Macquarie-Castlereagh Regional Water Strategy: Analysis of using some of the flood mitigation storage in Burrendong Dam for water supply

This paper presents preliminary analysis on the potential benefits and impacts of using some of the flood mitigation storage in Burrendong Dam for water supply. It includes results presented in the *Draft Macquarie-Castlereagh Regional Water Strategy: Shortlisted Actions – Consultation Paper* [1] and additional analysis that responds to feedback received during public consultation on the draft strategy.

1. About the proposed action

The *Draft Macquarie-Castlereagh Regional Water Strategy: Shortlisted Actions – Consultation Paper* (consultation paper) released for public exhibition in October 2022 shortlisted an action that proposed to use a portion of Burrendong Dam's flood mitigation zone for water supply (also referred to as increasing Burrendong Dam's full supply level).

The consultation paper identified that this option warranted further investigation because it had the potential to:

- reduce water security risks for towns in the mid and lower Wambuul / Macquarie River system
- improve the drought security of water dependent industries
- be operated to ensure there is minimal change in the average volume of water flowing into the Macquarie Marshes.

2. Stakeholder feedback on the proposed action

During public consultation we heard strong support to progress the proposed action as a high priority as it was viewed as more cost effective and easier to implement than other major infrastructure options. There was also a suggestion to consider increasing the dam's full supply volume further to 120%.

There were concerns raised about this proposed action, including its impact on:

- the timing, duration and frequency of water releases from Burrendong Dam's flood mitigation zone and dam spills, and the resulting river flows in the mid and lower Macquarie river system.

[1] See Attachment 2 of the *Draft Macquarie-Castlereagh Regional Water Strategy: Shortlisted Actions – Consultation Paper* available from: www.water.dpie.nsw.gov.au/plans-and-programs/regional-water-strategies/what-we-heard/macquarie-castlereagh-regional-water-strategy

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Some stakeholders raised concerns that water releases from the flood mitigation zone are critical triggers for bird breeding events

- flooding risk for towns and properties downstream of Burrendong Dam
- changes to the effectiveness of planned environmental water.[2]

This paper has been published to provide information in response to this feedback and allow all parts of the community to use this analysis to inform future discussions and investigation of this option.

Important next steps for progressing this option will include:

- assessing the infrastructure and safety of the dam under Dam Safety NSW guidelines in order to understand whether the risks associated with reducing the capacity of Burrendong Dam to manage floods can be effectively mitigated
- discussions with the Murray Darling Basin Authority to ensure the option does not result in a net reduction in planned environmental water, as is required under the Basin Plan.

3. How the proposed action was assessed

The Macquarie Integrated Quantity and Quality Model (IQQM)[3] was used to assess how increasing Burrendong Dam's full supply level would impact the supply, demand and allocation of water in the river valley. It was assessed under the historic climate record, the long-term historical past climate (paleo-stochastic) and a dry future climate change (NARCliM) scenario.

The analysis assumed that:

- extraction remained within the long-term average annual extraction limit – i.e., the option could not be operated to exceed the extraction limits within the valley
- flows into the Macquarie Marshes and to the end of the system should not decrease on average over the long-term
- the current operational rules for managing the dam's flood bays (airspace operation rules) in the *Water Sharing Plan for the Macquarie and Cudgegong Regulated Rivers Water Source 2016* (water sharing plan) were maintained but the volume of water in the flood bays was changed to those in Table 1
- any increases in water supply would be used for increasing general security availability and reliability. This reflects the current rules and resource assessment system within the water sharing plan. However, this approach has only been used as a surrogate for quantifying the extra water available under the option. There are opportunities to share the benefits of the water availability from this option more evenly across town, Aboriginal, environment and consumptive needs but this would require changes in the water sharing and allocation processes in the valley.

[2] The regulated Macquarie and Cudgegong water sources have a number of planned environmental water provisions which are implemented under the water sharing plan, with the aim of enhancing environmental benefits.

[3] The IQQM model is a tool for planning and evaluating water resource management policies at the river basin scale.

