Department of Planning and Environment

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Procedures Manual for the Murrumbidgee Regulated River (2022)

PREREQUISITE POLICY MEASURES

December 2022

Acknowledgement of Country

The Department of Planning and Environment acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

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More information

Environmental Water Management | Operations Division

www.industry.nsw.gov.au/water/environmental-water-hub

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Paul Simpson Consulting Pty Ltd

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Cover image: Murrumbidgee River – Lorraine Hardwick, NSW DPI

Document revisions

Revision	Date	Publication number	Summary of revisions
1	30/06/2019	PUB19/313	Procedures Manual developed to meet MDBA requirements for PPMs
2	December 2022	PUB22/564	Updated to include new accounting arrangements (Table 6 and Appendix C) and other minor edits. Reviewed by the NSW PPM Working Group.

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Abbreviations

Abbreviation	Description
CEWH	Commonwealth Environmental Water Holder
CEWO	Commonwealth Environmental Water Office
EWAG	Environmental Water Advisory Group
HEW	Held Environmental Water
MDB	Murray-Darling Basin
MDBA	Murray-Darling Basin Authority
PPM	Prerequisite Policy Measure
PPM IP	NSW Prerequisite Policy Measure Implementation Plan
RMIF	River Murray Increased Flows
RMO	River Murray Operations
SO&Os	Specific objectives and outcomes for river operations in the River Murray System
SCBEWC	Southern Connected Basin Environmental Watering Committee
SDL	Sustainable Diversion Limit
TAG	Technical Advisory Group
TLM	The Living Murray
WMA	Water Management Act 2000
WRP	Water Resource Plan
WSP	Water Sharing Plan

1. Introduction

1.1 Purpose

This Procedures Manual (the Manual) has been prepared to provide a detailed framework for the operation and continual improvement of PPMs in the NSW Murrumbidgee regulated river water source. The implementation of PPMs will maximise the efficient use and beneficial outcomes from the use of water for the environment.

The objective of this Manual is to sufficiently codify the process of using PPMs in the Murrumbidgee regulated river water source to achieve an appropriate balance between providing protection for other water licence holders and allowing for the efficient and effective use of water for the environment to achieve the environmental outcomes envisaged under the Basin Plan.

1.2 Context

Prerequisite Policy Measures (PPMs) seek to maximise the beneficial outcomes of water recovered for the environment under the Basin Plan. In developing the Basin Plan, the Murray-Darling Basin Authority (MDBA) assumed that rivers will be managed to maximise environmental outcomes with the water available without impacting on other water users. This concept was being explored by Basin States for the multi-site environmental watering trials in the River Murray. The intended outcomes were for:

- environmental water flows throughout the length of the river, and between rivers; and protected from extraction, re-regulation or substitution
- to allow the release of environmental water on top of other in-stream flows, including unregulated flow events.

These outcomes were intended to be achieved through the unimplemented policy measures described under 7.15 of the Basin Plan, and are now referred to as PPMs:

- credit environmental return flows for downstream environmental use (return flows)
- allow the call of water for the environment from storage during unregulated flow events (piggybacking).

Implementing PPMs is critical to achieving the environmental outcomes of the Basin Plan with the water identified for recovery. PPMs are implemented via legislative and operational rule changes to create secure and enduring arrangements for the use and accounting of water for the environment. PPMs will assist to minimise the volume of water recovered by allowing for more efficient and effective use of water for the environment to maximise environmental outcomes, without impacting on the reliability of other water users.

In developing the PPMs, the NSW government is discharging its obligations to implement water reform and deliver on the Basin Plan. PPMs are supported by the NSW *Water Management Act 2000* and will enable the effective and efficient delivery of environmental water for beneficial outcomes.

1.3 Background

PPMs allows the use of water for the environment at multiple sites along the length of the river, and between rivers (environmental flow reuse, or return flows), and for HEW to be ordered from a headwater storage during unregulated events (piggybacking). These measures are significant changes to the way that water has historically been managed and accounted for in the Murray-Darling Basin.

Under the *Intergovernmental Agreement on Implementing Water Reform in the Murray-Darling Basin 2013*, NSW agreed to deliver a Prerequisite Policy Measures Implementation Plan by June 2017 to the Murray-Darling Basin Authority (MDBA). The NSW Prerequisite Policy Measures Implementation Plan (PPM IP) was endorsed by the MDBA in May 2017.

The MDBA has assessed the measures made through amendments to water sharing plans and changes to regulations and operational manuals and determined that PPMs are in effect. As of 1 July 2019, PPMs were considered to be in effect.

PPMs are applied during the operation of the SDL Adjustment Mechanism in the Basin Plan. Any increase to the SDL resulting from supply measures will be calculated by adding notified supply measures and removing any unimplemented PPMs from the benchmark conditions of development, while maintaining equivalent environmental outcomes and no detrimental impacts on reliability of supply of water to the holders of water access rights that are not offset or negated.

1.4 Relationship to other plans and legislation

The management of environmental water in accordance with PPMs occurs within the NSW water management framework, guided by the *Water Management Act 2000*.

PPMs are implemented within NSW through the NSW PPM Implementation Plan and this Manual, together with supporting changes to Water Sharing Plans (WSPs) in each water source and the WaterNSW water supply works approval.

To establish statutory support for the process set out in the NSW PPM Implementation Plan and the Manual, amendments will be made to the *Water Sharing Plan for the Murrumbidgee Regulated River Water Source 2016*. Amendments to the water sharing plan require concurrence from the NSW Minister for Environment.

The roles and obligations of the river operator to implement PPMs is also recognised through the inclusion of specific conditions to the WaterNSW Murrumbidgee water supply works approval.

A table demonstrating how PPMs relate to Commonwealth and State plans and legislation is provided in Appendix A.

1.5 Overview of the PPM Procedures Manual

This Manual will be made publicly available by Department of Planning and Environment–Water (DPE-Water), and will be reviewed annually via the process set out in this Manual. Changes may

arise from the annual review, or as a result of proposals brought forward for consideration. The publicly available Manual will be kept updated as changes are approved.

This Manual is set out as described in Table 1.

Table 1: Overview of the Manual

Section	Content
Section 1	**Introduction** Purpose Context Background Relationship of the Manual to other plans and legislation Overview of the NSW PPM Procedures Manuals
Section 2	**Overview of PPMs in NSW** NSW principles and objectives for PPM implementation Call of water from storage Environmental flow reuse Operability of PPMs in NSW from planning to reporting and review
Section 3	**Framework for the operation of PPMs** Key framework components Roles and responsibilities Consultation
Section 4	**The Murrumbidgee system** Environmental water sites Water delivery pathways Murrumbidgee PPM actions Risk mitigation
Section 5	**Adaptive management** Annual reporting Annual evaluation and review for continuous improvement

2. Overview of PPMs in NSW

This section describes how the PPM requirements to call water from storage and recognise environmental flows that are returned to the water source for downstream environmental benefits are enabled in NSW legislative and policy settings. This NSW overview includes arrangements for both the Murrumbidgee and NSW Murray and Lower Darling regulated rivers. These NSW arrangements will be strengthened and refined through the processes described in this Manual.

In NSW, PPMs apply to held environmental water (HEW) in the Murrumbidgee, NSW Murray and Lower Darling regulated rivers water sources. HEW is environmental water that is held as part of a licensed volumetric entitlement (see Appendix B).

In the NSW Murray regulated river water source, PPMs also apply to River Murray Increased Flows (RMIF) account water.

2.1 Principles underpinning NSW PPM implementation

The NSW PPM IP sets out four guiding principles for the implementation of PPMs:

1. NSW will implement PPMs to the extent that impacts on other licence holders can be mitigated or offset, while also enabling optimum environmental outcomes.
2. NSW will develop operational tools that are simple, practical to implement and cost effective.
3. Reliability and access characteristics of licensed entitlements held for environmental water purposes are the same as other licensed entitlements.
4. Adaptive management is required.

The development of this Manual has been based on these principles. The application of the processes in this manual will be guided by these principles to seek to maximise the beneficial outcomes of water recovered for the environment under the Basin Plan while maintaining reliability to other licence holders. Where there is uncertainty, NSW will adopt a precautionary approach to minimise potential detrimental impacts.

It is recognised that there are also benefits stemming from the implementation of PPMs. In some instances, these benefits may offset any detrimental impacts over the longer term. However, until the benefits and impacts can be determined, NSW will continue to implement PPMs based on the above principles.

PPM Assessment Guidelines were provided by the MDBA to inform the content and format of states' implementation plans for PPMs. The Guidelines require the arrangements for the implementation of PPMs to:

- be secure and enduring
- be fully operable
- be transparent
- identify and mitigate risks
- provide for releases of Held Environmental Water from storages on top of other in-stream flows, including unregulated events
- allow environmental water to flow throughout the length of the river, and between rivers; and be protected from extraction, re-regulation or substitution.

2.2 Call water from storage using piggybacking

PPMs enable HEW to be ordered from a headwater storage during unregulated flow events (piggybacking). Piggybacking allows the environmental water holders to target flows to nominated delivery points along the river.

The NSW environmental water manager works with WaterNSW to develop a water order including the target flow and location. This process is an extension of the consultation already undertaken via the EWAGs. The water order can request that the order be met from a headwater storage. Piggybacking allows such a water order to be placed during delivery of other system demands, including during unregulated flow events, with agreement from WaterNSW on matters such as the rates of releases, accounting arrangements, and flood/water quality risk mitigation measures. The planning, ordering and delivery process for HEW orders is set out in more detail in Section 2.3.

As the river operator in NSW, WaterNSW is required to meet system orders subject to operating constraints of the system. Flows that result from water orders made using piggybacking cannot be used to be meet other access licence water orders, planned environmental water rules or general system operational rules. HEW is recognised as it moves through the system through the delivery of target volumes according to the agreed water order and requires ongoing monitoring of flows along the river reach.

For shared resources in the Murray and Lower Darling, when water is called from storage, WaterNSW approves orders placed by the environmental water manager, following consultation with MDBA where necessary. WaterNSW then directs the MDBA to release orders in accordance with the Murray-Darling Basin Agreement and the 'Objectives and Outcomes for River Operations in the River Murray System' document.

The methodology adopted in the Murrumbidgee and NSW Murray and Lower Darling for calculating the volume to be debited from an environmental account when using piggybacking is to determine the difference between releases made with the environmental water holder's order and the releases that would have (hypothetically) been made without the environmental water order.

2.3 Environmental flow reuse

This section describes how the PPM requirement to recognise environmental flows that return to the water source from an environmental event is implemented.

Environmental flow reuse, or return flows, recognises the return flow of water downstream of an environmental watering event, allowing that water to be used for downstream environmental benefits. These return flows are protected from extraction and re-regulation, including in the downstream system.

The procedures for environmental flow reuse, or return flows, are:

- A delivery pathway is nominated to describe the intended environmental watering event. The nominated delivery pathway allows a water order using HEW to nominate multiple environmental use sites along the length of a river, subject to delivery capacity and operating constraints.
- For environmental sites that are not considered accurate, an assumed use method is required. The assumed use method is used to estimate the delivery of environmental water and the downstream return flows.
- For each order using an assumed use method, an Assumed Use Statement is required for the purposes of debiting accounts.
- Return flows that result from water orders made using environmental flow reuse cannot be used to be meet other access licence water orders, planned environmental water rules or other general system operational rules. Return flows are recognised as they move through the system in line with the assumed use method.

Environmental flow reuse also applies when HEW is delivered into a downstream river system, such as inflow from the Murrumbidgee to the River Murray.

HEW flows from the Murrumbidgee River into the River Murray are managed under the bulk entitlement delivery arrangement provided under the Murray Darling Basin Agreement (Clause 98 MDBA's Role in the Operation of Storages). WaterNSW, as the NSW river operator, applies an agreed incremental loss rate, to recognise HEW delivery in the Murray from Balranald to South Australia. WaterNSW provides MDBA River Murray Operations (RMO) with daily flow volumes of HEW passing beyond the point of delivery (i.e., Balranald) for recognition in the Murray and delivery to the South Australian border. This flow is to be adjusted by RMO for travel time to the South Australian border and the water accounted as a bulk entitlement delivery to South Australia. This water is not to be reregulated for any use, and not to be reregulated into Lake Victoria. These accounting arrangements are outlined in Section 2.4.3 of this Manual.

For shared resources in the Murray system, to recognise and protect downstream environmental flows in the River Murray, NSW also uses Clause 98 of the Murray Darling Basin Agreement to direct the MDBA to deliver a bulk volume of NSW HEW to South Australia. These instructions reflect the assumed uses specified in the relevant Specific Objective and Outcome (SO&O).

