vegetation Class (EVC) inundation and % change on current constraint base case for each flow scenario along the Goulburn River

Overall, the relaxation of constraints offers a net improvement in the overall condition of floodplain vegetation of the Goulburn River. As the magnitude of constraint relaxation increases, so does the proportion of

vegetation that becomes inundated with environmental water. The advantages of higher relaxation scenarios lie in their ability to maintain watered vegetation in a resilient state. However, there is a trade-off to consider – in the outer areas, further from the river channel, environmental water would only reach them during unregulated floods resulting from spills.

Despite some risks posed to vegetation at higher elevations on the floodplain, it's important to underscore that the relaxation of constraints carries substantial and tangible benefits for floodplain vegetation communities that rely on water. These benefits contribute significantly to the overall health and vitality of these ecosystems.

4.7 Instream production and macroinvertebrates

Modelling suggests enhancements in the populations of aquatic insects and overall productivity are foreseen in the Goulburn and Murray Rivers as constraints are relaxed. These improvements stem from the periodic and in-season delivery of food sources (carbon) from the floodplain.

Stochastic modelling conducted by the University of Melbourne specifically examined the expected outcomes on communities of macroinvertebrates in the river channel. However, it's important to note that this reported improvement is likely an underestimate of the total benefit. This is because significant areas of habitat for macroinvertebrates would be created in wetlands and floodplains, and these creatures serve as a food source for both land and water birds.

This modelling identified positive changes in the populations of macroinvertebrates as constraints were relaxed to enable higher flows to connect the river and the floodplain. In the mid Goulburn area, improvements were identified from flows above 12,000 ML/day, and in the lower Goulburn River area, improvements would come from flows above 20,000 ML/day. Comparable positive outcomes could be inferred for stretches of the Murray River. Importantly, no major risks to instream production were identified.

These benefits to macroinvertebrates and overall productivity are expected to translate into better food availability for larger animals in the river system, such as fish and platypus.

4.8 River and floodplain dependent fish

The relaxation of constraints creates connections between the main river channel and crucial floodplain wetland habitats for fish. These wetlands offer a rich source of food that supports the growth and survival of fish larvae.

Through the investigations, significant advantages have been identified for certain fish species in both the Goulburn and Murray Rivers. In the Goulburn River, all three groups of fish – Equilibrium species like Murray cod, Opportunistic species like native carp gudgeon or Australian smelt, and Periodic species like golden perch – benefited from the relaxation of constraints. Please see Figure 57 for a visual representation of these findings. This shows that the benefits for these species increase with the progressive relaxation of constraints up to at least 20,000 ML/d in the Lower Goulburn and around 12,000 ML/d in the mid-Goulburn River. The modelling suggests sustained benefits above these flow levels.

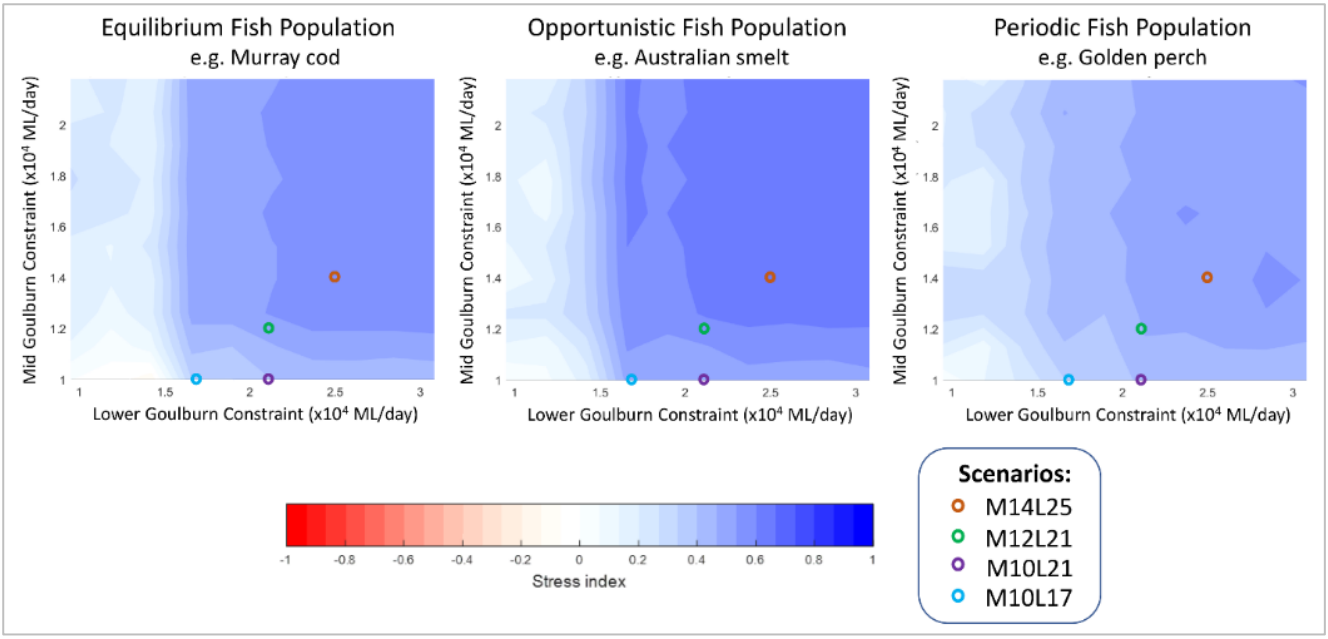


Figure 57 Ecological model results for fish response in the Goulburn River. Deepening shades of blue represent improvements in the stress index that result in better outcomes for fish, deepening shades or red represent declines in the stress index which offer worse outcomes for fish.

4.9 The watering of areas of cultural and environmental significance

Increased floodplain connection to the main Goulburn River channel occurs as constraints are further relaxed and flow rates increase. How the relaxation of constraints can improve connectivity in areas of environmental, recreational, and cultural significance along the Goulburn study area have been further investigated and represented below.

4.9.1 Gemmill Swamp

Gemmill Swamp is a wildlife reserve covering an area of approximately 170 hectares of Goulburn River floodplain forest and wetland between the urban centres of Mooroopna and Shepparton. Gemmill Swamp is a high conservation value wetland of State significance with a surrounding area of relatively natural river red gum forest.

Gemmill Swamp Wildlife Reserve is significant in a statewide context because it provides habitat for some of Victoria's rare and vulnerable mammals, birds and reptiles including squirrel glider, turquoise parrots and superb parrots.

The modelling results for Gemmill Swamp under the range of relaxed constraint scenarios are shown in Figure 58. The potential area of inundation substantially increases for the 21,000 ML/d scenario. Flows below 21,000 ML/d at Shepparton generally remain in-channel and do not engage the flood runners required for watering of Gemmill Swamp.

As constraints are further relaxed to 25,000 ML/d at Shepparton, the extent and depth of inundation at Gemmill Swamp and surrounding floodplain areas increases.

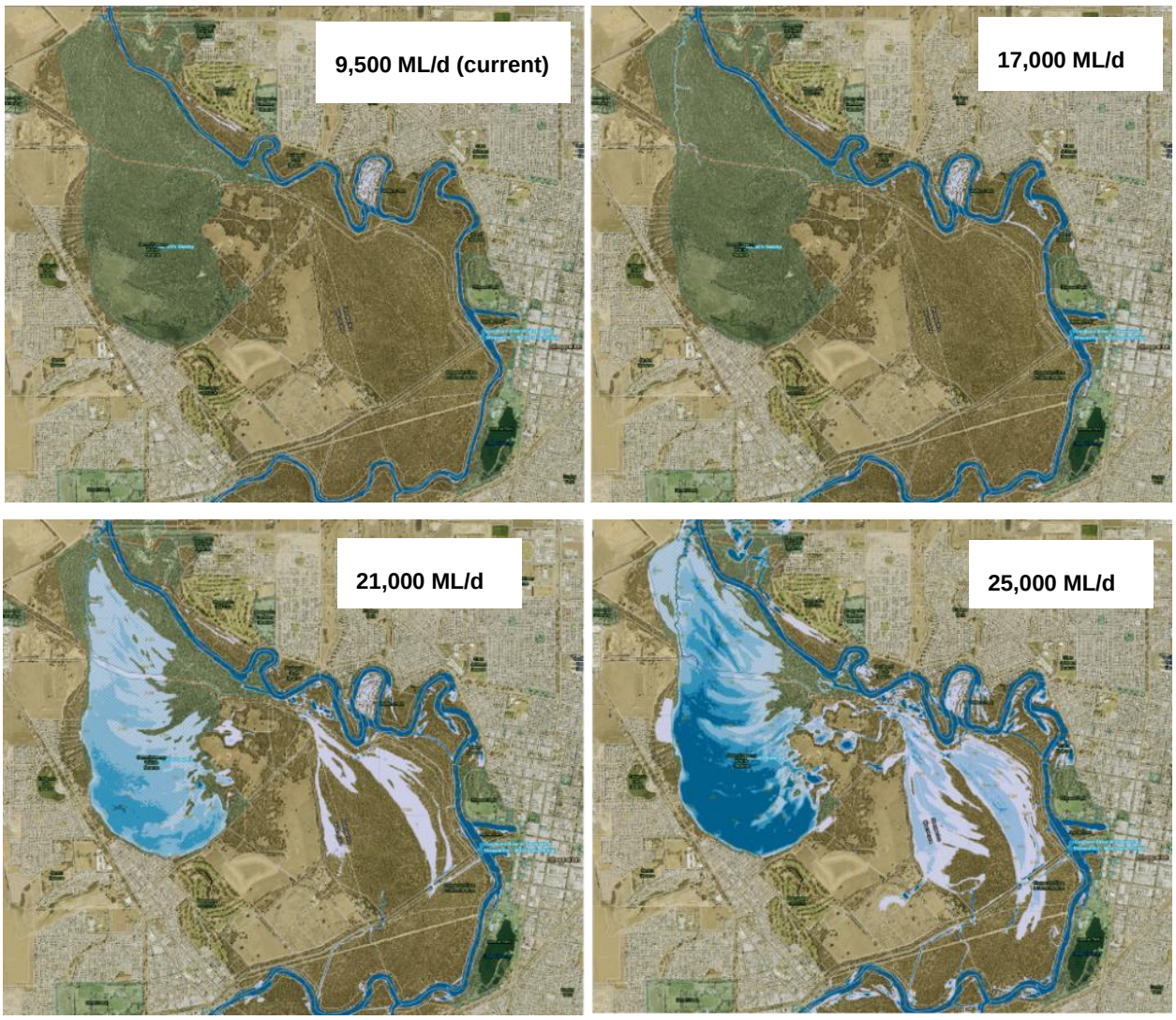


Figure 58: The modelled extent of inundation at Gemmill Swamp, Lower Goulburn at the increasing flow scenarios (measured at Shepparton)

4.9.2 Reedy Swamp

Reedy Swamp is a 130 hectare wetland on the Goulburn River Floodplain north of Shepparton. It is a high value wetland hosting a range of significant wetland dependent species. Relaxing constraints in the Goulburn to at least 21,000 ML/d would provide the ability to water important wetlands in the lower Goulburn, although Reedy Swamp does not benefit from any inundation until flows of 25,000 ML/d are achieved Figure 59). Of the modelled scenarios, only 25,000 ML/d results in water entering Reedy Swamp.

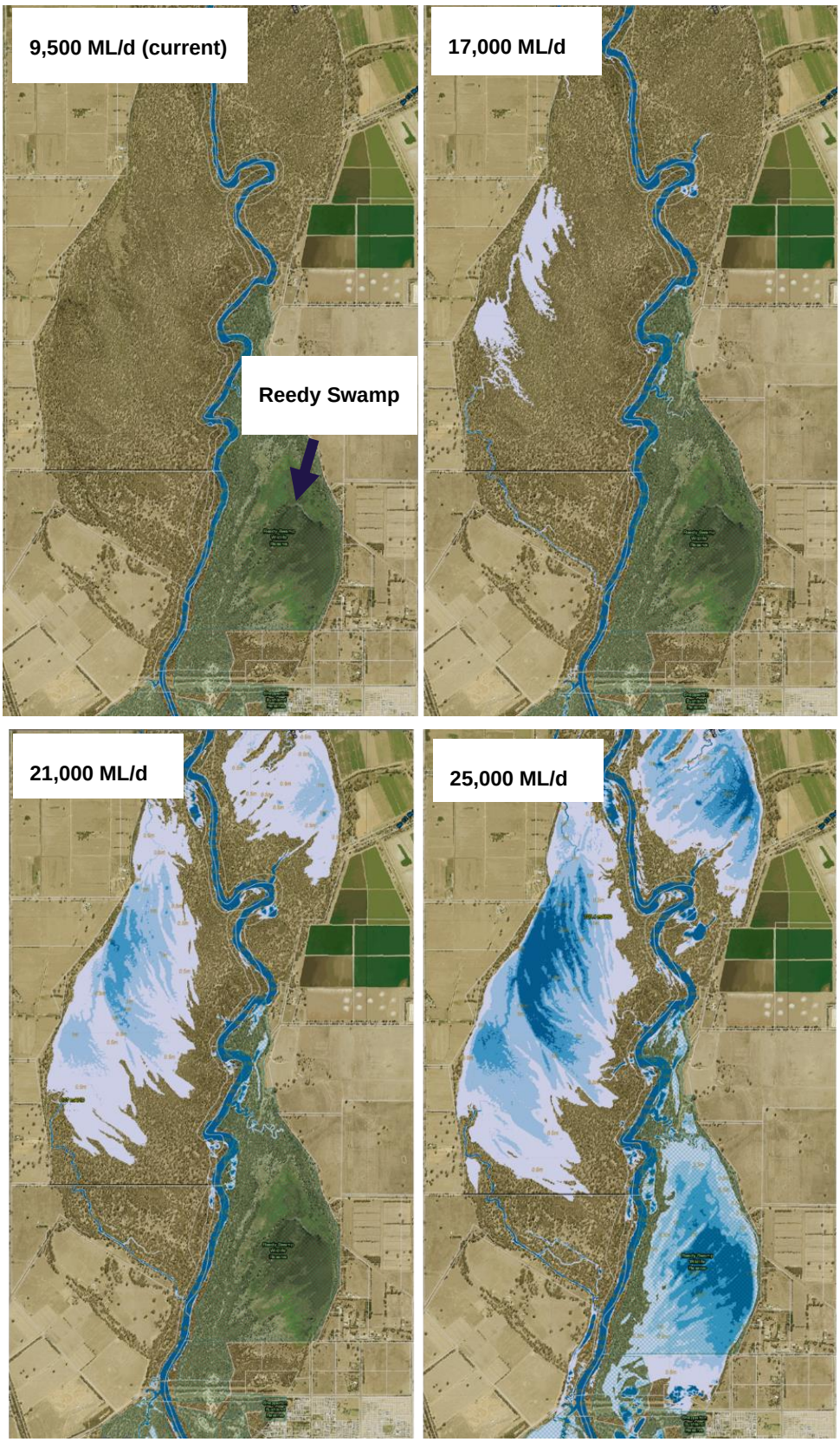


Figure 59: The modelled extent of inundation at Reedy Swamp Wildlife Reserve (located in the bottom right of the image), Lower Goulburn at the increasing flow scenarios (measured at Shepparton)

4.9.4 Loch Garry Wildlife Reserve

Loch Garry is a 680 hectare wetland located on the lower Goulburn River floodplain, approximately 20 kilometres north of Shepparton. This wetland encompasses a former course of the Goulburn River and has a maximum depth exceeding two meters. It is surrounded by shallow wetlands, riverine forest, and sand ridges.

When it holds water, Loch Garry serves as essential habitat for various wildlife, including frogs, fish, turtles, and numerous waterbirds such as ducks, grebes, cormorants, darters, ibis, and spoonbills. Parks Victoria manages this wetland within a wildlife reserve, and a narrow section adjacent to the Goulburn River is part of the Lower Goulburn River National Park. Loch Garry is situated within traditional Yorta Yorta lands and contains several culturally significant sites. Additionally, it's a popular recreational destination.

Modelling shows that there is some potential floodplain inundation to the south of Loch Garry under relaxed constraints of 21,000 ML/d at Shepparton scenario, however relaxation of constraints to 25,000 ML/d at Shepparton sees inundation of the Loch Garry wetland itself with flows contained by the Lower Goulburn levee system (Figure 60).

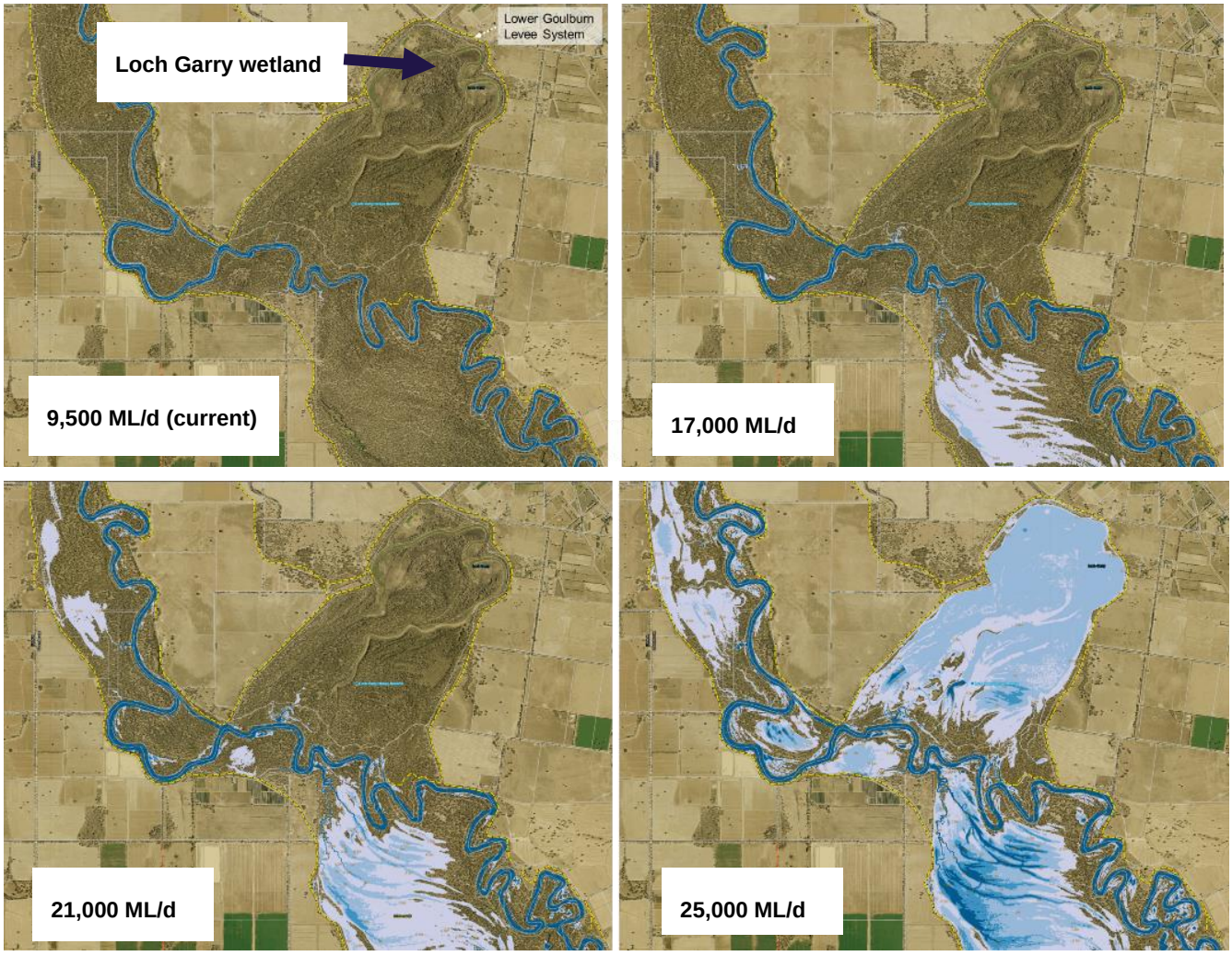


Figure 60: The modelled extent of inundation at Loch Garry Wildlife Reserve, Lower Goulburn at the increasing flow scenarios (measured at Shepparton)

4.10 Summary of flow scenario benefits and impacts

Table 15 below summarises a range of key parameters identified in the modelling of the different constraints relaxation scenarios in the Goulburn River.

Table 15: Summary of key parameters across the modelled flow scenarios – Goulburn River

Indicator	Relaxed constraint flow scenario			
	M10L17	M10L21	M12L21	M14L25
Native vegetation inundation (ha)	2,426	3,973	4,216	7,189
% change on River Red Gum condition	+19%	+0%	+83%	+83%
% change on Blackbox Woodland condition	-52%	-52%	+91%	+91%
Relative improvement in fish population stress index (across 3 guilds)	Minor (+)	High (+)	High (+)	Highest (+)
Increase in efficiency of environmental water use	+77%	+108%	+108%	+131%
Extent of public land inundated (ha)	2,064	3,476	3,588	6,064
Extent of private land inundated (ha)	478	620	838	1,505
Additional private properties inundated	71	150	178	289
Average extent of private land inundation (ha)	1.3	1.4	1.8	2.6

5 Murray River outcomes

- Relaxing constraints in the study areas of the Murray River can enhance the efficient use of existing environmental water holdings, especially during planned environmental flow events from July to October. The benefits increase as constraints are further relaxed and floodplain inundation increases.
- Almost 30 times the area of public floodplain has the potential to be watered compared to private land in the Yarrawonga to Wakool Junction reach under the highest constraint relaxation scenario. This reach experiences the greatest floodplain benefits when constraints are relaxed, including larger areas of environmentally valuable and culturally significant public land including Gunbower and Barmah forests.
- However, the reach directly downstream of Hume Dam sees minimal ecological improvement from relaxed constraints.
- Relaxing constraints in the Hume to Yarrawonga reach is crucial for protecting and restoring vegetation quality in the public land and National Parks downstream of Yarrawonga, however more private land may need to be inundated in the upstream reach to capitalise on these downstream environmental benefits.
- Private property in the Hume to Yarrawonga reach is disproportionately affected compared to downstream of Yarrawonga, where environmental benefits are greater. At the highest modelled constraint an additional 1,476ha of private land on an additional 52 properties are impacted in this reach, Due to the impacts on land directly downstream of Hume Dam, flows of 40,000 ML/day are likely to be unacceptable to landowners in the Hume to Yarrawonga reach.
- Although flows generally below the minor flood level are targeted, the modelling reveals that if constraints are relaxed above 30,000 ML/day on the Murray at Doctors Point, flows above the minor flood level may occur at Corowa. Downstream of Corowa flows are generally forecast below the minor flood although they could be slightly higher in some circumstances.
- No dwellings or major assets are impacted at the modelled flow rates, but river pumps and tracks, especially through public land downstream of Yarrawonga, would be affected. Discussions with individual property owners are necessary to fully determine the extent of impacts at these flow rates, especially for impacts beyond the directly inundated area such as property management and impeded access.
- Modelling suggests that flows of 40,000 ML/d may be achieved an additional 1 in 10 years at Doctor’s point under the highest modelled scenario. However, achieving targeted flows at the modelled constraint at Yarrawonga is less frequent and depends on ‘piggy backing’ on unregulated tributary inflows. Flow targets in the lower reach cannot be achieved by dam releases alone.
- Modelling of Goulburn inflows to the Murray River indicates improved environmental Murray outcomes by relaxing constraints in the Goulburn River.
- The beneficial environmental impacts of relaxing constraints in the mid-Murray and Goulburn tend to decrease with increasing distance downstream of the Barmah Choke. Modelling suggests relaxing constraints would result in no change in the frequency of environmentally desirable higher flow rates in the Murray River at the South Australian border under all relaxed constraints scenarios tested in this stage of the Victorian CMP. Further work is required through the EEWD project to develop the tools and processes to further forecast and coordinate flows across all tributaries.
- All constraint scenarios' modelling shows that the reliability of Murray water entitlements would not be reduced.
- Relaxing constraints would enable more environmental water to be released from storages than under current rules, increasing dam airspace and reducing the size of moderate floods. Releasing environmental water throughout the year can provide flood mitigation as a secondary benefit, depending on how the entitlement holders chose to use their water. Furthermore, floodplain landowners would benefit from mitigation works up to constraint flow levels and a risk buffer, whereas they are currently directly affected by natural flood impacts.
- Given the disproportionate impact on private land in the Hume to Yarrawonga reach, exploring additional scenarios, such as Y40D30 and Y45D30, is recommended to assess different combinations of relaxed constraints and potential environmental benefits.

- Except for the most severe climate scenario, where water availability is the major limiting factor, relaxing constraints can serve as a valuable tool for Murray environmental water managers to adapt to a drying climate. It's crucial to recognise that in such an environment, river management would need to significantly differ from current practices.

5.1 Murray modelled scenarios

The different relaxed constraints flow scenarios modelled for the Murray River are shown in Table 16 below.

Table 16: Murray River constraint scenarios modelled as part of the feasibility study

Constraint Location	Current Constraint (ML/d)	Relaxed constraint scenario			
		Y25D25	Y30D30	Y40D40	Y45D40
Doctors Point (Hume to Yarrawonga)	25,000	25,000	30,000	40,000	40,000
Yarrawonga Weir (Yarrawonga to Wakool)	15,000	25,000	30,000	40,000	45,000

The results in the following sections relate to each of these modelled scenarios.

5.2 Land potentially inundated

As the constraint is further relaxed and the river flow increases, the area of inundation increases. The area of both public and private land inundated for each of the reaches is shown in the following graphs. A greater extent of private land compared to public land may be inundated at the highest constraint relaxation scenario in the Hume to Yarrawonga reach (Figure 61).

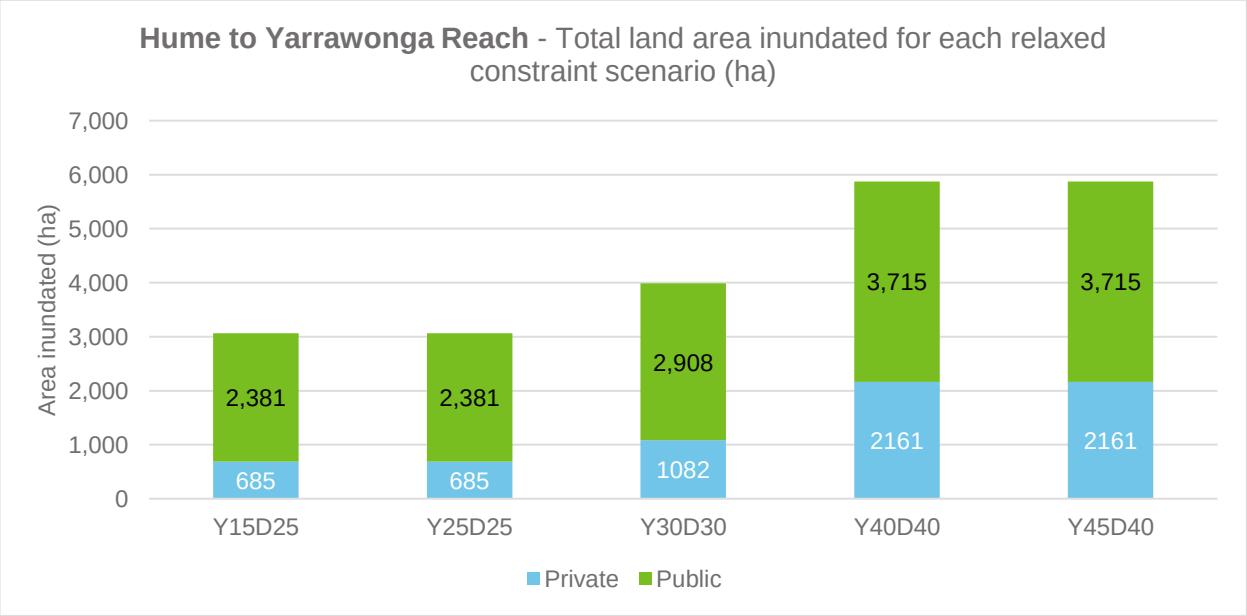


Figure 61: Total modelled area of private and public land inundated at each constraint scenario for the Murray River Hume to Yarrawonga reach (Victorian study area only)

As constraint scenarios are relaxed below Yarrawonga, a greater area of higher environmental value public land is inundated compared to private land. Almost 30 times the area of public floodplain has the potential to be watered compared to private land in the Yarrawonga to Wakool Junction reach under the highest constraint relaxation scenario (Figure 62).

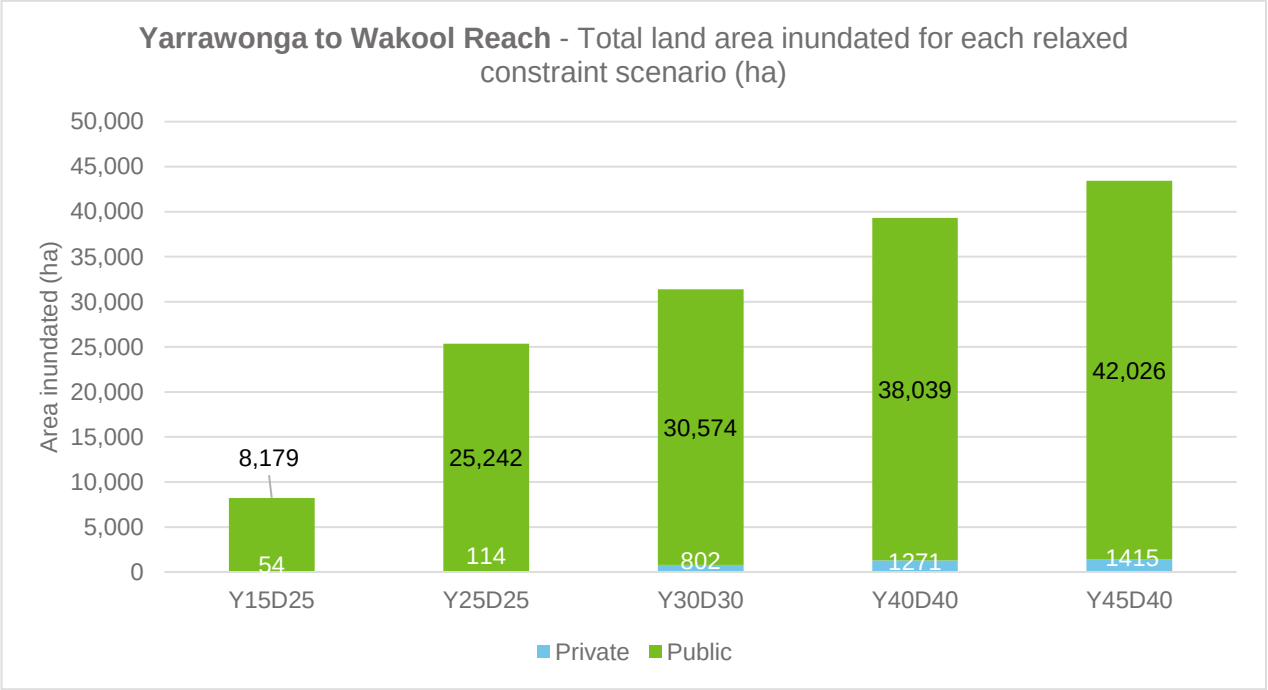


Figure 62: Total modelled area of private and public land inundated at each constraint scenario for the Murray River Yarrawonga to Wakool reach (Victorian study area only)

Across the entire Victorian Murray study area, relaxing constraints along the Murray has the potential to water almost 30 times the area of Victorian public land compared to private property (Figure 63).

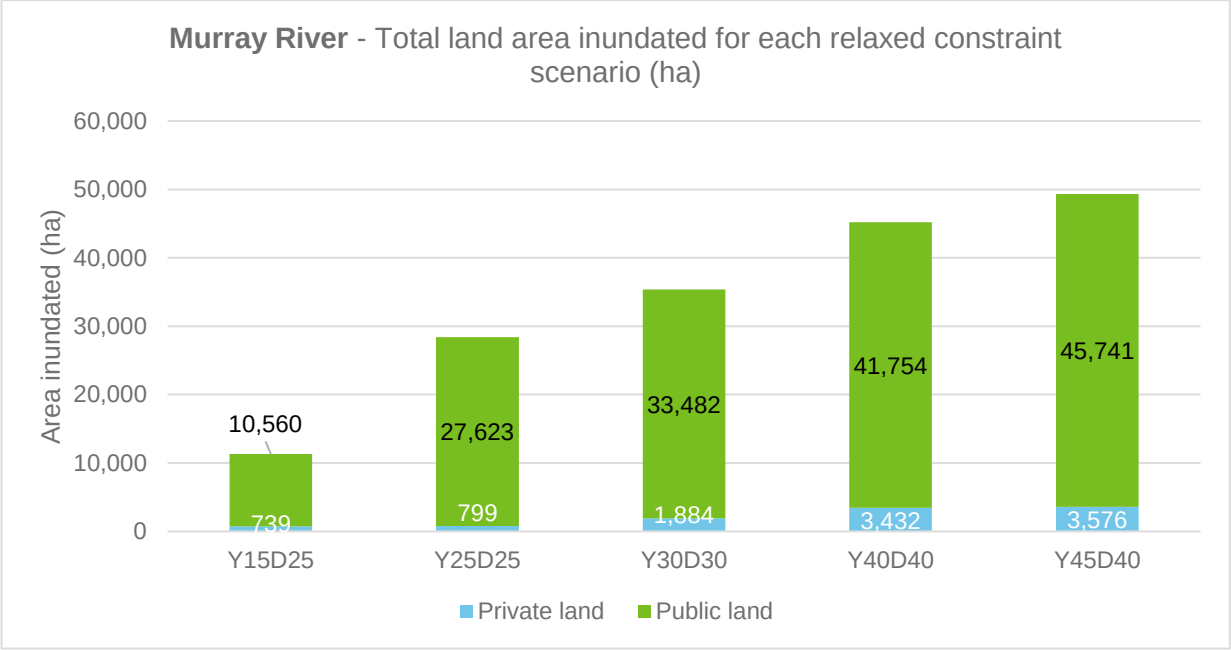


Figure 63: Total modelled area of private and public land inundated at each constraint scenario on the Murray River (Victorian study area only)

5.3 Properties potentially impacted

Under current constraint conditions there are a total of 244 properties that have been identified as subject to inundation. This is predominantly due to how land title boundaries have been drawn in relation to the river.

