Pike and Katarapko Floodplains
Hydrological model update and scenario modelling

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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, Landscape 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.

John Schutz
CHIEF EXECUTIVE
DEPARTMENT FOR ENVIRONMENT AND WATER

Acknowledgements

This technical report has been delivered as part of the suite of science projects that are informing the South Australian Riverland Floodplain Integrated Infrastructure Program (SARFIIP). SARFIIP is a $155 million investment program funded by the Australian Government through the Murray-Darling Basin Authority and implemented by the South Australian Government to improve the watering and management of River Murray floodplains in South Australia's Riverland.

The following professionals are acknowledged for their contributions to this study:

- Dr Daniel McCullough of DEW who advised on surface water and hydraulic modelling, and provided data inputs for this project
- Carl Purczel of DEW who provided modelled salt load data to be use as input
- Samantha Walters of DEW who provided leaf litter data to be use as input
- Jan Whittle, Brett Ibbotson, Michelle Denny, Nathan Creeper, Rebecca Turner all of DEW who provided project direction and coordinated monitoring data for this project, much of this data was collected by DEW's Water Resources Monitoring Unit.
- Technology Branch for maintaining the servers to be able to the models.

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1 Introduction

Construction of new floodplain management infrastructure at Pike and Katarapko Floodplains was completed in 2020 under the South Australian Riverland Floodplains Integrated Infrastructure Program (SARFIIP) and first operations undertaken at both sites between August and December 2020. First operations involved raising water levels within the floodplain and main river channel under a "managed inundation" mode of operation, with a wide-ranging amount of operational and observational data collected.

Upon completion of the first operations at each floodplain site, the MIKE FLOOD Flexible Mesh (FM) hydrodynamic models were calibrated and validated with the observed data from the operational infrastructure. In addition, further steady state scenarios were run to update previously calculated relationships of floodplain height against impounded volumes and areas of inundation at given operational conditions. The details of the hydrodynamic models updates are summarised in DEW (2021).

The modelling of dissolved oxygen and dissolved organic carbon via the DODOC plugin, as well as the groundwater model of the Pike Floodplain are other key tools incorporated into the SA River Murray Source model to enable water quality assessments, with both updated and improved in 2020. The details of these key tools used as inputs to the Source model are summarised in Purczel, et al. (2020) and Mosley et al. (2021).

Information from these three key models as well as data collected through monitoring during first operations were used to parameterise, calibrate and validate the hydrological models of Pike and Katarapko Floodplains. These nodes are components of the existing SA River Murray Source model outlined in DEW (2020).

This document provides the details of the method used for the model updates and also summaries the scenario modellings undertaken to assess the impact of a range of a range of inundation operations on water quality and quantity at Pike and Katarapko Floodplains.

2 Model updates

The hydrological models of Pike and Katarapko Floodplains were initially developed and calibrated using the eWater Source platform. The methodology for initial development and calibration of both hydrological Models has been outlined in DEW (2020).

The Pike floodplain model was constructed by defining three main sections; Mundic, Upper Pike and Lower Pike. As part of the SARFIIP program, two key environmental regulators together with blocking banks have been constructed to manage flow and water level throughout the Pike Floodplain under a range of operational phases. Two model nodes were required to simulate the separate capacity and operations of these two regulators upstream of blocking banks. The section downstream of blocking banks (Lower Pike) is represented by two controlled splitters that simulate movement of water through the complex of Swift, Wood Duck and Rumpagunyah Creeks, as well as the Lower Pike River. Figure 2.1 shows the main creeks and structures associated with the Pike floodplain.

The Katarapko floodplain model was initially constructed by defining one main section representing the whole floodplain upstream of blocking banks. This work has refined the model representation to represent the terminal Carpark Lagoon explicitly to improve the representation of the filling of this lagoon and its effect on other processes (e.g. turnover rates) in the model. It should be noted that the travel time and processes occurring in Katarapko Creek has not been represented in the model, and flow out of the Katarapko floodplain is directly returned to the River Murray in the next time step. This means that salinity in Katarapko Creek is not accurately estimated, but is expected to be between the increases in the floodplain and that in the River Murray, given there is additional dilution provided in Katarapko Creek downstream of Lock 4 compared to the floodplain. Figure 2.2 shows the main creeks and structures associated with the Katarapko floodplain.

These hydrological models were improved and validated after completion of further updates of the following key tools, as well as the collection of observed data during first operations in 2020:

- Hydrodynamic models (DEW, 2021)
- Salinity models (Purczel, et al., 2020)
- DODOC model (Mosely et al, 2020)

The schematics of updated hydrological models of Pike and Katarapko Floodplains are shown in Appendix A and B

Figure 2.1 **Pike Floodplain creeks and structures**

Figure 2.2 Katarapko Floodplain creeks and structures

2.1 Storage dimensions and inflows based on hydrodynamic models

Numerous scenarios were simulated through the hydrodynamic model updates under a range of operating conditions for each floodplain, representing the total inflow into the floodplains, inundated area and impounded volume upstream of blocking banks. The following sets of outputs were used in this study in order to reflect these updates in the hydrological models of Pike and Katarapko Floodplains:

- for 'normal' floodplain operations between river flows of 5 and 50 GL/d, in 5 GL/d steady state increments; and
- for managed inundation operations at water levels ranging from normal to maximum operating height upstream of the environmental regulators at each site, initially in 0.1 m steady state increments and for a river flow of 10 GL/d and various Lock 4 and 5 weir pool levels (WPLs).

The hydrological models of Pike and Katarapko Floodplains were updated by manually adjusting the rating curves, reach widths, travel-time tables and storage dimensions as well as improving the in-built functions to provide the best estimates of the inflow, area and volume simulated through hydrodynamic modelling. Travel times calibrated at lower flow rates have an effect on the storage, and in-turn travel times for higher flow rates in the piecewise relationship with flow in the model, thus the values calibrated earlier were re-visited and re-adjusted if required when calibration was undertaken for increasing flow rates. Details of the model updates and adjustments performed from the base model are contained in Appendix C.

Visual comparison of modelled inflow, impounded area and volume using hydrological models (i.e. Source) compared to those derived from hydrodynamic models (i.e. MIKE) demonstrates that the results align well, as seen in Figure 2.3 for Pike floodplain and Figure 2.4 for Katarapko Floodplain under normal operation conditions. This approach of comparing the hydrodynamic and hydrological models allows for a wide range of conditions to be evaluated, many of which have not happened in reality yet, and hence there is no observed data to compare to. Comparisons to observed data for the 2020 operational events are presented in Section 3.

In both floodplains, inflow remained relatively constant up to about 30 000 ML/d QSA (approximately 500 ML/d for Katarapko Floodplain and at 1200 ML/d for Pike Floodplain) before beginning to rise at a more rapid rate with increasing QSA. In all of these conditions, all inlet structures were assumed to be operated in a fully open condition to provide an indication of the maximum total inflow possible at each site for a given set of river conditions.

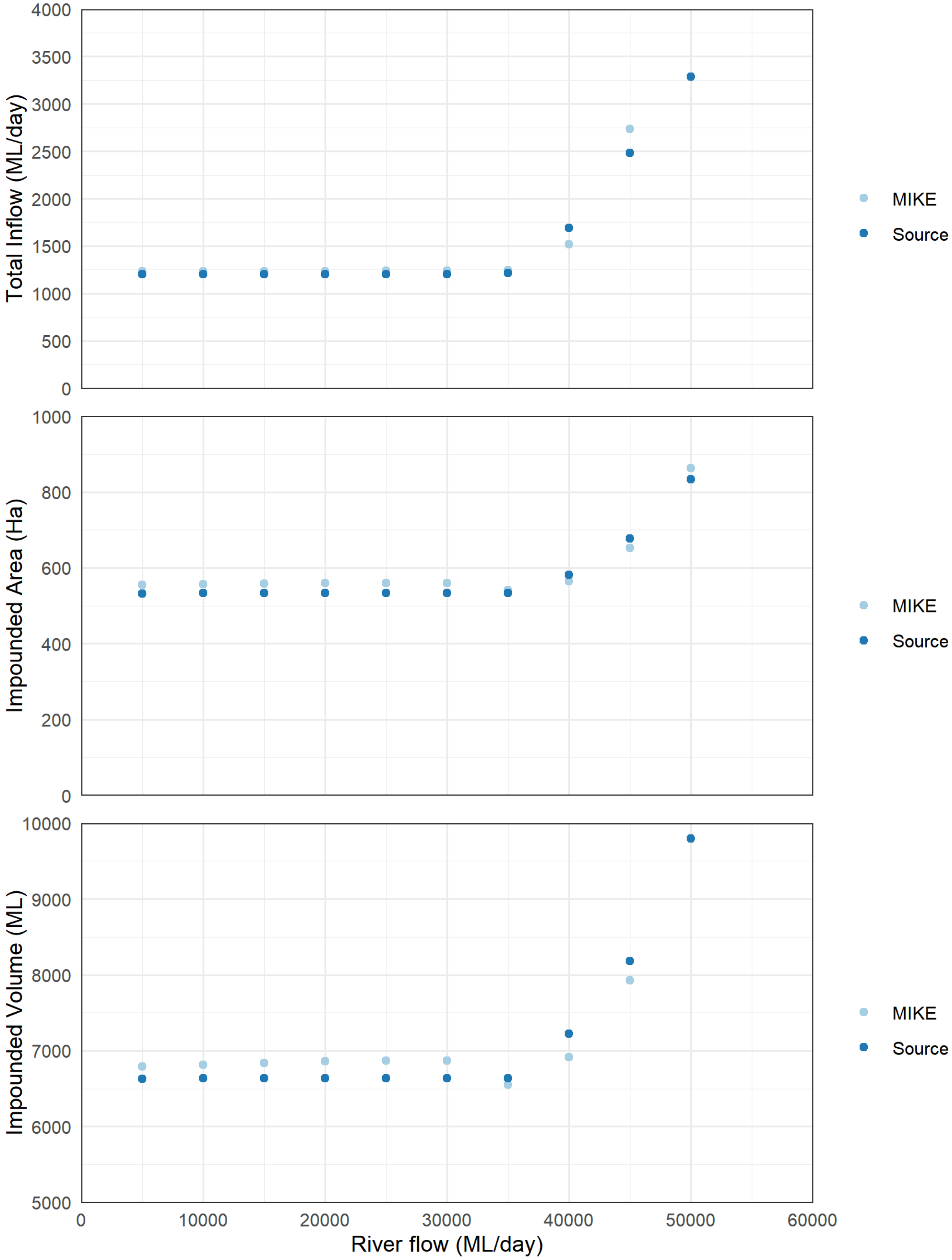


Figure 2.3 **Comparison of modelled outputs under normal conditions at Pike Floodplain**

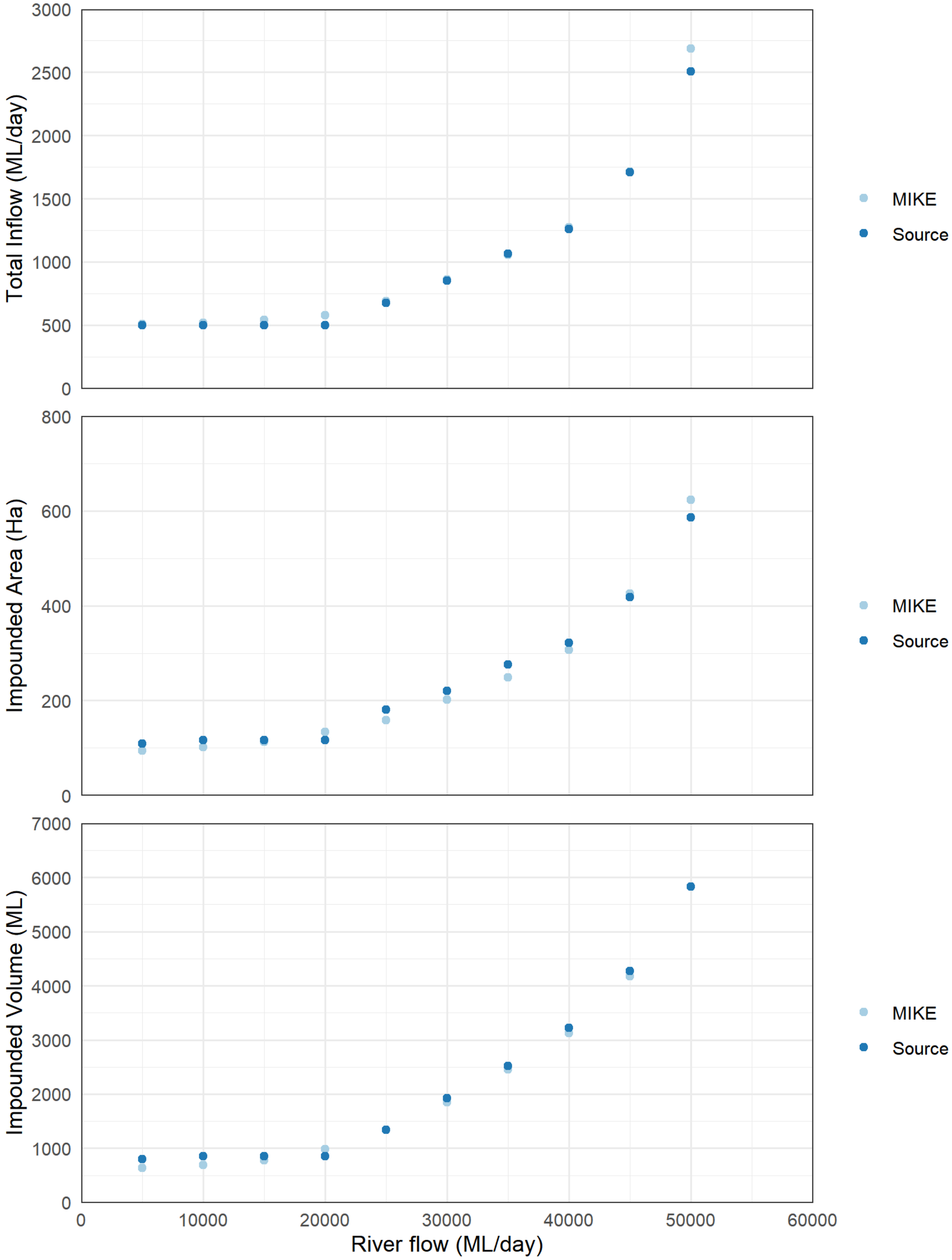


Figure 2.4 **Comparison of modelled outputs under normal conditions at Katarapko Floodplain**

Total modelled inflows for Pike Floodplain are shown in Figure 2.5. Differentiation between Lock 5 WPLs are made in each case. Similar to MIKE modelled outputs, total inflows at each Lock 5 WPL were maximised at the normal Pike regulator operating height of 14.55 m AHD. At a normal operating pool level of 16.3 m AHD the maximum total inflow (assuming fully open inlets) was modelled at just under 1250 ML/d, while at top of piers operation (16.8 m AHD) at just over 1900 ML/d. The inflows gradually decreased with increasing Pike regulator height, due to the increasing impacts of rising tail water level creating backwater influences at each inlet creek.

Comparison of total modelled inundated area and volume upstream of the blocking alignment for Pike are shown in Figure 2.6 and Figure 2.7 respectively. The impact of Lock 5 level on inundated areas as volume is also differentiated in each plot.

Similar to MIKE modelled outputs, the largest differences in inundation between lock levels is at Pike Regulator levels below approximately 15.5 m AHD, whereas the differences above this level appear to be minimal.

The Source model underestimates the total areas and volumes at Pike Regulator levels below 14.8 m AHD when Lock 5 level is raised which might represent the initial days of a managed inundation event, but as soon as the levels at Pike regulator rises above 14.8 m AHD there is good agreement between MIKE and Source modelled outputs.

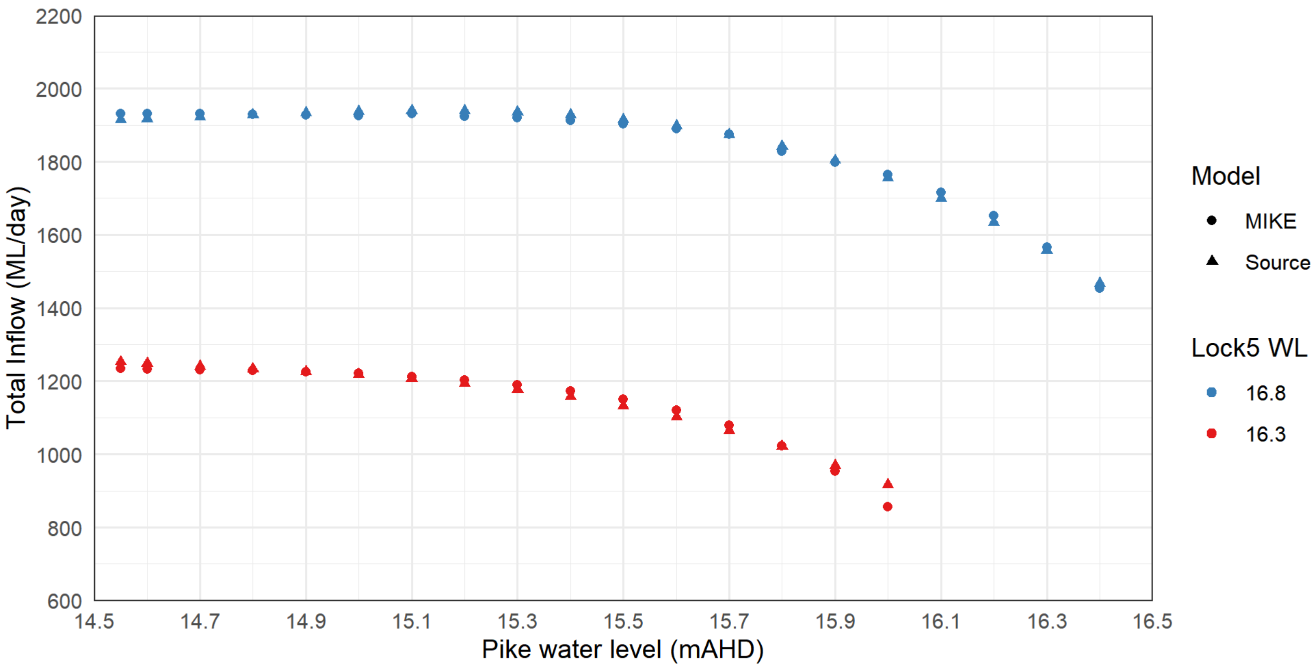


Figure 2.5 **Comparison of total modelled inflows under managed inundation conditions at Pike Floodplain**

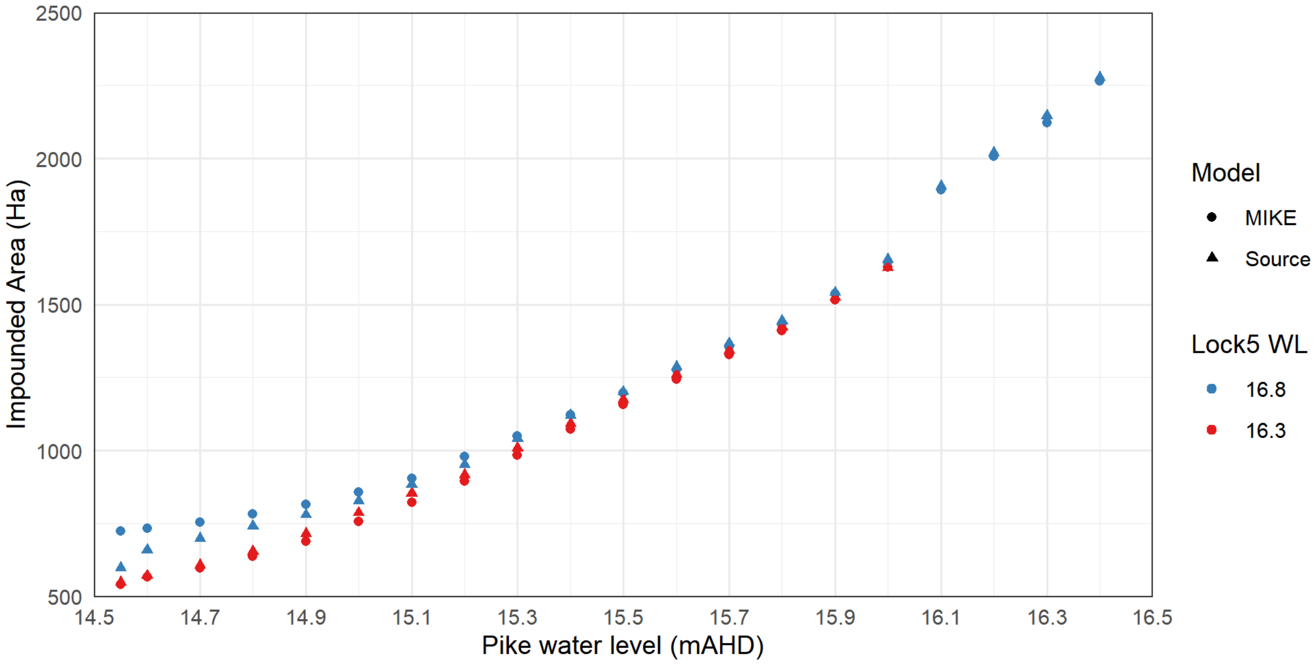


Figure 2.6 **Comparison of total modelled areas under managed inundation conditions at Pike Floodplain**