Inter-state environmental flow reuse will be facilitated by 'in-stream' adjustments. Endorsed by BOC (BOC 65), the 'in-stream' adjustment trial allows for the adjustment of environmental return flows between NSW and Victoria and provides an enabling mechanism to allow return flows in Victoria to be traded for immediate delivery in NSW and vice versa. Existing provisions can facilitate these actions, through allocation trade of returned flows for immediate delivery, and where necessary reallocation of resources between Victoria and NSW under clause 113 of the Murray-Darling Basin Agreement.

The 'in-stream' adjustment trial allows the use of HEW in an efficient manner. This option is available for use, on a trial basis, at any time(s) in the three years from 1 July 2019 to 30 June 2022. BOC will consider the permanent adoption of the arrangements following a review of the results.

If an individual watering action is proposed to use inter-state trade of return flows between NSW and Victoria, it will be assessed by State Constructing Authorities in collaboration with MDBA River Operators. The State Constructing Authorities (WaterNSW in the case of NSW) provides written approval for the action to MDBA, recognising that the in-stream accounting option is used to make the trade adjustment. MDBA's monthly accounts model is revised as necessary to document the volume of trade which was adjusted in-stream, the month(s) of delivery and the river reaches involved. In addition, the volumes of trade adjustment in Hume that are reversed are also documented. The operation of the in-stream adjustments for inter-state trades are also reported as part of River Murray Operations' Annual Summary of River Operations, and be reviewed by the Independent River Operations Review Group in September of the year following any individual trial.

2.4 Operability of PPMs in NSW

PPMs are operationalised through the valley-specific Procedures Manuals and supporting conditions in the relevant water supply work approvals held by WaterNSW. The Procedures Manual codify the operational process and accounting arrangements so that an appropriate balance is achieved between providing for the efficient and effective use of water for the environment and providing protection for other water licence holders.

Relevant NSW agencies (Department of Planning Environment - Water as the regulator, WaterNSW as the river operator and Department of Planning Industry and Environment – Environment and Heritage as the NSW environmental water manager) provided a joint letter of commitment to MDBA confirming that PPMs will continue to be implemented as per the arrangements described in the Procedures Manuals from 1 July 2019. This letter remains in effect until the new clauses in the relevant WSPs are gazetted and new conditions are placed on the water supply work approvals.

The sections below detail the arrangements for the implementation of PPMs, including event planning, water ordering, delivery, accounting, report and review processes.

2.4.1 Planning

Environmental watering events are complex and require a process for developing and placing water orders. This process includes a requirement for river operators to be involved in the development process to ensure that events can be managed over a range of climatic and operational conditions. Existing forums such as the environmental water advisory groups (EWAGs) are used by the environmental water managers for consultation required at various stages in the development of environmental watering events. Environmental water holders (CEWO and Department of Planning and Environment-Environment and Heritage) also work together to develop watering schedules which outline the purpose, conditions and arrangements for environmental watering events in NSW that use Commonwealth environmental water. Environmental water holders develop annual environmental watering priorities and plans which consider a range of weather and water availability scenarios.

The environmental water holders will work with WaterNSW to develop a proposal including the target flow and location.

An iterative process may be required during this planning phase and requires cooperation between the regulator, the river operator and the environmental water holders, including agreement on any assumed use rates, consideration of impacts (both positive and negative) and risks, and any mitigation measures to be applied.

For significant environmental watering events, development of water orders must commence well in advance of the target release period to allow sufficient time for collaboration between environmental water managers and WaterNSW.

2.4.2 Ordering and release of water

Following the above planning process, the NSW environmental water manager (i.e., the Department of Planning and Environment-Environment and Heritage) prepares and places a water order.

The water order should contain:

- a general description of the proposed event, including its environmental objectives
- delivery details, including:
  - target flow and/or diversion rates and locations
  - start and end dates
  - any return flows (if applicable)
  - when delivery should cease (e.g. if particular flow threshold reached or if unregulated flows commence)
  - delivery pathway, if more than one site is nominated for watering.
- accounting arrangements (reflecting any discussions from Section 2.3.1 above), including any assumed use method to be used
- nominate the entitlements to be used (and an upper volume limit if required) and any associated instructions regarding the split across water access licences
- the decision-making process proposed to manage any potential variation in weather conditions or other relevant factors.

Water orders must be sufficiently detailed to provide guidance for river operators over a range of potential climatic conditions and may also require protocols for within-event decision making.

The river operator is required under their water supply work approval to provide timely advice regarding system flow limits, any matters that might vary the volume of water that would be required, and risks in delivery of the proposed order. An iterative process may be required to settle complex water orders and will require cooperation between the river operator and the environmental water manager.

Environmental water holders are responsible for estimating the volume of water required to meet their environmental objectives in their water orders, having regard to advice from WaterNSW.

The river operator is responsible for operating the river including approving a water order. Operational risks and the available mitigation measures are to be considered by WaterNSW when

considering water orders that require the release of water using PPMs. This will be undertaken in consultation with the environmental water manager prior to approval (or rejection) of an order using PPMs. Any orders that are refused/rejected will be documented in the annual environmental release river operations report, together with supporting explanations and rationale.

When an order that relies on the use of PPMs is accepted by the river operator, the release of water to meet that order should be incorporated into delivery planning for the valley, and included in any advice regarding operation of the regulated river system to licensed water users and publicly for the community. The environmental water manager, in placing a water order relying on PPMs, is required to undertake appropriate communication actions to ensure that potentially affected landholders and the general community are aware of the proposed watering event.

The river operator is required to provide operational reporting on release of held environmental water, including regular environmental water use accounting during events.

2.4.3 Accounting

WaterNSW maintains water allocation accounts that record water allocation announcements, water ordered, water taken and carry over for each water access licence, including those licenses owned by environmental water holders. They are responsible for determining and debiting volumes of held environmental water used during environmental watering events that rely on PPMs.

As accounting methods become established through the application of the process set out in the Procedures manual, the arrangements will be conditions in the Manuals (see Section 4) and provided on the department's website.

The methodology generally adopted in the Murrumbidgee and NSW Murray and Lower Darling for calculating the volume to be debited from an environmental account when using piggybacking is to determine the difference between releases made with the environmental water holder's order and the releases that would have been (hypothetically) made without the environmental water order.

Where there is accurate measurement of take, the volume of take shall be debited from the account. Similarly, where there is accurate measurement of return flows, this volume shall be recognised downstream of the environmental site, with any agreed mitigation measures applied.

For environmental sites where measurement is not considered accurate, an assumed use method is used to estimate the volume of debit and/or return flow. WaterNSW will provide an assumed use statement to the environmental water manager that sets out the calculation of the volumes of water to be debited from water access licence accounts. Where relevant, the volume of water accounted as held environmental water that is to be passed into the Murray will also be specified, split by contributing environmental water holders/licences. Any additional assumptions made will also be identified.

As much as possible, assumed use statements reflect the requirements of the water order and capture the decisions made during the planning and ordering phases between the regulator, the river operator, and the environmental water holders, including agreement on any assumed use rates and mitigation measures to be applied. Existing dispute resolution procedures are to be applied in the event of a dispute.

Monthly reporting on water usage split by water holder/licence for each PPM watering action is to be provided (cumulative for the water year to the end of the previous month). Similarly, monthly reporting on return flows is required, again split by water holder/licence.

Bulk accounting arrangements for the shared resources in the River Murray System are detailed in the Specific Objective and Outcomes for directed release and assumed use in the Objectives and Outcomes for River Operations in the River Murray System document.

Murrumbidgee end-of-system HEW will be recognised in the Murray. WaterNSW will apply an agreed incremental loss to the HEW passing Balranald, and will provide MDBA River Murray Operations with the daily flow volumes of HEW for recognition in the Murray. This flow is to be adjusted by RMO for travel time to the South Australian border and the water accounted as a bulk entitlement delivery to South Australia. A similar approach is used for NSW HEW entering the River Murray from the Lower Darling at Burtundy.

Monthly reporting on return flows split by water holder/licence at the South Australian border is also required for each PPM watering action.

As much as practicably possible, losses applied to environmental water will be based on the 'incremental loss' resulting from the additional flow created by environmental water.

Determining loss rates is based on best available information and will become more accurate as more data and information becomes available. In the early stage of PPM implementation, a more conservative or higher loss rate may be applied to ensure no detrimental impacts to reliability for other licensed water users. Methods will become more refined through their application in successive years.

2.4.4 Reporting

The river operator provides operational reporting on releases of environmental water during events. At a minimum, this will include monthly reporting on water usage split by water holder/licence for each PPM watering action, as well as return flow volumes again split by water holder/licence. Reporting on end-of-system return flows and any return flows reaching the South Australian border is required.

An Annual Environmental River Operations Report is to be prepared by the River Operator that documents the application of the specific watering actions that used PPMs in that water year, including the accounting of river flows, transmission losses, and water delivery that occurred. Where information is available, the report includes comparisons of assumed use with actual/estimated river transmission losses and use, associated with watering actions that rely on that assumed use methods.

The environmental water manager will prepare an Annual Environmental Watering Statement that documents any issues that arose in the ordering or delivery and accounting of environmental water using PPMs. The environmental water manager consults with other environmental water holders and stakeholders including the CEWO, TLM and EWAGs when preparing these reports.

These annual reports form the basis for the annual review process.

2.4.5 Evaluation and review

The NSW PPM framework is underpinned by an adaptive management process to provide for the continuous improvement of the processes set out above.

The Department of Planning and Environment-Water, as the regulator, will conduct an annual evaluation and review of the implementation of PPMs for each water year. The review will be guided by the principles set out in the NSW PPM IP, this Manual and the MDBA's position statement on PPMs (2019). The Department of Planning and Environment-Water is responsible for ensuring that appropriate changes to the regulatory framework are made to give effect to any recommendations arising from this review, in consultation with key stakeholders including the Department of Planning and Environment-Environment and Heritage and WaterNSW.

This framework provides the necessary flexibility to enable the regulator, the environmental water holders, and river operators to learn, adapt and refine as environmental watering evolves. A structured review process provides an opportunity for capturing learnings and identifying areas for allows for improvement to the framework to facilitate continuous improvement for effective and efficient delivery of water for the environment.

The Department of Planning and Environment–Water will prepare and publish an annual evaluation and review report, including any findings of the review and recommendations.

2.4.6 Governance

The inter-agency PPM Working Group provides a forum for the collaboration on matters regarding the operation, implementation, review, and improvement of PPMs in NSW. Agencies responsible for water planning, operations and environmental water management are represented:

- NSW Department of Planning and Environment-Water (Chair)
- NSW Department of Planning and Environment-Environment and Heritage
- WaterNSW
- Murray-Darling Basin Authority
- Commonwealth Environmental Water Office.

The Department of Primary Industries-Fisheries also attend as observers.

The PPM Working Group considers the annual evaluation and review report and its recommendations to guide adaptive management and continual improvement, and provide recommendations as necessary. The PPM Working Group also assists in identifying and prioritising tasks on the NSW PPM work plan.

3. Framework for the operation of PPMs

3.1 Key framework components

The operational framework for PPMs consists of the following components:

- PPM actions agreed and approved for use
- Operational processes for planning, ordering and delivering events using PPMs (as set out in Section 2 of this Manual),
- Accounting methods for managing environmental water released using PPMs and debiting accounts.
- An annual review process to provide transparency regarding use of PPMs in that year, and inform consideration of any changes or new measures that may be appropriate.

The annual process involving these elements is shown in Figure 1. Roles and responsibilities are detailed in Section 3.2.

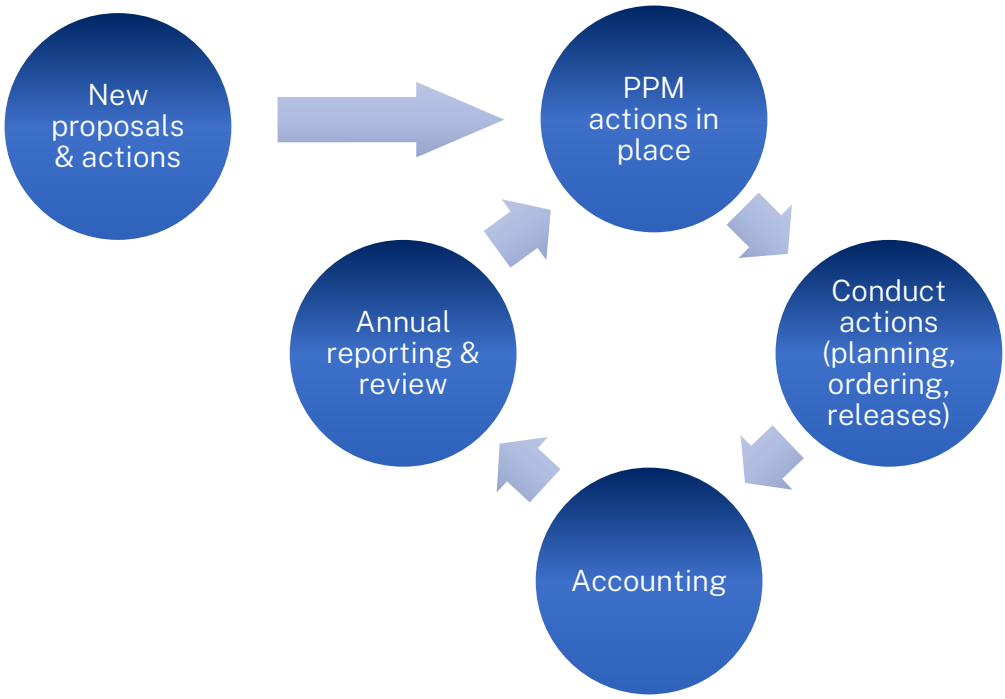

Figure 1: An overview of the PPM process

3.1.1 Actions

In consultation with WaterNSW and environmental water holders, Department of Planning and Environment – Water can agree to actions that will allow HEW to be managed in new ways to using PPMs. These actions must operate in conjunction with a number of supporting measures of the NSW PPM framework, including, where necessary:

- A delivery pathway,
- An assumed use method, and
- Linked mitigation measures.