Increasing river flows increases the number of private properties impacted along both studied reaches of the Murray River. The hydraulic modelling suggests an additional 222 private properties are potentially inundated along these areas of the Murray River at the greatest relaxed modelled constraint scenario compared to current conditions (Figure 64).

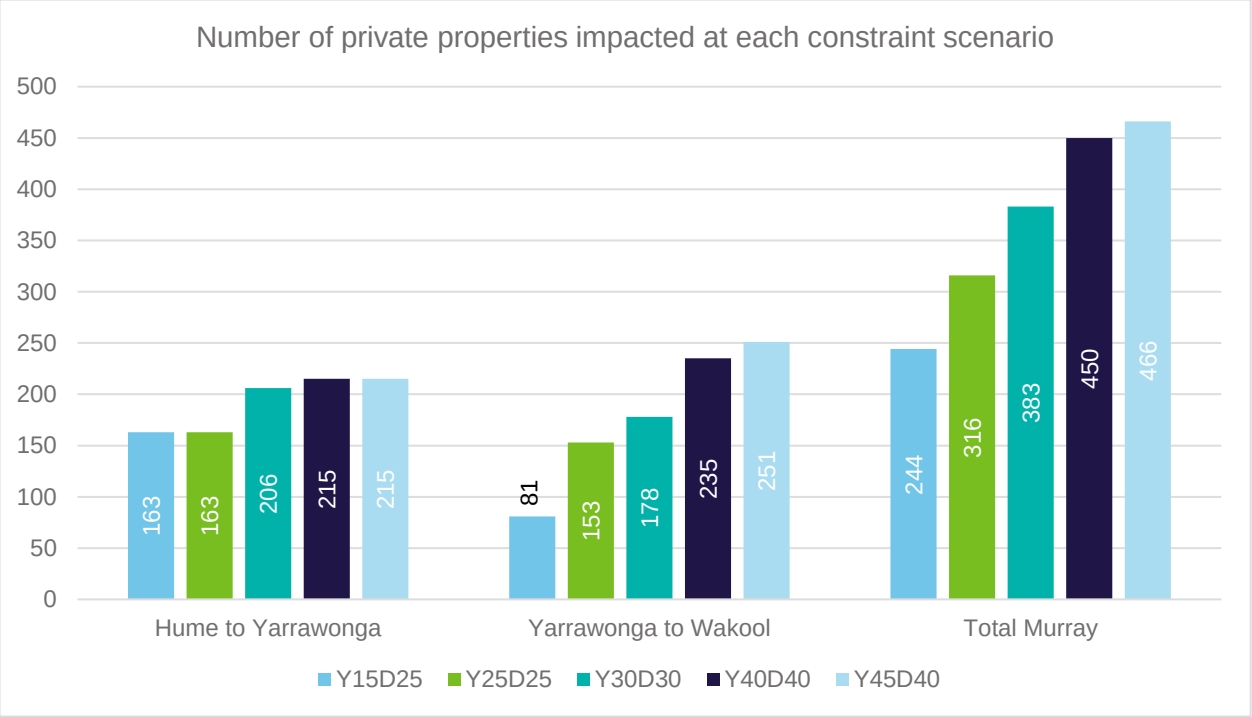


Figure 64: Number of private properties impacted at each constraint scenario on the Murray River (Victorian study area only)

As constraints are relaxed at Doctors Point, further private properties are impacted. In the Hume to Yarrawonga reach, there are an additional 52 properties that will experience some level of inundation at the highest modelled flow scenario of 40,000 ML/d compared to current operating practices (Table 17).

Table 17: Impacts of different constraint scenarios on the inundation on private land for the Hume to Yarrawonga reach (Victorian study area only)

Hume to Yarrawonga				
Scenario	**Area of private land inundated (ha)**	**Change from current (ha)**	**No of private properties impacted**	**Change from current**
Y15D25	685	0	163	0
Y25D25	685	0	163	0
Y30D30	1,082	397	206	43
Y40D40	2,161	1,476	215	52
Y45D40	2,161	1,476	215	52

Modelling suggests that at the highest flow scenario, there will be a larger number of newly impacted properties in the Yarrawonga to Wakool reach compared to the Hume to Yarrawonga reach. At the highest modelled flow

scenario of 45,000 ML/d at Yarrawonga, an additional 170 private properties are anticipated to be impacted (Table 18).

Table 18: Impacts of different constraint scenarios on the inundation on private land for the Yarrawonga to Wakool reach (Victorian study area only)

Yarrawonga to Wakool				
Scenario	**Area of private land inundated (ha)**	**Change from current (ha)**	**No of private properties impacted**	**Change from current**
Y15D25	54	0	81	0
Y25D25	114	60	153	72
Y30D30	802	748	178	97
Y40D40	1,271	1,217,	235	154
Y45D40	1,415	1,361	251	170

Relaxing constraints is shown to inundate more private properties in the Yarrawonga to Wakool reach, however the area of private land inundated is higher in the Hume to Yarrawonga reach.

Analysis of individual private land parcels shows that 239 parcels (55%) are inundated up to 1ha at the highest constraint relaxation scenario of 40,000 ML/d in the Hume to Yarrawonga reach (Figure 65). It is noted that a property may consist of one or many individual land parcels.

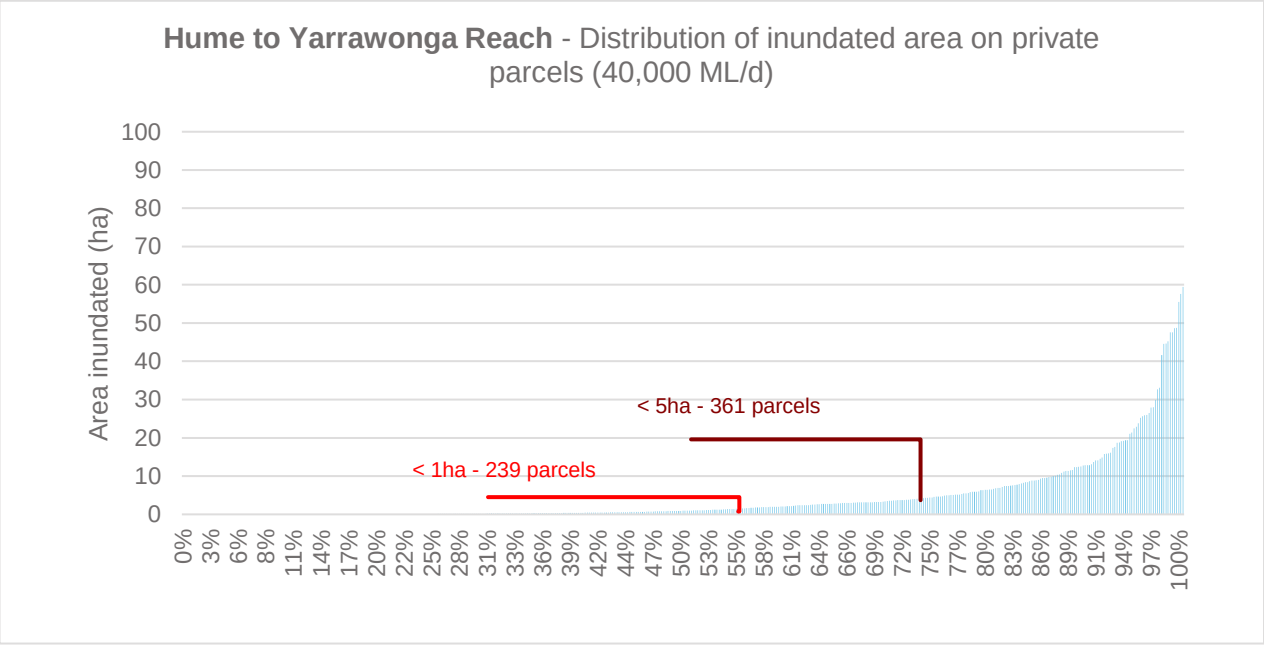


Figure 65: Distribution of potentially inundated area on private parcels at the highest constraint relaxation scenario of 40,000 ML/d along the Hume to Yarrawonga reach (Victorian study area only)

At the highest modelled constraint scenario of 45,000 ML/d in the Yarrawonga to Wakool reach, 257 private land parcels (51%) are inundated up to 1ha. This extends to 291 private parcels (65%) inundated less than 5ha under flows of 45,000 ML/d (Figure 66).

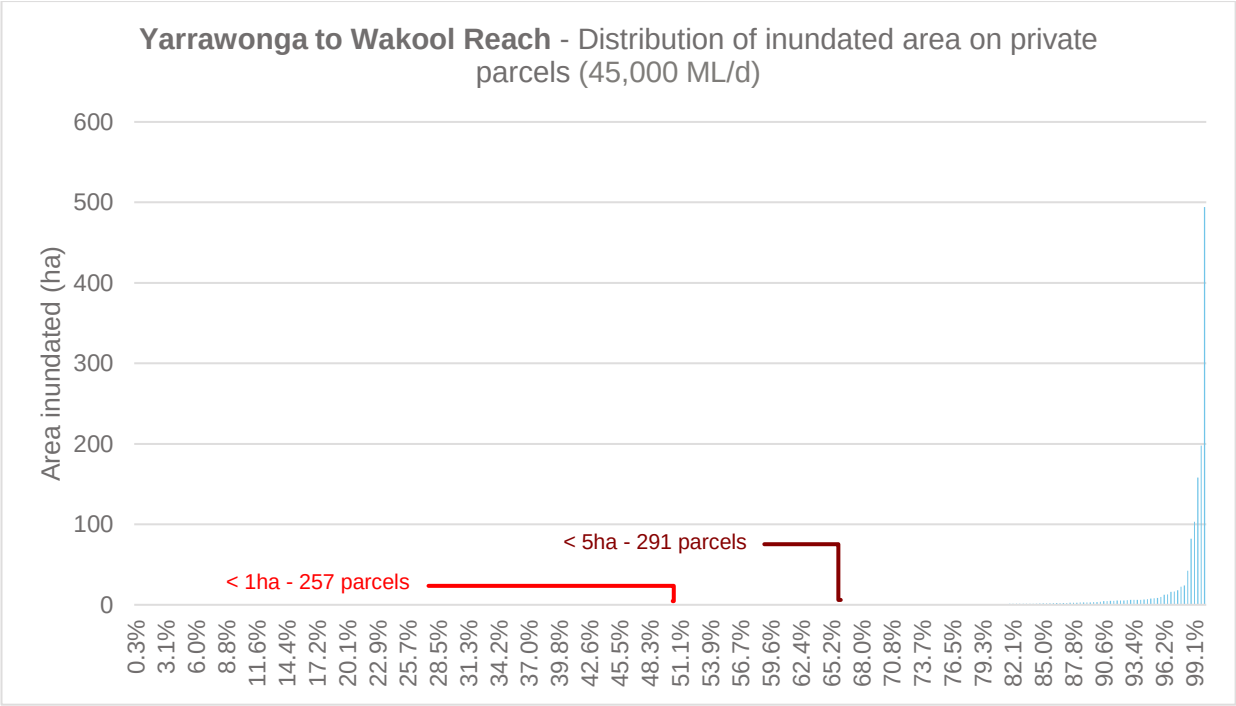


Figure 66: Distribution of potentially inundated area on private parcels at the highest constraint relaxation scenario of 45,000 ML/d along the Yarrawonga to Wakool reach (Victorian study area only)

Table 19: Average area of private land potentially inundated (ha and %) for each scenario in the Hume to Yarrawonga reach of the Murray River (Victorian study area only).

Hume to Yarrawonga				
Scenario	**Average area of private land inundated (ha)**	**Change from current (ha)**	**Average % of property inundated**	**Change from current**
Y15D25	2.2	0	12%	0%
Y25D25	2.2	0	12%	0%
Y30D30	2.6	0.4	15.7%	3.7%
Y40D40	4.6	2.4	23.9%	11.9%
Y45D40	4.6	2.4	23.9%	11.9%

Table 20: Average area of private land potentially inundated (ha and %) for each scenario in the Yarrawonga to Wakool reach of the Murray River (Victorian study area only).

Yarrawonga to Wakool				
Scenario	**Average area of private land inundated (ha)**	**Change from current (ha)**	**Average % of property inundated**	**Change from current**
Y15D25	0.5	0	4.4%	0%
Y25D25	0.6	0.1	7.9%	3.5%
Y30D30	3.6	3.1	9.3%	4.9%
Y40D40	4.2	3.7	10.0%	5.6%
Y45D40	4.4	3.9	10.5%	6.1%

5.4 Potential inundation of existing assets

The desktop assessment of the impact of higher flow scenarios on existing infrastructure shows that a range of assets are impacted, predominantly river pumps and tracks and roads. No dwellings are impacted under any of the scenarios as the flows target areas below the minor flood level. On-ground assessment would be required in any future potential stages to further investigate the potential impacts of changed flow scenarios. This is particularly important to determine the impact of inundation on property management and private access tracks as this information is not currently available in spatial datasets.

Table 21: Extent of potentially impacted assets along the Victorian Murray River study area at different constraint relaxation scenarios

Relaxed constraint scenario	**Roads (km)**	**2WD & 4WD Tracks (km)[11]**	**Structures**	**Pumps**		**Dwellings**
				Irrigation	**Stock and Domestic**	
Y30D30	8.5	163.8	4	52	143	0
Y45D40	43	636	18	88	204	0

The number of pumps potentially inundated is high due to being located on or close to the riverbank. A higher relaxed constraint flow rate does not produce a significant change on the number pumps within the inundation extent.

Up to 636 km of tracks are potentially impacted at the maximum relaxed constraint scenario. These tracks are largely contained within public land in the Yarrawonga to Wakool reach.

An example of how increasing river flows can impact tracks along the study areas of the Murray River is shown in Figure 67 to Figure 69. These show that as flows in the Murray increase from 25,000 ML/d through to 45,000 ML/d at Barmah National Park, the extent and depth of inundation of tracks through the area are impacted.

Any future stages of the CMP will require consultation with land managers regarding mitigation options.

[11] The desktop assessment is limited by data available within public spatial datasets. It is acknowledged there are privately owned access tracks and driveways not captured within this dataset and therefore not included in this assessment. In any future stages of investigation, further assessment is required to quantify the impacts at a property level.

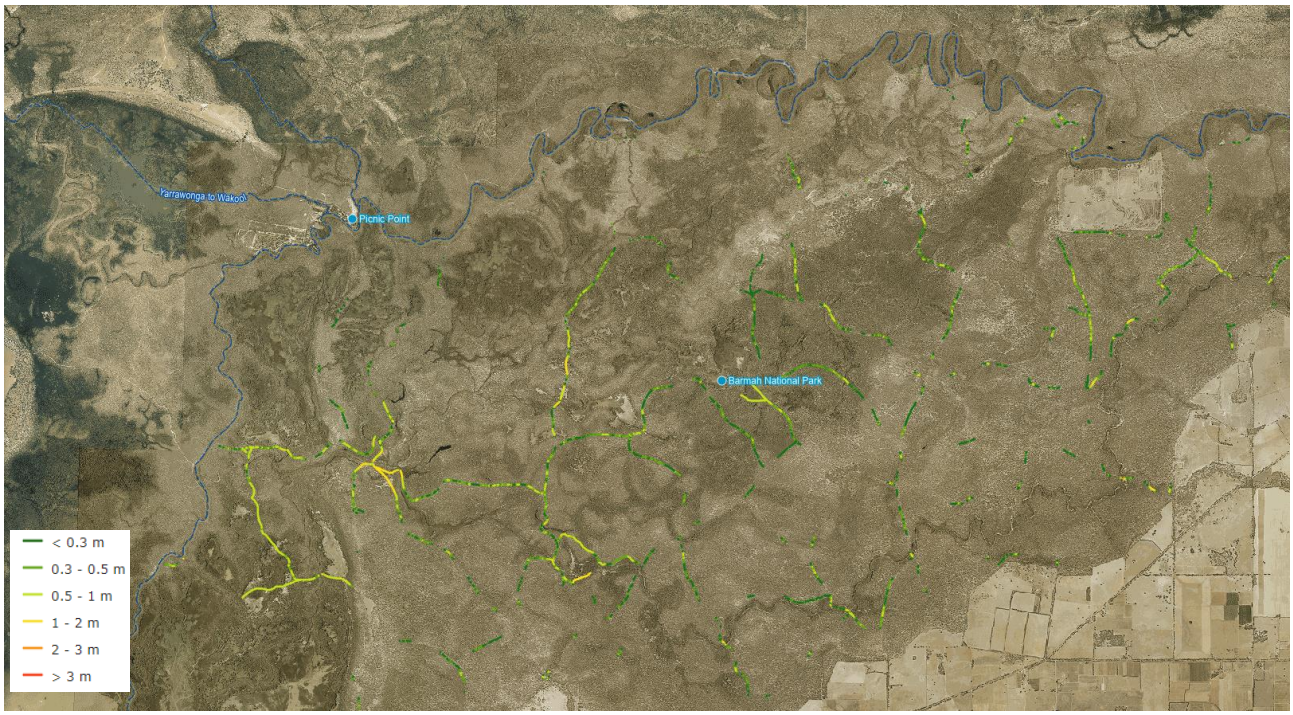


Figure 67: Extent and depth of tracks inundated at flows of 25,000 ML/d through the Barmah National Park

As the flow increases from 25,000 ML/d through Barmah National Park (Figure 67 above) to 45,000 ML/d (Figure 68 below), there is a greater length of track impacted. There is also an increase in depth of inundation across some areas, signified by increased areas of yellow colours.

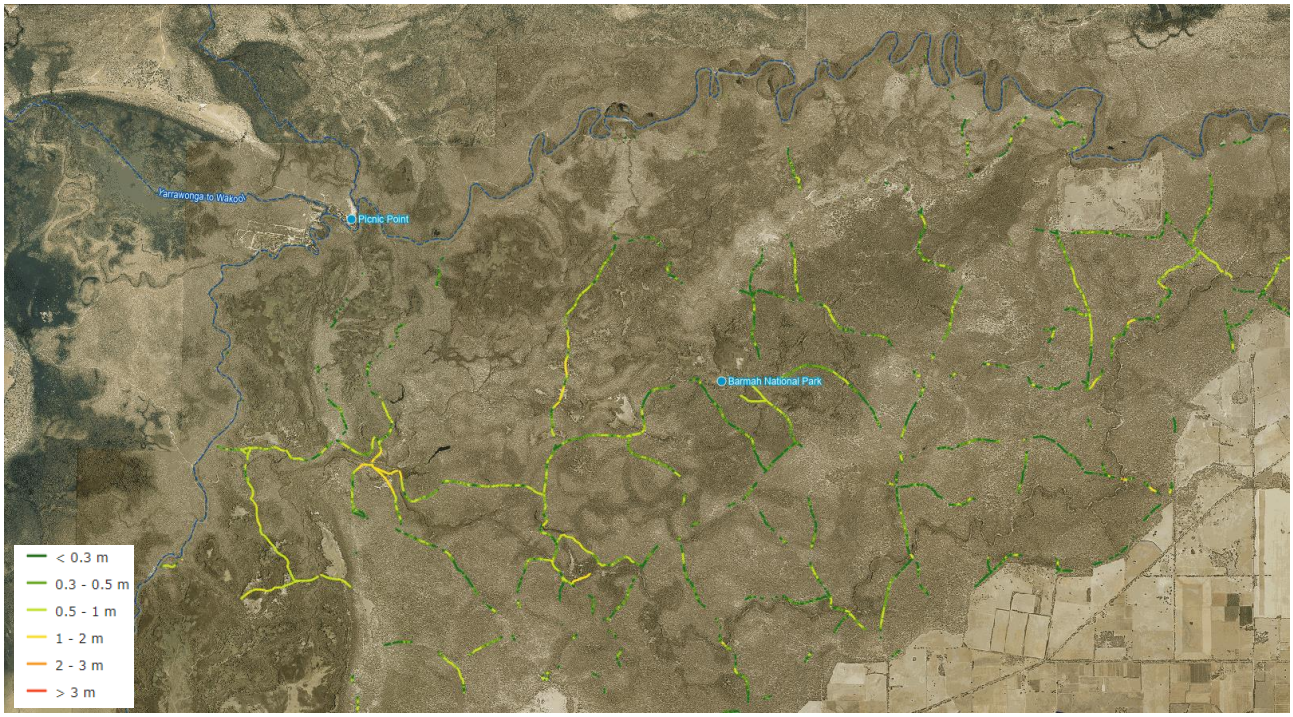


Figure 68: Extent and depth of tracks inundated at flows of 40,000 ML/d through the Barmah National Park

As the flows increase further to 45,000 ML/d (Figure 69), the track network is further inundated and the depth continues to increase, as represented by more yellow extents in the area.

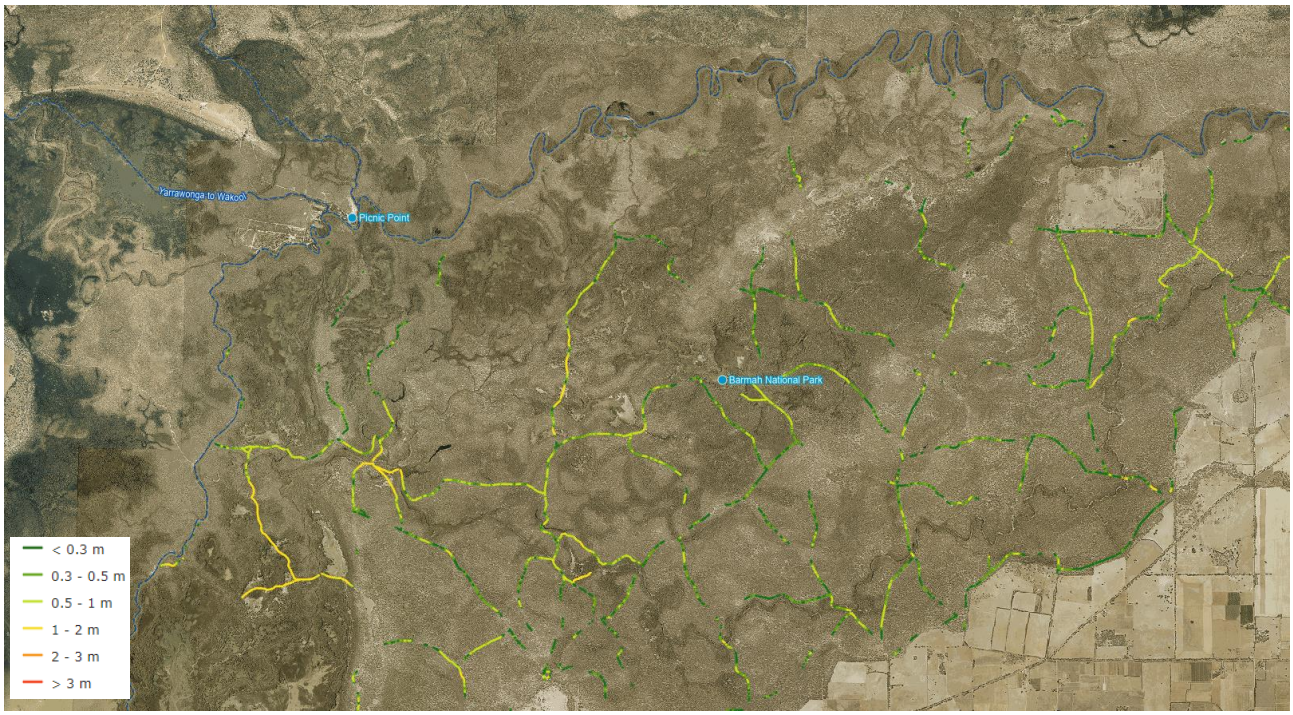


Figure 69: Extent and depth of tracks inundated at flows of 45,000 ML/d through the Barmah National Park

A similar outcome is observed across the tracks through the Gunbower National Park and State Forest as river levels increase under relaxed constraints flows (Figure 70 to Figure 73 below).

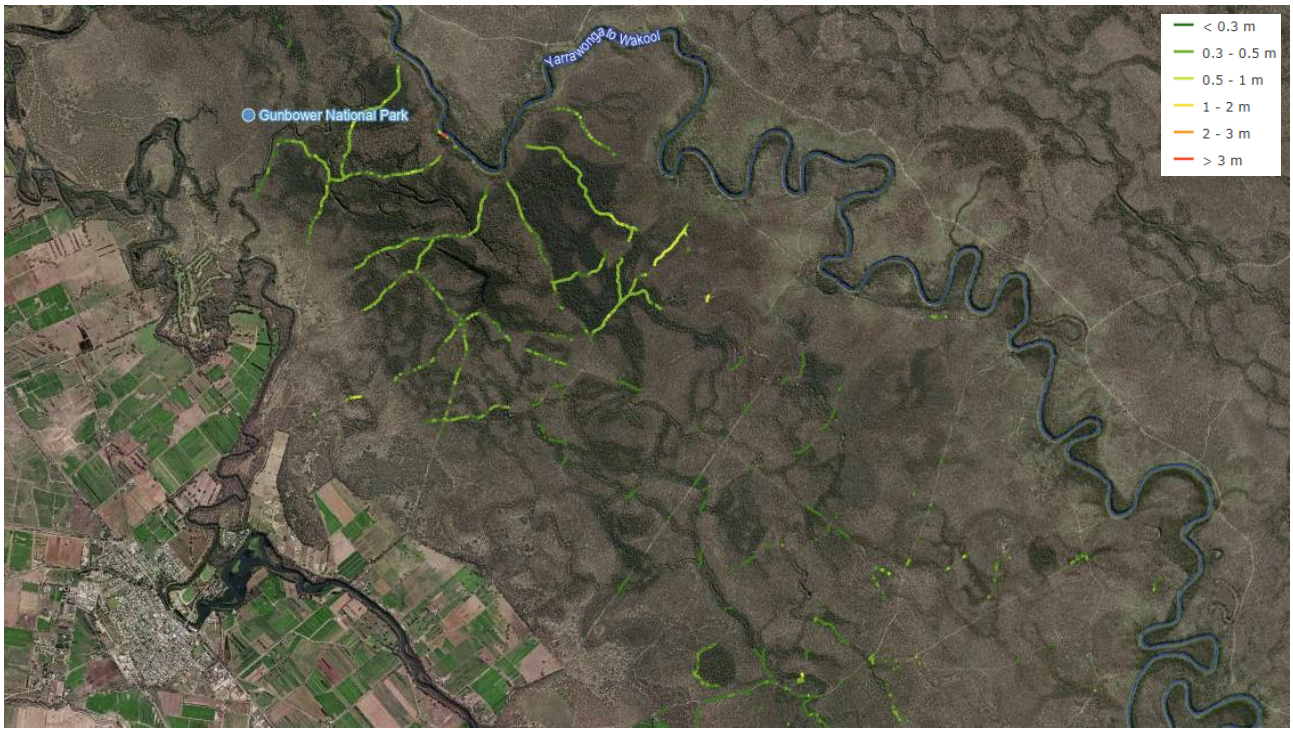


Figure 70: Extent and depth of tracks inundated at flows of 25,000 ML/d through the Gunbower National Park and State Forest

As the flow increases from 25,000 ML/d through Gunbower National Park and State Forest (Figure 70 above) to 45,000 ML/d (Figure 73 below), there is a greater length of track impacted, signified by the area of yellow colours. With further constraint relaxation there is also an increase in depth of inundation across some areas.

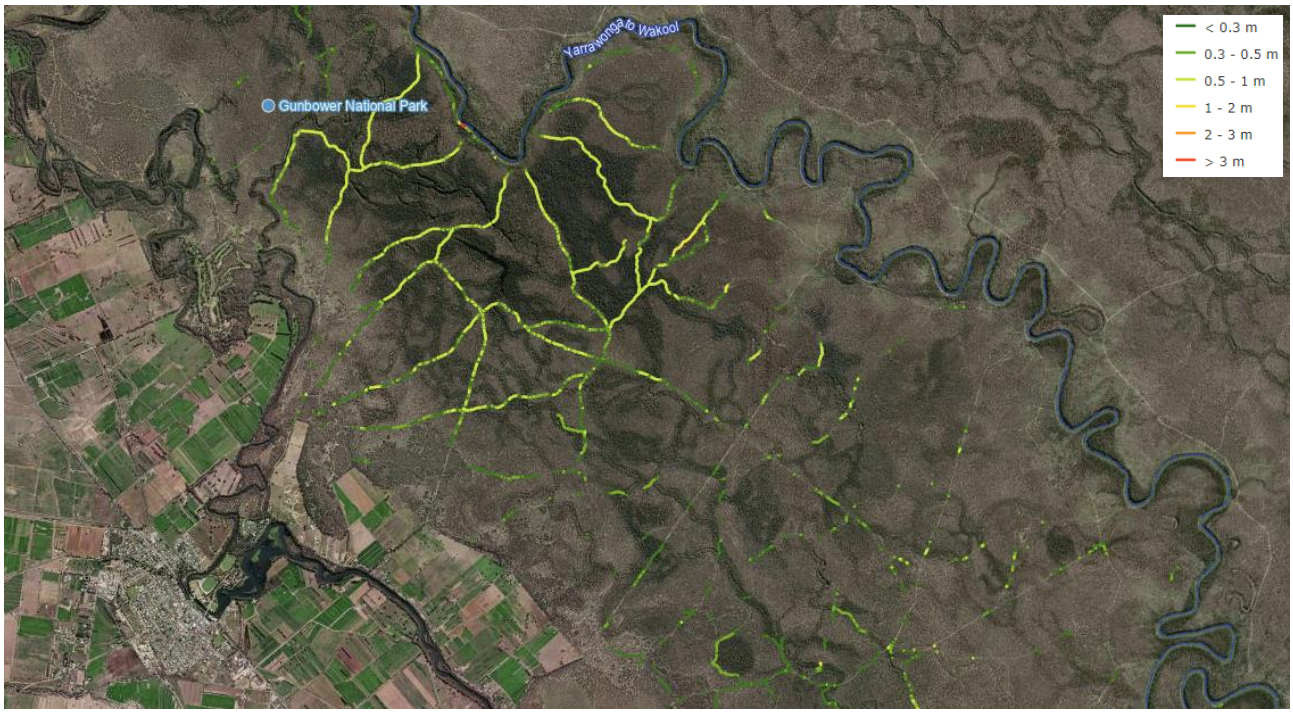


Figure 71: Extent and depth of tracks inundated at flows of 30,000 ML/d through the Gunbower National Park and State Forest

By 30,000 ML/d (Figure 71), Corduroy track is nearly completely inundated which is one of the primary linking tracks from the township of Cohuna to the Murray River. Further inundation is seen with increasing relaxed constraint flows across smaller linking tracks between Corduroy and Nursery Tracks.

