Updated methodology to calculate water use losses for environmental water delivery in South Australia

Department for Environment and Water

May, 2023

DEW Technical Note 2023/14

Government of South Australia

Department for Environment and Water

Department for Environment and Water

Government of South Australia

December 2023

81-95 Waymouth St, ADELAIDE SA 5000

Telephone +61 (8) 8463 6946

Facsimile +61 (8) 8463 6999

ABN 36702093234

www.environment.sa.gov.au

Disclaimer

The Department for Environment and Water and its employees do not warrant or make any representation regarding the use, or results of the use, of the information contained herein as regards to its correctness, accuracy, reliability, currency or otherwise. The Department for Environment and Water and its employees expressly disclaims all liability or responsibility to any person using the information or advice. Information contained in this document is correct at the time of writing.

With the exception of the Piping Shrike emblem, other material or devices protected by Aboriginal rights or a trademark, and subject to review by the Government of South Australia at all times, the content of this document is licensed under the Creative Commons Attribution 4.0 Licence. All other rights are reserved.

© Crown in right of the State of South Australia, through the Department for Environment and Water 2023

Report prepared by:

Eva Beh and Claire Sims

Water Science Unit

Water Science and Monitoring Branch

Water and River Murray Division

Department for Environment and Water

Preferred way to cite this publication

Department for Environment and Water (2023). *Updated methodology to calculate water use losses for environmental water delivery in South Australia,* DEW Technical Note 2023/14, Government of South Australia, Department for Environment and Water, Adelaide.

Foreword

The Department for Environment and Water (DEW) is responsible for the management of the State's natural resources, ranging from policy leadership to on-ground delivery in consultation with government, industry and communities.

High-quality science and effective monitoring provides the foundation for the successful management of our environment and natural resources. This is achieved through undertaking appropriate research, investigations, assessments, monitoring and evaluation.

DEW's strong partnerships with educational and research institutions, industries, government agencies, Natural Resources Management Boards and the community ensures that there is continual capacity building across the sector, and that the best skills and expertise are used to inform decision making.

Ben Bruce
CHIEF EXECUTIVE
DEPARTMENT FOR ENVIRONMENT AND WATER

Contents

1 Introduction

This document provides detail of the method used to calculate losses from environmental watering actions to inform the application of the *Policy for Application of Losses to Environmental Water* and corresponding procedure.

It is difficult to determine losses due to flow enhancement and watering actions based on monitoring of discharge alone. For example, the change in measured volume downstream of a weir pool during a raising action over a period of time is influenced by the additional loss (seepage and evapotranspiration) due to the increase in inundated area from the environmental watering action, the losses from the reach that would have occurred without the action, as well as diversions from within the reach. Monitoring alone cannot separate these different effects and, as such, this methodology is based on a relative comparison of hydrological model runs.

2 Assessing losses from controlled environmental watering actions

2.1 Hydrological model

The SA River Murray Source model, outlined in Department for Environment and Water (2020), is used to calculate losses due to environmental water actions that this model has the functionality to represent. These actions, the relevant model nodes and data sources are outlined in more detail below.

This model is based on the Source Murray Model (SMM) developed and calibrated by Murray Darling Basin Authority (MDBA) documented in MDBA (2015). This model has been extended by Department for Environment and Water (DEW) to represent all of the weir pools in South Australia and the Pike and Katarapko floodplain structures. This extended model also includes the more detailed representation of the Chowilla floodplain developed by the MDBA for water accounting purposes, not currently included in the SMM. The South Australian section of the Source model has been developed and calibrated from outputs of numerous runs of the existing detailed MIKE FLOOD hydrodynamic models, outlined in DHI (2014), McCullough et al. (2017) and DEW (2021). Details of the SA River Murray Source model refinements and calibration results are presented in DEW (2020). This hydrological model will continue to be validated and updated as necessary as data are collected from additional operations into the future and the currency of climate and other inputs are maintained so that the best available model at the time is applied.