Actions and their supporting measures will be considered to mitigate or offset any detrimental impacts on the access rights of licensed water holders and any impacts to the efficient use of held environmental water. Actions can include mitigation measures to offset these risks as necessary. The Department of Planning, and Environment – Water in its role as the regulator is responsible for approving actions, including accounting arrangements. and any subsequent variations following review.

Recognising that environmental watering actions using PPMs will develop over time, an adaptive management approach is required. To provide for changes over time, actions can be modified or new actions agreed, by the Department of Planning and Environment – Water in its role as the regulator. Changes will be made after consultation with the environmental water managers, WaterNSW, primarily via the PPM Working Group.

It is noted that at times both piggybacking and environmental flow reuse (or return flows) will operate together. For example, when the environmental licence holder makes an order from a nominated water storage (piggybacking), whether during a regulated or unregulated flow event, they may also request the use of environment flow reuse to use any return flows further downstream, including in a downstream river systems.

In recognition that actions and their supporting measures will need to be tested to build a body of knowledge, particular actions and supporting measures may be trialled initially. These trial actions will ensure that material risks are appropriately identified and mitigated and that the actions are operable. Trial actions will also operate in conjunction with supporting measures including a delivery pathway, an assumed use method and linked mitigation measures. Trial actions and their supporting measures must be reviewed and re-approved annually. If the application of a trial action proves successful, then it may be determined as an (ongoing) action following the annual review of the operation of PPMs.

3.1.2 Supporting measures

Watering actions rely on a number of supporting measures of the framework in order to operate. These are:

- **Delivery pathways:** describe the intended environmental watering event, and show how the watering actions, assumed use methods and mitigation measures link together.
- **Assumed use methods:** a method of estimating the delivery of environmental water is required whenever that use cannot be accurately measured. These methods will be used to produce Assumed Use Statements for the purposes of debiting accounts of HEW licences.
- **Mitigation measures:** any measures that must be taken to ensure that detrimental impacts on the access rights of licensed water holders are mitigated or offset.

Assumed use methods and accounting arrangements must be consistent with legal instruments. As much as practicably possible, assumed used methods are to:

- use accurate metering and measurement where and when available (as nominated in the Manual)
- be fit-for-purpose with appropriate balance between rigour and practicality of implementation
- balance the delivery of HEW using PPMS for its efficient and effective use without generating unacceptable adverse impacts to licensed water holders
- provide a level of conservatism that is proportional to the confidence in the assumed use method and risks
- be reviewed over time and improved as experience and knowledge grows.

3.2 Roles and responsibilities

The key roles and responsibilities within the framework for the operation of PPMs are set out in Table 2.

Table 2: Roles and responsibilities for the implementation of PPMs

Role	Organisation	Responsibilities
Regulator	NSW Department of Planning and Environment - Water	• The effective implementation of PPMs via NSW's policy and regulatory framework • Adhere to the principles of the NSW PPM IP • Ensure the required statutory instruments are in place to give effect to agreed actions • Undertake annual review of the implementation of PPMs • Review and approve actions and any subsequent variations following the review phase of PPM operations including trials • Assess assumed use/in-stream loss rates/methods as per principles and rules in this Manual • Approve proposed trials of new actions if suitable conditions and mitigation measures are demonstrated • Consult with the PPM Working Group on any new or revised actions or supporting measures • Consult with WaterNSW, Department of Planning and Environment–Environment and Heritage, MDBA and CEWO when conducting each annual review, including the annual evaluation and review report and its recommendations • Classification of take/return measurement at recognised environmental watering sites

Role	Organisation	Responsibilities
River Operator	WaterNSW	• Work collaboratively with Department of Planning and Environment – Environment and Heritage to develop orders for environmental water actions and recommend appropriate mitigation strategies • Assist in developing assumed use/in-stream loss rates/methods as per principles and rules in this Manual • Undertake risk assessment of proposed actions and recommended mitigation strategies in collaboration with Department of Planning and Environment – Environment and Heritage prior to approval or rejection of water orders • Operate the river to give effect to actions for the delivery of PPMs, including advice and action on events (e.g. rain/inflows) that trigger changes to the action • Prepare an assumed use statement for an environmental watering event that relies on an assumed use method • Provide operational reporting on release of environmental water, including regular environmental water use accounting during events • Provide monthly reporting to environmental water holders on water usage and return flows • Submit an annual Environmental Releases River Operations Report on river operations involving actions • Support the development of new proposals and trial actions for the operation of PPMs • Classification of take/return measurement at recognised environmental watering sites
Environmental Water Holders	Department of Planning and Environment – Environment and Heritage	• Work collaboratively with other environmental water holders (including the CEWO and through the Southern Connected Basin Environmental Watering Committee (SCBEWC) if appropriate) in the planning and coordinated use of environmental water in consultation with river operators, including risk assessments and mitigation measures • Work collaboratively with the river operator when developing orders for environmental water that rely on actions • In collaboration with other environmental water managers, submit an annual environmental watering statement to the Department of Planning and Environment – Water that reports on the environmental outcomes of environmental watering relying on the use of PPMs • Development of new proposals for the operation of PPMs • As the environmental water manager for NSW, place water orders with WaterNSW

Role	Organisation	Responsibilities
	Commonwealth Environmental Water Office	• Work collaboratively with Department of Planning and Environment – Environment and Heritage and other environmental water holders as appropriate, in the planning and coordinated use of environmental water in consultation with river operators, including risk assessments and mitigation measures • Work collaboratively with Department of Planning and Environment – Environment and Heritage to develop orders for environmental water that rely on PPM actions and their mitigation measures, and to develop new proposals for the operation of PPMs • Provide input into the annual environmental watering statement prepared by Department of Planning and Environment – Environment and Heritage
	MDBA via The Living Murray Initiative	• Work collaboratively with Department of Planning and Environment-Environment and Heritage and other environmental water managers as appropriate, in the planning and coordinated use of environmental water in consultation with river operators, including risk assessments and mitigation measures • Work collaboratively with Department of Planning and Environment–Environment and Heritage to develop orders for environmental water that rely on PPM actions and their mitigation measures, and to develop new proposals for the operation of PPMs • Provide input into the annual environmental watering statement prepared by Department of Planning and Environment–Environment and Heritage

3.3 Consultation

Consultation is an important element in the delivery of water for the environment that relies on trial or agreed PPM actions. Consultation provides transparency regarding the operation of the agreed actions, and the performance of any mitigation measures.

The minimum consultation requirements associated with the implementation of PPMs within NSW are:

- The regulator (Department of Planning and Environment–Water) will consult with WaterNSW, Department of Planning and Environment–Environment and Heritage, MDBA (River Operations and TLM) and the CEWO via the NSW PPM Working Group when conducting each annual review, and when developing new, or revising existing, actions or supporting measures.

- The river operator (WaterNSW) will consult with water users or their representative groups via existing forums (such as Customer Advisory Groups) as necessary, and provide a summary as part of the requirements of the Annual Environmental Releases River Operations Report.
- The environmental water manager (Department of Planning and Environment–Environment and Heritage) will consult with:
  - the river operator (WaterNSW) regarding proposed watering actions using PPMs before placing an order
  - affected stakeholders when developing, and the community more generally when delivering, environmental water orders relying on the use of PPM actions as appropriate
  - other environmental water managers (including the CEWO) when preparing the Annual Environmental Watering Statement.

The NSW PPM Working Group includes relevant NSW and Commonwealth agencies to provide a forum regarding the operation, implementation and review of PPMs (see Section 2.4.6).

4. Murrumbidgee system

4.1 Environmental sites

The classification of the accuracy of water use and return flow at environmental sites is intended to provide transparency and support the development of appropriate accounting arrangements and mitigation measures.

When developing actions, including accounting arrangements, that use PPMs, the accuracy of water take and/or return flows by sites must be categorised as described in Table 3.

Table 3: Classification of water take and return flows measurement sites

Classification	Description
Category 1 **Accurate (+/-5%)**	Take is metered or accurately measured, meeting the requirements of the NSW Non-Urban Water Metering Policy, and is suitable for water account debiting
Category 2	Does not meet requirements for Category 1; take and/or return flow is measured or estimated, but requires mitigation measures to address uncertainty

Examples of methods of measurement for category 2 sites could include:

- meters (including direct measurement devices using ultra-sonic or infra-red sensors at major canal offtakes)
- hydrographic flow measurement (rating table)
- extrapolation from single, point-in-time flow gauging
- assumed use/estimation method (including operationally estimated loss rates/method, calculations based on areas of inundation, seepage and evapotranspiration; simplified rules based on modelling results)
- models (including hydro-dynamic models, or hydrologic such as IQQM/Source).

If no site classification is provided, then a site will be deemed to be Category 2.

Environmental sites that receive water via PPM actions provided for under this Manual are to be nominated in Table 4.

Table 4: Recognised environmental sites for PPMs in the Murrumbidgee

Environmental site	Description	Measurement method	Classification
Lowbidgee (Nimmie/Caira)	Wetlands and forest to the south of the Murrumbidgee River watered from the Nimmie, South Caira, and North Caira regulators within the Maude Weir pool.	Take: Meters at flow gauge d/s of 3 x undershot sluice gate regulators. Return flows: To be determined (e.g. rating table to flow gauge on Yanga Creek)	Category 1 Category 2
Lowbidgee (Redbank South, Yanga)	Wetlands and forest to the south of the Murrumbidgee River watered from the Yanga, Waugorah, and Mercedes Pipe regulators within the Redbank Weir pool.	Meters at offtakes	Category 1
Lowbidgee (Redbank North)	Wetlands and forest to the north of the Murrumbidgee River watered from the Glenn Dee and Juanbung regulators, and Patto's and Bill's pipes within the Redbank Weir pool.	Meters at offtakes	Category 1
Lowbidgee overbank flows	Flows in excess of around 6,000 ML/d d/s Redbank Weir cause overbank flows into Lowbidgee. Higher flows break out further upstream.	To be determined e.g. water balance between Hay and Balranald	Category 2
Mid-Murrumbidgee wetlands	Floodplain wetlands and forest between Wagga Wagga and Hay that is progressively inundated as flows exceed 20,000 ML/day at Wagga Wagga.	Directed release from storage, being the additional release of water based on the difference between the actual release and a hypothetical release case meeting all other water requirements. Return flows recognised at Hay or Balranald either as the additional flows arriving at Balranald calculated as the difference between actual flows at Balranald and those that are estimated would have occurred without the environmental water order, or	Category 2

Environmental site	Description	Measurement method	Classification
		by application of suitable assumed use loss rate.	
Gooragool Lagoon (Mid-Murrumbidgee wetlands)	Managed pumping of environmental water directly to this wetland complex in the mid-Murrumbidgee	Regulator / irrigation pump meter (Kooba station)	TBD
Yarradda (Mid-Murrumbidgee wetlands)	Managed pumping of environmental water directly to this wetland complex in the mid-Murrumbidgee	Pump	TBD
Coonancoocabil Lagoon (Mid-Murrumbidgee wetlands)	Managed inflows of environmental water directly to this wetland complex in the mid-Murrumbidgee	Regulator	TBD
Oak Creek and Gras Innes Swamp (Mid-Murrumbidgee wetlands)	Managed inflows of environmental water from Bundidgerry Storage	Regulators	TBD
Yanco Creek system	Lagoon and overbank flows. Return flows at Darlot for recognition in the Murray system.	To be determined, e.g. water balance between inflows and Darlot	Category 2
Molleys Lagoon, Forest Creek Anabranch, Wilson's Anabranch (Yanco Creek system)	Managed inflows from Yanco or Billabong Creeks	Regulators	TBD

Environmental site	Description	Measurement method	Classification
Beavers/Old Man Creek system	For fish and habitat condition flows, particularly outside irrigation season.	To be determined Take can potentially be determined via ratings table for Mundowey Weir on Beavers Creek. Return flows can possibly be determined from ratings table at Kywong (Old Man Creek) or at Brewarrana Lane (41000215). Suitable losses may need to be applied.	Category 2 Category 2
Murrumbidgee main channel and key anabranches	Productivity and fish spawning/ condition/ dispersal flows that remains in channel and are able to be used downstream in the Lowbidgee or Murray. Flows to mitigate low dissolved oxygen.	Directed release from storage, being the additional release of water based on the difference between the actual release and a hypothetical release case meeting all other water requirements, or additional flows at the nominated river gauge (above other system requirements and orders). Return flows recognised at Balranald either as the additional flows arriving at Balranald calculated as the difference between actual flows at Balranald and those that are estimated would have occurred without the environmental water order, or by application of suitable assumed use loss rate.	Category 2 Category 2

4.2 Delivery pathways

Delivery pathways describe the intended environmental watering event, and show how the watering actions, assumed use methods, and mitigation measures link together. An example is the release of environmental water from the major storages (Blowering and/or Burrinjuck dams) to coincide with downstream tributary inflows, often referred to as a “piggybacking” release, with the intent of:

- creating a peak flow of sufficient duration to inundate the many wetlands along the Murrumbidgee River – principally between Wagga Wagga and Hay

- watering wetlands and forests in the Lowbidgee area
- flow through to the Murray River to the South Australian border.