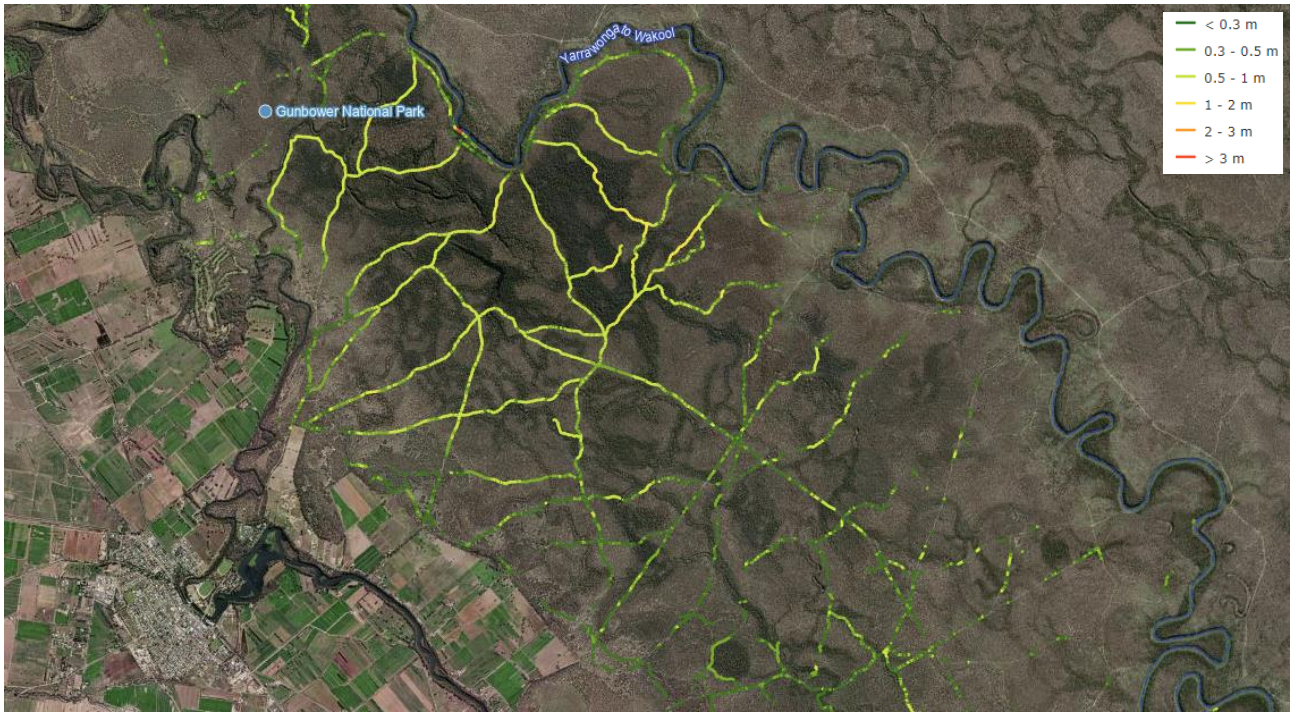


Figure 72: Extent and depth of tracks inundated at flows of 40,000 ML/d through the Gunbower National Park and State Forest

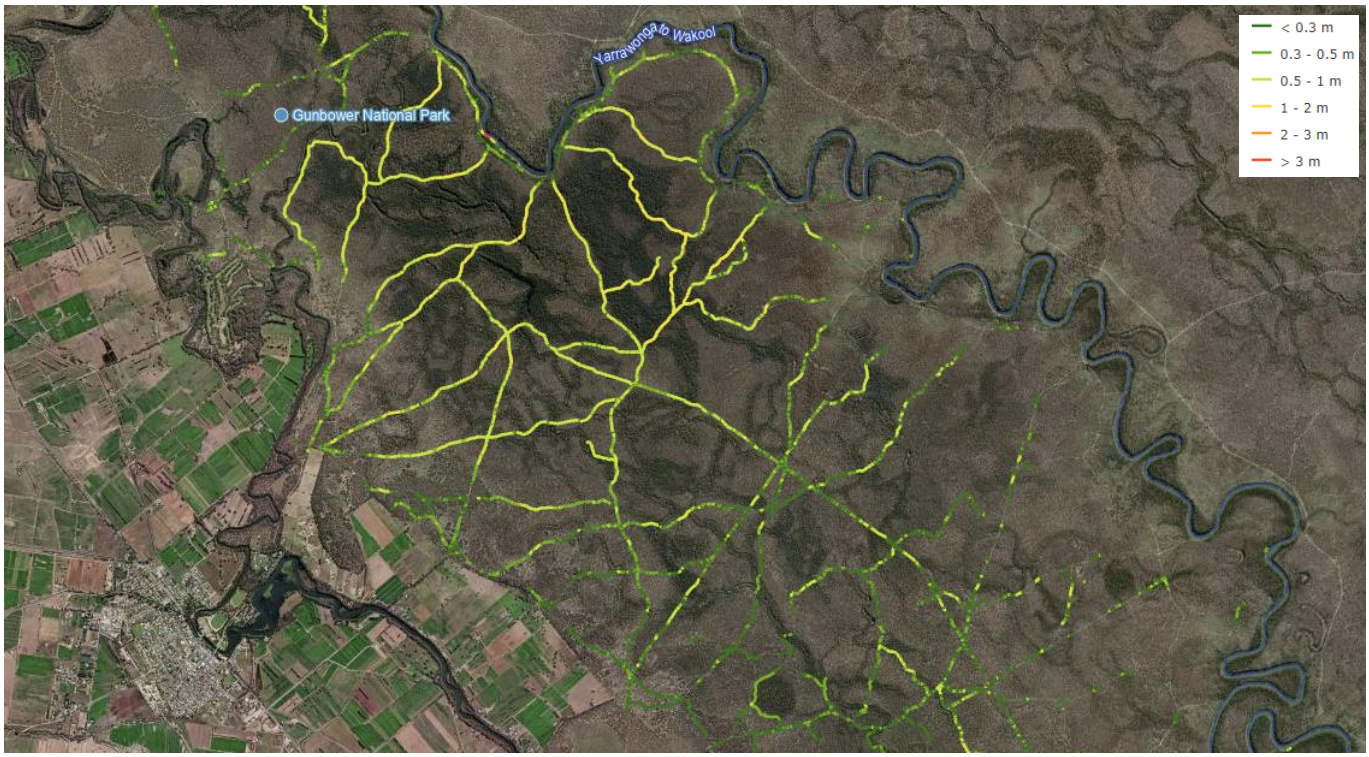


Figure 73: Extent and depth of tracks inundated at flows of 45,000 ML/d through the Gunbower National Park and State Forest

From 40,000 ML/d to 45,000 ML/d, few new tracks are inundated in this area. Instead, the level of track inundation increases across this area signified by the slight change of yellow colours.

5.5 Flow timing, frequency and duration

The flow behaviour is extremely important to understand when assessing the potential benefits and impacts from different scenarios. The flow behaviour targets for the Murray River are outlined in Table 22. The flow behaviour is described in terms of the timing, frequency and duration of flow scenarios.

Table 22: Target flow behaviour to meet Murray River environmental flow recommendations (summarised from Appendix 1- Table 25)

Flow behaviour	Target
Timing	• Mostly August to October, though occasionally earlier or later
Frequency	• Align with ecological requirements and pre-regulation flow patterns • Depends on season, storage volumes, tributary flows
Duration	• Will vary depending on flow size, water availability, river operations and environmental needs but mostly around 7 to 14 days at target flows • Occasionally up to 30 days for flows • Gradual recession to reduce erosion risk and stranding of fish

The Committee was interested in how frequently the low-lying floodplain may be inundated for greater than 5 days. This is because after 5 days, inundation can negatively impact productive pastures. Figure 74 shows for Doctors Point the percentage of years that will have 5 or more days of winter/spring flow for each of the relaxed constraint scenarios.

Relaxation of constraints at both Doctors Point and Yarrawonga increases the number of days during winter/spring where flows are more than the current constraint but less than or equal to the relaxed constraint flow. Once the flow of interest is above the relaxed constraint, the number of days during winter/spring where flows are more than the relaxed constraint flow are reduced.

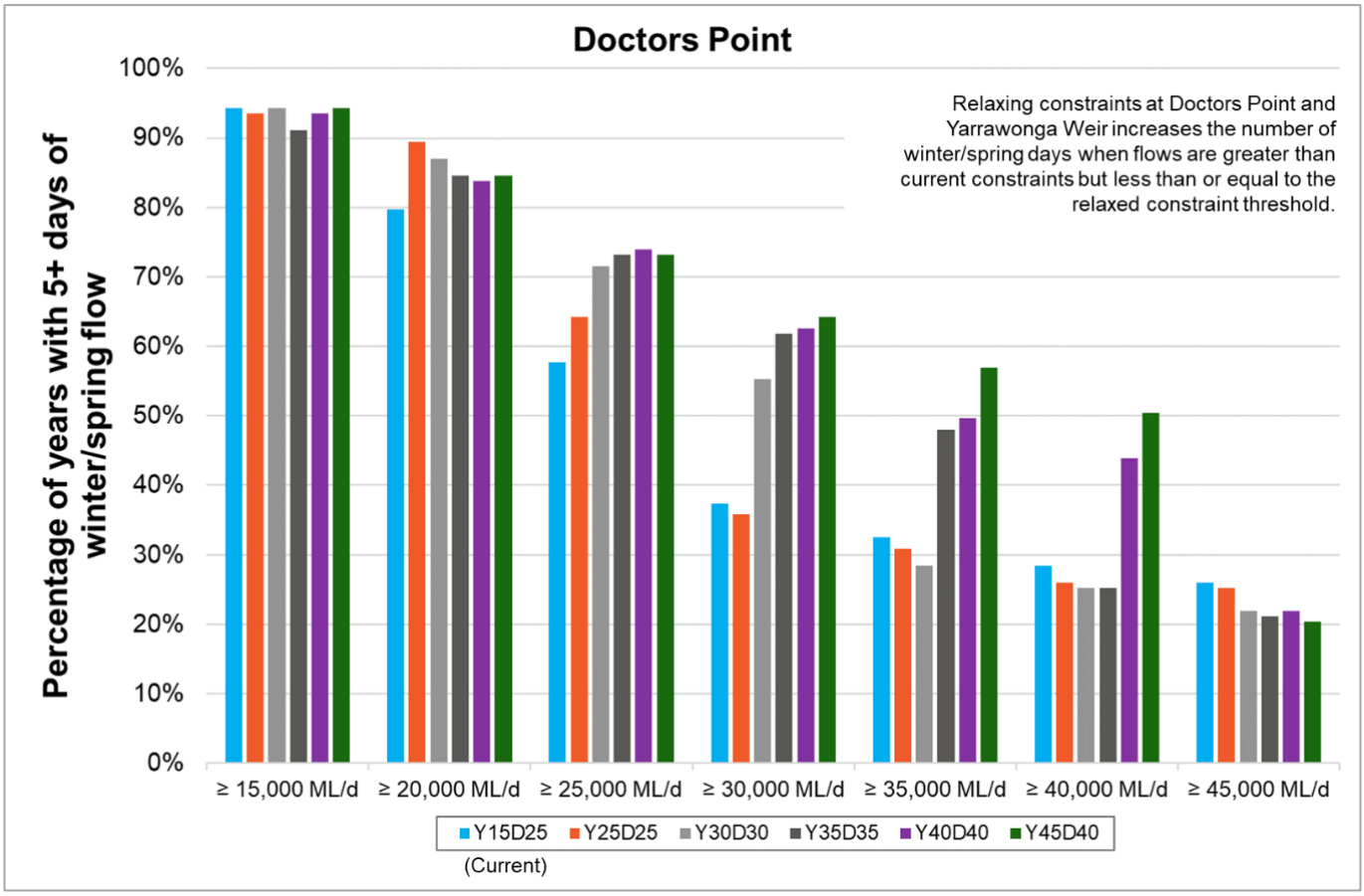


Figure 74: Example of the proportion of years (1895-2019) with 5+ days of winter/spring flow exceeding defined flow rates at Doctors Point comparing the current constraints (blue) to the Y35D35 scenario (grey)

A similar response is seen for downstream of Yarrawonga Weir (Figure 75) where relaxing constraints at both Doctors Point and Yarrawonga Weir increases the number of winter/spring days when flows are greater than current constraints but less than or equal to the relaxed constraint thresholds.

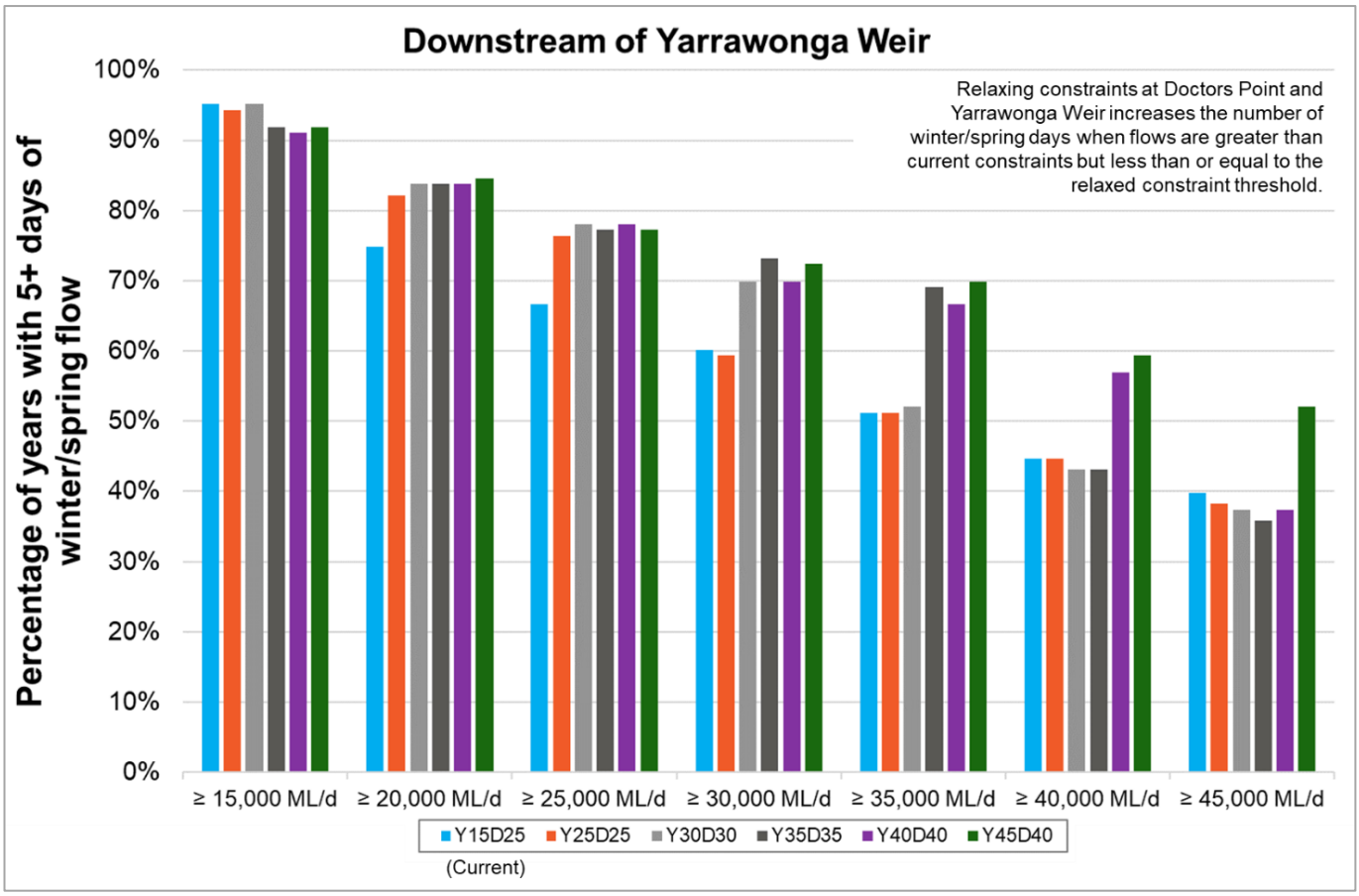


Figure 75: Proportion of years (1895-2019) with 5+ days of winter/spring flow exceeding defined flow rates at Downstream of Yarrawonga weir for different relaxed constraint scenarios

The MDBA modelling suggests that in line with environmental flow recommendations, the relaxation of constraints enables higher flows to be targeted between April and November compared to the current constraints which contributes to the increased efficiency of use of the available water for the environment.

Figure 76 shows that regulated releases at the relaxed constraint at Doctors Point or Downstream of Yarrawonga Weir are not expected to occur every year under the highest constraint relaxation scenario of Y40D40.

The modelling indicates that at Doctors Point under the Y40D40 scenario, there would have been four more instances of events at 40,000 ML/d compared to under current constraints. This result is not seen downstream at Yarrawonga where under the same scenario the modelling is suggesting that only one additional event of 40,000 ML/d flows are achieved. However, modelling suggests there would have been another three events where flows were enhanced that would provide additional environmental benefits to the surrounding floodplain.

Where there are instances in Figure 76 that show the blue line (current constraint flows) above the orange (modelled scenario constraint conditions), this means that flows are reduced compared to current conditions.

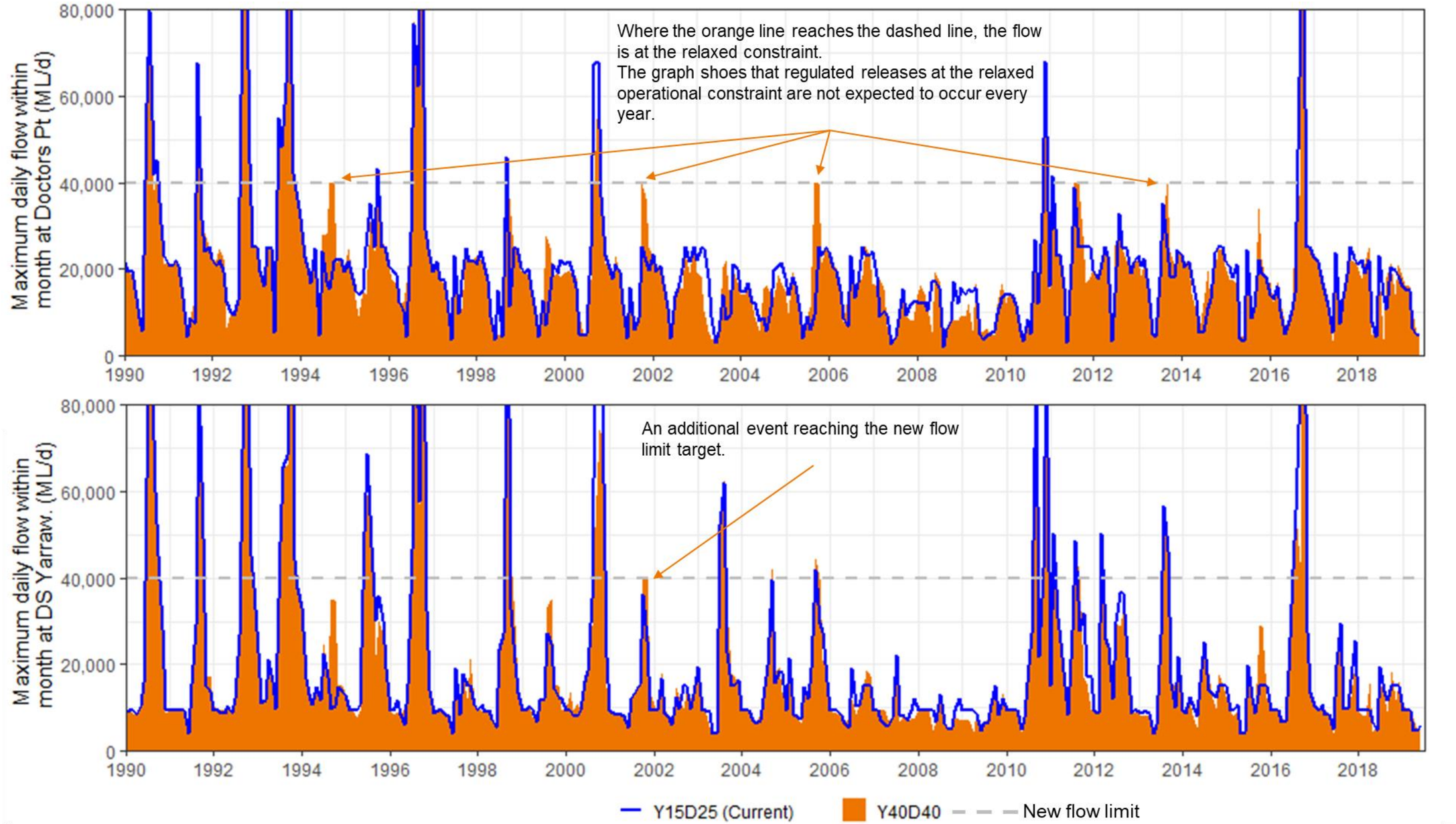


Figure 76: The modelled maximum daily flow at Doctor's Point (top) and downstream of Yarrawonga Weir (bottom) within each month from 1990 to 2020 under current constraints (blue) and Y40D40 (orange)

5.5.1 Consideration of benefits and costs downstream of Wakool Junction

The technical work and Committee discussions have primarily addressed the benefits and costs of relaxed constraints on landowners and the environment along the Goulburn River and the Victorian Murray, in the defined study areas from Hume to Wakool junction. However, it is expected that enhanced environmental flow regimes enabled by relaxing constraints would also extend downstream below Wakool into the Mallee Catchment area.

The Mallee Catchment area encompasses a 760-kilometer stretch along the Murray River, extending from Nyah to the South Australian border. There are more than 900 wetlands within the Mallee Catchment area with just over 200 of them situated on the lower floodplain area. Wetland types are diverse and support a high abundance of water dependent species, which require regular inundation as part of the natural hydrological cycle. In the absence of natural flooding, water for the environment is used to maintain and improve the character of certain wetlands. Every year a selection of priority sites are chosen to receive environmental water – these sites can be actively managed and are where ecological benefits are achievable.

Separate to the technical work undertaken for this feasibility study, Mallee CMA engaged Water Technology in 2022 to undertake modelling of various flow scenarios in the Murray River between Tyntynder to Lindsay Point (SA border). The study area included the Murray River floodplain and associated tributaries on the Victorian side of the river. The models were created using several LiDAR and photogrammetry datasets of the waterways on the floodplain area. Additional modelling scenarios were sought by the CMP to better understand what potential inundation in the Mallee region could arise from relaxing constraints. The modelling uses steady state modelling – this is important as it shows what inundation would be achievable if the river was held at a consistent rate irrespective of time. This assists to demonstrate the maximum extents but does not provide analysis of how frequently these footprints are achieved, or how long the flows were held for.

The study found that:

- There is a significant difference in the percentage of wetland inundation between the lower catchment (downstream) and upper catchment (upstream) areas, due to attenuation of flows and geomorphology.
- The volumes required to fill lower catchment wetlands are more than what is achievable as part of constraints relaxation. Typically, their ecological needs are only met through major flooding.

A total of 133 key wetlands on the lower floodplain between Tyntynder and Lindsay Point were selected and modelled, capturing commence to flow rates, inundation extent and time to fill for each of the wetlands. The wetlands were modelled at 10,000 ML/day flow increments, which showed 107 of the 133 wetlands experience some level of inundation at 60,000 ML/day (Figure 77). Of these 107 wetlands, 72 were inundated to less than 50% of their full capacity at flows of 60,000 ML/day. This effect is mirrored for the lower flow rates, with wetlands not meeting their maximum inundation extent. By not being filled under steady state modelling, it demonstrates that these flow rates cannot effectively meet the ecological objectives and hydrological requirements of these wetlands.

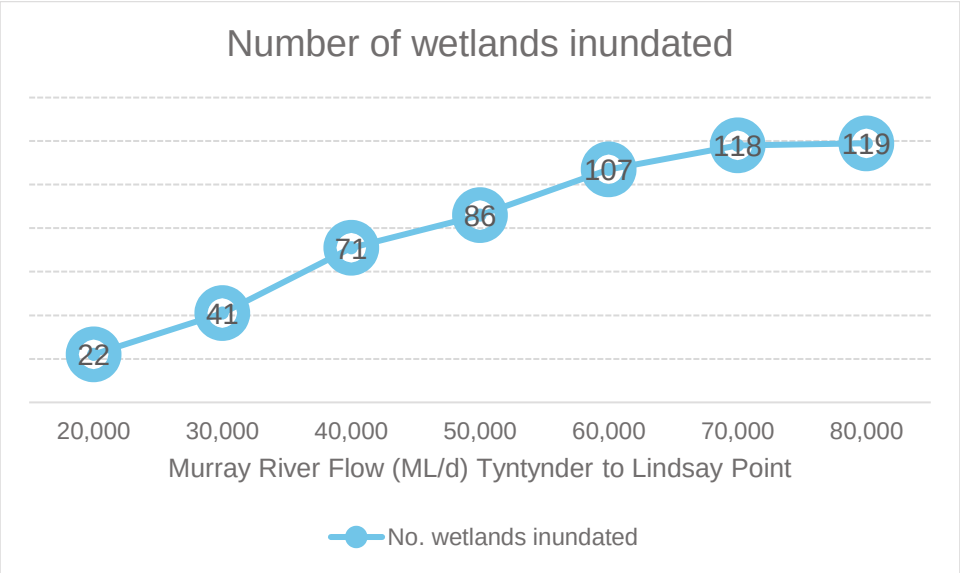


Figure 77 Number of wetlands inundated at modelled flow rates on the Murray River between Tyntynder to Lindsay Point (note that this model includes only the 133 key selected wetlands)

The model also highlighted that 14 wetlands between Tyntynder to Lindsay Point require Murray River flows more than 80,000 ML/d before inundation commenced. Additionally, the model shows 36 wetlands reach their maximum inundation volume during flows of 80,000 ML/d in the Murray River. The report describes that wetland filling time generally ranged from 20 to 40+ days depending on proximity to the river. The modelling also showed that at a 45,000 ML/d flow in the Murray River, 30,337 hectares is inundated out of the 139,062-hectare landscape on the Murray River floodplain between Nyah and the SA Border.

This shows that many of the Mallee region's wetlands only commence to fill during major flooding events as seen in late 2022.

There is a significant difference in the percentage of wetland inundation between the lower catchment (downstream) and upper catchment (upstream) areas. Most wetlands within the upper catchment's Vinifera to Burra floodplain area experience a high percentage of inundation at the various flow rates modelled in the Murray River. In contrast, less than 70% of the total wetland capacity within the lower catchment areas around Lindsay Island are inundated when river flows are at 80,000 ML/d (Figure 78).

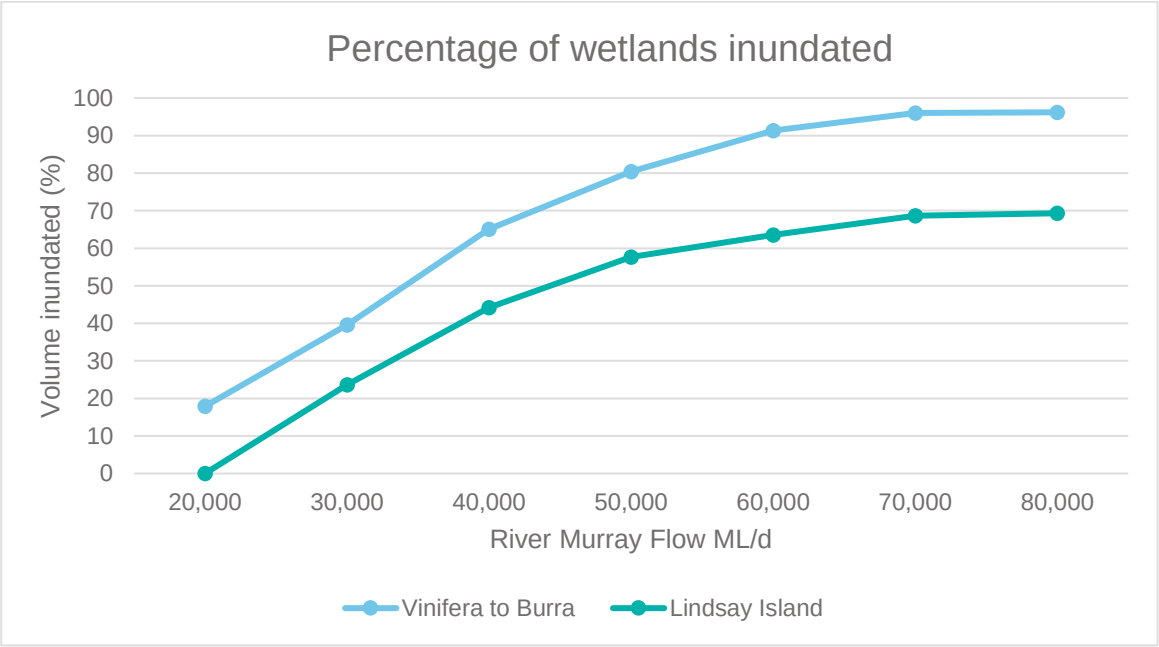


Figure 78 Percentage of wetland inundation volume at modelled Murray River flow rates at Vinifera to Burra and Lindsay Island

Model limitations include assuming inflow from tributaries such as the Murrumbidgee, Wakool and the Darling Rivers to be zero. Additionally, the model does not account for local catchment run off and infiltration as this does not significantly influence the water levels within the Mallee Catchment Management area.

A supplementary desktop ecological assessment was undertaken to understand the impact of a trial flow release from Torrumbarry Weir of 24,000 ML/day during October 2021[12]. Key findings from this report concluded the release from Torrumbarry did not have a significant ecological benefit to the floodplain along the Murray River, with modelling suggesting the water generally remained in-channel with few floodplain areas inundated away from the Murray River.

This report described how plant communities are dependent on specific depth and duration of watering and that long-term changes to water regimes can permanently alter the composition of the plant communities. The report also reiterated that some wetlands would experience some inundation at a lower flow scenario in the Murray River; however, it would be unable to reach the inundation extent required to meet hydrological targets.

These studies highlight the significant flow requirements of many wetlands within the Mallee CMA region. Despite the technical work for this feasibility study demonstrating the significance of relaxing constraints in the Goulburn to enhance flows in the Murray River, the modelling completed by the MDBA suggests relaxing constraints has minimal impact on higher flow levels (greater than 60,000 ML/d) at the South Australian border. These are the magnitude of flows that the Mallee CMA work shows are important for wetland and floodplain reconnection in the Mallee region.

While constraints cannot inundate floodplains of the lower Murray, it can provide an increase to daily average low flows which is presently not available at times of peak consumptive user demand and VMFRP can deliver the water to where it's needed.

Enabling environmental water managers to utilise their available water more effectively through relaxed constraints will likely reduce storage levels at times, creating dam airspace and reducing the chance of spills at higher levels. The modelling suggests that due to greater airspace in storages the magnitude of natural flood peaks is likely to be reduced compared to current operations. As a result, Figure 79 shows that the peak flow events modelled at the South Australian border under relaxed constraints would be reduced compared to current operating conditions (the blue line).

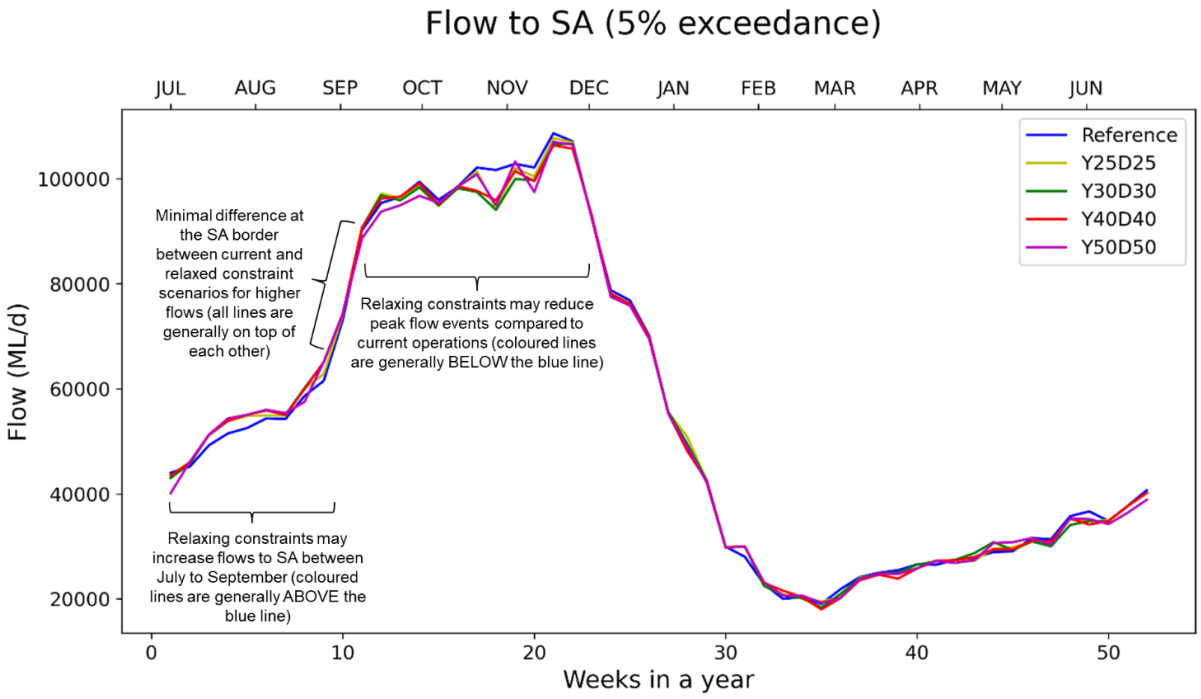


Figure 79: 'High flow' regime of flows at the South Australian Border at various constraints levels (from MDBA 2022)

[12] Nexus Ecology (2023) High Flow Assessment Tyntynder to Lindsay Point – Report prepared for the Mallee Catchment Management Authority

In comparison to the high flows, modelling suggests that relaxing constraints will generally result in greater daily average low flows (between 9,000 ML/d and 15,000 ML/d) at the South Australian border between August and December (Figure 80). Relaxing constraints will enable environmental managers to provide greater enhanced flows at these lower or mid-levels.

