Multi-site environmental water planning in South Australia using eWater Source

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Key Points

- Environmental water delivery throughout the Murray-Darling Basin requires coordinated planning
- The coordinated delivery of environmental water will improve efficiency in the system and maximise the environmental outcomes that can be achieved.
- Current environmental water delivery within South Australia is undertaken at the site scale using the eWater Source modelling platform. Water demands from different sites are combined to assess the complementary and contrasting nature of demands, to allow a coordinated approach to environmental water planning and delivery.
- The eWater Source modelling platform has new functionality to facilitate a dynamic approach to consider and align environmental water demands across multiple sites that will improve this process in the future.

Abstract

Annual environmental water planning is undertaken prior to the start of each water year in the Southern Connected System of the Murray-Darling Basin to identify watering priorities. This includes efforts to align watering actions across sites to maximise the environmental objectives that can be achieved for a given volume of environmental water available. One example within South Australia has been considered, to align in-channel flows in the South Australian River Murray channel, target water levels in Lake Alexandrina, and also maintain end of system flows out of the barrages into the Coorong and Murray Mouth. Current approaches to align watering actions using eWater Source are presented in this paper. This involved testing different inflow scenarios, and evaluating the resulting hydrological regime along the River Murray in South Australia against a range of environmental water requirements. This can be a time consuming and iterative process, requiring multiple model runs to align flow requirements for each asset. This paper details the current approach to eWater planning, and as an example, presents the results for the previous 2017/18 water year. The new Environmental Flow Node is also discussed, which allows environmental orders to be created based on watering targets and a more dynamic approach to consider and align environmental water demands, enabling a range of scenarios to be evaluated quickly.

Keywords

Environmental water, multi-site, eWater Source, Environmental Flow Node

Introduction

River Murray Environmental Water

The considerable environmental water (e-water) recovered in the Murray-Darling Basin (the Basin) under the Basin Plan is managed by the Commonwealth Environmental Water Holder (CEWH). This position was established under the *Water Act 2007* to make decisions on the allocation of water to meet the ecological needs of plant and animal communities and restore the long term health of the Murray-Darling Basin. This watering regime has necessitated new approaches to managing the allocation of e-water to environmental assets and sites throughout the Basin (DEW, 2018).

E-water is a very important additional source of water available to South Australia (SA). There are two primary water holders for e-water delivered to SA; the Murray-Darling Basin Authority (MDBA) through The Living Murray (TLM) Program, and the CEWH. The entire TLM portfolio is approximately 480 GL and the SA-held TLM component is 45 GL. As at 31 March, 2018, the CEWH portfolio totals 2,673 GL of which 1,984 GL is available in the Southern Connected Basin (CEWO, 2018). The Lower Murray-Darling region is one of ten key regions within the Basin that the CEWH deliver water to (Figure 1). The region features a number of internationally significant wetlands including the Coorong, and Lakes Alexandrina and Albert Wetlands.