The following are general environmental watering delivery pathways (Table 5) for actions using PPMs in the Murrumbidgee, subject to approval of appropriate supporting measures. Delivery pathways for the application of PPMs in the Murrumbidgee regulated river water source will continue to be reviewed and refined in accordance with this Procedures Manual.

Table 5: General delivery pathways for the Murrumbidgee Valley

Delivery pathway	Description
Headworks storages to Murray River	Blowering and/or Burrinjuck Dam/s to provide flows within the normal operating limits to achieve outcomes within the Murrumbidgee River, and then to be delivered to the Murray River.
Headworks storages to Murray River via mid-Murrumbidgee wetlands	Blowering and/or Burrinjuck Dam/s to provide flows above the normal operating limits to achieve outcomes within the Murrumbidgee River and the mid-Murrumbidgee wetlands, and then to be delivered to the Murray River.
Headworks storages and enroute storages to Murray River via mid-Murrumbidgee wetlands.	Blowering and/or Burrinjuck Dam/s, supplemented by releases from Tombullen storage and enroute storages, to provide flows above the normal operating limits to achieve outcomes within the Murrumbidgee River and the mid-Murrumbidgee wetlands, overbank into Lowbidgee, and then to be delivered to the Murray River.
Headworks storages to Lowbidgee	Blowering and/or Burrinjuck Dam/s to provide flows within the normal operating limits to achieve outcomes within the Murrumbidgee River, and then to be delivered to the Lowbidgee offtake regulators in the Maude and Redbank Weir pools.
Headworks storages to Lowbidgee via mid-Murrumbidgee wetlands	Blowering and/or Burrinjuck Dam/s to provide flows above the normal operating limits to achieve outcomes within the Murrumbidgee River and the mid-Murrumbidgee wetlands, and then to be delivered to the Lowbidgee offtake regulators in the Maude and Redbank Weir pools and overbank into Lowbidgee.
Yanco Offtake and Coleambally escapes to Murray River via Yanco-Billabong Creek system	Release through Yanco Creek Offtake or through Coleambally Irrigation Area escapes to provide flows to achieve outcomes within the Yanco-Billabong Creek system and then to be delivered to the Murray River system (Edward River).

Note 1: Associated Assumed Use methods for these pathways are to be nominated in Section 4.3.
Note 2: Normal operating limits refers to historical practice of operating the river based on time of year and system conditions.

4.3 Murrumbidgee actions

PPMs allow HEW to be used and accounted for in new ways. The actions described in this manual include agreed actions which have been approved for ongoing use, as well as trial or interim actions which are to be approved annually. These watering actions are developed in consultation with WaterNSW and environmental water holders (see Section 2 and Section 3.3).

Actions for the Murrumbidgee are shown in Table 6, together with their linked delivery pathways, relevant assumed use methods and mitigation measures.

The trialling of new actions is also expected to be important to balance the effective implementation of PPMs with ensuring that there are no detrimental impacts to the reliability of licensed entitlements. The regulator (Department of Planning and Environment - Water) may agree to trial an action for a period, with additional conditions applied where appropriate and developed according to the processes described in Section 2 of this Manual. Trials and supporting measures, including mitigation measures, will be considered by the NSW PPM Working Group. Trial actions must be re-assessed each year as part of the NSW annual review process.

All actions and the supporting measures have been considered to minimise or offset, where necessary, potential detrimental impacts to the reliability of licensed water users.

Recognising that environmental watering actions using PPMs will require ongoing development over time, the adaptive management approach in Section 5 provides a process for including further actions or variations to existing actions and their supporting measures.

Table 6: Actions and supporting measures for the Murrumbidgee Valley

Action	Delivery Pathway	Assumed Use Method	Mitigation Measure/s
Directed releases from storage/s to meet a target flow at downstream site/s	Upper storage/s to nominated downstream site/s. Estimated return flows are to be protected downstream, including for delivery to the Murray River.	Debit: additional releases from storage, calculated as the difference between the actual releases from storage and those that are estimated would have been made without the environmental water order.	Daily debits capped at the lesser of: • target flow + 10% - required operational flow, or • observed flow - required operational flow. Post-event accounting using actual water use. Consideration to be given to how tributary inflows are accounted for during the planning phase. Release rates are limited to ensure downstream flows remain within the channel capacity limits (as per WSP) and normal operating limits. Orders are subject to “out-of-balance” assessment to consider any possible implications to delivery from storages.

Action	Delivery Pathway	Assumed Use Method	Mitigation Measure/s
Directed releases from storage/s to meet a target flow/s in the mid-Murrumbidgee wetlands (on top of tributary inflows)	Upper storage/s to Wagga Wagga and subsequent nominated downstream site/s. Estimated return flows are to be protected downstream, including for delivery to the Murray River.	Debit: additional releases from storage, calculated as the difference between the actual releases from storage and those that are estimated would have been made without the environmental water order, assumed to be. Releases from storage + d/s tributary flows - consumptive flow requirement d/s Wagga	Daily debits capped at the lesser of: • target flow + 10% - required operational flow, or • observed flow - required operational flow. Post-event accounting using actual water use.
Recognition of return flows from Yanco Creek	Release through Yanco Creek Offtake or through Coleambally Irrigation Area escapes through the Yanco-Billabong Creek system and then delivery to the Murray River (Edward River).	NSW will undertake consultation with river operators and environmental water holders to determine an assumed use to estimate return flows from Yanco Creek at Darlot for consideration by the PPM Working Group.	An interim arrangement with an appropriate level of conservatism will be applied and subject to review as per the protocols for adaptive management set out in this Manual.
Recognition of return flows along the Murrumbidgee River	Upper storage/s to River Murray. Estimated return flows are to be protected downstream of target sites, including for reuse downstream and delivery to the Murray River.	An appropriate reduction for incremental losses shall be applied to determine the volume of return flows to be recognised. NSW will undertake consultation with river operators and environmental water holders to develop loss lookup tables for river reach/es in the Murrumbidgee to estimate return flows, for consideration by the PPM Working Group.	Protection is limited to additional release volumes, with appropriate reductions for incremental transmission losses, allowing for travel time.

Action	Delivery Pathway	Assumed Use Method	Mitigation Measure/s
Recognition of Murrumbidgee return flows at Balranald	Recognition of return flows (of residual HEW) at Balranald.	The return flows arriving at Balranald shall be calculated as nominated above, being the residual flow after an appropriate reduction for incremental transmission losses is applied. Alternatively, the additional HEW arriving at Balranald will be calculated as the difference between actual flows at Balranald and those that are estimated would have occurred without the environmental water order.	Protection is limited to additional release volumes, with appropriate reductions for incremental transmission losses.
Recognition of return flows from the Murrumbidgee at South Australia	Recognition of residual HEW from the Murrumbidgee River at Balranald through to the South Australian border (without regulation in Lake Victoria).	Return flows are managed in the River Murray under Bulk Entitlement Delivery arrangements. When the Murray River is in regulated conditions an incremental loss will be applied to residual HEW from the Murrumbidgee recognised at Balranald. The appropriate loss will be determined from the loss look-up table based on flow at Boundary Bend in the River Murray and the corresponding residual HEW recognised at Balranald. See Appendix C. When the Murray River in unregulated conditions, no loss rate is to be applied to return flows recognised at Balranald.	WaterNSW will provide River Murray Operations (MDBA) with the daily flow volume of HEW passing Balranald which will be adjusted by RMO for travel time to the SA border and reduced incrementally for transmission losses.

Note: normal operating limits/levels refers to historical practice of operating the river based on time of year and system conditions.

4.4 Risk mitigation

The use and accounting of HEW using PPMs is a change to the way that water has traditionally been managed and accounted for in the Murrumbidgee. Managing environmental water in different ways can potentially result in positive or negative impacts to other water users. Possible risks include impacts on the reliability of allocations due to directed releases and impacts to the efficient use of held environmental water. Both positive and detrimental effects of PPMs will be taken into account when considering any potential impacts and their mitigation measures to achieve an appropriate balance between allowing for the efficient and effective use of held environmental water licences to achieve the environmental outcomes and providing protection for other water licence holders.

Where there is uncertainty, initially conservative estimates of environmental water use will be applied. These methods and approaches will be improved over time as a body of knowledge is developed and more accurate measurement and modelling becomes available. These estimates will be based on best available information and subject to review, refinement and improvement. The level of conservatism applied will be proportional to the confidence in the assumed use and level of risk. Over time, new and more innovative approaches to environmental watering will likely be developed and there needs to be flexibility in the way that rules are applied.

A description of possible risks and the mitigation measures that could be applied is shown below in Table 7. Mitigation measures will be considered in collaboration with the environmental water holders and the river operator. Mitigation measures for actions are also set out in Table 6 and further described in supporting documents as necessary.

Environmental watering using PPMs is still relatively new in the Murrumbidgee. Processes for review are described in Section 5 to provide an opportunity to review and reassess risks over time.

Table 7: Potential risks and mitigation measures associated with the operation of PPMs

Potential risk	Relevant Action / supporting measure	Possible mitigation measure
Lower reliability of allocations due to lower utilisation of tributary inflows below major dams through directed releases from dams	Directed releases from dams	Additional debits may be applied at a future point in based on assessment of reduced utilisation of tributary inflows downstream of the dams. Increased reliability could also be recognised.
Under/over-estimating the volume of environmental water used: **Inaccurate measurement** **Environmental water use estimated based on averages**	Directed releases from storage	Use appropriate estimates of unaccounted differences and operational decisions when estimating the 'without environmental order' when calculated additional release from storage

Potential risk	Relevant Action / supporting measure	Possible mitigation measure
Under/over-estimating the volume of environmental water used: **Inaccurate measurement** **Environmental water use estimated based on averages**	Protection of flows along the river	Assumed use/river transmission loss estimates when: • Sharing access to flows with consumptive water users, and • Environmental flows exceed normal operating levels. Post event accounting Improved management of supplementary Water use based on total volume of water released for directed releases
Increased river transmission losses, as a larger proportion of licensed water is required to be released for the end of the river system	Protection of flows along the river	Possible mitigation measures for this potential risk will be considered as PPMs are implemented and there is better understanding of environmental watering use under PPMs
"Out of balance" or deliverability issues exacerbated by large volume of directed releases from Burrinjuck Dam	Directed releases from dams (particularly at high rate)	"Out-of-balance' assessment by WaterNSW
Over-estimating the proportion of flows that are environmental along the river system, resulting in unduly restricted access for consumptive water users	Protection of flows along the river	Conservative assumed use estimates. Closer management of supplementary access
Under-estimating the proportion of flows that are environmental water in the river system resulting in excessive consumptive use	Protection of flows along the river	Regular assessment and review of assumed use Post event reconciliation
Unwanted inundation	Directed releases from dams for environmental watering	Release rates limit to ensure flow remains within channel capacity limits as nominated in WSP Evidence of consultation with potentially impacted landholders

Potential risk	Relevant Action / supporting measure	Possible mitigation measure
Mitigation measures are unduly conservative that impacts the efficient and/or effective use of HEW	Directed releases from dams Protection of flows along the river	Mitigation measures are evidence based and proportionate to actual risks Post event accounting Assumed use methods reviewed and refined Documentation of procedures and methods Consultation with environmental water holders Annual review process Assessments based on best available information/science

Note: normal operating limits/levels refers to historical practice of operating the river based on time of year and system conditions.

