SARFIIP – Preliminary investigations

Pike Floodplain hydraulic model setup and review

DEWNR Technical note 2016/04

Government of South Australia
Department of Environment, Water and Natural Resources

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DEWNR Technical Note 2016/04

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Summary

The purpose of this report is to:

- Document and evaluate the current MIKE FLOOD model version of Pike Floodplain that will be used for scenario analysis for SARFIIP. This includes describing changes that have been progressively implemented since development of the original model scheme and any gaps in its makeup
- Document work that has been conducted as part of this model modification study, including additional survey work and update of structures and model branches to render it fit for purpose for SARFIIP investigations
- To describe existing and potential future SARFIIP-related scenarios.

To address identified information gaps in bathymetric data used in previous model configurations, additional cross-section surveys were conducted and included in the model for:

- The waterways on the southern side of Bank B Complex, which were previously incorrectly assigned as land in the DEM
- The area typically inundated on the southern side of Banks F and F1, which was not represented in the DEM
- Upper Pike River (upstream of Col Col Bank), Pike Lagoon, Mundic Creek (northern section) and the Mundic Creek outlets on the eastern side of the floodplain (where navigation is possible), which were conducted for a separate investigation
- The latest River Murray bathymetric survey (downstream of Lock 5) that had not yet been included in the model.

To address the latest structure configurations, the following updates to the model were made:

- Removal of Banks G, H, Snake Creek Stock Crossing and Coombs Bridge from the model configuration, which have been or are scheduled to be removed from the floodplain as part of the Riverine Recovery Project (RRP) (note that evaluation runs continued to include these structures to ensure consistency with conditions at the time of each simulated event)
- Inclusion of waterways and associated banks in the 1-D portion of the model that are currently only represented in 2-D, including the southern side of Bank B Complex (including reconfiguring the representation of Banks B and B2 regulators), and Banks E and F waterways
- Modified 1-D representations of Mundic Creek outlets connecting Mundic Creek to Pike Lagoon/Upper Pike River, to better represent their actual flow paths
- Alteration of the blocking alignment in the model as required through the options assessment.

The model was evaluated against flow events from 1996 (peak at approximately 75 000 ML/d Flow to South Australia) and 2000 (peak at approximately 65 000 ML/d Flow to South Australia), which were used to calibrate a previous version of the model. The model was validated against the most recent River Murray high flow event in 2011 (that was not considered in the original model configuration), which peaked at over 90 000 ML/d Flow to South Australia (although imagery was only available up to a Flow to South Australia of approximately 77 500 ML/d for this event for validation).

Previous hydraulic modelling scenarios that have been conducted by Water Technology, and subsequently by Department of Environment, Water and Natural Resources (DEWNR), for investigations are as follows:

- Simulation of a number of managed inundation event concepts, including testing of alternative inundation methods (e.g. temporary aquadam), and pool level lowering upstream of Col Col bank for ecological benefit
- Modelling of potential new structures within the floodplain for design activities and providing a general hydraulic understanding of managed flow paths within the system, e.g. Margaret Dowling Creek and Deep Creek inlets, potential upgrade of existing embankments (i.e. Banks B, C, D, E, F and F1) to regulating structures

- Modelling of natural hydraulics through the system with removal of all surface water management infrastructure
- Studies on floodplain extractions to support a number of DEWNR policy initiatives.

Future scenarios may include refinement and or replacement of these previous scenarios to support investigations within SARFIIP, including modelling of the current system for assessments of the baseline condition of the floodplain against potential changes to flow regimes through the Basin Plan; modelling of potential changes to proposed infrastructure solutions such as updated structures and blocking bank alignment, and related investigations to support these solutions; and other as yet undefined scenarios for a variety of purposes.

1 Background

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. Figure 1.1 shows the main creeks and structures associated with the floodplain.

Owing to the general degradation of the floodplain condition in comparison to that under natural conditions, 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. The following review of information pertaining to the updating of the existing hydraulic model of Pike Floodplain (McCullough, 2013) was conducted to support the Preliminary Investigations phase of SARFIIP. The state of the model and previous hydraulic scenarios conducted have been reviewed, and recommendations for further updates to the model, as well as gaps in the hydraulic scenarios conducted to date, have been identified.