Table 1. Burrendong Dam flood bay modelling assumptions

Flood operation zone	1,188 GL full supply level (Base case)	1,306.5 GL full supply level (Proposed option)
Bay 1	1,188 GL to 1,425 GL	1306.5 GL to 1,487 GL
Bay 2	1,425 GL to 1,545 GL	1,487 GL to 1,579 GL
Bay 3	1,545 GL to 1,687 GL	1,579 GL to 1,687 GL
Spillway	>1687 GL	>1687 GL

4. Modelling results

The strategic assessment showed that increasing the full supply level of Burrendong Dam to 1,306.5 GL (113% of active storage) could:

- increase long-term average annual diversions under the historic, long-term climate and dry climate change scenarios while maintaining total diversions below the diversion limit (Table 2)
- improve end of year water allocations to general security water users (irrigation and environmental water) under the historical climate (see Figure 1)
- maintain average end-of-system flows in the lower Bogan (Table 3)
- slightly reduce the average end-of-system flow into the Barwon River (Table 3, Macquarie End-of-System flow), but the option may be able to be operated to ensure there is no reduction in long-term average inflows downstream
- be operated to try and ensure there is no reduction in the average volume of water flowing into the Macquarie Marshes and end-of-system flows into the Barwon River; however, this needs further investigation, noting that further analysis is also needed on implications for timing, duration and frequency of end of system flows (Table 3).

Table 2. Changes in long-term average water diversions by licences in the Wambuul / Macquarie Regulated River under the option to increase Burrendong Dam's full supply level. These are compared to the base case.

Climate dataset	General security	Supplementary	High security
Historical	+9.1 (+3.7%)	+0.1 (+0.2%)	No change
Long-term climate	+8.4 (+3.2%)	-0.2 (-0.8%)	No change
Dry climate change scenario	+4.1 (+3.1%)	No change	No change

Figure 1. General security end of water year effective allocation based on the historical climate