4.4.1 Consideration of impacts

Some impacts to licensed water users are a result of existing operational arrangements and practices within the NSW water management framework. For example, water users can purchase and activate or trade previously unused water access licences, subject to rules within in the relevant water sharing plan. Alternatively, a large irrigator may change their water ordering behaviour which may impact the amount of water available in the dam for other water users.

However, there are other impacts that may arise during the implementation of PPMs which are not permitted under the current framework. These kinds of impacts would include allowing one licence holder to request priority of delivery over other water users during times when the amount of water that can be delivered is constrained. Priority of delivery is determined by the category of access licence that is being used to make the order.

NSW has and will continue to develop and implement PPMs in a way that achieves the objective of maximising environmental outcomes through the efficient and effective use of HEW without impacting on the reliability to other water users or by negating or offsetting unacceptable impacts. Where there is uncertainty, NSW will adopt a precautionary approach to minimise detrimental impacts.

5. Adaptive management

5.1 Reporting

Environmental watering actions provided by PPMs are different to traditional regulated river system operations and will require ongoing development over time. Therefore, an adaptive management approach is required with a rigorous process of review and evaluation to allow arrangements to evolve and improve over time. It is also recognised that environmental watering actions will evolve and improve over time, and that there are benefits to ensuring that environmental watering actions using PPMs are conducted openly and transparently. The adaptive management starts with an annual reporting process to inform the ongoing development of environmental watering actions that use PPMs, and to provide transparency about the management and implementation of PPMs. The reporting process documents the environmental watering actions that have been conducted under the PPM provisions of this Manual and provides the necessary basis to inform the annual evaluation of PPMs.

There are two main reporting elements that are inputs to the annual review process:

1. Annual environmental release river operations report that documents the application of specific agreed actions, trial actions, and associated supporting measures, including the accounting of river flows, transmission losses, and water delivery that occurred.
2. Annual environmental watering statement that documents any issues that arose in the ordering or delivery and accounting of environmental water using the agreed and trial actions.

Both reports must document:

- any issues encountered in undertaking agreed actions, and any recommendations to address those issues or improve the operation of PPMs
- any feedback from consultation with stakeholders on the actions undertaken.

Submissions may also be invited form other key stakeholders such as the CEWO.

5.1.1 Annual environmental release river operations report

The annual environmental river operations report shall be prepared by the river operator (WaterNSW), and be submitted to the regulator (Department of Planning and Environment - Water) within three months of the end of each water year.

This report will include the following:

- a description of environmental watering actions undertaken during the relevant water year
- the performance in delivering the environmental water to meet the target flows and volumes requested in the orders
- the accounting undertaken for these actions, including:

  - a general description of the environmental flow events undertaken that rely on the use of agreed and trial actions
  - the water orders placed by the environmental water holders
  - accounts of environmental water use according to agreed methods for Assumed Use Statements
  - comparisons of assumed use with actual river transmission losses associated with watering actions that rely on that assumed use
  - the volumes of water delivered to the Murray Valley that have been accounted as environmental
- documentation of any issues that arose in the ordering or delivery and accounting of environmental water using the agreed and trial actions and details of how any issues were resolved
- documentation of any orders that were refused/rejected and supporting rationale.

The regulator may request additional content that is related to the delivery of environmental water using the agreed and trial actions, following consultation with WaterNSW and other stakeholders

5.1.2 Annual environmental watering statement

The annual environmental watering statement shall be prepared by the Department of Planning and Environment – Environment and Heritage, and be submitted to the regulator (Department of Planning and Environment - Water) within three months of the end of each water year. As the NSW environmental water manager, the Department of Planning and Environment – Environment and Heritage will consult with other environmental water holders and stakeholders including the CEWO and EWAGs as necessary.

This report shall include the following:

- a brief description of environmental outcomes of the watering actions undertaken during the relevant water year, and the degree to which those environmental objectives were able to be satisfied
- documentation of any issues that arose in the ordering or delivery and accounting of environmental water using the agreed and trial actions.

The regulator may request additional content that is related to the delivery of environmental water using the agreed or trial actions, following consultation with the NSW environmental water manager or other environmental water holders.

5.2 Annual evaluation and review of PPM operations

The Department of Planning and Environment – Water will conduct an annual evaluation and review of the implementation of PPMs that will consider the outcomes of undertaking PPMs actions, based on the two reporting elements described above. This annual review report is to include:

- whether general operational procedures were followed for the delivery of HEW via PPMs

- whether the current PPM actions and the associated supporting measures provide for the effective and efficient use of held environmental water
- whether there are sufficient mitigation measures in place, and whether they have been effective
- any proposals for variations or new actions and/or supporting measures that may be brought forward by the river operator or the environmental water holder
- any issues relating to PPMs raised through consultation with stakeholders in the valley
- the results and recommendations of the reporting elements provided by the river operator and environmental water manager
- whether the actions and associated supporting measures should be expanded, modified, or remain unchanged
- reporting on the implementation of recommendations from previous reviews
- recommendations endorsed by the PPM Working Group.

The review will be guided by the principles set out in the NSW PPM IP, and the assessment guidelines set out by the MDBA. The review may be undertaken by an independent body.

The Department of Planning and Environment – Water is responsible for ensuring that appropriate changes to the regulatory framework are made to give effect to any recommendations arising from this review, in consultation with key stakeholders including Department of Planning and Environment – Environment and Heritage and WaterNSW.

The Department of Planning and Environment – Water will prepare and publish the annual evaluation and review report each year, including any findings of the review and recommendations.

It is proposed that the annual review (Figure 2) will operate to a two to three-year cycle (Table 8) to adequately allow for reporting, consultation and review, including any consequential amendments that made be required to this Manual. A 3-month period has been provided for each review element (e.g. reporting, consultation, review).

Table 8: Annual PPM review cycle

	Review Activity				
	Watering Actions	Reporting & consultation	Reporting	Review & consultation	Manual amendments
	Department of Planning and Environment-Environment and Heritage, WaterNSW	WaterNSW, Department of Planning and Environment-Environment and Heritage	Department of Planning and Environment-Water	Department of Planning and Environment-Water together with the PPM Working Group	Department of Planning and Environment-Water
July					
August					

	Review Activity				
September					
October					
November					
December					
January					
February					
March					
April					
May					
June					Publication

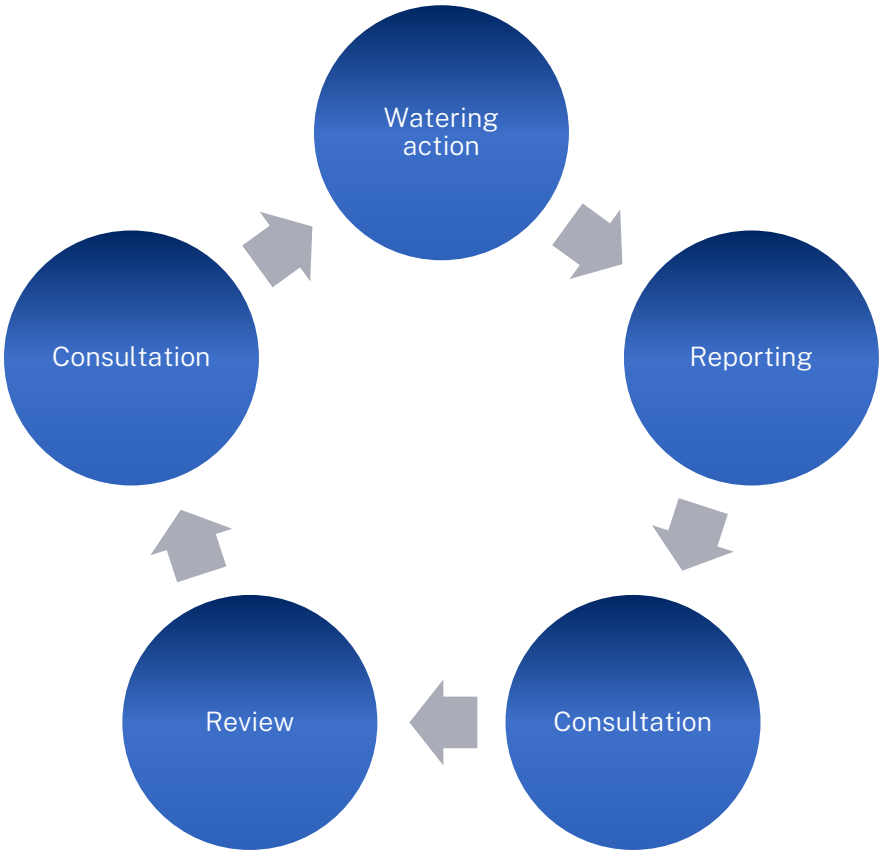

Figure 2: An overview of the annual PPM review cycle

References

MDBA, 2015. *Pre-requisite Policy Measures Assessment Guidelines*. 9 April 2015.

Appendix A Relationship of NSW PPMs to other plans and legislation

Table A.1: Relationship of NSW PPMs to other plans and legislation

Legislation or Plan	Overview and relationship to Procedures Manual
Commonwealth	
Water Act 2007 (Commonwealth Government)	Makes provision for the management of water resources of the Murray-Darling Basin.
Public Governance, Performance and Accountability Act 2013 (Cwth)	Establishes the requirements of Commonwealth Officials in the use of Commonwealth resources, including both financial and water resources. These requirements relate to procedures associated with risk management, public accountability, governance and reporting.
Murray Darling Basin Plan (MDBA)	A legislative instrument developed as a requirement of the Water Act 2007. Aims to protect and restore key water-dependent ecosystems. Determines the amount of water that can be extracted annually from the Basin for consumptive use. **PPMs are a requirement of the Plan.**
Basin-wide Environmental Watering Strategy (MDBA)	Sets out the expected outcomes at a whole-of-basin scale that should be achievable with the environmental water available, and efficient and effective strategies to achieve them. This document guides the work of governments, water holders and environmental managers. **PPMs will assist in achieving expected outcomes.**
Environmental Watering Plan (MDBA)	The purposes of the environmental watering plan are to safeguard existing environmental water; plan for the recovery of additional environmental water; and coordinate the management of existing environmental water. **PPMs will assist in meeting the purposes of the Environmental Watering Plan.**

Legislation or Plan	Overview and relationship to Procedures Manual
Environmental Watering Schedule (CEWO)	Developed by the CEWO in conjunction with water delivery partners, for the purpose of communicating the agreed purpose for the use of Commonwealth water holdings, and giving effect to the CEWH's portfolio management plans. **PPMs will assist in meeting the outcomes of the Basin-wide environmental watering strategy.**
Basin Annual Environmental Watering Priorities (MDBA)	Guide the annual planning and prioritisation of environmental watering across the Basin. They represent annual steps toward the long-term outcomes in the Basin-wide Environmental Watering Strategy. They aim to achieve the most effective use of water for the environment; promote better environmental outcomes across the Basin; and coordinate watering between environmental water holders and water managers. **PPMs will assist in achieving the aims of the Basin Annual Environmental Watering Priorities.**
Portfolio Management Plan (CEWO)	Sets out plans for managing the Commonwealth environmental water portfolio in the Murrumbidgee for each water year. **PPMs will assist in managing Commonwealth environmental water portfolio**
NSW	
Water Management Act 2000	The WMA provides the legislative framework for the sharing of water between industry, communities and the environment in NSW. **PPMs must be implemented in accordance with the WMA.**
Water Management Regulation 2011	The Regulation is a supporting instrument to the WMA. It provides the administrative direction for the management of NSW's water resources and specifies how issues are to be dealt with at a local level. **PPMs must be implemented in accordance with the Regulation.**

Legislation or Plan	Overview and relationship to Procedures Manual
Protection of the Environment Operations Act 1997	The POEO Act enables the NSW Government to set out explicit protection of the environment policies and adopt more innovative approaches to reducing pollution. The POEO Act includes prohibition of pollution of waters. **PPMs must be implemented in such a way as to avoid pollution of waters (e.g. triggering of blackwater events)**
Murrumbidgee Water Resource Plan	The WRP outlines how water resources will be managed to be consistent with the Murray-Darling Basin Plan. **PPMs must be implemented in accordance with the WRP.**
Murrumbidgee Water Sharing Plan	The WSP is a legislative tool under the WMA that sets out rules for access licences and water supply works approvals. The WSP contains rules which specify how water is shared between the environment and water users in a water source. **PPMs must be implemented in accordance with the WSP.**
Annual Watering Priorities (Department of Planning and Environment-Environment and Heritage)	Outlines the priorities for environmental water use in the coming year, depending on climatic factors and water availability. **PPMs will assist in meeting the priorities of the Annual Watering Plan.**
Water Supply Works Approval (WaterNSW)	Water Supply Works Approvals manage river operations and are controlled by Department of Planning, Industry and Environment - Water. They will specify the role/obligations of the river operator in implementing PPMs. **PPM Procedures Manuals will translate how these approval conditions are to be managed in day-to-day river operations.**
NSW PPM Implementation Plan	The PPM Implementation Plan sets out high level principles to guide PPM development and implementation. It identifies preferred implementation options and associated processes required to incorporate PPMs into the regulatory and operational frameworks that guide water management and operation in NSW. **PPM Implementation Plan and review of this plan by MDBA informs the development of the PPM Procedures Manual.**

Appendix B List of water access licences

Access licences that are either licensed environmental water under section 8 of the *Water Management Act 2000*, held by the Commonwealth Environmental Water Holder, or are specified in the table below may order water under the Environmental Flow Reuse Rules or the Piggybacking Rules set out in this PPM Procedures Manual for the Murrumbidgee Regulated River Water Source.

