REVIEW OF PERFORMANCE AGAINST OBJECTIVES AND OUTCOMES – 2022-23

Report of the Independent River Operations Review Group - an advisory committee established by, and reporting to, the Murray-Darling Basin Authority

September 2023

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Draft for comment	8/9/2023	IRORG	Draft to jurisdictional contact officers and MDBA for comment
Final report	29/9/2023	IRORG	Final report to MDBA

Reviewers' Foreword

Mr Andrew McConville
Chief Executive Officer
Murray-Darling Basin Authority

29 September 2023

Dear Andrew

The Independent River Operations Review Group (IRORG) is pleased to submit to the Murray-Darling Basin Authority its review of the River Murray operations for 2021-22, and in particular the Authority's compliance with the General and Specific Objectives and Outcomes set out in the O&O document, Version 12, effective from 1 June 2022.

IRORG believes that the Authority has fulfilled its obligations under the Objectives and Outcomes document during 2022-23.

We note the high levels of satisfaction expressed by all four jurisdictions of the work of the River Murray Operations group during extended periods of flood operations across multiple catchments.

For this review IRORG has welcomed a new member, Professor Darren Baldwin.

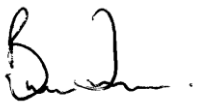
IRORG appreciates the assistance provided by your staff, together with that of key staff in the jurisdictions.

Yours sincerely

Peter Hoey
Chair

Darren Baldwin
Member

Garry Smith
Member



Brett Tucker
Member

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Acknowledgement of Traditional Owners

We pay our respects to Elders past and present, and acknowledge and recognise Traditional Owners' obligations, rights and responsibilities to use and care for their traditional lands and waters.

Executive Summary

This report sets out the findings of the Independent River Operations Review Group's (IRORG) 2023 review of the Murray-Darling Basin Authority's (MDBA's) performance in river operations. The review covers the MDBA's performance during the 2022-23 water year in relation to managing the River Murray system to meet the states' consumptive and environmental water demands, and its compliance with the provisions of the Objectives and Outcomes for river operations in the River Murray System (O&O document).

Consistent with our previous reviews, IRORG has based this review around identification of key issues via three main lines of evidence:

- issues documented in the MDBA's River Murray System - Summary of River Operations report – 2022-23 Water Year,
- issues raised in interviews with and in submissions from the jurisdictions; and
- any issues arising from IRORG's own review of available information.

The 2022-23 water year was the third consecutive La Nina year. This key climate driver saw wet conditions across much of the basin for extended periods during the water year, with wide-spread flooding affecting the River Murray system and its tributaries.

Inflows to the River Murray system were more than double the equivalent inflows in the previous year and placed the 2022-23 water year in the wettest 4% of years, based on historical records. High inflows across the system also resulted in unregulated flows to South Australia experienced in the later part of the 2021-22 water year continuing throughout the 2022-23 water year.

The Murray-Darling Basin Agreement sets out the functions of the Basin Officials Committee (BOC), which includes making high-level decisions in relation to river operations within the River Murray System. The key river operations decisions approved by BOC are captured in the O&O document, which specifies the General and Specific objectives and outcomes that the Authority should achieve in relation to river operations.

Wet conditions and high inflows meant that much of the focus on river operations was on managing air space and extended periods of flood operations at Dartmouth Dam, Hume Dam and Yarrawonga Weir. Significant resources were also needed to continually update and share information on system inflows, reservoir release plans and river flow forecasts with other water agencies and the community.

IRORG 's overall assessment is that the MDBA performed well in the 2022-23 water year. All jurisdictions endorsed this assessment of the MDBA's performance.

IRORG considers that all the general objectives and outcomes set out in the O&O document were achieved in 2022-23. The Authority also performed well in complying with all the specific objectives and outcomes specified in the O&O document.

Part of IRORG's role also includes identifying any improvements to MDBA's processes or the O&O document that would improve MDBA's performance against the objectives and outcomes or improve

the relevance of the O&O document to support current day operations. The challenges operators faced during 2022-23 highlighted several opportunities for potential improvement, including:

- The risk of shortfalls in meeting demands in the River Murray system downstream of Barmah has been recognised as a problem for some time now and has been reported on in IRORG's reviews of river operations since 2016. IRORG is concerned that the priority of this issue appears to have decreased for water managers in some jurisdictions. While this is understandable given the significant attention and resources that had to be directed to flood operations in 2022-23, shortfalls remain a major source of risk to the timely and effective delivery of water to meet demands in the lower river. All parties should continue to allocate a high priority to this issue, and to progress the development of policies and processes to codify the approaches to managing and mitigating this risk.

- There have been a number of concerning water quality issues during 2022-23 in the southern Murray-Darling Basin. Communities across the system are concerned about the apparent increase in the severity and frequency of these events. The Authority has only limited scope to intercede in adverse water quality events and needs to work in collaboration with other agencies to respond to these issues. IRORG has previously made a recommendation about developing an improved coordination framework to respond to water quality events, and given recent experience, it is suggested that the MDBA should revisit this recommendation.

  In reviewing the causes of a massive 2023 fish kill in the Darling River, the NSW Office of the Chief Scientist and Engineer found a general emphasis on water volume over water quality. IRORG is of the view that the Authority needs to consider both short term and longer term actions to provide a stronger focus on water quality matters and to also provide river operators with more effective tools to respond to these issues.

- Unregulated flows are declared when actual or forecasted flows exceed the water required to meet all system demands and cannot be captured and stored in Lake Victoria. Any unregulated flows that remain available after states exercise their prior rights are available to become River Murray Unregulated Flows (RMUF), which can be used to protect, and where possible, restore priority environmental assets and ecosystem functions. In discussions with jurisdictions concerns were raised that advice on unregulated flows, including RMUF was irregular or missing in 2022-23. IRORG has identified a number of actions to address this concern.

- The management of river systems within sustainable flow limits, while also meeting the demands of a diverse water user base continues to be a complex balancing act for river operators and water managers. There are now well structured rules around the call-out of water from the Goulburn IVT. When IVT deliveries are occurring, this limits the scope for release of other demands including environmental deliveries, into this reach of the system. In order to plan effectively, environmental water managers need to understand when IVT call-outs (or any other demands) may limit the ability to make environ mean water releases. In the past, river operators have been reluctant to provide specific advice on the timing of Goulburn IVT deliveries as this was seen as sensitive water market information. The recent

changes to the Victorian Goulburn to Murray trade rules mean that there is no longer any direct link between the call-out of Goulburn IVT volumes and trade opportunities from the Goulburn to the Murray systems. IRORG believes that the MDBA can offer better sharing of critical system operating information while still ensuring water market integrity.

- IRORG has been concerned about significant delays in the provision of important water usage data by NSW, which were experienced again in 2022-23. NSW has acknowledged the shortfall in their performance and has put in place additional resources dedicated to water accounting. IRORG strongly urges the parties to address this issue as soon as possible, as accurate water usage data is essential for effective water sharing and management.

- The MDBA has been working on the development of new operational planning and accounting tools built on the powerful Source river modelling software platform. Significant improvements were made to the Source operations model in 2022-23, and IRORG was encouraged to learn that the MDBA expects the Source operations model to be the primary operational planning tool for the river Murray system for the 2024-25 water year. The Source Accounts Model has progressed to the point where the MDBA is now moving use it as the production accounting model for the River Murray system.
  These new planning and accounting models will provide the MDBA with tools that allow them to better understand and manage the River Murray system in an increasing complex operational environment and deliver multiple benefits from the system.

Summary of recommendations

During the 2023 review, IRORG has identified six recommendations to support improvement in river operations and water sharing activities. The recommendations from the 2023 review are summarised below, together with a reference to the relevant section of the report where further detail can be found.

Water quality issues (Section 7.2, page 22)

2023.01 IRORG **recommends** that the MDBA reconsiders IRORG recommendation 2021.01. *(Recommendation 2021.01 recommended that the MDBA and jurisdictions should consider whether a wider range of water quality response actions can be brought under a coordination framework, such as existing well-developed regional Blue Green Algae co-ordination arrangements, to provide integrated response capabilities to adverse water quality events).*

2023.02 IRORG **recommends** that the scope of the Authority's current emergency response plan is expanded to include other significant water quality risks beyond bushfires and significant spills).

2023.03 IRORG **recommends** that during the Basin Plan Review the Authority considers a commitment to more tangible water quality targets within the Plan, and that where these targets are related to flow management decisions, they are subsequently reflected in the Objectives and Outcomes document.

2023.04 IRORG **recommends** the Authority, in conjunction with the jurisdictions, develop contingency plans for dealing with large, harmful water-quality events in the basin.

River Murray Unregulated Flows (Section 7.3, page 26)

2023.05 IRORG **recommends** that:

- The O&O document is amended to include:
    - a definition of 'River Murray Unregulated Flows' (RMUF) and guidance on how a declaration of RMUF is determined.
    - a requirement that the Chair of the Southern Connected Basin Environmental Watering Committee is notified when RMUF has been, or is likely to be, declared.
- Appropriate accounting arrangements are developed for RMUF return flows so as to maximise the benefit to the environment.

Goulburn IVT call outs (Section 7.4, page 27)

2023.06 IRORG **recommends** that the MDBA develop arrangements to enable better sharing of critical operational information to support more effective planning of environmental watering actions, whilst still ensuring water market integrity.

List of Abbreviations

Act	Commonwealth *Water Act 2007*
Agreement	Murray-Darling Basin Agreement
AOO	Annual Operating Outlook
Authority	Murray-Darling Basin Authority
BOC	Basin Officials Committee
BMF	Barmah Millewa Forest
Committee	Basin Officials Committee
GO&O	General Objectives and Outcomes, clause 4 of the O&O document
IPCPR	Independent Panel for Capacity Project Review
IRORG	The Independent River Operations Review Group
IVT	Inter-Valley Transfer (account)
MDBA	Murray-Darling Basin Authority
MDB Agreement	Murray-Darling Basin Agreement
MinCo	Murray-Darling Basin Ministerial Council
O&O document	Objectives and Outcomes for river operations in the River Murray System
RMO	River Murray Operations group
RMOC	River Murray Operations Committee
RMUF	River Murray Unregulated Flows
SCBEWC	Southern Connected Basin Environmental Watering Committee
SO&O	Specific Outcomes and Objectives, Section 2 of the O&O document
WLWG	Water Liaison Working Group

1 Introduction

The River Murray system is the central spine of the major water distribution and delivery systems in the southern-connected Murray-Darling Basin. It is used to harvest, store and deliver the available shared water resources to New South Wales, Victoria and South Australia. The Murray-Darling Basin Authority (MDBA), acting on behalf of the Basin states, is responsible for water sharing and operational management of the River Murray system.