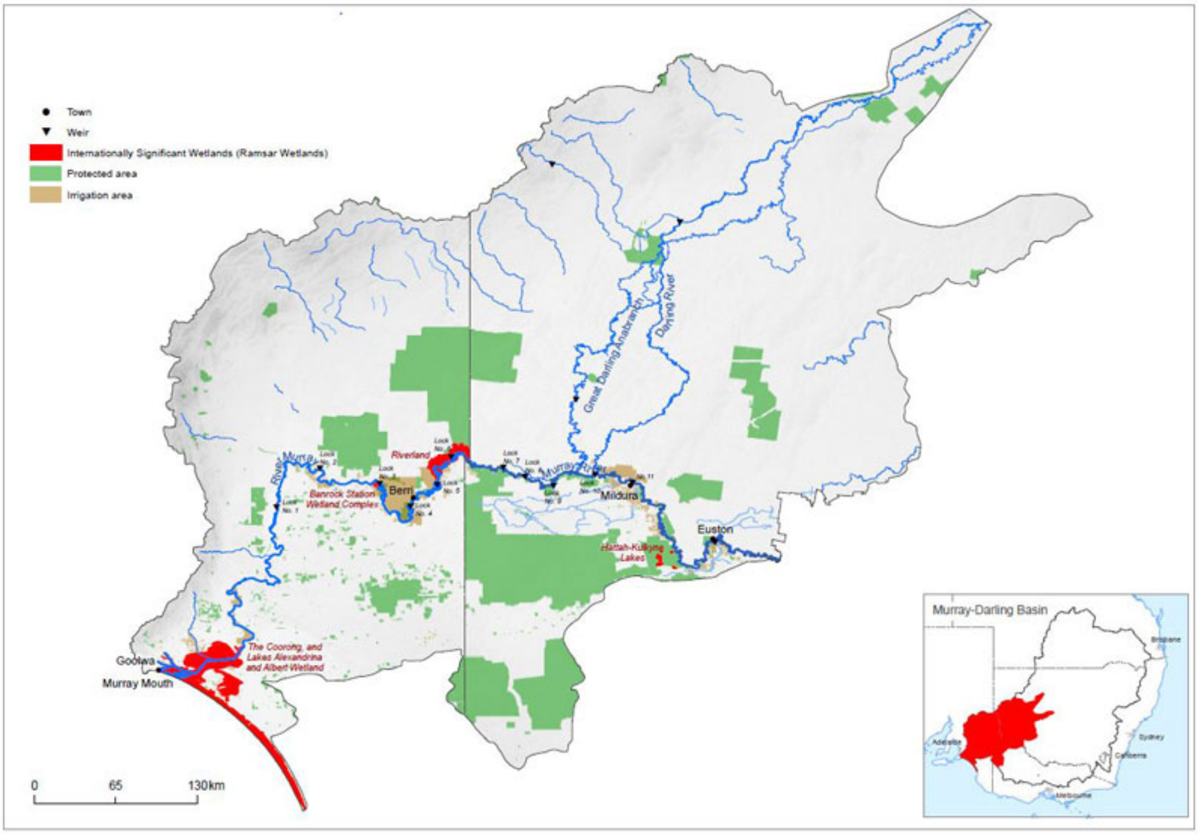

Figure 1. Lower Murray-Darling environmental watering region (Source: www.environment.gov.au)

Environmental water planning

E–water planning occurs at a number of spatial and temporal scales within the Basin. The Basin-wide Environmental Watering Strategy, published by the MDBA in 2014, guides e-water holders and Basin governments in the planning and management of environmental watering to meet long-term environmental objectives. The long-term state priorities for the SA River Murray are contained in the South Australian River Murray Long-term Environmental Watering Plan, which describes the pattern of water delivery required to support the health of this ecosystem over a multi-year time period. It covers the main River Murray channel, its floodplain and wetlands, and the Ramsar-listed Coorong, Lakes and Murray Mouth region. This long-term plan informs the annual planning and decision-making around the delivery of water that has been recovered for the environment. The Basin Plan requires Basin states to identify the annual environmental watering priorities for the following year for each region and the MDBA produces basin-wide annual priorities as well (DEW, 2018).

Currently e-water planning within SA occurs initially on a site-by-site basis (albeit large sites in the order of hundreds of kilometres) utilising a range of methods including various modelling software, hydrograph design, and water balance calculations. Initial modelling to support planning at an individual site scale uses Annual Operating Probability (AOP) hydrographs provided by the MDBA, representing the range in potential future flows to South Australia, based on current storage levels across the basin and the historical climate record.

Currently there are five sites within the SA River Murray, which are included in annual e-water planning:

- SA River Murray channel
- Chowilla Floodplain icon site
- River Murray weir pools (raising and lowering)
- River Murray wetlands
- Lower Lakes, Coorong and Murray Mouth (LLCMM) icon site

Given the various portfolios of e-water, sites and both competing and complementary priorities, there is a need for a coordinated approach to e-water planning and delivery modelling. This paper outlines the current hydrological modelling approach used to assess and align the annual environmental water planning within the SA River Murray, and the potential to expand this approach using new eWater Source Environmental Node functionality to support multi-site planning within SA.