Table B.1: List of water access licences (as of October 2022, accessed via the NSW environmental water register)

WAL No	Environmental Holder Group
3648	NSW DPE (ENVIRONMENT, ENERGY and SCIENCE)
11078	NSW DPE (WATER)
11079	NSW DPE (WATER)
11328	NSW DPE (WATER)
11395	NSW DPE (WATER)
13770	NSW DPE (ENVIRONMENT, ENERGY and SCIENCE)
15938	NSW DPE (ENVIRONMENT, ENERGY and SCIENCE)
16355	NSW DPE (WATER)
27788	NSW DPE (WATER)
36338	NSW DPE (ENVIRONMENT, ENERGY and SCIENCE)
36610	NSW DPE (ENVIRONMENT, ENERGY and SCIENCE)
36994	NSW DPE (ENVIRONMENT, ENERGY and SCIENCE)
42427	NSW DPE (ENVIRONMENT, ENERGY and SCIENCE)
42428	NSW DPE (ENVIRONMENT, ENERGY and SCIENCE)
42477	NSW DPE (ENVIRONMENT, ENERGY and SCIENCE)

Appendix C Incremental loss method for return flows of environmental water in the River Murray from the Murrumbidgee

The accounting arrangement described below was documented in July 2021.

The arrangement was updated following NSW PPM Working Group #7 (31 March 2022) to include a new loss lookup table for flows greater than 20,000 ML/day.

Introduction

River and floodplain connectivity in the southern Basin is a key objective for environmental water managers. Pre-requisite Policy Measures (PPMs) seek to maximise the beneficial outcomes of water recovered for the environment, including recognising environmental water throughout the length of the river, and between rivers. Accounting of environmental water delivered along the Murray regulated valley and across the South Australian border is important for recognising the volume of environmental water crossing the border and for helping environmental managers make good decisions for use of held environmental water (HEW) accounts.

Understanding the relationship between flow conditions and losses is a key element of river forecasting and operations. Accounting and distribution of those losses have a significant influence on the system. This paper focuses particularly on the losses and recognition of volumes of HEW, as the greater the losses attributed to HEW, the greater the volume of HEW may be required to achieve connectivity.

Previous methods took a proportional loss approach for all water delivery, where the total loss was determined and then apportioned to the volumes of HEW delivered. The proportional method overestimates the loss, as the total loss experienced by the system is considered to be caused equally by all water deliveries (e.g. irrigation diversion and South Australia's entitlement flow). This includes HEW delivered from the Murrumbidgee River, and results in a lower volume of environmental water recognised at the South Australian border. However, the bulk of the loss experienced by the system is due to normal River Murray deliveries. The addition of HEW from the Murrumbidgee River in the River Murray only results in an incremental increase in loss.

The incremental loss approach pre-calculates the likely losses, based on conservative conditions, without affecting water users. Likely losses associated with different flow conditions are captured in a flow look-up table. Operators can assign losses for Murrumbidgee River HEW entering the River Murray to recognise the volume of environmental water at the South Australian border.

This paper describes the method used for accounting for HEW losses for HEW from the regulated Murrumbidgee River entering the River Murray and as it travels through to the South Australian border. HEW accounting within the Murrumbidgee valley is out-of-scope and is dealt with via a separate method. Later sections of the paper discuss the potential for applying this method to other HEW entering the River Murray and other systems where a method for determining losses to HEW is required.

Method & requirements

The method presented here is used to calculate the losses to HEW based on the flow conditions during delivery, determined using historical loss data. This is the loss incurred as it travels through the River Murray. Analysis of historical flow and loss data resulted in a loss look-up table based on conservative estimates of losses in each flow range. This table can then be used to determine what losses to apply to HEW that has entered the River Murray from an upstream tributary when it reaches the South Australian border.

The method requires data sets of long-term daily flows and corresponding losses. This is typically obtained through a well-calibrated daily hydrological model of the system.

Data

The Murray Darling Basin Authority (MDBA) has developed a daily hydrological model (in SOURCE) for the River Murray system. The model outputs used in this analysis were from a model using historical data, which covered over 100 years of simulation. Loss data was extracted from this model for the reaches from Boundary Bend to the South Australian border. Daily data was filtered to remove days on which large inflows from the Lower Darling would significantly influence the loss behaviour of this reach, resulting in about 70 years of simulation data remaining.

The daily data was separated into flow classes, with a summary of data available for these flow classes shown in Figure C.1.

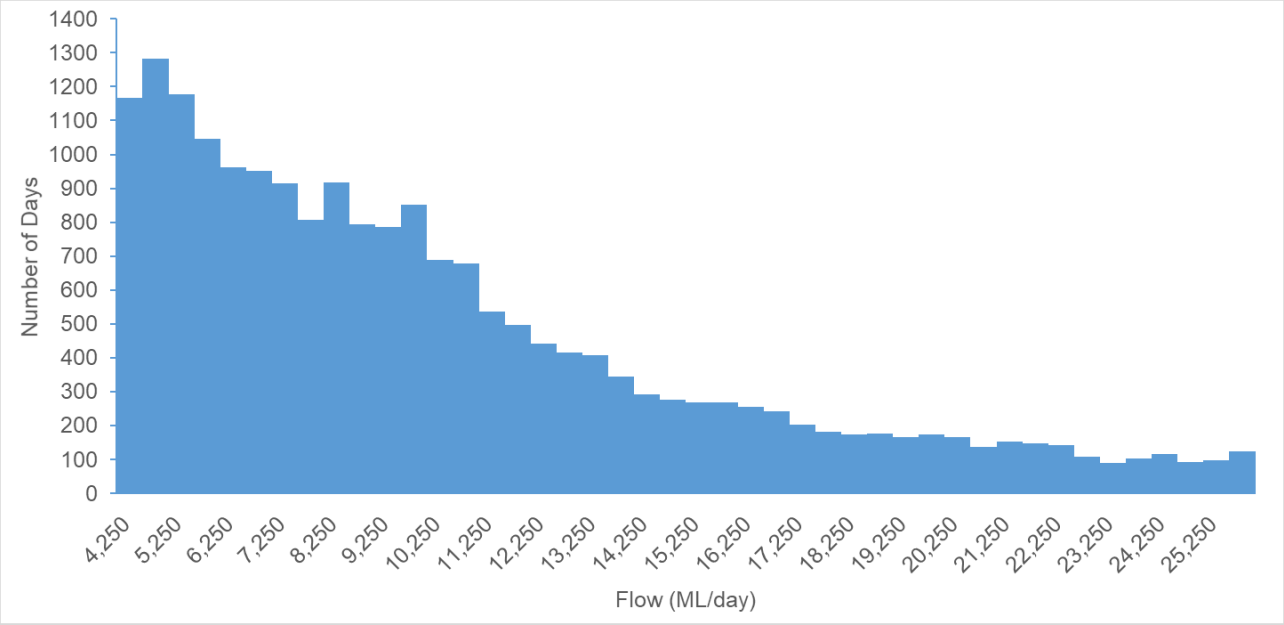

Figure C.1: Days of data available by daily flow rate.

Data was checked for uniformity of distribution within each flow class by comparing the mid-flow value of the flow range against the average flow within the class. Results showed that the average flow and the mid-flow values matched very closely, indicating likely uniform distribution of datapoints. This provided a smooth transitional behaviour in loss rates between classes.

Consideration must be given to the amount of data underpinning this analysis for a given flow. For example, greater than 500 days of data is available for flows below 12,000 ML/day, therefore, there is low risk of underestimating the losses. However, if a flow class has a small number of data points (<200 days), the confidence in the associated loss value is lower. This means the confidence in the method is lower when there are larger flows in the system, and higher when there are smaller flows. Losses are of particular importance when only small volumes are moving through the system.

Incremental loss method

The incremental loss method analyses the daily losses experienced for each flow class range over 100 years, examines the range of values, and uses the most conservative losses to produce a loss look-up table for river operators.

To calculate incremental losses:

- separate daily flow data into flow classes, keeping each data point with its associated loss value
- analyse each flow class and determine loss values at key percentile intervals
- create non-linear smoothing curves fitted to key loss percentiles across all flow classes
- determine the rate of change for each curve (representing a particular loss percentile)
- determine the incremental loss by finding the cumulative rate of change along the smooth curve to jump from one flow class to another
- identify the most conservative estimate for the flow class. That is, the worst-case incremental loss is taken as the final incremental loss value associated with increasing flow from one flow class to another.

This loss analysis adopts a worst-case incremental loss to ensure other water users in the NSW Murray are not paying for losses for the delivery of HEW from the Murrumbidgee River to the South Australian border. These incremental losses are significantly less than the proportional method used previously and demonstrates progress in accounting for losses resulting from the additional flow created by HEW moving through the system.

Results

The availability of uniformly distributed data resulted in a relatively smooth transition of loss values between classes for most loss exceedance plots (Appendix C.1), but the loss function over a number of flow classes still showed rapid fluctuating changes. To smooth the loss function further, a 4th degree polynomial was fitted for each exceedance condition. This results in a smooth loss function for each exceedance condition (Figure C.2), which shows consistent behaviour between flow classes within an exceedance conditions, and also smooth transitional behaviour between exceedance conditions, ultimately aiding in the creation of a smooth loss look-up table.

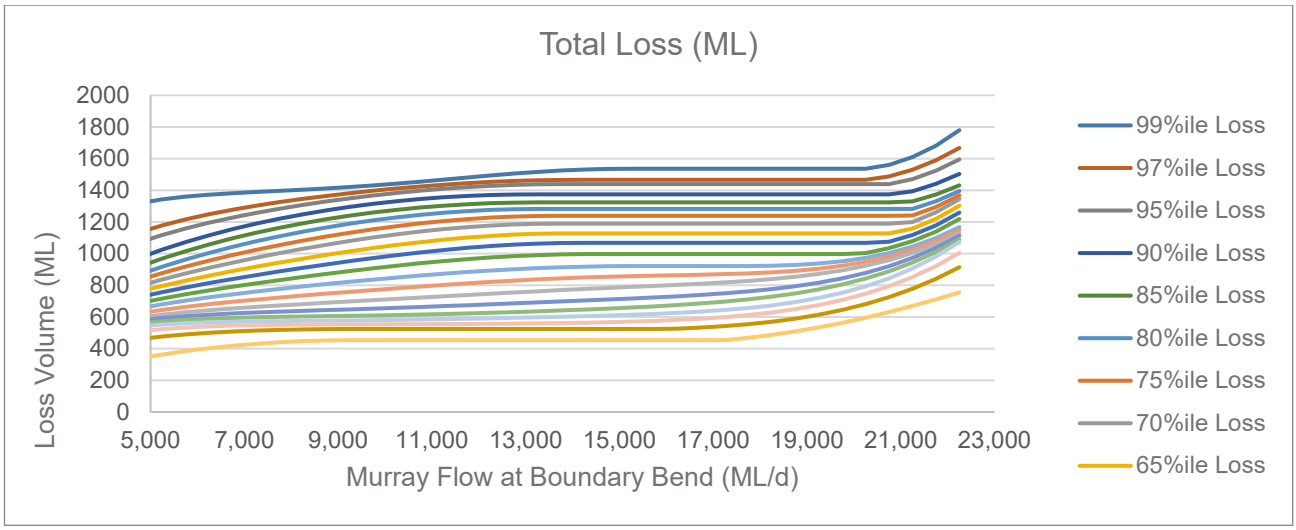

Figure C.2: Loss volumes at various Murray River flow rates.

Figure C.3 shows the change in loss volumes between flow classes. It plots the incremental loss behaviour of each exceedance condition over all the flow classes and shows consistent, graduated differences between the various percentiles. Losses generally increase for all exceedance conditions for flows under 15,000 ML/day. For flows between 13,000 ML/day and 20,000 ML/day, exceedance conditions below the 50th percentile generally show a minimal increase in losses. All exceedance conditions show a rapid increase in losses for flows above 20,000 ML/day.