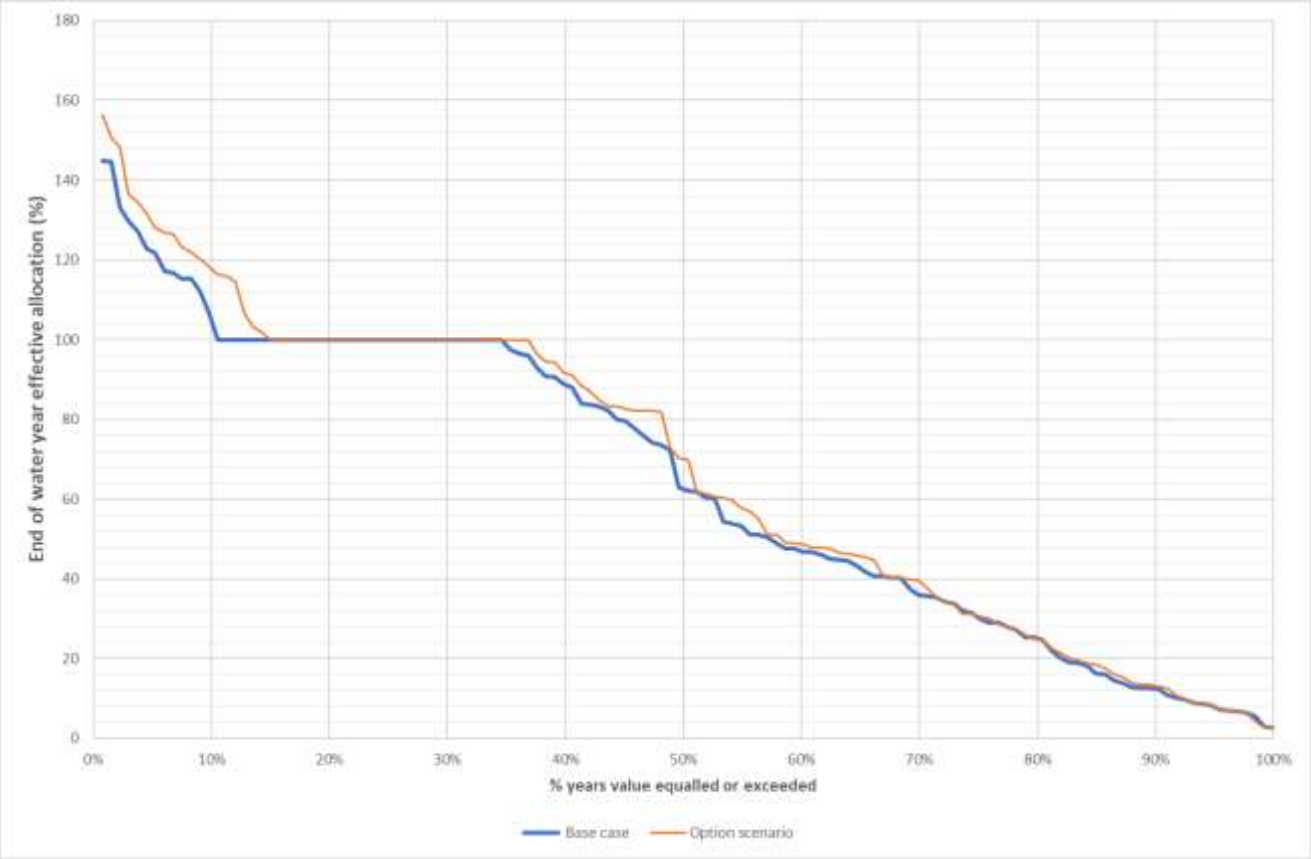

Table 3. Average annual river flow at selected locations (GL/year)

Stream gauge	Base case (GL/year)	Proposed option (GL/year)
Macquarie River downstream Marebone Weir (421090) *Marebone Weir supplies water to Marra and Bulgeraga creeks.*	305.3	305.0
Marebone Break downstream regulator (421088) + Macquarie River downstream Marebone Weir (421090) *Represent inflows into the Macquarie Marshes.*	466.7	462.0
Macquarie River at Oxley Station (421022) *Located in the Southern Macquarie Marshes.*	239.2	239.4
Gum Cowal at Bifurcation (421146) *Located in the Eastern Macquarie Marshes, which includes the Wilgara Wetlands portion of the Macquarie Marshes Ramsar site.*	47.5	46.1
Macquarie End-of-System flow (excluding Bogan)[4] *Represent inflows into the Barwon-Darling River system, excluding the Bogan.*	308.8	305.7
Bogan River at Gongolgon (421023) *Represents inflows into the Barwon-Darling River system from the Bogan River.*	159.9	160.0

[4] This is calculated using a combination of 421107 - Marra River at Billybingbone, 421012 - Macquarie River at Carinda, 421011 - Marthaguy Creek at Carinda, plus a number of ungauged flows.

5. Additional analysis

Additional analysis was undertaken in response to consultation feedback to understand how using a portion of Burrendong Dam's flood mitigation zone for water supply would change the frequency, timing and duration of flows at different points in the river, including changes to dam spills and water releases from Burrendong Dam's flood mitigation zone that are needed to support bird breeding events. This information can help inform future discussions about how to ensure there is no erosion in planned environmental water from the option.

Limitations

The following important limitations will be addressed in future analysis.

- The option needs further refinement around how the benefits of the additional water supply would be shared between water users, including the environment, Aboriginal water needs and town water supplies. Sharing of the additional water from the option would potentially require changes to water sharing plan rules or the available water determination process.
- Data is largely presented as long-term averages. Understanding how the option will change water availability and flows in specific events will be important to understand the benefits, impacts and potential mitigating actions required. The next stage of analysis will need to look at specific flood mitigation and operation events in greater detail to assess changes to flood peak flows, duration and seasonality. Gauge selection will also be important as some gauges do not operate beyond certain flooding levels.
- The modelling does not include the benefits of modern weather and rainfall forecasting, or the WaterNSW Flood Operation procedures that use this data to schedule releases to lessen flood impacts to a greater extent. This limits the model's ability to compare the option's impacts on flood operations and downstream flood levels with the base case. Recent flood mitigation operations in the Macquarie Valley have also produced a set of flood thresholds that could be used in future analysis.