The Murray-Darling Basin Agreement (the Agreement) sets out detailed provisions for the management and sharing of the Basin water resources. The Agreement also establishes the functions of the Basin Officials Committee (BOC), which includes high-level decision making in relation to river operations within the River Murray System. The key river operations decisions approved by BOC are captured in the Objectives and Outcomes (O&O) document, which specifies the objectives and outcomes that the Authority should achieve in relation to river operations (refer clause 31 of the Agreement).

The Agreement and the O&O document provide a framework for the Authority to undertake its river operation functions. The O&O document includes provisions for the Authority to appoint an Independent River Operations Review Group (IRORG) to review river operations. IRORG is an advisory committee established under the provisions of Section 203 of the Water Act 2007 (the Act). IRORG's current members[1] are:

- Peter Hoey (Chair)
- Darren Baldwin
- Garry Smith
- Brett Tucker

IRORG's terms of reference require it to assess whether the MDBA, in operating the River Murray System, has complied with the General and Specific Objectives and Outcomes set out in the O&O document. IRORG's role also includes identifying any improvements to either the MDBA's processes or the O&O document.

This report sets out IRORG's findings, observations and recommendations on these issues.

[1] IRORG members have wide ranging expertise in water management issues. As part of their consulting roles or involvements with state water resource management agencies, IRORG members may have knowledge of or prior exposure to some water management matters that may be addressed in the review. Members disclose these matters, and where appropriate the Chair of IRORG, in consultation with the MDBA's Executive Director River Management, ensures that members with a potential conflict of interest in relation to an issue do not participate in development of IRORG findings on that issue.

2 Review Process

The Authority provided IRORG with a range of material to assist it in reviewing river operations undertaken during 2022-23. This material included:

- River Murray System Summary of River Operations report – 2022-2023 Water Year[2].
- River Murray System Annual Operating Outlook 2022-23 Water Year[3].
- River Murray System Annual Operating Outlook 2022-23 water year – End December 2022 update[4].
- The River Murray System Water accounts – as at end of May 2023.
- Objectives and outcomes for river operations in the River Murray System Version 12 – 1 June 2022[5].
- Other internal reports and documents as required

In the course of its review, IRORG also sought and received additional information from the MDBA to address specific questions and information gaps.

IRORG's review process is based around identification of key issues via three main lines of evidence:

- issues documented in the Summary of River Operations report
- issues raised in interviews with and in submissions from the jurisdictions[6]; and
- any issues arising from IRORG's own review of available information

This review addresses the MDBA's performance for the 2022-23 water year, which covers the period 1 June 2022 – 31 May 2023. IRORG developed its findings, observations and recommendations following investigation and analysis of the identified issues.

IRORG has relied on the information provided to it by the MDBA and in the verbal and written submissions from jurisdictions in helping it to formulate its findings; however, the conclusions and recommendations included in this report are entirely those of IRORG.

[2] This report is subsequently referred to as the Summary of River Operations report.
[3] This report is available on the MDBA website
4 ibid
5 ibid
6 In relation to the operation of the River Murray System, the relevant jurisdictions are the Commonwealth, New South Wales, South Australia and Victoria. These jurisdictions are all represented on the Water Liaison Working Group (WLWG) which advises the MDBA on river operations issues and on the Southern Connected Basin Environmental Watering Committee (SCBEWC), which advises the MDBA on environmental watering actions.

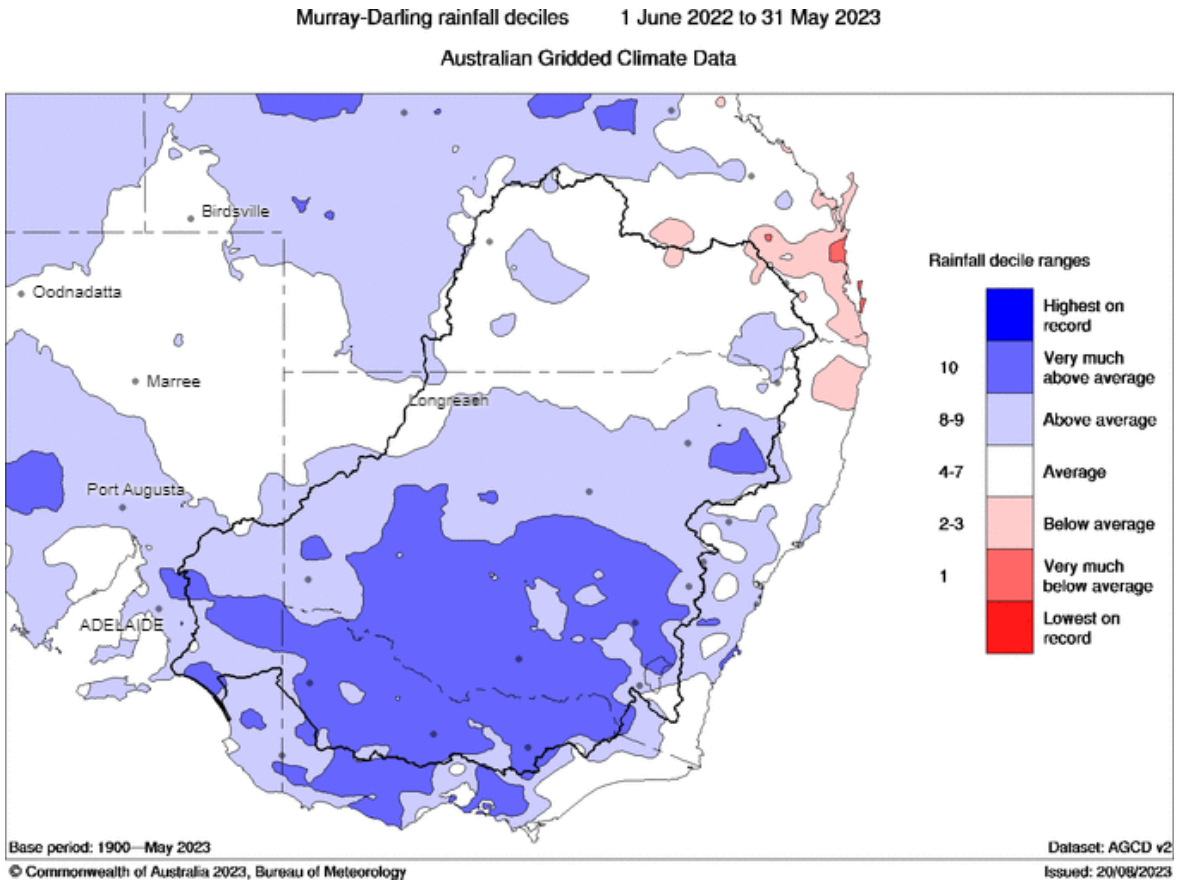
3 Seasonal context for river operations

The 2022-23 water year was the third consecutive La Nina year. This key climate driver saw wet conditions across much of the basin for extended periods during the water year, with wide-spread flooding affecting the River Murray system and its tributaries.

Rainfall was above average to very much above average over virtually all of the Victorian and New South Wales sections of the Basin. The Queensland section of the Basin largely experienced average rainfall, while isolated areas also experienced above average rainfall during the water year (refer Figure 1). The wet conditions resulted in well above average inflows to the River Murray system over most of the water year (refer Figure 2).

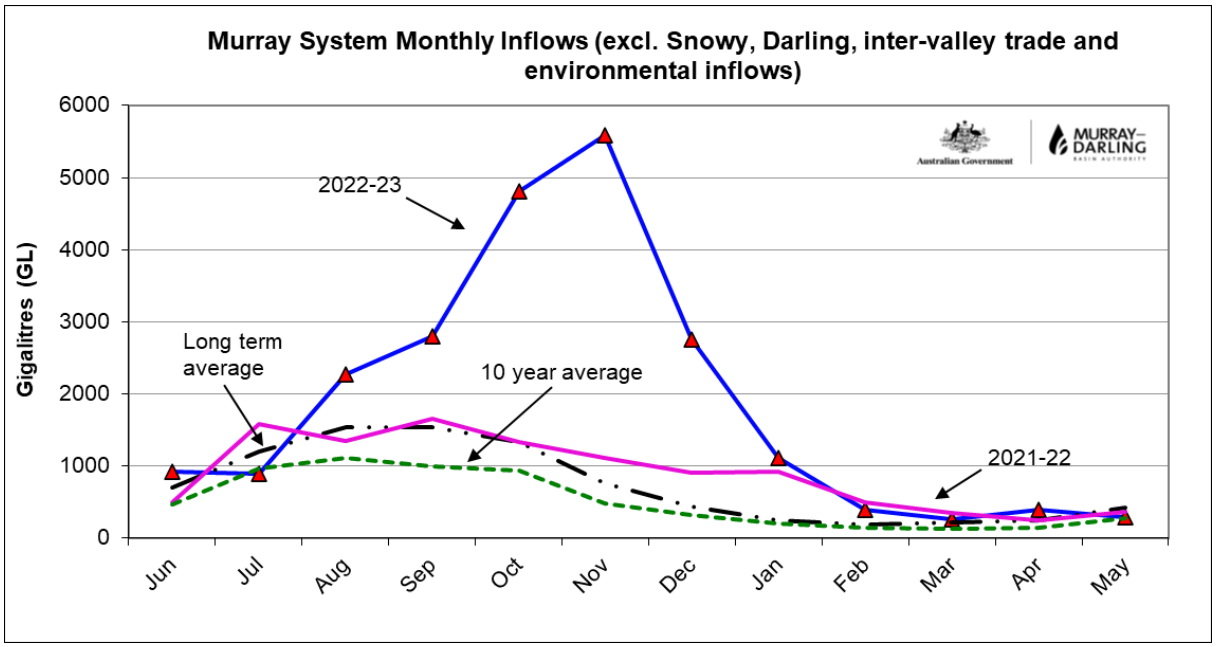
Wet conditions and high inflows meant that much of the focus on river operations in 2022-23 was on managing air space and extended periods of flood operations at Dartmouth Dam, Hume Dam and Yarrawonga Weir.