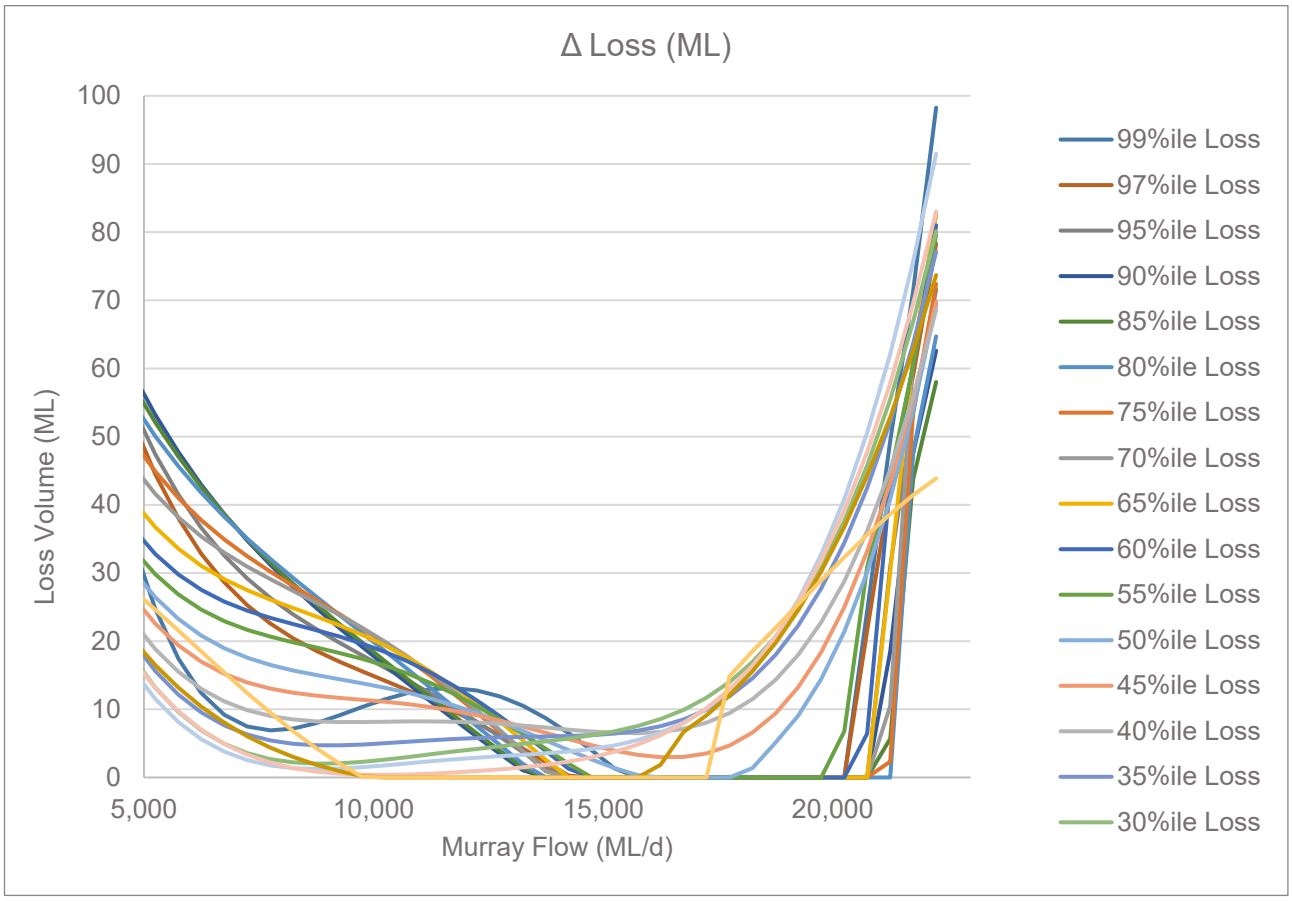

Figure C.3: Change in loss volumes between flow rates.

The incremental loss analysis approach undertaken grouped all the data together and used 500 ML/day increments. This analysis could have been undertaken on a seasonal basis, and with various flow increments. Testing this method under various seasonal conditions and flow increments does not yield significant differences in the results (Appendix C.2). Further analysis of seasonal data and flow increments should be part of a review process.

Application

Flows up to 20,000 ML/day

Table C.1 shows the final incremental loss table. The table shows the River Murray is generally highly efficient in the flow ranges from 10,000-20,000 ML/day, with any increases in flow typically resulting in a 2-5% increase in loss.

Operators can use Table C.1 to look up a flow on a given day in the Murray River at Boundary Bend on the vertical axis, up to 20,000 ML/day, after removing the influence of the HEW being delivered from the Murrumbidgee River through Balranald. The HEW volume being delivered through Balranald is then taken from the horizontal axis. The corresponding value at the intersection of the appropriate vertical and horizontal axis values is the loss value which can be applied to the HEW being delivered that day.

No loss value is applied if the River Murray is in unregulated conditions.

Flows exceeding 20,000 ML/day

For flows above 20,000 ML/day there is a rapid increase in losses (Figure C.3).

As an interim arrangement, operators can use Table C.2 to look up a flow on a given day in the Murray River at Boundary Bend on the vertical axis, over 20,000 ML/day, after removing the influence of the HEW being delivered from the Murrumbidgee River through Balranald.

The HEW volume being delivered through Balranald is then taken from the horizontal axis. The corresponding value at the intersection of the appropriate vertical and horizontal axis values is the loss value which can be applied to the HEW being delivered that day. If the corresponding loss is greater than 100%, the loss value will be capped at 100%.

No loss value is applied if the River Murray is in unregulated conditions.

Future work to incorporate climate change

The incremental loss method is based on conditions experienced during the last 100 years. Stochastic climate modelling work being done for Regional Water Strategies could help examine whether the range of losses experienced during the model run is likely to be sufficiently broad to cater for future climate variability.

Review

The incremental loss analysis could be periodically performed with extended model data to ensure the conservative loss volumes captured in the look-up table are still reflective of River Murray flow conditions.

Table C.1: Loss look-up table for Murrumbidgee water (HEW) entering the Murray (flows up to 20,000 ML/day at Boundary Bend).

Murray	Incremental Loss Vol (by Murrumbidgee Return Vol)										Incremental Loss % (by Murrumbidgee Return Vol)									
Flow Range	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000
4000 - 4500	65	124	176	223	266	305	339	370	397	421	13.0%	12.4%	11.7%	11.2%	10.6%	10.2%	9.7%	9.2%	8.8%	8.4%
4500 - 5000	124	176	223	266	305	339	370	397	421	442	24.9%	17.6%	14.9%	13.3%	12.2%	11.3%	10.6%	9.9%	9.4%	8.8%
5000 - 5500	111	158	200	239	273	304	331	355	378	398	22.2%	15.8%	13.3%	11.9%	10.9%	10.1%	9.5%	8.9%	8.4%	8.0%
5500 - 6000	100	142	180	215	245	274	299	323	343	361	20.0%	14.2%	12.0%	10.7%	9.8%	9.1%	8.5%	8.1%	7.6%	7.2%
6000 - 6500	90	128	163	194	223	250	273	294	310	325	18.0%	12.8%	10.9%	9.7%	8.9%	8.3%	7.8%	7.3%	6.9%	6.5%
6500 - 7000	81	116	149	177	204	227	248	265	279	290	16.3%	11.6%	9.9%	8.9%	8.1%	7.6%	7.1%	6.6%	6.2%	5.8%
7000 - 7500	74	106	135	162	185	206	222	237	250	260	14.7%	10.6%	9.0%	8.1%	7.4%	6.9%	6.3%	5.9%	5.5%	5.2%
7500 - 8000	67	97	123	146	167	184	200	213	224	232	13.4%	9.7%	8.2%	7.3%	6.7%	6.1%	5.7%	5.3%	5.0%	4.6%
8000 - 8500	62	88	111	132	151	167	180	191	199	204	12.3%	8.8%	7.4%	6.6%	6.0%	5.6%	5.2%	4.8%	4.4%	4.1%
8500 - 9000	55	79	101	120	136	151	162	169	174	176	11.0%	7.9%	6.7%	6.0%	5.5%	5.0%	4.6%	4.2%	3.9%	3.5%
9000 - 9500	51	73	91	109	122	133	141	146	150	150	10.1%	7.3%	6.1%	5.4%	4.9%	4.4%	4.0%	3.7%	3.3%	3.0%
9500 - 10000	46	66	83	96	107	117	122	125	128	128	9.2%	6.6%	5.5%	4.8%	4.3%	3.9%	3.5%	3.1%	2.8%	2.6%
10000 - 10500	42	58	73	85	94	100	105	110	114	117	8.4%	5.8%	4.8%	4.2%	3.7%	3.3%	3.0%	2.8%	2.5%	2.3%
10500 - 11000	36	51	63	73	81	90	98	102	103	103	7.3%	5.1%	4.2%	3.6%	3.3%	3.0%	2.8%	2.6%	2.3%	2.1%
11000 - 11500	32	44	56	67	77	84	88	90	90	90	6.4%	4.4%	3.7%	3.4%	3.1%	2.8%	2.5%	2.3%	2.0%	1.8%
11500 - 12000	29	42	53	63	69	74	76	76	80	88	5.7%	4.2%	3.5%	3.1%	2.8%	2.5%	2.2%	1.9%	1.8%	1.8%
12000 - 12500	28	39	48	55	59	62	64	70	78	88	5.5%	3.9%	3.2%	2.8%	2.4%	2.1%	1.8%	1.8%	1.7%	1.8%
12500 - 13000	24	34	42	46	47	55	62	69	78	94	4.8%	3.4%	2.8%	2.3%	1.9%	1.8%	1.8%	1.7%	1.7%	1.9%
13000 - 13500	21	29	33	39	46	53	62	74	89	108	4.2%	2.9%	2.2%	1.9%	1.8%	1.8%	1.8%	1.8%	2.0%	2.2%
13500 - 14000	17	23	31	37	45	55	68	84	102	124	3.3%	2.3%	2.1%	1.9%	1.8%	1.8%	1.9%	2.1%	2.3%	2.5%
14000 - 14500	15	22	30	39	50	62	77	96	119	146	3.1%	2.2%	2.0%	1.9%	2.0%	2.1%	2.2%	2.4%	2.6%	2.9%
14500 - 15000	14	22	32	43	56	72	90	112	140	174	2.9%	2.2%	2.1%	2.1%	2.2%	2.4%	2.6%	2.8%	3.1%	3.5%
15000 - 15500	15	25	36	50	64	83	106	133	167	209	3.1%	2.5%	2.4%	2.5%	2.6%	2.8%	3.0%	3.3%	3.7%	4.2%
15500 - 16000	18	29	42	57	76	98	125	160	201	253	3.5%	2.9%	2.8%	2.9%	3.0%	3.3%	3.6%	4.0%	4.5%	5.1%
16000 - 16500	20	33	48	67	90	118	152	193	246	316	4.0%	3.3%	3.2%	3.4%	3.6%	3.9%	4.3%	4.8%	5.5%	6.3%
16500 - 17000	24	40	58	80	108	142	184	240	308	392	4.8%	4.0%	3.9%	4.0%	4.3%	4.7%	5.2%	6.0%	6.8%	7.8%
17000 - 17500	29	47	69	97	131	175	231	299	383	483	5.7%	4.7%	4.6%	4.8%	5.2%	5.8%	6.6%	7.5%	8.5%	9.7%
17500 - 18000	36	61	89	121	164	220	288	372	472		7.3%	6.1%	5.9%	6.1%	6.6%	7.3%	8.2%	9.3%	10.5%	
18000 - 18500	44	73	106	150	206	274	358	458			8.8%	7.3%	7.0%	7.5%	8.2%	9.1%	10.2%	11.4%		
18500 - 19000	52	87	132	188	256	340	440				10.3%	8.7%	8.8%	9.4%	10.3%	11.3%	12.6%			
19000 - 19500	65	110	165	233	317	418					13.0%	11.0%	11.0%	11.7%	12.7%	13.9%				
19500 - 20000	81	136	205	288	388						16.3%	13.6%	13.6%	14.4%	15.5%					
20000 - 20500	100	169	252	353							20.0%	16.9%	16.8%	17.7%						
20500 - 21000	124	207	308								24.9%	20.7%	20.5%							
21000 - 21500	152	252									30.4%	25.2%								
21500 - 22000	187										37.4%									
22000 - 22500																				

Table C.2: Loss look-up table for Murrumbidgee water (HEW) entering the Murray (flows over 20,000 ML/day at Boundary Bend)[1].

