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Brisbane River Catchment Flood Study – Hydrology Phase

Hydrologic Model Calibration and Verification Review Report

Prepared for the State of Development (acting through): Department of State Development, Infrastructure and Planning/Department of Natural Resources and Mines

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Aurecon team

The Aurecon Team consists of Aurecon as lead consultant, supported by Deltares, Royal HaskoningDHV, and Don Carroll Project Management and Hydrobiology.

Executive summary

A detailed review of Seqwater's URBS model has been undertaken. This review has included:

- Sub-catchment resolution
- Spatially varying catchment characteristics: impervious areas and slope/reach length factors
- Sub-catchment routing methods and parameters and channel routing parameters
- Loss models
- Base flow
- Conceptual storages in the Lower Brisbane River model

The following changes are recommended to the Seqwater URBS model representation for use in the assessment of the Brisbane River Catchment Flood Study Hydrology Phase:

1. Remove the Kedron Brook catchment from the Brisbane River catchment area in the Lower Brisbane model
2. Adopt the inclusion of: impervious fraction to represent increased runoff volume in urban areas; urbanised areas to represent reduced response times; and reduced reach length factors for heavily modified reaches in the Lower Brisbane model
3. Adopt changes to the channel routing parameters for the following sub-catchment models:

   Lockyer Creek to O'Reilys Weir – n = 0.85

   Purga Creek to Loamside – n = 0.85

   Bremer River to Walloon – n = 0.85

4. Reject amendments to conceptual storages based upon DMT hydraulic model, but modify the adopted relationships by reducing the storage for flows above 10,000 m^3/s. Do not change the representation of the online conceptual storages as doing so introduces greater complexity that is not warranted
5. Reject the suggested change of including a diminishing CL rate by introducing a maximum soil storage infiltration capacity. This adds further complexity without necessarily producing a better model calibration
6. Maintain the linear base flow model as the introduction of a non-linear base flow model does not change the model calibration performance significantly. Introduce a Base flow Volume Factor to cap the base flow based upon the findings of the ARR Revision Project 7 Stage 2 Final Report

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1 Introduction

Section 3.6.6.2 of the Brisbane River Catchment Flood Study (BRCFS) brief (dated 1 July 2013) provides details of the requirements of the review of the Seqwater hydrologic (URBS) model. The brief indicates the following:

'For the purpose of the BRCFS, it is considered that the transformation of the design rainfall event inputs to design flood hydrographs at points of interest requires a hydrologic model (runoff routing model) that satisfies the following requirements:

- *ability to input dimensionless space-time fields of rainfall in combination with design rainfall depths for different durations and AEPs*
- *ability to run with loss models that adequately reflect the runoff formation process and its variability with different antecedent conditions and event magnitudes*
- *adequate spatial resolution to reflect the important variations in rainfall inputs over the catchment and to reproduce the hydrograph formation process in smaller tributary catchments*
- *ability to model significant storages and their routing impacts, including the ability to interface with a module that simulates the complex dam operations procedures*
- *ability to produce and store ensembles of hydrograph outputs at key locations and summary statistics of key hydrograph characteristics from multiple runs and*
- *efficient running time to allow simulation of large number of events in a Monte Carlo Simulation (MCS) framework*

It appears that the URBS model being developed, calibrated and used by Seqwater for the purposes of the WSDOS project should satisfy most of the above requirements for the BRCFS. The Consultant is required to review and adapt the latest URBS model to ensure that all the requirements for the BRCFS are satisfied. The Consultant will need to ensure that they are using the latest version of URBS. They will need to discuss with Seqwater to ensure consistency in the application of the model software as well as the model results derived.

Calibrated hydrologic models (URBS) of the entire Brisbane River catchment that have been developed by Seqwater will be provided to the Consultant at the outset of the project. Documentation of the model is currently being prepared and will be provided as soon as it becomes available (expected around June 2013).

The Consultant is required to:

Undertake a critical review of the setup of Seqwater's hydrologic model and determine whether the setup of Seqwater's hydrologic model is suitable for the objectives of the study. This is to include an assessment of:

- *Sub-catchment resolution and stream/floodplain delineation and characterisation (including base flow simulation methodology and parameters)*
- *Spatially varying catchment characteristics (including impervious fraction, slope and soil moisture characteristics)*
- *Sub-catchment routing methods and parameters*
- *Channel routing methods and parameters*
- *Ratings at locations not previously assessed and handling of downstream backwater and sea level influences*
- *The type of loss model and*
- *All other key model parameters*

Review the level of calibration achieved in the hydrologic model and the appropriateness and reasonableness of the parameters involved in the calibration. Identify any persistent calibration differences between modelled and observed data.

Identify all hydrologic model modifications that may be required to achieve the objectives of the study (including an ability of the model – in conjunction with hydraulic models to be subsequently developed – to consider a broad spectrum of possible flood mitigation options), and provide an estimate of their cost; and

Prepare a brief report summarising the outcomes of the above tasks including recommendations for modification and or refinement including justification and costs as well as providing a brief discussion of any alternative approaches.'

As noted in the sections below, Seqwater's hydrologic modelling was developed primarily for the purposes of dam flood operation and optimisation. Although there is significant overlap, the BRCFS hydrologic model has different purpose and focus, including but not limited to:

- Increased emphasis on catchments downstream from Wivenhoe Dam
- Ability to model synthetic flood events much larger than those for which the Seqwater model was calibrated

This report provides the summary of the investigations that have been undertaken to assess the required modifications to the Seqwater hydrologic model to ensure that it is fit for purpose in deriving design flood estimates for the Brisbane River Catchment Flood Study (BRCFS).

2 Seqwater URBS model

2.1 Introduction

The Seqwater URBS Model was detailed in a final report and relevant model files provided to Aurecon on 10 October 2013. The final report is titled, 'Brisbane River Flood Hydrology Models', dated December 2013. This report indicates that the primary purpose of the revised flood hydrology models is to *'provide a best estimate of flood hydrographs for:*

- Flood Operations – To use in Real Time Flood Operations to estimate flows through the Brisbane River basin and, in particular, estimate the inflows to Somerset and Wivenhoe Dams
- Wivenhoe and Somerset Dam Optimisation Study (WSDOS) – To support evaluation of alternative dam flood operations rules using a range of historical, design and stochastic (synthetic) events to be derived using the hydrology models
- Brisbane River Catchment Flood Study (BRCFS) – This study requires consistent flood estimation for planning and flood operations. The revised flood models developed by Seqwater may provide a useful starting position for the BRCFS hydrology investigations'

The report also emphasises that the hydrologic models developed and calibrated as part of the investigation were designed primarily to satisfy the first two objectives, but may also be considered a basis for the third purpose. Various aspects of the hydrologic model configuration and calibration have been described in the Seqwater report. The following sections describe the main features of this work.

Seqwater also provided a copy of the Peer Review Panel report that considered the Version 2 Seqwater Draft report dated 22 August 2013, that was provided to the PRP on 10 September 2013.

2.2 Sub-catchment resolution

Seqwater divided the Brisbane River basin into seven sub-catchments (refer to Figure 2-1), representing the main contributing tributaries and the mainstream of the Brisbane River. When considering the sub-division adopted for this investigation, the following factors were considered:

- Scale/definition of models
- Efficiencies of model run times
- Uncertainties in rainfall and ratings
- Operational requirements for derivation of inflows to dams and flows in catchments below dams

Seqwater recognised that decreased scale (increased number of models) could provide an opportunity for applying locally specific loss and routing parameters. For comparison, the 1994 study conducted by DNRM subdivided the Brisbane Basin into 20 sub-catchments, including six sub-catchments above Wivenhoe Dam as shown in Figure 2-1.

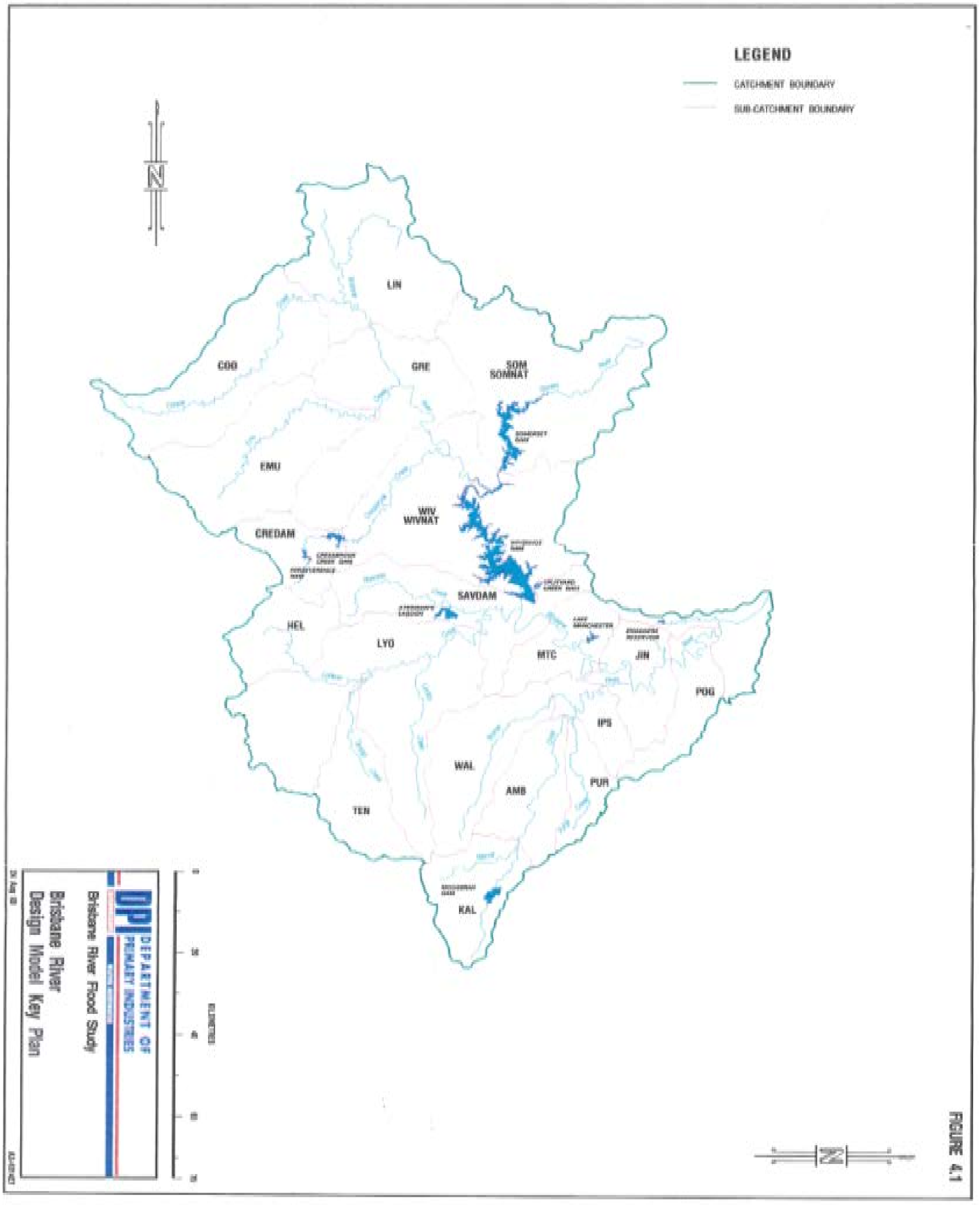


Figure 2-1 Brisbane River Basin DNRM sub-catchments (Source: Brisbane River and Pine River Flood Study (DNR, 1993))

However, the increased spatial representation adds complications due to increased numbers of model parameters. It was also noted that the sub-catchment models located within the cascade arrangement are dominated by upstream inflows, resulting in the routing parameters of the lower models being relatively ineffectual, and hence the routing response being dominated by the performance of the upstream models.

Seqwater argued that the increased division and number of models adds greater complexity (hence potential for errors) and also decreases the potential to make best use of available gauge data with consideration of rating uncertainties. The final adopted basin sub-division was considered an optimal compromise between the factors above. The resultant sub-models are shown in Figure 2-2.

The hydrologic models were developed using a one-second hydrologically enforced DEM from Geosciences Australia. CatchmentSIM was used to delineate the Brisbane basin into seven sub-catchments representing the major tributaries and mainstream of the Brisbane basin. Each catchment was then sub-divided into smaller equally sized sub-areas where possible.

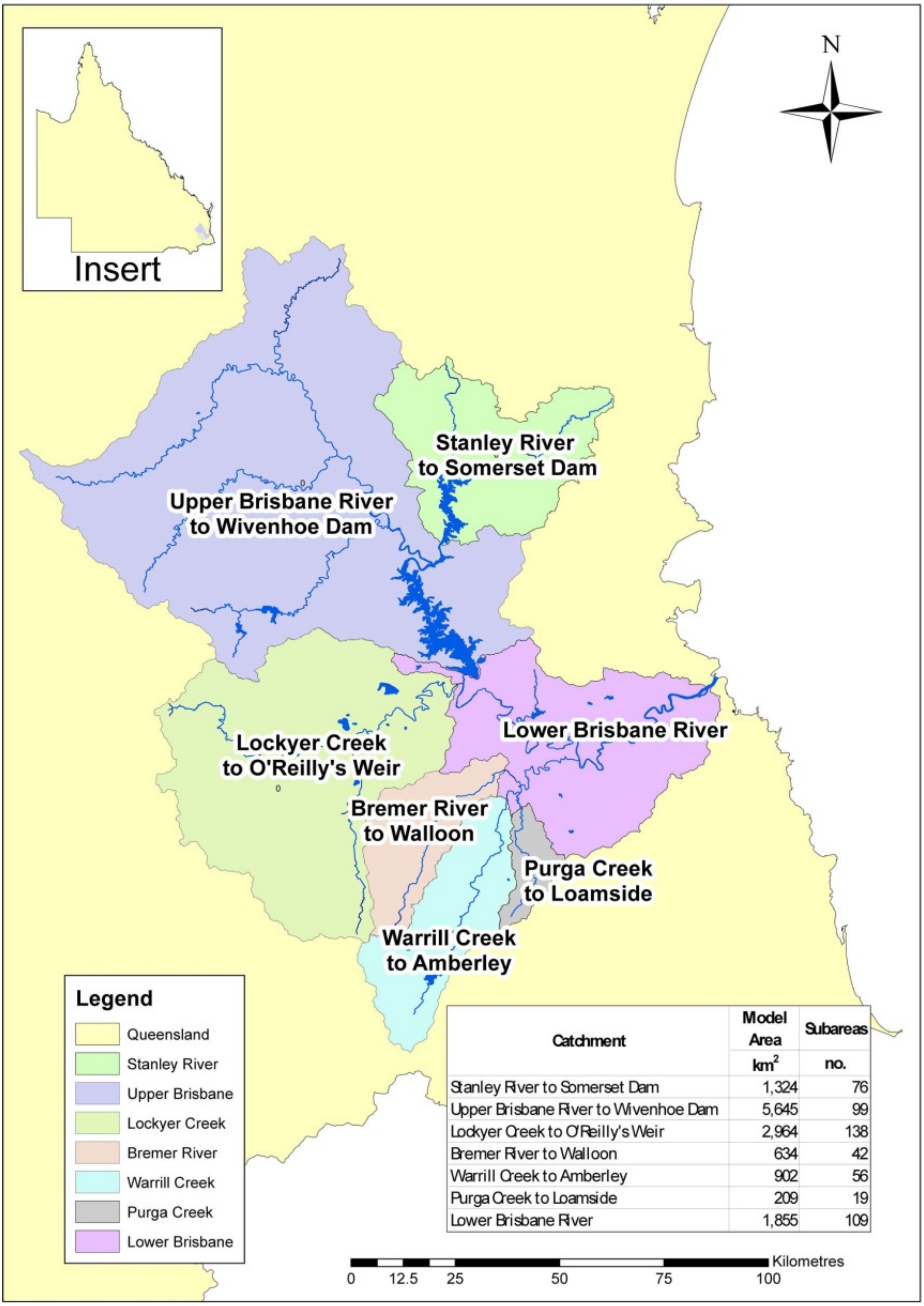
The adopted sub-area characteristics for each of the seven catchments are shown in Table 2-1.

Table 2-1 Sub-catchment characteristics

Sub-catchment	Area (km^2)	Proportion (%)	Number of sub-areas	Average size of sub-area (km^2)
Stanley River to Somerset Dam	1,324	9.8	76	17.4
Upper Brisbane River to Wivenhoe Dam	5,645	41.7	99	57.0
Lockyer Creek to O'Reilly's Weir	2,964	21.9	138	14.2
Bremer River to Walloon	634	4.7	42	15.1
Warrill Creek to Amberley	902	6.7	56	16.1
Purga Creek to Loamside	209	1.5	19	11.0
Lower Brisbane River	1,855	13.7	109	17.0
Total	13,533	100.0	539	25.1

The Seqwater Peer Review Panel endorsed the catchment sub-division as they considered it allowed *'for separate parameterisation and calibration of the tributary models, and different vector files for pre- and post-dam conditions reflect the specific characteristics of each catchment area. Overall, the adopted URBS model representation of the Brisbane River catchment is considered to strike the right balance between model complexity and modelling efficiency.'*

Aurecon agree with this conclusion and concur that the URBS model representation is appropriate for use in the BRCFS Hydrology assessment in all but one location. It was found that the DEM used by Seqwater included the Kedron Brook catchment as part of the Lower Brisbane River sub-catchment. This is not the case (as represented in more detailed topographic information) therefore subareas associated with Kedron Brook catchment have been removed from the Lower Brisbane model. No further refinement to the sub-catchment configuration is suggested for the use of the hydrologic model in the BRCFS – Hydrology phase.



Catchment	Model Area km^2	Subareas no.
Stanley River to Somerset Dam	1,324	76
Upper Brisbane River to Wivenhoe Dam	5,645	99
Lockyer Creek to O'Reilly's Weir	2,964	138
Bremer River to Walloon	634	42
Warrill Creek to Amberley	902	56
Purga Creek to Loamside	209	19
Lower Brisbane River	1,855	109

Figure 2-2 Brisbane River Basin Seqwater sub-catchments (Source: Brisbane River Flood Hydrology Models (Seqwater, 2013))

2.3 Spatially varying catchment characteristics

2.3.1 Impervious areas

2.3.1.1 Reservoir surface areas

The Seqwater URBS models have assumed impervious areas for the reservoir surface areas only and have not included impervious areas associated with urbanised areas. This was also noted by SKM in their review (SKM, 2013). The reservoir surface areas of the six reservoirs considered significant represent nearly 170 km^2 or 1.3% of the total surface area of the Brisbane River basin. Details of the reservoirs represented in the URBS models are shown in Table 2-2.

Table 2-2 Reservoirs included

Reservoir	Year completed	Capacity (ML)	Surface area (ha)
Lake Manchester	1916	25,690	281
Somerset Dam	1953	369,000	4,350
Moogerah Dam	1961	83,700	827
Perservence Dam	1965	30,140	220
Cressbrook Creek Dam	1983	81,840	517
Wivenhoe Dam	1985	1,165,000	10,800
Total		**1,755,370**	**16,995**

2.3.1.2 Urbanisation

Seqwater did not include any allowance for impervious fractions of urban areas. This was because their focus was pre-dominantly on estimating flows at Moggill, which is located upstream of the Brisbane City urban area. Therefore, the effect of the urbanisation was not considered to be significant. [Note for long duration events and high ARI's, pervious areas becomes saturated and the effect of urbanisation is diminished]

SKM concluded: *'Nor do they have sub-catchment or channel routing modified to represent urbanisation of the catchment. Urbanisation around Brisbane and Ipswich is likely to have changed the routing response in parts of the lower Brisbane model over time. Since most of this urbanisation occurs downstream of Moggill, which is the location of primary interest to Seqwater for dam operations, this was not a serious concern for the current project. However, it is recommended that the representation of the runoff generation and routing response from urban areas of Brisbane and Ipswich is checked and updated as part of the BRCFS.'*

In URBS there are three ways to account for the effects of urbanisation: inclusion of impervious areas to account for increased runoff volumes, inclusion of urbanisation to account for the reduced response times, and reduction in channel routing characteristics to account for the increased conveyance of heavily modified channel reaches. The change in sub-catchment response however decreases with increasing event magnitude.

SKM's recommendation has been investigated by consideration of the inclusion of impervious fraction, urbanisation and reduced reach length parameters in the urban areas. Aurecon recently completed a flood study of Oxley Creek on behalf of Brisbane City Council (Aurecon, 2013). This assessment included representation of impervious areas within the Oxley Creek catchment based upon land use/planning coverage's. Typical values of impervious fraction have been translated from the Oxley Creek hydrologic model and expanded to cover the entire lower Brisbane model. Urbanised areas have also been identified from this dataset. In addition, heavily modified channel reaches have been identified from aerial imagery.

2.3.2 Slope/reach length factors

Reach length factors can be applied to accommodate varying river reach travel times. In steeper parts of the catchment, channel velocities tend to be higher than in the lower reaches. This may be represented by applying a low reach length factor (effectively shortening the river reach) in the upper reaches and a higher reach length factor in the lower reaches. Reach length factors ranged from 0.5 (steep slope) to 1 (normal) and up to a maximum of 2 (mild slope).

The influence of drowned reaches through the dam reservoirs can be represented by reducing the relative travel time in reservoir reaches. In the URBS model, this is achieved by using a reduced reach length factor; in this case a factor of 0.5 was adopted, which effectively halves the travel time in the reservoir reaches. The factor of 0.5 is similar to that adopted in other south east Queensland dams and was verified by hydraulic modelling in the Wyaralong Dam design.

The PRP (Peer Review Panel, 2013) noted that: *'Reach length factors allow for reduced travel times through river reaches where the flood wave travels faster than through normal reaches. The adoption of a reach length factor of 0.5 for the reaches drowned by reservoirs (implying a travel speed twice as fast as through normal river reaches) seems to underestimate the dynamic flood wave travel speed, which in relatively deep reservoirs can be 10 times faster than the kinematic wave speed in normal river reaches (implying a reach length factor of 0.1).'*

Additional analysis undertaken by Seqwater (2013) into the impacts of various reach length factors in Warragamba, Somerset and Wivenhoe dams concluded that alteration of the reach length factor from 0.5 to 0 typically resulted in an increase in peak flows of up to 5% and a reduction in timing of arrival of the peak of up to 4 hours. In Somerset and Wivenhoe dams this resulted in an overestimation of the peak flow and time of travel within the reservoir.

A review of the 1994 DNRM report on the Somerset Dam – Dam Failure Analysis yields estimates of flood wave celerity for Lake Wivenhoe for a range of design and failure flood scenarios. In this study a one-dimensional hydraulic model (Rubicon) was calibrated to a number of historical events including the January 1974 flood (pre-Wivenhoe Dam), and the April 1989 flood (post-Wivenhoe Dam). Design flood scenarios had flow ranges varying from 2,500 m^3/s to 12,000 m^3/s assuming an initial lake level of EL67.0 m AHD. The typical flood wave celerity for Lake Wivenhoe varies between 14 m/s and 21 m/s. The depth of Lake Wivenhoe varies between 13 m to 48 m for the reach under consideration. Typical travel time of a flood wave from Somerset Dam tailwater to Wivenhoe Dam headwater, (an assumed distance of approximately 73.8 km), is typically around one hour according to the assessments conducted. Whilst this effect is noted, without specific data on each of the reservoirs under investigation, Aurecon consider the reach length factors to be reasonable and justifiable based upon hydraulic modelling and known physical catchment characteristics. Therefore, no modifications of the reach length factors are recommended.

2.4 Sub-catchment routing methods and parameters and channel routing parameters

URBS simulates catchment routing by a network of conceptual storages representing the sub-catchment routing, channel (stream network) routing and reservoir routing. Seqwater used the URBS split model mode in the study which separates the catchment and channel routing for each sub-catchment. In this model arrangement, excess rainfall on a sub-catchment is routed to the creek channel. The lag of the sub-catchment storage is assumed proportional to the square root of the sub-catchment area. The inflow from the sub-catchment into the channel is assumed to occur at the centroid of the sub-catchment. The sub-catchment 'outflow' is then routed along a channel reach using linear (or non-linear) Muskingum method. The channel reach lag time is assumed proportional to the length (or derivative) of the reach.

The sub-catchment routing is defined by:

$$S_{catch} = \beta.\sqrt{A}.\ Q^{m}$$

Where, S_{catch}= Catchment Storage

β = Catchment Lag Parameter

A = Area of sub-catchment (km2)

m = Catchment non-linearity parameter

Channel routing is defined by:

$$S_{chnl} = \alpha.f.L.(x.Q_u + (1-x).Q_d)^{n}$$

Where, S_{chnl}= Channel Storage

α = Channel Lag Parameter

f = Reach Length Factor

L = length of reach (km)

Q_u = inflow at upstream end of reach (includes catchment inflow) (m^3/s)

Q_d = outflow at downstream end of the channel reach (m^3/s)

x = Muskingum translation parameter (normally 0.2 to 0.3)

n (exponent) = non-linearity exponent (normally use n = 1)

The sub-catchment routing exponent (m) is typically adopted as 0.8. For channel routing, linear Muskingum routing is typically adopted (exponent n=1). To calibrate the routing behaviour of the model, the main two parameters that are varied to be catchment specific are:

- Alpha (α) which is a measure of channel travel time
- Beta (β) which is a measure of sub-catchment storage

For linear Muskingum channel routing, the value of alpha is close to the inverse of travel time in km/hour and may be initially estimated from recorded data and/or hydraulic river models, an allowance however needs to made for numerical diffusion effects. A low value of alpha reduces channel travel time. Previous studies in south east Queensland have found beta to be between 1 and 4. A high value of beta increases sub-catchment storage and results in a slower hydrograph recession. Adopted model parameters are summarised in Table 2-3.

Table 2-3 Adopted sub-catchment model parameters

Sub-catchment	Alpha (α)	Beta (β)	m	n
Stanley River to Somerset Dam	0.16	4.3	0.8	1.0
Upper Brisbane River to Wivenhoe Dam	0.13	2.8	0.8	1.0
Lockyer Creek to O'Reilly's Weir	0.30	3.0	0.8	1.0
Bremer River to Walloon	0.35	3.0	0.8	1.0
Warrill Creek to Amberley	0.75	2.8	0.8	0.85
Purga Creek to Loamside	0.40	3.4	0.8	1.0
Lower Brisbane River	0.15	2.9	0.8	1.0

Note: * Non-linear routing used

The Peer Review Panel suggested that for a number of the URBS sub-catchment models, *'it would be desirable to examine more closely any trends in routing parameters and storage-discharge characteristics with flood magnitude, and to base extrapolation on links with physical catchment, river and floodplain morphology characteristics.'*

SKM (October 2013) reviewed the relationship between alpha and beta, alpha and event peak and beta and event peak and concluded that:

- There was no systematic relationship between Alpha and Beta, and hence the sub-catchment and channel routing components of the URBS models are being utilised appropriately
- There is no evidence of systematic relationship between Beta and Event Peak, and hence there is an appropriate degree of non-linearity captured in the models
- There is some evidence that Alpha reduces with event magnitude in those models that adopted linear channel routing. This may lead to an underestimation of design events that are larger than the calibration event magnitudes that have been considered

Aurecon has investigated channel routing linearity for each sub-catchment using available sub-catchment recorded data. It is suspected that any evident non-linearity may be due to short circuiting of the channel in the larger flood events.

2.5 Rating curves

This topic is covered in the Data, Rating Curve and Historical Flood Review Report (Aurecon, 2013).

2.6 Loss models

Seqwater adopted an initial loss/continuing loss (IL-CL) type rainfall loss model. The IL-CL type model is a simplistic yet effective representation of the rainfall-runoff process and is commonly used in flood modelling in Australia.

Essentially, the initial loss represents the depth of rain that occurs between the event start time and the commencement of runoff which is typically defined by the initial rise in river water levels. Physically the initial loss is assumed to represent the rainfall lost to interception by vegetation, infiltration and shallow depression storage which occurs before surface runoff commences.

The continuing loss rate lumps together on-going losses such as infiltration, interception and evapo-transpiration which occur during a storm.

Spatially varying initial and continuing loss rates can be accounted in the URBS model at the sub-area level but this typically requires comprehensive detail in rainfall data and a dense network of gauging stations with good quality rating relationships throughout each sub-catchment model. Seqwater adopted an initial loss and continuing loss rate that was applied uniformly over each sub-catchment model. Aurecon considers that this is an appropriate level of complexity.

To calibrate the rainfall-runoff component of the model, two parameters are required:

- Initial loss (IL) in mm
- Continuing Loss (CL) in mm/hour

Adopted rainfall loss parameters for the calibration events are summarised in Table 7.81 and 7.82 of the Seqwater Report.

In summary the initial loss rates varied from 0 to 180 mm for the 38 calibration events post 1955 (only daily data are available prior to 1955). The results demonstrate a general consistency between events and they also tend to reflect the antecedent conditions that prevailed before the flood events. Lowest initial losses generally occurred in the Stanley River catchment located in the north east of the Brisbane catchment. Highest initial losses and continuing losses generally occur in the Lockyer Creek catchment, and this is consistent with lower rainfall that occurs in this area as well as the relatively large areas available for groundwater recharge. Figure 2-3 shows the distribution of initial loss rates adopted by Seqwater for the 38 post 1955 calibration events.

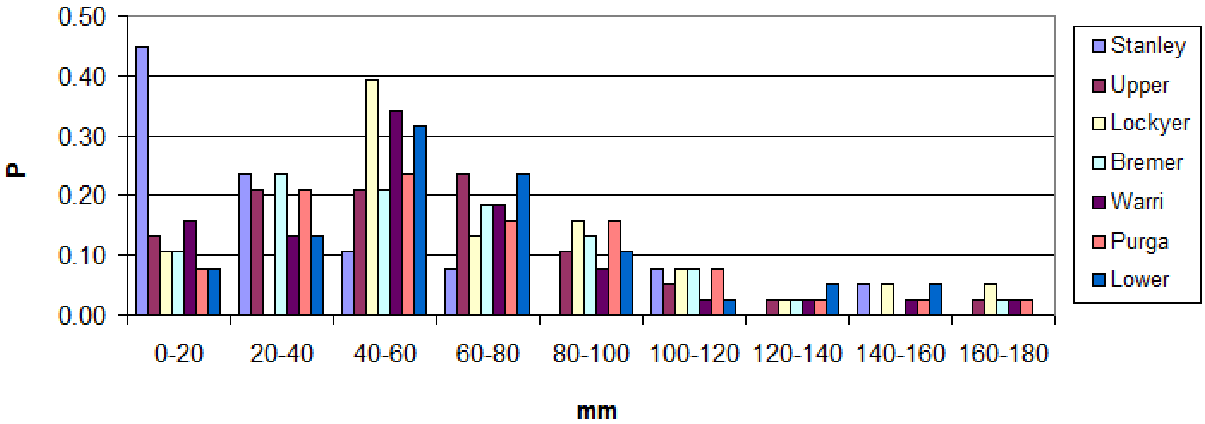


Figure 2-3 Initial loss rate distribution – Seqwater calibration events

The average continuing loss rate across all 38 calibration events for each of the sub-catchment models is shown in Table 2-4. The adopted continuing losses vary from 0 to 7.5 mm/hour, but are generally in the range of 2 to 3 mm/hour.

Table 2-4 Average continuing loss rate

Sub-catchment	Continuing loss (mm/hour)
Stanley River to Somerset Dam	2.0
Upper Brisbane River to Wivenhoe Dam	2.5
Lockyer Creek to O'Reilly's Weir	2.7
Bremer River to Walloon	1.8
Warrill Creek to Amberley	2.0
Purga Creek to Loamside	2.2
Lower Brisbane River	2.4

Figure 2-4 shows the distribution of continuing loss rates adopted by Seqwater for the 38 post 1955 calibration events.

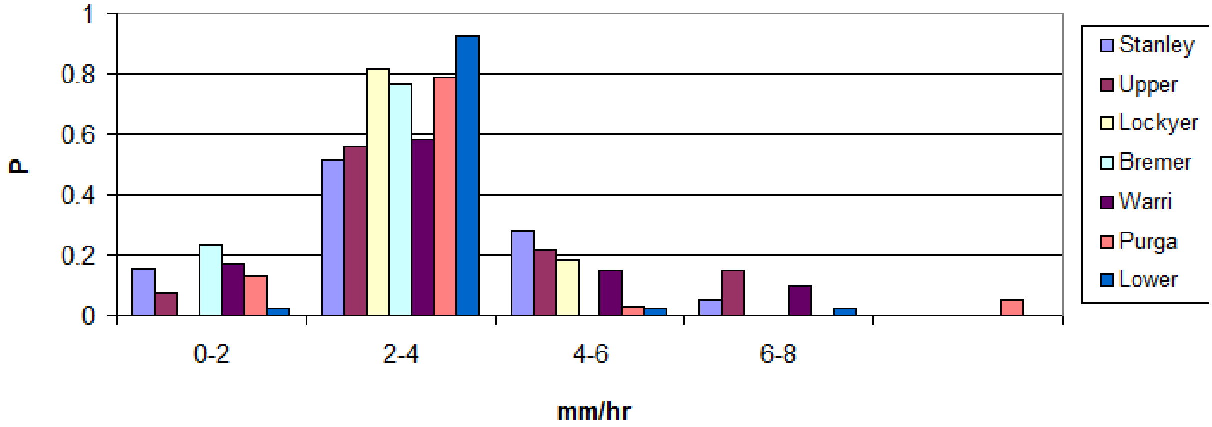


Figure 2-4 Continuing loss rate distribution – Seqwater calibration events

[Interestingly, the Consultant also conducted studies using Monte Carlo techniques to determine the relationship between continuing loss and model time interval. This was important as all events prior to 1955 were based on a daily rainfall. The Consultant found that it was necessary to reduce the 1 hourly CL by 50% when daily rainfall is applied. This is in accord with Seqwater's findings.]

SKM (October 2013) concluded that:

'The adopted values of initial and continuing loss parameters (IL, CL) appear to be consistent between adjacent catchments and appear to vary between events in a manner that would be consistent with variability in climatic conditions.'

It was mentioned in discussions between Aurecon and Seqwater that the performance of the loss model may be improved by including a diminishing continuing loss rate, especially for the long duration flood events, such as January 1974 and January 2013.

Aurecon investigated the inclusion of the URBS' spatially varying soil storage model (assumed linear) that effectively reduces the continuing loss rate to zero once the soil stores are full. The key parameter is the maximum soil storage capacity and as a linear distribution of soil stores are assumed, halving this value represents the mean soil storage capacity for the catchment (refer to Figure 2-5).

Sensitivity comparisons were then conducted between the adopted parameters and the modified CL rate estimates including the starting CL rate.

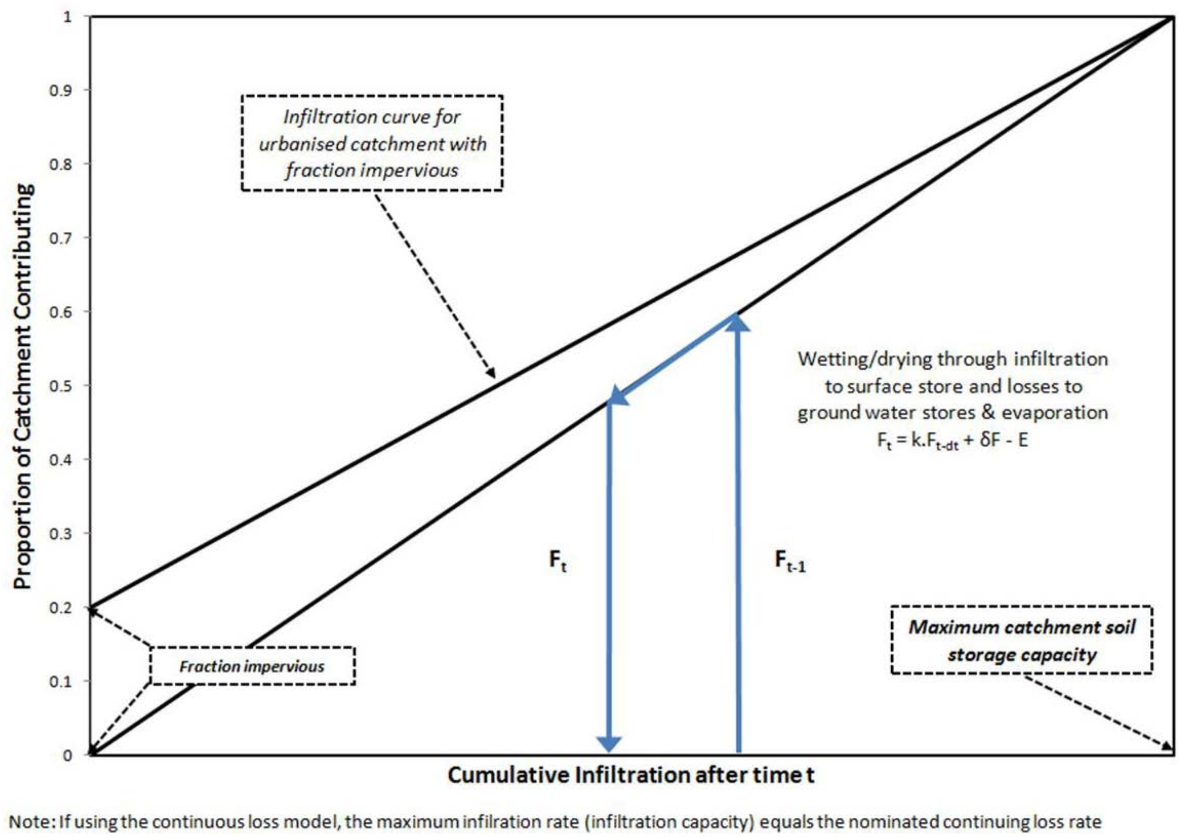


Figure 2-5 Definition of infiltration capacity characteristics (Source: URBS Manual, 2012)

2.7 Other key model parameters

2.7.1 Base flow

As the volume of runoff becomes a critical component in accurately forecasting water levels in real-time flood operations of dams, Seqwater incorporated base flow into the sub-catchment estimates of runoff using the linear base flow model included in URBS.