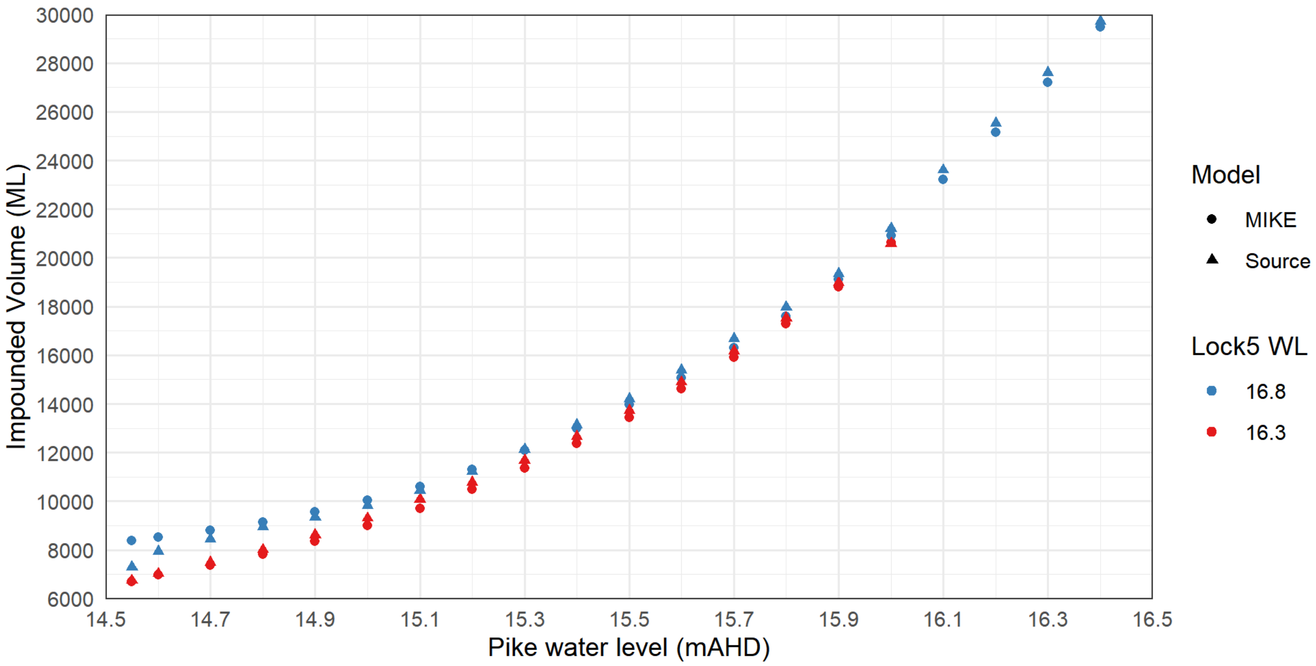


Figure 2.7 **Comparison of total modelled volumes under managed inundation conditions at Pike Floodplain**

Total modelled inflows for Katarapko Floodplain are shown in Figure 2.8. Differentiation between Lock 4 WPLs are made in each case. Similar to MIKE modelled outputs, total inflows at each Lock 4 WPL were maximised at the normal Splash regulator operating height of 10.0 m AHD. At a normal operating pool level of 13.2 m AHD the maximum total inflow (assuming fully open inlets) was modelled at just over 500 ML/d, while at top of piers operation (13.8 m AHD) at just over 1400 ML/d. Similar to Pike Floodplain, the inflows gradually decreased with increasing regulator height, due to the increasing impacts of rising tail water level creating backwater influences at each inlet creek.

Comparisons of total modelled inundated area and volume upstream of the blocking alignment for Katarapko Floodplain are shown in Figure 2.9 and Figure 2.10, respectively. The impact of Lock 4 level on inundated areas and volumes is also differentiated in each plot.

Similar to MIKE modelled outputs, the largest differences in inundation between models is at lower regulator levels whereas the differences appear to be minimal when increasing the managed inundation level.

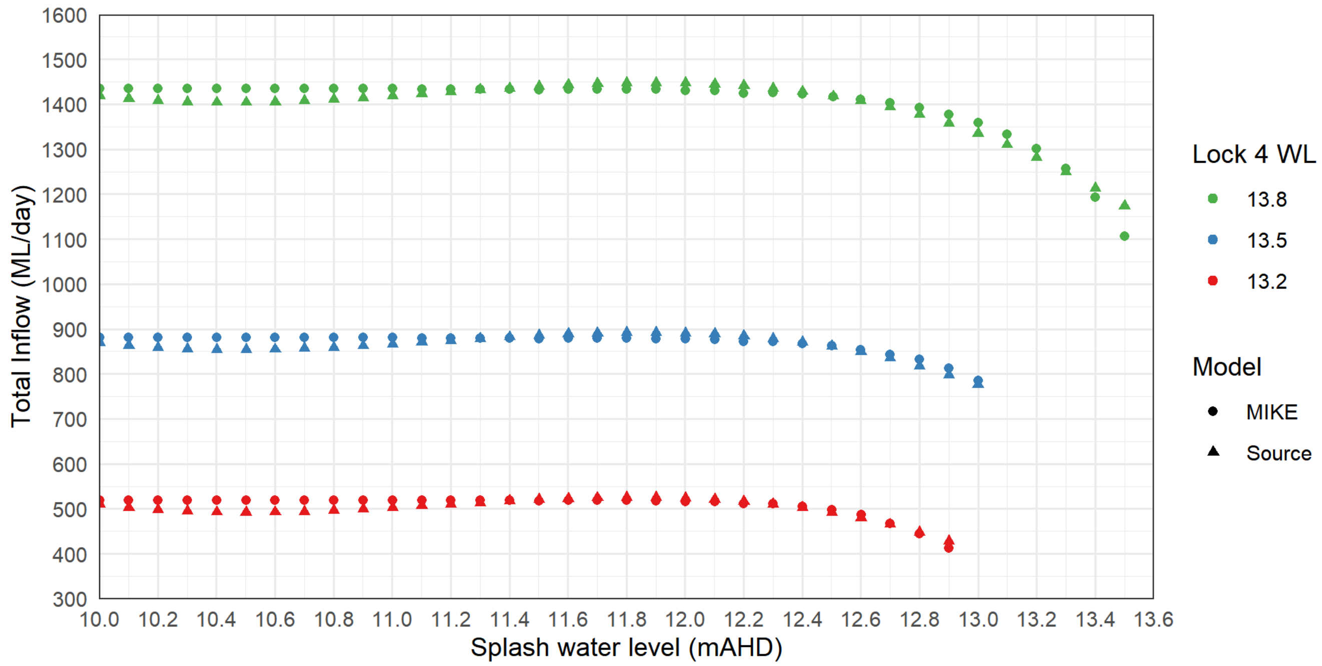


Figure 2.8 **Comparison of total modelled inflows under managed inundation conditions at Katarapko Floodplain**

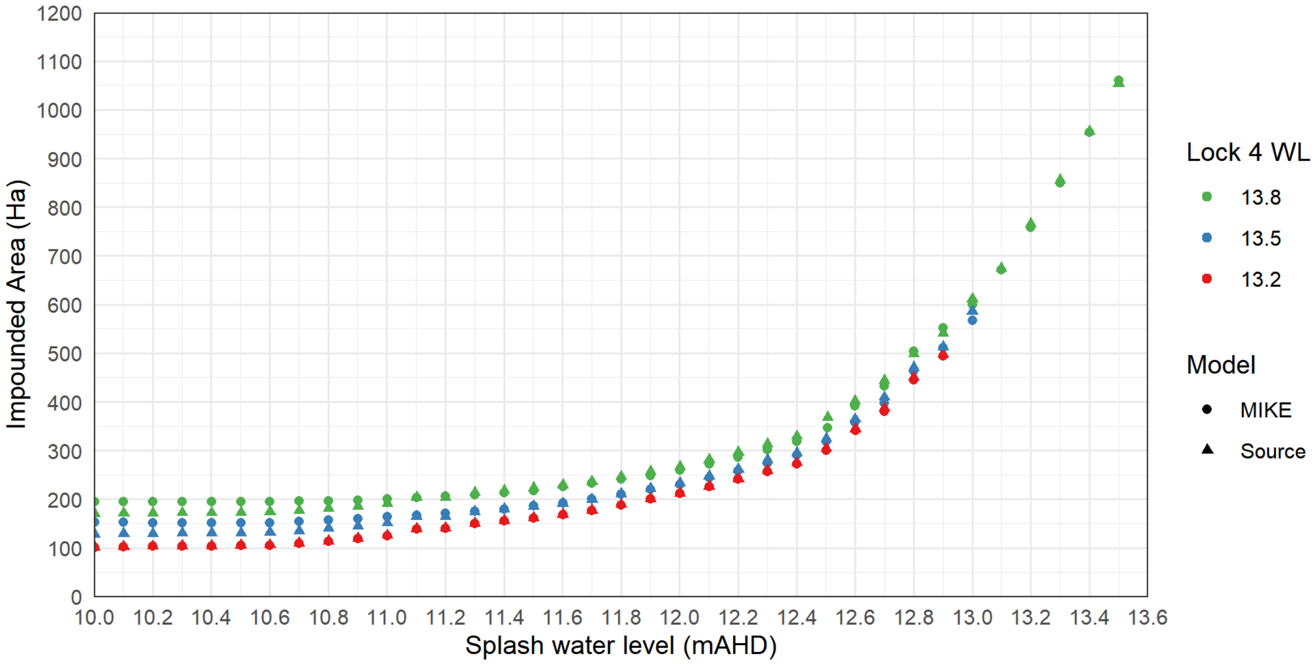


Figure 2.9 **Comparison of total modelled areas under managed inundation conditions at Katarapko Floodplain**

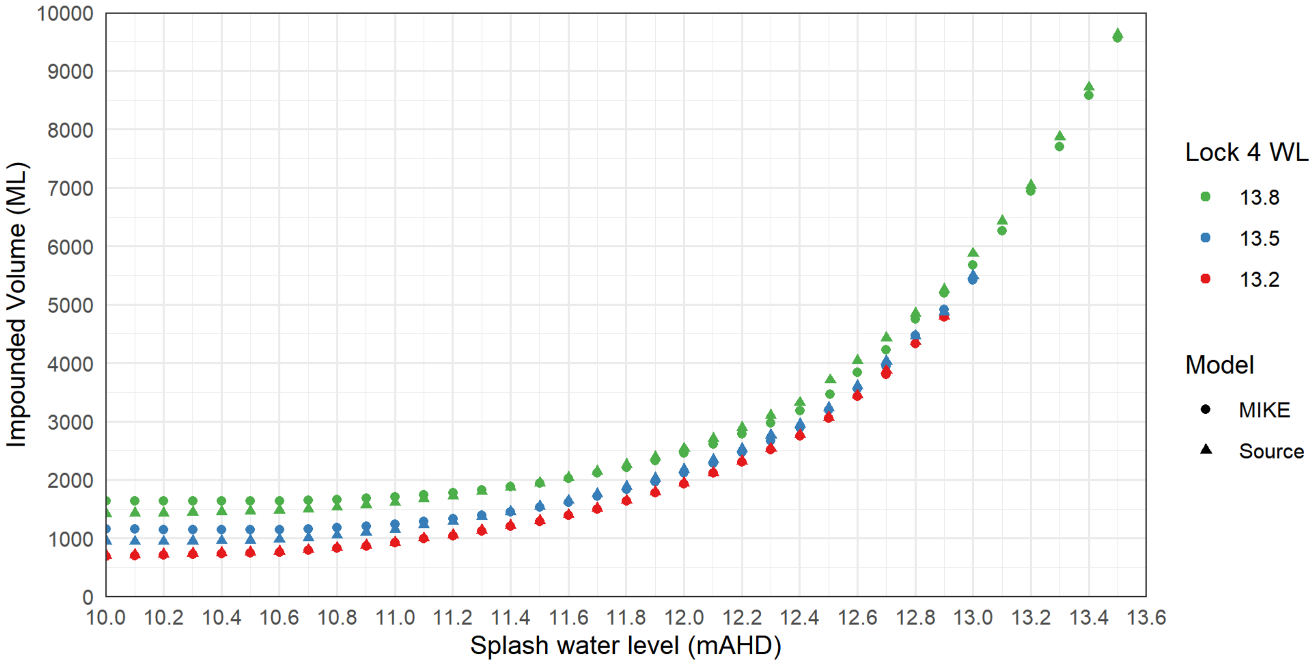


Figure 2.10 **Comparison of total modelled volumes under managed inundation conditions at Katarapko Floodplain**

2.2 Salt load responses to operations

During operation of the floodplain regulators, the water level in channels increases resulting in the reduction of the gradient between the groundwater and permanent channels (main river or anabranches), which will reduce the background salt load to the river for a short period. However, during regulator lowering phase, the combined effect of raised groundwater level due to inundation and bank recharge, and the falling river level, will result in as increased salt load to the river. Salt loads peak at the end of the lowering phase when river levels return to normal conditions, and then can take a number of months before returning to pre-operation levels. This section outlines how groundwater models have been used to derive the inputs necessary to represent these processes in the Source model.

2.2.1 Pike Floodplain

The salt mobilisation processes that are activated by the operation of the regulator at the Pike Floodplain were investigated by AWE (2016). Two salt mobilisation processes are expected to be activated during floodplain inundation that will mobilise salt from all of the salt stores on the floodplain:

- Salt mobilisation from soils and backwaters via surface water (salt wash-off), which occurs on the filling phase of the inundation event, and
- Salt mobilisation via groundwater, which commences during the inundation phase and peaks following the end of the holding phase as river levels start to lower, persisting after surface water levels have returned to normal conditions.

2.2.1.1 Salt mobilisation via surface water

Impacts due to salt wash-off are likely to occur during the filling stage of an inundation event rather than persisting during the entire watering event, assuming that passing flows are utilised throughout the filling phase (AWE, 2016). The salt wash-off as a result of the managed inundation events at Pike Floodplain is estimated using the following assumptions:

- For the upper section of the Pike Floodplain a wash-off mass of 1 tonne/ha is estimated while for the Mid to Lower Pike Floodplain a wash-off mass of 10 tonnes/ha is used;
- The calculation assumes that one third of the inundation area occurs in the upper section of the Pike Floodplain (wash-off mass of 1 tonnes/ha applied) and two thirds of the inundation area occurs on the Mid to Lower Pike Floodplain (10 tonnes/ha wash-off applied); and
- Salt loads due to salt wash-off are delivered to the river over a 90 day filling period (August to October).

To estimate the salt wash-off impact, the assumed wash-off mass per hectare is multiplied by the inundation extent, (Figure 2.3).

The maximum salt wash-off for medium (15.6m AHD) and maximum (16.4m AHD) inundation events (shown in Figure 2.11) is estimated to be 58 tonnes/day and 135 tonnes/day, respectively. It should be noted that the salt wash off assumptions are highly uncertain and are expected to be toward the upper end of salt loads generated during the filling phase.

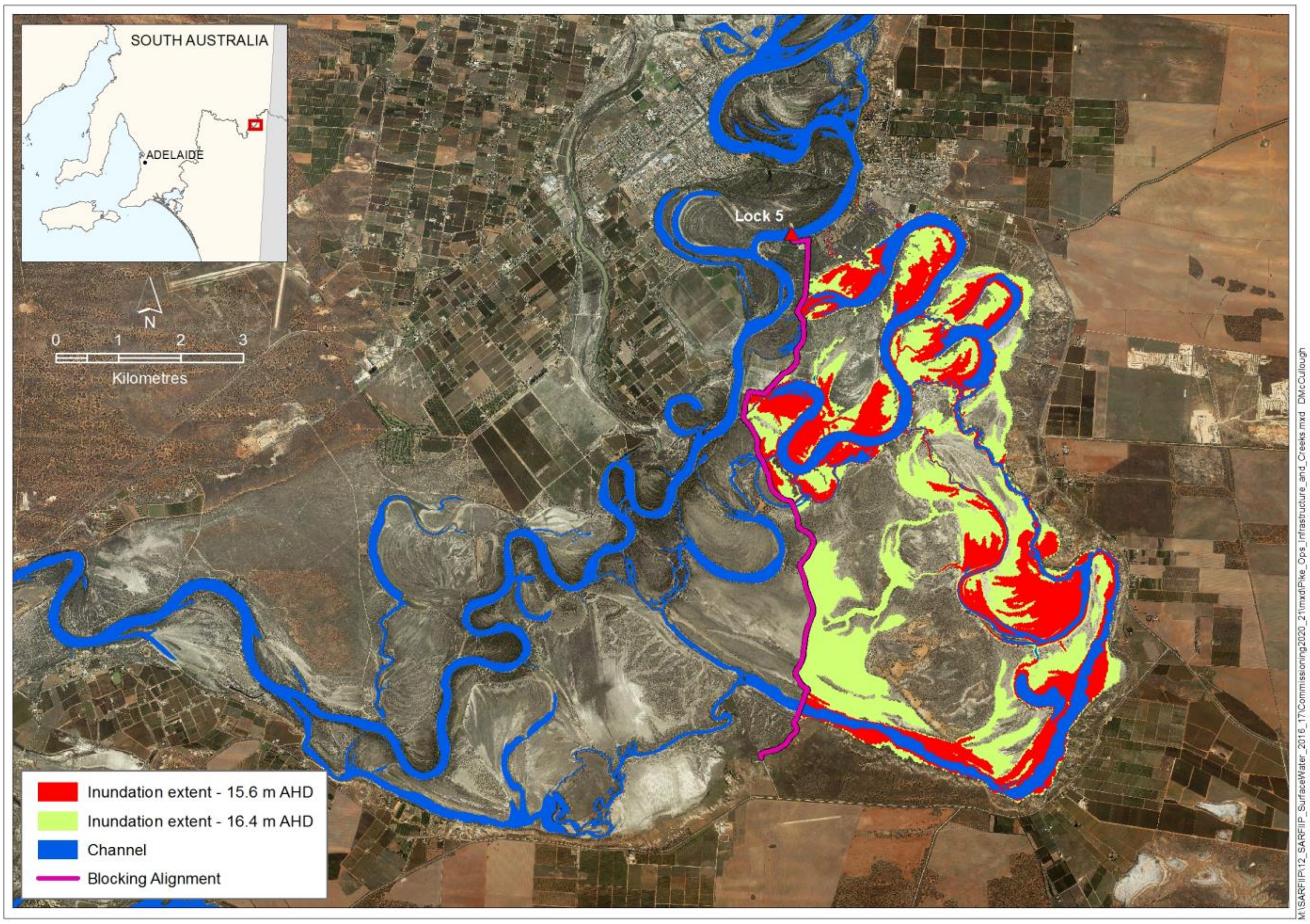


Figure 2.11 Modelled extent of inundation at Pike Floodplain for medium and maximum inundation events

2.2.1.2 Salt mobilisation via groundwater

The changes in groundwater discharge salt loads due to regulator operations was calculated using the Pike Floodplain numerical groundwater model (Purczel et al., 2020). A 42-month period was simulated for normal (i.e. no floodplain operations) and operating conditions with daily time scale under a medium operation level (i.e. 15.6m AHD) with river flow of approximately 5000 ML/day and also a maximum operating level (i.e. 16.4m AHD) with river flow of approximately 10,000 ML/day. Tranche 1 salt interception scheme groundwater management actions was assumed to be in place under both conditions. Figure 2.12 shows time series of modelled salt loads generated upstream of blocking alignments within the Pike Floodplain by groundwater dynamics under the normal and the proposed operating scenarios.

