SARFIIP – Pike Floodplain hydraulic modelling

Managed inundation options assessment scenarios – 2014–15

DEWNR Technical note 2016/05

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Summary

Pike Floodplain is an anabranch of the River Murray located in the vicinity of Renmark, South Australia. Its main inlets are located upstream of Lock 5, with return flows re-entering the River Murray on the downstream side of Lock 5. A number of structures and banks have been constructed over the years, both internal and external to the floodplain, which have modified the natural hydraulics of the system and resulted in a general degradation of the ecological condition of the floodplain and associated wetlands. Owing to this general degradation of floodplain condition, the South Australian Riverland Floodplains Integrated Infrastructure Program (SARFIIP) has been initiated to improve the flexibility of managing the system via new infrastructure and operational solutions.

Hydraulic modelling of the Pike Floodplain, using a 1-D/2-D coupled model, was conducted as part of the investigations under SARFIIP, with specific scenarios designed to provide insights into a range of important management decisions, including the siting of infrastructure, design of infrastructure, and potential benefits and risks associated with various managed and natural hydraulic scenarios. Note that individual scenarios presented may not be directly comparable to other scenarios due to alterations in objectives or updated understandings of the system over the course of the period of investigations (i.e. 2014–15), such that configurations such as bank alignments or maximum inflows expected may differ between earlier and later scenarios conducted, however all scenarios are presented in the context of their aims and understandings at the time of completion.

Scenario 1 investigated the difference in hydraulics between siting the regulator Pike regulator at the existing Col Col Bank site (i.e. eastern alternative), and a western alternative located directly upstream of the Pike–Rumpagunyah junction. The results indicated that moving the regulator alignment downstream on the Pike River to the western regulator location resulted in a greater volume detained in the reach between the eastern and western regulator locations under normal in-channel operating conditions, compared to the eastern regulator alternative. This resulted in reduced in-channel velocities in this reach under the western regulator option for given flow conditions, although velocities upstream and downstream of this reach remained identical between the alternatives. Note that the in-channel hydraulic conditions of these scenarios compared favourably to existing floodplain conditions with respect to the substantially greater inflows achievable under the upgraded system configuration, while the shift in alignment also provides a greater inundation capacity during managed inundation of the floodplain compared to the eastern Pike regulator alternative.

The location of the regulator on Pike River did not influence flow in Rumpagunyah Creek. However, additional flows into the floodplain and through Tanyaca Creek via upgraded structures results in Rumpagunyah Creek acting predominantly as an outlet from the floodplain at river flows of approximately 10 000 ML/d, seemingly independent of flow split between the environmental regulators.

Scenario 2 investigated the impact of varying floodplain inflows and Tanyaca Creek regulator outflows on Mundic Creek level and flows through uncontrolled Mundic Creek eastern outlets i.e. Mundic Northern Outlet, Mundic Southern Outlet and Snake Creek. Scenario 3 expanded on Scenario 2 modelling to investigate the ability for minor regulating structures at these Mundic Creek eastern outlets to raise the water level in Mundic Creek for localised inundation, and to control flow through Pike River. The results indicated that flow conditions through the Mundic outlets into Pike River can be manipulated by altering floodplain inflows through Deep Creek and Margaret Dowling Creek and outflows through Tanyaca Creek regulator, while regulating structures are likely to be required on the outlets of Mundic creek in order to inundate areas of Mundic Creek floodplain area independent from the operation of the Pike River regulator.

Scenario 4 investigated the impact of reducing the size of regulators at Tanyaca and Lower Pike by 50% of that defined in the original concept designs on a natural high flow event through the system (90 000 ML/d). Some changes in hydraulics through the floodplain were incurred by reducing the regulator sizing, resulting in a reduction in outflow through the regulating structures and a minor increase in level behind the blocking bank alignment under the 50% regulator sizing case. This consequently resulted in greater flows overtopping the blocking alignment and bypassing the regulators, with an increase in velocities over the banks adjacent to the environmental regulators.

Scenario 5 presented a managed inundation scenario with the western Pike River environmental regulator option under steady state conditions at maximum inundation height of 16.4 m AHD, while Scenario 7 complemented the results by presenting a dynamic inundation event from commencement of filling to completion of draining phases. Volumes in the Pike River side of the floodplain were approximately double that of the Mundic–Tanyaca side during a managed inundation event of

16.4 m AHD, suggesting that concentrating flows towards the Pike River during an inundation event may be required for water quality considerations, while also maintaining local land holder supply flows, although equal consideration will also be required for ensuring that faster flowing habitat is maintained in the reach downstream of Tanyaca regulator. Overall turnover rates were modelled in the order of 25% behind the blocking bank at normal in-channel flows, falling to a minimum of approximately 4% at maximum inundation height, with velocities within the impounded area maintained predominantly in the very low velocity category of up to 0.01 m/s.

Scenario 6 was devised to investigate the impact of blocking banks and regulators at Tanyaca and Pike River (western location) with regards to ability for allowing natural flood events to enter the floodplain without being significantly impeded, complementing Scenario 4 investigations. The 1981 flood event was modelled given it presented the fastest rising limb on record up to flows of over 100 000 ML/d, and would therefore be expected to highlight any restriction of inflows to the floodplain that the structures or blocking alignment may present. Structures at Tanyaca and Pike River were set at 50% of the concept design size as used in Scenario 4, which was intended as a first step for future scenarios to investigate modelled structure resizing on an iterative basis to inform structure designs. The regulating structures at Tanyaca Creek and Pike River did not appear to directly prevent natural inflows to the floodplain from the River Murray during a natural flood event, with only outflows through these regulators modelled over the hydrograph considered. However, inundation of an area to the north-east of the Pike River regulator was prevented by the blocking alignment between River Murray flows of between 50 000 and 80 000 ML/d, suggesting that smaller ancillary structures may be required in the blocking alignment adjacent to this area to allow inundation during natural flood events.

Scenario 8 investigated the potential increase in dilution flows that may be achieved into the floodplain by raising Lock 4 weir pool by 1 m, to 14.2 m AHD, under an elevated River Murray flow of 30 000 ML/d, which was considered for the purposes of the scenarios as a potential maximum flow that a Lock 4 weir pool level raising could be conducted under controlled river flow conditions. Scenarios were investigated for in-channel flow conditions and also during a managed inundation event to 16.4 m AHD. The results indicated that increasing Lock 4 weir pool level to 14.2 m AHD at elevated River Murray flow (30 000 ML/d) resulted in elevated river levels in the Lock 4 to 5 reach that were sufficient to allow additional inflows through Banks B, B2 and C under in-channel flow conditions, but not during a managed inundation event to 16.4 m AHD. Under both in-channel and managed inundation conditions, Rumpagunyah Creek acted as an inlet to the floodplain under the modelled hydraulic conditions in the river, contrasting with previous scenarios conducted at 10 000 ML/d River Murray flow and normal Lock 4 operating level, in which Rumpagunyah Creek acted as a floodplain outlet to the river. Overall, the results indicate that additional dilution flows to the floodplain in the Lower Pike River may be achieved by manipulating water levels in the Lock 4 to 5 reach.

A further suite of scenarios (Scenario 9) was developed to investigate the impact of potential floodplain structure operational schemes on velocity conditions generated in relevant creeks impacted directly by structure operations. Relevant creeks investigated included Deep Creek and Margaret Dowling Creek with respect to the inlet regulators; Tanyaca Creek with respect to the Tanyaca environmental regulator; and Mundic northern outlet for the Mundic northern outlet regulator. The results indicated that velocity distributions in the various inlet and outlet creeks to Mundic Creek are sensitive to manipulation of tailwater levels and/or regulator flows within each relevant creek. Velocities in Margaret Dowling Creek and Deep Creek are modelled to generally decrease when raising the downstream Mundic Creek level, or by operating at reduced inflows from above Lock 5. Velocities in Mundic northern outlet are modelled to generally increase when raising Mundic Creek level and/or flow through the creek by manipulating the proposed Mundic northern outlet regulator. Velocities in Tanyaca Creek are modelled to increase when increasing flows through the Tanyaca regulator and/or operating at lower River Murray flows, which creates lower tailwater levels in Rumpagunyah Creek.

1 Hydraulic model summary

The Pike floodplain hydraulic model is a 1-D/2-D coupled model designed in the MIKE FLOOD software package by DHI Water and Environment. The details of the base model used for these scenarios is detailed in McCullough (2013). Updates implemented for this work on the MIKE FLOOD model used in previous scenarios are listed in McCullough (2016).

Creeks and the locations of existing and proposed structures on which the model is based are shown in Figure 1.1. Note that of the structures identified:

- Bank G, H, Coombs Bridge and Snake Creek Stock crossing have been removed or slated for removal through Riverine Recovery Project (RRP)
- The structure at Col Col Bank is slated for removal, with alternative locations at 1 and 2/3 (i.e. the regulator is placed in a common location for blocking alignment alternatives 2 and 3) indicated in the figure
- Regulators at Mundic Northern, Central and Southern Outlets are proposed as potential options for local seasonal inundation of Mundic Creek fringes
- Banks, D, F and F1 are proposed for removal once the proposed SARFIIP regulators are completed, and Bank E being potentially moved to form part of the SARFIIP blocking alignment for managed inundation purposes.

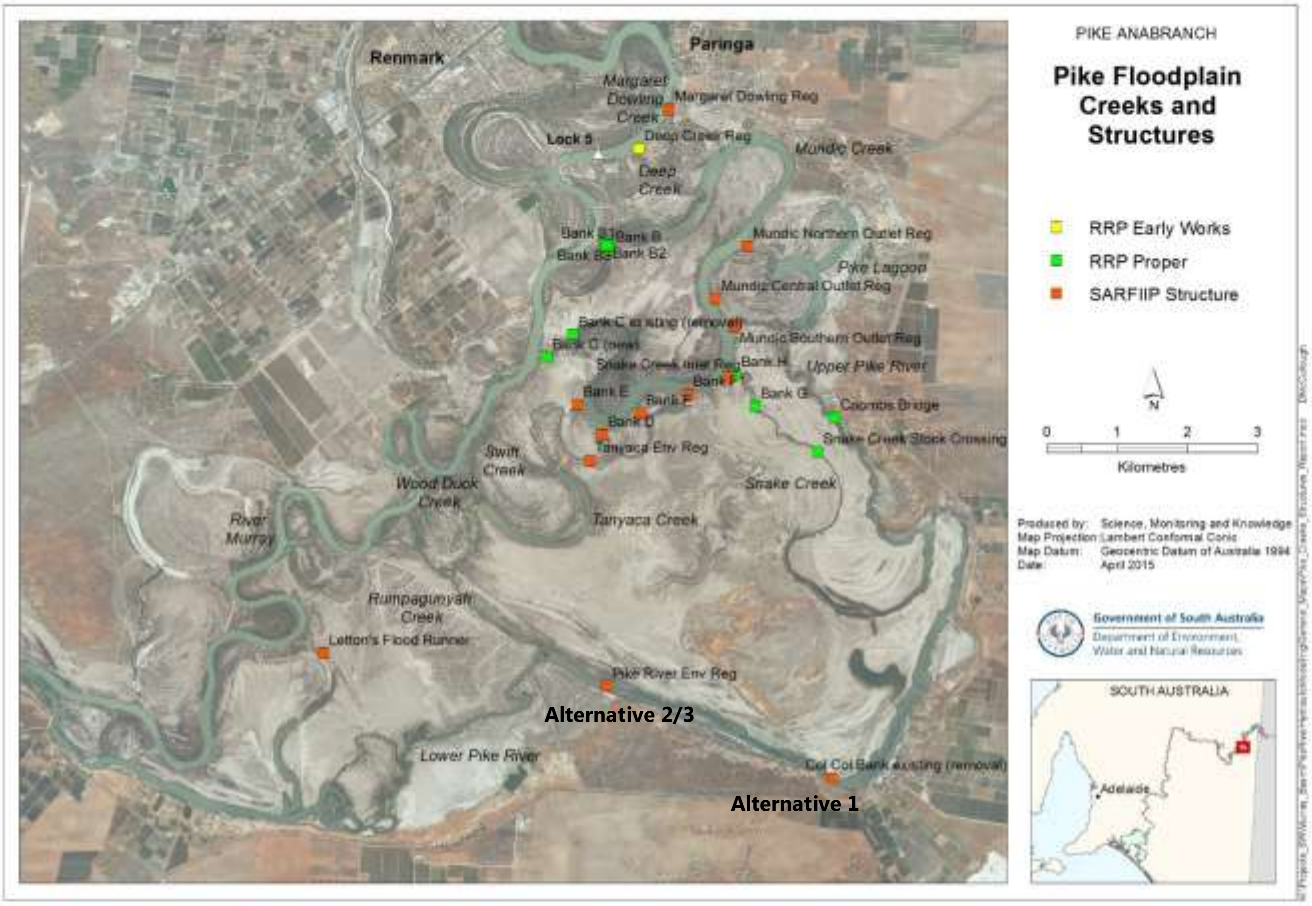

Figure 1.1 Pike Floodplain creeks and structures (existing and proposed)

2 Management options scenario summary

Scenarios were designed to provide technical data to inform further management options development for Pike Floodplain. Table 2.1 shows the simulation configurations used for the scenarios designed for preliminary management options investigations, while Table 2.2 shows the details of further scenarios that were refined based on the outcomes of the preliminary investigations scenarios. For each of the scenarios presented, the model boundaries in each setup include (1) the model inflow upstream of Lock 5, and (2) tailwater level upstream of Lock 4. Structure control targets are indicated against Lock 5, Deep Creek/Margaret Dowling Creek (i.e. total floodplain inflow), and Pike River and Tanyaca Creek environmental regulators. Note that for Pike and Tanyaca regulators, control typically involves setting Tanyaca regulator upstream level to a target level (i.e. model calculating flow through structure), and Pike regulator to the indicated flow (i.e. model calculating upstream level), or vice versa. Note that the mode of control for each structure is indicated against each scenario in the tables below.

The chapters presented represent a collection of scenarios that were developed on a case by case basis, under different timeframes, to fulfil specific purposes for further options assessments. Direct comparison of results are therefore mainly applicable between simulations conducted under the same scenario numbering (i.e. within a given chapter). Later scenarios may reflect differing objectives for options assessments or updated understandings of the system based on earlier scenarios, and may in turn make earlier scenarios ultimately redundant when considered as a full body of work. For instance, Scenario 1 considers a comparison of the Pike regulator position between eastern and western locations, whereas later scenarios were conducted under an updated understanding that the eastern location was no longer preferred due to a number of factors. The blocking alignment is also set to the Alternative 3 alignment in scenarios from 1 to 5 (note that for Scenario 1, Alternative 3 is compared with the original concept alignment that intersects with the eastern regulator location), while Alternative 2 is set for the remaining scenarios as this became the preferred focus of scenarios through external options assessments (refer to figures in each specific scenario for the alignment used in each case). Note that the preferred alignment may alter again in future, depending on the outcomes of the design phase of works. Also, the total maximum inflow rate under controlled river conditions – through upgraded structures at Margaret Dowling (yet to be constructed) and Deep Creek (constructed and currently in the commissioning phase) – is assumed to be 1200 ML/d for the majority of scenarios based on prior modelling results and structure specifications, however experience with construction and operation of the new Deep Creek regulator indicates that a higher flow of 1400 ML/d may be possible at raised Lock 5 pool level, and hence was used as the total inflow rate for Scenarios 8c and d (note that this understanding may again alter in future once both structures are constructed and fully operational, and will require flow gauging at a range of flow conditions for calibration of the model).

Table 2.1 Management options development scenario model configurations

Scenario	Model Inflow U/S Lock 5 (ML/d)	Tailwater level U/S Lock 4 (m AHD)	Lock 5 U/S (m AHD)	Total inflow (ML/d)	Tanyaca regulator flow (ML/d)	U/S Lower Pike regulator level (m AHD)	Pike regulator location
1a	10 000	13.2	16.3	1200	600	14.35	eastern
1b	10 000	13.2	16.3	1200	600	14.35	western
1c	10 000	13.2	16.3	1200	400	14.35	eastern
1d	10 000	13.2	16.3	1200	400	14.35	western
2a	10 000	13.2	16.3	800	400	14.35	western
2b	10 000	13.2	16.3	1200	400	14.35	western
2c	10 000	13.2	16.3	1200	800	14.35	western
3a	10 000	13.2	16.3	800	400	14.35[a]	western
3b	10 000	13.2	16.3	1200	400	14.35[a]	western
4a[b]	90 000	14.8	Uncontrolled	Uncontrolled	Uncontrolled	Uncontrolled	western
4b[b]	90 000	14.8	Uncontrolled	Uncontrolled	Uncontrolled	Uncontrolled	western
5	10 000	13.2	16.8	1200	Variable[c]	16.4	western

[a] Water level in Mundic Creek set to 15.5 m AHD

[b] Tanyaca and Lower Pike regulators at 100% (4a) and 50% (4b) of existing concept design structure size

[c] Tested at flows of 100, 400 and 800 ML/d

Table 2.2 Additional management options development scenario model configurations

Scenario	Model inflow U/S Lock 5 (ML/d)	Tailwater level U/S Lock 4 (m AHD)	Lock 5 U/S (m AHD)	Total inflow (ML/d)	Tanyaca regulator operation	Pike regulator operation	Pike regulator location
6	Based on 1981 flood hydrograph (up to 105 000 ML/d QSA)			Uncontrolled	Set to control U/S level at 14.75 m AHD, fully open when D/S level equilibrates with U/S level	Base set at 14.35 m AHD, open when D/S level equilibrates with U/S level	western
7	10 000	13.2	16.8	Filling and holding – 1200; Draining – 800	Filling – 250 ML/d; Holding – Alternate between 400 and 600 ML/d (7 day intervals); Draining – 600 ML/d	Filling – Set to control flow at 50 ML/d; Holding – 16.4 m AHD; Draining – Set to control flow at 600 ML/d	western
8a	30 000	14.2	16.3	1200 (i.e. 600 Deep Creek and Margaret Dowling Creeks	U/S level > 14.75 m AHD	400 ML/d, model sets U/S level > 14.35 m AHD	western
8b	30 000	13.2	16.3	1200 (i.e. 600 Deep Creek and Margaret Dowling Creeks	U/S level > 14.75 m AHD	400 ML/d, model sets U/S level > 14.35 m AHD	western
8c	30 000	14.2	16.8	1400 (i.e. 800 Deep Creek and 600 Margaret Dowling)	U/S level 16.4 m AHD	400 ML/d, U/S level to ~16.4 m AHD	western
8d	30 000	13.2	16.8	1400 (i.e. 800 Deep Creek and 600 Margaret Dowling)	U/S level 16.4 m AHD	400 ML/d, U/S level to ~16.4 m AHD	western

2.1 Scenario descriptions

Initial management options scenarios

In Scenario 1, four simulations were developed to investigate the hydraulic impact of relocating the Pike River environmental regulator from the eastern alternative, as defined in the original concept design (URS, 2010) at the existing Col Col Bank site, to a western alternative, directly upstream of the Pike–Rumpagunyah junction. The eastern location of the Pike regulator corresponds to the original concept blocking alignment, while the western location relates to the Alternative 3 alignment, although the in-channel conditions of this scenario does not cause the blocking alignment on the floodplain areas to become active in holding back water.

In Scenario 2, three simulations were conducted to investigate the impact of varying floodplain inflows and Tanyaca Creek regulator outflows on Mundic Creek level and flows through uncontrolled Mundic Creek outlets – Mundic Northern Outlet, Mundic Southern Outlet and Snake Creek (note that Mundic Central Outlet is typically non-flowing at normal pool levels to a higher elevation than the other outlets).

Scenario 3 expands on Scenario 2, with two scenarios conducted to investigate the ability for minor regulating structures at the outlets of Mundic Creek (i.e. Mundic Northern Outlet, Mundic Southern Outlet and Snake Creek) to raise the Mundic water level for localised inundation, and to control flow through Pike River. For simplicity, no regulating structure is designed for Mundic Central Outlet, and is assumed to be blocked by a simple bank.

In Scenario 4, two simulations were designed to investigate the impact of reducing the size of regulators at Tanyaca and Lower Pike by 50% of that defined in the original concept designs (URS, 2010) on a natural high flow event through the system (90 000 ML/d). The Alternative 3 blocking alignment is modelled (refer to figures under the Scenario 4 chapter for alignment), and all floodplain structures are fully opened.

Scenario 5 presents a managed inundation scenario with the western Pike River environmental regulator option and the Alternative 3 blocking alignment as used in Scenario 4. The level in Mundic Creek and upstream of Pike River environmental regulator was set to the expected maximum height of 16.4 m AHD, while inflow to the Pike system was set to 1200 ML/d. Given that flow splits can be varied between Pike River and Tanyaca Creek, flows of 100, 400 and 800 ML/d through Tanyaca Regulator at maximum inundation (i.e. 16.4 m AHD) were tested to investigate the impact on velocity distributions through the floodplain, with the remainder of flow passing through the Pike River environmental regulator.

Additional management options scenarios

Scenario 6 was devised to investigate the impact of blocking banks and regulators at Tanyaca and Pike River (western location) with regards to ability for allowing natural flood events to enter the floodplain without being significantly impeded, complementing Scenario 4 investigations. The blocking alignment tested was configured under the Alternative 2 option (refer to figures produced under Scenario 6), differing from previous scenarios given that this alternative was anticipated to be preferred over Alternative 3 at the time of modelling due to a shorter blocking bank length required. Structures at Tanyaca and Pike River were set at 50% of the concept design size as used in Scenario 4, which was intended as a first step for future scenarios to investigate modelled structure resizing on an iterative basis to inform structure designs. Of particular focus in the scenario was any potential impedance of inflows to the floodplain from the river side of the blocking alignment. Outputs from the scenarios included discharges through each environmental regulators and water levels upstream and downstream of the respective regulators as they change through the hydrograph, noting that once the blocking banks are overtopped the flows through the structures represent only a portion of the total outflow from behind the blocking alignment.

Scenario 7 was devised to reproduce a previously modelled dynamic operating regime (Water Technology, 2012; McCullough, 2013) for a managed inundation event with the updated Alternative 2 blocking alignment. The operating regime used in the model configuration was designed for generation of updated system volumes and flows from these previous modelling exercises, and may not represent an optimised control methodology. Operating regimes will likely require further refinement through additional investigations. The basic configuration of the model setup is as follows, noting some adjustment to the inflows and corresponding outflows from the previous scenarios have been implemented to address specific scenario requirements, while accounting for an updated understanding of the capacities of current and future structures:

- Filling phase: Inflows of 600 ML/d at each of Margaret Dowling and Deep Creek under a Lock 5 raised pool level of 16.8 m AHD, flows through Tanyaca and Pike River regulators at 250 ML/d and 50 ML/d, respectively over a period of approximately 1 month (note that higher filling rates, and hence reduced rate of filling, may be required in practice for exchange considerations upstream of the blocking alignment);

- Holding phase: Inflows maintained at 600 ML/d at each of Margaret Dowling and Deep Creek under raised Lock 5 level of 16.8 m AHD, flow through Tanyaca regulator varied between 600 and 400 ML/d over a 4 week period, alternating between the flows every 7 days, with the remaining flows (less system losses) exiting Pike River environmental regulator at flows required to maintain an inundation level of 16.4 m AHD. Note that this variation was employed in previous modelling exercises (Water Technology, 2012; McCullough, 2013) to provide variation of flow distribution within the system during the holding phase. This mode of operation may not reflect operation in practice, however the variation was maintained in this scenario to provide an indication of the change in velocity patterns in the floodplain by altering flow split between Pike and Tanyaca regulators; and

- Draining phase: Inflows reduced to 400 ML/d at each of Margaret Dowling and Deep Creek (note that actual operation may require full capacity flows to continue through and/or following the draining phase for exchange considerations, and thus these inflows may require refinement in future scenarios). Flow through Tanyaca and Lower Pike regulators set at 600 ML/d each to maintain reduction in water level at less than 0.1 m/day.

Outputs include plots showing discharges and water levels, and changes to volumes, inundation extent and losses as operation proceeds, as well as maps showing depth and velocity distributions at nominal 10-day intervals over the duration of operation to provide an indication of how inundation proceeds over the duration of managed inundation operation.

Scenario 8 investigated the potential increase in dilution flows that may be achieved into the floodplain by raising Lock 4 weir pool by 1 m, to 14.2 m AHD, under an elevated River Murray flow of 30 000 ML/d, which was considered for the purposes of these scenarios as a potential maximum flow that a Lock 4 weir pool level raising could be conducted under controlled river flow conditions. These scenarios were investigated to provide data on possible future operational measures that may be implemented to mitigate potential water quality issues, in the event that they arise, within the southern sections of floodplain in particular. Scenario 8a considered the floodplain under typical, in-stream operating conditions to allow Banks B, B2 and C to be opened under the raised Lock 4 weir pool, while Scenario 8c considered the system during a managed inundation event at raised Lock 5 weir pool level (16.8 m AHD) and maximum inundation height (i.e. 16.4 m AHD). In both cases, flow through Pike Regulator was controlled to 400 ML/d, with the remainder passing through Tanyaca Regulator. Discharges through contributing streams to Lower Pike River are considered, including Rumpagunyah, Swift, Wood Duck and Tanyaca Creeks, as well as discharge through the Pike River regulator. Direction of flow in Rumpagunyah Creek is of particular interest, which can flow either towards the River Murray or towards the floodplain depending on hydraulic conditions. For comparison purposes for these scenarios, the results were compared to simulations with identical flow configurations, with the exception of Lock 4 pool level set at normal water level (i.e. 13.2 m AHD) in order to isolate the specific effect on floodplain inflows from raising Lock 4 at raised river flows, designated as Scenario 8b (in-stream conditions) and 8d (inundation to 16.4 m AHD). Velocity maps and distribution plots throughout the floodplain were additionally presented.

A further suite of scenarios (Scenario 9) was developed to investigate the impact of potential floodplain structure operational schemes on velocity conditions generated in relevant creeks impacted directly by structure operations. Relevant creeks investigated included Deep Creek and Margaret Dowling Creek with respect to the inlet regulators; Tanyaca Creek with respect to the Tanyaca environmental regulator (note that the section of Pike Creek below the Pike environmental regulator was not considered due to the relatively short length of creek between the regulator and the Rumpagunyah junction); and Mundic Northern Outlet for the Mundic Northern Outlet regulator (note that for the purposes of this modelling and due to the number of operational scenarios that are possible for the Mundic outlet creeks into Pike River, other Mundic outlets, at the Mundic Southern Outlet and Snake Creek, were considered closed, with only Mundic Northern outlet and Tanyaca Creek controlling outflows from Mundic – this may not represent actual operation of the Mundic outlet regulators however). The configuration of simulations for each operational regime are presented in Table 2.3, including target water levels upstream and downstream of each relevant structure that may be encountered during each operational regime.

Table 2.3 Operating regimes for velocity profile analysis by floodplain stream

Floodplain stream	Operating regime	Regulator U/S level m AHD	Tailwater level m AHD	Regulator discharge ML/d	Comments
Deep Creek	Baseflow – low inflow	16.3	≥14.75	400	
	Baseflow – high inflow/ Spring fresh – low tail water	16.3	≥14.75	600	
	Spring fresh – high tail water	16.3	15.6	600	
	Floodplain inundation – low inflow	16.8	16.4	400	
	Floodplain inundation – high inflow	16.8	16.4	600	
Margaret Dowling	Baseflow – low inflow	16.3	≥14.75	400	Maximum flow at normal Lock 5
	Baseflow – high inflow/ Spring fresh – low tail water	16.3	≥14.75	500	pool level (16.3 m AHD) is modelled at ~500 ML/d, and this
	Spring fresh – high tail water	16.3	15.6	500	therefore sets the maximum flow
	Floodplain Inundation – low inflow	16.8	16.4	400	investigated at these levels
	Floodplain Inundation – high inflow	16.8	16.4	600	
Tanyaca Creek	Low flow – low tailwater	≥14.75	TBA	400	Downstream (tailwater) level to
	Mod flow – low tailwater	≥14.75	TBA	600	be determined via modelling in
	Max outflow – low tailwater	≥14.75	TBA	800	each case.
	Low flow – mod tailwater	≥14.75	TBA	400	
	Mod flow – mod tailwater	≥14.75	TBA	600	Scenarios are tested at Lock 4
	Max outflow – mod tailwater	≥14.75	TBA	800	pool levels of 13.2 and 14.2

Floodplain stream	Operating regime	Regulator U/S level m AHD	Tailwater level m AHD	Regulator discharge ML/d	Comments
	Low flow – high tailwater	≥14.75	TBA	400	m AHD
	Mod flow – high tailwater	≥14.75	TBA	600	
	Max outflow – high tailwater	≥14.75	TBA	800	
Mundic Northern Outlet	Low flow	≥14.75	14.35	245	Assumes regulators at other eastern Mundic outlets are in place and set to closed.
	Spring fresh – low flow	15.6	14.35	500	
	Spring fresh – high flow	15.6	14.35	600	

For the simulations conducted under Scenario 9, structures at the inlets (Deep Creek and Margaret Dowling Creek) were operated against draft operational regimes proposed for the Pike Floodplain at the time of modelling (Tonkin Consulting 2015, *pers. comm.*, 29 April), which in essence include: baseflow conditions, spring fresh events, and floodplain managed inundation events. Different flow and tailwater conditions were considered in each case. Mundic northern outlet simulations were only considered at baseflow and spring fresh operational regimes given that the Mundic outlets to Pike River are considered fully open during a managed inundation event. Tanyaca Creek simulations had the focus of investigating the impact of flows through the regulator and tailwater levels, as influenced by River Murray flows and Lock 4 upstream levels. For all simulation conducted, velocity distributions within the creeks directly downstream of each regulator were produced.

The following sections present the outputs of each scenario conducted, including water depth and spatial distribution, velocity distribution and velocity profiles in selected creeks, and targeted hydraulic data including water level and discharge as required. Where velocity profiles are developed in various creeks, the locations of each creek on which these profiles are based are shown in Figure 2.1 (note that velocity profiles for the entire impounded area of various scenarios are also presented in Appendix A for reference). Note that in Scenarios 1 to 7, velocity profiles have been analysed from the modelled 2-D outputs based on wetted area, as the creeks of importance in these scenarios (e.g. sections of Pike River) are only based in the 2-D portion of the model. In Scenarios 8 and 9 however, this velocity analysis has been altered to be based on stream length from 1-D results by necessity, given that some of the specific creeks in focus for these scenarios (e.g. Deep Creek, Margaret Dowling, Swift and Wood Duck Creeks) are represented in 1-D in the model configuration, and their small size does not translate adequately to the 2-D output.

Summary tables, which include discharge (inflow and outflow), water level, inundation area, volume, and daily turnover rate (i.e. percentage of outflow divided by impounded volume) have also been developed for steady-state scenarios where a whole of floodplain analysis approach has been used. These summary tables present the hydraulics from a total floodplain perspective, upstream of the blocking alignment, and also divide the floodplain into two sections, namely Mundic Creek–Tanyaca Creek on the western side of the floodplain and Pike River (including Mundic Creek outlets and Snake Creek) on the eastern side of the floodplain, as indicated by the white and green dashed lines in Figure 2.1, respectively. Note that turnover in the Mundic–Tanyaca section of floodplain is calculated based on total outflows from Mundic Creek, including through Tanyaca Creek and Pike River, while turnover in the Pike River section of the floodplain is based on flow over the Pike River regulator only.

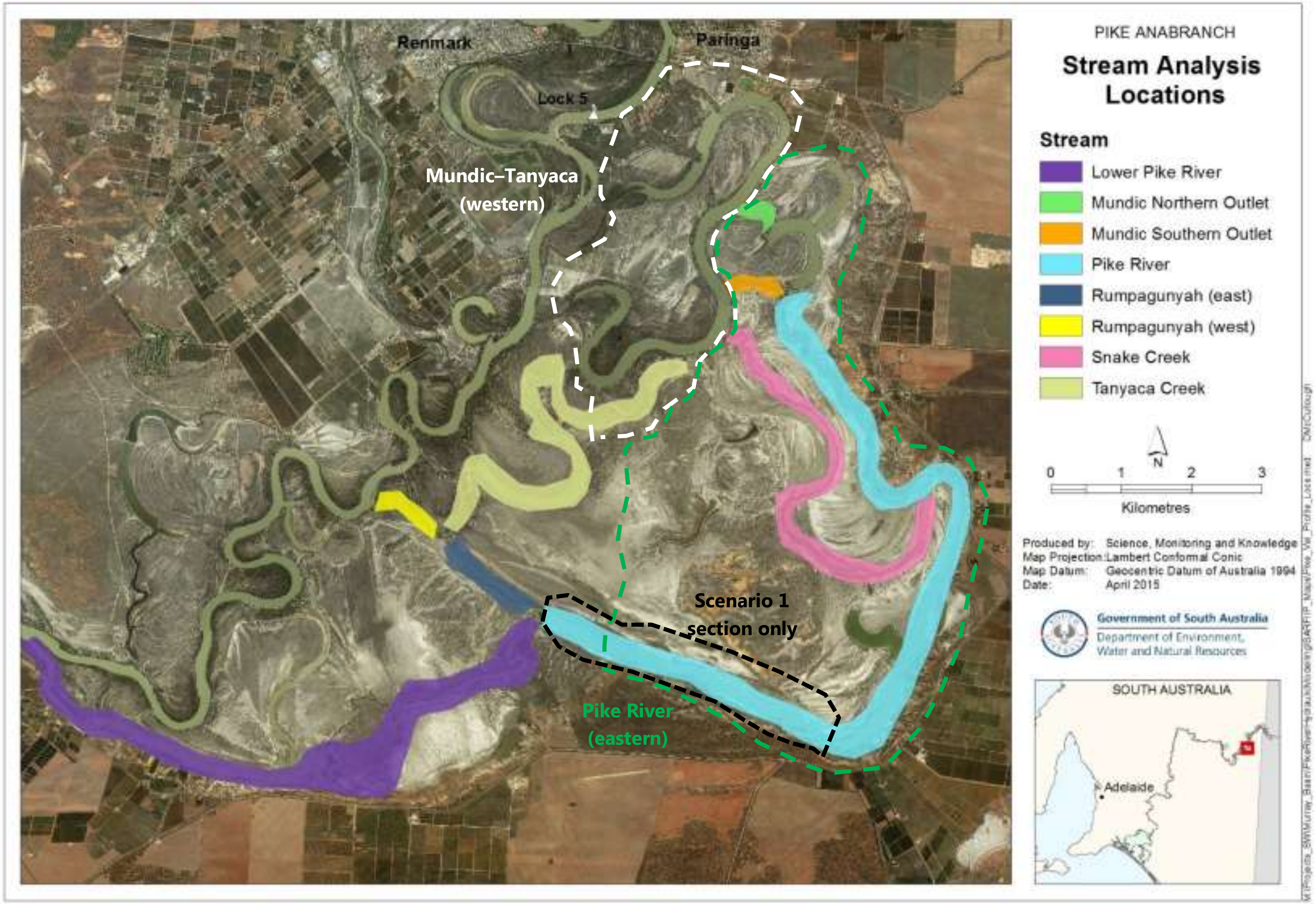

Figure 2.1 Stream locations where velocity profiles are acquired. Green and white dashed lines indicate division of floodplain areas for summary information, while black dashed line indicates area of Pike River considered under Scenario 1 only (i.e. below eastern regulator location).

3 Scenario 1 – Hydraulic effects of relocating the concept design regulator placement

3.1 Hydraulic results

Scenario 1 involves four simulations designed to compare the floodplain hydraulics when locating the Pike regulator at alternative locations, namely at the current Col Col Bank site (eastern Pike regulator alternative) and at a western location, immediately upstream of the Rumpagunyah Creek junction in Pike River. Velocity distribution analysis on a stream by stream basis is framed from the point of view of the original concept design location of the Pike regulator (URS, 2010), focusing on the impact of relocating the regulator placement to the western location on potential changes in in-stream velocities within the southern section of the floodplain, specifically in Rumpagunyah and Pike River, below the eastern (concept design) regulator alternative. For completeness, different blocking alignments are also applied to the bathymetry for eastern and western placements, where the eastern placement involves the original concept blocking alignment while the western placement involves the Alternative 3 alignment.

An inflow of 1200 ML/d to the anabranch was used at a River Murray inflow (upstream of Lock 5) of 10 000 ML/d, with Locks 4 and 5 set at normal upper pool levels of 13.2 m AHD and 16.3 m AHD, respectively. Flow was controlled through Tanyaca regulator, while the remainder of flow passed through Pike regulator at a typical target upstream level of 14.35 m AHD for the eastern regulator location. For the purposes of these specific scenarios, the water levels directly upstream of the western Pike regulator were controlled to a lower elevation than 14.35 m AHD (i.e. 14.315 m AHD for 400 ML/d through Pike River, and 14.300 m AHD for 600 ML/d) to account for water level gradient in the reach between eastern and western locations. This difference in control ensured that water levels upstream in the Pike Floodplain system (e.g. upper reaches of Pike River, Mundic Creek, etc.) were consistent for a given flow, regardless of Pike regulator location (i.e. in order to maintain consistency in levels and volumes, and hence velocities, upstream in the floodplain). Water levels upstream of the western Pike regulator placement were set by iteratively changing the controlled upstream water level at regulator until water levels upstream in Pike River were relatively consistent with that of the eastern location for a given flow split between the Pike River and Tanyaca Creek regulators.

Scenarios 1a and 1b investigate the difference in velocity distribution between eastern and western regulator locations with a flow over Tanyaca regulator of 600 ML/d, while Scenarios 1c and 1d investigate the system at a Tanyaca flow of 400 ML/d. A specified loss of 200 ML/d was applied as a model point extraction from Mundic Creek to account for losses such as evaporation and irrigator extractions for the purposes of the simulations.

Modelled outputs focus on velocity distribution in the Pike–Rumpagunyah area in the southern part of the anabranch, with the change in distribution observed with alternative Pike regulator placements and the regulator maintaining the current water level height (i.e. 14.35 m AHD) under baseflow conditions.

Figure 3.1 and Figure 3.2 show the velocity distribution and direction of flow at a set Tanyaca Creek flow of 600 ML/d for the system with the Pike regulator situated at the eastern (existing Col Col Bank) site (Scenario 1a) and downstream of this site (Scenario 1b), respectively. Velocities in the reach below Col Col Bank are shown to be significantly reduced under the western Pike regulator placement scenario compared to the eastern regulator placement (at the existing Col Col Bank site). A mathematical comparison of the velocities over the entire floodplain between these scenarios is shown by the velocity difference map indicated in Figure 3.3. The only difference observed is in the reach directly downstream of the eastern regulator placement, with a difference of up to 0.10 m/s for the majority of the reach. This difference is due to the greater volume, and hence cross sectional area, existing upstream of the western regulator location when compared to the eastern location, whereas volumes and hence velocities are not impacted elsewhere in the floodplain for a given flow split between the regulators.

Figure 3.4 and Figure 3.5 show velocity distribution and flow direction for a Tanyaca flow of 400 ML/d for eastern (Scenario 1c) and western (Scenario 1d) alternative regulator placements, respectively. Similar to the case of 600 ML/d through Tanyaca

Creek (Figure 3.3), velocity differences between the scenarios are observed only in the reach between eastern and western Pike regulator placements, with the remainder showing negligible difference in velocities, as indicated in Figure 3.6.

Flow paths shown in Figure 3.1 and Figure 3.2 indicate flow from Tanyaca Creek (at 600 ML/d) partitions at the junction with Rumpagunyah, with approximately half of the flow entering the Lower Pike and the remainder flowing to the west into the River Murray. Flow paths in Figure 3.4 and Figure 3.5 for a Tanyaca flow of 400 ML/d are similar to those shown for the 600 ML/d Tanyaca flow case, however the velocities are biased towards the western side of Rumpagunyah. This redistribution results in a flow through Rumpagunyah to the River Murray of approximately 270 ML/d, with the remainder (approximately 130 ML/d) diverting towards Lower Pike River.

Figure 3.7 indicates the difference in velocity generated throughout the anabranch between Tanyaca Creek flows at 600 ML/d (Scenario 1a) and 400 ML/d (Scenario 1c) for Pike regulator at the eastern location, while Figure 3.8 indicates the velocity difference between the corresponding Tanyaca flows (Scenarios 1b and d) with the regulator positioned at the western location. In each case, lowering the flow through Tanyaca Creek from 600 ML/d to 400 ML/d results in reduced velocity through Mundic Creek (between Deep Creek and Bank D), Tanyaca Creek and Rumpagunyah Creek, with velocities increasing in Mundic Creek outlets (Northern, Southern and Snake Creek), Pike Lagoon and Pike Creek. This behaviour in velocity highlights an apparent split in the hydraulic behaviour of the floodplain, with Tanyaca Creek regulator having the largest influence on velocity from Mundic Creek through Tanyaca and Rumpagunyah Creeks, while the Pike regulator has the largest influence from Mundic Northern and Southern outlets, Snake Creek, and Pike River. This behaviour may present implications with operational management of water quality and exchange rates within the floodplain during a managed inundation event, such as required regulator flow splits. This split is used to assess the volume detained by the two main structures (Tanyaca and Pike regulators).

Velocity distributions by wetted area in Pike River downstream of the eastern regulator placement (as shown by the area enclosed in the black dashed line in Figure 2.1), in Rumpagunyah Creek (divided into western and eastern sections as in Figure 2.1) and in Lower Pike (below the Pike River–Rumpagunyah junction, as in Figure 2.1) are shown in Figure 3.9 to Figure 3.12, respectively. These plots are calculated based on the number of modelled cells present spatially in a given velocity range, in 0.05 m/s increments from 0 to >0.35 m/s. As indicated in the velocity maps above, the main differences in velocity distribution for a given flow regulator flow split are shown in the reach below the eastern regulator placement resulting from the alternate regulator placements, with other reaches showing similar velocity distributions for a given flow split regardless of Pike regulator placement. Note however that altering the flow split from 600 ML/d to 400 ML/d at Tanyaca regulator shows a change in velocity distribution in all reaches downstream of the regulators (note that velocity distributions upstream of the regulators also vary with flow split as evidenced by mapped velocity differences in Figure 3.7 and Figure 3.8, but these are not included in the velocity distribution analysis owing to the focus of these scenarios). In all reaches analysed, the velocities are predominantly distributed in the slow to moderate velocity categories up to 0.10 m/s at the baseflow conditions investigated.

Hydraulic characteristics of the total floodplain upstream of the blocking alignment, as well as in the floodplain split between Mundic–Tanyaca creeks and Pike River, are indicated in Table 3.1. The results indicate that the additional volume contained behind the Pike regulator in the western location (almost 700 ML/d by difference under both flow splits investigated) reduces the turnover rate for a given Pike River flow (e.g. at 400 ML/d through Pike River, a turnover of 27% is modelled in the Pike River side of the floodplain at the eastern regulator location, compared with 18% at the western location), while the turnover rate in Mundic–Tanyaca creeks remains constant for a given Tanyaca regulator flow (e.g. 41% for the same flow split). Note that the turnover rate for the Mundic–Tanyaca side of the floodplain is based on all outflow from Mundic Creek, including Tanyaca regulator and through Pike River. Overall turnover rate in the floodplain across all scenarios varies between 20 to 25%. Comparing these results to current, in-channel floodplain conditions at 10 000 ML/d River Murray flow, modelled data indicates a total system volume of approximately 4000 ML when assuming the same coverage area of the western regulator placement, providing an overall turnover rate of approximately 5% against an outflow of approximately 200 ML/d through Pike River (i.e. approximately 300 ML/d total inflow through Margaret Dowling Creek and Deep Creek less losses).

Reducing outflow over Tanyaca regulator is also observed to increase total volume through the system for a given Pike regulator location. This effect is expected given that Tanyaca Creek is the naturally dominant flow path as indicated in McCullough (2013), and as such restriction of flow through this creek has a substantial impact on system hydraulics.

Table 3.1 Summary of hydraulic characteristics for Scenarios 1a to d

Scenario	Total inflow ML/d	Parameter	Units	Mundic-Tanyaca Creek	Pike River	Total
1a	1200	Outflow[1]	ML/d	600	400	1000
		Volume	ML	2456	1492	3948
		Turnover[2]	%	41	27	25
		Water Level[3]	m AHD	14.69	14.35	-
		Wetted Area	ha	170	175	345
1b	1200	Outflow[1]	ML/d	600	400	1000
		Volume	ML	2456	2179	4635
		Turnover[2]	%	41	18	22
		Water Level[3]	m AHD	14.69	14.35	-
		Wetted Area	ha	170	230	400
1c	1200	Outflow[1]	ML/d	400	600	1000
		Volume	ML	2736	1589	4325
		Turnover[2]	%	37	38	23
		Water Level[3]	m AHD	14.84	14.35	-
		Wetted Area	ha	187	178	365
1d	1200	Outflow[1]	ML/d	400	600	1000
		Volume	ML	2737	2279	5016
		Turnover[2]	%	37	26	20
		Water Level[3]	m AHD	14.84	14.35	-
		Wetted Area	ha	187	234	421

[1] Outflow from regulating structures in Tanyaca and Pike for respective floodplain sections (combined for total floodplain)
[2] Outflow as a percentage of total volume (Mundic–Tanyaca Creek sections includes outflow from both Tanyaca and Pike sections)
[3] Water level upstream of each relevant structure (not applicable for total floodplain)

Figure 3.1 Velocity and flow direction in the Pike Floodplain for Tanyaca regulated flow of 600 ML/d and eastern Pike regulator alternative (Scenario 1a)

Figure 3.2 Velocity and flow direction in the Pike Floodplain for Tanyaca regulated flow of 600 ML/d and western Pike regulator alternative (Scenario 1b)

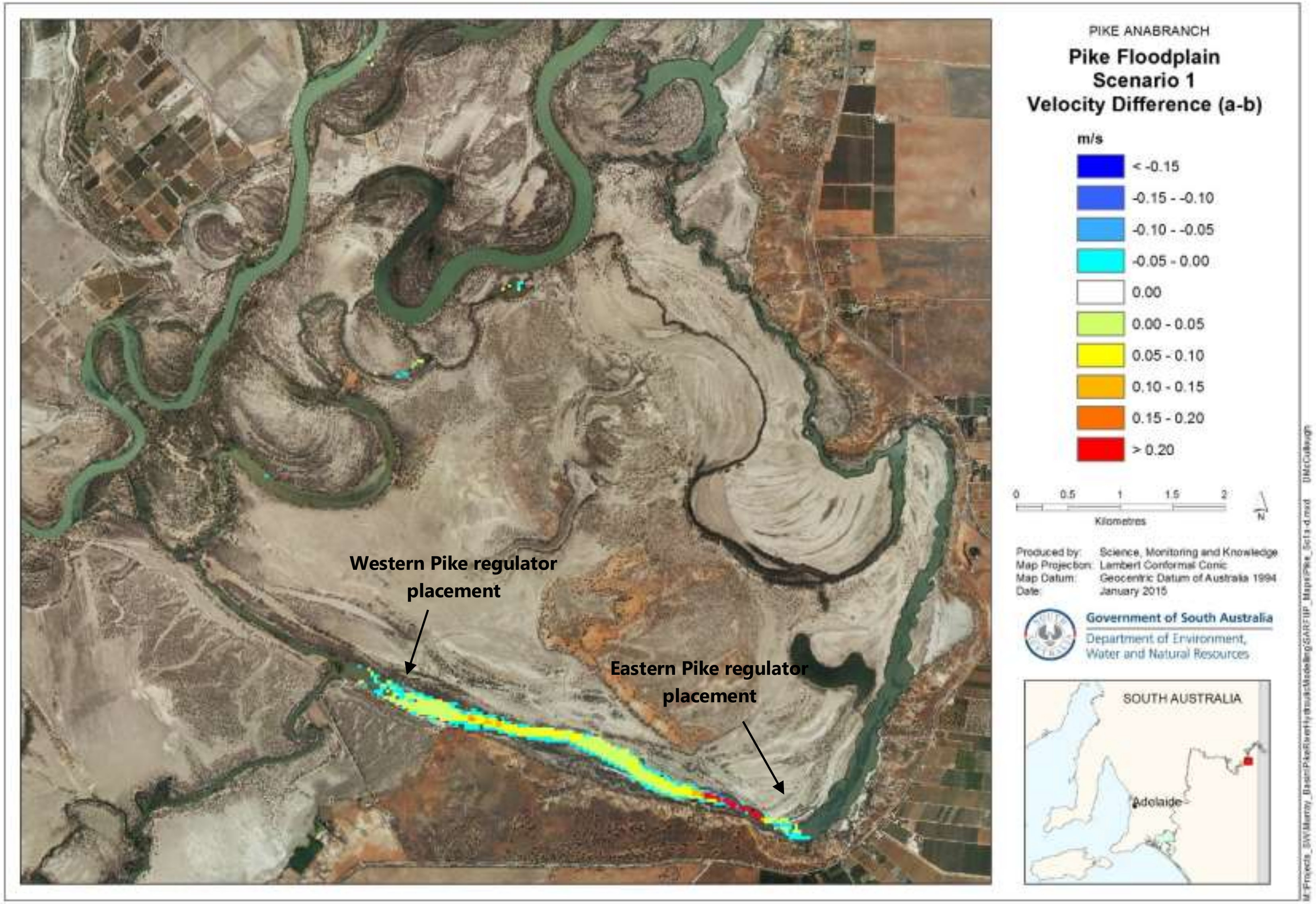

Figure 3.3 Velocity difference over entire floodplain between alternative Pike regulator placements for a Tanyaca regulated flow of 600 ML/d

Figure 3.4 Velocity and flow direction in the Pike Floodplain for Tanyaca regulated flow of 400 ML/d and eastern Pike regulator alternative (Scenario 1c)

Figure 3.5 Velocity and flow direction in the Pike Floodplain for Tanyaca regulated flow of 400 ML/d and western Pike regulator alternative (Scenario 1d)

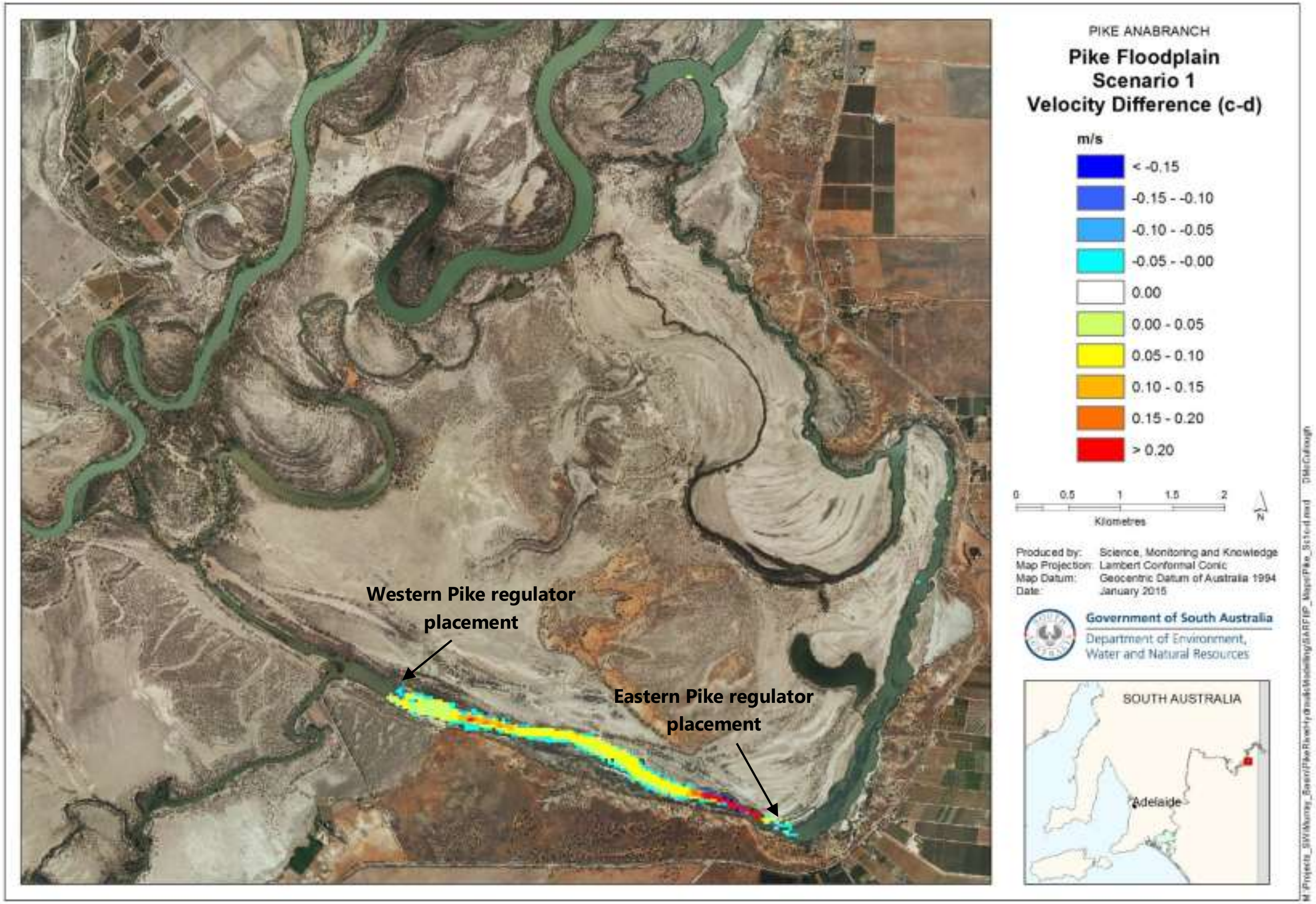

Figure 3.6 Velocity difference over entire floodplain between alternative Pike regulator placements for a Tanyaca regulated flow of 400 ML/d

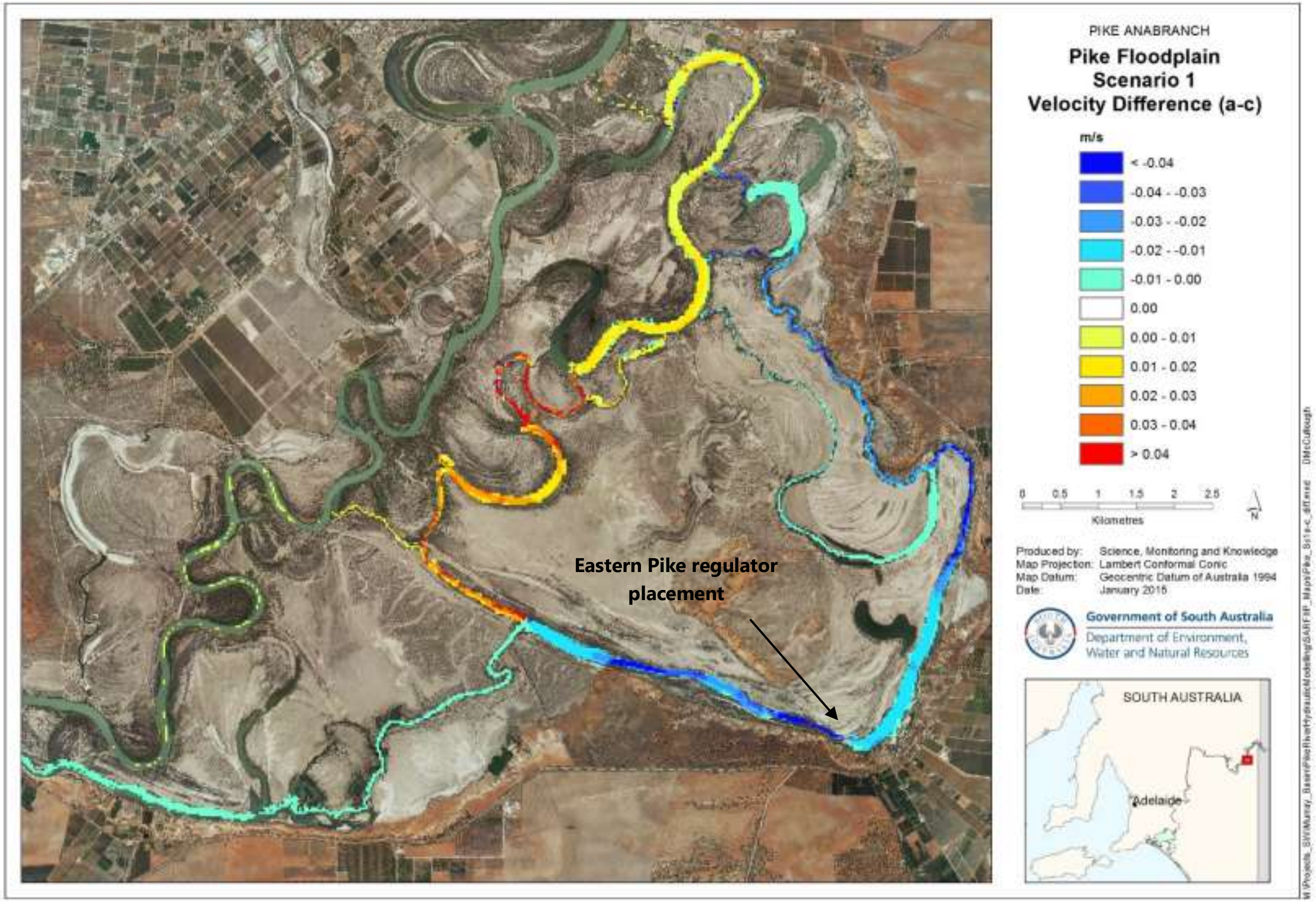

Figure 3.7 Velocity difference over entire floodplain with eastern Pike regulator alternative between Tanyaca flows of 600 and 400 ML/d, respectively

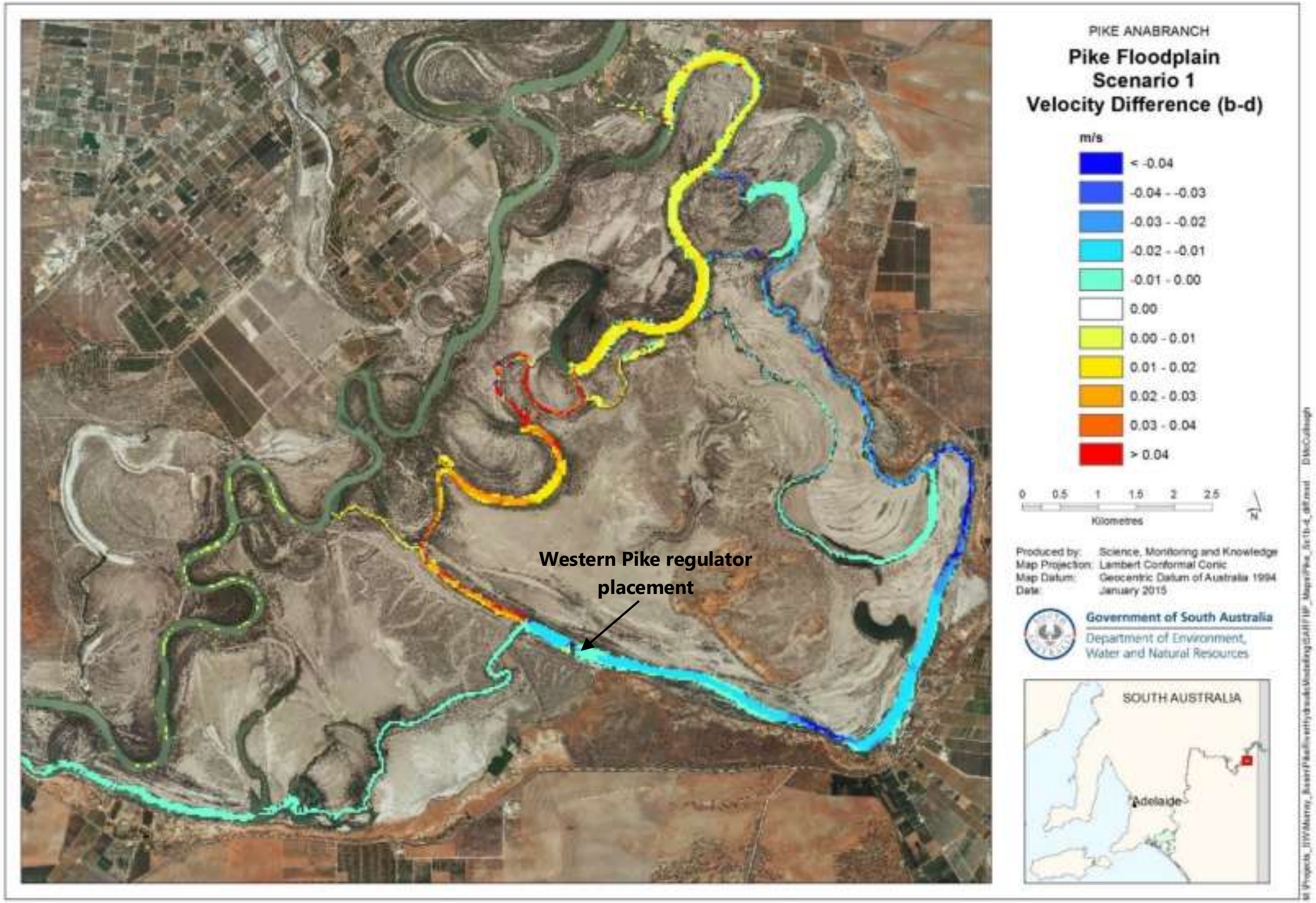

Figure 3.8 Velocity difference over entire floodplain with western Pike regulator alternative between Tanyaca flows of 600 and 400 ML/d, respectively