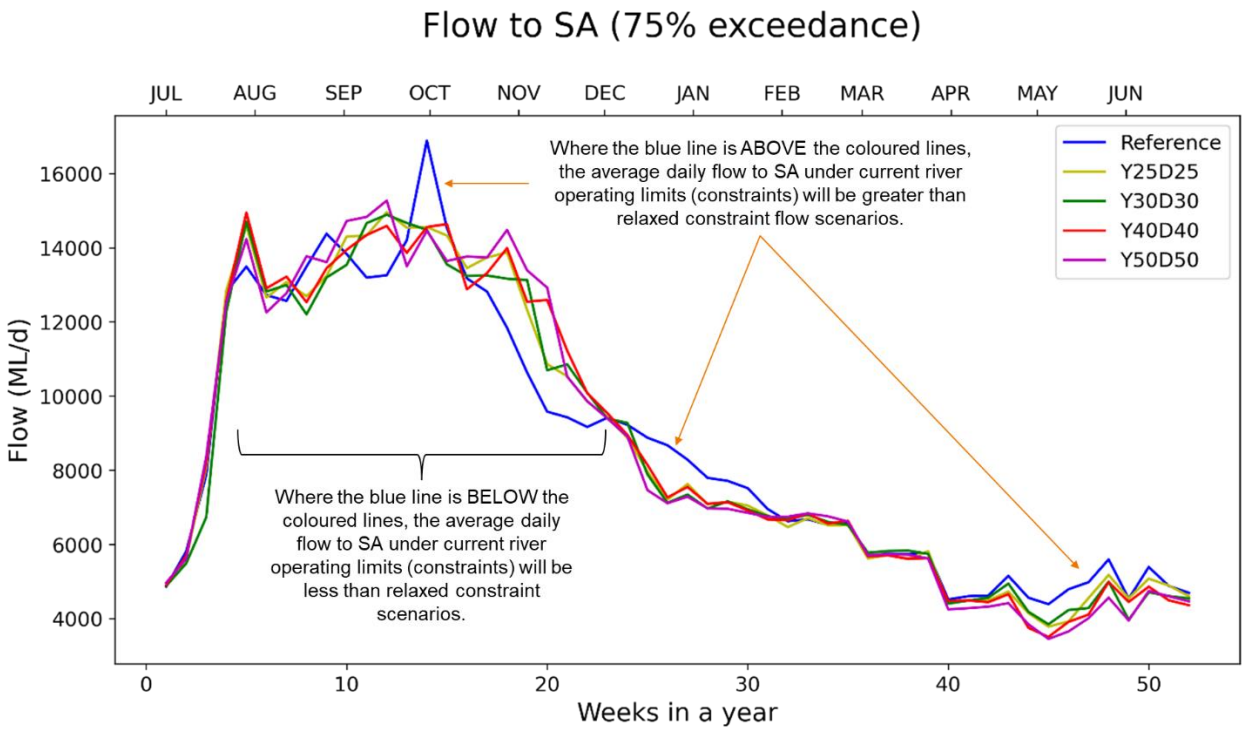


Figure 80: 'Low flow' regime of flows at the South Australian Border at various constraints levels (from MDBC 2022)

The reduction at the higher flow levels reflects the geographical nature of the mid-Murray section and the Edward-Wakool section where water needs to travel through the flat and wide landscapes once water goes beyond in-channel pathways. Therefore, the peak of events is largely diminished by the time they reach Wakool Junction. It also shows difficulties in influencing the peak of events solely by releasing environmental water from upper storages.

"We have been telling people for so long that the 80,000 ML/d at the South Australian border is not physically possible, so while it has still been in the picture for so long it makes you question the process."

Consultative Committee Member

Although environmental water managers and river operators are already successfully combining unregulated flows with storage releases to achieve environmental outcomes, the targeting of the much higher flows of a river's environmental flow requirements will require further tools and consideration. Forecasting tools are not yet sophisticated enough to allow river operators to coincide tributary flows with main channel flows and storage releases to create very large flow events such as 80,000 ML/d. There are considerable travel times from storage water release that need to be considered. The further downstream from a regulating structure such as a dam or weir, the more difficult the flows are to coincide. The higher the flows that are targeted the greater the risk and the required risk buffers and mitigations. The EEWD project is looking at the required tools, processes and systems to be able to slowly increase targeted flows through an adaptive management approach if the CMP is implemented.

The modelling shows that the Victorian Constraints Measures Program alone does not deliver the required hydrological flows to reach the ecological targets of the Mallee floodplain; however, a combination of both constraints relaxation and the Victorian Murray Floodplain Restoration Project would offer more opportunities to achieve ecological targets at a landscape scale. For example, increased flows delivered via constraints

relaxation would raise river heights and make it possible to pump water for the environment into areas of the floodplain that would otherwise not be reached.

Delivering water for the environment efficiently, when and where it is needed most, will achieve improved ecosystem health and lead to more resilient floodplain systems. This is critically important to retaining the ecological character of Mallee floodplain ecosystems to survive longer periods of drought and improve long-term resilience.

Despite the modelling indicating that the constraint flow scenarios are not able to achieve a greater frequency of the very high flow events and meet the hydrological flows to achieve ecological targets of the Mallee floodplain, the flows able to be achieved under relaxed constraints are anticipated to provide increased environmental benefits downstream of the Wakool junction compared to current operations.

5.5.2 Constraints relaxation and climate change

MDBA conducted modelling to simulate two scenarios: the current constraints scenario and the most significant constraint relaxation scenario (Y40D40) for the Murray River system, taking into account conditions from post-1975 and projected conditions for the year 2070 with medium or high levels of climate change.

Figure 81 and Figure 82 (over) illustrate the variations in peak flows between the current constraint and Y40D40 scenarios at Doctor's Point and downstream of Yarrawonga. This comparison is made for historical, post-1975, and year 2070 conditions, considering both medium and high climate change scenarios.

Notably, this figure demonstrates that, in contrast to the 'do nothing' scenario, the difference in peak flows after constraint relaxation remains relatively consistent across the various simulated climate conditions. However, the 2070 high climate change scenario exhibits greater deviation from the other cases, particularly when compared to what was observed for the Goulburn River.

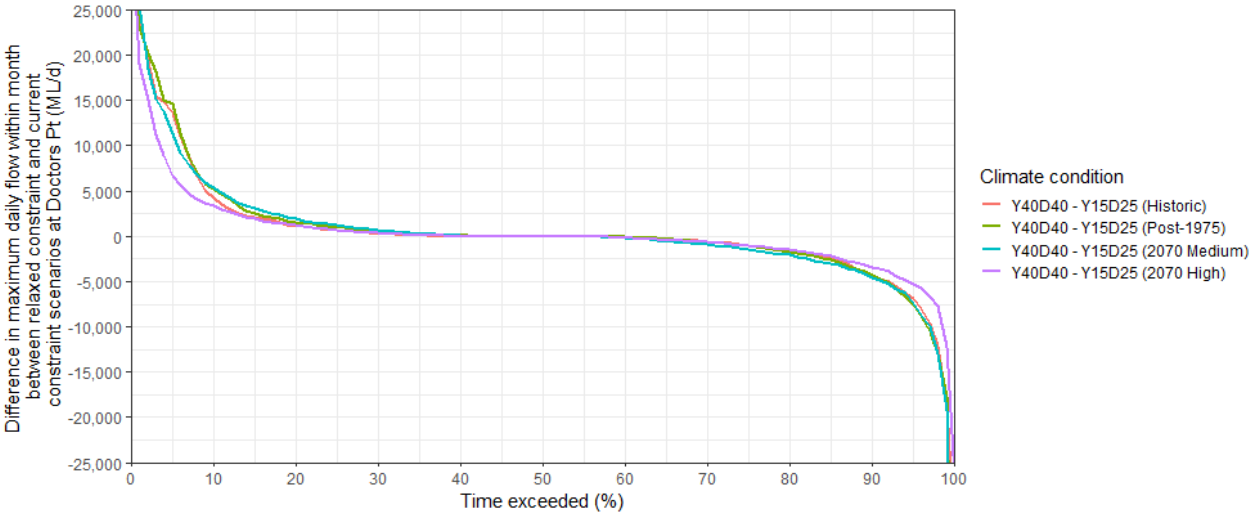


Figure 81: Modelled difference in the peak daily flows at Doctors Point when current constraints (Y15D25) are relaxed to 40,000 ML/d at both Yarrawonga and Doctors Point (Y40D40) under historic conditions and three representations of potential future climate conditions

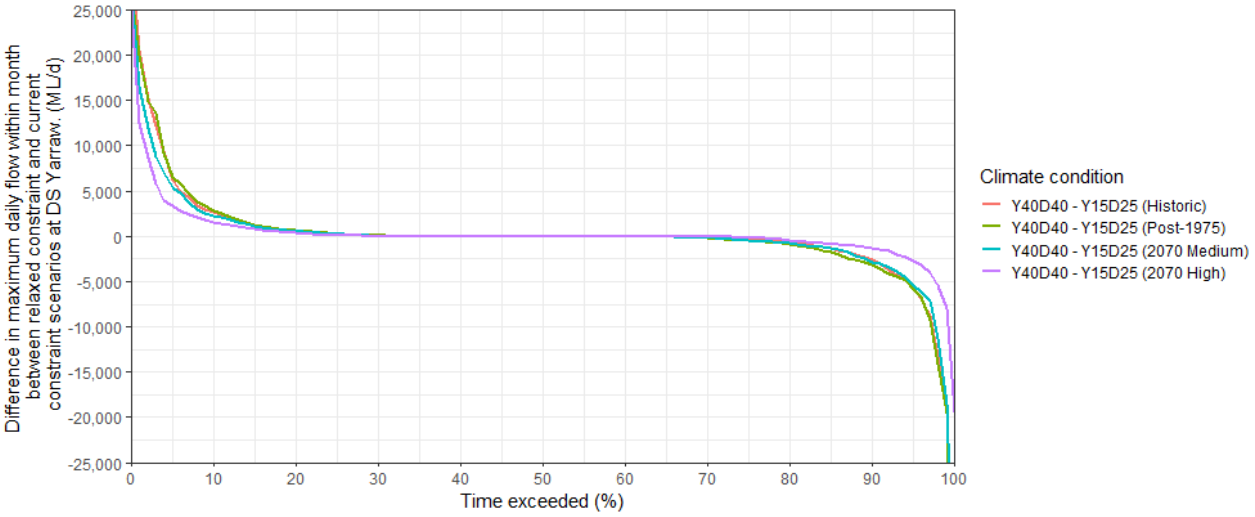


Figure 82: Modelled difference in the peak daily flows Downstream of Yarrawonga when current constraints (Y15D25) are relaxed to 40,000 ML/d at both Yarrawonga and Doctors Point (Y40D40) under historic conditions and three representations of potential future climate conditions

As constraints in the study areas of the Murray River are relaxed, the use of environmental water becomes more efficient because it allows the environment to target higher flow events. Consequently, both the environmental water balance and allocation decrease due to the greater utilisation of the environmental portfolio.

In future climatic conditions, the reduced water availability in the system leads to significant reductions in both allocation and balance under both the current constraint and constraint relaxed (Y40D40) scenarios. In the 2070 medium climate, the environmental account balance is more heavily utilised to meet the increased environmental demand. Under the current constraint regime, there is a greater amount of unused account balance available compared to the relaxed constraint scenario. As a result, the increased utilisation in the 2070 medium climatic condition is more pronounced under the current constraint. In the 2070 high climate scenario, the environmental water balance and allocation see substantial reductions, and the environmental water use ultimately experiences a very high utilisation of the available balance.

This suggests that environmental water holders can efficiently use the relaxed constraints to maintain ecological outcomes in the face of medium future climate conditions. However, their effectiveness is significantly hampered in much drier future climate conditions. The primary reason for this limitation is the substantial decrease in piggybacking opportunities and the limited water availability, stemming from reduced allocations across all water holders. In such conditions, initiating environmental events from scratch, without the assistance of unregulated events to supplement environmental demand, becomes particularly challenging.

The key findings from the modelling for relaxed constraints and potential future climate conditions in the Murray River are:

- **Reductions in Flow**: Significant reductions in flows are anticipated across the entire flow regime as future climates become drier.
- **Seasonal Impact:** Flows during the winter-spring seasons are more profoundly affected, whereas flows during typical irrigation seasons remain relatively stable.
- **Environmental Water Utilisation:** The utilisation of available environmental water holdings increases if constraints are relaxed under post-1975 and year 2070 medium climate change conditions. However, constraint relaxation has little impact on the average annual volumes of modelled environmental water use under the year 2070 high climate change conditions.
- **Peak Flow Variations:** The difference in peak flows after constraint relaxation remains relatively consistent across the simulated climate conditions. However, for the Murray River, the 2070 high climate change scenario shows more significant divergence from the other instances compared to what was observed for the Goulburn River.

- **Impact on Flow Thresholds:** When considering the number of winter/spring days per year above various flow thresholds, a noticeable difference between the current and relaxed constraint scenarios is evident. The total number of days above these flow thresholds decreases as the climate condition becomes drier.
- **Duration of Flows:** As the climate becomes drier, the duration of flows at or near relaxed constraints is expected to decrease, with longer intervals between flows of this magnitude.
- **Improved Flow Regimes:** In the mid- and lower Murray regions, there are improved flow regimes with the relaxed constraint scenarios. These improved flow patterns are more evenly distributed across different future climate scenarios, indicating the potential benefits of relaxing constraints and the importance of coordinated water delivery, especially under dry climatic conditions.

If future stages are to proceed of the Victorian CMP, these observations should be tested further by using the MDBA model to simulate other constraint relaxation scenarios (e.g., Y25D25, Y30D30, Y35D35) under potential future climate conditions. However, it is also noted that operation rules and business decision processes are more likely to be adaptive to emerging drier climatic conditions in the future.

5.6 Potential vegetation benefits and impacts

5.6.1 Potential extent of vegetation inundated

The hydraulic modelling provides an indication of the extent of vegetation that has the potential to be inundated at the relaxed constraint conditions. Along the study areas of the Murray River, a large portion of area potentially inundated on private property is mapped as native vegetation (Ecological Vegetation Class) (Figure 83). This is characteristic of the low-lying floodplain.

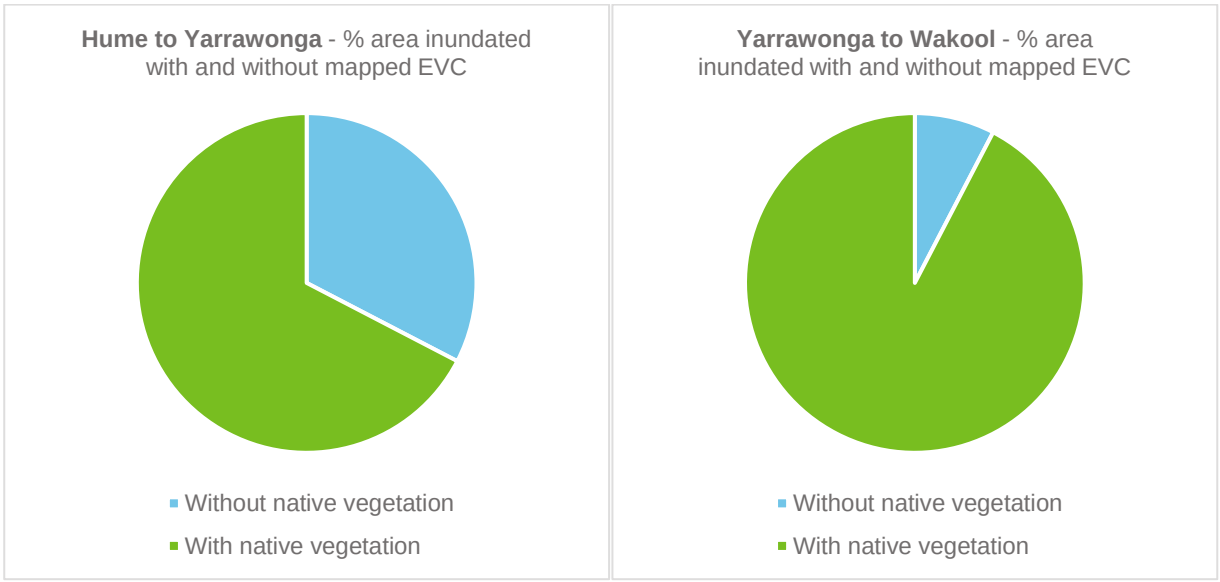
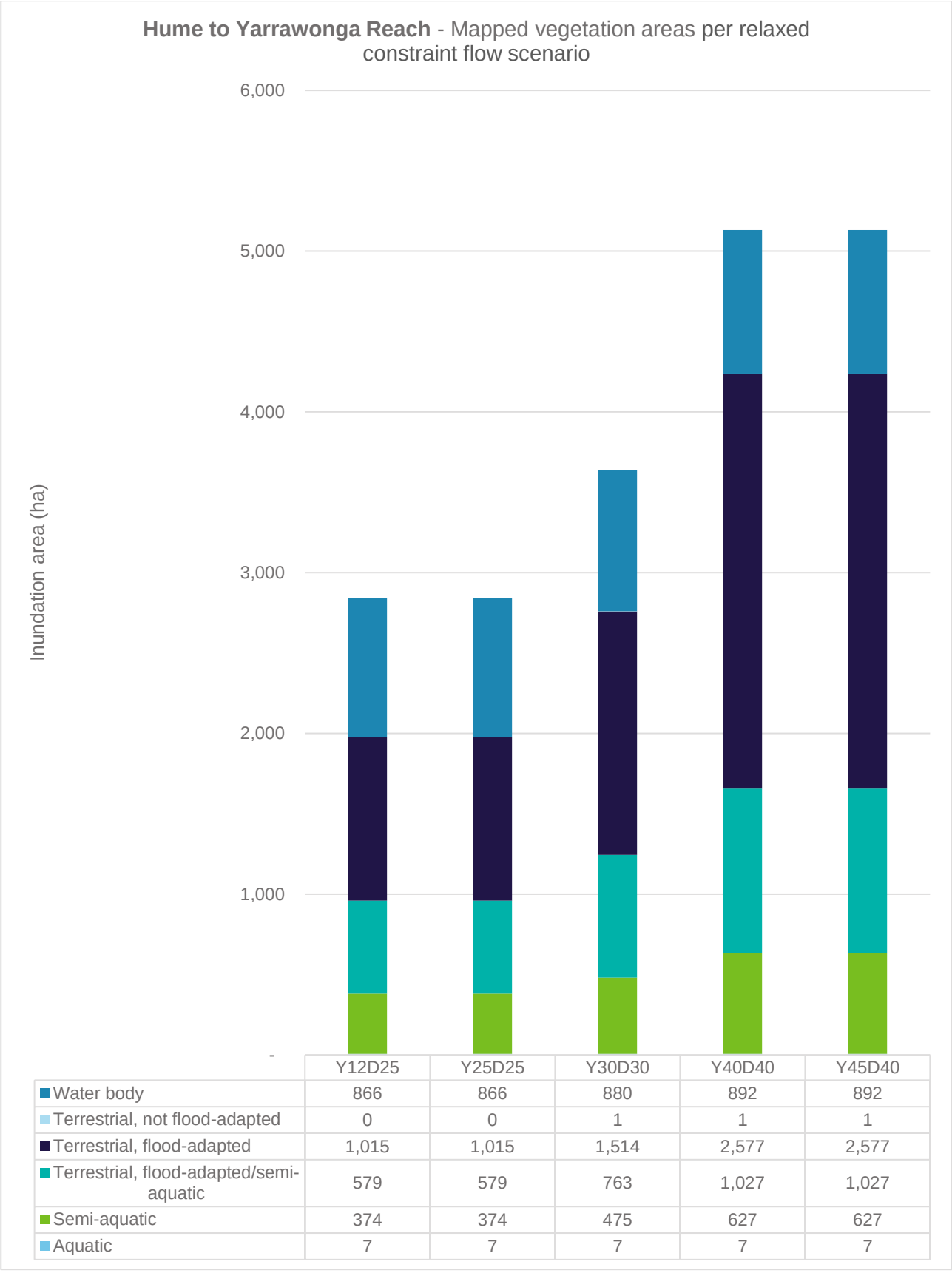


Figure 83: Distribution of native vegetation in the potentially inundated areas at the highest constraint relaxation scenario on the Murray River (40,000 ML/d in the Hume to Yarrawonga reach and 45,000 ML/d in the Yarrawonga to Wakool reach)

Vegetation watered within the Victorian Hume to Yarrawonga reach is largely flood-adapted terrestrial which is mainly characterised by River Red Gums and Blackbox Woodlands (Figure 83).

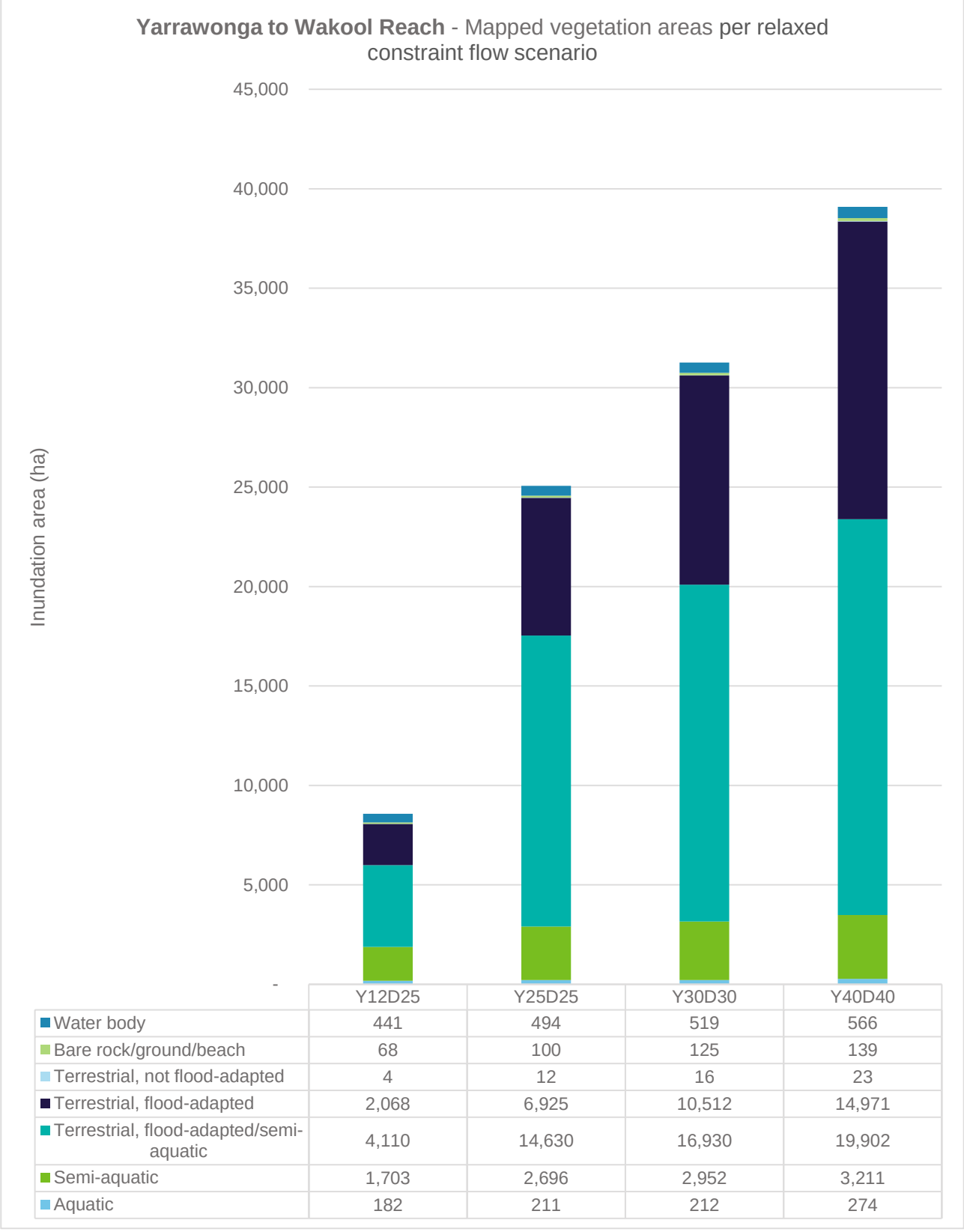


	Y12D25	Y25D25	Y30D30	Y40D40	Y45D40
Water body	866	866	880	892	892
Terrestrial, not flood-adapted	0	0	1	1	1
Terrestrial, flood-adapted	1,015	1,015	1,514	2,577	2,577
Terrestrial, flood-adapted/semi-aquatic	579	579	763	1,027	1,027
Semi-aquatic	374	374	475	627	627
Aquatic	7	7	7	7	7

Figure 84: Mapped vegetation areas (ha) for each flow scenario along the Victorian Hume to Yarrawonga reach

In the Yarrawonga to Wakool reach (Figure 85) the dominant vegetation type is terrestrial, flood adapted/semi-aquatic which reflects the larger area of wetlands in this reach such as Gunbower and Barmah. The area is mainly characterised by River Reg Gums and Blackbox Woodlands.

In this reach, nearly four times the area of aquatic, semi aquatic and terrestrial flood adapted vegetation can be inundated with environmental water as a result of relaxed constraints, with inundation extending from approximately 8,000 Ha to over 30,000 Ha with constraints relaxed to 40,000 ML/d.

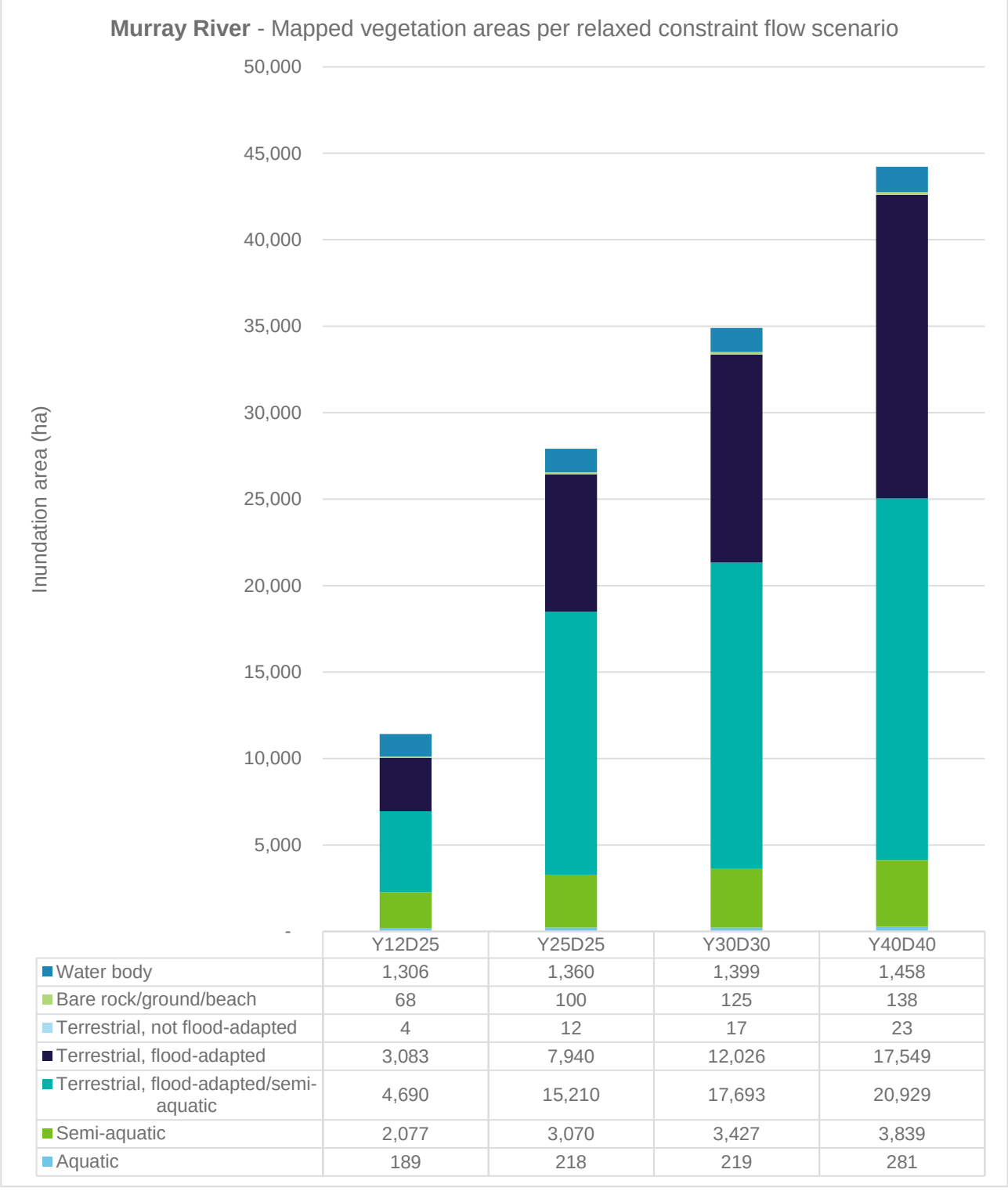


	Y12D25	Y25D25	Y30D30	Y40D40
Water body	441	494	519	566
Bare rock/ground/beach	68	100	125	139
Terrestrial, not flood-adapted	4	12	16	23
Terrestrial, flood-adapted	2,068	6,925	10,512	14,971
Terrestrial, flood-adapted/semi-aquatic	4,110	14,630	16,930	19,902
Semi-aquatic	1,703	2,696	2,952	3,211
Aquatic	182	211	212	274

Figure 85: Mapped vegetation areas (ha) for each flow scenario along the Victorian Yarrawonga to Wakool reach

Along the Murray River study reaches, a large portion of area potentially inundated on private property is mapped as native vegetation (Ecological Vegetation Class) (Figure 84). This is characteristic of the low-lying floodplain.

Relaxing constraints to the highest scenario has the potential to enable almost 4.5 times the area of vegetation to be watered compared to current constraints. A significant portion of private land potentially inundated occurs over areas with mapped EVC that may hold environmental value.



	Y12D25	Y25D25	Y30D30	Y40D40
Water body	1,306	1,360	1,399	1,458
Bare rock/ground/beach	68	100	125	138
Terrestrial, not flood-adapted	4	12	17	23
Terrestrial, flood-adapted	3,083	7,940	12,026	17,549
Terrestrial, flood-adapted/semi-aquatic	4,690	15,210	17,693	20,929
Semi-aquatic	2,077	3,070	3,427	3,839
Aquatic	189	218	219	281

Figure 86: Mapped vegetation areas (ha) for each flow scenario along the Victorian study area of the Murray River

5.6.3 Vegetation condition response

As with the Goulburn River, the ecological response of vegetation to relaxed constraints in the Murray River is heavily dependent upon not only the extent of inundation which drives which part of the floodplain are watered, but also the inundation frequency and duration. The modelled flow, frequency, timing and duration under the different constraint scenarios are driving the ecological response models.

The duration of inundation is a key driver influencing the ecological response. The flows targeted under the environmental flow recommendations and achieved within the modelling are not of a duration for optimal positive vegetation response. Only inundation events of 30 days or more will improve the condition (state) of Blackbox woodland and River Redgum forests and woodland. However, inundation of any duration, within the drying spell time, will prevent a decline in condition of these forests and woodlands to the next state.

As seen with the relaxation of constraints in the Goulburn River, the duration of inundation under the modelled Murray River constraints scenario is not sufficient to enhance the condition.