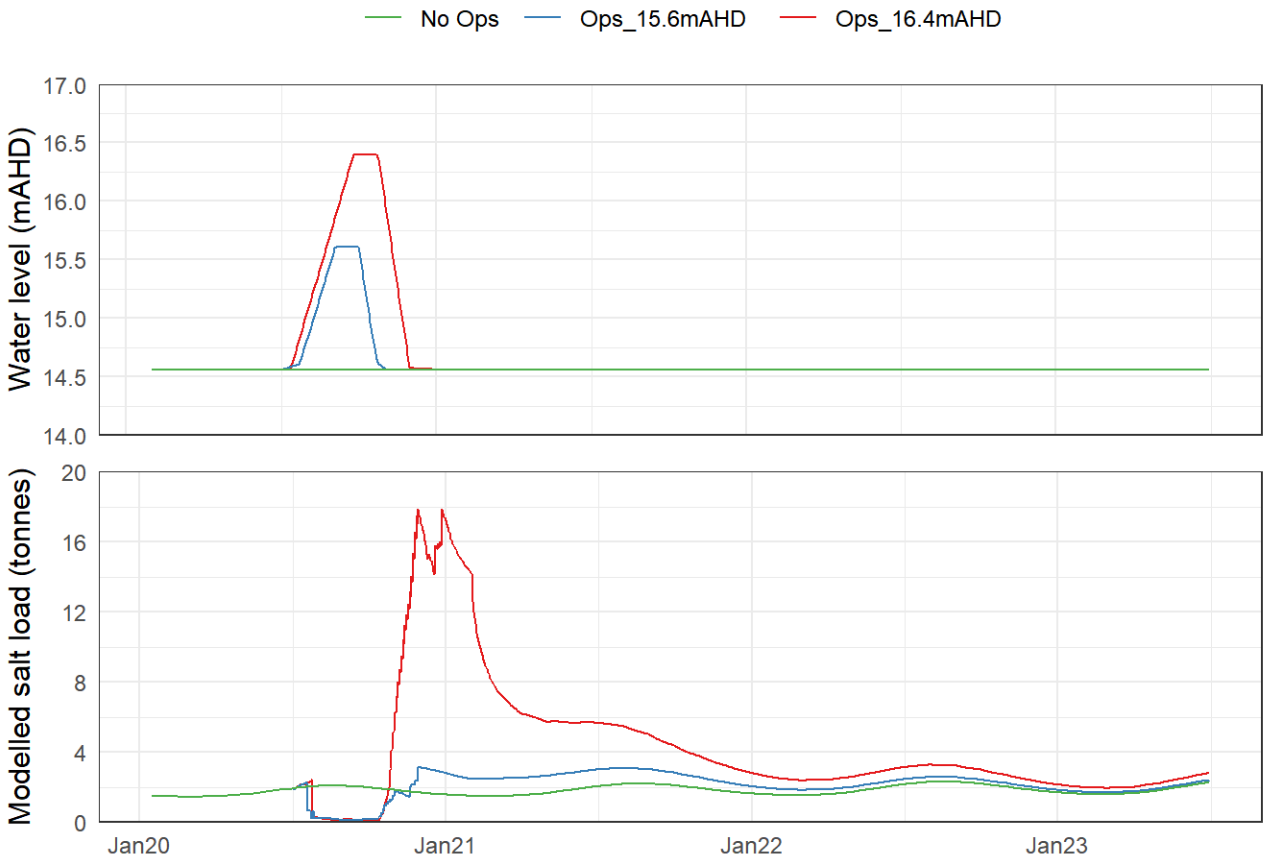


Figure 2.12 Modelled groundwater salt loads under ranges of conditions, Pike Floodplain

The salt load impacts were calculated as the salt load difference between a scenario with the infrastructure operating, and a scenario with the infrastructure in place, but not operated, with this difference representing the salt load created by the infrastructure operation.

The resulting estimated total salt loads generated by surface water (i.e. salt wash-off) and groundwater processes due to the following inundation events are shown in Figure 2.13

- Medium inundation (15.6m AHD)
- Maximum inundation (16.4m AHD)

The results show that peak salt loads due to maximum inundation event is around 15 tonnes/day and is expected to reduce to a difference of less than 1 tonne/day compared to normal conditions within 12 months. The peak salt load impact due to low inundation event is expected to be approximately 1.5 tonnes/day, which then reduces to a difference of less than 0.5 tonnes/day compared to normal conditions within 12 months.

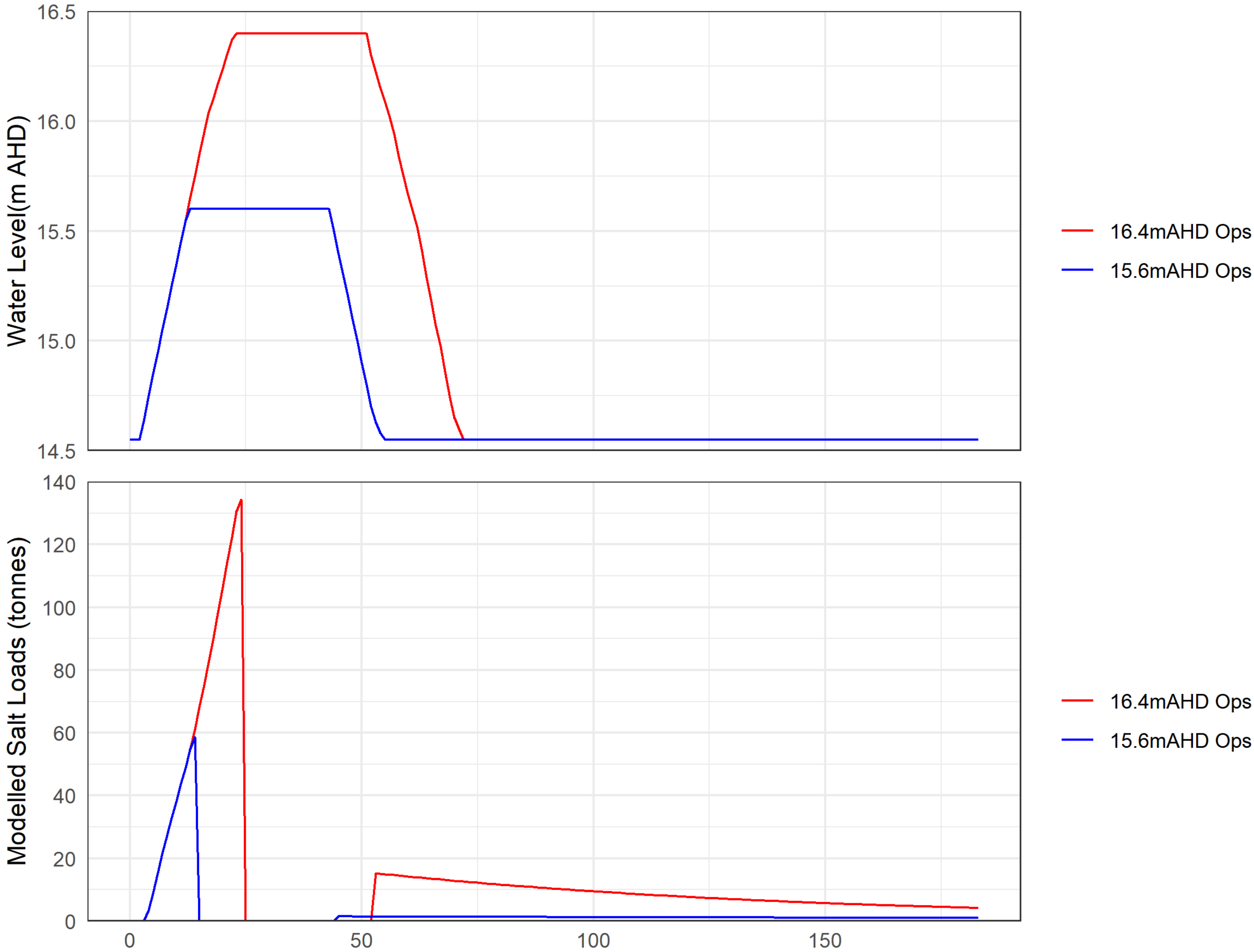


Figure 2.13 **Total salt load impact due to operations at Pike Floodplain**

A function was developed and incorporated in the hydrological model of the Pike Floodplain in order to add corresponding total salt loads due to inundation events based on these calculated salt loads. The total modelled salt load due to the operation in 2020 were then compared with the observed salt load. Comparison to observed salt load for the 2020 operational event at the Pike Floodplain is presented in Section 3.1.

2.2.2 Katarapko Floodplain

The salt mobilisation due to groundwater discharge was calculated using the Katarapko Floodplain numerical groundwater model (Purczel et al., 2020). It should be noted that the assumed recharge rate used in the groundwater model of Katarapko Floodplain was similar to the recharge rate used in the initial round of modelling for the Pike Floodplain which was subsequently lowered in the second round of modelling for Pike Floodplain resulting in lower groundwater salt loads. The recharge rate for the Katarapko modelling was unchanged.

The period 2015 to 2040 was simulated for normal (i.e. no floodplain operations) and operating conditions, with floodplain operations assumed based on flow regime with water recovery of 2750 GL (BP 2750) from 1975 to 2000. The assumed operating conditions were derived from the Katarapko Floodplain Operations Plan. The time discretisation in the groundwater model is one month, so the salt loads are averaged over a month.

Figure 2.14 shows time series of modelled salt loads generated upstream of blocking alignments within the Katarapko Floodplain by the numerical groundwater model, under the normal and the proposed operating scenarios.

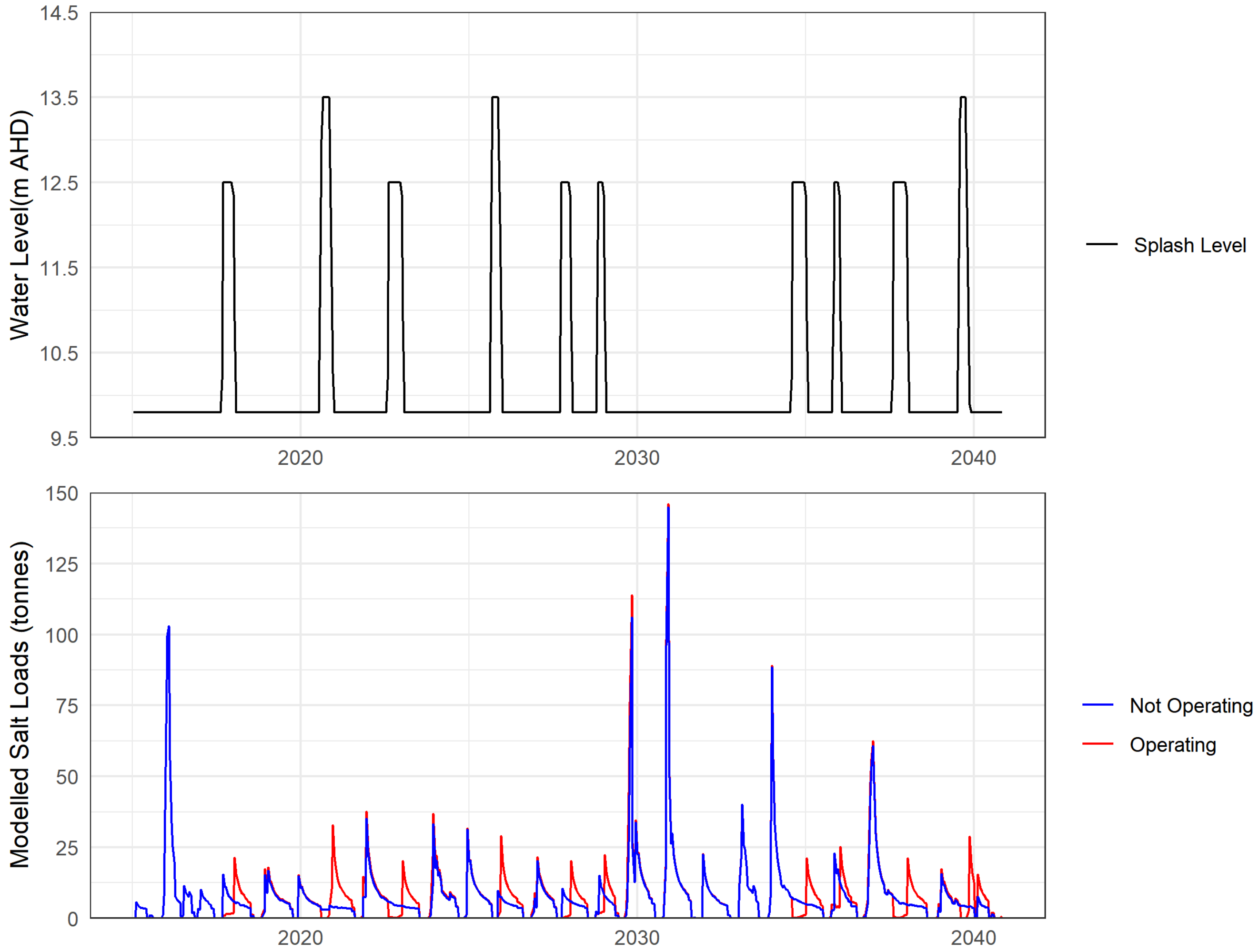


Figure 2.14 Modelled groundwater salt loads at Katarapko Floodplain under operating (blue) and not operating (red) conditions

The salt load impacts were calculated as the salt load difference between a scenario with the infrastructure operating, and a scenario with the infrastructure in place, but not operated, with this difference representing the salt load created by the infrastructure operation.

The resulting estimated salt loads generated by groundwater processes due to the inundation events are shown in Figure 2.15

The results show that peak salt loads due to inundation events ranges between 15 tonnes/day to 27 tonnes/day and are expected to reduce to normal condition within 5 to 6 months.

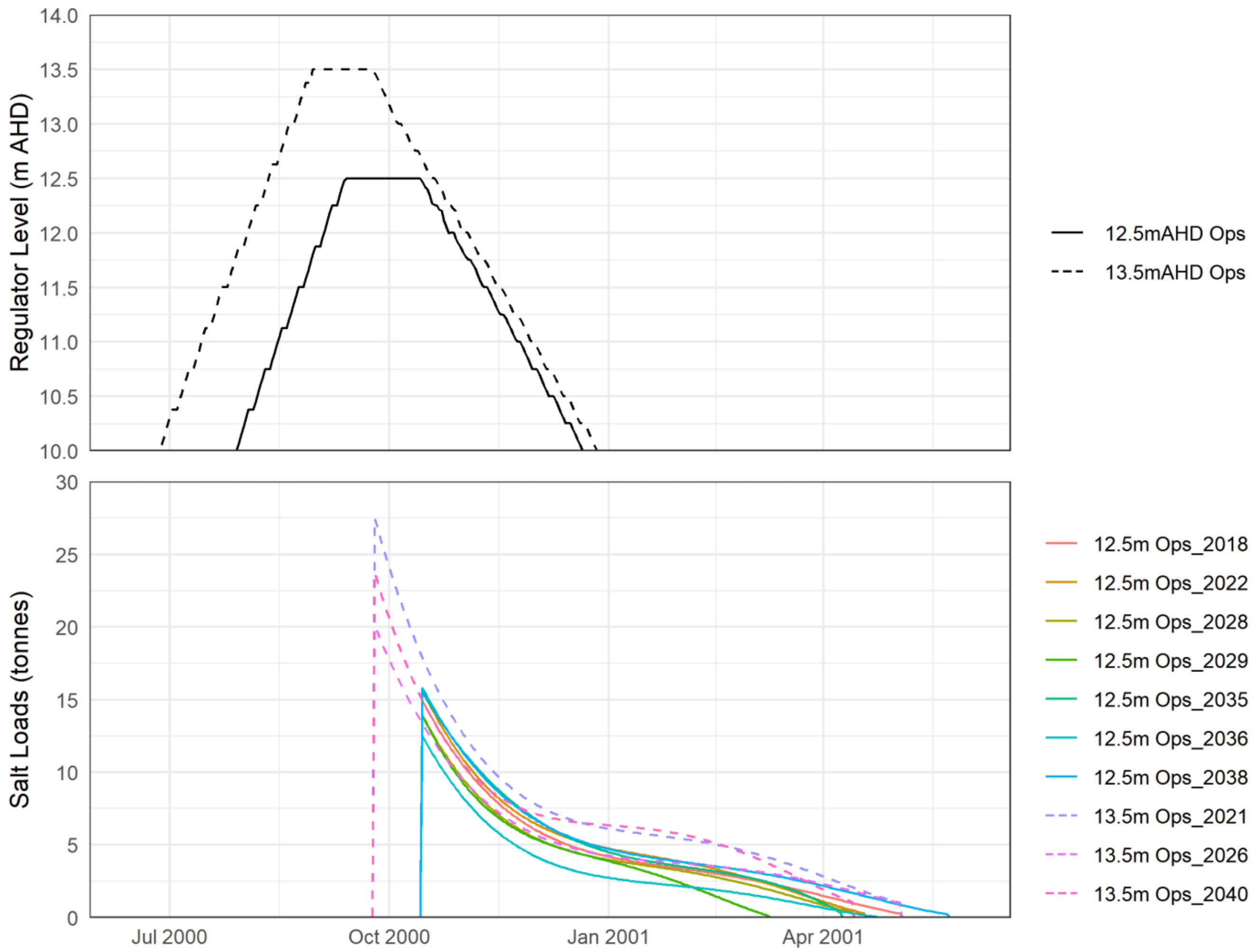


Figure 2.15 **Total salt load impact due to operations at Katarapko Floodplain**

A function was developed and incorporated in the hydrological model of the Katarapko Floodplain in order to add corresponding total salt loads due to inundation events based on these calculated salt loads.

2.3 DODOC model inputs

A DODOC plugin model was developed by Mosely et al. (2021) for the Source hydrological modelling software, to enable the dissolved oxygen (DO) changes expected from different hydrological conditions and organic litter loads to be evaluated. This section outlines the method for incorporating organic litter loads data into the plugin based on the standing load sampling undertaken on both floodplains.

2.3.1 Pike Floodplain organic litter loads

It could be expected that litter loads may decrease up the floodplain elevation gradient, as vegetation is typically denser and in better condition near the permanent watercourses. Figure 2.16 shows litter loads (kg/Ha) for each standing load sampling location (average of the replicate samples at a given location), for each year and for different vegetation classifications. The results highlight the high variability in litter loads, even for the same vegetation type and floodplain elevation. No obvious trend in litter loads with elevation was observed for a given vegetation type, with the slope of the regression equation for each vegetation type seen in Table 2.1, including the 95th percentile estimates and the significance of the slope (as a p-value, with values less than 0.05 typically considered significant). The results indicate that the slopes are not significant given the variability, with p-values ≥ 0.05 and no consistency in the direction of the slope in the 95th percentile estimates for most vegetation types (i.e. the lower estimate suggests litter decreases with elevation, the upper estimate that litter increases with elevation). Grasslands is the exception, with a consistent decreasing litter load for sites higher up the elevation gradient, and p=0.05. However, Grasslands also have the lowest litter loads of the vegetation classes and only sampled over a narrow elevation band, and as such, it was determined there was limited value in accounting for this linear trend.