Figure 1: Seasonal rainfall deciles for 2022-23 water year (June 2022-May 2023)



Wet conditions also resulted in extended periods of flood operations at major storages on tributaries of the River Murray in NSW (Murrumbidgee River and Menindee Lakes Lower Darling/Baaka system) and Victoria (Goulburn-Broken, Campaspe and Loddon River systems). Communities along all these tributaries and the River Murray system also experienced major flooding impacts during 2022-23.

Figure 2: River Murray system monthly inflows for 2022-23



Source: River Murray Weekly Report – 31 May 2023

High inflows across the system also resulted in unregulated flows to South Australia experienced in the later part of the 2021-22 water year continuing throughout the 2022-23 water year. Widespread rainfall and flooding across the system also reduced irrigation demands compared to the 2021-22 water year.

Overall, total inflows to the River Murray system[7] were 21,900 GL for the 2022-23 water year, which was over double the equivalent inflows in the previous year and four times the inflows received in the 2020-21 water year. This volume of inflows would be expected to be equalled or exceeded in only 4% of years, based on historical records. Total MDBA active storage reached 100% of full capacity for the first time since 2012 During the 2022-23. At the end of the water year active storage was 7,594 GL (88% of full capacity).

Extended periods of high inflows and overbank flows also resulted in high losses from the system. Losses in 2022-23 were the highest observed since 1989. Conditions also met the triggers for provision of Additional Dilution Flows (ADF) to SA.

Water quality issues in Lake Hume that have occurred since the 2020 bushfires recurred in the 2022-23 water year. RMO worked closely with other parties to try and increase dissolved oxygen concentrations downstream of the storage. During autumn, a significant hypoxic blackwater event occurred in the Darling /Baaka River immediately downstream of Menindee Lakes. The MDBA participated in the response efforts, which were led by the NSW government. Further detail on these water quality issues is provided in Section 7.2 of this report.

[7] River Murray System inflows include unregulated inflows to Dartmouth, Hume and from the Kiewa River, plus inflows from the NSW and Victorian tributaries, but exclude Snowy Hydro releases, tributary environmental water deliveries and IVT, and Menindee inflows.

4 Performance against General O&Os (O&O clause 4)

Clause 4 of the O&O document sets out a series of general objectives that the Authority should aim to achieve. The O&O also describes a series of target outcomes that are to be delivered in support of these objectives. The General Objectives and Outcomes (GO&Os) are grouped under five main themes:

- Water storage and delivery accounting.
- RMO assets.
- People and communities.
- Environment.
- Communications and information management

The Authority has reported in detail on its performance against each of the target outcomes.

Key points

- The 2022-23 water year was challenging for River Murry system operators and for their colleagues managing state tributaries, as widespread major flood events affected the southern-connected Murray-Darling basin for extended periods.
- Intensive airspace management and flood operations dominated operational activities, however consumptive and environment demands were also delivered.
- All jurisdictions were uniformly of the view that the MDBA performed well in relation to overall river operations activities.
- IRORG considers that all the general objectives were achieved in 2022-23.

***How to read Table 1**:* A brief example of Table 1 content is provided below. The text [IN SQUARE BRACKETS AND CAPITALS] summarises the key content of the table, and the additional column to the right provides a description of how the colour coding applied the IRORG assessment column in Table 1 should be interpreted.

O&O Clause	Outcome area	Target outcome	IRORG comments/assessment*	Legend for IRORG assessment rating in the previous column
4(2)	**Water Storage and delivery accounting** [GENERAL OBJECTIVE CATEGORY]		***IRORG considers that the objectives for water storage and delivery and accounting were achieved.*** [IRORG COMMENTS OR NOTES ON OVERALL ACHIEVEMENT AGAINST THE GENERAL OBJECTIVE. COLOUR OF CELL SHADING INDICATES IRORG ASSESMENT RATING]	Achieved Qualified achievement Not achieved
4 (2) (b) (i)	Water conservation [INDIVIDUAL OUTCOMES UNDER EACH GENERAL OBJECTIVE]	The conservation of water and minimisation of losses [BRIEF SUMMARY OF THE TARGET OUTCOME STATEMENT FROM O&O]	The Authority effectively managed losses in a year with high temperatures and low tributary inflows… [IRORG COMMENTS OR NOTES ON ACHIEVEMENT AGAINST EACH OUTCOME AREA UNDER A GENERAL OBJECTIVE]	Achieved Qualified achievement Not achieved

* IRORG's assessment of achievement against General O&O. Key to assessment levels is:

- Achieved – Intended outcome was fully achieved in line with the General O&O provisions, or was achieved with only relatively minor or limited deviations, which had no material impact (*indicated by green shading in table*).
- Qualified achievement – Intended outcome was generally achieved; however, some deviations from the intended outcomes occurred. Deviations were limited in duration, or were largely outside of the control of the MDBA and did not result in significant adverse impacts (*indicated by amber shading in table*).
- Not achieved - Intended outcome was generally not achieved, or deviations which occurred resulted in significant adverse impacts (*indicated by red shading in table)*.

Table 1: Summary of MDBA performance against General O&Os for 2022-23

O&O Clause	Outcome area	Target outcome	IRORG comments/assessment
4(2)	**Water Storage and delivery accounting**		***IRORG considers that the outcomes for water storage and delivery and accounting were achieved.***
4 (2) (b) (i)	Water conservation	The conservation of water and minimisation of losses	The Authority operated the system so as to maximise water availability in 2022-23. Unregulated flows occurred for the entire water year. Active storage across all MDBA storages reached 100% of full capacity in Jan 2023. While losses were high, this was largely driven by high unregulated inflows and widespread flooding, rather than by planned operational actions.
4(2) (b) (ii)	Preparation of accounts and water resource assessments	The accurate and timely preparation, delivery, review and, where necessary, amendment of water accounts and water resource assessments.	No jurisdictions raised concerns with the accuracy or timeliness of accounts. Jurisdictions had confidence in the water resource assessments. The accounts also accurately tracked the volumes of water held in and delivered from SA's storage right under Schedule G of the MDB Agreement.
4 (2) (b) (iii)	Delivery of state water orders	The delivery to the Southern Basin states of their authorised water orders unless physical constraints of the River Murray System prevent this from occurring.	The MDBA met all authorised state water orders in 2022-23. Delivery shortfall risks were not a significant issue given the existence of unregulated flows across the entire water year.
4 (3)	**RMO assets**		***IRORG considers that the outcomes for RMO assets were achieved.***
4 (3) (b) (i)	Effective management of RMO assets	The effective management, maintenance, repair, renewal and replacement, and the protection of the security, of RMO assets.	Overall, MDBA assets performed well in the face of major flooding. Some bank failures on the Lake Victoria/Tar-ru inlet channel took the lake offline until repairs were affected. No overall impact on harvesting or delivery of state shares. Many of the River Murray monitoring stations in SA (operated on behalf of the joint venture) were not designed to be operable at very high flow/flood river levels and were removed for three months during the worst of the flooding, with only a small number left in-river recording continuous water levels throughout the event. A project to make the stations more flood resilient is underway.
4 (3) (b) (ii)	Emergency management	The effective management and mitigation of any emergency occurring at RMO assets.	No emergencies occurred during 2022-23 at RMO assets. Torrumbarry Dam Safety Emergency Plan was triggered to ensure detailed surveillance and monitoring due to highest record flows for that structure (MDBA emergency action plan was not activated due to the low associated risk).
4 (3) (b) (iii)	Structural and operational integrity of RMO assets	Conduct river operations in ways that protect the structural and operational integrity of RMO assets	Operations were conducted in collaboration with state constructing authorities and within specified operating ranges. Flood operations also protected the security of RMO assets.
4 (3) (b) (iv)	Flood management	The management of floods in accordance with the criteria established in the O&O.	In 2022-23, flood operations extended from August – January at Dartmouth, Hume and Yarrawonga. The MDBA managed floods at storages in accordance

O&O Clause	Outcome area	Target outcome	IRORG comments/assessment
			with the criteria and priorities set out in the O&O document and provided significant food mitigation benefits where possible.
4 (3) (b) (v)	More effective environmental delivery	Use existing and new RMO assets to deliver environmental water more effectively.	MDBA used existing assets to support environmental deliveries, including through the use of the Barmah Millewa Forest regulators to manage unregulated flows as well as environmental water deliveries. Weir pool levels were also manipulated for environmental benefit.
4(4)	**People and communities**		***IRORG considers that the outcomes for people and communities were achieved.***
4 (4) (b) (i)	Maintenance of productive relationships	Productive relationships are maintained with river managers and other stakeholders.	The MDBA maintained effective relationships with jurisdictions. The MDBA provided briefings to community members downstream of Lake Dartmouth and Lake Hume in relation to pre-release and flood operations, and also provided regular online briefings on Hume Dam operations. In addition, over 80 media releases and alerts kept communities informed on river conditions.
4 (4) (b) (ii)	Limit flooding damage	Subject to the O&O provisions, damage to downstream communities is limited when managing flooding.	The MDBA actively managed airspace in Hume and Dartmouth storages to provide food mitigation benefits. Releases were able to be kept well below peak inflow rates. Flood operations at Menindee Lakes were directed by WaterNSW.
4 (4) (b) (iii)	Mitigating water quality impacts	Events that may adversely affect the water quality mitigated.	Significant efforts were made to mitigate on-going water quality risks at Lake Hume, particularly through the management of releases arrangements to mitigate poor water quality associated with runoff from bushfire affected areas. The MDBA participated in the response to a significant hypoxic blackwater event on the Lower Darling/Baaka River, which was led by the NSW government. See Section 7.2 for more detail.
4(4) (b) (iv)	Navigation and recreation	Navigational and recreational uses of the River Murray System are properly considered, including major public events using parts of the River Murray System	Planned river-based community events were identified and included considered in the AOO as part of the development of operational scenarios.
4 (4) (b) (vi)	Cultural heritage	Appropriate regard is given to cultural heritage matters.	Lake Victoria was operated in accordance with the cultural heritage protection strategy. Filling of the lake was deferred, due the extensive unregulated flows which ensured the lake could be filled if/when needed.
4 (5)	**Environment**		***IRORG considers that the overall outcomes for environment were achieved.***
4 (5) (b) (i)	Achieving multiple objectives	River operations are managed to ensure that multiple objectives can be achieved	MDBA facilitated environmental watering activities. The MDBA implemented post Hume flood operating arrangement this year to improve environmental outcomes whilst still optimising resources for all entitlement holders. The new arrangement enables