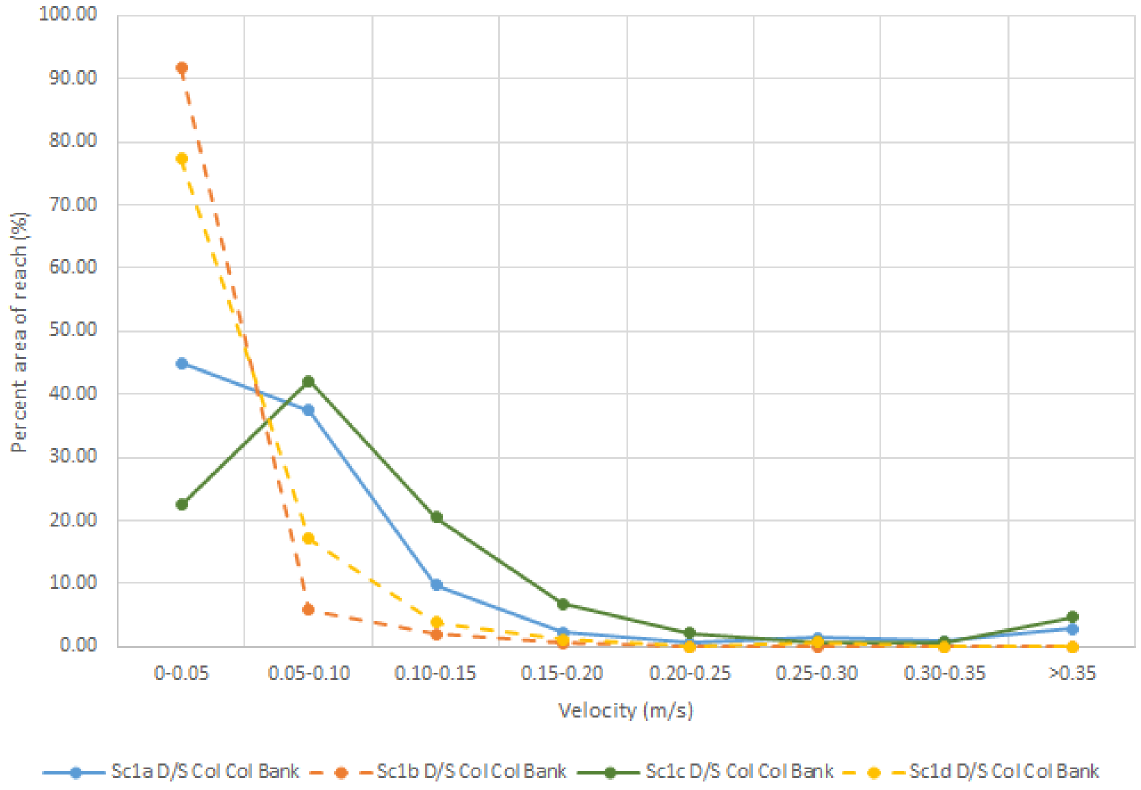

Figure 3.9 Velocity distribution by percent of reach downstream of existing Col Col Bank (i.e. eastern regulator placement) for Scenarios 1a to 1d (refer to Figure 2.1 for location, enclosed in black dashed line)

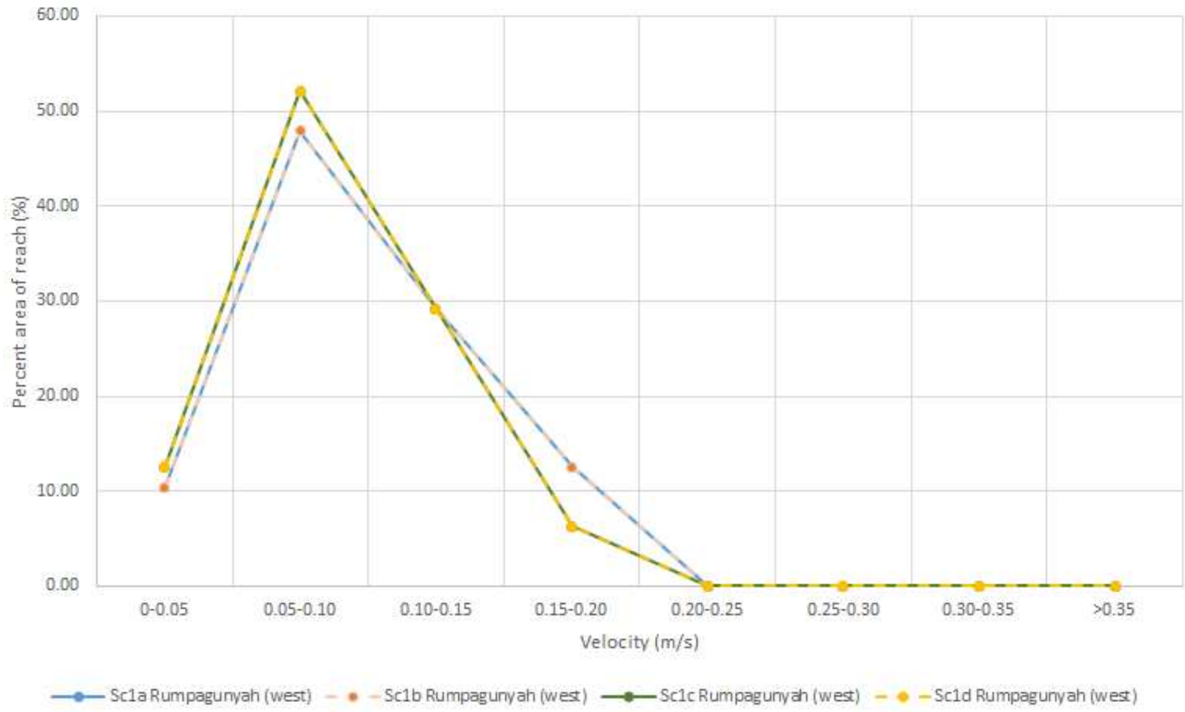

Figure 3.10 Velocity distribution by percent of reach in western section of Rumpagunyah Creek (between River Murray and Tanyaca outlet into Rumpagunyah) for Scenarios 1a to 1d (refer to Figure 2.1)

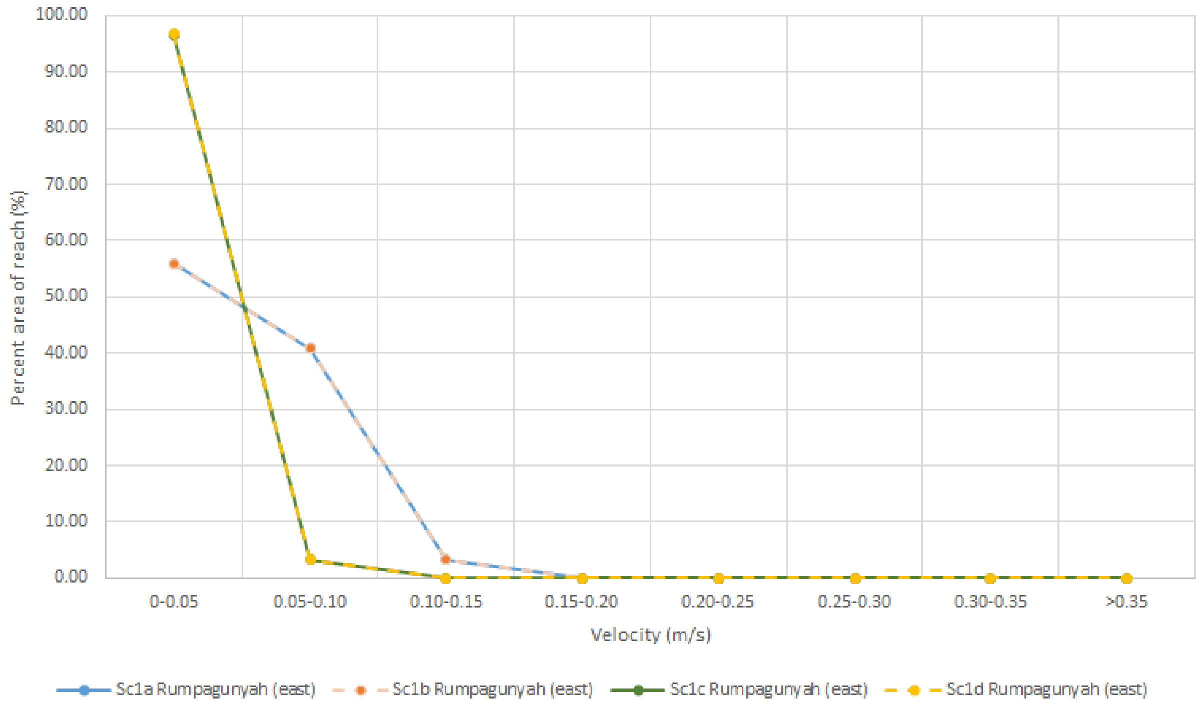

Figure 3.11 Velocity distribution by percent of reach in eastern section of Rumpagunyah Creek (between Pike River and Tanyaca outlet into Rumpagunyah) for Scenarios 1a to 1d (refer to Figure 2.1 for location)

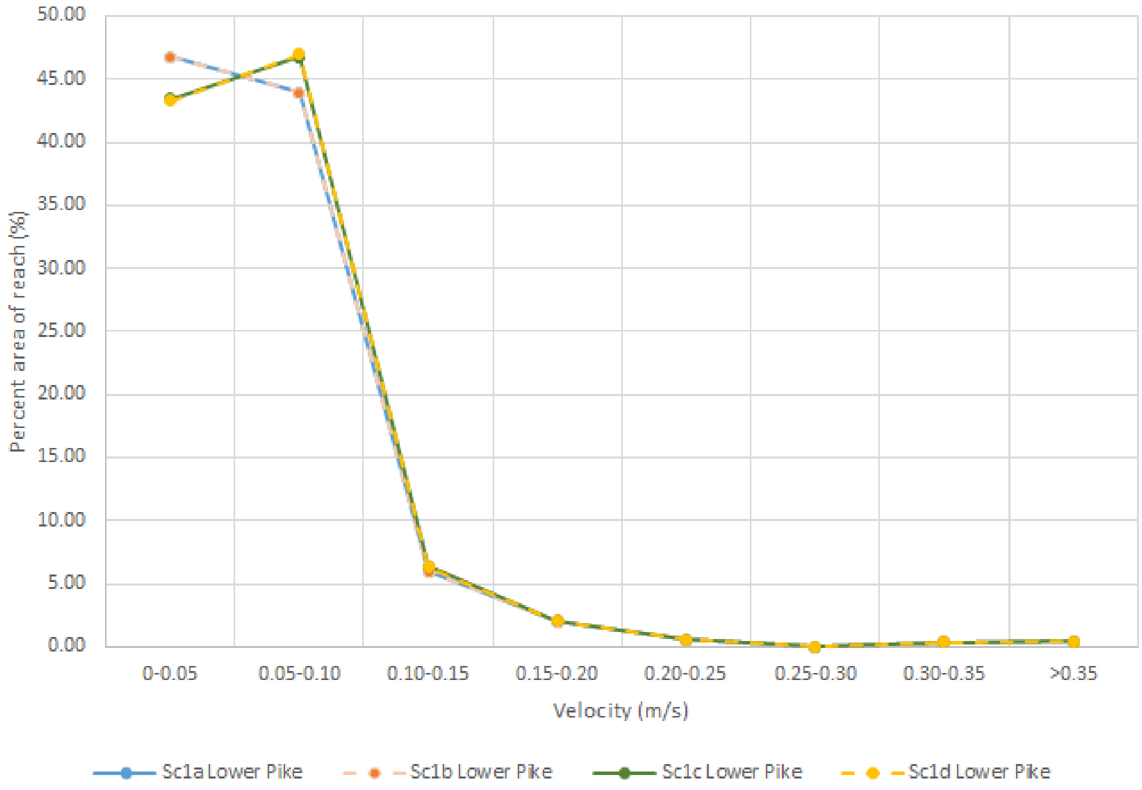

Figure 3.12 Velocity distribution by percent of reach in Lower Pike (downstream of Rumpagunyah) for Scenarios 1a to 1d (refer to Figure 2.1 for location)

4 Scenario 2 – Impact of increasing floodplain inflow and variation of Tanyaca regulator outflow

4.1 Hydraulic results

Scenario 2 investigates the impact of varying inflows and outflows (via Tanyaca regulator) from the area upstream of the blocking alignment on hydraulics through the system. Inflow is varied from 800 to 1200 ML/d across Scenarios 2a to 2c to reflect potential normal operating flow with upgraded structures and the maximum expected flow, respectively. The corresponding Tanyaca flow is varied from 400 to 800 ML/d. River Murray conditions are the same as for Scenario 1, while the upstream water level at Pike regulator in the western location differs by controlling to the standard control level of approximately 14.35 m AHD (note this control level is also applied in the remaining scenarios where in-channel conditions persist). The western Pike regulator placement is used for this and the remaining scenarios given that indications following completion of Scenario 1 are that placing the regulator at the eastern location will not be the preferred option due to a number of considerations, including Cultural Heritage and accessibility. Note that losses due to evaporation are calculated using similar methodology as in McCullough (2013) i.e. the maximum daily pan evaporation rate (9.5 mm/d for January from the nearest Bureau of Meteorology weather station at Loxton) is applied at a constant rate over the total inundated area upstream of the blocking bank to provide volume lost to evaporation per day. Losses in scenarios 3 to 5 are also applied in the same manner.

Results of the simulations against floodplain inflow and Tanyaca regulator outflow conditions are presented in Table 4.1, while a summary of hydraulic characteristics of the floodplain divided into Mundic and Pike sections is shown in Table 4.2. Water level in Mundic Creek (upstream of Tanyaca regulator) is equivalent in Scenarios 2a and 2c given the additional inflow is being matched by the additional outflow at Tanyaca regulator. Discharges through the outlets (Northern, Southern and Snake Creek) are also similar between the two simulations, although slightly greater in the Northern and Southern outlets for Scenario 2c. This marginal additional flow in Scenario 2c may be a result of an increase in the water level profile through Mundic Creek with the greater inflow of 1200 ML/d, thereby causing a greater flow to exit through the Northern and Southern Mundic outlets. Scenarios 2a and c also show an equivalent volume in the Pike River (eastern) side, with a similar total flow existing through the Mundic Creek outlets into Pike River.

The combination of maximum inflow (1200 ML/d) and 400 ML/d through Tanyaca Creek in Scenario 2b shows a Mundic Creek water level approximately 0.3 m greater than the other simulations, at 14.98 m AHD. This results in approximately double the flow through Northern and Southern Mundic Outlets and almost triple the flow through Snake Creek compared to Scenarios 2a and c. Note that the current water level in Mundic Creek with existing structures is approximately 14.75 m AHD, indicating the removals of banks and structure upgrades will not result in a substantial reduction in water level from current conditions in Mundic Creek, provided that increased inflows can be achieved from pre-upgrade conditions (i.e. approximately 300 ML/d total).

Table 4.1 Mundic Creek water level and flow distribution through the Mundic outlets (northern, southern and Snake Creek) for Scenarios 2a to 2c

Scenario	Inflow (ML/d)	Tanyaca outflow (ML/d)	Water level U/S Tanyaca regulator (m AHD)	Discharge Snake Creek* (ML/d)	Discharge northern Mundic outlet* (ML/d)	Discharge southern Mundic outlet* (ML/d)
2a	800	400	14.69	16	245	140
2b	1200	400	14.98	44	493	263
2c	1200	800	14.69	16	254	143

* Discharges not adjusted for calculated evaporation loss from Table 4.2

Water depth and spatial distribution is presented in Figure 4.1, Figure 4.3 and Figure 4.5 for Scenarios 2a, b and c, respectively. The main difference is observed in the spatial extent in Scenario 2b (Figure 4.3), with minor breakout in the Mundic Creek fringe occurring under the higher water level conditions. Scenario 2a (Figure 4.1) and 2c (Figure 4.5) show the extent remaining in-channel given the water level is approximately equal to the actual Mundic Creek height at existing floodplain conditions (i.e. approximately 14.75 m AHD).

Corresponding velocity distributions and direction for the three simulations are shown in Figure 4.2, Figure 4.4 and Figure 4.6. Again, the main difference is seen in Scenario 2b (Figure 4.4), with velocity noticeably greater in the Northern and Southern Mundic Outlets. This observation is supported by velocity profiles in the various creeks, as shown in Figure 4.7 to Figure 4.14. The velocity distribution data are also summarized in Table 4.3 to Table 4.10. The waterways on the eastern side of the floodplain, including Mundic northern, southern and Snake Creek outlets and Upper Pike River have velocity distributions biased to the higher velocity categories under Scenario 2b compared to 2a and c. Conversely, the main change in Tanyaca Creek velocity distribution is observed with Scenario 2c, where outflows are raised to 800 ML/d. Velocity distribution in the River Murray (western) side of Rumpagunyah are biased towards higher velocities for both Scenario 2b and 2c, suggesting that the inflow through Margaret Dowling and Deep Creeks has a significant influence on the diversion of flow from Tanyaca Creek to the River Murray. Note that similar behavior in velocity distribution is also observed in the Lower Pike River.

Table 4.2 Summary of hydraulic characteristics for Scenarios 2a to c

Scenario	Total inflow ML/d	Parameter	Units	Mundic–Tanyaca Creek	Pike River	Total
2a	800	Outflow[1]	ML/d	400	362	762
		Volume	ML	2417	2215	4632
		Turnover[2]	%	31	18	16
		Water Level[3]	m AHD	14.69	14.35	-
		Wetted Area	ha	169	233	402
		Evaporative Loss[4]	ML/d	16	22	38
2b	1200	Outflow[1]	ML/d	400	762	1162
		Volume	ML	3005	2472	5477
		Turnover[2]	%	38	32	21
		Water Level[3]	m AHD	14.98	14.35	-
		Wetted Area	ha	214	244	458
		Evaporative Loss[4]	ML/d	20	23	43
2c	1200	Outflow[1]	ML/d	800	362	1162
		Volume	ML	2454	2223	4677
		Turnover[2]	%	47	18	25
		Water Level[3]	m AHD	14.69	14.35	-
		Wetted Area	ha	171	233	404
		Evaporative Loss[4]	ML/d	16	22	38

[1] Outflow from regulating structures in Tanyaca and Pike for respective floodplain sections (combined for total floodplain)
[2] Outflow as a percentage of total volume (Mundic–Tanyaca Creek sections includes outflow from both Tanyaca and Pike sections)
[3] Water level upstream of each relevant structure (not applicable for total floodplain)
[4] Based on the long term average daily evaporation of 9.5 mm/d for January from the nearest BoM weather station

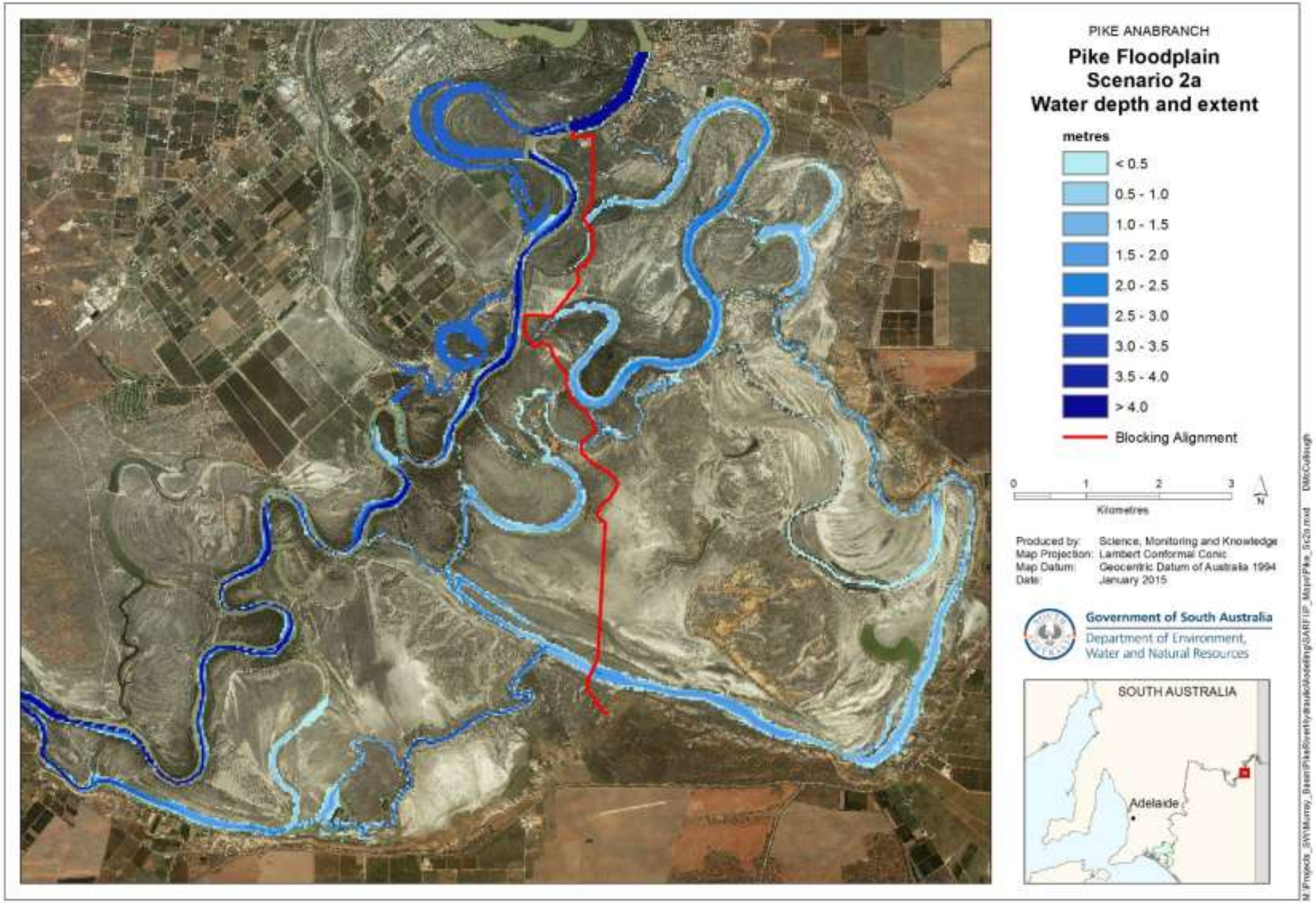

Figure 4.1 Water depth and extent for an inflow of 800 ML/d and Tanyaca flow of 400 ML/d (Scenario 2a)

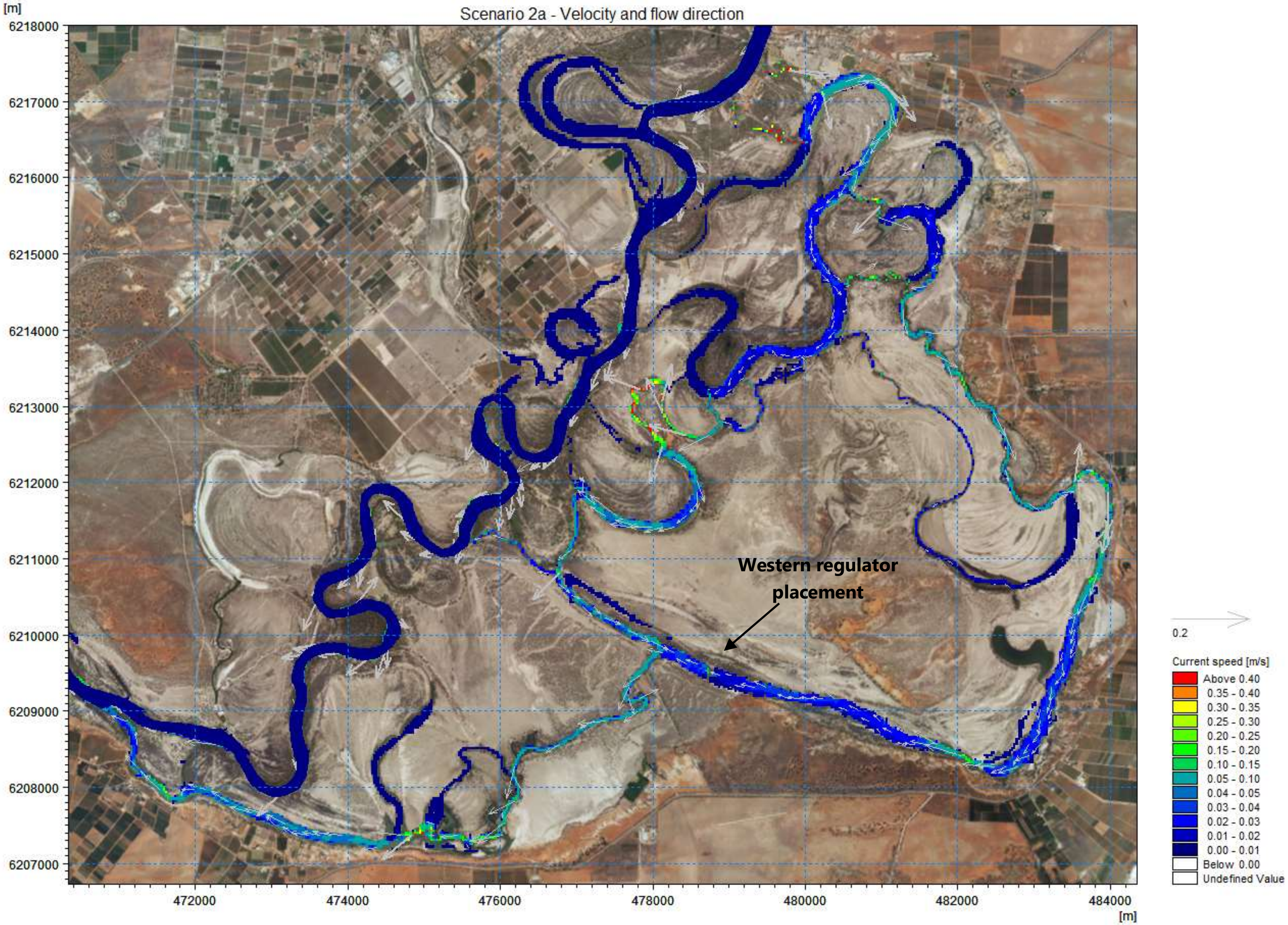

Figure 4.2 Velocity and flow direction for an inflow of 800 ML/d and Tanyaca flow of 400 ML/d (Scenario 2a)

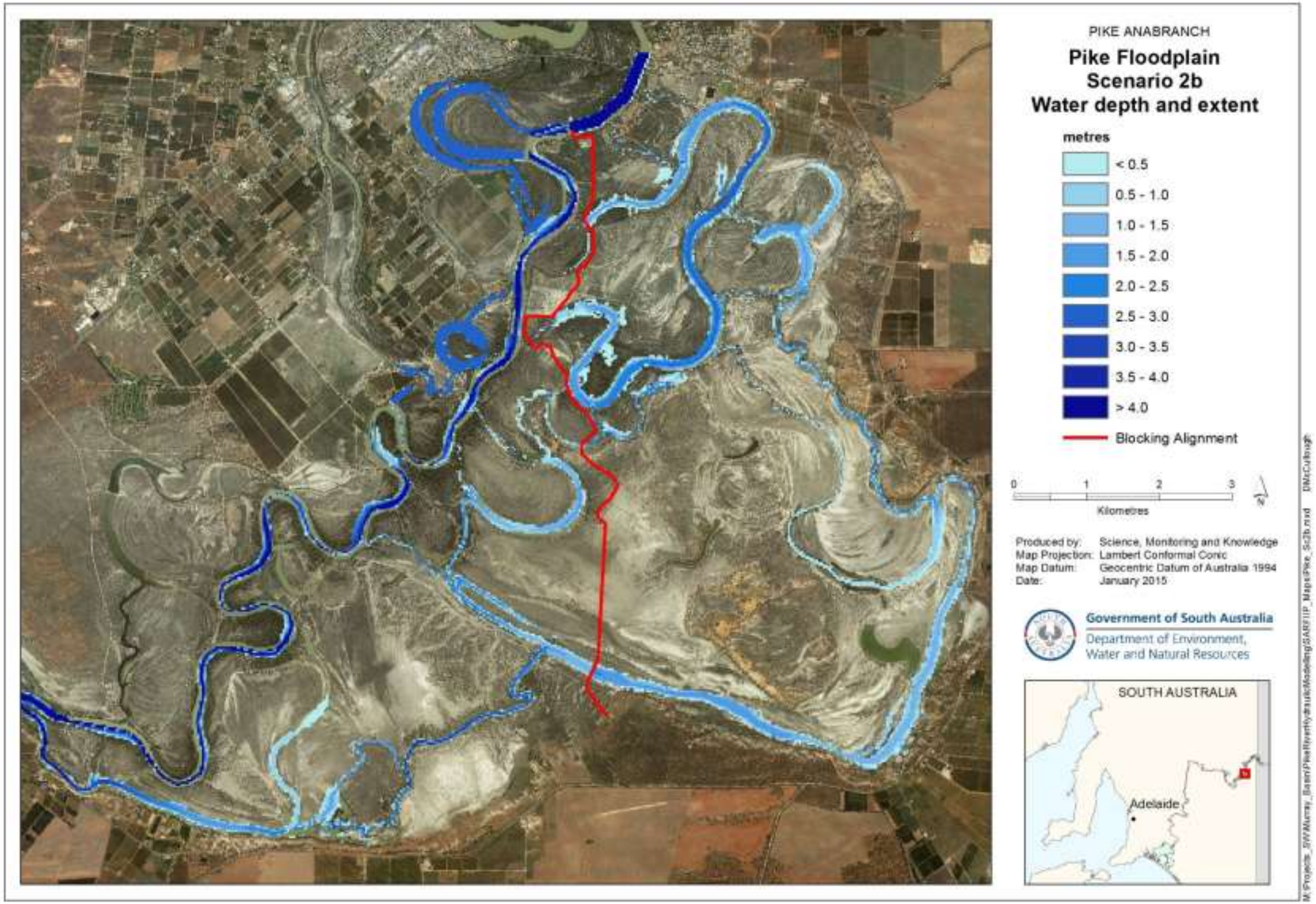

Figure 4.3 Water depth and extent for an inflow of 1200 ML/d and Tanyaca flow of 400 ML/d (Scenario 2b)

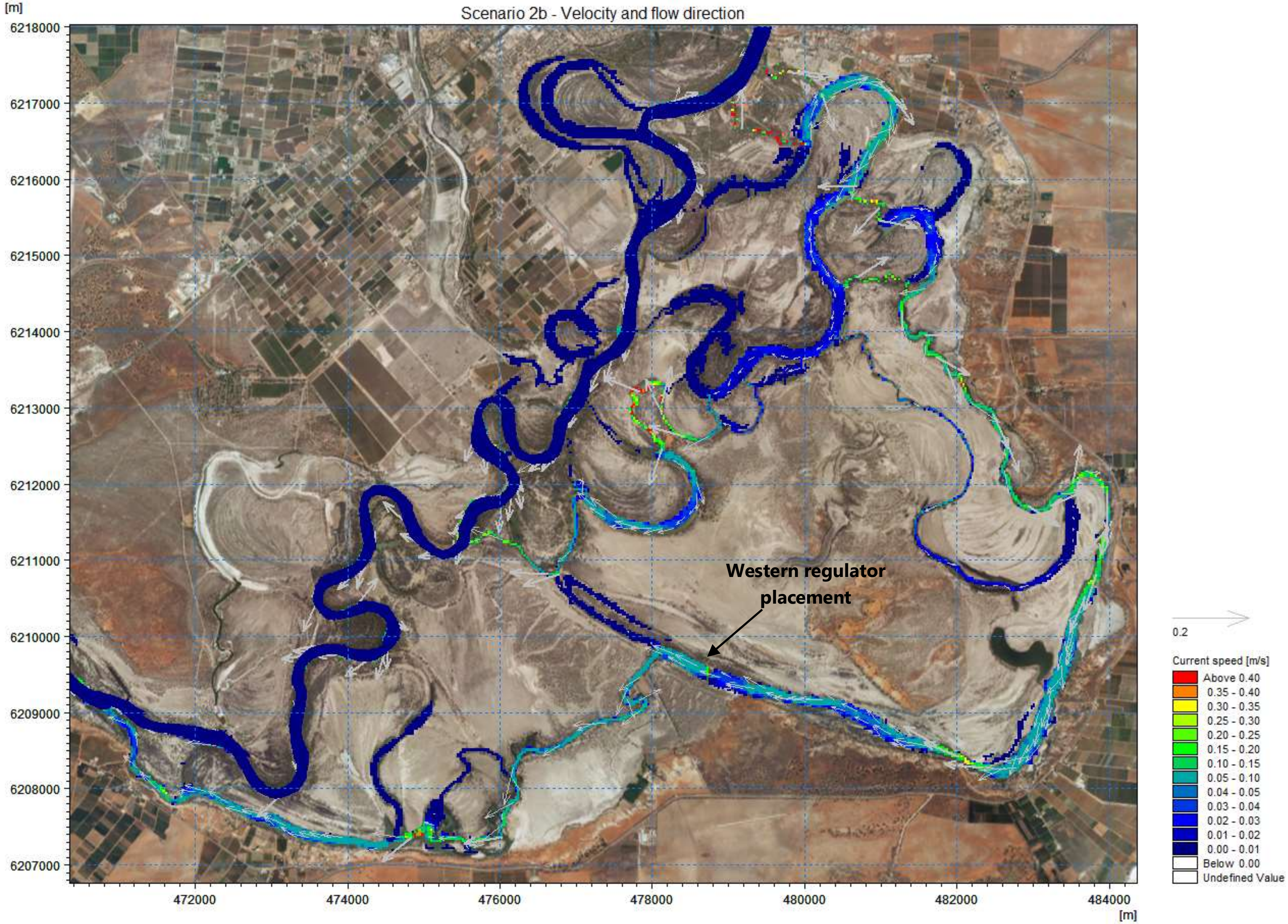

Figure 4.4 Velocity and flow direction for an inflow of 1200 ML/d and Tanyaca flow of 400 ML/d (Scenario 2b)

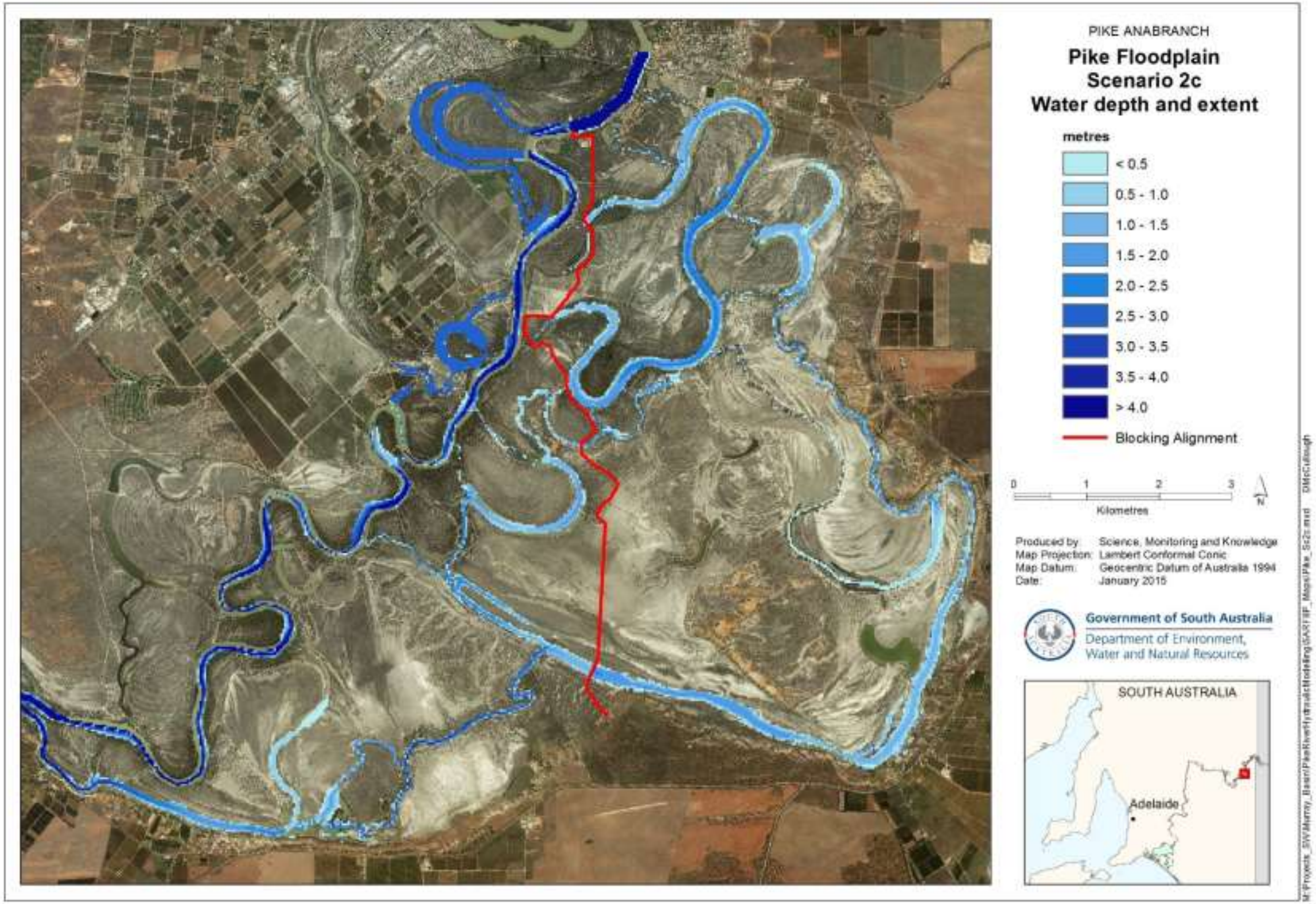

Figure 4.5 Water depth and extent for an inflow of 1200 ML/d and Tanyaca flow of 800 ML/d (Scenario 2c)

Figure 4.6 Velocity and flow direction for an inflow of 1200 ML/d and Tanyaca flow of 800 ML/d (Scenario 2c)

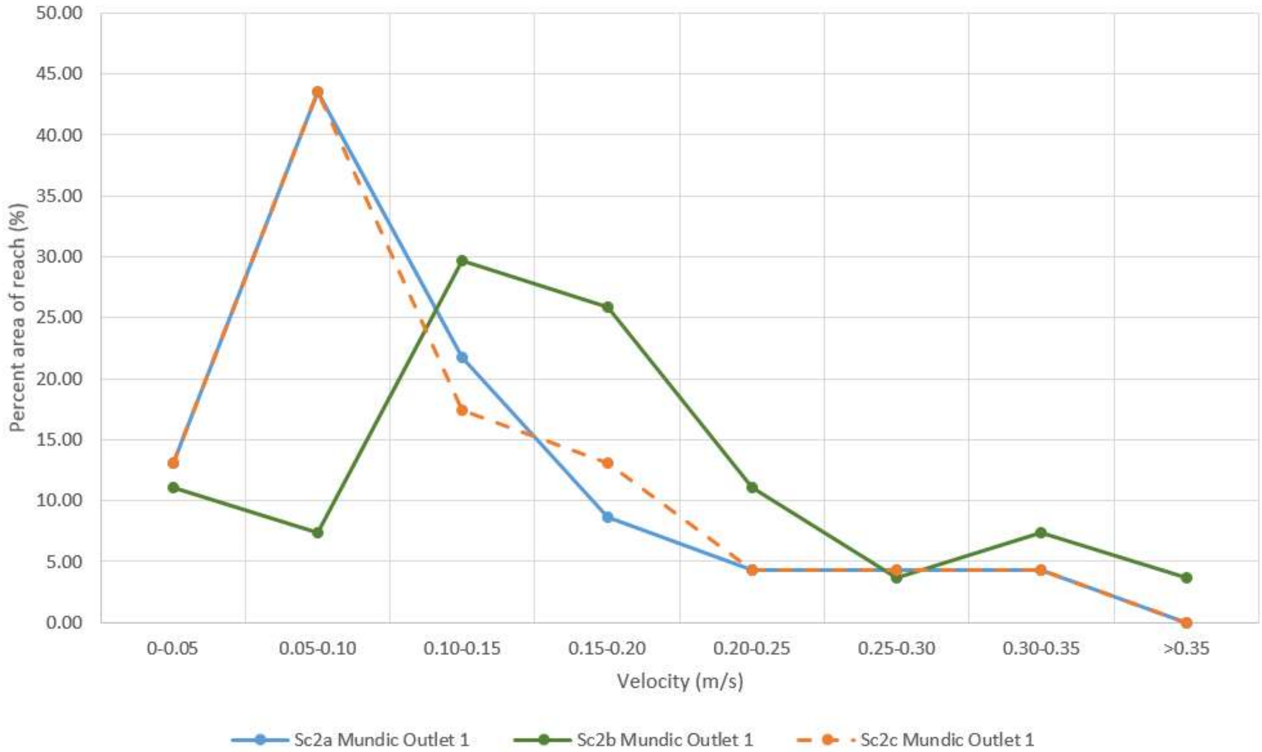

Figure 4.7 Velocity distribution by percent of reach in Mundic Creek Northern Outlet for Scenario 2 simulations (refer to Figure 2.1 for location)

Table 4.3 Velocity distribution by percent of reach in Mundic Creek Northern Outlet for Scenario 2 simulations

Scenario	0-0.05 m/s	0.05-0.10 m/s	0.10-0.15 m/s	0.15-0.20 m/s	0.20-0.25 m/s	0.25-0.30 m/s	0.30-0.35 m/s	>0.35 m/s	Total area ha
2a	13%	43%	22%	9%	4%	4%	4%	0%	2.07
2b	11%	7%	30%	26%	11%	4%	7%	4%	2.43
2c	13%	43%	17%	13%	4%	4%	4%	0%	2.07

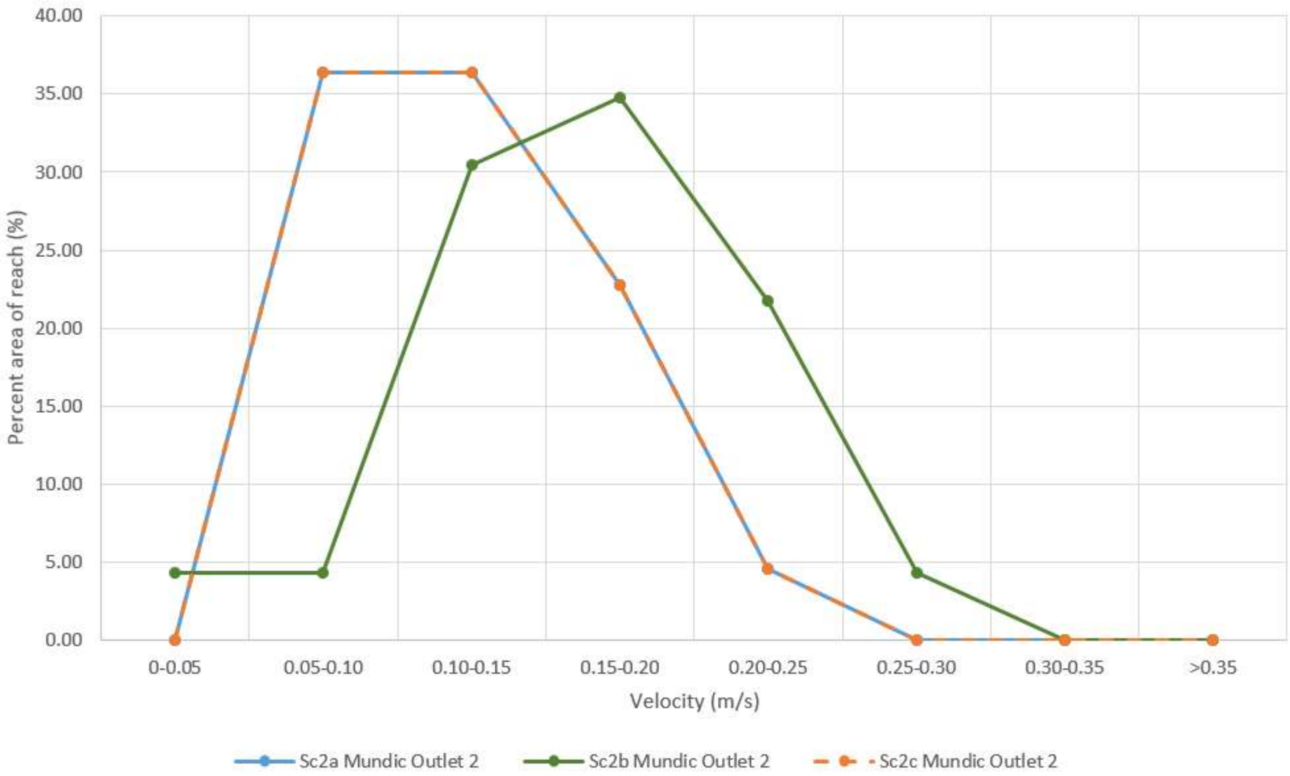

Figure 4.8 Velocity distribution by percent of reach in Mundic Creek Southern Outlet for Scenario 2 simulations (refer to Figure 2.1 for location)

Table 4.4 Velocity distribution by percent of reach in Mundic Creek Southern Outlet for Scenario 2 simulations

Scenario	0-0.05 m/s	0.05-0.10 m/s	0.10-0.15 m/s	0.15-0.20 m/s	0.20-0.25 m/s	0.25-0.30 m/s	0.30-0.35 m/s	>0.35 m/s	Total area ha
2a	0%	36%	36%	23%	5%	0%	0%	0%	1.98
2b	4%	4%	30%	35%	22%	4%	0%	0%	2.07
2c	0%	36%	36%	23%	5%	0%	0%	0%	1.98

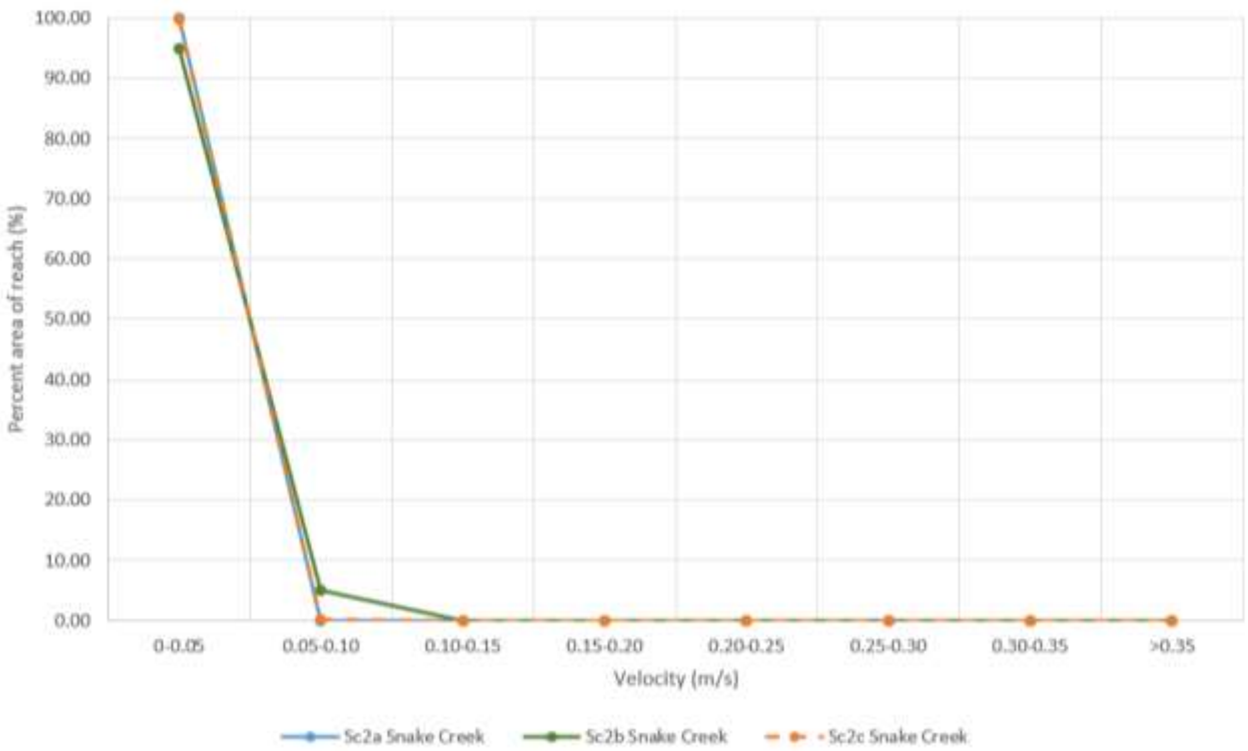

Figure 4.9 Velocity distribution by percent of reach in Snake Creek for Scenario 2 simulations (refer to Figure 2.1 for location)

Table 4.5 Velocity distribution by percent of reach in Snake Creek for Scenario 2 simulations

Scenario	0-0.05 m/s	0.05-0.10 m/s	0.10-0.15 m/s	0.15-0.20 m/s	0.20-0.25 m/s	0.25-0.30 m/s	0.30-0.35 m/s	>0.35 m/s	Total area ha
2a	100%	0%	0%	0%	0%	0%	0%	0%	33.93
2b	95%	5%	0%	0%	0%	0%	0%	0%	39.24
2c	100%	0%	0%	0%	0%	0%	0%	0%	34.11

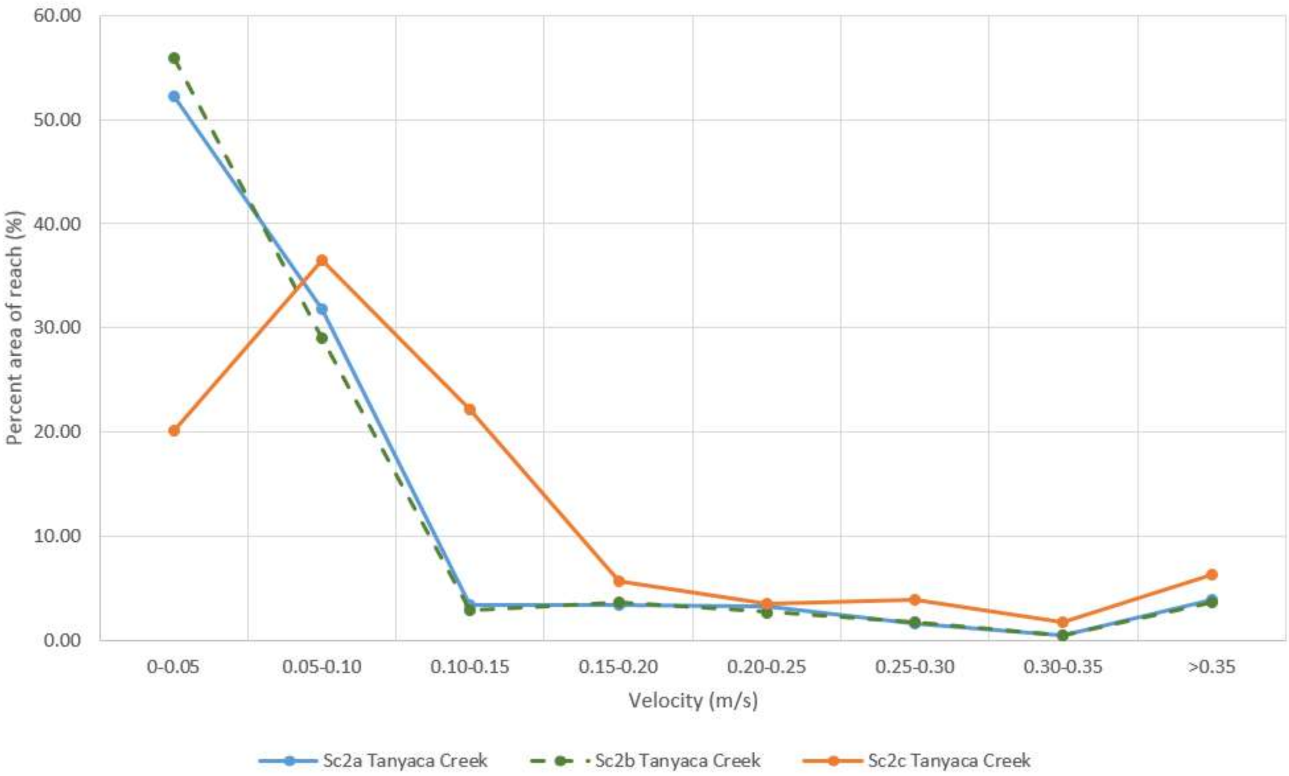

Figure 4.10 Velocity distribution by percent of reach in Tanyaca Creek for Scenario 2 simulations (refer to Figure 2.1 for location)

Table 4.6 Velocity distribution by percent of reach in Tanyaca Creek for Scenario 2 simulations

Scenario	0-0.05 m/s	0.05-0.10 m/s	0.10-0.15 m/s	0.15-0.20 m/s	0.20-0.25 m/s	0.25-0.30 m/s	0.30-0.35 m/s	>0.35 m/s	Total area ha
2a	52%	32%	3%	3%	3%	2%	0%	4%	60.84
2b	56%	29%	3%	4%	3%	2%	0%	4%	63.36
2c	20%	36%	22%	6%	4%	4%	2%	6%	63.63

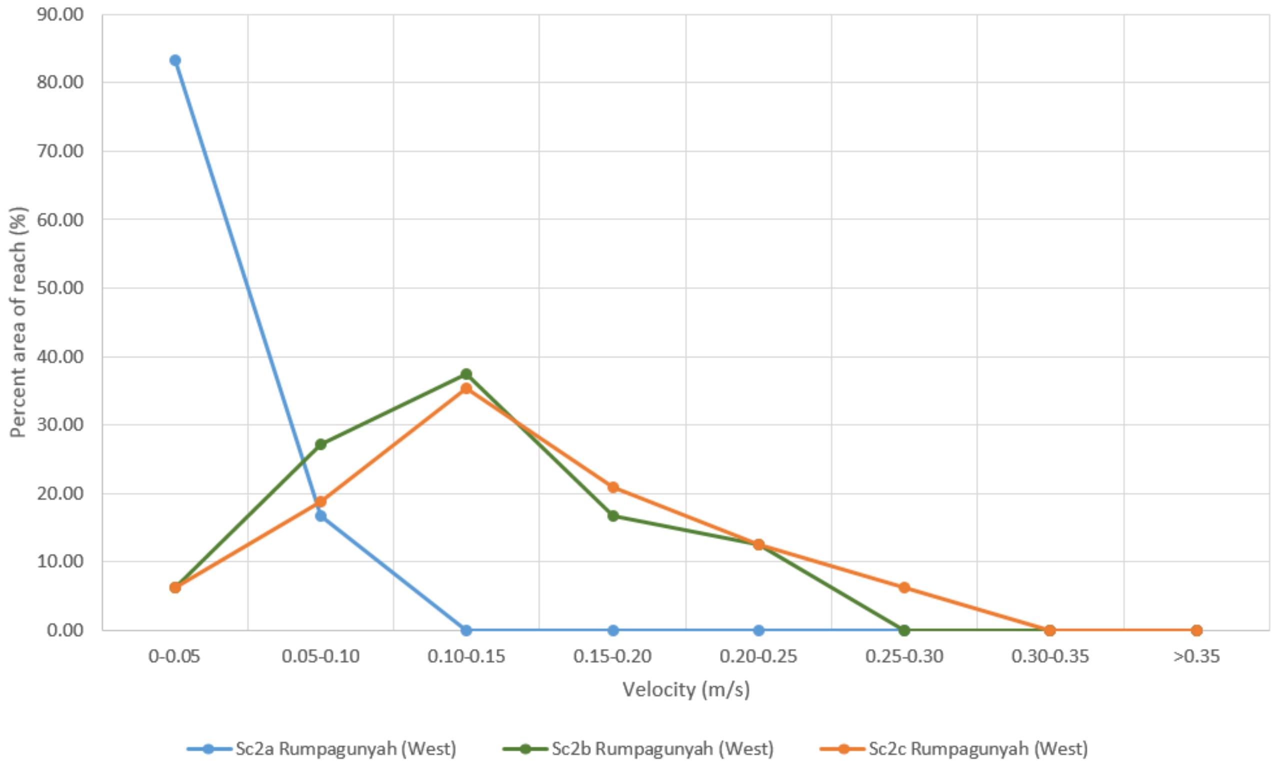

Figure 4.11 Velocity distribution by percent of reach in western section of Rumpagunyah Creek (between River Murray and Tanyaca outlet into Rumpagunyah) for Scenario 2 simulations (refer to Figure 2.1)

Table 4.7 Velocity distribution by percent of reach in western section of Rumpagunyah Creek (between River Murray and Tanyaca outlet into Rumpagunyah) for Scenario 2 simulations

Scenario	0-0.05 m/s	0.05-0.10 m/s	0.10-0.15 m/s	0.15-0.20 m/s	0.20-0.25 m/s	0.25-0.30 m/s	0.30-0.35 m/s	>0.35 m/s	Total area ha
2a	83%	17%	0%	0%	0%	0%	0%	0%	4.32
2b	6%	27%	38%	17%	13%	0%	0%	0%	4.32
2c	6%	19%	35%	21%	13%	6%	0%	0%	4.32

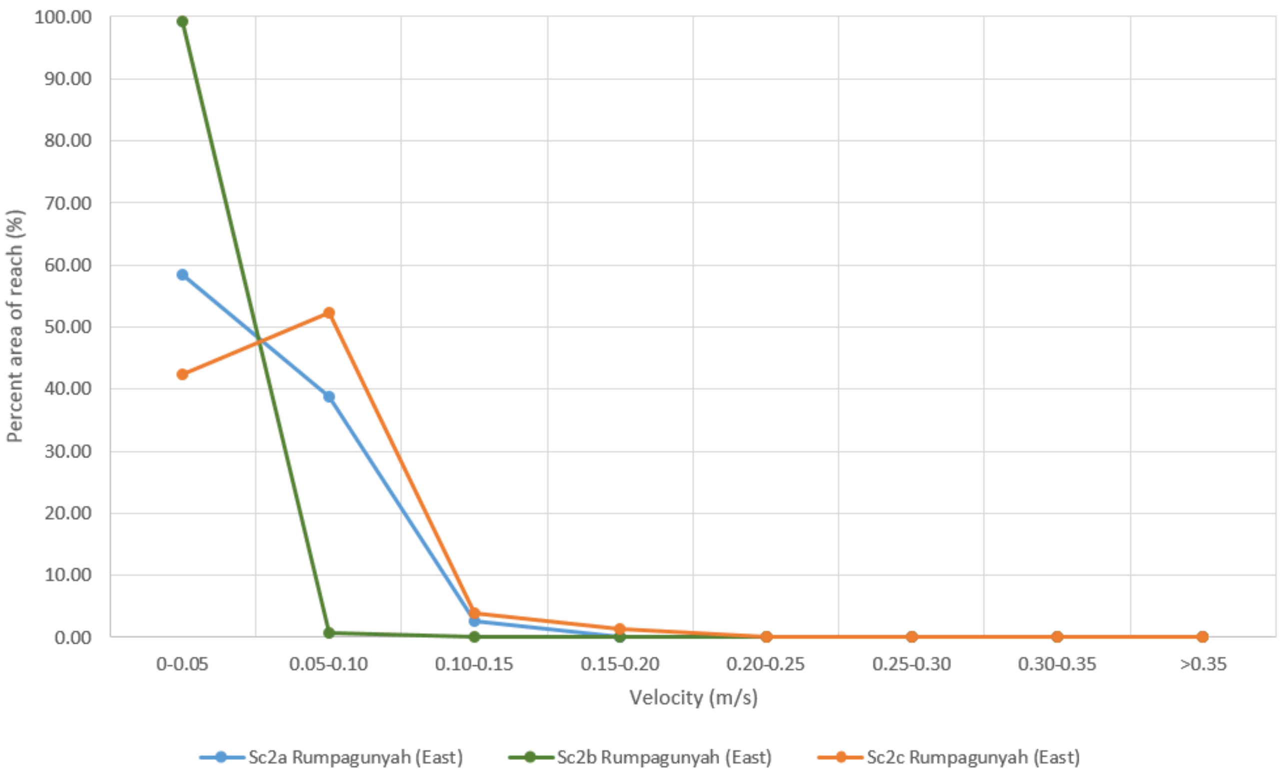

Figure 4.12 Velocity distribution by percent of reach in eastern section of Rumpagunyah Creek (between Pike River and Tanyaca outlet into Rumpagunyah) for Scenario 2 simulations (refer to Figure 2.1)

Table 4.8 Velocity distribution by percent of reach in eastern section of Rumpagunyah Creek (between Pike River and Tanyaca outlet into Rumpagunyah) for Scenario 2 simulations

Scenario	0-0.05 m/s	0.05-0.10 m/s	0.10-0.15 m/s	0.15-0.20 m/s	0.20-0.25 m/s	0.25-0.30 m/s	0.30-0.35 m/s	>0.35 m/s	Total area ha
2a	59%	39%	3%	0%	0%	0%	0%	0%	13.68
2b	99%	1%	0%	0%	0%	0%	0%	0%	13.77
2c	42%	52%	4%	1%	0%	0%	0%	0%	13.77

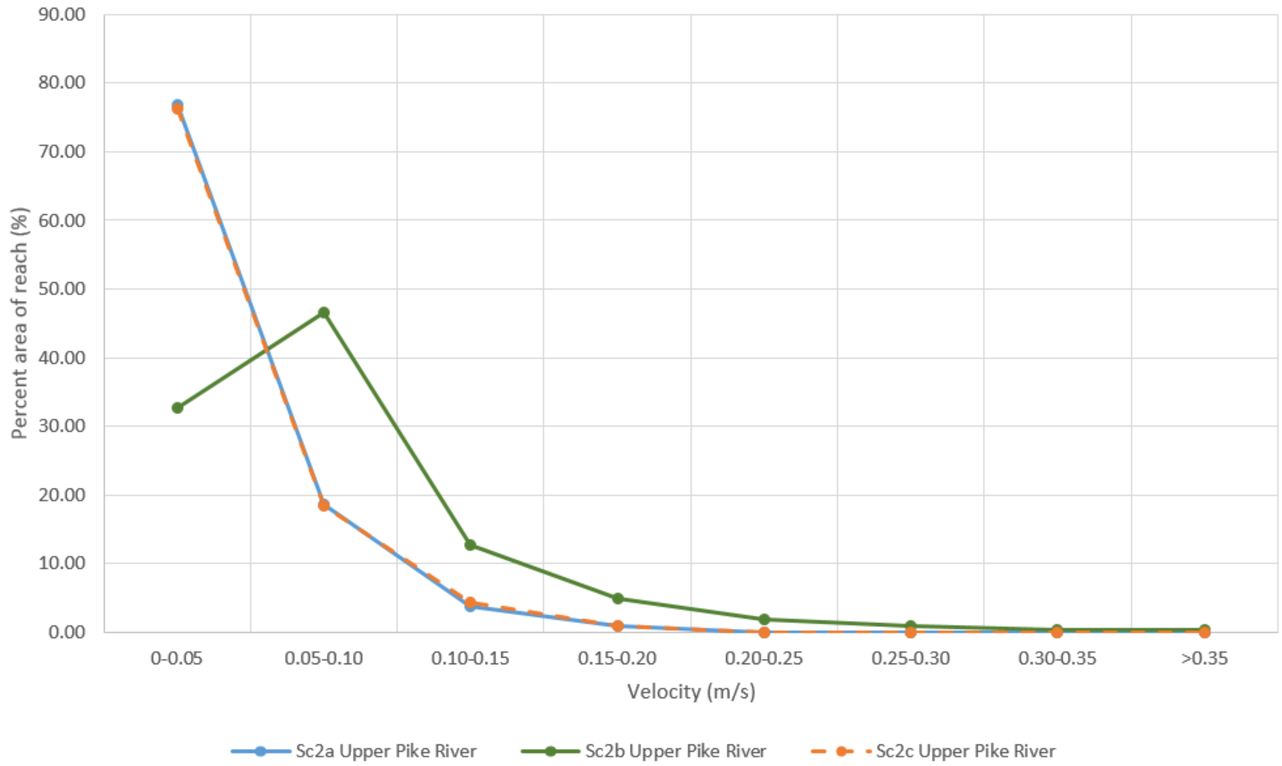

Figure 4.13 Velocity distribution by percent of reach in Upper Pike River for Scenario 2 simulations (refer to Figure 2.1 for location)

Table 4.9 Velocity distribution by percent of reach in Upper Pike River for Scenario 2 simulations

Scenario	0-0.05 m/s	0.05-0.10 m/s	0.10-0.15 m/s	0.15-0.20 m/s	0.20-0.25 m/s	0.25-0.30 m/s	0.30-0.35 m/s	>0.35 m/s	Total area ha
2a	77%	19%	4%	1%	0%	0%	0%	0%	155.25
2b	33%	46%	13%	5%	2%	1%	0%	0%	160.11
2c	76%	18%	4%	1%	0%	0%	0%	0%	155.34

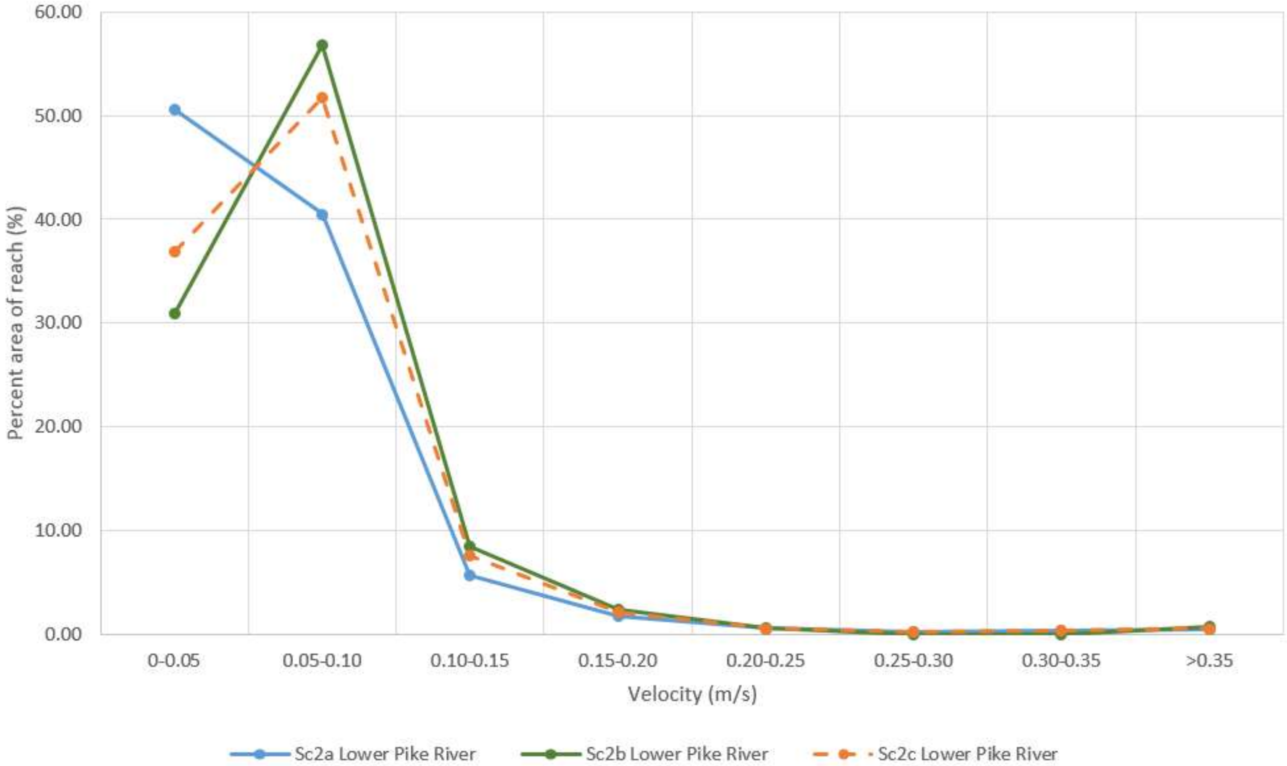

Figure 4.14 Velocity distribution by percent of reach in Lower Pike River for Scenario 2 simulations (refer to Figure 2.1 for location)

Table 4.10 Velocity distribution by percent of reach in Lower Pike River for Scenario 2 simulations

Scenario	0-0.05 m/s	0.05-0.10 m/s	0.10-0.15 m/s	0.15-0.20 m/s	0.20-0.25 m/s	0.25-0.30 m/s	0.30-0.35 m/s	>0.35 m/s	Total area ha
2a	51%	40%	6%	2%	1%	0%	0%	0%	82.89
2b	31%	57%	8%	2%	1%	0%	0%	1%	82.8
2c	37%	52%	8%	2%	1%	0%	0%	1%	83.07

5 Scenario 3 – Mundic level raising using minor regulating infrastructure

5.1 Hydraulic results

Scenario 3 investigates the option of constructing minor regulators on the Mundic Creek eastern outlets to provide a greater flexibility of floodplain operations, in particular the ability to perform seasonal inundation of the Mundic Creek fringe, using raised inflows and three small regulators (namely Mundic northern outlet, Mundic southern outlet and Snake Creek regulators). Note that the Mundic central outlet is typically non-flowing at normal floodplain water level conditions, and for the purposes of this scenario is assumed blocked by a fixed bank during elevated Mundic operating level.