2.2 Modelling approach

The SA River Murray Source model is capable of simulating the operation of the environmental regulators and associated works on floodplains, the weir and locks within the river. The model can then estimate the on-site water use due to operations by comparing the evaporation, seepage and water retention associated with operational scenarios (watering actions) against an equivalent model run without the watering action.

The model is run twice to determine post-event water use. The first model run represents actual conditions with the watering action. Recorded upstream flow (typically Flow to SA, depending on the action) is input to the model. Recorded water levels are used at relevant structures to represent the watering action and observed climate data for rainfall and Morton's Lake evaporation (Morton, 1983) are applied. Once an acceptable representation of actual conditions are achieved, based on comparison to downstream flow data and the actual operation, a second "no-operation" run is simulated by generating water level, and if necessary, flow time series to represent the no-operation case. The difference between these two model runs is then used to determine the water use due to the watering action.

Water use is estimated based on the difference between results of the two scenarios, i.e., the additional water use associated with the operation including increased evaporation and seepage due to increased inundation area and, where appropriate, retention of water on the floodplain during and following the operation. For each relevant node for a given site (outlined below), the following daily outputs are recorded.

- Rainfall volume
- Evaporation volume
- Seepage volume
- Storage Volume

The evaporation and seepage are summed, with rainfall subtracted, over the relevant period for the environmental watering action. The difference in storage volume between the end and start of the relevant period is used to determine any water retained within a node (e.g., trapped in a wetland or a floodplain). These volumes are summed for each node and then across the relevant nodes to determine the loss over the duration of the environmental watering action. The difference in the loss, between the with and without watering action model runs, provides the estimate of the loss due to the environmental watering action.

The methodology outlined above describes the case for a post event water use calculation when the observed water levels and climate data are available. Pre-event water use estimates are calculated using the same method but, in the place of observed data for planned operations, average climate and 'Annual Operating Plan Flow to SA' hydrographs are used.

The specific nodes used to calculate the loss for a given action and the input data used to configure the model are outlined in Table 1 to Table 10.

Table 1. Nodes used in the hydrological model to calculate the loss at Chowilla floodplain

Feature	Node Name	Climate Station	Downstream water level	Upstream flow
Chowilla Floodplain	Gum Flat 281	24004	-	-
Chowilla Floodplain	Lake Littra 280	24004	-	-
Chowilla Floodplain	Lake Limbra 282	24004	-	-
Chowilla Floodplain	Coombool Swamp 283	24004	-	-
Chowilla Floodplain	Werta Wert wetland 388	24004	-	-
Chowilla Floodplain	Chowilla Regulator 254	24004	A4261091	-
Chowilla Floodplain	Floodplain retention 389	24004	-	-
Chowilla Floodplain	Woolshed R256	24004	-	-
Chowilla Floodplain	Pipeclay Creek 150	-	-	Manual recordings during events.
Chowilla Floodplain	Slaney Creek 151	-	-	Manual recordings during events.
Weir pool 6	Lock 6	24004	A4260511	Flow to SA

Table 2. Nodes used in the hydrological model to calculate the loss at Pike floodplain

Feature	Node Name	Climate Station	Downstream water level	Upstream flow
Pike Floodplain	Pike inlet	-	-	Combined inflow at Deep Creek and Margret Dowling Creek
Pike Floodplain	Bank B offtake		-	-
Pike Floodplain	Mundic	24016	A4261244	-
Pike Floodplain	Upper Pike	24016	Recorded water level	-
Pike Floodplain	Lower Pike	24016	-	-
Weir pool 5	Lock 5	24016	A4260513	A4260511 + A4261091
Lake Merreti	Lake Merreti	24016	-	-
Lake Woolpolool	Lake Woolpolool	24016	-	-

Table 3. Nodes used in the hydrological model to calculate the loss at Katarapko floodplain