O&O Clause	Outcome area	Target outcome	IRORG comments/assessment
			water for the environment to be delivered to prevent the unnatural rapid drop in river levels as flood releases are ceased. Directed releases were also made from Lake Victoria. Since the storage subsequently refilled from further unregulated flows, there was no net debit from e-water accounts, and the releases enabled beneficial variation in the hydrograph.
4 (5) (b) (ii)	Improving environmental watering practices	The knowledge, documentary and practice bases for effective environmental watering are all improved.	Environmental watering demands were incorporated into the AOO scenarios. Environmental watering accounting practices were further developed.
4 (5) (b) (iii)	Timely provision of advice	WLWG and any other relevant committee receive timely information about any significant actual or predicted change to the River Murray System's water resources, in accordance with sub-clause 15(5).	WLWG & SCBEWC chairs were advised of and kept informed in relation to periods of declared unregulated flows. Some issues and opportunities were identified for improving advice around River Murray Unregulated flows for environmental purposes. Refer to Section 7.3 for further detail.
4 (5) (b) (iv)	Reducing adverse environmental impacts	The risk of significant adverse environmental events is reduced, or impacts are mitigated.	The MDBA sought to minimise adverse environmental impacts associated with river operations (see also 4 (4) (b) (iii)).
4 (5) (b) (v)	Timely provision of environmental water use estimates.	The Authority will supply, in a timely manner, the Water Liaison Working Group and the participating government environmental water holders with relevant retail and wholesale level estimates of environmental water use if requested by WLWG	Despite agreement being reached for MDBA to move out of provision of retail e-water usage data 2 years ago, the MDBA provided monthly operational estimates of e-water usage to cover gaps in data provision (largely by NSW). In the absence of any formal change to the O&O requirements, it could be argued that the MDBA had ongoing obligations to ensure suitable data was provided. (See also IRORG recommendation 2022.03)
4 (6)	**Communication and Information management**		***IRORG considers that the outcomes for communication and information management were achieved.***
4 (6) (b) (i)	Accurate river operations information	The Ministerial Council, BOC, the River Murray Operations Committee, WLWG, other relevant committees, other stakeholders with an interest in the Authority's river operations and the public are each provided with appropriate, timely and accurate information about the Authority's river operations.	The MDBA undertook a range of measures to provide information on river operations and to keep relevant committees and stakeholders appropriately informed. See also details under O&O clause 4 (4) (b) (i) of this report.
4 (6) (b) (ii)	Communications with WLWG and BOC	Effective referral of matters to the WLWG & BOC.	The MDBA provided information and sought advice on a range of relevant matters from WLWG and BOC.
4 (6) (b) (iii)	Implementing review	Any BOC recommendations in relation to the establishment,	The MDBA continued to apply the arrangements endorsed by BOC for the annual review.

O&O Clause	Outcome area	Target outcome	IRORG comments/assessment
	processes and outcomes	terms of reference, operations or recommendations of IRORG are implemented.	
4 (6) (b) (iv)	Management of hydrometric stations	Hydrometric stations forming part of RMO assets are managed according to best practice methods to collect, transfer, store and assure the quality of all data.	The MDBA contracts states to undertake hydrometric monitoring. All states have indicated that their practices comply with the relevant Australian Standard for hydrometric monitoring. See also Clause 4 (3) (b) (i) notes in relation to improving flood resilience of some monitoring stations

5 Performance against Specific O&Os (O&O clause 5)

The O&O document includes a range of Specific Objectives and Outcomes (SO&Os) for designated reaches of the River Murray System, designated river operation activities or specific assets.

IRORG's assessment of the Authority's performance in relation to each of the SO&Os for the 2022-23 water year is provided in Table 2. The MDBA also provided detailed reporting to the jurisdictions, so IRORG has focussed on reporting by exception on any breaches of the SO&Os in Table 2.

Key Points

- Overall, the Authority again performed very well in delivery against the SO&Os in 2022-23 (see table below).
- Issues continue to be experienced with accuracy of Heywood's gauging station which measures releases from Lake Hume (SO&O 2.3). WaterNSW is investigating this issue to develop a solution. IRORG believes the MDBA should ensure this matter is resolved in a timely manner now that flood operations and very high flows are less probable. Accurate measurement at this critical location is an important element in effective management of the River Murray system.

Performance against SO&O	Number of SO&Os	Percentage
Achieved (or not applicable in 2022-23)	57	100%
Qualified achievement	0	0%
Not achieved	0	0%
Total	**57**	**100%**

Table 2: Assessment of MDBA performance against Specific O&Os for 2022-23

SO&O Ref. No. [1]	Summary interpretation of SO&O[2]	Assessment[3] (see notes for info. on ratings)	Comments or reference to further explanatory notes
1.1	Dartmouth Dam - maximum planned regulated release	Achieved	Regulated releases for consumptive purposes maintained within adopted limits. Flood operations necessitated higher releases at times.
1.2	Dartmouth Dam– Airspace management and flood operations.	Achieved	Extended flood operations during 2022-23. Storage was above 99% capacity at the conclusion flood operations as per SO&O provisions.
1.3	Dartmouth Dam - Maximum rate of rise and fall in River level during planned regulated release	Achieved	Frequent minor breaches of rise/fall limits for short durations reported, with no identified material impacts. Breaches were associated with releases through Banimboola power station. IRORG has previously recommended reviewing rates of rise and fall targets to align with more realistic and achievable limits
1.4	Dartmouth Dam – Minimum planned regulated release	Achieved	Minor breaches of minimum flow rate
2.1	Hume Dam - Maximum planned regulated releases	Achieved	Note that maximum regulated release limits do not apply during essential flood operations.
2.2	Hume Dam – Maximum rate of fall in River level during planned regulated releases	Achieved	Seven minor breaches of rate of fall– associated with cuts at maximum rate to avoid increasing flows d/s of Yarrawonga and/or risk inundating Barmah Forest.
2.3	Hume Dam - Minimum planned regulated releases	Achieved	A number of apparent breaches occurred at this site. Accuracy of Heywood's gauge and irrigation valve release calibrations is problematic and continues to be investigated by WaterNSW to develop remedial actions. MDBA should ensure this matter is resolved in a timely manner now that flood operations are less probable.
2.4	Hume Dam – Directed releases	Achieved	
2.5	Hume Dam - Assumed use for directed releases of HEW	Achieved	
2.6	Hume Dam - post flood operations, storage to be 99% of full capacity when demand exceeds inflows. Target airspace to be between 30 GL – 386 GL.	Achieved	Extended flood operations during 2022-23. Storage was above 99% capacity at the conclusion flood operations as per SO&O provisions.
3.1	Yarrawonga Weir max. planned flows (a) When inundation of the Barmah-Millewa Forest is desirable (b When inundation of the Barmah-Millewa Forest is undesirable	Achieved Achieved	Flood operations necessitated higher releases than the regulated flow limits at times
3.2	Yarrawonga Weir – flood operations	Achieved	

SO&O Ref. No. [1]	Summary interpretation of SO&O[2]	Assessment[3] (see notes for info. on ratings)	Comments or reference to further explanatory notes
3.3	Lake Mulwala - pool level during the irrigation season.	Achieved	
3.4	Lake Mulwala – Supporting social and recreational use.	Achieved	
3.5	Yarrawonga Weir – Minimum planned regulated release	Achieved	
4.1	Barmah-Millewa Forest Environmental Water Allocation accounting provisions	Achieved	No BMF EWA was released during 2022-23
4.2	Barmah-Millewa Forest – Regulator operations	Achieved	
5.1	Wakool system – Use of system	Achieved	No MDBA transfers through the Wakool system in 2022-23. Mulwala Canal and MIL escapes were used on a number of occasions the help manage rain rejection flows
5.2	Edward River - Offtake operation	Achieved	
5.3	Gulpa Ck. - Offtake operation	Achieved	
5.4	Werai Forest – Regulator operations	Achieved	
5.5	MDBA water orders d/s of Stevens Weir	Achieved	No water orders were placed in 2022-23
7.1	Swan Hill – Minimum water level	Achieved	
8.1	Wentworth Weir – Minimum River Murray flow contribution	Achieved	
9.1	Lake Victoria – Operating Strategy	Achieved	
9.2	Lake Victoria - Inlet and outlet flow rates	Achieved	
9.3	Lake Victoria – Full supply level	Achieved	
9.4	Lake Victoria – Directed releases	Achieved	
9.5	Lake Victoria level – Maximum rate of rise in lake level	Achieved	
9.6	Lake Victoria - Improving water quality using Lake.	Achieved	Lake Victoria/Tar-ru was not used for water quality management. Flood damage to banks on Frenchman's Creek inlet also limited use of the lake for water quality purposes.
10.1	Menindee Lakes - Maximum planned regulated release downstream	Achieved	
10.2	Menindee Lakes – Maximum rate of rise and fall in flow rates downstream.	Achieved	
10.3	Menindee Lakes - Minimum planned regulated releases	Achieved	
10.4	Menindee Lakes - Directed releases	Achieved	Directed releases were required in 2022-23
10.5	Menindee Lakes – distribution of stored water.	Achieved	
11.1	Lower Lakes Barrages – operations.	Achieved	
12.1	Harmony operation of Dartmouth and Hume Reservoirs	Achieved	