Question 1: Will the option reduce the frequency of dam spills and water releases from Burrendong Dam's flood mitigation zone that are needed to support bird breeding events in the catchment?

Findings:

The analysis of the proposed option has found that:

- there is unlikely to be significant change in the frequency of spills from Burrendong Dam (see Table 4). Our modelling shows that the timing and frequency of spills from Burrendong Dam is the same under the base case and proposed option across the 130-year historic dataset
- the greatest change appears to be how much water is released from Burrendong Dam at the end of a flood event. Our modelling shows that more water would be released from the dam at the tail end of flood operations under the base case than under the proposed option. This could reduce the duration of bird breeding events and require the environmental water holders to use more held environmental water to complete nesting events. Conversely, the option could allow for more water to remain in storages for critical needs particularly if a future climate results in extreme wet and dry periods in close succession.
- the impact of these changes on bird breeding events, core wetland areas, floodplain vegetation, groundwater recharge, extending water supplies for critical needs during dry periods and connectivity to the Barwon-Darling will need to be assessed in further detail as part of further analysis of the option.

Table 4. Summary of flood mitigation release and spill frequency – historic climate dataset

Time in the flood mitigation zone	Base Case	Raised Full Supply Level
% days in Bay 1	5.3%	4.6%
% days in Bay 2	1.8%	1.8%
% days in Bay 3	1.7%	1.5%
% days spill	0.5%	0.6%

Question 2: Will the option erode planned environmental water?

There a number of planned environmental provisions within the regulated Macquarie and Cudgegong water sharing plan that aim to enhance environmental benefits.

Findings:

The impact of the option on planned environmental water will need to be considered in detail with the Murray Darling Basin Authority. The Basin Plan requires no net reduction in Planned Environmental Water. The analysis in this report can help to inform those discussions.

The analysis found that:

- the average volume of instream active planned environmental water would increase from 44.2 GL to 46.9 GL per year, but the instream translucent planned environmental water would decrease from 49.5 GL to 44.3 GL
- the number of fresh flows would increase but their average duration would decrease at selected locations (Table 5)
- the option would reduce the number of cease-to-flow periods at selected locations (Table 5)
- there are reductions in the average volumes of water flowing along different parts of the Macquarie River but increases in the median volumes (Table 5).

These changes will need to be considered in detail when considering any impacts on Planned Environmental Water, especially regarding the effectiveness of contributing to related ecological outcomes in the Macquarie Valley.

Further analysis will need to be undertaken on specific events to understand how flood peak flows, duration and seasonality may change to the wetland systems.

Table 5. Predicted change in river flows in the Wambuul / Macquarie River from increasing Burrendong Dam's full supply level to 1306.5 GL compared to the base case under the historic, long-term climate and dry climate change scenario

Stream gauge	Climate dataset	Mean annual flow	Median annual flow	Number of fresh events	Average length of fresh flows	Number of cease-to-flow events over a 130-year period
Dubbo (421001)	Historic	0%	1.8%	31.5 (+8.4%)	-7.7%	0%
	Long-term	-0.1%	2.4%	28 (+6.7%)	-6.3%	-0.1 (-5.8%)
	Dry climate	-0.1%	1.3%	14 (+4.1%)	-4%	-0.1 (-1.3%)
Warren Weir (421004)	Historic	-1.7%	2.5%	18 (+3.2%)	-3.1%	-5 (-19.2%)
	Long-term	-1.6%	1.8%	33 (+5.4%)	-5.1%	-0.2 (-0.9%)
	Dry climate	-1.2%	1.5%	6 (+1.2%)	-1.2%	-0.2 (-0.7%)
Inflow to Macquarie Marshes (421080 + 421090)	Historic	-1%	0.2%	16 (+2.8%)	-2.8%	-8 (-7.8%)
	Long-term	-0.9%	1.9%	36 (+6%)	-5.7%	-4 (-4.3%)
	Dry climate	-0.7%	1.1%	5 (+1%)	-1%	-1.5 (-0.8%)
Carinda (421012)	Historic	-2.1%	4.4%	13 (+5.2%)	-5%	5 (+12.8%)
	Long-term	-1.9%	1.1%	21 (+8.6%)	-7.9%	-1.5 (-3.7%)
	Dry climate	-2.2%	1.7%	0%	0%	-0.5 (-0.5%)

Question 3: How would the option impact downstream flooding?