Murray	Incremental Loss Vol (by Murrumbidgee Return Vol)										Incremental Loss % (by Murrumbidgee Return Vol)									
Flow Range	2,000	4,000	6,000	8,000	10,000	12,000	14,000	16,000	18,000	20,000	2,000	4,000	6,000	8,000	10,000	12,000	14,000	16,000	18,000	20,000
4000 - 6000	344	602	789	910	964	964	964	964	964	964	17.2%	15.0%	13.1%	11.4%	9.6%	8.0%	6.9%	6.0%	5.4%	4.8%
6000 - 8000	602	789	910	964	964	964	964	964	964	964	30.1%	19.7%	15.2%	12.0%	9.6%	8.0%	6.9%	6.0%	5.4%	4.8%
8000 - 10000	457	578	630	630	630	630	630	630	630	630	22.8%	14.4%	10.5%	7.9%	6.3%	5.3%	4.5%	3.9%	3.5%	3.2%
10000 - 12000	314	366	366	366	366	366	366	366	366	372	15.7%	9.2%	6.1%	4.6%	3.7%	3.1%	2.6%	2.3%	2.0%	1.9%
12000 - 14000	174	174	174	174	174	193	228	270	318	371	8.7%	4.3%	2.9%	2.2%	1.7%	1.6%	1.6%	1.7%	1.8%	1.9%
14000 - 16000	57	79	102	128	155	189	231	278	331	388	2.9%	2.0%	1.7%	1.6%	1.6%	1.6%	1.7%	1.7%	1.8%	1.9%
16000 - 18000	50	74	99	125	161	202	250	303	360	420	2.5%	1.8%	1.7%	1.6%	1.6%	1.7%	1.8%	1.9%	2.0%	2.1%
18000 - 20000	47	73	102	139	179	227	279	337	397	460	2.4%	1.8%	1.7%	1.7%	1.8%	1.9%	2.0%	2.1%	2.2%	2.3%
20000 - 22000	50	81	117	158	206	257	315	375	439	592	2.5%	2.0%	1.9%	2.0%	2.1%	2.1%	2.2%	2.3%	2.4%	3.0%
22000 - 24000	58	94	135	183	235	293	353	419	592	1236	2.9%	2.3%	2.3%	2.3%	2.4%	2.4%	2.5%	2.6%	3.3%	6.2%
24000 - 26000	67	109	156	209	266	327	396	592	1236	2026	3.4%	2.7%	2.6%	2.6%	2.7%	2.7%	2.8%	3.7%	6.9%	10.1%
26000 - 28000	78	125	178	235	299	369	592	1236	2026	2960	3.9%	3.1%	3.0%	2.9%	3.0%	3.1%	4.2%	7.7%	11.3%	14.8%
28000 - 30000	89	142	200	265	336	592	1236	2026	2960	4038	4.5%	3.5%	3.3%	3.3%	3.4%	4.9%	8.8%	12.7%	16.4%	20.2%
30000 - 32000	100	161	226	309	592	1236	2026	2960	4038	5253	5.0%	4.0%	3.8%	3.9%	5.9%	10.3%	14.5%	18.5%	22.4%	26.3%
32000 - 34000	113	185	309	592	1236	2026	2960	4038	5253	6591	5.7%	4.6%	5.2%	7.4%	12.4%	16.9%	21.1%	25.2%	29.2%	33.0%
34000 - 36000	168	293	592	1236	2026	2960	4038	5253	6591	8037	8.4%	7.3%	9.9%	15.5%	20.3%	24.7%	28.8%	32.8%	36.6%	40.2%
36000 - 38000	221	592	1236	2026	2960	4038	5253	6591	8037	9566	11.1%	14.8%	20.6%	25.3%	29.6%	33.7%	37.5%	41.2%	44.6%	47.8%
38000 - 40000	592	1236	2026	2960	4038	5253	6591	8037	9566	11150	29.6%	30.9%	33.8%	37.0%	40.4%	43.8%	47.1%	50.2%	53.1%	55.7%
40000 - 42000	1151	1939	2874	3952	5167	6504	7950	9479	11064	12667	57.5%	48.5%	47.9%	49.4%	51.7%	54.2%	56.8%	59.2%	61.5%	63.3%
42000 - 44000	1434	2368	3446	4661	5999	7444	8974	10558	12162	13742	71.7%	59.2%	57.4%	58.3%	60.0%	62.0%	64.1%	66.0%	67.6%	68.7%
44000 - 46000	1724	2802	4016	5354	6799	8329	9913	11517	13098	14606	86.2%	70.0%	66.9%	66.9%	68.0%	69.4%	70.8%	72.0%	72.8%	73.0%
46000 - 48000	2013	3227	4565	6010	7539	9123	10727	12308	13816	15193	100.7%	80.7%	76.1%	75.1%	75.4%	76.0%	76.6%	76.9%	76.8%	76.0%
48000 - 50000	2292	3630	5075	6604	8190	9793	11374	12881	14258	15439	114.6%	90.8%	84.6%	82.6%	81.9%	81.6%	81.2%	80.5%	79.2%	77.2%
50000 - 52000	2552	3997	5526	7112	8715	10296	11803	13180	14361	15270	127.6%	99.9%	92.1%	88.9%	87.2%	85.8%	84.3%	82.4%	79.8%	76.4%
52000 - 54000	2783	4313	5897	7501	9082	10590	11966	13147	14056	14610	139.2%	107.8%	98.3%	93.8%	90.8%	88.2%	85.5%	82.2%	78.1%	73.1%
54000 - 56000	2974	4558	6162	7743	9251	10628	11809	12717	13272	13377	148.7%	114.0%	102.7%	96.8%	92.5%	88.6%	84.3%	79.5%	73.7%	66.9%
56000 - 58000	3114	4718	6299	7806	9183	10363	11273	11826	11932	11932	155.7%	117.9%	105.0%	97.6%	91.8%	86.4%	80.5%	73.9%	66.3%	59.7%
58000 - 60000	3188	4769	6277	7654	8834	9743	10297	10403	10403		159.4%	119.2%	104.6%	95.7%	88.3%	81.2%	73.6%	65.0%	57.8%	
60000 - 62000	3185	4693	6070	7250	8159	8713	8819	8819			159.2%	117.3%	101.2%	90.6%	81.6%	72.6%	63.0%	55.1%		
62000 - 64000	3089	4466	5646	6555	7109	7215	7215				154.4%	111.7%	94.1%	81.9%	71.1%	60.1%	51.5%			
64000 - 66000	2885	4066	4974	5529	5634	5902					144.3%	101.6%	82.9%	69.1%	56.3%	49.2%				
66000 - 68000	2558	3466	4021	4176	5273						127.9%	86.7%	67.0%	52.2%	52.7%					
68000 - 70000	2089	2643	3487	4585							104.4%	66.1%	58.1%	57.3%						
70000 - 72000	1735	2732	3830								86.7%	68.3%	63.8%							
72000 - 74000	1905	3003									95.3%	75.1%								
74000 - 76000	2094										104.7%									
76000 - 78000																				

[1] The maximum loss value that can be applied is 100%

Appendix C.1: Exceedance curves for Murrumbidgee losses for Murray flow rates

Appendix C.2: Seasonal comparison tables (summer & winter)

Flow Class	Row Ref	Flow Range	n	TOT BB Flow	TOT Loss	Loss %
4,000.00	895	4000 - 4500	25	106107.29	13310.777	12.5%
4,500.00	2073	4500 - 5000	39	184804.58	22321.892	12.1%
5,000.00	3339	5000 - 5500	43	223371.02	27850.899	12.5%
5,500.00	4509	5500 - 6000	46	266450.8	30989.963	11.6%
6,000.00	5591	6000 - 6500	75	469062.81	51007.982	10.9%
6,500.00	6549	6500 - 7000	113	766733.96	82808.026	10.8%
7,000.00	7503	7000 - 7500	177	1286334.8	130448.83	10.1%
7,500.00	8417	7500 - 8000	199	1542689.9	159752.07	10.4%
8,000.00	9223	8000 - 8500	268	2208667.6	212924.16	9.6%
8,500.00	10137	8500 - 9000	214	1871294	168947.76	9.0%
9,000.00	10931	9000 - 9500	177	1636836.3	134288.44	8.2%
9,500.00	11722	9500 - 10000	204	1988389.4	175703.61	8.8%
10,000.00	12563	10000 - 10500	216	2214743.4	175754.89	7.9%
10,500.00	13262	10500 - 11000	208	2234270.4	182114.39	8.2%
11,000.00	13936	11000 - 11500	188	2112040	159099.22	7.5%
11,500.00	14477	11500 - 12000	171	2006112	154158.14	7.7%
12,000.00	14966	12000 - 12500	138	1688936.1	124950.45	7.4%
12,500.00	15416	12500 - 13000	159	2024874.3	142747.65	7.0%
13,000.00	15831	13000 - 13500	141	1863576.5	118115.71	6.3%
13,500.00	16239	13500 - 14000	113	1552161.3	90858.552	5.9%
14,000.00	16580	14000 - 14500	78	1109162.3	63218.891	5.7%
14,500.00	16871	14500 - 15000	61	899586.51	51565.067	5.7%
15,000.00	17146	15000 - 15500	78	1188021.4	67543.261	5.7%
15,500.00	17421	15500 - 16000	87	1369076.2	69577.478	5.1%
16,000.00	17686	16000 - 16500	46	745334.14	43595.684	5.8%
16,500.00	17927	16500 - 17000	39	651631.71	31826.641	4.9%
17,000.00	18186	17000 - 17500	27	464940.85	23569.186	5.1%
17,500.00	18390	17500 - 18000	21	370181.97	15842.413	4.3%
18,000.00	18546	18000 - 18500	16	291323.91	14610.051	5.0%
18,500.00	18737	18500 - 19000	20	374111.17	15427.546	4.1%
19,000.00	18922	19000 - 19500	26	499739.77	22428.159	4.5%
19,500.00	19088	19500 - 20000	13	256005.83	13043.2	5.1%
20,000.00	19245	20000 - 20500	20	404586.92	19334.594	4.8%

Flow Class	Row Ref	Flow Range	n	TOT BB Flow	TOT Loss	Loss %
4,000.00	916	4000 - 4500	220	930785.04	129199.43	13.9%
4,500.00	2081	4500 - 5000	209	989170.48	133533.31	13.5%
5,000.00	3357	5000 - 5500	276	1454195.1	183134.8	12.6%
5,500.00	4543	5500 - 6000	255	1463312.7	185161.6	12.7%
6,000.00	5590	6000 - 6500	282	1756479.5	205166.11	11.7%
6,500.00	6544	6500 - 7000	269	1812405.2	197608.91	10.9%
7,000.00	7500	7000 - 7500	226	1639698.7	168662.79	10.3%
7,500.00	8416	7500 - 8000	178	1375414	136115.27	9.9%
8,000.00	9226	8000 - 8500	244	2012572.2	187899.56	9.3%
8,500.00	10142	8500 - 9000	178	1555770.3	147301.57	9.5%
9,000.00	10935	9000 - 9500	190	1757578.6	153466.66	8.7%
9,500.00	11721	9500 - 10000	209	2037089.4	181042.25	8.9%
10,000.00	12573	10000 - 10500	162	1658343.6	138118.8	8.3%
10,500.00	13261	10500 - 11000	164	1762534.1	146455.62	8.3%
11,000.00	13939	11000 - 11500	149	1674443.6	123884.76	7.4%
11,500.00	14473	11500 - 12000	135	1585984.2	119397.13	7.5%
12,000.00	14973	12000 - 12500	114	1393078	95887.239	6.9%
12,500.00	15415	12500 - 13000	95	1210773	83272.649	6.9%
13,000.00	15830	13000 - 13500	113	1497634.5	97563.984	6.5%
13,500.00	16238	13500 - 14000	111	1522402.5	93074.851	6.1%
14,000.00	16583	14000 - 14500	99	1413464.3	78606.425	5.6%
14,500.00	16876	14500 - 15000	101	1487707.1	83795.118	5.6%
15,000.00	17151	15000 - 15500	90	1371716.3	90324.647	6.6%
15,500.00	17420	15500 - 16000	86	1353686.4	80910.976	6.0%
16,000.00	17688	16000 - 16500	86	1395110.4	82954.856	5.9%
16,500.00	17945	16500 - 17000	99	1653486.8	79987.52	4.8%
17,000.00	18185	17000 - 17500	90	1550872.4	76170.348	4.9%
17,500.00	18386	17500 - 18000	66	1171429.9	55835.482	4.8%
18,000.00	18572	18000 - 18500	76	1385184.6	65548.094	4.7%
18,500.00	18747	18500 - 19000	80	1498404.7	71336.472	4.8%
19,000.00	18923	19000 - 19500	70	1346160.6	61389.64	4.6%
19,500.00	19090	19500 - 20000	79	1558027.6	77550.831	5.0%
20,000.00	19262	20000 - 20500	81	1637320.5	73805.454	4.5%