Base flow is calculated using the following equation:

$$BF_{(t)} = BF_{(t-1)} \times BR + QF^{BM} \times BC$$

Where,

$BF_{(t)}$ = Base flow at time t

$BF_{(t-1)}$ = Base flow at previous time t-1

BR = Base flow Recession Constant (Daily Value)

QF = Quick-flow component of the hydrograph

BC = Base flow Constant (Daily Value)

BM = Base flow Exponent (1 for Linear or < 1.0 for Non-Linear)

Seqwater assumed a linear model and used the procedure described in Section 2.3 of Book V in Australian Rainfall and Runoff (IEAust, 2003a) to identify the base flow parameters BC and BR.

Whilst the linear assumption is a relatively simplistic approach of base flow representation, Seqwater considered that it was appropriate for their intended use for flood operations assessment.

It was noted that the simplistic representation of base flow was not considered appropriate for the Lockyer Creek catchment because of its complex groundwater characteristics and accordingly was not included in its sub-catchment model.

Table 2-5 shows the adopted base flow model parameters. It should be noted that these are daily values that are adjusted within URBS model to reflect hourly time steps.

Table 2-5 Adopted base flow model parameters

Sub-catchment	Daily			
	BFI*	BM	BR	BC
Stanley River to Somerset Dam	0.143	1.0	0.70	0.050
Upper Brisbane River to Wivenhoe Dam	0.122	1.0	0.87	0.018
Lockyer Creek to O'Reilly's Weir	N/A	N/A	N/A	N/A
Bremer River to Walloon	0.143	1.0	0.70	0.050
Warrill Creek to Amberley	0.250	1.0	0.70	0.100
Purga Creek to Loamside	0.143	1.0	0.70	0.050
Lower Brisbane River	N/A	N/A	N/A	N/A

Where BFI = BC/(1 – BR + BC). The BFI's calculated here are for events, and not for the entire flow regime.

The adopted base flow parameters were reviewed by SKM (October 2013) and the Seqwater Peer Review Panel (PRP). Concern was expressed by SKM that the adoption of a linear base flow model would tend to over-estimate the contribution of base flow for very large to extreme events. As a consequence SKM recommended that the method of base flow generation should be re-examined particularly to obtain an understanding of its likely behaviour in large to extreme flood events. This recommendation echoes the findings of the Stage 2 Final Report into base flow simulation (EA, 2013). This report implies that the proportion of base flow to total flow diminishes with event magnitude in terms of both peak and volume characteristics.

The PRP remarked that the base flow representation that has been adopted by Seqwater has the following impacts:

- The base flow contribution to Stanley River flood flows was found to be relatively low (up to 5%) and base flow recession relatively fast
- The base flow contribution to flood flows in the Upper Brisbane River was found to be very low (up to 2%) and base flow recession relatively slow
- Because of the presence of large aquifers and complex interactions of surface water and groundwater systems, the base flow processes in the Lockyer Creek catchment were considered to be too complex for identification of base flow contributions to flood hydrographs
- The base flow contribution to Bremer River flood flows was found to be relatively low (up to 5%) and base flow recession relatively fast, similar to the neighbouring Warrill Creek catchment
- The base flow contribution to Warrill Creek flood flows was found to be moderate (up to10%) and base flow recession relatively fast
- The base flow contribution to Purga Creek flood flows was found to be small to moderate (up to 5%) and base flow recession relatively fast
- It was not considered practical to include base flow in the Lower Brisbane River model – this would not pose any significant limitation on modelling of floods in this river reach

Aurecon have investigated the base flow parameters that were adopted by Seqwater. A sensitivity analysis was conducted to examine the impact of modifying BM and using a non-linear base flow response. The sensitivity analysis was conducted by varying the base flow exponent (BM) value whilst maintaining the Base flow Index (BFI) adopted during calibration through changing the value of BC alone. A methodology for implementing the capping of the base flow contribution for large to extreme flood event magnitudes have also been devised for implementation in assessing design floods and is discussed in Section 5.5 of this report.

2.7.2 Storages

2.7.2.1 Reservoirs

Fixed crest reservoirs such as Cressbrook Creek Dam, Moogerah Dam and Lake Manchester were modelled in URBS by defining the reservoir stage-storage relationship, spillway stage discharge relationship and the initial level in the dam at the start of the event. These storages are represented by elevation-storage and storage-discharge relationships through a level–pool routing algorithm.

2.7.2.2 Conceptual floodplain storages

Seqwater also introduced conceptual storages into the some of the sub-catchment models to represent distinct floodplain routing behaviour. This methodology used a similar approach of storage definition adopted above for the reservoirs by defining a storage-discharge relationship. It must be noted however that the hydrodynamics of the lower Brisbane River, including interactions of the lower Brisbane River with the Lockyer Creek and Bremer River floodplains, are very complex. Although it may be possible to produce a generally reasonable representation of general flood characteristics across a wide range of magnitudes, there are many situations that cannot be represented by a simple hydrologic routing model.

The location of the conceptual storages is shown in Figure 2-6 and are defined as follows:

A. Junction of Lockyer Creek and Brisbane River upstream of Savages Crossing
B. Brisbane River between Savages Crossing and Mt Crosby near the junction with Black Snake Creek
C. Junction of Bremer River and Warrill Creek near Amberley
D. Lower Bremer River from upstream of Ipswich to the Brisbane junction near Moggill
E. Brisbane River downstream of the Bremer and Brisbane Rivers near Goodna and Wacol, and
F. Junction of Brisbane River and Oxley Creek around Rocklea

Figure 2-6 is based on the Seqwater Figure 7-95 (Seqwater (2013). This figure in turn is based on the *Brisbane River Hydraulic Model to PMF Report*, (BCC,2009) inundation mapping for a flow of 10,000 m^3/s.

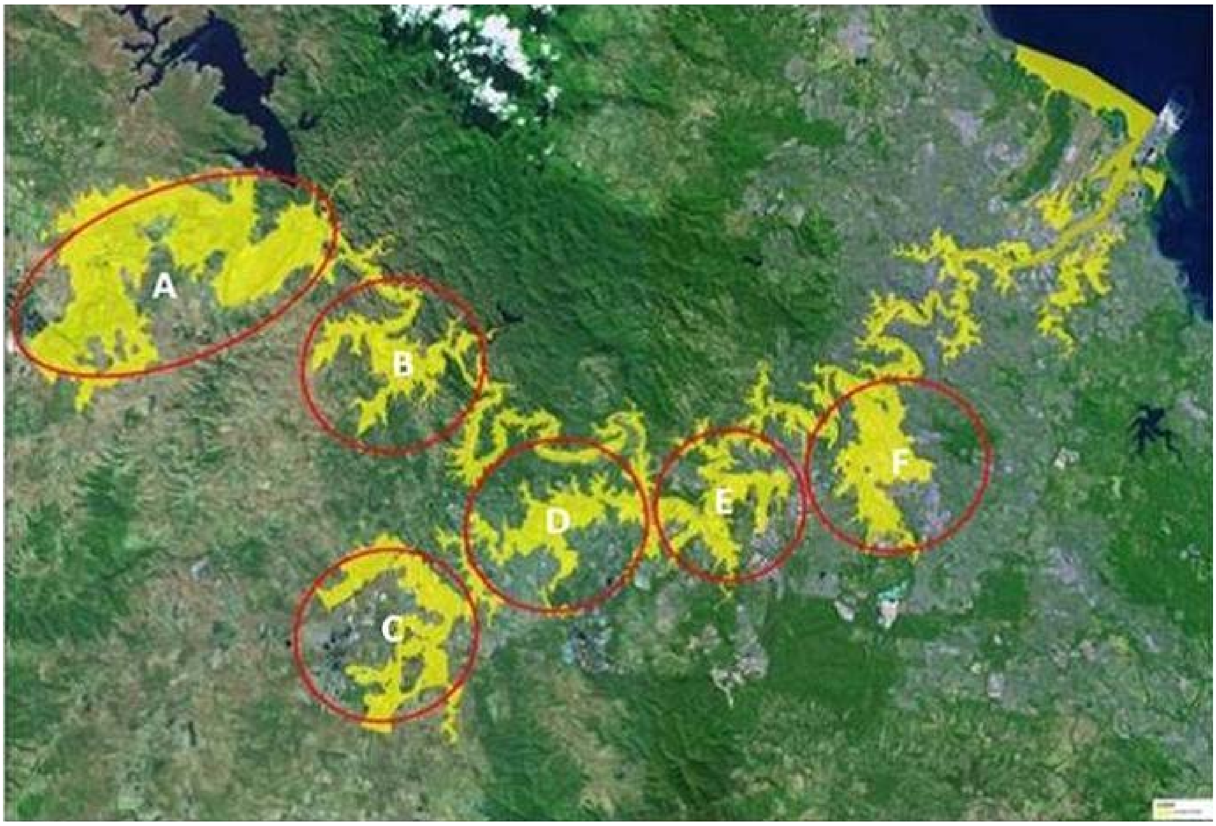


Figure 2-6 Location of conceptual storages in Lower Brisbane River (Source: Brisbane River Flood Hydrology Models (Seqwater, 2013))

SKM (October 2013) concluded that:

'For floods with peak flows in the Lower Brisbane of up to approximately 8,000 m³/s peak flow, the conceptual storages appear to be producing correct routing behaviour. Conceptual storage parameters were extrapolated and have not been confirmed using hydraulic models. Simulation of floods with peak flows in excess of 8,000 m³/s downstream of Wivenhoe Dam may introduce additional errors, but this is only of potential concern for the estimation of design floods.'

This recommendation was implemented and an assessment undertaken using the hydraulic model results available from the BCC Disaster Management Tool hydraulic modelling available at the time (January and February 2014). It was noted from the Interim Calibration Report (BCC, October 2013), that whilst the initial TUFLOW modelling using a 30 m grid replicated flood levels for the January 2011 flood event within reasonable tolerances, it tended to under estimate the recorded flow, especially at Centenary Bridge. A flow of approximately 9,800 m^3/s was recorded during the January 2011 flood event, but the BCC DMT model had a peak of only 8,800 m^3/s at this location. This is contrary to what is suggested by the storage-discharge relationship comparison.

In January 2014, BCC issued a revised calibration using a 20 m grid resolution hydraulic model that achieved better agreement with the flow comparison at Centenary Bridge. A peak flow of 10,050 m^3/s was calculated at this location for the January 2011 event, whilst the peak flood level was 12.10 m. The re-calibrated DMT model also included increased localised flows. These revised calibration results were adopted as for this assessment. BCC published final results from the DMT model in June 2014, after this review had been completed. The results presented in this report are similar to but may not exactly match final BCC results. All results presented below, including ratings, hydrologic and hydraulic model results are presented for the purpose of comparison of the different methodologies only, and have been subject to ongoing change.

This assessment was revisited during the hydrologic model recalibration process using updated results (June 2014) and is reported in the Hydrologic Model Recalibration Report. The review may need to be further re-considered during the hydraulic modelling phase of the BRCFS as the BCC hydraulic modelling is regarded as interim.

The re-calibrated DMT model also included increased localised flows. Section 7 of BCC (2014) outlines the calibration approach and multiple sensitivity analysis undertaken as part of the DMT project in order to achieve an improved calibration outcome and ultimately better match ADCP flow gaugings for the 2011 and 2013 flood events.

BCC published final results from the DMT model in June 2014, after this review had been completed. The results presented in this report are similar to but may not exactly match final BCC results. All results presented below, including ratings, hydrologic and hydraulic model results are presented for the purpose of comparison of the different methodologies only, and have been subject to ongoing change

BCC expedited the provision of the revised DMT calibration results to Aurecon (February 2014) in advance of the DMT reporting phase and these calibration outcomes remained unchanged and were incorporated into the final BCC DMT reports (final draft and final) that were issued in June 2014 and November 2014 respectively. (So the calibration outcomes utilised by Aurecon in this study have not changed since February 2014).

2.8 Seqwater model calibration process

Seqwater adopted a ranking scheme to assess the calibration performance for the calibration events. The criteria used to assess calibration performance considered quantitative measures of the flood hydrograph calibration and qualitative assessment of the quality of data and significance (magnitude) of the flood event. Each calibration result was assigned a class score on a five point scale ranging from zero (no data) to five (excellent calibration).

The calibration class scores were then used to weight the parameters for each event calibration to calculate recommended model parameters (refer to Table 2-6).

Table 2-6 Criteria for ranking and weighting of calibration events

Class	Score	Peak ratio	Volume ratio	Nash-Sutcliffe	Event magnitude	Quality of rainfall data
Excellent	5	< +/- 10%	< +/- 15%	≥ 0.95	Major	Post – 2008
Good	4	< +/- 15%	< +/- 25%	≥ 0.90	Moderate	Post – 1994
Fair	3			≥ 0.85	Minor	Post – 1955
Poor	2	< +/- 50%	< +/- 50%	≥ 0.50		Pre – 1955
No data	0	> +/- 50%	> +/- 50%	< 0.50		

Peak ratio (PR) represents the calculated (modelled) peak flow divided by the estimated (rated) peak flow. The estimated peak flow is calculated using the recorded peak height and the gauge site rating curve.

Volume ratio (VR) represents the calculated (modelled) event volume divided by the estimated event volume. The estimated event volume is calculated by converting the recorded water level hydrograph to a rated flow using the gauge site rating curve.

Nash-Sutcliffe (NS) represents the calibration event modelled hydrograph goodness of fit (ie shape and timing). Nash-Sutcliffe can range from -∞ to 1, with a NS value of 1 being a perfect fit.

The magnitude of the flood event was classified using the BoM flood warning classification scale of Minor, Moderate and Major.

This process was considered systematic and robust, and is therefore appropriate for model parameter selection.

2.9 Seqwater recommendations

Seqwater recommended that the priority areas for potential improvement of the URBS models are:

- Better definition of ratings, particularly in the Lockyer Creek catchment, but also in the mid and lower Brisbane River reaches. Preferably this would be informed by hydraulic analyses, additional survey data, and on-going flow gauging data collection
- Characterising rating uncertainty and understanding of temporal change in ratings would also be valuable
- Review of floodplain storage influences in the lower Brisbane model, particularly the backwater storage influences with the Bremer River, and preferably informed by quality hydrodynamic modelling
- Improved understanding of flood routing behaviour and rainfall loss representation in the Lockyer Creek catchment
- Review of the significance of base flow for flood hydrographs in the Lockyer Creek catchment and possible simple but effective simulation method to represent base flow if deemed necessary
- Consider representation of urbanised areas in the Lower Brisbane URBS model to account for the influence of impervious areas surrounding Ipswich and Brisbane cities

A number of these recommendations have been assessed in the following sections of this report, in an effort to refine the overall hydrologic model performance. The recommendations relating to the rating curve reviews are considered in Aurecon's, Data Review, Rating Curve Review and Historical Flood Review Report (Aurecon, 2013).

3 Peer review panel report

The Seqwater Draft report was peer reviewed and a report was prepared by the peer review panel (PRP) on 30 September 2013 and provided by Seqwater to Aurecon on 31 October 2013.

The PRP concluding remarks are as follows:

The PRP review of the calibrated URBS models for the seven Brisbane River sub-catchments has indicated that they perform well in reproducing the characteristics of observed flood events within the flood magnitude range of historic flood events in the Brisbane River catchment. The PRP recognises that, as with all conceptual hydrologic models, there may be different combinations of catchment representations and parameter sets that will perform satisfactorily in reproducing flood characteristics over a limited range of flood magnitudes. However, different representations may perform quite differently in the range of larger flood magnitudes, where significant extrapolation beyond the observations is required. The PRP therefore considers it important to recognise the additional uncertainty involved if the models are to be applied to estimate floods outside the range of observed events, and to base extrapolations as far as possible on established links with physical catchment, river and floodplain characteristics.

The PRP endorses recommendations in the report for on-going gauging of high flows to improve rating curves at key sites, and for hydraulic modelling to confirm rating curve extensions and develop a better understanding of the storage-discharge characteristics of significant floodplain areas. The Executive Summary of the report draws appropriate attention to the fact that the URBS hydrologic models have been developed and calibrated to serve Seqwater's specific requirements in the context of its WSDOS and real-time flood operation responsibilities. The PRP considers it important that the limitations of the models are clearly communicated to all future users of the URBS models, and it endorses the continuous improvement philosophy advocated by Seqwater.

The recommendations and conclusions reached by the PRP have been considered in undertaking the assessments summarised in later sections of this report.

4 SKM investigation

Seqwater commissioned consultants SKM, to undertake an investigation as part of the Wivenhoe Somerset Dam Optimisation Study (WSDOS) project that was implemented to further improve dam operations in light of the learnings from the 2011 flood event. SKM produced a report entitled, 'Brisbane River Catchment Dams and Operational Alternatives Study, Generation of Inflow Hydrographs and Preliminary Flood Frequency Analysis, Final Report', dated 8 October 2013. As part of this report SKM reviewed the Seqwater URBS models and prepared a summary of recommendations regarding the model. These findings are shown below and are based upon model files provided by Seqwater in April 2013:

4.1 Summary of review

SKM concluded that:

The calibrated URBS models are considered appropriate for the purpose that they were applied to for this study, i.e. the transformation of stochastically generated space-time rainfall patterns into stochastic flow hydrographs at the key inflow locations to the dam operations simulation model.

There was no evidence identified for compensation of routing between α and β parameters in the model. The adopted values of initial and continuing loss parameters (IL, CL) appear to be consistent between adjacent catchments and appear to vary between events in a manner that would be consistent with variability in climatic conditions.

For floods with peak flows in the Lower Brisbane of up to approximately 8,000 m^3/s peak flow, the conceptual storages appear to be producing correct routing behaviour. Conceptual storage parameters were extrapolated and have not been confirmed using hydraulic models. Simulation of floods with peak flows in excess of 8,000 m^3/s downstream of Wivenhoe Dam may introduce additional errors, but this is only of potential concern for the estimation of design floods.

4.2 Update of URBS model

SKM made the following recommendations in relation to the Seqwater URBS model:

It is recommended that further effort is placed into calibration of conceptual storage parameters as part of the BRCFS. The calibration of conceptual storages should use hydraulic modelling of the Lower Brisbane River and floodplain to calibrate, in tandem, the storage-discharge relationships for the conceptual storages and the rating curves at the gauging stations. The hydraulic model should be run up into the range of extreme flood events to provide a firmer basis for extrapolation of the storage-discharge relationships.

Several of the URBS models included an additional base flow component to the runoff. For modelling of floods in the very large and extreme range and assuming that probability distributions of initial and continuing loss do not change with event magnitude, the fraction of total rainfall absorbed by losses will reduce. Since base flow represents an attenuated fraction of the loss component from surface runoff, there is potential that the method that was applied for generating base flow from the URBS models for this current project will over-estimate the base flow contribution for very large and extreme events. The base flow generation method should be re-examined for the BRCFS, particularly with a view to understanding its potential impact for very large and extreme events.

It was noted that none of the models included impervious fractions for urbanisation nor did they have sub-catchment or channel routing modified to represent urbanisation of the catchment. Urbanisation around Brisbane and Ipswich is likely to have changed the routing response in parts of the lower Brisbane model over time. Since most of this urbanisation occurs downstream of Moggill, which is the location of primary interest to Seqwater for dam operations, this was not a serious concern for the current project. However, it is recommended that the representation of the runoff generation and routing response from urban areas of Brisbane and Ipswich is checked and updated as part of the BRCFS.

It is recommended that flood quantiles produced from the Monte-Carlo simulations of design events for the BRCFS are verified against flood frequency analysis under both no-dams and with-dams conditions. It is recommended that the distributions of initial and continuing loss and the values of routing parameters adopted for each of the URBS models are reviewed and updated as necessary through this verification process.

A number of these recommendations have been assessed in the following sections of this report, in an effort to refine the overall hydrologic model performance.

5 Assessment of proposed refinements

5.1 Impervious areas

An assessment of the impacts of urbanisation has been undertaken through:

- Inclusion of impervious areas to represent increased runoff volume
- Inclusion of urbanised areas to represent reduced response time
- Reduction of reach length factors for heavily modified reaches

The impacts of urbanisation have been tested by comparing the hydrologic model calibration results for a number of recent flood events. This assessment has implications for the Lower Brisbane River model only as there are very few urbanised areas within the remainder of the catchment.

Impervious fractions were based upon various land use types as shown in Table 5-1.

Table 5-1 Urban areas – Impervious fractions

Land use	Fraction impervious (%)
Lots up to 0.2ha	70
Lots 0.2 to 2 ha	20
Lots 2 to 4 ha	10
Lots larger than 4 ha	5
Commercial/industrial	90
Major reservoirs	100

Urbanisation fractions were based upon a combined GIS and visual assessment of cadastral data and aerial imagery. Areas with a number of adjacent lots up to 0.2 ha in size were assumed to have piped/channelised stormwater systems. These were verified using aerial imagery.

The inclusion of urbanisation affects the Lower Brisbane River URBS model. These effects were assessed by modifying the model vector file lowerv3.vec to include the additional impervious fractions and urbanisation fractions. The Lower Brisbane River catchment area is 1,855 km^2 and the area affected by urbanisation is 490 km^2 or approximately 26% of this sub-catchment. The impervious area is approximately 365 km^2 or 20% of the sub-catchment or approximately 2.7% of the overall Brisbane River catchment.

A review of the primary drainage pathways was undertaken using aerial imagery. This review showed that most of the primary drainage paths would not be considered heavily modified, and it is the tributaries of these drainage paths which are heavily modified. The impacts of reduced travel times in these tributaries should be accounted for through the inclusion of urbanisation effects. Only two primary drainage paths were identified as being heavily modified, as identified in Figure 5-1.

Figure 5-1 Heavily modified channel: (a) Sandy Creek in Wacol (b) Stable Swamp Creek in Coopers Plains/Rocklea

The effect of including the impervious fraction, urbanised fraction and reduced channel reach factors on the Brisbane River catchment has been assessed by running the Lower Brisbane River URBS model for a number of recent calibration events and comparing the outcomes with the Seqwater Recommended Model Parameter results. The Recommended Model Parameters for the Lower Brisbane River Model are:

- Alpha (α) = 0.15
- Beta (β) = 2.9
- m = 0.8 and
- n = 1.0

The relative effect of including urbanisation impacts has been assessed on the basis of the change to the peak flow, volume and timing of the peak at various gauge locations for a range of recent flood events.

The sensitivity analysis was based upon a range of recent flood events (post-Wivenhoe Dam) as the GIS land use classification utilised represented 2010 conditions. Those events considered include:

- April 1989
- May 1996
- February 1999
- January 2011
- January 2013

Indicative results for key sites in Ipswich and Brisbane are summarised below, whilst Appendix A provides a summary of the results for all events and a number of sites in the Lower Brisbane River model. Appendix A also includes hydrographs showing the comparison of discharges at the Brisbane City Gauge for the five events.

5.1.1 Ipswich

Figure 5-2 shows the comparison of flood volumes for the various events due to the inclusion of impervious fraction in the urban areas. As expected the largest increase in flood volume is associated with the events that have high rainfall that was spatially distributed downstream of Wivenhoe Dam, and adjacent to the urban areas, such as April 1989 and May 1996.

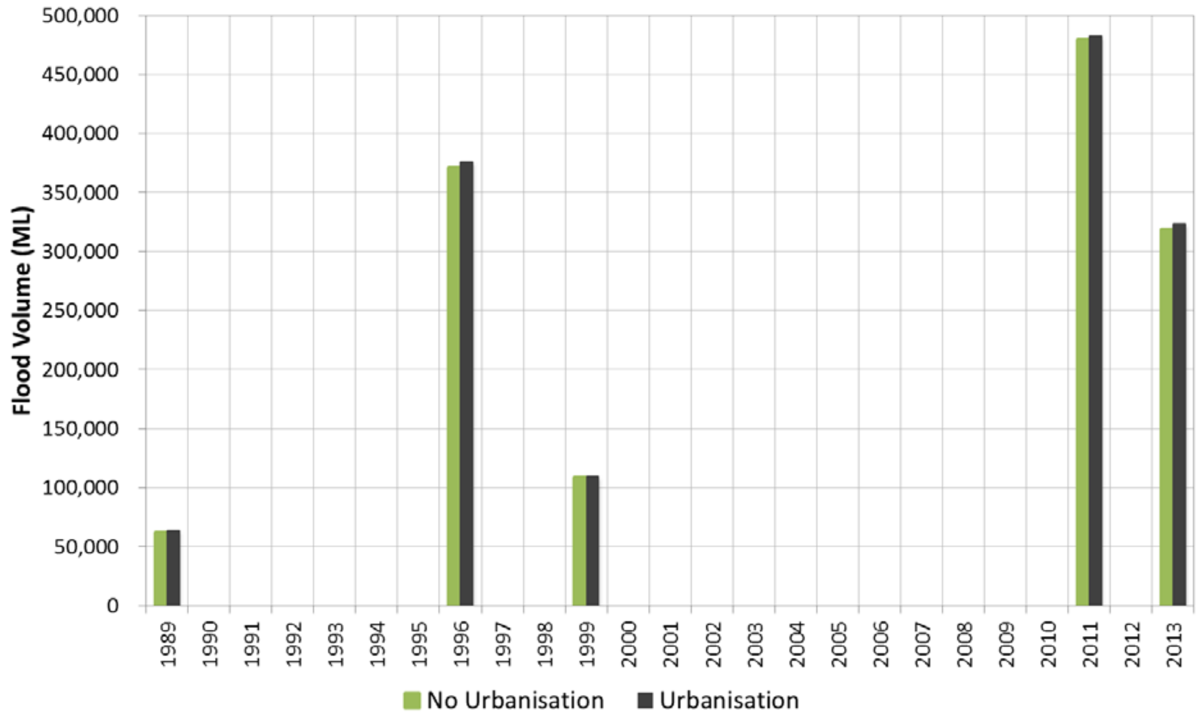


Figure 5-2 Comparison of event flood volumes, Bremer River at Ipswich

Figure 5-3 shows the relative increase in flood volume due to the inclusion of impervious fraction in the urban area surrounding Ipswich. Flood Volumes increased by up to 2.4% at Ipswich due to the inclusion of the impervious fraction of the urban areas.

The timing of the peak flow was not impacted to any discernible amount due to the inclusion of the urbanisation of the urban areas.

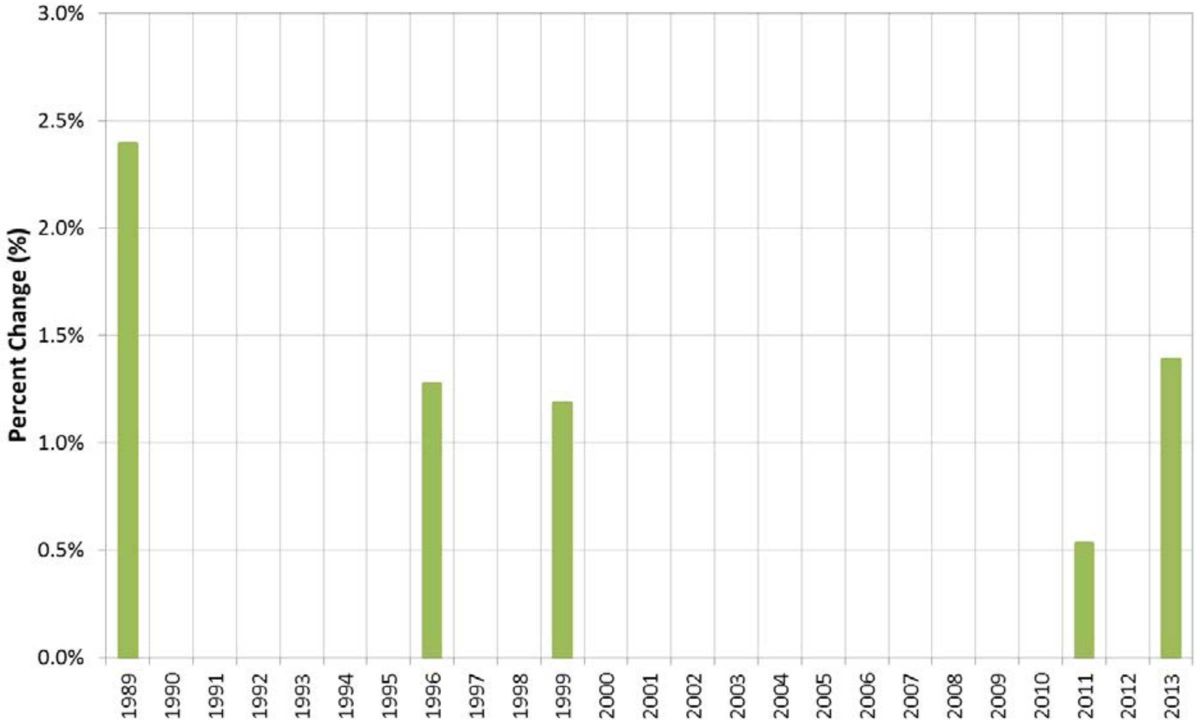


Figure 5-3 Percentage increase in flood volume due to inclusion of impervious fraction, Bremer River at Ipswich

5.1.2 Brisbane City gauge

Figure 5-4 shows the comparison of peak flood volumes for the various events due to the inclusion of impervious fraction in the urban areas. The largest increase in peak flood volume is associated with the May 1996 flood event which had high runoff from the metropolitan areas in the Lower Brisbane River reaches.

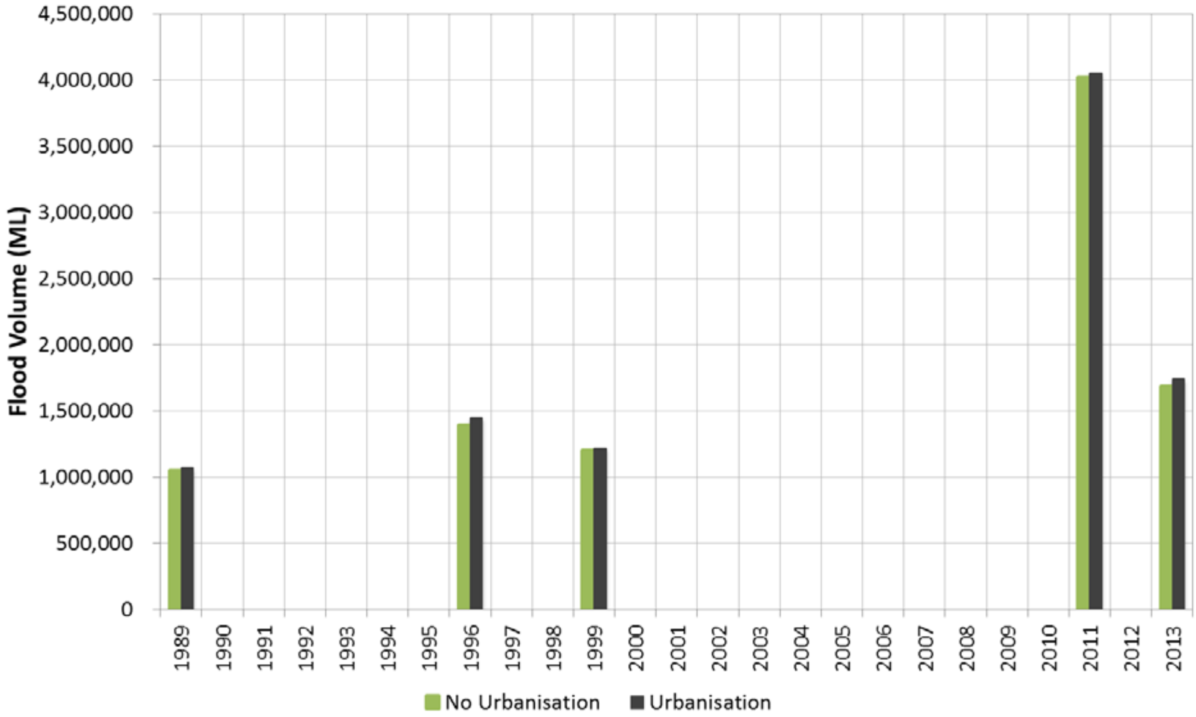


Figure 5-4 Comparison of flood volumes, Brisbane river at Brisbane City gauge

The percentage increase in peak volumes for the various events is shown in Figure 5-5. Peak Volumes increased by up to 4.1% at BCG for the range of events considered through the inclusion of urbanisation impacts.

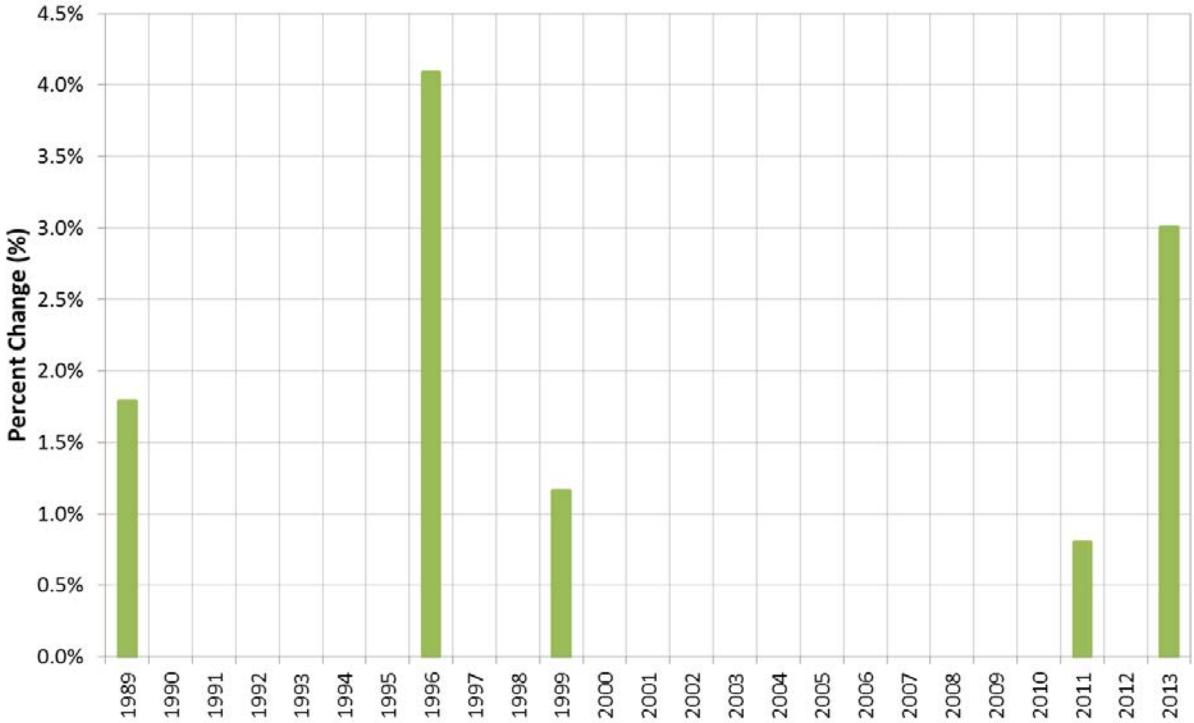


Figure 5-5 Percentage increase in flood volumes due to inclusion of impervious fraction, Brisbane River at Brisbane City gauge

The resulting effect on peak flood levels due to the increase in runoff volume and peak flow is shown in Table 5-2.

Table 5-2 Comparison of Increase in peak flood height due to inclusion of impervious fraction, Brisbane River at Brisbane City gauge

Event	Peak height (m)		Difference (m)
	No impervious fraction	With urbanisation	
Apr-89	1.36	1.36	0.00
May-96	2.17	2.21	0.04
Feb-99	1.56	1.56	0.00
Jan-11	4.55	4.55	0.00
Jan-13	2.46	2.49	0.03

The maximum increase in peak flood height for any of the events considered was 40 mm, viz. the May 1996 event. This is consistent with greater runoff response emanating from the metropolitan reaches of the Lower Brisbane River.