SO&O Ref. No. [1]	Summary interpretation of SO&O[2]	Assessment[3] (see notes for info. on ratings)	Comments or reference to further explanatory notes
12.2	Harmony operation of Menindee Lakes and Lake Victoria	Achieved	
12.3	Additional Dilution Flows to SA	Achieved	Additional Dilution Flows to South Australia were triggered and met from unregulated flows
12.4	Bulk transfer from Dartmouth Reservoir to Hume Reservoir	Achieved	None required
12.5	Bulk transfers from Hume Reservoir to Lake Victoria	Achieved	None required
12.6	Management of rain rejection events	Achieved	
12.7	Unregulated flow advice planning and communication	Achieved	Unregulated flows occurred from 1 June 2022 to 31 May 2023. Some issues were noted in relation to declarations of RMUF availability – see Section 7.3.
12.8	River flow variability.	Achieved	
12.9	Use of bypasses of the Barmah Choke	Achieved	
12.10	Lindsay River Allowance	Achieved	
12.11	Dealing with shortfalls in meeting water demands.	Achieved	
12.12	Adjustment of flows to SA for rating table changes.	Achieved	
12.13	Determining the minimum inflow prediction	Achieved	
13.1	Maintenance of the Water Accounts, Water Accounting Model, model code and associated data	Achieved	
14.1	Maintenance of the Water Resource Assessment model, including the model code and associated data.	Achieved	
14.2	Minimising the impacts of one state leaving a period of special accounting.	Achieved	Vic and NSW were not in a period of special accounting during 2022-23
15.1	Advances of water – advances should support critical human water needs and the conveyance reserve.	Achieved	No Tier 2 or 3 water sharing arrangements were in place
15.2	Remedial actions are implemented to support the provision of water for critical human needs, conveyance and the conveyance reserve.	Achieved	No Tier 2 or 3 water sharing arrangements were in place
15.3	Priority for water allocations to meet and deliver critical human water needs.	Achieved	No Tier 2 or 3 water sharing arrangements were in place
15.4	Setting aside the conveyance reserve	Achieved	

Notes:

1. SO&O reference is the clause number from Section 2 of the O&O document, Specific Outcomes and Objectives.
2. For full description of outcomes and interpretation, refer to Section 2 of the O&O document, Specific Outcomes and Objectives.
3. IRORG's assessment of achievement against SO&O. Key to assessment levels is:

- Achieved – Intended outcome was fully achieved in line with the nominated targets in SO&O, or was achieved with only relatively minor or limited duration deviations from the targets, which had no material impact (*indicated by green shading in table*).
- Qualified achievement – Intended outcome was generally achieved; however, deviations occurred that were either significantly outside targets or extended for a considerable period (e.g. around 10% of time or longer). Deviations did not result in significant adverse impacts (*indicated by amber shading in table*).
- Not achieved - Intended outcome was generally not achieved, or deviations which occurred resulted in significant adverse impacts (*indicated by red shading in table)*.

6 Other provisions in the O&O document

There are range of provisions in the O&O document that set out procedural arrangements to support and enable delivery of outcomes in the GO&Os and SO&Os. The MDBA's performance in relation to these provisions is summarised in this section of the report.

Key Points

- IRORG believes that the Authority has generally complied with the requirements of clauses 7 to 19 of the O&O document.

Referring instances of conflicts and/or possible non-compliance to others [O&O cl 7]

If the MDBA concludes that it may be unable to achieve one or more of the general or specific objectives and outcomes because of a conflict between either or both of those objectives and outcomes, or for any other various specified reasons, it is required to seek the advice of the WLWG, on the need for further referral to the River Murray Operations Committee (RMOC) or BOC.

The Summary of River Operations Report states that there were no instances of conflict between achieving the objectives and outcomes and/or possible non-compliance, and therefore no instances needed to be referred to WLWG, RMOC or BOC. IRORG accepts this statement.

Emergencies [O&O cl 9]

Clause 9 states that the Authority, having regard to the possibility of the occurrence of an emergency, must have and maintain an Emergency Action Plan (EAP) and conduct its river operations in accordance with the EAP.

IRORG received a copy of the EAP. This EAP is built around a scaled system of 'Alert Levels'. As the seriousness of a situation increases, so too will the Alert Level. As an emergency event de-escalates, the alert level will be decreased accordingly. Section 4 of the EAP lists six types of emergencies covered by, but not confined to, the EAP:

1. Floods
2. Intentional threats; e.g. terrorist attack
3. Earthquake
4. Significant structural damage; e.g. piping failure
5. Major contamination of a waterway or storage
6. Bushfires

Reference is made in the EAP to the MDBA's Flood Operations manuals; however, IRORG has been advised that these documents are still in preparation.

IRORG notes that the regular updating and other processes related to the EAP are managed thoroughly. IRORG accepts that the EAP dated April 2022 remained in effect for 2022-23. In the absence of any emergency during 2022-23, the EAP was not activated.

Preparation of AOO [O&O cl 10]

O&O clause 10 requires the MDBA to prepare and adopt an Annual Operating Outlook (AOO), by 31 July each water year, monitor its implementation, and review it in October of each year, or at such other times, either recommended by WLWG or when the Authority thinks appropriate.

IRORG has been advised that the AOO was adopted on 31 July 2022, and a copy was provided to RMOC and BOC. It was published on the MDBA website on 8 August 2022.

With the agreement of WLWG, the October update of the AOO was delayed (by intensive flood operations) until its adoption on 27 February 2023 and publication on 3 March 2023. BOC was advised of this change on 1 December 2022. It was also agreed that the update would address only the extreme dry and very wet scenarios for the remainder of the water year.

Clauses 10(1)(c) and 10(3)(d) require the Authority to provide copies of the AOO and its update to the EWC. This did not happen, although IRORG was advised that all staff were made fully aware of the AOO availability through Authority-wide emails, together with discussions held at Directors' meetings, during this period.

On the basis of IRORG's review of the AOO and the February 2023 update, together with advice received from the MDBA, and in the absence of any concerns from jurisdictions, IRORG is generally satisfied with the processes and content of the AOO and the update.

Determining the volume of State water entitlements [O&O cl 11]

O&O clause 11 (Determining the volume of State water entitlements) requires the Authority to make monthly water resource assessments and to provide these to the WLWG.

The Summary of River Operations report states that NSW High and General entitlements, Victorian High and Low Reliability entitlements, SA's monthly entitlements and the Minimum Reserve all reached maximum levels in 2022-23. Water resource assessments were provided to WLWG from the end of May, then twice monthly from June to September 2022. States then advised, via the WLWG, that they did not require assessments for December 2022 and January 2023. Monthly assessments resumed for February to April 2023. Year 2 assessments were provided to the WLWG via GovTEAMS on 6 April and 11 May 2023.

IRORG believes that the determination of the volume of States' water entitlements was appropriate for 2022-23.

Water accounts [O&O cl 12 (1)]

O&O clause 12(1) requires the Authority to prepare monthly water accounts for each Southern Basin State.

IRORG has been advised that water resource assessments were uploaded onto GovTEAMS, and hence provided to all relevant parties at the end of each month during 2022-23.

The lack of NSW water usage data for a significant part of 2022-23 is addressed in Section 7.5 of this report.

Annual River Operations report [O&O cl 12 (2)]

The Authority is required to prepare and give BOC and RMOC an Annual River Operations Report [entitled the *River Murray System Summary of River Operations*] by 31 July each year.

The report was provided to BOC and RMOC on 2 August 2023, and provided to IRORG on 1 August 2023.

IRORG the 2023 Summary report to be helpful to this assessment, and we will continue to suggest improvements from time to time.

Matters referred to BOC for advice, information or determination [O&O cl 13]

Clause 13 is a general descriptive clause, not requiring assessment. Clause 13 states that the Authority must refer to BOC for determination, after first seeking the advice of RMOC on any decision that the Authority proposes to make in relation to river operations that has the potential to have a material effect on a State water entitlement. This a general clause covered by the more detailed requirements of clauses 14, 15 and 16.

Matters referred to BOC [O&O cl 14]

Under clause 14, the Authority must refer to the BOC for determination, after first seeking the advice of RMOC, matters arising from the following circumstances:

a) Insufficient channel capacity if it is likely to result in either insufficient water for downstream orders for water, or downstream channel capacity being exceeded if all downstream orders for water are met.
b) Reduction in water allocations within a State if such an adjustment is likely to require a State to reduce the volume of allocations it has previously announced.
c) Matters referred to BOC by the Authority when it has received notification from two or more members of BOC re matters not covered by the O&O document, and that the matter has the potential to have a material effect on a State water entitlement.

The Summary of River Operations report states that no matters arising from the circumstances described above were identified that required referral to the Committee for determination. IRORG accepts this advice.

Other matters referred to BOC [O&O cl 15]

Clause 15 (1) states that the Authority must refer to BOC for determination, after first seeking the advice of the RMOC, any matter relating to river operations that:

a) is not dealt with in, or is inconsistent with, a specific objective, a specific outcome or with any other provision of the O&O document; or
b) two or more members of WLWG consider may have the potential to have a material effect on any State water entitlement because a determination relating to that matter may require a State to reduce the volume of allocations it has previously announced as being available to water entitlement holders in that water year.

IRORG agrees with the advice that no matter covered by Clause 15 (1) occurred during 2022-23.

Clause 15 (2) states that if the Authority considers that any of the following events is reasonably likely to occur, it must notify the WLWG as soon as practicable:

a) Special accounting, where the Authority declares or terminates a period of special accounting pursuant to clauses 123 or 129 of the Agreement.
   Special accounting between NSW and SA, and between Victoria and SA, did not apply during 2022-23.

b) Direction about a valley account, where the Authority gives, amends or cancels a direction about water standing to the credit of a valley account pursuant to sub-clause 11(4) of Schedule D of the Agreement.
   WLWG was notified of the very minor IVT call-outs when required: 21 GL in March and 7 GL in April 2023 to support river levels in the mid-Murray.

c) Unregulated flows, as defined in sub-clause 15(2)(c) of the O&O. Clause 15(5) requires the notification of the Chair of SCBEWC on unregulated flows as soon as is practicable.
   Unregulated flows occurred throughout 2022-23. The Summary of River Operations report states that the "RMO continued communication during the event and notified WLWG and SCBEWC (via the Chair) of potential ongoing unregulated flows. MDBA gave and received necessary advice to enable an announcement to be issued. - - - The event was monitored, and updated advice provided on the extent and duration of the event as additional inflows occurred until the end of the water year.