Current modelling methodology

Source Lower Murray model

The eWater Source Lower Murray model (Lower Murray model) has been adapted from the MDBA's Source Murray Model (SMM) (MDBA, 2015) and is used to model e-water scenarios for the LLCMM icon site (Figure 2). The node-link river system model represents the travel times, diversions and net evaporative losses within each reach of the river, as well as Lakes Alexandrina and Albert (the Lower Lakes) and barrages at the end of the system. The barrages separate the River Murray from the sea and are designed and operated to maintain lake levels and minimise salt ingress to the lakes. The barrages are operated subject to upstream lake levels (as dictated by inflows and net evaporation), and downstream tide and swell conditions. Barrage releases maintain the connectivity between the river and the ocean, contributing to Murray Mouth openness and the estuarine conditions of the Coorong (MDBA, 2011).

The Lower Murray model is configured for a given scenario of flow at the South Australian border (QSA), and different barrage operational scenarios can be tested, targeting variability in the Lake Alexandrina water level or certain minimum flows over the barrages. The model is run using a multi-history approach where the historical climate is used to consider the potential distribution in volumes at the end of the system.

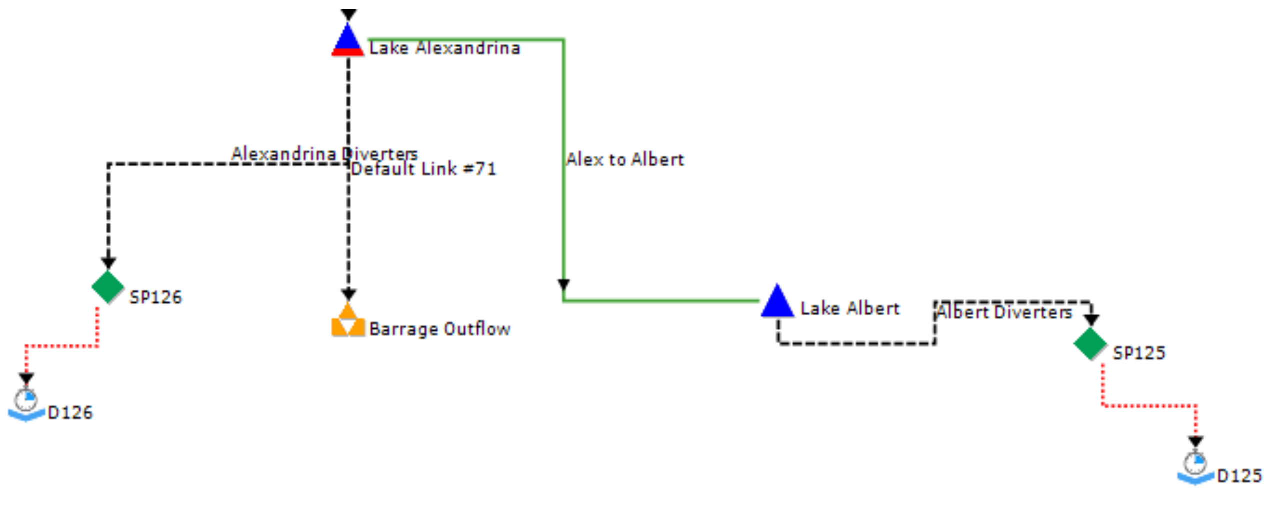

Figure 2. Subset of the eWater Source Lower Murray model showing the end of system (LLCMM icon site)

Annual environmental water planning scenarios

A two stage approach is typically used in the current planning process:

- Stage one involves the e-water managers distributing e-water volumes associated with each AOP across the water year to build a hydrograph designed to achieve specific environmental outcomes at the site. The AOPs provided by the MDBA are percentage based resource availability scenarios and refer to the likelihood of exceeding different water resource availability based on the analysis of historical inflows, current storage volumes, and operational considerations for the coming water year. Individual site-based modelling is undertaken using eWater Source. The six scenarios considered are 95% (worst case/very dry), 90% (dry), 75% (moderate), 50% (near average), 25% (wet) and 10% (very wet) (DEWNR, 2017).
- Stage two of the modelling represents the alignment of watering actions across sites by e-water managers based on the various Stage one modelling outputs. The aim is to maximise the environmental objectives that can be achieved for a given volume of environmental water available. This includes increasing efficiency by looking at opportunities to align actions and re-use water (return flows) as it travels through the system. A subsequent round of modelling is undertaken, which reflects this alignment of actions across sites within SA.