For all events, urbanisation increases the volume of runoff, with this increased volume occurring early in the flood event. For all events other than the May 1996 event, this increased volume has little effect on the peak flow, as shown in the hydrographs in Appendix A.

5.1.3 Conclusion: Impacts of urbanisation

As expected, the inclusion of urbanisation effects does not have significant impacts within the Lower Brisbane River and does not appear to alter the outcomes of the model calibration. The effect of urbanisation only impacts a relatively small proportion of the Lower Brisbane River model sub-areas that are predominately located at the bottom end of the system.

Within the urbanised regions of the model themselves, such as those along Bundamba, Oxley, Breakfast and Bulimba Creeks, urbanisation is expected to increase peak flows and volumes. However, within the main Brisbane River the impacts of urbanisation are negligible. This occurs as the urbanised areas are located within the lower part of the overall catchment. The increased runoff volume from these areas tends to enter the Brisbane River earlier than for the main riverine flows that originate further up the catchment. This increased runoff is able to drain into Moreton Bay before flows from upstream enter these lower reaches; hence it has little to no effect on peak discharges and peak water levels. In some cases the peak flows and peak levels are reduced as a result of this effect.

It is acknowledged that the impact of urbanisation with increasing ARI will be conservative given the current model representation, although as the effects are not particularly significant, this conservatism does not affect the overall calibration outcome.

Aurecon recommend that the impervious fraction, urbanised fraction and reduced reach length factors be included in the model for use in the assessment of the hydrology of the BRCFS.

5.2 Catchment routing parameters

Seqwater undertook an investigation into channel non-linear routing characteristics for the Warrill Creek to Amberley sub-catchment. This examination involved the assessment of the average travel time of a range of historical events. To identify a suitable non-linear exponent parameter for the Muskingum channel routing model, Seqwater performed an analysis of event peak lag times (inverse of flood wave speed) and event magnitude between key catchment locations. Time differences in event peaks were divided by distances between the gauge locations to evaluate event-peak lag time in hours/km, which is effectively the same measure as the alpha parameter. For the selected events, the lag time was plotted against the rated flow for that event at the Amberley gauge.

The analysis showed a trend of faster flood peak travel times with increasing peak flow for Warrill Creek sub-catchment to Amberley. A power equation (ie lag = flow ^ exponent) was fitted to the available data. The data indicates an exponent in the order of -0.15 to -0.20. This exponent can be applied to estimate the exponent n for the Muskingum channel routing equations applied in URBS:

Where n-1 = the exponent of the power equation fit to the lag time versus flow plot

Based on these findings, it was identified that a non-linearity exponent around 0.80 to 0.85 was suitable for Muskingum channel routing.

The selection of events for use in this analysis is critical to ensure that only those events that describe the characteristics of the channel routing are included, otherwise the assessment is compromised. Hence any events that include significant inflows within the reach of interest have been discarded. Likewise, multi-peaked events, where it is not clear if the corresponding peaks in upstream and downstream sites can be correlated have also been discarded. This filtering of events can lead to a reduction in the number of valid events available, reducing the confidence in the relationships that are identified.

This exercise was repeated for the other sub-catchments to determine if any trends could be identified for the other sub-catchments. Appendix B provides details of this assessment.

For each model, either one or two downstream locations were selected for the non-linearity assessment. Only gauges which were on the main stream were assessed (ie no tributaries were assessed). Events were selected as those:

- With available gauged data
- Considered non-minor events
- With evident single peaks
- With travel time through the catchment
- Without large amounts of rainfall occurring in the mid-catchment between gauges

It is important to note that this process is very subjective and it is quite likely the results would vary according to the person carrying out the analysis.

Further to the assessment of historical event data, a test of the impacts of standardised non-linearity parameters on the URBS model predictions was carried out. This process included the following steps:

- Modify n to 0.8 for each catchment (except Warrill Creek)
- Recalibrate the 1974 event in each catchment by modifying the alpha and beta values
- Run the model with double the 1974 event flows using n = 1 and the recommended parameters
- Run the model with double the 1974 event flows using n = 0.8 and the revised parameters

5.2.1 Upper Brisbane River

Available data for the Upper Brisbane River sub-catchment is summarised in Table 5-3.

Table 5-3 Upper Brisbane River to Middle Creek and Gregor Creek– Adopted events and values

Event	Upstream peak time	Downstream peak time	Rated flow (m^3/s)	Travel time	Peak lag (hrs/km)
Linville to Middle Creek (132.4km)					
19711226	28/12/1971 2:00	29/12/1971 0:00	600	22	0.166
19730705	8/07/1973 0:00	8/07/1973 17:00	2456	17	0.128
Gregor Creek to Middle Creek (61.5km)					
19711226	28/12/1971 8:00	29/12/1971 0:00	600	16	0.260
19730705	8/07/1973 5:00	8/07/1973 17:00	2456	12	0.195
Linville to Gregor Creek (70.9km)					
19711226	28/12/1971 2:00	28/12/1971 8:00	863	6	0.085
19730705	8/07/1973 0:00	8/07/1973 5:00	3415	5	0.071
19890423	26/04/1989 0:00	26/04/1989 5:00	4405	5	0.071
19911210	12/12/1991 10:00	12/12/1991 17:00	319	7	0.099
20101216	20/12/2010 2:00	20/12/2010 6:00	1278	4	0.056
20101223	27/12/2010 22:00	28/12/2010 3:00	1334	5	0.071
Devon Hills to Gregor Creek (57.7km)					
20101216	20/12/2010 3:00	20/12/2010 6:00	1278	3	0.052
20101223	28/12/2010 1:00	28/12/2010 3:00	1334	2	0.035

This data has been summarised in Figure 5-6 and Figure 5-7 for the Upper Brisbane River.

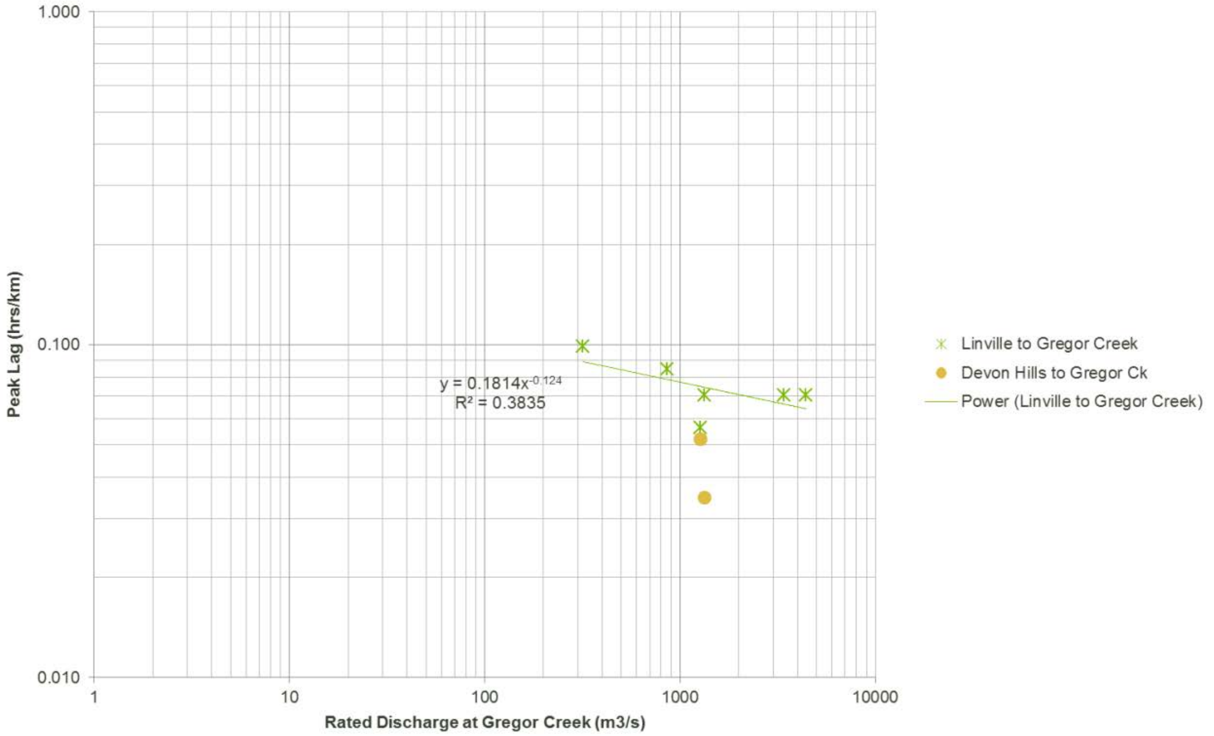


Figure 5-6 Non-linearity assessment: Upper Brisbane River to Gregor Creek

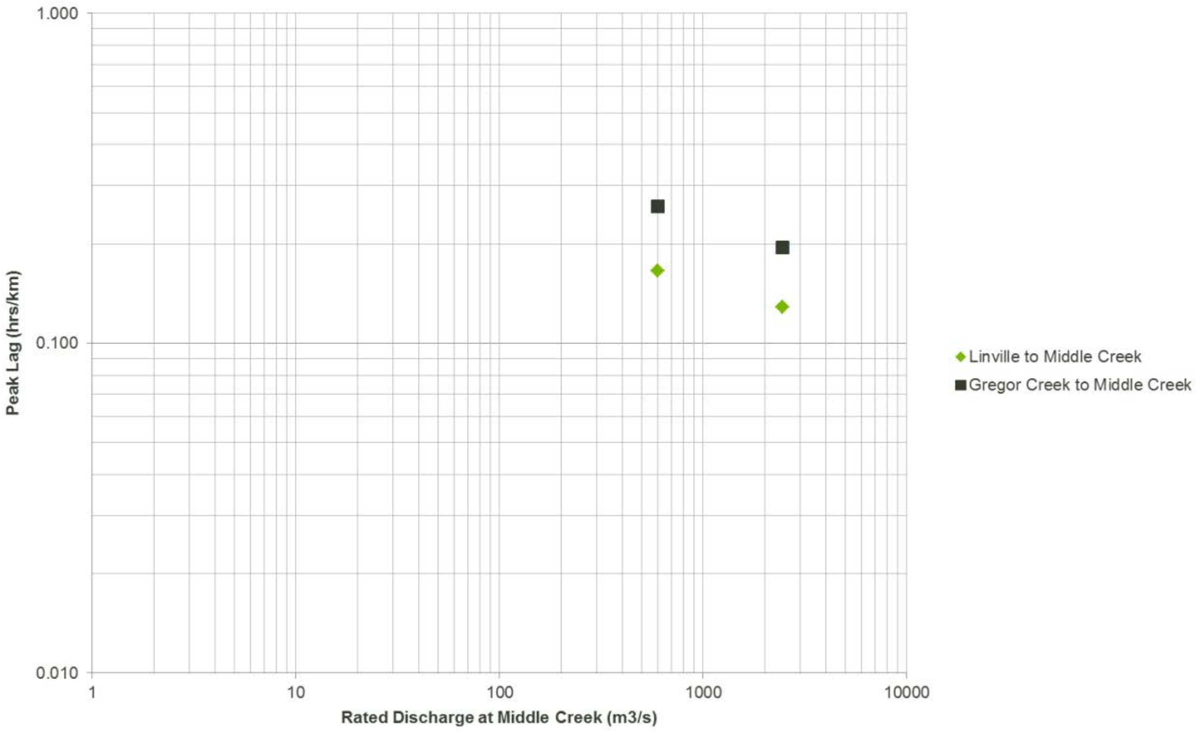


Figure 5-7 Non-linearity assessment: Upper Brisbane River to Middle Creek

The relationship defined for the Upper Brisbane River to Gregors Creek suggests that an n value of between 0.85 and 0.90 could be considered appropriate for this sub-catchment. However, the relationship is not particularly strong as evidenced by the R2 value of 0.3835. There is a large variance within the available data meaning any adopted relationship is subjective.

The lack of suitable event data to establish a similar relationship for the Upper Brisbane River to Middle Creek means that establishing a relationship for this sub-catchment is not conclusive. Figure 5-7 suggests that there is insufficient data on which to base a definitive relationship.

In light of the uncertainty associated with these observations, and despite their being some evidence to suggest that there is non-linear channel routing behaviour it is recommended that linear channel routing be adopted for the Upper Brisbane River sub-catchment. It is more important to accurately model volumes in this sub-catchment, which non-linearity will not impact upon.

5.2.2 Stanley River

The data for the Stanley River sub-catchment has been summarised in Table 5-4. The available data for the Stanley River catchment is limited to the headwater gauges. These sites are located in the upper reaches of the catchment and will not necessarily reflect the lower reaches which are inundated by Lake Somerset.

The analysis was not conducted for Somerset Dam inflows as the recorded stage hydrographs are influenced by the adopted dam operations. Therefore only derived inflow hydrographs could be considered, resulting in further subjectivity in the assessment.

Table 5-4 Stanley River to Peachester– Adopted events and values

Event	Upstream peak time	Downstream peak time	Rated flow (m^3/s)	Travel time	Peak lag (hrs/km)
Peachester to Woodford (23.5km)					
20120121	25/01/2012 3:00	25/01/2012 16:00	208	13	0.553
20120220-1	25/02/2012 6:00	25/02/2012 18:00	220	12	0.511
20120220-2	5/03/2012 21:00	6/03/2012 8:00	215	11	0.468

Figure 5-8 shows the resulting data available for the relationship between Peachester and Woodford. There is insufficient data on which to base a reliable relationship, and so the adoption of linear channel routing is recommended for this sub-catchment.

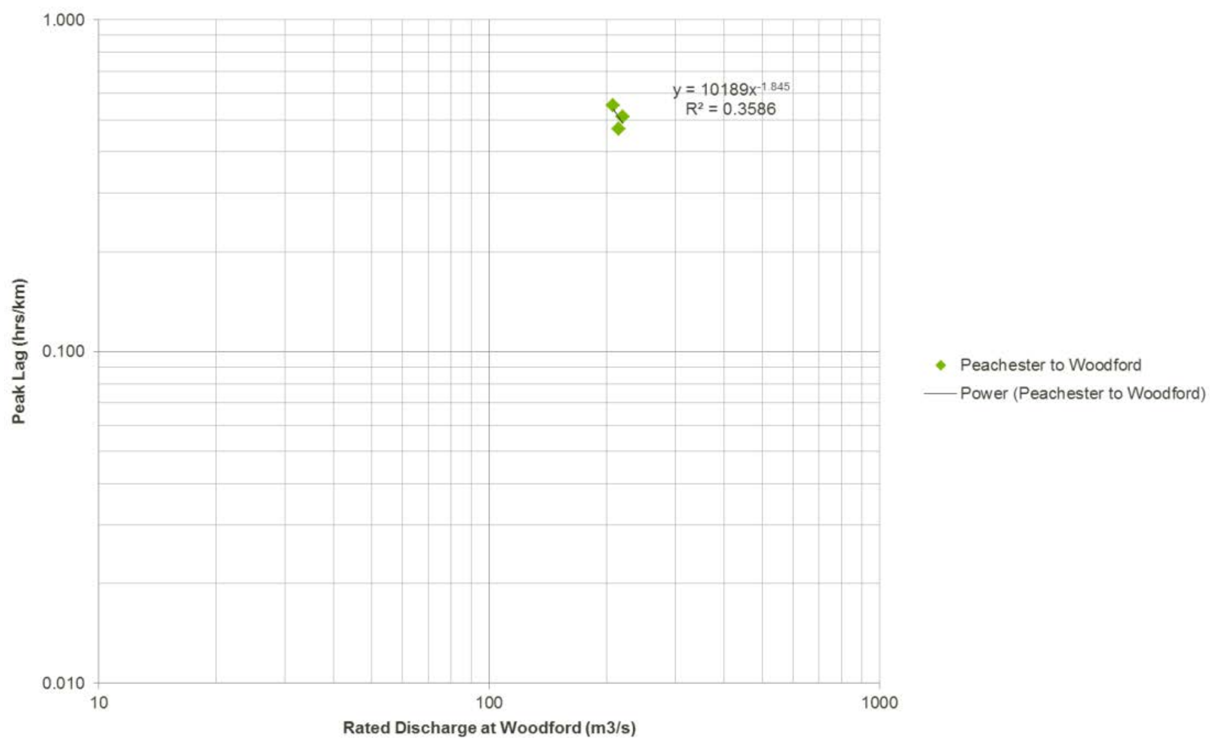


Figure 5-8 Non-linearity assessment: Stanley River to Woodford

5.2.3 Lockyer Creek

The Lockyer Creek assessment was carried out to two locations: Glenore Grove and Lyons Bridge. An assessment was also carried out for Laidley Creek to the Warrego Highway. A summary of the available data for the Lockyer Creek sub-catchment is presented in Table 5-5 and Table 5-6.

Table 5-5 Lockyer Creek to Glenore Grove and Lyons Bridge – Adopted events and values

Event	Upstream peak time	Downstream peak time	Rated flow (m^3/s)	Travel time	Peak lag (hrs/km)
Helidon to Glenore Grove (46.8km)					
20101201	4/12/2010 21:00	5/12/2010 14:00	304	17	0.363
20101216-1	16/12/2010 22:00	17/12/2010 13:00	231	15	0.321
20101216-2	19/12/2010 21:00	20/12/2010 8:00	401	11	0.235
20101223	27/12/2010 16:00	27/12/2010 22:00	2568	6	0.128
US Gatton to Glenore Grove (19.9km)					
20100226-1	3/03/2010 5:00	3/03/2010 9:00	192	4	0.201
20100226-2	7/03/2010 6:00	7/03/2010 11:00	193	5	0.251
20101201	5/12/2010 8:00	5/12/2010 14:00	304	6	0.302
20101216-1	17/12/2010 8:00	17/12/2010 13:00	231	5	0.251
20101216-2	20/12/2010 3:00	20/12/2010 8:00	401	5	0.251
20101223	27/12/2010 19:00	27/12/2010 22:00	2568	3	0.151
Gatton to Glenore Grove (19.1km)					
19990207	9/02/1999 14:00	9/02/1999 17:00	494	3	0.157

Event	Upstream peak time	Downstream peak time	Rated flow (m^3/s)	Travel time	Peak lag (hrs/km)
20100226-1	3/03/2010 5:00	3/03/2010 9:00	192	4	0.209
20100226-2	7/03/2010 6:00	7/03/2010 11:00	193	5	0.262
Helidon to Lyons bridge (69.0km)					
20101201	4/12/2010 21:00	6/12/2010 1:00	177	28	0.406
20101216-1	16/12/2010 22:00	17/12/2010 22:00	130	24	0.348
20101216-2	19/12/2010 21:00	20/12/2010 16:00	260	19	0.275
US Gatton to Lyons Bridge (42.1km)					
20100226-1	3/03/2010 5:00	3/03/2010 20:00	126	15	0.356
20100226-2	7/03/2010 6:00	7/03/2010 20:00	128	14	0.333
20101201	5/12/2010 8:00	6/12/2010 1:00	177	17	0.404
20101216-1	17/12/2010 8:00	17/12/2010 22:00	130	14	0.333
20101216-2	20/12/2010 3:00	20/12/2010 16:00	260	13	0.309
Gatton to Lyons Bridge (41.3km)					
19990207	9/02/1999 14:00	9/02/1999 22:00	394	8	0.194
20100226-1	3/03/2010 5:00	3/03/2010 20:00	126	15	0.363
20100226-2	7/03/2010 6:00	7/03/2010 20:00	128	14	0.339
Glenore Grove to Lyons Bridge (22.2km)					
19990207	9/02/1999 17:00	9/02/1999 22:00	394	5	0.225
20100226-1	3/03/2010 9:00	3/03/2010 20:00	126	11	0.495
20100226-2	7/03/2010 11:00	7/03/2010 20:00	128	9	0.405
20101201	5/12/2010 14:00	6/12/2010 1:00	177	11	0.495
20101216-1	17/12/2010 13:00	17/12/2010 22:00	130	9	0.405
20101216-2	20/12/2010 8:00	20/12/2010 16:00	260	8	0.360
20120220	26/02/2012 21:00	27/02/2012 6:00	52	9	0.405

Table 5-6 Laidley Creek to Warrego Highway – Adopted events and values

Event	Upstream peak time	Downstream peak time	Rated flow (m^3/s)	Travel time	Peak lag (hrs/km)
Mulgowie to Warrego Highway (27.0km)					
20100226-2	6/03/2010 17:00	7/03/2010 11:00	48	18	0.667
20101006	11/10/2010 16:00	12/10/2010 6:00	51	14	0.519
20101216-1	16/12/2010 21:00	17/12/2010 13:00	34	16	0.593
20120220	26/02/2012 6:00	26/02/2012 18:00	65	12	0.444
Showgrounds to Warrego Highway (12.9km)					
19910205	8/02/1991 6:00	8/02/1991 14:00	131	8	0.620
20120220	26/02/2012 8:00	26/02/2012 18:00	65	10	0.775

Figure 5-9, Figure 5-10 and Figure 5-11 present the relationships for the three Lockyer Creek sub-catchments. These figures show a general non-linear trend in the peak travel time relationships, however there is no consistency in the relationships, with n values ranging from 0.474 to 0.925 and R^2 values ranging from 0.054 to 0.992. This variance indicates that adoption of a relationship will be somewhat subjective; however the general trend indicates that a relationship is present and is supported by assessments to a number of locations. Based on these assessments, it is recommended that a moderate n value (0.85) be adopted similar to the non-linearity values adopted in the other sub-catchments.

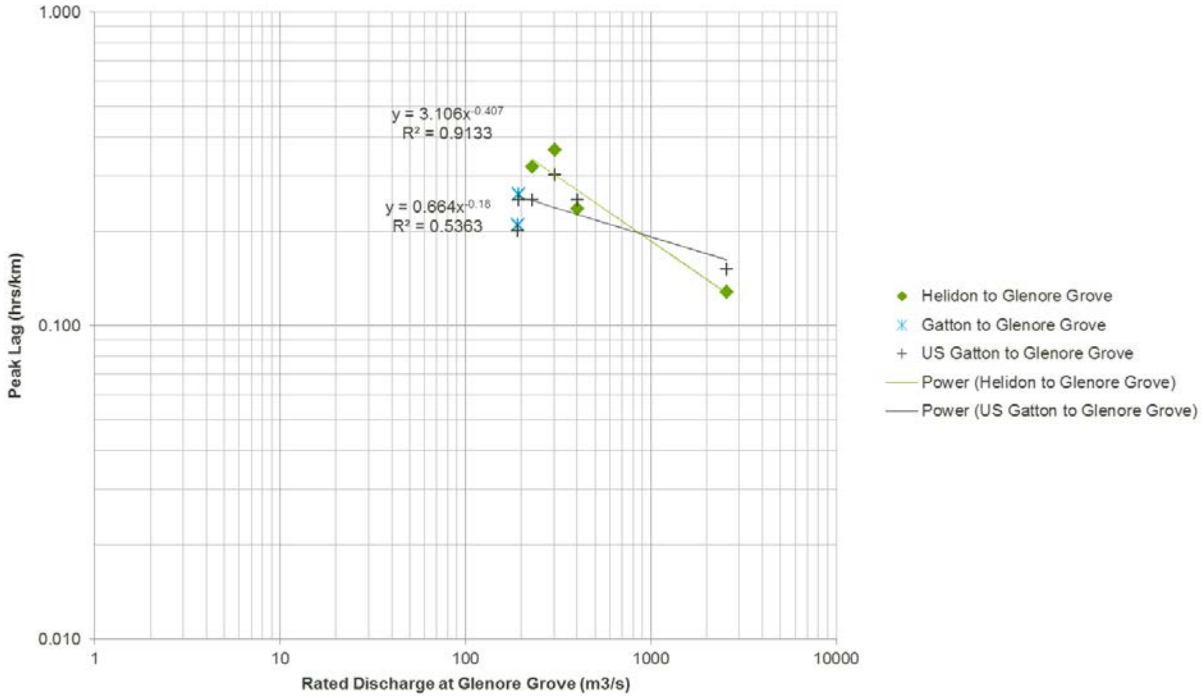


Figure 5-9 Non-linearity assessment: Lockyer Creek to Glenore Grove

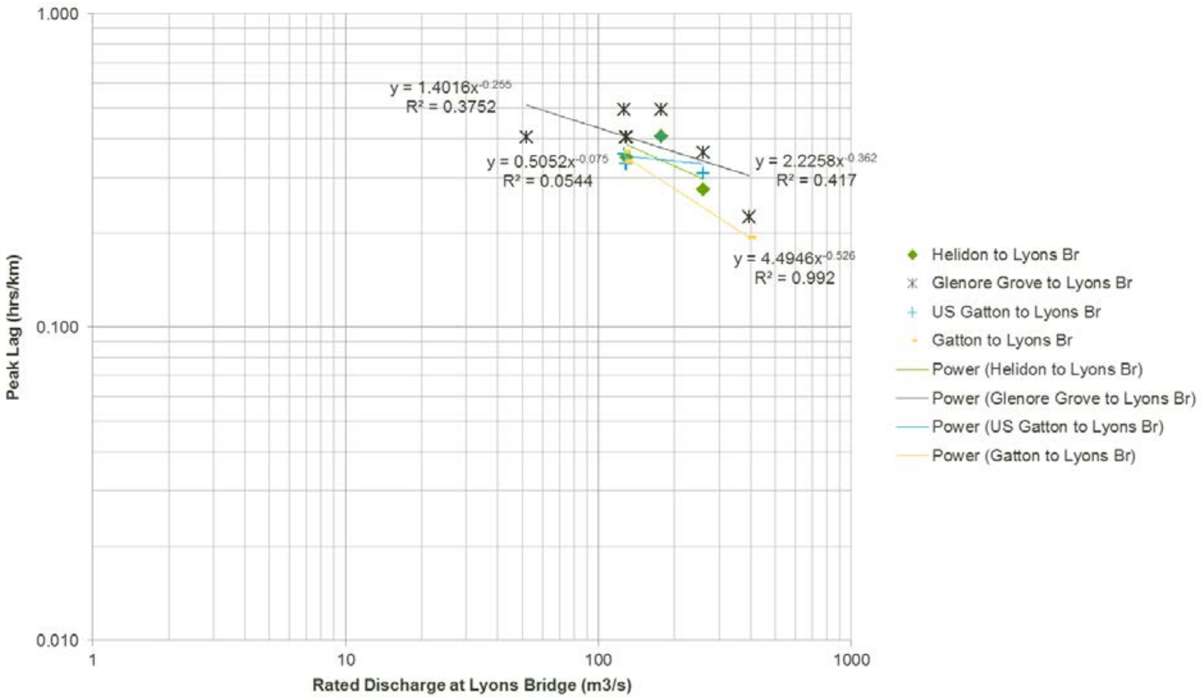


Figure 5-10 Non-linearity assessment: Lockyer Creek to Lyons Bridge

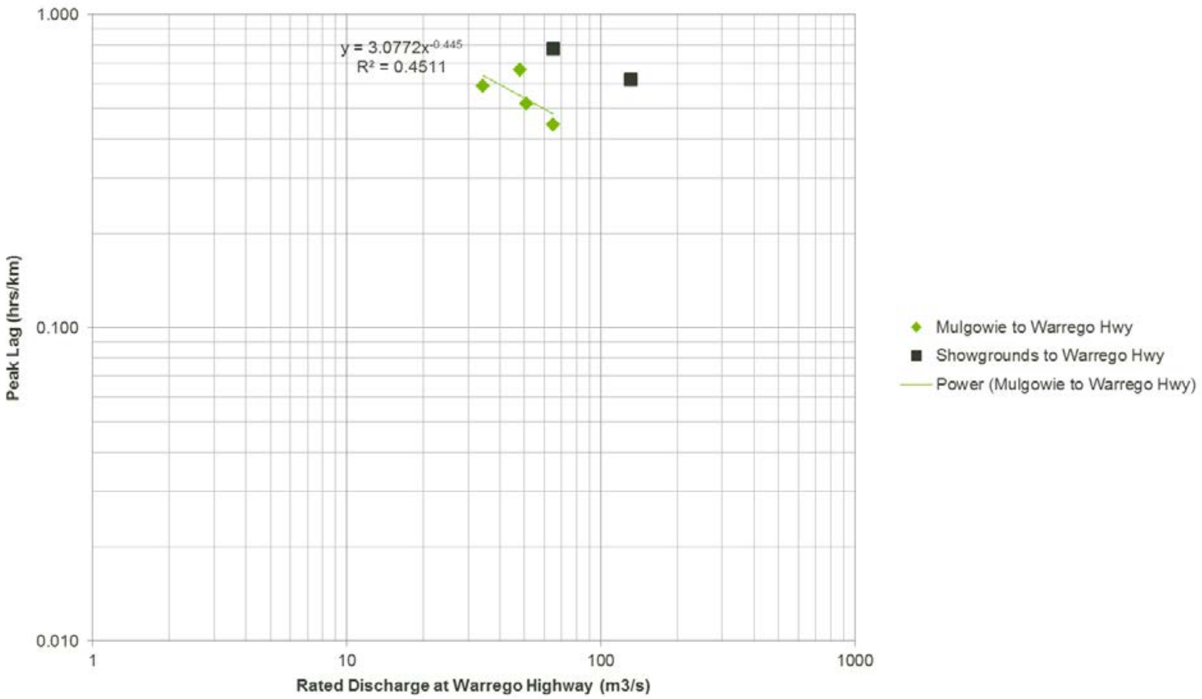


Figure 5-11 Non-linearity assessment: Laidley Creek to Warrego Highway

5.2.4 Bremer River

A summary of the available data for the Bremer River catchment is provided in Table 5-7.

Table 5-7 Bremer River to Walloon – Adopted events and values

Event	Upstream Peak Time	Downstream Peak Time	Rated Flow (m^3/s)	Travel Time	Peak Lag (hrs/km)
Adams Br to Walloon (43.4km)					
19910205	7/02/1991 23:00	8/02/1991 16:00	267	17	0.392
20040304	6/03/2004 6:00	6/03/2004 22:00	140	16	0.369
20100226-2	6/03/2010 21:00	7/03/2010 14:00	87	17	0.392
20100226-3	11/03/2010 2:00	11/03/2010 21:00	90	19	0.438
20101006	11/10/2010 14:00	12/10/2010 4:00	293	14	0.323
20101216-1	16/12/2010 17:00	17/12/2010 11:00	183	18	0.415
20101216-2	19/12/2010 17:00	20/12/2010 9:00	273	16	0.369
20120220	26/02/2012 0:00	26/02/2012 20:00	203	20	0.461
20130215-2	2/03/2013 18:00	3/03/2013 7:00	363	13	0.300
Stokes Xing to Walloon (33.9km)					
20100226-2	6/03/2010 23:00	7/03/2010 14:00	87	15	0.442
20100226-3	11/03/2010 4:00	11/03/2010 21:00	90	17	0.501
20101006	11/10/2010 16:00	12/10/2010 4:00	293	12	0.354
20101216-1	16/12/2010 20:00	17/12/2010 11:00	183	15	0.442
20101216-2	19/12/2010 20:00	20/12/2010 9:00	273	13	0.383
Rosewood to Walloon (14.9km)					
19960430	3/05/1996 11:00	3/05/1996 17:00	912	6	0.403
20040304	6/03/2004 15:00	6/03/2004 22:00	140	7	0.470
20100226-2	7/03/2010 6:00	7/03/2010 14:00	87	8	0.537
20100226-3	11/03/2010 14:00	11/03/2010 21:00	90	7	0.470
20101006	11/10/2010 22:00	12/10/2010 4:00	293	6	0.403
20101216-1	17/12/2010 5:00	17/12/2010 11:00	183	6	0.403
20101216-2	20/12/2010 3:00	20/12/2010 9:00	273	6	0.403
20120220	26/02/2012 13:00	26/02/2012 20:00	203	7	0.470
20130123	28/01/2013 1:00	28/01/2013 6:00	1143	5	0.336
20130215-1	26/02/2013 6:00	26/02/2013 12:00	520	6	0.403
20130215-2	3/03/2013 1:00	3/03/2013 7:00	363	6	0.403
Five Mile to Walloon (5.6km)					
19960430	3/05/1996 14:00	3/05/1996 17:00	912	3	0.536
20040304	6/03/2004 19:00	6/03/2004 22:00	140	3	0.536
20081116	20/11/2008 6:00	20/11/2008 8:00	927	2	0.357
20090518	21/05/2009 6:00	21/05/2009 8:00	518	2	0.357

Event	Upstream Peak Time	Downstream Peak Time	Rated Flow (m^3/s)	Travel Time	Peak Lag (hrs/km)
20100226-2	7/03/2010 11:00	7/03/2010 14:00	87	3	0.536
20101216-1	17/12/2010 9:00	17/12/2010 11:00	183	2	0.357
20101216-2	20/12/2010 7:00	20/12/2010 9:00	273	2	0.357
20120220	26/02/2012 18:00	26/02/2012 20:00	203	2	0.357
20130123	28/01/2013 4:00	28/01/2013 6:00	1143	2	0.357
20130215-1	26/02/2013 10:00	26/02/2013 12:00	520	2	0.357

The data provided is summarised in Figure 5-12 for the Bremer River sub-catchment. The gradient of the various relationships suggest that there is a consistent trend with the data for the various gauging stations considered. The relationships suggest that an n value of between 0.80 and 0.90 could be considered for the Bremer River sub-catchment.

Considering the similarity with Warrill Creek catchment, it is recommended that a value of n = 0.85 be adopted for this catchment.

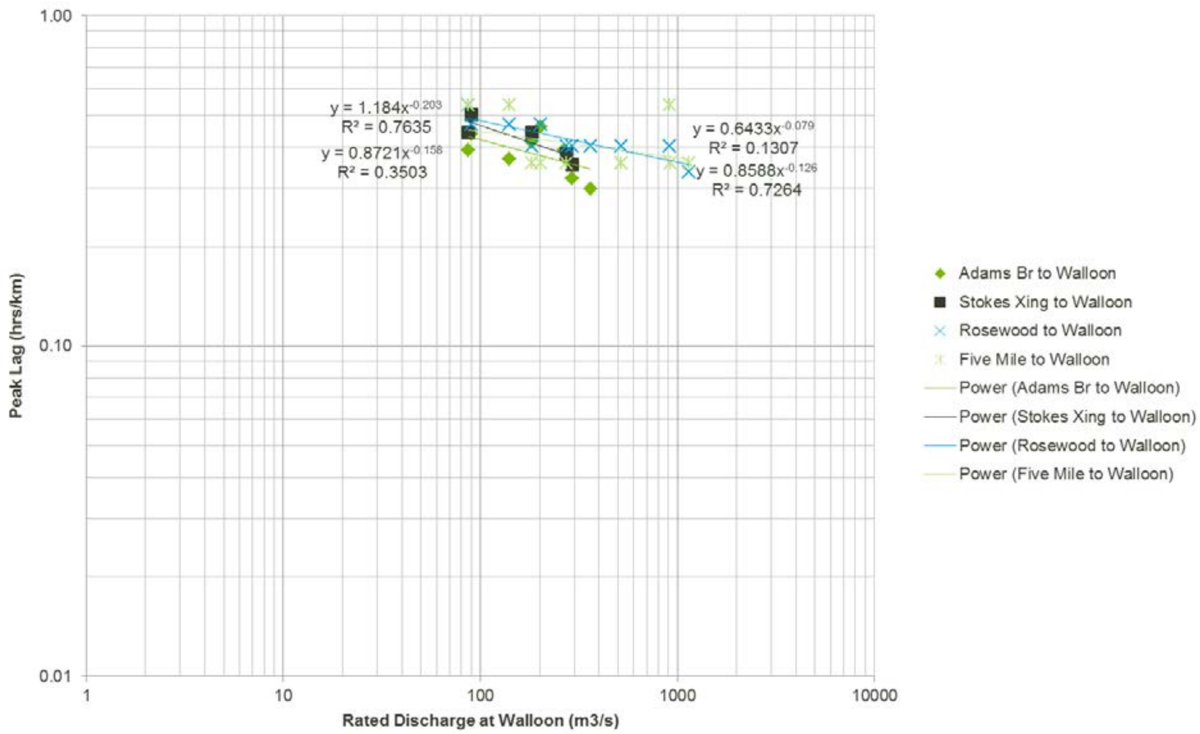


Figure 5-12 Non-linearity assessment: Bremer River to Walloon

5.2.5 Purga Creek

Available data for the Purga Creek catchment is presented in Table 5-8 and Figure 5-13. This data shows a relationship for the Purga Creek catchment with an n value of 0.623 and an R2 value of 0.99. However this relationship is based upon only three events which is not considered to be a sufficient sample size to justify a change in n value for the Purga Creek sub-catchment. Consistent with recommendations for surrounding catchments, we recommend that an n value of 0.85 be adopted for Purga Creek.