   IRORG accepts that the requirements of sub-clauses 15(2)(c) and 15(5) of the O&O document were met during 2022-23. The opportunity for RMUF is addressed in Section 7.3 of this report.

d) Variation of monthly quantities for SA, where the Authority varies any monthly quantity which South Australia is otherwise entitled to receive, pursuant to clause 90 of the Agreement.
   There was no variation of SA's monthly entitlements during 2022-23.

e) Change in the Authority's ability to direct releases from Menindee Lakes.
MDBA's access to Menindee Lakes continued throughout 2022-23.

f) Internal spill within the meaning of clause 116 of the Agreement.
During August, September and October 2022, 366 GL spilled from Dartmouth Dam. As soon as practicable WLWG was advised of internal spills.

At the request of two or more members of WLWG, Clause 15 (4) requires the elevation of events covered in Clause 15 (2) and 15(3) to RMOC and BOC.

IRORG is satisfied that the range of notifications made to WLWG were in accordance with clause 15 (2), and that no requests were made by two or more WLWG members, pursuant to clause 15(4).

Matters which need not be referred to BOC if the Authority seeks the advice of the WLWG [O&O cl 16]

Clause 16 of the O&O document requires the Authority to notify WLWG when it proposes to exercise a function relating to river operations which might be regarded as being of particular significance, and to consider any relevant advice from WLWG.

A comprehensive description of the Authority's interactions with WLWG on a wide range of issues is provided in the Summary of River Operations report (pp 125-127). On the basis of information provided in the Summary report, and the absence of any jurisdictions' expressed concerns, IRORG is satisfied that the Authority fulfilled its obligations under this clause.

Providing relevant information [O&O cl 18]

When it refers matters to WLWG, RMOC or BOC, the MDBA is required to give those bodies all information available to the Authority that is relevant to the matter referred, together with any further information sought.

IRORG found no evidence from jurisdictions that the Authority had intentionally not provided full information to advisers and decision-makers.

Review and Revision [O&O cl 19]

BOC is obliged to review the operation of the Objectives and Outcomes document at least annually, and to have regard for IRORG's report as part of its review of the O&O document operation.

Revision 13 of the O&O document was approved by BOC Meeting 92 – 14 April 2023. Revision 13 contains a number of amendments to be effective from 1 June 2023:

i. Inclusion of the first nations name for Lake Victoria. Text has been altered to Tar-Ru/Lake Victoria in several locations.
ii. Update O&O 11 Determining the volume of state water entitlements
iii. Update O&O 12 Reports

iv. SO&O 3.1 a (d) Removal of the paragraph referring to a method to account losses (use by the forest) as the method has been established.

In our 2021-22 review, IRORG suggested a clarification of the structure of the O&O document, the benefits of which would accrue to the MDBA officers who are tasked with reporting performance against objectives and outcomes, and the IRORG reviewers of that performance. IRORG also previously recommended that clause 4 (5) (b) (v) of the O&O document should be amended to align with agreed changes in roles for providing retail environmental water usage data (recommendation 2022.03).

A small typographic error appears in Revision 13, page 10 and carried over from previous revisions: Emergency Action Plan means the Emergency Action Plan referred to in sub-clause 9(3), not 10(3).

7 Issues relevant to the General and Specific O&Os

In the course of its 2022-23 review of river operations, IRORG has identified a number of opportunities for improvements to current operating arrangements. These are discussed below, with a cross reference to the General O&O (GO&O) or Specific O&O (SO&O) that each issue relates to.

7.1 Capacity sharing and shortfall risks [GO&O 4(2)(b)(iii); SO&O 12.11]

The risk of shortfalls in meeting demands in the River Murray system downstream of Barmah has been recognised as a problem for some time now and has been reported on in IRORG's reviews of river operations since 2016.

In 2022-23 the MDBA continued to progress technical work, including the publications of the Barmah-Millewa Feasibility Study in December 2022. In response to this report, the Murray-Darling Basin Ministerial Council in February 2023 agreed on an annual work plan to progress the preferred suite of options and approved funding to further develop and implement solutions.

The MDBA also ran another shortfall drill to simulate a shortfall event and test response processes and capabilities across the MDBA and partner organisations.

Despite this good work, and the positive engagement of BOC in developing draft principles for responding to shortfalls, IRORG is concerned that the priority of this issue appears to have decreased for water managers in some jurisdictions.

While this is understandable given the significant attention and resources that had to be directed to flood operations in 2022-23, shortfalls remain a major source of risk to the timely and effective delivery of water to meet demands in the lower river. As noted previously, IRORG is of the view that jurisdictions need to accept that this is a problem for all parties, and it is essential that they reach a shared solution as soon as possible, rather than trying to resolve such a complex question in the middle of a serious shortfall event.

IRORG urges the parties to continue to allocate a high priority to this issue, and to progress the development of policies and processes to codify the approaches to managing and mitigating this risk.

7.2 Water quality issues [GO&O 4(4)(b)(iii)]

There have been a number of concerning water quality issues during 2022-23 in the southern Murray-Darling Basin. Communities across the system are concerned about the apparent increase in the severity and frequency of these events. They are also concerned about the lack of effective tools available to river operators to respond to these issues.

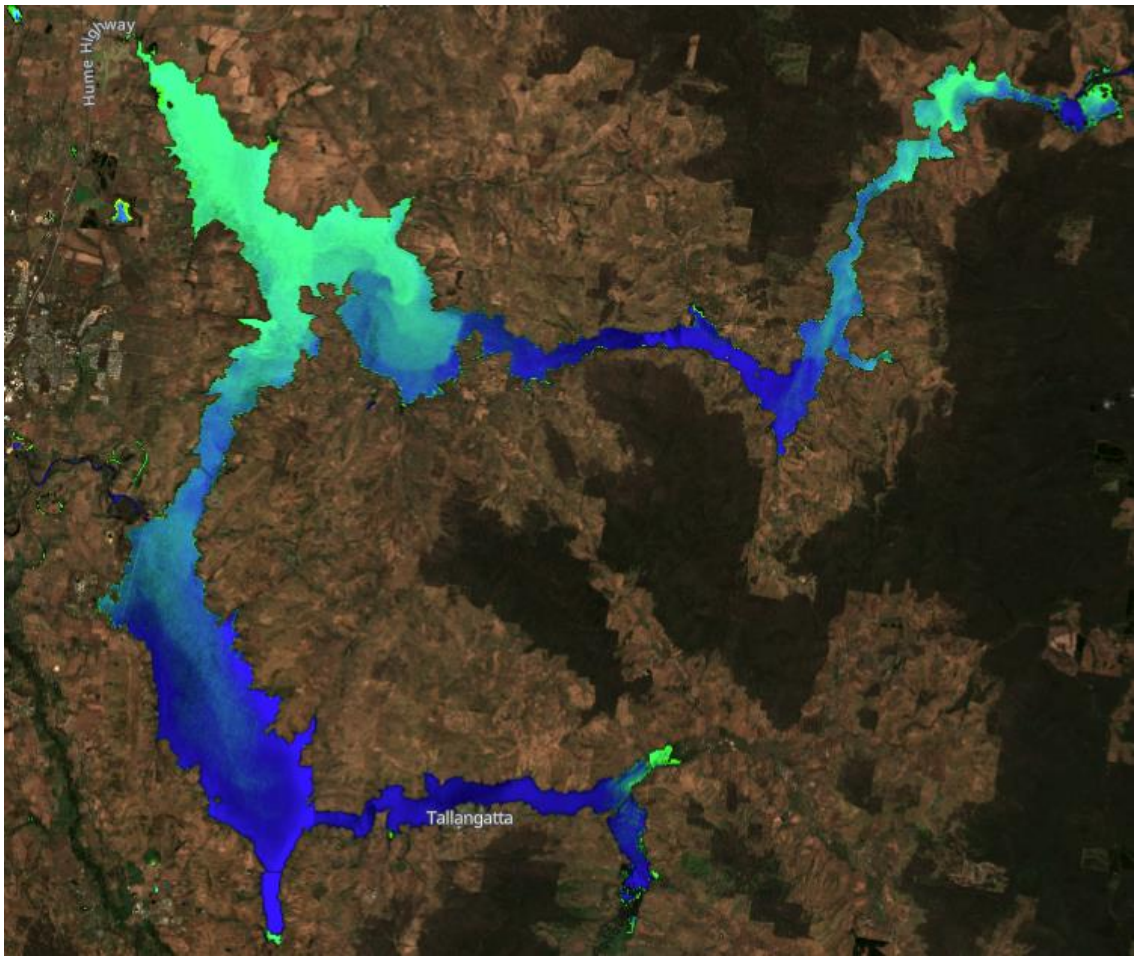
- There was a persistent blue green algal bloom in Lake Hume (at amber or red alert levels) since at least May 2022 (e.g. Figure 3). It is highly unusual for a blue-green algal bloom to

persist over the colder months of the year. High algal counts were also observed at times in both the Murray and Darling-Baaka Rivers.

- Operation of the hydro-electric plant at Lake Hume in late 2022 and early 2023 resulted in hypoxia immediately downstream of the dam and a plume of soluble manganese that interfered with potable water treatment for the cities of Albury and Wodonga. As was the case with a similar event that occurred in January 2022, the MDBA, in co-operation with impacted stakeholders, adjusted releases to mitigate the impact.
- Dissolved oxygen concentrations in much of the southern Basin reached levels that were lethal to large-bodied fish during extensive flooding. The low levels of oxygen were caused by bacteria consuming carbon leached from dead plant matter on the floodplain. (The leached carbon turns the water black - hence the term 'blackwater'). As the bacteria consume the carbon, they also consume oxygen. If the rate of oxygen consumption is faster than the rate that it is re-supplied from the atmosphere, the oxygen concentration can fall to levels that are lethal to large-bodied fish (nominally 2 mg/L). Low oxygen concentration is called hypoxia. While hypoxic blackwater events have been recorded in the Murray-Darling Basin since at least the 1860's, large events like that that occurred in 2022-23 are relatively rare, with incidences in the southern Basin only dating from 2000 (with events in 2000, 2010-11, 2012, 2016 and 2022-23). The Authority has commissioned a comprehensive review into the 2022-23 hypoxic blackwater event to determine amongst other things including operations and communications during the event, and the scope of interventions during future events.
- There was a massive fish kill in the Darling River in the Weir 32 weir pool in mid-March 2023. It was estimated that at least 30 million fish were killed in the weir pool in the space of less than a day. The cause(s) of the fish deaths is the subject of two enquires by the NSW Government - Office of the Chief Scientist and Engineer -(OCSE) and the NSW Environment Protection Agency (EPA). THE OCSE released the Executive Summary of their report on 31 August 2023[8]. They found that the likely cause of the fish deaths was hypoxia. Specifically,"[l]ow dissolved oxygen in the water column was driven by a confluence of factors, including high biomass (particularly carp and algae), poor water quality, reduced inflows and high temperature" (emphasis added).