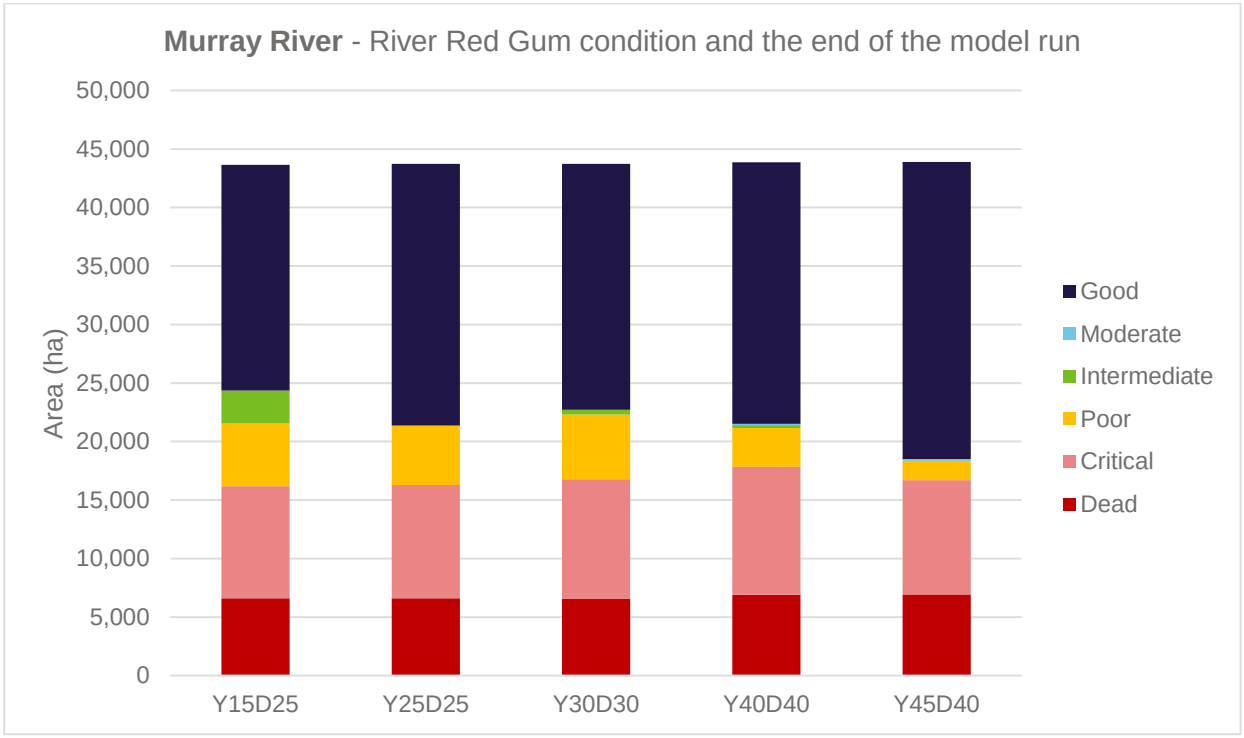


Figure 87: End state condition of the modelling for River Red Gum Communities (ha) on the Murray River under modelled relaxed constraint scenarios (for the Victorian Murray study areas)

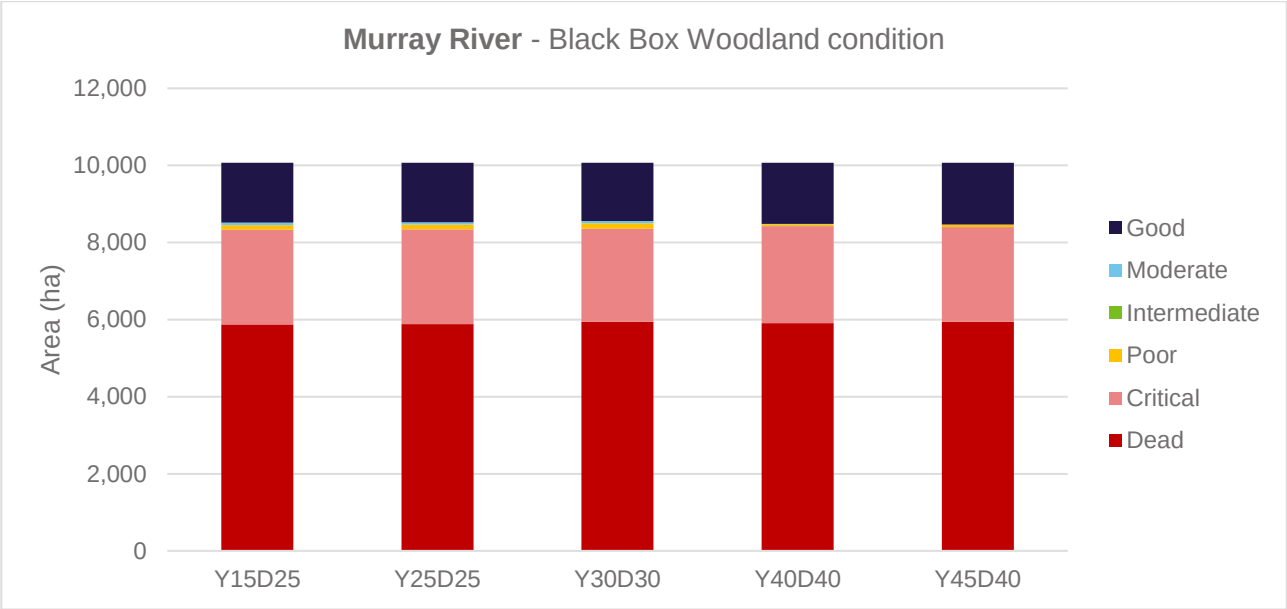


Figure 88: Modelled area and condition of Black Box Woodland (BBW) along the Victorian Murray River study areas under each modelled flow scenario

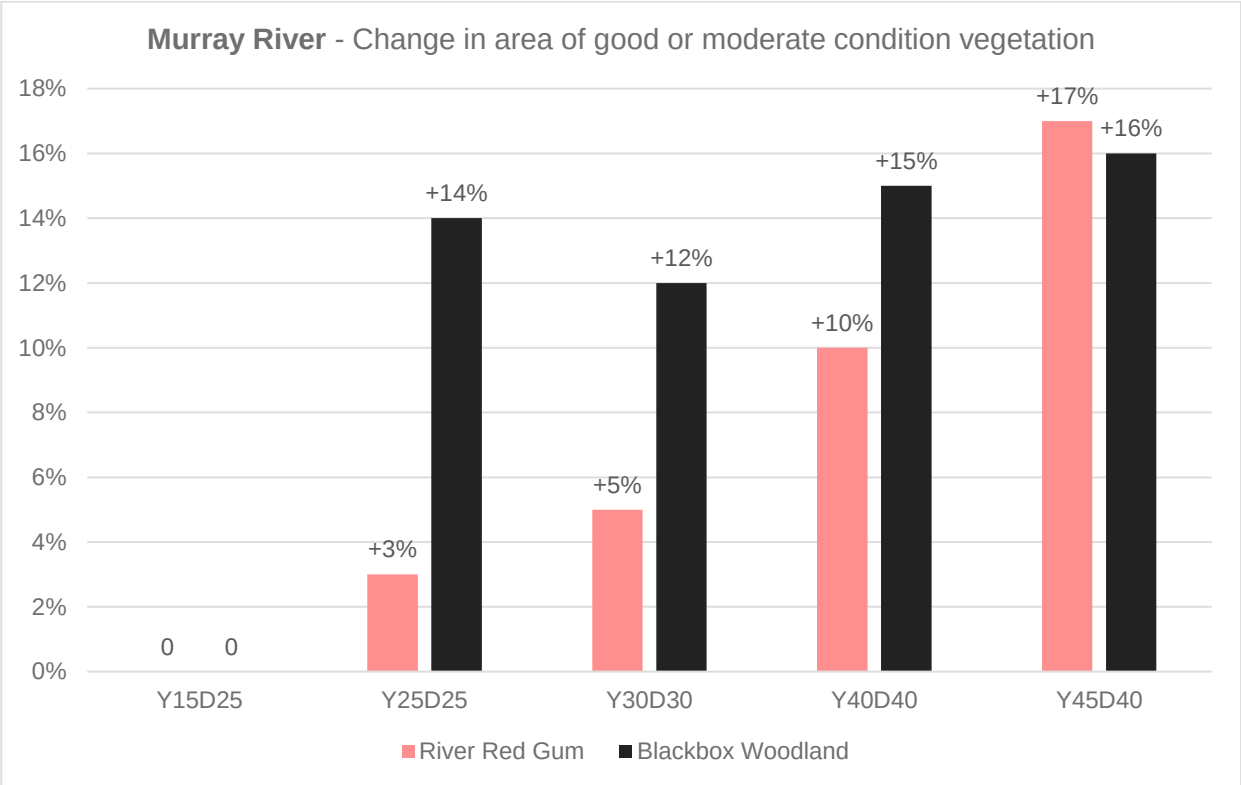


Figure 89: Vegetation condition change of Black Box Woodland (BBW) and River Red Gum (RRG) along the Victorian Murray River study areas under each modelled flow scenario

The most significant improvements in River Red Gum occur with the highest relaxed constraint scenarios.

While there are some risks for vegetation at higher elevations on the floodplain, the relaxation of constraints would provide a real and significant benefit to floodplain water dependent vegetation communities.

Figure 90 overlays the potential area of EVC inundated (on both public and private land), and the vegetation quality results presented for the Hume to Yarrawonga and Yarrawonga to Wakool river reaches. This holistic view of the Murray River brings together the hydrology (as indicated by vegetation quality) and hydraulics (as indicated by the potential area inundated). The analysis completed to inform the feasibility study shows:

- The Y25D25 scenario generates more substantial vegetation quality improvements for Blackbox Woodland (14 per cent) compared to River red gums (3 per cent).This shows that there is potential for vegetation quality benefits by relaxing the Yarrawonga to Wakool constraint from 15,000 ML/d (current) to 25,000 ML/d for the same constraint in the Hume to Yarrawonga river reach, i.e. holding the constraint at 25,000 ML/d (current).
- Further relaxation to Y30D30 still shows an improvement in vegetation quality for Black box woodland (12 per cent) on the base case, but slightly less than the previous scenario. Vegetation quality for River Red gums further increases to 5 per cent.
- The most substantial vegetation quality improvement is shown by the Y45D40 scenario, with 16 per cent for Blackbox Woodland and 17 per cent for River red gum above the base case.
- Community feedback on the potentially unacceptable extent of impacts to private property associated with relaxation of constraints in the Hume to Yarrawonga reach to 40,000 ML/d must be considered.
- The vegetation quality outcomes suggest that relaxing as much as possible in both river reaches will maximise outcomes. Additional scenarios should be considered to assess the impacts and benefits for scenarios which may closer align to community expectations. These scenarios could be Y45D35, Y45D30, i.e. relaxing constraints in the Hume to Yarrawonga reach to 35,000 ML/d or 30,000 ML/d paired with the highest relaxation in the Yarrawonga to Wakool reach.

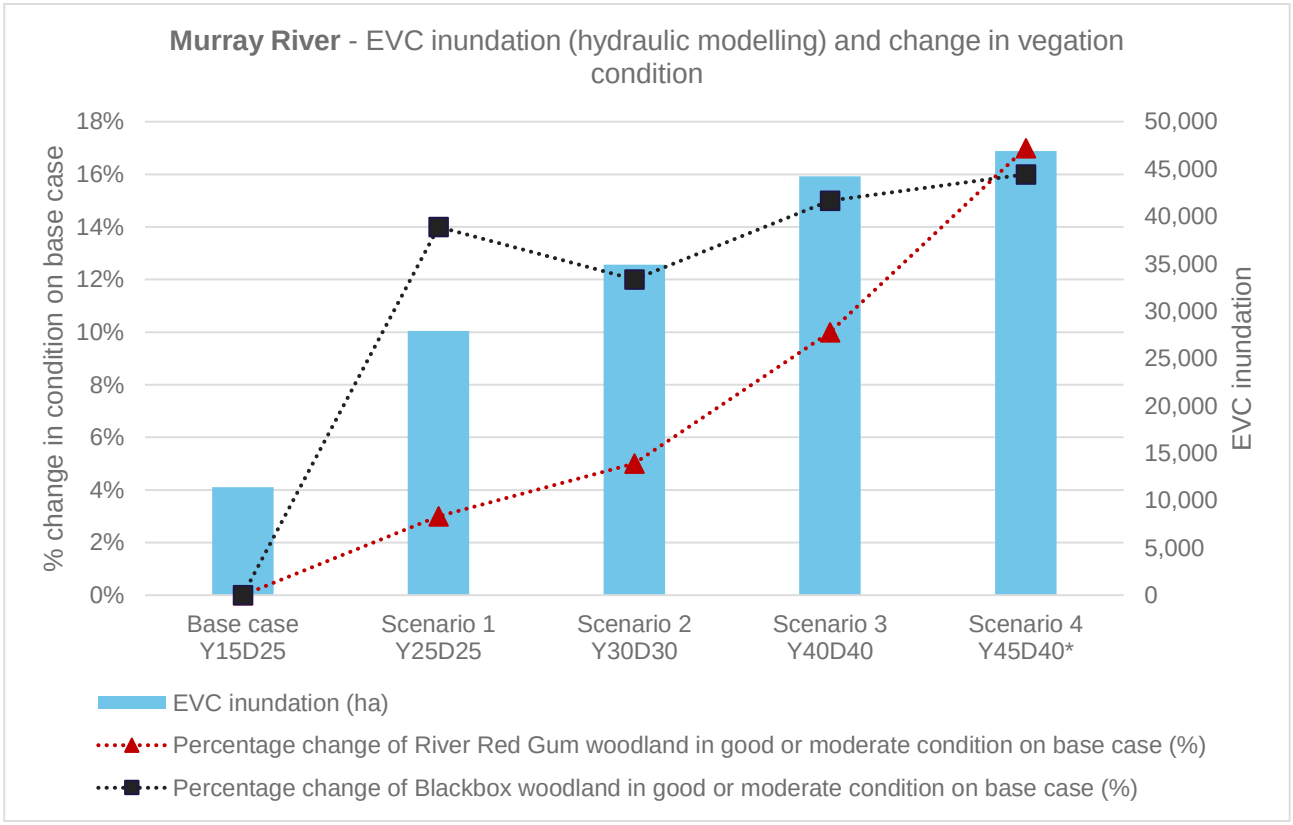


Figure 90: Ecological Vegetation Class (EVC) inundation and % change on current constraint base case for River Redgum (RRG) and Blackbox Woodland (BBW) for each flow scenario along the Victorian Murray River study areas

Overall, the relaxation of constraints offers a net improvement in the overall condition of floodplain vegetation. As the magnitude of constraint relaxation increases, so does the proportion of vegetation that becomes inundated with environmental water. The advantages of higher relaxation scenarios lie in their ability to maintain watered vegetation in a resilient state. However, there is a trade-off to consider – in the outer areas, further from the river channel, environmental water would only reach them during unregulated floods resulting from spills.

Despite some risks posed to vegetation at higher elevations on the floodplain, it's important to underscore that the relaxation of constraints carries tangible benefits for floodplain vegetation communities that rely on water. These benefits contribute to the overall health and vitality of these ecosystems.

5.7 Instream production and macroinvertebrates

Enhancements in the populations of aquatic insects and overall productivity are foreseen as constraints are relaxed. These improvements stem from the periodic and in-season delivery of food sources (carbon) from the floodplain.

Unlike for the Goulburn River, stochastic modelling was not explicitly undertaken for the study areas of the Murray River. As outlined in Section 4.7, the Goulburn modelling identified positive changes in the populations of macroinvertebrates as constraints were relaxed to enable higher flows to connect the river and the floodplain. Comparable positive outcomes could be inferred for stretches of the Murray River. Importantly, no major risks to instream production were identified.

These benefits to macroinvertebrates and overall productivity are expected to translate into better food availability for larger animals in the river system, such as fish and platypus.

5.8 River and floodplain dependent fish

Modelling was undertaken to investigate potential fish benefits and impacts of relaxing constraints in the Murray River.

Figure 91 shows the modelled Golden Perch outcomes for each constraint scenario modelled along reaches of the Murray River.

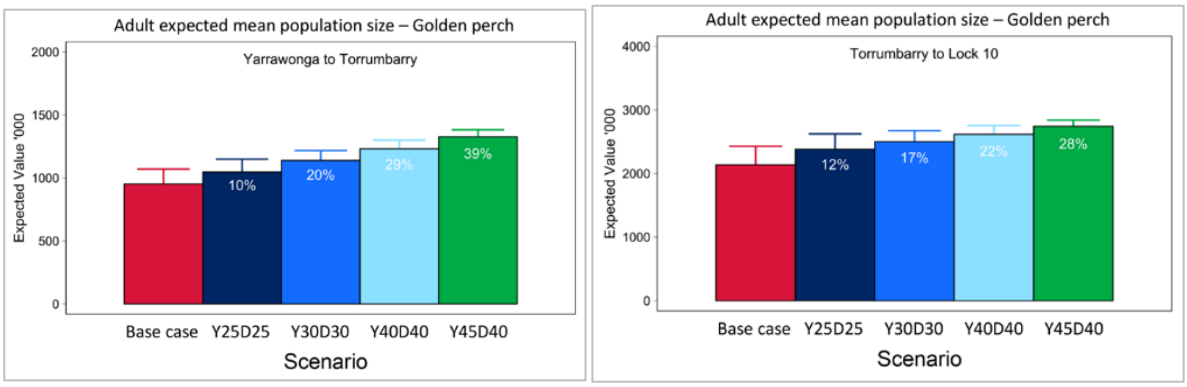


Figure 91: Modelled Golden Perch outcomes for population size for the Murray River under each modelled flow scenario (Todd et al. 2022)

- This modelling suggests:
- up to 39% increase in Golden Perch abundance in both Hume to Yarrawonga and Yarrawonga to Torrumbarry reaches
- up to 28% increase in Golden Perch abundance in the Torrumbarry to Loch 10 reach
- Murray Cod showed no improvement in the Murray River at higher constraint flows.

The modelling for the Murray study area focused on the fish response to changes in flow. As Murray Cod is an equilibrium species who breed at the same time each year, they have a more limited response to flow changes such as floodplain inundation events. An improvement for Murray Cod would be likely if modelling was undertaken for the Murray using a broader interaction response model as used for the Goulburn River.

5.8.2 Waterbirds

The assessment of waterbirds showed that relaxing constraints would benefit certain bird species but might lead to declines in others. It also revealed that while waterbird numbers would significantly improve during dry years, there wouldn't be an overall increase in their total numbers.

One crucial finding from the modelling is that the minimum population size of waterbirds would increase, and this has several important implications. Firstly, when opportunities for breeding arise, there would be better responses from these populations. Secondly, the modelling of egret populations indicated high mortality rates, suggesting they could be sensitive to changes in the frequency of breeding events. Improvements in foraging habitats on floodplains might lower mortality rates and act as a buffer against declines in breeding, especially in the southern basin.

It's important to note that the changes in risks related to waterbird breeding and abundance are challenging to attribute to a specific location due to the migratory patterns of many bird species. However, by offering more waterbird species larger areas to live in, there's a better chance of these species growing in numbers, and this reduces the risk of their populations declining irreversibly. This is supported by the modelling results, which indicate that the most significant impact of relaxing constraints is the reduced likelihood of negative outcomes for birds.

The relaxation of constraints will enhance waterbird numbers, particularly during dry years, reducing the chances and extent of declines in these periods. According to the modelling:

- In the Gunbower-Koondrook-Perricoota area, there could be up to a 48% increase in waterbird numbers, and up to a 34% increase during drier years (when waterbird numbers are at the 25th percentile).
- In the Barmah Millewa Forest, relaxing constraints could result in an 80% increase in waterbird density (based on the 25th percentile waterbird density) and an increased likelihood of colonial waterbird breeding, with potential improvements of up to 17% (in the 25th percentile probability) during dry conditions.

Figure 92 Male Australasian Darter on nest with chicks, Little Gunbower Complex (photo courtesy of D Cook)

5.9 The watering of areas of cultural and environmental significance

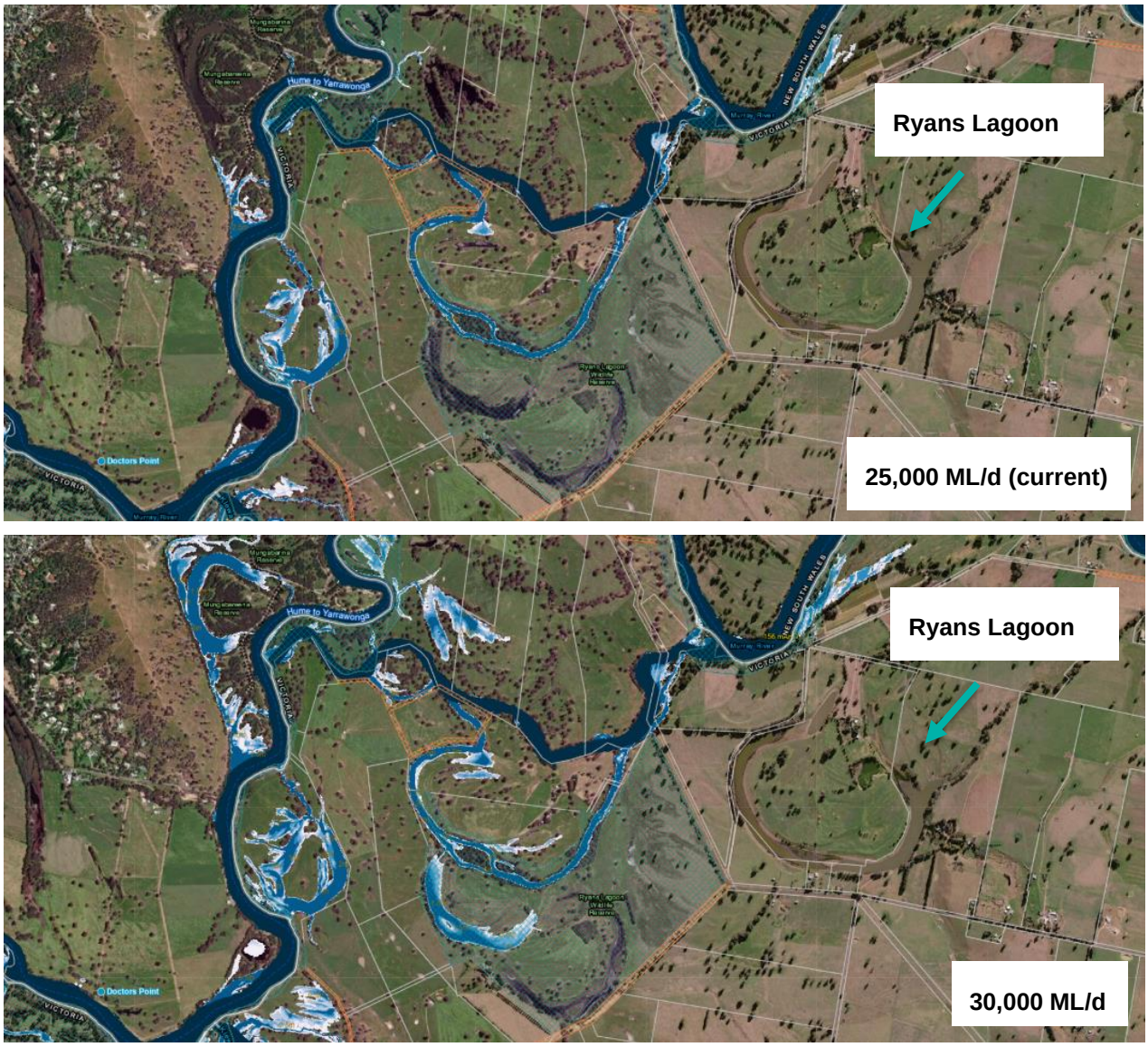
Increased floodplain connection to the main Murray River channel occurs as constraints are further relaxed and flow rates increase. How the relaxation of constraints can improve connectivity in areas of environmental and cultural significance along the study area have been further investigated and represented below.

5.9.1 Ryans Lagoon Nature Conservation Reserve

The Ryans Lagoon wetland complex is a network of wetlands positioned downstream of the Lake Hume water storage and upstream of the Kiewa River confluence with the Murray River.

This area is highly valued and nationally recognised by the North East CMA as an important wetland system. This wetland complex provides a habitat for several bird, fish, and plant species that are protected under the Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 and/or the Victorian Flora and Fauna Guarantee Act 1988. The wetlands are also culturally significant to the Duduroa Dhargal Traditional Owner Group.

Flows into the complex are mainly influenced by regulated releases from Lake Hume, which travel via Ryans Creek, an anabranch of the Murray River. As flow rates increase above the current constraint of 25,000 ML/d at Doctors Point, more sections of Ryans Lagoon Nature Conservation Reserve are connected to the river (Figure 93).



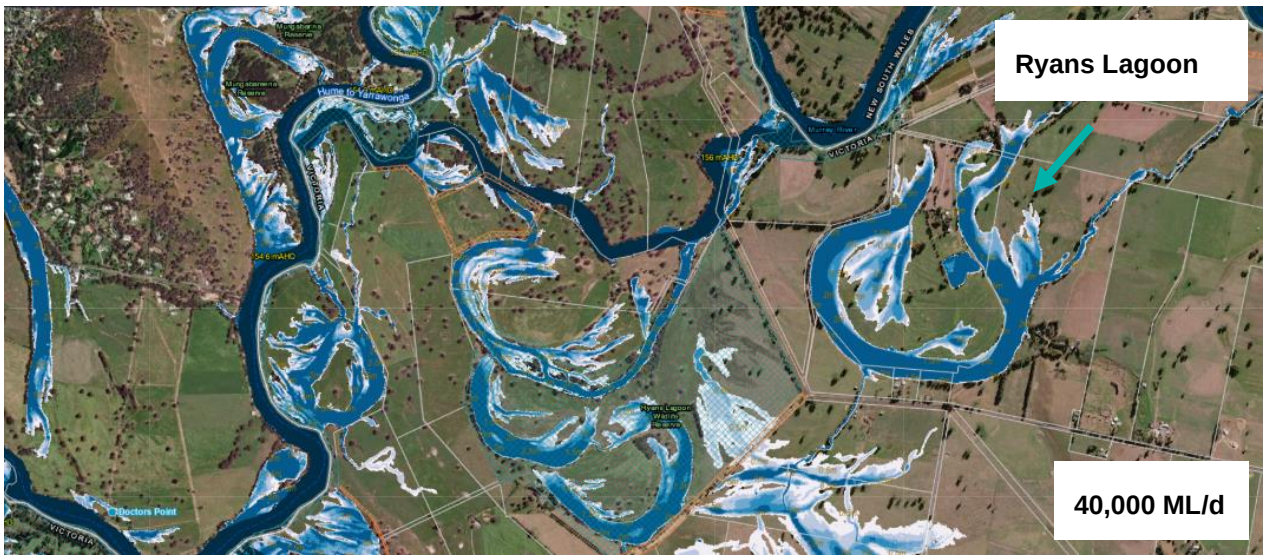


Figure 93: The modelled extent of inundation at Ryans Lagoon Nature Conservation Reserve, Hume to Yarrawonga reach on the Murray River at the increasing flow scenarios (measured at Doctors Point)

5.9.2 Guttrum State Forest

Guttrum and Benwell Forests make up almost 2,000 hectares of the northern Victorian Mid-Murray Floodplain. They support a range of rare and threatened flora and fauna species and huge old river red gums. For thousands of years Traditional Owners have called the area home and is known for its significant cultural heritage sites that are some of the oldest in the world. Guttrum and Benwell Forests are two of the few remaining river red gum floodplain systems in Victoria and have significant ecological importance in the Murray Darling Basin. They are prime examples of remnant floodplain, and the remaining habitats have high conservation value, providing refuges and hotspots for biodiversity.

Figure 94 shows the increase in potential inundation extent and depth as flow levels in the Murray are increased from the relaxation of constraints.

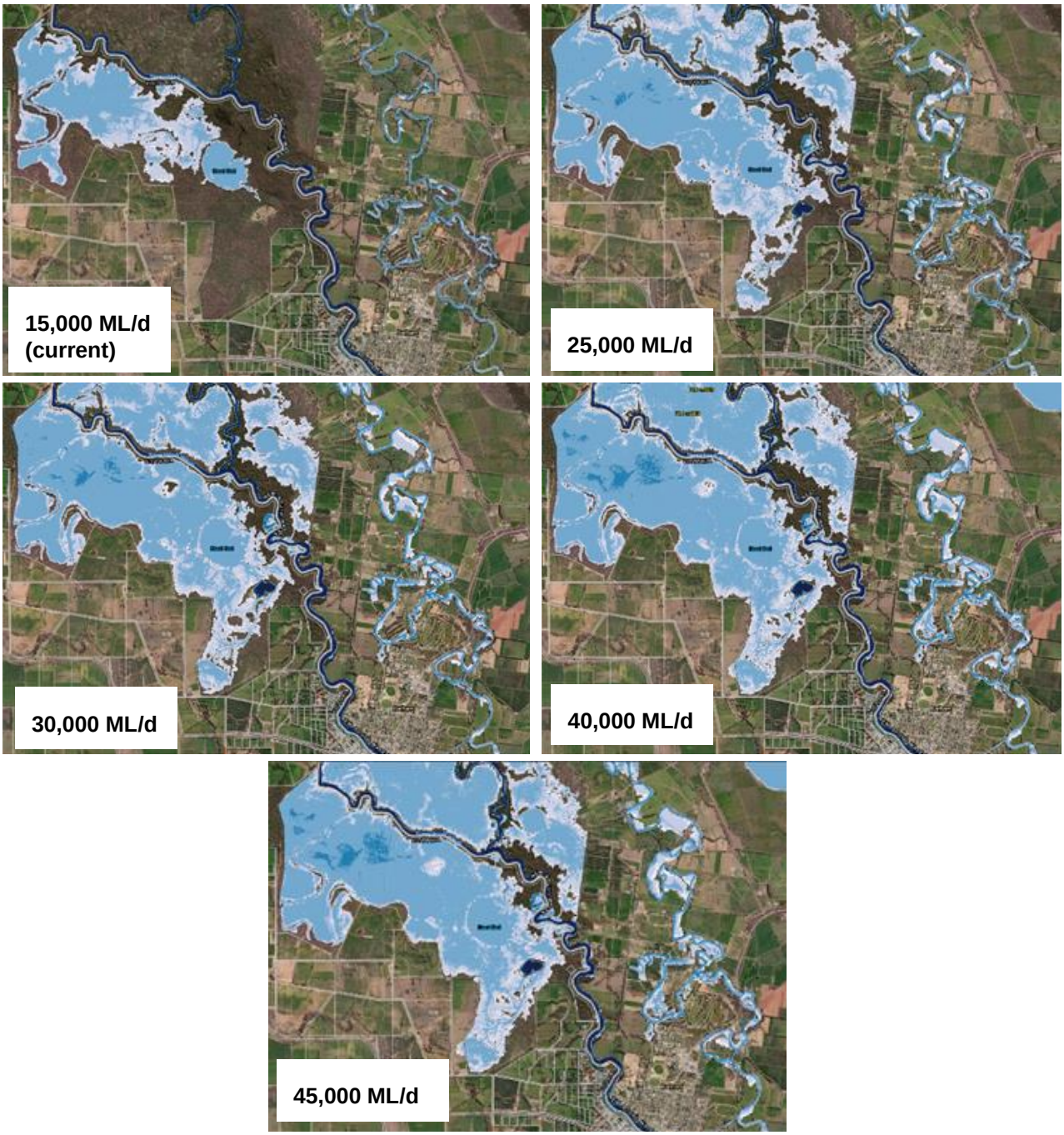


Figure 94: The modelled extent of inundation at Guttrum State Forest, Yarrawonga to Wakool reach on the Murray River at the increasing flow scenarios

5.9.3 Barmah National Park

The Barmah Forest is located within Yorta Yorta's traditional boundaries. The Barmah-Millewa Forest covers 66,000 ha and spans the New South Wales – Victoria border between Tocumwal, Deniliquin, and Echuca. The Barmah-Millewa Forest is listed under the Convention on Wetlands of International Importance (the Ramsar Convention) as well as the Directory of Important Wetlands in Australia, and it is one of six Living Murray icon sites. The forest's Victorian components are the Barmah National Park and part of the River Murray Reserve, covering 29,305 ha of forest and wetlands that support a vast range of significant plant and animal species and culturally significant sites to the Yorta Yorta.

Hydraulic modelling shows how the extent of potential inundation of the Barmah floodplain increases as Murray River flows increase through relaxed constraints (Figure 95).

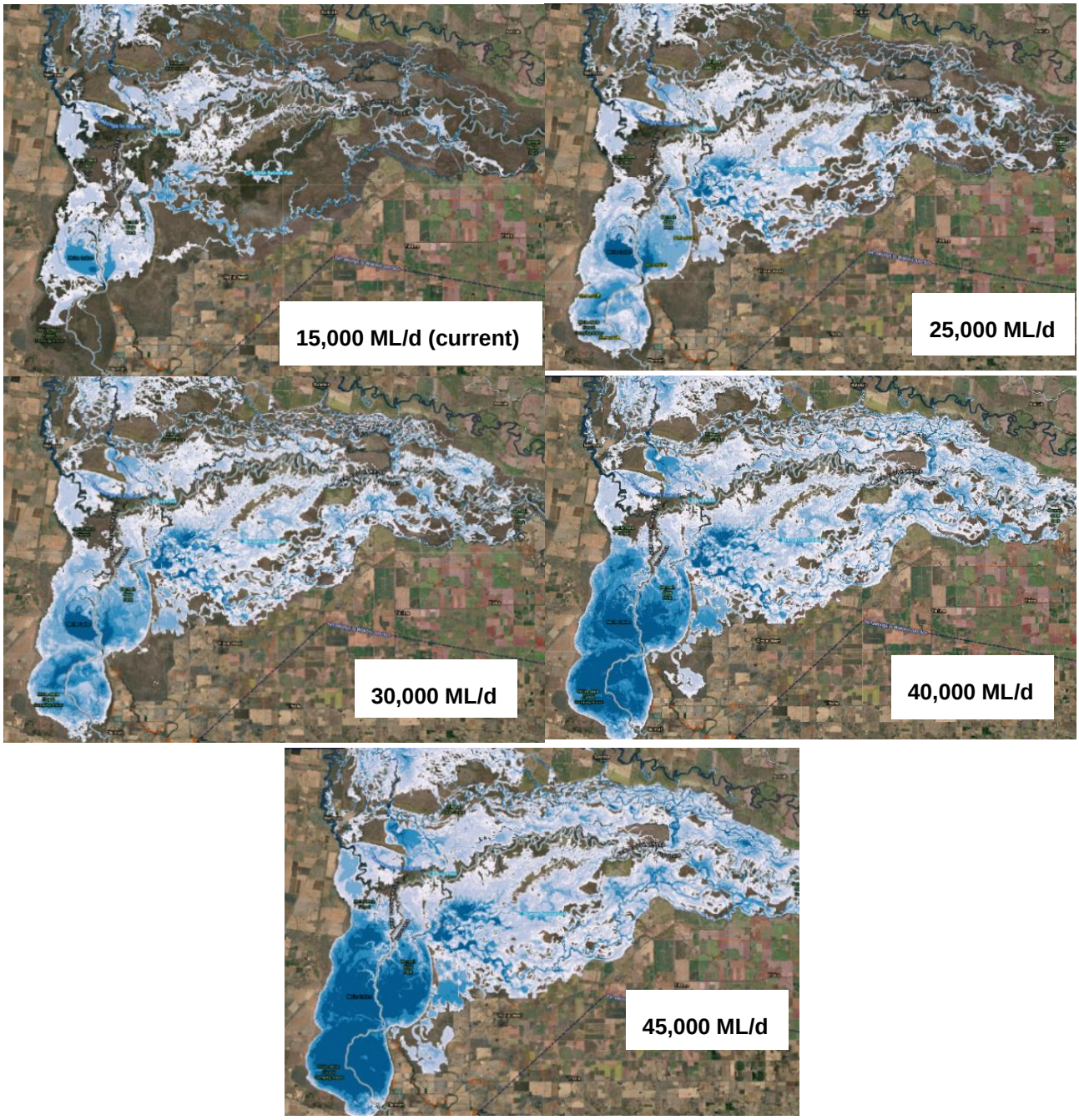


Figure 95: The modelled extent of inundation at Barmah National Park, Yarrawonga to Wakool reach on the Murray River at the increasing flow scenarios

5.9.4 Gunbower Island

Gunbower National Park and State Forest is home to the second largest River Red Gum forest in Victoria. Gunbower Island spans 26,400ha that lies between Gunbower Creek and the Murray River in North Central Victoria.

The area comprises vast areas of floodplain, forest and wetland that is listed as a Ramsar wetland of international significance. Gunbower Island is home to a range of native flora and fauna species as well as holding areas of cultural significance. Evidence of Aboriginal occupation can be found in the various scar trees, cooking mounds and middens dispersed across the island.

