TECHNICAL PAPER 04

Hydrology and Flooding Impact Assessment

Appendix B Peer review

ILLABO TO STOCKINBINGAL ENVIRONMENTAL IMPACT STATEMENT

B.1 Background

SEAR 4 Hydrology and Flooding, section 3 part c required a peer review of the models to be completed. WMA Water were commissioned to undertake the peer review of the models. The first review occurred in October 2019 and a subsequent review followed in June 2021. The peer reviewed involved a review of the hydrologic and hydraulic models to confirm their suitability for use to inform the reference design for the proposal and the environmental impact assessment.

B.2 October 2019 review summary

The review identified a number of areas of improvement in the flood. These related to the following:

- Accuracy of delineation of catchment boundaries
- Gauge 412134 data
- Flood Frequency Analysis (FFA)
- Regional Flood Frequency Estimate (RFFE)
- Hydrologic model lag time
- Hydrologic model roughness values
- Hydrologic model Initial and continuing losses
- Extreme Event modelling
- Boundaries and inflows
- Hydraulic model – cut-off depths
- Hydraulic model version.

These issues were then worked through as the reference design was progressed and a subsequent review completed in June 2021.

B.3 June 2021 review

For the June 2021 review, the IRDJV provided the following detailed responses to closeout the comments from the October 2019 review.

B.3.1 Catchment boundaries

The original catchment boundaries were based on limited topographic data which was available in early 2018 and therefore limited the definition of catchment boundaries. The peer review identified areas where the proposed catchment boundaries could be improved.

Response

In 2020, more detailed topographic data was made available through the Elvis – Elevation and Depth – Foundation Spatial Data (Commonwealth of Australia (Geoscience Australia) 2021). The catchment boundaries were then updated using the NSW Government 5m DEM data available from the Elvis foundation website. The DEMs are 2km by 2km and were captured in 2015. This data superseded the previously available 20m DEM data.

The images below includes an example of where the updates where made with the previous (blue) and refined (yellow) model boundaries.