Findings:

An indication of how the proposed option would impact flooding downstream of Burrendong Dam was assessed using flows at Narromine.[5] The hydrologic modelling provides an indication of river heights and flood flow volumes but it is not a flood hydraulic model, and therefore cannot predict flood inundation. Specific dam safety and flood risks will need to be considered as part of the detailed investigation of this option.

The hydrological modelling found that the proposed option would:

- increase the total days with above the medium flood level, but cause no change to the total days above the high flood level
- increase the percentage of years with 1 or more floods above medium flood level but cause no change to the percentage of years with 1 or more floods above the high flood level.

Table 6. Flood behaviour in the Macquarie River at Narromine

Metric	Base case	Proposed option
Total days with floods above medium (65,950 ML/day)	140	149
Total days floods above high (158,092 ML/day)	24	24
% years with 1 or more floods above medium	15.2%	17.4%
% years with 1 or more floods above high	4.5%	4.5%

Question 4: Why was an option of raising the full supply level to 1306.5 GL proposed?

The option in the consultation paper proposed further investigation of raising Burrendong Dam's full supply level from 1,188 to 1306.5 GL. This equates to an additional 151 GL of additional active storage volume[6] (13% increase).

Arriving at increasing Burrendong Dam's Full Supply Level to 1306.5 GL was the result of a two-stage assessment:

- **Stage 1:** Burrendong Dam's Flood Mitigation Zone has three bays. Bay 1 (100% to 120% Full Supply Level) contains almost half of the available flood mitigation airspace. Limiting an

[5] The hydrologic modelling provides an indication of flood flow volume but it is not a flood hydraulic model, and therefore cannot predict flood inundation. Specific dam safety and flood risks will need to be considered as part of the detailed investigation of this option.

[6] Active storage volume is total storage volume minus the dead storage volume of 34 GL. WaterNSW uses this value when reporting regional NSW dam levels on www.waternsw.com.au/supply/regional-nsw/dam-levels.

increase to the full supply level to within this bay is based on dam safety analysis of extreme floods.

- **Stage 2:** The analysis undertaken for the Macquarie Regional Water Strategy arrived at 1306.5 GL to ensure there was compliance with the Macquarie-Castlereagh's surface water sustainable diversion limit and that average flows to the Macquarie Marshes and the end-of-system were maintained over the long-term. Increases significantly above this full supply level may not meet these requirements.

The sustainable diversion limit referred to above is a term used in the Commonwealth's Basin Plan to define limits on the amount of water that can be used in the Murray–Darling Basin.[7] The Basin Plan prescribes a sustainable diversion limit volume for each surface water and groundwater management unit (SDL resource unit) in the Basin, including the Macquarie-Castlereagh. The Basin Plan requires NSW to manage extractions within sustainable diversion limits. The sustainable diversion limits can only be altered by the Murray–Darling Basin Authority if better information becomes available about the surface water or groundwater resources and the factors relevant to setting the limit.

[7] Surface water sustainable diversion limits are specified as a long-term average annual water use at a water management unit (SDL resource unit) level and on a Basin-wide scale.

Attachment 1

Figure 2. Annual flow exceedance: Macquarie River at Dubbo (421001)