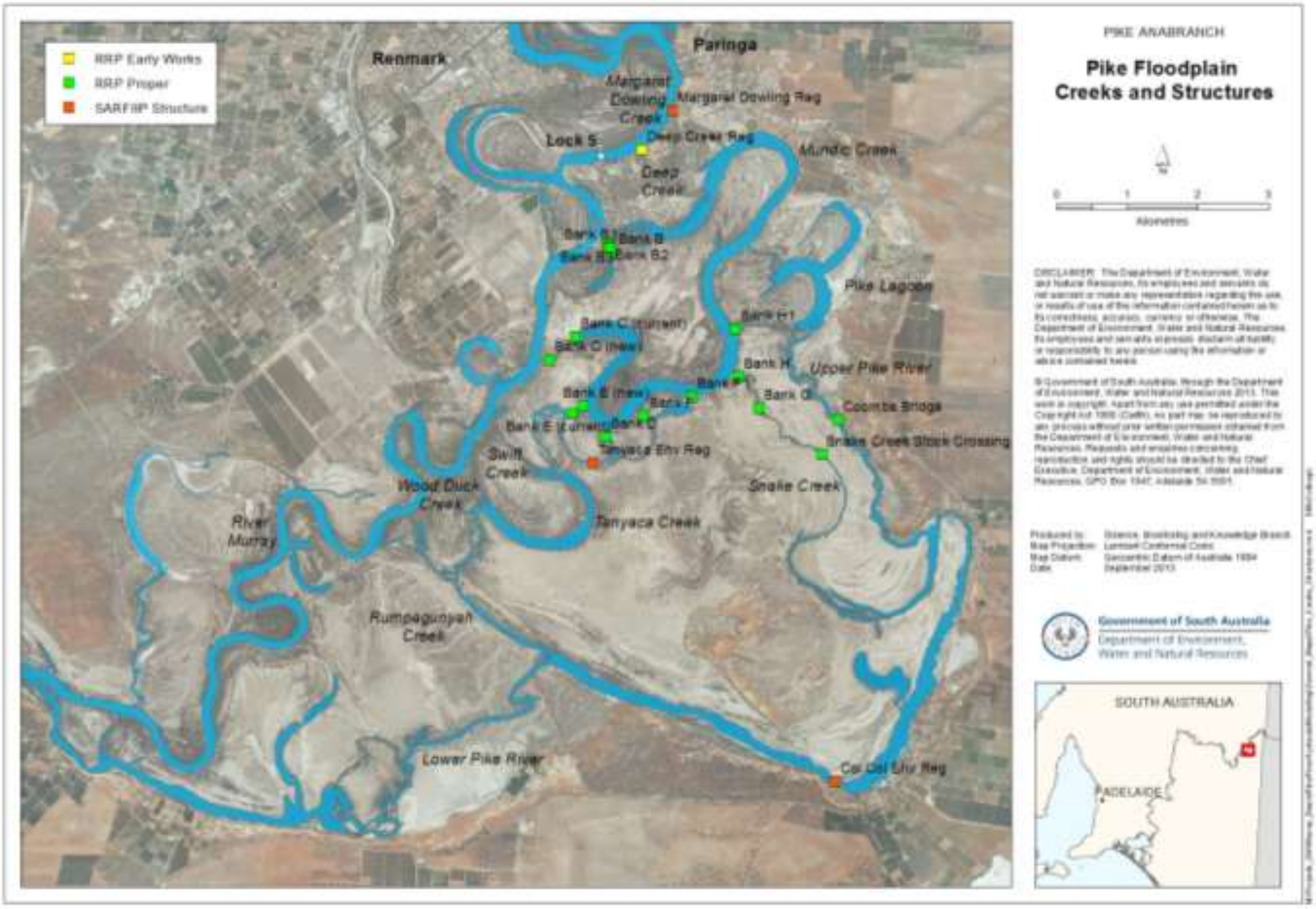


Figure 1.1 Pike Floodplain creeks and structures

2 Hydraulic model

2.1 Existing model configuration

Details of the original MIKE FLOOD model configuration are presented in Water Technology (2009), which is supported by a preliminary review of the data available for producing the hydraulic model (Water Technology, 2008). The original version of the model used a two dimensional (2-D) bathymetric grid cell size of 20 m^2, however this was re-schematised to a 30 m^2 grid size to improve model run times, as detailed in Water Technology (2010b). At the same time, an issue with double counting of floodplain volumes in 1-D and 2-D portions of the model was addressed. Several modelling studies were subsequently conducted by Water Technology until approximately 2012, at which time DEWNR assumed modelling responsibilities. The model has received progressive updates as new survey data has become available, along with minor adjustments for calibration purposes, as presented in McCullough (2013). Table 2.1 shows the various model versions that have been used for modelling relating to the Pike Floodplain.

Table 2.1 Existing MIKE model versions for Pike Floodplain

Model version	Abbreviation	Description
Water Technology, MIKE11	M11–WT	Original 1-D-only version of Pike Floodplain. Used for early in-channel investigations where reduced run-times were advantageous, including for an extraction limit investigation where the advection-dispersion module was used.
DEWNR, MIKE11	M11–DEWNR	Incorporation of updates to the M11-WT model to include: • Addition/modification of floodplain structures as required by the respective scenarios • Update of cross-sectional data in model • Addition of branches at Banks E and F, which were not included in the original M11–WT model • Adjustment of roughness values to better reflect water levels throughout floodplain based on observed values Used for limited in-channel scenarios in 2012–13 and in an updated extraction limit investigation in 2013–14, which used updated extraction parameters and from the earlier equivalent Water Technology investigation.
Water Technology, MIKE FLOOD	MF–WT	Original MIKE FLOOD model configuration, initially 20 m^2 grid sizing revised to 30 m^2 sizing for later scenarios by Water Technology. Includes model variations of existing floodplain condition and upgraded floodplain condition including proposed structures and blocking alignment for managed inundation.
DEWNR, MIKE FLOOD (Riverine Recovery Project)	MF–DEWNR (RRP)	Incorporating updates as required to the MF–WT model (upgraded floodplain condition version) including: • Addition of survey data collected as part of detailed designs • Modification of structure definitions at RRP structures including Bank B, B2, C, D, E, F, F1 as required for scenario purposes • Addition of 1-D branches at Banks E and F, which were not included in the MF–WT model.
DEWNR, MIKE FLOOD (SARFIIP)	MF–DEWNR (SARFIIP)	Current model updated under SARFIIP.

Figure 2.1 shows the hydraulic model setup in MIKE FLOOD, comprising selected branches in a one dimensional (1-D) representation coupled to the two dimensional (2-D) topographic map, with 30 m^2 grid size. Coloured areas of the figure represent the topographic grid, with red colouring at the highest elevation (~36.5m AHD) grading to purple at the lowest elevation (~10.5m AHD). 1D sections of model are represented with node points (black and white) connected with black lines to represent model branches, with cross-sections, structures and boundary conditions represented by rectangles. Axes on the figure represent easting and northing coordinates (i.e. Geocentric Datum of Australia 94 – Map Grid of Australia Zone 54 system).

The following branches are specified in the model as 1-D representations (refer to Figure 1.1 for locations of creeks and structures):

- River Murray (between Locks 4 to 6)
- Margaret Dowling Creek (anabranch inlet upstream of Lock 5)
- Deep Creek (anabranch inlet upstream of Lock 5)
- Tanyaca Creek (section directly south of Mundic Creek only, not including horseshoe lagoon)
- Swift Creek (inlet to Tanyaca Creek)
- Wood Duck Creek (inlet to Tanyaca Creek)
- Rumpagunyah Creek
- Snake Creek
- Upper Pike River
- Lower Pike River (section approximately 5 km downstream of junction between Lower Pike and Rumpagunyah)

Structures represented in the model are as follows:

- Margaret Dowling inlet structure
- Deep Creek inlet structure
- Bank B regulator
- Bank C – existing earthen bank and new regulator
- Bank D, F, F1, G, H, Snake Creek Stock Crossing – existing earthen banks
- Coombs Bridge – existing bridge with culverts
- Col Col Bank – existing bank and environmental regulator
- Tanyaca Creek environmental regulator