Operation of the Mundic regulators to produce localised inundation has the potential to contribute to ecological objectives and targets for maintaining viable populations of perennial native woody vegetation, including River Red Gum, Black Box and Lignum. Potentially, inundation of the floodplain surrounding Mundic, without inundation of the floodplain adjacent Pike River, could be undertaken in years of lower water availability and may provide flexibility to undertake environmental watering in part of the floodplain only. An operation to undertake watering in only the floodplain adjacent Mundic would be informed through assessment of monitoring results against the ecological targets, and prevailing conditions of water quality and availability.

In the simulation configuration, Mundic Creek level is controlled to an elevation of 15.5 m AHD, with anabranch inflows varied from 800 ML/d (Scenario 3a) to 1200 ML/d (Scenario 3b) and Tanyaca flow set to 400 ML/d for both simulations. River Murray conditions and Pike regulator upstream water level are the same as for Scenario 2. Table 5.1 indicates the set discharge over each minor regulator. Table 5.1 additionally indicates the head difference over each regulating structure for the given discharge. Note that Scenario 3b was altered from the original devised flow configuration (400 ML/d through Mundic northern outlet regulator and 200 ML/d at each of Mundic southern outlet and Snake Creek regulators) after it was found that 200 ML/d through Snake Creek at 15.5 m AHD was unattainable with the current model configuration. It was found that only approximately 150 ML/d could be passed through Snake Creek before upstream and downstream levels equalised over the structure, preventing any further control of the discharge into Snake Creek. The discharge into Snake Creek was therefore set at 150 ML/d, with the additional 50 ML/d diverted to the flow through the Mundic Southern Outlet regulator. Note that the assumed Manning's roughness coefficient for Snake Creek is 0.12 to account for thick reed growth within the reach. Reducing this value would allow additional flow through the creek, however no change was made to the bed roughness coefficient for the purposes of the current scenario without a solid basis for reducing the roughness value, and to maintain consistency with the other scenarios conducted. Little calibration data for Snake Creek exists at this time, so further gauging data should be collected – particularly following proposed removal of Bank G – to assist with future calibration of this creek in the model.

Table 5.1 Head difference over minor regulating structures at Mundic Creek outlets (northern, southern and Snake Creek) and Pike regulator

Structure	Scenario 3a (Total inflow = 800 ML/d)				Scenario 3b (Total inflow = 1200 ML/d)			
	discharge	U/S level	D/S level	Head difference	discharge	U/S level	D/S level	Head difference
	ML/d	m AHD	m AHD	m	ML/d	m AHD	m AHD	m
Mundic northern outlet	200	15.50	14.62	0.88	400	15.50	14.88	0.62
Mundic southern outlet	100	15.50	14.60	0.90	250	15.50	14.93	0.57
Snake Creek	100	15.50	15.30	0.20	150	15.50	15.50	0.00
Pike regulator	342*	14.35	13.39	0.96	742*	14.35	13.42	0.93

* Flow accounting for evaporative losses

The spatial distribution and depth of water over the floodplain for Scenarios 3a and b are shown in Figure 5.1 and Figure 5.3, respectively. The surface area of the impounded water upstream of the regulators surrounding Mundic Creek (including the permanently inundated channels) is approximately 370 ha in both cases, with the corresponding volume held being approximately 4800 ML.

Spatial velocity distributions are shown in Figure 5.2 and Figure 5.4 for Scenarios 3a and b, respectively. Velocity distributions of each creek reach by area are also displayed in Figure 5.5 to Figure 5.12, and summarised in Table 5.3 to Table 5.10. Velocities appear to be similar downstream of the regulators on the western side of the floodplain for each scenario owing to the same flow (400 ML/d) being applied through Tanyaca regulator. Doubling of the flow through Mundic Creek outlets from Scenario 3a to 3b results in noticeably raised velocities in the latter scenario on the eastern side of the floodplain in the Mundic Creek outlets and Pike River. In Table 4.3, velocities under Scenario 3b are seen to bias towards higher velocities in Mundic Creek Outlets (Northern and Southern) and in the Pike River (Upper and Lower) compared to Scenario 3a, although the effect appears not as pronounced in Snake Creek, with similar velocity profiles for each scenario.

The impact of increased flow through Pike River also impacts on Rumpagunyah Creek velocity profiles, with a bias towards lower velocities in the eastern side of Rumpagunyah (Tanyaca Outlet to Lower Pike) and a bias towards higher velocities on the western side of the Rumpagunyah for Scenario 3b. The corresponding contribution of flows from Tanyaca through the western side of the Rumpagunyah to the River Murray is approximately 100 ML/d in Scenario 3a (i.e. 300 ML/d returning to the Lower Pike) and approximately 385 ML/d in Scenario 3b (i.e. 15 ML/d returning to Lower Pike). This can be attributed to the raised water level downstream of the Lower Pike regulator as Pike River flows increase, thereby reducing the amount of flow from the Rumpagunyah entering the Lower Pike, and diverting greater flows through Rumpagunyah into the River Murray for a given flow through Tanyaca Creek.

A summary of the hydraulics in the floodplain in the Mundic–Tanyaca (western) side of the floodplain, the Pike River (eastern) side and the total floodplain upstream of the blocking alignment is presented in Table 5.2. The results show the additional inflow in Scenario 3b results in a greater Mundic–Tanyaca turnover rate, from 16% in Scenario 3a to 24% in Scenario 3b. The approximate doubling of the flow into Pike River in Scenario 3b results in an additional inundated area of 10 ha and 250 ML additional volume held in the Pike River side of the system, almost doubling the turnover rate from 17% under Scenario 3a to 32% under Scenario 3b.

Table 5.2 Summary of hydraulic characteristics for Scenarios 3a to b

Scenario	Total inflow ML/d	Parameter	Units	Mundic–Tanyaca Creek	Pike River	Total
3a	800	Outflow[1]	ML/d	400	342	742
		Volume	ML	4727	2266	6993
		Turnover[2]	%	16	17	11
		Water Level[3]	m AHD	15.5	14.35	-
		Wetted Area	ha	369	239	608
		Evaporative Loss[4]	ML/d	35	23	58
3b	1200	Outflow[1]	ML/d	400	742	1142
		Volume	ML	4741	2514	7255
		Turnover[2]	%	24	32	16
		Water Level[3]	m AHD	15.5	14.35	-
		Wetted Area	ha	370	249	619
		Evaporative Loss[4]	ML/d	35	24	59

[1] Outflow from regulating structures in Tanyaca and Pike for respective floodplain sections (combined for total floodplain)
[2] Outflow as a percentage of total volume (Mundic–Tanyaca Creek sections includes outflow from both Tanyaca and Pike sections)
[3] Water level upstream of each relevant structure (not applicable for total floodplain)
[4] Based on the long term average daily evaporation of 9.5 mm/d for January from the nearest BoM weather station

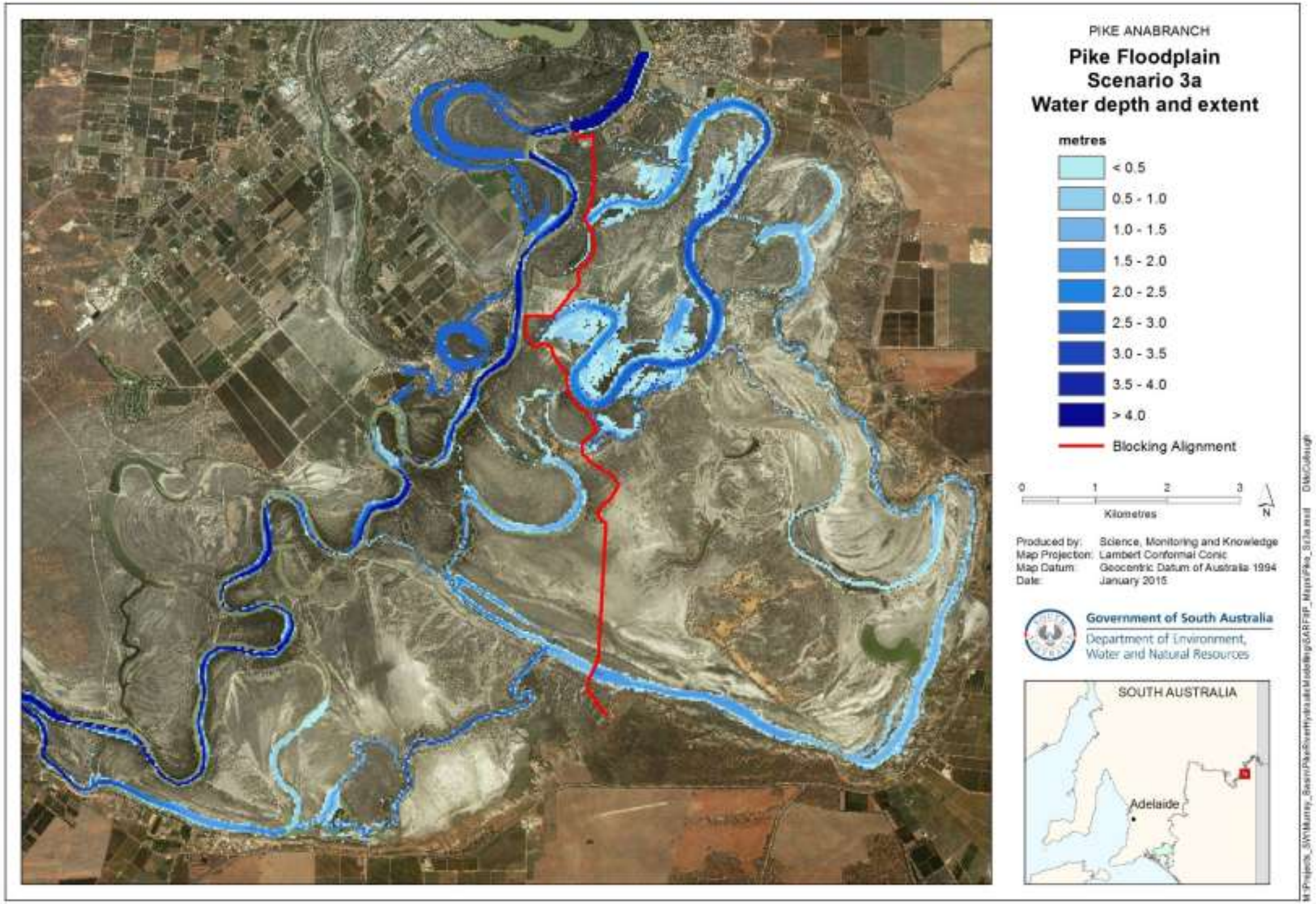

Figure 5.1 Water depth and extent for an inflow of 800 ML/d and minor regulators on Mundic Creek outlets passing 400 ML/d (Scenario 3a)

Figure 5.2 Velocity and flow direction for an inflow of 800 ML/d and minor regulators on Mundic Creek outlets passing 400 ML/d (Scenario 3a)

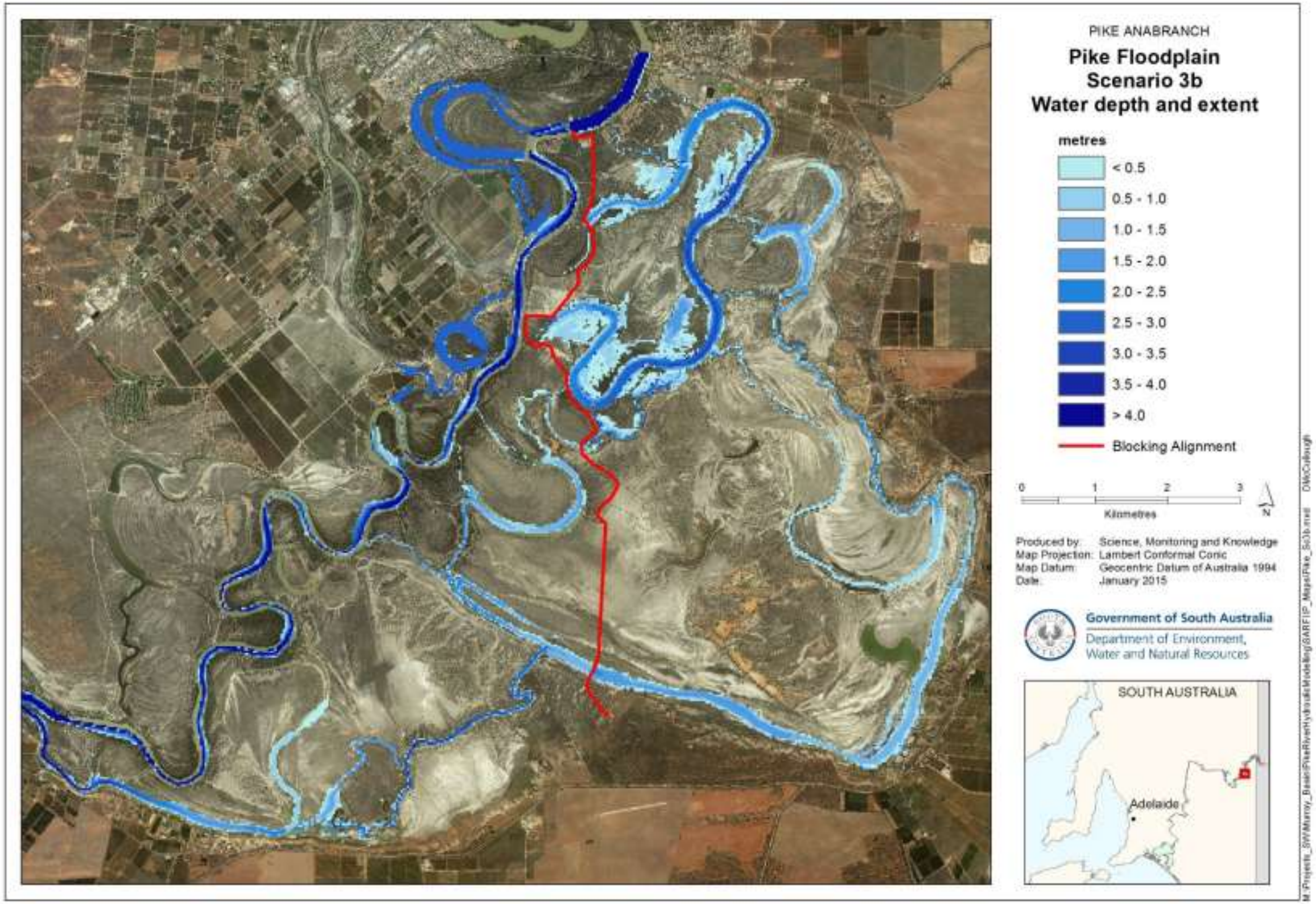

Figure 5.3 Water depth and extent for an inflow of 1200 ML/d and minor regulators on Mundic Creek outlets passing 800 ML/d (Scenario 3b)

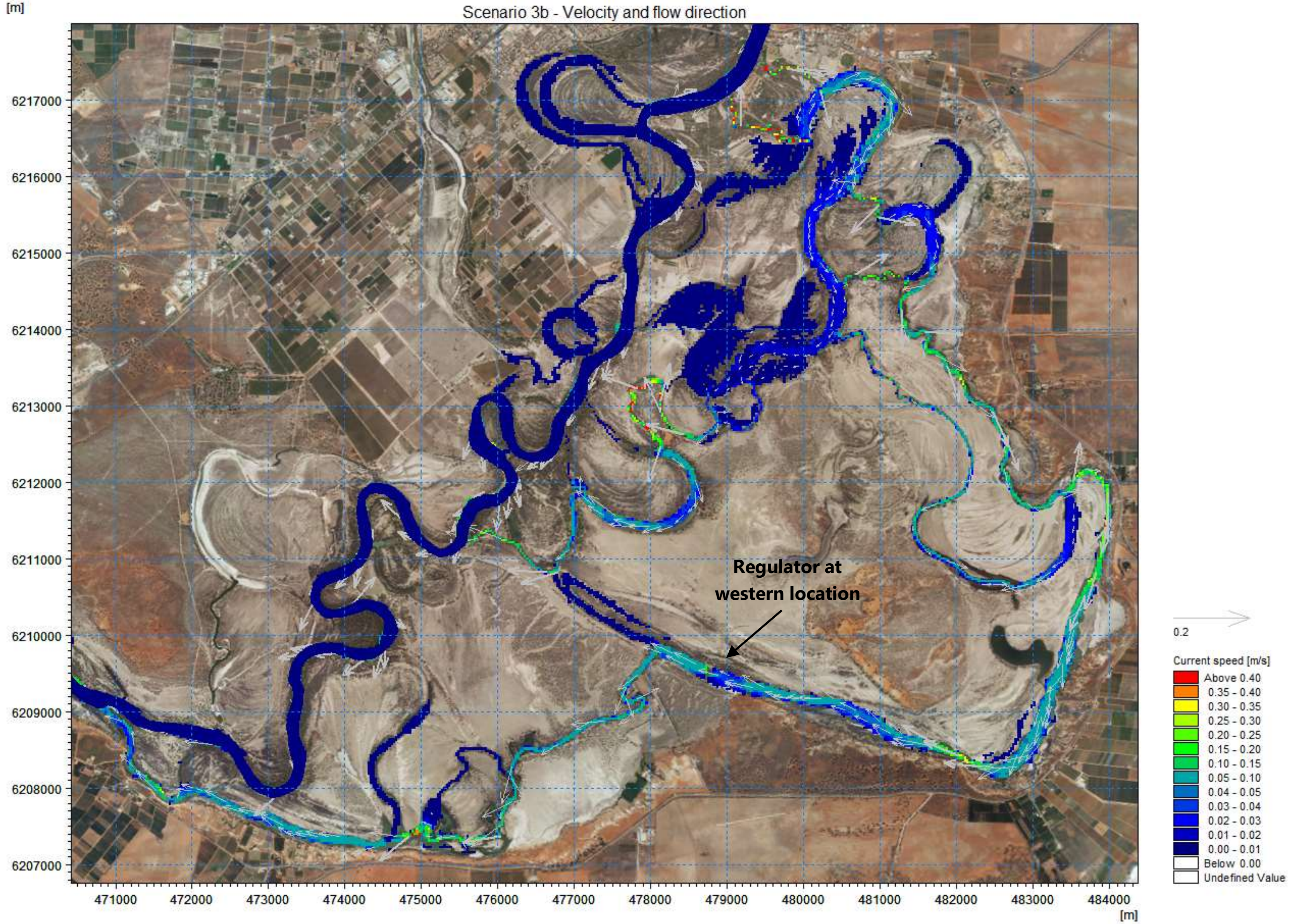

Figure 5.4 Velocity and flow direction for an inflow of 1200 ML/d and minor regulators on Mundic Creek outlets passing 800 ML/d (Scenario 3b)

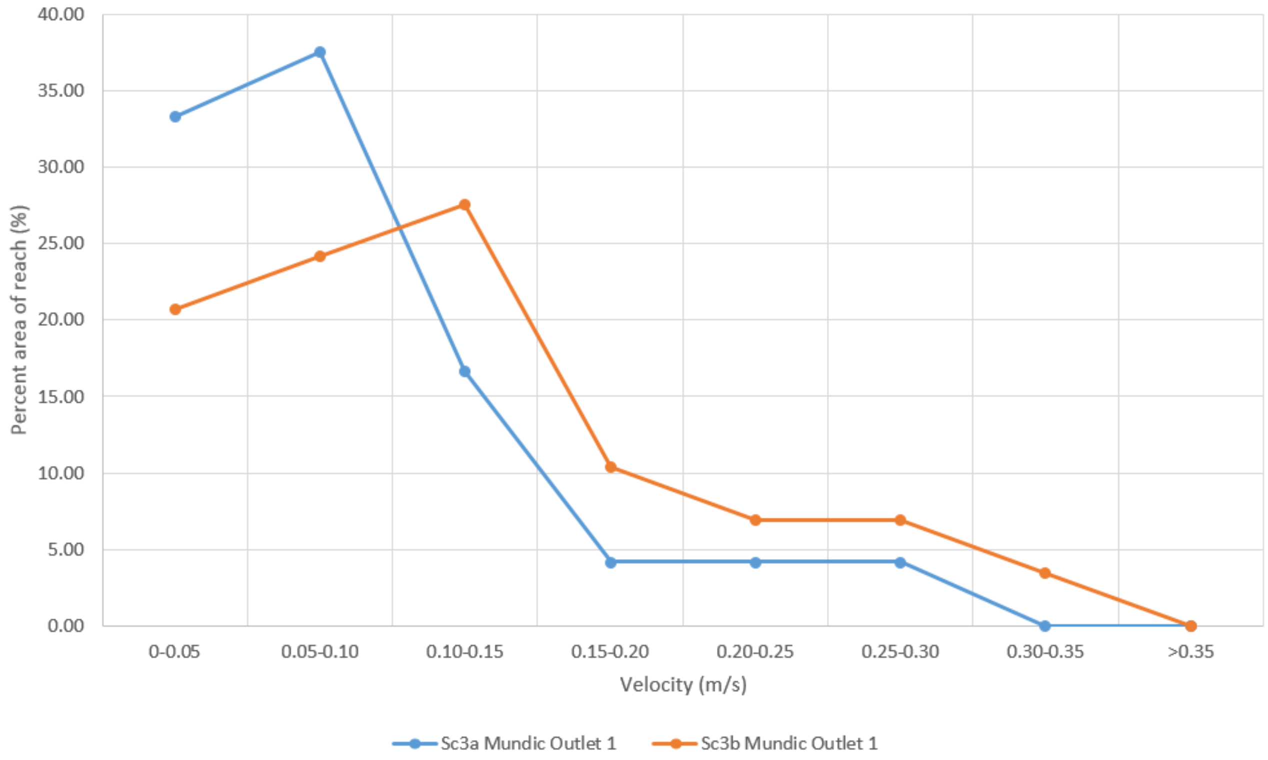

Figure 5.5 Velocity distribution by percent of reach in Mundic Creek Northern Outlet for Scenario 3 simulations (refer to Figure 2.1 for location)

Table 5.3 Velocity distribution by percent of reach in Mundic Creek Northern Outlet for Scenario 3 simulations

Scenario	0-0.05 m/s	0.05-0.10 m/s	0.10-0.15 m/s	0.15-0.20 m/s	0.20-0.25 m/s	0.25-0.30 m/s	0.30-0.35 m/s	>0.35 m/s	Total area ha
3a	33%	38%	17%	4%	4%	4%	0%	0%	2.16
3b	21%	24%	28%	10%	7%	7%	3%	0%	2.61

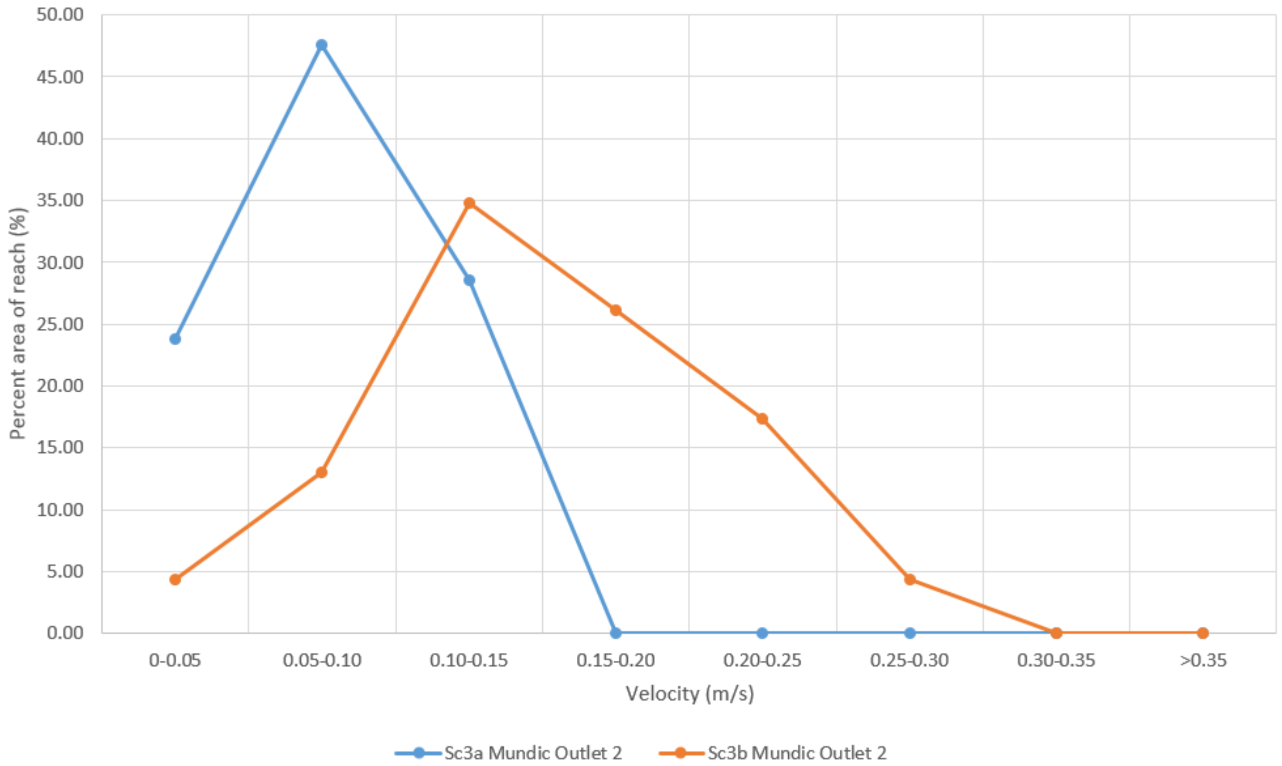

Figure 5.6 Velocity distribution by percent of reach in Mundic Creek Southern Outlet for Scenario 3 simulations (refer to Figure 2.1 for location).

Table 5.4 Velocity distribution by percent of reach in Mundic Creek Southern Outlet for Scenario 3 simulations

Scenario	0-0.05 m/s	0.05-0.10 m/s	0.10-0.15 m/s	0.15-0.20 m/s	0.20-0.25 m/s	0.25-0.30 m/s	0.30-0.35 m/s	>0.35 m/s	Total area ha
3a	24%	48%	29%	0%	0%	0%	0%	0%	1.89
3b	4%	13%	35%	26%	17%	4%	0%	0%	2.07

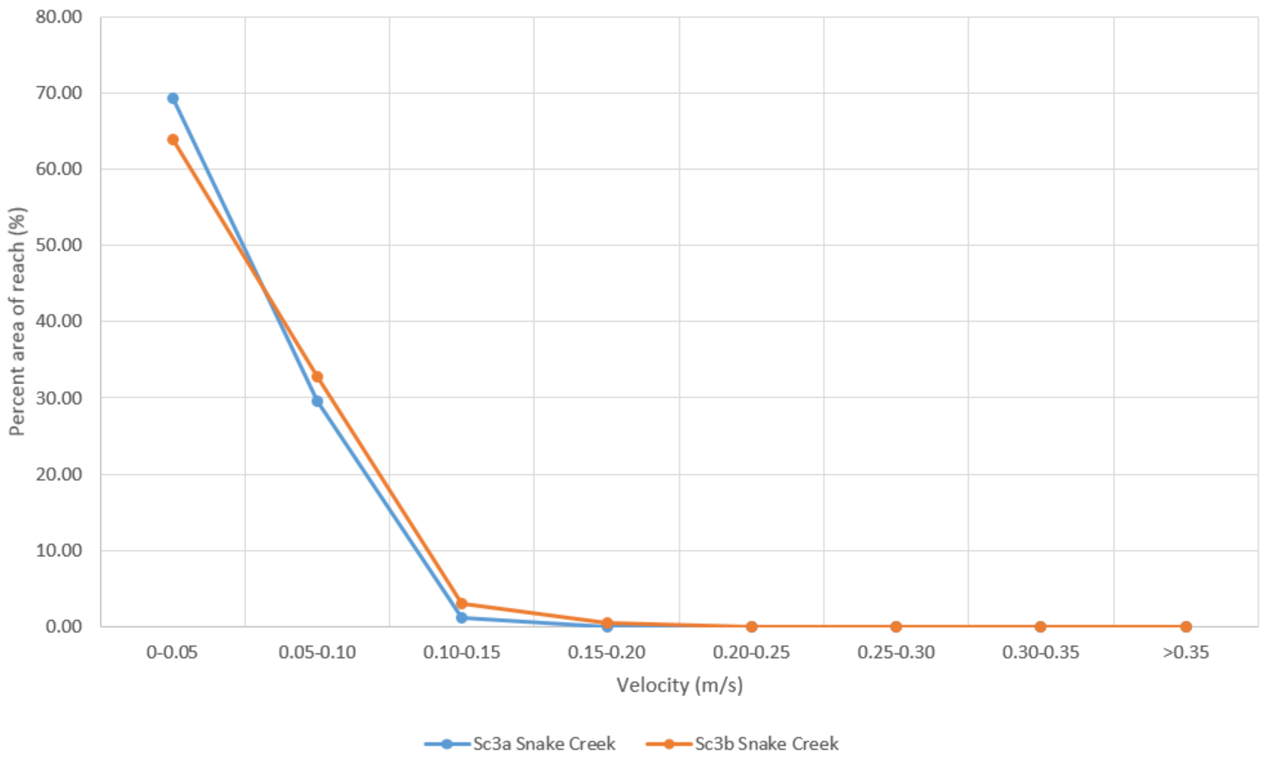

Figure 5.7 Velocity distribution by percent of reach in Snake Creek for Scenario 3 simulations (refer to Figure 2.1 for location).

Table 5.5 Velocity distribution by percent of reach in Snake Creek for Scenario 3 simulations

Scenario	0-0.05 m/s	0.05-0.10 m/s	0.10-0.15 m/s	0.15-0.20 m/s	0.20-0.25 m/s	0.25-0.30 m/s	0.30-0.35 m/s	>0.35 m/s	Total area ha
3a	69%	30%	1%	0%	0%	0%	0%	0%	40.41
3b	64%	33%	3%	0%	0%	0%	0%	0%	45.54

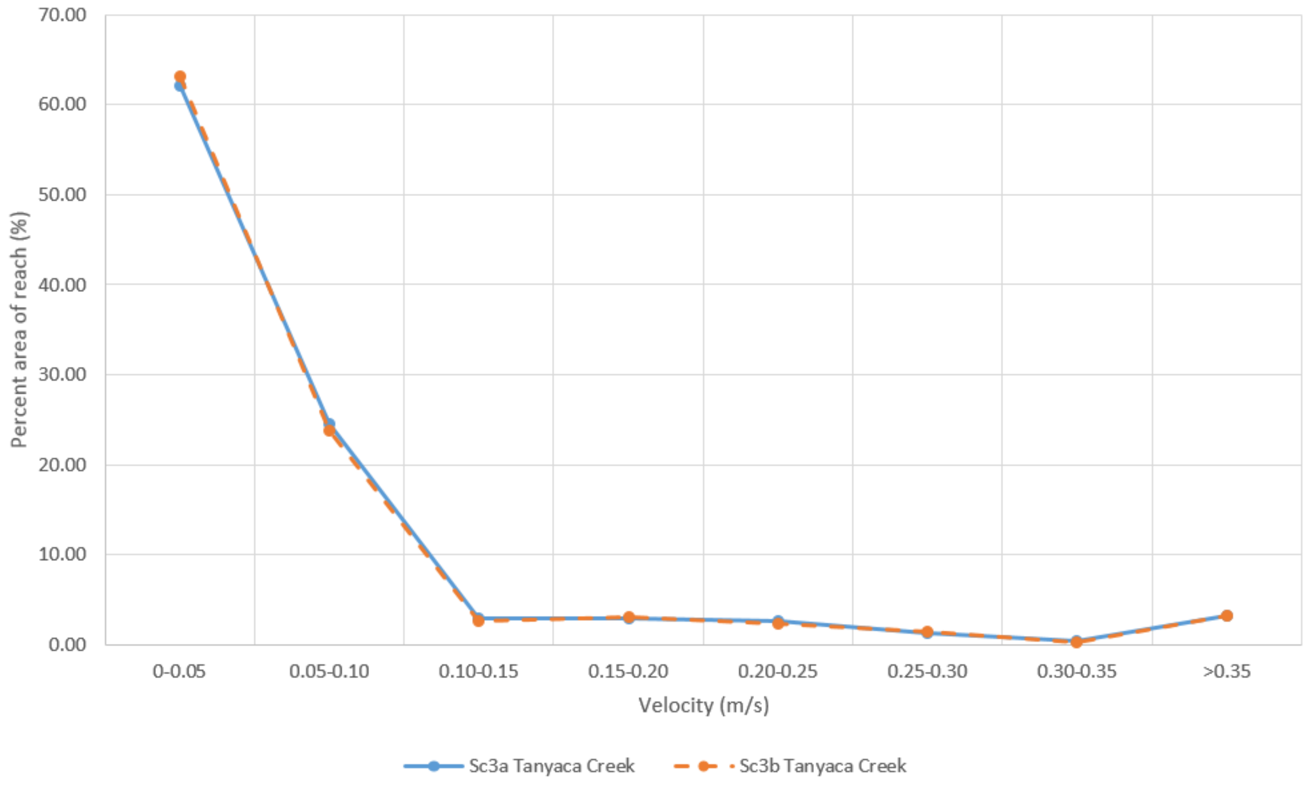

Figure 5.8 Velocity distribution by percent of reach in Tanyaca Creek for Scenario 3 simulations (refer to Figure 2.1 for location)

Table 5.6 Velocity distribution by percent of reach in Tanyaca Creek for Scenario 3 simulations

Scenario	0-0.05 m/s	0.05-0.10 m/s	0.10-0.15 m/s	0.15-0.20 m/s	0.20-0.25 m/s	0.25-0.30 m/s	0.30-0.35 m/s	>0.35 m/s	Total area ha
3a	62%	25%	3%	3%	3%	1%	0%	3%	72.36
3b	63%	24%	3%	3%	2%	1%	0%	3%	72.45

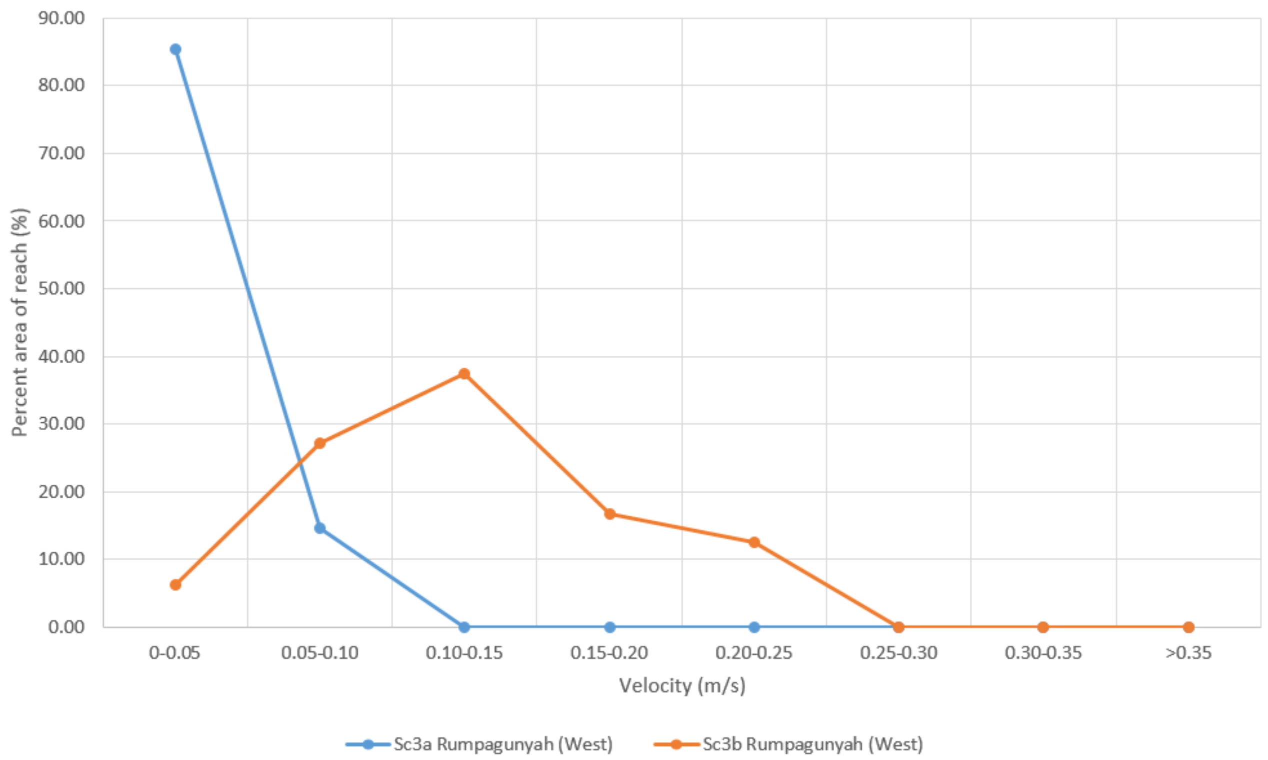

Figure 5.9 Velocity distribution by percent of reach in western section of Rumpagunyah Creek (between River Murray and Tanyaca outlet into Rumpagunyah) for Scenario 3 simulations (refer to Figure 2.1)

Table 5.7 Velocity distribution by percent of reach in western section of Rumpagunyah Creek (between River Murray and Tanyaca outlet into Rumpagunyah) for Scenario 3 simulations

Scenario	0-0.05 m/s	0.05-0.10 m/s	0.10-0.15 m/s	0.15-0.20 m/s	0.20-0.25 m/s	0.25-0.30 m/s	0.30-0.35 m/s	>0.35 m/s	Total area ha
3a	85%	15%	0%	0%	0%	0%	0%	0%	4.32
3b	6%	27%	38%	17%	13%	0%	0%	0%	4.32

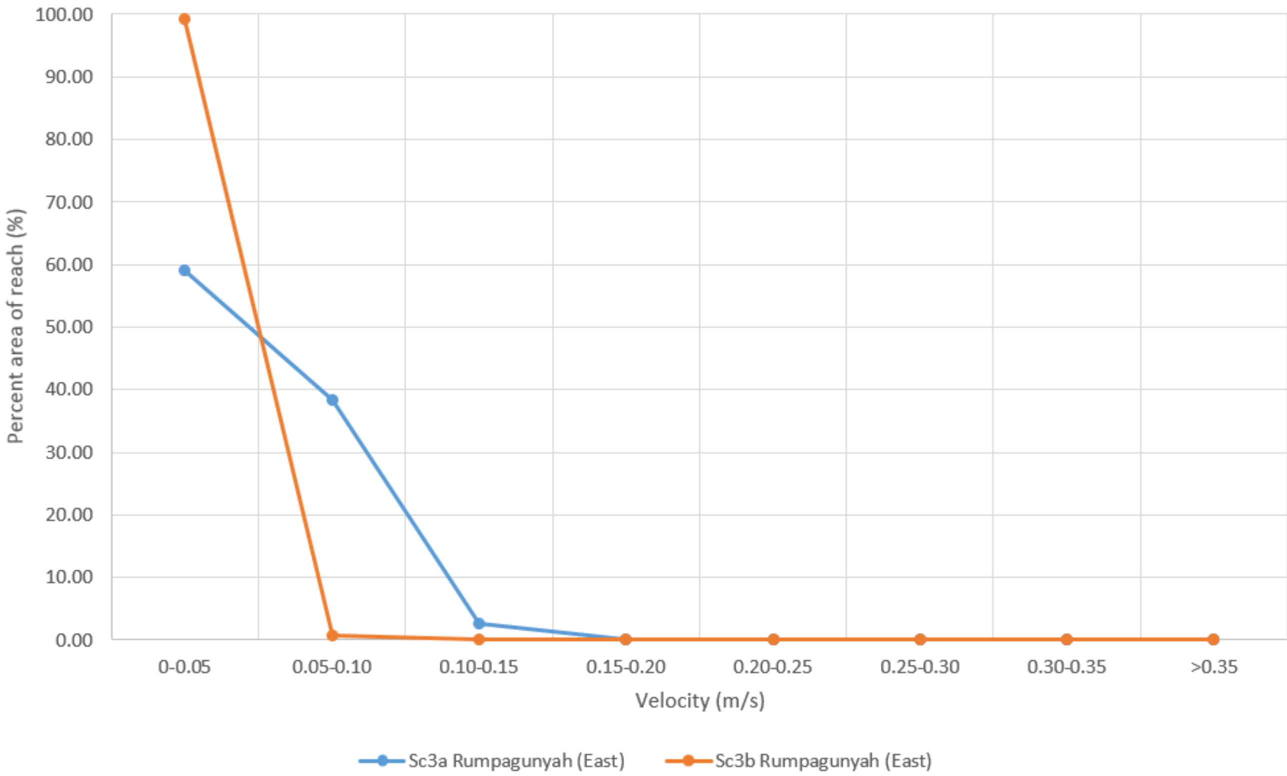

Figure 5.10 Velocity distribution by percent of reach in eastern section of Rumpagunyah Creek (between Pike River and Tanyaca outlet into Rumpagunyah) for Scenario 3 simulations (refer to Figure 2.1)

Table 5.8 Velocity distribution by percent of reach in eastern section of Rumpagunyah Creek (between Pike River and Tanyaca outlet into Rumpagunyah) for Scenario 3 simulations

Scenario	0-0.05 m/s	0.05-0.10 m/s	0.10-0.15 m/s	0.15-0.20 m/s	0.20-0.25 m/s	0.25-0.30 m/s	0.30-0.35 m/s	>0.35 m/s	Total area ha
3a	59%	38%	3%	0%	0%	0%	0%	0%	13.86
3b	99%	1%	0%	0%	0%	0%	0%	0%	13.68

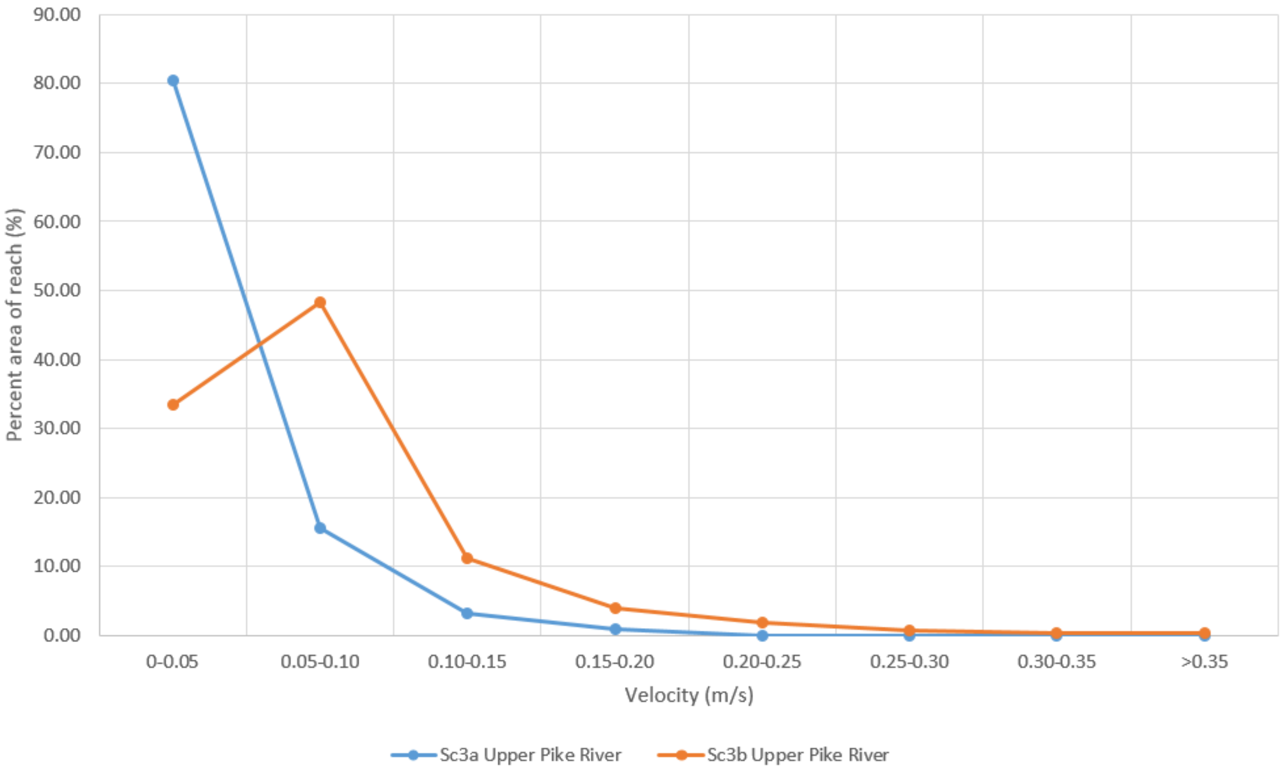

Figure 5.11 Velocity distribution by percent of reach in Pike River (upstream of Rumpagunyah junction) for Scenario 3 simulations (refer to Figure 2.1 for location)

Table 5.9 Velocity distribution by percent of reach in Pike River (upstream of Rumpagunyah junction) for Scenario 3 simulations

Scenario	0-0.05 m/s	0.05-0.10 m/s	0.10-0.15 m/s	0.15-0.20 m/s	0.20-0.25 m/s	0.25-0.30 m/s	0.30-0.35 m/s	>0.35 m/s	Total area ha
3a	80%	15%	3%	1%	0%	0%	0%	0%	156.24
3b	34%	48%	11%	4%	2%	1%	0%	0%	160.56

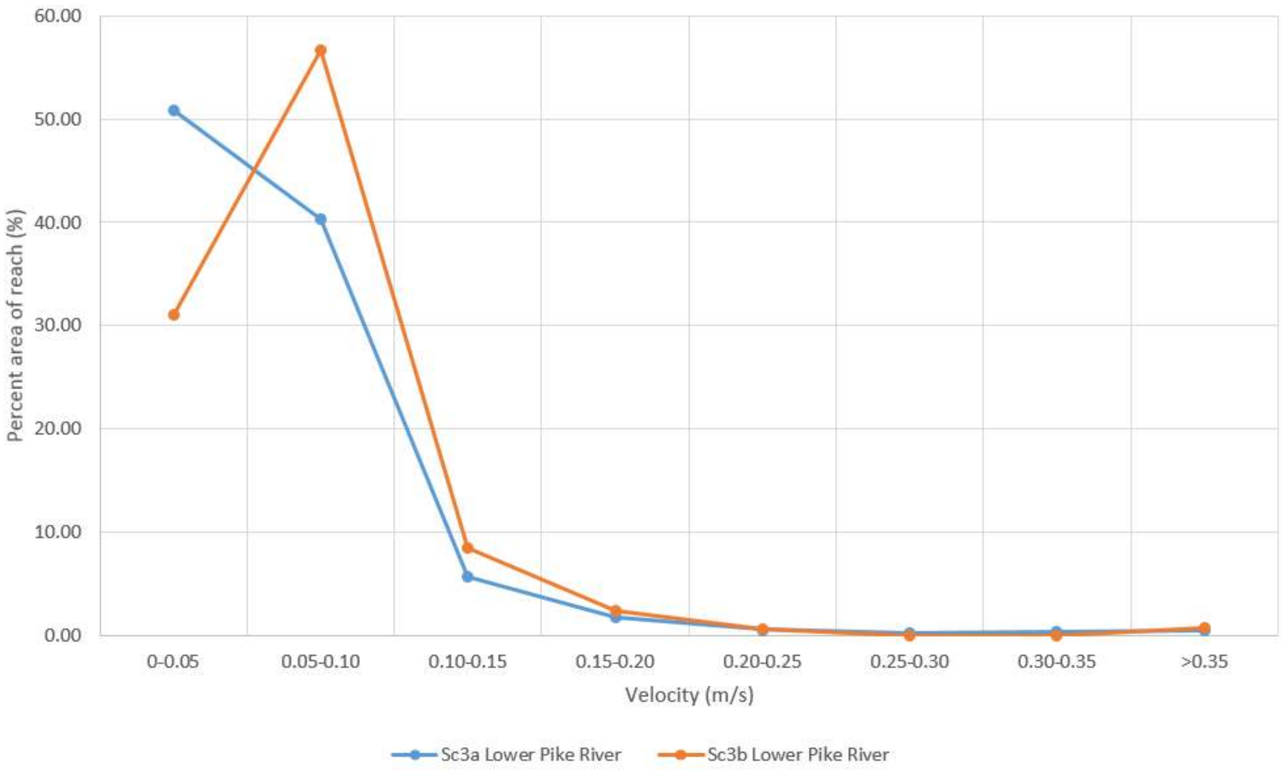

Figure 5.12 Velocity distribution by percent of reach in Lower Pike River (downstream of Rumpagunyah junction) for Scenario 3 simulations (refer to Figure 2.1 for location)

Table 5.10 Velocity distribution by percent of reach in Lower Pike River (downstream of Rumpagunyah junction) for Scenario 3 simulations

Scenario	0-0.05 m/s	0.05-0.10 m/s	0.10-0.15 m/s	0.15-0.20 m/s	0.20-0.25 m/s	0.25-0.30 m/s	0.30-0.35 m/s	>0.35 m/s	Total area ha
3a	51%	40%	6%	2%	1%	0%	0%	0%	83.07
3b	31%	57%	8%	2%	1%	0%	0%	1%	82.89

6 Scenario 4 – Impact of regulator sizing on a natural River Murray flood event

6.1 Hydraulic results

Scenario 4 investigates the impact of the physical size, and hence capacity, of the environmental regulators on an arbitrary natural flooding event, with the aim of providing data for future engineering design work, in particular relating to regulator cost. Scenarios are framed to provide a relative indication of how structure sizing may impact on floodplain hydraulics during a natural flood of approximately 90 000 ML/d upstream of Lock 5 (note that this does not equate to Flow to South Australia due to partial flows diverted around Lock 6 through Chowilla floodplain). Scenario 4a shows the hydraulics with regulators at 100% of the concept design size (i.e. eight bays wide) and Scenario 4b presents the hydraulics under a regulator sizing of 50% of the concept design size (i.e. four bays wide). The analysis is considered with the Alternative 3 blocking alignment, with all structures fully open and the system allowed to reach equilibrium, with no control implemented.

Spatial velocity distributions from Scenarios 4a and b are presented in Figure 6.1 and Figure 6.2, respectively. Subtracting the velocities under the 50% concept design structure size scenario (4b) from the 100% concept design scenario (4a) indicates localised differences in the velocity distribution, as in Figure 6.3. The variation in velocity predominantly falls within the range of -0.01 to 0.01 m/s across the wider floodplain, with velocities through the Tanyaca and Pike structures reduced in the 50% concept design case (indicated by a positive velocity difference), and increased over the blocking banks in the immediate vicinity of each regulator (negative velocity difference). The highest velocity difference is observed downstream of Tanyaca regulator, at 0.40 to 0.45 m/s less under the 50% concept design structure size relative to the 100% concept design sizing. Variation in surface water elevation is also observed with a decrease in regulator size, with Figure 6.4 indicating that surface water elevation upstream of the blocking alignment is increased by less than 0.01 m under the 50% concept design regulator case, relative to the 100% concept design regulator sizing.

In-stream discharge, water levels and direction of flow at blocking bank infrastructure is presented in Table 6.1. Note that the reported discharge data does not take into account any flow entering or exiting the impounded area of floodplain over the blocking bank, and thus does not represent an overall outflow and/or inflow to the floodplain. This is particularly apparent by comparing totals of the inflows via each structure to outflows through outlet structures (i.e. Tanyaca and Pike regulators, and over Bank E), with a discrepancy of approximately 3320 ML/d for the 100% concept design sizing and 4440 ML/d for the 50% regulator sizing scenario. Note that the inflow and outflow values in this table should be used with caution in further assessments given the undefined nature of overbank flows in the results, and should therefore be considered as indicative for comparison only.

Reducing the size of structures at Tanyaca and Pike reduces flow through the environmental regulators from 2520 to 1600 ML/d at Tanyaca regulator, and from 780 to 460 ML/d through Pike regulator. The differences between structure inflows and outflows, as indicated in the preceding paragraph, provides an indication that overbank flow increases as flow through the regulators decreases, if assuming these differences can act as an approximation for overbank flow. This effect is further highlighted by the increase in velocity observed at blocking banks adjacent to the structures with the reduction in regulator size (refer to Figure 6.3). This information indicates that increased flow is being routed over the blocking banks to compensate for the reduction of flow passing directly through the regulators. This may act as an erosion hazard at high flows, requiring management to avoid scouring of the local floodplain and/or banks.

A summary of the hydraulics of each side of the floodplain and total floodplain in the impounded area is presented in Table 6.2. Estimated inflow and outflow values are calculated using the data in Table 6.1, with the outflow values based on the inflow values less the evaporative loss shown in Table 6.2. These estimated outflows in turn are used to calculate an indicative turnover rate, which suggests in both regulator sizing cases that turnover is at approximately 17%.

In summary, reducing the size of regulating structures to 50% of the concept design size results in some alteration to the hydraulics of the floodplain, in particular with the outflows exiting through Tanyaca and Pike regulators, with the main differences in velocities being located at blocking bank locations adjacent to the regulating structures. The inclusion of smaller ancillary structures along the length of the artificial blocking bank in these adjacent areas could be used to reduce the velocity differences between the different structure sizes, provided that erosion considerations are accounted for.