Table 5-8 Purga Creek to Loamside – Adopted events and values

Event	Upstream Peak Time	Downstream Peak Time	Rated Flow (m^3/s)	Travel Time	Peak Lag (hrs/km)
Peak Crossing to Loamside (15.3km)					
20040304	6/03/2004 6:00	6/03/2004 14:00	87	8	0.523
20110102	10/01/2011 15:00	10/01/2011 21:00	170	6	0.392
20120220	26/02/2012 4:00	26/02/2012 14:00	44	10	0.654

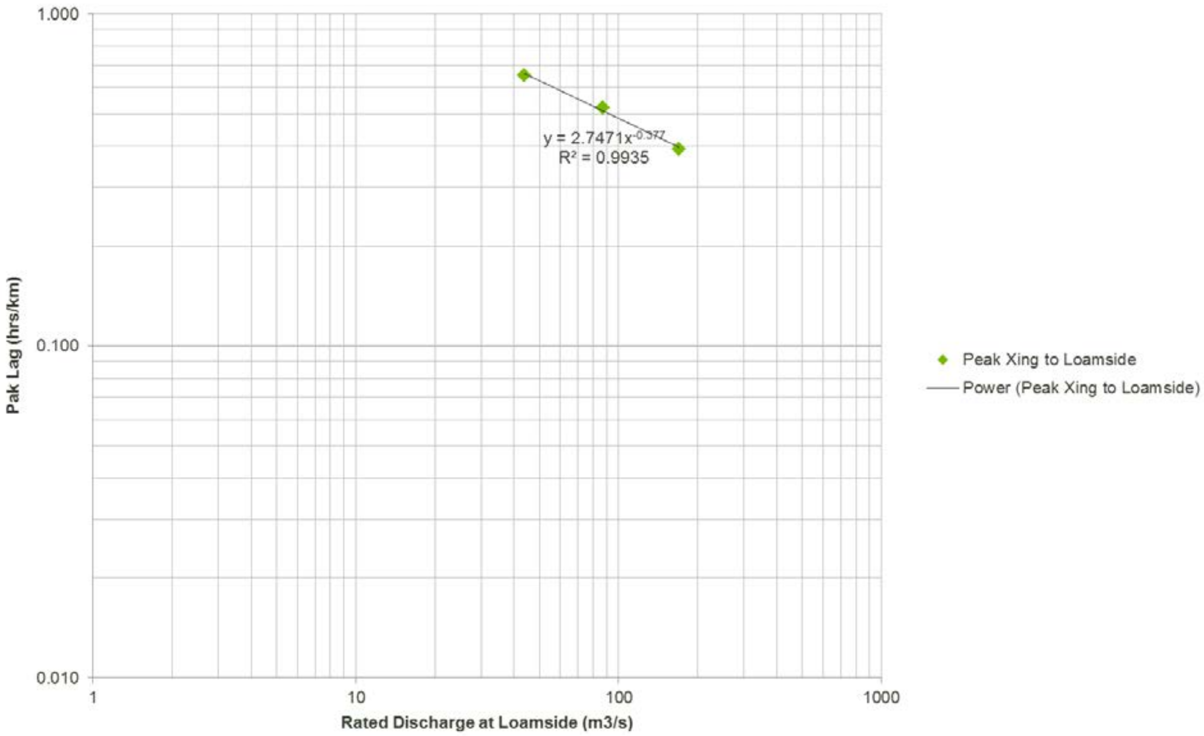


Figure 5-13 Non-linearity assessment: Purga Creek to Loamside

5.2.6 Lower Brisbane River

Table 5-9, Table 5-10 and Table 5-11 present the available data for the Lower Brisbane River to Mt Crosby Weir, Moggill and Centenary Bridge respectively.

Table 5-9 Lower Brisbane River to Mt Crosby Weir – Adopted events and values

Event	Upstream Peak Time	Downstream Peak Time	Rated Flow (m^3/s)	Travel Time	Peak Lag (hrs/km)
Lowood to Mt Crosby (49.4km)					
19680107	13/01/1968 21:00	14/01/1968 8:00	3775	11	0.223
19730705	9/07/1973 7:00	9/07/1973 20:00	2714	13	0.263
19740124	28/01/1974 2:00	28/01/1974 11:00	10375	9	0.182
20110102	12/01/2011 0:00	12/01/2011 10:00	9842	10	0.202
20130123	29/01/2013 0:00	29/01/2013 8:00	2250	8	0.162

Event	Upstream Peak Time	Downstream Peak Time	Rated Flow (m^3/s)	Travel Time	Peak Lag (hrs/km)
Savages Crossing to Mt Crosby (39.6km)					
19590215	19/02/1959 10:00	19/02/1959 16:00	1881	6	0.152
19650718	21/07/1965 10:00	21/07/1965 19:00	1758	9	0.227
19670607	12/06/1967 5:00	12/06/1967 13:00	3036	8	0.202
19680107	13/01/1968 23:00	14/01/1968 8:00	3775	9	0.227
19720201	14/02/1972 14:00	14/02/1972 20:00	2086	6	0.152
19730705	9/07/1973 10:00	9/07/1973 20:00	2714	10	0.253
19740124	28/01/1974 1:00	28/01/1974 11:00	10375	10	0.253
19760119	22/01/1976 9:00	22/01/1976 19:00	1869	10	0.253
19760209	12/12/1976 18:00	12/12/1976 23:00	1010	5	0.126
19830620	24/06/1983 1:00	24/06/1983 6:00	1892	5	0.126
19890423	27/04/1989 7:00	27/04/1989 15:00	1508	8	0.202
20010130	4/02/2001 14:00	4/02/2001 23:00	511	9	0.227
20101006	14/10/2010 10:00	14/10/2010 20:00	1493	10	0.253
20110102	12/01/2011 2:00	12/01/2011 10:00	9842	8	0.202
20120121	29/01/2012 13:00	29/01/2012 19:00	536	6	0.152
20130123	29/01/2013 3:00	29/01/2013 8:00	2250	5	0.126

Table 5-10 Lower Brisbane River to Moggill – Adopted events and values

Event	Upstream Peak Time	Downstream Peak Time	Rated Flow (m^3/s)	Travel Time	Peak Lag (hrs/km)
Lowood to Moggill (68.2km)					
19680107	13/01/1968 21:00	14/01/1968 11:00	4877	14	0.205
19740124	28/01/1974 2:00	28/01/1974 12:00	11664	10	0.147
20110102	12/01/2011 0:00	12/01/2011 16:00	9580	16	0.235
Savages Crossing to Moggill (58.4km)					
19680107	13/01/1968 23:00	14/01/1968 11:00	4877	12	0.205
19740124	28/01/1974 2:00	28/01/1974 12:00	11664	10	0.171
20110102	12/01/2011 2:00	12/01/2011 16:00	9580	14	0.240

Table 5-11 Lower Brisbane River to Centenary Bridge – Adopted events and values

Event	Upstream Peak Time	Downstream Peak Time	Rated Flow (m^3/s)	Travel Time	Peak Lag (hrs/km)
Mt Crosby to Centenary Bridge (47.2km)					
19740124	28/01/1974 11:00	28/01/1974 20:00	11672	9	0.191
20110102	12/01/2011 10:00	12/01/2011 19:00	9483	9	0.191
Moggill to Centenary Bridge (28.4km)					
19740124	28/01/1974 12:00	28/01/1974 20:00	11672	8	0.282
20110102	12/01/2011 16:00	12/01/2011 19:00	9484	3	0.106

This information is also presented in Figure 5-14 and Figure 5-15, which show that there is no clear channel routing relationship in the Lower Brisbane River sub-catchment. It is therefore recommended that the current linear relationship continue to be used in the Lower Brisbane River sub-catchment.

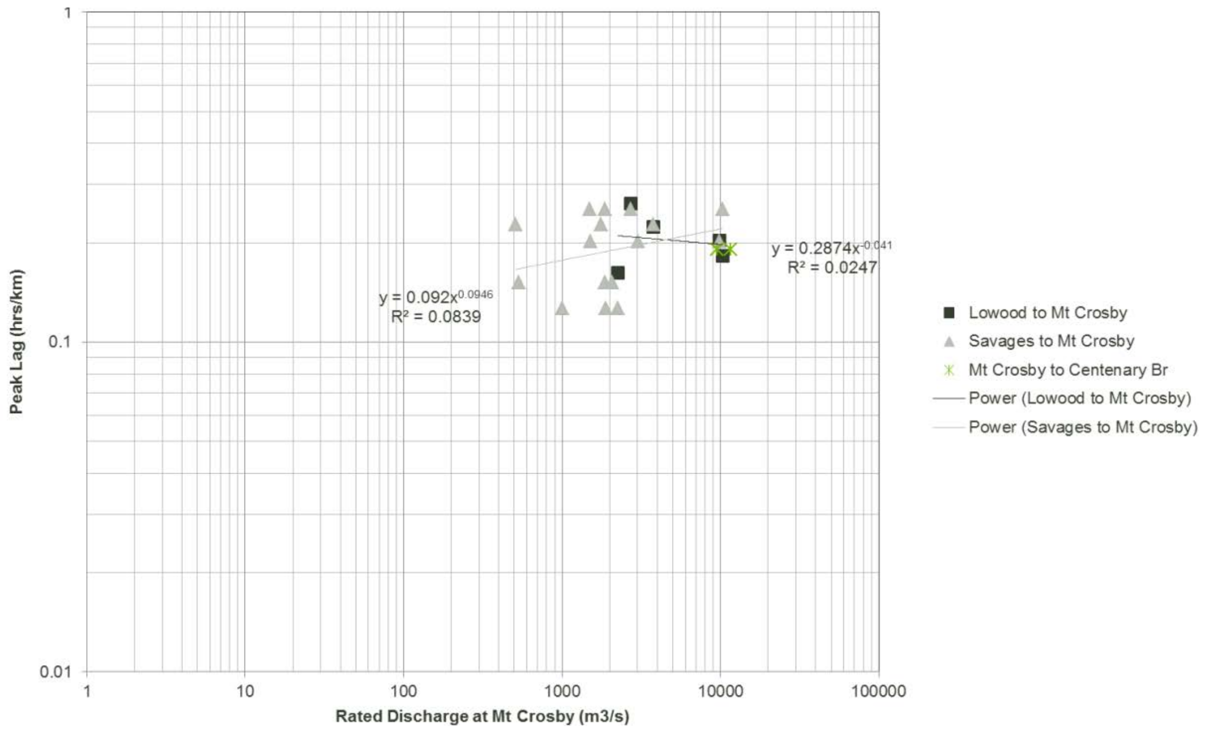


Figure 5-14 Non-linearity assessment: Lower Brisbane River to Mt Crosby Weir

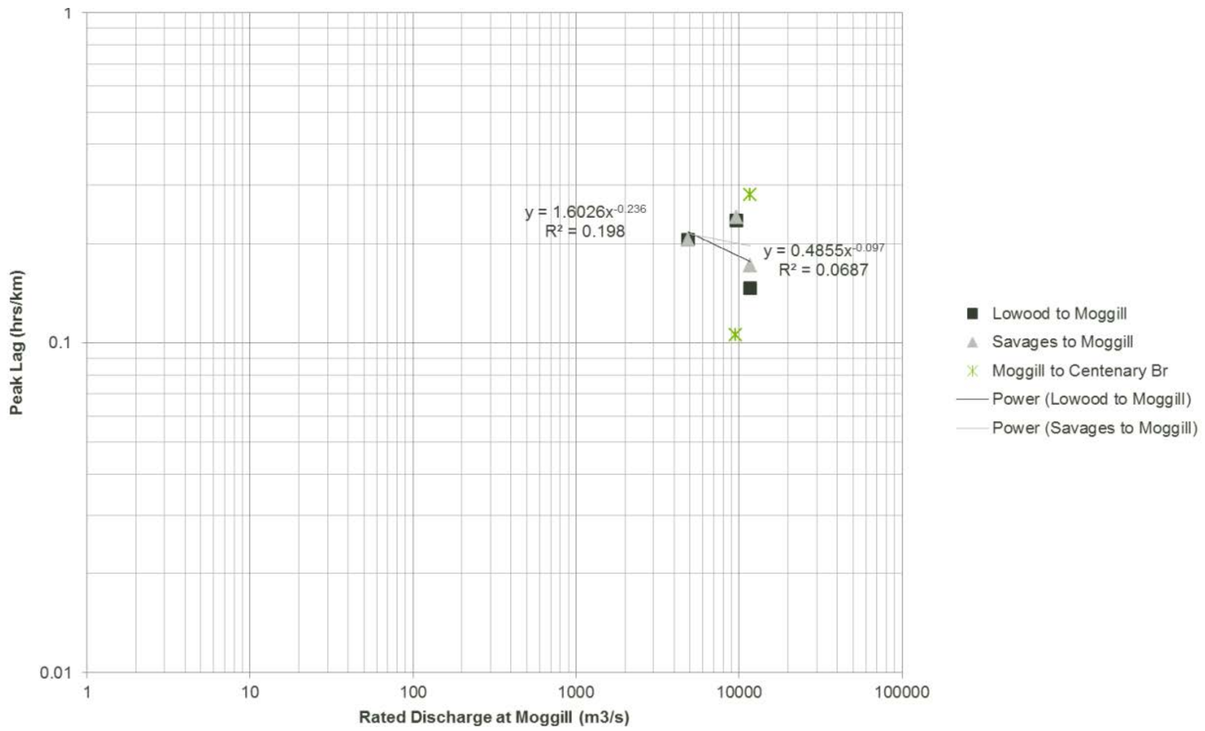


Figure 5-15 Non-linearity assessment: Lower Brisbane River to Moggill

5.2.7 URBS model test

Table 5-12 presents the revised alpha and beta parameters as a result of the preliminary recalibration of the 1974 event model. Model results are presented in Appendix B. In general, this assessment showed that:

- There was no significant improvement to calibration of the 1974 event
- The value of alpha loses physicality, making inter catchment comparison difficult
- For extreme events based on doubling 1974 event rainfalls, peak discharges are increased on average by: 145% with n = 1 and the recommended parameters; and 158% with n = 0.8 and the recalibrated alpha and beta values
- There are no historical events upon which to base a non-linear n value at these flows
- The adopted Seqwater conceptual storages do not extend into the flow ranges for these extreme events, therefore the results from this assessment in the Lower Brisbane River are indicative only

Table 5-12 Non-linearity assessment: Adopted model parameters

Catchment	Recommended Alpha	Muskingham n value	Recommended Beta	Revised Alpha	Muskingham n value	Revised Beta
Stanley	0.16	1.0	4.3	1.5	1.0	2.7
Upper Brisbane	0.13	1.0	2.8	1.5	1.0	2.7
Lockyer	0.30	1.0	3.0	1.6	0.85	3.3
Bremer	0.35	1.0	3.0	0.6	0.85	4.1
Purga	0.40	1.0	3.4	0.7	0.85	2.4
Lower Brisbane	0.15	1.0	3.0	1.0	1.0	2.0

We recognise that it would have been better to carry out this assessment using an n value of 0.85, however the results using n = 0.8 are indicative of the changes that would occur with n = 0.85.

The recommendations for the Bremer River, Lockyer Creek and Purga Creek are based on historical data only. There is no data available to test whether these recommendations are appropriate for extreme events; therefore we are recommending that these changes only be adopted for events up to and including the 1% AEP event at this stage. It is recommended that matching the results of the hydrologic model to the fully calibrated hydraulic model (to be developed during the hydraulics phase of the Brisbane River Catchment Flood Study) for extreme events would provide justification for, and confidence in, an approach to be adopted for the extreme events.

5.2.8 Conclusion: Channel routing linearity

Channel routing linearity has been investigated for the various sub-catchments and tested using the URBS model. The analysis has concluded that catchment non-linearity be adopted for the following sub-catchments:

- Lockyer Creek to Lyons Bridge n = 0.85
- Bremer River to Walloon n = 0.85
- Warrill Creek to Amberley n = 0.85* *(Note * Already adopted by Seqwater)*
- Purga Creek to Loamside n = 0.85

Channel routing non-linearity for the following is not considered appropriate because of the lack of a definitive relationship:

- Upper Brisbane River to Wivenhoe Dam n = 1.00
- Stanley River to Somerset Dam n = 1.00
- Lower Brisbane River n = 1.00

Further analysis of appropriate parameters to be adopted for extreme events above the 1% AEP event will be required when data is available from the BRCFS hydraulics phase.

5.3 Conceptual storages

5.3.1 Floodplain storage representation

The conceptual storages included in the Lower Brisbane River by Seqwater were all treated as online storages, whereas the conceptual storage located in the Warrill Creek model was represented as an off-line storage. In the Warrill Creek model calibration it was noted that the floodplain areas downstream of Churchbank Weir would provide substantial storage of floodwaters, but that this area does not appear to be connected to the main channel efficiently and therefore would not contribute to the conveyance of flow significantly. It could be argued that a similar situation applies to the conceptual storage of Area F, Oxley Creek Junction, but less so for the other storages in the Lower Brisbane River.

In the Warrill Creek model the conceptual storage was included as a two-stage flow bypass specification with separate conceptual floodplain storage (URBS dam route option) applied to represent floodplain routing effects for flows between 300 m^3/s and 700 m^3/s between Churchbank Weir and the junction of Ebenezer Creek and Warrill Creek (upstream of Amberley). The arrangement is shown in Figure 7-66 of the Seqwater report and is repeated below for completeness.

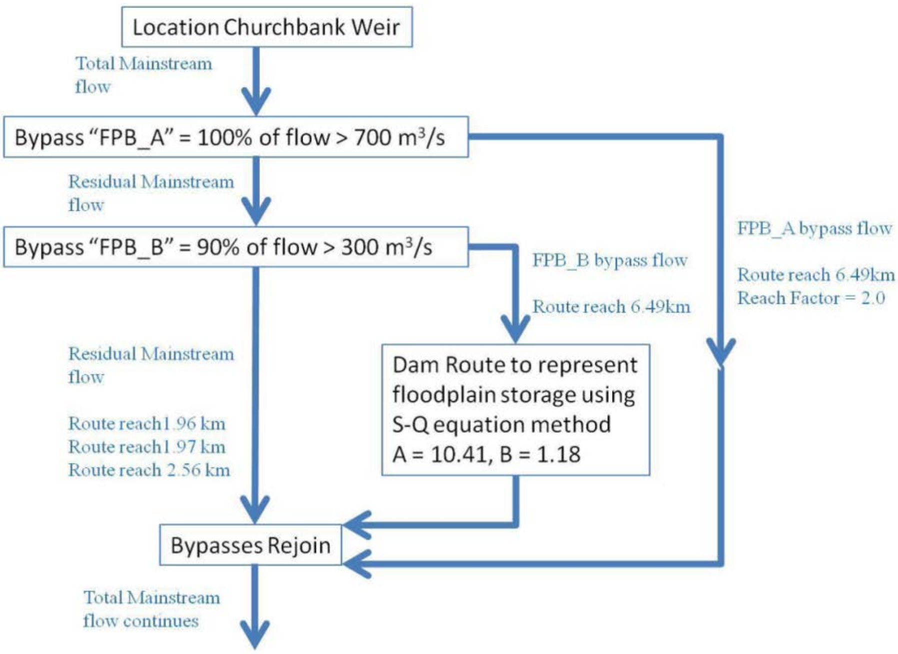


Figure 5-16 Schematic representation of floodplain storage downstream of Churchbank Weir

This arrangement requires several additional parameters to be specified including the proportion of flow that is included in each bypass channel and the reach length factors and the flow range threshold for each bypass.

The application of this arrangement to the conceptual storages in the Lower Brisbane River is complicated by the fact that there is no intermediate stream gauge data to help define the various parameters that are required for its implementation. The conceptual storages representing the junction storage at the confluence of Lockyer Creek (Area A) and the Bremer River (Area D) are also complicated by the fact that they cover two main stream channels, which further complicates the definition of any off-line arrangement.

As mentioned earlier, Area F (Oxley Creek junction) may be the only conceptual storage where an off-line conceptual storage configuration could be considered appropriate.

Therefore, the online conceptual storage arrangement has not been modified as part of this review, but rather the basis of the storage-discharge relationship has been examined to determine if it is possible to relate the conceptual storage characteristics to the physical floodplain characteristics, so as to provide confidence in the extrapolation of the relationship for application to extreme design floods.

5.3.2 Floodplain storage relationships

The conceptual storage relationships were examined with reference to the BCC Disaster Management Tool 10 m grid Digital Elevation Model (DEM) (BCC October 2013). Stage (Elevation) – storage relationships were derived from the 10 m grid DEM, to establish the physical characteristics of these locations. The relationships are based upon a level pool assumption, which is acknowledged is not correct in reality.

The stage-storage relationships were then combined with stage-discharge relationships obtained from results of the BCC DMT model runs for a range of large to extreme flood events. A listing of the model runs used in presented in Appendix C. These relationships were then compared to the calibrated relationships adopted by Seqwater. Figure 5-17 shows the adopted storage-discharge relationships used by Seqwater.

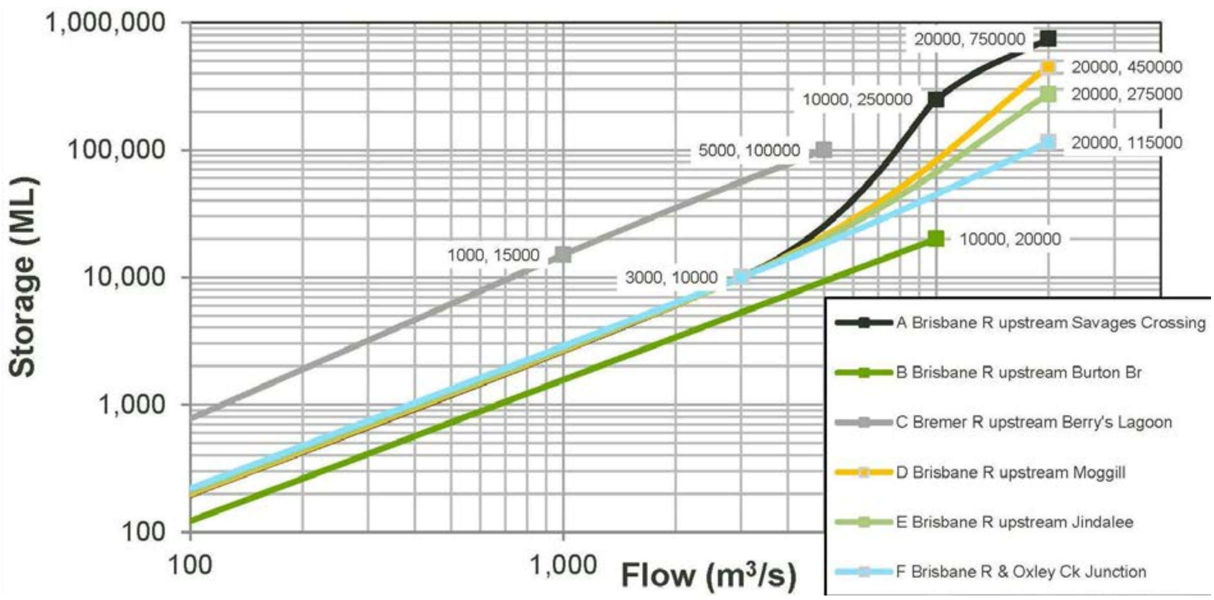


Figure 5-17 Seqwater definition of conceptual storages in Lower Brisbane River

As the Seqwater relationships were defined as storage-discharge equations based upon trial and error fits of modelled and recorded hydrographs, a means of relating the adopted and physical relationships was investigated in order to confirm the application of the adopted relationships to design floods that are larger than the available observed historical events.

The translation between the physical stage (elevation) – storage relationship obtained from the DEM with the storage-discharge relationship was achieved by comparing hydrographs extracted from the TUFLOW model used in the Disaster Management Tool (DMT) at these locations. The degree of attenuation of hydrographs for a range of simulated flows (up to and including 46,000 m^3/s) was determined and contrasted to the hydrologic model performance.

The adopted relationship for Area E is shown in Figure 5-18 by way of example. The remaining relationships can be found in Appendix C.

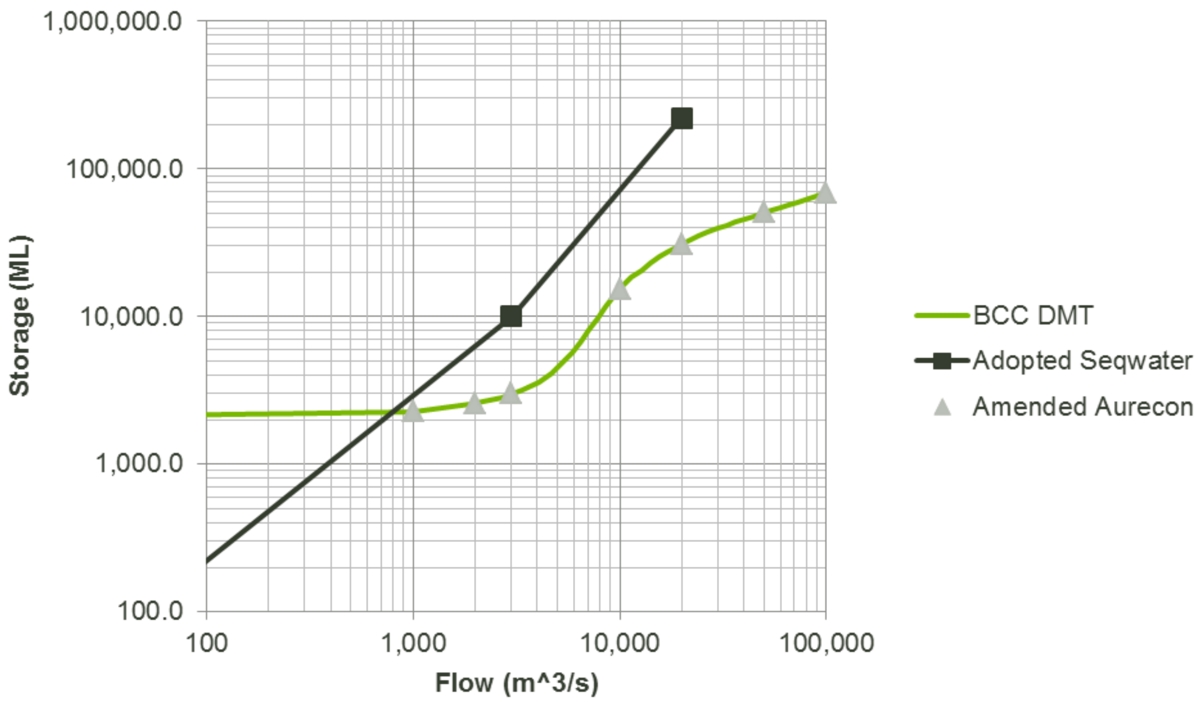


Figure 5-18 Comparison of Conceptual Storage Relationship: Area E Brisbane River at Jindalee

The storage associated with the channel routing model parameter needs to be added to the adopted Seqwater relationship to provide a true comparison between the different approaches. The adopted Alpha for the Lower Brisbane Model has been set at 0.15 and represents the additional channel storage defined by the reach length.

This relationship comparison highlights the difference between the Seqwater adopted curve and the curve derived from the BCC DMT hydraulic model. The curves are not too dissimilar for the range of flows up to around 3,000 m^3/s, (with the Seqwater storage being approximately twice that of storage derived from the BCC DMT model), but then they deviate above this threshold. The Seqwater relationship has significantly more storage for a given flow, and this difference in storage markedly increases with increasing peak flow.

This relationship is typical of most of the other areas. The only exception being Area B – Brisbane River upstream of Burtons Bridge, in which the BCC DMT relationship has greater storage than that adopted by Seqwater.

It was noted from the Interim Calibration Report (BCC, October 2013), that whilst the initial TUFLOW modelling using a 30 m grid replicated flood levels for the January 2011 flood event within reasonable tolerances, it tended to under estimate the recorded flow, especially at Centenary Bridge. A flow of approximately 9,800 m^3/s was recorded during the January 2011 flood event, but the BCC DMT model had a peak of only 8,800 m^3/s at this location. This is contrary to what is suggested by the storage-discharge relationship comparison.

In January 2014, BCC issued a revised calibration using a 20 m grid resolution hydraulic model that achieved better agreement with the flow comparison at Centenary Bridge. A peak flow of 10,050 m^3/s was calculated at this location for the January 2011 event, whilst the peak flood level was 12.10 m. The re-calibrated DMT model also included increased localised flows. These revised calibration results were adopted as for this assessment. BCC published final results from the DMT model in June 2014, after this review had been completed. The results presented in this report are similar to but may not exactly match final BCC results. All results presented below, including ratings, hydrologic and hydraulic model results are presented for the purpose of comparison of the different methodologies only, and have been subject to ongoing change.

5.3.3 Sensitivity analysis

Three cases were assessed:

- Storages modified based on BCC TUFLOW model
- Storages A, C, D, E & F with high flow volumes reduced 10%
- Storages A, C, D, E & F with high flow volumes reduced 20%

For each case, the URBS model was run with $\alpha = 0.15$. The α value was then modified until the best match of peaks across all events and locations occurred.

Adopted α values were:

- $\alpha = 0.5$ for storages modified based on BCC TUFLOW model
- $\alpha = 0.18$ for storages A, C, D, E & F with high flow volumes reduced 10%
- $\alpha = 0.19$ for storages A, C, D, E & F with high flow volumes reduced 20%

Only six of the larger events were assessed as part of the sensitivity analysis as the investigation is tailored to the upper end of the relationship:

- March 1955
- January 1968
- January 1974
- May 1996
- January 2011
- January 2013

Appendix C presents the peak flows, volumes and peak water levels for each of the three modelled cases respectively. The tables in Appendix C also present the differences in flow, volume and water level. The figures in Appendix C show the modelled hydrographs at the Brisbane City Gauge for the six events respectively.

The impact of reducing the storage volume of the conceptual storages results in increasing peak flow rates in the Lower Brisbane River and as a consequence the hydrographs exhibit less attenuation and are advanced in terms of timing. This is shown in Figure 5-19 and Figure 5-20 for the January 2011 flood event. These plots show the (i) recorded hydrograph, (ii) modelled hydrograph based upon the recommended model parameters and adopted conceptual storages and (iii) the modelled hydrograph using the same model parameters but including the BCC DMT conceptual storages.

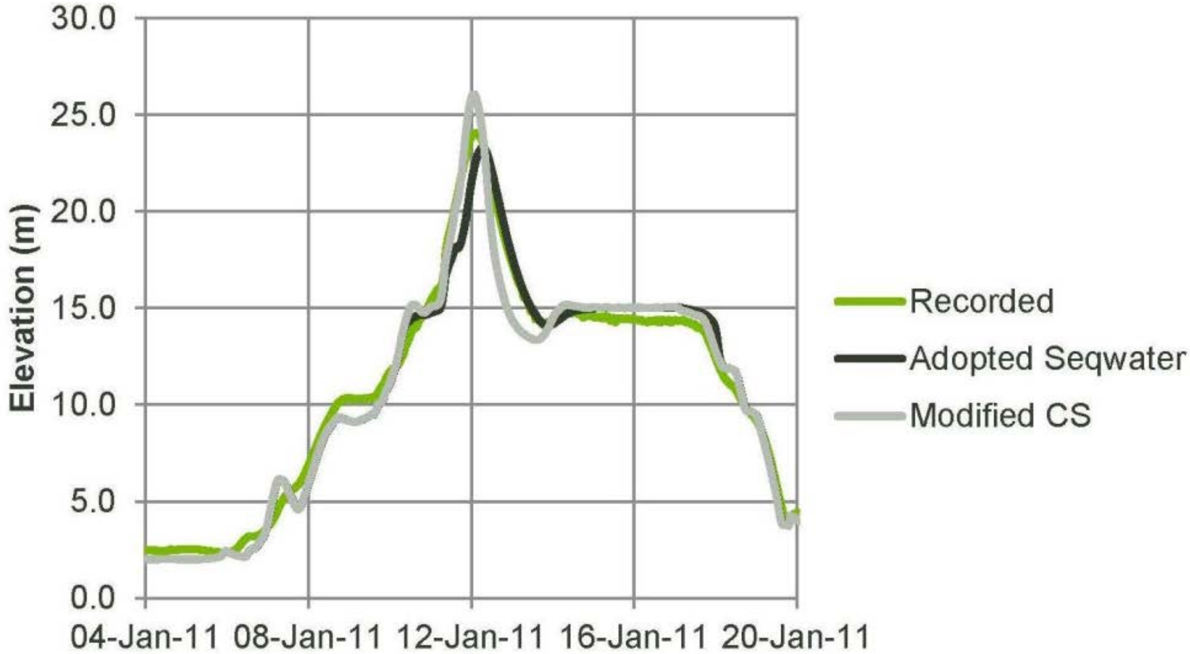


Figure 5-19 January 2011 stage hydrographs, Brisbane River at Savages crossing

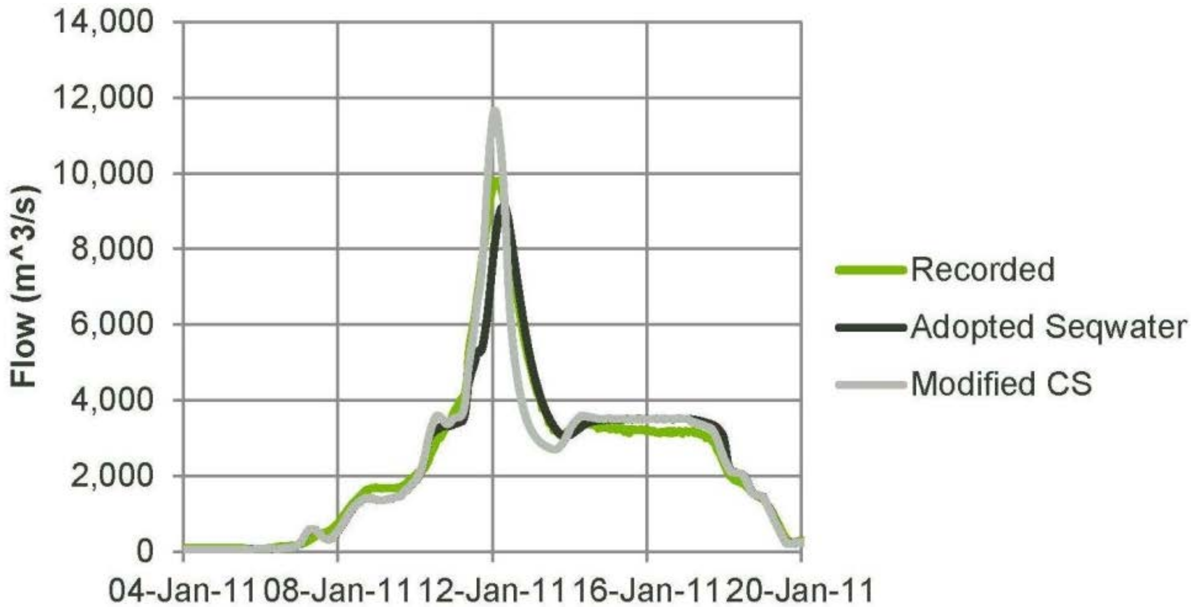


Figure 5-20 January 2011 flow hydrographs, Brisbane River at Savages Crossing

The effect of the reduced storage magnifies the further downstream the flood wave travels. Therefore by the time the flood reaches the Brisbane City Gauge the peak flow has amplified and the lag has reduced even further culminating in a significant change in the flood hydrograph. This is reflected in Figure 5-21 and Figure 5-22.