Results of current approach in 2017-18

The Lower Murray model was used to examine a series of AOPs for 2017-18, provided by the MDBA to assist with e-water planning for the year. The model assesses the expected lake level profile and barrage releases under a series of (45 year) historic climatic and fixed diversion patterns. The mid-point of a target lake level envelope was assumed for all AOP scenarios and minimum barrage releases were set to zero for all scenarios to assess how the lake levels respond. A lower limit of 0.5 m AHD was imposed for lake level, below which barrage releases cease, which is a reflection of operational reality. The model was run from 1 July 2017 to 30 June 2018. Example lake level (Figure 3) and 7-day rolling average barrage releases (Figure 4) are shown below for the Dry AOP scenario generated for stage one of the planning process for the LLCMM site.

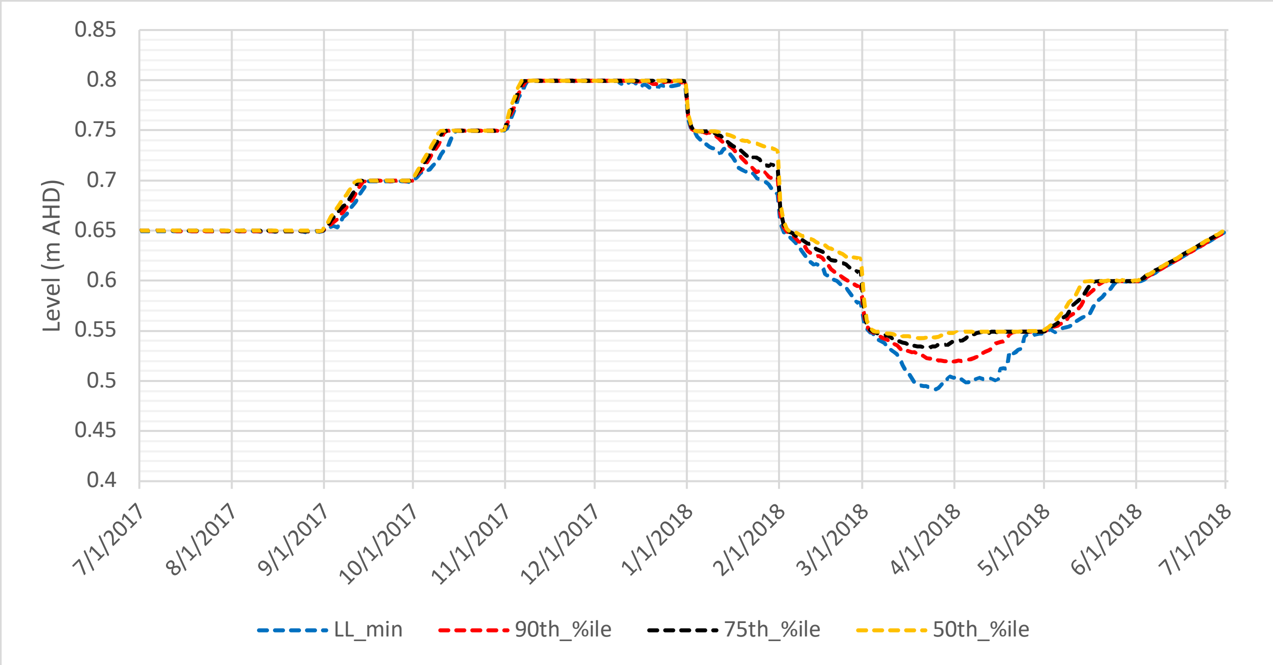

Figure 3. Average daily lake level percentiles under the Dry AOP with e-water added, stage 1