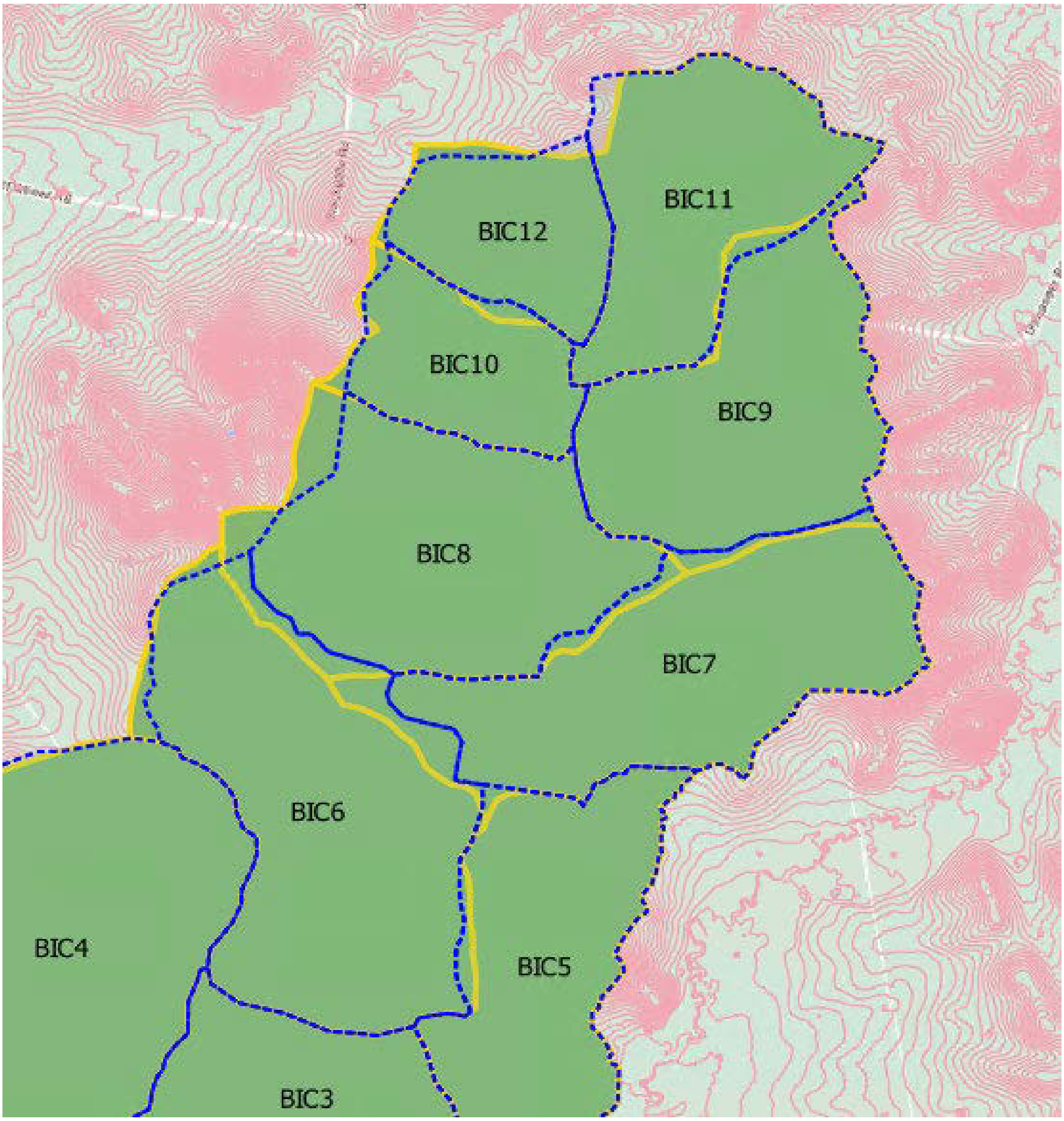

Figure B.1 Catchment refinement examples

At another location, there was a double up with the inflow boundaries. The image shows the SA boundaries used where the W047 appeared twice. This has been rectified and catchment names changed in both the Xp-RAFTS model and the 2d_SA file.

Figure B.2 SA boundary name updates

Resolution

11/6/2021 – the changes to catchment boundaries have been made and the comment is closed.

B.3.2 Gauge 412134 data

The flood modelling involved an extensive review of the Wattle Creek at Dudauman #412134 recorded data. But the peer review felt there were several potential issues with using gauge 412134 which could impact its use for calibration purposes. These issues are:

- potential errors in recorded data or gauge rating curve
- limited record length
- small upstream catchment to gauge may not be representative for whole model extent(s).

Response

Detailed analysis of the data concluded that the Wattle Creek stage discharge curve is underestimating flows for larger flood events and ultimately could not be used in model calibration. It was therefore proposed that RFFE be used to verify the models.

Resolution

1/6/2021 – Agreed – removing focus from event calibration makes sense if there is insufficient information to undertake this with reasonable confidence.

B.3.3 Flood Frequency Analysis (FFA)

The FFA was completed using the available Wattle Creek at Dudauman #412134 gauge. The data was censored to remove low flows that can sometime influence the results. The peer review recommended the Grubbs Beck method for censoring flows.

Response

The Grubbs Beck method for censoring low flows was adopted and the results are presented below.

Table B.1 FFA flows with no censoring and Grubbs Beck censored data

AEP (%)	Non-censored data discharge m^3/s	Grubbs Beck censored data discharge m^3/s
50	0.4	0.33
20	1.51	1.35
10	2.7	2.6
5	4.15	4.3
2	6.4	7.25
1	8.3	10.01

The updated FFA results in 8 points being censored at the flow of 1.25m^3/s or less. The December 2010 event was estimated to be 1.9% AEP previously it was estimated to be a 2.5% AEP (after censoring at 0.5m^3/s).

Resolution

Agreed

B.3.4 Regional Flood Frequency Estimate (RFFE)

The ARR Regional Flood Frequency Estimation Model for the 4th edition of Australian Rainfall and Runoff was utilised to provide estimated peak flows. The peer review highlighted the limited value of the RFFE at this location. The peer reviewer advised that an alternative RFFE technique was available and provided results from this alternative technique to use as part of the establishment of design flows to validate initial and continuing losses.