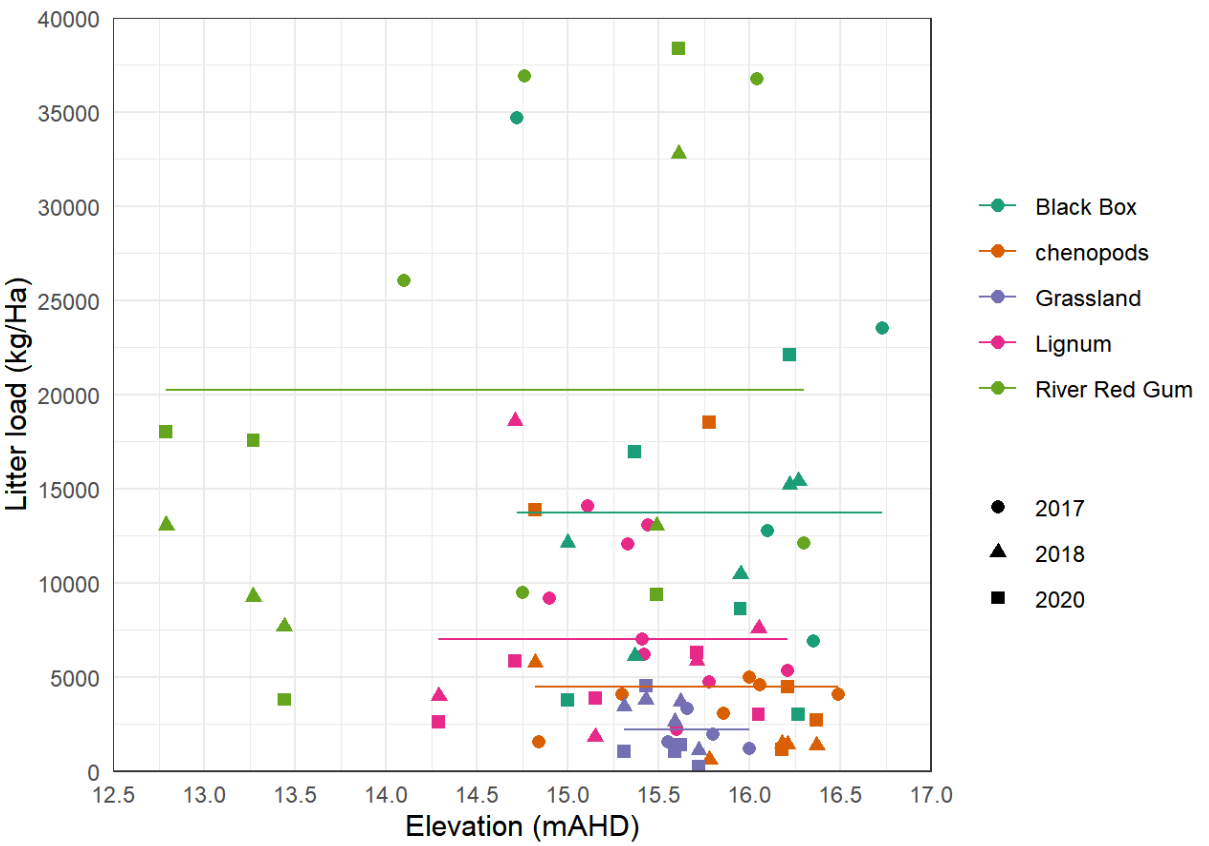


Figure 2.16 **Variation in litter load at Pike Floodplain for a given vegetation type with elevation**

Table 2.1 Slopes of litter load against elevation for different vegetation classes

Vegetation	Slope of load vs elevation(kg/ha/m)			P-value
	Lower 95%	best estimate	Upper 95%	
Black box	-14962	-3547	7867	0.49
red gum	-3014	4235	11483	0.21
Chenopod	-2795	-673	1449	0.50
Grassland	-7154	-3593	-32	0.05
Lignum	-8385	-2691	3003	0.32

The above result considers how litter load for a given vegetation type changes with elevation. However, the type of vegetation also changes up the elevation gradient, which may also create some spatial variability in litter loads. The average litter load for each vegetation type, seen as the horizontal lines in Figure 2.16, was used to calculate the weighted average litter load for different inundation elevations, based on the vegetation present.

The variable litter loads for the two key sections upstream of the blocking alignments can be seen in Figure 2.17. The litter load was split in a 30:70 ratio between readily and non-readily available litter, and no litter decay was applied, i.e. the litter loads remained static on the floodplain until inundated, considered appropriate for these short term scenarios that do not consider the accumulation of litter over time. The remaining DODOC model parameters were used as outlined in Mosely et al. (2021).

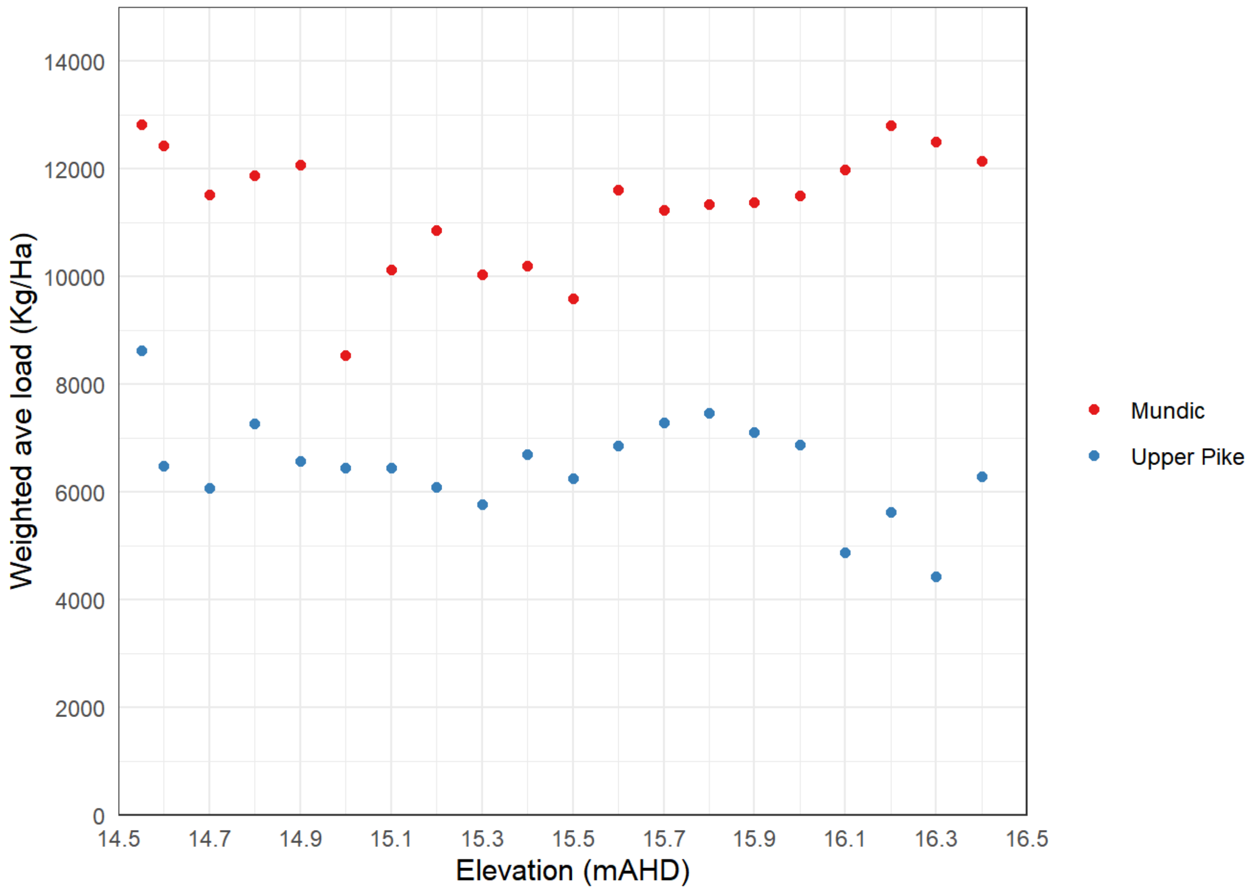


Figure 2.17 Variation in weighted averaged load with elevation

2.3.2 Katarapko Floodplain organic litter loads

Spatial variability in litter loads was not considered for the Katarapko Floodplain and instead the average litter load data derived from number of collected samples within the Katarapko Floodplain was applied in the DODOC model. However, similar to the Pike Floodplain, the litter load was split in a 30:70 ratio between readily and non-readily available litter, and no decay of litter over time was applied given the short time period of the operational simulations. Similar to the Pike Floodplain, the remaining DODOC model parameters were used as outlined in Mosely et al. (2021).

3 Model comparison to 2020 operations

Following the updates to the Source model based on updated input information from other models, this section presents a comparison to the monitoring data collected during the first operation of both the Pike and Katarapko Floodplains.

3.1 2020 event

The first operations at both Pike and Katarapko Floodplains were undertaken between August and December 2020. Data were collected using a combination of targeted field monitoring as well as continuous observational data recorded at various monitoring stations. Figure 3.1 shows the main hydraulics governing the event operations, including Flow to South Australia (QSA) and water levels at Locks 4 and 5, and floodplain levels at the Splash and Pike Environmental Regulators.

In order to simulate the first operations at both sites, the updated River Murray Source model was parameterised using the following key datasets;

- Governing hydraulics shown in Figure 3.1
- Actual climate data
- Annual diversion data, disaggregated to the monthly scale
- Observed salinity and dissolved oxygen data at a node representing Renmark gauge (upstream of both sites)

The updated model was then used to simulate outputs to compare to the observed data, as well as understand other outputs of interest such as water use and exchange rate. Time series of modelled outputs for the 2020 inundation events including water level, inundated area (i.e. total wetted area, including permanent channels), impounded volume, daily exchange rate, salinity and dissolved oxygen concentrations are shown in Figure 3.2 - Figure 3.9 for Pike and Katarapko Floodplains,

3.1.1 Pike Floodplain

3.1.1.1 Floodplain summary

For Pike Floodplain operations, as shown in Figure 3.2, the daily exchange was maintained at around 15% for much of the period. Total maximum inundated area and volume at the peak of the event (including permanently inundated areas), with a water level upstream of Pike environmental regulator of 15.28 m AHD, was modelled at approximately 1000 ha and 11 630 ML respectively, and aligned well with the MIKE modelled outputs.

For the Lower Pike River, daily modelled flow, salinity and DO were compared with the observed data in Figure 3.3, which shows good agreement between modelled and observed flows. However similar to upstream of blocking alignments, modelled salinity concentration was underestimated. Modelled DO also fitted well with the observed data before November, but from November onward, the observed DO started to recover and rapidly increased up to 12 mg/L at the end of December which could not be replicated in the hydrological model. It is likely the DO concentrations above the saturated concentration of 9 mg/L for a water temperature of 20 °C indicates primary productivity producing increased DO levels not represented by the DODOC model.

3.1.1.2 Salinity and salt load

Salinity concentration at Pike Floodplain is modelled to increase by 70 EC and reach up to ~240 EC, compared to an initial salinity concentration of ~170 EC. This modelled result includes the total salt load functions derived from the salinity analysis which is mainly controlled by the salt wash-off process (Section 2.2.1).

The modelled salt load increase due to this operation were also compared with the observed salt load increase as shown in Figure 3.4. Maximum salt load increase were modelled to reach to approximately 45 tonnes/day while the maximum salt load increase of approximately 95 tonnes/ day were calculated using the observed data. The modelled and observed salt load during recession of water levels following the peak match relatively well, suggesting the salt load derived from groundwater modelling relocated the observed salt load response. The main differences were on the rising limb of the operation, where the salt load derived from observed increases in salinity had greater peaks than that derived from assuming 1 t/ha of salt wash off. The salt load for this period assumed in the model is currently all due to salt wash-off, however some of this salt load may be derived from connecting backwaters. The salt load could be adjusted to match the observed salinity concentration at Pike Floodplain, however currently the information available is only from this one operation, and currently it is considered that further information is required to warrant this assessment. Future operations with higher inundation levels at Pike Floodplain will help to understand the salinity impacts better and the adjustments can be made with more confident.

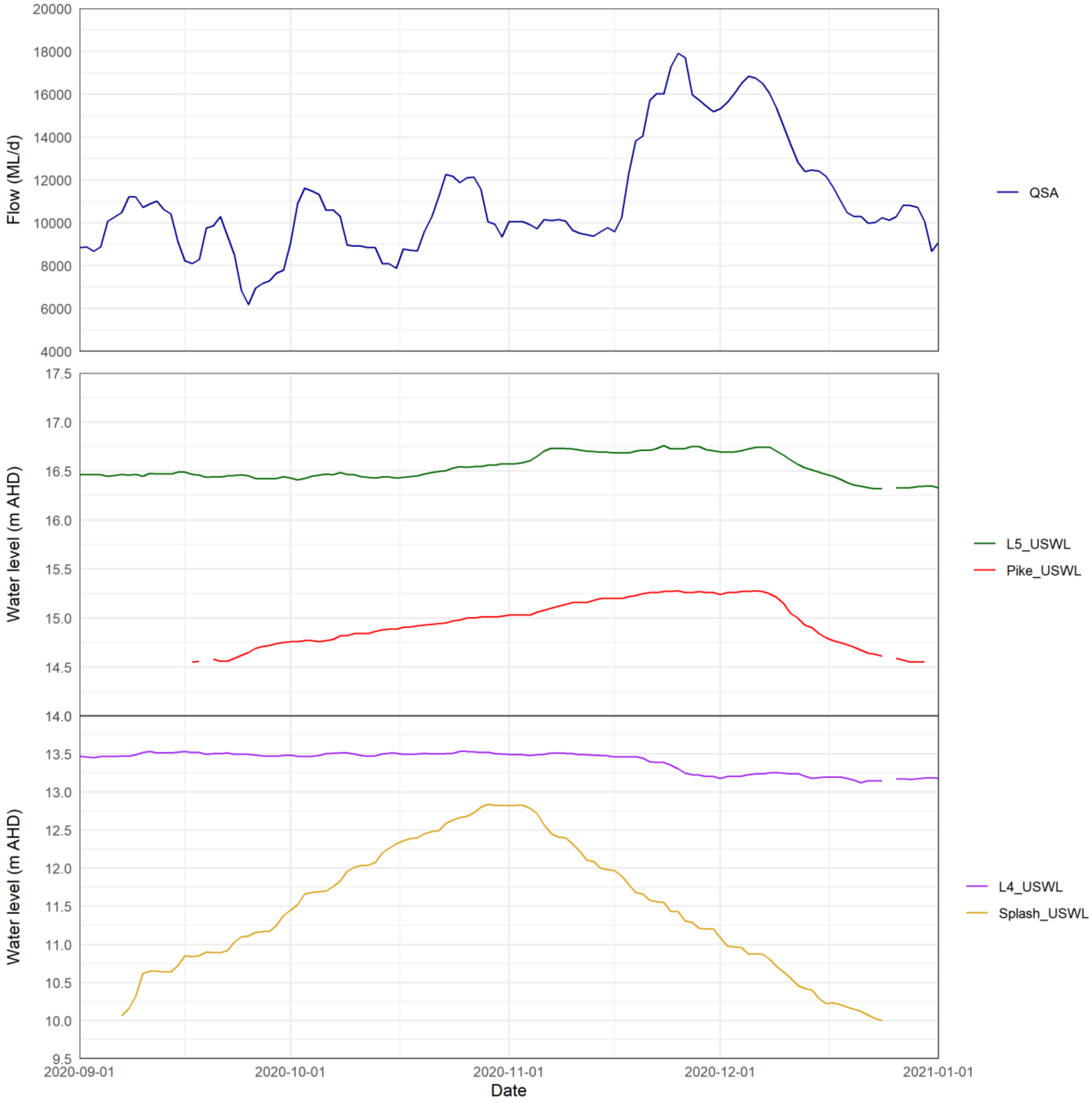


Figure 3.1 River flow and water level hydrographs used for event simulations from DEW (2021)

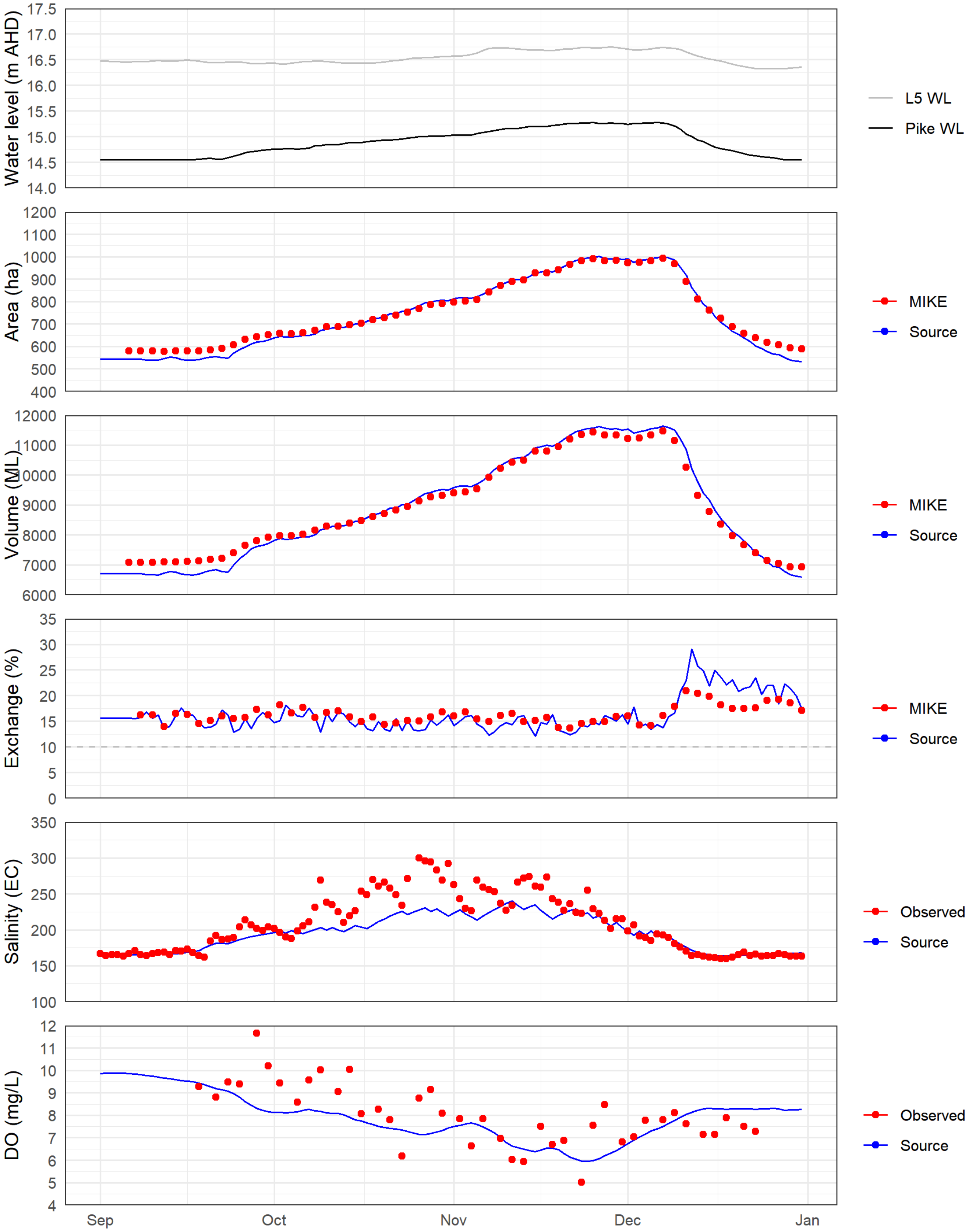


Figure 3.2 **Modelled daily outputs at Pike Floodplain for 2020 event simulation. Daily observed salinity data recorded at gauging station A4261053 (Pike river upstream of ColCol bank) and manual DO readings from upstream of Pike environmental regulator were used for comparison against daily modelled DO data.**