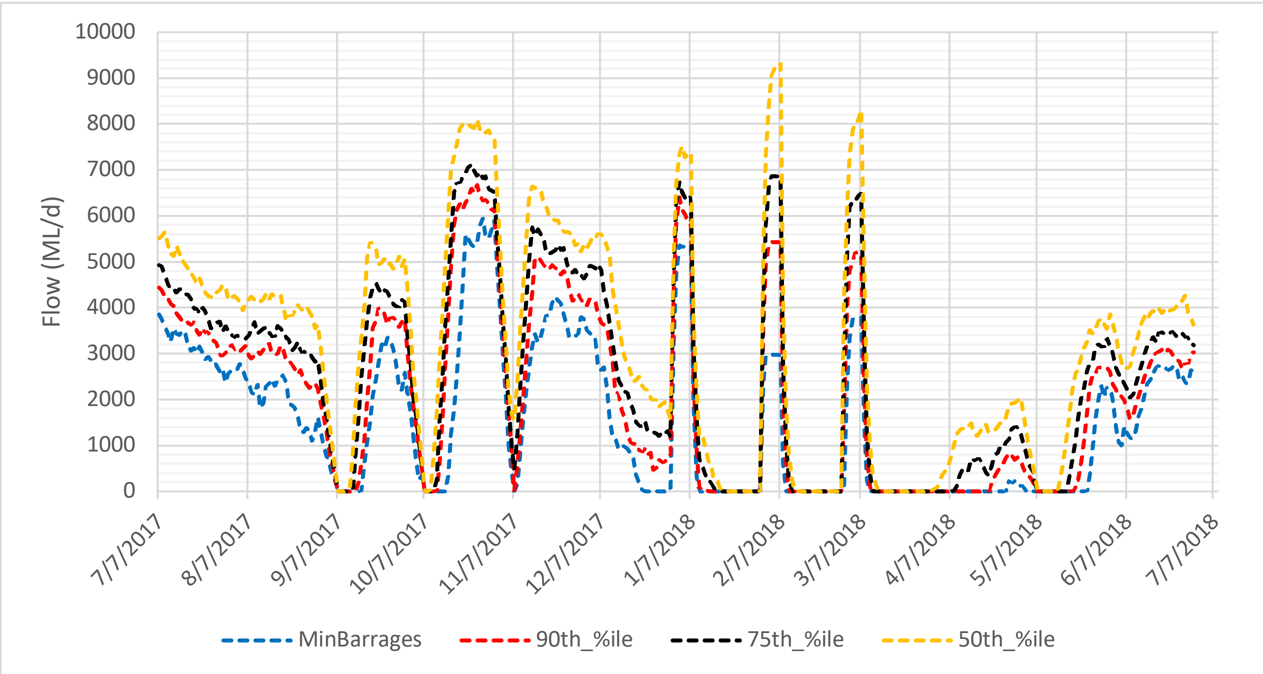

Figure 4. 7-day rolling average barrage release percentiles under the Dry AOP with e-water added, stage 1

Stage two modelling incorporated the outcomes of planning discussions between e-water managers across all SA sites, and a redistribution of e-water in order to address potential lake level reductions below the target and resulting barrage closures at the LLCMM site. The subsequent modelling showed that the target lake level could be achieved under all AOP scenarios, with the exception of a brief period in January and February for one of the options considered. As a result, the barrages would remain open with continuous releases under all AOP scenarios except the worst case considered by the model. The amended outputs for the Dry AOP are shown below in Figures 5 and 6.