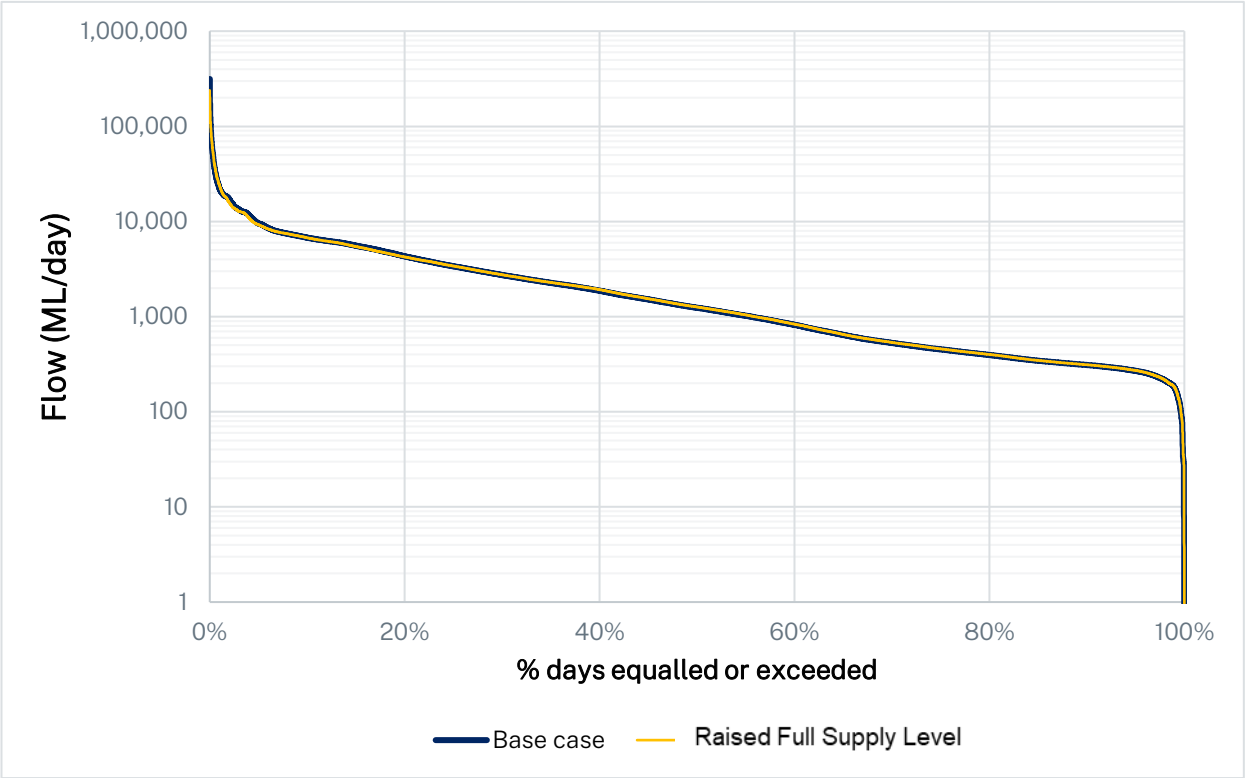

Figure 3. Annual flow exceedance: Macquarie River at Warren Weir (421004)