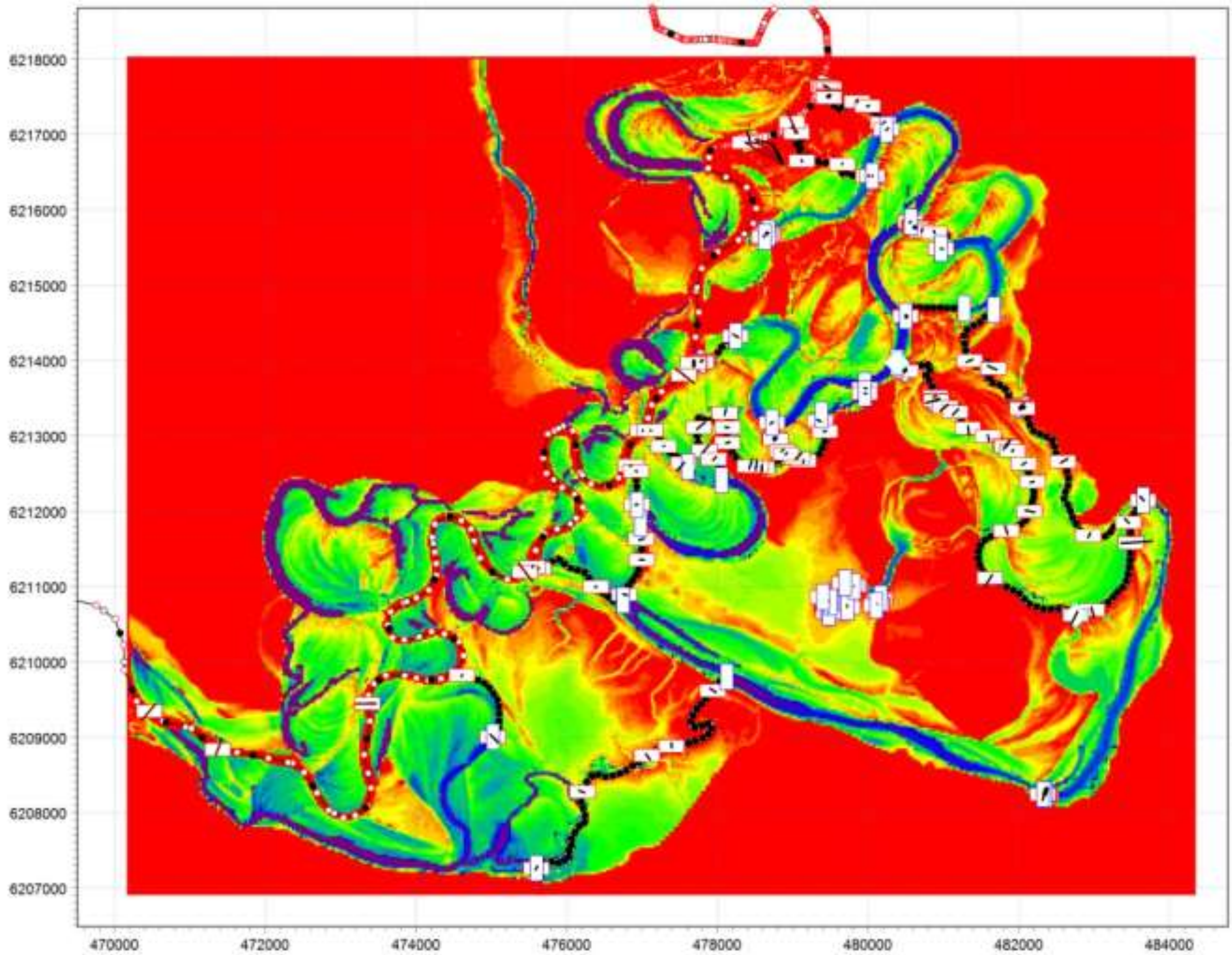


Figure 2.1 MIKE FLOOD 1-D/2-D coupled model of Pike Floodplain

Bathymetric data included in the hydraulic model configuration is extracted from a number of sources, including:

- Digital Elevation Model (DEM), developed from 2 m^2 LiDAR
- Bathymetric survey data collected from a combination of boat mounted and land-based survey techniques.

Figure 2.2 indicates the extent of the DEM and bathymetric survey data that was used in the hydraulic model, which includes the latest survey data incorporated into the model as part of this study. Note that the highest reliability of model results is within the floodplain boundary to the east of the River Murray. Areas to the west of the river are considered less reliable due to low lying areas to the west of the river, which were submerged during the collection of topographic data, appearing as gaps in the DEM, and as such were estimated in the model topographic grid. This estimation results in higher uncertainty and coarser modelling of these areas than areas within the floodplain that have been surveyed more intensively.

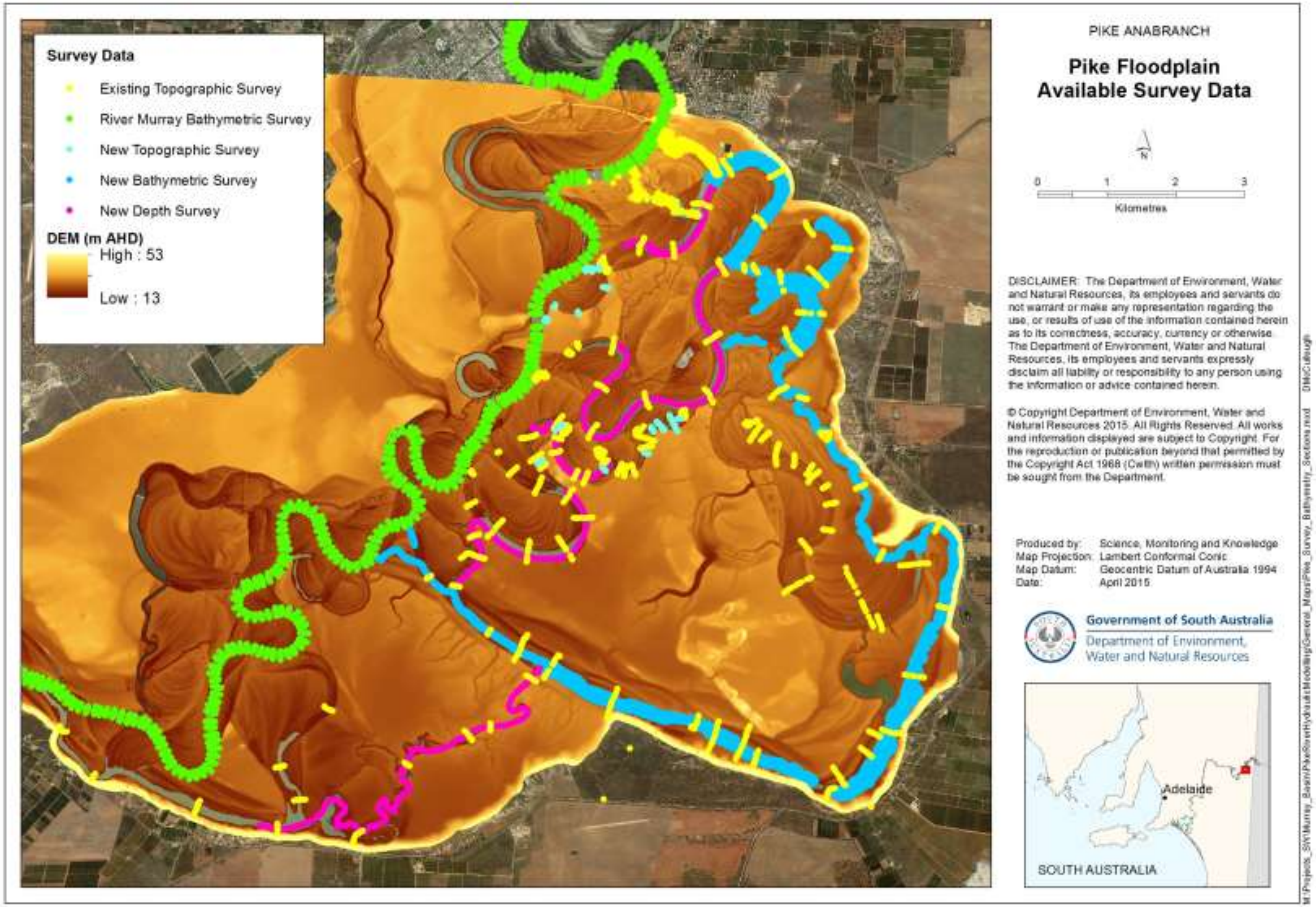


Figure 2.2 Topographic and bathymetric survey data for Pike Floodplain

2.2 Addressing hydraulic model gaps

2.2.1 Bathymetric data

As shown in Figure 2.2, bathymetric and topographic survey data presents reasonably comprehensive coverage throughout the waterways of the anabranch and within the River Murray reach relevant to the hydraulic model, providing the basis for a reliable representation of much of the floodplain. DEM data covers the majority of the floodplain except for permanently inundated waterways within the floodplain. These gaps in the DEM within the floodplain have predominantly been addressed by extensive survey of cross-sections within the creeks using traditional survey techniques. Boat mounted surveying has been conducted recently within the River Murray extending up to Lock 6, replacing earlier bathymetric data collected by SA Water that was included in the original model by Water Technology (assumed to be from the previous survey conducted in the 1980s). As indicated in the previous section, gaps exist in the DEM to the west of the River Murray and therefore depths in these areas are estimated only.