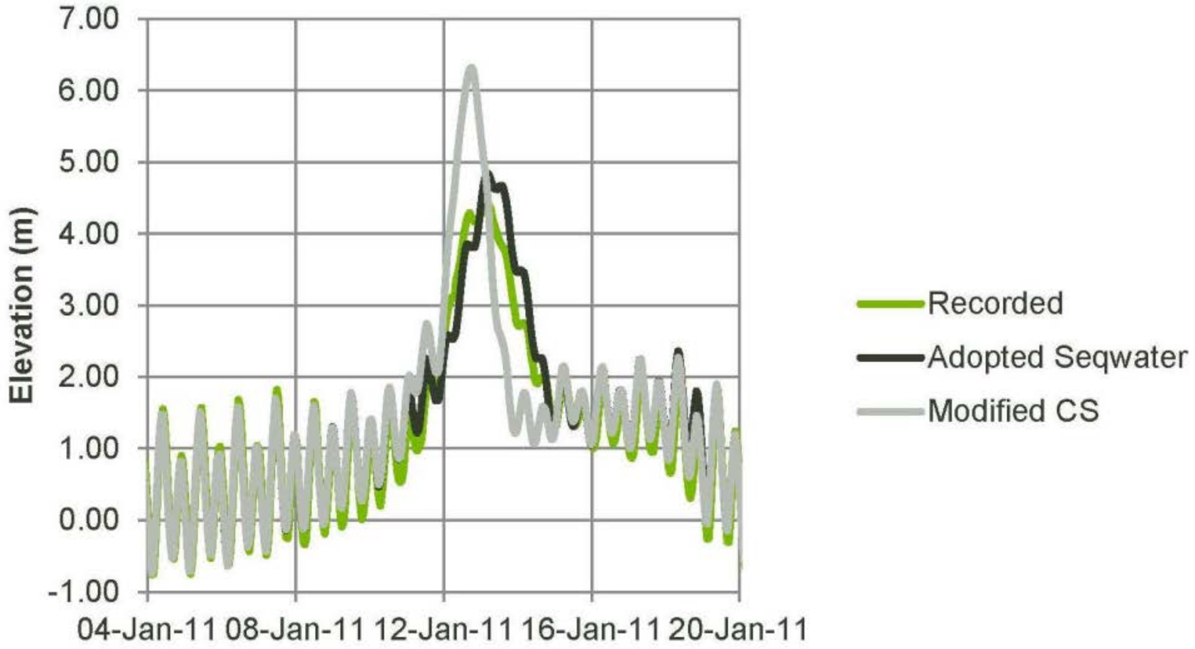


Figure 5-21 January 2011 stage hydrographs, Brisbane River at Brisbane City gauge

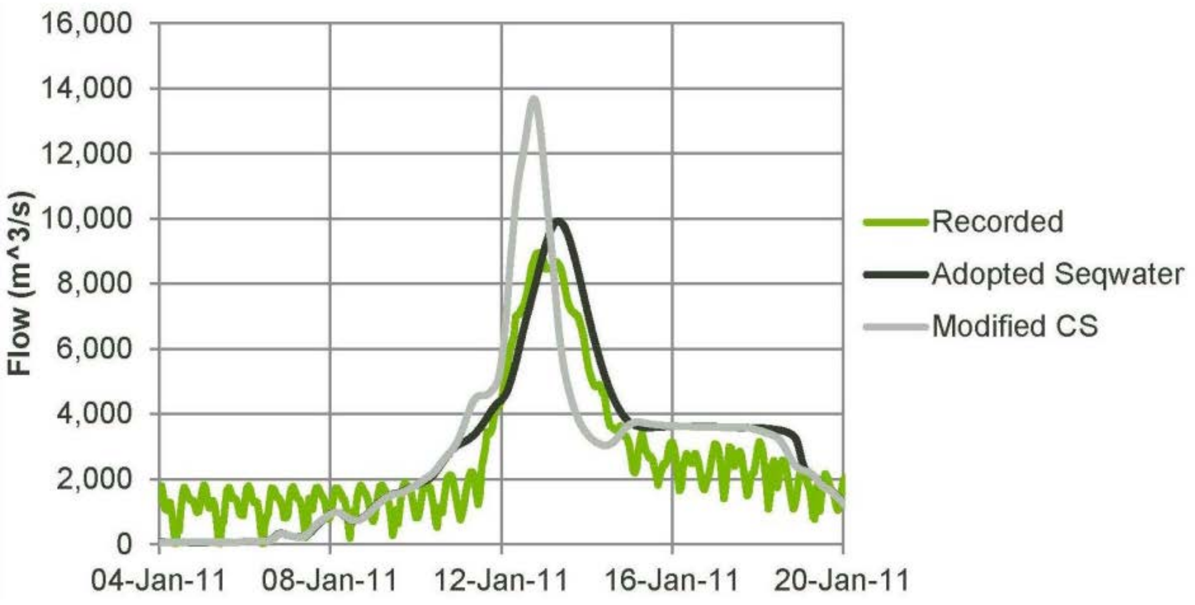


Figure 5-22 January 2011 flow hydrograph, Brisbane River at Brisbane city gauge

Table 5-13 summarises the performance of the amended conceptual storages for a range of locations within the Lower Brisbane River model for the January 2011 flood event.

Table 5-13 Model performance comparison – January 2011 flood event

Location	Recorded	Adopted Seqwater	BCC DMT	Difference Seqwater – BCC DMT
Peak Flow (m^3/s)				
Savages Crossing	9,809	9,124	9,796	-672
Mt Crosby Weir	9,842	9,172	9,089	+83
Ipswich	1,715*	2,538	3,333	-795
Moggill	9,580	10,275	10,592	-317
Centenary Bridge	9,483	9,984	10,053	-69
Brisbane City Gauge	8,962	9,926	9,386	-540
Peak Height (m)				
Savages Crossing	24.08	23.09	23.93	-0.89
Mt Crosby Weir	26.11	25.31	25.57	-0.26
Ipswich	19.30	20.01	18.92	+1.09
Moggill	17.68	18.40	17.84	+0.56
Centenary Bridge	12.06	12.57	12.10	+0.47
Brisbane City Gauge	4.46	4.85	4.29	+0.57
Time to Peak				
Savages Crossing	12/01/2011 2:00	12/01/2011 7:00	12/01/2011 6:00	-1:00
Mt Crosby Weir	12/01/2011 10:00	12/01/2011 13:00	12/01/2011 12:00	-1:00
Ipswich	12/01/2011 13:00	12/01/2011 16:00	12/01/2011 16:00	0:00
Moggill	12/01/2011 16:00	12/01/2011 19:00	12/01/2011 18:00	-1:00
Centenary Bridge	12/01/2011 19:00	13/01/2011 2:00	13/01/2011 0:00	-2:00
Brisbane City Gauge	13/01/2011 3:00	13/01/2011 4:00	13/01/2011 5:00	+1:00

*Note * Flow at Ipswich is based upon a dependent rating curve, and as such should be regarded as estimated.*

5.3.4 Comparison with BCC DMT

In March 2014, Seqwater completed a comparison between the URBS model routing configuration and the results obtained from the BCC DMT TUFLOW hydraulic model for a range of synthetic outflows from Wivenhoe Dam used as the basis of assessing the storage-flow relationships investigated above. The series of synthetic hydrographs were derived by scaling estimated January 1974 flows ranging from 4,000 to 46,000 m^3/s.

Both the hydrologic model and the hydraulic model were calibrated for events up to and including the February 1893 flood event which has a peak flow of approximately 16,000 m^3/s at the Port Office Gauge.

Seqwater concluded the following from this comparison:

- At Savages Crossing, both models produce similar results up to 8,000 m^3/s. Beyond this peak flow, TUFLOW generates higher (up to 15%) and earlier peaks (up to 8 hours) than the URBS model. This suggests that for peak flows over 8,000 m^3/s the adopted conceptual storage may be too large at this location. This implies that for Conceptual Storage A, the adopted relationship of S-Q contains too much storage for the higher flow range and so the storage should be reduced for flows above 8,000 m^3/s
- Both models produce similar results in terms of peak flows (within 3%) at Mt Crosby and Moggill for flows up to about 15,000 m^3/s. However, the TUFLOW model consistently generates earlier peaks by up to 9 hours. Beyond flows of this magnitude, the URBS model peaks are slightly later and lower but still within acceptable tolerances. This implies that Conceptual Storage B and Conceptual Storage D again have too much storage and can therefore be adjusted lower for the higher flow rates
- Peak to peak travel time to the Port office Gauge in the URBS model ranges from 35 hours up to 41 hours while the TUFLOW model ranges from 20 to 36 hours. TUFLOW exhibits an marked increase in travel time from small in bank flows (less than 6,000 m^3/s at the Port Office) to a stepped increase to flows above bank full (greater than 10,000 m^3/s). This impact is attributable to the fact that the URBS model cannot accommodate the effect of tidal flux on flows which can be significant in the lower flow regimes, whereas the TUFLOW does take this into account
- At the Port Office Gauge, the URBS model tends to produce slightly higher (up to 10%) and later results (up to 5 hours) than the TUFLOW over the full range of flood magnitude. This outcome is somewhat contradictory as it suggests that especially for the larger flood events there in insufficient storage in the URBS model below Moggill, even though the timing of the peak indicates otherwise. The conclusions regarding lag (see below) may be relevant to this aspect
- Between Wivenhoe and Moggill (a distance of 78 km), both models show that the lag (hours per kilometre) is relatively independent of flood magnitude and is nearly linear. The URBS model peak to peak travel time estimate varies between 21 to 27 hours, whereas the TUFLOW model varies from 16 to 20 hours. The TUFLOW model is more consistent with typical travel times of observed events
- Between Moggill and Brisbane (a distance of 50 km), the two models give conflicting results. The URBS model indicates that lag increases with flood magnitude while the TUFLOW model shows lag decreasing with increasing event magnitude. The finding of the TUFLOW model is consistent with the 1994 Rubicon hydraulic model results
- Overall the comparison shows that the URBS model performs reasonably well when compared to the BCC DMT hydraulic model, although the results suggest that there is too much storage in the URBS model for flows above 15,000 m^3/s. The URBS model performance also does not match the lag observed in the TUFLOW hydraulic model in the tidal reach below Moggill

5.3.5 Discussion

The impact of changing the conceptual storages based upon the physical characteristics of the DTM has a detrimental impact on the performance of the model calibration. The model calibration appears sensitive to the conceptual storages in the flow range from 3,000 to 15,000 m^3/s. However, there appears to be no real obvious translational relationship between the physically derived storage-discharge relationships and the storage-discharge relationships adopted from the Seqwater hydrologic model calibration process. Modifying the Alpha to a value of 0.50 from 0.15 to compensate for the reduction in storage, results in a significant delay in the hydrograph for all events. This is evidenced by the comparisons shown in Appendix C for the Brisbane City Gauge for a range of flood events. As this approach does not improve the performance of the model calibration, it is not recommended that the conceptual storages be adjusted in this fashion.

The sensitivity analysis conducted on the adopted conceptual storage relationships indicate that a slight improvement can be achieved by reducing the higher stage storage by 20%. This adjustment is quite arbitrary and may only be verified once a fully calibrated hydraulic model is established.

As a result of the review discussed in this report, Aurecon recommended that the adopted relationships be retained in their current form but modified by reducing the upper range by a relative proportion of say 20% to improve performance in the lower reaches over the largest floods of Jan 1974, Jan 2011 and Mar 1955. Conceptual storage relationships for Area B and Area F should not be reduced as the adopted storage is less than that physically available.

As part of the hydrologic model re-calibration process, re-assessment of the model calibration and additional data from the BCC Disaster Management Tool modelling completed in June 2014 allowed the conceptual storage characteristics to be linked to physical floodplain characteristics. This is discussed further in the Hydrologic Model Recalibration Report. These relationships may need to be reviewed as more detailed hydrodynamic modelling of the Lower Brisbane River becomes available.

5.4 Loss rates

The adopted IL-CL loss model was assessed by including a diminishing continuing loss rate for a number of the long duration flood events. This assessment was conducted by specifying a maximum soil water storage capacity (default is infinite capacity to absorb infiltrated losses) in the catchment vector. This capacity is usually between 0 to 500 mm, and is typically of the order of 300 mm. A range of capacities were tested varying from 150 mm up to 350 mm.

The effect of including this parameter was contrasted against the results obtained from the recommended calibration parameters.

A range of long duration events considered:

- Mar 1956 – 408 hours
- Jan 1968 – 360 hours
- Feb 1972 – 408 hours
- May 1996 – 240 hours
- Jan 2001 – 360 hours
- Feb 2010 – 408 hours
- Jan 2011 – 432 hours
- Feb 2012 – 624 hours
- Jan 2013 – 504 hours
- Feb 2013 – 480 hours

The results of this comparison indicate that the model calibration is sensitive to incorporating soil water storage capacity. The lower the capacity the more runoff is created and this impacts on the peak flow, flood volume and shape of the hydrograph. Figure 5-23 and Figure 5-24 show the percentage increase in peak flow and flood volume for the Brisbane City Gauge for the range of flood events considered when a maximum soil water capacity of 350 mm is adopted. Results for the range of events and various locations are contained in Appendix D.

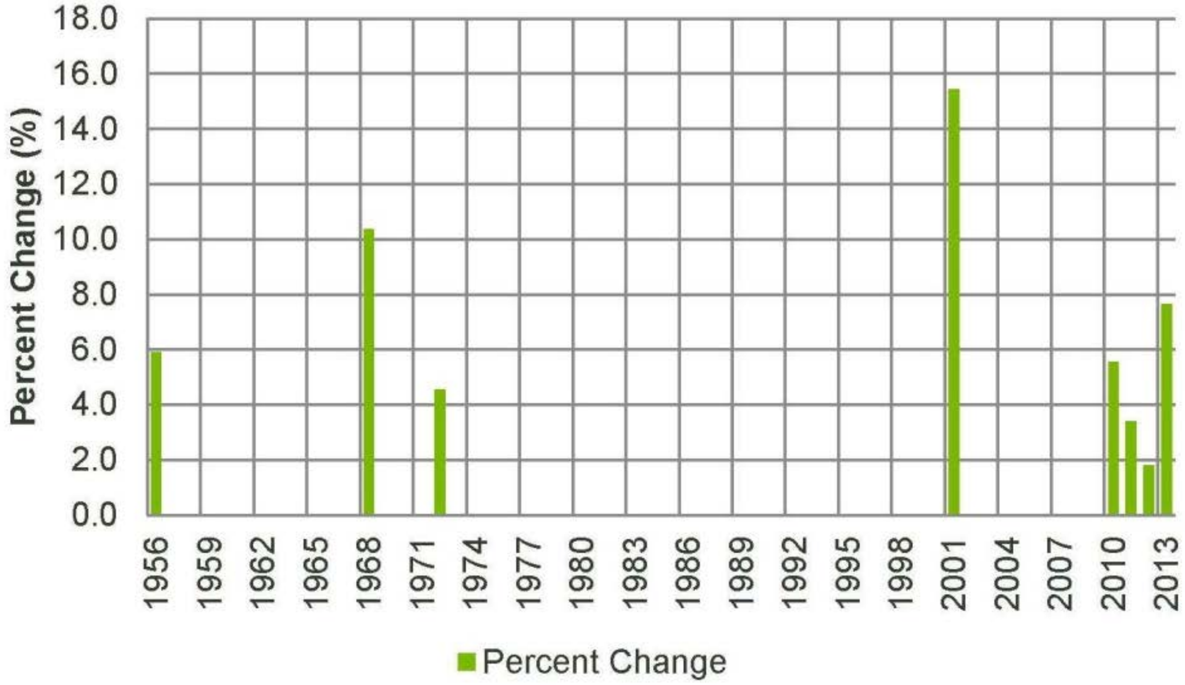


Figure 5-23 Percentage increase in peak flow at Brisbane city gauge for an infiltration capacity of 350mm

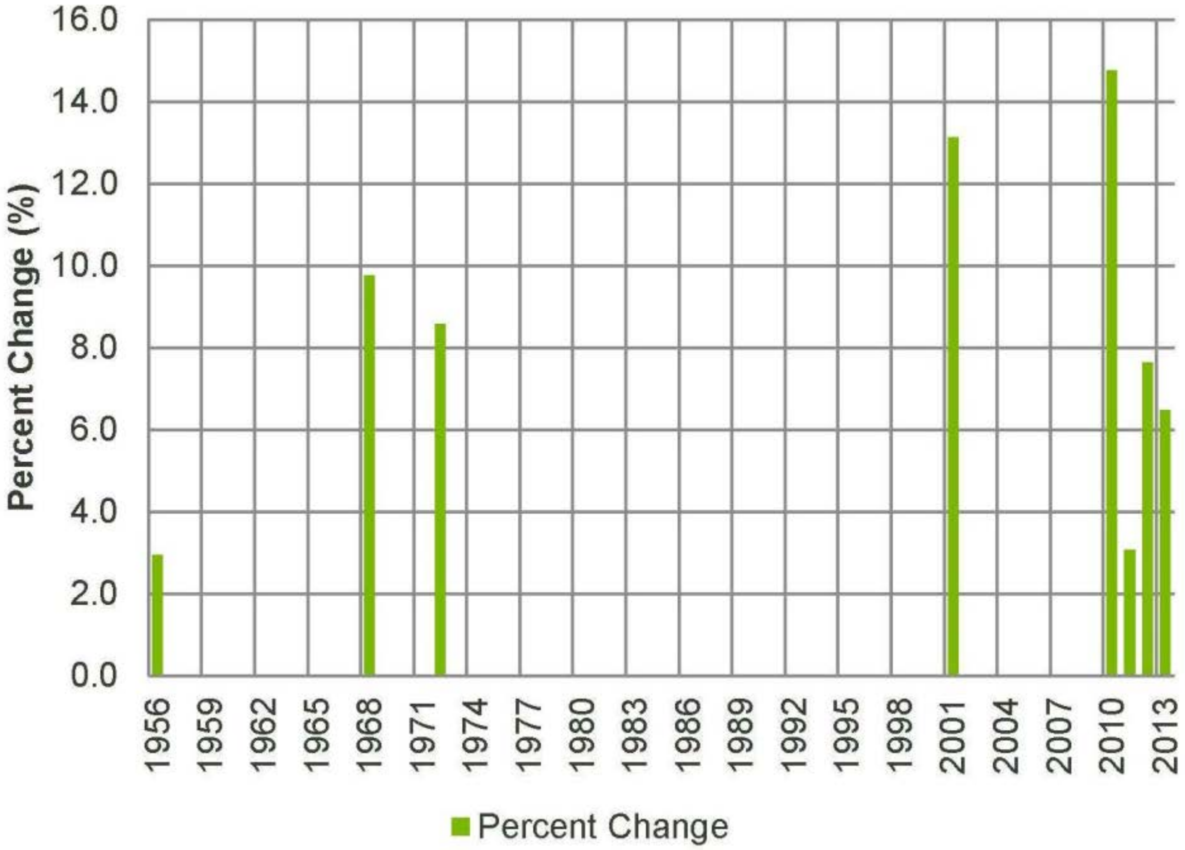


Figure 5-24 Percentage increase in flood volume at Brisbane City gauge for an infiltration capacity of 350mm

5.4.1 Sensitivity analysis

To compensate for the capped infiltration capacity, the starting continuing loss rate needs to be adjusted to ensure that the overall volume balance is maintained for the calibration flood events. Two cases were assessed:

- Infiltration limit set to 350 mm
- Infiltration limit set to 350 mm and continuing loss value modified until event peaks matched those of the recommended parameters model

Only the May 1996 event was assessed for this sensitivity analysis. The initial loss rates were held constant for the sensitivity analysis.

For the continuing loss, a best fit value was selected to provide an overall match across each of the catchments. The adopted continuing loss values are as shown in Table 5-14.

Table 5-14 Comparison of continuing loss rates

	Seqwater recommended continuing loss (mm/hr)	Modified continuing loss value (mm/hr)
Stanley	1.6	3.9
Upper	3.5	20.0*
Lockyer	1.5	3.7
Bremer	1.5	2.5
Purga	0.5	0.6
Warrill	1.5	3.0
Lower	2.0	8.0*

* The peaks for these events are higher than those with the recommended continuing loss rates. It was considered that these loss values are unrealistic and therefore the loss value was not modified further

5.4.2 Discussion

The inclusion of the infiltration capacity and adjusted CL rate results in no real improvement in the hydrologic model calibration performance. There is little guidance available on how to use infiltration capacity for design flood modelling and so this is another reason not to adopt this approach.

Aurecon do not recommend the inclusion of the infiltration capacity factor and the corresponding adjustment of the starting CL rate.

5.5 Base flow

The long term linear base flow index is calculated as:

$$BFI = BC/(1 - BR + BC)$$

Where,
BFI = Base flow Index
BR = Base flow Recession Constant (Daily Value)
BC = Base flow Constant (Daily Value)

The BFI for the various sub-catchments where base flow was included have been calculated as part of the calibration process assuming a linear base flow model.

The adopted linear base flow model parameters are shown in Table 5-15.

Table 5-15 Seqwater adopted linear base flow model parameters

Sub-catchment	Daily			
	BFI	BM	BR	BC
Stanley River to Somerset Dam	0.143	1.0	0.70	0.050
Upper Brisbane River to Wivenhoe Dam	0.122	1.0	0.87	0.018
Lockyer Creek to O'Reilly's Weir	N/A	N/A	N/A	N/A
Bremer River to Walloon	0.143	1.0	0.70	0.050
Warrill Creek to Amberley	0.250	1.0	0.70	0.100
Purga Creek to Loamside	0.143	1.0	0.70	0.050
Lower Brisbane River	N/A	N/A	N/A	N/A

5.5.1 Base flow sensitivity analysis

A sensitivity analysis was therefore undertaken assuming various values of BM < 1.0. The lower bound value considered was BM = 0.5. The BFI was maintained the same as the calibrated value and the BR and BC adjusted accordingly.

Using the Bremer River sub-catchment model as an example, Seqwater adopted the following linear base flow model parameters:

- BC = 0.05
- BM = 1.0
- BR = 0.70

Therefore by keeping the long term BFI constant (and hence BR) the following sensitivity runs were conducted:

- BC = 0.5 for BM = 0.5
- BC = 0.19 for BM = 0.75

The results were tested on a range of events:

- Jul 1965
- Jan 1974
- Apr 1988
- Feb 1999
- Jan 2001
- Mar 2004
- Dec 2010
- Jan 2011
- Jan 2013

The effect of the change in base flow parameters is shown in Figure 5-25 for the Bremer River to Walloon model calibration event for January 1974.

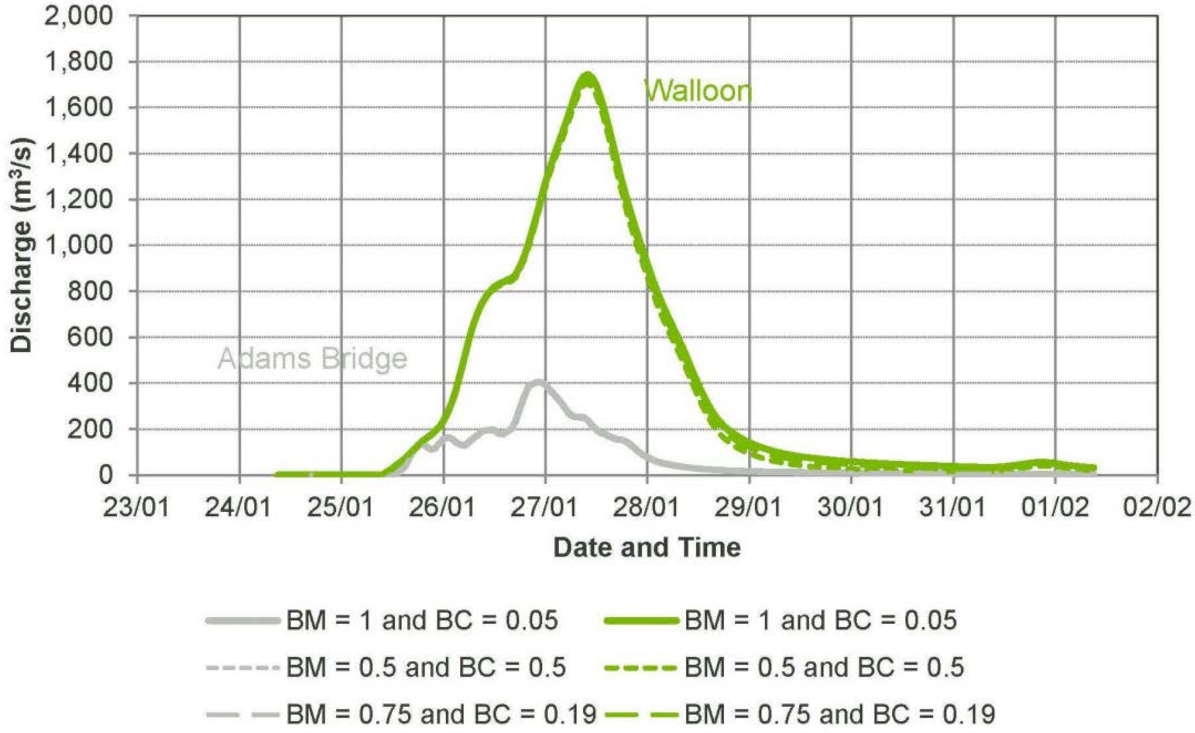


Figure 5-25 Bremer River to Walloon, January 1974 base flow comparison

The comparison indicates that the adoption of a non-linear base flow model does not impact on the overall peak flow significantly and overall the flood volume and hydrograph shape is not unduly affected. Changes to the peak flow are less than 2.5%. The introduction of a non-linear base flow model does not appear to be warranted based upon this assessment. Further information is provided in Appendix D.

5.5.2 Base flow model configuration

Seqwater adopted a linear base flow model as part of the hydrologic model calibration. This representation suggests that the base flow will be proportionate to the 'quickflow' for the range of flood magnitudes. However, the ARR Revision Project 7 Stage 2 Final Report (EA, 2011) prepared as part of the ARR Revision on base flow simulation, implies that there is a relationship between the ARI of the total stream flow and the ARI Factor for both the base flow peak and the base flow volume that diminishes with flood magnitude. By way of definition,

- Base flow Peak Factor (RPBF). This factor is applied to the estimated surface runoff peak flow to give the value of peak base flow for a 10-year ARI event
- Base flow Volume Factor (RVBF). This factor is applied to the estimated surface runoff volume to give the volume of the base flow for a 10-year ARI event

Figure 4 of the ARR Revision Project 7 Stage 2 Final Report shows the relationship between the factors and ARI of the total stream flow and the trend indicates that the base flow contribution to flood events is largest for small events. For rare events, base flow is only a small proportion of the total surface runoff, tending to approach a threshold or capped value of around 0.5 of the 10-year ARI event factor. The 100-year ARI event factor is 0.6. Table 1 from the Stage 2 Final Report is reproduced for completeness.

Table 5-16 ARI factors

ARI (years)	ARI factor Base flow peak factor	ARI factor Base flow volume factor
0.5	3.0	2.6
1	2.2	2.0
2	1.7	1.6
5	1.2	1.2
10	1.0	1.0
20	0.8	0.8
50	0.7	0.7
100	0.6	0.6

5.5.3 Base flow model performance – calibration events

The performance of the adopted linear base flow model has been investigated using five large historic events and assessing the peak base flow index for these events at different locations. These results have then been compared to the ARR Revision Project 7 Stage 2 Final Report indices to gain an appreciation of how well the adopted base flow model fits the recommended relationship.

Various sub-catchment models and events have been used for this assessment. The assignment of an ARI of the historical events was based upon the preliminary flood frequency analysis as outlined in the SKM 2013 report. These estimates are based upon a flood frequency assessment of censored annual series data using a Generalised Extreme Value distribution fitted by L-Moments. The assessment was performed assuming a ‘no-dams condition’. The rank and ARI shown in the comparisons are based upon the SKM flood frequency assessment outcomes.

The hydrologic models are based upon a similar ‘no-dams condition’ using the recommended hydrologic model parameters and specific event loss rates. It is noted that the hydrologic model performance for some events is not consistent with the corresponding flood frequency analysis estimates in terms of resulting relativity of peak flow.

5.5.3.1 Brisbane River at Gregors Creek

The results of the base flow peak flow index assessment are presented in the Table 5-17.

Table 5-17 Brisbane River at Gregors Creek baseflow peak flow index

Event	Modelled Peak Flow (m^3/s)	Modelled Peak Base Flow (m^3/s)	Ratio (%)	Rank	ARI	Peak Flow Index
Jan 1974	5,285	113	2.14	2	56	2.14
May 1996	615	11	1.80	-	< 10	0.21
Feb 1999	5,567	90	1.61	3	50	1.70
Jan 2011	5,431	149	2.74	1	83	2.83
Jan 2013	4,055	53	1.30	10	10	1.00

The base flow peaks are consistent for the range of events considered, in that the ratio of peak base flow to peak flow varies from 1.3 to 2.7%. This is expected given the adoption of a linear base flow model. The corresponding base flow flood volume ratio varies between 6.0 and 8.2% for this catchment.

The results suggest that the derived Peak Flow Index relationship is not consistent with the outcomes of the ARR Revision Project 7 Stage 2 Final Report recommended index behaviour. Moreover the peak flow index for this catchment appears to increase with ARI for this catchment, which is contrary to expectations.

The base flow flood volume indices vary from 1.42 to 3.03 for this catchment. No direct comparison of the base flow flood volume is possible at this time as the SKM preliminary frequency analysis was only performed on the peak flow annual series.

5.5.3.2 Stanley River at Somerset Dam

The results of the base flow peak flow index assessment are presented in the Table 5-18.

Table 5-18 Stanley River at Somerset Dam baseflow peak flow index

Event	Modelled Peak Flow (m^3/s)	Modelled Peak Base Flow (m^3/s)	Ratio (%)	Rank	ARI	Peak Flow Index
Jan 1968	1,710	86	5.00	10	10	1.00
Jan 1974	3,496	264	7.55	5	33	3.09
May 1996	1,753	70	4.01	-		
Feb 1999	3,391	204	6.01	4	36	2.38
Jan 2011	3,848	264	6.87	1	357	3.09
Jan 2013	2,668	109	4.07	-		

The peak base flow ratio is higher in the Stanley River catchment than that of the Upper Brisbane River for similar flood events. Likewise, the base flow flood volume ratio for this catchment varies from 14.8% to 18.2%.

The results suggest that the derived relationship is not consistent with the outcomes of the ARR Revision Project 7 Stage 2 Final Report recommended indices. The peak flow index appears to increase with ARI, which is consistent with the finding for the Upper Brisbane catchment but contrary to that expected.

The base flow flood volume indices range from 0.36 up to 1.71 for this catchment indicating perhaps a closer agreement with the flood volume index relationship.

5.5.3.3 Brisbane River at Wivenhoe Dam

The results of the base flow peak flow index assessment are presented in the Table 5-19.

Table 5-19 Brisbane River at Wivenhoe Dam baseflow peak flow index

Event	Modelled Peak Flow (m^3/s)	Modelled Peak Base Flow (m^3/s)	Ratio (%)	Rank	ARI	Peak Flow Index
Jan 1974	8,344	237	2.84	4	50	2.19
May 1996	1,627	37	2.25	-	< 10	0.34
Feb 1999	6,980	137	1.96	2	56	1.26
Jan 2011	9,293	296	3.18	3	53	2.74
Jan 2013	6,072	108	1.78	11	12	1.00

The modelled peak flow for the February 1999 event is not consistent with the recorded flood frequency estimates adopted by SKM, which ranked this event as the second largest on record, behind the February 1893 event.

The results suggest that the derived relationship is not consistent with the outcomes of the ARR Revision Project 7 Stage 2 Final Report recommended index behaviour. The peak flow index for this catchment appears to increase with ARI, although there is considerable scatter in the between the largest events considered.

The base flow flood volume indices range from 1.14 up to 3.01 for this catchment suggesting a similar conclusion to that of the peak flow index comparison.

5.5.3.4 Warrill Creek at Amberley

The results of the base flow peak flow index assessment are presented in the Table 5-20.

Table 5-20 Warrill Creek at Amberley baseflow peak flow index

Event	Modelled Peak Flow (m^3/s)	Modelled Peak Base Flow (m^3/s)	Ratio (%)	Rank	ARI	Peak Flow Index
Jan 1974	1,687	155	9.20	1	143	3.49
May 1996	486	45	9.15	9	10	1.00
Jan 2011	782	95	12.10	4	14	2.13
Jan 2013	1,004	90	8.93	2	40	2.01

The results suggest that the derived relationship is not consistent with the outcomes of the ARR Revision Project 7 Stage 2 Final Report recommended index behaviour. This particular catchment is influenced by the presence of Moogerah Dam and so the flood frequency estimates may be somewhat biased as a consequence.

The ratio of peak base flow for each of the historic events is relatively consistent as is expected with the adoption of a linear base flow model. The base flow flood volume ratios vary from 18.2% to 20.5%.

The base flow flood volume indices range from 1.67 up to 2.37 for this catchment.

5.5.3.5 Purga Creek at Loamside

The results of the base flow peak flow index assessment are presented in the Table 5-21.

Table 5-21 Purga Creek at Loamside baseflow peak flow index

Event	Modelled Peak Flow (m^3/s)	Modelled Peak Base Flow (m^3/s)	Ratio (%)	Rank	ARI	Peak Flow Index
Jan 1974	693	25	3.54	1	170	1.87
May 1996	280	13	4.66	5	10	1.00
Jan 2011	185	10	5.18	9	5	0.75
Jan 2013	161	4	2.37	3	15	0.31

The results suggest that the derived relationship is not consistent with the outcomes of the ARR Revision Project 7 Stage 2 Final Report recommended index behaviour. The base flow flood volume index values obtained for this catchment show the best agreement with the recommended relationship even though there is still a wide scatter amongst the results. The base flow flood volume indices vary from 0.21 to 1.21 for the range of events assessed.

5.5.3.6 Bremer River at Walloon

The results of the base flow peak flow index assessment are presented in the Table 5-22.

Table 5-22 Bremer River at Walloon baseflow peak flow index

Event	Modelled Peak Flow (m^3/s)	Modelled Peak Base Flow (m^3/s)	Ratio (%)	Rank	ARI	Peak Flow Index
Jan 1974	1,744	83	4.76	1	100	1.97
May 1996	933	42	4.53	6	10	1.00
Feb 1999	448	18	4.10	15	4	0.43
Jan 2011	1,863	66	3.53	2	71	1.56
Jan 2013	1,146	42	3.65	3	17	0.99

The results suggest that the derived relationship is not consistent with the outcomes of the ARR Revision Project 7 Stage 2 Final Report recommended index behaviour. The peak flow index appears to increase with ARI unlike the recommended relationship which suggests that the index tends to a constant value.

The base flow flood volume indices vary from 0.34 to 1.38 for the range of events assessed.

5.5.3.7 Discussion

The comparison between the various sub-catchment model estimates and the recommended base flow index relationships indicates that the observed Peak Flow Index do not conform to the expected trend. The observed values generally suggest that base flow index increases with increasing ARI, whilst the recommended relationship indicates that it should approach a constant value. This observation is more pronounced for the Peak Flow Index than the Flood Volume Index.

5.5.4 Base flow configuration design models

The adoption of the capped base flow can be incorporated for the design case based on rainfall depths (which is total flow depth).

This will be implemented by using the following representation:

RVBF = BC/(1 – BR)

Where, RVBF is the volumetric ratio of base flow to quick runoff. BR will be treated as a constant as derived in the calibration of the hydrologic models so the only change will be to BC.

The Base Flow Volume factor criterion will be used together with the ARI of the design rainfall event contained in the design rainfall definition file.

The value of BC for any location then will be adjusted accordingly:

BC(Max) = (1 - BR) * RVBF(10) * FARI (assuming BM = 1 for all locations)

Where RVCF(10) is the base flow quick runoff volumetric ratio for the 10-year ARI event. FARI is a factor to account for the design ARI under consideration and is presented in Table 5-16.

If the BC value for a specific location exceeds BC(max), then it is set to BC(Max).

Table 5-23 ARI factor for URBS model implementation

ARI	ARI factor Base flow volume factor
0.5	2.6
1	2.0
2	1.6
5	1.2
10	1.0
20	0.8
50	0.7
100	0.6
PMP	0.5

The value of RVBF(10) for the Brisbane River catchment is typically 0.1.

5.5.5 Conclusion

The linear base flow model is a commonly utilised model and is included in models such as the AWBM. The concerns expressed by SKM in the application of such a model to the extreme design flood range is noted, nevertheless the linear base flow model is considered appropriate for use in the overall assessment provided it is modified to ensure that the base flow is not over estimated for the extreme flood range.

Therefore, it is recommended that the linear base flow model continue to be used, but the use of a Base flow Volume Factor be incorporated into the design estimation process to cap the proportion of base flow for events greater than a 1 in 100 AEP event.

6 Recommendations

The following changes are recommended to the Seqwater URBS model representation for use in the assessment of the Brisbane River Catchment Flood Study Hydrology Phase:

1. Remove the Kedron Brook catchment from the Brisbane River catchment area in the Lower Brisbane model
2. Adopt the inclusion of: impervious fractions to represent increased runoff volume in urban areas; urbanised areas to represent reduced response times; and reduced reach length factors for heavily modified reaches in the Lower Brisbane model
3. Adopt changes to the channel routing parameters for the following sub-catchment models:

   Lockyer Creek to O'Reilys Weir – n = 0.85

   Purga Creek to Loamside – n = 0.85

   Bremer River to Walloon – n = 0.85
4. Reject amendments to conceptual storages based upon DMT hydraulic model, but modify the adopted relationships by reducing the storage for flows above 10,000 m^3/s by 20%. Do not change the representation of the online conceptual storages as doing so introduces greater complexity that is not warranted
5. Reject the suggested change of including a diminishing CL rate by introducing a maximum soil storage infiltration capacity. This adds further complexity without necessarily producing a better model calibration
6. Maintain the linear base flow model as the introduction of a non-linear base flow model does not change the model calibration performance significantly. Introduce a Base flow Volume Factor to cap the base flow for events above a 1 in 100 AEP event based upon the findings of the ARR Revision Project 7 Stage 2 Final Report

The recommended changes to the URBS model calibration are intended to improve the representation of the hydrologic model however the hydrodynamics of the Lower Brisbane River are very complex and cannot be reliably reproduced in all events. It is noted that it is possible to adjust the lag and add additional storage to improve model performance for some events, but there is a lack of consistency between events. Therefore, whilst the best overall fit for a range of events has been developed, the reliability of modelling of individual events will vary considerably.