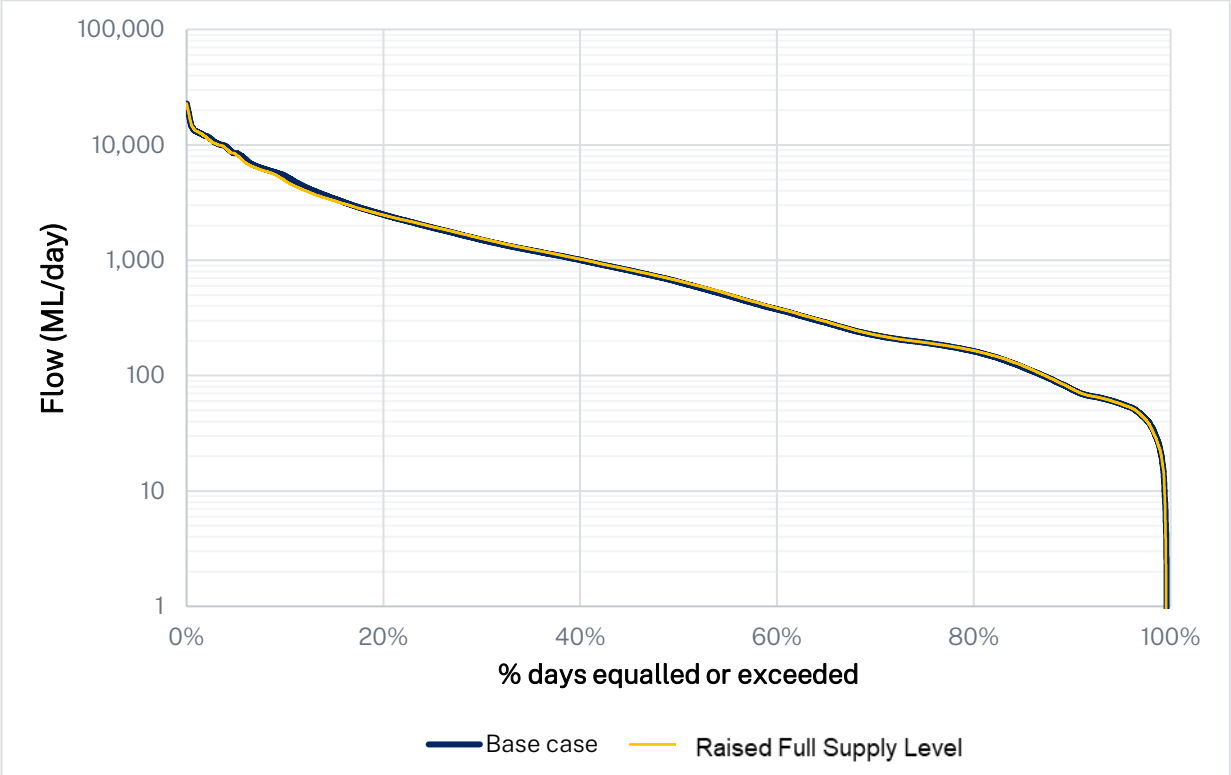

Figure 4. Annual flow exceedance: Macquarie River at Carinda (421012)