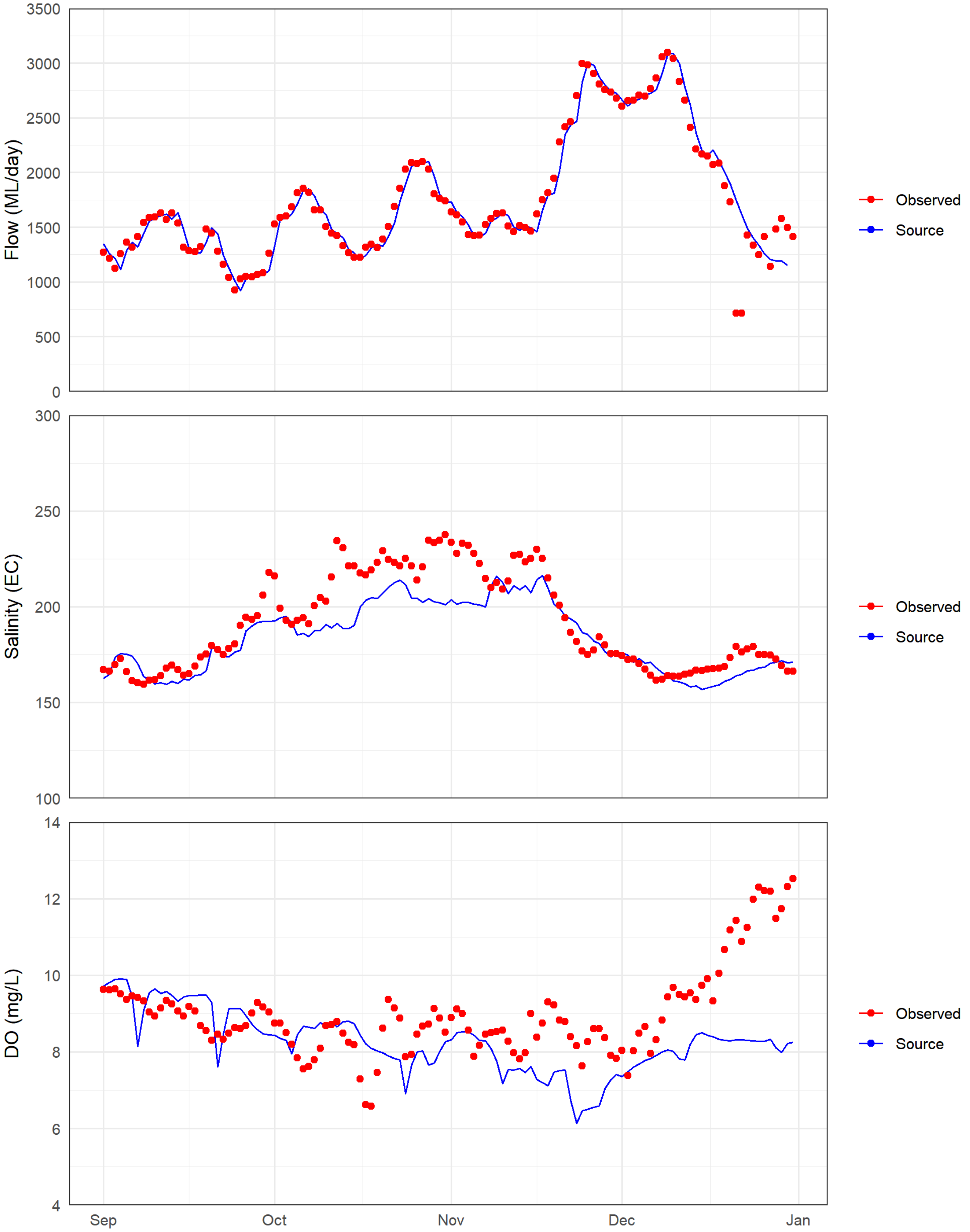


Figure 3.3 **Modelled daily outputs at Lower Pike River for 2020 event simulation. Daily flow data recorded at gauging station A4260644 (Pike river at Lettons downstream of Rumpagunyah Creek. Daily salinity**

and DO data recorded at gauging station A4260645 (Pike river at Picnic Grounds upstream of River Murray)

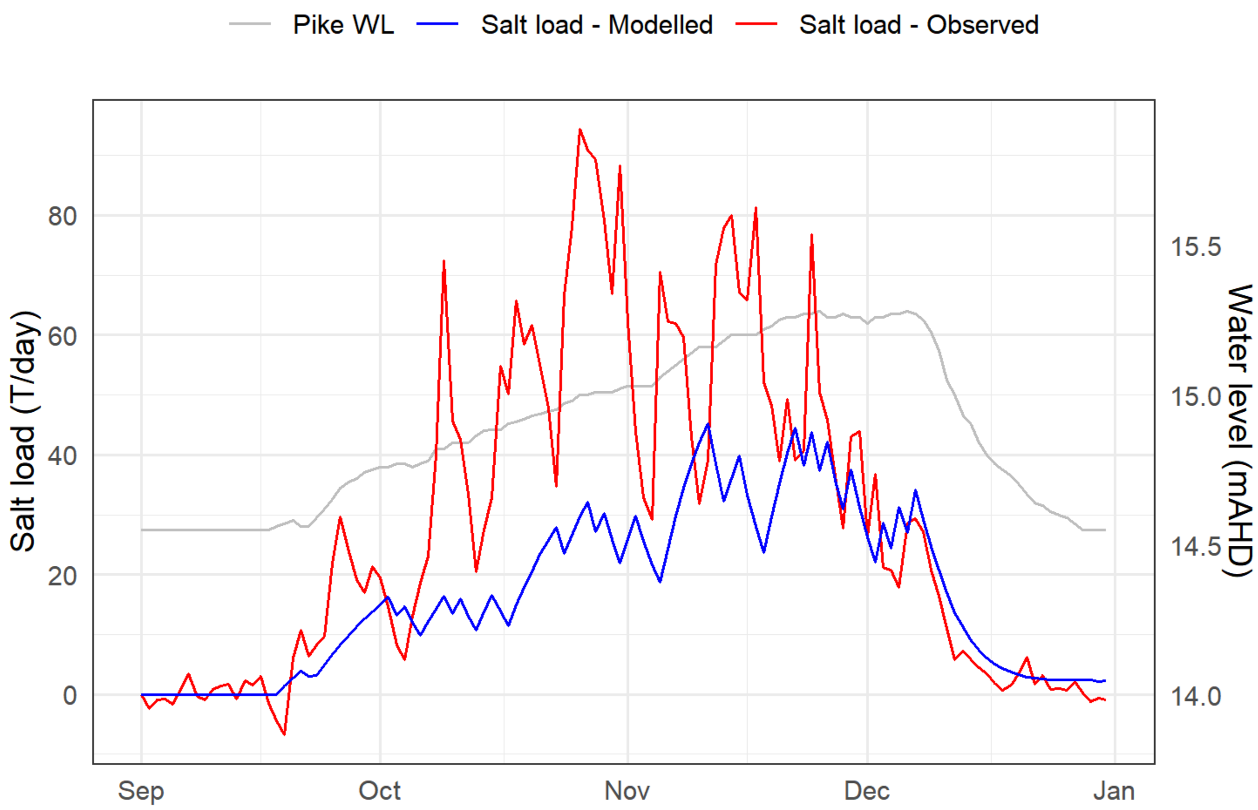


Figure 3.4 **Modelled salt load Vs. observed salt load due to operation at Pike Floodplain**

3.1.1.3 DO and DOC

Dissolved Oxygen (DO) concentration at Pike Floodplain was modelled to reduce to minimum of ~6 mg/L and as can be seen in Figure 3.2 the modelled DO aligns well with the observed values during 2020 operation.

A broad scale water quality monitoring program was undertaken during the Pike regulator operation, sampling water for analysis from 10 locations over the event (Figure 3.5**Error! Reference source not found.**). The data are presented in Figure 3.6, separated into sections of river where particular responses might be expected, above and below each of the Tanyaca and Pike regulators.

Above the regulators, particularly during the filling phase as new floodplain is being inundated, increased in DOC might be expected. This was not observed in Mundic Creek, with Site 1 and 3 variable around the upstream Site 10, where on some dates the upstream site has a higher DOC, as much as any increases downstream. Above Pike regulator DOC concentrations did tend to be higher than in the River Murray at Site 10, but again the variability in measurements makes attributing specific responses difficult (data recorded from one location at Site 2 around early December was extremely higher than Site 5, represented by the asterisks) .

Below the regulators, the DOC concentrations might be expected to decrease at the further downstream sites, with DOC consumed by microbes but with no additional source of carbon from inundation. Again, this process was difficult to distinguish for the sites in Tanyaca Creek. The longer reach in Pike River did record some lower concentrations for sites further downstream from the regulator, but again the variability in measurements made it difficult to interpret a change in underlying DOC from the variability of measurement.

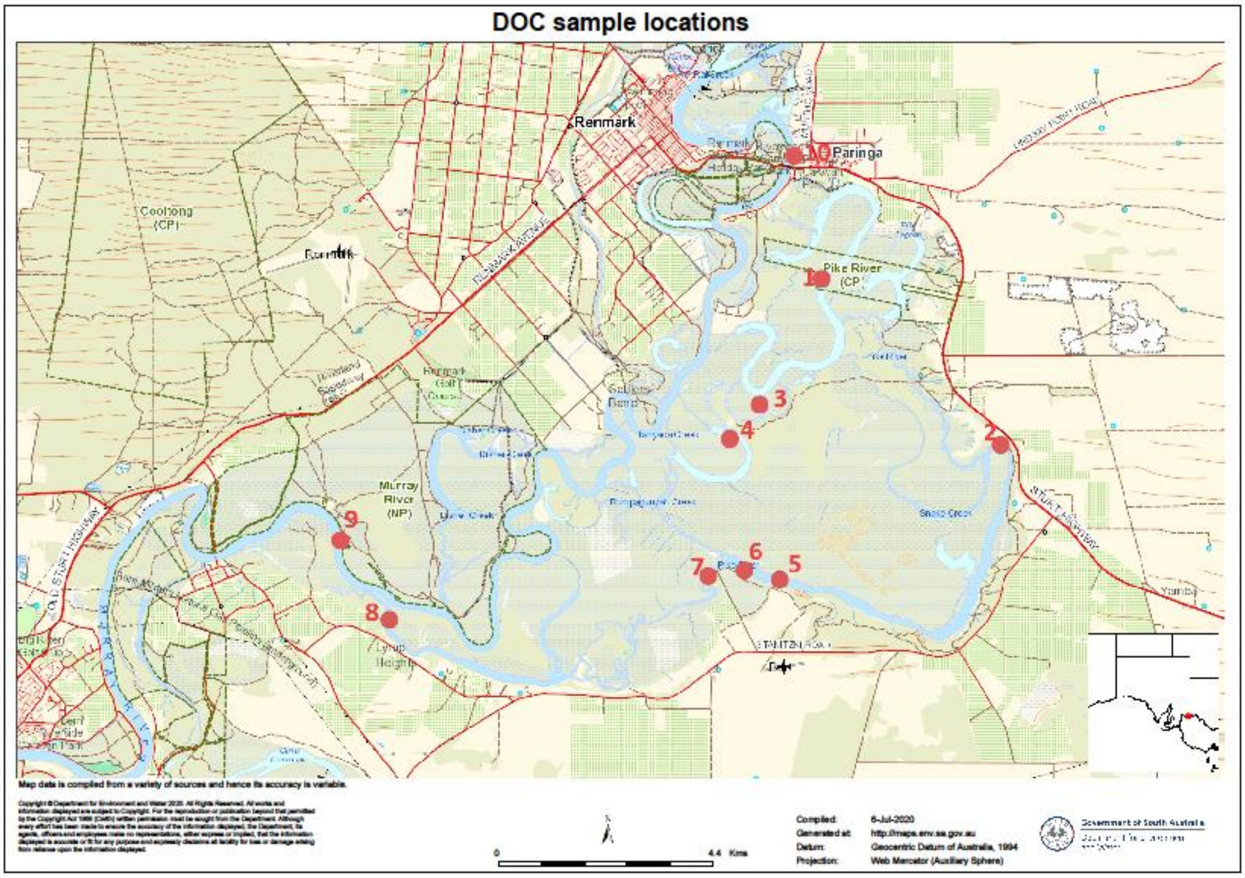


Figure 3.5 **Location of water quality samples**

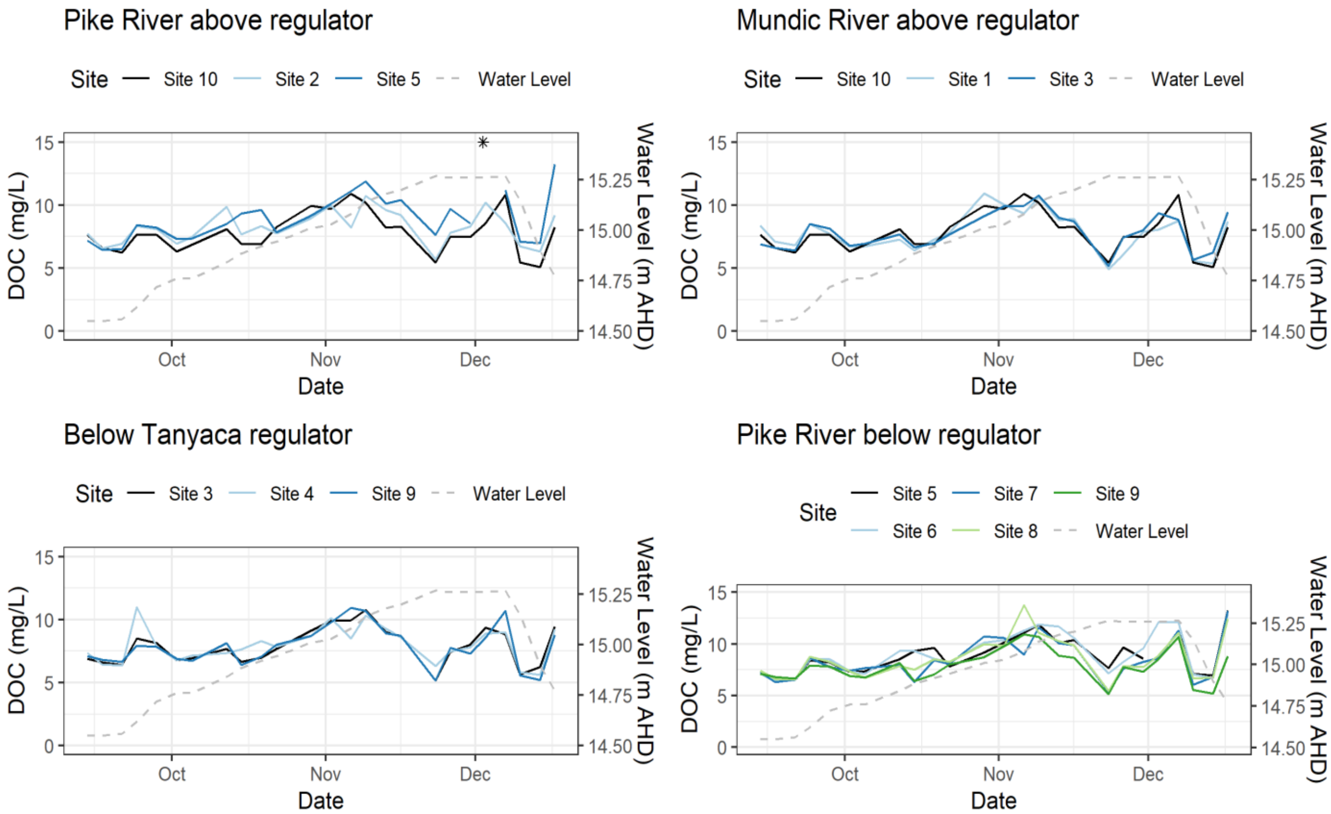


Figure 3.6 **Observed DOC data at monitoring sites, presented in groups for sections of river**

The DOC data collected has been compared to where the model outputs are available above the two regulators (Figure 3.7). The DOC added by the model due to floodplain inundation within the Pike Floodplain can be seen on the DOC Labile panel of Figure 3.7, in the order of 0.5 mg/L over the filling period. This is a much lower concentration than the labile DOC analysed from the water quality samples, however it is expected that the two components, i.e. what is termed 'labile' in the model (i.e. what has been generated from the floodplain) and what is analysed in the laboratory are not directly comparable. This is also informed by the labile DOC analysed in the River Murray before entering Pike Floodplain, at approximately half of the total DOC. Potentially some of this labile DOC was recently generated by the weir pool raising in Lock 5, and then comparable to the model, however water quality monitoring undertaken by SA Water does not suggested an increase in DOC in weir pool 5 in line with the labile DOC analysed. Nonetheless, the total DOC concentrations simulated at the two regulator locations, are similar to the analysed data (middle panel), albeit largely driven by the inflowing concentration from the River Murray.

DOC concentrations after 5 days of decay were also analysed. This allows a consumption rate to be estimated as $k=-\ln(DOC_{5d}-DOC_{0d})/5$. The values can be seen in Figure 3.8, to be in the order of $k= 0.05$ day^{-1}. This consumption rate is in line with measurements from other floodplains (e.g. Whitworth and Baldwin, 2016). However, this rate represents the bulk DOC consumption rate, where the model is only processing the new generated, and assumed to be quickly consumed, DOC with a higher consumption rate of 0.2 day^{-1}. Based on a "refractory" DOC already in stream of 8 mg/L (middle panel) and a "labile" DOC generated of 0.5 mg/L (bottom panel), the modelled bulk consumption rate is in line with the laboratory analyses, as:

$$k=-\ln((8+0.5*0.2)/(8+0.5))=0.0482 \text{ day}^{-1} \qquad \text{Equation 1}$$

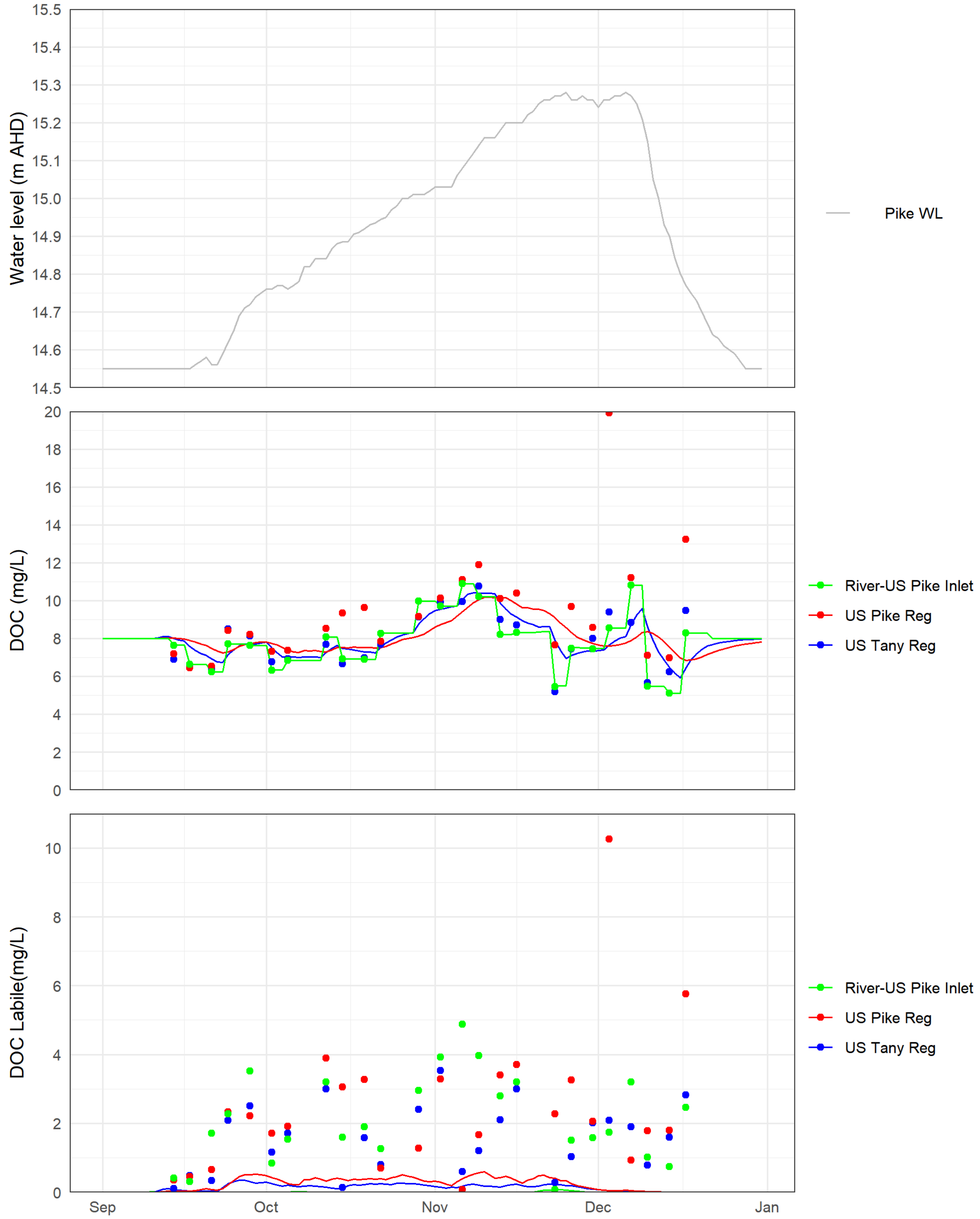


Figure 3.7 **Comparison between observed (dots) and modelled (lines) DOC and labile component of DOC at output locations from the DODOC model, upstream of the Pike and Tanyaca regulators. Inflowing DOC from the River Murray is also presented (green).**