7 References

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8 Glossary

8.1 Hydrologic terms

AEP: Annual Exceedance Probability – is a measure of the likelihood (expressed as a probability) of a flood event reaching or exceeding a particular magnitude in any one year. A 1% (AEP) flood has a 1% (or 1 in 100) chance of occurring or being exceeded at a location in any year

AHD: Australian Height Datum (m), the standard reference level in Australia

AR&R: Australian Rainfall and Runoff (AR&R) is a national guideline document for the estimation of design flood characteristics in Australia. It is published by Engineers Australia. The current 2003 edition is now being revised. The revision process includes 21 research projects, which have been designed to fill knowledge gaps that have arisen since the 1987 edition

CHA: Comprehensive Hydrologic Assessment

CL: Continuing Loss (mm/hour). The amount of rainfall during the later stages of the event that infiltrates into the soil and is not converted to surface runoff in the hydrologic model

CRC-CH: Cooperative Research Centre – Catchment Hydrology. In this report, CRCH-CH usually refers to a Monte Carlo sampling method that was developed by the CRC-CH

CSS: Complete Storm Simulation. This is one of the proposed Monte Carlo sampling methods

Cumulative probability: The probability of an event occurring over a period of time, any time in that period. This probability increases over time

DEA: Design Event Approach. A semi-probabilistic approach to establish flood levels, which only accounts for the variability of the rainfall intensity

Design flood event: Hypothetical flood events based on a design rainfall event of a given probability of occurrence (ie AEP). The probability of occurrence for a design flood event is assumed to be the same as the probability of rainfall event upon which it is based (EA, 2003)

DMT: Disaster Management Tool. Work completed by BCC in 2014 for Queensland Government as part of the development of an interim disaster management tool until the completion of the BRCFS

DTM: Digital Terrain Model

EL (m AHD): Elevation (in metres) above the Australian Height Datum

FFA: Flood Frequency Analysis – a direct statistical assessment of flood characteristics

Flood mitigation manual (Flood Manual): A flood mitigation manual approved under section 371E(1)(a) or 372(3) of the Water Supply (Safety and Reliability) Act 2008 (QLD)

FOSM: Flood Operations Simulation Model (refer Seqwater 2014)

Floodplain: Area of land adjacent to a creek, river, estuary, lake, dam or artificial channel, which is subject to inundation by the PMF (CSIRO, 2000)

FSL: Full Supply Level - maximum normal water supply storage level of a reservoir behind a dam

FSV: Full Supply Volume – volume of the reservoir at FSL

GEV: Generalised Extreme Value statistical distribution

GIS: Geographic Information System

GL: Gigalitres This is a unit of volume used in reservoir studies. A Gigalitre = 1,000,000,000 litres or equivalently 1,000,000 m^3

GSDM: Generalised Short Duration Method of extreme precipitation estimation for storms of less than 6 hour duration and catchments of less than 1,000 km^2. Refer BoM, 2003

GTSMR: Revised Generalised Tropical Storm Method of extreme precipitation estimation for storms of tropical origin. Applicable to storm durations of up to 168 hours and catchments up to 150,000km^2. Refer BoM, 2003

IFD-curves: Intensity-Frequency-Duration curves, describing the point- or area-rainfall statistics. In the current report rainfall depth is generally used as an alternative to rainfall intensity. Rainfall depth is the product of duration and intensity. It was decided to maintain the term "IFD" as this is the terminology that the reader is most likely to be familiar with

IL: Initial Loss (mm). The amount of rainfall that is intercepted by vegetation or absorbed by the ground and is therefore not converted to runoff during the initial stages of the rainfall event

LOC: Loss of Communications dam operating procedure, refer Flood Manual (Seqwater 2013)

LPIII: Log-Pearson Type III statistical distribution

IQQM: Integrated Quantity and Quality Model for water resources planning

JPA: Joint Probability Approach. A general term for probabilistic methods to establish design flood levels

MCS: Monte Carlo Simulation

MHWS: Mean High Water Spring Tide level

ML: Megalitre. This is a unit of volume used in reservoir studies. A megalitre is equal to 1,000,000 litres or, equivalently, 1,000 m^3

m^3/s: Cubic metre per second – unit of measurement for instantaneous flow or discharge

PMF: Probable Maximum Flood – the largest flood that could conceivably occur at a particular location, resulting from the PMP (CSIRO, 2000) and Australia Rainfall and Runoff, 2003 (EA, 2003)

PMP: Probable Maximum Precipitation – the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of year, with no allowance made for long-term climatic trends (CSIRO, 2000; EA 2003)

PMP DF: Probable Maximum Precipitation Design Flood – the flood event that results from the PMP event

Quantiles: Values taken at regular intervals from the inverse of the cumulative distribution function (CDF) of a random variable

Stochastic flood event: Statistically generated synthetic flood event. Stochastic flood events include variability in flood input parameters (eg temporal and spatial rainfall patterns) compared to design flood events. Stochastic flood events by their method of generation exhibit a greater degree of variability and randomness compared to design flood events (See also Design flood event)

Synthetic flood event: See Stochastic flood event

TPT: Total Probability Theorem. This is one of the fundamental theorems in statistics. In this report, TPT refers to a Monte Carlo sampling method that is based on stratified sampling and, hence, makes use of the total probability theorem

URBS: Unified River Basin Simulator. A rainfall runoff routing hydrologic model (Carroll, 2012)

8.2 Study related terms

BCC: Brisbane City Council

BoM: Australian Bureau of Meteorology

BRCFS: Brisbane River Catchment Flood Study

BRCFM: Brisbane River Catchment Floodplain Management Study

BRCFMP: Brisbane River Catchment Floodplain Management Plan

Delft-FEWS: Flood Early Warning Systems, a software package developed by Deltares, initially for the purpose of real-time flood forecasting. Delft-FEWS is used all over the world, including by the Environment Agency (UK) and the National Weather Service (US). Currently, it is also being implemented by Deltares and BoM for flood forecasting in Australia. The Monte Carlo framework for the BRCFS-Hydrology Phase will be implemented in Delft-FEWS

DEWS: Department of Energy and Water Supply

DIG: Dams Implementation Group

DNRM: Department of Natural Resources and Mines

DSITIA: Department of Science Information Technology, Innovation and the Arts

DSDIP: Department of State Development and Infrastructure Planning

EA: Engineers Australia formally known as The Institute of Engineers, Australia

GA: General Adapter, an interface between the Delft-FEWS environment and an external module

IC: Implementation Committee of the BRCFS

ICC: Ipswich City Council

IPE: Independent panel of experts to the BRCFS

LVRC: Lockyer Valley Regional Council

ND: No-dams condition. This scenario represents the catchment condition without the influence of the dams and reservoirs. The reservoir reaches have effectively been returned to their natural condition

NPDOS: North Pine Dam Optimisation Study conducted in response to the QFCOI Final Report

PIG: Planning Implementation Group

QFCOI: Queensland Floods Commission of Inquiry

RTC: Real-Time Control. A software package for simulations of reservoir operation. RTC tools is used for the simulation of Wivenhoe and Somerset reservoirs

SC: Steering Committee of the BRCFS

SRC: Somerset Regional Council

TWG: Technical Working Group

WD: With-dams condition. This scenario represents the catchment condition with the influence of the dams and reservoirs represented in their current (2013) configuration

WSDOS: Wivenhoe and Somerset Dam Optimisation Study conducted in response to the QFCOI Final report

Appendices

Appendix A Sensitivity analysis – impervious fraction

Event	Location	Peak Flow (m^3/s)			Volume (ML)			Peak Level (m)			Time of Peak		
		Recommend Parameters	With Urbanisation	% Difference	Recommend Parameters	With Urbanisation	% Difference	Recommend Parameters	With Urbanisation	Difference (m)	Recommend Parameters	With Urbanisation	Difference (hrs:mins)
Apr-89	Mt Crosby Weir	1793	1794	0.02%	939693	942564	0.31%	12.16	12.16	0.00	28/04/1989 0:00	28/04/1989 0:00	0:00
	Colleges Crossing	1793	1793	0.02%	939981	942881	0.31%	11.14	11.14	0.00	28/04/1989 0:00	28/04/1989 0:00	0:00
	Ipswich	456	457	0.11%	62151	63638	2.39%	6.09	6.09	0.00	26/04/1989 20:00	26/04/1989 20:00	0:00
	Moggill	1948	1948	0.00%	1011968	1018497	0.65%	3.88	3.88	0.00	27/04/1989 18:00	27/04/1989 18:00	0:00
	Goodna	1949	1948	-0.05%	1015413	1023657	0.81%	4.32	4.32	0.00	27/04/1989 21:00	27/04/1989 21:00	0:00
	Jindalee	1948	1946	-0.09%	1021700	1032021	1.01%	2.11	2.11	0.00	28/04/1989 4:00	28/04/1989 4:00	0:00
	Centenary Bridge	1948	1946	-0.10%	1028555	1039899	1.10%	1.83	1.83	0.00	28/04/1989 4:00	28/04/1989 4:00	0:00
	Brisbane City Gauge	1948	1944	-0.18%	1048014	1066768	1.79%	1.36	1.36	0.00	28/04/1989 3:00	28/04/1989 3:00	0:00
May-96	Mt Crosby Weir	2657	2674	0.66%	757857	766069	1.08%	14.54	14.59	0.05	4/05/1996 19:00	4/05/1996 19:00	0:00
	Colleges Crossing	2662	2680	0.67%	759583	767883	1.09%	13.56	13.6	0.04	4/05/1996 19:00	4/05/1996 19:00	0:00
	Ipswich	1534	1530	-0.23%	371191	375921	1.27%	11.52	11.51	-0.01	4/05/1996 1:00	4/05/1996 1:00	0:00
	Moggill	3301	3337	1.08%	1193932	1213729	1.66%	6.75	6.84	0.09	4/05/1996 23:00	4/05/1996 23:00	0:00
	Goodna	3379	3436	1.70%	1223892	1248678	2.03%	7.85	7.97	0.12	5/05/1996 2:00	5/05/1996 2:00	0:00
	Jindalee	3448	3506	1.69%	1257998	1289541	2.51%	4.26	4.36	0.10	5/05/1996 6:00	5/05/1996 5:00	-1:00
	Centenary Bridge	3576	3632	1.59%	1296663	1331508	2.69%	4.12	4.21	0.09	5/05/1996 5:00	5/05/1996 4:00	-1:00
	Brisbane City Gauge	3729	3790	1.64%	1389388	1446176	4.09%	2.17	2.21	0.04	6/05/1996 0:00	6/05/1996 0:00	0:00
Feb-99	Mt Crosby Weir	2539	2541	0.07%	1021781	1024039	0.22%	14.21	14.21	0.00	10/02/1999 16:00	10/02/1999 16:00	0:00
	Colleges Crossing	2539	2541	0.07%	1022260	1024541	0.22%	13.25	13.25	0.00	10/02/1999 17:00	10/02/1999 17:00	0:00
	Ipswich	683	678	-0.74%	108324	109609	1.19%	7.21	7.18	-0.03	9/02/1999 18:00	9/02/1999 19:00	1:00
	Moggill	2840	2841	0.02%	1150242	1155389	0.45%	5.68	5.68	0.00	10/02/1999 16:00	10/02/1999 16:00	0:00
	Goodna	2844	2843	-0.04%	1160275	1166560	0.54%	6.67	6.66	-0.01	10/02/1999 17:00	10/02/1999 17:00	0:00
	Jindalee	2844	2842	-0.08%	1170158	1178008	0.67%	3.26	3.26	0.00	10/02/1999 19:00	10/02/1999 19:00	0:00
	Centenary Bridge	2846	2844	-0.08%	1178588	1187243	0.73%	2.97	2.96	-0.01	10/02/1999 20:00	10/02/1999 20:00	0:00
	Brisbane City Gauge	2851	2847	-0.11%	1203122	1217133	1.16%	1.56	1.56	0.00	15/02/1999 10:00	15/02/1999 10:00	0:00
Jan-11	Mt Crosby Weir	7662	7666	0.05%	3450461	3455159	0.14%	23.44	23.44	0.00	12/01/2011 13:00	12/01/2011 13:00	0:00
	Colleges Crossing	7664	7668	0.05%	3450368	3455109	0.14%	22.58	22.58	0.00	12/01/2011 13:00	12/01/2011 13:00	0:00
	Ipswich	2437	2431	-0.26%	479756	482306	0.53%	19.62	19.62	0.00	12/01/2011 14:00	12/01/2011 14:00	0:00
	Moggill	9252	9252	0.00%	3951405	3961975	0.27%	17.35	17.35	0.00	12/01/2011 19:00	12/01/2011 19:00	0:00
	Goodna	9253	9251	-0.02%	3961490	3974430	0.33%	16.5	16.5	0.00	12/01/2011 20:00	12/01/2011 20:00	0:00
	Jindalee	9029	9027	-0.03%	3969394	3986194	0.42%	12.37	12.36	-0.01	13/01/2011 2:00	13/01/2011 2:00	0:00
	Centenary Bridge	9029	9026	-0.03%	3987292	4006199	0.47%	11.59	11.58	-0.01	13/01/2011 2:00	13/01/2011 2:00	0:00
	Brisbane City Gauge	8990	8985	-0.05%	4018337	4050605	0.80%	4.55	4.55	0.00	13/01/2011 5:00	13/01/2011 5:00	0:00
Jan-13	Mt Crosby Weir	2589	2591	0.09%	1251744	1258879	0.57%	14.35	14.36	0.01	29/01/2013 15:00	29/01/2013 15:00	0:00
	Colleges Crossing	2588	2590	0.09%	1252293	1259501	0.58%	13.37	13.38	0.01	29/01/2013 16:00	29/01/2013 16:00	0:00
	Ipswich	1844	1844	0.04%	318735	323166	1.39%	12.91	12.92	0.01	29/01/2013 1:00	29/01/2013 1:00	0:00
	Moggill	3581	3584	0.08%	1599659	1617116	1.09%	7.45	7.46	0.01	29/01/2013 20:00	29/01/2013 20:00	0:00

Event	Location	Peak Flow (m^3/s)			Volume (ML)			Peak Level (m)			Time of Peak		
		Recommend Parameters	With Urbanisation	% Difference	Recommend Parameters	With Urbanisation	% Difference	Recommend Parameters	With Urbanisation	Difference (m)	Recommend Parameters	With Urbanisation	Difference (hrs:mins)
	Goodna	3582	3585	0.07%	1611717	1633515	1.35%	8.27	8.27	0.00	29/01/2013 21:00	29/01/2013 21:00	0:00
	Jindalee	3526	3527	0.05%	1625266	1652853	1.70%	4.39	4.4	0.01	30/01/2013 2:00	30/01/2013 2:00	0:00
	Centenary Bridge	3526	3527	0.05%	1642465	1673212	1.87%	4.04	4.04	0.00	30/01/2013 2:00	30/01/2013 2:00	0:00
	Brisbane City Gauge	3516	3517	0.02%	1686176	1736902	3.01%	2.46	2.49	0.03	28/01/2013 10:00	28/01/2013 10:00	0:00

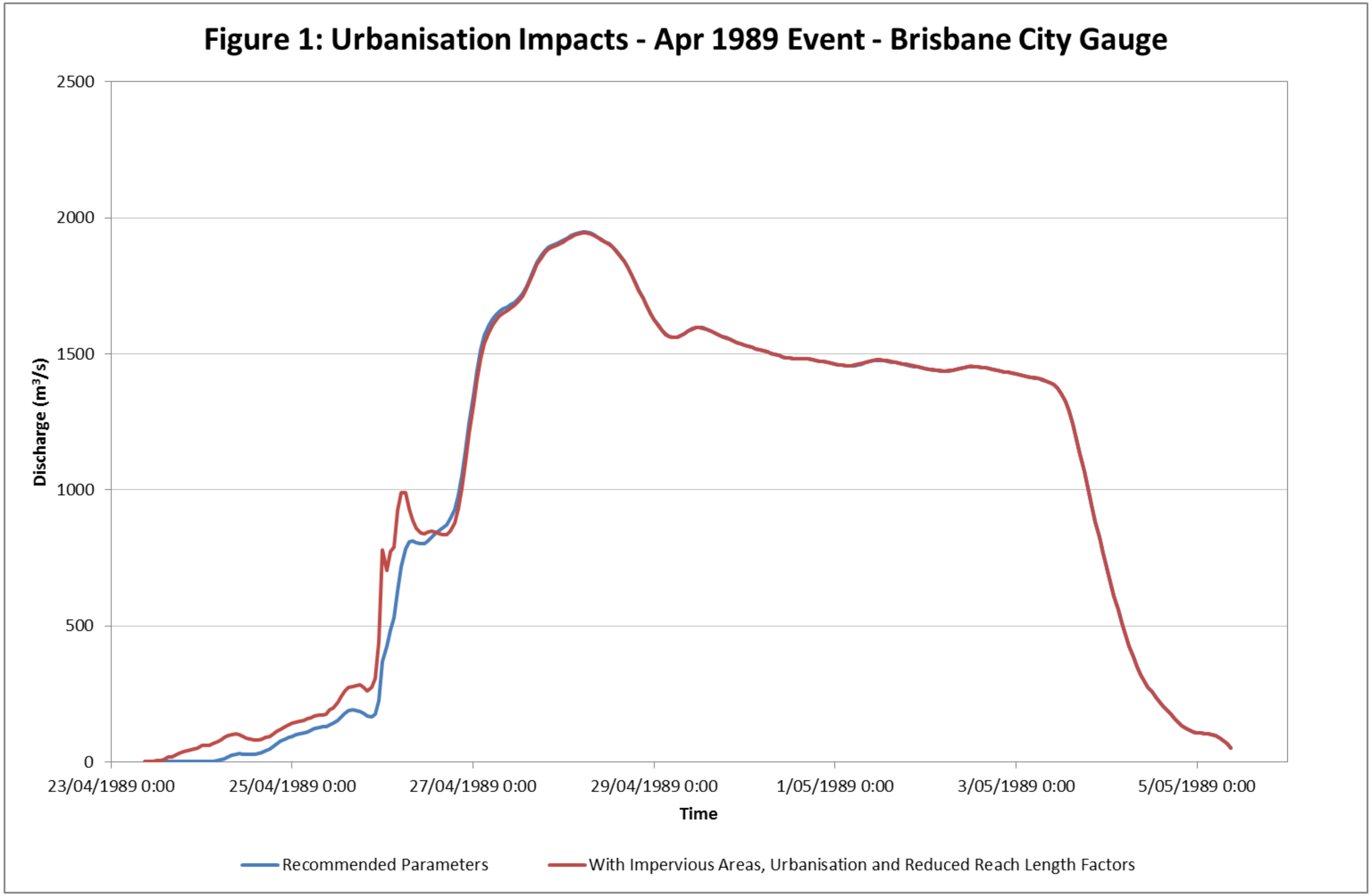
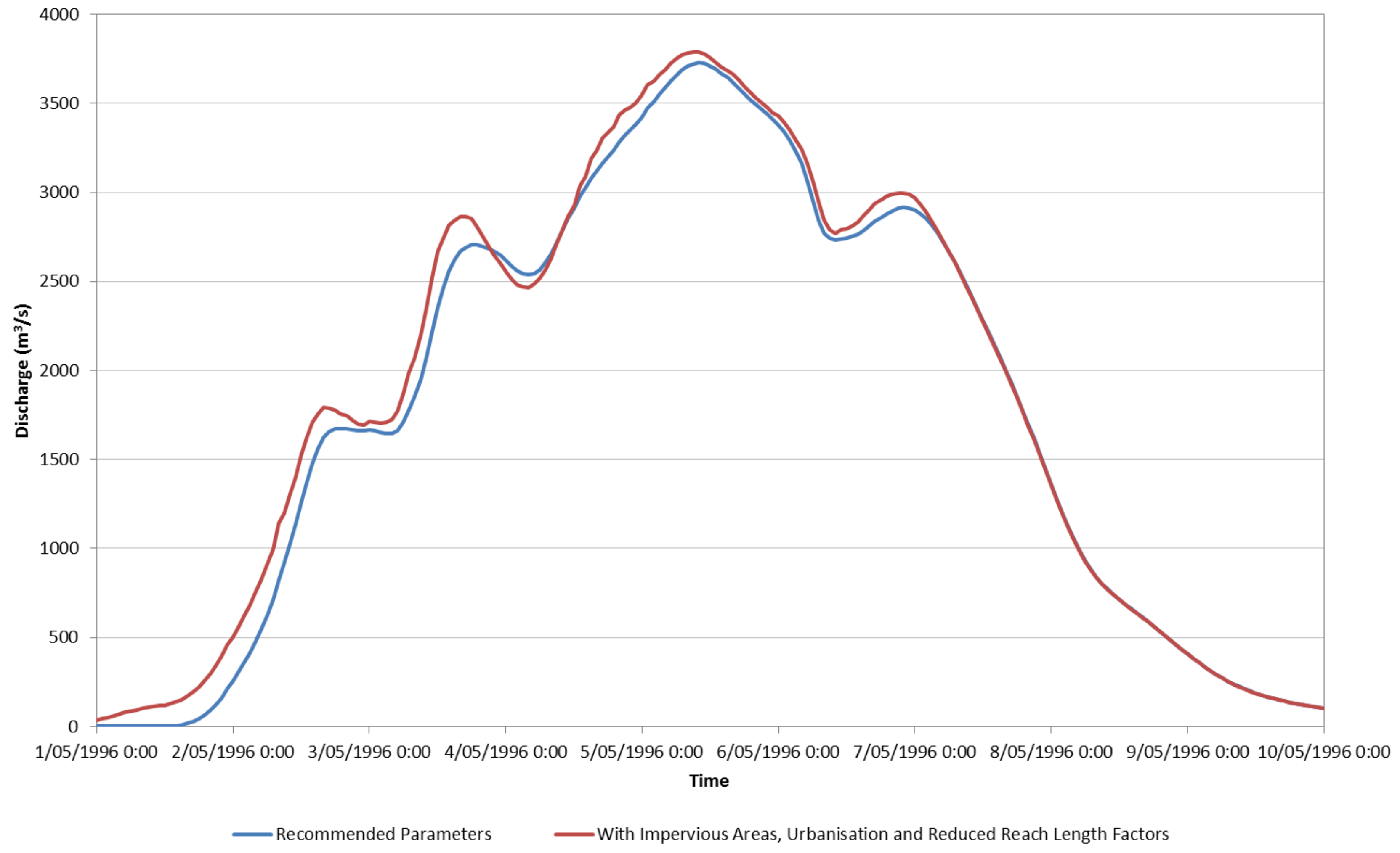


Figure 1: Urbanisation Impacts - Apr 1989 Event - Brisbane City Gauge
2500
2000
1500
1000
500
0
Discharge (m³/s)
23/04/1989 0:00
25/04/1989 0:00
27/04/1989 0:00
29/04/1989 0:00
1/05/1989 0:00
3/05/1989 0:00
5/05/1989 0:00
Time
Recommended Parameters
With Impervious Areas, Urbanisation and Reduced Reach Length Factors

Figure 2: Urbanisation Impacts - May 1996 Event - Brisbane City Gauge



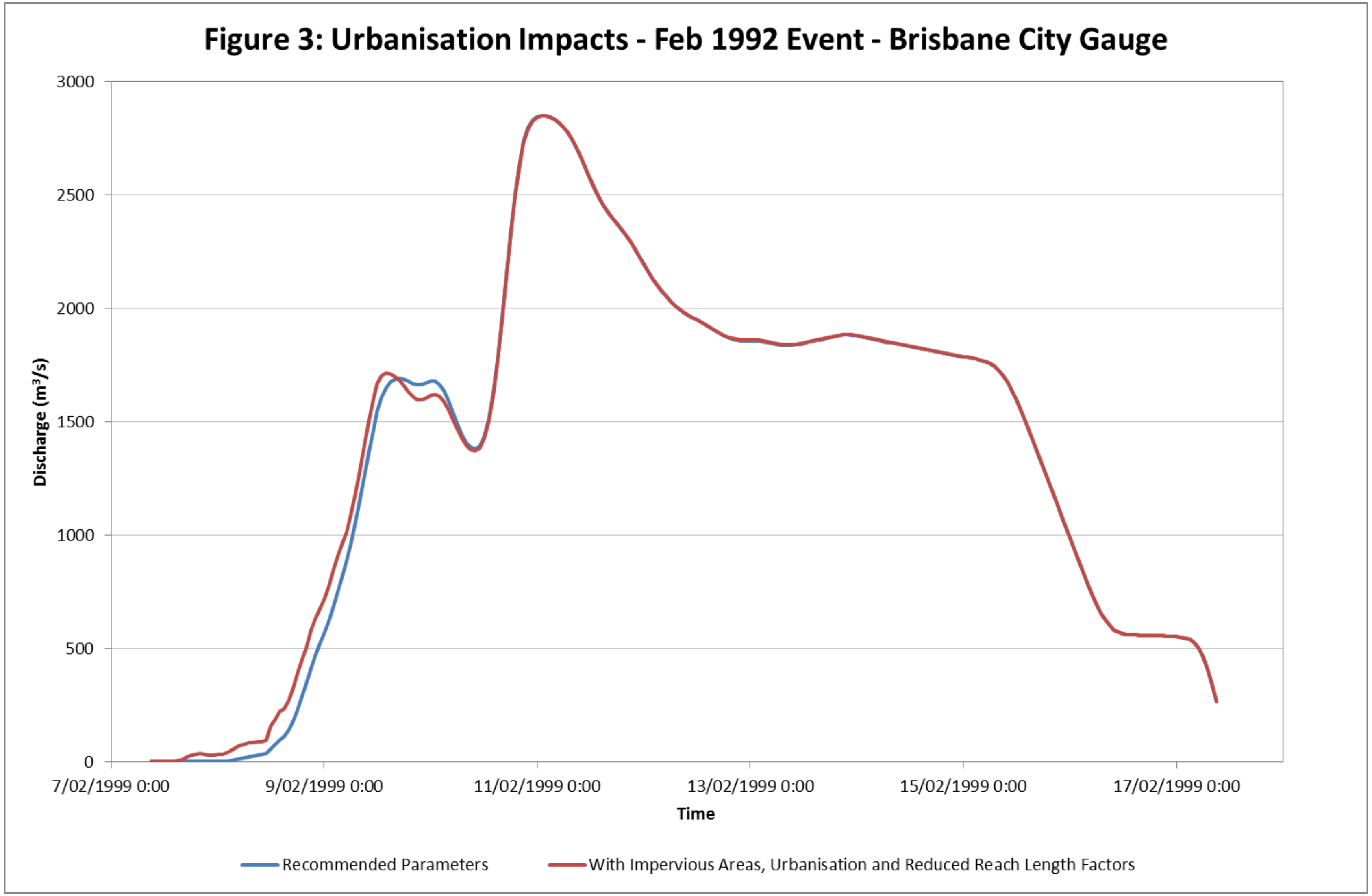


Figure 3: Urbanisation Impacts - Feb 1992 Event - Brisbane City Gauge
Discharge (m³/s)
3000
2500
2000
1500
1000
500
0
7/02/1999 0:00
9/02/1999 0:00
11/02/1999 0:00
13/02/1999 0:00
15/02/1999 0:00
17/02/1999 0:00
Time
Recommended Parameters
With Impervious Areas, Urbanisation and Reduced Reach Length Factors

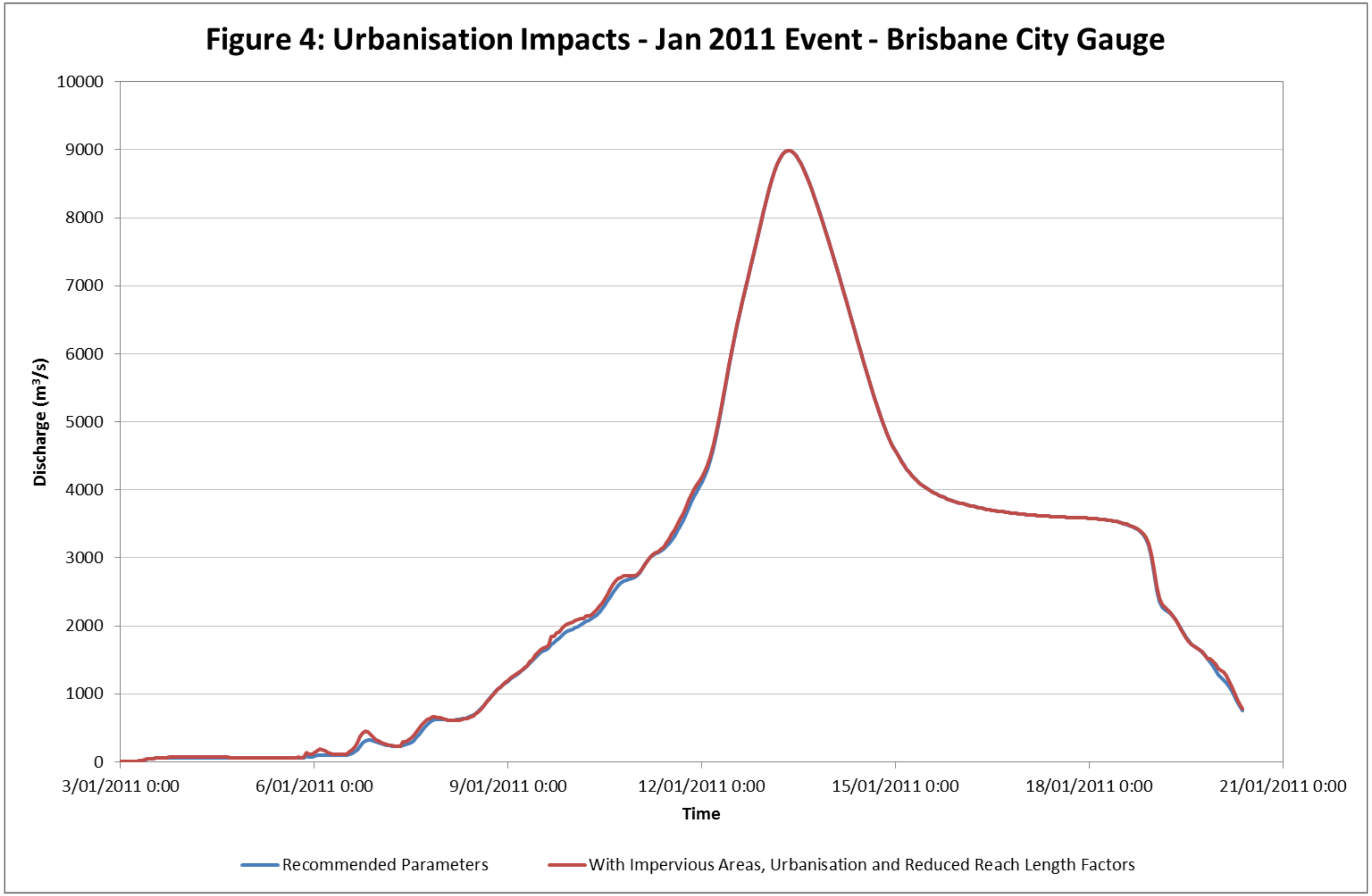


Figure 4: Urbanisation Impacts - Jan 2011 Event - Brisbane City Gauge
Discharge (m³/s)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
3/01/2011 0:00
6/01/2011 0:00
9/01/2011 0:00
12/01/2011 0:00
15/01/2011 0:00
18/01/2011 0:00
21/01/2011 0:00
Time
Recommended Parameters
With Impervious Areas, Urbanisation and Reduced Reach Length Factors

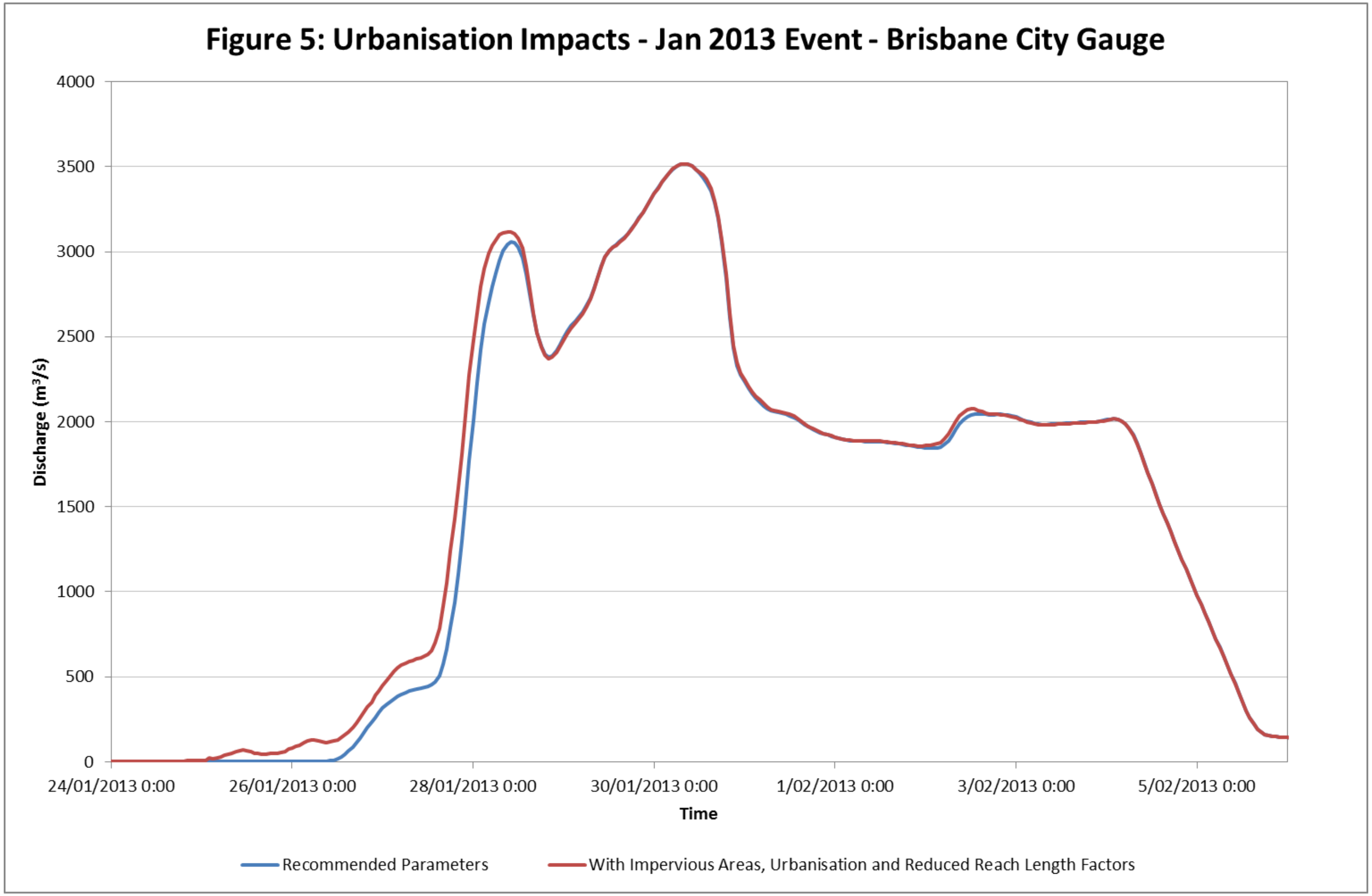


Figure 5: Urbanisation Impacts - Jan 2013 Event - Brisbane City Gauge
Discharge (m³/s)
4000
3500
3000
2500
2000
1500
1000
500
0
24/01/2013 0:00
26/01/2013 0:00
28/01/2013 0:00
30/01/2013 0:00
1/02/2013 0:00
3/02/2013 0:00
5/02/2013 0:00
Time
Recommended Parameters
With Impervious Areas, Urbanisation and Reduced Reach Length Factors

Appendix B
Channel routing parameter assessment

Non-linearity assessment

For each model, either one or two downstream locations were selected for the non-linearity assessment. Only gauges which were on the main stream were assessed (ie no tributaries were assessed). Events were selected as those:

- With available gauged data
- Considered non-minor events
- With evident single peaks
- With travel time through the catchment
- Without large amounts of rainfall occurring in the mid-catchment between gauges

It is important to note that this process is very subjective and it is quite likely the results would vary according to the person carrying out the analysis.

The following sections present the results of the non-linearity assessment as well as hydrographs for the events and gauges which were adopted for use. Tables presenting the event details are also included.