Figure 96 shows the increase in potential inundation of Gunbower Island as flow levels in the Murray are increased through relaxed constraints.

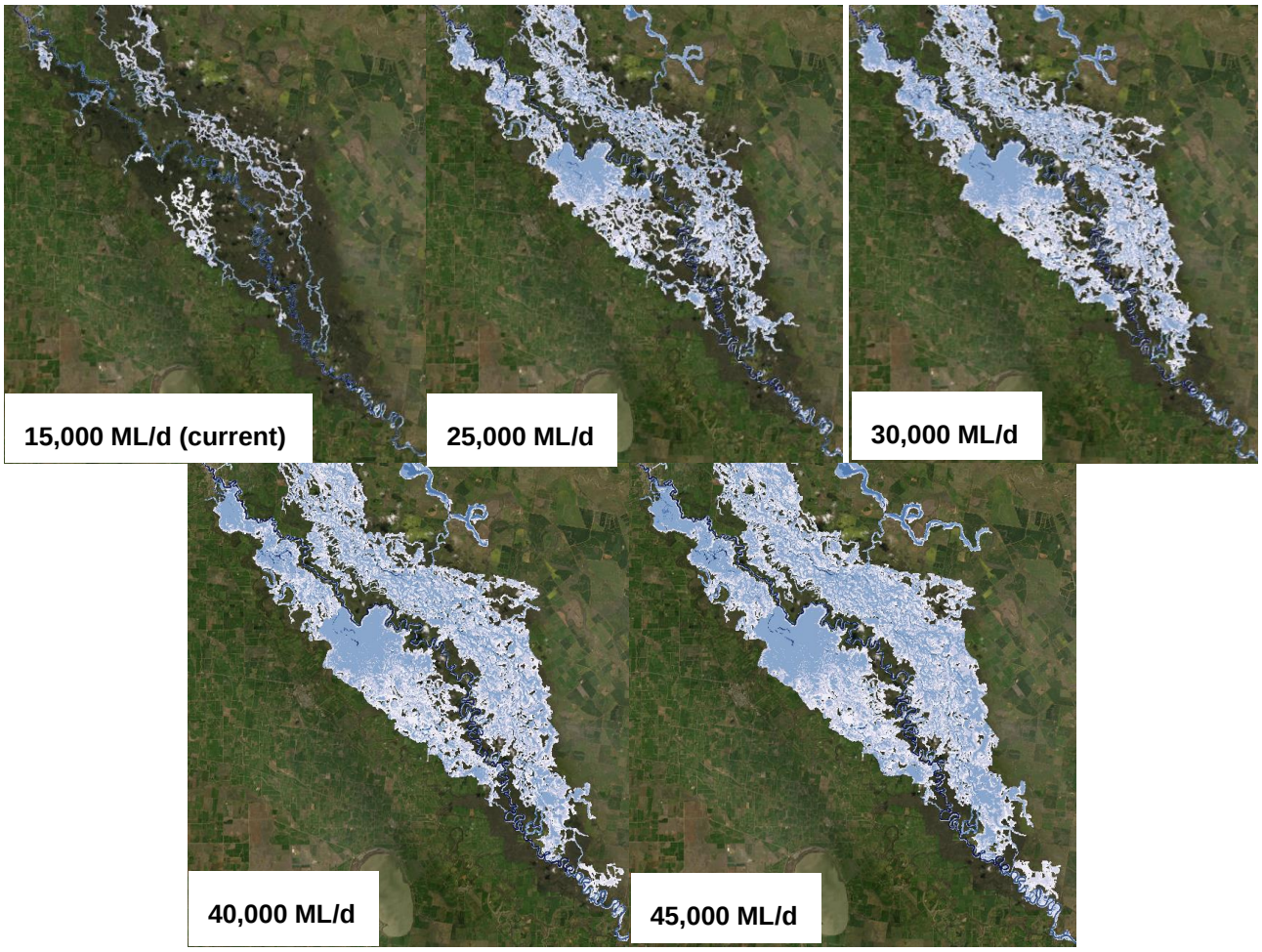


Figure 96: The modelled extent of inundation at Gunbower National Park and State Forest, Yarrawonga to Wakool reach on the Murray River at the increasing flow scenarios

5.10 Summary of flow scenario benefits and impacts

Table 23 below summarises a range of key parameters identified in the modelling of the different constraint relaxation scenarios in the Victorian study areas of the Murray River.

Table 23: Summary of key parameters across the modelled flow scenarios – Murray River

Indicator	Relaxed constraint flow scenario			
	Y25D25	Y30D30	Y40D40	Y45D40
Native vegetation inundation (ha)	27,910	34,910	44,218	46,902
% change on RRG condition	+3%	+5%	+10%	+17%
% change on BBW condition	+14%	+12%	+15%	+16%
Murray Cod population	+[0-7]%	+[0-7]%	+[0-7]%	-[0-1]%
Golden Perch adult population	+[10-11]%	+[12-20]%	+[25-29[%	+39%
Increase in efficiency of environmental water use	+48%	+73%	+104%	+127%
Public land inundated (ha)	27,623	33,482	41,754	45,741
Private land inundated (ha)	799	1,884	3,432	3,576
Additional properties inundated	72	139	206	222
Average extent of private land inundation (ha)	2.5	4.9	7.6	7.7

6 Environmental risks of relaxing constraints

- Based on ecological response modelling and expert review, relaxing constraints offers greater environmental benefits than environmental risks.
- Regardless of whether constraints are relaxed or the current river operating rules continue, bank erosion will persist.
- The investigated flow scenarios propose a level of inundation that is not expected to increase the overall number of carp in the river system. However, there are likely to be local increases in biomass. Further investigation into the effects of carp is recommended for future program stages including management measures such as carp exclusion barriers at high value wetlands.
- Since the relaxation of constraints is specifically targeting a shorter inundation period below the minor flood level, any changes in the frequency and extent of severe blackwater events is insignificant.
- Modelling shows that relaxing constraints would enable the environmental water portfolio to be used more frequently. Allowing more environmental water to be delivered up to the relaxed constraints will likely reduce storage levels at times, creating dam airspace and reducing the chance of spills at higher levels. This can reduce the duration and frequency of more extensive floodplain inundation and reduce flooding of species such as Blackbox.
- There needs to be a conscious decision to ensure the environmental benefits of increasing lower-level floodplain inundation outweigh the potential risks associated with reduced high-level floodplain inundation.

6.1 Erosion

The Committee was concerned about erosion, a critical issue affecting both current and potential river operations under relaxed constraints. The Committee shared numerous examples of erosion currently occurring in the Goulburn and Murray catchments and expressed fears that relaxing constraints may exacerbate erosion rates. They observed that erosion rates have seemingly increased over the past two decades, likely due to prolonged periods of high-water flows. The observed erosion has been linked to river regulation and changed water delivery patterns to meet evolving water use for both the environment and irrigation. Examples were cited such as the increased water requirement for permanent plantings in Sunraysia and reduced demands down the National Channel have altered flows patterns down the rivers. Other factors specific to some reaches like boat wake and sediment deprivation downstream of Lake Hume due to the dam's operation were also highlighted.

The key erosion concerns raised by the Committee within the Goulburn and Murray catchments include:

- loss of dense Cumbungi vegetation;
- bank slumping and erosion;
- damage to trees;
- undermining of private infrastructure (such as individual pump houses) and
- undermining of public infrastructure (like the Barham Wharf and boardwalk

Figure 97: Bank erosion on the Murray River at Brimin (photo courtesy of P Noble)

Figure 98: Bank Erosion on Gunbower Creek (photo courtesy of A Hodge)

Figure 99: Erosion on the mid-Goulburn (photo courtesy of J Beer)

"There is a need to urge government to act to address the significant deterioration of the Riparian zone caused by higher delivery needs downstream that have evolved as part of the Murray-Darling Basin Plan."

Consultative Committee Member

River regulation is a primary contributor to erosion affecting the Goulburn and Murray River systems. This regulation involves storing high-flow events during winter and spring, then releasing this water over the subsequent summer irrigation season. As this water is delivered down the rivers for irrigation use, it remains confined within the river channel and exerts its force on the adjacent riverbanks. The increased frequency and duration of flows remaining within the channel escalate the potential for bank erosion. However, the reintroduction or increase in overbank events redistributes this energy and has the potential to mitigate the extent of bank erosion.

The environmental benefit and impact modelling was expanded to include an assessment of the erosional impacts associated with each flow scenario in response to the Committee's concerns.

The analysis revealed that the current flow regime has intensified the erosion susceptibility in comparison to a scenario without river regulation. The relaxation of constraints would reduce the likelihood of bank erosion. The reintegration of environmental water into the floodplain at a seasonally appropriate time to benefit riparian vegetation, has the capacity to diminish the frequency, extent, and magnitude of bank erosion along the Goulburn and Murray Rivers. Specifically, modelling suggests the relaxation of constraints could potentially yield up to a 12% reduction in erosion potential along the Goulburn River compared to current operations.

Significant enhancements in geomorphic complexity, which directly affects the quality of in-stream habitat, are anticipated in the Goulburn River. Comparable improvements are anticipated for the Murray River.

"The emphasis should not be on gaining and delivering a certain volume of water, and thinking that this will gain the greatest benefit. There has been little attention paid to the many complementary measures that should be employed to gain greater benefits".

Consultative Committee Member

While modelling undertaken for this feasibility study did not encompass an in-depth assessment of erosion potential within the Murray River system, a review of overbank event occurrences under different constraint levels highlighted the potential to diminish erosion in the Hume to Yarrawonga stretch. However, the benefits in the Yarrawonga to Wakool reach might be more restricted.

Although the investigation undertaken for this study did not uncover significant erosion risks, these assessments had certain limitations in scope, warranting potential further investigations. Such inquiries could also incorporate considerations of relaxed constraints on anabranch (branch of a river) development within the Hume to Yarrawonga section. The Committee was supportive of further investigations in any future stages of the program.

> *"Some erosion forces such as boat wake and riparian grazing pressures would need to be addressed through complementary measures outside of the Constraints Measures Program.*
>
> Consultative Committee Member

The Committee advised that there was still an urgent need for the MDBA to address the significant deterioration and erosion of the riparian zone of the Murray River under current river operations as well as any relaxed constraints scenarios.

6.2 Water quality

Currently, there are water quality risks linked the return of carbon and nutrients from the floodplain to the rivers due to unregulated flows, particularly during the height of summer. Known as hypoxic blackwater events, the increase in carbon in the water leads to a decrease in dissolved oxygen, which is vital for aquatic organisms to breathe. This can harm the environment temporarily, causing low oxygen levels and potentially toxic effects on aquatic life such as fish.

Blackwater events are often a result of prolonged dry periods and infrequent flooding. During dry spells, organic matter like leaves accumulates on riverbanks and floodplains. When a flood occurs after a dry period, this organic matter is washed into the water, where bacteria consume it, releasing carbon and using up oxygen in the water. This is particularly of concern during the heat of Summer.

Figure 100: Blackwater event at Barmah November 2011 (photo courtesy of GBCMA)

The flow scenarios considered by this study focus on delivering environmental water when the environment needs it during the winter and spring seasons, thereby not increasing this risk. The relaxation of constraints presents the potential to mitigate the risk of hypoxic blackwater events. This positive outcome is achievable through the following mechanisms:

- **Improved Environmental Water Use**: By enhancing the efficient utilisation of available environmental water, this would contribute to a reduction of the overall volume of water held in storage, potentially reducing the likelihood of spill events occurring out of their designated season (such as summer).
- **Reduced Carbon Accumulation on Floodplains**: The relaxation of constraints also has the potential to reduce the accumulation of carbon on the lower floodplain, which acts as a buffer for carbon and nutrients present on the upper floodplain. This reduction in carbon buildup on the lower floodplain can mitigate water quality impacts resulting from unregulated events that cause upper floodplain inundation. This reduction can be achieved by:
  - Minimising stress on trees, which in turn decreases leaf fall and associated carbon input into the system.
  - Facilitating the increased return of floodplain-derived carbon back into the river system.

More effective use of the volume and timing of water for the environment permits the return of carbon into the river during periods when water temperatures are cooler (winter and spring). This approach supports instream productivity and concurrently diminishes the likelihood of hypoxic blackwater incidents arising during the late spring and summer periods.

Although the investigations suggest relaxing constraints will contribute to water quality benefits, a risk of hypoxic blackwater events would remain from moderate and major floods. The extent of the floodplain inundated during these larger unregulated flows are not reached by the much smaller flow levels that are being considered by this program.

No other water quality risks were identified to arise as a result of the relaxation of constraints.

6.3 Platypus and turtles

Platypus and turtle benefits and risks were only evaluated in the Goulburn River, and the results were mixed, reflecting uncertainties regarding the flow requirements of these species. Increases in productivity and invertebrates are expected to create better conditions for platypus and turtles. However, the modelling indicated potential risks for both species linked to the impact of high flows on nesting success.

In the case of platypus, high flows during the breeding season could flood their nesting burrows. There is still uncertainty surrounding this hypothesis, partly because breeding can begin as early as August, although observations in Tasmania and the Victorian high country have recorded breeding instances starting in October. This hypothesis also seems inconsistent with the fact that platypus populations have been negatively affected by river regulation, with significant declines observed in the last three decades. This raises questions about how platypus respond to changes in flow. It's possible that platypus consider winter flows when finding and building their burrows. Therefore, in planning environmental flows, managers should take previous flows into account when scheduling high flows to minimise the risk to nesting burrows.

The University of Melbourne models made similar predictions for turtles, modelling three turtle species together, which might increase uncertainty given that each species has different breeding habitats. There's also evidence that other turtle species use flows as a cue for selecting nest sites. In this regard, managing the river's long-term shape and features may be a suitable way to influence the availability of suitable nesting sites.

Overall the modelling undertaken for this feasibility study offers a cautious message about potential risks to these two important species. These risks should be considered in the broader context of how these species have evolved and thrived in these systems for thousands of years, including their adaptation to late winter and spring events. It is recommended that the risk triggers and responses are identified through ongoing research, monitoring, and adaptation of environmental water delivery programs, rather than using these risks as a reason to halt further development of relaxed constraints.

6.4 Carp

Committee members expressed concern about the risk of increasing carp populations as a result of relaxing constraints. This concern was also heightened from community observations of carp following the 2022 flood event.

While there is a potential risk of increased floodplain watering leading to higher carp populations, this risk is unlikely to significantly affect the benefits for native fish. Young carp in wetlands can actually become a food source for waterbirds and larger native fish, as they haven't adapted to changes in flow patterns like native species have and may become stranded in wetlands.

The Committee supports further investigation of the impacts of constraints relaxation on carp populations. This should include potential impacts on wetland habitat, including impacts on native vegetation and fish, the waterbird benefits, and the potential flow management options that benefit native fish without exacerbating carp risks.

Figure 101: The prevalence of Common Carp (*Cyprinus carpio*) is a concern to communities in Northern Victoria

7 Traditional Owner Engagement

- The feasibility study's consultation approach supported Traditional Owner self-determination, enabling Traditional Owners to decide if and how they participated in the project and by enabling them to guide the engagement process, including the place and style of the consultations including meeting on-Country.
- The majority of Traditional Owner groups consulted supported further exploration of relaxing constraints to achieve the broader environmental and cultural outcomes and gave in-principle support to see the project go forward to the next stage of investigation. Some groups requested further information to have a better understanding of the project before they determine their level of support.
- Although a consolidated viewpoint was not sought, no single summary view on the project was agreed to by all Traditional Owner groups. Each submission has been presented as separate, stand-alone statement to the Victorian Minister for Water as several groups stated it would be inappropriate to merge their statement with that of another group.
- Continued partnerships with Traditional Owners are essential. Moving forward, the next phase of the program presents further opportunities to continue to actively engage with Traditional Owners as rights holders and to extend involvement into further partnerships including on-ground investigations. There may be further opportunities to partner with Traditional Owners to identify areas of key cultural value that can be watered beyond the boundary or capability of the Constraints Measures Program.

Traditional Owners have an enduring connection to Country and a crucial interest in water resource management. Everything on Country - the land, water, life, culture, and resources - is connected. Traditional Owners have moral and cultural obligations to care for, protect and heal Country, and have done so holistically and sustainably for tens of thousands of years. Country connects Traditional Owners to their past, present and future, and is foundational for identity.

Water is an integral part of Country. Traditional Owners actively managing water contributes to the health, wellbeing, and economic benefits of individuals and communities while also benefiting the environment and other water users. The Victorian CMP recognises the essential need for Traditional Owner involvement in identifying and expressing the cultural, environmental, and social benefits and risks associated with relaxing constraints.

The project team has worked closely with Traditional Owners, CMAs and representatives from DEECA throughout this stage of the Victorian CMP to deliver the Cultural Benefits and Risks Workstream. The approach supported Traditional Owner self-determination, enabling Traditional Owners to decide if and how they participated in the project and by enabling them to guide the engagement process, including the place and style of the consultations. This provided opportunities for Traditional Owners to strengthen partnerships with water/land management agencies, and for Traditional ecological science and approaches to be valued, protected, and integrated with 'western' approaches to water management.

Twenty-one Traditional Owner groups with potential interest in the relaxation of constraints were identified for consultation. Fifteen groups shared their perspectives with the engagement team in seven on-Country workshops. The engagement resulted in five submissions on behalf of twelve groups.

> *"Continued engagement and partnerships with Traditional Owners should be embedded in every stage of the program."*
>
> Consultative Committee Member

This included Traditional Owner groups with formal recognition under Victorian or Commonwealth legislation (e.g. Registered Aboriginal Parties (RAP) under the *Aboriginal Heritage Act 2006 (Vic)*) and groups without formal recognition across the project area and downstream to the Victoria/South Australia border. Traditional Owner involvement in this stage of the Victorian CMP was structured to support meaningful and authentic conversations with Traditional Owner Groups.

This approach was designed to support genuine and meaningful conversations with Traditional Owners and empower groups to contribute to current and any potential future stages of the project. The workshops captured Traditional Owner perspectives and helped establish what further information or steps may be required (from a Traditional Owner viewpoint), should the project proceed to a business case.

The purpose of the consultation was to understand Traditional Owner perspectives of the types of benefits and risks expected to arise from relaxing constraints within designated reaches of the Goulburn and Murray Rivers, and further downstream across the Mallee floodplains (from the Wakool River Junction to South Australia)

No single summary view on the project was agreed to by all Traditional Owner groups. Each submission has been presented as separate, stand-alone statement to the Victorian Minister for Water as several groups stated it would be inappropriate to merge their statement with that of another group.

The project team identified a set of key themes from the consultation that can be summarised as follows. The majority of Traditional Owner groups engaged:

- Identified potential benefits of relaxing constraints including benefits for flora, fauna, and wellbeing benefits to individuals and community of healthy Country.
- Identified potential impacts of relaxing constraints on Country and cultural heritage assets from inappropriate timing of water releases, poor water quality and erosion.
- Identified that the true benefits and risks cannot be assessed without both detailed mapping of cultural assets and detailed knowledge of the flow regimes and implications.
- Emphasised the importance of detailed investigation into the cultural, environmental, and broader community benefits and impact associated with the project.
- Supported further exploration of relaxing constraints to achieve the broader environmental and cultural outcomes and gave in principle support to see the project go forward to the next stage of investigation, although some groups require further information to have a better understanding of the project before they determine their level of support.

Furthermore, the majority of the representatives from Traditional Owner groups engaged expressed the desire to see:

- Significant collaboration with Traditional Owner groups in the next stages, including in decision making over water use.
- Holistic management of land and water, considering the interconnectedness and interdependence of these resources.
- Improved information and engagement if the project continues, to ensure that the information about the project can be understood by the broader community.
- Improved integration between government departments and programs to ensure consistency and continuity in government knowledge.

From the feedback received, it is recommended that future stages include:

- There is a need to support Traditional Owners to undertake mapping of cultural values for Country and the many wetlands that would be engaged under relaxed constraints. Traditional Owners want to ensure the protection of current values from any potential negative impacts from relaxing constraints.
- There is a need to improve the integration of planning complementary works for land and water. Relaxing constraints alone will not deliver the full potential for Country. Land and water need to be managed holistically to achieve the full range of potential benefits.
- There is a need to increase the role of Traditional Owners in governance and decision-making regarding water allocation, use and management as per the *Water is Life* policy. Traditional Owners expressed the need for improved Traditional Owner involvement in future Constraints Measures Program governance. Traditional Owners highlighted the need for actions in relation to many of the wetlands identified, such as the development of cultural management plans and cultural flow requirements to inform and guide planning.
- Future waterways work should be increasingly led and undertaken by Traditional Owner groups. This will help to address the loss of knowledge about Country due to the dislocation of Traditional Owners from Country, and to provide opportunities for employment and knowledge transfer to future generations.

8 Mitigation and compensation measures

- While the overarching aim is to water high environmental value public land, private land, assets and infrastructure would also be unavoidably inundated.
- Investigations have found that as the potential inundation extent is below the minor flood level, no residential structures are affected. The inundation on private property primarily affects productive pasture, stock grazing areas, river pumps, fencing, and farm access routes. On public land the greatest impacts are associated with local 2WD and 4WD tracks with associated disruption to recreation activities.
- Inundation impacts may extend beyond the land directly affected, including causing farm access issues, impacting property management and impeding stock movement.
- Compensation approaches must address the overall property impacts and encompass potential long-term recurring impacts resulting from inundation, rather than just the number of days of inundation. There are clean-up and reinstatement costs following an inundation event. Productive pastures may take 12 months to re-establish following periods of prolonged inundation.
- If the CMP proceeds, the next stage will need to focus on gauging community sentiment and understanding on-ground benefits and impacts through a community co-design approach. This can only occur as a joined-up project that considers benefits, risks, engagement, and policies across borders. Details of how landholders or assets managers will be compensated need to be presented during this process.
- A key first step would be to develop the approach to mitigation for impacts. Compensation and mitigation approaches should consider all impacted assets and recurring impacts, such as loss of production, restoration, clean-up, impeded access and maintenance.
- Unless otherwise advised by governments, any future implementation must adhere to the *Victorian Government Land Transaction Policy 2022* for compensating against impacts.
- There must be consistency in compensation and mitigation approaches across state borders to ensure that landowners on both sides of the river are treated fairly.
- Public land managers are integral to this program. Relaxing constraints would result in a range of on-going land and asset management activities that require appropriate planning and support by public land managers.
- River operators require landowner agreement before they release environmental water from storages that will create over bank flows. Landholder agreements would require appropriate works and measures to offset the costs of inundating their land. Obtaining agreement from all landowners would be very challenging.
- Governments (State and Commonwealth) should agree to reserve the right to use compulsory powers. This should only be where inundation of private land has been avoided as far as practical, and where transparent compensation approaches are in place, all voluntary options have been exhausted, and there are overwhelming environmental outcomes (greater public good).
- Any future compensation must consider the potential impacts up to not only the target flow rate, but a higher level that includes an additional risk buffer for river operations. The extent of the risk buffer will depend on developing appropriate forecasting and associated tools as part of the Enhancing Environmental Water Delivery (EEWD) project.
- This study's impact assessment was based on a desk-top analysis and did not examine location-specific private impacts with verification from individual landowners. This must form part of any future program.
- The government, through its land managers, will take steps to mitigate and manage risks to public land.
- Relaxing constraints should not result in a material increase in local government rates.
- Relaxing constraints can lead to a reduction in the magnitude of natural flood peaks. Constraints relaxation mitigating works may also reduce the costs to floodplain landholders of these events.

8.1 Impacts to private land

The delivery of flows under relaxed constraints for environmental watering would target environmentally valuable public land managed by Parks Victoria and DEECA but would unavoidably inundate council and private land and assets on the lower floodplain as well.

Public and private assets within the inundated areas include pumps, culverts, access tracks and fence. No dwellings would be inundated.

In addition to direct asset impacts, there are potential long-term recurring impacts resulting from regular inundation, such as loss of production, pasture restoration, debris clean-up, fence reinstatement, agistment costs, maintenance and other related factors. As compensation payments are unlikely to be on-going or event based, any upfront compensation for impacted landowners must consider the enduring nature of the impacts from relaxing constraints.

It is important to acknowledge that the impact of inundation extends beyond the directly affected land. It can also disrupt crucial access points to properties, significantly impacting business operations. This concern is particularly significant in the Hume to Yarrawonga reach, where Committee members emphasised the substantial impact on private infrastructure and the potential harm to property and landowners if the highest flow rate scenario of 40,000 ML/d is implemented. Any future compensation and mitigation arrangement must include consideration of impeded access.

Figure 102: Access impeded on a Hume to Yarrawonga property on the Murray River at flows of the order of 40,000 ML/day at Doctors Point

Water corporations are liable for the intentional or negligent release of water from their works (eg Eildon Reservoir) that causes injury, damage to property or any other person to suffers economic loss in accordance with Section 157 of the *Water Act*. This means that agreements must be established before river operators (Goulburn Murray Water) (GMW)) release water to create over bank flows that cause damage to property or economic loss. The *Water Act* does enable water corporations to voluntarily or compulsorily

acquire easements in accordance with the Compensation of Land Act to avoid liability arising from the release of water from their works.

Given this legislative framework, this project proposes that agreements are established with landholders and land managers to enable river operators to make controlled releases of water to create overbank flows that may damage private or public property or cause economic loss. The agreements need to be enduring (i.e. are tied to the land, not the property owner) and enable both GMW and the MDBA to cause over bank flows.

8.2 Property types considered

Three types of property owners have been considered because of their different characteristics:

- Private landholders (farmers or residential landholders) who could own assets that are damaged or suffer economic loss through reduced production and increased production costs. Their rights are enforced by the courts.
- Councils whose assets (i.e., roads and recreational facilities) may be damaged by managed over bank flows. Councils most often hold crown land rather than freehold land. They are unlikely to suffer economic losses but their assets may be damaged.
- Government agencies (i.e., Parks Victoria and DEECA) who manage Crown land. Access tracks and recreational facilities may be damaged by managed over bank flows and operating costs (i.e. weed control) may increase. In practice the government would make decisions about making good asset damage and the impact of inundation on ongoing operating costs of their agencies.

The Committee advised that the process mitigating the costs of relaxing constraints to landholders, councils and government agencies must be fair, robust, transparent and consistently applied to ensure equity and that all affected parties understand the calculation methodology. Impacts on local government assets should be compensated and mitigated so that relaxing constraints does not result in rates increases for communities. Committee members shared their insights from previous projects, where discretionary compensation approaches were used. They noted that in some cases, individual landowners openly discussed the details of their compensation packages, which resulted in others holding out in anticipation of receiving better offers. According to the *Victorian Government Land Transactions Policy 2022*, which applies to this program, there is no room for discretion in determining compensation amounts. Whether through compulsory acquisition or voluntary agreements, the compensation provided remains the same.

8.3 Principles for mitigating impacts

Mitigating the effects of relaxing constraints and increasing the frequency of inundating low parts of the floodplain would involve a range of solutions. A draft mitigation selection and compensation framework has been developed with the Committee to provide a framework for a transparent, fair and equitable approach when negotiating agreements with land managers and landholders. The following mitigation principles are proposed:

Table 24: Proposed mitigation principles

1	Affected parties shall be provided with sufficient information on inundation extent/duration/ frequency/timing, mitigation options and compensation so they can make informed decisions regarding measures that could satisfactorily mitigate impacts.
2	Affected parties would be best placed to identify measures that could mitigate impacts on their property/business/assets.
3	Where opportunities exist, mitigations should aim to deliver benefits to the affected party to complement the broader environmental benefits associated with constraint relaxation.
4	Where an affected party elects to upgrade infrastructure beyond the standard required to mitigate the relaxed constraint, that party would fund the marginal cost difference
5	Mitigations for impacted private or public land or assets shall be the lowest whole-of-life cost solution.
6	Where assets are constructed or upgraded, asset ownership must be agreed upon and documented prior to works commencing.

7	Where easements are the agreed mitigation, easement boundaries shall be based on the inundation extent and an additional buffer area to provide a margin of safety for river operators.
8	Inundation easements would not be acquired over public land.
9	Mitigations must be enduring

Existing assets may require upgrades to enhance their resilience against higher flows, or in some cases, relocation may be necessary. Additionally, new assets, such as access crossings, may be required to address the challenges of impeded access during periods of higher flow rates. The aim would be to ensure that infrastructure is suitable for increased flows and effectively serve the needs of the community and landowners in the affected areas.

"There is a need to be very careful about the expectations of landowners. There needs to be a uniform approach as people will try for the highest standard and compensation all of the time."

Consultative Committee Member

"You want to put in clear parameters as to how compensation is determined because all [landowners] talk about what they got and some will hold out [for a better deal]. You need to explain how the package was put together and be transparent about it."

Consultative Committee Member

It is important to establish and communicate clearly documented standards for different types of assets to ensure consistency, transparency and to minimise disputes. The standards would be appropriate for the particular asset. For example, farm tracks would be built to a standard appropriate for farm tracks, which would be different to the standard required for a public road. This would help landowners and managers to understand the level of service they can expect from any proposed asset works.

The Committee agreed with the concept of a "co-contribution" arrangement, where landowners have the option to contribute financially if they desire a higher level of service than what is provided by the program's established standards. This approach allows for flexibility and ensures that landowners can customise the works to meet their specific needs and preferences, while also taking into consideration the cost implications of such modifications.

8.4 Private landholder easements

Compensation and mitigation would be provided to private landholders for the area inundated by the targeted flows and an additional buffer. The draft framework acknowledges the need for acquiring inundation easements as outlined in the *Land Acquisition and Compensation Act 1986*. These easements are enduring when property ownership changes. The framework outlines a negotiation process and uses compensation valuation methods that align with government legislation and guidelines pertaining to public procurement, land acquisition, and public grants. Where applicable, the compensation offered under the once-off payment to landowners would encompass potential long-term recurring impacts resulting from inundation, such as loss of production, pasture restoration, debris clean-up, fence reinstatement, agistment costs, maintenance and other related factors.

"We could put in mitigants such as weed control to look at a broader package of solutions to address any negative aspects."

Consultative Committee Member

The framework has been developed in line with the Victorian Government's stance that land would not be inundated without the consent of the landowners, and there

would be no compulsory acquisition of land or easements for the purpose of relaxing constraints. As a result, acquiring easements for the Victorian CMP relies on achieving 100% voluntary agreement with affected landowners. This presents a significant challenge for the program since landowners are not obligated to accept the compensation offer, even if it is a fair assessment of the market value.

The Committee advised that attaining 100% voluntary agreement from landowners for mitigation and compensation packages is highly unlikely given previous experiences with programs such as the surface drainage program and the GMW Connections Project. Most of the Committee supported the use of compulsory powers on the understanding that a threshold of voluntary agreements was achieved, i.e. compulsory powers were only used as a last resort to ensure the broad environmental benefits of relaxing constraints are not realised because of the opposition of a small minority of property owners.

Establishing policies for mitigation of inundation raises complexities associated with land tenure. The recognition of leaseholders would require considerations, such as determining the thresholds for engaging with leaseholders based on the remaining tenure of their lease (e.g., one year remaining on the lease). An example was given by the Committee where an asset is privately owned but located on Crown land, requiring engagement with both the asset owner and the relevant land authority. The Committee agreed that occupiers and legal landowners should be included in the engagement process.

8.5 Landholder, council and government agency assets

The aim of relaxing constraints is to maximise the area of higher environmental value public land being watered while minimising the private impacts. Although flows would be targeted to water public land, restoring flows generally to below minor flood levels would have an impact on private land, agricultural production, stock, assets, private access roads, rural levees and other public infrastructure such as roads, bridges, and culverts.

If the CMP should proceed to implementation there would be a requirement to mitigate the impacts on affected public and private assets, generally through upgrades to the asset to bring the asset above the inundation water level. These works could only be undertaken when the land manager/asset owner agrees to their land being inundated by managed environmental flows. The works would provide benefits to the asset owner by:

- upgrading the condition of existing assets
- delaying the need for the owner to replace the assets
- potentially reducing ongoing maintenance costs of existing assets
- ensuring the assets meet contemporary standards (e.g., works licence conditions for pumps)
- improving resilience to natural floods within the design parameters.

The Committee supported an integrated approach working closely with affected landholders to consider the whole farm when identifying mitigation measures. By adopting a process like the development of 'whole farm plans', all possible options for mitigations can be explored, rather than solely focusing on replacing old assets with new within the inundated area. This approach would also address potential impacts on other aspects of the property, such as access limitations, which may be inadvertently affected by inundation.

Some members of the Committee emphasised that the program would bring benefits to landowners from nutrient movements and by implementing asset works that enhance flood resilience under natural flow events to the minor flood level. Furthermore, they highlighted potential opportunities for alternative forms of production, such as agroforestry, which could be explored within the lower floodplain areas. This approach should also apply to Council and Government agency assets.

Currently, some areas of the floodplain are protected from natural flooding by rural levees. These levees have been constructed along the Goulburn and Murray Rivers on both private and public land since the mid-1800s and early 1900s. The relaxed constraints scenarios consider flows up to the minor flood level, and therefore, are not expected to significantly engage the existing levees that offer flood protection for much higher flow rates. If managed environmental watering requires the use of this infrastructure as a containment bank to prevent inundation of private land, then environmental water holders should pay for these services in line with existing government policy.

The Committee identified that a detailed landowner guide would be required to inform discussions with impacted landowners and managers. The guide should be developed in partnership with community members, agencies and interested parties such as the VFF to clearly detail the process, compensation, and

mitigation approach. This documented approach must also be consistent with government principles and regulations.