Response

As a means of checking the alternative RFFE values the peak flows for Billabong Creek as generated by the XP-RAFTS model and extracted from the TUFLOW model were compared against the alternative RFFE results. The tables below show the proposed results of the alternative RFFE approach in comparison to the XP-RAFTS and TUFLOW peak flows at Billabong Creek. The results indicate that the proposed TEST 4 initial and continuing loss values show a good match to the alternative RFFE values.

Table B.2 RFFE results for Billabong Creek

AEP	Test 4 TUFLOW flow (m^3/s)	Test 4 XP-RAFTS flow (m^3/s)	RFFE 2021 best overall flow (m^3/s)	RFFE 2021 average flow (m^3/s)
10%	83	123	110	105
5%	160	218	166.3	153
2%	235	289	243.3	218
1%	274	350	298.8	267

Resolution

Confirmed and agreed.

B.3.5 Hydrologic model lag time

The hydrologic model has assumed a channel lag routing speed it 0.6 m/s. While this value may be suitable for in bank flow in the lower reaches of the catchment, a review of the velocity map provided by WSP for the 1% AEP event indicates the general response of the system is slower. Additionally, it is considered that the use of a single velocity value is unlikely to provide an appropriate response for all catchments within the model.

It is noted that due to the hydraulic modelling inflow approach, this issue does not necessarily translate to large issues within the hydraulic model as local catchment runoff is used.

Response

Local inflows from each subcatchment are extracted from the XP-RAFTS model and input as local inflows. Many of the catchments are a single catchments upstream of the alignment and therefore the routing in XP-RAFTS is not relevant. For the LAC model there are 33 banks of culverts and all catchments to the 33 banks are included in the TUFLOW model. For Powder Horn Creek there are 2 bridges in this catchment and there is only 2.8km^2 of the total 24.3km^2 outside of the TUFLOW model which means 88% of the catchment is in the TUFLOW model and the routing is being undertaken in the TUFLOW model.

For the Murrumbidgee model, 33 culvert banks in this section of the project, 22 culvert catchments are completely within the TUFLOW model and therefore the routing occurs in the TUFLOW model. For the Billabong Creek bridge catchment, 147km^2 (95km^2 for Ironbong Creek and 51km^2 of Ulandra Creek) of the 320km^2 total catchment area are within the TUFLOW model. The Billabong Creek and Dudauman Creek peak flows have been calibrated to the RFFE.

Resolution

Noting focus at alignment is key this may not be of particular importance but does again hinge on the check the hydrologic and hydraulic model responds somewhat consistently to ensure the correct duration and TP are picked for hydraulic model.

Approach agreed and closed.

B.3.6 Hydrologic model roughness values

The roughness parameter, of 0.07 Manning's 'n', applied homogenously across the design model catchments, was chosen based on a review of The Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains United States Geological Survey Water-supply Paper 2339 (G.J. Arcement, Jr. and V.R. Schneider, USGS, 1989).

While the parameter may be appropriate there is a concern the friction was selected to fit an answer, rather than to fit the physical properties of the system. Working calculations and justification should be provided to confirm appropriate processes have been followed.

Response

Equation 6 of the document was adopted to estimate roughness. See workings below.

channels, the following equation can be used to estimate n values for a flood plain:

$$n=(n_b + n_1 + n_2 + n_3 + n_4)m \quad (6)$$

where:

n_b =a base value of n for the flood plain's natural bare soil surface
n_1 =a correction factor for the effect of surface irregularities on the flood plain
n_2 =a value for variations in shape and size of the flood-plain cross section, assumed to equal 0.0
n_3 =a value for obstructions on the flood plain
n_4 =a value for vegetation on the flood plain
m=a correction factor for sinuosity of the flood plain, equal to 1.0

By using Equation 6, the roughness value for the flood plain is determined by selecting a base value of n_b for the natural bare soil surface of the flood plain and adding adjustment factors due to surface irregularity, obstructions, and vegetation. The selection of an n_b value is the same as outlined for channels in Channel n Values. See Table 3 for n value adjustments for flood plains. The adjustment for cross-sectional shape and size is assumed

Floodplain roughness considered. Noting that many of the channels are only overland flow paths that occur following a rainfall event

Nb =	firm soil, smooth channel assumed	
from table 1	0.02	
N1 = moderate	0.006	
N2 = gradual	0	
from table 3		
N3 = negligible	0.003	
from table 3		
N4 = large	0.04	turf grass growing where average depth of flow is about equal to the height of vegetation
from table 3		
m = not applicable	1	
from table 3		
Equation 6	**0.069**	

Resolution

Agreed and closed.