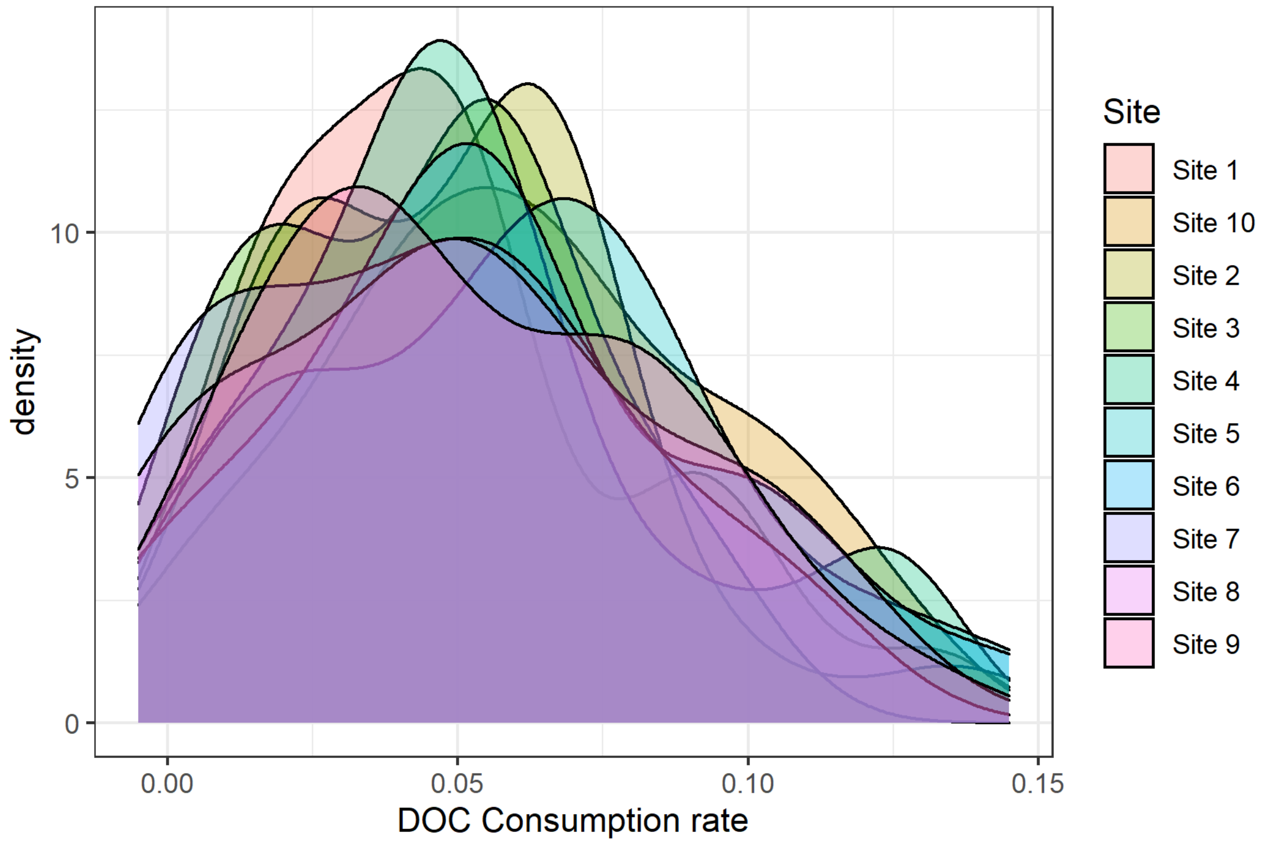


Figure 3.8 Distribution of DOC consumption rates calculated at each site

3.1.2 Katarapko Floodplain

3.1.2.1 Floodplain summary

For Katarapko Floodplain operations, as shown in Figure 3.9, the daily exchange was maintained above 20% for most of the operation, only dropping below 20% for few days at the peak of operation. Total maximum inundated area and volume at the peak of the event, with a water level upstream of the Splash environmental regulator of 12.8 m AHD (including permanently inundated areas), was modelled at approximately 480 ha and 4640 ML respectively, and aligned well with the MIKE modelled outputs.

Total modelled outflows derived from both Source and MIKE models for Katarapko Floodplain were also compared. As can be seen in Figure 3.10 there is a departure towards the start and end of operation. Comparison of modelled outflows with the observed data has been discussed in DEW (2021). It is stated that, the river levels downstream of Splash regulator were overestimated, particularly at the low end of operation, as there is an issue with overestimation of water levels downstream of Lock 4, which causes more flow to push down Kat creek than it should and consequently outflows through Splash regulator are believed to be underestimated in MIKE model due to overestimation of water levels downstream of Splash regulator. At the higher floodplain levels however, where the water level upstream of Splash regulator is sufficiently higher than downstream level, there is no issue and modelled outflows from both Source and MIKE models show good agreement.

3.1.2.2 Salinity and salt load

Salinity concentration at Katarapko Floodplain (upstream of the Splash environmental regulator) is modelled to be increased by 90 EC and reach up to ~240 EC from initial salinity concentration of ~150 EC, which is an overestimation compared to observed salinity values.

The modelled salt load increase due to this operation were also compared with the observed salt load increase as shown in Figure 3.11. Maximum salt load increase were modelled to reach to approximately 20 tonnes/day during lowering which is due to current understanding of salt mobilisation via groundwater, however the maximum salt load increase of approximately 15 tonnes/ day were calculated using the observed data during raising phase of operation which is understood to be the result of salt mobilisation from soils and backwaters via surface water (salt wash-off) and almost no groundwater salt load intrusion were observed for this low level event.

Salt mobilisation processes need to be studied in more details upon availability of more observed data from further and higher operations in order to improve current understanding of these salt processes at Katarapko Floodplain.

Also as discussed in section 2.2.2, the modelled groundwater salt load will be updated if the recharge rate is further calibrated (similar to adjusted recharge rate for Pike Floodplain).

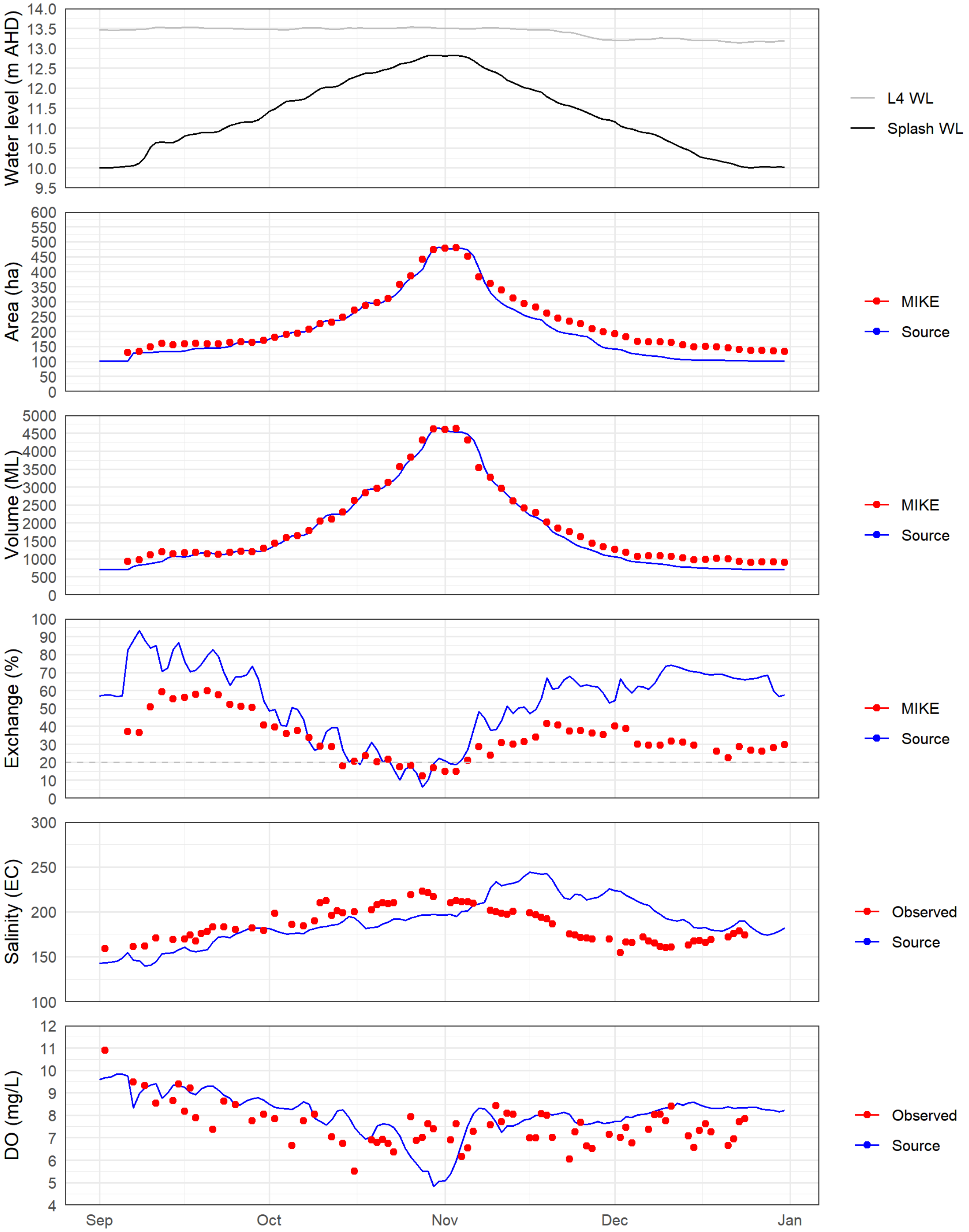


Figure 3.9 **Modelled daily outputs at Katarapko Floodplain for 2020 event simulation. Manual salinity and DO readings from upstream of Splash environmental regulator were used as observed data for comparison against daily modelled data.**

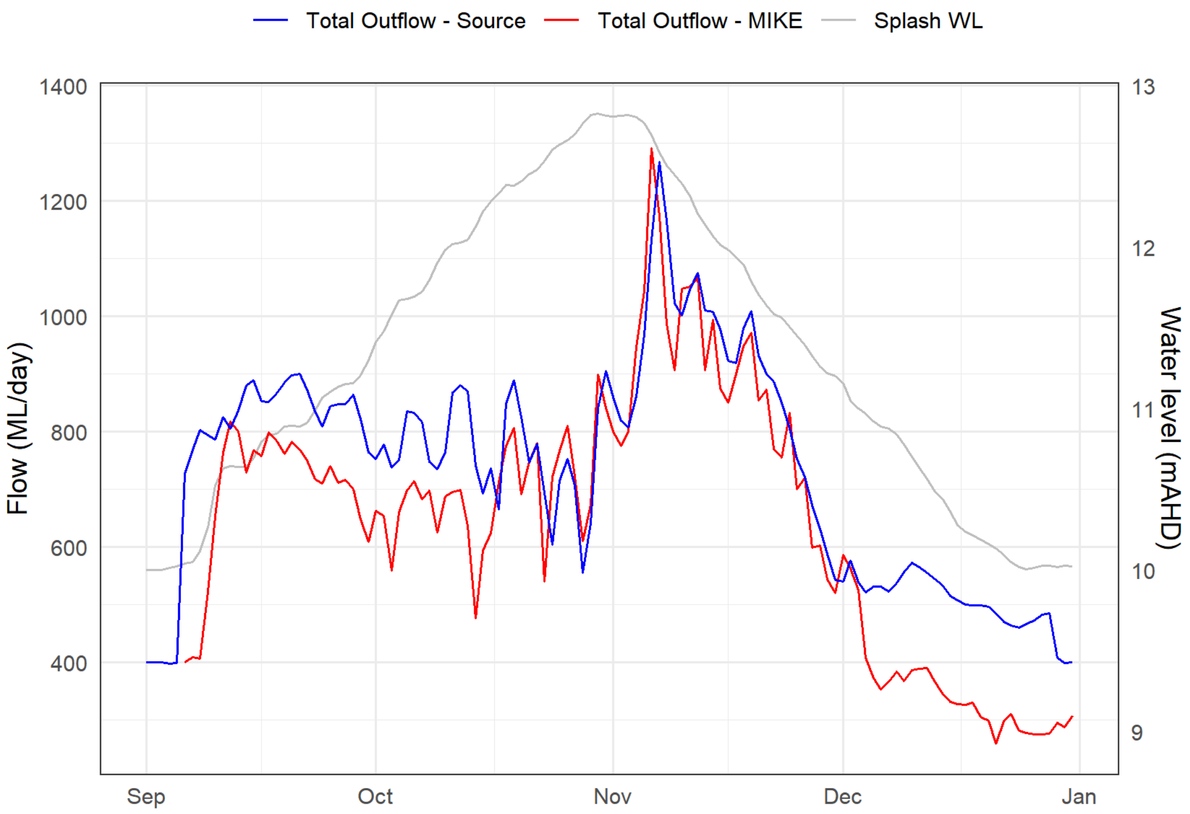


Figure 3.10 **Comparison of total modelled outflows using MIKE and Source models**

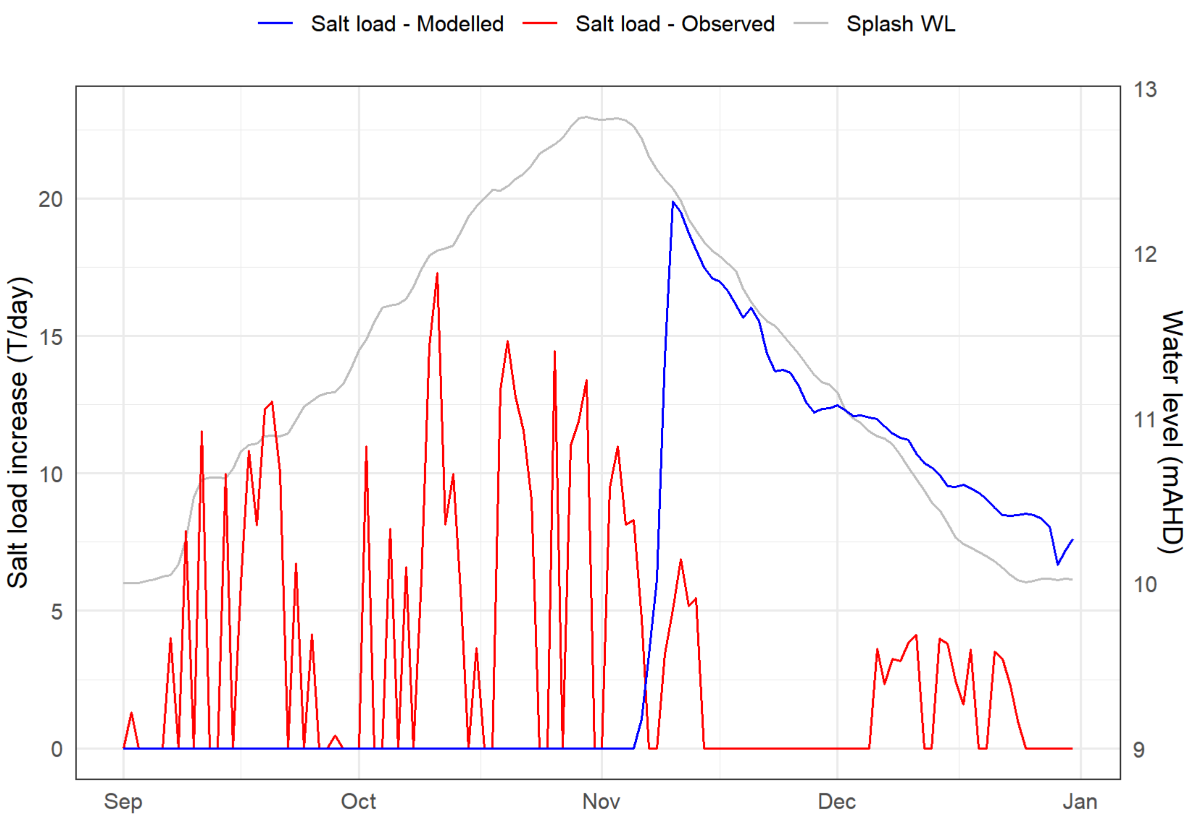


Figure 3.11 **Modelled salt load vs. observed salt load due to operation at Katarapko Floodplain**

3.1.2.3 DO and reaeration

DO at Katarpko Floodplain was modelled to reduce to minimum of ~5 mg/L and as can be seen in Figure 3.9 the modelled DO fits well with the observed values during 2020 operation.

Reaeration process plays an important role in improving the dissolved oxygen (DO) content in the streams and rivers. Flow over structures (e.g. weirs, dams, spillways) create reaeration. The reaeration is a function of the type of water quality, hydraulic structure, and the head loss across it (Mosley et al., 2021). This function was incorporated in the DODOC model using a modified version of the Gameson equation, as cited in Butts and Evans (1983):

$$r = 1 + 0.38abZ\,(1 - 0.11Z)\,(1 + 0.046T) \qquad \text{Equation 2}$$

Where r is the ratio of the oxygen deficit (difference from saturation) above and below the structure; Z is the distance of fall over the structure (m); a and b are empirical coefficients for water quality and structure aeration respectively (see Table 3.1) and T is the water temperature (°C), as defined by Butts and Evans (1983).

Table 3.1 Coefficients for water quality and structure aeration

Water quality coefficient (polluted state), a		
Gross	a =	0.65
Moderate	a =	1
Slight	a =	1.6
Clean	a =	1.8
Structure (weir/dam/spillway) aeration coefficient, b		
Flat broad-crested regular step	b =	0.7
Flat broad-crested irregular step	b =	0.8
Flat broad-crested vertical face	b =	0.6
Flat broad-crested straight-slope face	b =	0.75
Flat broad-crested curved face	b =	0.45
Round broad-crested curved face	b =	0.75
Sharp crested straight-slope face	b =	1
Sharp crested vertical face	b =	0.8
Sluice gates	b =	0.05

Recorded DO concentrations at Sawmill Creek were used to calibrate the parameters for the equation in the DODOC model that represent reaeration over structures. Firstly, DO observed at upstream and downstream were compared to make sure DO at downstream logger was higher than the upstream due to hydraulic structure aeration. It was found that the observed DO in the water were more than saturation (calculated based on water temperature) when water temperatures were higher as shown in Figure 3.12. This super saturation during the afternoon period most days is likely due to photosynthesis from primary productivity.