The Committee supported offering landowners financial support to access legal and technical advice. This assistance would enable them to make informed decisions about accepting compensation and mitigation terms.

> *"People need to be able to access legal help to determine their rights."*
>
> Consultative Committee Member

During the discussions on compensation approaches, it was recognised that assessing compensation should be based on the current use and management of the land. Some landowners and managers may have expectations for compensation to consider future use possibilities. However, taking future use into account is inconsistent with the Compensation of Land Act and past experience has shown that it leads to unrealistic claims for compensation and disputes. It is also recognised that there should be no material impact on local government rates as a result of constraints mitigation works.

The Committee recognised the importance of flexibility in the approach to delivering asset works. Based on experiences from similar projects, the majority of landowners and managers prefer a dedicated project delivery team to undertake works on private infrastructure. However, a minority of landowners may prefer to manage the works themselves while having the program cover the associated costs. Additionally, some landowners may take the opportunity to upgrade their affected infrastructure to a higher standard (at their cost) than what is required by the program.

8.6 Consultative Committee key advice

The Consultative Committee advise that:

- Compensation and mitigation must be provided for inundation up to and including the target flows and an appropriate risk buffer.
- Landowners who would be affected by the project would have concerns about the recurring impacts on their land.
- There may be benefits and opportunities for some landowners including nutrient movement and opportunities for changed enterprises such as plantations.
- Consideration should be made as to equity in compensation approaches along both sides of the Murray River
- It is crucial to have long-lasting rights through easements to inundate land, even if ownership changes hands.
- Support should be provided to the community to facilitate decision-making such as access to legal and technical advice.
- Some landowners would agree to easements voluntarily, while others may not.
- If this program is to proceed, the government may need to use its powers of compulsory acquisition to acquire land from some landowners to successfully implement the relaxation of constraints.
- The wider community may be more accepting of the use of compulsory powers if there is general support for relaxing constraints, and if:
  - There has been a reasonable number of voluntary agreements for easements.
  - Individuals affected by the project are treated fairly.
  - There has been genuine community consultation and the proposed flow rates are seen as reasonable and aimed at maximising environmental outcomes while avoiding and minimising impacts on private properties

9 River operations

- River operators and environmental water managers have developed detailed arrangements and have extensive experience in delivering environmental water. This includes coordinating flows and 'piggy backing' to a lower level than under the proposed relaxed constraint scenarios.
- Relaxing constraints will see an increase in the flow rates that river operators will target compared to under current operations.
- Flow buffers or other risk mitigation measures are vital to managing the residual risk of unintentional damage resulting from exceeding flow targets. In the river Murray, buffers need to be agreed across border and consider risks to both Victorian and NSW landholders.
- River operators and environmental managers need new and improved tools to better predict catchment conditions. This is so river operators do not exceed target flows and environmental managers are able to achieve the desired environmental flow regime. Environmental water is already being managed and delivered through existing operating arrangements.
- To provide confidence to community and stakeholders, river operators would implement an adaptive management approach and gradually phase increasing flows up to the relaxed constraint level. This staged approach is recognised as an important mitigation measure.
- River operators are exposed to the residual risks of unintentionally causing overbank flows that exceed agreed limits. Even after implementing a range of mitigation actions, there would still be a residual risk to river operators. A government decision is required to finalise accountability for this residual liability.
- As such, river operators need to have increased certainty in mitigation measures before agreeing to release flows. These mitigation measures include establishing buffers, easements or guarantees from beneficiaries around compensation.
- A clear statutory responsibility or function is required for river operator organisations to deliver overbank environmental flows. This is being progressed by the Enhancing Environmental Water Delivery (EEWD) project.

9.1 Existing Operations Arrangements

Delivering the environmental flows envisioned by the CMP requires river operators to release water from storages at flow rates that will inundate low-lying areas of the floodplain including private property. River operators traditionally aim to control river flows within the banks of the rivers and avoid overbank flows to avoid inundating private property.

Environmental water is already being managed and delivered through existing operating arrangements within the Goulburn and Victorian Murray Systems. Environmental water managers and river operators currently coordinate the delivery of environmental water while managing delivery risks within the system. The *Operating Arrangements* (September 2020) are an established arrangement amongst the key Victorian stakeholders for the planning, ordering and delivery of environmental water in the Goulburn and Victorian Murray Systems.

9.1.1 Goulburn Operating Arrangements

Goulburn-Murray Water (GMW) operates the Goulburn system to meet demands for water from entitlement holders in accordance with the Bulk Entitlement Order. Planning for the release of water from Lake Eildon requires information about tributary inflows in the mid-Goulburn catchment which can contribute to meeting the total flow requirements for diversion and downstream flows at Goulburn Weir.

Estimates of tributary hydrographs and the response of the total catchment is required. This is currently done by monitoring data from the hydrometric network and through the operators' understanding of the catchment behaviour for the prevailing and forecast weather conditions.

GMW, Goulburn Broken Catchment Management Authority (GBCMA) and Victorian Environmental Water Holder (VEWH) are signatories to the Goulburn Operating Arrangements document, which sets out the roles and responsibilities of the parties for operating and risk management arrangements.

- the VEWH has primary responsibility for mitigating actions that relate to the demonstration of outcomes from environmental water delivery and portfolio management.
- GBCMA has primary responsibility for mitigating actions relating to engaging with the community in relation to environmental watering, adequate planning and monitoring of environmental water delivery and incorporating learnings into improved environmental water management.
- GMW has primary responsibility for mitigating actions relating to system operations associated with the delivery of environmental water.

9.1.2 Murray Operating Arrangements

The operating arrangements for the River Murray system are governed by the *Water Act 2007* (Commonwealth) and the Murray Darling Basin Agreement. The Agreement sets out the water sharing arrangements for the River Murray system, and also provides for key water accounting and operational arrangements. The Agreement also empowers the Basin Officials Committee to set arrangements for the operation of the River Murray system.

The primary way this is done is through the approval of the Objectives and Outcomes for River Operations in the River Murray System (the O&O document). The O&O document sets out the operational limits and practices and any detailed water accounting procedures for all key points in the River Murray system. It has recently been extended to include arrangements for a range of environmental water delivery procedures (including water accounting treatments). These arrangements also cover the measures necessary to implement the Prerequisite Policy Measures such as arrangements to allow 'piggybacking' storage releases onto unregulated or natural events in the River Murray.

River operators have also developed a range of detailed procedures, manuals, and guidance material to assist in applying the O&O provisions in day-to-day operations.

Victorian Murray Operating Arrangements

- the VEWH has primary responsibility for mitigating actions that relate to the demonstration of outcomes from environmental water delivery and portfolio management.
- the relevant CMAs (Goulburn Broken, Mallee, North East and North Central) in their role as Waterway Managers have primary responsibility for mitigating actions relating to engaging with the community in relation to environmental watering within Victoria, adequate planning and monitoring of environmental water delivery and incorporating learnings into improved environmental water management.
- the Murray-Darling Basin Authority (MDBA) has primary responsibility for mitigating actions relating to system operations associated with the delivery of environmental water. The River Operator (MDBA) has the authority to reject or cease delivery of an order immediately if it reasonably believes it will create unacceptable risks to public safety or may expose the storage manager to liability for payments of claims for loss or damage to property.

9.2 River operations risk assessment

An assessment of the risks and mitigations for river operations from relaxing flow constraints was undertaken for this feasibility study.

The assessment involved conducting risk workshops with representatives from various organisations involved in river operations and environmental water management. These workshops identified and reviewed key risks and explored potential options to mitigate these risks to facilitate the delivery of higher environmental flows.

The key risks identified include:

- Implementing higher environmental flows under relaxed constraints requires better cooperation and coordination among multiple organisations and jurisdictions. Clear roles and responsibilities are crucial for a coordinated approach.
- Uncertainty regarding managing liability related to overbank environmental flows, and unclear boundaries for managing this responsibility.
- Needing comprehensive system-wide and landscape-scale environmental water planning. It is unclear who would be responsible for managing this expanded scale of planning under the current arrangements.

- Lack of investment in resources, capacity, and capability to effectively carry out landscape planning and coordination.
- Concerns about the understanding of risk-based flow forecasting, especially among landholders and the general public. There is a worry that public expectations regarding the accuracy of flow forecasts may be unrealistic.
- Risks associated with notifying landholders and the public about current and projected flows.

Based on the analysis, several key mitigations have been identified to support river operations under a relaxed constraints regime. Many of these already form part of the key mitigations being progressed as part of the EEWD project. These mitigations could include:

- Establishing a clear statutory responsibility or function for river operator organisations to deliver overbank environmental flows. This ensures that river operators can release water within agreed limits and have the necessary legal certainty.
- Reviewing statutory functions and accountabilities of GMW and the MDBA. This issue has also been recognised by the EEWD and NSW Reconnecting River Country projects.
- Incorporating an additional buffer zone when determining primary mitigation measures, such as easements and other works. This accounts for residual forecasting uncertainty despite efforts to improve river flow forecasting tools.
- Implementing arrangements for compensation in rare cases where river flows exceed agreed limits, even if the river operator organisations have followed the agreed procedures and arrangements. This serves as a fail-safe mechanism for stakeholders and river operators.
- Reviewing policies and procedures to ensure best practices and quality assurance for delivering higher environmental flows. This also helps build understanding and confidence among stakeholders regarding the management of risks.
- Phasing implementing higher environmental flows and conducting trials to manage risks effectively. This staged approach is recognised as an important mitigation measure.
- Investing in the capacity and capability of human resources, developing operations tools for improved flow forecasting, and providing better information to support enhanced flow forecasting. This would ensure a stronger foundation for managing environmental flows.

River Operators believe all relaxed constraint scenarios are operationally feasible, considering appropriate mitigations to address identified risks.

9.3 Residual liability of river operations

In Victoria, the *Water Act 1989* sets the framework for river operations. Under Section 157 of this legislation, water corporations are legally liable for damage to property or economic loss caused by intentional releases of water from their works. Goulburn Murray Water, as river operator has managed this liability by ensuring releases from storages do not exceed the capacity of the river and do not cause overbank flows. The only exception to this approach is to make releases to manage floods and to protect the structural integrity of the dams.

The purpose of relaxing constraints is to enable river operators to release water from their works to generate overbank flows. Environmental managers propose that river operators increase releases from storage to add to or piggy-back onto high downstream tributary flows to create overbank flows. River operators are unlikely to do this unless they are satisfied that their legal liability is adequately managed.

The Committee expressed concerns about the potential risks associated with combining (or 'piggybacking') environmental water releases on top of higher unregulated flows, as this could lead to unintended and increased inundation.

Figure 103: River operators release water from storages such as Hume Dam on the Murray River

The Committee heard that environmental water managers currently work together with river operators to align flows from the Murray and Goulburn systems. Under regulated conditions, the timing of events to coincide and/or extend higher flows downstream of the Murray-Goulburn confluence are planned for and delivered. When the Murray is experiencing higher unregulated flows, coordinated delivery from the Goulburn (and other tributaries) is more challenging as the variables of further rainfall and unregulated inflows are more relevant to decisions to release and manage third-party risks.

As discussed previously, creating easements over the inundated land is the fairest way to manage this risk. However, river operators do not have perfect control on downstream flows due to the time it takes for water released from Eildon or Hume to travel along the river. For example, it takes approximately 7 to 10 days for water released from Eildon Reservoir to reach the Murray River, and 24 to 49 days to reach South Australia, and it can take 10 to 16 days for water released from Hume dam to reach the confluence of the Goulburn River. These time lags introduce significant uncertainty and risk because river operators need to forecast tributary flows and over these periods to manage overbank flows to agreed limits.

River operators are exposed to the residual risks of unintentionally causing overbank flows that exceed agreed limits. This is the case in the Goulburn River where the flows in the tributaries between Eildon and Shepparton respond very rapidly to rainfall particularly when their catchments are already wet. Catchments are likely to be wet when the river operators are asked to make releases from storages to piggyback onto high tributary flows. Wet catchments usually have large rapid responses to additional rainfall. This means that the river operators must rely on the precision and accuracy of 7-day rainfall forecasts, which are themselves uncertain, to avoid unintentionally high overbank flows.

Similar risks apply in the Murray below Hume Dam.

It is proposed that the residual risks would be minimised by:

- Acquiring buffers above targeted flow levels to provide operational flow tolerances should the river operator unintentionally exceed the agreed flow limits.
- Cautiously trial relaxing constraints involving progressively increasing flow rates to develop operational experience delivering overbank flows.
- Improving the real-time rainfall and flow data available to river operators through the installation of additional gauges as part of this feasibility study .
- Investing in more sophisticated river operating models that include short-term rainfall and catchment runoff forecasts. This is being progressed through EEWD.

Even after these actions there would remain a residual risk to river operators. A government decision is required to finalise accountability for this residual liability.

Environmental water managers and river operators have worked together for over 15 years to deliver environmental water deliveries. The planning, processes, capabilities and operational practices that have developed over this time provide a sound foundation for delivering environmental overbank flows.

The Committee acknowledged this expertise and supported the use of trials to gradually increase environmental water deliveries under relaxed constraints.

The Committee was also advised of the work currently being undertaken as part of the EEWD project to improve the tools and resources available to river operators and environmental water managers to

coordinate environmental releases from the Murray and its tributaries, and piggyback releases from storages on to unregulated flows and maximise the outcomes of the constraints measures.

The Committee advised that it would be important that mitigations are in place or well progressed when speaking to the wider community and were concerned that there may be a mismatch in timing of EEWD mitigation outcomes and the broader constraints consultation.

The Consultative Committee discussed the river operations issues and advises that:

- There is strong support for the creation of risk buffers on top of target flows. Compensation and mitigation measures should be calculated at inundation extents that include the buffer.
- There is support for the identified mitigation measures.
- It would be important to communicate to the wider community that the approach would be adaptive and that higher flow rates would not be targeted immediately, but rather introduced gradually over time.
- Mitigation measures should be proposed to inform broader community engagement to determine if community concerns can be addressed.

10 Other considerations

- The inundation extent and duration of flows enabled by relaxing constraints would not meet the ecological watering requirements of key environmental sites, particularly higher in the floodplain. The Victorian Murray Floodplain Restoration Project (VMFRP) is needed to complement constraints relaxation to reach higher areas in the floodplain and provide inundation durations more aligned with ecological requirements.
- The severity of climate change scenarios influences the benefits of constraints relaxation with respect to changes in environmental entitlement/allocations and unregulated flow events for piggy backing flows.
- Under a moderate climate change scenario, the benefits of relaxed constraints are evident.
- The most severe climate change scenario will result in rare occurrences of achieving the environmental flow requirements due to low water availability for all water holders within the system. Benefits of constraints relaxation are still seen under this climate change scenario compared to maintaining current river operations.
- The current environmental approval process for a project of this scale, nature and cross-border interfaces is complex. As part of any future stage of the CMP, the New South Wales, Victorian and Commonwealth (as funder) Ministers must agree on the interjurisdictional approval framework across all states.
- The Committee supports further system level modelling to determine whether the notified flow rates can be achieved through the system or whether lower levels may be more appropriate.
- The Committee supports an assessment of the broader system-level benefits and risks. This includes a detailed system-level cost-benefit analysis to inform future stages of the Victorian CMP and the broader MDBA Constraints Management Strategy.
- There may be opportunities to gain greater environmental outcomes from the available environmental water through the better coordination of flows through the system. To improve how this can be done, the Enhanced Environmental Water Delivery (EEWD) project is looking at the tools needed to improve outcomes under relaxed constraints.

10.1 Climate change implications

Climate change represents significant risks for ecological outcomes with the condition of ecological values expected to decline as the climate warms and dries. Environmental water shortfall volumes are also expected to increase under climate change as tributary flows and water allocations for all entitlement holders decrease.

There is a significant risk that climate change will cause further ecosystem decline assuming current river operations. Resilience to climate change would be improved by relaxing constraints. However, under severe climate change and conditions like the Millennium Drought, the modelling suggests the benefits of relaxing constraints are far less.

The modelling suggests all proposed constraint options would increase resilience to climate change and provide benefits that are relevant across a wide range of climate models and scenarios. However, in extremely dry future climates characterised by significant reductions in precipitation (20% or more), the advantages of relaxing constraints become less evident. In the year 2070, under high climate change conditions, flows rarely reach or exceed these constraints.

This implies that, except for the most severe climate scenario where water availability is the major limiting factor, relaxing constraints can serve as a valuable tool for environmental water managers to adapt to a drying climate. It's important to recognise that in such an environment, river management would need to significantly differ from what we are familiar with today.

In future stages of the program, it is recommended to undertake additional modelling at a system level to assess the benefits of relaxing constraints under potential future climate conditions.

10.2 Integration with the Victorian Murray Floodplain Restoration Project

Several Committee members spoke of the importance of the interaction of relaxed constraints and the implementation of the Victorian Murray Floodplain Restoration Project (VMFRP). While the scenarios investigated by the Consultative Committee aim to reinstate a more natural flow regime to low-lying floodplains below the minor flood level, the VMFRP targets ecologically important floodplain sites higher in the landscape that flows under relaxed constraints may not reach (see Figure 104).

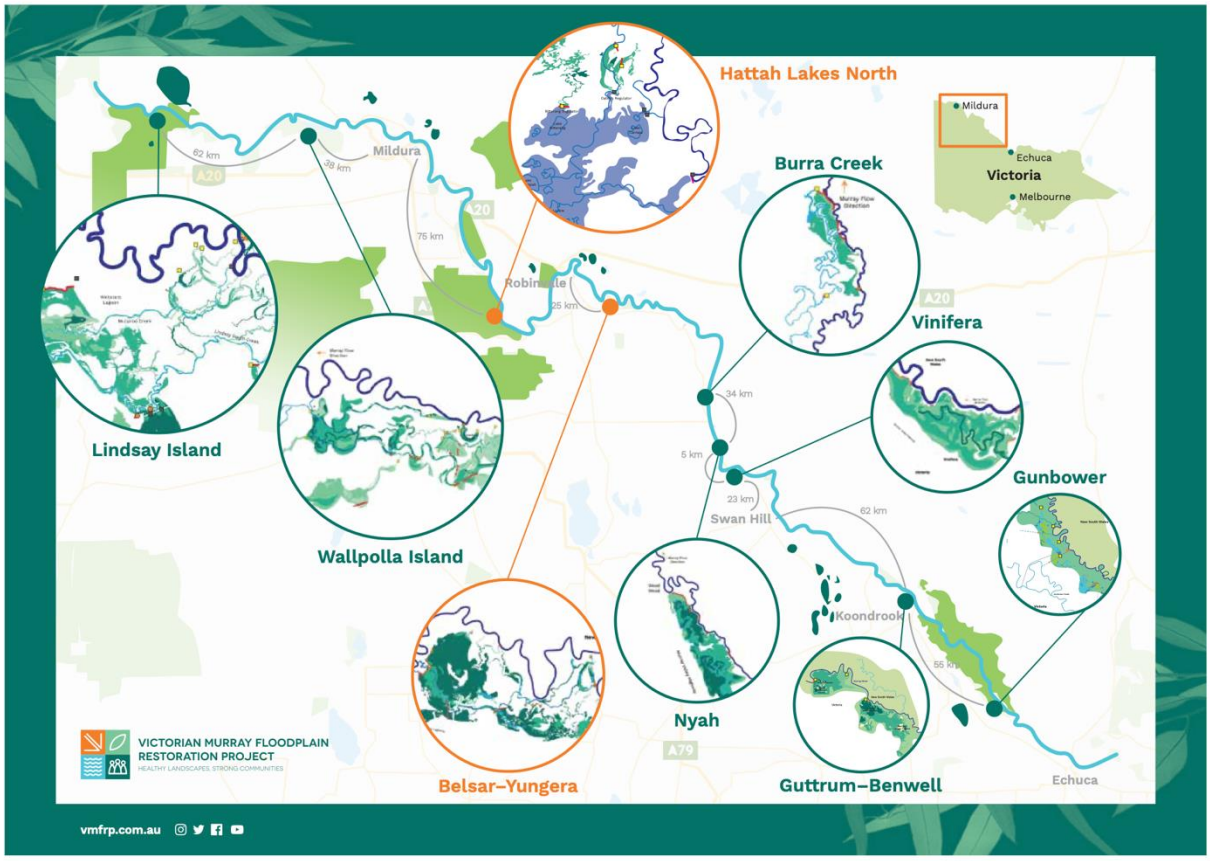


Figure 104: Victorian Murray Floodplain Restoration Project sites (courtesy of VMFRP)

The ecological benefits of environmental watering events depend on their extent, timing, duration, and frequency. By relaxing constraints, we can provide short duration events extending to the minor flood level. The VMFRP, on the other hand, allows for extended watering events at flows equivalent to major flood events when necessary.

Analysis of the interaction between constraints relaxation and the Victorian Murray Floodplain Restoration Project (VMFRP) was undertaken by DEECA. For each VMFRP site, the modelled flow frequency, duration and the longest intervals between environmental watering events for the primary ecological water regime classes of each of the VMFRP sites was compared with the flows that would be achieved by implementing the notified relaxation of constraints alone.

The flow regime in the Murray was modelled by the MDBA. Models were run for:

- Current river operating rules assuming 2,100 ML of water have been recovered for the environment using both historic conditions and climate change conditions; and
- Revised river operating rules assuming the notified Constraints have been implemented for both historic and climate change conditions.

The main findings of the analysis were that the flows enabled by relaxing constraints cannot meet the key ecological watering requirements of any of the VMFRP sites during prolonged droughts or under climate change.

Relaxing constraints would provide little or no watering to the floodplain of the following VMFRP sites:

- Hattah North
- Wallpolla Island
- Lindsay Island

Parts of the floodplains of the following VMFRP sites would be watered for varying extents under relaxed constraints, but not during prolonged droughts or climate change:

- Gunbower
- Belsar-Yungera,
- Guttrum
- Benwell,
- Burra and
- Nyah
- Vinifera

> *"Relaxing constraints and the Victorian Murray Floodplain Restoration Project (VMFRP) are essential to the preservation of regional communities in Northern Victoria."*
>
> Consultative Committee Member

Overall, modelling indicates that the flows enabled by relaxed constraints would not remove the need for the VMFRP works to reconnect the higher parts of the VMFRP sites to the river. While relaxing constraints could improve the environmental flow regime at the lowest parts of some of the VMFRP sites, it would not meet their key ecological watering requirements particularly under extended droughts and climate change. VMFRP works are needed to provide the timing, duration and frequency of watering required to restore the wetlands and floodplains of the VMFRP sites.

The Committee spoke of the need for both projects to ensure that key ecological sites across Northern Victoria are maintained and restored through environmental watering.

10.3 Regulatory approvals

The regulatory approvals process for relaxing constraints along the Murray River would have to comply with Victorian, New South Wales and Commonwealth legislation and many regulatory authorities because the project spans jurisdictional boundaries. The approach to navigating regulatory approvals must consider how relaxing constraints on the Goulburn River would affect the Murray River, as well as how relaxing constraints on the Murray River could affect downstream reaches of the Murray, including within South Australia.

The cross-border nature of the Murray River and its floodplains means that Key Approvals must be obtained under both Victorian and New South Wales legislation for the Murray River constraints measures to be delivered, whilst delivery of the Goulburn River constraint measures requires Victorian-based Key Approvals. Both projects require consideration under Commonwealth environmental approval.

The Victorian Constraints Measures Program must be considered in context with the Basin Plan, and the other Basin Plan related projects that complement and support improved environmental outcomes. Legislation in each jurisdiction has been designed to assess projects that have the potential to cause adverse environmental impacts. They have not been designed to assess environmental enhancement projects such as the Constraints Measures Program and experience with other projects of this nature such as the VMFRP has shown that the processes are complex, costly and time consuming.

The Committee expressed concern that the Victorian CMP would be assessed in the same manner as a freeway or coal mine which would be a very expensive process, take many years and be inappropriate. The Committee confirmed a sensible approach should be taken in relation to the environmental approvals of projects of this nature.

An indicative schedule was prepared for the feasibility study that assumed current regulatory pathway. It indicated that key approvals would take approximately 36 months to complete, noting that this is reliant on successful engagement between the Australian Government, New South Wales and Victorian governments to establish a partner agreement that allows for a workable interjurisdictional environmental assessment approach.

The feasibility study strategy identified the key steps to expedite the regulatory approvals including:

- clear and ongoing engagement with regulatory authorities
- early identification of program assets, values and uses to inform development of an interjurisdictional framework to frame the program's benefits and adverse impacts; and
- commencement of a referral self-assessment process informed by assets, values and uses.

The current environmental approval process for a project of this scale, nature and cross-border interfaces is complex, expected to be very expensive and take 3 years or more to complete. As part of any future stage of the Constraints Measures Program, the New South Wales, Victorian and Commonwealth (as funder) Ministers must agree on the interjurisdictional approval framework for the program across all states.

10.4 Water for the Environment Special Account

The Committee raised concerns that the work undertaken to date as part of the Victorian CMP has not demonstrated that the environmental outcomes of the Water for the Environment Special Account (WESA) can be achieved. Part 2AA of the Commonwealth *Water Act (2007)* deals with the Water for the Environment Special Account (WESA).

The WESA was established in 2013, with the aim of enhancing the environmental outcomes of the Basin Plan via the protection of environmental assets and biodiversity. Section 86AA of the Water Act details the ways in which the WESA can enhance environmental outcomes, such as reducing salinity in the Coorong and Lower Lakes, and increasing the water resources available for environmental use.

Many of the environmental outcomes included under Section 86AA relate specifically to outcomes measured in South Australia. This feasibility study has not attempted to include the outcomes in South Australia as part of the investigation, however as discussed above, the relaxing constraints scenarios modelled for the Goulburn and Murray Rivers do not appear to have a significant effect on the frequency and duration of high flows at the South Australian border. It is therefore assumed that the enhanced flows enabled by relaxing constraints in Victoria alone would be unlikely to meet all of the objectives of Section 86AA.

It is expected that relaxing constraints would support sub-clauses (f) and (g) of Section 86AA, namely:

- providing opportunities for environmental watering of floodplains in the River Murray System to
    i. improve the health of forests and the habitats of fish and birds
    ii. improve connections between the floodplains and rivers in the River Murray System
    iii. replenish groundwater.
- increasing the flows of rivers and streams, and providing water to low and middle level floodplains and habitats that are adjacent to rivers and streams, in the River Murray System to:
    i. enhance environmental outcomes within those floodplains, habitats, rivers and streams
    ii. improve connections between those floodplains and habitats, and those rivers and streams.

This feasibility study has looked at the Goulburn and two reaches of the Murray River in isolation. Further investigations are required to determine the combined and cumulative benefits and risks of relaxing constraints through all SDLAM constraint project areas along the Murray and tributaries.

The Committee supports an assessment of the broader system-level benefits and risks including a detailed system-level cost-benefit analysis to inform future stages of the Victorian CMP and the broader MDBA Constraints Management Strategy.

10.6 Co-ordinating environmental flows

The modelling undertaken for this investigation has not attempted to optimise river releases based on coinciding flows from the Goulburn in the Murray. Modelling for this study has looked at the scenarios of increasing the constraint limits under current river operations to achieve the flows under consideration. The modelling takes every opportunity to boost flows to best meet each individual environmental target flow downstream over winter and spring for the full period of modelling. In fact, if releases were optimised to align flows as part of the modelling assumptions, it is likely it would show improved River Murray system environmental outcomes compared to those presented because releases would be more targeted.

Environmental water managers and river operators already consider and achieve coordinated flows. In order to improve how this can be done, the Enhanced Environmental Water Delivery (EEWD) project is looking at the tools that would be required to improve outcomes under relaxed constraints.

This is the first time that model outputs from relaxed constraint scenarios in the Goulburn have been used as inputs to the Murray model. There are future opportunities to also incorporate the outcomes of constraint relaxation through the other rivers in the other states as part of the MDBA's Constraints Management Strategy. Such system level modelling should be undertaken to provide a complete picture of what may be achievable.

The Committee supports further system level modelling to determine whether the notified flow rates can be achieved through the system or whether lower levels may be more appropriate.

11 Moving forward

- Proceeding to the next phase is recommended. However, this would require the support and alignment of Ministers from the Australian Government, New South Wales, and South Australia.
- To ensure fairness and consistency for landowners on both sides of the river, a unified and consolidated approach by the Australian Government and all states is needed.
- Further coordinated planning between states is needed to understand system-wide implications, including the feasibility of achieving flow objectives at the SA border.
- Since the river system is interconnected, it is crucial to consider the benefits and costs for both sides of the Murray River, and downstream at a system level. This should be completed as part of prudent whole-of-system business case development.
- Current regulatory approval processes may not be suitable for assessing interjurisdictional environmental enhancement projects like the CMP. This may warrant a review of these processes with the Australian Government and other states.
- Most Committee members recommend that relaxed constraints should only be used to provide greater flexibility to deliver water for the environment.
- It's crucial that communities and individual landowners have ample information and time to understand the impacts and implications of compensation and mitigation approaches.
- Meeting the original 2024 deadline for full program implementation is impractical, due to the need for extensive consultation and impacts assessment. This could potentially raise concerns among regional communities if additional water buybacks are pursued. It is noted that the *Water Amendment (Restoring Our Rivers) Act 2023* was enacted at the end of the Committee's tenure which extended the completion date of the SDLAM projects to 31 December 2026.
- Progression of the CMP must continue to be carried out using a community co-design approach, which puts those who will be affected by the project at the centre of discussions.
- As the CMP progresses, DEECA will continue to partner with Traditional Owners in line with Pupangarli marnmarnepu. DEECA acknowledge Aboriginal Victorians have the right to make choices that best reflect them on their journey to self-determination and are committed to delivering real outcomes by following their lead.

11.2 What is expected if we do nothing more?

Moving to the next stage of the Victorian Constraints Measures Program (CMP) is recommended.

In a scenario where no further action is taken and current river operations persist, regulated environmental flows would mostly be restricted to the primary channels of the Goulburn and Murray Rivers. In addition, the currently available water for the environment would continue to face competition for channel capacity against other entitlements. This approach proves insufficient as the species targeted for environmental preservation are predominantly situated within the floodplain areas. Additionally, species present in the main river channels also rely on connections to the floodplain. Consequently, this approach lacks the capability to break the cycle of severe decline that currently afflicts both river systems and the broader Basin.

Figure 105: Defoliation of vegetation – courtesy of GBCMA

Species relying on floodplain habitats for crucial stages of their life cycles are anticipated to diminish progressively. Likewise, species within the river channels will also experience population decreases. The disconnection of vital floodplain-originating food sources reverberates through the entire food web. This impact extends from the foundational biofilms and macroinvertebrates, through small fish and crustaceans, up to the birds and platypus that rely on these fish and smaller invertebrates as sustenance.

By constraining flows within the river channels, there is a notable increase in the erosive action of water along the riverbanks, leading to escalated erosion rates. In a "do nothing more" scenario, the accelerated pace of bank erosion will persist. Such rapid erosion holds implications for populations of species heavily dependent on bank habitats. This includes aquatic plants, macroinvertebrates, fish, and platypus.

Moreover, the continuous delivery of environmental water within the river channels does not optimise its efficient use. Allowing more environmental water to be delivered up to the new constraints will likely reduce storage levels at times, creating dam airspace and reducing the chance of spills at higher levels. Instances of late-season spills onto floodplains can elevate the influx of carbon into rivers, intensifying the risk of water

quality problems. Additionally, there's an increased potential for the flooding of critical breeding sites for platypus and turtles.

All constraints study reaches are predicted to experience a warmer and drier future climate, with increased likelihood of extreme droughts and floods. Modelling undertaken for the current constraints for different climatic conditions show negative impacts on hydrological metrics in both rivers, causing substantial decreases in mean annual flows, overbank events, and freshes and increases in cease-to-flow events. Climate change represents significant risks for ecological outcomes with the condition of ecological values expected to decline as the climate warms and dries. Environmental water shortfall volumes are also expected to increase under climate change as tributary flows and entitlements decrease.

The investigations have determined that substantial and meaningful environmental advantages can be anticipated through the relaxation of existing constraints. These benefits extend broadly across the landscape and encompass all valued aspects. These positive outcomes are observed not only within specific sections of the river but also accumulate system wide. Although some environmental risks accompany the relaxation of constraints, they are expected to be primarily localised and manageable.

Moving to the next stage of the Victorian Constraints Measures Program (CMP) is recommended, however this would require the support and alignment of Ministers from the Australian Government, New South Wales, and South Australia.

Since the river system is interconnected, it is crucial to assess and consider the benefits and costs for both sides of the Murray River, and downstream at a system level.

11.3 The need for a coordinated approach

The key focus area of the Murray River scope within the Victorian CMP are cross-jurisdictional in nature - the river serves as the boundary between New South Wales and Victoria. Higher flows in the river result in the inundation of land on both sides of the river, impacting both states. The Hume to Yarrawonga scope is jointly led by Victoria and New South Wales, while the investigation along the Yarrawonga to Wakool reach is primarily led by New South Wales.

Decisions on relaxed constraint flow rates for the Murray River cannot be made by either state in isolation. Victoria, New South Wales and the Australian Government need to agree on which relaxation options should be considered should Ministers agree to progress the Program.

Constraints relaxation decisions in the Hume to Yarrawonga reach should affect the decision on the extent of relaxation in the downstream Yarrawonga to Wakool reach of the Murray. This is also the case for the mid and lower reaches of the Goulburn River. Similarly, constraints relaxation decisions on the Murrumbidgee and Goulburn rivers may be influenced by the downstream benefits and costs on the Murray.