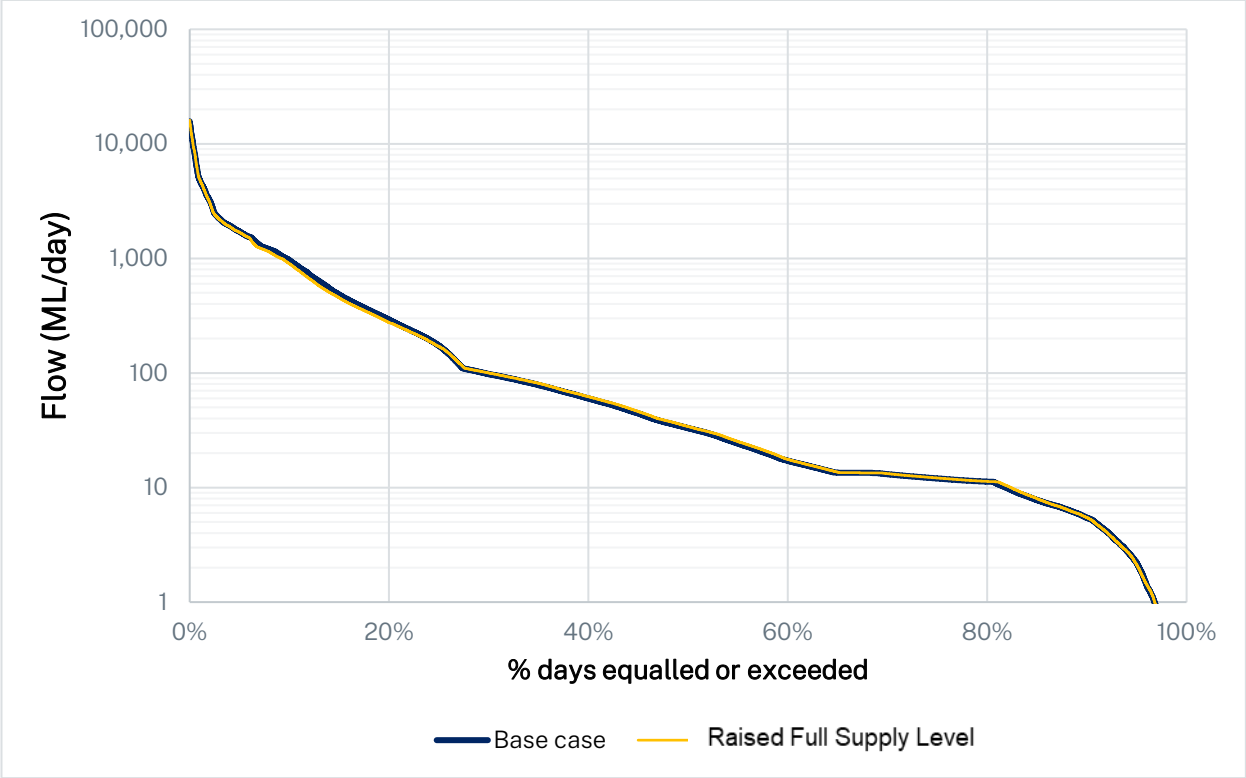

Figure 5. Annual flow exceedance: Macquarie River at Baroona (421127)

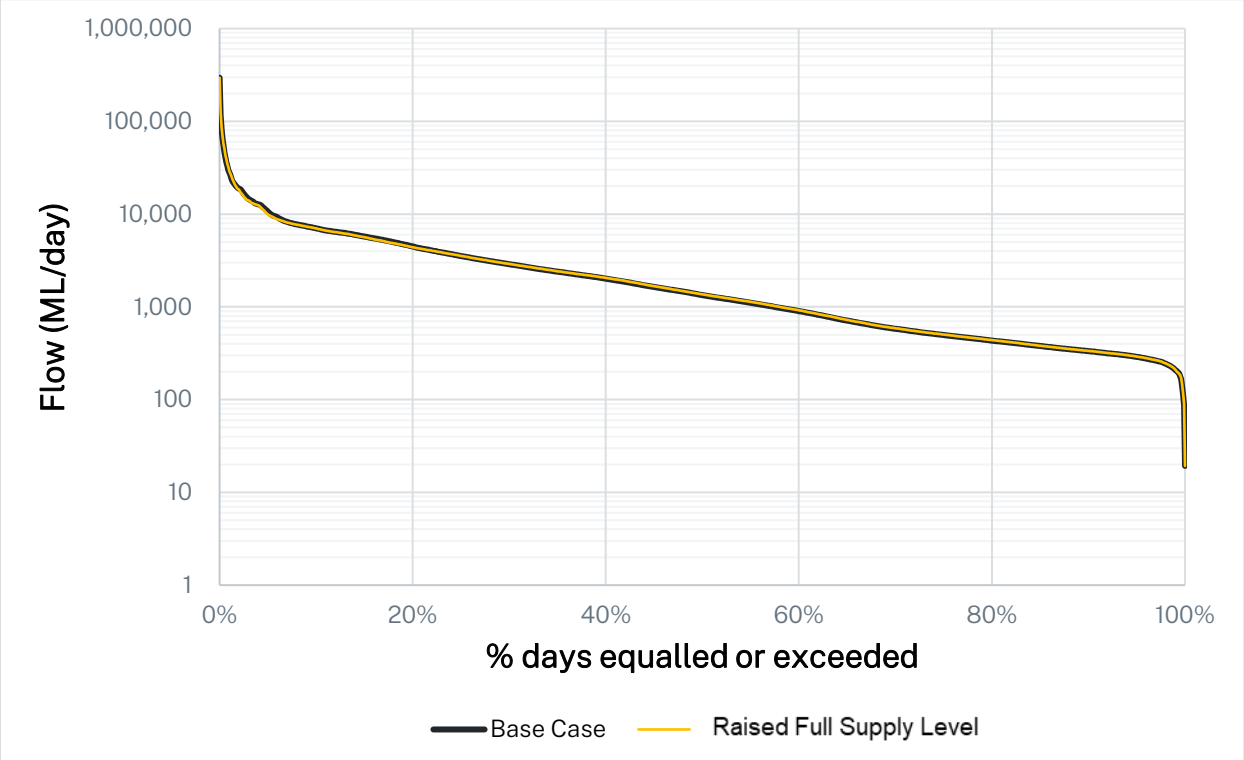

Figure 6. Annual flow exceedance: Gunningbar Creek downstream regulator (421005)