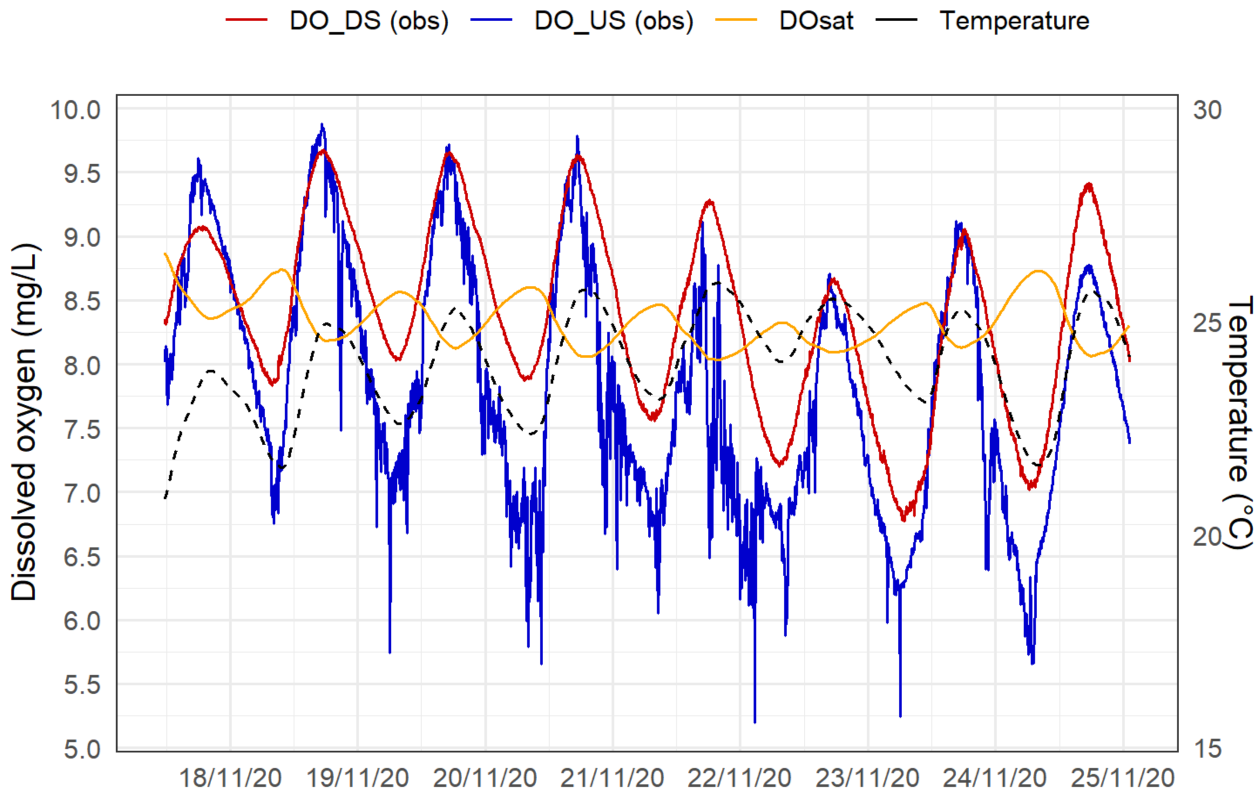


Figure 3.12 **Comparison of observed DO at upstream and downstream to saturation**

Supersaturation was not represented in the model, thus to ensure suitable application of Equation 1, DO concentrations upstream and downstream of Sawmill Regulator were capped at saturation (Equation 3) for the calibration purpose.

$$DO_{sat} = 14.652 - 0.41022T + 0.00799T^2 - 7.7774 \times 10^{-5} T^3 \qquad \text{Equation 3}$$

Assumptions were made that water was slightly polluted (a=1.6) and the Sawmill creek regulator is sharp crested vertical face structure (b=0.8). DO from structure (Equation Equation 4) was calculated and compared to the DO recorded at downstream logger of Sawmill Creek as shown in Figure 3.13.

$$DO_{structure} = DO_{sat} - (DO_{sat} - DO_{upstream}) / r \qquad \text{Equation 4}$$

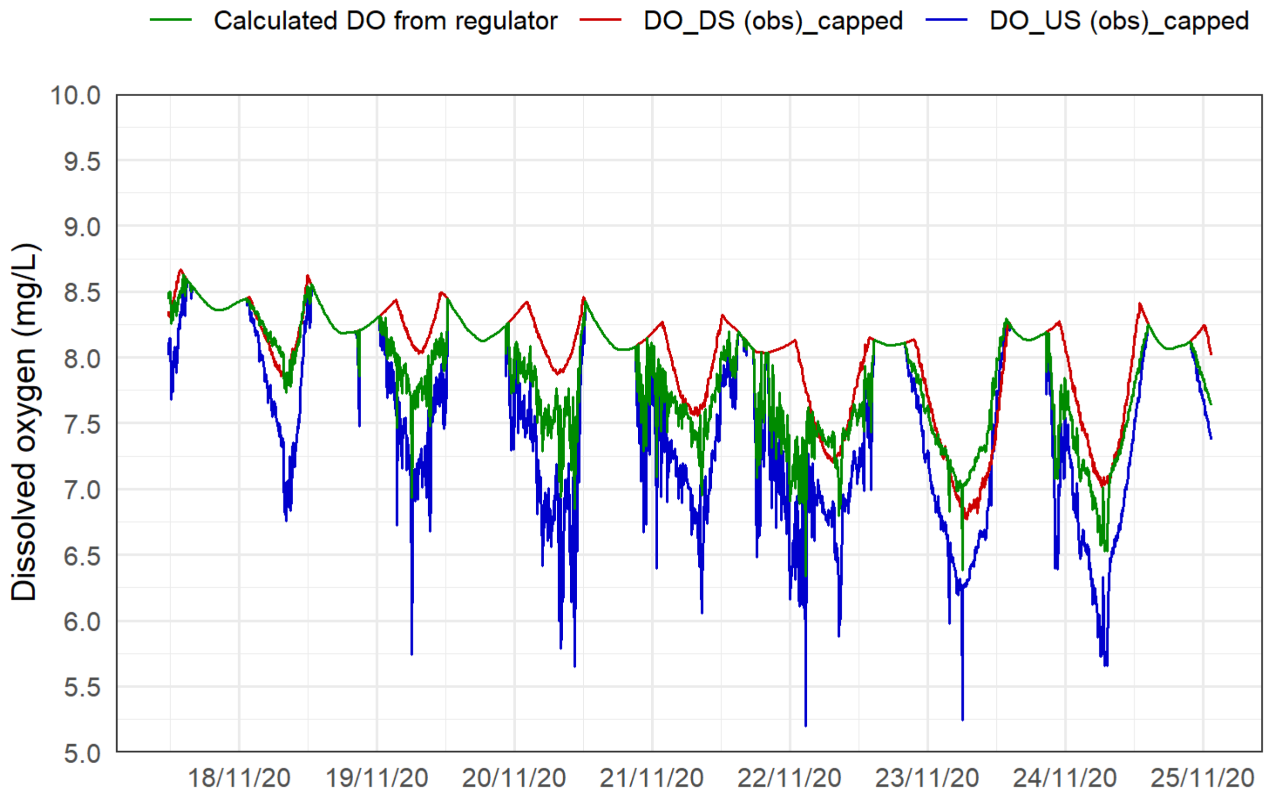


Figure 3.13 **Comparison of observed DO and calculated DO below the Sawmill Regulator. Note that the observed DO has been capped at the saturated DO concentration based on water temperature.**

It can be seen that calculated DO concentration downstream of regulator matched observed DO relatively well as shown in Figure 3.13, with comparable trends between the inflowing DO concentration (blue), the model (red) and the observed (green). The comparison has shown that the reaeration equations in the DODOC model can be used to represent reaeration over the Sawmill Regulator observed in 2020. To implement this approach across all structures in the model and estimate of the distance of fall over the structure is required. The upstream water level is typically an input to the model, however the downstream water level is dependent on flow and potentially downstream structures (e.g. weir pool raising). Future work could develop relationships based on hydraulic model outputs to interpolate a downstream water level for each structure, to enable the reaeration calculations to be undertaken.

3.2 Modelled water use due to first operations

The hydrological model was used to estimate the volume of water used due to operations at Pike and Katarapko Floodplains and associated weir pools in 2020. The model accounts for travel time and losses from the SA border to the barrages and the methodology to estimate the water use, as outlined in DEW (2019).

The model was run over a period from 1 July to 30 December 2021 using recorded river flow, estimate of diversions and climate data under a base case scenario (no operations) and also the actual operations scenario to calculate fill and return volumes and also losses (i.e. net evaporation) resulted from these operations.

Hydrographs of water levels for Pike and Katarapko Floodplains and associated weir pools were derived from running sheets provided by DEW Water Resource Monitoring Unit and shown in Figure 3.14 and Figure 3.15.

Lock 4 water level was already raised by 0.13 m at the start of modelling period (1 July 2020), therefore water use due to operations were calculated from and to this raised weir pool 4 level.

Retained volumes due to operations at the weir pools were modelled separately using the MIKE model that can account for depressions on the floodplains. Steady state conditions at the peak of the weir pool raising and a river flow of 15 000 ML/d were assumed. These assumptions, of steady state conditions and a slightly higher river flow than observed, are likely to result in calculated retained volumes that are conservative values. Total monthly losses and fill/return volumes resulted from these operations are presented in Table 3.2 and Table 3.3.

Table 3.2 Volume of water used due to operations at Pike Floodplain and Lock 5 (negative values indicate volumes returned to the river)

Month	Pike FP = 15.28m AHD			Lock 5 = 16.8m AHD		
	Pike Loss	Pike Fill/Return	Pike Retained	WP5 Loss	WP5 Fill/Return	WP5 Retained
	ML	ML	ML	ML	ML	ML
Jul	0	38	0	35	2606	0
Aug	0	19	0	100	1766	0
Sep	13	1940	0	232	-1205	0
Oct	145	2337	0	147	2872	0
Nov	828	2308	0	1269	2380	0
Dec	510	-6481	0	698	-6978	0
Total	**1496**	**162**	**162**	**2482**	**1440**	**1440**

Table 3.3 Volume of water use due to operations at Katarapko Floodplain and Lock 4 (negative values indicate volumes returned to the river)

Month	Kat FP = 12.83m AHD			Lock 4 = 13.53m AHD		
	Kat Loss	Kat Fill/Return	Kat Retained	WP4 Loss	WP4 Fill/Return	WP4 Retained
	ML	ML	ML	ML	ML	ML
Jul	0	0	0	8	2182	0
Aug	0	0	0	48	627	0
Sep	27	815	0	113	0	0
Oct	120	2894	0	113	0	0
Nov	333	-3247	0	253	-2520	0
Dec	30	-419	0	56	0	0
Total	**509**	**43**	**43**	**591**	**290**	**290**

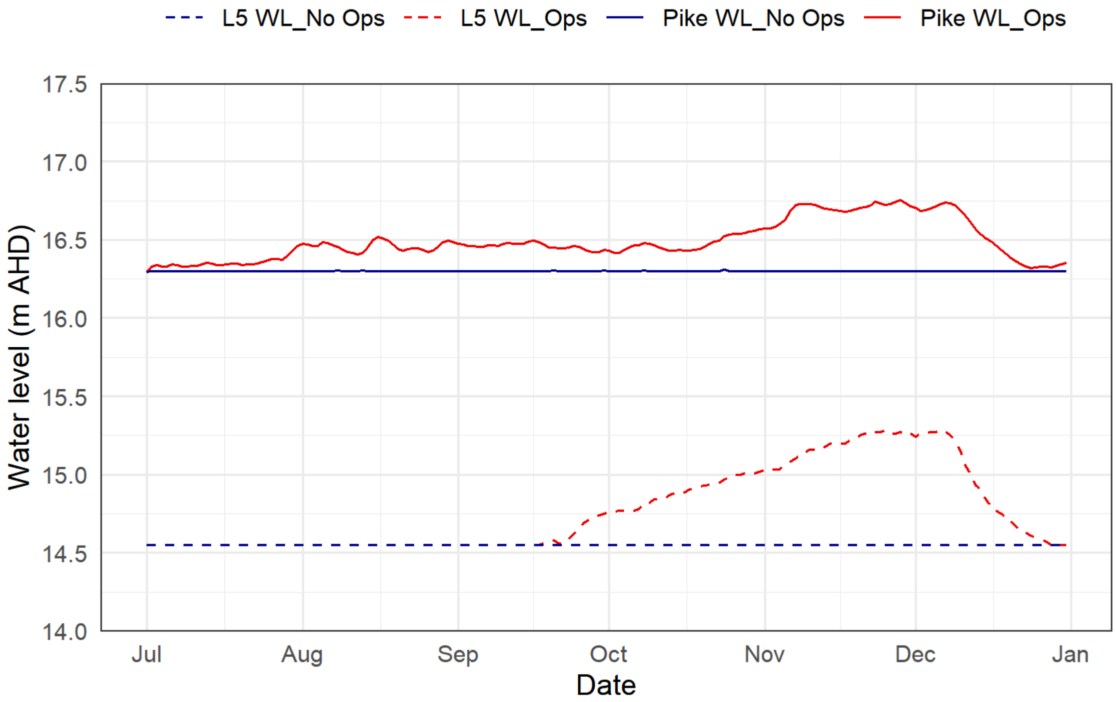


Figure 3.14 **Water elevation at Pike Floodplain and Lock 5**

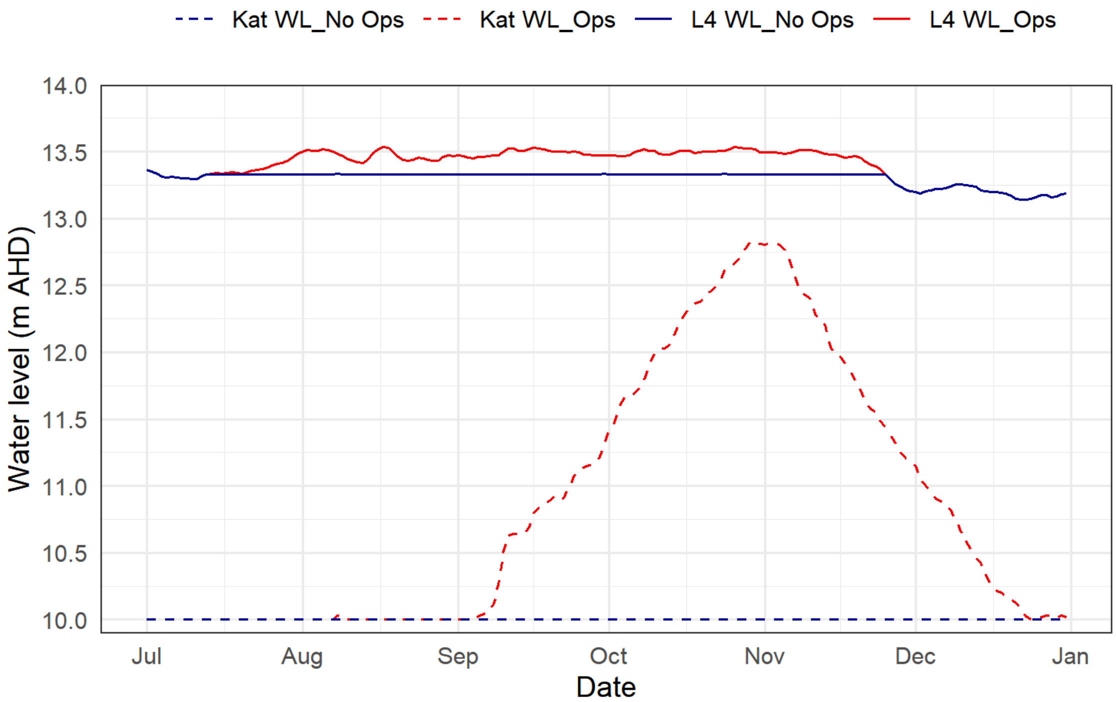


Figure 3.15 **Water elevation at Katarapko Floodplain and Lock 4**

4 Generalised assessment of managed inundation operations

The updated SA River Murray Source model was also used to simulate a range of scenarios to assess the impacts of different levels of inundation operations on water quality and quantity. Ranges of managed inundation operations at water levels ranging from normal to maximum operating height upstream of the environmental regulators at each site have been considered.

A series of managed inundation operations at both floodplains were simulated with assumed river flow of 10 000 ML/d and monthly average climate data to assess the impact of operations under ranges of conditions. For Pike Floodplain, it was assumed that outflow through Tanyaca regulator was operated at a constant 400 ML/day, and the remaining outflows directed through the Pike regulator to maximise dilution along the Pike River. Table 4.1 and Table 4.2 summarises the scenarios considered.

The modelled outputs are shown in Figure 4.1 and Figure 4.2 for Pike and Katarapko floodplains respectively. The results of all 60 scenarios were summarised in these figures, in a way to represent the impact of the following key variables on total inflow into the floodplains, minimum exchange rate, minimum DO concentration and maximum change in salinity concentration during operations:

- Inundation heights
- Corresponding weir pool level during inundation
- Time of operation
- Rate of operation

The results demonstrate that:

- Regardless of rate, time of year of the operation or height of operation, the additional inflow created by raising Locks during operation has a substantial influence on water quality conditions.
- Operations throughout comparatively warmer month result in lower DO concentrations due to typically warmer water temperatures.
- Faster rates of rise to fill the floodplain result in lower DO concentrations, as larger areas of litter are inundated for a given period, releasing more DOC compared to a slower rate of rise.

Table 4.1 Scenarios considered for Pike Floodplain

Lock 5 Level m AHD	Start	Rate of Rise cm/day	Inundation Level m AHD
	July	5	15.3 - 15.6 - 16.0
16.3	July	2.5	15.3 - 15.6 - 16.0
	Sep	5	15.3 - 15.6 - 16.0
	July	5	15.3 - 15.6 - 16.0
16.5	July	2.5	15.3 - 15.6 - 16.0
	Sep	5	15.3 - 15.6 - 16.0
	July	5	15.3 - 15.6 - 16.0 - 16.4
16.8	July	2.5	15.3 - 15.6 - 16.0 - 16.4
	Sep	5	15.3 - 15.6 - 16.0 - 16.4

Table 4.2 Scenarios considered for Katarapko Floodplain

Lock 4 Level m AHD	Start	Rate of Rise cm/day	Inundation Level m AHD
	July	7.5	12.0 – 12.5 - 13.0
13.2	July	5	12.0 – 12.5 - 13.0
	Sep	7.5	12.0 – 12.5 - 13.0
	July	7.5	12.0 – 12.5 - 13.0
13.5	July	5	12.0 – 12.5 - 13.0
	Sep	7.5	12.0 – 12.5 - 13.0
	July	7.5	12.0 – 12.5 - 13.0 – 13.5
13.8	July	5	12.0 – 12.5 - 13.0 – 13.5
	Sep	7.5	12.0 – 12.5 - 13.0 – 13.5

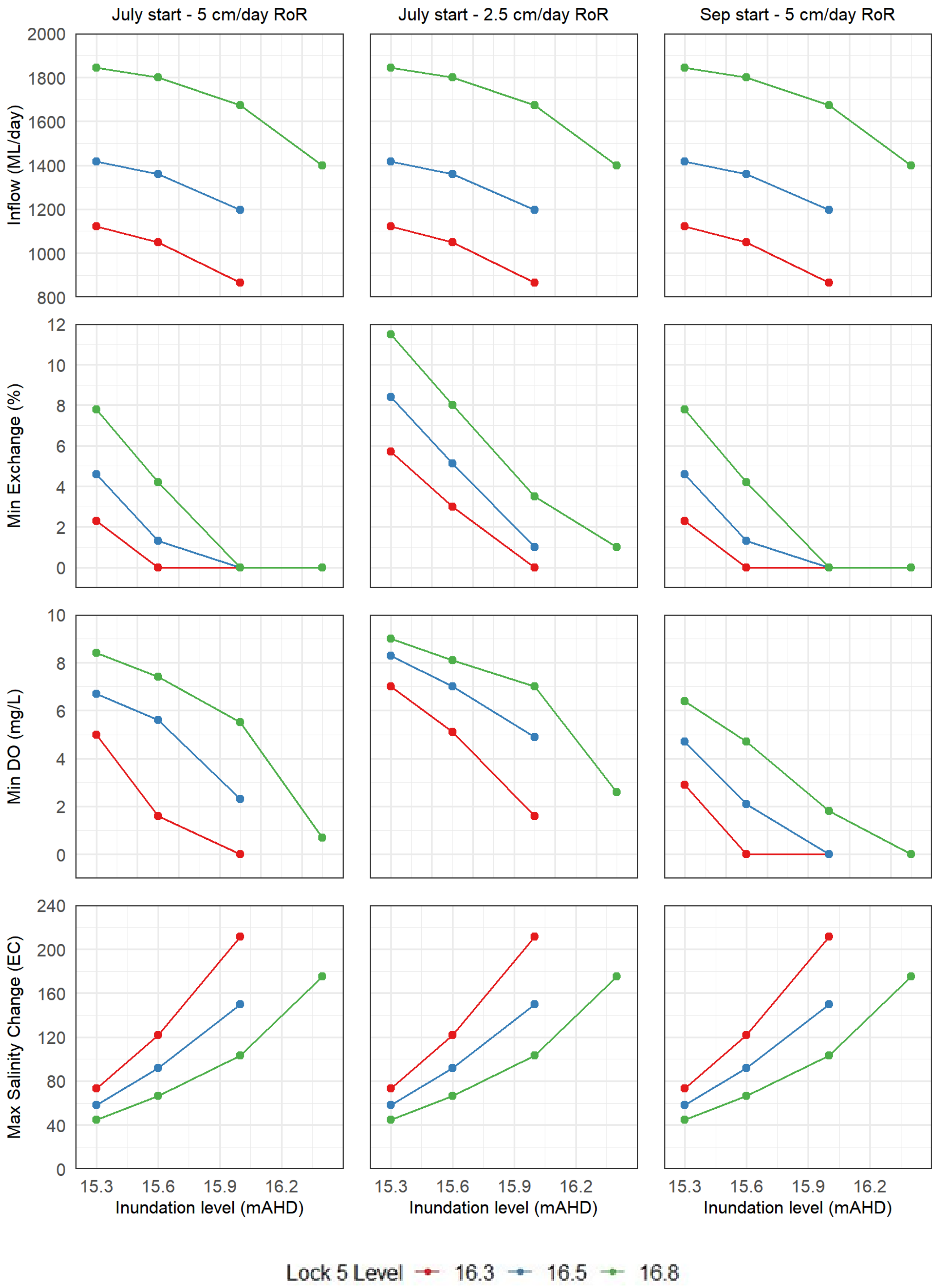


Figure 4.1 **Impact of operations at Pike Floodplain on inflow, Min exchange rate, Min DO and Max Salinity**