Comparison of the DEM grid with surveyed locations indicates a reasonable reliability of the DEM in parts of the floodplain not inundated at the time of data collection. Inspection of the DEM against surveyed elevations suggests that the DEM accuracy generally falls within approximately 0.1 m of the corresponding survey point (note that larger discrepancies appear to exist on steep surfaces such as the sides of banks). Considering each cell on the DEM represents 2 m^2, while the modelled topographic grid is resampled to 30 m^2, this accuracy should be generally sufficient to represent the floodplain in the 2-D portions of the model. The exception may be the representation of any minor floodplain flow paths, if required for a more detailed or targeted analysis.

The representation of inundation area on the floodplain through hydraulic scenarios could be improved by using a finer resolution for the topographic grid, such as the 20 m^2 grid size used in the original model version (Water Technology, 2009). Note that the trade-off for finer resolution imagery is a potentially significant increase in run times for a given simulation period (approximately 125% increase in runtime, ignoring the overheads from 1-D part), as well as an increase in the time and effort required for model reconfiguration and recalibration. Based on the results of previous inundation scenarios conducted under the Riverine Recovery Project (RRP), the current resolution of 30 m^2 is sufficient for the purposes of analysing inundation extents, and it is not anticipated that an increase in resolution would significantly improve the results beyond any inherent uncertainty in the model. Therefore, it is suggested to retain the current topographic resolution and take advantage of the faster model run times afforded by the coarser grid.

Only limited gaps in the survey data were identified as part of this model modification study for further surveying (refer also to Figure 2.2), which include:

- River Murray side of Bank B Complex (i.e. southern side): This was implemented in the original model as part of the 2-D bathymetric grid, however the streams are considerably smaller than the 30 m^2 grid size and so were not accurately represented in the model, while the DEM incorrectly identified the inundated creeks as land. Two main waterways are present downstream of Banks B and B2, at which additional cross-sectional surveying was completed
- Area downstream of Banks F and F1: This area is typically inundated and therefore is not represented in the base DEM. While estimated bathymetries were used in the original model 2-D grid, accurate bathymetric representation of this area is desired given the proposed change in operational management of this area following construction of the Tanyaca Creek Environmental Regulator. Therefore this area was subjected to surveying as part of this study.

Additional bathymetric surveying by SA Water was also commissioned to provide detailed bathymetry at locations adjacent to areas with private water extractions in the Upper Pike system, including in Upper Pike River (upstream of Col Col Bank), Pike lagoon, the Mundic Creek outlets on the eastern side of the floodplain (where navigable) and the northern section of Mundic Creek. While this service has been commissioned as part of SARFIIP to inform a separate feasibility investigation into potential lowering of water level for ecological purposes, the resultant data has also proven useful for addressing gaps in the DEM, and hence has benefitted model development.

2.2.2 Structures

The majority of structures have been defined at least to the concept design phase, with several having their detailed design completed and others that have been fully constructed. Table 2.2 indicates the infrastructure in Pike Floodplain against program and current status. The latest structure configurations and their positioning, based on detailed or concept designs, were predominantly included in the original model version (Water Technology, 2009), with a number of exceptions as follows:

- Banks G, H, Snake Creek Stock Crossing and Coombs Bridge have been or will be removed as part of Riverine Recovery Project (RRP) Proper. Similarly, Banks D, F and F1 were previously proposed to be replaced by new structures through RRP Proper, however a change in project scope has resulted in these structures becoming redundant with construction of the proposed Tanyaca Creek Environmental Regulator, and so are proposed to be removed pending SARFIIP investigations. Each of these structures have therefore been removed prior to running managed inundation scenarios (although will remain in the model versions used for evaluation of the model against previous flow events).
- Bank B Complex was poorly represented in the model, being defined as a single structure rather than two separate regulators at Banks B and B2. This resulted in an inaccurate representation of the bank complex operation, as the Bank B2 regulator will be typically closed while Bank B will be typically open as per the current bank configuration. These structures were therefore separated in the model to allow independent operation.

The two proposed environmental regulators have also received updates to include new configuration and locational information as investigations progress to the detailed design phase.

Table 2.2 Pike Floodplain infrastructure with associated program and current status

Structure	Program	Current status
Deep Creek	RRP Early Works	Construction commenced
Margaret Dowling	SARFIIP	Detailed design phase commenced
Bank B Complex	RRP Proper	Construction tender phase
Bank C	RRP Proper	Construction tender phase
Bank D	RRP Proper/SARFIIP	Detailed design (RRP Proper), redundant if Tanyaca Creek Environmental regulator constructed – for review by SARFIIP
Bank E	RRP Proper/SARFIIP	Detailed design (RRP Proper), forms part of blocking alignment – for review by SARFIIP
Bank F	RRP Proper/SARFIIP	Detailed design (RRP Proper), redundant if Tanyaca Creek Environmental regulator constructed – for review by SARFIIP
Bank F1	RRP Proper/SARFIIP	Detailed design (RRP Proper), redundant if Tanyaca Creek Environmental regulator constructed – for review by SARFIIP
Bank H (removal)	RRP Proper	Removal complete
Bank G (removal)	RRP Proper	Removal pending construction of Bank B Complex
Snake Creek Stock Crossing (removal)	RRP Proper	Removal complete
Coombs Bridge (removal)	RRP Proper	Removal pending construction of Bank B Complex
Col Col environmental regulator	SARFIIP	Concept design complete, for review by SARFIIP
Tanyaca Creek environmental regulator	SARFIIP	Concept design complete, for review by SARFIIP

2.2.3 Model Configuration

The creeks containing Banks E and F were not represented in the 1-D portion of the original model, relying on the 2-D grid to coarsely represent each stream. While there is typically no flow through these creeks under normal operating conditions due to the presence of the banks, it is important to accurately model these streams for future scenarios. Bank F is intended to be removed and so will contain a portion of the outflow from Mundic Creek, while Bank E forms part of the currently proposed blocking alignment but could potentially be removed altogether depending on whether the alignment is altered through SARFIIP investigation outcomes. The model has therefore been updated to include these creeks in the 1-D portion of the model.