> *"It is essential for the delivery of the Constraints Measures Program that there is a pathway to coordinate projects across the states. System wide environmental water deliveries will be critical to the resilience of the Basin under a changing climate."*
>
> Consultative Committee Member

The hydrology models for the Goulburn and Murrumbidgee are independent of the MDBA Murray model. This is managed by inputting outputs from the Goulburn and Murrumbidgee models into the Murray model. The limitation of this approach is that the Murray model cannot call out and optimise the use of environmental water from the Goulburn and Murrumbidgee models to supply environmental demands in the Murray. Work arounds have been developed by including Murray environmental water demands to be delivered from the Goulburn River in the Goulburn model.

This is the first time that model outputs from relaxed constraint scenarios in the Goulburn have been used as inputs to the Murray model. Work completed to date shows that the relaxation of constraints in the Goulburn River will have flow on impacts to the benefits in the Murray River. There are future opportunities to also incorporate the outcomes of constraint relaxation through the other rivers in the other states as part of the Constraints Management Strategy. Such system-level modelling should be undertaken to provide a complete picture of what may be achievable. Further work may determine whether the notified flow rates can be achieved through the system or whether lower levels may be more appropriate.

The Committee advises that broader system level modelling including considerations of all tributary inflows should be undertaken. It is also important that the costs and benefits (including a detailed cost-benefit analysis) of constraint relaxation downstream of Wakool should be assessed. This would involve assessing the benefits and costs along the Murray from Wakool Junction to at least the South Australian border and engaging with Traditional Owners, affected landholders, communities and stakeholders.

11.4 An agreed scope

To ensure fairness and consistency for landowners on both sides of the river, a unified and consolidated approach is needed to be agreed by the Australian Government and all states. This approach should:

- Assess and combine the benefits and costs from New South Wales, Victoria, and South Australia.
- Establish a clear plan for further engagement with landholders and communities.
- Define the selection of flow scenarios.
- Address the approach for acquiring easements.
- Outline the strategy for mitigating impacts on landholders and public land managers.
- Detail the process for obtaining interjurisdictional regulatory approvals.
- Define river operating arrangements and accountability, including for any residual liabilities.

Additionally, it is essential to have a clear commitment from the Australian Government regarding funding to support the program's advancement in all states.

Progression of the Constraints Measures Program must continue to be carried out using a community co-design approach, which puts those who will be affected by the project at the centre of discussions. This is in line with previous MinCo directives and the *MDBA Constraints Management Strategy (2013).* This inclusive approach aims to identify potential impacts and seek solutions collectively.

By following this aligned approach, all states can move ahead with the program in a way that considers the interests of all stakeholders and the benefits and costs at a system level.

11.5 Coordinated delivery of future project stages

The Murray-Darling Basin Agreement requires decisions regarding Murray River operating rules to be made jointly by the states and must be unanimous. The Murray must be operated on a single set of operating rules and Victoria and New South Wales must agree on the relaxation of constraints along the Murray. Victoria is accountable for decisions to change in flow rules that apply to the Goulburn River and New South Wales is accountable for changes to flow rules on the Murrumbidgee.

The project teams from Victoria and New South Wales have shared data and information, participated in joint risk workshops, attended committee and governance meetings, and held regular progress meetings. NSW Reconnecting River Country Departmental representatives and the MDBA have also attended the Constraints Consultative Committee meetings. One of the landholder Consultative Committee members was also engaged in the NSW process.

Victoria and New South Wales have different delivery models for their respective constraints programs, reflecting differences in funding, and work programs. Each state has been responsible for engaging with landholders who may be affected within their own jurisdictions.

It would be critical that the treatment of landholders, communication and messaging is consistent across both sides of the border should the constraints project progress to development of a business case. This would include aligning program delivery approaches and timelines, as well as maintaining a consistent approach when engaging with landowners and Traditional Owners. Additionally, it is important to strive for consistency in approaches to acquiring easements, compensating impacted landowners, and implementing mitigation measures.

> *"It makes sense to have a consistent approach."*
>
> Consultative Committee Member

> *" A comprehensive cost-benefit analysis should be included in the next stage and should be conducted to align with the process being conducted in other states to allow for equitable compensation for affected landholders*
>
> Consultative Committee Member

Although legislative frameworks may differ, consistent approaches across state boundaries must be adopted.

In future phases of the Victorian CMP, the Committee supports further coordination between the project teams from all relevant state jurisdictions.

11.6 Future engagement

The Committee advised that, if the CMP proceeds to the next stage of business case development, wider stakeholder and community engagement should be a core component of program delivery. The Committee has provided guidance on its expectations around engagement for the next stages of the project. They have recommended that the next stage of the project meets with impacted landowners and occupiers. The Committee has stressed that any engagement needs to be supported with clear and concise information on the benefits, potential impacts, and mitigation as well as compensation options for different constraint relaxation scenarios.

The Committee raised concerns regarding the consultation process during this phase of the program, as they believed that all affected landowners should have been involved in the development of the feasibility study. The Victorian Government's approach is to initially assess the project's feasibility in collaboration with the Committee, before engaging with individual landowners. It is noted that although one-on-one landowner consultation is not part of this stage, it would be included if the program moves beyond the feasibility phase.

> *"We are not negotiating to put water on properties that have never had water on them before. You need to walk onto a property and discuss how they handle it when it happens now under natural conditions."*
>
> Consultative Committee Member

The Committee encouraged engaging with landowners and the community early and extensively to increase the chances of the program's success. They advised that presenting an inundation map to landowners without prior knowledge of the program's broader context is unlikely to yield positive results. Some Committee members suggested that as a program, Constraints may require multiple years of engagement to effectively involve the community based on their experience with previous projects that significantly changed landowner operations. The Committee advised that it is not feasible to implement the Victorian CMP by June 2024 in line with the original Basin Plan deadline. The *Water Amendment (Restoring Our Rivers) Act 2023* was enacted at the end of the Committee's tenure which extended the completion date of the SDLAM projects to 31 December 2026.

> *"Not only can't it [be implemented by June 2024], it is not desirable to rush the Program to give the work and consultation needed to maximise chances of its success."*
>
> Consultative Committee Member

Identifying and reaching out to individual property owners may pose challenges. However, it would be essential to conduct one-on-one consultations with all affected landowners to discuss the modelling outputs and evaluate potential impacts on their specific properties. In some instances, this would involve engaging with multiple individuals listed on the title and some land titles would also be held up in probate. Occupiers of affected lands (i.e. leaseholders) as well as landowners would need to be engaged.

The extent of inundation, as well as the timing, frequency, and duration of the flows should be discussed. The Committee advised that consistent messaging would be crucial to ensure everyone has equal access to the relevant information.

> *"What is risky is not telling everyone the same thing. Everyone needs to have the same information."*
>
> Consultative Committee Member

The Committee also noted that some people may feel impacted, despite not having properties that fall within the inundation footprint. The Committee recommended that to ensure a fair and inclusive process there would need to be a mechanism to ensure landowners who may not have property directly in the inundation areas have an opportunity to express their concerns and discuss potential or perceived impacts.

The Committee advised that future communication and engagement efforts should also emphasise the potential benefits of the program and clearly articulate the reasons behind its implementation.

The Committee recognised the need to address a potential mismatch between community expectations and the observed outcomes in the rivers, particularly regarding the reason for flows. Committee members highlighted a deficiency in the current communication of river flow information. While real-time data on river heights and flows can be found online, they believe there is a lack of clarity regarding the reasons behind the observed flows and the proportion attributed to environmental water deliveries compared to irrigation and other consumptive uses. There is a common perception among the community that high flows in the rivers are solely due to environmental water, whereas the reality is different.

Addressing this information gap and providing a clearer understanding of the various factors influencing river flows would be important in informing the public and avoiding misconceptions. The Committee suggests that developing tools such as mobile apps could facilitate this communication process. These tools would enable stakeholders to easily access and understand information about water deliveries, irrespective of whether constraints are relaxed or not.

The Committee recommended conducting additional validation of the inundation modelling output by involving individual impacted landowners and occupiers in the future engagement process. The imagery captured during the scenario flow rates in Spring 2022 would be instrumental in supporting the engagement activities and ensuring that the modelling accurately represents the areas inundated. This process aims to provide landowners with comprehensive information regarding the potential impacts of the program on their land.

> *"I would love to know in real time why the river is going up or down."*
>
> Consultative Committee Member

In addition to expanding engagement with impacted landowners and the broader community, continued partnerships with Traditional Owners are essential in any progression of the program. Moving forward, the next phase of the program presents further opportunities to continue to actively engage with Traditional Owners as rights holders and to extend involvement into further partnerships including on-ground investigations. There may be further opportunities to partner with Traditional Owners to identify areas of key cultural value that can be watered beyond the boundary or capability of the Constraints Measures Program.

The Consultative Committee discussed the need and approach for community engagement and advised that:

- The wider community does not currently understand the benefits and costs of relaxing constraints.
- Impacted landowners and managers are unaware of:
  - How their land is impacted by the relaxing of constraints through inundation extents and flow frequency, timing and duration.
  - How impacts and costs would be mitigated.
- It is unclear if there is broad community acceptance and sufficient social licence to implement any of the constraint relaxation scenarios.
- A consolidated report and engagement program should be prepared and released to inform the community and build understanding and social licence.
- It would take time to bring the community along with this program.
- Whole of system and engagement is required with a consistent approach
- One on one engagement with impacted landowners is needed if the project is to progress.

- Imagery from the higher flows in Spring 2022 would be a vital tool in on-going communication and engagement activities

11.7 Implications for the Basin Plan

Due to the time required to establish an agreed project scope with the Australian Government, New South Wales, and South Australia, along with further stakeholder engagement in line with the MinCo co-designed approach, it is not feasible to implement the CMP by the Basin Plan's original requirement of June 2024. The *Water Amendment (Restoring Our Rivers) Act* 2023 was enacted at the end of the Committee's tenure which extended the completion date of the SDLAM projects to 31 December 2026.

As recommended by the Committee, a comprehensive cost and benefit assessment at a broader system-wide level should be completed as part of prudent Business Case development. It's crucial that communities and individual landowners have ample information and time to understand the impacts and implications of compensation and mitigation approaches.

Given that the Victorian CMP is a component of the Basin Plan SDLAM suite of projects contributing to an offset of 605 GL, there is a risk to the success of future implementation if the Australian Government were to initiate potential shortfall recovery activities against the 605 GL before the CMP progresses through the necessary Business Case development, engagement, approvals, and implementation stages.

Furthermore, the recommendation from the majority of the Committee to consider overbank flows in the Goulburn River would lead to an increase in the notified constraint flowrate for the Goulburn River, which could potentially designate the Goulburn Project as a supply measure.

Since the success of this project relies on obtaining voluntary agreement from thousands of affected landowners, many of whom also hold water entitlements, initiating any potential shortfall recovery before implementing and subsequently evaluating the CMP would significantly hinder the attainment of social approval for the program's advancement.

Appendices

Appendix 1: Victorian Constraints Consultative Committee membership

The project team would like to acknowledge the efforts of all members and those who contributed to the Victorian Constraints Consultative Committee:

- Hon Patrick McNamara AM – Committee Chair
- Richard Anderson
- Jan Beer
- Margot Henty
- Ann Hodge
- Philippa Noble
- John Pettigrew
- Russell Pell
- Richard Sargood
- Sonia Cooper and Jay Whittaker – Yorta Yorta Nation Aboriginal Council
- Voytek Lapinski – Taungurung Land and Waters Council
- Norman (Tinawin) Wilson – First People of Millewa-Mallee Aboriginal Corporation
- Adam McLean – MDBA – River Operations
- Andrew Shields – GMW
- Chris Cumming, Mark Turner and Simon Casanelia – GBCMA
- James Kellerman – MCMA
- Erin Round, Anna Parker and Genevieve Smith– NCCMA
- Katie Warner and Corinne Hutchinson – NECMA
- Andrew Leahy – Victorian Farmers Federation Water Council Chair
- Sarina Loo and Beth Ashworth – Victorian Environmental Water Holder
- Geoff Turner and Adrian Weston – Murray River Group of Councils
- Adam Nitschke – Parks Victoria
- Amanda Johnson – DELWP Regions (Hume)
- Anthony Judd - DELWP Regions (Loddon)

Appendix 2: Environmental Flow Requirements

Table 25: Overbank flow recommendations for the Murray River[13]

Flow Component	Flow Rate (ML/day)	Timing	Duration	Frequency	Maximum Inter-Event Period	Ecological or Environmental Values	Constraints Scenarios it would apply to
Murray River – Hume to Yarrawonga Representative Gauge: Murray at Doctor's Point (409017) *DPIE (2020)*							
Small Overbank (OB2) Relies on relaxed constraints	>35,000	Aug–Feb (or anytime for natural events)	12 days minimum cumulative duration	3–4 years in 10 (35%)	5 years	Native Fish Native Vegetation Ecosystem Functions Breeding of Frogs	Y40D40 Y45D40
Small Overbank (OB1) Relies on relaxed constraints	>30,000	Aug–Oct (or anytime for natural events)	21 days minimum cumulative duration	3–4 years in 10 (35%)	5 years	Native Fish Native Vegetation Ecosystem Functions Breeding of Frogs	Y30D30
Murray River – Yarrawonga to Barmah Representative Gauge: Murray River d/s Yarrawonga Weir (409025) *DPIE (2020)*							
Small overbank (OB6) Relies on relaxed constraints	>40,000	Aug–Feb (or anytime)	21 days minimum cumulative duration (ideally >30 days)		5 years	Native Fish Native Vegetation Waterbirds Ecosystem Functions Breeding of Frogs	Y40D40 Y45D40

[13] Department Of Planning, Industry & Environment DPIE. (2020). Murray–Lower Darling Long Term Water Plan Part A: Murray–Lower Darling catchment. Retrieved from https://www.environment.nsw.gov.au/topics/water/water-for-the-environment/planning-and-reporting/long-term-water-plans/all-long-term-water-plans

Flow Component	Flow Rate (ML/day)	Timing	Duration	Frequency	Maximum Inter-Event Period	Ecological or Environmental Values	Constraints Scenarios it would apply to
Small overbank (OB4) Relies on relaxed constraints	>35,000	Aug–Nov (or anytime for natural events)	14 days minimum cumulative duration	5–8 years in 10 (65%)	3 years (ideally not more than 2 years)	Native Fish Native Vegetation Ecosystem Functions Breeding of Frogs	Y40D40 Y45D40
Small overbank (OB5) Relies on relaxed constraints	>35,000	Aug–Oct (or anytime for natural events)	30 days minimum cumulative duration^	3–4 years in 10* (35%)	5 years	Native Fish Native Vegetation Waterbirds Ecosystem Functions Breeding of Frogs	Y40D40 Y45D40
Small overbank (OB3) Relies on relaxed constraints	>25,000 for 21 days minimum cumulative duration & (before or after) >15,000 for 90 days minimum cumulative duration	Aug–Nov (or Aug–Jan for natural events)	21 days minimum (>25,000 ML/d) & (before or after) 90 days minimum cumulative duration (>15,000 ML/d) *for a total 3.5 months minimum cumulative duration of flow (for 4–5 months minimum inundation of Moira grass)*	6–10 years in 10 (70%)	3 years (ideally not more than 2 years to maintain vigour & cover of non-woody vegetation)	Native Fish Native Vegetation Waterbirds Ecosystem Functions Breeding of Frogs	Y25D25 Y30D30 Y40D40 Y45D40
Small overbank (OB2) Only overbank in some areas	>15,000 for 45 days minimum cumulative duration followed by >9,000 for 105 days minimum cumulative duration	Sep–Nov (or anytime for natural events) *Event can run until March depending on start of waterbird breeding*	45 days minimum >15,000 ML/d followed by 105 days minimum > 9000 ML/d (& 500 ML/d in Gulpa Creek) *for a total 5 months minimum cumulative duration to support*	4–8 years in 10 (60%)	2 years	Native Fish Native Vegetation Waterbirds Ecosystem Functions	Y25D25 Y30D30 Y40D40 Y45D40

Flow Component	Flow Rate (ML/day)	Timing	Duration	Frequency	Maximum Inter-Event Period	Ecological or Environmental Values	Constraints Scenarios it would apply to
			waterbird breeding to completion				
Small overbank (OB1) Dry scenario, only overbank in some areas	>15,000 (ideally 18,000 ML/d)	Aug–Nov (or anytime for natural events)	45 days minimum cumulative duration (ideally 90–120 days)	6–10 years in 10 (75%)	2 years	Native Fish Native Vegetation Ecosystem Functions Breeding of Frogs	Y25D25 Y30D30 Y40D40 Y45D40

Table 26: Overbank flow requirements for the Goulburn River

Flow Component	Flow Rate (ML/day)	Timing	Duration	Frequency	Maximum Inter-Event Period	Ecological or Environmental Values	Constraints Scenarios it would apply to
Lower Goulburn River **McCoy's Bridge** ***University of Melbourne (2020)[14]***							
Overbank or high flows (channel forming event)	Opportunistic event – aim to provide as high as possible an event by utilising or re-creating natural events. Where overbank not possible, still provide as large an event as possible for channel maintenance and	Ideally late winter to spring or as naturally induced Not during summer to minimise black water events	Areas on the lower floodplain will fill instantaneously 5 days at peak to fill larger wetlands (base this on opportunity to piggyback).	As often as possible given natural flow events. Aim for an event >10,500 or as high as possible each year (rainfall runoff or release) >20,000 7 in		Opportunistic Fish Periodic/Equilibrium Fish Instream Productivity Macroinvertebrates Littoral/Bank Vegetation Instream Habitat Complexity Turtles Platypus	M10L17 (targeting flows up to 17,000 ML/d at Shepparton) M10L21 (targeting flows up to 21,000 ML/d at Shepparton)

[14] University of Melbourne (2020) Kaiela (Lower Goulburn River) Environmental Flows Study

	forming. >30,000 ML/d allow significant area of floodplain vegetation to be inundated >20,000 ML/d inundates floodplain near Loch Garry >10,500 ML/d starts to inundate low lying floodrunners and anabranches			10 years or as per natural rainfall runoff >30,000 Natural frequency.		M12L21 (targeting flows up to 21,000 ML/d at Shepparton) M14L25 (targeting flows up to 25,000 ML/d at Shepparton)
Mid Goulburn River **Reach 1: Downstream of Lake Eildon to Yea; 85km** **Reach 2: Yea River Confluence to Sunday Creek; 45km** **Reach 3: Sunday Creek to Nagambie (Upstream of Goulburn Weir); 65km** ***GBCMA (2014)[15]***							
Overbank	15000 – 20000	Winter/Spring	1-4 days	1 every three years in dry years, 1 in 2 years in average and wet years	Geomorphology Native Fish Native Vegetation Macroinvertebrates	Although no flow scenarios meet these requirements, any flows at the levels of relaxed constraints (12,000 ML/d or 14,000 ML/d) would be targeted once per year for mid-Goulburn environmental outcomes.

The Goulburn and Murray hydrological models targeted the environmental flow demands, including the overbank flows listed above.

[15] GBCMA (2014) Mid Goulburn River FLOWS study- Final report: Flow recommendations. Retrieved from https://www.vewh.vic.gov.au/__data/assets/pdf_file/0003/357546/Mid-Goulburn-FLOWS-study-final-report-051214.pdf

Appendix 2: Glossary

Term	Definition
Assets	Assets are resources that provide benefit. This includes, for example, infrastructure such as roads, bridges, pipes and pumps, water assets such as dams, and community assets such as sporting facilities, camping grounds and Parks. Natural assets are assets of the natural environment, for example waterways, wetlands and vegetation.
Anabranches	Branch of a river that leaves the mainstem and re-joins it downstream.
Bank-full flows	The maximum amount of water a river channel can hold before overflowing over or through the riverbanks onto the adjacent floodplain. Engages the riparian zone, anabranches and flood runners and wetlands located within the meander train. Inundates all in channel habitats including all benches, snags, and backwaters. Source: DPIE
Baseline, or base case	Conditions regarded as a reference point for the purpose of comparison.
Basin Plan	Is an agreed approach between the Basin state governments on how water is to be managed in the Murray Darling Basin. The Basin Plan was passed into law in November 2012 under the Water Act 2007.
Basin state	A state (or territory) with an area of the Murray–Darling Basin within its borders. Usually, the term is used to mean the governments of those states. The Basin state governments are New South Wales, Queensland, South Australia, Victoria and the Australian Capital Territory.
Billabong	Billabongs are wetlands will lakes on the floodplain that originate from a change in the course of the river over time. They are also called, oxbows, or cut-off meanders. Ryan's lagoon downstream of Lake Hume is an example of the cut-off meanders.
Black box	Black Box (*Eucalyptus largiflorens*) is a tree native to Australia, which relies on regular flooding to maintain health and promote regeneration. Black box typically are found on the outer edge of the floodplain.
Bulk entitlement	A right to use and supply water in a waterway, water in storage works of a water corporation. Water corporations and other specified bodies defined in the Water Act 1989 can hold bulk entitlements
Commonwealth Environmental Water Holder	Commonwealth government body responsible for managing the Commonwealth environmental water portfolio.
Carryover	An arrangement that allows a water entitlement holder to take unused water allocations from one season into the next season to use and/or trade.
Confluence	The place where a tributary stream flows into the mainstem of river.
Connectivity	Connections between natural habitats, such as a river channel and adjacent wetland areas. Connectivity is a measure or indicator of whether a water body (river, wetland, floodplain) has water connections or flow connections to another body.
Constraint	An operating limit on the rate of regulated flow that can be released from a storage put in place by river operators to minimise the risk of inundating private land on the floodplain.
Constraints Measures	Constraints Measures are projects for relaxing constraints within specified river reaches defined in the Constraints Management Strategy and notified as Supply Measures projects under the Sustainable Diversion Limit Adjustment Mechanism.

Term	Definition
Constraints Management Strategy	Is a strategy released by the MDBA in 2013 that identifies the primary operating constraints in the southern connected basin and sets out a strategy for relaxing constraints, including Constraints Measures projects in the Goulburn River and the Hume to Yarrawonga and Yarrawonga to Wakool reaches of the Murray River.
Country	A geographic area and its lands, waters, seas and living things to which Traditional Owners have a connection and are part of. The term also carries with it concepts that include but are not exclusive to cultural practice, language, lore, family and identity.
Crown land	Land is owned by the state, often referred to as public land.
Dam	A structure built across a river , primarily to store water , but sometimes also to control flooding and generate electricity
Delivery of water	Physically getting water to the users who have ordered it. This includes providing water to state storages (in some cases), individual irrigators and environmental water holders. This involves managing the flows and connections of water in the river system.
Ecological Vegetation Classes (EVCs)	A vegetation classification system used in Victoria derived from groupings of vegetation communities based on floristic, structural and ecological features.
Ecosystem	A biological community of interacting organisms and their physical environment. It includes all the living things in that community, interacting with their non-living environment (weather, earth, sun, soil, climate and atmosphere) and with each other.
Edward Wakool system	The Edward River (Kolety River) is the largest anabranch of the Murray River and breaks away from the river at the Barmah choke. The Edward River flows through the Southern river land of New South Wales. Before re-joining the Murray, the Edward splits into the Wakool River. The Wakool River flows into the Murray River north of Swan Hill.
Environmental entitlement	A right to water granted to the Victorian Environmental Water Holder to maintain an environmental water reserve or improve the environmental values and health of the water ecosystems and other users depending on the condition of the environment. Source: Victorian Water Register
Environmental flow	The release of environmental water from storage with the intention of maintaining or improving river health.
Environmental flow event	A single event of the release of environmental water from storage.
Environmental water	Water available under a water access right or a bulk entitlement for the purposes of achieving environmental outcomes (including water specified in a water access right to be for environmental use).
Environmental water requirements	The amount of water needed to meet and ecological environmental objectives.
Flood	Flows that are high enough at their peak to overrun riverbanks or cause flow through high-level anabranches, flood runners or to wetlands and other floodplain features.
Floodplain	Flat or nearly flat land adjacent to a stream or river that experiences occasional or periodic flooding. Natural floodplains are some of the most diverse and productive ecosystems on Earth.
Floodplain depression	Floodplain depressions are shallow depressions on the floodplain that resemble lakes and are connected to the river system and can be inundated at a high bank full flows and low overbank flows undated. An example of a floodplain depression in the study area is Lake Moodemere.

Term	Definition
Flood-runner	A natural channel on the floodplain, which carries flowing water, only during periods of high flow or flood.
Flow	The rate of water discharged by a river measured in terms of volume per unit time, e.g.ML/day.
Flow components	A classification of the different elements that make up the characteristic patterns of river flow. They typically include ‘cease-to-flow’ periods, ‘base flows’, ‘freshes’, ‘bank-full flows’ and ‘over-bank flows'.
Flow regime	The characteristic pattern of river’s flow quantity, timing, and variability.
Gauging	Physical measurement of instantaneous streamflow to develop the stage-discharge relationship.
Gigalitre	1,000 megalitres, which also is 1,000,000,000 litres.
Goulburn River	The Goulburn River is a tributary of the Murray River that is located in northern Victoria. It is the largest river in Victoria by annual discharge and by length.
Goulburn Murray Water	Is a Victorian Water Corporation that manages water resources and water delivery in the Victorian Murray River and Goulburn Rivers.
Hume to Yarrawonga Reach	Is the section of the Murray River between Lake Hume and Lake Mulwala at Yarrawonga.
Hydraulics	The study of the conveyance of liquids through pipes and channels.
Hydraulic modelling	A computer simulation that combines topographic data and river flow equations to generate information about the depths and velocity of floods for different river flow levels.
Hydrology	The study of the occurrence, distribution, and movement of water.
Hydrological connectivity	The flow that links natural aquatic environments. Lateral connectivity is the flow linking river channels and the floodplain. Longitudinal connectivity relates to the consistent downstream flow along the length of rivers.
Hydrological modelling	Mathematical process or computer simulation representing part of the hydrologic cycle, used primarily for prediction of water behaviour within catchments and associated water supply systems.
Hydrometric	Monitoring of the hydrological cycle including rainfall, surface water and groundwater characteristics, as well as water quality.
Hypoxic Blackwater	Hypoxic (low oxygen) blackwater can be caused by high levels of organic matter in waterways combined with warm weather resulting in oxygen levels in water to drop. When too much oxygen is removed from the water, fish and other organisms struggle to breathe and may suffocate and die.
Inflows	Water flowing into a storage (reservoir or lake) or river system.
Inter-valley water trade	A transaction to transfer a water right or water allocation from one legal entity to another in a different trading zone or valley.
Inundation	To cover with water, usually by the process of flooding.
Key Approvals	Key Approvals are those that would typically by obtained by the Program proponent and include Commonwealth environmental approval, Victorian environmental assessment, Victorian planning approval, and Cultural Heritage Management Plan.
Levee	An embankment that is built next to a river in order to prevent the river from flowing onto adjacent land on the floodplain.

Term	Definition
Lower-Goulburn	Is the reach of the Goulburn River between Goulburn Weir and the confluence of the Goulburn River, with the Murray River.
Meander	A curve or bend in the course of a river.
Megalitre	1,000,000 litres.
Mid Goulburn	Is the catchment of the Goulburn River between Eildon Dam and Goulburn Weir.
Minor flooding	Flooding causing inconvenience. Low-lying areas next to watercourses are inundated which may require the removal of stock and equipment. Minor roads may be closed, and low-level bridges submerged.
Modelling	Application of a mathematical process or computer algorithm (such as a hydraulic or hydrololologic model) to simulate a natural phenomenon and Alan analyse the effects of changes in some characteristics.
Murray River	The Murray River (in South Australia: River Murray) is a river in south-eastern Australia. It is Australia's longest river at 2,508 km in length and flows through Victoria and New South Wales and South Australia. It forms the border between New South Wales and Victoria.
Murray Darling Basin	The Murray–Darling Basin is a large area of south-eastern Australia where water flows through a system of interconnected rivers and lakes. The mainstem of the Basin river system is the Murray River.
Murray Darling Basin Authority	The Murray Darling Basin Authority (MDBA) is a Commonwealth government agency that was established under the Water Act 2007 to manage water resources in the Murray Darling Basin.
Natural flow regime	Flow of a stream under natural, as opposed to regulated, conditions.
Over-bank flows	Flows that spill over the riverbank or extend onto the adjacent floodplain. They benefit a broad range of biota (including floodplain vegetation communities, birds and native fish) and support important ecosystem functions.
RAP	Registered Aboriginal Party. A corporate entity appointed by the Victorian Aboriginal Heritage Council that performs functions related to the protection and management of Aboriginal cultural heritage under the *Aboriginal Heritage Act* 2006 (Vic) and have access to the Victorian Aboriginal Heritage Register for their agreed RAP area[16]
Regulated flows	A river flow resulting from an upstream release from a dam and storage.
Regulated river	A river in which flow is controlled or regulated by dams and weirs.
Relaxing constraints	Lifting the operating limit on the rate of regulated flow that can be released from storage.
Riparian	The part of the landscape adjoining rivers and streams that has a direct influence on the water and aquatic ecosystems within them.
River channel	The part of the river where the water usually flows; it includes the bed and the lower part of the banks.
Riverbank	Riverbanks are the sides of the river between which water normally flows.
River reach	In this study defined as the length of river between two geographic points, such as between storages or between storages and the confluence with major tributaries.

16 DELWP's Traditional Owner and Aboriginal Community Engagement Framework, 2019

Term	Definition
River Murray System	The River Murray system (RMS) extends from Hume Dam, at Albury New South Wales, downstream to the Coorong, Lower Lakes and Murray Mouth in South Australia. It includes connected anabranches, creeks and major tributaries such as the Murrumbidgee, Edward–Wakool, Kiewa, Ovens, Goulburn, Broken, Campaspe, Loddon, Avoca and the lower Darling River (south of Menindee Lakes). Water delivery in the RMS is managed by the MDBA on behalf of Victoria, New South Wales and South Australia.
River red gum	A tree of the genus Eucalyptus Camaldulensis. It is one of around 800 in the genus. It is native to Australia where it is widespread, especially beside inland water courses.
Southern connected Basin	The southern-connected Basin is a term used to describe the River Murray and regulated reaches of its major tributaries, which include Murrumbidgee, lower Darling, Kiewa, Ovens, Broken, Goulburn, Campaspe and Loddon rivers.
Spill	When water is discharged from the storage when there is more water in supply than demand for water.
Stock and domestic	Use of water for nonurban domestic consumption (e.g., drinking, cooking, washing, watering household gardens, filling swimming pools associated with domestic premises) and to water stock on a property.
Storage	A hydrological feature in which water is stored including the bodies of water held behind weirs and dams. Examples of storages include Lake Eildon, Goulburn Weir, Hume Dam and Yarrawonga Weir.
Streamflow	The flow of water in streams, rivers, and other channels.
Sustainable Diversion Limit	The limit on how much water can be used by Basin towns, communities, farmers, and industries, over the long-term, while leaving enough water in the river system to sustain natural ecosystems. Sustainable diversion limits are set at a catchment level and defined in the Basin Plan.
Sustainable Diversion Limit Adjustment Mechanism (SDLAM)	A mechanism to adjust Sustainable Diversion Limits, requiring a suite of projects (supply and efficiency measures) to be implemented which offset the need to recover water from consumptive use under the Basin Plan
Traditional Owner	People who have cultural connections to country as First People and custodians of the land who may or may not be members of formally recognised groups. This is in accordance with the “to be heard and for the words to have actions” Traditional Owner voices report[17]
Traditional Owner Group	A group that represents the interests of Traditional Owners in a particular area.
Tributary	A river or creek contributing its flow to a larger river or other body of water.
Vegetation Quality	For this study relates to the vigour of the tree canopy, where health is measured by reference to the crown extent and density.
Victorian Environmental Water Holder	Is a Victorian Government statutory body responsible for holding and managing Victoria’s environmental water entitlements and allocations.

[17] Victorian Government’s *To be heard and for the words to have actions. Traditional Owner voices: improving government relationships and supporting strong foundations*, 2019

Term	Definition
Victorian Murray River	is the area covered by the Victorian Murray water resource plan area. The area is made up to connected regions. The part of the Victorian Murray within the study area of the Victorian Constraints Measures Program is the Victorian Murray River floodplain between Hume Dam and the confluence of the Wakool River.
Watercourse	A river, creek, or other natural watercourse (whether modified or not) in which water is contained or flows (whether permanently or from time to time). Source: Bureau of Meteorology
Water allocation	The specific volume of water allocated to water access entitlements in a given season or given accounting period.
Water - dependent ecosystem	An ecosystem or species that depends on periodic or sustained inundation, waterlogging or significant inputs of water for natural functioning and survival.
Water entitlement	A right to take/use/extract/have water delivered to a property boundary.
Water level	The elevation of the water surface at a particular time and date, measured relative to a specified datum.
Water trade	A transaction to transfer a water right or water allocation from one legal entity to another.
Weir	A structure built across a river to raise water levels to enable water to be diverted by gravity onto land. May also have a water storage function.
Wetland	Wetlands are areas whether natural, modified or artificial, subject to permanent or temporary inundation, that hold static or very slow-moving water and develop, or have the potential to develop, biota adapted to inundation and the aquatic environment. The definition of a wetland in the Victorian wetland classification framework includes This includes waterbodies such as lakes, swamps, billabongs, bogs, and marshes. Wetlands can be permanent, seasonal into medical and episodic. Source DELWP
Unregulated flow	A river flow not resulting from the upstream release from a dam and storage. Note unregulated flows can occur in both regulated and unregulated rivers.
Unregulated river	A river where flows are not controlled by upstream release from a dam and weirs.
Yarrawonga to Wakool	Is the section of the Murray River from downstream of Yarrawonga Weir to the junction of the Wakool River with the Murray River.