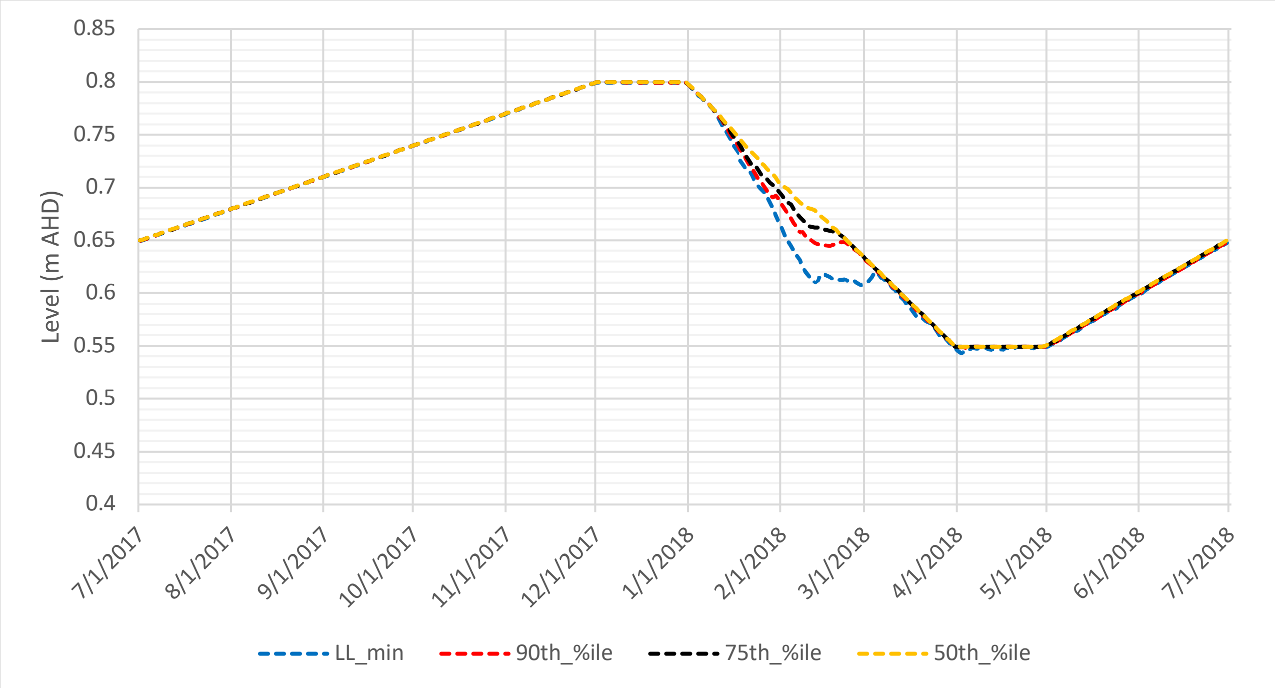

Figure 5. Average daily lake level percentiles under the Dry AOP with e-water added, stage 2

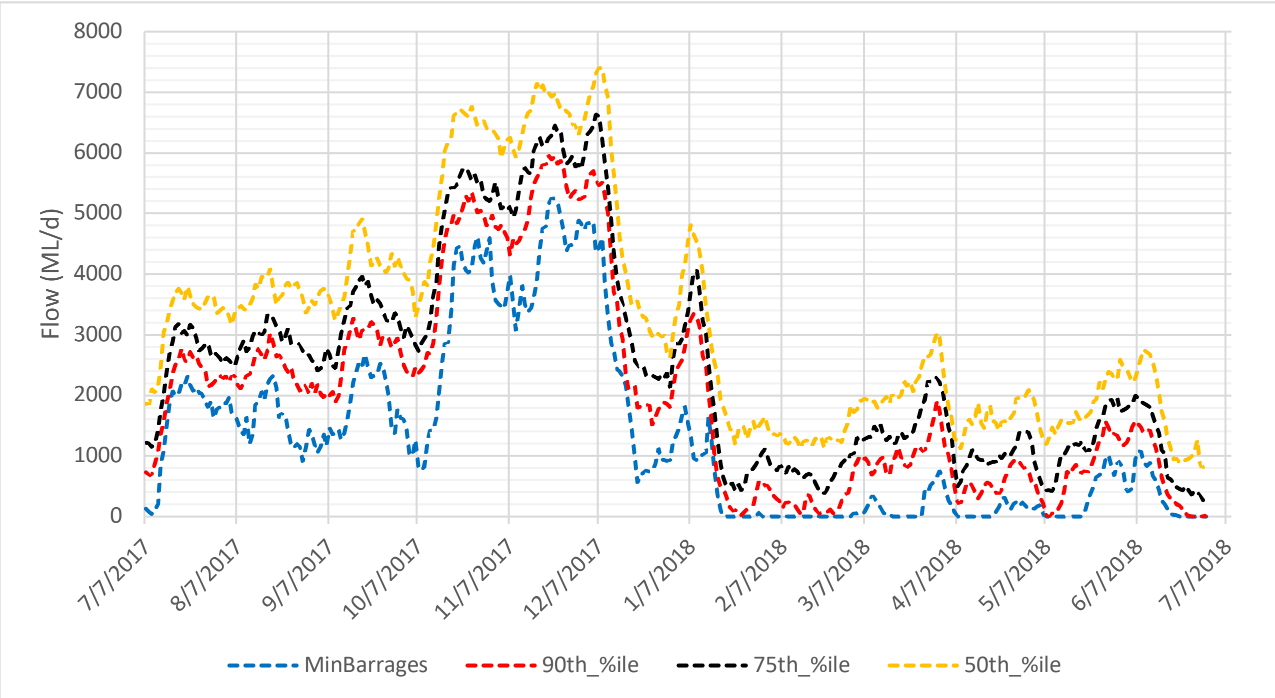

Figure 6. Seven day rolling average barrage release percentiles under the Dry AOP with e-water added, stage 2

The modelled outputs above are an integral component in e-water planning at a site-based scale within SA. However, the inability to integrate planned e-water delivery across multiple sites and test concurrent operations and impacts with the current model design is an impediment to a holistic assessment and efficient e-water delivery. The increasing complexity and scale of operations permitted by new infrastructure and e-water volumes will place increasingly greater demands on modelled outputs and a revised approach which accommodates this is required.