As indicated in the preceding sections, the planned regulators at Bank B Complex are poorly represented in the model, while the associated waterways downstream of the bank complex are inaccurately represented in the 2-D grid. Two separate streams have been defined downstream of Banks B and B2, while the regulator configurations have been updated to the latest construction designs.

Also indicated in the preceding sections is the typically inundated area downstream of Banks F and F1 that was not accurately represented in the 2-D grid or the original model. The grid was checked and updated against the recent survey data collected as part of this model modification study to ensure that the bathymetry of the area is accurate.

Some of the Mundic Creek outlet streams connecting Mundic Creek to Pike Lagoon/Upper Pike River were simplistically represented in 1-D in the original model i.e. a meandering stream pattern has been represented by a straight stream path. This simplistic representation was therefore updated to better match the actual flow path of the relevant streams.

Another part of the model configuration that may require modification is the blocking bank alignment, depending on the outcomes of SARFIIP options assessment. Any change to the alignment from that currently proposed in the concept design will require update in the model configuration.

The following updates have been implemented for the latest MIKE FLOOD model (MF–DEWNR SARFIIP), including:

- Inclusion of two separate 1-D branches at Banks B and B2, including new bank structure definitions
- Define 1-D branches of waterways associated with Banks E and F, and alter the 1-D representations of Mundic Creek outlets connecting Mundic Creek to Pike Lagoon/Upper Pike River
- Deletion of banks removed/scheduled for removal from the model, including Banks G, H, Snake Creek Stock Crossing and Coombs Bridge
- Update of River Murray bathymetric cross-sections to the latest survey data in the Lock 4 to 5 reach
- Inclusion of additional survey data on the southern side of Bank B Complex and downstream of Banks F and F1, as well as the bathymetric survey data from the eastern side of the floodplain
- Adjustment of blocking alignment as required following review of options.

2.3 Model evaluation

2.3.1 Available data

The original version of the model (MF-WT) was calibrated against flow events in 1996, 2000 and 2005 as described in Water Technology (2009), which covered River Murray flows up to approximately 60 000 ML/d based on the imagery dates available for comparison (note this does not represent the peak flow of the events tested, but rather the flows corresponding to the dates of available imagery). The latest high flow event in 2011, which occurred after the calibration was conducted, reached a peak Flow to South Australia exceeding 90 000 ML/d, providing additional data for validation of the updated model. Table 2.3 shows relevant imagery available for recent high flow events and corresponding river flows where available (i.e. Flow to South Australia and Flow at Lock 5).

Table 2.3 Available USGS Landsat Imagery dates and corresponding Flow to South Australia and flow at Lock 5 (where available)

USGS Landsat imagery date	Flow to South Australia ML/d	Flow at Lock 5 ML/d
9 December 1996	72 430	59 100
13 December 2000	60 399	~45 000
7 March 2011	77 569	N/A
8 April 2011	69 307	N/A

In-stream data sources available within the vicinity of the Pike Floodplain are as follows:

- Continuous monitoring data from the State Water Data Archive, including:
  - Rated flow: Flow to South Australia, Lyrup Gauging Station, Lock 5
  - Water levels – River Murray: Lock 6, 5 and 4 (upstream and downstream), Lyrup Gauging Station
  - Water levels – Floodplain: North Pike Lagoon (since 2012), Coombs Bridge, Col Col Bank, Lettons, Picnic Ground.
- Flow gaugings (including velocity data) conducted at Lyrup Gauging Station, Margaret Dowling Creek, Deep Creek, Coombs Bridge, Col Col Bank, Rumpagunyah Creek, Lettons, and Bank B2 (during latest high flow event in 2010–11).

Locations of continuous monitoring and flow gauging sites in and adjacent to the Pike Floodplain are indicated in Figure 2.3.

2.3.2 Selected data for comparison

The preceding data is predominantly relevant for comparisons under in-channel flow conditions. For the purposes of model evaluation of high flow events, Lock 5 downstream level and Lyrup gauging station are the most relevant sites for comparison with high flow model outputs as they each provide a continuous record during high flow events. Many sites within the floodplain were either not available at the time of high flow events, or had limited operability during these events due to site limitations, and as such possess limited suitability for evaluation of high flow events exceeding 40 000 to 60 000 ML/d. Instead, satellite imagery is the main basis for evaluation run comparisons by necessity.

Figure 2.3 Current surface water monitoring sites in Pike Floodplain

2.3.3 Runs

Following updates implemented in the model as part of this study, model runs consistent with those conditions identified in Table 2.3 were performed and compared with available Landsat imagery. Imagery for each event was selected as close as possible to the peak of each event. Note that the 2005 event used for the original model calibration was not a major inundation event, reaching a maximum peak of only 15 000 ML/d Flow to South Australia, and as such was not suitable for model output comparison from an inundation perspective. Instead, the most recent high flow event in 2011 was used for validation purposes. Additionally, a baseflow comparison run was conducted at 10 000 ML/d for evaluation of in-stream conditions against continuous monitoring data. Note that since the 1996 and 2000 events were used to calibrate the original model, we cannot use them for validating the updated model, and we refer to these comparisons as model evaluation; however, the 2011 events were not used in the original calibration, and can therefore be used for validating the model. Model boundary conditions for each of the simulated events are indicated in Table 2.4. Note that Lock 5 upstream level is controlled to the observed level for each event.

Table 2.4 Model boundary and Lock 5 control parameters for comparison simulations.

Simulation	Model inflow ML/d	Model tailwater m AHD	Lock 5 U/S Level m AHD
1996 Event	60 000	14.34	16.85
2000 Event	45 000	13.60	16.32
March 2011 Event	75 000	14.66	16.95
April 2011 Event	69 200	14.51	16.79
Low flow	10 000	13.20	16.30

Inflow into the model was approximated based on Lock 5 flow data (Table 2.3), where available, rather than Flow to South Australia, as differences of varying degrees between these locations were encountered for a given time step depending on the stage of the flow event. Where Lock 5 flow was not available due to levels exceeding the rating – i.e. for both 2011 modelled events – an approximation was made by cross-checking Flow to South Australia with gauged and/or rated flows downstream of Pike Floodplain at the Lyrup gauging station (site number A4260663). The model inflow for the modelled event at 7 March 2011 was approximated at 75 000 ML/d based on a Flow to South Australia of approximately 77 500 ML/d and flow at Lyrup approximately 73 500 ML/d, while the inflow of the modelled event at 8 April 2011 was set at 69 000 ML/d given that both Flow to South Australia and Lyrup flows were relatively equivalent at approximately 69 000 ML/d. Note that while a higher river flow was present for the April 2011 event compared to the 1996 event, the water level upstream of Lock 5 is greater under the 1996 event case – this is likely a result of Lock 5 operations, where rated lock flow was available at the time of the 1996 event, suggesting the lock was still in place at that time, whereas for the 2011 event there was no rated flow, indicating the lock was removed from operation at the time.

Steady state simulations were used in preference to dynamic flooding runs, as primarily the gaps in available flow data complicated the development of a dynamic hydrograph for all flow events tested. Instead, the steady-state approach was used to provide a 'snapshot' of the state of inundation over the floodplain at defined flow conditions.