Stanley River

Table 1 Stanley River to Peachester– Adopted Events and Values

Event	Upstream Peak Time	Downstream Peak Time	Rated Flow at Walloon (m^3/s)	Travel Time	Peak Lag (hrs/km)
Peachester to Woodford					
20120121	25/01/2012 3:00	25/01/2012 16:00	208.32	13	0.553
20120220-1	25/02/2012 6:00	25/02/2012 18:00	219.81	12	0.511
20120220-2	5/03/2012 21:00	6/03/2012 8:00	215.42	11	0.468

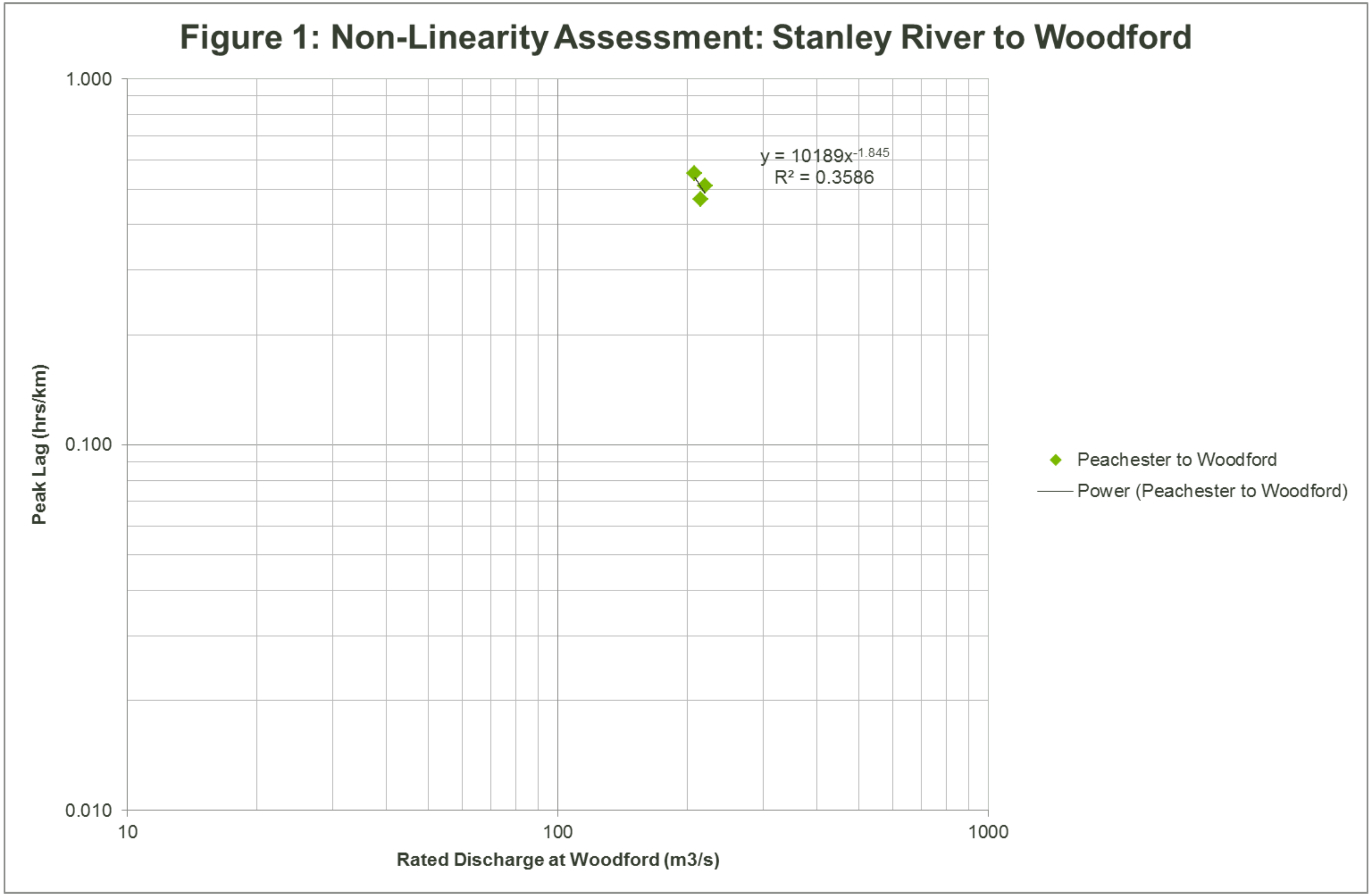


Figure 1: Non-Linearity Assessment: Stanley River to Woodford
1.000
0.100
0.010
10
100
1000
Peak Lag (hrs/km)
Rated Discharge at Woodford (m3/s)
y = 10189x-1.845
R² = 0.3586
Peachester to Woodford
Power (Peachester to Woodford)

Figure 2: Stanley River to Woodford - 20120121 Event

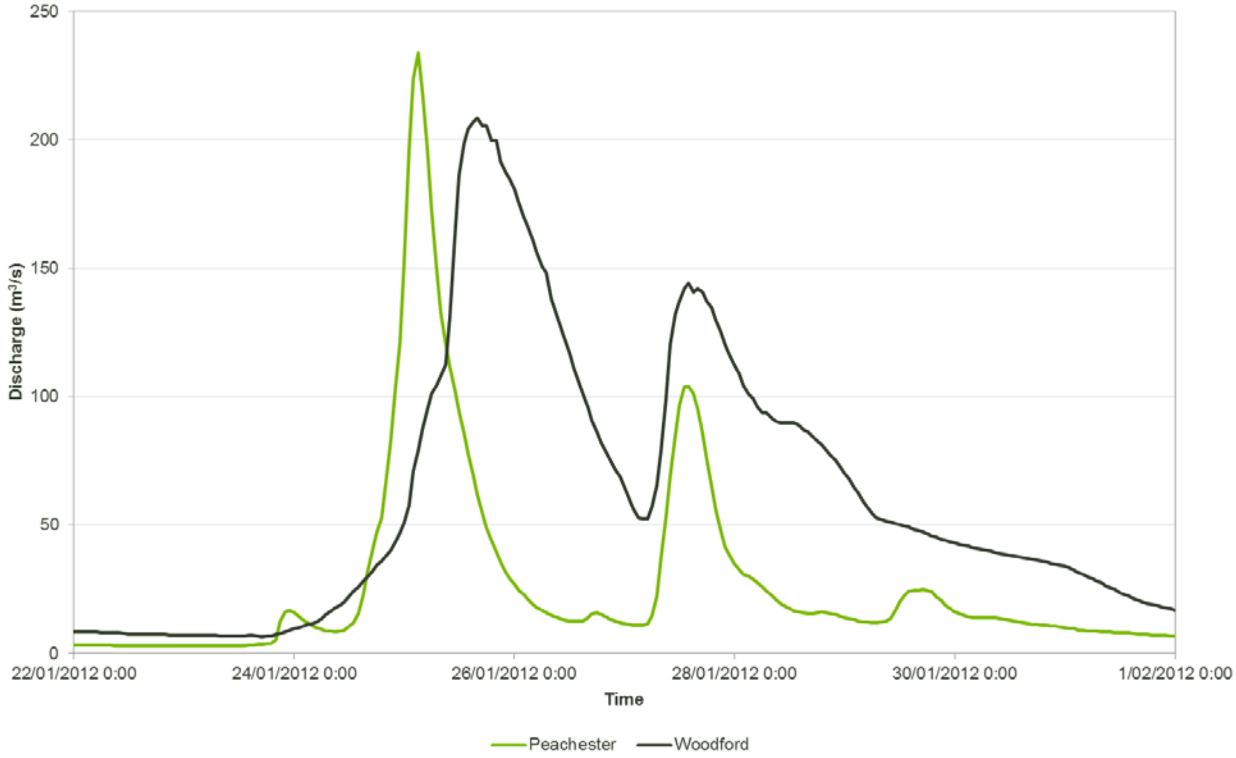
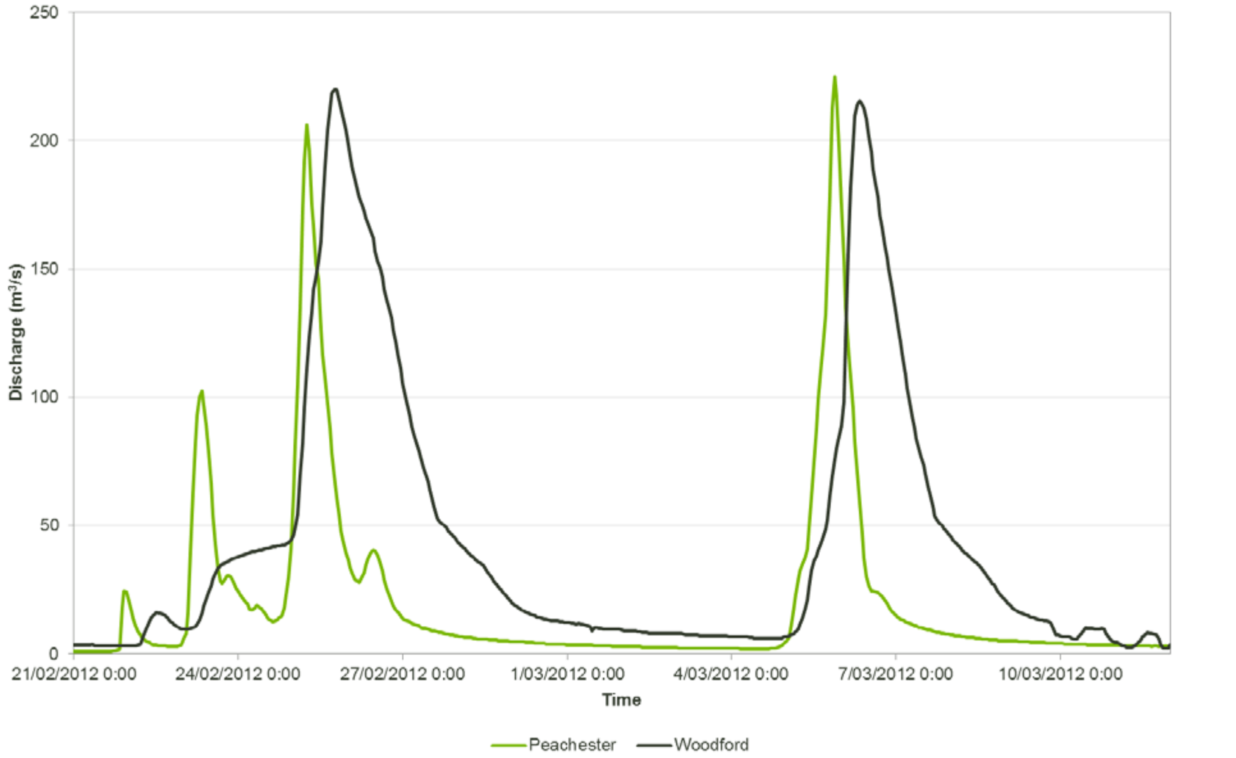


Figure 3: Stanley River to Woodford - 20120220 Event



Upper Brisbane

Table 2 Upper Brisbane River to Middle Creek and Gregor Creek– Adopted Events and Values

Event	Upstream Peak Time	Downstream Peak Time	Rated Flow at Walloon (m^3/s)	Travel Time	Peak Lag (hrs/km)
Linville to Middle Creek					
19711226	28/12/1971 2:00	29/12/1971 0:00	600	22	0.166
19730705	8/07/1973 0:00	8/07/1973 17:00	2456	17	0.128
Gregor Creek to Middle Creek					
19711226	28/12/1971 8:00	29/12/1971 0:00	600	16	0.260
19730705	8/07/1973 5:00	8/07/1973 17:00	2456	12	0.195
Linville to Gregor Creek					
19711226	28/12/1971 2:00	28/12/1971 8:00	863	6	0.085
19730705	8/07/1973 0:00	8/07/1973 5:00	3415	5	0.071
19890423	26/04/1989 0:00	26/04/1989 5:00	4405	5	0.071
19911210	12/12/1991 10:00	12/12/1991 17:00	319	7	0.099
20101216	20/12/2010 2:00	20/12/2010 6:00	1278	4	0.056
20101223	27/12/2010 22:00	28/12/2010 3:00	1334	5	0.071
Devon Hills to Gregor Ck					
20101216	20/12/2010 3:00	20/12/2010 6:00	1278	3	0.052
20101223	28/12/2010 1:00	28/12/2010 3:00	1334	2	0.035

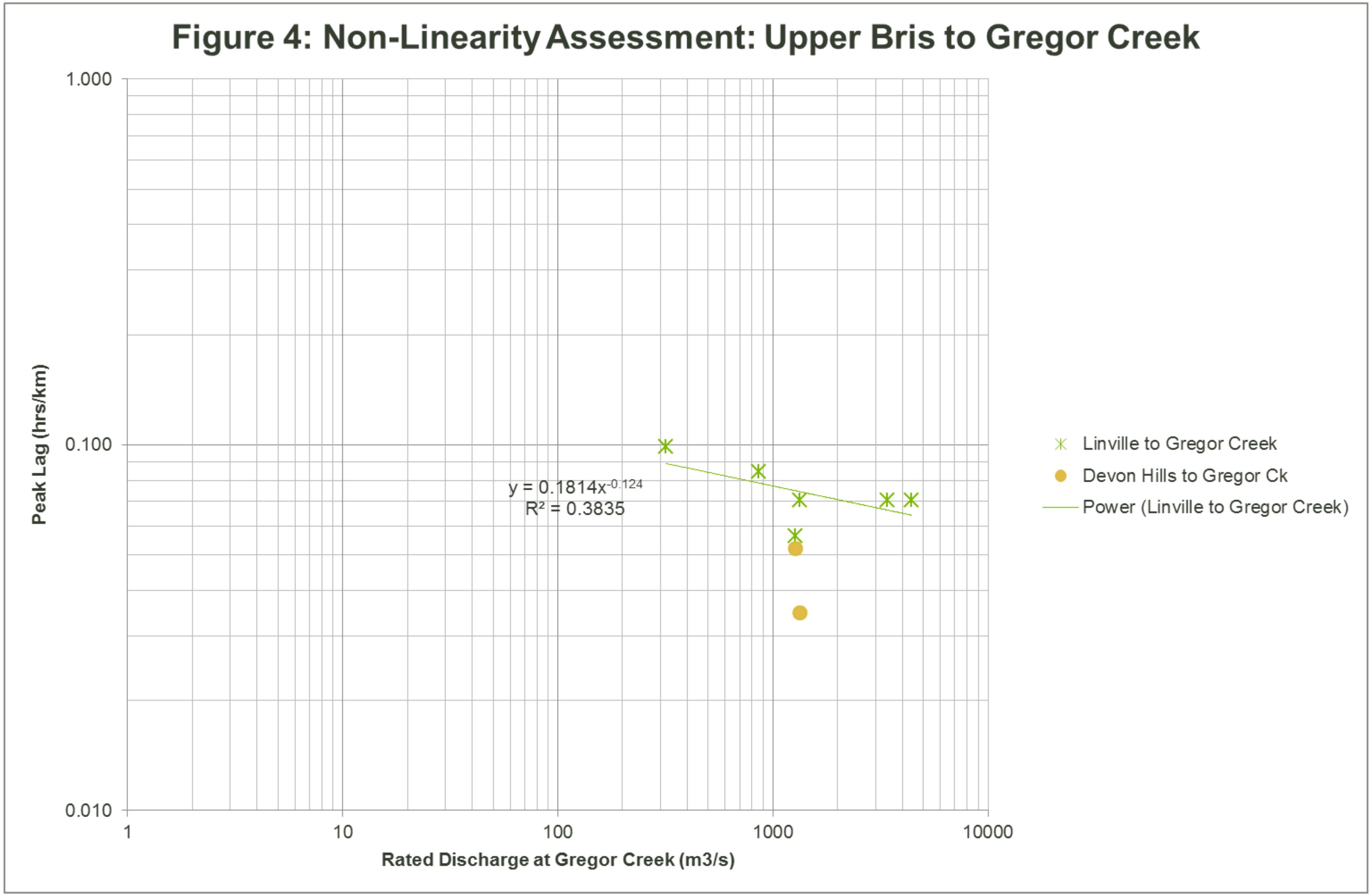


Figure 4: Non-Linearity Assessment: Upper Bris to Gregor Creek
1.000
0.100
0.010
Peak Lag (hrs/km)
y = 0.1814x-0.124
R² = 0.3835
1
10
100
1000
10000
Rated Discharge at Gregor Creek (m3/s)
Linville to Gregor Creek
Devon Hills to Gregor Ck
Power (Linville to Gregor Creek)

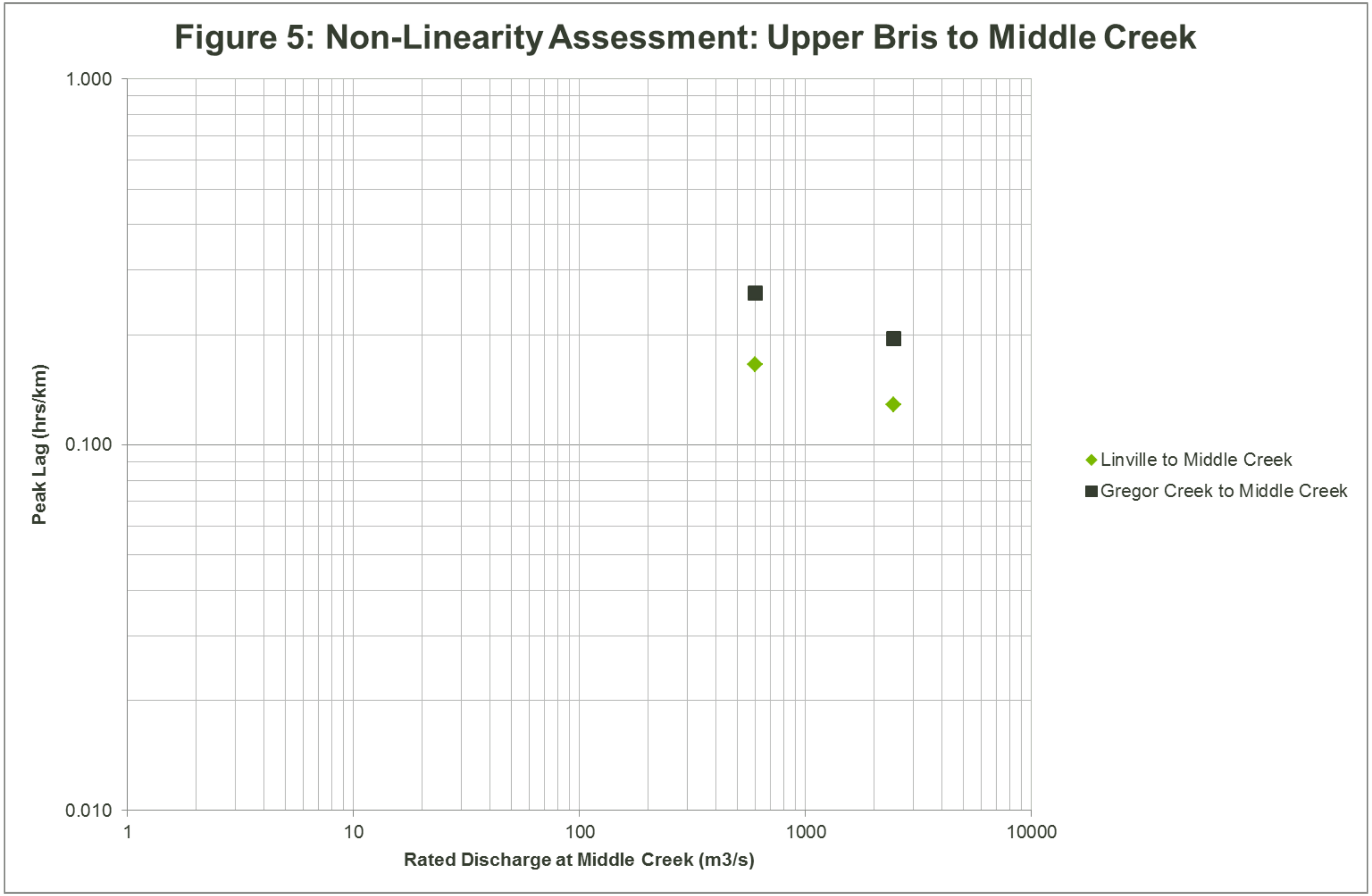


Figure 5: Non-Linearity Assessment: Upper Bris to Middle Creek
1.000
0.100
0.010
Peak Lag (hrs/km)
1
10
100
1000
10000
Rated Discharge at Middle Creek (m3/s)
Linville to Middle Creek
Gregor Creek to Middle Creek

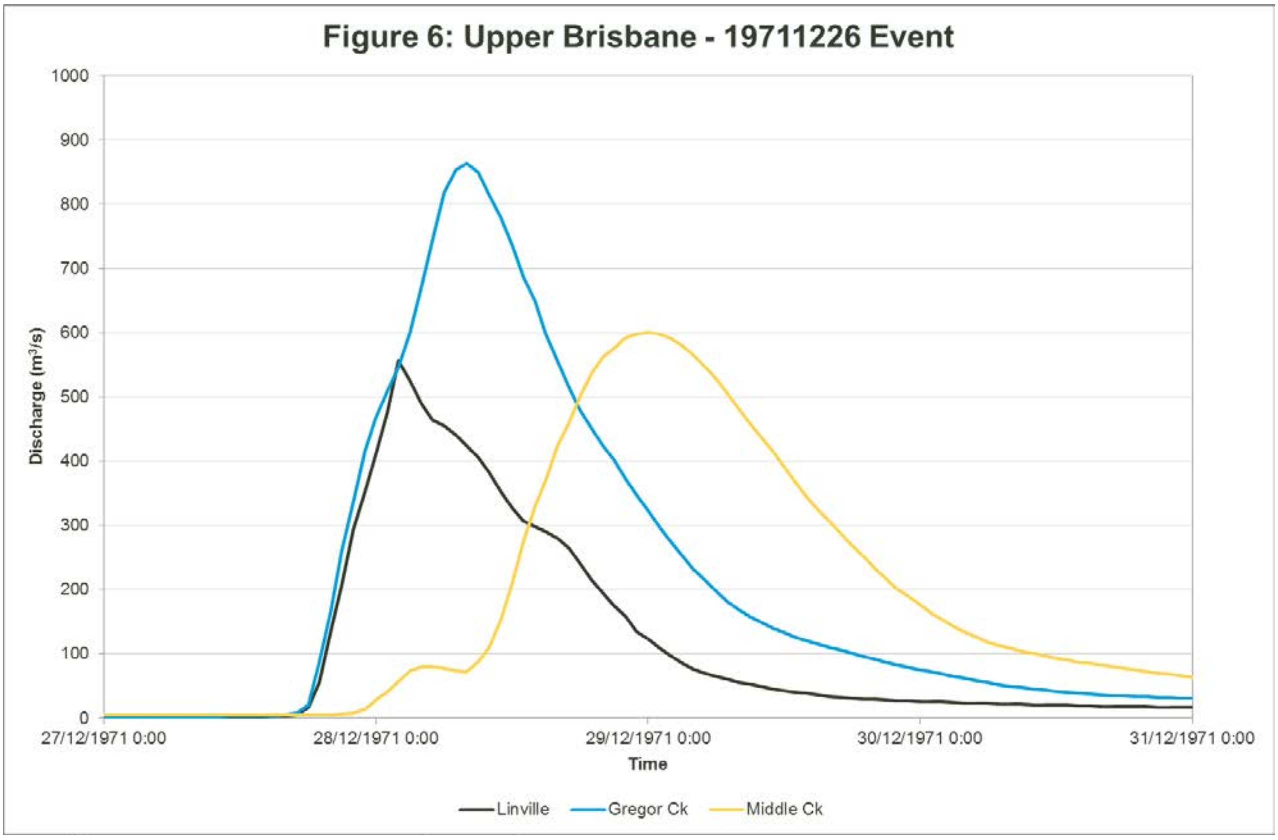


Figure 6: Upper Brisbane - 19711226 Event
1000
900
800
700
600
500
400
300
200
100
0
Discharge (m3/s)
27/12/1971 0:00
28/12/1971 0:00
29/12/1971 0:00
30/12/1971 0:00
31/12/1971 0:00
Time
Linville
Gregor Ck
Middle Ck

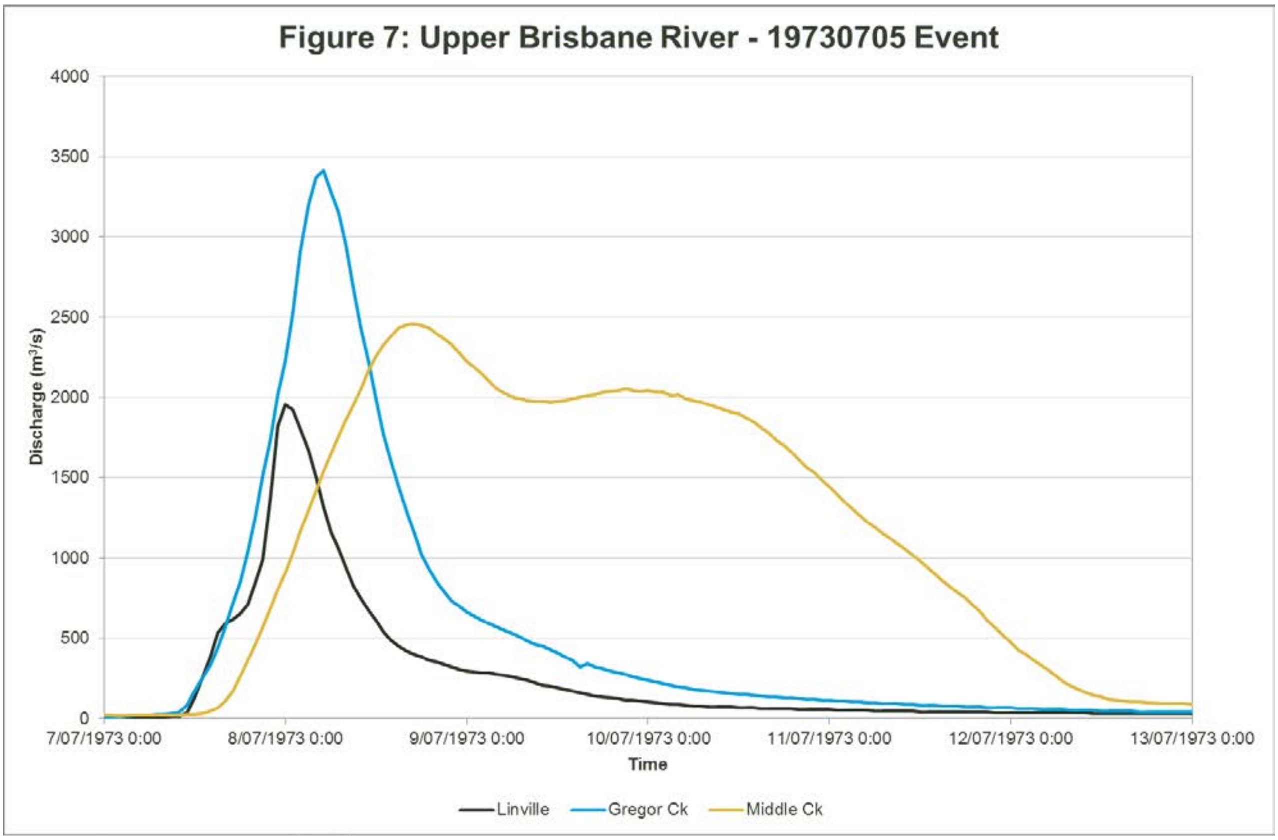


Figure 7: Upper Brisbane River - 19730705 Event
4000
3500
3000
2500
2000
1500
1000
500
0
Discharge (m3/s)
7/07/1973 0:00
8/07/1973 0:00
9/07/1973 0:00
10/07/1973 0:00
11/07/1973 0:00
12/07/1973 0:00
13/07/1973 0:00
Time
Linville
Gregor Ck
Middle Ck

Figure 8: Upper Brisbane River - 19890423 Event

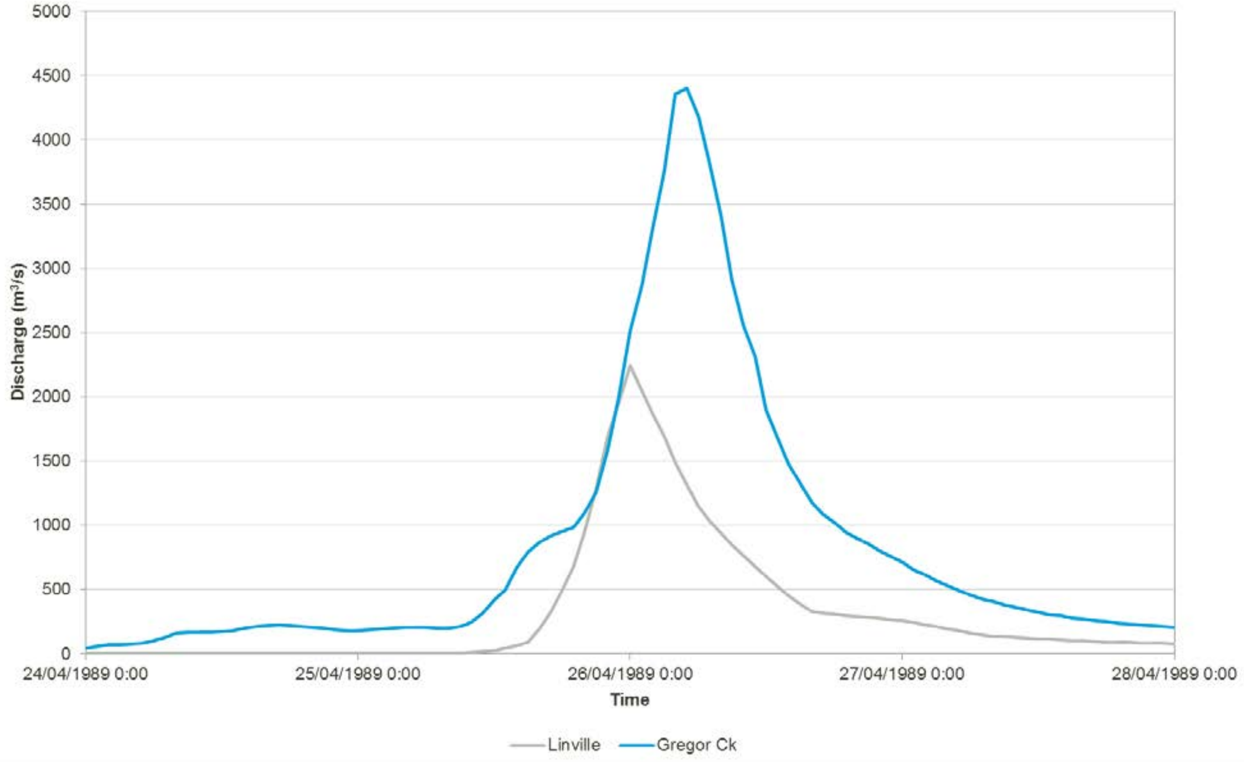
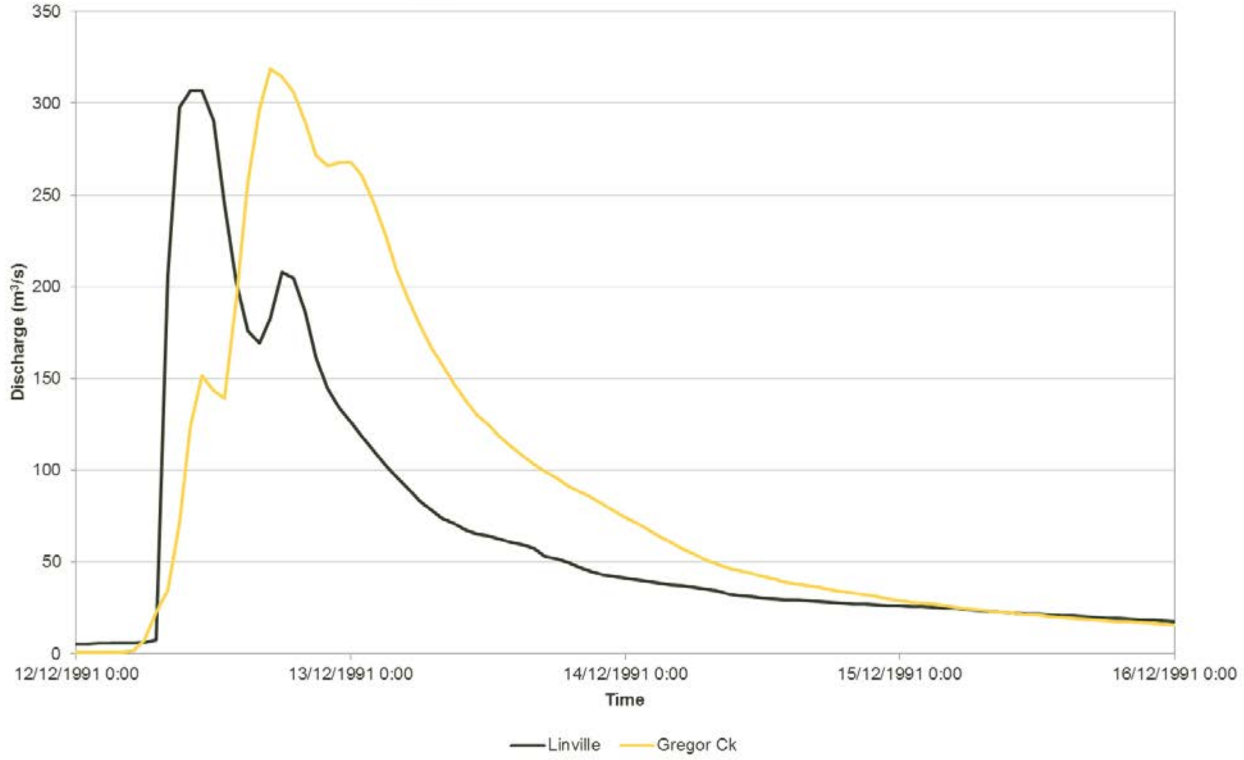


Figure 9: Upper Brisbane River - 19911210 Event



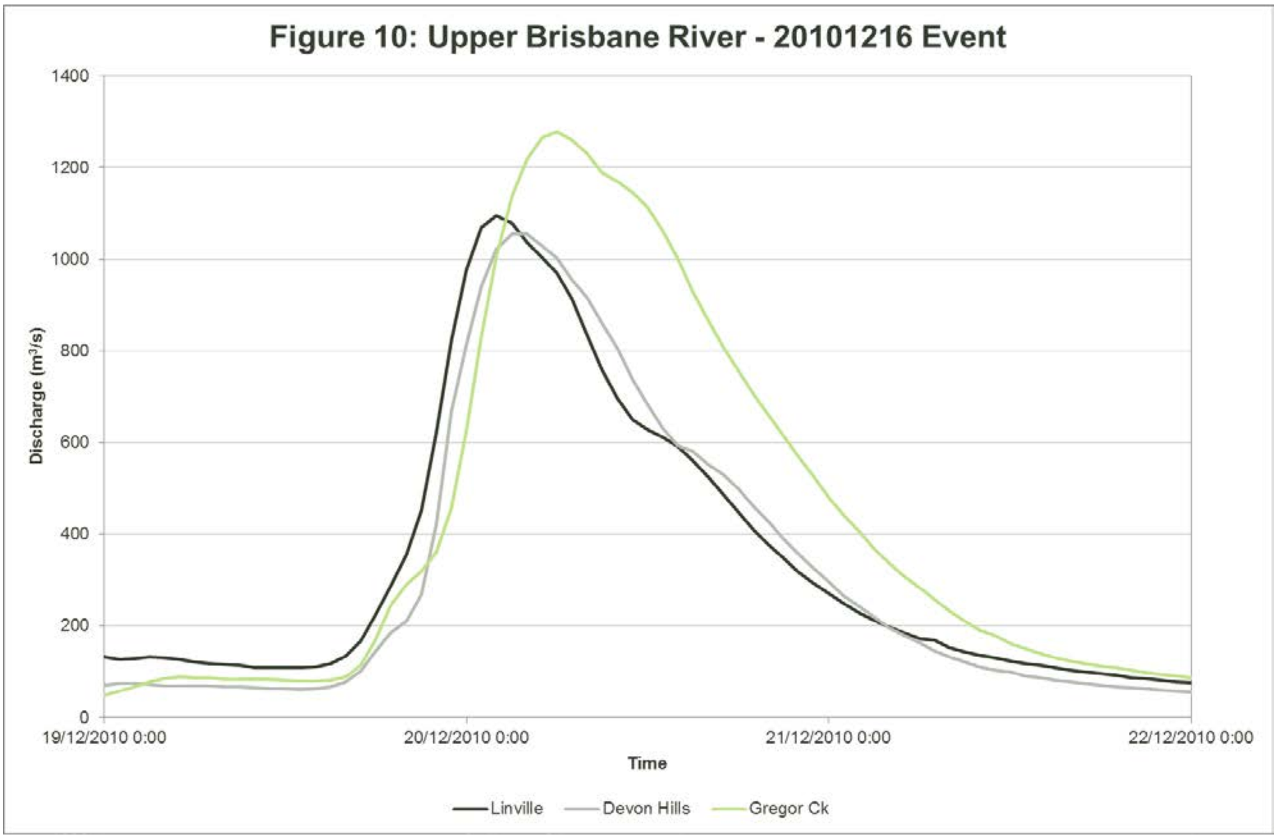


Figure 10: Upper Brisbane River - 20101216 Event
1400
1200
1000
800
600
400
200
0
Discharge (m³/s)
19/12/2010 0:00
20/12/2010 0:00
21/12/2010 0:00
22/12/2010 0:00
Time
Linville
Devon Hills
Gregor Ck