Feature	Node Name	Climate Station	Downstream water level	Upstream flow
Katarapko Floodplain	Katarapko inlet	-	-	Combined inflow
Katarapko Floodplain	Katarapko	24008	A4261225	-
Weir pool 4	Lock 4	24008	A4260514	A4260513
Gurra Gurra Lake	Gurra Gurra	24008	A4261170	A4260663
Berri Basin	Berri	24008	-	-

Table 4. Nodes used in the hydrological model to calculate the loss at Weir Pool 6

Feature	Node Name	Climate Station	Downstream water level	Upstream flow
Weir pool 6	Lock 6	24004	A4260510	A4261001

Table 5. Nodes used in the hydrological model to calculate the loss at Weir Pool 5

Feature	Node Name	Climate Station	Downstream water level	Upstream flow
Weir pool 5	Lock 5	24016	A4260512	A4260511 + A4261091
Lake Merreti	Lake Merreti	24016	-	-
Lake Woolpolool	Lake Woolpolool	24016	-	-

Table 6. Nodes used in the hydrological model to calculate the loss at Weir Pool 4

Feature	Node Name	Climate Station	Downstream water level	Upstream flow
Weir pool 4	Lock 4	24008	A4260514	A4260513
Gurra Gurra Lake	Gurra Gurra	24008	A4261170	A4260663
Berri Basin	Berri	24008	-	-

Table 7. Nodes used in the hydrological model to calculate the loss at Weir Pool 3

Feature	Node Name	Climate Station	Downstream water level	Upstream flow
Weir pool 3	Lock 3	24007	A4260516	A4260515
Lake Bonney	Lake Bonney	24007	-	-

Table 8. Nodes used in the hydrological model to calculate the loss at Weir Pool 2

Feature	Node Name	Climate Station	Downstream water level	Upstream flow
Weir pool 2	Lock 2	24012	A4260518	A4260517

Table 9. Nodes used in the hydrological model to calculate the loss at Weir Pool 1

Feature	Node Name	Climate Station	Downstream water level	Upstream flow
Weir pool 1	Lock 1	24578	A4260902	A4260519

Table 10. Nodes/Links used in the hydrological model to calculate the loss below lock 1

Feature	Node/Link Name	Climate Station	Downstream water level	Upstream flow
Lock1 to Swan Reach	R120	24564	-	A4260903
Swan Reach to Walker Flat	R121	24547	-	-
Walker Flat to Mannum	R122	24517	-	-
Lower Lakes	Lake Alexandrina	Average of stations; 23718 24518 24537 24539 24572 24576	Average of stations; A4260574 A4260575 A4260527 A4261133 A4260524	-
Lower Lakes	Lake Albert	Average of stations; 23718 24518 24537 24539 24572 24576	-	-

3 Assessing losses due to flow enhancement

3.1 Hydrological model

The SA River Murray Source model as described in Section 2.1 is applied.

3.2 Modelling approach

A methodology to assess the increase in loss due to increases in flow at the SA Border has been developed to inform the *Policy and Procedure for Application of Losses to Environmental Water*. The intention is to consider the case where environmental water and/or unregulated flow results in an increase in the flow to South Australia above Entitlement to enable accounting of any additional losses due to this increased flow. It should be noted that this analysis only considers the additional losses due to the additional inundation achieved under delivery of higher flow and no structures are operated in this analysis.

Rainfall and evaporation data from each climate station listed in the Table 1- Table 10 above were used to generate an average net evaporation value for December from the historical period spanning 1970 to 2022. This value was applied as a constant at a daily timestep to represent relatively high, and thus conservative, losses (i.e., environmental water delivery may typically occur earlier in the year with lower net evaporation rates).