Table 6.1 Discharge (in-channel), flow direction relative to the impounded area behind the blocking bank and upstream water level of blocking bank infrastructure for Scenarios 4a and 4b

Location	Scenario 4a discharge (ML/d)	Flow relative to impounded area	Water level (m AHD)	Scenario 4b discharge (ML/d)	Flow relative to impounded area	Water level (m AHD)
Deep Creek	1310	Inflow	17.1	1300	Inflow	17.1
Margaret Dowling	880	Inflow	17.1	880	Inflow	17.1
Bank B	1010	Inflow	17.0	990	Inflow	17.0
Bank B2	2040	Inflow	17.0	2020	Inflow	17.0
Bank C	1780	Inflow	17.0	1720	Inflow	17.0
Tanyaca Regulator	2520	Outflow	16.9	1600	Outflow	17.0
Bank E	400	Outflow	16.9	410	Outflow	16.9
Pike Regulator	780	Outflow	16.8	460	Outflow	16.8
Total inflow (via structures)[1]	7020	-	-	6910	-	-
Total outflow (via regulators)[1]	3700	-	-	2470	-	-

[1] Flow values do not account for over-bank flow

Table 6.2 Summary of hydraulic characteristics for Scenarios 4a to b

Scenario	Total estimated inflow ML/d	Parameter	Units	Mundic-Tanyaca Creek	Pike River	Total
4a	7020	Est outflow[1]	ML/d	-	-	6760
		Volume	ML	13 246	25 979	39 225
		Est turnover[2]	%	-	-	17
		Water Level[3]	m AHD	17	16.84	-
		Wetted Area	ha	779	1955	2734
		Evaporative Loss[4]	ML/d	74	186	260
4b	6910	Est outflow[1]	ML/d	-	-	6650
		Volume	ML	13 281	26 019	39 300
		Est turnover[2]	%	-	-	17
		Water Level[3]	m AHD	17	16.84	-
		Wetted Area	ha	779	1956	2735
		Evaporative Loss[4]	ML/d	74	186	260

[1] Estimated outflows based on approximation using modelled inflows through structures minus calculated evaporative loss. Does not account for over-bank flow

[2] Estimated turnover based on estimated outflows as a percentage of modelled volume – indicative only

[3] Water level upstream of each relevant structure (not applicable for total floodplain)

[3] Based on the long term average daily evaporation of 9.5 mm/d for January from the nearest BoM weather station

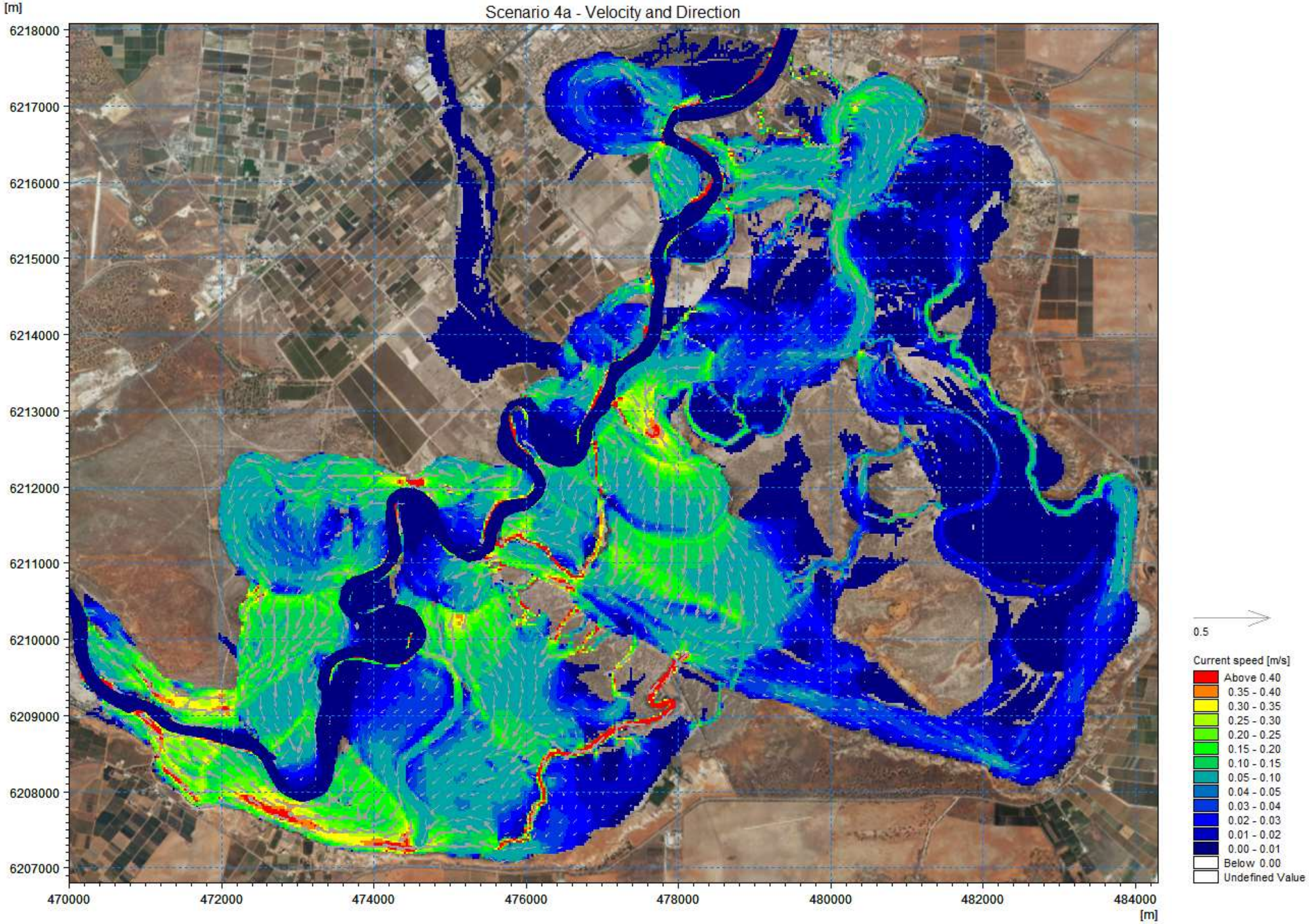

Figure 6.1 Velocity distribution and direction for River Murray flow of 90 000 ML/d with all structures open. Environmental regulators at Tanyaca and Pike at 100% of concept design size

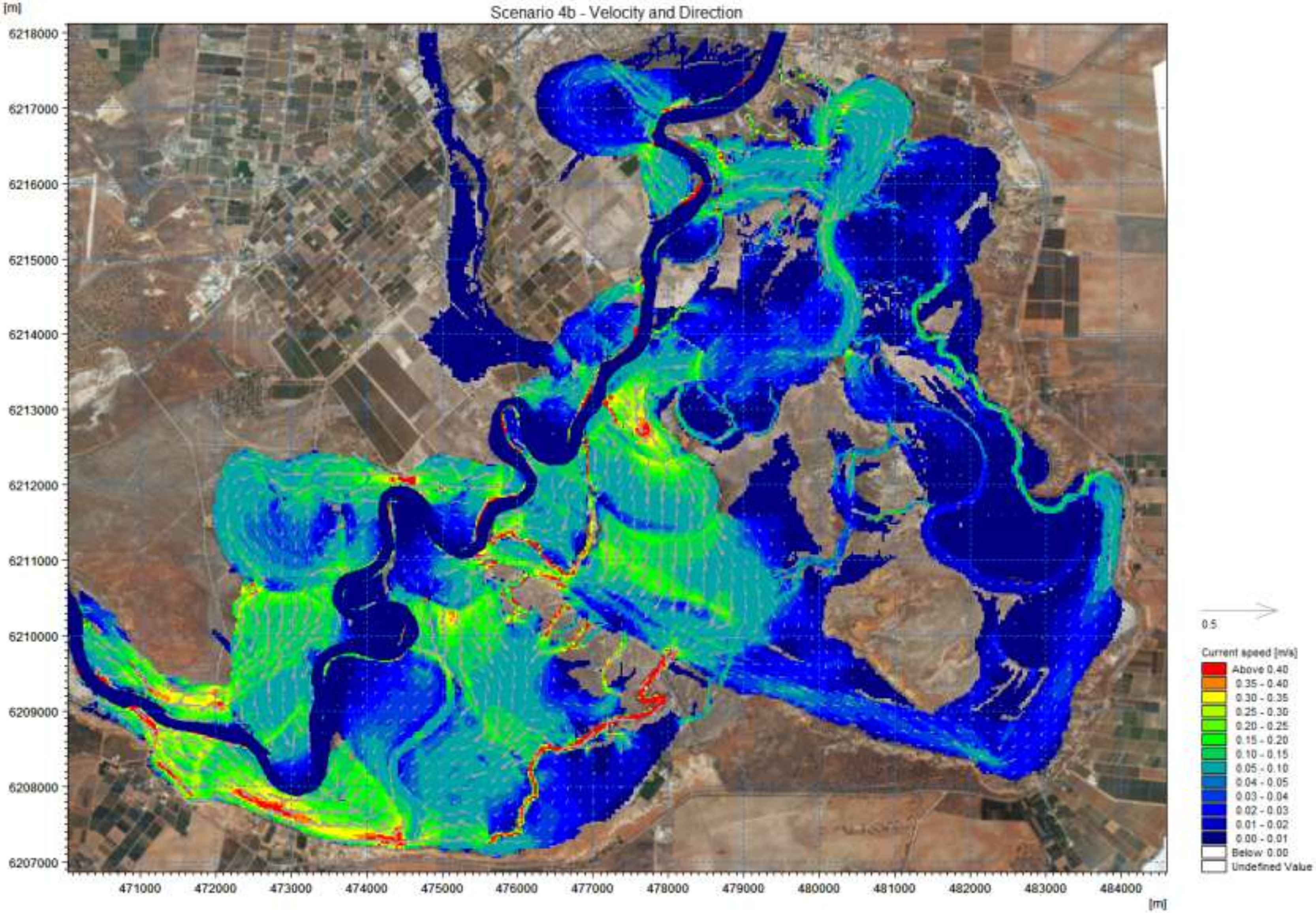

Figure 6.2 Velocity distribution and direction for River Murray flow of 90 000 ML/d with all structures open. Environmental regulators at Tanyaca and Pike at 50% of concept design size

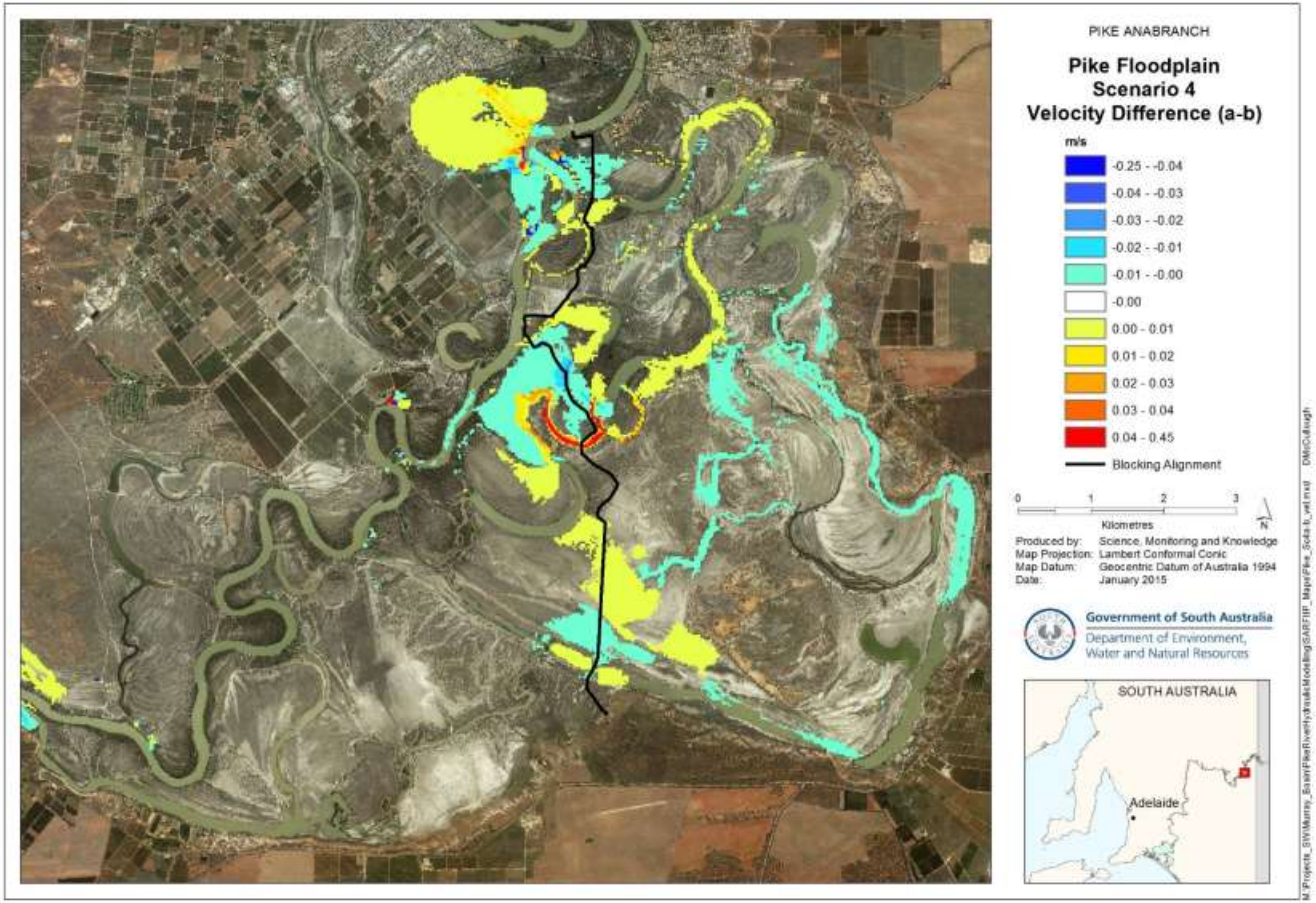

Figure 6.3 Velocity difference encountered at a River Murray flow of 90 000 ML/d between 100% and 50% concept design regulator sizes

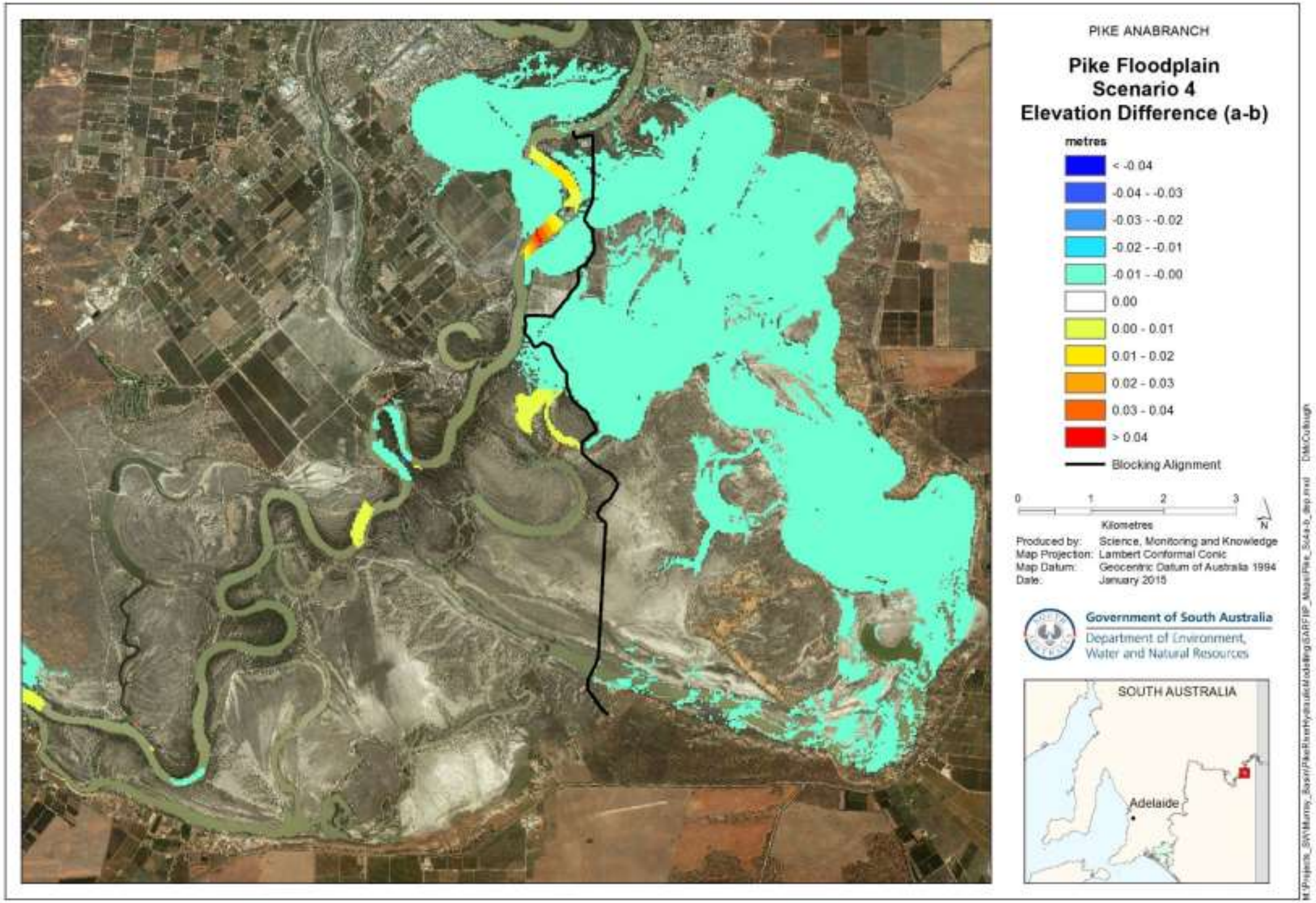

Figure 6.4 Surface water elevation difference at a River Murray flow of 90 000 ML/d between 100% and 50% concept design regulator sizes

7 Scenario 5 – Managed inundation scenario with alternative placement of Pike River environmental regulator

Operation of managed inundation infrastructure for inundating the Pike Floodplain to a maximum height of 16.4 m AHD has been previously investigated in McCullough (2013) under the concept design blocking bank alignment (i.e. the regulator in the Pike River situated at the existing, Eastern, Col Col Bank site). The current scenario investigates managed inundation of the floodplain to a maximum height of 16.4 m AHD, with the Pike River regulator situated at the western location.

Configuration of the scenario is indicated in Table 2.1. Three different flows through Tanyaca Regulator are investigated at the maximum inundation height, namely at 100, 400 and 800 ML/d, which are designed to indicate the hydraulic impact on the system through manipulating the regulators during inundation. In particular, the turnover rates at various inundation heights are calculated by the total outflow from the system as a percentage of the total system volume. This value indicates the exchange of water within the impounded area, and forms an important consideration for potential water quality impacts.

Note that the turnover rate is limited by flows through Margaret Dowling and Deep Creek regulators up to the river flow at which Lock 5 becomes submerged (i.e. over approximately 60 000 ML/d). The modelling focused only on inflows to the floodplain through these creeks – additional inflows through the current Bank B and C locations (i.e. the only other current inlets to the floodplain upstream of the blocking alignment) are not possible at river flows that would be conducive to managed inundation events under operating conditions up to 16.4 m AHD, as the river is unable to create a positive head difference from river to floodplain through these additional inflow locations. From Figure 7.1 it can be seen that a Flow to South Australia of at least approximately 60 000 ML/d is required to raise the water level downstream of Lock 5 to exceed 16.4 m AHD and thereby create the positive head difference required for flow, which is well in excess of flows under which the Lock 5 pool level can be realistically raised as required for managed inundation (note that Flow to South Australia has been used in the plot as opposed to Lock 5 flow as Lock 5 flow is unavailable above approximately 60 000 ML/d, and the Flow to South Australia has been lagged 3 days to account for travel time).

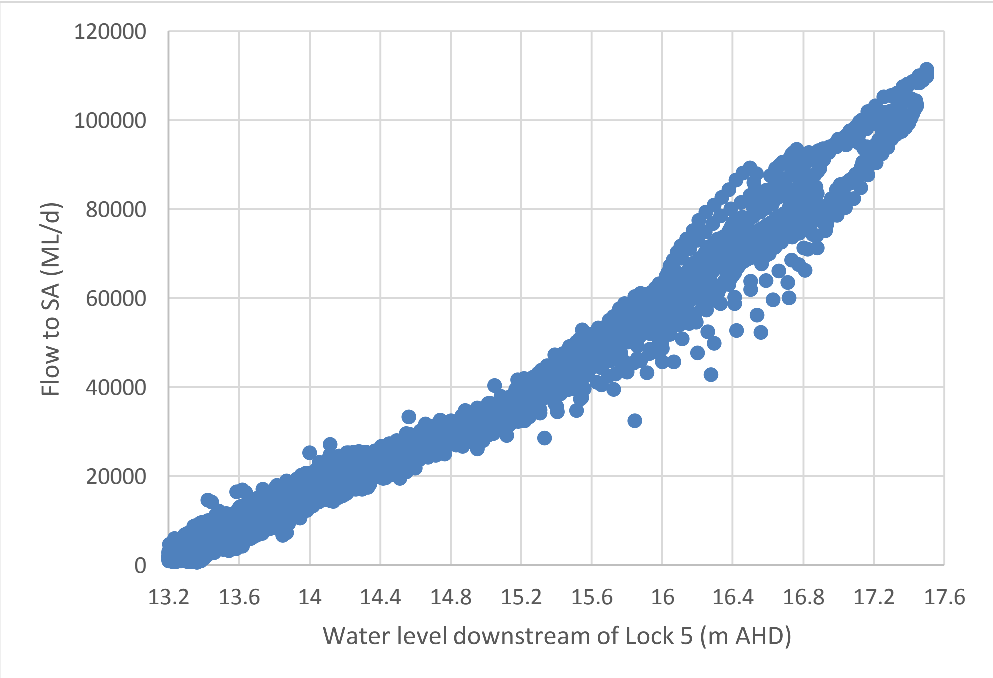

Figure 7.1 Flow to South Australia versus water level downstream of Lock 5

While additional inflows to improve turnover rates in the floodplain are not possible at river flows conducive to managed inundation, raising the downstream pool level at Lock 4 to further raise levels in the Lock 4 to 5 reach also do not appear likely to allow additional inflows through Banks B and C. Modelling was therefore focused on Lock 4 under normal pool level only (i.e. 13.2 m AHD) for the purpose of this scenario. The impact of raising Lock 4 pool level on water levels in the Lock 4 to 5 reach has been previously modelled in Macky and Bloss (2012), and also to a limited extent in McCullough et al. (2016), with a selection of the modelling results shown in Figure 7.2. Note that the modelled levels presented in McCullough et al. (2016) should be considered as indicative only, as they are derived from scenarios conducted using the existing Katarapko Floodplain MIKE FLOOD model – this model only provides 1-D/2-D coupling of the floodplain area, while the river further upstream of the floodplain is represented in 1-D only. The Lock 4 weir pool level was also only considered at 14.20 m AHD for the purposes of this modelling, rather than top of piers level at 14.34 m AHD. In contrast, the modelled data presented in Macky and Bloss (2015) is based on a full 2-D representation of the reach and considers the weir pool level at top of piers height, and as such can be considered as possessing greater accuracy compared to the McCullough et al. (2016) results. The indicative modelling results show that under all combinations of Lock 4 weir pool level and River Murray flows considered, the maximum level achievable is in the order of between 15.40 to 15.42 m AHD at the Banks B, B2 and C inlets, which is approximately 1 m lower than the maximum inundation height of 16.4 m AHD. These results suggest that manipulation of Lock 4 weir pool level at river flows up to 40 000 ML/d alone will be unlikely to enable Banks B, B2 and C to be used as additional inlets to the floodplain during a managed inundation event at full inundation height (i.e. 16.4 m AHD).

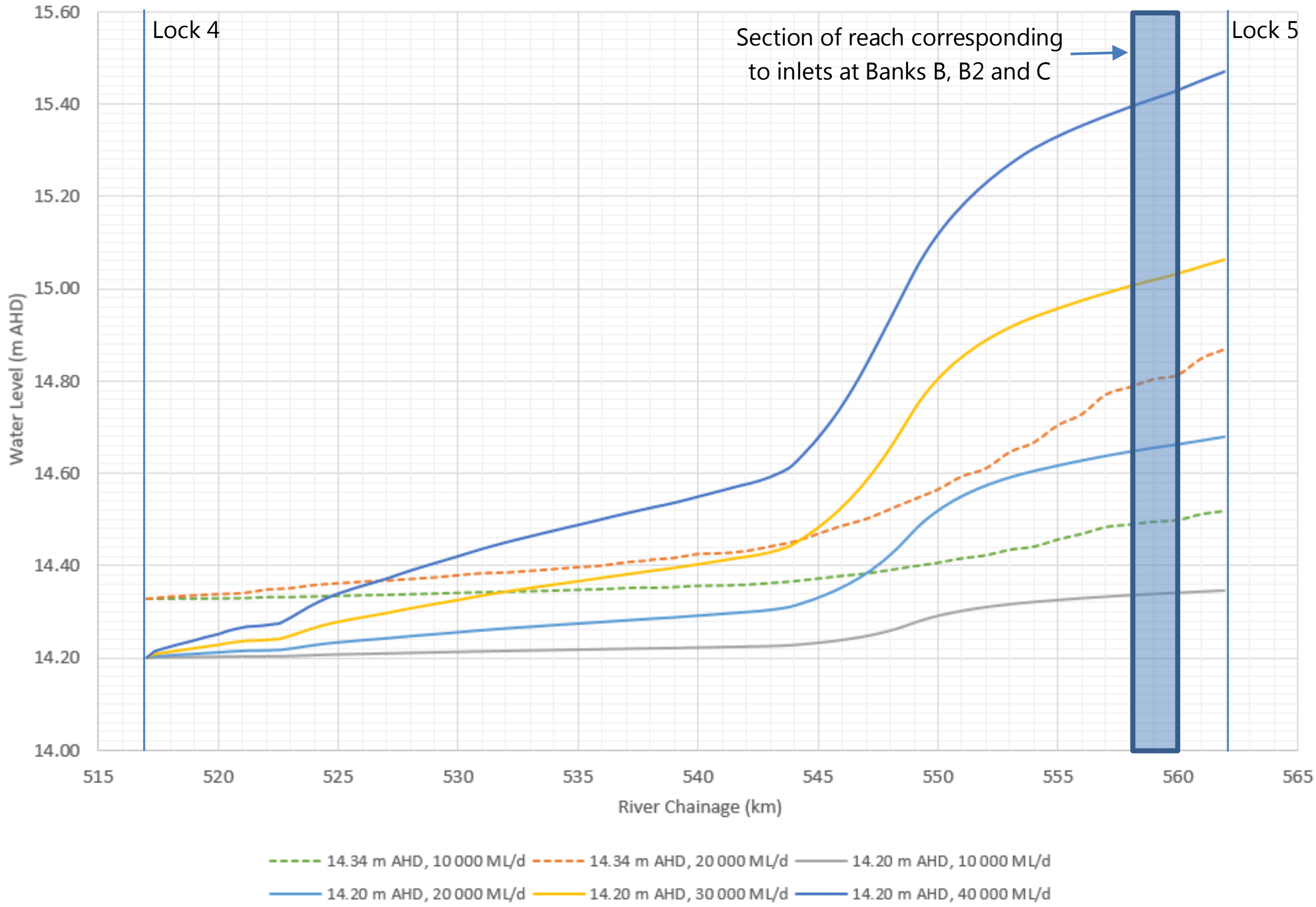

Figure 7.2 Modelled water levels between Locks 4 and 5 for raised Lock 4 weir pool levels of 14.34 m AHD (Macky and Bloss, 2012) and 14.20 m AHD (McCullough et al., 2016), at various River Murray flows downstream of Lock 5. Locations of Locks 4 and 5, and section of reach corresponding to inlets at Banks B, B2 and C are indicated.

Under the conditions modelled, the maximum inundation extent achievable by the western alternative location of the Pike River environmental regulator is shown in Figure 7.3. This provides a total inundated area of approximately 2170 ha, and total impounded volume of approximately 27 000 ML. The velocity maps for the various Tanyaca flow rates tested (i.e. 100, 400 and 800 ML/d) are presented in Figure 7.4 to Figure 7.6, respectively.

The velocity vectors in the velocity distribution maps highlight that velocities through the Pike River side of the floodplain gradually decrease as Tanyaca flow varies from 100 ML/d to 800 ML/d, resulting in a corresponding improvement in the velocities through Mundic and Tanyaca creeks. Despite the variation in flow split between the two regulators, the velocities in the impounded area predominantly remain in the lowest velocity range of 0 to 0.02 m/s for all cases.

The low velocities through the system during maximum inundation are reflected in the corresponding turnover rates for each flow split, as shown in summary Table 7.1. Turnover in the Mundic–Tanyaca area of the floodplain varies from 10% with a flow of 100 ML/d through Tanyaca to 11% at 800 ML/d. Conversely, turnover in the Pike River side of the floodplain varies from 6% to 2% over the same Tanyaca flow variation. Overall, turnover rate of the total impounded area of floodplain remains relatively constant at approximately 4%.

The variation of total inundated area, impounded volume and estimated loss to evaporation with Mundic Creek water level is shown in Figure 7.7, while Figure 7.8 indicates the change in total turnover rate with increasing Mundic level (note that turnover in this case assumes full outflow over the range of heights). These results show that a turnover rate of approximately 20% is encountered with flow confined to the channels (approximately 400 ha inundated area and 5000 ML impounded volume), reducing gradually to 9% for a level of 15.5 m AHD (inundated area of approximately 1000 ha and impounded volume of 11 000 ML), and reducing to 4% at the full inundation level under the assumed maximum inflow to the floodplain of 1200 ML/d. This indicates that turnover rates over the floodplain do not exceed 20% where managed inundation is being implemented with an assumed maximum flow into the floodplain of 1200 ML/d. As an example, increasing the inflow to a hypothetical value in the order of 2300 ML/d is likely to achieve a 20% turnover rate (after evaporation and diversion losses) at an operational level of 15.5 m AHD upstream of Mundic outlets, Snake Creek inlet and Tanyaca Creek environmental regulator, corresponding to an impounded volume of 11 000 ML. Further investigation is required to identify the feasibility of increased inflow to the floodplain, for example:

- Maximum flow in each of Margaret Dowling and Deep Creek inlets is assumed to be 600 ML/d, however this may be conservative and should be confirmed through monitoring once the upgraded inlet structures are operational
- Raising the water level downstream of Lock 5, through higher river flows and raising Lock 4 in combination with operating heights below 16.4 m, to create inflow through Banks B, B2 and C.

Table 7.1 Summary of hydraulic characteristics for Scenario 5, various Tanyaca Creek flows

Scenario	Total inflow ML/d	Parameter	Units	Mundic-Tanyaca Creek	Pike River	Total
5	1200	Outflow[1]	ML/d	100	894	994
		Volume	ML	9486	17 721	27 207
		Turnover[2]	%	10	6	4
		Water Level[3]	m AHD	16.4	16.4	-
		Wetted Area	ha	601	1572	2173
		Evaporative Loss[4]	ML/d	57	149	206
5	1200	Outflow[1]	ML/d	400	594	994
		Volume	ML	9411	17 665	27 076
		Turnover[2]	%	10	4	4
		Water Level[3]	m AHD	16.4	16.4	-
		Wetted Area	ha	599	1569	2168
		Evaporative Loss[4]	ML/d	57	149	206

5	1200	Outflow[1]	ML/d	800	194	994
		Volume	ML	9338	17 595	26 933
		Turnover[2]	%	11	2	4
		Water Level[3]	m AHD	16.4	16.4	-
		Wetted Area	ha	597	1564	2161
		Evaporative Loss[4]	ML/d	57	149	206

[1] Outflow from regulating structures in Tanyaca and Pike for respective floodplain sections (combined for total floodplain)
[2] Outflow as a percentage of total volume (Mundic–Tanyaca Creek sections includes outflow from both Tanyaca and Pike sections)
[3] Water level upstream of each relevant structure (not applicable for total floodplain)
[4] Based on the long term average daily evaporation of 9.5 mm/d for January from the nearest BoM weather station

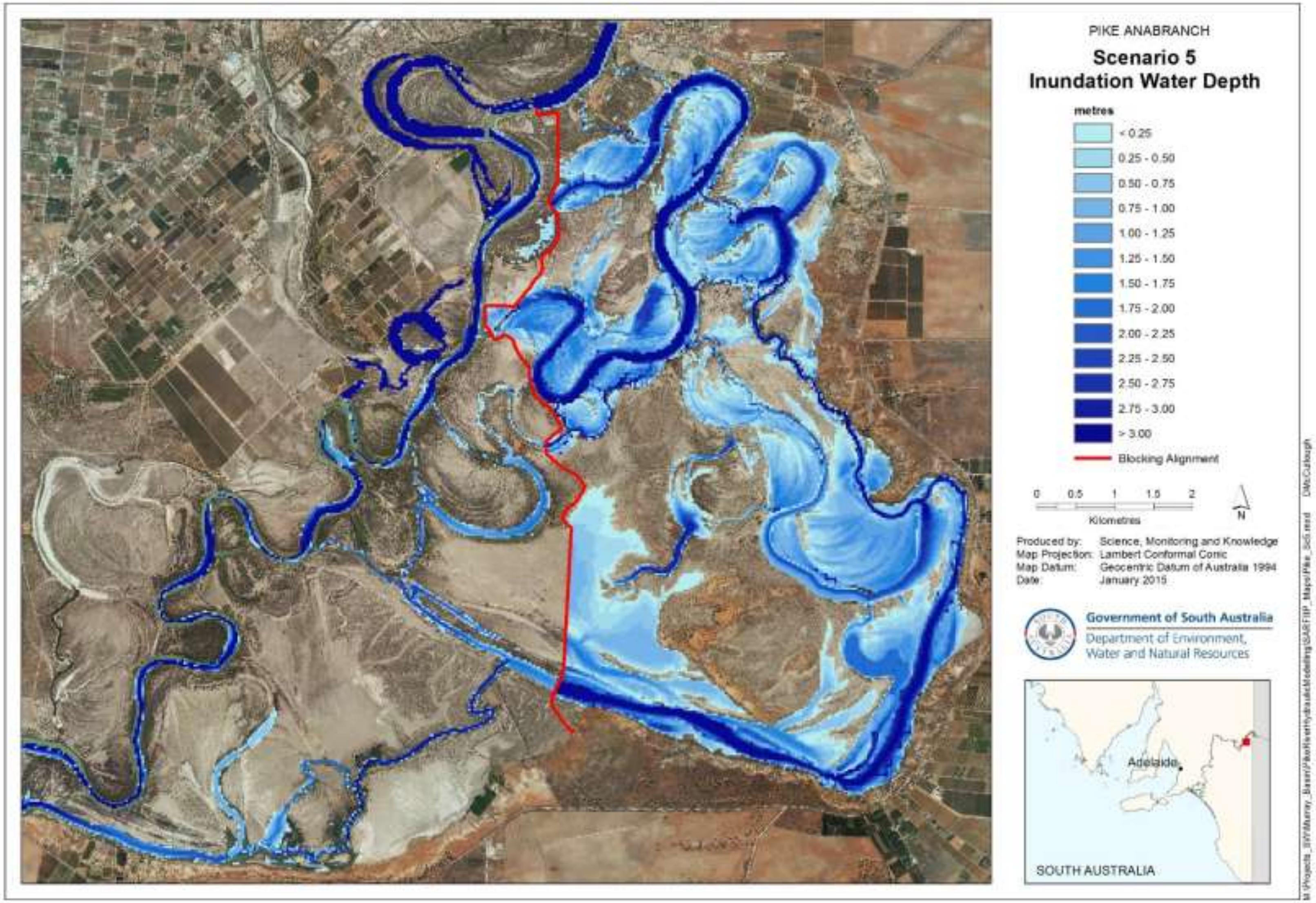

Figure 7.3 Inundation extent and water depth at an inundation level of 16.4 m AHD with alternative Pike River environmental regulator placement (flow of 100 ML/d through Tanyaca Creek)

Figure 7.4 Velocity distribution and flow direction at an inundation level of 16.4 m AHD with alternative Pike River environmental regulator placement and a flow of 100 ML/d through Tanyaca Creek

Figure 7.5 Velocity distribution and flow direction at an inundation level of 16.4 m AHD with alternative Pike River environmental regulator placement and a flow of 400 ML/d through Tanyaca Creek

Figure 7.6 Velocity distribution and flow direction at an inundation level of 16.4 m AHD with alternative Pike River environmental regulator placement and a flow of 800 ML/d through Tanyaca Creek

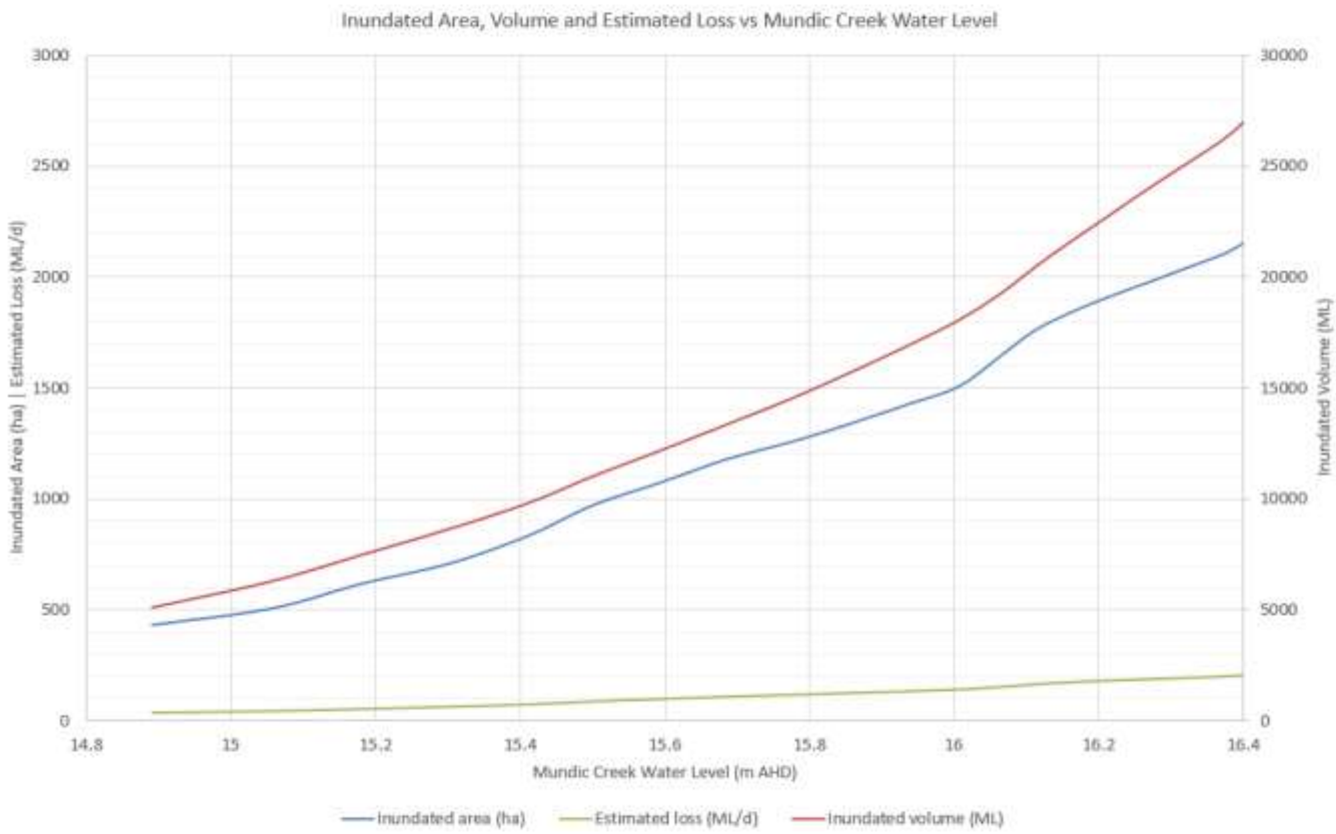

Figure 7.7 Inundated area (ha), impounded volume (ML) and estimated loss (ML/d) versus Mundic Creek water level

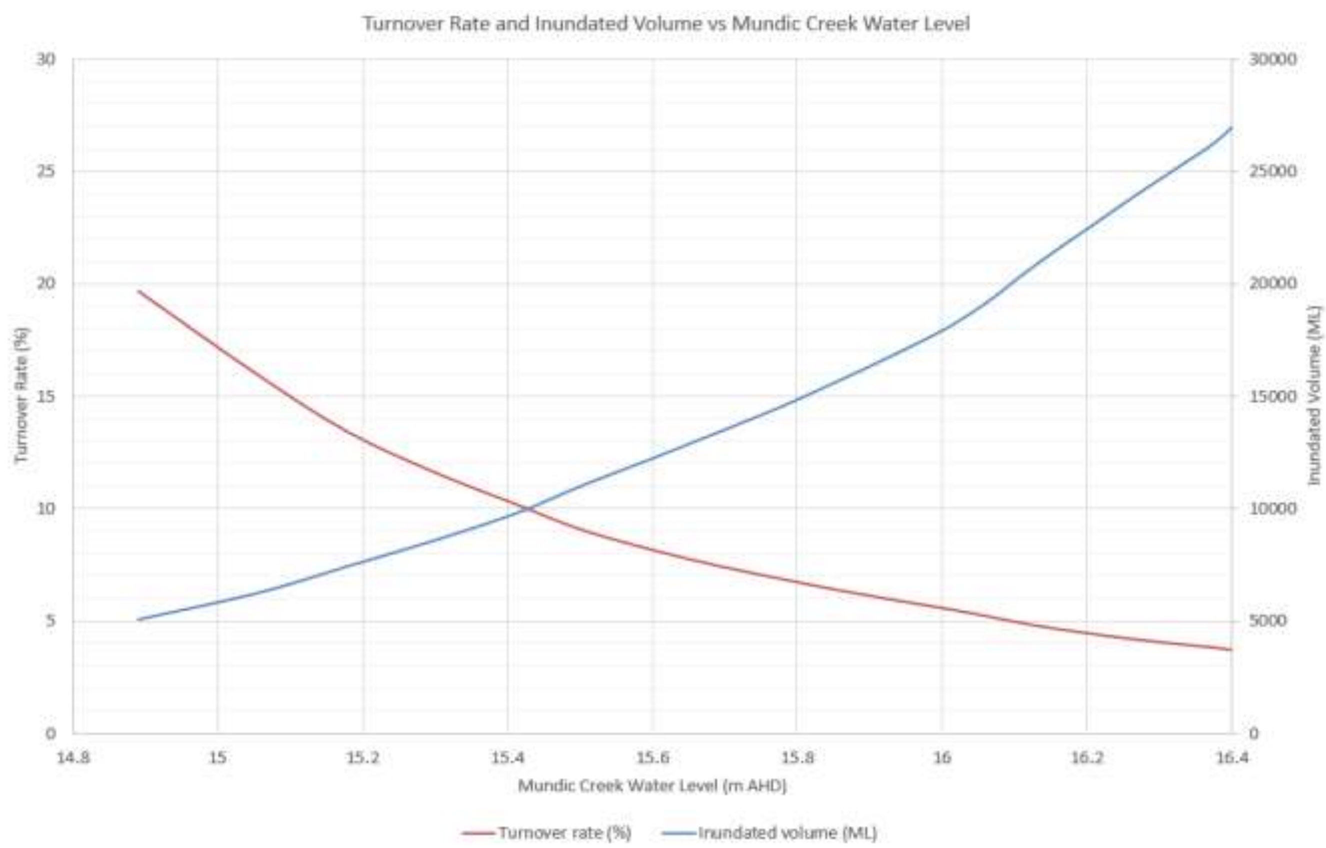

Figure 7.8 Overall turnover rate and impounded volume versus inundation height at Mundic Creek

8 Scenario 6 – Regulator and blocking bank impacts of a natural flood event with fast rising limb

Scenario 6 was configured to investigate the hydraulic impact of the blocking banks and regulators as it relates to a fast rising natural flood, with a focus on head difference across Pike and Tanyaca regulators and identification of any areas that may be prevented from inundating by presence of the blocking bank. The scenario was modelled on an extreme case of the fastest rising limb of historical flood events on record, namely the high flow event in 1981, as shown in Figure 8.1. River flows are shown to rise from under 10 000 ML/d up to a maximum of 105 000 ML/d over a period of approximately 100 days. All structures and banks have been modelled assuming upgraded structures, with Tanyaca and Pike River environmental regulators modelled at 50% of the concept design sizes. Given this scenario is set up dynamically, the representation of loss in the model has been changed from previous steady state scenarios in that it is applied as a constant evaporation loss of 9.5 mm/d, in order to allow losses to be applied inherently in the model results. Losses are also applied in this way for all subsequent scenarios.

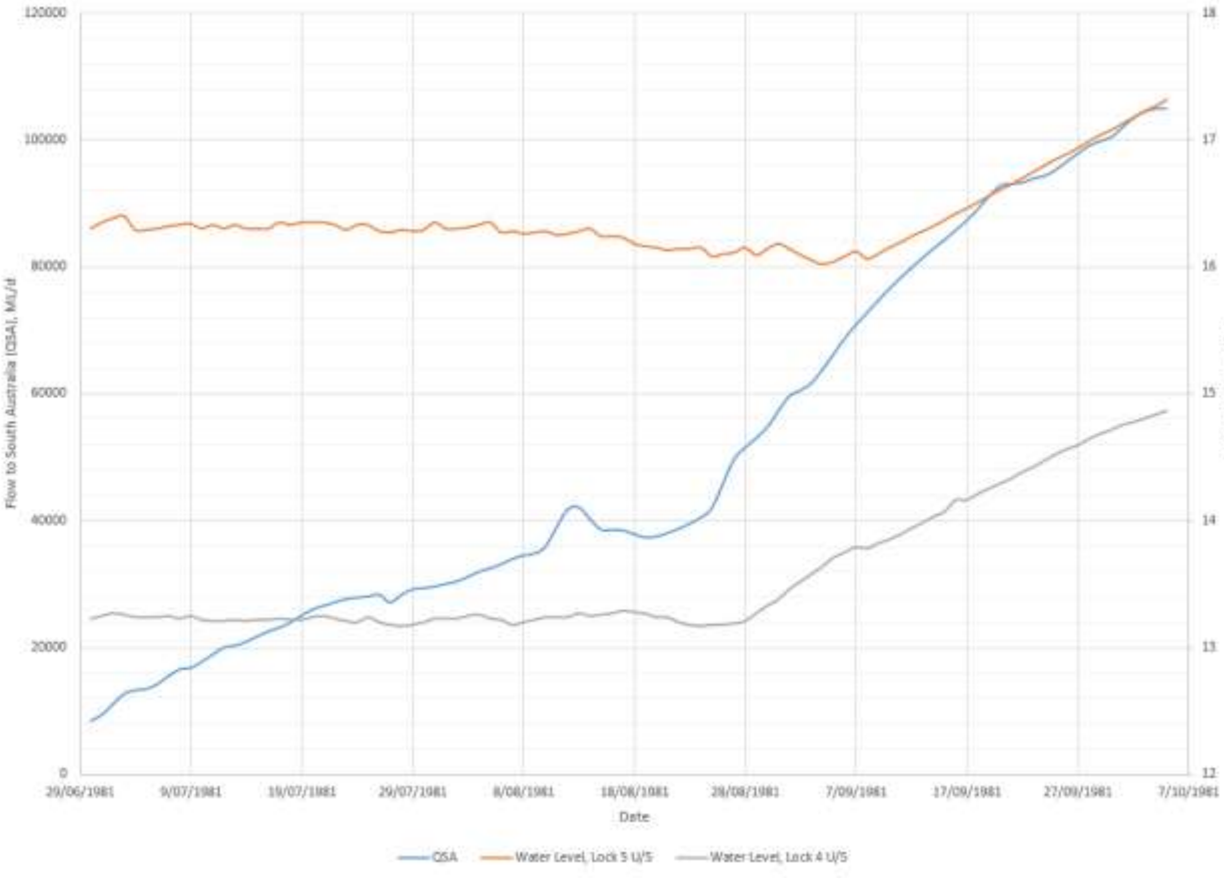

Figure 8.1 Hydrograph for 1981 flood event, including Flow to South Australia (QSA) and corresponding water levels upstream of Locks 4 and 5

Regulators at Tanyaca and Pike River have been configured to control water levels upstream of the blocking alignment to 14.75 m AHD in Mundic Creek and 14.35 m AHD in the Upper Pike River, until the water levels on the River Murray side equilibrate across each structure, after which the regulators are fully opened. Banks B, B2 and C have also been configured to remain closed until water levels equilibrate across each structure, upon which the structures are similarly opened. For simplicity, structures at Deep Creek and Margaret Dowling were configured as fully open for the entire hydrograph, allowing inflows to be controlled only by Lock 5 weir pool level. Water levels upstream and downstream of Tanyaca and Pike River regulating structures, as well as discharges through each structure are reported as they vary through the hydrograph, with particular interest on whether any inflows occur through these structures for the duration of the hydrograph.

The variation of discharges through all inlet structures (i.e. total inlet through Margaret Dowling and Deep Creeks, Banks B, B2 and C) in comparison to River Murray flow upstream of Lock 5 are shown in Figure 8.2. Water levels upstream and downstream of Tanyaca Creek regulator, including flow through the structure, are shown in Figure 8.3, while the equivalent plot for Pike River regulator is shown in Figure 8.4. Tabulated data for daily flows through Tanyaca and Pike regulators, as well as corresponding water levels upstream and downstream of each structure (including head difference) for the entire rising limb of the 1981 flood event are shown in Appendix B, Table B.1.

The results indicate that no inflows from the River Murray to the impounded area of floodplain occur through the Tanyaca and Pike River regulators for the entire hydrograph, with all flows occurring consistently as outflows from the impounded area. All inflows to the floodplain occur at structures in the northern part of the floodplain, including the typical inlets at Margaret Dowling and Deep Creeks, and Banks B, B2 and C (when fully opened). In the case of Banks B, B2 and C, only short periods of outflow through these structures are encountered following the point at which the structures are fully opened from a closed position, corresponding to River Murray flows of between 31 000 to 36 000 ML/d. Head differences across each regulator (once fully opened) are relatively minor, at only approximately 0.06 m at Tanyaca regulator and 0.01 m at Pike River regulator under the highest River Murray flows modelled.

While no inflows to the impounded area from the River Murray are modelled through the regulating structures, the results indicate that some inundation of the floodplain is prevented by the blocking bank at certain River Murray flows. Figure 8.5 shows the inundation extents in the vicinity of Pike regulator at River Murray flows of approximately 50 000 and 80 000 ML/d, between which the area immediately to the north-east of the regulator (circled in dark blue in Figure 8.5) is prevented from natural inundation by the blocking bank. These flows correspond to water levels upstream of the Pike River regulator of approximately 14.61 m AHD and 15.95 m AHD, respectively, with head losses of 0.01 m across structure in each case. This area remains disconnected from the channel upstream of the regulator below a level of approximately 16.0 m AHD, resulting in an area of up to approximately 100 ha that is prevented from inundation by the blocking alignment. Measures to introduce inundation to the area at the flows identified may include a smaller ancillary structure in the blocking bank adjacent to this area, which would remain open outside of managed inundation events to allow natural elevated flows to enter the area, subject to further investigations.

Of additional note is the total inlet flow, through Margaret Dowling and Deep Creeks in their fully open configuration (Figure 8.2), is equivalent to approximately 1400 to 1500 ML/d under River Murray flows of up to approximately 30 000 ML/d, with the majority of flow during this period entering through Deep Creek at an average flow of approximately 950 ML/d. This suggests the possibility that total inflows marginally greater than the currently assumed maximum of 1200 ML/d may be possible if both structures are fully opened under typical Lock 5 weir pool levels. It should be noted however that the modelled structures have not yet been calibrated to actual flow data given Deep Creek regulator has only recently been constructed, and construction at Margaret Dowling regulator has yet to be commenced.

Note that a temporary period of minor instability was identified in the model results at Banks B, B2 and C around 28 August during the simulation period, which can be seen as localised spikes in the data (particularly at Bank C) in Figure 8.2. This is attributable to wetland areas to the west of the River Murray, where depths are estimated since they coincide with gaps in the DEM. These areas appear to cause instabilities only at specific hydraulic conditions within the river, and are therefore only seen under certain scenarios involving high flow and/or raised River Murray water levels. The cause of these instabilities were only identified under extensive troubleshooting while conducting modelling under Scenario 8, and were addressed by “filling in” the offending wetland areas given they are outside the reliable model boundary, however the source of instability was not identified at the time of analysis of this scenario. As the instability is limited to only 2 to 3 days in the modelling period the overall outcomes of this scenario are not adversely affected.

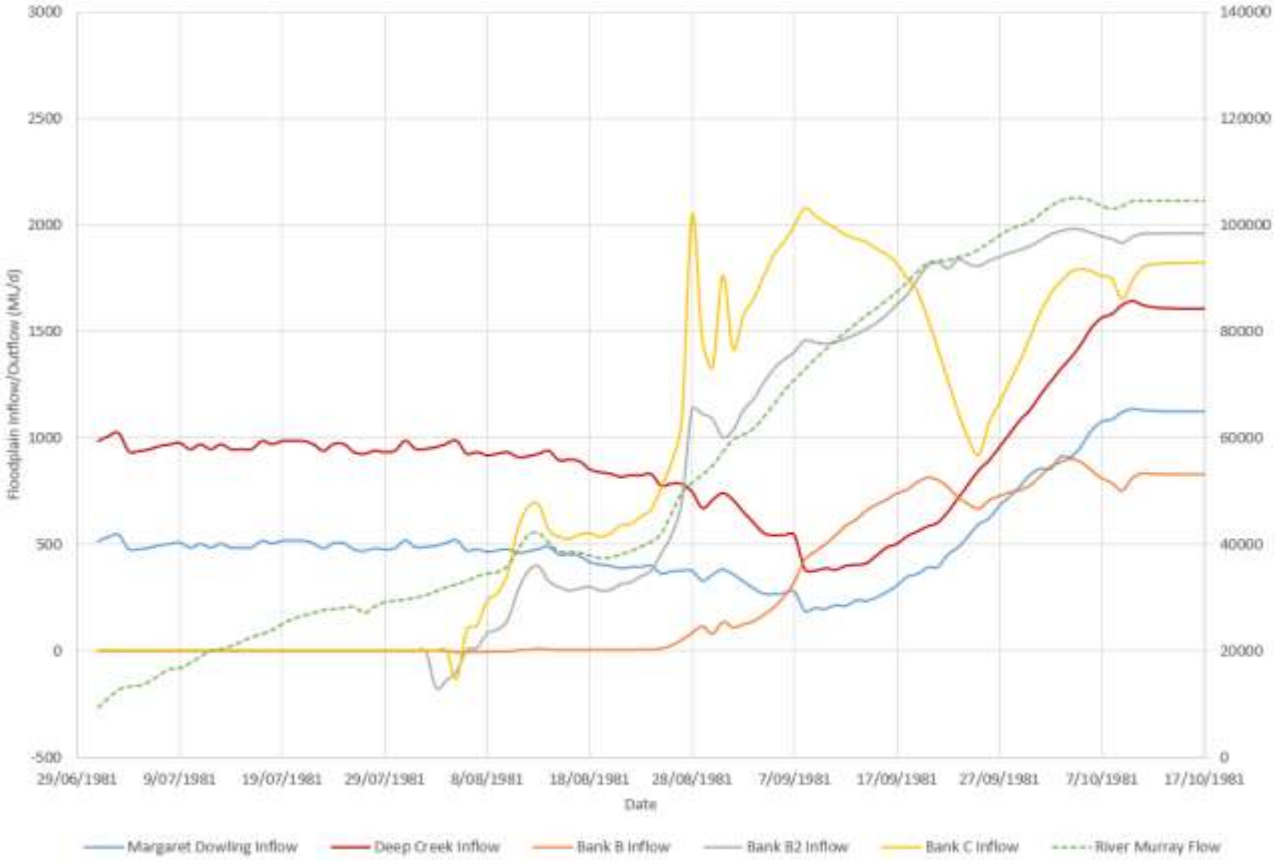

Figure 8.2 Flows into the floodplain through inlets (total of Margaret Dowling and Deep Creek), Banks B, B2 and C, compared to River Murray flow upstream of Lock 5. Direction of flow at inflow structures indicated by positive (into floodplain) and negative (out of floodplain) values.

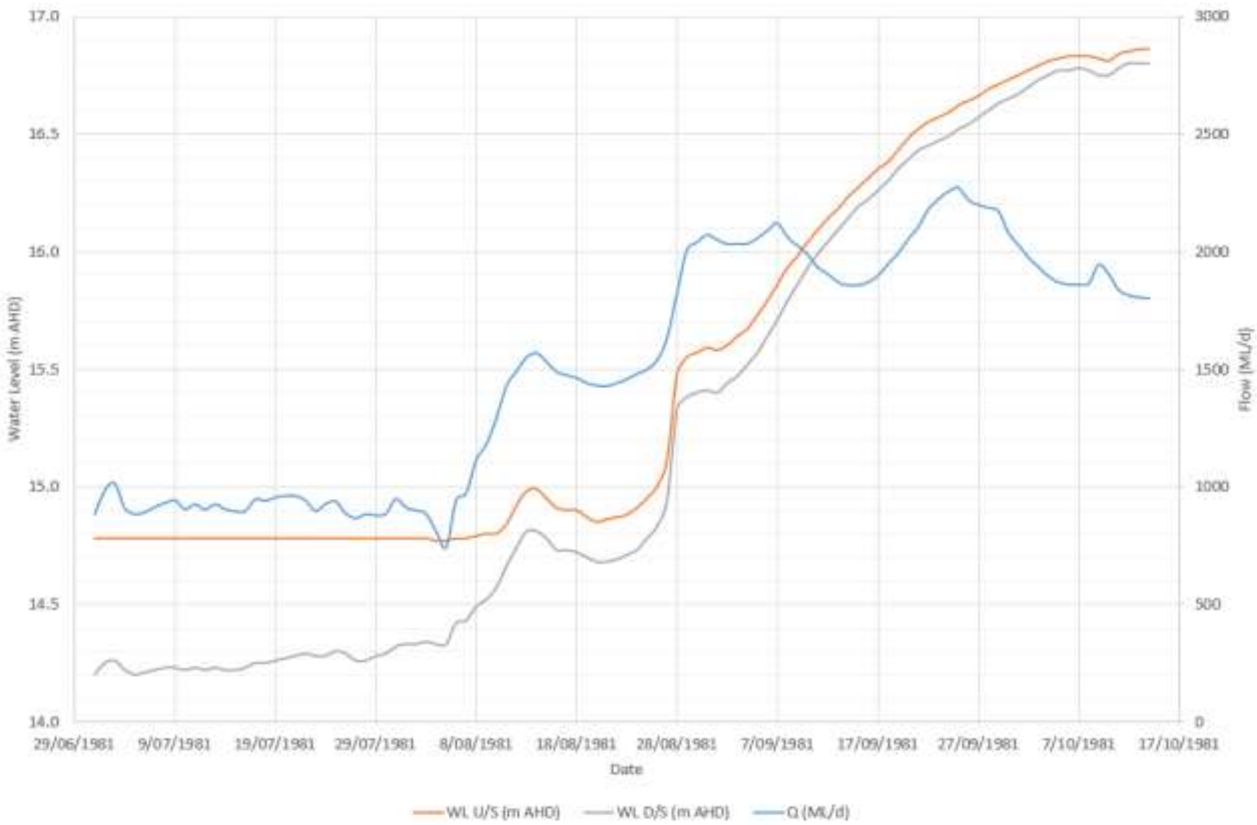

Figure 8.3 Water levels upstream, downstream and flow through Tanyaca Creek regulator

Figure 8.4 Water levels upstream, downstream and flow through Pike River regulator

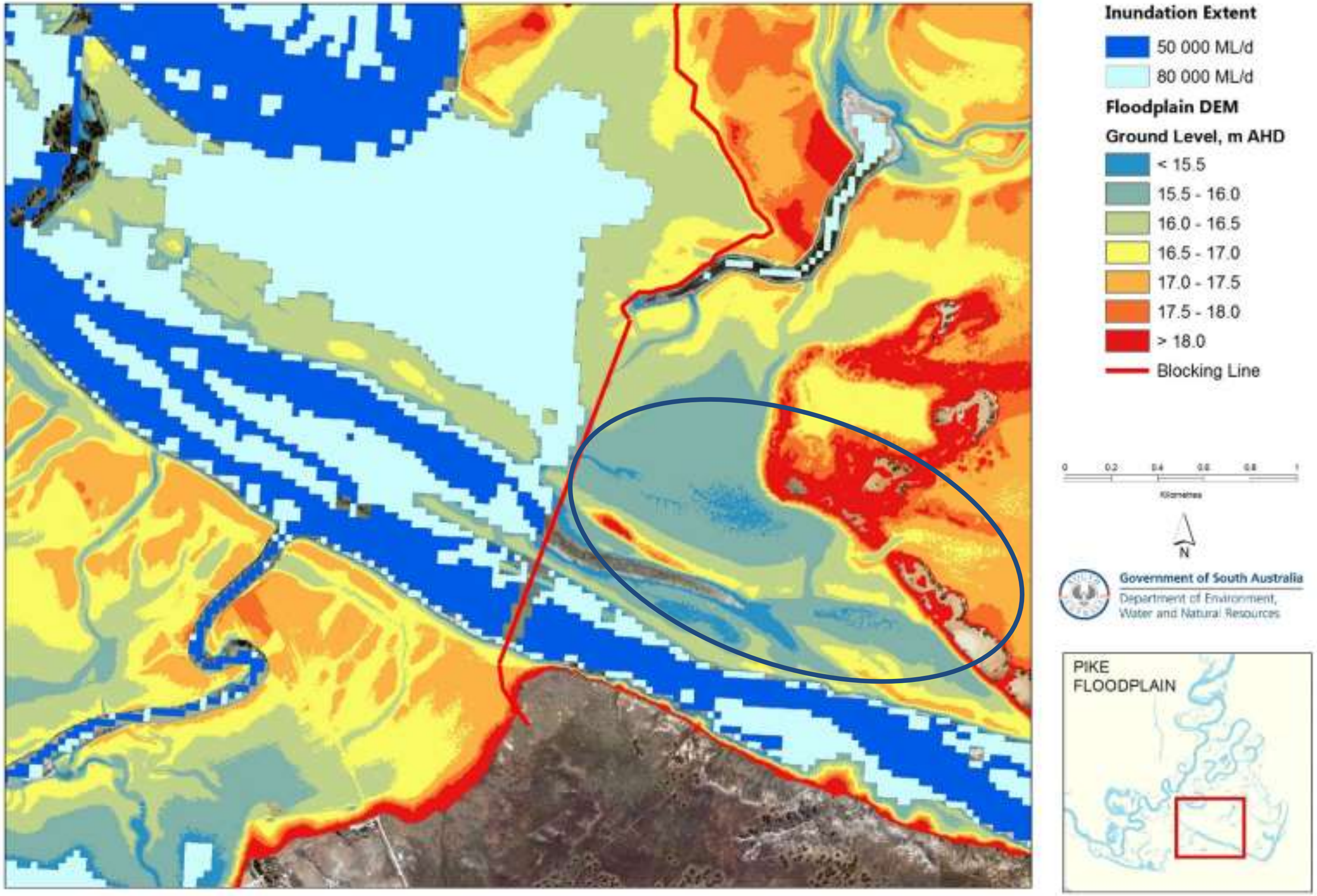

Figure 8.5 Inundation extents at River Murray flows of 50 000 ML/d (water level at Pike regulator of 14.61 m AHD) and 80 000 ML/d (water level at Pike River regulator of 15.95 m AHD), with reference to ground level elevation from Digital Elevation Model (DEM) of floodplain. Approximate area prevented from inundation by blocking bank is encircled in dark blue.

9 Scenario 7 – Dynamic inundation scenario, Alternative 2 blocking alignment

Scenario 7 was configured to reproduce a previously modelled dynamic operating regime (Water Technology, 2012; McCullough, 2013) for a managed inundation event with the updated Alternative 2 blocking alignment. The operating regime in the model configuration uses nominal inflow and outflow values that may not represent an optimised control methodology, and will likely require further refinement through additional investigations.

The complete control scheme used for the modelled managed inundation event is shown in Figure 9.1. Outflows were selected from Tanyaca and Pike River environmental regulators in line with the aforementioned previous modelling work of 250 and 50 ML/d, respectively, which provides a filling phase spanning approximately 30 days when operating below the critical maximum filling rate of 0.1 m/d under total inflows of 1200 ML/d through Margaret Dowling and Deep Creeks i.e. an average rate of impounded water level rise of 0.07 m/d upstream of the Pike River environmental regulator, and approximately 0.06 m/d upstream of Tanyaca regulator, over the filling period of 30 days. Note that greater outflow rates may be required for water quality considerations during the filling phase, which would act to reduce the rate of filling further below the critical maximum rate, and hence increase the period of filling.