B.3.7 Hydrologic model Initial and continuing losses

The adopted initial and continuing losses for the hydrologic models has been subject to the variation due to the range of attempts made to calibrate the model. As described in sections B.3.2 and B.3.4 the available flow data to calibrate to has been suspect.

Response

In agreement with the peer reviewer the alternative RFFE as described in section B.3.4 was ultimately used to calibrate the hydrologic models. The resulting initial and continuing losses can from TEST4 and are:

- initial loss – 30mm
- continuing loss – 1.72mm/hr.

Resolution

Agreed and closed.

B.3.8 Extreme event modelling

The extreme event was estimated using an outdated practice. However, in December 2015 the BoM released 0.05% AEP design rainfall.

Response

The BOM 0.05% AEP design rainfall data was adopted for use in the flood models with corresponding temporal patterns.

Resolution

Agreed and closed.

B.3.9 Boundaries and inflows

Issues were raised with regards to ponding at the boundary, with the boundary lines being too small to manage the outflow.

Response

The MUR model boundary was extended with the distance from the Olympic Highway to the end of the model is 2.6km direct and 3.5km along the stream. The flows and levels at the proposal are not affected by this downstream boundary.

The LAC hydraulic model boundary has been adjusted to encompass all overland flows.

Resolution

Agreed and closed.

B.3.10 Hydraulic model – cut-off depths

The TUFLOW model was a set map cut-off depth of 0.05m (50mm) and therefore all result layers do not show flooding under 50mm depth. Therefore, with the flood model results, some QDL criteria cannot be assessed.

Response

The cut-off depth was reduced to 0.0m.

Resolution

Agreed and closed.

B.3.11 Hydraulic model version

The software version of TUFLOW that has been utilised for the initial modelling was 2017-09-AC UFLOW_iSP_w64.exe. The model is utilising TUFLOW HPC (Heavily Parallelised Compute) on GPU (Graphics Processing Unit) hardware.

The TUFLOW 2018-03 release notes state the following: all users of the 2017-09 release are strongly recommended to upgrade to the latest 2018-03 release. It is therefore recommended that the TUFLOW model be updated prior to any re-runs to the latest TUFLOW version (currently 2018-03-AE) and that the software vendors notes are adhered to. This has the potential to affect the reported impacts of the project.

Response

The software version was updated to 2020-10-AB\TUFLOW_iSP_w64.exe.

Resolution

Agreed and closed.

B.4 Peer review closeout

The independent peer review was completed in June 2021 and found that generally the hydrological and hydraulic modelling undertaken for the proposal is consistent with the relevant guidelines and is appropriate for the Reference Design phase of the proposal.

The made the following recommendations for further model refinement at the detailed design stage:

1. For Billabong Creek, peak flow estimated by the TUFLOW model closely matches the RFFE expected peak flow. For detailed design a review of the peak flow timing and flood hydrograph volume will need to be completed to ensure the TUFLOW model includes the full flood volume.
2. Sensitivity testing on blockage of culverts. ARR2019 Book 6, Chapter 6 (Ball et al, 2019) outlines the most up to date guidance for the estimation of the risk of blockage of culvert structures. The approach considers a range of site specific factors to understand the risk and then calculate the estimated percentage blocked for a structure. ARR2019 suggests that there are several factors that most influence the likely blockage of bridge and culvert structures. For the Reference Design, the ARR2019 approach for blockage determined values from 0% blockage to 25% blockage. For existing culverts the same assessment was applied except for the Stockinbingal to Parkes rail line and Lake Cargelligo line culverts for which maintenance records and visual inspections during site visits indicated 50% blockage. Subsequently, a uniform blockage factor of 15% was applied to all new culverts. Sensitivity testing at detailed design should investigate the effects of higher blockage factors.