Limitations of the approach used here are that:

- Running the model to steady state conditions allows the hydraulics to reach equilibrium over the floodplain and the river reach between Locks 6 and 4, where under actual conditions the duration of the peak flow may not have permitted this to occur
- Using data for a given time step may not account for the dynamic nature of hydraulics between upstream and downstream states in the model despite being close to the peak of the event, and as such may create a difference to observed inundation
- Differences in approximated and actual flow values at the floodplain at Lock 5, where no Lock 5 flow data is available, may exist due to attenuation of the event.

These differences in inundation may tend to result in an overestimation of inundation extent in the model compared to observed extent.

For these evaluation runs, the model was configured with existing infrastructure only to remain consistent with the condition of the floodplain under the evaluation events chosen.

2.3.4 Results and discussion

The relationship between Lock 5 upstream, downstream, and Lyrup gauging station water levels with Lock 5 flow is presented in Figure 2.4, showing the steady-state modelled results against historical data. These results indicate that modelled River Murray levels are comparable to the range of historical water level observations. Additionally, historical water levels at various monitoring sites within the floodplain are compared with modelled results at a given Lock 5 flow in Figure 2.5. These results again indicate comparable modelled levels with available observed data, particularly at 10 000 ML/d flow and under the 2000 event simulation, although there is limited data availability within the floodplain for appropriate comparisons under the higher flow events tested.

Comparisons of modelled events to available satellite imagery (USGS Landsat Imagery) for each flow event are shown in Figure 2.6 to Figure 2.9, which generally show a reasonable correspondence between the extents (excluding consideration of areas to the west of the River Murray as previously discussed). Some additional fringe inundation is apparent in the modelled results when compared to the corresponding actual inundation extent – particularly in the southern part of the floodplain – which may be attributed in part to the factors listed in the preceding section regarding limitations of the steady state approach. Also, inundation in the USGS Landsat Imagery becomes obscured in areas of thick vegetation, which reduces the ability to delineate flooded from dry areas. Overall, the evaluation comparisons indicate that the model is fit for purpose for future SARFIIP modelling investigations.

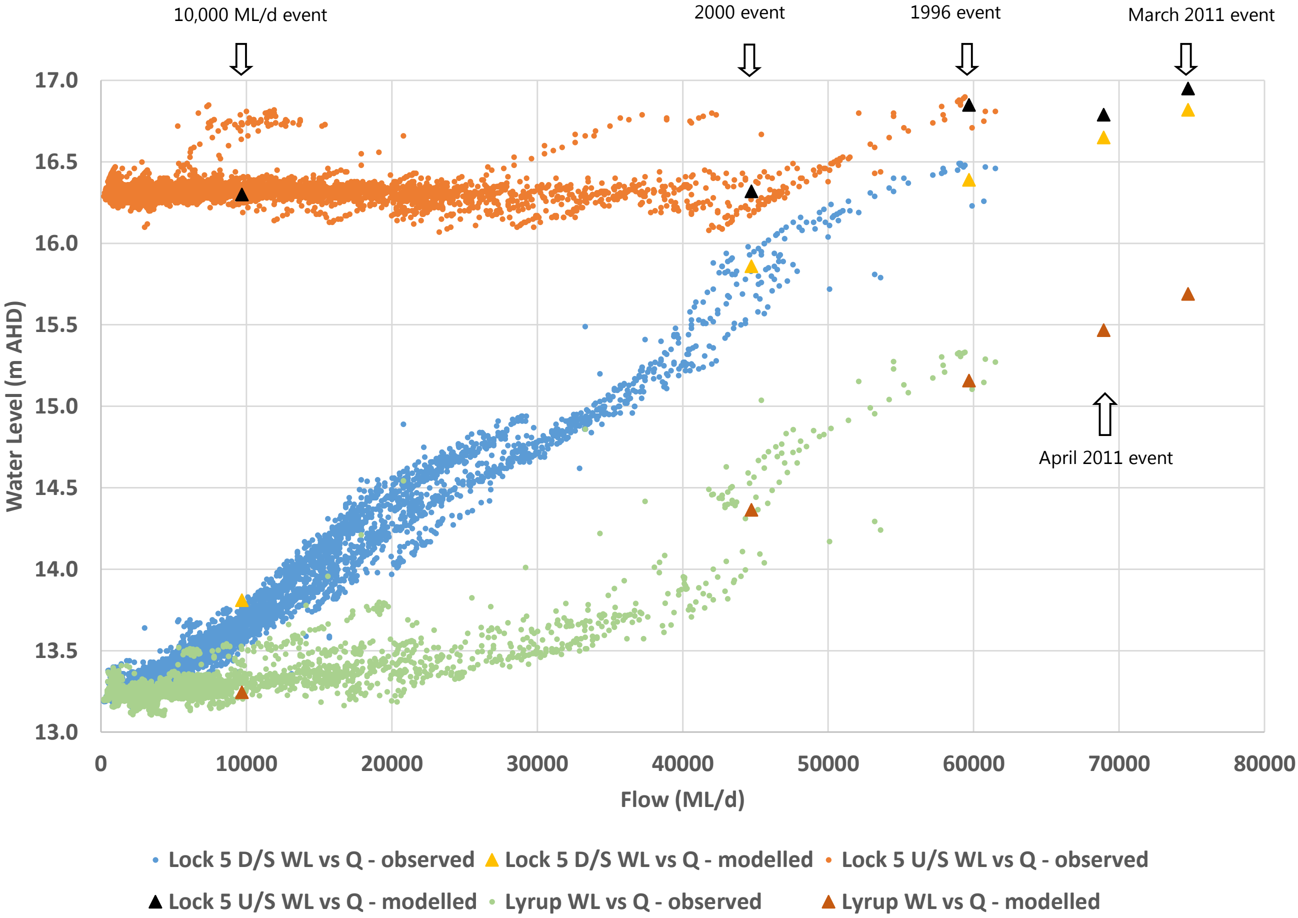


Figure 2.4 Comparison of River Murray water levels with Lock 5 flow – historical record and modelled events