[8] At the time of preparation of this report, the full OCSE report had not been released.

Figure 3: False-colour Sentinel-2 satellite images of Lake Hume taken on January 7, 2023



The images have been processed using the APA Script (Pelioiva et al, undated)[9]. High algal concentrations are shown in green, clear water in blue.

What is concerning are the drivers underlying these and similar recent events[10] (e.g. bushfire runoff, stratification, unseasonal flooding, elevated water temperature, competition for scarce water resources etc) are only going to intensify under a changing climate[11]. Hence it is highly likely that events like these will become both more frequent and more intense into the future.

[9] Peliova A, Garcia-Lozano C, Sitjar J (undated). Aquatic plants and algae custom script detector (APA script). https://github.com/sentinel-hub/custom-scripts/tree/master/sentinel-2/apa_script accessed July 28 2020.

[10] e.g. see Bevis SG, Wong VN, Mosley LM, Baldwin DS, Latimer JO, Lane P Lal Al (2023) Water quality risks in the Murray-Darling Basin. Australasian Journal of Water Science DOI10.1080/13241583.2022.2163475

[11] For a more detailed discussion see Baldwin (2020) Water quality in the Murray-Darling Basin: The potential impacts of climate change In Ecohydrology from catchment to coast Murray-Darling Basin, Australia: Its Future Management (BT Hart, NR Bond, N Byron CA Pollino and MJ Stewardson (eds). Elsevier, Amsterdam, Netherlands. pp 137 - 159.

The Authority has only limited scope to intercede in adverse water quality events. For example, Section 9.14(5) of the Basin Plan sets out the water quality targets that water managers (including the Authority) must have regard to when managing water flows. There are targets for only three constituents:

- Dissolved oxygen saturation;
- Microcystins concentration (or cyanobacterial biovolume as a surrogate); and,
- Electrical conductivity.

Of the three, the Authority is only required to monitor and report on electrical conductivity (a surrogate for salinity) and then only at a sub-set of sites. Notwithstanding the limited scope the Authority has in managing and monitoring water quality issues that arise when managing water flows, the reputational risk associated with large scale water quality events (like the massive fish kill that occurred in Weir 32 weir Pool in March 2023) is large. In 2021, in response to a water quality incident in Lake Hume, IRORG recommended "the MDBA and jurisdictions should consider whether a wider range of water quality response actions can be brought under a coordination framework, such as existing well-developed regional Blue Green Algae co-ordination arrangements, to provide integrated response capabilities to adverse water quality events" (IRORG Recommendation 2021.01). RMOC at Meeting 36 requested WQAP to consider this action. At WQAP 39, Recommendation 2021.01 was discussed but ultimately rejected. Given the likelihood of continual (and potential worsening) water quality issues in the basin, and in light of the OCSE finding that the Menindee fish kill in March 2023 was "symptomatic of broader degradation to ecosystem health and consequential long-term risks to the Darling-Baaka system", IRORG **recommends** that the MDBA reconsiders IRORG recommendation 2021.01.

The Authority has a *River Murray System Emergency Action Plan.* While this action plan includes responses to major contamination of waterways or storages or, risk to water quality from bushfires, events like the on-going blue-green algal bloom in Lake Hume, the widespread hypoxic event following flooding in the River Murray and its tributaries, or the one that caused the fish deaths in in Weir 32 weir pool may apparently fall outside of the remit of the current Emergency Action Plan. It should be noted that in their executive summary, OCSE were particularly critical of emergency responses following the Menindee fish kill. IRORG **recommends** that the scope of the Authority's current emergency response plan is expanded to include other significant water quality risks beyond bushfires and significant spills).

The OCSE report was also critical on the prioritisation of water quantity over water quality - [e]xplicit environmental protections in existing water management legislation are neither enforced nor reflected in current policy and operations. Water policy and operations focus largely on water volume, not water quality. This failure in policy implementation is the root cause of the decline in the river ecosystem and the consequent fish deaths." An examination of the specific objectives and outcomes for named assets shows that almost all have fairly specific flow targets (e.g. maximum or minimum flows or heights, rates of recession etc). For most of the sites, the "Purpose" of one of the objectives and outcomes usually contains the phrase "....contributing to the protection and, where possible, restoration of priority environmental assets and ecosystem functions....." but few have specific water quality objectives and outcomes associated with them:

- Dartmouth Dam has a minimum planned regulated releases with a specific objective to "to provide for riparian, amenity and in-stream needs, will be managed to conserve water in the Dartmouth Reservoir whilst supporting environmental assets and ecosystem functions between Dartmouth and Hume Reservoirs " (SO&O 1.4).[12]
- Wentworth Weir has a specific objective to have minimum flows to "maintain water quality ..... in the River Murray between Euston and Wentworth Weirs" (SO&O 8.1(b)).
- Lake Victoria has a specific outcome to limit scouring and ground water inclusion (SO&O 9.2 (c)) and can be used to improve water quality (specifically salinity, although blackwater and algal blooms are also mentioned) into South Australia (SO&O 9.6)
- The Menindee Lake Storages have an objective to preferentially conserve water but with consideration to "evaporative losses and water quality" (SO&O 10.5(b))
- The Lower Lakes Barrages are managed to maintain water levels in the Lower Lakes above 0.35 M (AHD) ".... to avoid issues of acidification...." (SO&O 11.1 (b)).

In light of the OCSE report's finding of a general emphasis on water volume over water quality IRORG **recommends** that during the Basin Plan Review the Authority considers a commitment to more tangible water quality targets within the Plan, and that where these targets are related to flow management decisions, they are subsequently reflected in the Objectives and Outcomes document.

If water is required to mitigate the impact(s) of an adverse water quality event, contingency plans should be developed to identify the potential source(s) of that water. The plans will help inform a better integration of water quality objectives within a revised Basin Plan. IRORG **recommends** the Authority**,** in conjunction with the jurisdictions, develop contingency plans for dealing with large, harmful water-quality events in the basin

7.3 River Murray Unregulated Flows

In the Murray River system unregulated flows are declared when actual or forecasted flows exceed the water required to meet all system demands and cannot be captured and stored in Lake Victoria. A more precise definition of "unregulated flows" is provided at O&O sub-clause 15(2)(c). In May 2007 the Ministerial Council agreed in principal that any unregulated flows that remains available after states exercise their prior rights would become River Murray Unregulated Flows (RMUF). RMUF is to be used "to protect, and where possible, restore priority environmental assets and ecosystem functions" (SO&O 12.7(a)). Therefore, RMUF is a sub-component of unregulated flows in the Murray River which should be used to benefit the environment.

In discussions with jurisdictions concerns were raised that advice on unregulated flows, including RMUF was irregular or missing in 2022-23. This was in part because RMO's attention was focused on flood operations (including predictions of flood extent) and also a reflection of the extensive natural flooding. While a call on RMUF is less likely in wet years like 2022-23, it could become a valuable source of additional environmental water in more moderate years.

[12] Both Dartmouth Dam and Hume Dam have maximum rates of rises and falls to help stop bank instability - but whether or not this is a water quality issue or a geomorphic issue is open to debate.

There appears a number of impediments to the uptake of RMUF. The first is, unlike 'unregulated flows' there is no formal definition of the meaning of RMUF or the conditions under which RMUF is declared within the O &O documentation[13]. Secondly, again unlike 'unregulated flows' there isn't a formal requirement for the Authority to notify the Chair of the Southern Connected Basin Environmental Watering Committee when RMUF available becomes, and its estimated volume. Finally, without clear arrangements in place to cover issues regarding the accounting of return flows, there is a reluctance to use RMUF at sites with any appreciable return flows. This final point is counter to the intentions of the Basin Plan to ensure connectivity between floodplain and the main channel of the river (e.g. Chapter. 8.06(f) and Schedule 9).

IRORG **recommends** that:

- The O&O document is amended to include:
  - a definition of 'River Murray Unregulated Flows' (RMUF) and guidance on how a declaration of RMUF is determined.
  - a requirement that the Chair of the Southern Connected Basin Environmental Watering Committee is notified when RMUF has been, or is likely to be, declared.
- Appropriate accounting arrangements are developed for RMUF return flows so as to maximise the benefit to the environment.

IRORG also notes that the shift to Source modelling should enhance RMUF planning into the future.

7.4 Goulburn IVT call outs [GO&Os 4(2)(b)(iii), 4(5)(b)(i)]

The management of river systems within sustainable flow limits, while also meeting the demands of a diverse water user base continues to be a complex balancing act for river operators and water managers.

One area of intense focus in this regard has been the lower Goulburn River. Collaborative work by jurisdictions and the MDBA have led to the adoption of flow limits in this system that are designed to reduce the risk of environmental damage from regulated flow releases. Much of the focus of this work was driven by the negative impacts observed following high volume of call-out from the Goulburn inter-valley transfer (IVT) account.

There are now well structured rules around the call-out of water from the Goulburn IVT; however, when IVT deliveries are occurring, this limits the scope for release of other demands including environmental deliveries, into this reach of the system. The rules also include greater flexibility for delivery of environmental flows to help manage this issue.

[13] It should be noted that RMUF is not defined in the *Water Act*, nor the *Basin Plan*.

Environmental releases like a spring fresh are important not only for maintaining and restoring the health of the Goulburn system, but also for enabling the use of environmental water at multiple sites as it travels out of the Goulburn River and down the River Murray system. In order for environmental water managers to plan for these types of events and maximise the benefits from available environmental water, they need to understand when IVT call-outs that may limit the ability to deliver environmental water will be commencing so that they can plan accordingly. This will help to increase the benefits from available environmental water holdings.