B.4.1 Billabong Creek volume

The Billabong Creek flow hydrograph has been compared between the TUFLOW model and the XP-RAFTS models to ensure the full flood hydrograph volume is being accounted for in the model. The graphs below present the evidence that the TUFLOW model includes the full flood hydrograph for a number of key locations across the proposal, including Billabong Creek.

It is therefore believed that this issue has been resolved. The flow hydrograph for the original peer review did not capture the entire floodplain flow extent. Figure B.4 below presents in green the previous PO line and the yellow line is the adjusted PO line. The resulting peak flow is now higher at a peak of 437m^3/s and the volume is estimated to 14,140 megalitres for the TUFLOW model. For the XP-RAFTS model the peak flow is approximately 382m^3/s with a volume of 15,700 Mega litres. It is noted that the peak flow estimates at all upstream locations where the proposal intersects the catchments are of the same magnitude. The design at Billabong Creek is constrained by the existing main southern rail tie in point.

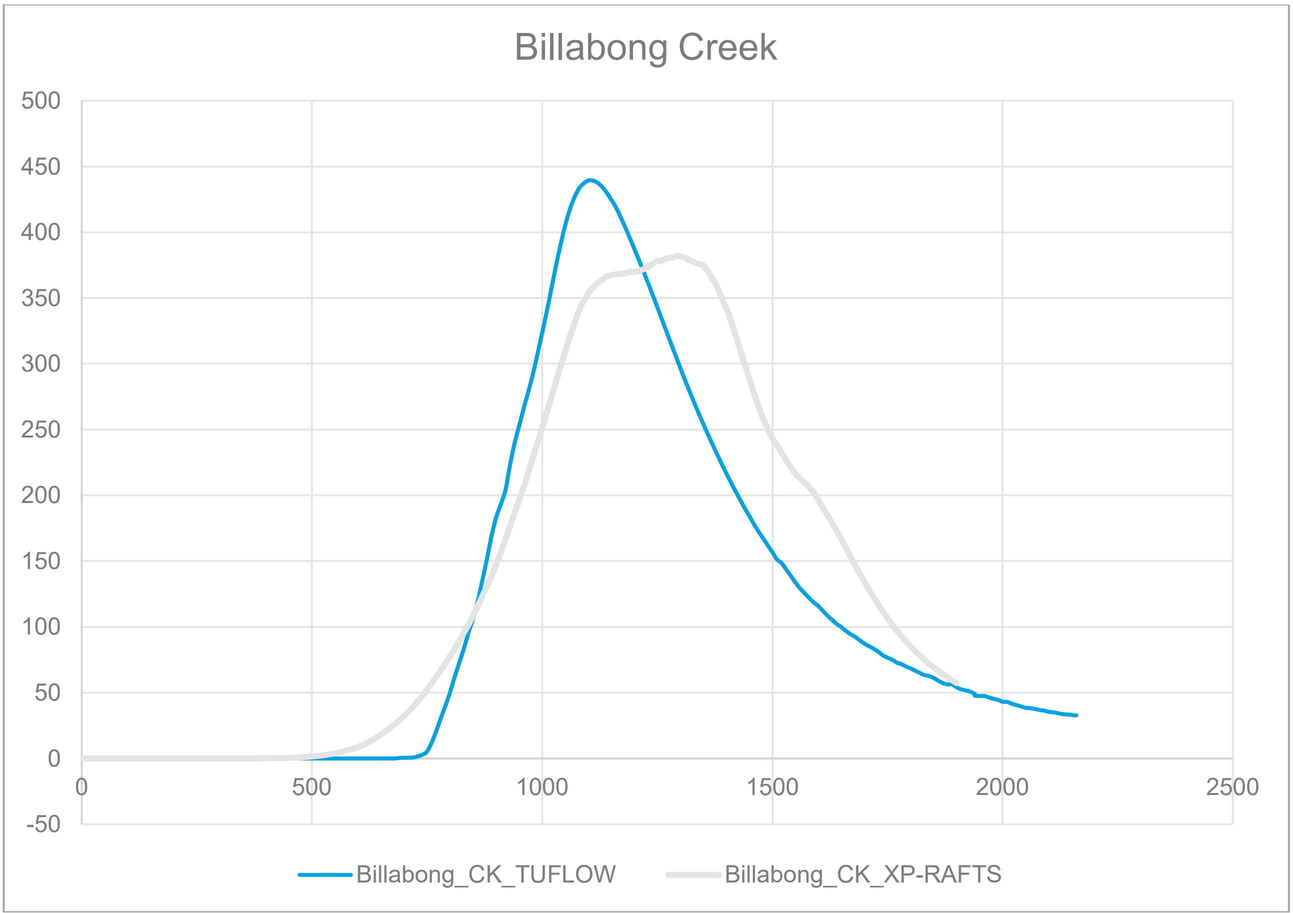

Figure B.3 Tuflow and XP-RAFTS flow hydrographs for Billabong Creek

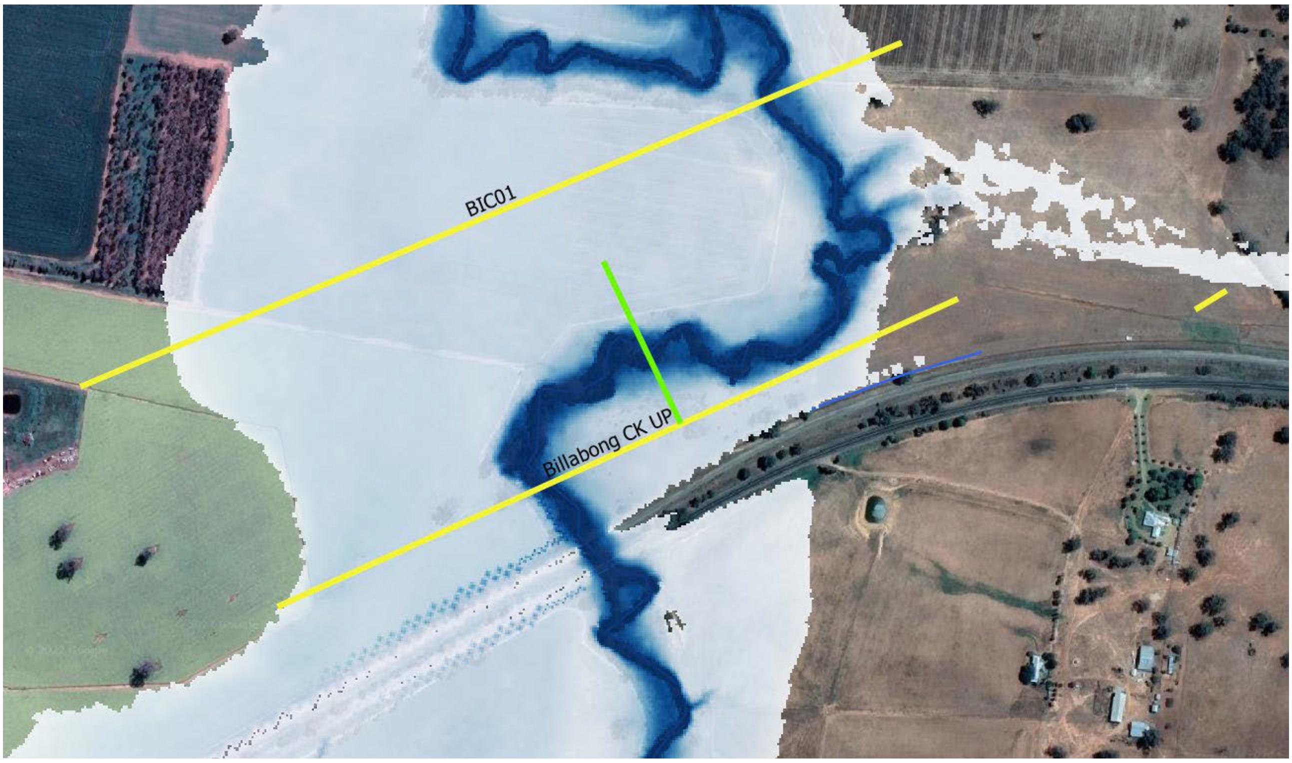

Figure B.4 Tuflow peak flow recording locations

B.4.2 Blockage

The results of the blockage assessment are presented in the main body of the report but the following two scenarios have been used to test the sensitivity of the proposal design to assumed blockage conditions at each culvert.

1. Clear – no blockage
2. 25% blockage