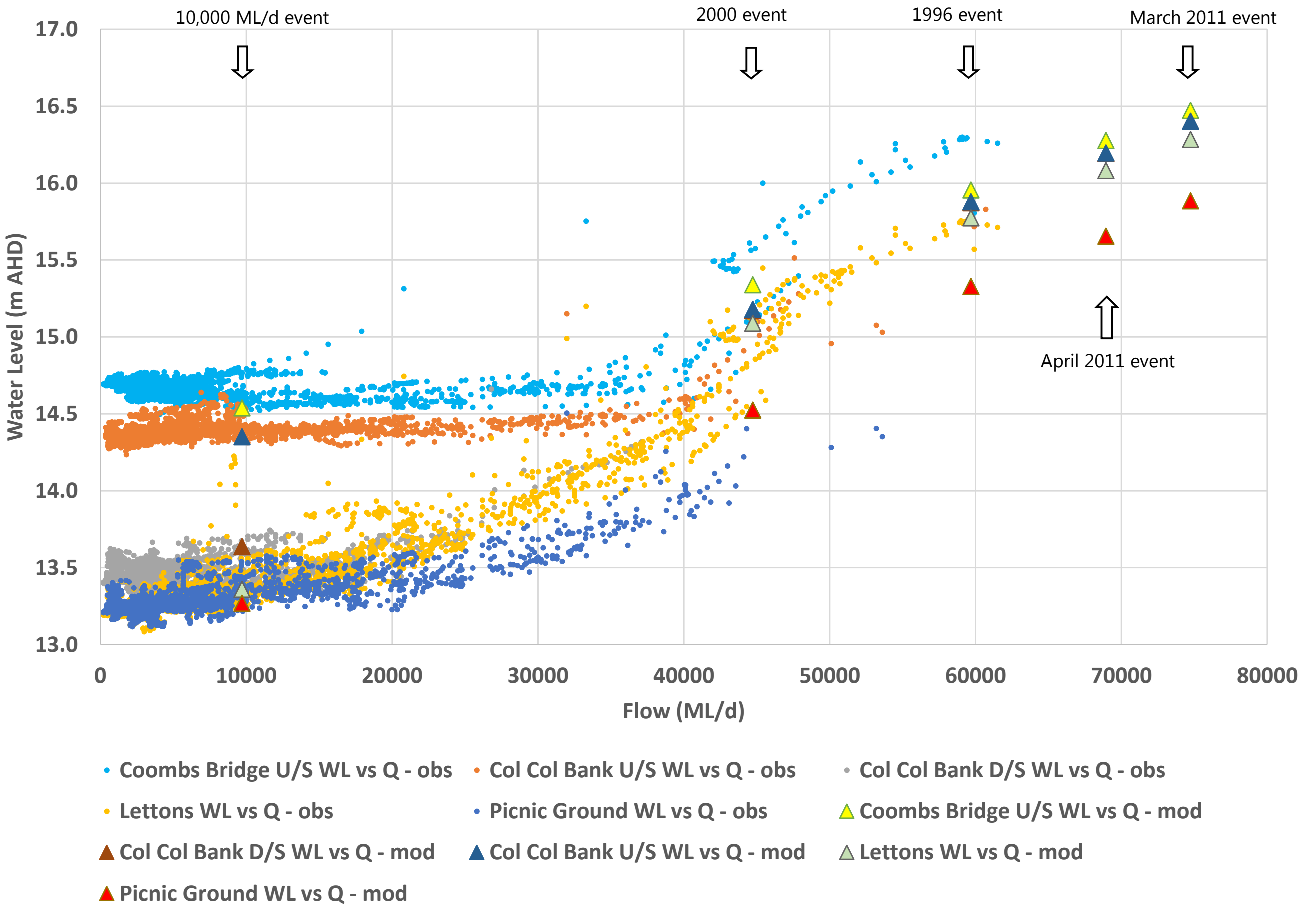


Figure 2.5 Comparison of Pike Floodplain water levels with Lock 5 flow – historical record and modelled events

(a) (b)

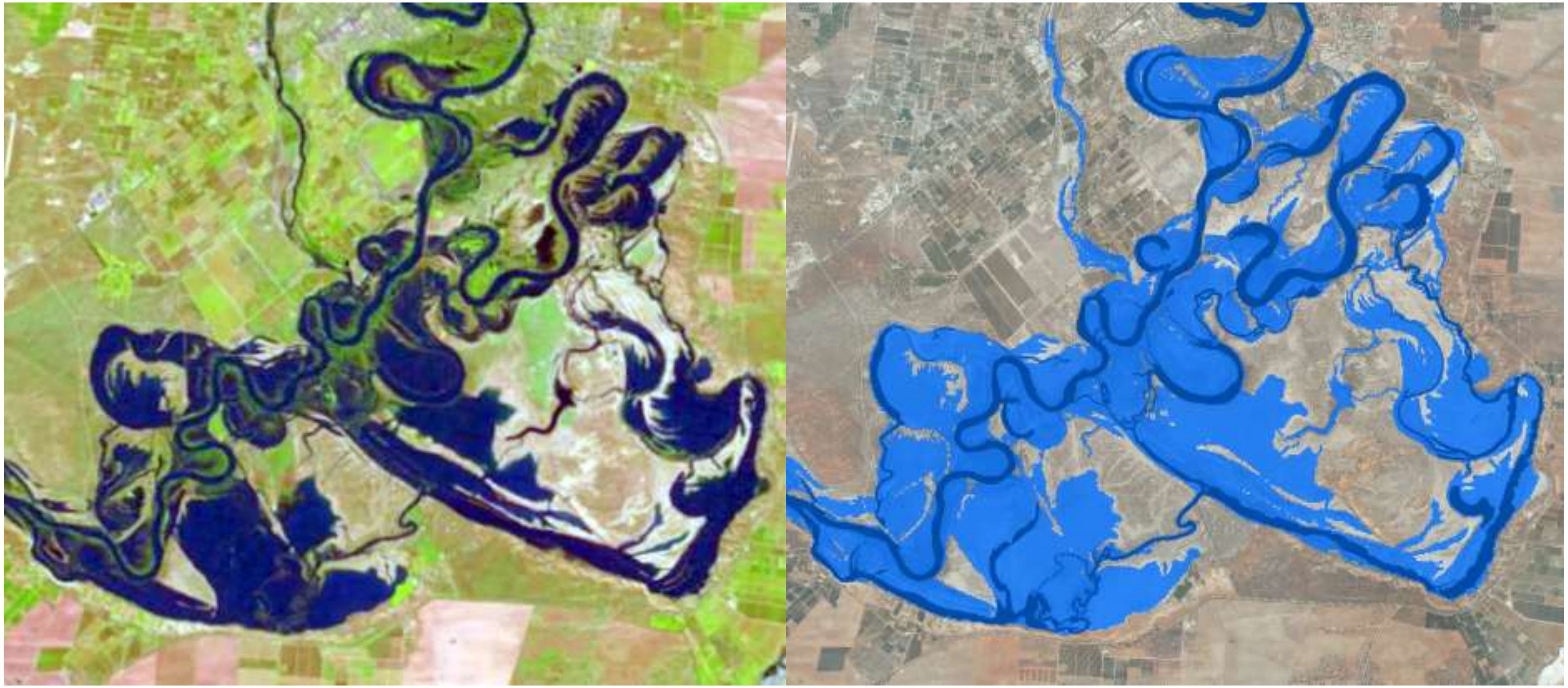
Figure 2.6 Comparison of (a) actual (USGS Landsat imagery) to (b) modelled inundation extents for 1996 flood event (9 December 1996, Flow to SA of ~72 400 ML/d)

(a) (b)

Figure 2.7 Comparison of (a) actual (USGS Landsat imagery) to (b) modelled inundation extents for 2000 flood event (13 December 2000, Flow to SA of ~60 400 ML/d)

(a) **(b)**

Figure 2.8 Comparison of (a) actual (USGS Landsat imagery) to (b) modelled inundation extents for 2011 flood event (7 March 2011, Flow to SA of ~77 600 ML/d)



(a) (b)

Figure 2.9 Comparison of (a) actual (USGS Landsat imagery) to (b) modelled inundation extents for 2011 flood event (8 April 2011, Flow to SA of ~69 300 ML/d)

3 Hydraulic scenarios

3.1 Previous hydraulic scenario modelling

Water Technology developed the original MIKE FLOOD model (MF-WT) and conducted the initial hydraulic modelling of scenarios until 2012, after which DEWNR (Science, Monitoring and Knowledge Branch) assumed modelling responsibilities. Minor updates have been progressively implemented by DEWNR as additional data has become available. The various model versions used for each of the modelling studies as presented in Table 2.1 are referred to in the following sections.