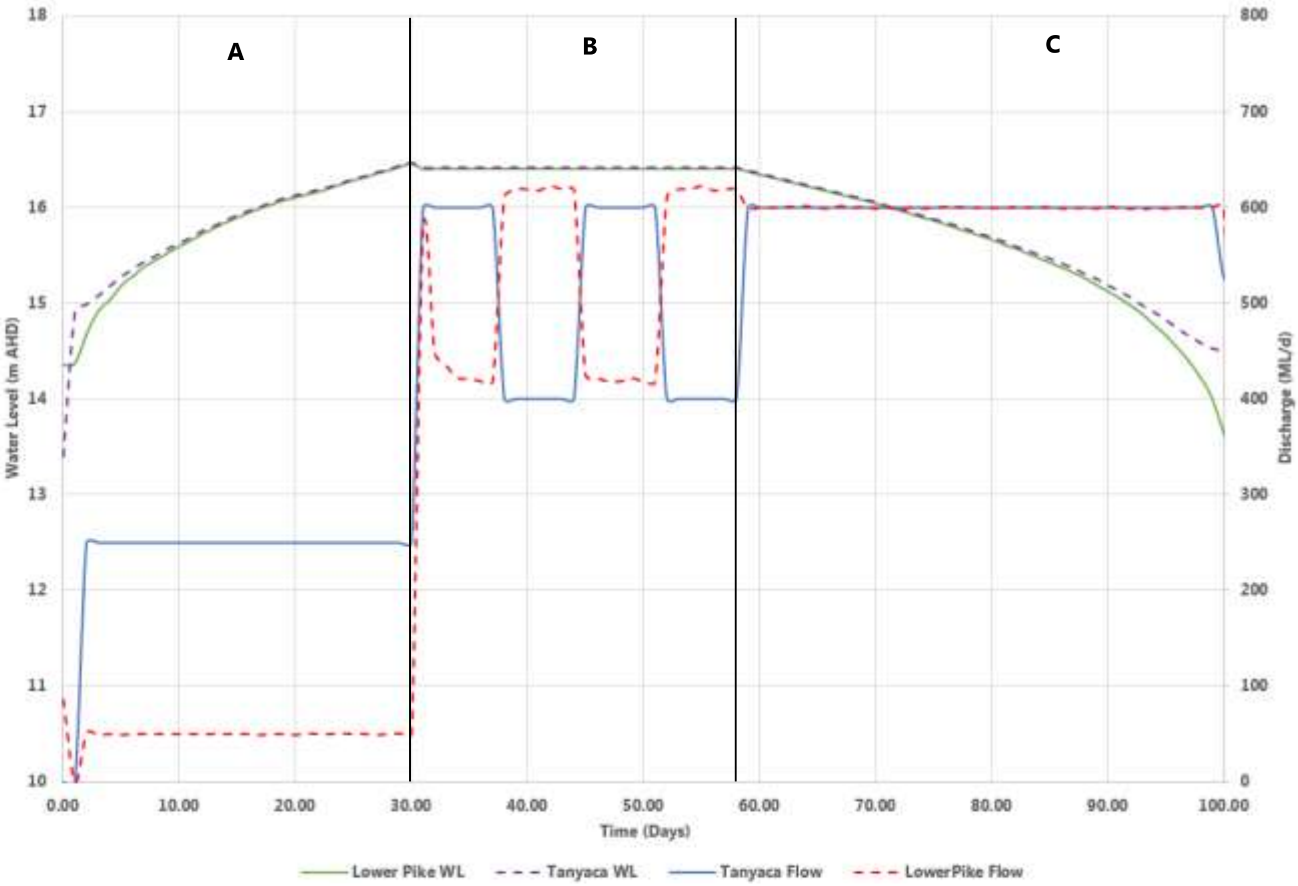

Figure 9.1 Operating scheme for managed inundation event to 16.4 m AHD full inundation height. Various phases of operation indicated: A – Filling phase; B – Holding phase; and C – Draining phase.

During the draining phase of approximately 40 days, under outflow rates of 600 ML/d at each of Tanyaca and Pike River environmental regulators and a total inflow rate to the floodplain of 800 ML/d (i.e. reduced during the draining phase only), the average rate of draining upstream of both the Pike River and Tanyaca regulators is approximately 0.05 m/d, again remaining within the critical operating maximum rate of 0.1 m/d. Note that there may be additional benefit in continuing to operate the inlet structures at maximum flow (rather than under reduced inflows) during the draining phase from a turnover rate perspective, allowing greater outflows from the Pike River and Tanyaca regulators to be achieved while maintaining water level reduction under 0.1 m/d.

Flows through each structure during the four week holding period are varied between 400 and 600 ML/d at Tanyaca regulator in 7-day cycles, with the remainder of flow exiting through Pike River regulator at 16.4 m AHD maximum inundation elevation (i.e. approximately 620 and 420 ML/d, respectively). This variation in outflows was introduced to the model configuration in line with a previous inundation scenario presented in McCullough (2013) (i.e. Scenario 2) based on Water Technology (2012), and was maintained for the purposes of the current scenario to allow comparison in hydraulics between differing flow splits, however this mode of operation may not represent an optimised or practical operational methodology.

A plot of inundated volume and area in the impounded area (including permanently inundated channels) as it changes through the modelled inundation event is shown in Figure 9.2. This shows that a maximum impounded volume of approximately 26 000 ML during the holding phase, and a corresponding total area of approximately 2000 ha is reached at the maximum inundation extent of 16.4 m AHD. The total water balance including inflow, outflow and loss volumes (based on a constant loss rate of 9.5 mm/d, representing the highest average daily evaporation rate from nearby BoM weather station data) in the impounded area from start to end of the managed inundation event is also shown in Table 9.1. A total inflow volume of approximately 100 800 ML occurred, with approximately 16 600 ML lost from the system due to evaporation, resulting in a total outflow volume of approximately 84 200 ML. Note that the inundated extent at the end of the run is approximately 300 ha greater than at the start of the run (i.e. increase of approximately 75%), while volume is greater by approximately 1000 ML (i.e. 25% greater). These differences can be attributed to stored water in the floodplain following inundation, which appears as shallow areas on the floodplain, and hence results in a greater increase in the inundated area compared to inundated volume.

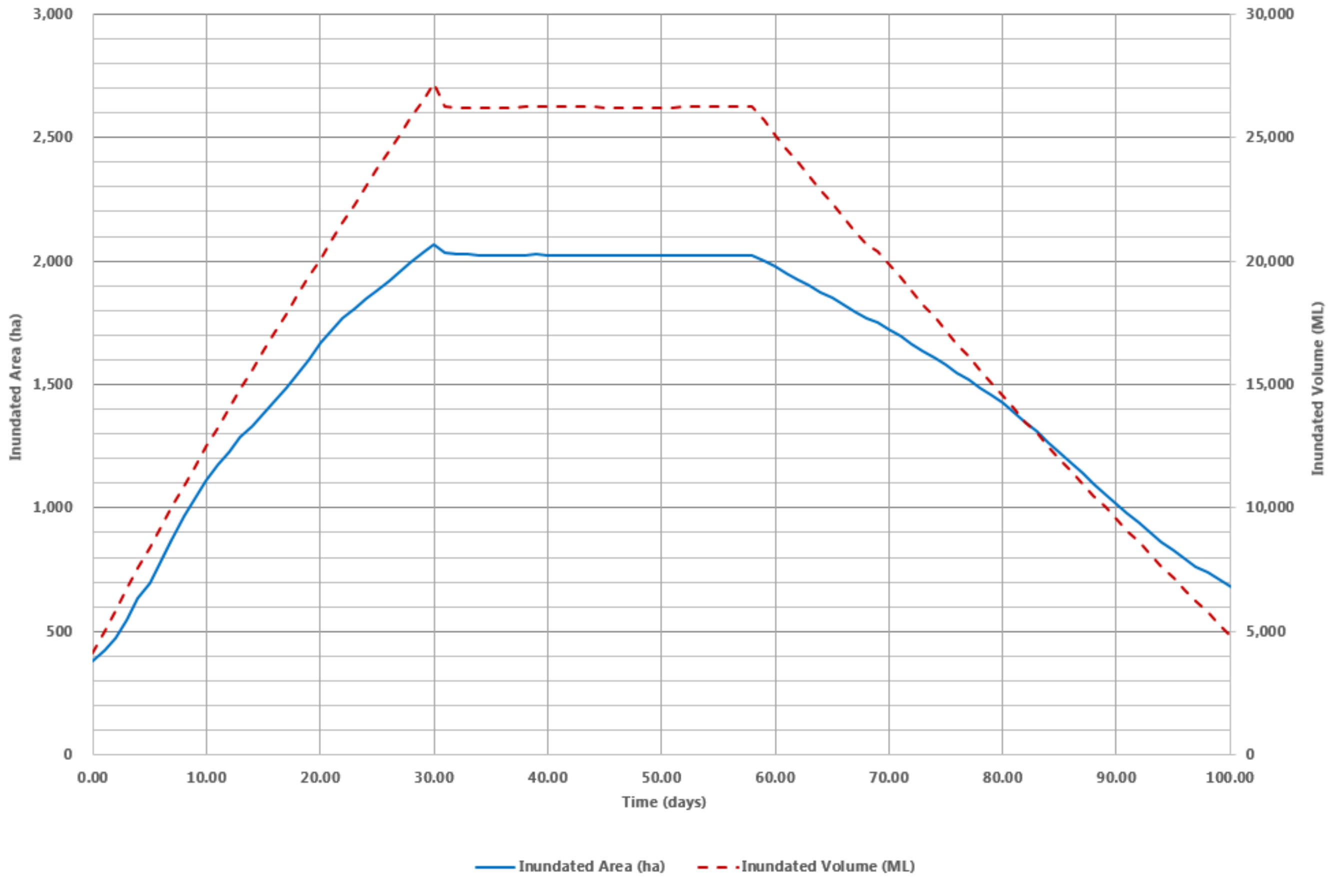

Figure 9.2 Inundated area and volume during period of operation.

Table 9.1 Water balance of total inflow, outflow and loss volumes during period of operation.

Water balance component (from start of filling phase to end of draining phase)	Total volume ML (% of inflow)
Inflow	100 800
Outflow	84 200 (84%)
Total loss (inflow – outflow)	16 600 (16%)

Turnover rate, as calculated using modelled outflows divided by the total impounded volume, is shown to remain below 5% for the duration of the filling phase, as shown in Figure 9.3. Note that the low turnover rate shown at the commencement of the filling phase is due to initial full closure of structures for the purposes of the model configuration prior to outflow commencing, and does not represent practical operation of the regulators. Turnover rate reduces as the filling phase progresses due to constant outflows of approximately 300 ML/d against a rising impounded volume, resulting in a minimum turnover rate of approximately 1% at the end of the filling phase under the outflows used. These low turnover rates at the outflows modelled indicate that higher outflows are likely to be required in practice for water quality considerations.

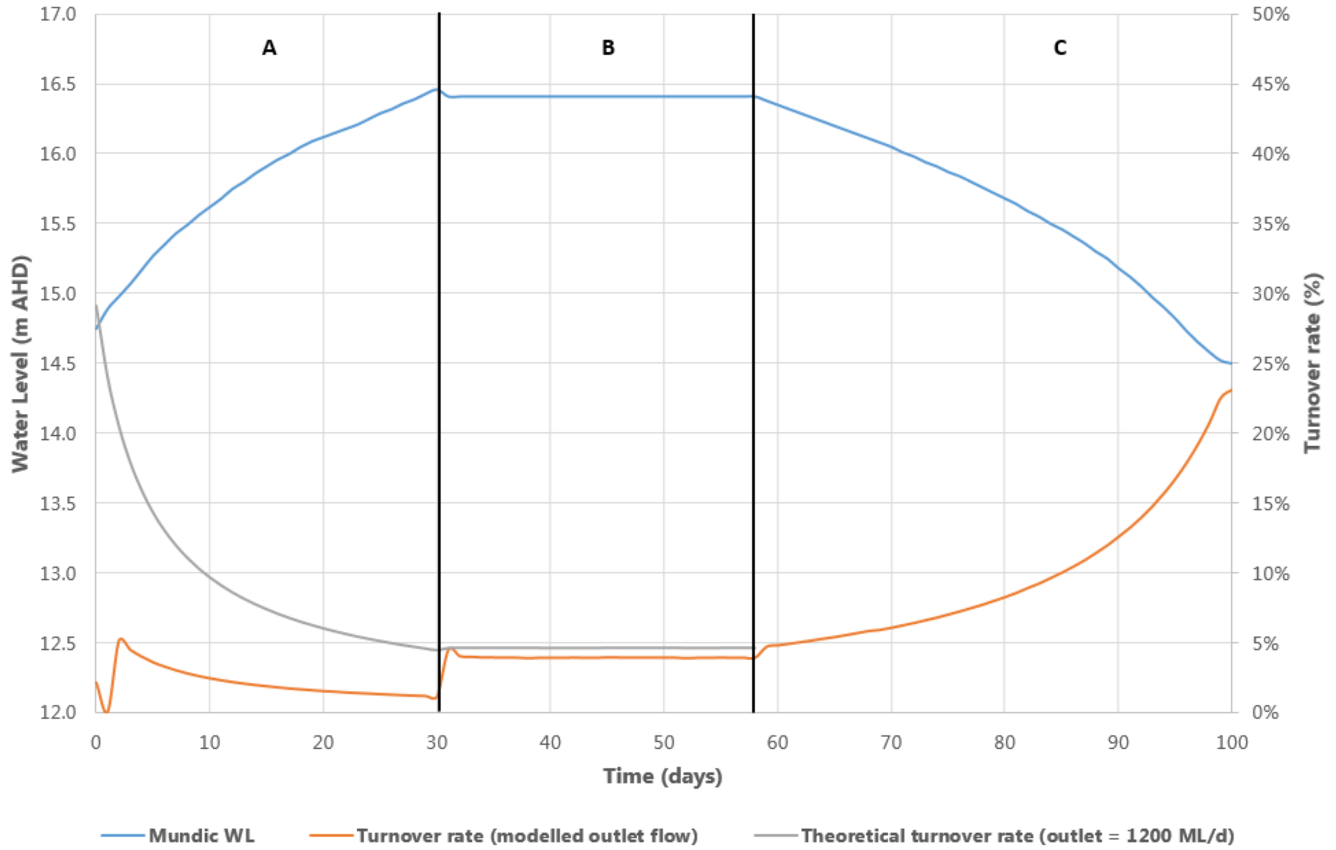

Figure 9.3 Modelled turnover rate (based on modelled outlet flow) and theoretical turnover rate (outlet flow based on maximum inlet flow of 1200 ML/d), during managed inundation event, with reference to Mundic Creek water level. Various phases of operation indicated: A – Filling phase; B – Holding phase; and C – Draining phase.

To provide a theoretical upper limit of turnover rates during the filling phase, turnover rates are alternatively calculated based on outflows equalling the currently understood maximum inflow of 1200 ML/d, as presented in Figure 9.3. Note that this outflow setting does not account for system losses and the component of inflow required to allow filling to proceed, assuming that this flow rate represents the practical maximum inflow rates achievable with fully upgraded and operational inlet structures. However, this theoretical turnover rate will alter if maximum inflow rates deviate from current understanding once the inlet structures are completed. The theoretical turnover calculation indicates a maximum rate of approximately 24% at the commencement of filling, gradually decreasing to approximately 5%. It can be inferred that by accounting for system losses and the filling component of inflows, an optimised control scheme will provide turnover rates between the modelled turnover rate and the calculated theoretical upper limit, depending on inflow rates achievable and outflow rates assumed.

During the holding phase a modelled turnover rate of approximately 4% is maintained. Extending the theoretical turnover rate through the holding phase shows a theoretical turnover of approximately 5%, with the difference between these rates being indicative of the impact of system losses on turnover. However, in the context of the current modelling, the overall turnover rate will lie at the modelled outflow rate given that system losses cannot be adjusted for a given inundated area.

During the draining phase, the turnover rate is modelled to rise as outflows are increased against decreasing impounded volumes, from approximately 4% at the commencement of draining to a rate exceeding 20%. As this is based on a modelled total outflow of 1200 ML/d, these turnover rates are equivalent to the theoretical turnover rates based on outflows equalling a maximum total inlet flow of 1200 ML/d. Note that turnover rates during the filling and draining phases will change if outflows from the regulators, and hence rate of filling or draining, alter from the operating regime tested. Similarly, turnover rates will increase if greater inflows to the floodplain through upgraded structures at Margaret Dowling and Deep Creek are achievable than those assumed for the current hydraulic modelling scenarios.

The progress of inundation is shown in Figure 9.4 to Figure 9.13 , showing depths throughout the extent of inundation in 10-day intervals over the period of operation. The corresponding velocity maps are also presented in 10-day intervals in Figure 9.14 to Figure 9.23.

The results indicate that during the filling phase (Days 10 to 30), velocities in the majority of the impounded area under 300 ML/d total outflows remains in the very low velocity range, up to 0.01 m/s. Raising outflow rates may promote a shifting of velocities to higher categories, and should be the focus of further investigations. During the holding phase (Day 40 and 50), velocities in the very low categories, particularly at zero flow, increase in prevalence compared to lower inundation heights during filling, with the zero flow areas located predominantly in areas directly upstream of Bank B Complex and Bank C (which currently exhibit no flows due to the presence of Banks B, B2 and C), and in the area between Pike River and the southern part of Snake Creek. Only minor changes are observed with this velocity distribution when varying the Tanyaca regulator outflow from 600 to 400 ML/d, corresponding to Day 40 and Day 50, respectively, indicating further investigations are required in the development of operating strategies for the proposed structures. During the draining phase (Days 60 to 100), velocities again remain predominantly in the very low velocity category, with much of the zero velocity areas limited to the fringes of the inundated area, particularly at the commencement of draining (Days 60 and 70). Areas containing no flow velocities again become noticeable from approximately Day 80, although this can be attributed predominantly to disconnection of these areas from the channels as water level decreases, particularly in the impounded area directly to the north of Pike River Regulator.

Outside of the impounded area, velocities in Tanyaca Creek downstream of the regulator remain in the range from 0.15 m/s up to approximately 0.50 m/s for the entire managed inundation scheme. Conversely, velocities directly downstream of Pike regulator remain below 0.05 m/s for filling and holding phases, with an increase in velocities only observed to occur during the draining phase, up to 0.15 m/s. These differences in velocity distribution may be altered however with changes to the flow magnitude and direction between Tanyaca and Pike regulators.

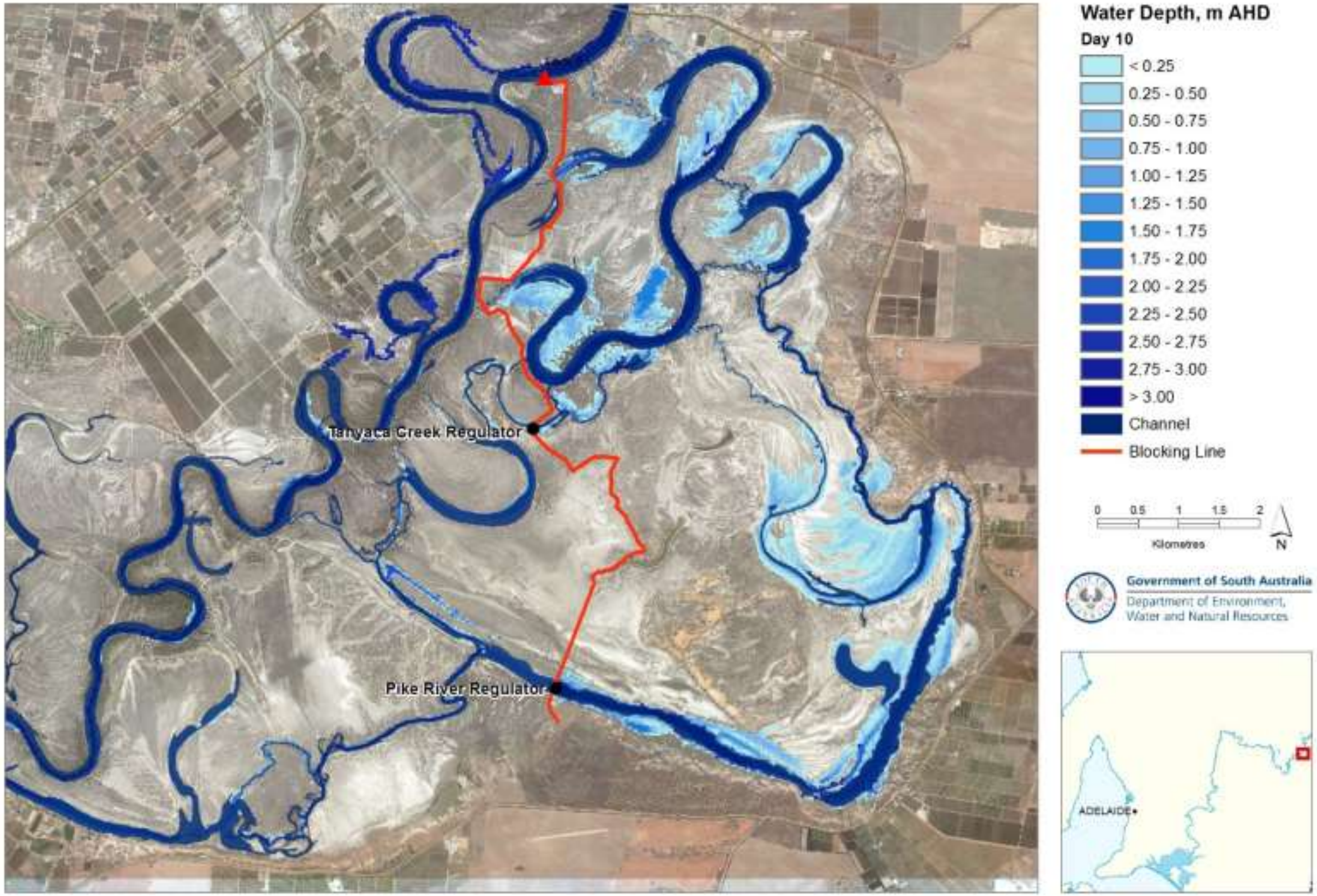

Figure 9.4 Inundation extent and water depth at Day 10 (water level at Pike Regulator 15.59 m AHD) of managed inundation under Alternative 2 blocking alignment

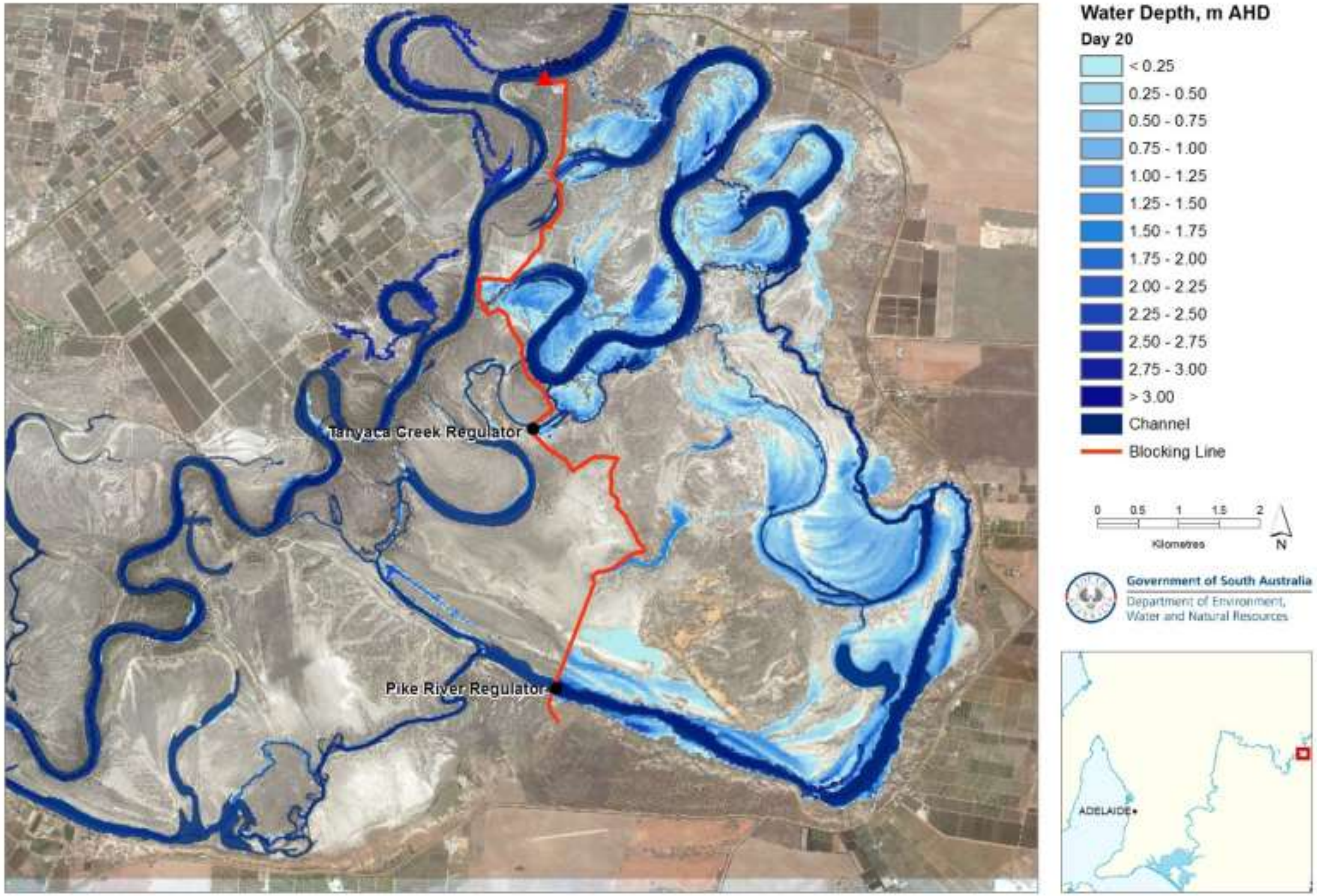

Figure 9.5 Inundation extent and water depth at Day 20 (water level at Pike Regulator 16.10 m AHD) of managed inundation under Alternative 2 blocking alignment

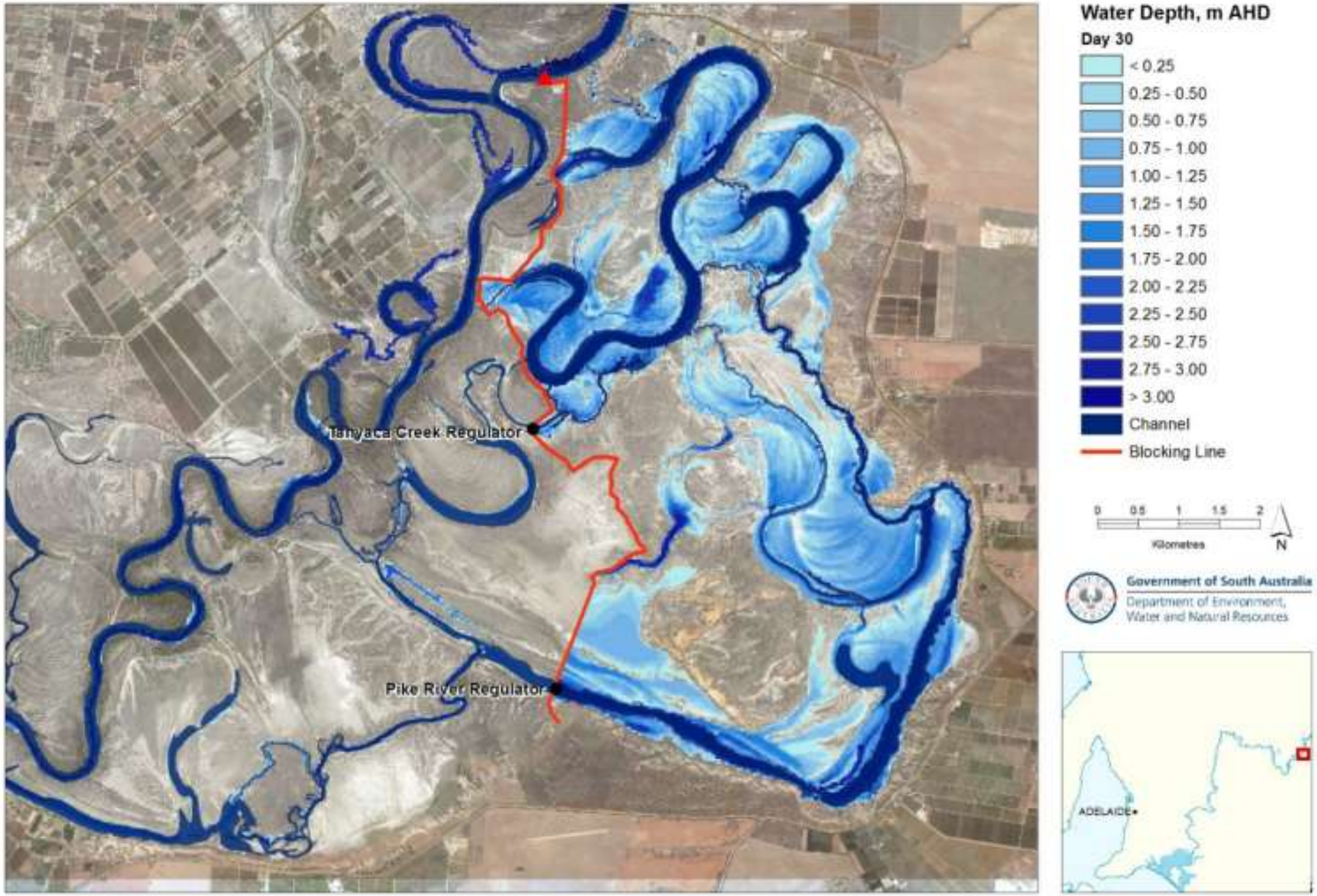

Figure 9.6 Inundation extent and water depth at Day 30 (water level at Pike Regulator 16.40 m AHD) of managed inundation under Alternative 2 blocking alignment

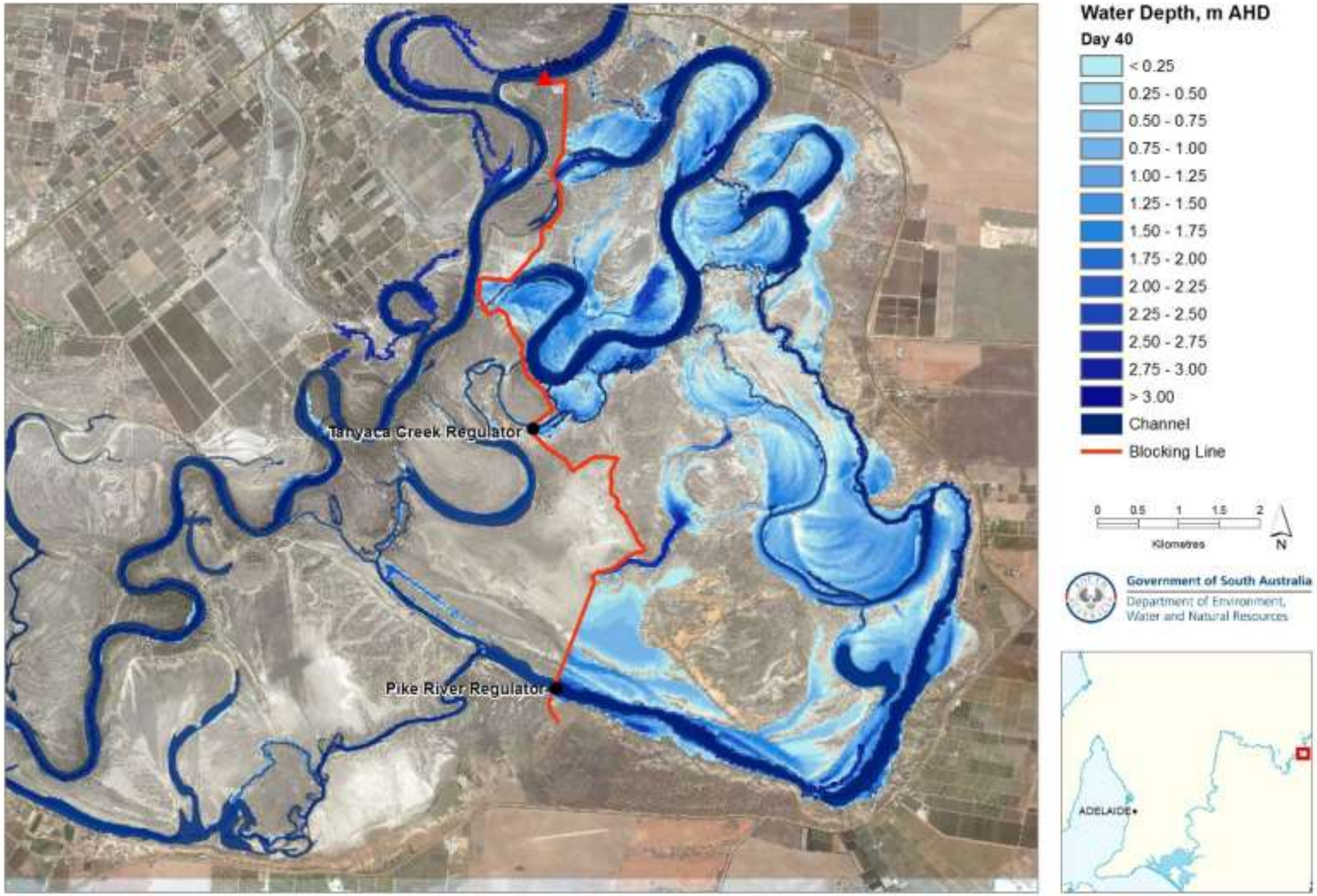

Figure 9.7 Inundation extent and water depth at Day 40 (water level at Pike Regulator 16.40 m AHD) of managed inundation under Alternative 2 blocking alignment

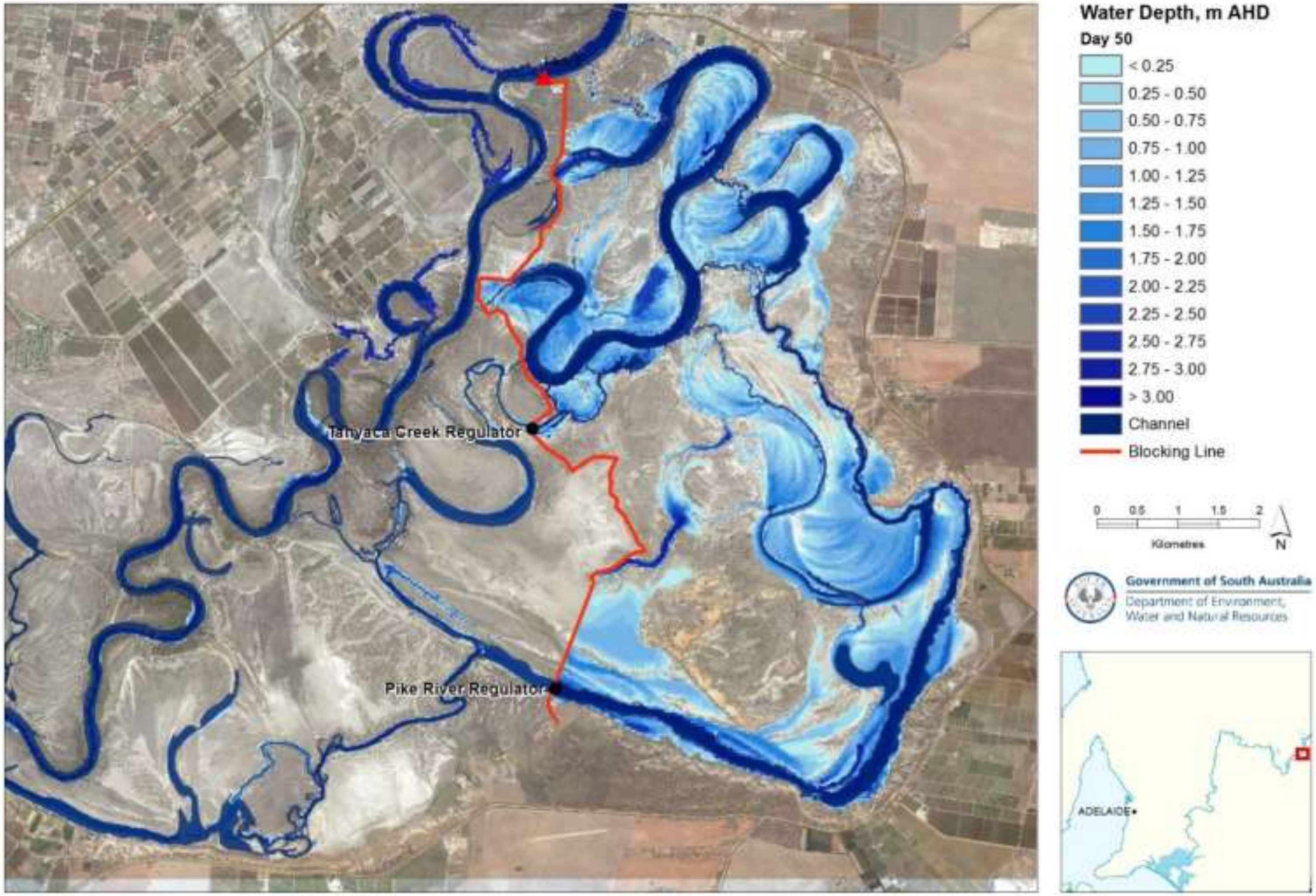

Figure 9.8 Inundation extent and water depth at Day 50 (water level at Pike Regulator 16.40 m AHD) of managed inundation under Alternative 2 blocking alignment

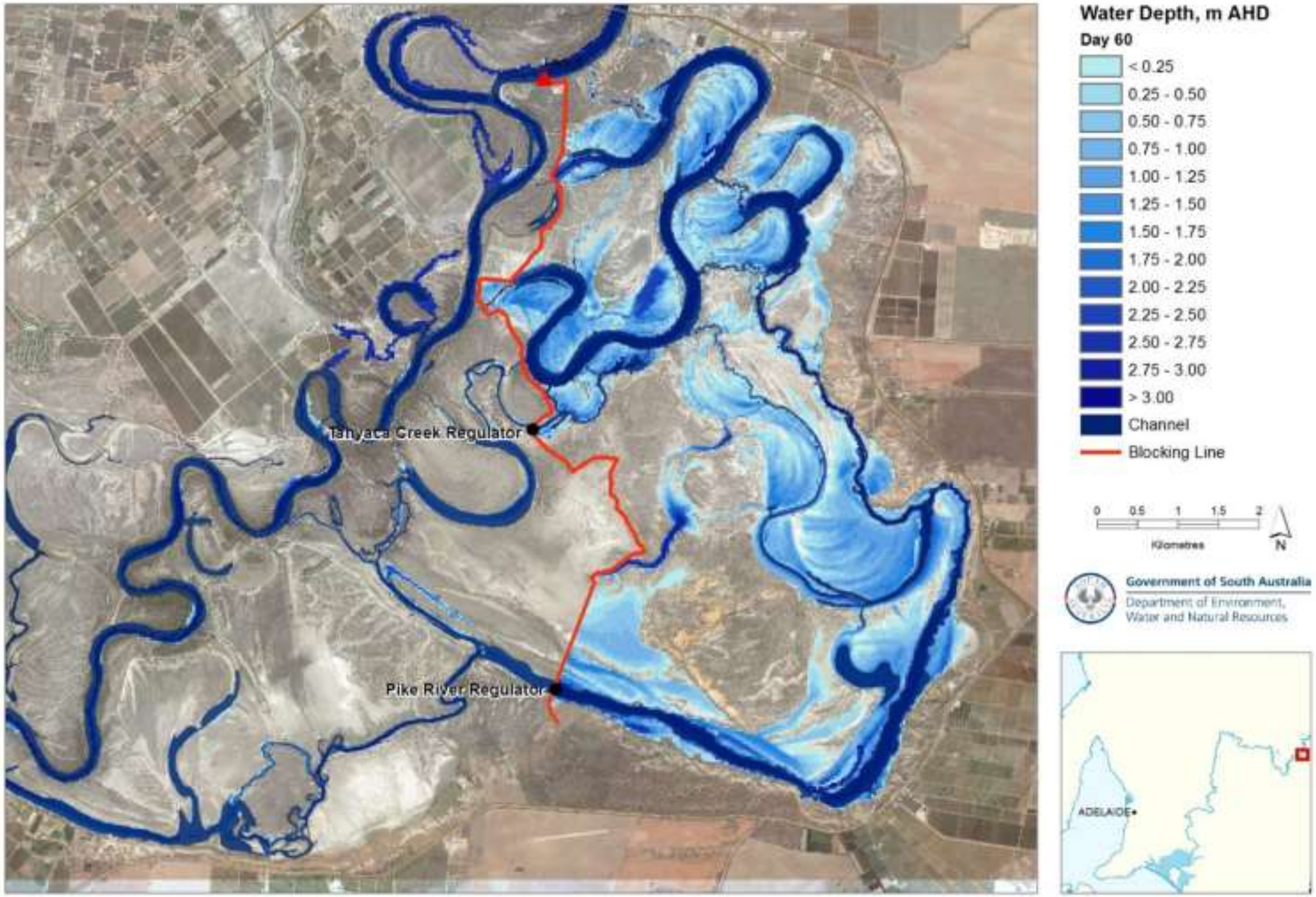

Figure 9.9 Inundation extent and water depth at Day 60 (water level at Pike Regulator 16.34 m AHD) of managed inundation under Alternative 2 blocking alignment

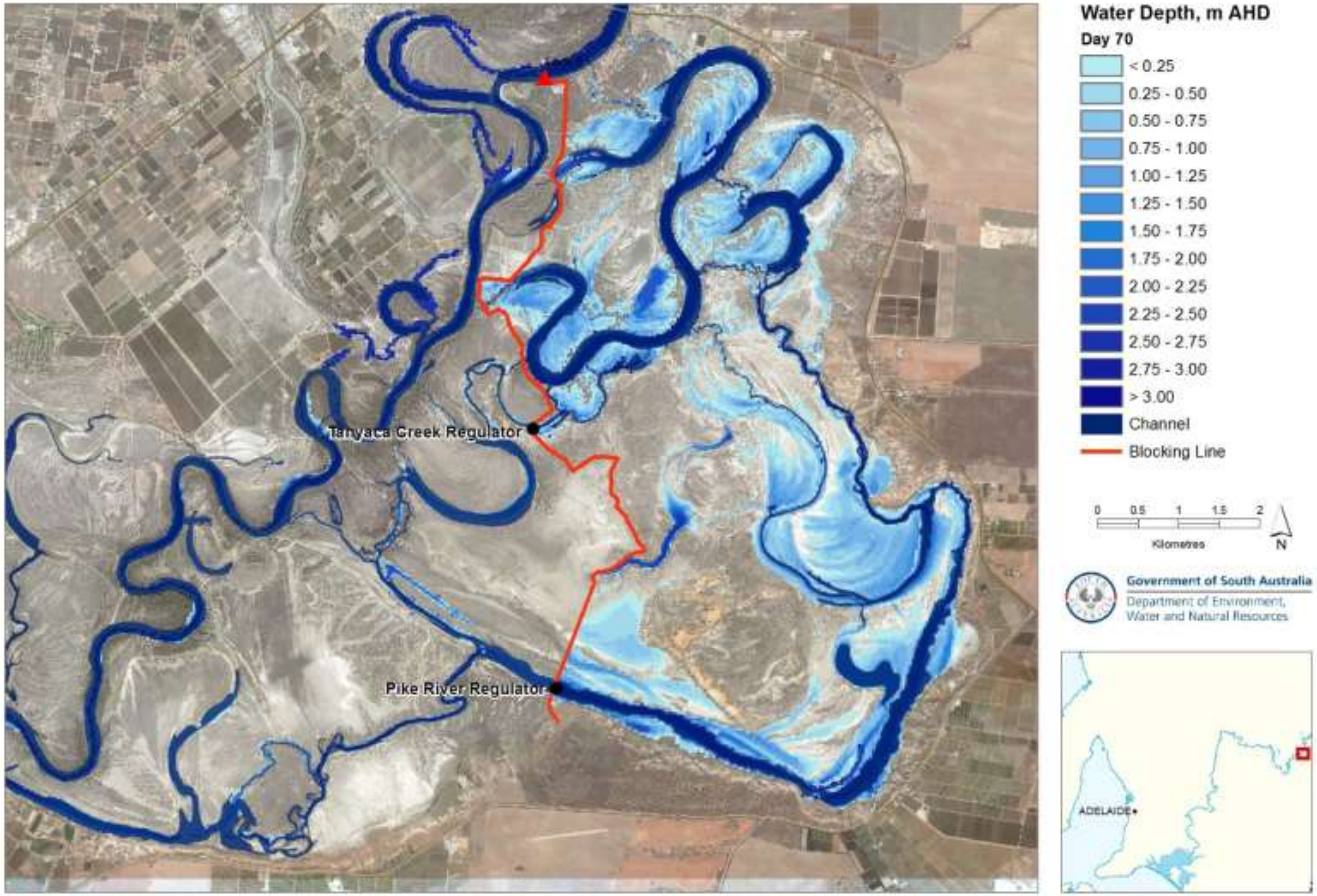

Figure 9.10 Inundation extent and water depth at Day 70 (water level at Pike Regulator 16.04 m AHD) of managed inundation under Alternative 2 blocking alignment

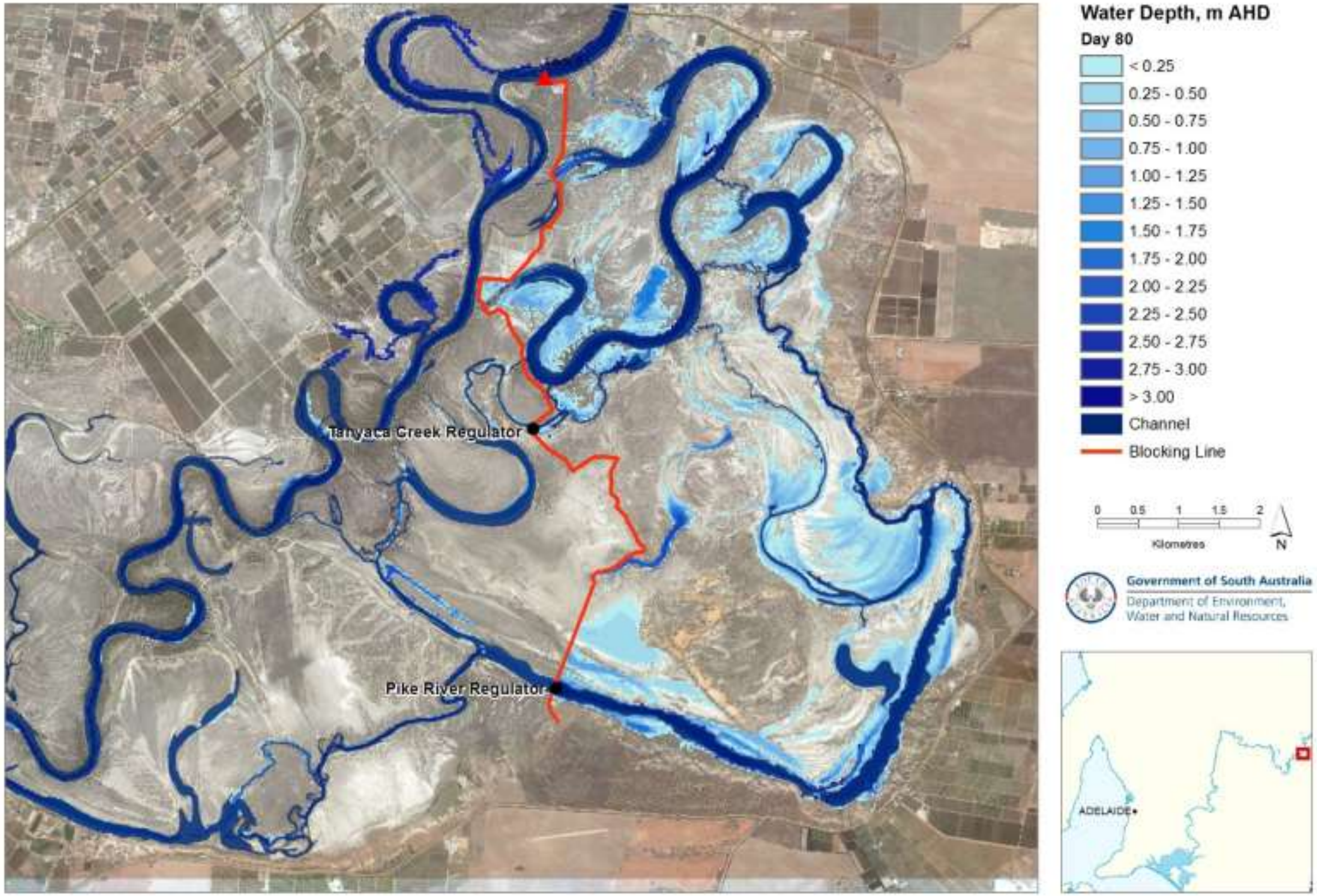

Figure 9.11 Inundation extent and water depth at Day 80 (water level at Pike Regulator 15.66 m AHD) of managed inundation under Alternative 2 blocking alignment

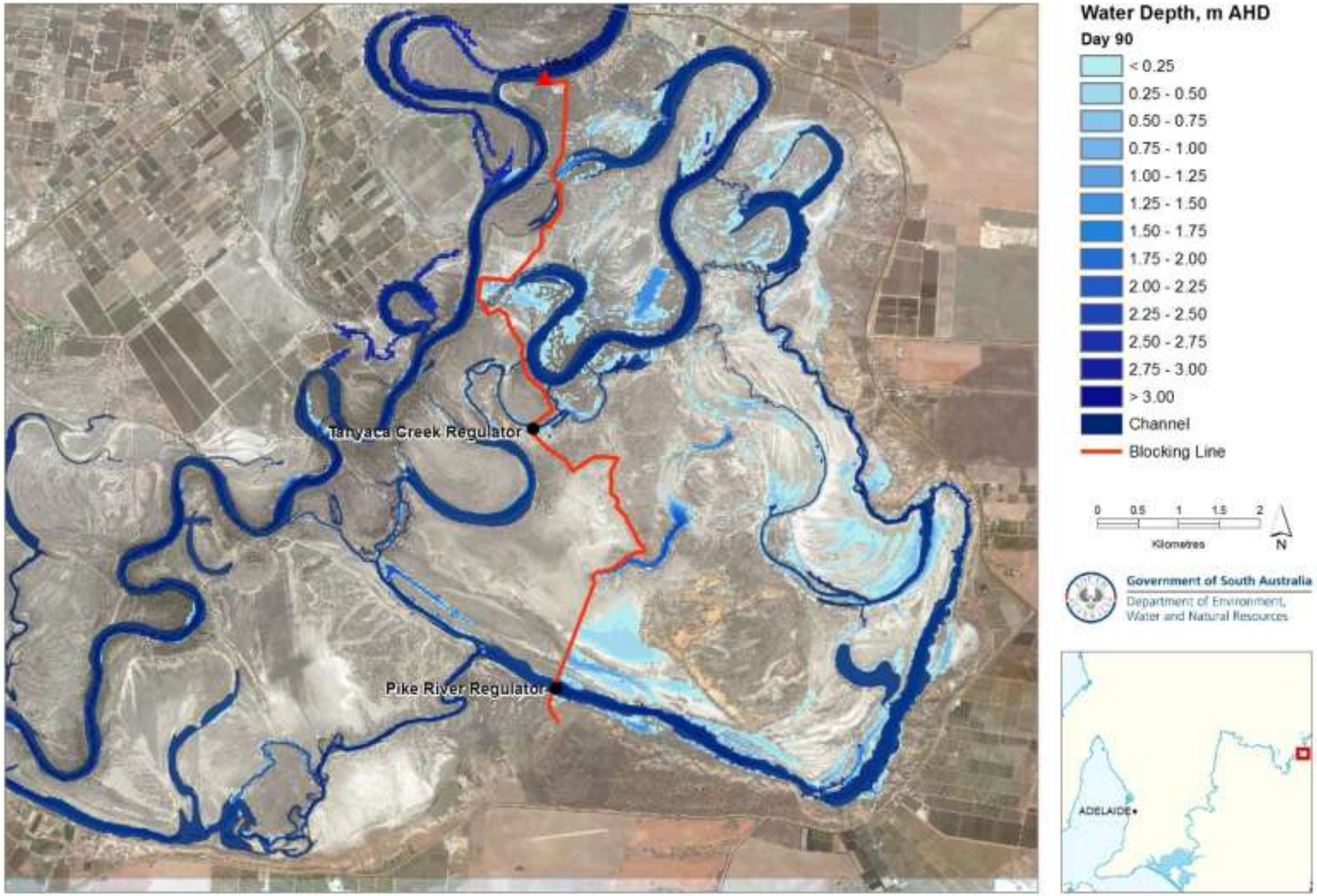

Figure 9.12 Inundation extent and water depth at Day 90 (water level at Pike Regulator 15.12 m AHD) of managed inundation under Alternative 2 blocking alignment

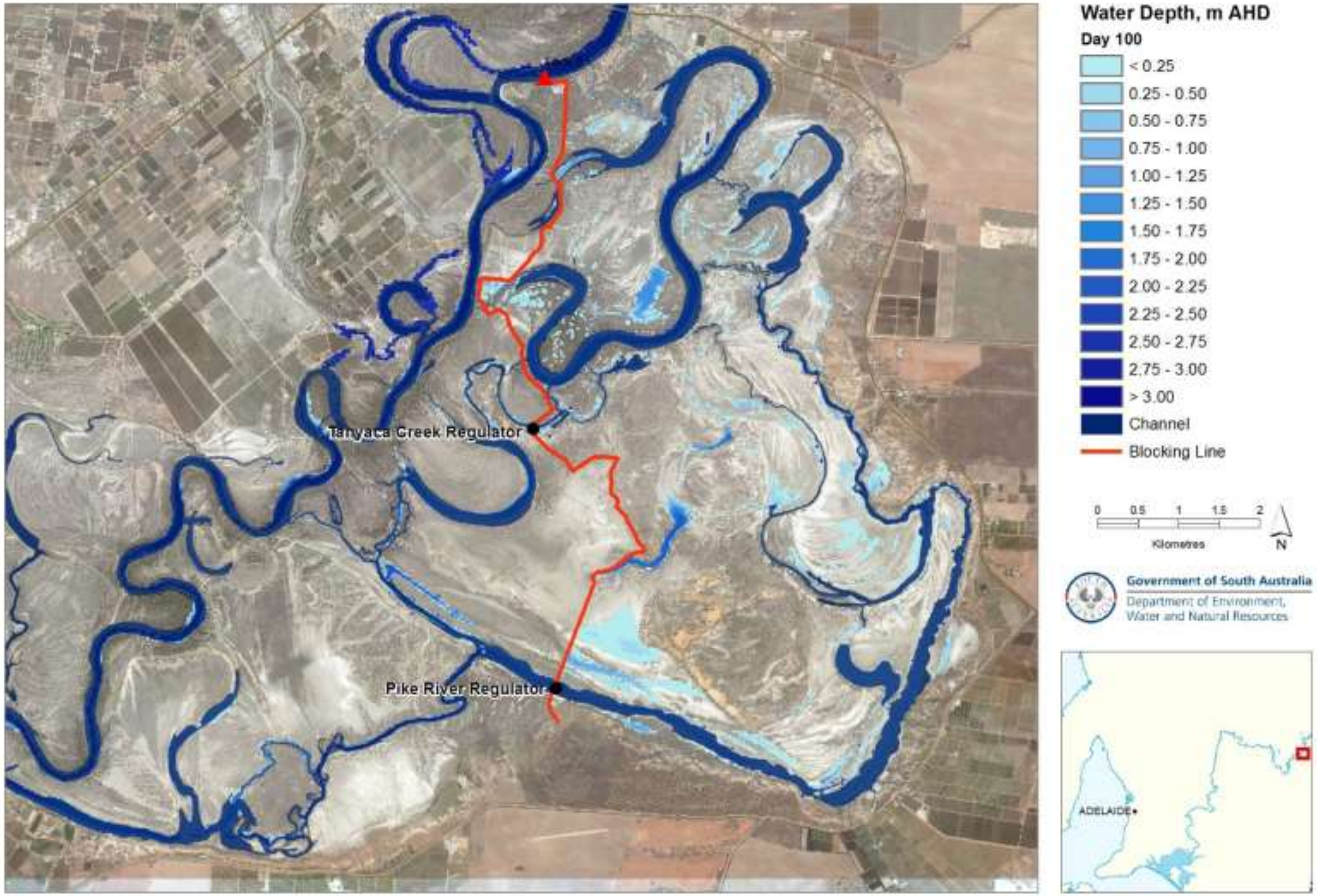

Figure 9.13 Inundation extent and water depth at Day 100 (water level at Pike Regulator 13.64 m AHD – below typical water level) of managed inundation under Alternative 2 blocking alignment

Figure 9.14 Velocity distribution at Day 10 (water level at Pike Regulator 15.59 m AHD) of managed inundation under Alternative 2 blocking alignment

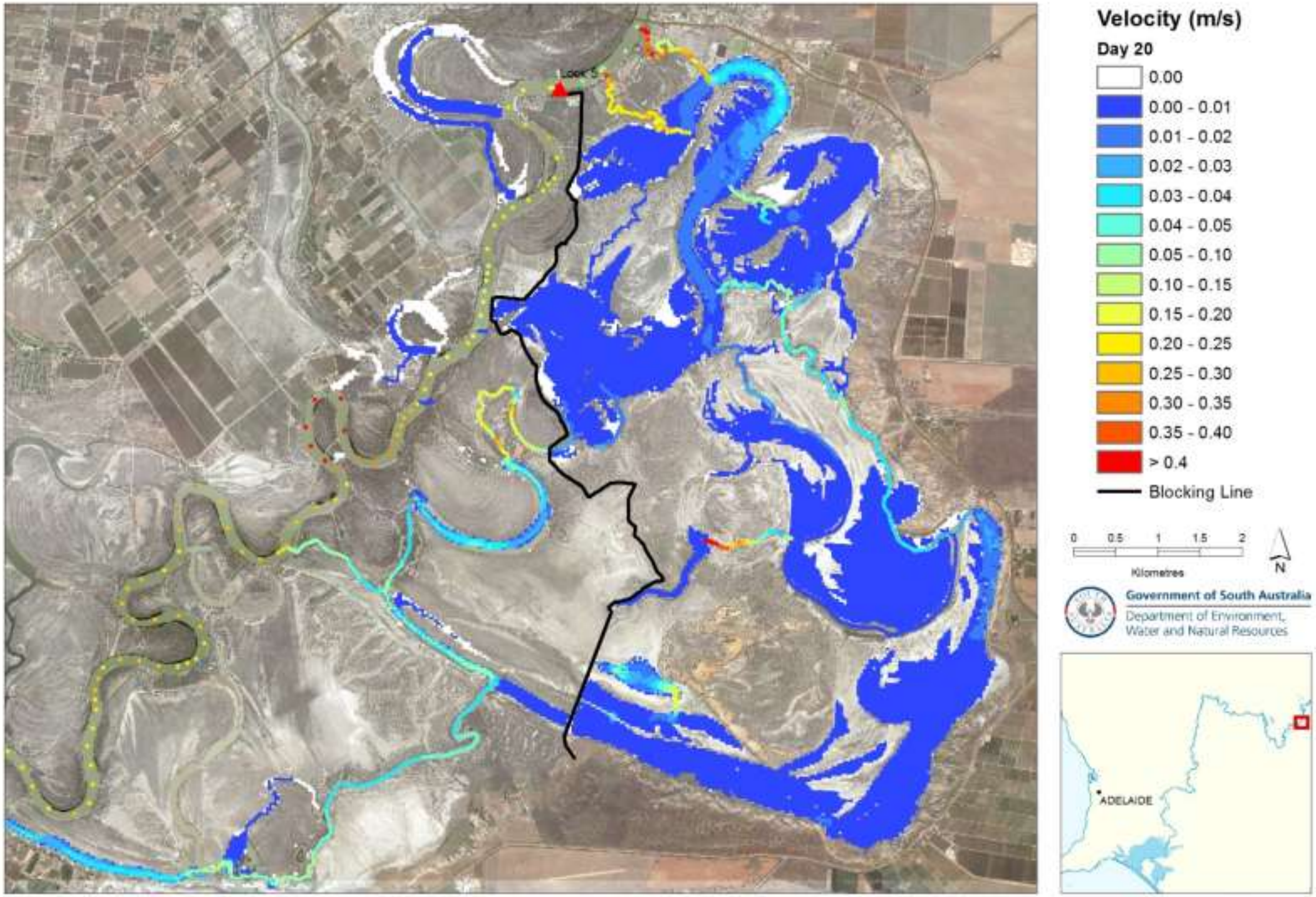

Figure 9.15 Velocity distribution at Day 20 (water level at Pike Regulator 16.10 m AHD) of managed inundation under Alternative 2 blocking alignment

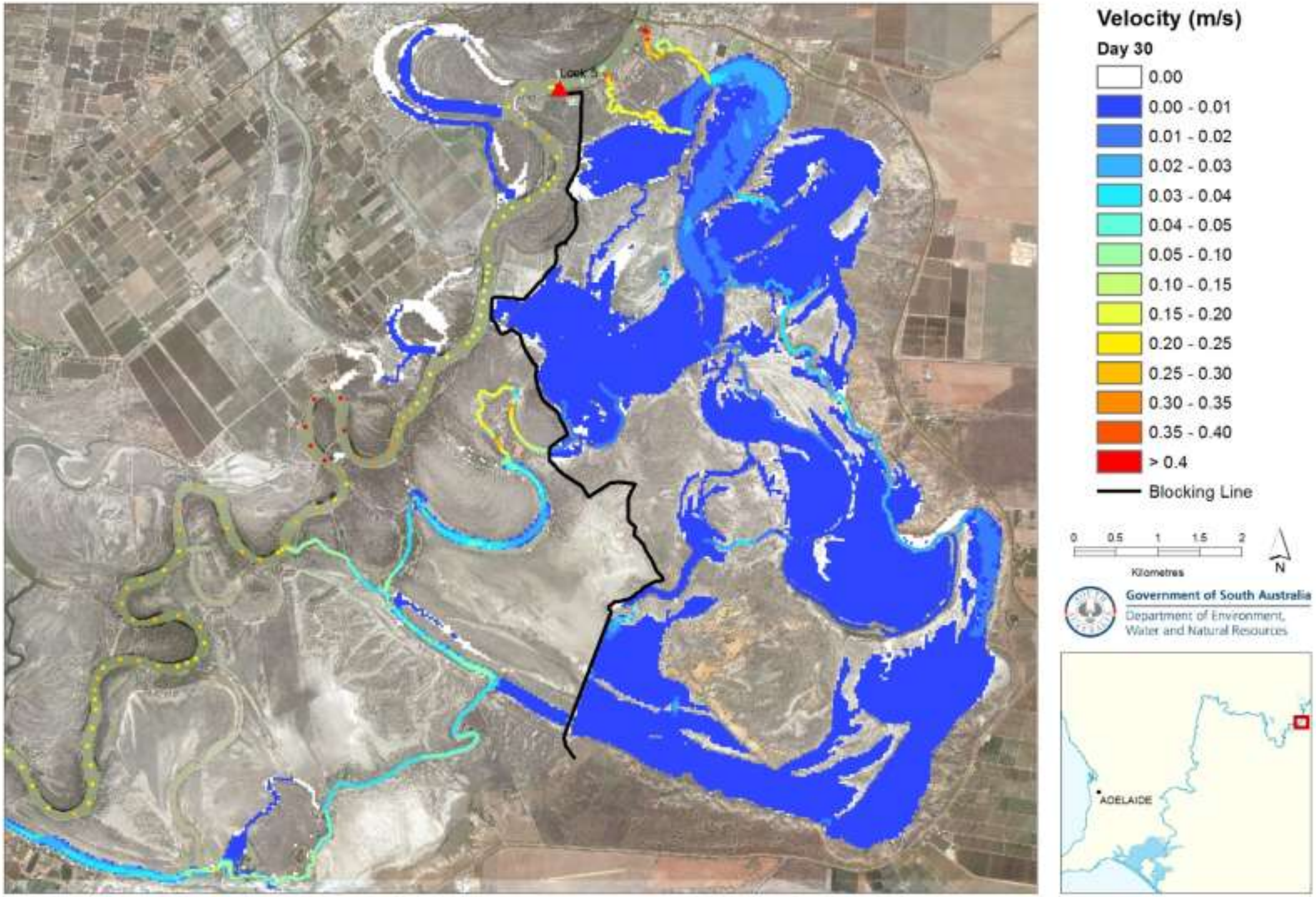

Figure 9.16 Velocity distribution at Day 30 (water level at Pike Regulator 16.45 m AHD) of managed inundation under Alternative 2 blocking alignment