To generate the percentage rate of incremental transmission loss, the model is run using a constant flow to SA for each of the flow increments listed in Table 11 and flow at the routing link immediately above Lake Alexandrina recorded (Column 2, Table 11). The losses (Column 3, Table 11) for each flow increment are calculated as the difference between flow to SA and the flow into the Lower Lakes, adopting the average net evaporation for December as described above and assuming a fixed pattern of diversions informed by historical data (assuming full allocation and use). Column 4 of Table 11 provides the additional loss per day (ML/day) expected after increasing the flow at the SA border from 5,000 ML/day (representative of Entitlement flow conditions) up to 80,000 ML/day. To note, given that these percentage values are influenced by the average climate pattern used, they could be expected to differ slightly following extensions to the climate inputs in the model to maintain their currency.

The rate of incremental transmission loss applicable to each total flow band above 5,000 ML/day is presented in column 5. Where applicable, apportioning the additional losses due to the increased flow between environmental and unregulated flow is a post-processing or accounting exercise and the method outlined here is agnostic of flow sources. The additional loss due to the increase in flow above 5,000 ML/day has increased across all flow bands since the initial development of this methodology, as presented in DEW, 2019 as a result of improvements to the SA River Murray hydrodynamic models and, in turn, the Source hydrological model. Specifically, the conveyance relationships representing the movement of water between the River (weir pools) and the floodplains at varying weir pool levels and flow rates have been updated which impacts the modelled area of inundation under each flow band. These updates are described in DEW, 2020. It is not expected that future potential updates to the Source model of this nature will have a material impact on the additional loss calculations.

While the percentage loss rates presented in Column 5 are a small percentage of the total flow, they are not immaterial. As such, it is recommended to determine losses due to flow enhancement on a case-by-case basis, including flows to South Australia greater than 80,000 ML/day.

Table 11. Additional water use losses from increasing the flow at the SA border above 5,000 ML/d, based on average net evaporation in December.

SA Border flow (1)	Flow into Lower Lakes (2)	Loss within SA (Incl. diversions, etc.) (3)	Additional loss due to increase in flow above 5,000 ML/day (4)	% rate of incremental transmission loss applied to flow above 5,000 ML/day (5)
ML/day	ML/day	ML/day	ML/day	%
5000	1078	3922		
10,000	5901	4099	177	3.5%
20,000	15813	4187	265	1.8%
30,000	25658	4342	420	1.7%
40,000	35382	4618	695	2.0%
50,000	44930	5070	1147	2.5%
60,000	54280	5720	1798	3.3%
70,000	63598	6402	2479	3.8%
80,000	72804	7196	3274	4.4%

4 References

Department for Environment and Water (2019). Methodology to Calculate Water Use Losses for Environmental Water Delivery in South Australia, DEW Technical Report 2019/22, Government of South Australia, Department for Environment and Water, Adelaide.

Department for Environment and Water (2020). Refinements to the River Murray Source model in South Australia, DEW Technical report 2020/06, Government of South Australia, Adelaide.

Department for Environment and Water (2021). SARFIIP First Operations – Hydrodynamic model review, update and scenario modelling, DEW Technical note 2021/05, Government of South Australia, Department for Environment and Water, Adelaide.

DHI (2014) *Lower Murray Hydrodynamic Model – Model development and calibration report*. Final Report to Department of Environment, Water and Natural Resources(DEWNR), Dec 2014

McCullough DP, Montazeri M & Esprey L (2017). *Refinement and calibration of Pike and Katarapko floodplain flexible mesh models*. DEWNR Technical note 2017/11, Government of South Australia, Department of Environment, Water and Natural Resources, Adelaide.

MDBA (2015) *Source Model for the Murray and Lower Darling System*. Technical Report No. 2015/03, version 2, November 2016, Murray-Darling Basin Authority.

Morton, F. I. (1983) Operational estimates of areal evapotranspiration and their significance to the science and practice of hydrology, Journal of Hydrology, 66(1–4). pp 1-76.

Government
of South Australia

Department for
Environment and Water