3.1.1 External scenarios

Water Technology developed a number of hydraulic scenarios for various purposes, to investigate both in-channel (i.e. model version M11–WT) and managed inundation (i.e. model version MF–WT) processes.

Managed inundation of the floodplain involving operation of the proposed environmental regulators was investigated via scenarios presented in Water Technology (2010a, 2012a). River Murray flows of 10 000, 30 000, 40 000 and 50 000 ML/d were modelled for operation of the concept design regulating structures over a 120 day operating period, reaching a peak inundation water level behind the environmental regulators of 16.4 m AHD. Modelled outputs include peak area of inundation and water balance volumes impounded on the floodplain, while also reporting on other hydraulic properties including water level, flow, velocity and bed shear stress at various reporting locations.

Scenarios modelling the inlets at Margaret Dowling and Deep Creek have been modelled relating to the construction of new structures to increase the inlet capacity of the Pike system, which is required to enable the viability of SARFIIP solutions. Modelling results are presented in Water Technology (2010c, 2010d, 2011a, 2011b, 2011c), which are supported by the concept design for the inlet regulators (SKM, 2010). Scenarios include an analysis of the hydraulic impacts of the concept design structures on the Pike system, and investigations relating to the impact from inlet closures (partial and full closures) on the system hydraulics during construction. The scenarios also include a consideration of private water extractions from the Pike system.

Scenarios were developed to investigate the use of a temporary Aquadam on Tanyaca Creek to facilitate localised flooding to a maximum water level of 14.8 m AHD, as in Water Technology (2010e). The scenarios included upgraded inflow structures through Margaret Dowling and Deep Creek, and investigated the change in water levels and flow patterns caused by the Aquadam.

A number of scenarios were designed to support the designs of upgraded bank structures, including Banks B, C, D, E, F and F1. Water Technology (2012b) presents the results of an investigation into the hydraulic impacts of upgraded banks from concept designs at River Murray flows of 30 000, 40 000 and 50 000 ML/d, with the environmental regulators at Tanyaca Creek and Col Col Bank not included. A further set of scenarios was developed (refer to Water Technology, 2012c), which investigated the system hydraulics with Banks D, E, F and F1 completely removed to provide an indication of the preferred flow paths in the system, and hence allow structure designs to reflect these flow paths. Water Technology (2012d) further refines the preceding analysis to investigate system hydraulics through removal of Bank D, which was identified as the main flow path from Mundic Creek in the investigation presented in Water Technology (2012c).

Some further scenarios were run to assess the hydraulic impact on the Pike system of lowering pool level upstream of Col Col Bank, as presented in Water Technology (2012e). Such a lowering may be conducted for ecological purposes to provide a greater variation in flows in the Upper Pike system. Note that impact on water extraction offtakes was not analysed in the study. The impact on Mundic Creek level was a particular focus of the investigation, and was used to support the engineering design of a regulator at Bank F1.

3.1.2 DEWNR scenarios

A number of hydraulic scenarios were completed by DEWNR using both the MIKE FLOOD (MF–DEWNR (RRP)) and MIKE11 (M11–DEWNR) model versions originally developed by Water Technology, with updates applied to the models on a progressive basis, which primarily include:

- Updating of structure configurations based on the latest designs and/or changes to existing structures as required on a scenario by scenario basis
- Insertion of new survey data, conducted at the various bank locations relevant to the detailed design phase.

Details of any modelling updates conducted are detailed in McCullough (2013) under each relevant scenario chapter.

McCullough (2013) presents a number of miscellaneous scenarios for informing several investigations relating to Pike, including for informing engineering designs of structures at the detailed design phase (N.B. detailed design presented in GHD, 2013). Scenarios investigated include:

- Investigation of the floodplain hydraulics under removal of all surface water management infrastructure for River Murray flows of 10 000, 30 000 and 50 000 ML/d, designed to investigate quasi-natural flow paths for informing infrastructure option development
- Two separate managed inundation scenarios (water level raising to 16.4 m AHD within the floodplain), investigating floodplain hydraulics when operating the environmental regulators to manage salinity effects in Pike River; and hydraulics associated with a staggered filling phase to minimise black water creation
- Several scenarios focusing on Bank D to inform detailed designs of a proposed structure, including maximum flow capacity through the Bank D site under various conditions and investigating different structure options for upgraded Bank D
- Investigation of options pertaining to control of Mundic Creek water level by upgraded Banks D, F and F1 (as under existing conditions) or by the proposed Tanyaca Creek Environmental Regulator (i.e. banks completely removed), with the main focus being on the area between Banks D, F, F1 and the environmental regulator.

A further modelling investigation was conducted to support an assessment on a potential extraction limit for the floodplain, as presented in McCullough (2014).

3.2 Hydraulic scenario modelling gaps

Future hydraulic modelling will be required to inform a number of different investigations within SARFIIP. Some potential hydraulic scenarios include:

- Further modelling required to determine the impact of expected basin plan return flows against baseline conditions, and also the impact of the proposed inundation management options when compared to inundation expected under natural conditions in the floodplain. Hydrologic modelling would be conducted to identify event magnitudes, durations and frequencies under natural, current and basin plan flow regimes, which will then identify the various flow scenarios to test in the hydraulic model for producing inundation extents and other hydraulic data.
- Updating the SARFIIP managed inundation scenarios previously conducted, with updated structure configurations and additional survey data. These runs have also only been conducted with fixed locations of the environmental regulators, and have not specifically investigated any change to the location of these regulators and blocking alignment if required.
- As indicated in Table 2.2, the environmental regulator structures proposed under SARFIIP are at the concept design phase, requiring further investigation through SARFIIP that may result in an alteration of structure dimensions, placements, etc. Hydraulic modelling will be required to inform the detailed design of these structures.
- Investigation of the flow paths through Tanyaca Creek, Rumpagunyah Creek and Lower Pike River under a number of flow scenarios, including those expected through managed inundation events.
- Update of scenarios investigating the impact of pool level lowering upstream of Col Col Bank/Pike River regulator using updated bathymetric data.

It is expected that other hydraulic modelling scenarios will be required that are as yet undefined, and these will need to be included in the hydraulic modelling program.

4 References

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