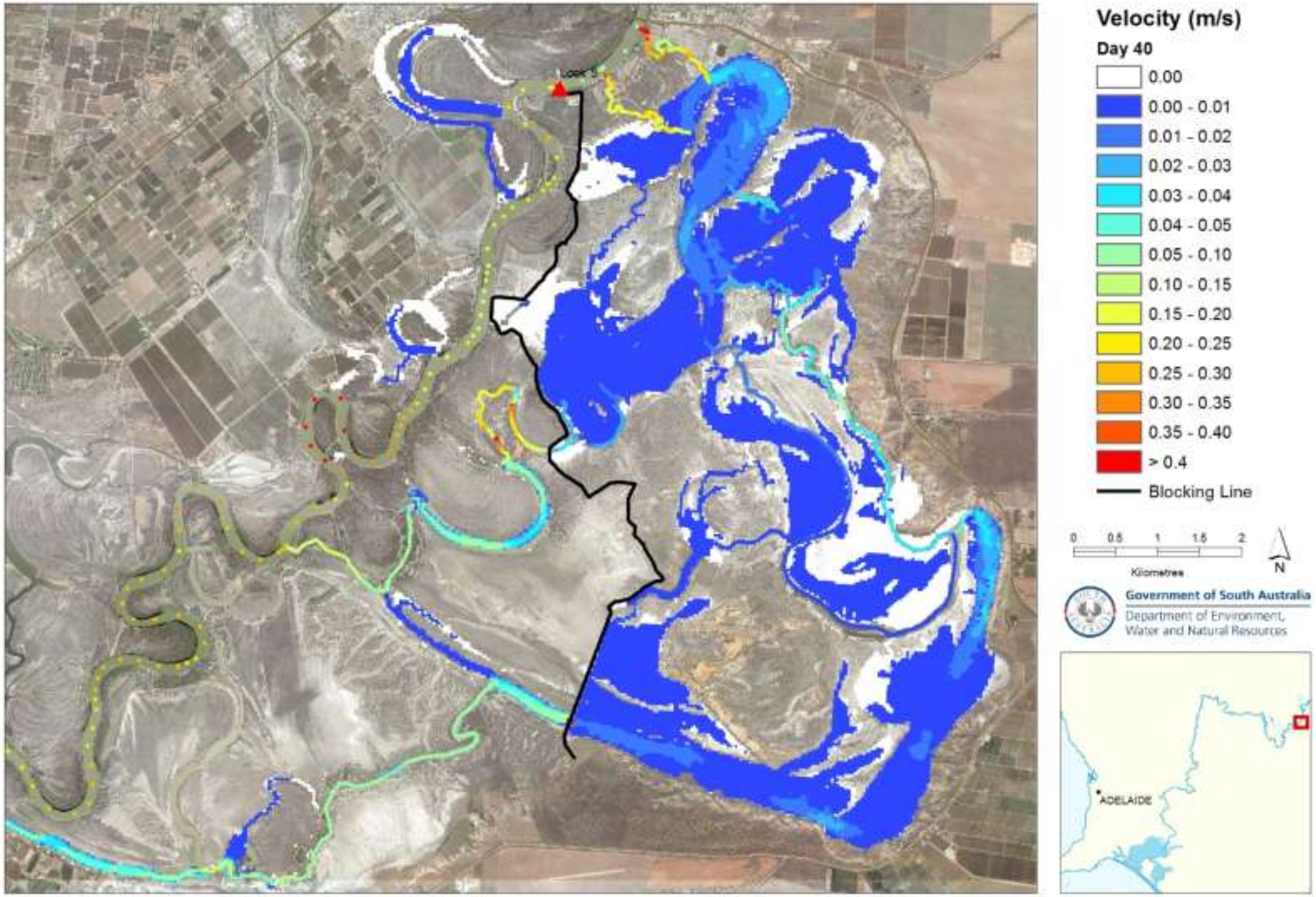

Figure 9.17 Velocity distribution at Day 40 (water level at Pike Regulator 16.40 m AHD) of managed inundation under Alternative 2 blocking alignment

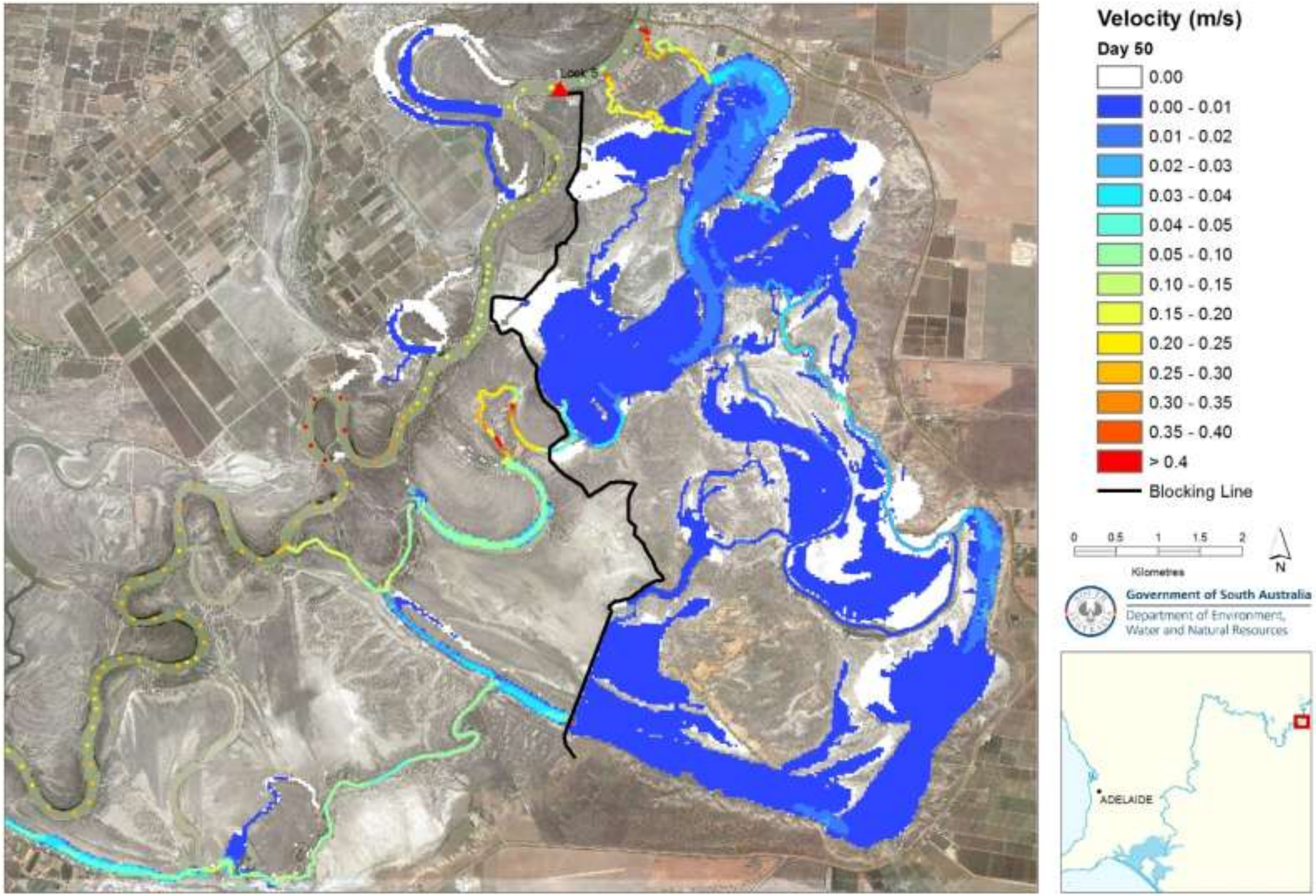

Figure 9.18 Velocity distribution at Day 50 (water level at Pike Regulator 16.40 m AHD) of managed inundation under Alternative 2 blocking alignment

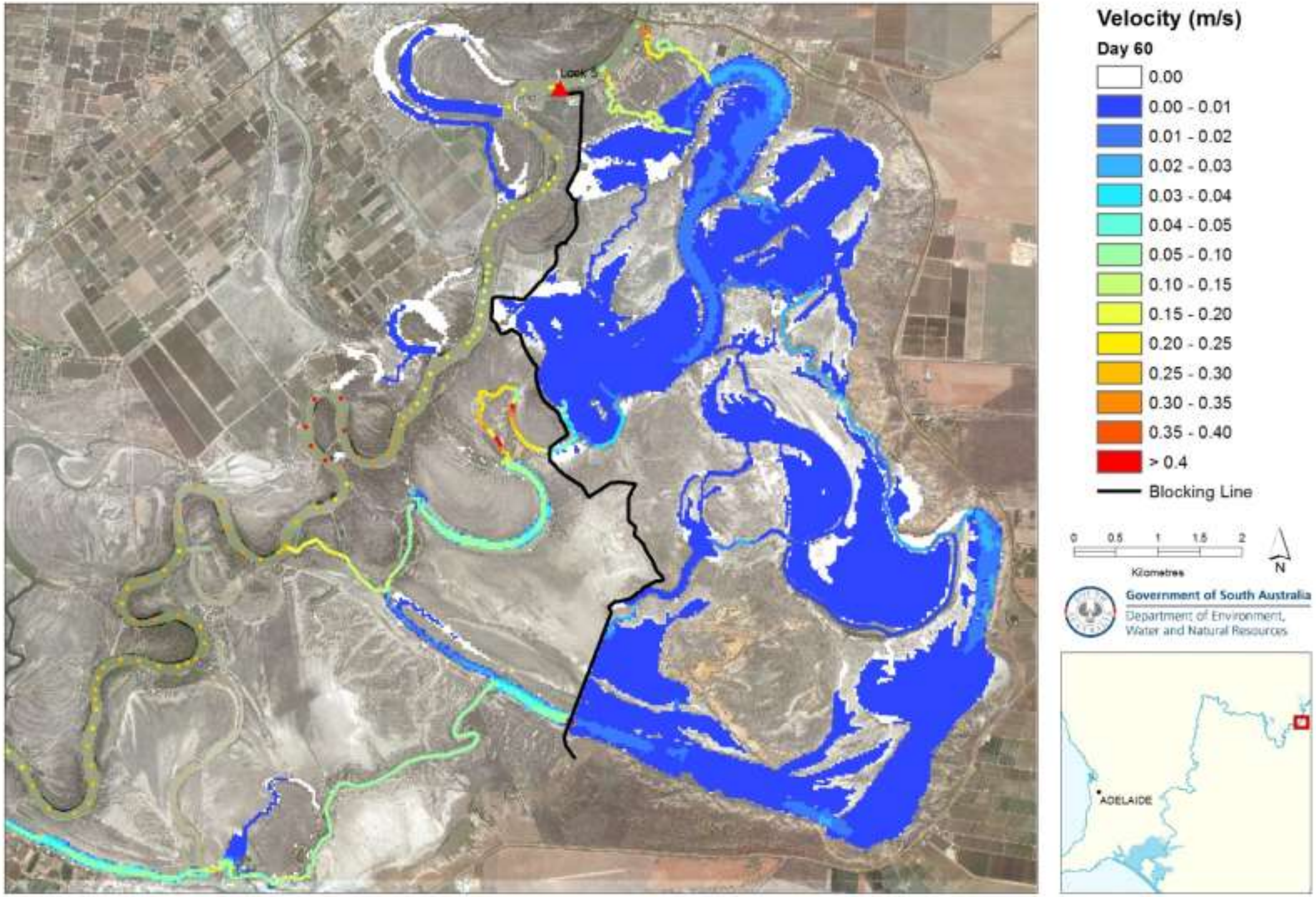

Figure 9.19 Velocity distribution at Day 60 (water level at Pike Regulator 16.34 m AHD) of managed inundation under Alternative 2 blocking alignment

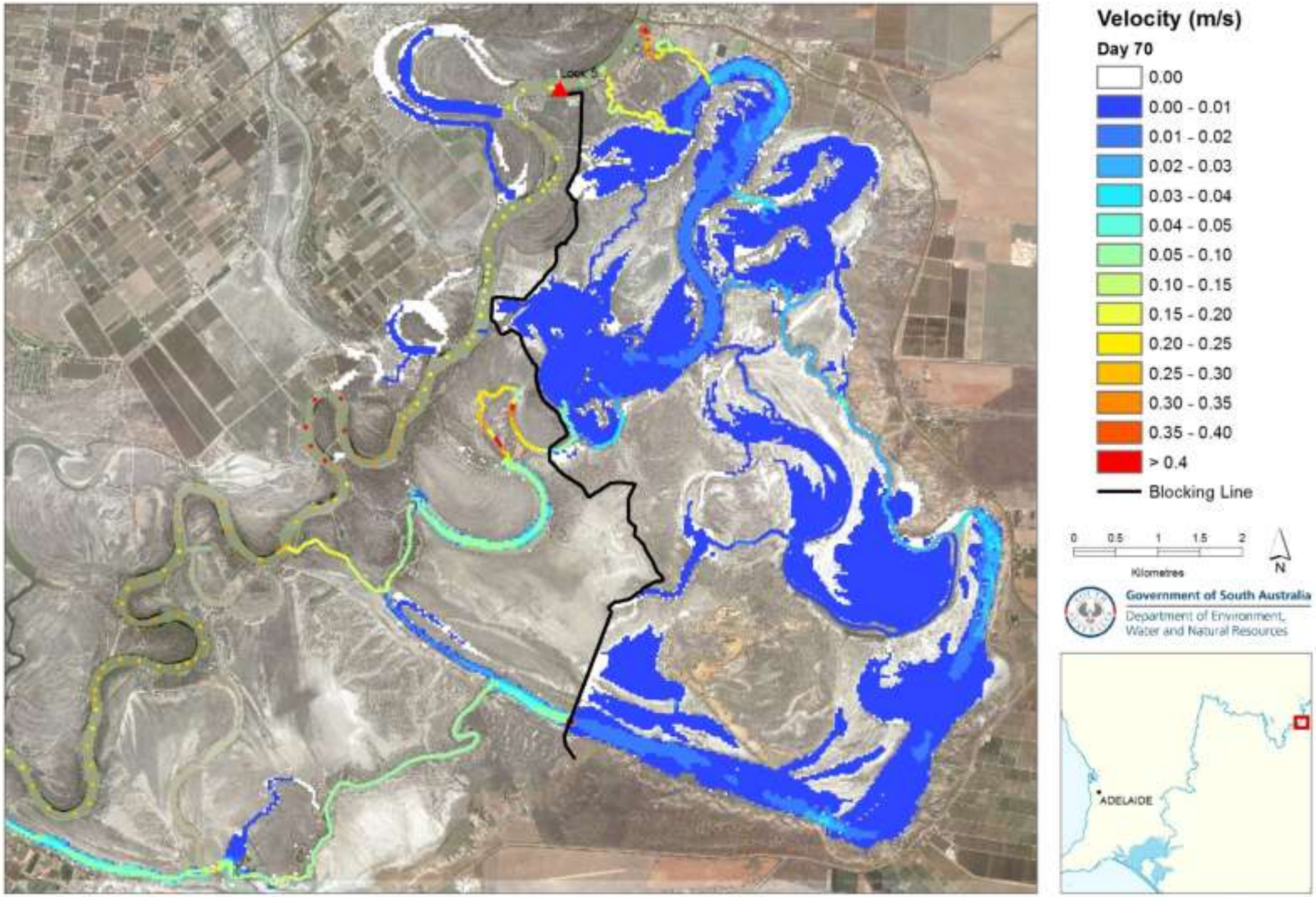

Figure 9.20 Velocity distribution at Day 70 (water level at Pike Regulator 16.04 m AHD) of managed inundation under Alternative 2 blocking alignment

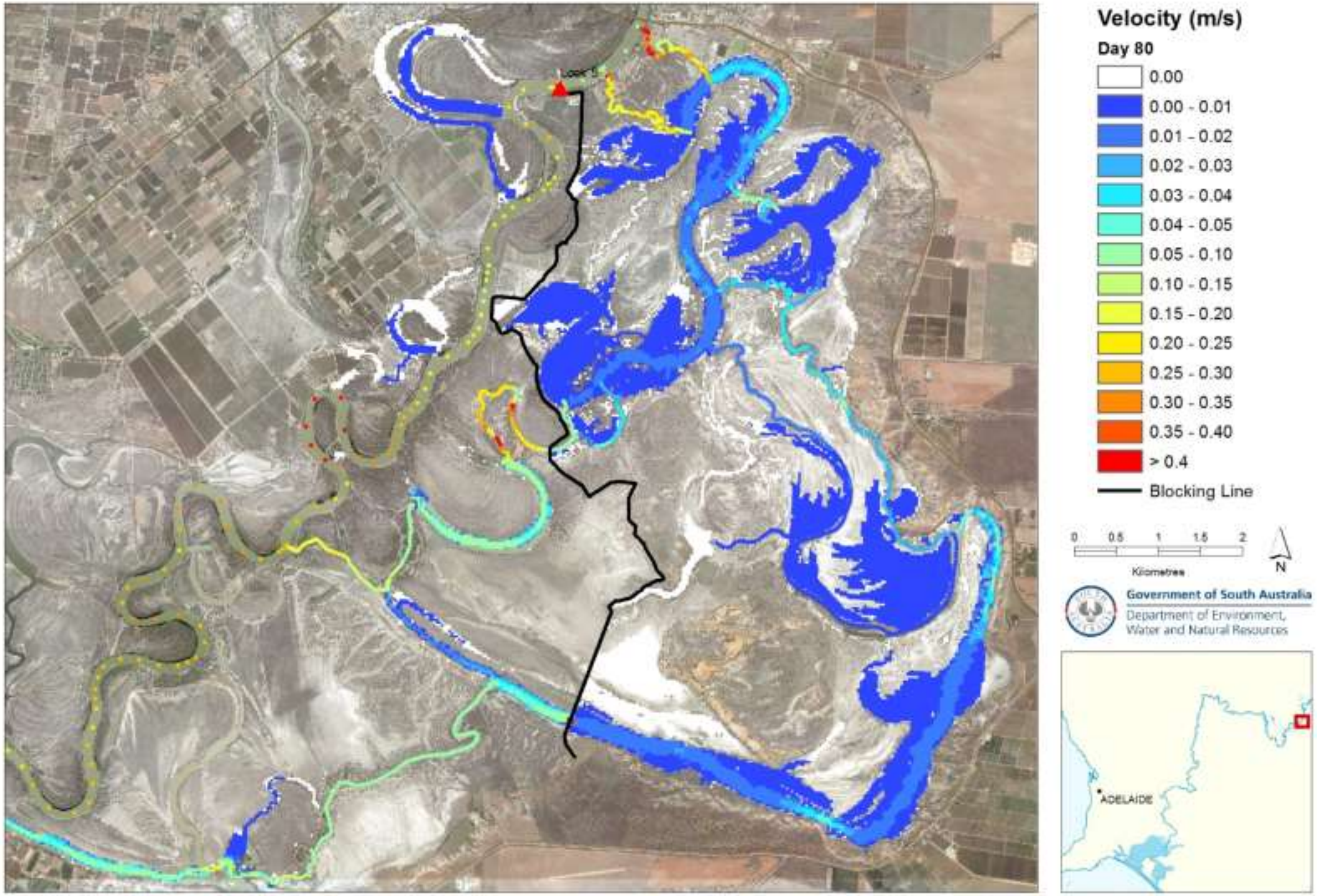

Figure 9.21 Velocity distribution at Day 80 (water level at Pike Regulator 15.66 m AHD) of managed inundation under Alternative 2 blocking alignment

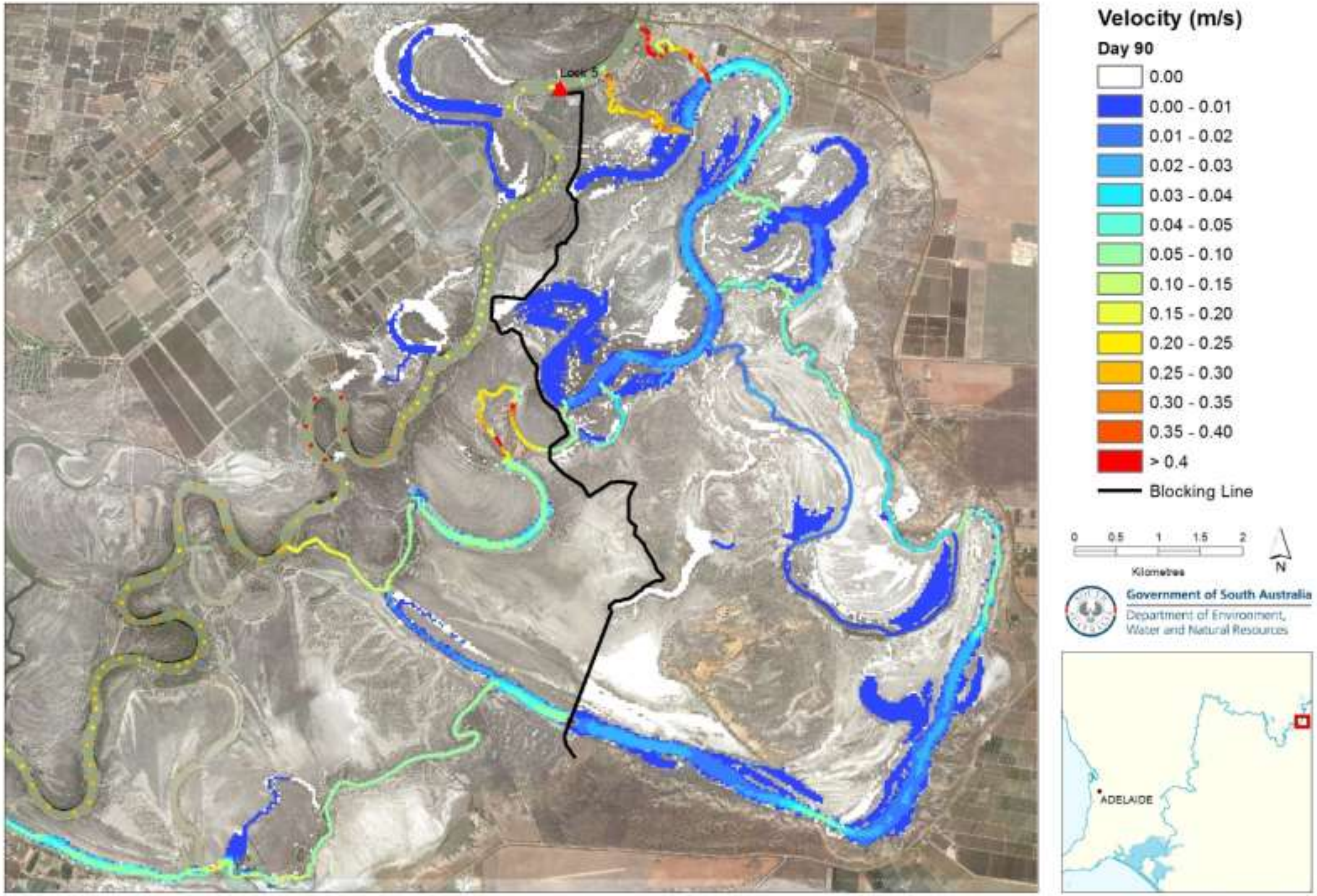

Figure 9.22 Velocity distribution at Day 90 (water level at Pike Regulator 15.12 m AHD) of managed inundation under Alternative 2 blocking alignment

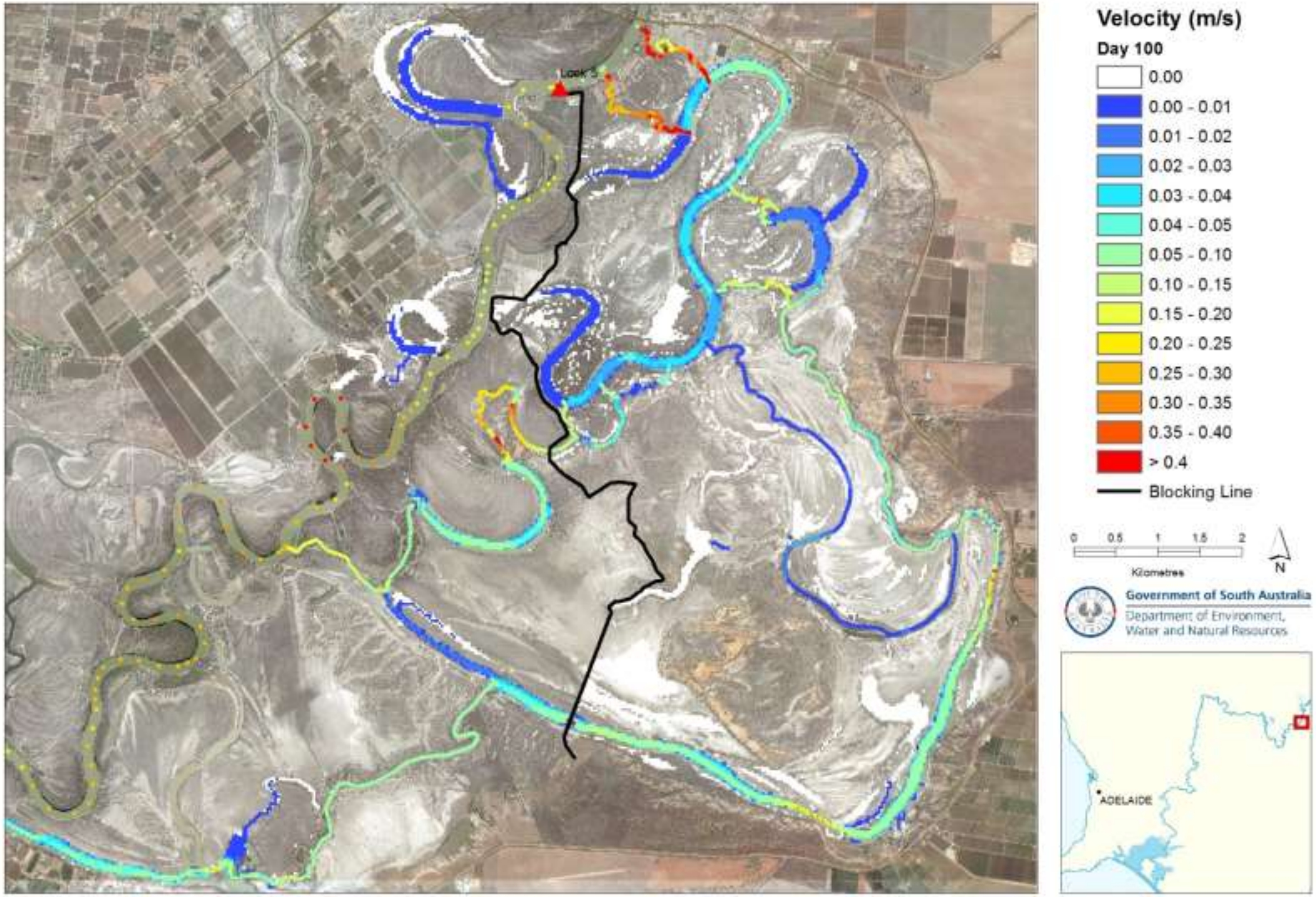

Figure 9.23 Velocity distribution at Day 100 (water level at Pike Regulator 13.64 m AHD – below typical water level) of managed inundation under Alternative 2 blocking alignment

10 Scenario 8 – Increase of floodplain inflows through manipulation of Lock 4 weir pool under elevated River Murray flows

Preceding scenarios have indicated that a flow of 10 000 ML/d upstream of Lock 5, with upgraded floodplain structures and improved inflow conditions, results in improved flows through Tanyaca Creek and Pike River compared to existing floodplain conditions. However, further inflows to the floodplain below Lock 5 may be achievable by increasing river level, through either or both of raising the Lock 4 weir pool level or increased river flows. The effects of weir pool raising on the modelled water level profile between Locks 4 and 5 are shown in Figure 10.1. For example, compared to a river flow above Lock 5 of 10 000 ML/d and normal Lock 4 pool level (i.e. 13.2 m AHD), the level directly downstream of Lock 5 can be raised by approximately 1.5 m by a 1 m raising of Lock 4 pool level to 14.2 m AHD in conjunction with a raised river flow above Lock 5 of 30 000 ML/d. This raising of river level can increase inflows to the floodplain (either above or below the blocking alignment), and may be desirable for operational considerations, such as improving water quality in the receiving waters downstream of the proposed environmental regulators in Tanyaca Creek and Pike River, or for ecological considerations, such as for increasing the proportion of flowing habitat within the floodplain. Raising Lock 4 level may also reflect a typical operating condition for managed inundation of Pike Floodplain, given that operation of the Katarapko Floodplain managed inundation scheme is likely to require raising of the Lock 4 weir pool, and concurrent operation of the sites may be likely during favorable river flow conditions.

Referring to Figure 10.1, additional inflows to the floodplain may occur upstream of the blocking alignment through Banks B, B2 and C by raising river level to this extent, given that existing surveyed Mundic Creek water level exists at approximately 14.75 m AHD, while the river level is raised to over 15.0 m AHD at these locations. Note however that this raising will not allow flow through these banks when operating at the full inundation height of 16.4 m AHD, so is likely to only be possible during in-stream conditions within the floodplain. Inflows downstream of the blocking bank may also be achieved through Rumpagunyah, Swift and Wood Duck Creeks, and Letton's flood runner, increasing velocities and allowing additional dilution flows to the Lower Pike River.

The ability to increase inflows to the floodplain below Lock 5 have been considered in the following scenarios by:

- Considering an increased river flow to 30 000 ML/d, which will increase water levels in the upper reaches of the Lock 4 weir pool
- Considering a 1 m raising of Lock 4 from 13.2 m AHD to 14.2 m AHD.

It should be noted that, for the purposes of this modelling, a river flow of 30 000 ML/d is considered the upper limit for raising Lock 4 under controlled flow conditions, and further engineering considerations at Lock 4 will need to be taken into account to determine whether a 1 m raising at Lock 4 would be permitted at this river flow. Modelled system configurations for the tested scenarios are shown in Table 2.2.

Scenario 8a considers a hypothetical system configuration of operating at raised Lock 4 pool level and 30 000 ML/d with the floodplain at in-channel flows, enabling Banks B, B2 and C to be opened for additional inflows. A comparison scenario (8b) is designed to show how the system hydraulics may vary during a 30 000 ML/d flow without the Lock 4 weir pool raising. Similarly, Scenario 8c examines the system hydraulics at raised Lock 4 and river flow, but under managed inundation operation to a level of 16.4 m AHD, while the comparison scenario (8d) at normal Lock 4 weir pool is also presented. Note that inflows to the floodplain through Margaret Dowling and Deep Creek are set at a total of 1200 ML/d for in-channel conditions, which is currently anticipated to be the maximum inflow possible at normal Lock 5 pool level (16.3 m AHD), while a total flow is used for the managed inundation scenarios is 1400 ML/d, with the increase resulting from a raised Lock 5 weir pool level of 16.8 m AHD. This flow differs from previously modelled inundation scenarios as it reflects the latest understanding, at the time of writing, for potential maximum inflows at a raised Lock 5 weir pool.

A further section briefly examines Letton's flood runner, at which lowering of the commence-to-flow threshold at the river inlet to the flood runner is currently being considered as a complementary management option to the floodplain.

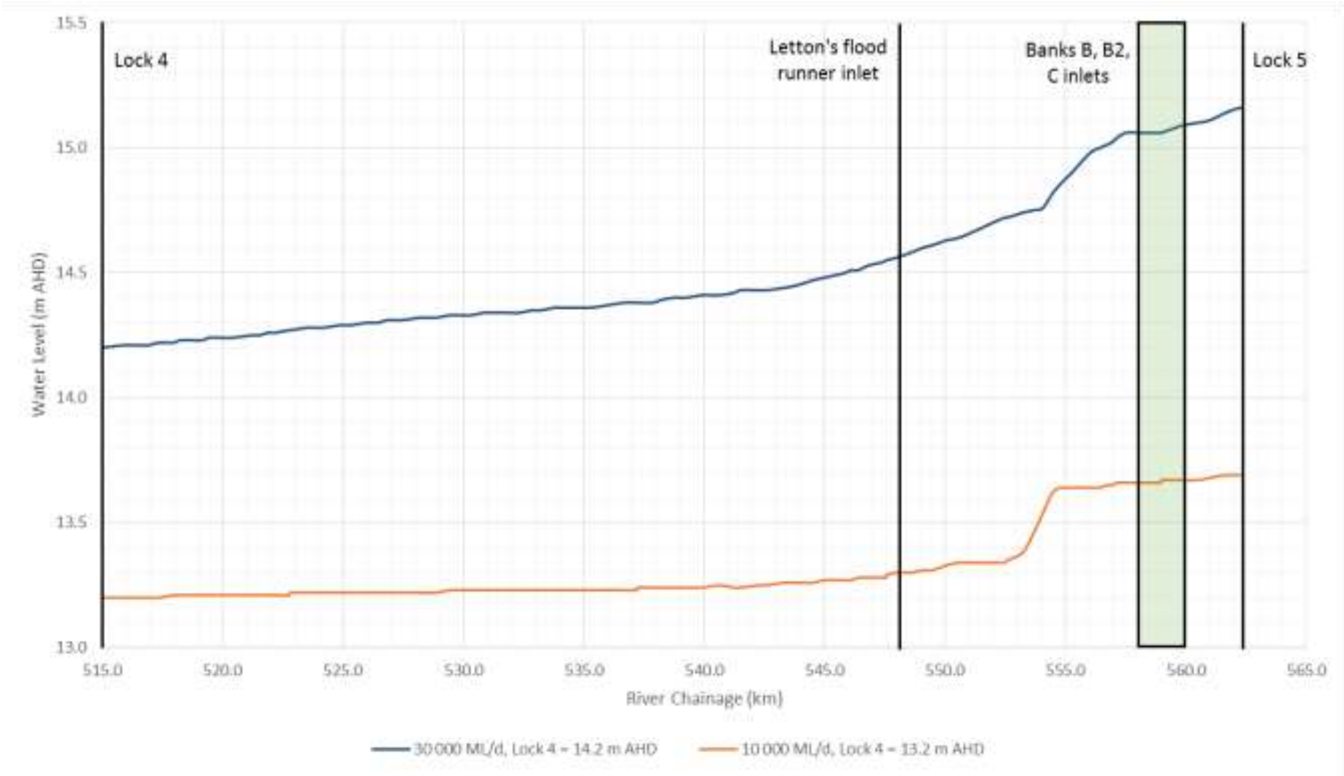

Figure 10.1 River Murray water level profiles for raised Lock 4 pool level to 14.2 m AHD (flow of 30 000 ML/d above Lock 5) and typical Lock 4 pool level at 13.2 m AHD (flow of 10 000 ML/d above Lock 5)

Discharges through creeks relevant to flows in the Lower Pike River are presented in Table 10.1, which include:

- Banks B, B2 and C in fully open configuration (closed at normal Lock 4 pool level of 13.2 m AHD)
- Tanyaca Creek
- Swift Creek
- Wood Duck Creek
- Rumpagunyah Creek
- Lower Pike River at Letton's
- Letton's flood runner.

Velocity distribution maps of the scenarios tested are presented in Figure 10.3 to Figure 10.6. Velocity distributions for Tanyaca, Swift, Wood Duck and Rumpagunyah Creeks, and parts of Lower Pike River (below the Pike–Rumpagunyah junction), are also presented for reference in Table 10.3 to Table 10.7 and Figure 10.7 to Figure 10.11. Note that these distributions are generated from the 1-D portions of the model outputs by necessity, as Swift and Wood Duck Creeks in particular are not adequately represented in the 2-D modelled outputs due to their relatively small size. As such, the velocity distributions are presented by stream length by necessity, differing from outputs in previous scenario chapters, and as such any 2-D components of each stream are not considered for the velocity distribution analysis (e.g. wide horseshoe section of Tanyaca Creek).

In-channel flow conditions

The results indicate that under a raised Lock 4 level and elevated River Murray flow of 30 000 ML/d, flows of approximately 3, 67 and 427 ML/d are modelled to pass through Banks B, B2 and C regulators, respectively. This contributes to a total inflow upstream of the blocking alignment of approximately 1700 ML/d, or approximately 40% increase in inflows compared to closure of Banks B, B2 and C. The additional inflows generated by opening Banks B, B2 and C raises water level in Mundic Creek (upstream of Tanyaca Creek regulator) to approximately 14.9 m AHD. In contrast, at normal Lock 4 pool levels and 30 000 ML/d above Lock 5, no additional inflows through Banks B, B2 and C are achieved as the River Murray level is below that of Mundic Creek, which is at approximately 14.75 m AHD upstream of Tanyaca Creek regulator.

Considering the lower (southern) section of floodplain, at 30 000 ML/d above Lock 5 and raised Lock 4 weir pool level, approximately 230 ML/d passes through Rumpagunyah Creek from the River Murray under the elevated river levels, with an additional 1260 ML/d at Tanyaca Creek Regulator, 680 ML/d through Wood Duck Creek and 1340 ML/d through Swift Creek. The water level at the Tanyaca–Rumpagunyah junction is approximately 14.7 m AHD at these flows. Total flow in the Lower Pike River, comprising of contributions from Tanyaca, Rumpagunyah and over the Pike River environmental regulator (400 ML/d) is approximately 3900 ML/d. Additional inflow to Lower Pike River is also generated through Letton's flood runner, at a flow of approximately 90 ML/d, contributing to a total flow at the downstream end of the Lower Pike River of almost 4000 ML/d.

Comparing the preceding results against the system at normal Lock 4 pool level (13.2 m AHD) and 30 000 ML/d River Murray flow, Rumpagunyah Creek flows at a rate of approximately 840 ML/d into the floodplain, 80 ML/d through Wood Duck Creek, 590 ML/d through Swift Creek, and 770 ML/d over Tanyaca Creek environmental regulator. The water level at the Tanyaca–Rumpagunyah junction is approximately 14.1 m AHD at these flows. Combining flows through Rumpagunyah and Tanyaca Creeks (approximately 2280 ML/d combined) with flow over Pike River environmental regulator (400 ML/d) results in a total flow in the Lower Pike River of approximately 2670 ML/d. No flow is observed to enter Lower Pike River through Letton's flood runner.

The modelled results indicate that raising Lock 4 weir pool level in conjunction with elevated River Murray flow will allow additional flows to the floodplain to be achieved compared to Lock 4 remaining at typical weir pool level, providing a potential management option if additional dilution flows to the floodplain are required. Additional inflows through Banks B, B2 and C become possible at the elevated Lock 4 weir pool level, increasing inflows upstream of the blocking alignment by approximately 40%, whereas under typical pool level the river level at the inlets to these banks is insufficient to allow their opening. Flows through the Lower Pike River are also improved by approximately 50% by increasing Lock 4 weir pool at 30 000 ML/d upstream of Lock 5.

The distribution of inflows change with the increase in Lock 4 weir pool, with Rumpagunyah inflows decreasing by over 70%, while inflows through Swift and Wood Duck creeks increase by approximately 130% and 750%, respectively. This redistribution of flows can be seen by a comparison of the velocity maps at raised Lock 4 weir pool level (Figure 10.3) and at typical Lock 4 level (Figure 10.4). Velocities in Rumpagunyah between the River Murray and junction with Tanyaca Creek are seen to exist in the range of 0.02 to 0.04 m/s with Lock 4 pool level raised to 14.2 m AHD at 30 000 ML/d, while velocities increase to predominantly exist within the range 0.10 to 0.20 m/s, with some isolated points in the stream exceeding 0.20 m/s. The decrease in Rumpagunyah inflow with increasing Lock 4 weir pool level can be attributed to the increase in flow through Tanyaca Creek (including inlets at Swift and Wood Duck creeks), which results in an increased water level at the Tanyaca–Rumpagunyah junction. This behavior is apparent in the velocity maps present in Figure 10.3 and Figure 10.4, with velocities predominantly exceeding 0.20 m/s in Swift and Wood Duck creeks under the Lock 4 weir raising scenario, which reduces to the range of 0.02 to 0.04 m/s in Wood Duck Creek and a lower limit of 0.05 m/s in Swift Creek under the typical Lock 4 pool level scenario.

Velocity profiles in Tanyaca Creek (Figure 10.7 and Table 10.3) shows the maximum length of stream falling within velocity category 0.20-0.30 m/s under the raised Lock 4 weir pool scenario (Scenario 8a). This differs from the normal Lock 4 weir pool level scenario (8b), which has the maximum length of stream falling in the 0.15-0.20 m/s category. One significant factor contributing to the increased velocities under raised Lock 4 level is the additional inflows through Banks B, B2 and C possible under raised pool level at in-channel floodplain conditions, which contributes an additional approximately 500 ML/d flowing over Tanyaca regulator at fixed Pike River regulator flow.

Raising Lock 4 level also contributes to an increase in velocity distribution to higher velocity categories in Swift Creek (Table 10.4 and Figure 10.8) and Wood Duck Creek (Table 10.5 and Figure 10.9), owing to the greater inflows in these creeks generated by the raised river level at their respective inlets. Maximum velocities were simulated to be less than 0.6 m/s, and as such any increased risk of erosion is expected to be minimal. Conversely, Rumpagunyah velocity distribution (Figure 10.10 and Table 10.6) decreases considerably when raising Lock 4 weir pool level by 1 m, with velocities existing in the range 0.10-0.30 m/s under normal Lock 4 level, decreasing to velocities in the 0.02-0.05 m/s range under raised Lock 4 pool level. This can be attributed to the greater flow through Tanyaca Creek discharging into Rumpagunyah Creek under raised river level, generated by Banks B, B2 and C inflows and the greater inflows through Swift and Wood Duck Creeks, which reduces the hydraulic grade between the Rumpagunyah inlet and Pike River and reduces Rumpagunyah inflows. Despite this, inflows to Lower Pike increase in general under raised Lock 4 level, contributing to the maximum length of stream in lower Pike falling in the 0.20-0.30 m/s category under raised Lock 4 level, and in the 0.15-0.20 m/s category under normal Lock 4 level (Table 10.7 and Figure 10.11).

Managed inundation flow conditions

The results indicate that under raised Lock 4 level and 30 000 ML/d upstream of Lock 5 under a managed inundation event, a flow of approximately 560 ML/d flows into the floodplain through Rumpagunyah Creek, 700 ML/d through Wood Duck Creek, 1390 ML/d through Swift Creek, and 820 ML/d over Tanyaca Creek environmental regulator. Water level at the Rumpagunyah–Tanyaca Creek junction is approximately 14.66 m AHD. The inflows from Tanyaca and Rumpagunyah creeks and flow over Pike environmental regulator (400 ML/d) combines for a total flow in Lower Pike River, downstream of the Rumpagunyah–Pike junction, is approximately 3840 ML/d. A further 90 ML/d enters the lower Pike through Letton's flood runner, resulting in a total flow exiting Lower Pike into the River Murray of approximately 3930 ML/d.

Considering the system at normal Lock 4 pool level (13.2 m AHD) and 30 000 ML/d River Murray flow, approximately 840 ML/d flows into the floodplain through Rumpagunyah Creek, 70 ML/d through Wood Duck Creek, 570 ML/d through Swift Creek, and 820 ML/d over Tanyaca Creek environmental regulator (as well as 400 ML/d over Pike River environmental regulator), resulting in approximately 2680 ML/d total flow through Lower Pike River. A water level of approximately 14.04 m AHD is observed at the Rumpagunyah–Tanyaca Creek junction. No additional inflow to Lower Pike River is encountered through Letton's flood runner.

The impact of raising Lock 4 pool level at 30 000 ML/d during a managed inundation event does not impact on the flows upstream of the blocking bank given the greater elevation of Mundic Creek, however total flow through Lower Pike increases by approximately 47% compared to maintaining Lock 4 weir pool at a typical level, which may be of additional benefit for flow dilution of the receiving waters where required from a water quality perspective.

Flow distribution through Rumpagunyah, Swift and Wood Duck creeks change with the raising of Lock 4 weir pool level, resulting in inflows through Swift and Wood Duck creeks increasing by approximately 145% and 890%, respectively, with inflows through Rumpagunyah decreasing by approximately 34%. Velocity distribution in each scenario, as shown in Figure 10.5 (raised Lock 4 level) and Figure 10.6 (typical Lock 4 level), reflects this change in flow split; velocity through Swift and Wood Duck creeks predominantly exceeds 0.20 m/s under the Lock 4 raised weir pool case, with velocity in Rumpagunyah within the range of 0.05 to 0.10 m/s under the same conditions. In comparison, at a typical Lock 4 weir pool level the velocities in Swift Creek exist as low as approximately 0.05 m/s and Wood Duck Creek in the range of 0.02 to 0.05 m/s, while velocities in Rumpagunyah exist upwards of 0.10 m/s, with isolated points exceeding 0.20 m/s. This change in velocity distribution can be attributed to a greater hydraulic head existing in Tanyaca Creek under the raised Lock 4 level, causing water level at the Rumpagunyah–Tanyaca Creek junction to increase by approximately 0.6 m. This therefore reduces the hydraulic gradient along Rumpagunyah Creek and consequently reduces inflow through this channel.

Changes in velocity distribution are similar to those in the in-channel scenarios (8a and 8b), with the main exception of Tanyaca Creek, which indicates a minor "spreading out" of the velocity profile under raised Lock 4 level compared with normal Lock 4 level. This results in a greater length of creek in the lower velocity categories, but also a minor increase in length of creek at higher velocities, compared to the case under normal Lock 4 levels. These differences can be attributed to tailwater conditions in the upper section of Tanyaca Creek between the Tanyaca regulator and the Swift Creek discharge location, and also in the lower section of Tanyaca Creek between Wood Duck discharge location and Rumpagunyah Creek; under raised Lock 4 level velocities are reduced in the upper section of Tanyaca due to the higher discharges through Swift and Wood Duck Creeks (and hence higher tailwater level), but raised in the lower section of Tanyaca due to the increased headwater and lower tailwater levels of this section of creek.

Letton's flood runner

The results in the previous sections indicates that additional flow from the River Murray into Lower Pike River through Letton's flood runner is possible at raised Lock 4 pool level and 30 000 ML/d, but the flood runner becomes disconnected at typical Lock 4 pool level. The flood runner has a maximum crest level of approximately 14.0 m AHD in at least four separate locations based on the digital elevation model (DEM), as indicated in the approximate long section of the flood runner in Figure 10.2. River level is modelled at approximately 14.5 m AHD at the flood runner inlet under 30 000 ML/d and raised Lock 4 pool level, generating approximately 90 ML/d flow into the Lower Pike. The river level decreases to approximately 13.8 m AHD at typical

Lock 4 weir pool level however, generating no additional inflow through this flood runner. These results align with empirical River Murray backwater curves, which indicates a Flow to South Australia (QSA) above 30 000 ML/d is required to activate the Letton's flood runner at a typical Lock 4 weir pool level, as indicated in Table 10.2.

A complementary management option currently being considered under SARFIIP is lowering the crest level of the flood runner such that the commence-to-flow can be reduced. The modelled results show that a crest lowering of approximately 0.5 m, to 13.5 m AHD, will allow inflows to occur at a river flow above Lock 5 of 30 000 ML/d and normal Lock 4 pool level. Based on the River Murray backwater curves, the flood runner may commence to flow at between 15 000 to 20 000 ML/d with such a crest lowering.

Table 10.1 Flows and water levels at various locations in Pike Floodplain for raised Lock 4 (14.2 m AHD) and normal Lock 4 (13.2 m AHD) levels under in-stream and inundated flow conditions, as modelled in Scenarios 8a to 8d.

Scenario	River flow U/S L5	L5 Upper pool	L4 Upper pool	Margaret Dowling Creek	Deep Creek	Swift Creek	Wood Duck Creek	Lower Pike at Letton's	Rumpa-gunyah (inflow)	Letton's flood runner	Bank C	Tanyaca Creek regulator	Bank B2	Bank B	Pike River regulator
	ML/d	m AHD	m AHD	ML/d	ML/d	ML/d	ML/d	ML/d	ML/d	ML/d	ML/d	ML/d	ML/d	ML/d	ML/d
8a	30 000	16.3	14.2	400	800	1339	683	3900	232	86	427	1263	67	3	400
8b	30 000	16.3	13.2	400	800	589	78	2671	837	0	0	774	0	0	400
8c	30 000	16.8	14.2	600	800	1389	696	3843	556	87	0	820	0	0	400
8d	30 000	16.8	13.2	600	800	567	70	2684	837	0	0	820	0	0	400
	ML/d	m AHD	m AHD	m AHD	m AHD	m AHD	m AHD	m AHD	m AHD	m AHD	m AHD	m AHD	m AHD	m AHD	m AHD
8a	30 000	16.3	14.2	16.31	16.3	14.94	14.92	14.62	14.66	14.52	14.95[a] 14.94[b]	14.90[a] 14.86[b]	14.96[a] 14.96[b]	14.96[a] 14.96[b]	14.78[a] 14.62[b]
8b	30 000	16.3	13.2	16.31	16.3	14.65	14.63	13.98	14.05	13.79	14.76[a] 14.68[b]	14.75[a] 14.33[b]	14.81[a] 14.72[b]	14.81[a] 14.69[b]	14.51[a] 13.99[b]
8c	30 000	16.8	14.2	16.81	16.8	14.94	14.92	14.61	14.66	14.51	16.40[a] 14.97[b]	16.40[a] 14.78[b]	16.41[a] 15.00[b]	16.41[a] 14.98[b]	16.39[a] 14.61[b]
8d	30 000	16.8	13.2	16.81	16.80	14.65	14.62	13.97	14.04	13.79	16.40[a] 14.68[b]	16.40[a] 14.35[b]	16.41[a] 14.72[b]	16.41[a] 14.69[b]	16.39[a] 13.98[b]

[a] Water level upstream of structure

[b] Water level downstream of structure

Table 10.2 Approximate river levels at Letton's flood runner inlet against Flow to South Australia (based on historical River Murray backwater curves)

Flow to South Australia ML/d	Approximate river level at Letton's flood runner inlet m AHD
10 000	13.3
15 000	13.4
20 000	13.6
30 000	13.9
40 000	14.3

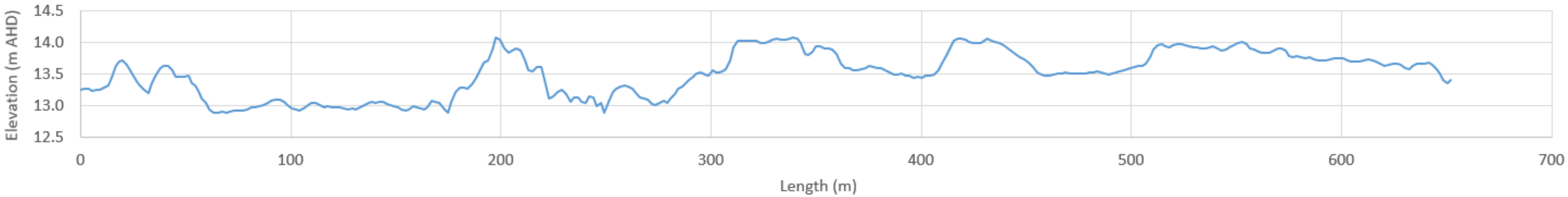

Figure 10.2 Long section of Letton's flood runner inlet showing approximate minimum levels along the flow path from River Murray to Lower Pike River

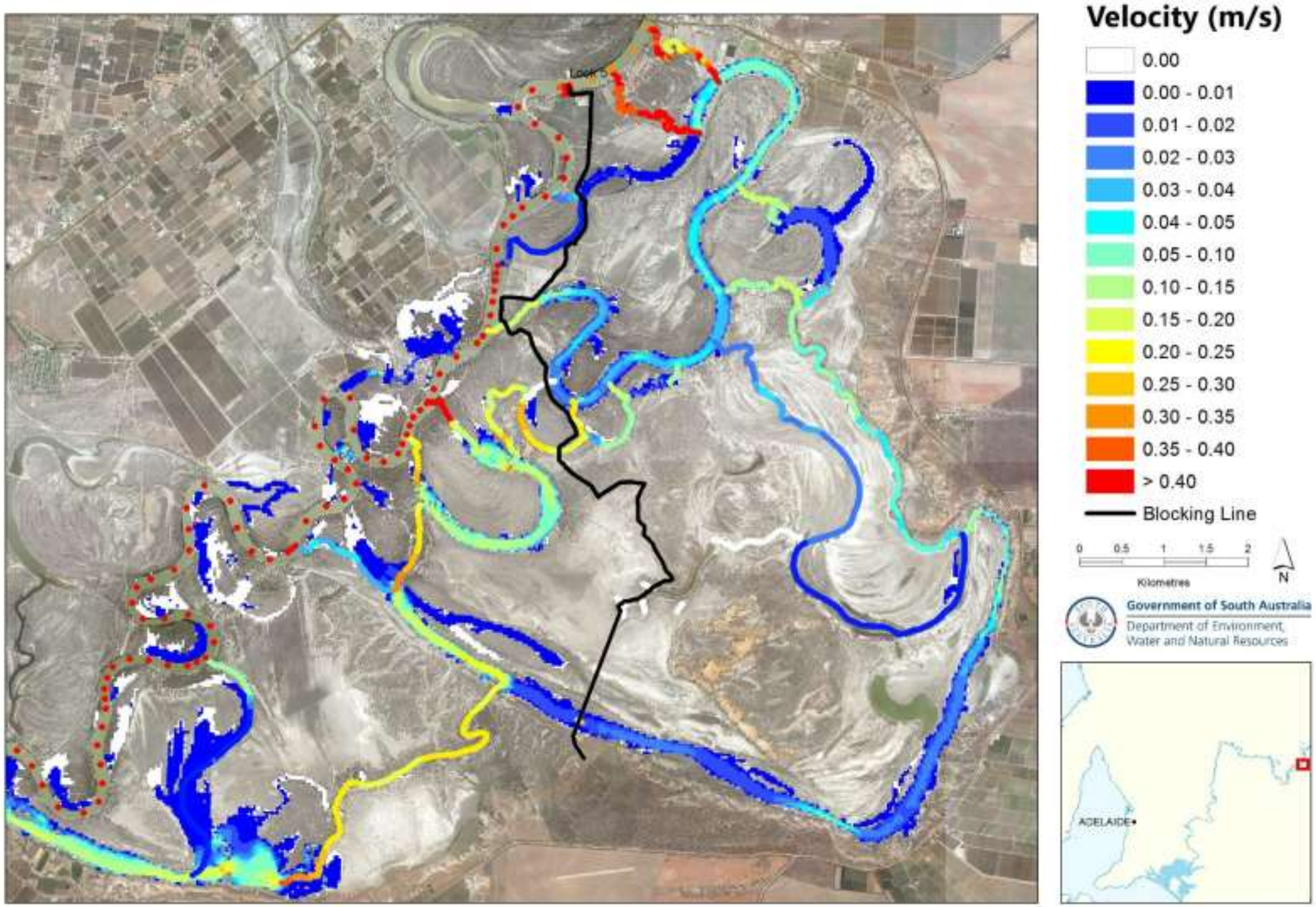

Figure 10.3 Velocity distribution in Pike Floodplain at flow upstream of Lock 5 at 30 000 ML/d and raised Lock 4 weir pool level at 14.2 m AHD under in-stream flow conditions

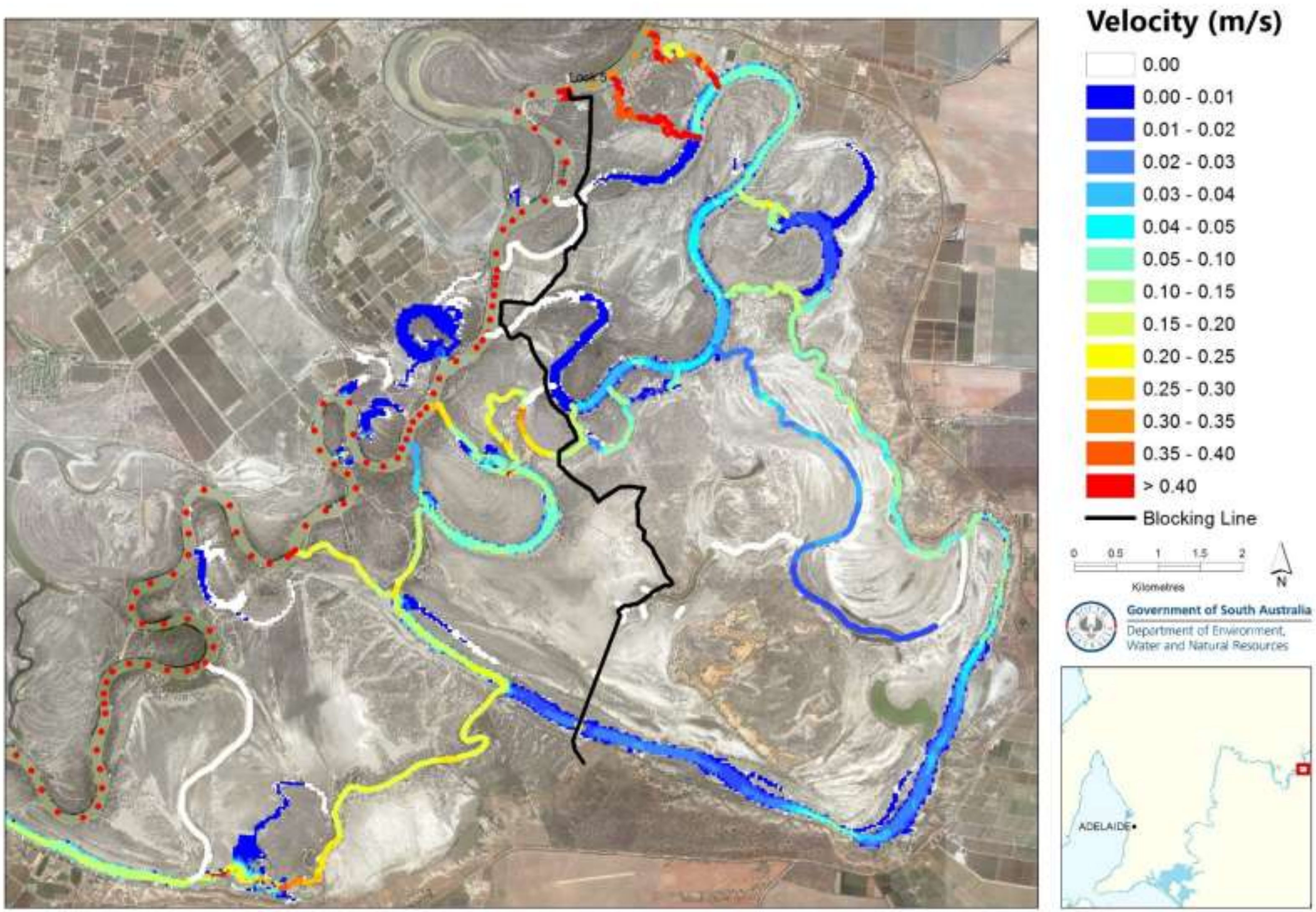

Figure 10.4 Velocity distribution in Pike Floodplain at flow upstream of Lock 5 at 30 000 ML/d and typical Lock 4 weir pool level at 13.2 m AHD under in-stream flow conditions