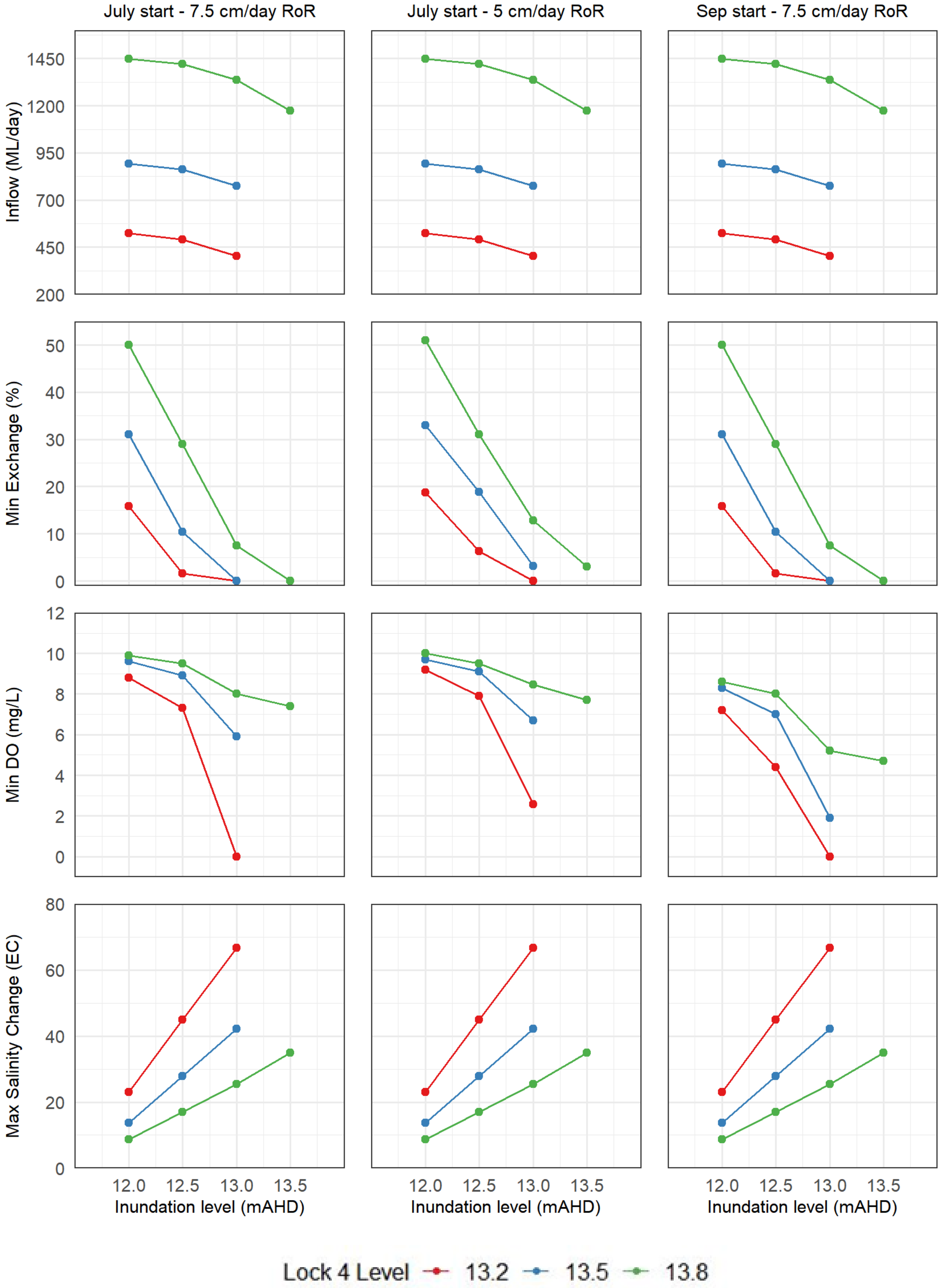


Figure 4.2 **Impact of operations at Katarapko Floodplain on inflow, Min exchange rate, Min DO and Max Salinity**

5 Conclusions and recommendation

Upon completion of the first operations at each floodplain site, the hydrodynamic models were calibrated and validated with representation of the new infrastructure and operational scenarios (see DEW, 2021). In addition, DODOC models and Groundwater models of the Pike and Katarapko Floodplains were also updated and improved in 2020, also representing an important input to be incorporated into the hydrological models.

Information from these three key modelling tools as well as data collected through monitoring during the first operation at each site, were used to parameterise, calibrate and validate the hydrological models.

The first operations were specifically implemented as low level test operations, and so the model review was unable to generalise to higher operations. Different height operations will allow all of the key hydrodynamic, hydrological, water quality and groundwater models to continue to be validated and improved.

The Source model represents the floodplains at a lumped scale (see Appendices A and B). Hence, monitoring at the end of floodplain (e.g. at the regulators) is sufficient to evaluate the water quality outputs of salinity, DO and DOC. For this purpose, there is limited additional value from a high spatial resolution of data within the floodplain. Flow and water quality data inputs to the floodplain from the River Murray are still required to be observed.

The exception to this is the standing load of plant litter, as leaves (i.e. readily available DOC source) and total load. If higher risk operations are planned where hypoxic DO conditions are possible, targeted monitoring of litter loads within the inundation extent may be worthwhile to reduce the uncertainty in DOC and DO predictions.

For DOC sampling, it is recommended to include replicate samples at key locations (River Murray inflow, above each regulator) to enable an estimate of mean DOC at a location to be derived, understanding measurement variability and error, to enable further comparison of modelled and observed DOC concentrations. The laboratory analysis effort could be made similar by reducing the sampling locations to the key model output locations, of Pike and Tanyaca regulators.

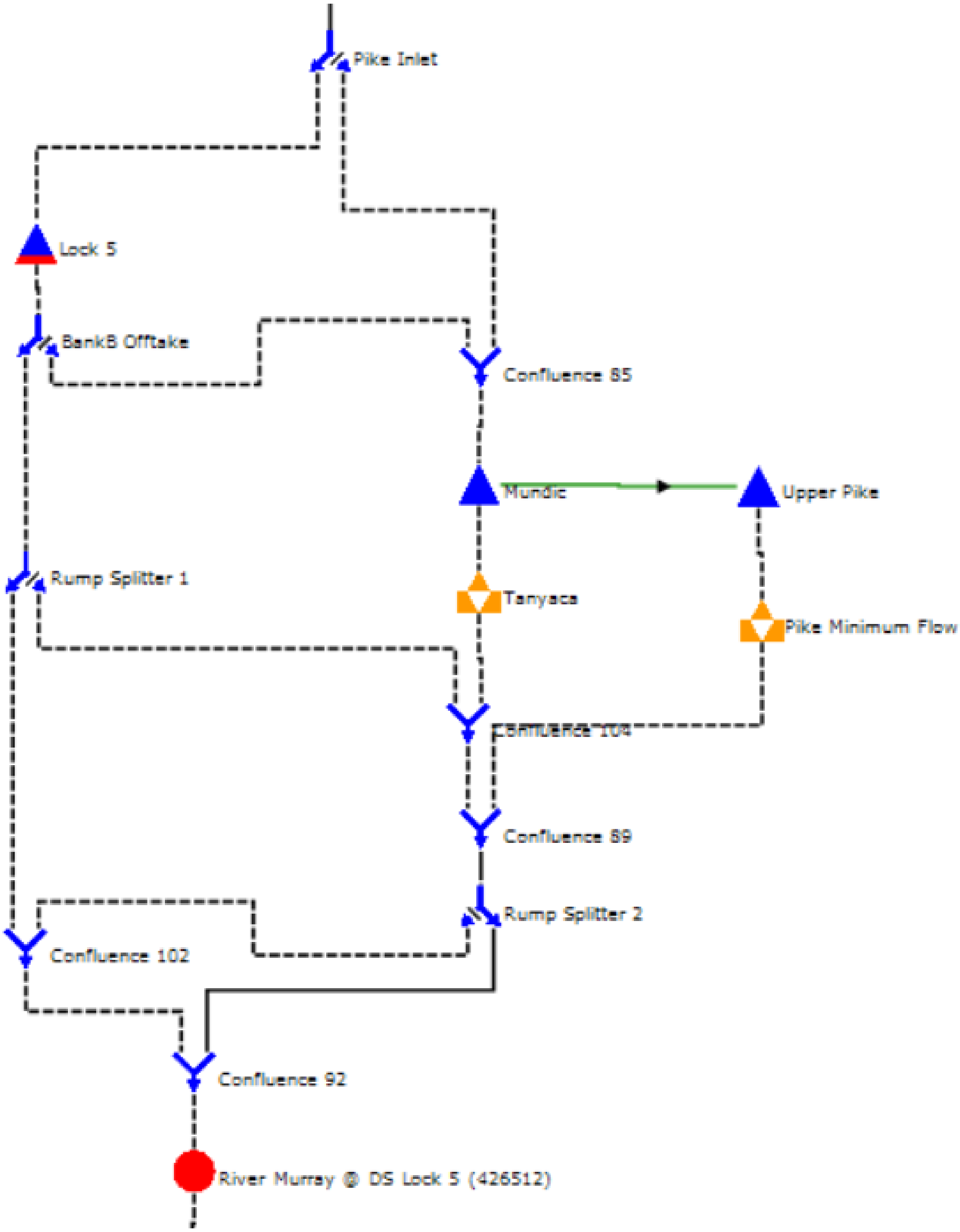
Scenarios defining preliminary operating limits have been simulated under a wide range of conditions to understand the impact of operations on water quantity and quality at both floodplains, which will continue to be developed for providing an easy to reference source of data for the initial stages of future event planning.

To assist with better understanding of the impact of ranges of operations and in particular the salinity responses, the model accuracy needs to be reviewed as different size and duration operations are undertaken at each floodplain.

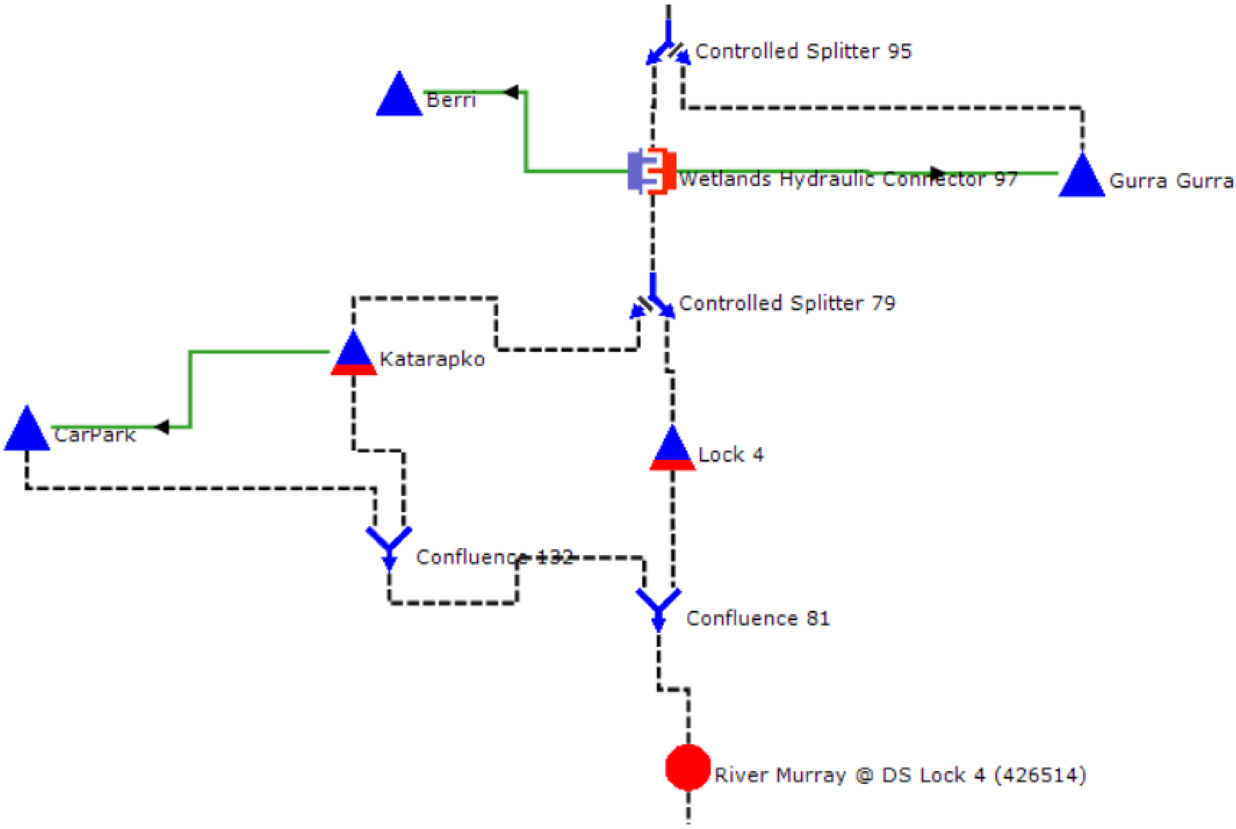
Consideration should be given to including downstream water level interpolation at each structure to enable reaeration calculations.

6 Appendices

A. Schematic of Pike hydrological models



B. Schematic of Katarapko hydrological models



C. Calibrated parameters

Table 6.1 Calibrated storage dimensions for Upper Pike

Elevation (mAHD)	Upper Pike	
	Volume (ML)	*Area (Ha)*
9	0	0
12	4	1
12.5	14	4
13	137	54
13.5	541	122
14	1371	194
14.5	2431	249
14.55	2980.1	303.4
14.6	3121	312.5
14.7	3387.7	331.9
14.8	3695.1	359
14.9	4050.3	394.3
15	4458.4	438.3
15.1	4912	479.1
15.2	5404.8	526.4
15.3	5968.7	591.3
15.4	6590.5	649.7
15.5	7272.3	708.2
15.6	8018.7	771.3
15.7	8831.7	829
15.8	9701.9	885.6
15.9	10707.7	966
16	12113	1062
16.1	13855	1289
16.2	15210	1385
16.3	16659	1480
16.4	18213	1581
17	28057	2019

Table 6.2 Calibrated travel time and upstream reach width for Lower Pike

Flow (ML/day)	Lower Pike	
	Travel time (day)	*Upstream reach width (m)*
282.83	4.46979	123.09
521	2.850199	123.61
1018.44	1.671147	127.31
1775.17	1.077207	147.56
2174.6	0.92611	157.15
3572.32	0.672787	203.25
6021.13	0.576096	318.82

Table 6.3 Calibrated storage dimensions for Mundic

Elevation (mAHD)	Mundic	
	Volume (ML)	*Area (Ha)*
9	0	0
10	2.03E-06	3.09E-06
10.5	9.81E-05	4.74E-05
11	0.00063	0.000182
11.5	0.002332	0.001703
12	0.916692	0.902083
12.5	44.45385	25.68839
13	263.2845	59.90628
13.5	652.1564	97.30815
14	1207.763	127.6229
14.5	1912.795	153.191
14.75	3508	220
14.855	3706.1	237.3
14.891	3848.3	255.1
14.934	3987.1	264.9
14.982	4134.7	279.2
15.041	4310.8	295.9
15.108	4529.5	318.4
15.18	4784.4	343.7
15.22	4952	358
15.259	5073	369.5
15.28	5179	377
15.31	5302	386
15.35	5457	397
15.4	5672	415
15.43	5771.5	423.1
15.46	5925	434
15.521	6174.4	449.9
15.53	6221	453
15.6	6558	472
15.68	6932	493
15.76	7351	515
15.807	7574.2	525.2
15.84	7801	537
15.93	8292	560
16.02	8812	582
16.12	9363	604
16.21	9943	623
16.31	10551	643
16.4	11273	685
17	13900.92	805.7019

Table 6.4 Calibrated storage dimensions for Katarapko

Elevation (mAHD)	Katarapko	
	Volume (ML)	*Area (Ha)*
0	0	0
9.8	636.457	92.6915
9.9	678.7619	96.8638
10	693.4438	100.4786
10.1	705.7081	102.325
10.2	717.0369	102.9636
10.3	728.9126	103.6701
10.4	739.6173	103.7767
10.5	751.3709	104.6305
10.6	763.49	105.5829
10.7	792.476	108.8034
10.8	826.5802	113.884
10.9	867.9804	119.0391
11	917.6412	125.3004
11.1	990.7698	139.0373
11.2	1038.348	139.5911
11.3	1124.482	150.0915
11.4	1201.836	155.392
11.5	1286.679	161.4541
11.6	1385.683	168.1398
11.7	1498.616	176.6714
11.8	1631.39	188.5172
11.9	1775.641	200.2955
12	1932.171	211.1973
12.1	2111.952	226.208
12.2	2306.054	240.779
12.3	2518.782	257.1085
12.4	2745.878	271.7835
12.5	3033.286	297.8005
12.6	3394.809	333.9728
12.7	3751.523	368.6306
12.8	4162.222	420.3849
12.9	4566.73	459.5309
13	5157.559	526.345
13.1	5689.284	585.2665
13.2	6284.782	670.494
13.3	7080.379	753.4654
13.4	7883.709	847.6391
13.5	8784.242	946.2216
14.5	18595.02	1250

Table 6.5 Calibrated travel time and upstream reach width for Katarapko

Flow (ML/day)	Katarapko	
	Travel time (day)	*Upstream reach width (m)*
100	0.01	1
350	0.01	1
500	0.2	1
750	0.2	40
800	3	40
1000	3	100
1010	0.5	100
5000	0.5	200

Table 6.6 Calibrated storage dimensions for Car Park

Elevation (mAHD)	Car Park	
	Volume (ML)	*Area (Ha)*
0	0	0
9.8	0.01235	0.01
12.1	0.15362	0.05
12.2	0.19107	0.055
12.3	0.23488	0.06
12.4	0.516529	0.121749
12.5	15.71422	2.939144
12.6	28.80574	7.438167
12.7	55.97419	11.57969
12.8	172.4526	25.08775
12.9	219.393	34.85332
13	260.6815	40.78203
13.1	306.4197	47.10695
13.2	359.9283	54.22585
13.3	423.0536	65.85862
13.4	497.0503	75.45975
13.5	579.9684	84.3335
14.5	580	85

7 References

AWE (2016) Salinity Impact Assessment for the Pike and Katarapko Floodplains. Prepared for DEW. AWE Ref 14190.

Butts TA, Evans RL (1983) Small stream channel dam aeration characteristics. J. Environ. Eng. 109, 555-573.

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 report 2021/05, Government of South Australia, Department for Environment and Water, Adelaide.

DHI (2020) L3-L6 calibration report, Report to Department for Environment and Water, rev3. DATE

Mosley LM, Wallace T, Rahman J, Roberts T, Gibbs M (2021) An integrated model to predict and prevent hypoxia in floodplain-river systems. J Environ Manage. 2021 May 15;286:112213. doi: 10.1016/j.jenvman.2021.112213. Epub 2021 Mar 5. PMID: 33684798.

Purczel C, Riches V, Woods J (2020) South Australian Riverland Floodplain Integrated Infrastructure Project – Katarapko Floodplain Numerical Groundwater Model. Government of South Australia, Department for Environment and Water, Adelaide. in prep.

Purczel C, Riches V, Li C, Woods J, Wood C, Costar A (2020) South Australian Riverland Floodplain Integrated Infrastructure Project – Pike Floodplain Numerical Groundwater Model 2020 – Flow and Solute Transport, DEW Technical report, Government of South Australia, Department for Environment and Water, Adelaide, in prep.

Whitworth KL, Baldwin DS (2016) Improving our capacity to manage hypoxic blackwater events in lowland rivers: the Blackwater Risk Assessment Tool. Ecol. Model. 320, 292-298.

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