While the Annual Operating Outlook gives some broad guidance on possible IVT call-outs, in the past river operators have been reluctant to provide specific advice on the timing of Goulburn IVT deliveries. One reason for this is the uncertainty in the seasonal climate, rainfall and water use patterns that drive the necessity to deliver IVT, which makes providing very early advice on specific call-out timings difficult. Another issue of concern for river operators in providing IVT advice to environmental water managers has been that it could constitute water market sensitive information, as Goulburn to Murray trading opportunities were closely linked to the IVT balance.

The recent changes to the Victorian Goulburn to Murray trade rules mean that there is no longer any direct link between the call-out of Goulburn IVT volumes and trade opportunities from the Goulburn to the Murray systems. This means that river operators should be able to provide advice on the timing of Goulburn IVT call-outs to environmental water managers without fear of compromising the integrity of water markets. If there are any other residual concerns about risks to water markets (in the Goulburn or in other systems), the MDBA could also explore measures including seeking signed undertakings from environmental water managers not to trade water until call-outs from IVTs (or other market sensitive operational information) is generally available to all market participants.

Accordingly, IRORG **recommends** that the MDBA develop arrangements to enable better sharing of critical operational information to support more effective planning of environmental watering actions, whilst still ensuring water market integrity.

7.5 Water usage reporting [GO&Os 4(2)(b)(ii) & 4(5)(b)(v); SO&O 13.1]

In its 2021 review of river operations, IRORG reported on two issues related to provision of water use data. During this 2023 review, IRORG was disappointed to learn that issues around delays in provision of water usage data by NSW had continued.

The two areas experiencing issues are:

- NSW has not yet been able to put in place arrangements to provide the retail environmental water use data to the CEWO, The Living Murray and SA, which is a concern to the parties.
- IRORG was advised that actual water usage data for NSW private diverters had not been provided to the MDBA for any part of the 2022-23, as at the end of that water year. The MDBA had been provided with estimates of usage, which were used for the water accounts, and to support assessment of state shares etc.

Environmental water holders need timely usage data to allow them to understand the volume of water available in their accounts and to plan additional watering actions.

Timely usage data is also important to enable the MDBA to be able to prepare accurate water accounts, resources assessments, and to manage delivery shortfalls. Given the extended extremely wet conditions in 2022-23, the use of estimates rather than actual usage data did not lead to any significant problems, however as we face the prospect of moving back to drier conditions, access to accurate data is extremely important for all parties.

NSW has acknowledged the shortfall in their performance and has put in place additional resources dedicated to environmental water accounting[14]. IRORG has also been advised that NSW has now been able to provide private diverter usage data for the 2022-23 water year and the accounts have been updated.

The MDBA has advised that discussions are underway with all states to improve the provision of usage data, including considering options for automating data sharing processes. IRORG strongly urges the parties to address this issue as soon as possible, as accurate water usage data is essential for effective water sharing and management. Climate change will add further pressure to water availability and only serves to increase the need for timely, accurate water usage data.

7.6 Source model development [GO&O 4(2)]

Source operations model

IRORG's 2022 review report offered a note of optimism in relation to the potential for the Source operational model to enhance the planning and operational management of the River Murray system. That report also struck a note of pessimism in relation to the delays in developing this powerful new tool and the lack of a clear development plan.

IRORG revisited this issue as part of its 2023 review and was pleased to find that the Authority has made significant progress in the development and application of the Source modelling software to river operations.

The need for accurate forecasts of river flows under very high inflows and bank full or overbank flow conditions further highlighted the limitations of the longstanding spreadsheet based planning tool. As a result of concerted efforts by expert modelling staff, significant improvements were made to the Source operations model. This enabled high quality forecast of flows into South Australia to be provided in a timely manner to guide flood preparations work by communities. The Source operations tool now offers better accuracy and more flexibility to evaluate multiple operational scenarios that the previous operations spreadsheet. Improved capabilities are available for:

- Forecasting flows, including flow to SA

[14] IRORG recommendation 2022.03 recommended that the MDBA request BOC to amend clause 4(5)(b)(v) of the O&O document to clarify that the MDBA does not have any ongoing responsibility for provision of retail environmental water usage data. Implementation of this recommendation will help clarify data provision responsibilities.

- Shortfall risk assessments
- Flow routing and travel time assessment, especially under higher flows
- The ability to quickly assess multiple possible future operating scenarios, which is facilitating improved planning for environmental water management and deliveries.

The MDBA advised that calibration and validation of the model's performance is largely completed for the river reaches downstream of Yarrawonga. Work is currently underway on the reaches upstream of Yarrawonga.

The improvements to the model and its wider use during the 2022-23 have also improved the skills and confidence of river operators to use this tool for day-to-day river operations planning. The MDBA advised that it expects the Source operations model to be the primary operational planning tool for the river Murray system for the 2024-25 water year.

IRORG notes this positive progress and also suggests that the MDBA could consider quantifying the quality of model forecasts vs actual flow outcomes to build further confidence amongst river operators and jurisdictional water managers in the suitability of this new tool for the primary operational role.

Source accounts model

Development work on the Source Accounts Model (SAM) has progressed to the point where the MDBA is now moving to SAM as the production accounting model for the River Murray system. It is proposed that the previous MSM accounts model will also be run in parallel as a shadow/backup system for a period of 12 months. The configuration of SAM has been documented and the MDBA has followed the procedures set out in SO&O 13 for changes to the water accounting models. SAM runs on a daily timestep. This allows better representation of reality, specific flows and orders through the system. Some of the key benefits offered by the new accounting platform include:

- Improved estimates of losses.
- Improved estimates of state ownership of releases from storages.
- Capacity to support future requirements such as environmental demands and accounting
- Improved representation of the River Murray System. For example:
    - Explicit modelling of high flows between the Murray and Wakool rivers.
    - Improved representation of where diversions occur, resulting in better representation of flows.
    - Improved representation of evaporation from Menindee Lakes.
- Inclusion of SA Storage right into the model.

These new planning and accounting models will provide the MDBA with tools that allow them to better understand and manage the River Murray system in an increasing complex operational environment and deliver multiple benefits from the system.

8 Conclusion

IRORG has reviewed the MDBA's performance in operation of the River Murray system for the 2022-23 water year and has assessed the MDBA's compliance with the General and Specific objectives and outcomes set out in the O&O document.

IRORG 's overall assessment is that the MDBA performed well in the 2022-23 water year. All jurisdictions endorsed this assessment of the MDBA's performance.

The general objectives for river operations were all achieved in 2022-23. Overall, MDBA assets performed well in the face of major flooding.

The Authority also performed well in complying with all the specific objectives and outcomes specified in the O&O document. IRORG also considers that the Authority has generally complied with the range of provisions in the O&O document that set out procedural arrangements to support the general and specific O&Os.

Part of IRORG's role also includes identifying any improvements to MDBA's processes or the O&O document that would improve MDBA's performance against the objectives and outcomes or improve the relevance of the O&O document to support current day operations. The challenges operators faced during 2022-23 highlighted several opportunities for potential improvement, including:

- The risk of shortfalls in meeting demands in the River Murray system downstream of Barmah has been recognised as a problem for some time now and has been reported on in IRORG's reviews of river operations since 2016. IRORG is concerned that the priority of this issue appears to have decreased. IRORG urges the parties to continue to progress the development of policies and processes to codify the approaches to managing and mitigating this risk.

- There have been a number of concerning water quality issues during 2022-23 in the southern Murray-Darling Basin. Communities across the system are concerned about the apparent increase in the severity and frequency of these events and the lack of effective tools available to river operators to respond to these issues.

  The Authority has only limited scope to intercede in adverse water quality events. IRORG previously recommended that "the MDBA and jurisdictions should consider whether a wider range of water quality response actions can be brought under a coordination framework, such as existing well-developed regional Blue Green Algae co-ordination arrangements, to provide integrated response capabilities to adverse water quality events" (IRORG Recommendation 2021.01). IRORG encourages the MDBA to revisit this issue.

  IRORG is of the view that the Authority needs to consider both short term and longer term actions to provide a stronger focus on water quality matters and to also provide river operators with more effective tools to respond to these issues.

- In the Murray River system unregulated flows are declared when actual or forecasted flows exceed the water required to meet all system demands and cannot be captured and stored

in Lake Victoria. Any unregulated flows that remain available after states exercise their prior rights are available to become River Murray Unregulated Flows (RMUF), which can be used for environmental benefits. Advice on unregulated flows, including RMUF, was irregular or missing in 2022-23. RMUF needs to be effectively defined and codified in the O&O document.

- The lower Goulburn River has been an area of intense focus to establish sustainable flow limits. There are now well structured rules around the call-out of water from the Goulburn IVT. In order for environmental water managers to plan and maximise the benefits from available environmental water, they need to understand when IVT call-outs (or any other demands) that may limit the ability to deliver environmental water will be commencing.

  The MDBA needs to develop arrangements to enable better sharing of critical operational information to support more effective planning of environmental watering actions, whilst still ensuring water market integrity.

- IRORG has been concerned about significant delays in the provision of important water usage data by NSW, which were experienced again in 2022-23. Timely usage data is important to enable the MDBA to be able to prepare accurate water accounts, resources assessments, and to manage delivery shortfalls. Environmental water holders need timely usage data to allow them to understand the volume of water available in their accounts and to plan additional watering actions.

  The MDBA has advised that discussions are underway with all states to improve the provision of usage data, including considering options for automating data sharing processes. IRORG strongly urges the parties to address this issue as soon as possible, as accurate water usage data is essential for effective water sharing and management.

- The MDBA has been working on the development of new operational planning and accounting tools built on the powerful Source river modelling software platform.

  As a result of concerted efforts by expert modelling staff during 2022-23, significant improvements were made to the Source operations model. The MDBA advised that it expects the Source operations model to be the primary operational planning tool for the river Murray system for the 2024-25 water year. Development work on the Source Accounts Model has progressed to the point where the MDBA is now moving use it as the production accounting model for the River Murray system.

  These new planning and accounting models will provide the MDBA with tools that allow them to better understand and manage the River Murray system in an increasing complex operational environment and deliver multiple benefits from the system.

The Independent River Operations Review Group – an advisory committee established by, and reporting to, the Murray-Darling Basin Authority