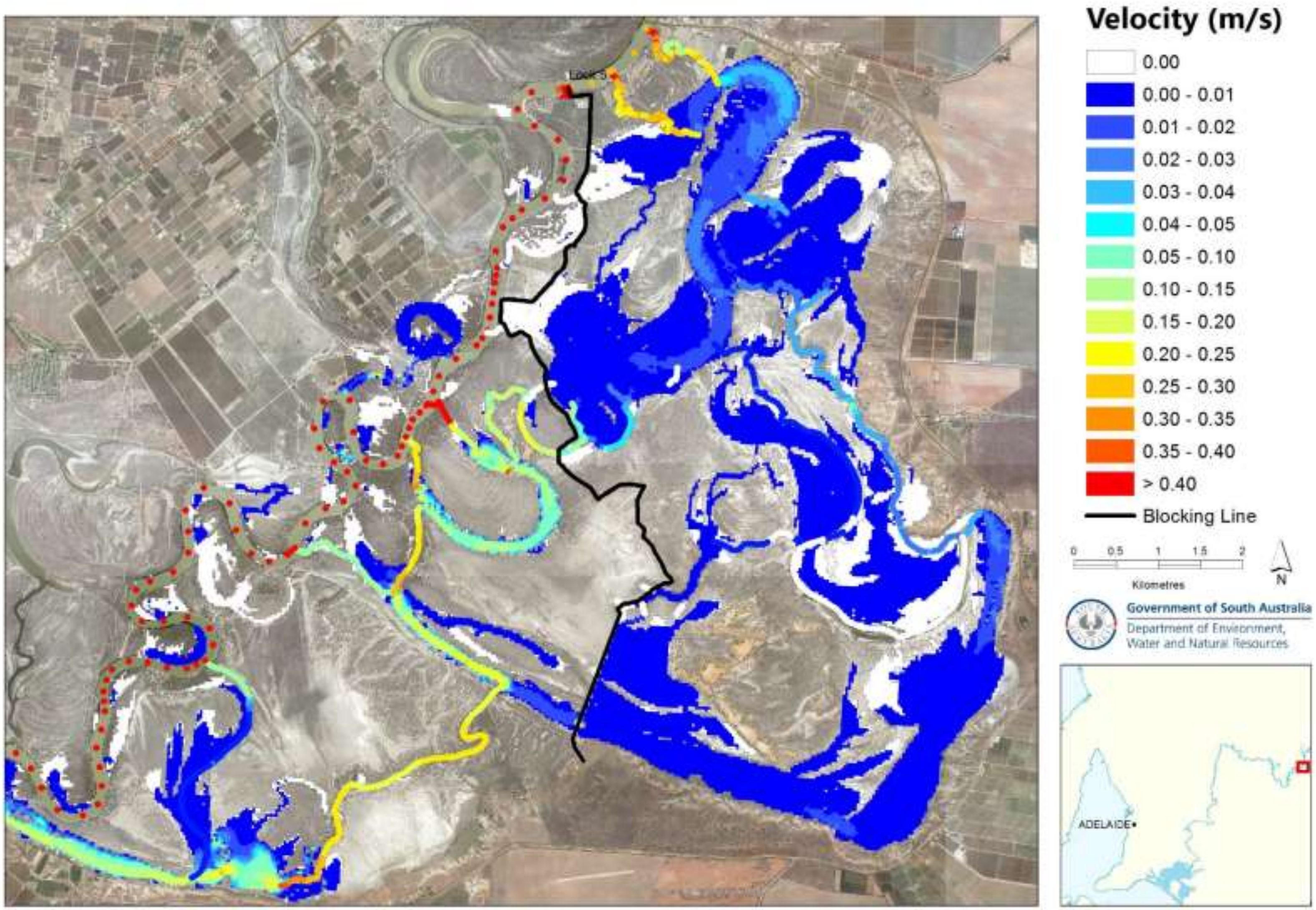

Figure 10.5 Velocity distribution in Pike Floodplain at flow upstream of Lock 5 at 30 000 ML/d and raised Lock 4 weir pool level at 14.2 m AHD under managed inundation operating conditions

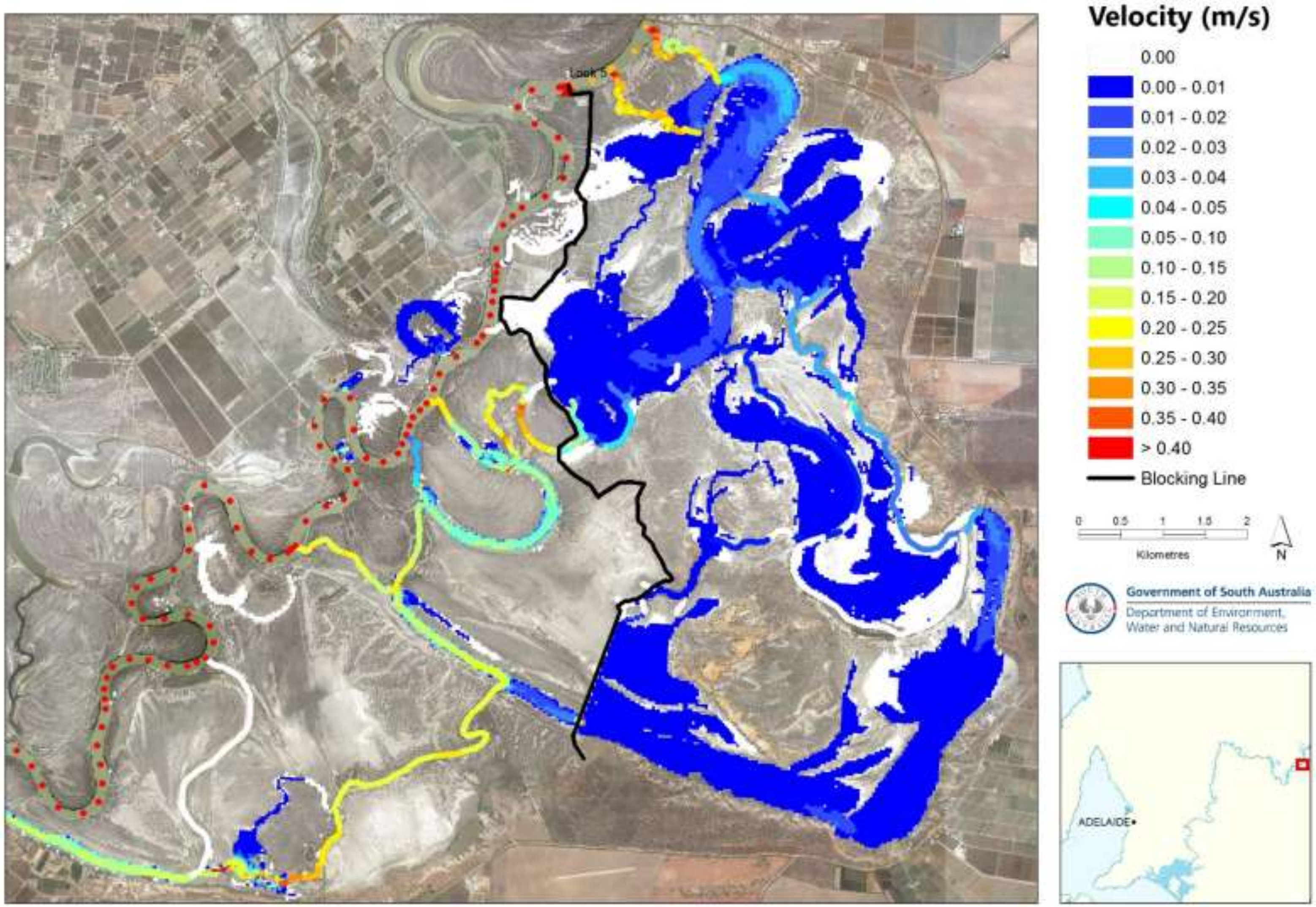

Figure 10.6 Velocity distribution in Pike Floodplain at flow upstream of Lock 5 at 30 000 ML/d and typical Lock 4 weir pool level at 13.2 m AHD under managed inundation operating conditions

Table 10.3 Velocity distribution by stream length in Tanyaca Creek

Scenario	8a		8b		8c		8d	
Mundic Creek water level	14.90 m AHD		14.75 m AHD		16.40 m AHD		16.40 m AHD	
Lock 4 U/S level	14.2 m AHD		13.2 m AHD		14.2 m AHD		13.2 m AHD	
Tanyaca regulator flow	1263 ML/d		774 ML/d		820 ML/d		820 ML/d	
Velocity range	Stream length							
(m/s)	m	%	m	%	m	%	m	%
<0.01	0	0	0	0	0	0	0	0
0.01-0.05	0	0	0	0	87	2	0	0
0.05-0.10	173	5	203	6	1076	30	276	8
0.10-0.15	289	8	856	24	995	28	871	24
0.15-0.20	1287	36	1279	36	486	14	1624	45
0.20-0.25	898	25	870	24	608	17	528	15
0.25-0.30	624	17	203	6	219	6	228	6
0.30-0.35	324	9	149	4	123	3	69	2
0.35-0.40	0	0	34	1	0	0	0	0
>0.40	0	0	0	0	0	0	0	0
Total	3595	100	3595	100	3595	100	3595	100

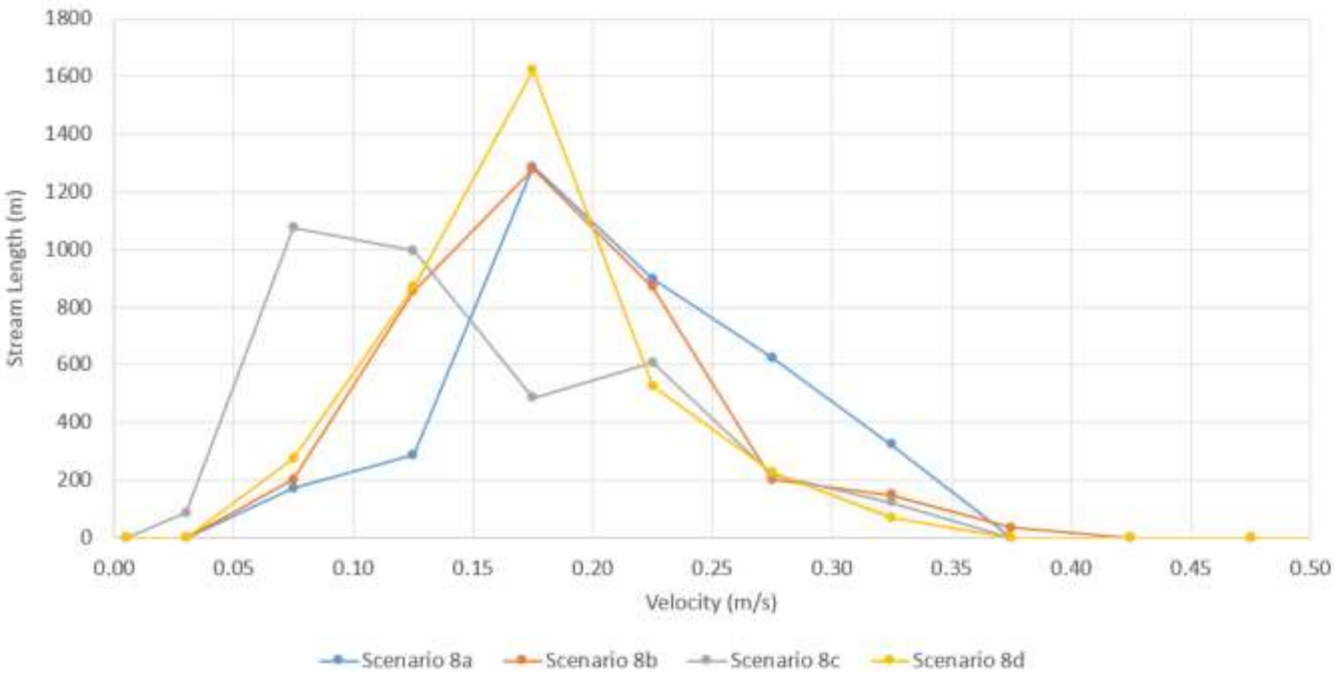

Figure 10.7 Velocity profiles by stream length for Tanyaca Creek, from Table 10.3

Table 10.4 Velocity distribution by stream length in Swift Creek

Scenario	8a		8b		8c		8d	
River level at Swift Creek inlet	14.94 m AHD		14.65 m AHD		14.94 m AHD		14.65 m AHD	
Lock 4 U/S level	14.2 m AHD		13.2 m AHD		14.2 m AHD		13.2 m AHD	
Swift Creek flow	1339 ML/d		589 ML/d		1389 ML/d		567 ML/d	
Velocity range	Stream length							
(m/s)	m	%	m	%	m	%	m	%
<0.01	0	0	0	0	0	0	0	0
0.01-0.05	0	0	0	0	0	0	0	0
0.05-0.10	0	0	377	44	0	0	333	39
0.10-0.15	289	34	44	5	132	15	88	10
0.15-0.20	88	10	0	0	245	28	0	0
0.20-0.25	44	5	291	34	0	0	125	14
0.25-0.30	0	0	149	17	44	5	316	37
0.30-0.35	0	0	0	0	0	0	0	0
0.35-0.40	0	0	0	0	0	0	0	0
0.40-0.45	167	19	0	0	42	5	0	0
0.45-0.50	274	32	0	0	167	19	0	0
0.50-0.60	0	0	0	0	233	27	0	0
>0.60	0	0	0	0	0	0	0	0
Total	862	100	862	100	862	100	862	100

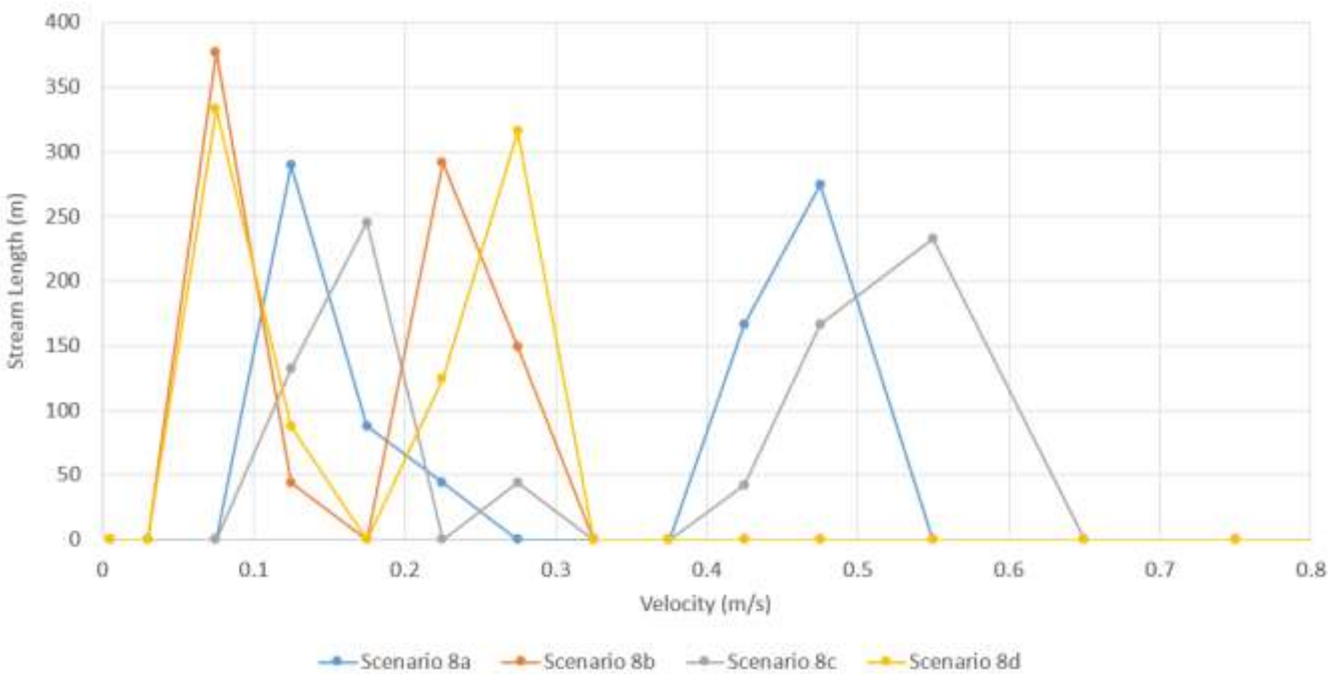

Figure 10.8 Velocity profiles by stream length for Swift Creek, from Table 10.4

Table 10.5 Velocity distribution by stream length in Wood Duck Creek

Scenario	8a		8b		8c		8d	
River level at Wood Duck Creek inlet	14.92 m AHD		14.63 m AHD		14.92 m AHD		14.62 m AHD	
Lock 4 U/S level	14.2 m AHD		13.2 m AHD		14.2 m AHD		13.2 m AHD	
Wood Duck Creek flow	683 ML/d		78 ML/d		696 ML/d		70 ML/d	
Velocity range	Stream length							
(m/s)	m	%	m	%	m	%	m	%
<0.01	0	0	0	0	0	0	0	0
0.01-0.05	0	0	710	100	0	0	558	79
0.05-0.10	0	0	0	0	0	0	152	21
0.10-0.15	0	0	0	0	0	0	0	0
0.15-0.20	156	22	0	0	0	0	0	0
0.20-0.25	354	50	0	0	365	51	0	0
0.25-0.30	145	20	0	0	194	27	0	0
0.30-0.35	55	8	0	0	152	21	0	0
0.35-0.40	0	0	0	0	0	0	0	0
>0.40	0	0	0	0	0	0	0	0
Total	710	100	710	100	710	100	710	100

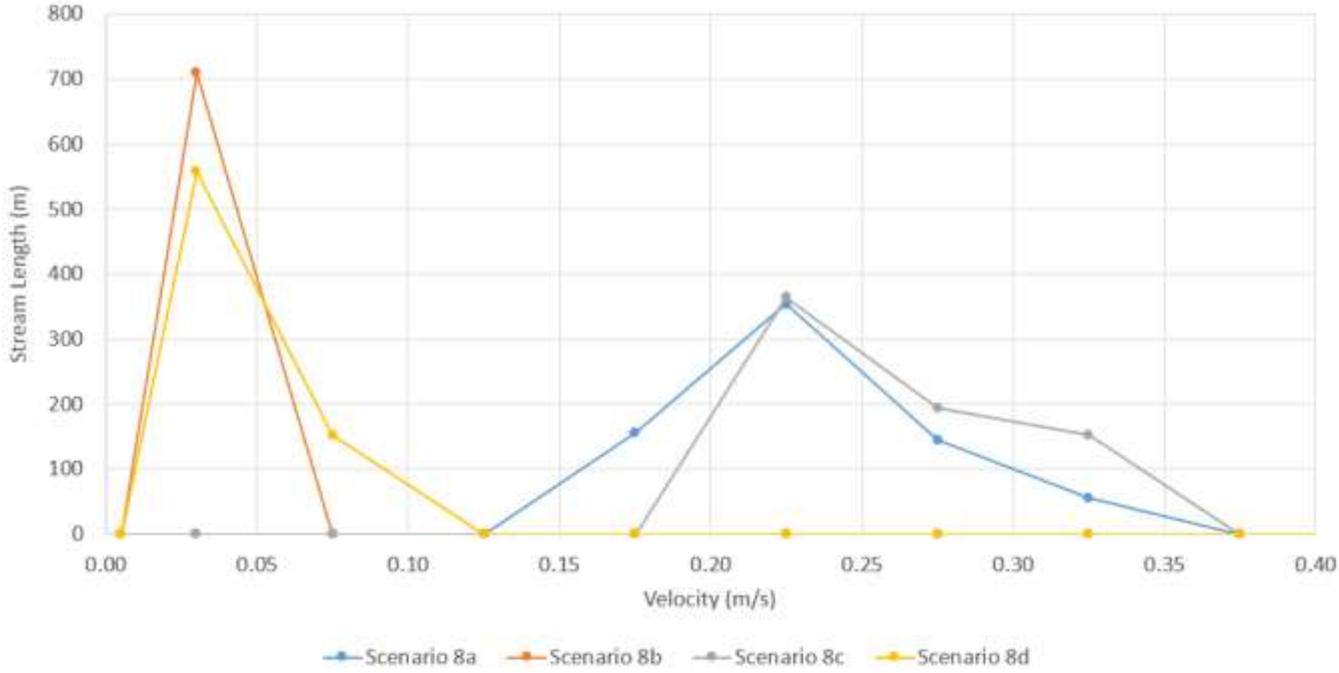

Figure 10.9 Velocity profiles by stream length for Wood Duck Creek, from Table 10.5

Table 10.6 Velocity distribution by stream length in Rumpagunyah Creek

Scenario	8a		8b		8c		8d	
River level at Rumpagunyah inlet	14.66 m AHD		14.05 m AHD		14.66 m AHD		14.04 m AHD	
Lock 4 U/S level	14.2 m AHD		13.2 m AHD		14.2 m AHD		13.2 m AHD	
Rumpagunyah flow	232 ML/d		837 ML/d		556 ML/d		837 ML/d	
Velocity range	Stream length							
(m/s)	m	%	m	%	m	%	m	%
<0.01	0	0	0	0	0	0	0	0
0.01-0.05	1490	100	0	0	0	0	0	0
0.05-0.10	0	0	0	0	1311	88	0	0
0.10-0.15	0	0	332	22	180	12	226	15
0.15-0.20	0	0	935	63	0	0	864	58
0.20-0.25	0	0	223	15	0	0	400	27
0.25-0.30	0	0	0	0	0	0	0	0
>0.30	0	0	0	0	0	0	0	0
Total	1490	100	1490	100	1490	100	1490	100

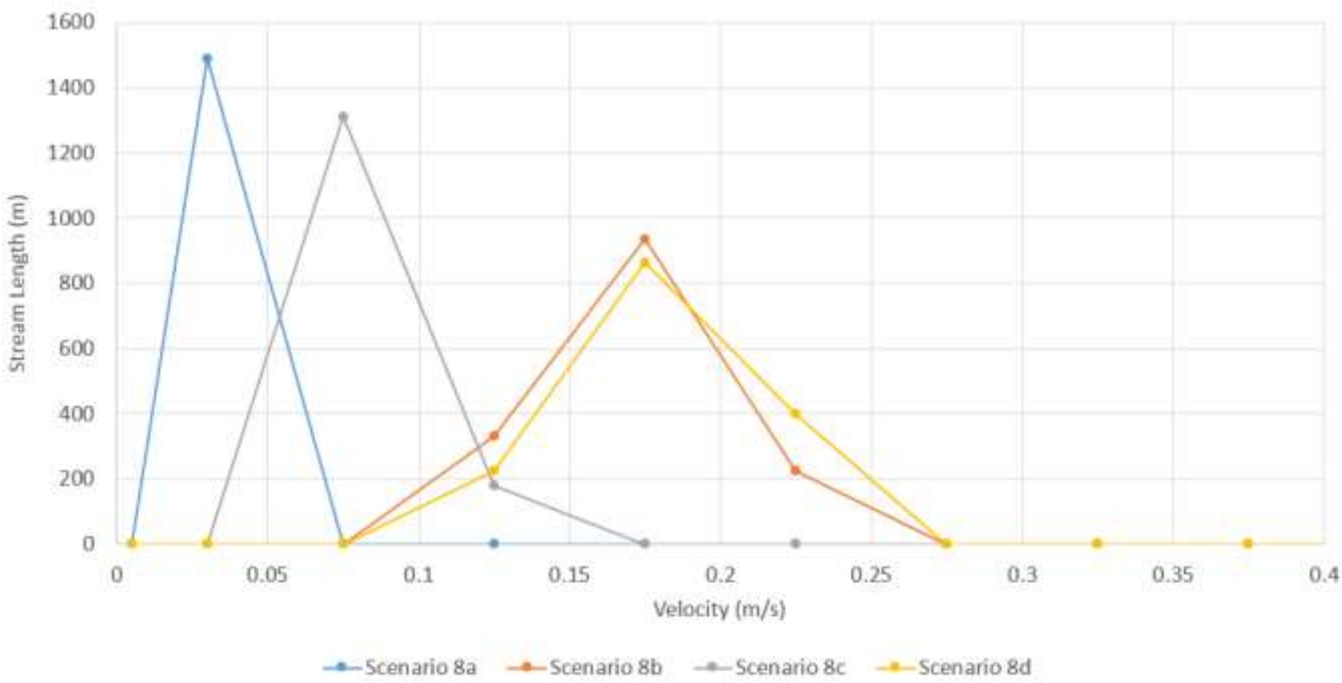

Figure 10.10 Velocity profiles by stream length for Rumpagunyah Creek, from Table 10.6

Table 10.7 Velocity distribution by stream length in Lower Pike River (below Rumpagunyah-Pike River junction)

Scenario	8a		8b		8c		8d	
Level at Rump.-Pike junction	14.62 m AHD		13.98 m AHD		14.61 m AHD		13.97 m AHD	
Lock 4 U/S level	14.2 m AHD		13.2 m AHD		14.2 m AHD		13.2 m AHD	
Lower Pike flow	3900 ML/d		2671 ML/d		3843 ML/d		2684 ML/d	
Velocity range	Stream length							
(m/s)	m	%	m	%	m	%	m	%
<0.01	0	0	0	0	0	0	0	0
0.01-0.05	0	0	0	0	0	0	0	0
0.05-0.10	0	0	0	0	0	0	0	0
0.10-0.15	0	0	0	0	0	0	0	0
0.15-0.20	986	21	3068	65	794	17	2788	59
0.20-0.25	2836	60	1038	22	2933	62	1271	27
0.25-0.30	521	11	284	6	568	12	332	7
0.30-0.35	237	5	237	5	284	6	190	4
0.35-0.40	142	3	95	2	142	3	142	3
>0.40	0	0	0	0	0	0	0	0
Total	0	100	0	100	0	100	0	100

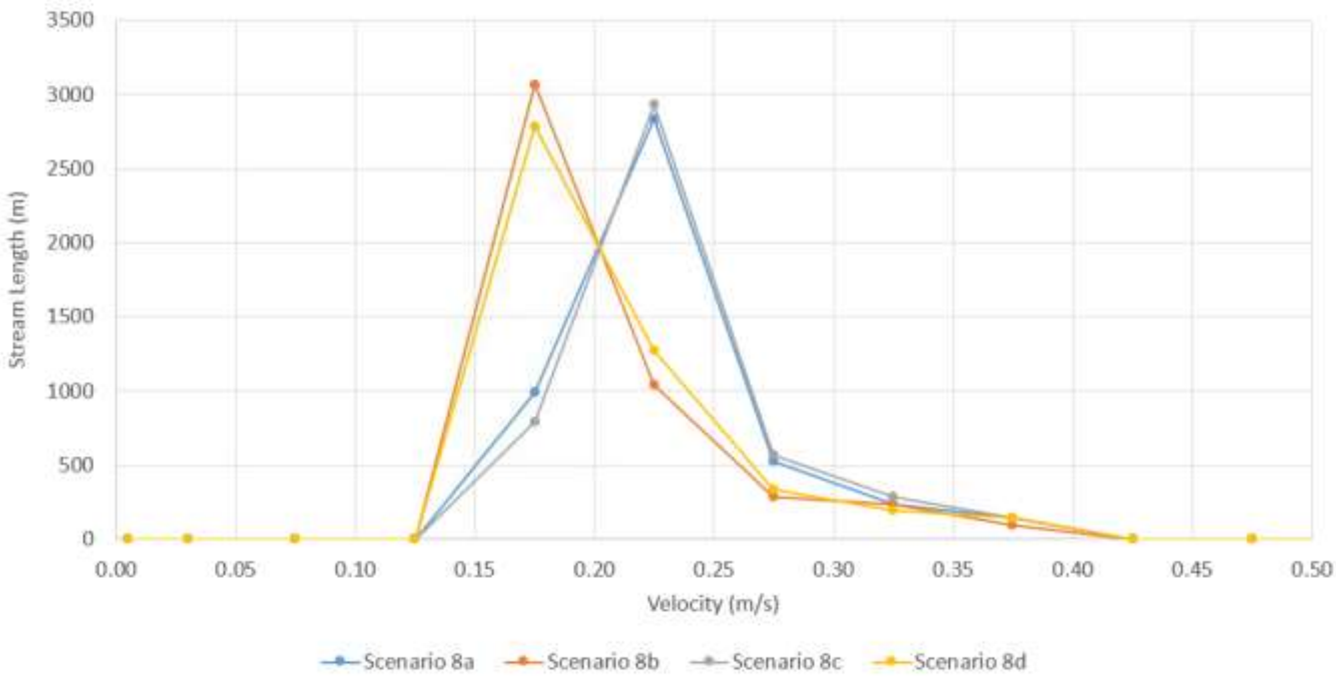

Figure 10.11 Velocity profiles by stream length for Lower Pike River (downstream of Rumpagunyah–Pike River junction), from Table 10.7

11 Scenario 9 – Impact of Pike infrastructure operations on in-stream velocities under various floodplain operational regimes

A suite of scenarios was developed to investigate the impact of structure operation on in-stream velocities immediately downstream of each relevant structure. Structures are operated against draft operational regimes for the Pike Floodplain (Tonkin Consulting 2015, *pers. comm.*, 29 April), which in essence include: baseflow conditions, spring fresh events, and floodplain managed inundation events. Scenarios developed for each operational regime against each relevant creek are presented in Table 2.3, which include testing the impact of variable head and tailwater conditions and flows under which structures may be operated. Velocity distributions are shown in tabular form in Table 11.1 to Table 11.6, and in graphical form in Figure 11.1 to Figure 11.6.

For Deep Creek and Margaret Dowling Creek scenarios, influence on velocities is related to the inflow and tailwater (i.e. Mundic Creek level) conditions.

For Mundic northern outlet scenarios, minor regulators are assumed on the northern outlet, southern outlet and Snake Creek inlet, and an additional bank on the central outlet, which enables localised inundation of the Mundic Creek fringe to be achieved. All Mundic Creek outflows are directed through the main Mundic outlets of Tanyaca Creek and Mundic Northern Outlet (other regulators closed) to provide simplicity in the analysis given the many different assumptions that could be made about flow out of Mundic to Pike River, and as such represents an upper limit of velocities in the Mundic northern outlet representation. Note that only baseflow (low flow) and spring fresh operating regimes are investigated, as it is assumed that the Mundic northern outlet structure (and other outlet structures) will be removed during a managed inundation event, and therefore velocities are influenced predominately by Pike and Tanyaca environmental regulators.

For Tanyaca Creek, the impact of Tanyaca regulator flows and tailwater levels, influenced by Lock 4 and River Murray flows, are analysed for their impact on Tanyaca Creek velocities downstream of the structure. Velocity analysis is complicated by the creek being represented in both 1-D and 2-D components in the model configuration. Although previous scenarios have focused on a velocity distribution by area, only 1-D parts of the stream are considered in this case to remain consistent with the other scenarios in the chapter, thereby excluding velocities in the wide horseshoe section of the creek. Velocities upstream of the regulator are also excluded from the analysis for Tanyaca Creek.

Additional data produced from each simulation is presented in Appendix C, with a focus on flows and water levels upstream and downstream of Pike and Tanyaca regulators. It should be noted that these simulations were configured to provide data on a stream by stream basis rather than representing realistic operating conditions on the whole of floodplain scale.

Velocities in the inlet streams at Margaret Dowling Creek and Deep Creek are shown to move to towards higher categories under lower tailwater levels and/or higher flows through the creeks (Margaret Dowling Creek in Table 11.1 and Figure 11.1, Deep Creek in Table 11.2 and Figure 11.2). The highest velocities are observed in the Baseflow – high inflow/spring fresh – low tailwater scenario, which shows the majority of velocities greater than 0.5 m/s. Conversely, velocities are shifted to the lower categories under the managed inundation scenarios (i.e. 16.4 m AHD Mundic Creek water level), with the Floodplain Inundation – low inflow scenario showing almost half of the creek length falling in the 0.15–0.20 m/s velocity category.

Table 11.1 Margaret Dowling Creek velocity profiles by stream length

Description	Baseflow – low inflow		Baseflow – high inflow/ spring fresh – low tail water		Spring fresh – high tail water		Floodplain Inundation – low inflow		Floodplain inundation – high inflow	
Stream flow	400 ML/d		500 ML/d		500 ML/d		400 ML/d		600 ML/d	
Headwater (river level)	16.30 m AHD		16.30 m AHD		16.30 m AHD		16.8 m AHD		16.8 m AHD	
Tailwater (Mundic level)	14.78 m AHD		14.79 m AHD		15.60 m AHD		16.4 m AHD		16.4 m AHD	
Velocity range					Stream length					
(m/s)	m	%	m	%	m	%	m	%	m	%
<0.01	0	0	0	0	0	0	0	0	0	0
0.01-0.05	0	0	0	0	0	0	0	0	0	0
0.05-0.10	0	0	0	0	0	0	28	2	0	0
0.10-0.15	0	0	0	0	0	0	301	23	28	2
0.15-0.20	0	0	0	0	28	2	582	44	161	12
0.20-0.25	33	3	0	0	134	10	255	19	512	39
0.25-0.30	143	11	106	8	192	14	65	5	355	27
0.30-0.35	214	16	111	8	232	17	63	5	125	9
0.35-0.40	213	16	238	18	371	28	25	2	32	2
0.40-0.45	198	15	195	15	135	10	0	0	68	5
0.45-0.50	175	13	188	14	95	7	0	0	23	2
0.50-0.60	238	18	360	27	125	9	5	0	15	1
0.60-0.70	57	4	30	2	7	1	0	0	0	0
0.70-0.80	47	4	42	3	5	0	0	0	5	0
0.80-0.90	0	0	54	4	0	0	0	0	0	0
0.90-1.00	7	1	0	0	0	0	0	0	0	0
1.00-1.20	5	<1*	5	<1*	5	<1*	5	<1*	5	<1*
>1.20	0	0	0	0	0	0	0	0	0	0
Total	1328	100	1328	100	1328	100	1328	100	1328	100

* Represents modelled velocity at Margaret Dowling Creek structure of 1 m/s

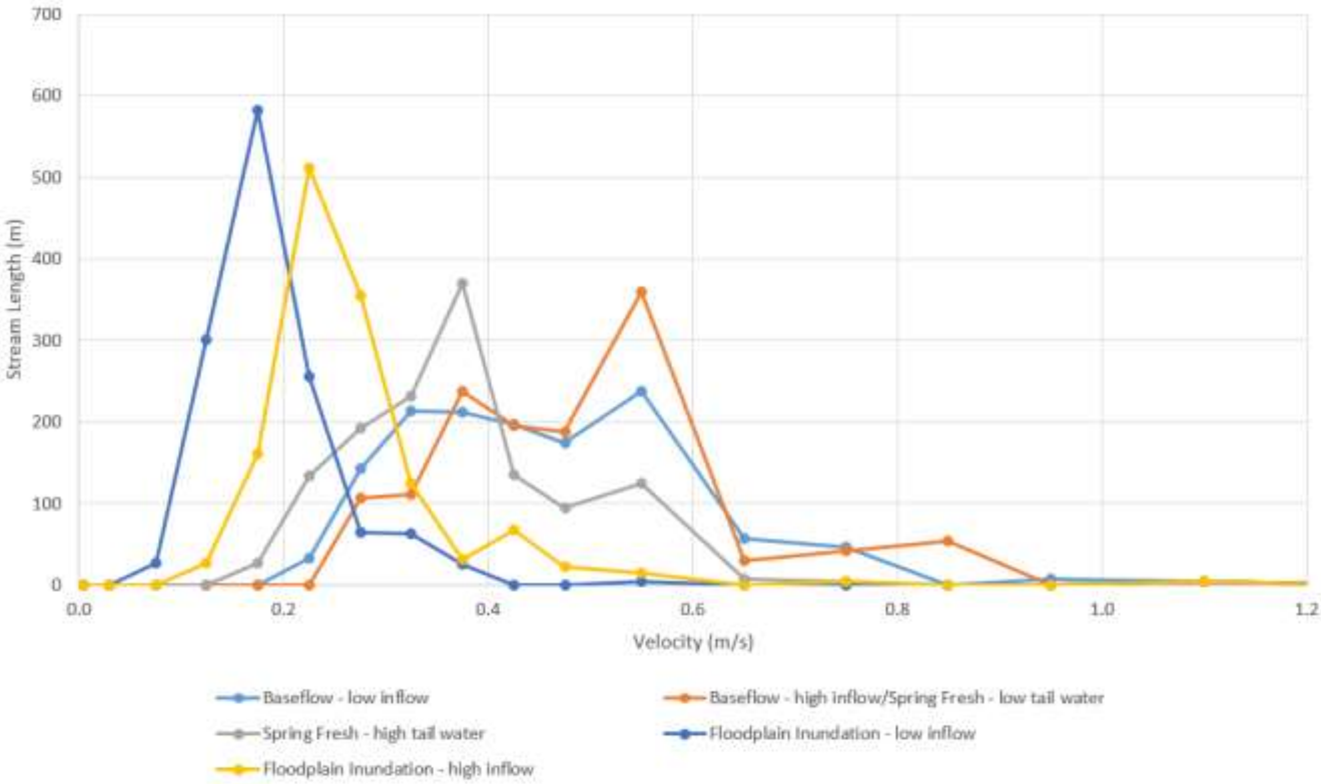

Figure 11.1 Margaret Dowling velocity profiles by stream length, from Table 11.1

Table 11.2 Deep Creek velocity profiles by stream length

Description	Baseflow – low inflow		Baseflow – high inflow/ spring fresh – low tail water		Spring fresh – high tail water		Floodplain inundation – low inflow		Floodplain inundation – high inflow	
Stream flow	**400 ML/d**		**500 ML/d**		**500 ML/d**		**400 ML/d**		**600 ML/d**	
River level (U/S regulator)	**16.30 m AHD**		**16.30 m AHD**		**16.30 m AHD**		**16.8 m AHD**		**16.8 m AHD**	
Tailwater level (Mundic)	**14.78 m AHD**		**14.79 m AHD**		**15.60 m AHD**		**16.4 m AHD**		**16.4 m AHD**	
Velocity range					**Stream length**					
(m/s)	**m**	**%**	**m**	**%**	**m**	**%**	**m**	**%**	**m**	**%**
<0.01	0	0	0	0	0	0	0	0	0	0
0.01-0.05	0	0	0	0	0	0	0	0	0	0
0.05-0.10	5	0	0	0	0	0	76	4	5	0
0.10-0.15	0	0	5	0	5	0	1830	85	71	3
0.15-0.20	0	0	0	0	0	0	172	8	1234	57
0.20-0.25	41	2	0	0	71	3	0	0	749	35
0.25-0.30	853	40	0	0	1128	53	22	1	19	1
0.30-0.35	625	29	564	26	724	34	0	0	0	0
0.35-0.40	224	10	627	29	132	6	0	0	22	1
0.40-0.45	224	10	385	18	19	1	0	0	0	0
0.45-0.50	109	5	42	2	0	0	0	0	0	0
0.50-0.60	17	1	411	19	22	1	3	0	0	0
0.60-0.70	0	0	65	3	0	0	0	0	0	0
0.70-0.80	0	0	0	0	0	0	0	0	0	0

Description	Baseflow – low inflow		Baseflow – high inflow/ spring fresh – low tail water		Spring fresh – high tail water		Floodplain inundation – low inflow		Floodplain inundation – high inflow	
Stream flow	400 ML/d		500 ML/d		500 ML/d		400 ML/d		600 ML/d	
River level (U/S regulator)	16.30 m AHD		16.30 m AHD		16.30 m AHD		16.8 m AHD		16.8 m AHD	
Tailwater level (Mundic)	14.78 m AHD		14.79 m AHD		15.60 m AHD		16.4 m AHD		16.4 m AHD	
Velocity range					Stream length					
(m/s)	m	%	m	%	m	%	m	%	m	%
0.80-0.90	0	0	0	0	0	0	0	0	3	0
0.90-1.00	0	0	0	0	0	0	0	0	0	0
1.00-1.20	48	2*	45	2*	48	2*	45	2*	45	2*
1.20-1.40	0	0	0	0	0	0	0	0	0	0
>1.40	0	0	3	0	0	0	0	0	0	0
Total	2147	100	2147	100	2147	100	2147	100	2147	100

* Represents modelled velocity at Deep Creek structure of 1 m/s

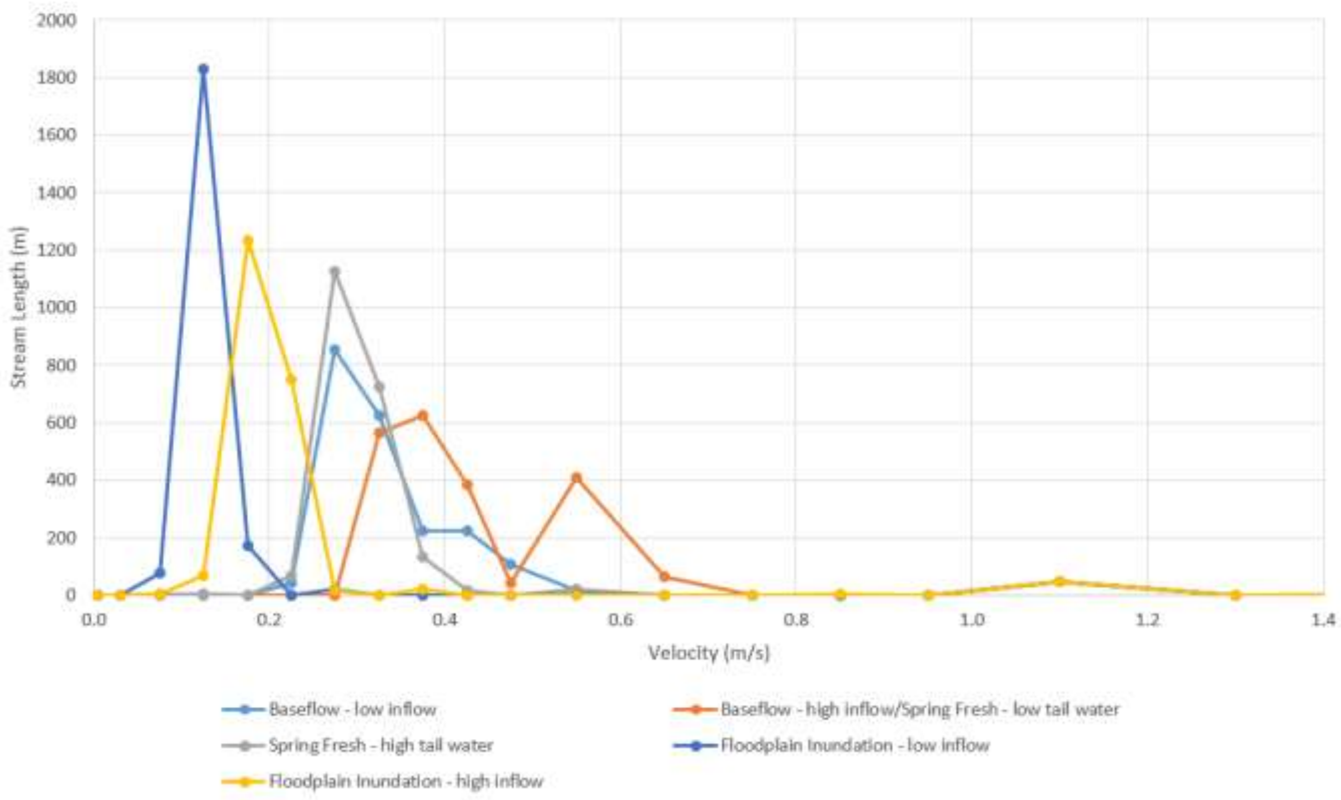

Figure 11.2 Deep Creek velocity profiles by stream length, from Table 11.2

In Mundic Northern Outlet, the headwater levels are altered while tailwater level (at Pike regulator) is controlled to a level of 14.35 m AHD, resulting in the velocities shifting to higher categories as flows through the creek are increased. A level of 15.6 m AHD is assumed as the level at which fringe inundation of Mundic Creek is implemented as part of a spring fresh event, using the proposed minor regulators on Mundic Northern and Southern outlets and Snake Creek to raise the water level locally in Mundic while operating the Pike River regulator to maintain current upstream levels. The results in Table 11.3 and Figure 11.3 indicate that velocities in the low flow scenario fall predominantly in the velocity category of 0.10–0.15 m/s, which increases up to 0.20–0.30 m/s under the spring fresh scenarios. There is also an apparent shift in velocities to the higher categories when increasing from low to high spring fresh flow scenarios.

This is particularly evident in the 0.30–0.40 m/s category, which increases in stream length from approximately 60 m (5% of stream length) to 180 m (15%) when raising flow from 500 ML/d to 600 ML/d.

Table 11.3 Mundic northern outlet velocity profiles by percent stream length

Description	Low flow		Spring fresh – low flow		Spring fresh – high flow	
Stream flow	245 ML/d		500 ML/d		600 ML/d	
Mundic level (U/S regulator)	14.76 m AHD		15.60 m AHD		15.60 m AHD	
Level D/S regulator	14.64 m AHD		14.89 m AHD		14.97 m AHD	
Velocity range			Stream length			
(m/s)	m	%	m	%	m	%
<0.01	0	0	0	0	0	0
0.01-0.05	0	0	0	0	0	0
0.05-0.10	0	0	108	9	0	0
0.10-0.15	753	63	0	0	108	9
0.15-0.20	265	22	222	19	30	2
0.20-0.25	85	7	456	38	469	40
0.25-0.30	0	0	231	19	263	22
0.30-0.35	38	3	34	3	148	12
0.35-0.40	0	0	29	2	34	3
0.40-0.45	0	0	60	5	78	7
0.45-0.50	0	0	0	0	11	1
0.50-0.60	0	0	0	0	0	0
0.60-0.70	0	0	0	0	0	0
0.70-0.80	0	0	0	0	0	0
0.80-0.90	0	0	0	0	0	0
0.90-1.00	0	0	0	0	0	0
1.00-1.20	47	4*	47	4*	47	4*
>1.20	0	0	0	0	0	0
Total	1186	100	1186	100	1186	100

* Represents modelled velocity at Mundic northern outlet structure of 1 m/s

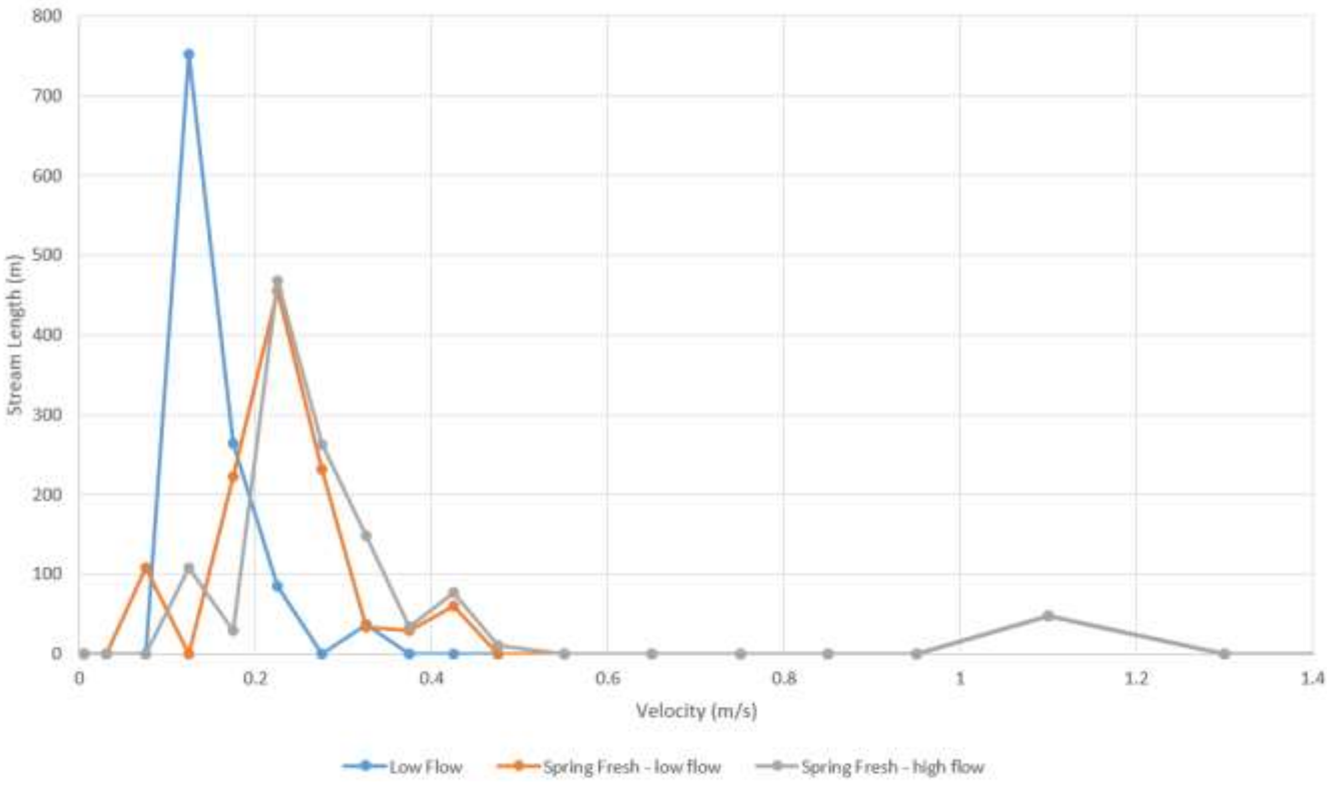

Figure 11.3 Mundic Northern Outlet velocity profiles by stream length, from Table 11.3

In Tanyaca Creek, operating at raised Lock 4 weir pool level and/or at increasing river flows results in an increase in tailwater level at the Tanyaca–Rumpagunyah junction, and results in an overall reduction in velocity magnitude in Tanyaca Creek for a given Tanyaca regulator flow. For instance, at a river flow of 5000 ML/d (refer to Table 11.4 and Figure 11.4), the velocities are predominantly within the 0.20–0.30 m/s category under normal Lock 4 levels at flows of 400 to 800 ML/d, whereas at raised Lock 4 level (14.2 m AHD) the velocities are predominantly in the 0.10–0.20 m/s category. Similarly, at a river flow of 30 000 ML/d and normal Lock 4 pool level (refer to Table 11.6 and Figure 11.6), the velocities are predominantly within the 0.10–0.20 m/s category.

Additionally, for a given river flow and Lock 4 pool level, velocities in Tanyaca Creek increase as flow through the regulator increase. For example, at a river flow of 15 000 ML/d and Lock 4 at 13.2 m AHD (refer to Table 11.5 and Figure 11.5), approximately 28% of the reach is present at velocities in the 0.15–0.20 m/s range at a Tanyaca regulator flow of 400 ML/d, and approximately 22% is present at 0.20–0.30 m/s. Raising the regulator flow to 600 ML/d results in approximately 45% of the reach present in the range 0.20–0.30 m/s, while raising the flow to 800 ML/d results in approximately 38% of the reach length in 0.20–0.30 m/s, and 16% in the 0.30–0.40 m/s range.

Overall, the results indicate velocity distributions can be varied by altering regulator flows and tailwater levels, either by manipulating Lock 4 operating heights or by operating at different River Murray flows.

Table 11.4 Tanyaca Creek velocity profiles by percent stream length, river flow 5000 ML/d

Description	Low outflow – low tailwater		Mod outflow – low tailwater		Max outflow – low tailwater		Low outflow – raised Lock 4		Mod outflow – raised Lock 4		Max outflow – raised Lock 4	
River flow	5000 ML/d		5000 ML/d		5000 ML/d		5000 ML/d		5000 ML/d		5000 ML/d	
Lock 4 U/S	13.2 m AHD		13.2 m AHD		13.2 m AHD		14.2 m AHD		14.2 m AHD		14.2 m AHD	
Stream flow	400 ML/d		600 ML/d		800 ML/d		400 ML/d		600 ML/d		800 ML/d	
Mundic level (U/S regulator)	14.78 m AHD		14.79 m AHD		14.75 m AHD		14.78 m AHD		14.79 m AHD		14.75 m AHD	
Level D/S regulator	14.00 m AHD		14.13 m AHD		14.25 m AHD		14.27 m AHD		14.34 m AHD		14.40 m AHD	
Tailwater level (Rumpagunyah)	13.27 m AHD		13.30 m AHD		13.30 m AHD		14.21 m AHD		14.21 m AHD		14.21 m AHD	
Velocity range	Stream length											
(m/s)	m	%	m	%	m	%	m	%	m	%	m	%
<0.01	0	0	0	0	0	0	0	0	0	0	0	0
0.01-0.05	112	3	0	0	0	0	1131	31	184	5	0	0
0.05-0.10	1184	33	843	23	187	5	1559	43	1261	35	1131	31
0.10-0.15	174	5	474	13	833	23	699	19	1245	35	441	12
0.15-0.20	879	24	153	4	364	10	207	6	564	16	1204	34
0.20-0.25	747	21	1182	33	216	6	0	0	273	8	477	13
0.25-0.30	208	6	444	12	1097	31	0	0	69	2	238	7
0.30-0.35	116	3	208	6	399	11	0	0	0	0	103	3
0.35-0.40	47	1	82	2	161	4	0	0	0	0	0	0
0.40-0.45	127	4	82	2	129	4	0	0	0	0	0	0
0.45-0.50	0	0	82	2	34	1	0	0	0	0	0	0
0.50-0.60	0	0	45	1	129	4	0	0	0	0	0	0
0.60-0.70	0	0	0	0	45	1	0	0	0	0	0	0
>0.70	0	0	0	0	0	0	0	0	0	0	0	0
Total	3595	100	3595	100	3595	100	3595	100	3595	100	3595	100

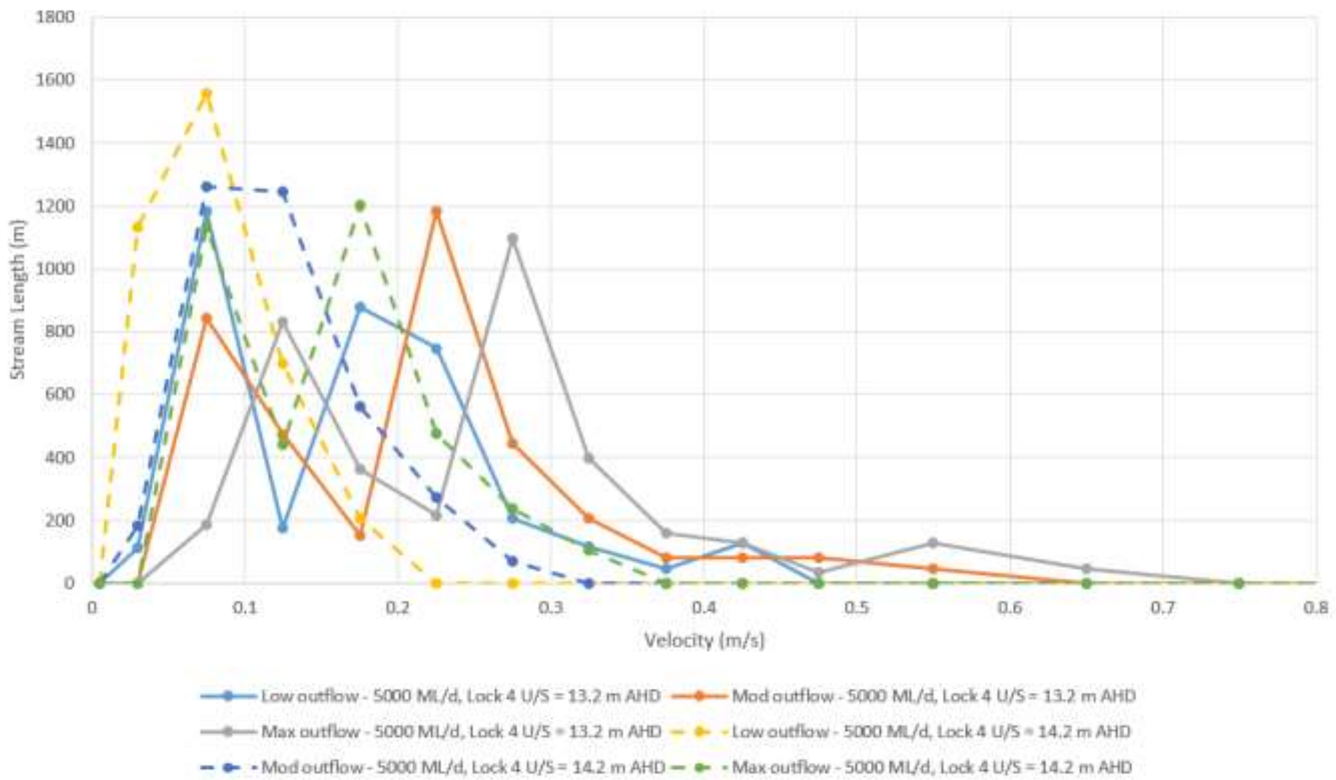

Figure 11.4 Tanyaca Creek velocity profiles by stream length, river flow 5000 ML/d, from Table 11.4

Table 11.5 Tanyaca Creek velocity profiles by percent stream length, river flow 15 000 ML/d

Description	Low outflow – mod tailwater		Mod outflow – mod tailwater		Max outflow – mod tailwater		Low outflow – raised Lock 4		Mod outflow – raised Lock 4		Max outflow – raised Lock 4	
River flow	15 000 ML/d		15 000 ML/d		15 000 ML/d		15 000 ML/d		15 000 ML/d		15 000 ML/d	
Lock 4 U/S	13.2 m AHD		13.2 m AHD		13.2 m AHD		14.2 m AHD		14.2 m AHD		14.2 m AHD	
Stream flow	400 ML/d		600 ML/d		800 ML/d		400 ML/d		600 ML/d		800 ML/d	
Mundic level (U/S regulator)	14.87 m AHD		14.82 m AHD		14.76 m AHD		14.87 m AHD		14.82 m AHD		14.76 m AHD	
Level D/S regulator	14.00 m AHD		14.13 m AHD		14.26 m AHD		14.37 m AHD		14.42 m AHD		14.48 m AHD	
Tailwater level (Rumpagunyah)	13.49 m AHD		13.50 m AHD		13.50 m AHD		14.32 m AHD		14.32 m AHD		14.32 m AHD	
Velocity range	Stream length											
(m/s)	m	%	m	%	m	%	m	%	m	%	m	%
<0.01	0	0	0	0	0	0	0	0	0	0	0	0
0.01-0.05	259	7	0	0	0	0	1091	30	148	4	0	0
0.05-0.10	1084	30	974	27	223	6	1690	47	1364	38	1135	32
0.10-0.15	269	7	390	11	859	24	745	21	1355	38	805	22
0.15-0.20	1013	28	200	6	356	10	69	2	556	15	972	27
0.20-0.25	611	17	1179	33	212	6	0	0	172	5	431	12
0.25-0.30	162	5	447	12	1140	32	0	0	0	0	218	6
0.30-0.35	116	3	161	4	354	10	0	0	0	0	34	1
0.35-0.40	80	2	82	2	208	6	0	0	0	0	0	0
0.40-0.45	0	0	82	2	82	2	0	0	0	0	0	0
0.45-0.50	0	0	80	2	82	2	0	0	0	0	0	0
0.50-0.60	0	0	0	0	80	2	0	0	0	0	0	0
>0.60	0	0	0	0	0	0	0	0	0	0	0	0
Total	3595	100	3595	100	3595	100	3595	100	3595	100	3595	100

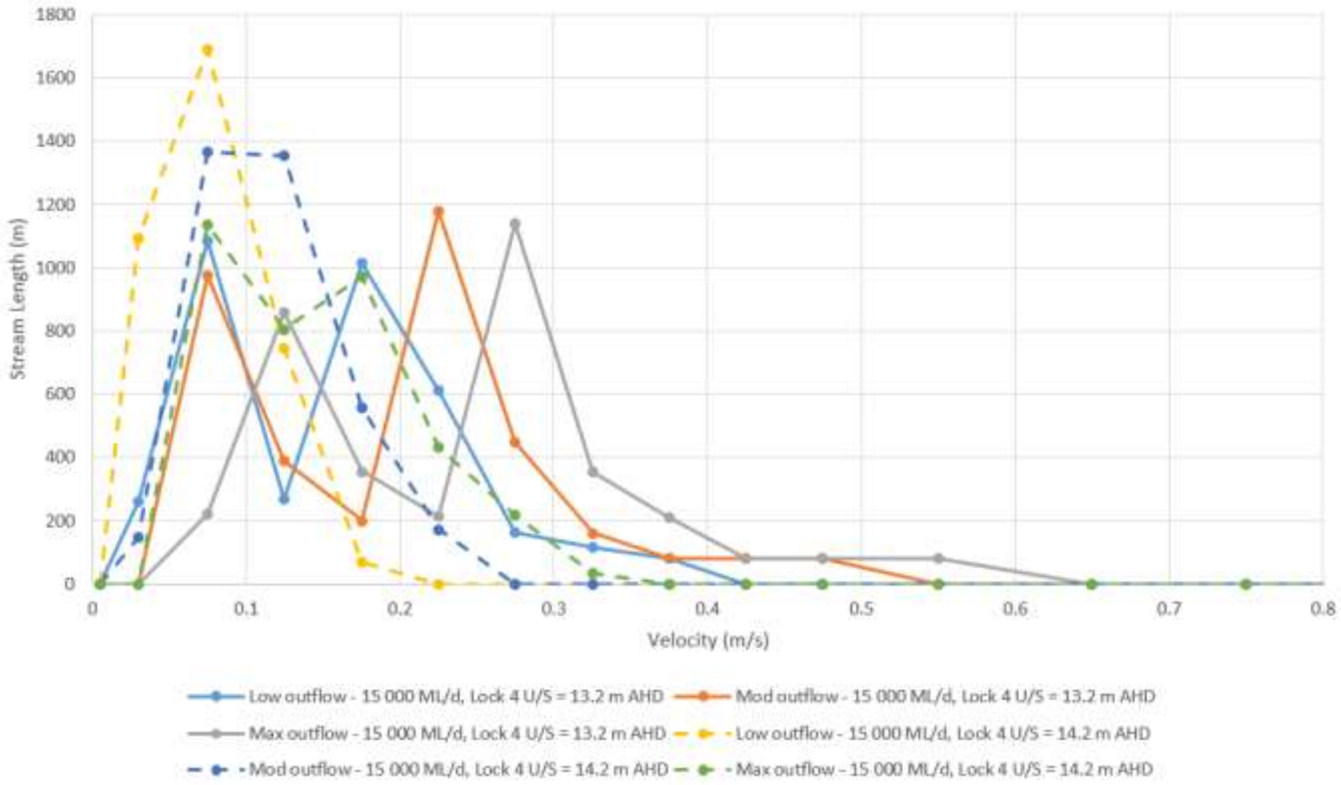

Figure 11.5 Tanyaca Creek velocity profiles by stream length, river flow 15 000 ML/d, from Table 11.5

Table 11.6 Tanyaca Creek velocity profiles by percent stream length, river flow 30 000 ML/d

Description	Low outflow – high tailwater		Mod outflow – high tailwater		Max outflow – high tailwater		Low outflow – raised Lock 4		Mod outflow – raised Lock 4		Max outflow – raised Lock 4	
River flow	30 000 ML/d		30 000 ML/d		30 000 ML/d		30 000 ML/d		30 000 ML/d		30 000 ML/d	
Lock 4 U/S	13.2 m AHD		13.2 m AHD		13.2 m AHD		14.2 m AHD		14.2 m AHD		14.2 m AHD	
Regulator flow	400 ML/d		600 ML/d		800 ML/d		400 ML/d		600 ML/d		800 ML/d	
Mundic level (U/S regulator)	14.87 m AHD		14.82 m AHD		14.77 m AHD		14.87 m AHD		14.82 m AHD		14.77 m AHD	
Level D/S regulator	14.17 m AHD		14.26 m AHD		14.34 m AHD		14.73 m AHD		14.75 m AHD		14.77 m AHD	
Tailwater level (Rumpagunyah)	14.04 m AHD		14.05 m AHD		14.05 m AHD		14.66 m AHD		14.66 m AHD		14.66 m AHD	
Velocity range	Stream length											
(m/s)	m	%	m	%	m	%	m	%	m	%	m	%
<0.01	0	0	0	0	0	0	0	0	0	0	0	0
0.01-0.05	126	4	39	1	0	0	462	13	173	5	0	0
0.05-0.10	893	25	309	9	156	4	1934	54	1467	41	579	16
0.10-0.15	2022	56	1509	42	812	23	176	5	826	23	1284	36
0.15-0.20	486	14	1261	35	1250	35	505	14	213	6	712	20
0.20-0.25	69	2	338	9	899	25	351	10	660	18	677	19
0.25-0.30	0	0	103	3	261	7	167	5	255	7	219	6
0.30-0.35	0	0	34	1	149	4	0	0	0	0	123	3
0.35-0.40	0	0	0	0	69	2	0	0	0	0	0	0
>0.40	0	0	0	0	0	0	0	0	0	0	0	0
Total	3595	100	3595	100	3595	100	3595	100	3595	100	3595	100

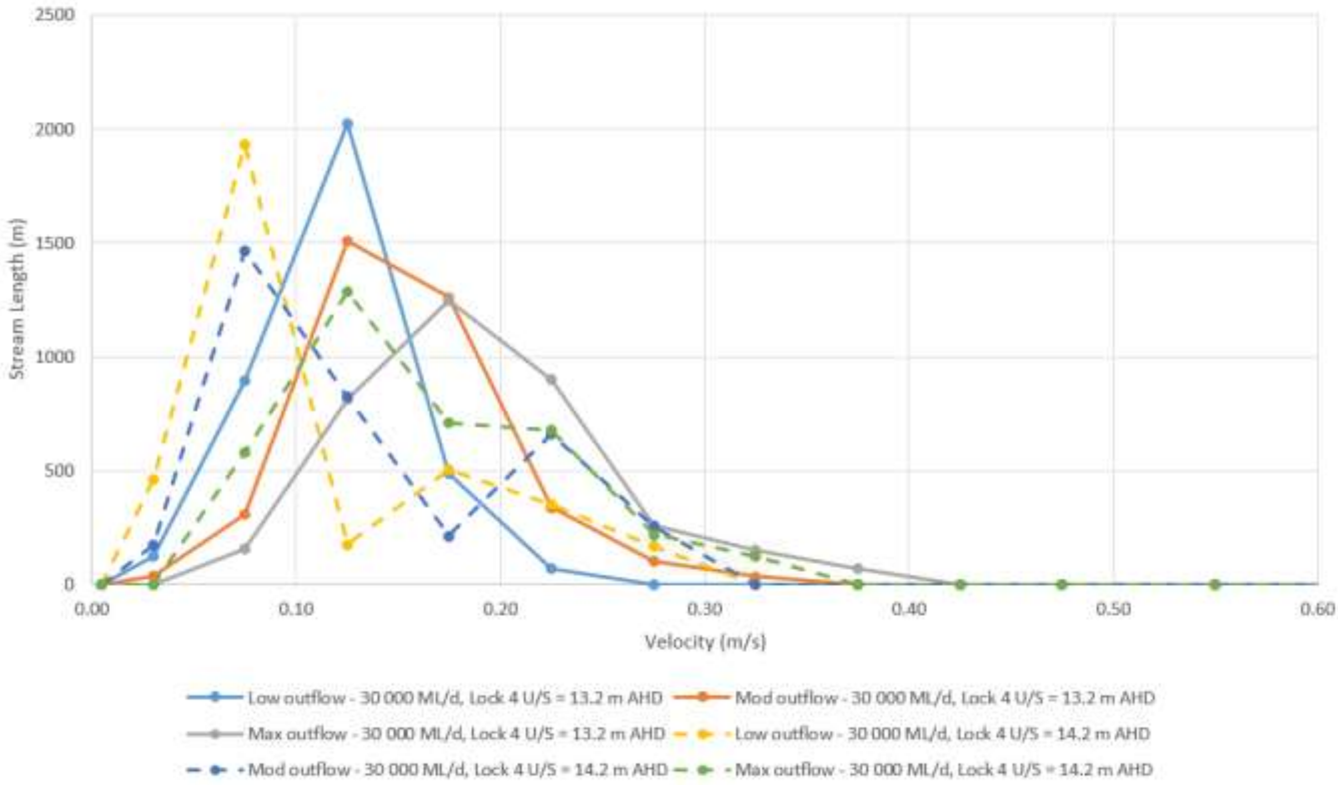

Figure 11.6 Tanyaca Creek velocity profiles by stream length, river flow 30 000 ML/d, from Table 11.6

12 Conclusion

Hydraulic results from the scenarios considered include:

1. Moving the regulator alignment downstream on the Pike River to the western regulator location resulted in a greater volume detained in the reach between the eastern and western regulator locations under normal in-channel operating conditions, compared to the eastern regulator alternative. This resulted in reduced in-channel velocities in this reach under the western regulator option for given flow conditions, although velocities upstream and downstream of this reach remained identical between the alternatives. Note that the in-channel hydraulic conditions of these scenarios compared favourably to existing floodplain conditions with respect to the substantially greater inflows achievable under the upgraded system configuration, while the shift in alignment also provides a greater inundation capacity during managed inundation of the floodplain compared to the eastern Pike regulator alternative.
2. The location of the regulator on Pike River did not influence flow in Rumpagunyah Creek. However, additional flows into the floodplain and through Tanyaca Creek via upgraded structures results in Rumpagunyah acting predominantly as an outlet from the floodplain at river flows of approximately 10 000 ML/d, seemingly independent of flow split between the environmental regulators (note that current conditions at typical river flows see Rumpagunyah act as a minor inlet to the Lower Pike under low QSA and major inlet under higher QSA).
3. Conversely, increasing Lock 4 weir pool level by 1 m (to 14.2 m AHD) at elevated River Murray flow (30 000 ML/d) results in elevated river levels in the Lock 4 to 5 reach, resulting in Rumpagunyah acting as an inlet to the floodplain. This manipulation of river level also allows Banks B, B2 and C to be used as additional floodplain inlets at in-stream flow conditions. These modelled results indicate that additional dilution flows to the floodplain in the Lower Pike River are possible by manipulating water levels in the Lock 4 to 5 reach, if required for operational purposes.
4. Comparing Scenarios 2 and 3, regulating structures are likely to be required on the outlets of Mundic creek if inundating areas of Mundic Floodplain independent from the operation of the Pike River regulator is a desirable management option.
5. Maximum overall turnover rates of approximately 25% were encountered only when flow was restricted to the regular channels (i.e. no inundation) at maximum inflow (1200 ML/d) to the floodplain (Scenario 1a, with 200 ML/d loss assumed for evaporation and irrigator extractions). Overall turnover rates were modelled to fall to a minimum of approximately 4% at maximum inundation height of a managed inundation event, with velocities within the impounded area maintained predominantly in the very low velocity category of up to 0.01 m/s.
6. Volumes in the Pike River side of the floodplain are approximately double that of the Mundic–Tanyaca Creek side during a managed inundation event of 16.4 m AHD. This suggests that flows should be mainly concentrated towards the Pike River during an inundation event for water quality considerations, while also maintaining local land holder supply flows, although consideration will also need to be given to ensuring that faster flowing habitat is maintained in the reach downstream of Tanyaca Creek regulator.
7. The regulating structures at Tanyaca Creek and Pike River do not appear to directly prevent natural inflows to the floodplain from the River Murray during a natural flood event (modelled on the 1981 flood event), with only outflows through these regulators modelled over the hydrograph considered. However, inundation of an area to the north-east of the Pike River regulator was prevented by the blocking alignment between River Murray flows of between 50 000 and 80 000 ML/d (under the 1981 flood event hydrograph), suggesting that smaller ancillary structures may be required in the blocking alignment adjacent to this area to allow inundation during natural flood events.
8. A dynamic simulation of a managed inundation event was modelled for the Alternative 2 alignment, providing operational data to inform further development of an operating strategy.