Discussion and future directions

The approach outlined above provides valuable information to support the annual watering planning process. Currently an iterative approach is used to develop design hydrographs for each AOP scenario, which is then assessed by each e-water manager. This is undertaken as manual adjustments in QSA, and the volume of water arriving at the Lower Lakes is assessed to evaluate how each of the actions might impact on each other. Although this modelling approach attempts to reflect the planning of other e-water managers within SA, it is manual, iterative and lacking a holistic, whole of system assessment. The process is not repeated when conditions dictate that planning changes and is still ultimately a series of site-based assessments.

Rather than using the "push" modelling approach outlined above, where a given upstream flow is trialled and tested, a "pull" based approach could be adopted, where e-water demands are specified for given conditions, which can augment the AOP flow based on the objectives. This "pull" based approach can be implemented in Source using the recently developed Environmental Flow Node (EFN) and Manager (EFM). Collectively, these features allow environmental flow to be represented and configured to reflect the spatial and temporal dependencies inherent in the system. This allows a holistic assessment of the overall impact of e-water in the system within the existing Source framework (eWater, 2018a).

The EFN operates on a daily time step and is used to generate orders to meet environmental water requirements (EWR) at a site. The EWR are defined in terms of the start criteria, flow response (magnitude) and frequency, and criteria for the success of the action (eWater, 2018a). The EFN is a prescriptive rather than a predictive tool and represents actions in the form of spell based or translucency flows, which are the two most commonly defined environmental flow requirements specified in environmental flow studies. A spell based action includes minimum flows (baseflow) usually required to maintain minimum habitat requirements; high flow or flood based, for example to trigger a fish breeding event; or pattern based, which may represent a multi-peak event. A translucency based action specifies the flow requirements in terms of a time series, usually the release from a dam, and is expressed as a portion of that inflow (eWater, 2018a, 2018b).

As this functionality in Source matures the benefits of this holistic, multi-site modelling approach are expected to include:

- Clear articulation of environmental demands (volume, frequency and duration),
- Multi-site representation and simultaneous action testing and assessment (including the impacts of infrastructure operation),
- Transparency, consistency and repeatability,
- Adaptable as forecast system inflows and upstream e-water actions change,
- Allow multiple iterations of a proposed action(s) under different scenarios to assess relative changes,
- Enable a 'bottom up' approach to be adopted, whereby end of system requirements could drive provision of e-water at the SA border and guide upstream watering actions.

Conclusions

Extensive e-water recovery throughout the Murray-Darling Basin has required a change in approach to how the river is managed to facilitate the co-ordinated allocation and delivery of water to maximise the achievement of environmental objectives. The allocation and delivery of e-water at the Basin scale presents a number of challenges, compounded by the constraints of operating the river to simultaneously deliver water for other users in a highly responsive and changing environment. Modelling is a key component in assessing Basin scale delivery options under various conditions and is currently used extensively for individual site e-water planning within SA. Although coordinated multi-site e-water planning occurs within SA, the modelling approach to support this is iterative and inefficient. There will be an increasing reliance on hydrological models to facilitate co-ordinated planning and delivery of e-water and the recent functionality improvements in the eWater Source modelling platform will be critical in this effort. Within SA, this functionality is being tested under a range of potential delivery scenarios, first at the site scale for the LLCMM site to assess the achievement of environmental outcomes, then at multiple sites within SA and across multiple portfolios. The ability to repeat the modelling when forecast conditions change will allow e-water managers to adapt and re-evaluate the impacts of changing delivery profiles. Ultimately this provides for a more efficient use of e-water and outcomes that meet the ecological needs of plant and animal communities and restore the long term health of the Murray-Darling Basin.

Acknowledgments

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