9. Manipulation of river level between Locks 4 and 5, by raising Lock 4 weir pool level to 14.2 m AHD in combination with a flow of 30 000 ML/d above Lock 5, has been shown to create further inflow to the floodplain below the blocking bank for dilution and habitat. Additional inflows above the blocking bank through Banks B, B2 and C is achievable at typical Mundic Creek water levels, but unlikely when undertaking a managed inundation event.
10. Velocity distributions in the various inlet and outlet creeks to Mundic Creek are shown to be sensitive to manipulation of tailwater levels and/or regulator flows within each relevant creek. Velocities in Margaret Dowling Creek and Deep Creek are modelled to generally decrease when raising the downstream Mundic Creek level, or by operating at reduced inflows from above Lock 5. Velocities in Mundic northern outlet are modelled to generally increase when raising Mundic level and/or flow through the creek by manipulating the proposed Mundic northern outlet regulator. Velocities in Tanyaca Creek are modelled to increase when increasing flows through the Tanyaca regulator and/or operating at lower River Murray flows, which creates lower tailwater levels in Rumpagunyah Creek.

13 References

Macky, G, Bloss, C, 2012, *Riverine Recovery Weir Pool Hydraulic Modelling*, DEWNR Technical Note, Government of South Australia, through Department of Environment, Water and Natural Resources, Adelaide

McCullough DP, 2013, *Riverine Recovery Pike Floodplain Hydraulic Modelling 2012–13*, DEWNR Technical Note, Government of South Australia, through Department of Environment, Water and Natural Resources, Berri

McCullough DP, 2016, *SARFIIP – Preliminary Investigations – Pike Floodplain Hydraulic Model Setup and Review,* DEWNR Technical Note 2016/04, Government of South Australia, through Department of Environment, Water and Natural Resources, Adelaide

McCullough DP, Montazeri, M, Gibbs, M, 2016, *SARFIIP – Katarapko Floodplain hydraulic modelling – Managed inundation options assessment scenarios – 2014–15,* DEWNR Technical note 2016/07, Government of South Australia, through the Department of Environment, Water and Natural Resources, Adelaide

URS, 2010, *Conceptual Designs for Surface Water Management Infrastructure for the Pike Floodplain*, URS Australia, Report prepared for South Australian Murray-Darling Basin Natural Resources Management Board, Berri

Water Technology, 2012, *Pike River Structures – Operational Scenario Investigations*, Report 2064–01_L01v04, Prepared for Department for Water, Berri

Appendix A – Velocity profiles by area of inundation

Table A.1 Velocity profiles for Scenarios 1a to d based on area of inundation upstream of blocking alignment. Includes comparison with equivalent flow regime under existing floodplain conditions.

		Inundated area of creek by scenario (ha)					
Velocity category	**Velocity range (m/s)**	**1a (Alt 1 location)**	**1b (Alt 3 location)**	**1c (Alt 1 location)**	**1d (Alt 3 location)**	**Existing conditions (Alt 1 location)**	**Existing conditions (Alt 3 location)**
Very slow	0-0.05	265	316	267	311	352	409
Slow	0.05-0.10	59	62	68	77	35	39
Slow-moderate	0.10-0.15	13	14	17	20	10	12
Moderate	0.15-0.20	3	3	6	6	3	3
Moderate-fast	0.20-0.25	1	1	3	3	1	1
Fast	>0.25	4	4	4	5	0	0
Total		345	401	365	421	402	465

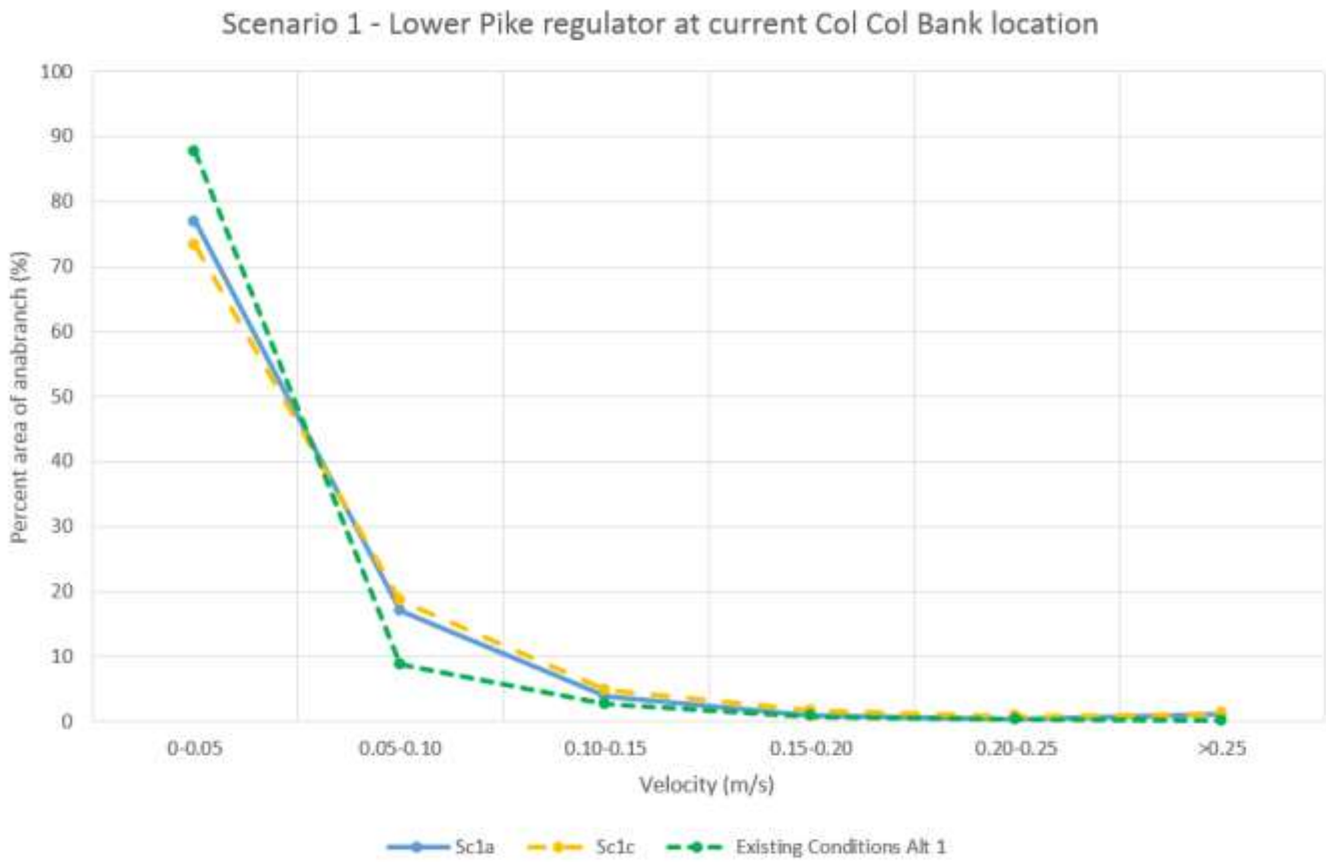

Figure A.1 Velocity profiles by percent of anabranch for Scenarios 1a and c (i.e. Pike regulator at current Col Col location) compared to existing floodplain conditions at equivalent flow regime

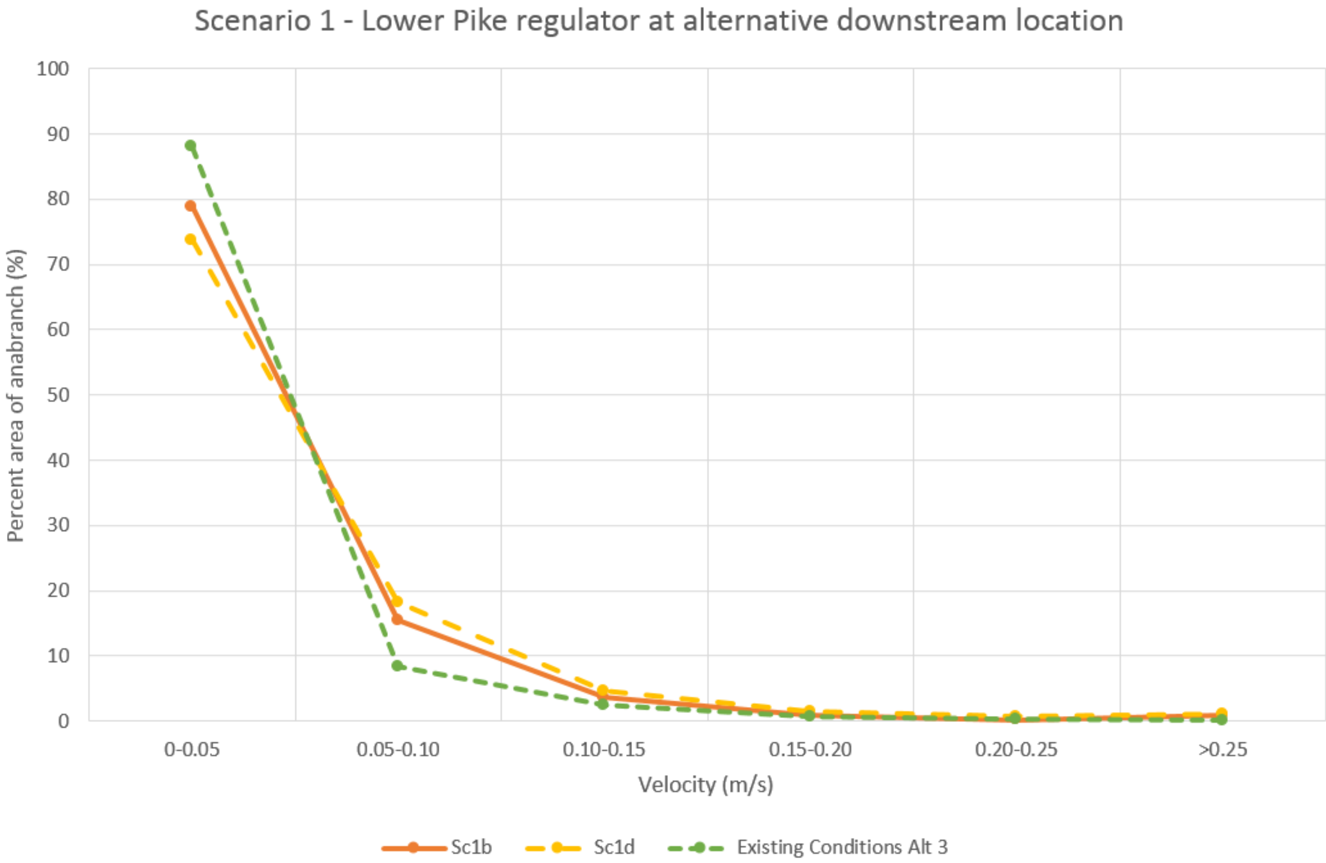

Figure A.2 Velocity profiles by percent of anabranch for Scenarios 1b and d (i.e. Pike regulator at Alternative 3 downstream location) compared to existing floodplain conditions with an equivalent flow regime

Table A.2 Velocity profiles for Scenarios 2a to c based on area of inundation upstream of blocking alignment. Includes comparison with equivalent flow regime under existing floodplain conditions.

		Inundated area of creek by scenario (ha)			
Velocity category	**Velocity range (m/s)**	**2a**	**2b**	**2c**	**Existing conditions**
Very slow	0-0.05	336	315	309	409
Slow	0.05-0.10	51	97	69	39
Slow-moderate	0.10-0.15	9	25	16	12
Moderate	0.15-0.20	2	10	4	3
Moderate-fast	0.20-0.25	1	4	1	1
Fast	>0.25	3	6	4	0
Total		402	457	404	465

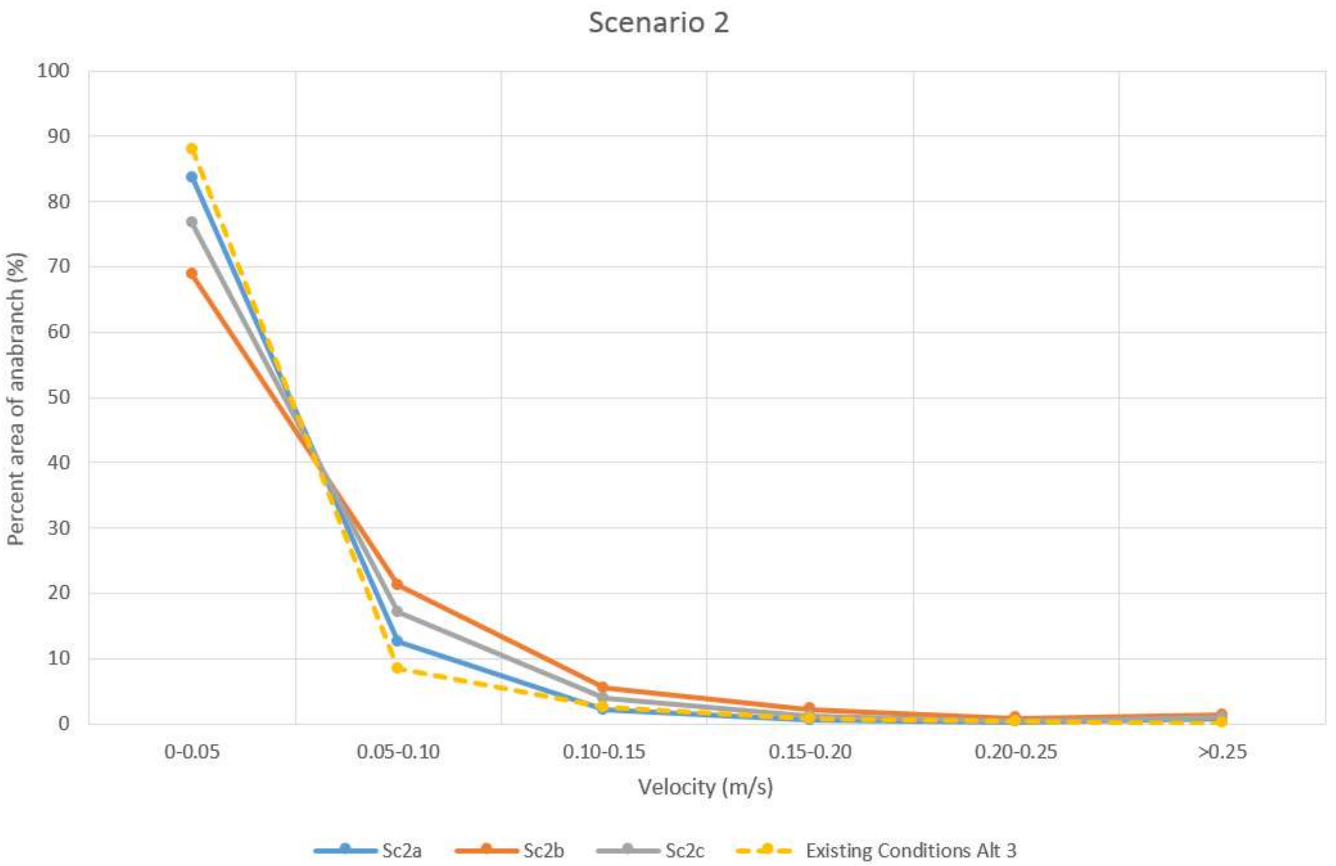

Figure A.3 Velocity profiles by percent of anabranch for Scenarios 2a to c compared to existing floodplain conditions with an equivalent flow regime

Table A.3 Velocity profiles for Scenarios 3a to b based on area of inundation upstream of blocking alignment. Includes comparison with equivalent flow regime under existing floodplain conditions

Velocity category	Velocity range (m/s)	Inundated area of creek by scenario (ha)		
		3a	3b	Existing conditions
Very slow	0-0.05	552	476	409
Slow	0.05-0.10	43	104	39
Slow-moderate	0.10-0.15	7	22	12
Moderate	0.15-0.20	3	8	3
Moderate-fast	0.20-0.25	1	4	1
Fast	>0.25	2	6	0
Total		608	620	465

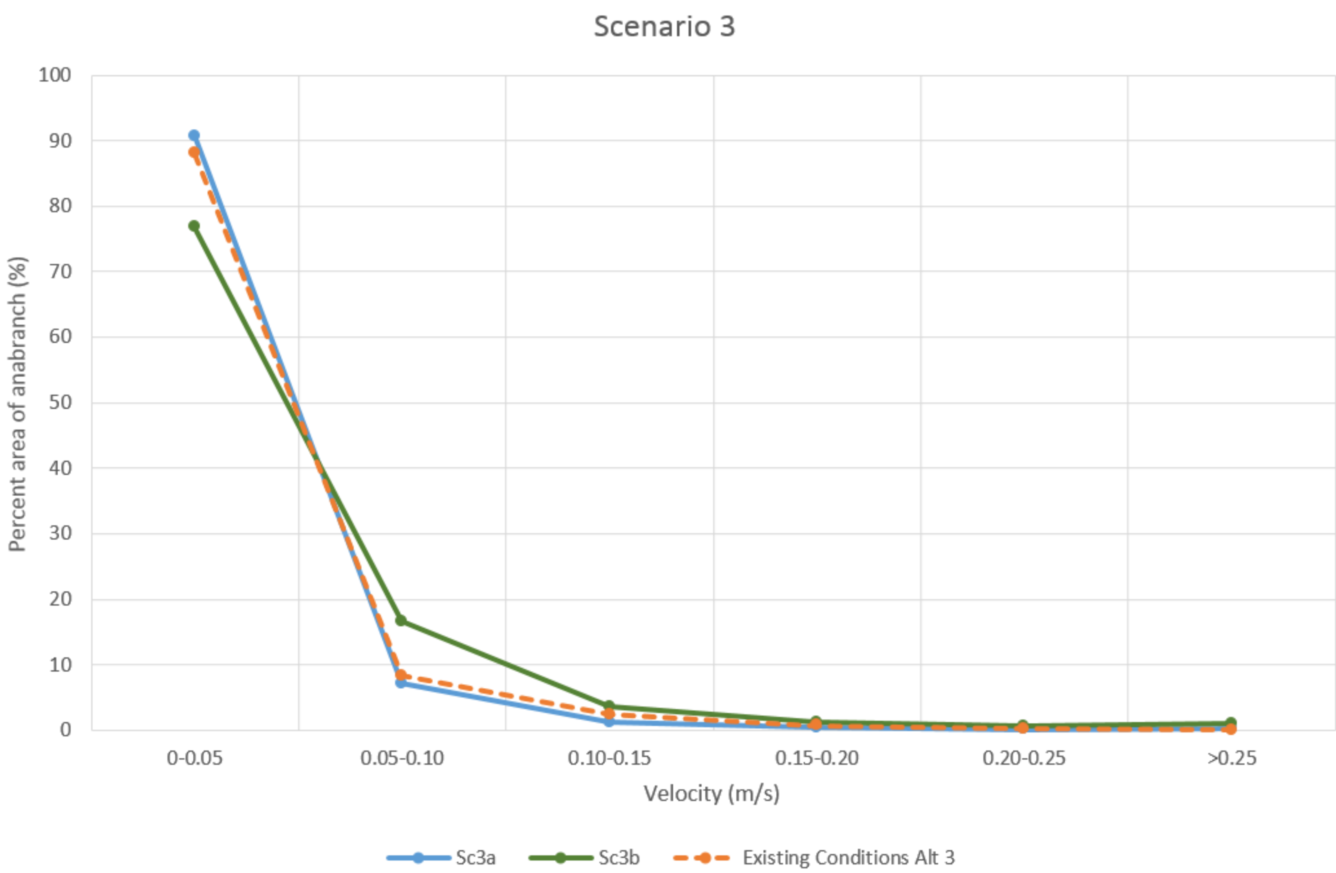

Figure A.4 Velocity profiles by percent of anabranch for Scenarios 3a and b compared to existing floodplain conditions with an equivalent flow regime

Table A.4 Velocity profiles for Scenarios 4a to b based on area of inundation upstream of blocking alignment. Includes comparison with equivalent flow regime under existing floodplain conditions (i.e. 85 000 ML/d flow upstream of Lock 5).

		Inundated area of creek by scenario (ha)		
Velocity category	**Velocity range (m/s)**	**4a**	**4b**	**Equivalent flow conditions (85 000 ML/d)**
Very slow	0-0.05	2220	2222	2077
Slow	0.05-0.10	390	390	297
Slow-moderate	0.10-0.15	101	101	61
Moderate	0.15-0.20	22	22	20
Moderate-fast	0.20-0.25	5	5	2
Fast	>0.25	6	6	2
Total		2745	2746	2460

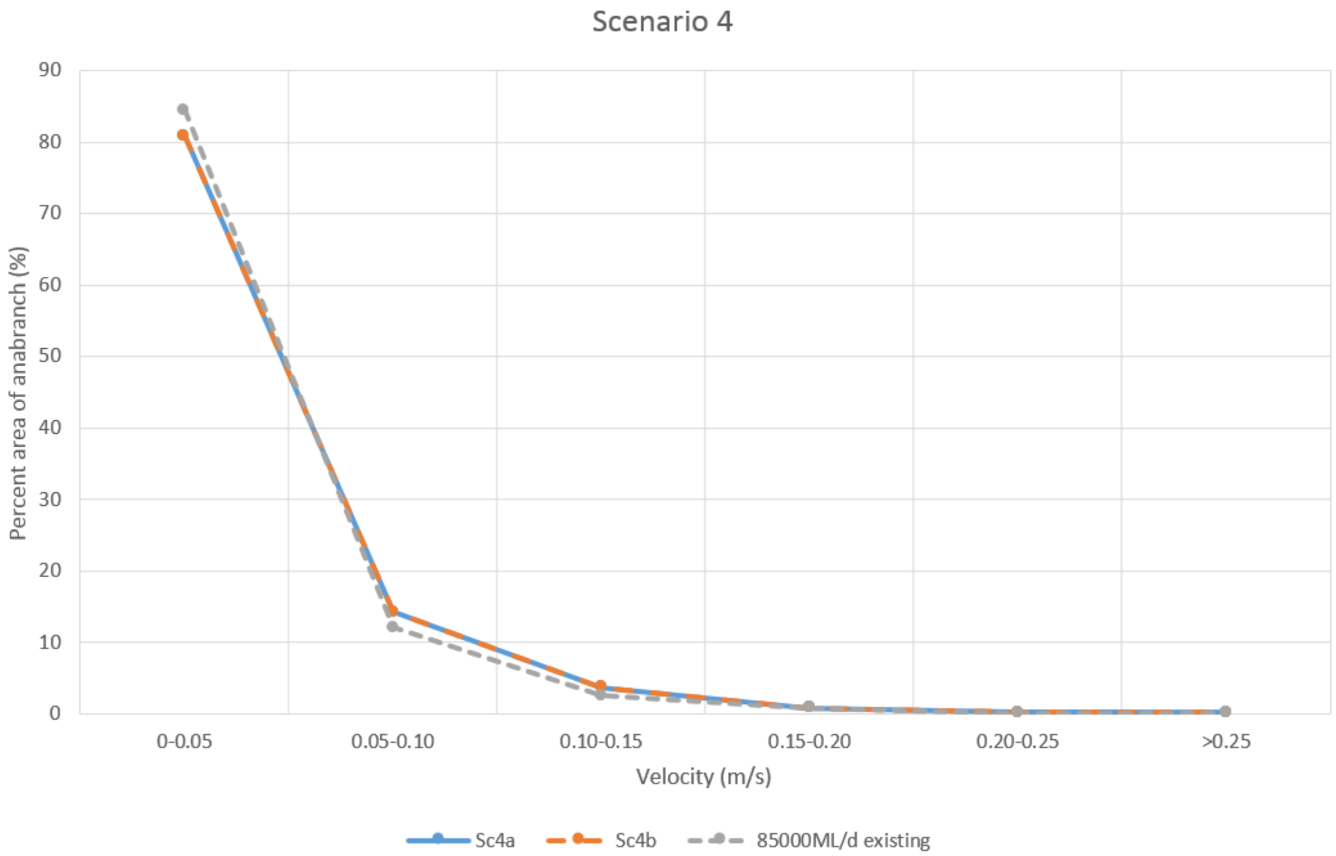

Figure A.5 Velocity profiles by percent of anabranch for Scenarios 4a and b compared to existing floodplain conditions with an equivalent flow regime (i.e. 85 000 ML/d flow upstream of Lock 5)

Table A.5 Velocity profiles for Scenarios 5 (Tanyaca flow at 100, 400 and 800 ML/d) based on area of inundation upstream of blocking alignment. Includes comparison with equivalent flow regime under existing floodplain conditions (i.e. 75 000 ML/d flow upstream of Lock 5).

		Inundated Area of Creek by Scenario (ha)			
Velocity category	Velocity range (m/s)	5–100 ML/d Tanyaca flow	5–400 ML/d Tanyaca flow	5–800 ML/d Tanyaca flow	Equivalent flow conditions (75 000 ML/d)
Very slow	0-0.05	2137	2151	2150	1879
Slow	0.05-0.10	31	13	6	187
Slow-moderate	0.10-0.15	2	1	1	50
Moderate	0.15-0.20	2	2	2	13
Moderate-fast	0.20-0.25	1	1	1	5
Fast	>0.25	2	2	2	3
Total		2174	2170	2162	2137

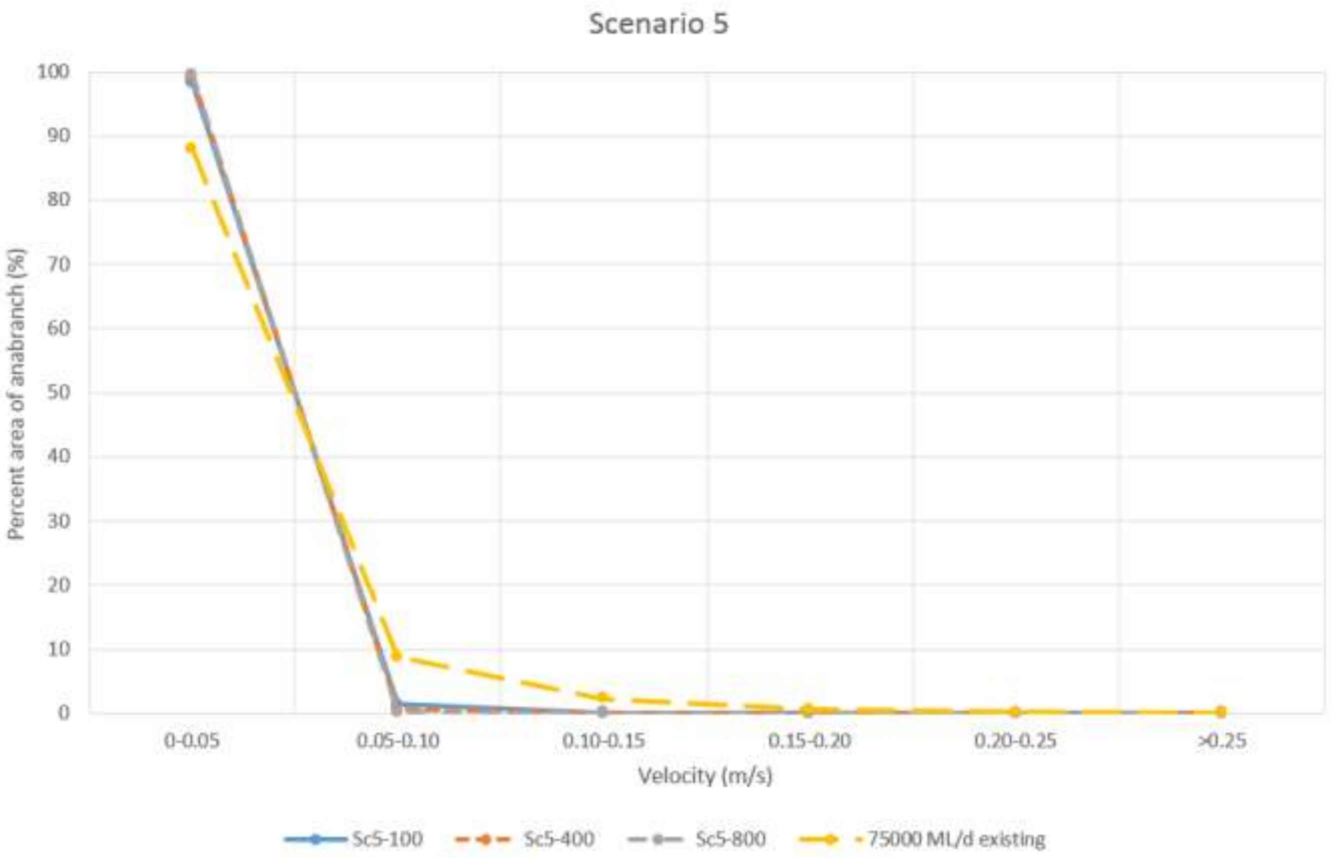

Figure A.6 Velocity profiles by percent of anabranch for Scenario 5 (Tanyaca flow at 100, 400 and 800 ML/d) compared to existing floodplain conditions with an equivalent flow regime (i.e. 75 000 ML/d flow upstream of Lock 5)

Table A.6 Velocity profiles for Scenario 6 based on area of inundation upstream of blocking alignment, referenced to modelled hydrograph date and corresponding river flow

		Inundated area of creek by scenario (ha)				
Velocity category	**Velocity range (m/s)**	**10/07/1981 16 380 ML/d**	**20/07/1981 24 250 ML/d**	**30/07/1981 27 850 ML/d**	**9/08/1981 33 280 ML/d**	**19/08/1981 36 470 ML/d**
Very slow	0-0.05	293	286	294	286	278
Slow	0.05-0.10	77	82	76	82	113
Slow-moderate	0.10-0.15	25	26	24	27	32
Moderate	0.15-0.20	6	7	7	7	11
Moderate-fast	0.20-0.25	2	3	2	4	5
Fast	>0.25	5	5	5	5	6
Total		408	408	407	411	445
		Inundated area of creek by scenario (ha)				
Velocity category	**Velocity range (m/s)**	**29/08/1981 51 650 ML/d**	**8/09/1981 71 800 ML/d**	**18/09/1981 87 450 ML/d**	**28/09/1981 96 850 ML/d**	**8/10/1981 100 220 ML/d**
Very slow	0-0.05	615	1086	1701	2025	2059
Slow	0.05-0.10	153	131	158	226	299
Slow-moderate	0.10-0.15	38	41	38	51	91
Moderate	0.15-0.20	20	19	21	15	23
Moderate-fast	0.20-0.25	7	6	5	5	6
Fast	>0.25	8	5	4	5	11
Total		841	1288	1927	2328	2489

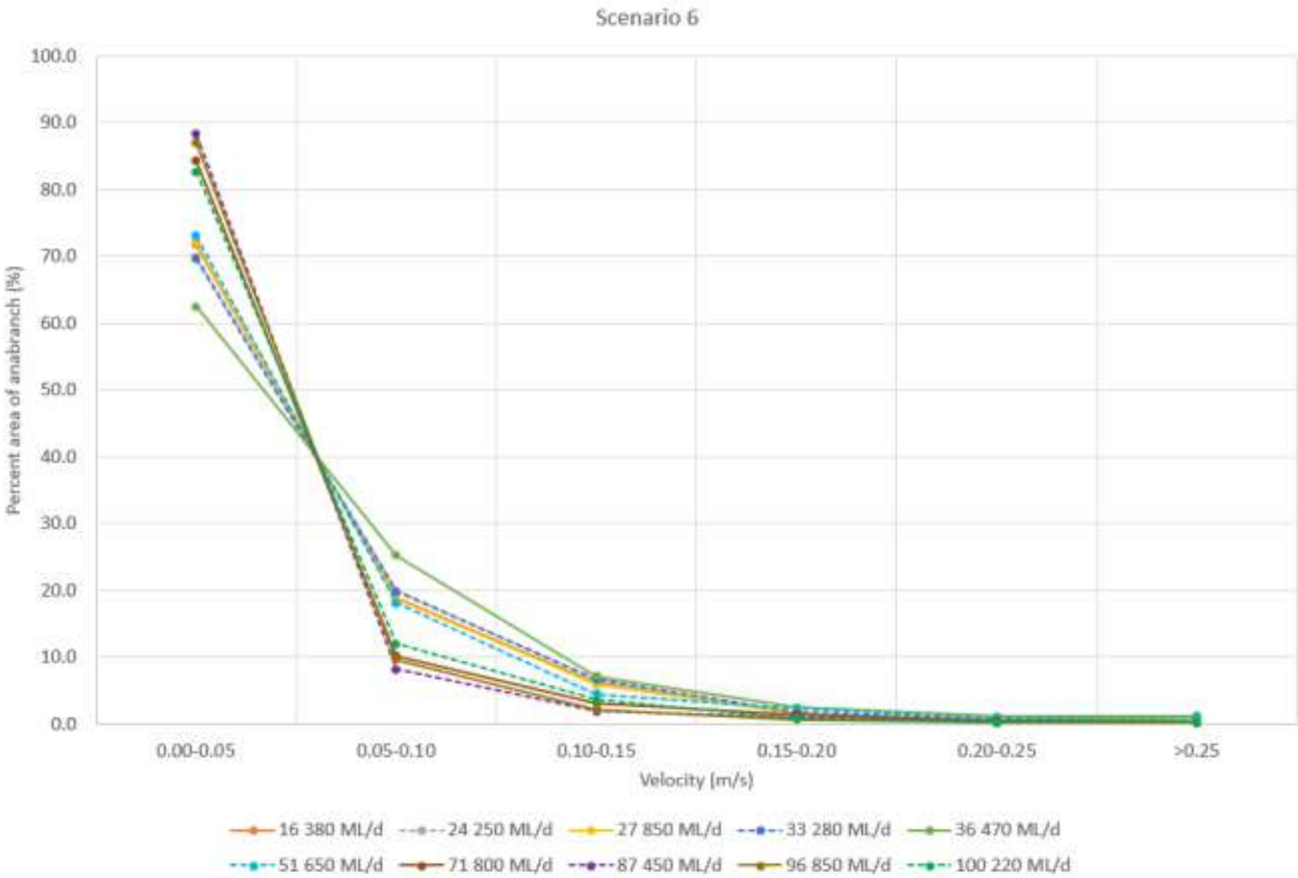

Figure A.7 Velocity profiles by percent of anabranch for Scenario 6 for various River Murray flows, corresponding to 10-day increments of the hydrograph

Table A.7 Velocity profiles for Scenario 7 based on area of inundation upstream of blocking alignment, referenced to day of modelled inundation event and water level at Pike regulator

		Inundated area of creek by scenario (ha)				
Velocity category	**Velocity range (m/s)**	**Day 10 15.59 m AHD**	**Day 20 16.10 m AHD**	**Day 30 16.45 m AHD**	**Day 40 16.40 m AHD**	**Day 50 16.40 m AHD**
Very Slow	0-0.05	1135	1701	2118	2056	2053
Slow	0.05-0.10	26	19	11	30	25
Slow-Moderate	0.10-0.15	5	6	5	4	5
Moderate	0.15-0.20	3	5	4	4	3
Moderate-fast	0.20-0.25	2	3	2	3	3
Fast	>0.25	6	6	4	5	7
Total		1177	1738	2143	2101	2098
		Inundated area of creek by scenario (ha)				
Velocity category	**Velocity range (m/s)**	**Day 60 16.34 m AHD**	**Day 70 16.04 m AHD**	**Day 80 15.66 m AHD**	**Day 90 15.12 m AHD**	**Day 100 13.64 m AHD**
Very slow	0-0.05	2008	1737	1421	991	586
Slow	0.05-0.10	29	30	38	56	116
Slow-moderate	0.10-0.15	6	5	5	6	21
Moderate	0.15-0.20	3	3	3	3	5
Moderate-fast	0.20-0.25	3	3	3	3	4
Fast	>0.25	6	7	7	8	11
Total		2054	1785	1477	1066	742

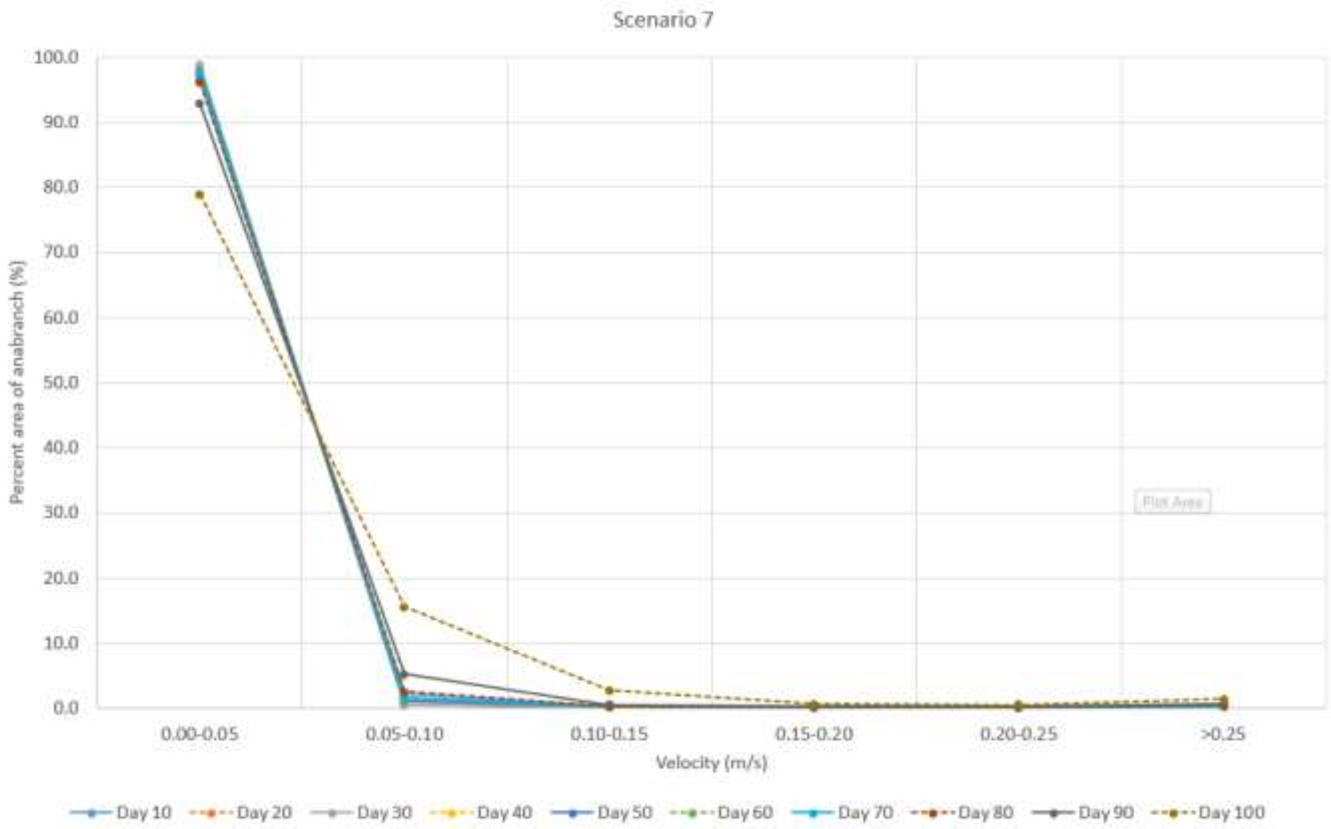

Figure A.8 Velocity profiles by percent of anabranch for Scenario 7, shown in 10-day increments over the duration of the modelled managed inundation event

Appendix B – Tabulated data from Scenario 6

Table B.1 Flows (Q), upstream and downstream water levels (WL), and head difference across Tanyaca and Pike regulators during rising limb of 1981 hydrograph, with corresponding River Murray flow upstream Lock 5. Direction of flow indicated by positive (out of floodplain) and negative (into floodplain) Q values.

		Tanyaca				Lower Pike			
Date	Q L5 U/S (ML/d)	Q (ML/d)	WL U/S (m AHD)	WL D/S (m AHD)	ΔH (m)	Q (ML/d)	WL U/S (m AHD)	WL D/S (m AHD)	ΔH (m)
1/07/1981	9410	881	14.78	14.20	0.58	335	14.35	13.35	1.00
2/07/1981	11140	982	14.78	14.25	0.53	518	14.35	13.44	0.91
3/07/1981	12720	1013	14.78	14.26	0.52	531	14.35	13.47	0.88
4/07/1981	13320	906	14.78	14.22	0.56	524	14.35	13.49	0.86
5/07/1981	13500	882	14.78	14.20	0.58	517	14.35	13.48	0.87
6/07/1981	14260	889	14.78	14.21	0.57	513	14.35	13.49	0.86
7/07/1981	15520	912	14.78	14.22	0.56	519	14.35	13.51	0.84
8/07/1981	16600	928	14.78	14.23	0.55	517	14.35	13.54	0.81
9/07/1981	16810	941	14.78	14.23	0.55	522	14.35	13.56	0.79
10/07/1981	17770	902	14.78	14.22	0.56	519	14.35	13.58	0.77
11/07/1981	18920	924	14.78	14.23	0.55	516	14.35	13.58	0.77
12/07/1981	20040	900	14.78	14.22	0.56	517	14.35	13.63	0.72
13/07/1981	20340	924	14.78	14.23	0.55	518	14.35	13.65	0.70
14/07/1981	20940	902	14.78	14.22	0.56	517	14.35	13.67	0.68
15/07/1981	21780	893	14.78	14.22	0.56	518	14.35	13.69	0.66
16/07/1981	22580	895	14.78	14.23	0.55	516	14.35	13.71	0.64
17/07/1981	23190	944	14.78	14.25	0.53	523	14.35	13.73	0.62
18/07/1981	23980	938	14.78	14.25	0.53	521	14.35	13.76	0.59
19/07/1981	25080	953	14.78	14.26	0.52	524	14.35	13.78	0.57
20/07/1981	26030	959	14.78	14.27	0.51	527	14.35	13.82	0.53
21/07/1981	26630	959	14.78	14.28	0.50	525	14.35	13.86	0.49
22/07/1981	27170	940	14.78	14.29	0.49	522	14.35	13.89	0.46
23/07/1981	27690	894	14.78	14.28	0.50	519	14.35	13.90	0.45
24/07/1981	27890	924	14.78	14.28	0.50	518	14.35	13.89	0.46
25/07/1981	28070	936	14.78	14.30	0.48	519	14.35	13.92	0.43
26/07/1981	28340	885	14.78	14.29	0.49	516	14.35	13.93	0.42
27/07/1981	27150	864	14.78	14.26	0.52	516	14.35	13.90	0.45
28/07/1981	28350	881	14.78	14.26	0.52	516	14.35	13.87	0.48
29/07/1981	29200	876	14.78	14.28	0.50	517	14.35	13.92	0.43
30/07/1981	29400	883	14.78	14.29	0.49	517	14.35	13.95	0.40
31/07/1981	29650	946	14.78	14.32	0.46	520	14.35	13.96	0.39
1/08/1981	30050	910	14.78	14.33	0.45	519	14.35	14.01	0.34
2/08/1981	30450	898	14.78	14.33	0.45	518	14.35	14.01	0.34
3/08/1981	31200	883	14.78	14.34	0.44	518	14.35	14.04	0.31
4/08/1981	32000	809	14.77	14.33	0.44	506	14.35	14.07	0.28
5/08/1981	32500	740	14.77	14.33	0.44	504	14.35	14.08	0.27
6/08/1981	33150	940	14.78	14.42	0.36	512	14.35	14.12	0.23
7/08/1981	34000	970	14.78	14.43	0.35	521	14.35	14.12	0.23
8/08/1981	34550	1113	14.79	14.49	0.30	533	14.35	14.16	0.19
9/08/1981	34850	1178	14.80	14.52	0.28	544	14.35	14.18	0.17
10/08/1981	35950	1290	14.80	14.57	0.23	556	14.35	14.21	0.14
11/08/1981	39000	1426	14.84	14.66	0.18	585	14.35	14.29	0.06
12/08/1981	41800	1490	14.92	14.74	0.18	553	14.39	14.37	0.02

Date	Q L5 U/S (ML/d)	Tanyaca Q (ML/d)	WL U/S (m AHD)	WL D/S (m AHD)	ΔH (m)	Lower Pike Q (ML/d)	WL U/S (m AHD)	WL D/S (m AHD)	ΔH (m)
13/08/1981	42150	1549	14.98	14.81	0.17	662	14.47	14.45	0.02
14/08/1981	40300	1567	14.99	14.81	0.18	839	14.48	14.46	0.02
15/08/1981	38650	1531	14.95	14.78	0.17	844	14.45	14.42	0.03
16/08/1981	38600	1489	14.91	14.73	0.18	772	14.40	14.37	0.03
17/08/1981	38500	1473	14.90	14.73	0.17	701	14.39	14.37	0.02
18/08/1981	37900	1462	14.90	14.72	0.18	708	14.38	14.36	0.02
19/08/1981	37400	1440	14.87	14.70	0.17	709	14.36	14.34	0.02
20/08/1981	37550	1429	14.85	14.68	0.17	647	14.35	14.31	0.04
21/08/1981	38100	1426	14.86	14.68	0.18	635	14.35	14.32	0.03
22/08/1981	38750	1439	14.87	14.69	0.18	647	14.35	14.32	0.03
23/08/1981	39550	1457	14.88	14.71	0.17	641	14.36	14.34	0.02
24/08/1981	40500	1479	14.91	14.73	0.18	651	14.38	14.36	0.02
25/08/1981	42050	1497	14.95	14.78	0.17	635	14.43	14.41	0.02
26/08/1981	45850	1537	15.00	14.83	0.17	633	14.50	14.48	0.02
27/08/1981	49700	1631	15.11	14.94	0.17	649	14.61	14.59	0.02
28/08/1981	51550	1823	15.48	15.33	0.15	259	15.03	15.02	0.01
29/08/1981	53050	2010	15.55	15.38	0.17	1242	15.14	15.09	0.05
30/08/1981	54800	2039	15.57	15.40	0.17	1393	15.17	15.12	0.05
31/08/1981	57350	2072	15.59	15.41	0.18	1480	15.20	15.13	0.07
1/09/1981	59700	2049	15.58	15.40	0.18	1522	15.20	15.13	0.07
2/09/1981	60600	2032	15.60	15.44	0.16	1387	15.23	15.17	0.06
3/09/1981	61750	2033	15.64	15.47	0.17	1375	15.27	15.22	0.05
4/09/1981	63950	2033	15.67	15.52	0.15	1310	15.32	15.27	0.05
5/09/1981	66350	2057	15.73	15.57	0.16	1301	15.38	15.34	0.04
6/09/1981	68800	2089	15.79	15.64	0.15	1370	15.46	15.41	0.05
7/09/1981	70950	2121	15.86	15.71	0.15	1421	15.53	15.48	0.05
8/09/1981	72850	2062	15.93	15.79	0.14	1402	15.62	15.57	0.05
9/09/1981	74750	2024	15.98	15.86	0.12	1528	15.69	15.64	0.05
10/09/1981	76550	1987	16.04	15.93	0.11	1575	15.76	15.71	0.05
11/09/1981	78300	1934	16.09	15.99	0.10	1627	15.83	15.78	0.05
12/09/1981	79900	1905	16.14	16.04	0.10	1689	15.89	15.84	0.05
13/09/1981	81450	1871	16.18	16.09	0.09	1748	15.95	15.90	0.05
14/09/1981	82950	1857	16.23	16.14	0.09	1814	16.01	15.95	0.06
15/09/1981	84350	1858	16.27	16.19	0.08	1838	16.06	16.01	0.05
16/09/1981	85850	1868	16.31	16.22	0.09	1812	16.11	16.06	0.05
17/09/1981	87400	1897	16.35	16.26	0.09	1849	16.16	16.10	0.06
18/09/1981	89200	1947	16.38	16.30	0.08	1988	16.21	16.15	0.06
19/09/1981	91200	1992	16.43	16.35	0.08	2033	16.27	16.21	0.06
20/09/1981	92850	2052	16.48	16.39	0.09	2103	16.33	16.27	0.06
21/09/1981	93150	2104	16.52	16.43	0.09	2224	16.38	16.31	0.07
22/09/1981	93350	2178	16.55	16.45	0.10	2345	16.42	16.35	0.07
23/09/1981	94000	2222	16.57	16.47	0.10	2424	16.45	16.37	0.08
24/09/1981	94400	2255	16.59	16.49	0.10	2457	16.48	16.40	0.08
25/09/1981	95350	2272	16.62	16.52	0.10	2470	16.50	16.43	0.07
26/09/1981	96650	2220	16.64	16.54	0.10	2433	16.53	16.46	0.07
27/09/1981	97950	2199	16.66	16.57	0.09	2422	16.56	16.49	0.07
28/09/1981	99150	2186	16.69	16.60	0.09	2402	16.59	16.52	0.07
29/09/1981	99850	2172	16.71	16.63	0.08	2331	16.62	16.56	0.06
30/09/1981	100500	2080	16.73	16.65	0.08	1947	16.63	16.58	0.05
1/10/1981	102000	2028	16.75	16.67	0.08	1628	16.64	16.61	0.03
2/10/1981	103500	1974	16.77	16.70	0.07	1324	16.66	16.64	0.02
3/10/1981	104500	1934	16.79	16.73	0.06	1110	16.68	16.67	0.01

Date	Q L5 U/S (ML/d)	Tanyaca Q (ML/d)	WL U/S (m AHD)	WL D/S (m AHD)	ΔH (m)	Lower Pike Q (ML/d)	WL U/S (m AHD)	WL D/S (m AHD)	ΔH (m)
4/10/1981	105000	1894	16.81	16.75	0.06	881	16.71	16.69	0.02
5/10/1981	105000	1869	16.82	16.77	0.05	743	16.72	16.71	0.01
6/10/1981	104500	1859	16.83	16.77	0.06	679	16.73	16.72	0.01
7/10/1981	103500	1860	16.83	16.78	0.05	671	16.73	16.72	0.01
8/10/1981	103000	1864	16.83	16.77	0.06	685	16.73	16.72	0.01
9/10/1981	103500	1944	16.82	16.75	0.07	1013	16.71	16.70	0.01
10/10/1981	104500	1903	16.81	16.75	0.06	810	16.71	16.69	0.02
11/10/1981	104500	1835	16.84	16.78	0.06	566	16.74	16.73	0.01
12/10/1981	104500	1814	16.85	16.80	0.05	509	16.76	16.74	0.02
13/10/1981	104500	1804	16.86	16.80	0.06	491	16.76	16.75	0.01
14/10/1981	104500	1801	16.86	16.80	0.06	482	16.76	16.75	0.01

Appendix C – Tabulated data from Scenario 9

Table C.1 Flow and water level data from simulations conducted in Scenario 9. Includes comparison data from Scenarios 7 and 8.

Scen-ario	River Murray flow	Lock 4 U/S level	Lock 5 D/S level	Deep Creek flow	Margaret Dowling flow	Total inflow	Tanyaca reg. flow	Tanyaca reg. U/S level	Tanyaca reg. D/S level	ΔH Tanyaca reg	Pike reg. flow	Pike reg. U/S level	Pike reg. D/S level	ΔH Pike Reg	Tanyaca–Rumpa-gunyah Jnct Level
	ML/d	m AHD	m AHD	ML/d	ML/d	ML/d	ML/d	m AHD	m AHD	m	ML/d	m AHD	m AHD	m	m AHD
9a	5000	13.2	16.8	400	400	800	541	14.75	14.10	0.65	230	14.35	13.27	1.08	13.27
9b	5000	13.2	16.3	400	400	800	400	14.78	14.00	0.78	371	14.35	13.27	1.08	13.27
9c	5000	13.2	16.8	400	400	800	400	16.40	14.00	2.41	220	16.40	13.25	3.15	13.25
9d	5000	13.2	16.3	600	500	1100	800	14.75	14.25	0.50	273	14.35	13.30	1.05	13.30
9e	5000	13.2	16.3	600	500	1100	600	14.79	14.13	0.66	471	14.35	13.30	1.05	13.30
9f*	5000	13.2	16.3	600	500	1100	400	15.60	14.00	1.61	649	14.35	13.31	1.04	13.29
9g*	5000	13.2	16.8	600	600	1200	663	15.60	14.17	1.43	484	14.35	13.31	1.04	13.31
9h*	5000	13.2	16.8	600	600	1200	563	15.60	14.11	1.49	585	14.35	13.32	1.03	13.31
9i	5000	13.2	16.8	600	600	1200	400	16.41	14.00	2.42	620	16.40	13.30	3.10	13.29
9j	5000	14.2	16.3	400	400	800	400	14.78	14.27	0.51	372	14.35	14.20	0.15	14.21
9k	5000	14.2	16.3	600	500	1100	800	14.75	14.40	0.35	271	14.35	14.20	0.15	14.21
9l	5000	14.2	16.3	600	500	1100	600	14.79	14.34	0.46	470	14.35	14.21	0.14	14.21
9m*	5000	14.2	16.3	600	500	1100	400	15.60	14.28	1.33	649	14.35	14.21	0.14	14.21
9n	15000	13.2	16.8	600	600	1200	800	14.76	14.26	0.50	349	14.35	13.47	0.88	13.50
9o	15000	13.2	16.8	600	600	1200	600	14.82	14.13	0.68	571	14.35	13.48	0.87	13.50
9p	15000	13.2	16.8	600	600	1200	400	14.87	14.00	0.87	770	14.35	13.49	0.86	13.49
9q	15000	14.2	16.8	600	600	1200	800	14.76	14.48	0.28	350	14.35	14.32	0.03	14.32
9r	15000	14.2	16.8	600	600	1200	600	14.82	14.42	0.40	569	14.35	14.32	0.03	14.32
9s	15000	14.2	16.8	600	600	1200	400	14.87	14.37	0.50	771	14.35	14.32	0.03	14.32
9t	30000	13.2	16.8	600	600	1200	800	14.77	14.34	0.42	372	14.35	13.99	0.36	14.05
9u	30000	13.2	16.8	600	600	1200	600	14.82	14.26	0.56	571	14.35	13.99	0.36	14.05
9v	30000	13.2	16.8	600	600	1200	400	14.87	14.17	0.70	771	14.35	14.00	0.35	14.04
9w	30000	14.2	16.8	600	600	1200	800	14.77	14.77	0.00	370	14.62	14.62	0.01	14.66
9x	30000	14.2	16.8	600	600	1200	600	14.82	14.75	0.07	569	14.63	14.62	0.01	14.66
9y	30000	14.2	16.8	600	600	1200	400	14.87	14.73	0.15	766	14.63	14.62	0.01	14.66
7	10000	13.2	16.8	600	600	1200	600	16.41	14.13	2.27	418	16.40	13.35	3.05	13.36
7	10000	13.2	16.8	600	600	1200	400	16.41	14.00	2.42	618	16.40	13.36	3.04	13.36
8c	30000	14.2	16.8	800	600	1400	699	16.40	14.78	1.62	400	16.39	14.63	1.76	14.67
8d	30000	13.2	16.8	800	600	1400	699	16.40	14.31	2.09	400	16.39	14.00	2.39	14.07

* Includes regulator control on Mundic northern outlet

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