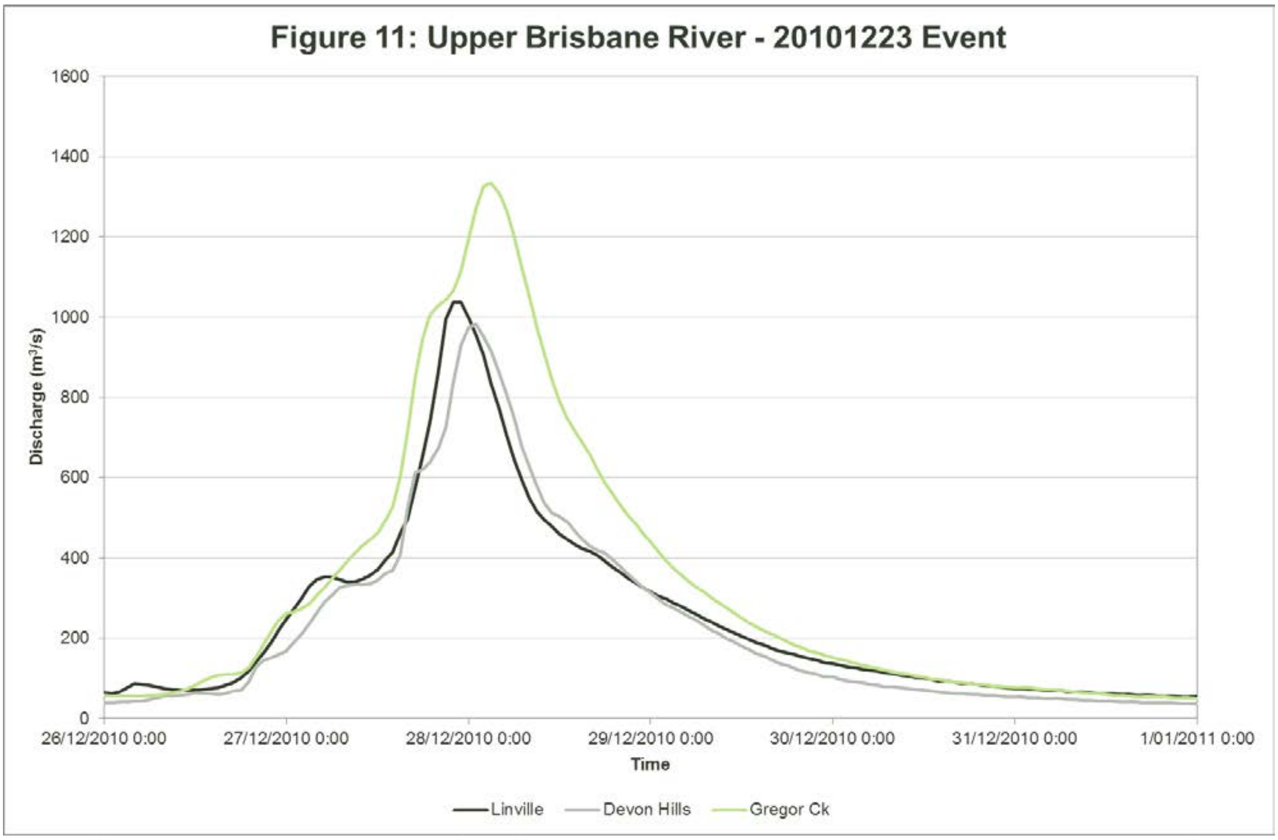


Figure 11: Upper Brisbane River - 20101223 Event
1600
1400
1200
1000
800
600
400
200
0
Discharge (m³/s)
26/12/2010 0:00
27/12/2010 0:00
28/12/2010 0:00
29/12/2010 0:00
30/12/2010 0:00
31/12/2010 0:00
1/01/2011 0:00
Time
Linville
Devon Hills
Gregor Ck

Bremer River

Table 3 Bremer River to Walloon – Adopted Events and Values

Event	Upstream Peak Time	Downstream Peak Time	Rated Flow at Walloon (m^3/s)	Travel Time	Peak Lag (hrs/km)
Adams Br to Walloon (43.4km)					
19910205	7/02/1991 23:00	8/02/1991 16:00	267	17	0.392
20040304	6/03/2004 6:00	6/03/2004 22:00	140	16	0.369
20100226-2	6/03/2010 21:00	7/03/2010 14:00	86.6	17	0.392
20100226-3	11/03/2010 2:00	11/03/2010 21:00	89.8	19	0.438
20101006	11/10/2010 14:00	12/10/2010 4:00	293.2	14	0.323
20101216-1	16/12/2010 17:00	17/12/2010 11:00	183.4	18	0.415
20101216-2	19/12/2010 17:00	20/12/2010 9:00	273	16	0.369
20120220	26/02/2012 0:00	26/02/2012 20:00	202.9	20	0.461
20130215-2	2/03/2013 18:00	3/03/2013 7:00	363.3	13	0.300
Stokes Xing to Walloon (33.9km)					
20100226-2	6/03/2010 23:00	7/03/2010 14:00	86.6	15	0.442
20100226-3	11/03/2010 4:00	11/03/2010 21:00	89.8	17	0.501
20101006	11/10/2010 16:00	12/10/2010 4:00	293.2	12	0.354
20101216-1	16/12/2010 20:00	17/12/2010 11:00	183.4	15	0.442
20101216-2	19/12/2010 20:00	20/12/2010 9:00	273	13	0.383
Rosewood to Walloon (14.9km)					
19960430	3/05/1996 11:00	3/05/1996 17:00	912.04	6	0.403
20040304	6/03/2004 15:00	6/03/2004 22:00	140	7	0.470
20100226-2	7/03/2010 6:00	7/03/2010 14:00	86.6	8	0.537
20100226-3	11/03/2010 14:00	11/03/2010 21:00	89.8	7	0.470
20101006	11/10/2010 22:00	12/10/2010 4:00	293.2	6	0.403
20101216-1	17/12/2010 5:00	17/12/2010 11:00	183.4	6	0.403
20101216-2	20/12/2010 3:00	20/12/2010 9:00	273	6	0.403
20120220	26/02/2012 13:00	26/02/2012 20:00	202.9	7	0.470
20130123	28/01/2013 1:00	28/01/2013 6:00	1143.17	5	0.336
20130215-1	26/02/2013 6:00	26/02/2013 12:00	519.8	6	0.403
20130215-2	3/03/2013 1:00	3/03/2013 7:00	363.3	6	0.403
Five Mile to Walloon (5.6km)					
19960430	3/05/1996 14:00	3/05/1996 17:00	912.04	3	0.536
20040304	6/03/2004 19:00	6/03/2004 22:00	140	3	0.536
20081116	20/11/2008 6:00	20/11/2008 8:00	927.2	2	0.357
20090518	21/05/2009 6:00	21/05/2009 8:00	517.7	2	0.357
20100226-2	7/03/2010 11:00	7/03/2010 14:00	86.6	3	0.536
20101216-1	17/12/2010 9:00	17/12/2010 11:00	183.4	2	0.357
20101216-2	20/12/2010 7:00	20/12/2010 9:00	273	2	0.357
20120220	26/02/2012 18:00	26/02/2012 20:00	202.9	2	0.357
20130123	28/01/2013 4:00	28/01/2013 6:00	1143.17	2	0.357
20130215-1	26/02/2013 10:00	26/02/2013 12:00	519.8	2	0.357

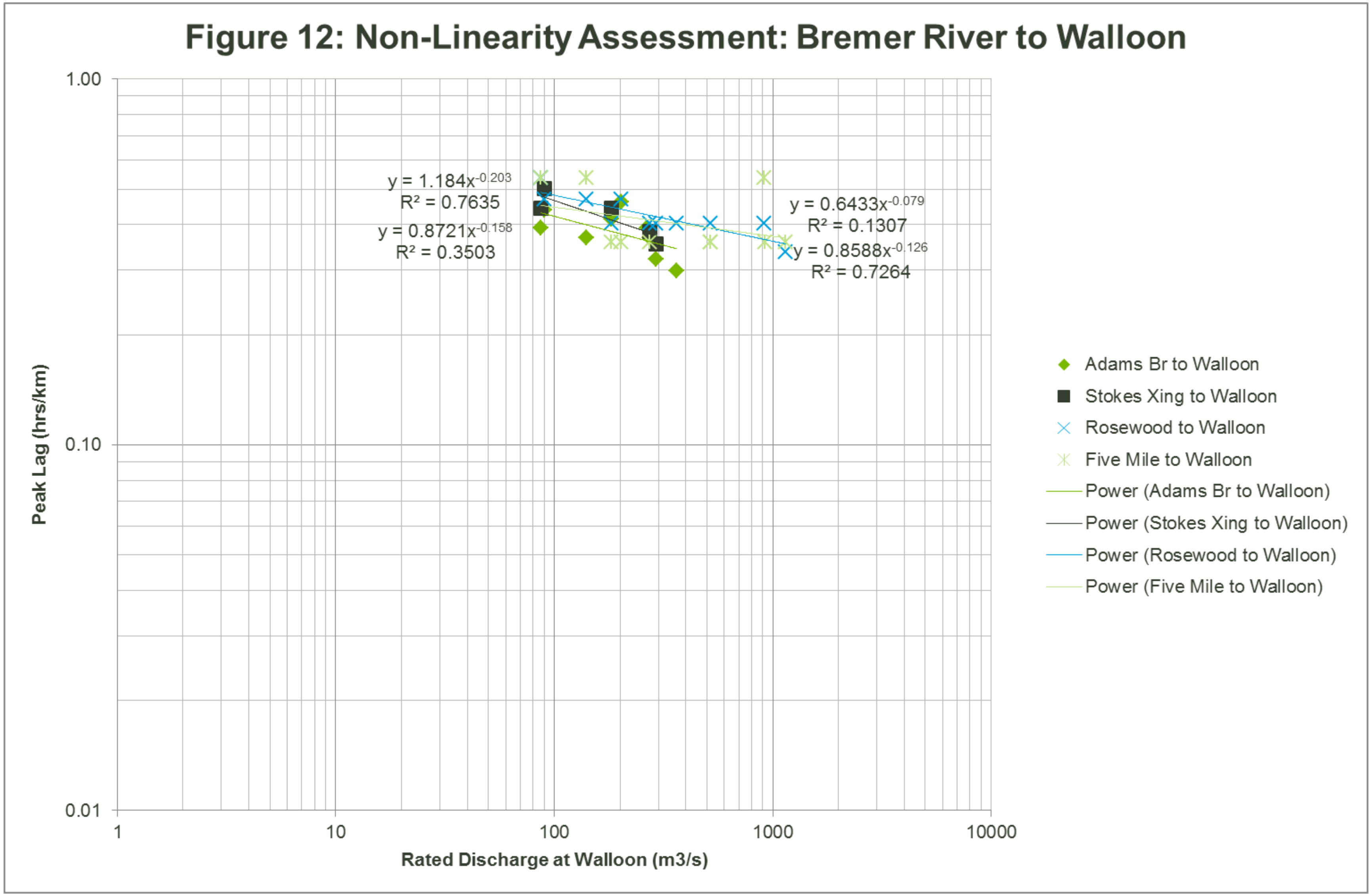


Figure 12: Non-Linearity Assessment: Bremer River to Walloon
1.00
0.10
0.01
1
10
100
1000
10000
Peak Lag (hrs/km)
Rated Discharge at Walloon (m3/s)
y = 1.184x-0.203
R² = 0.7635
y = 0.8721x-0.158
R² = 0.3503
y = 0.6433x-0.079
R² = 0.1307
y = 0.8588x-0.126
R² = 0.7264
Adams Br to Walloon
Stokes Xing to Walloon
Rosewood to Walloon
Five Mile to Walloon
Power (Adams Br to Walloon)
Power (Stokes Xing to Walloon)
Power (Rosewood to Walloon)
Power (Five Mile to Walloon)

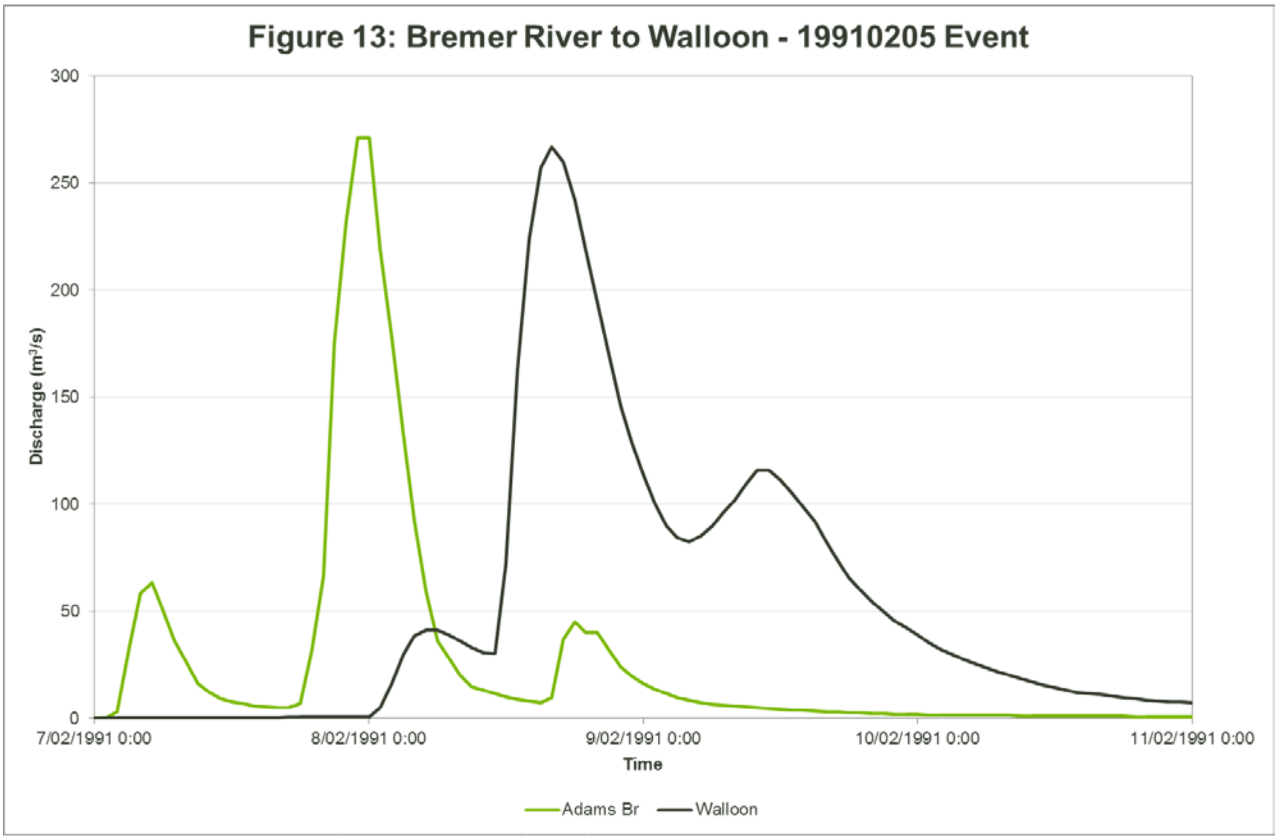


Figure 13: Bremer River to Walloon - 19910205 Event
Discharge (m3/s)
300
250
200
150
100
50
0
7/02/1991 0:00
8/02/1991 0:00
9/02/1991 0:00
10/02/1991 0:00
11/02/1991 0:00
Time
Adams Br
Walloon

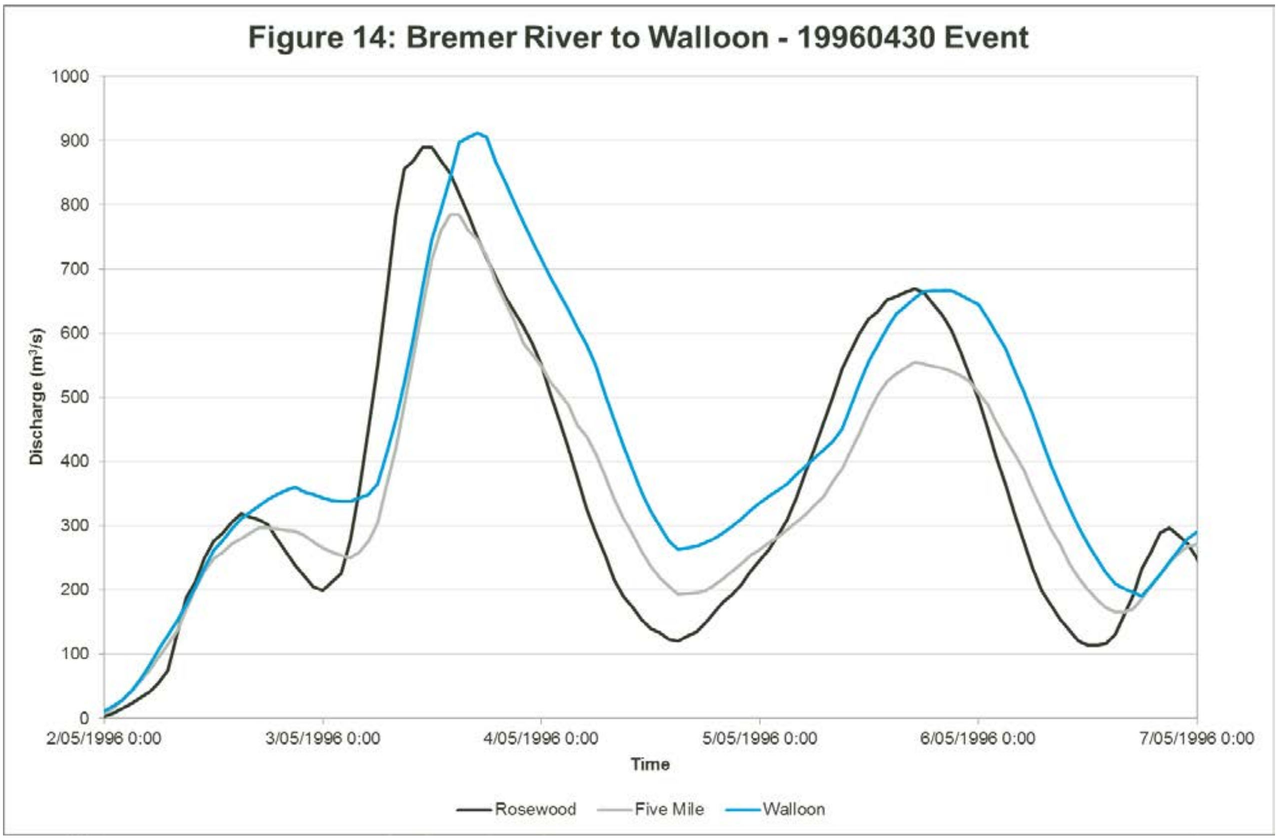


Figure 14: Bremer River to Walloon - 19960430 Event
Discharge (m3/s)
1000
900
800
700
600
500
400
300
200
100
0
2/05/1996 0:00
3/05/1996 0:00
4/05/1996 0:00
5/05/1996 0:00
6/05/1996 0:00
7/05/1996 0:00
Time
Rosewood
Five Mile
Walloon

Figure 15: Bremer River to Walloon - 20040304 Event

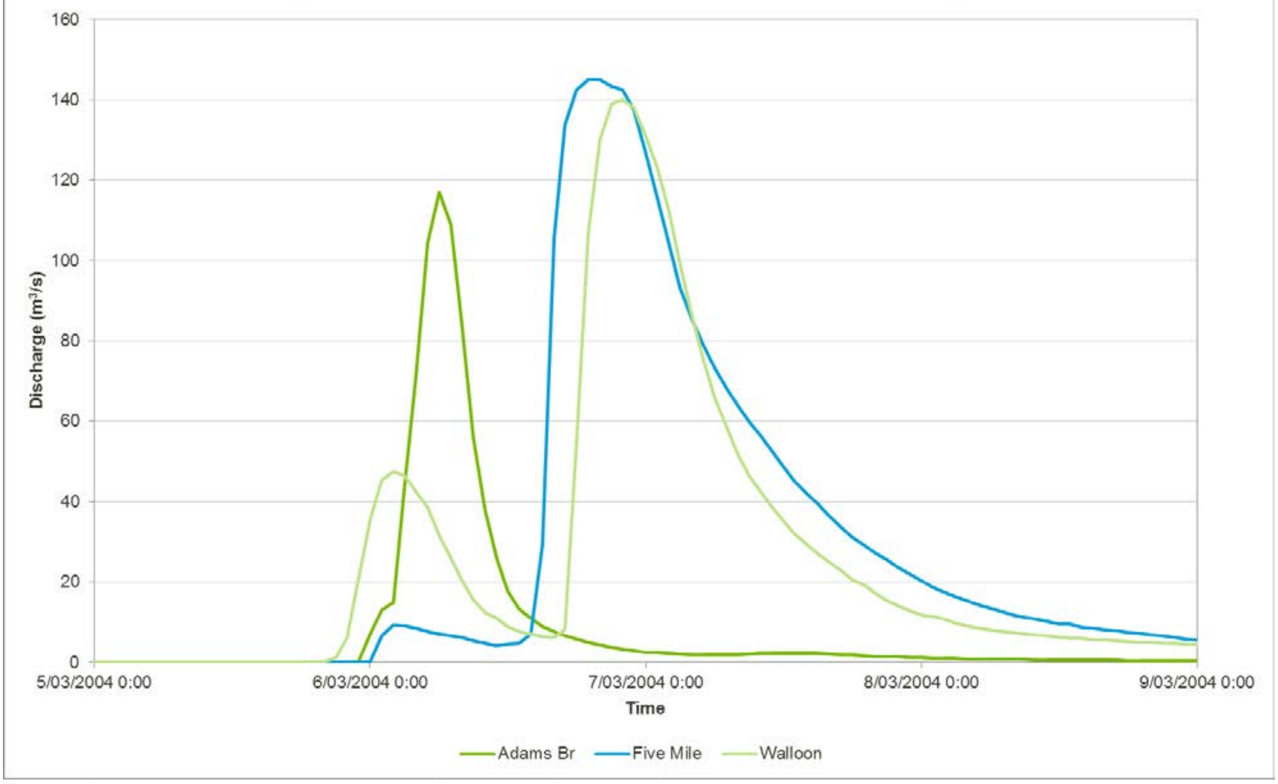
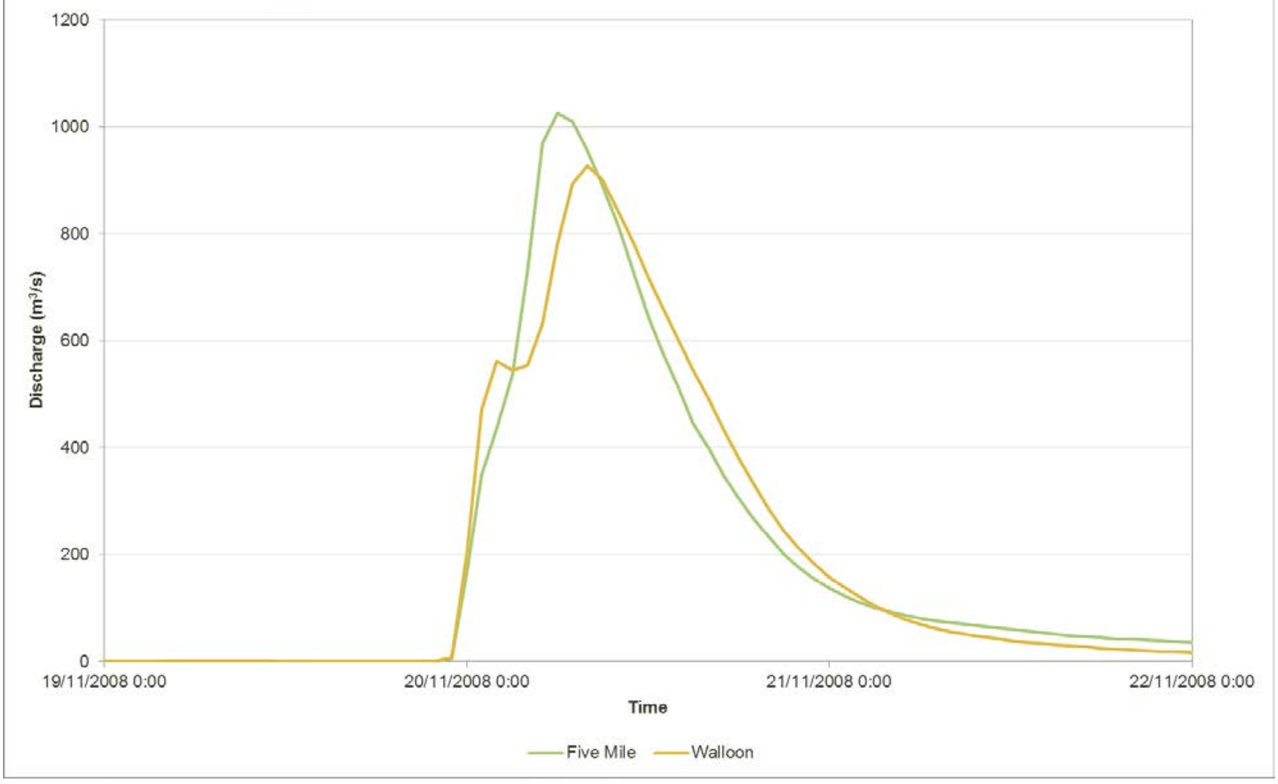


Figure 16: Bremer River to Walloon - 20081116 Event



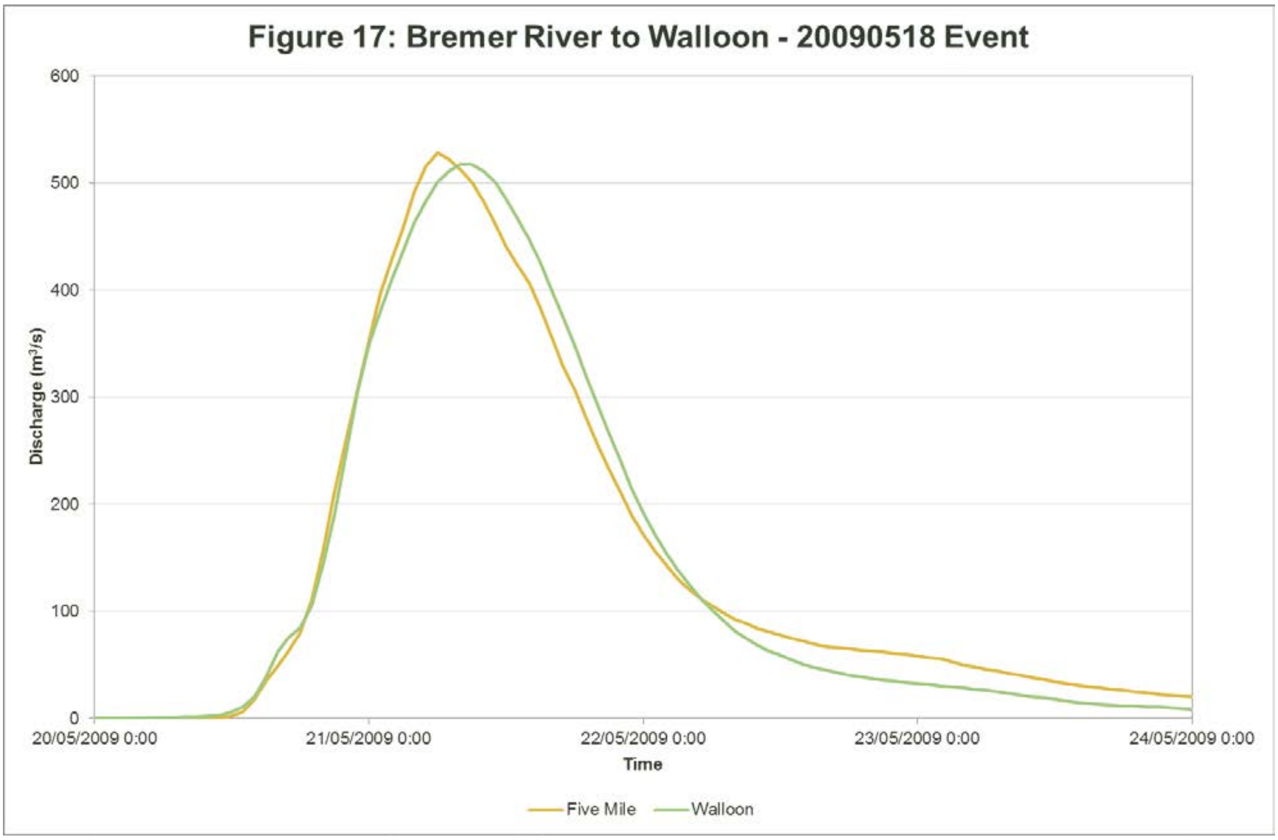


Figure 17: Bremer River to Walloon - 20090518 Event
600
500
400
300
200
100
0
Discharge (m3/s)
20/05/2009 0:00
21/05/2009 0:00
22/05/2009 0:00
23/05/2009 0:00
24/05/2009 0:00
Time
Five Mile
Walloon

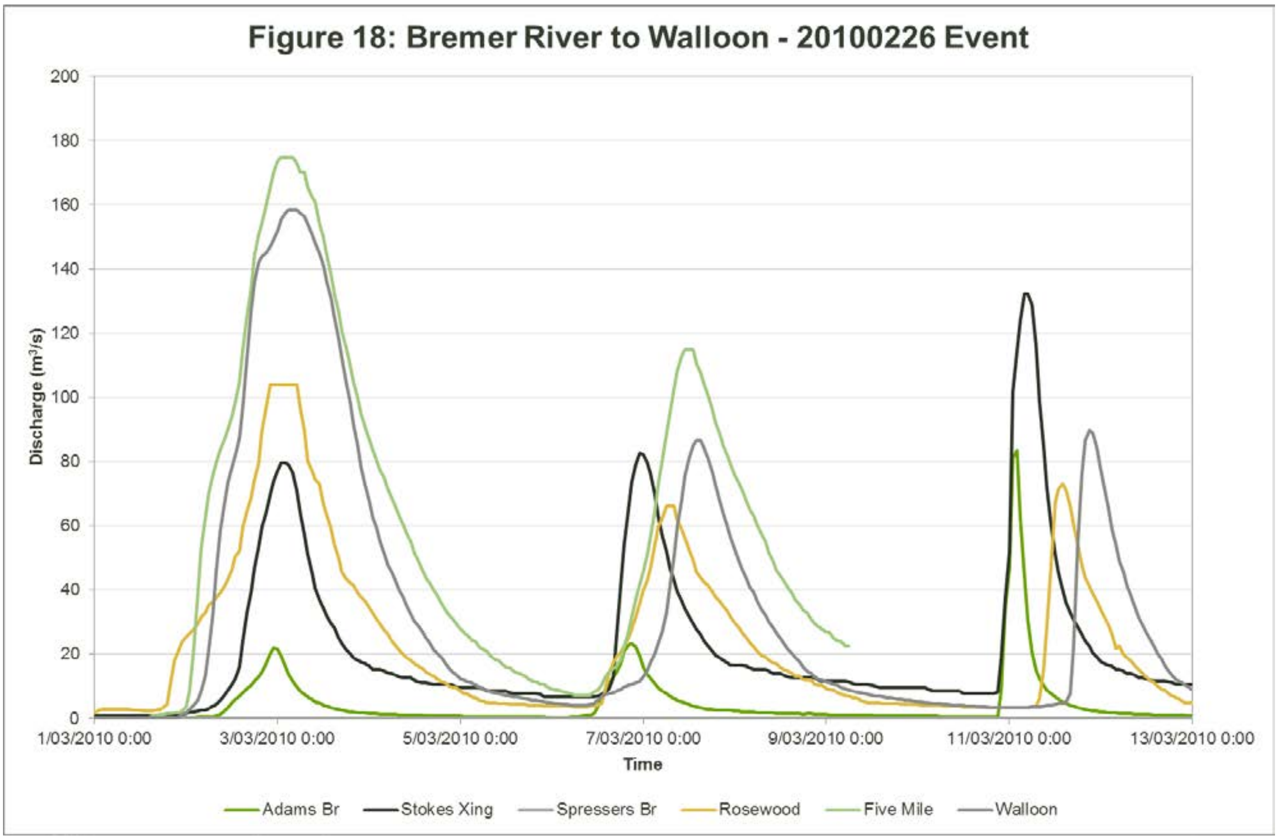


Figure 18: Bremer River to Walloon - 20100226 Event
200
180
160
140
120
100
80
60
40
20
0
Discharge (m3/s)
1/03/2010 0:00
3/03/2010 0:00
5/03/2010 0:00
7/03/2010 0:00
9/03/2010 0:00
11/03/2010 0:00
13/03/2010 0:00
Time
Adams Br
Stokes Xing
Spressers Br
Rosewood
Five Mile
Walloon

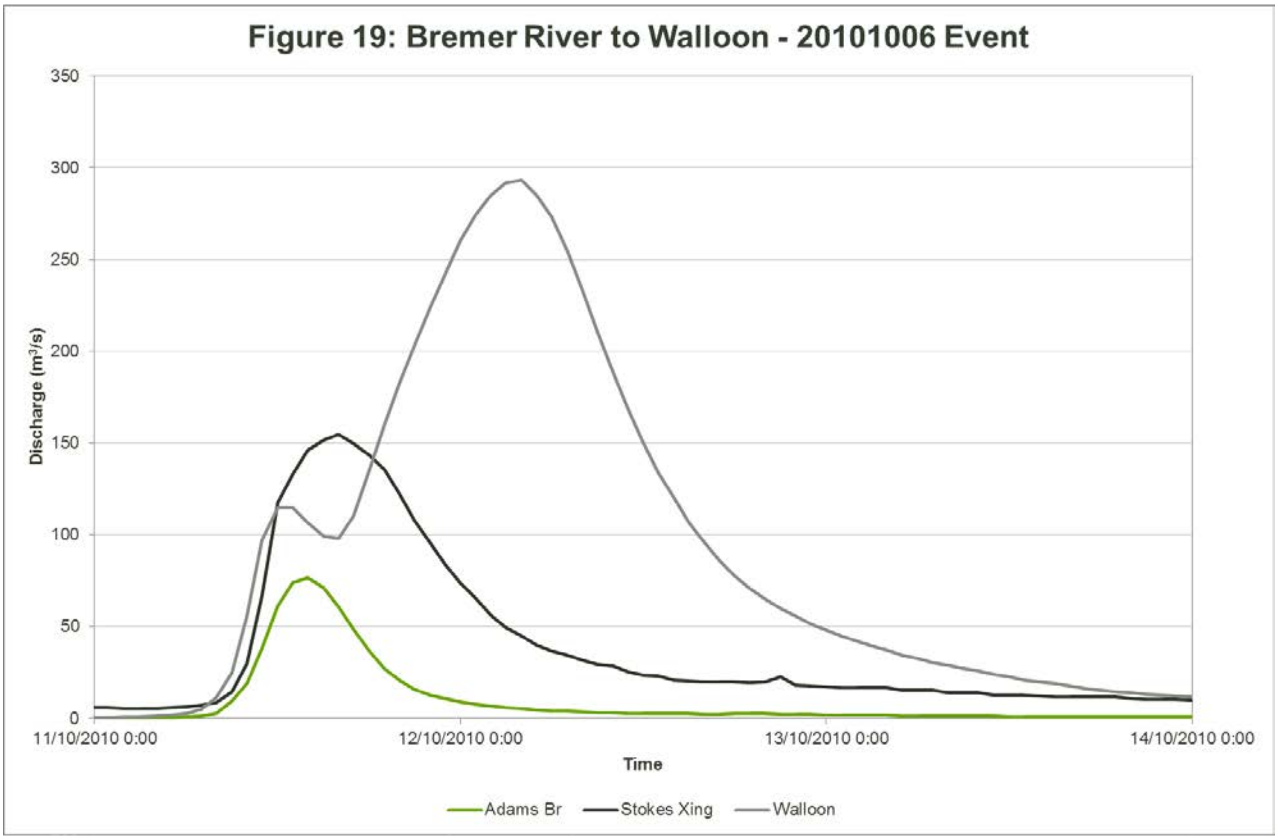


Figure 19: Bremer River to Walloon - 20101006 Event
Discharge (m³/s)
350
300
250
200
150
100
50
0
11/10/2010 0:00
12/10/2010 0:00
13/10/2010 0:00
14/10/2010 0:00
Time
Adams Br
Stokes Xing
Walloon

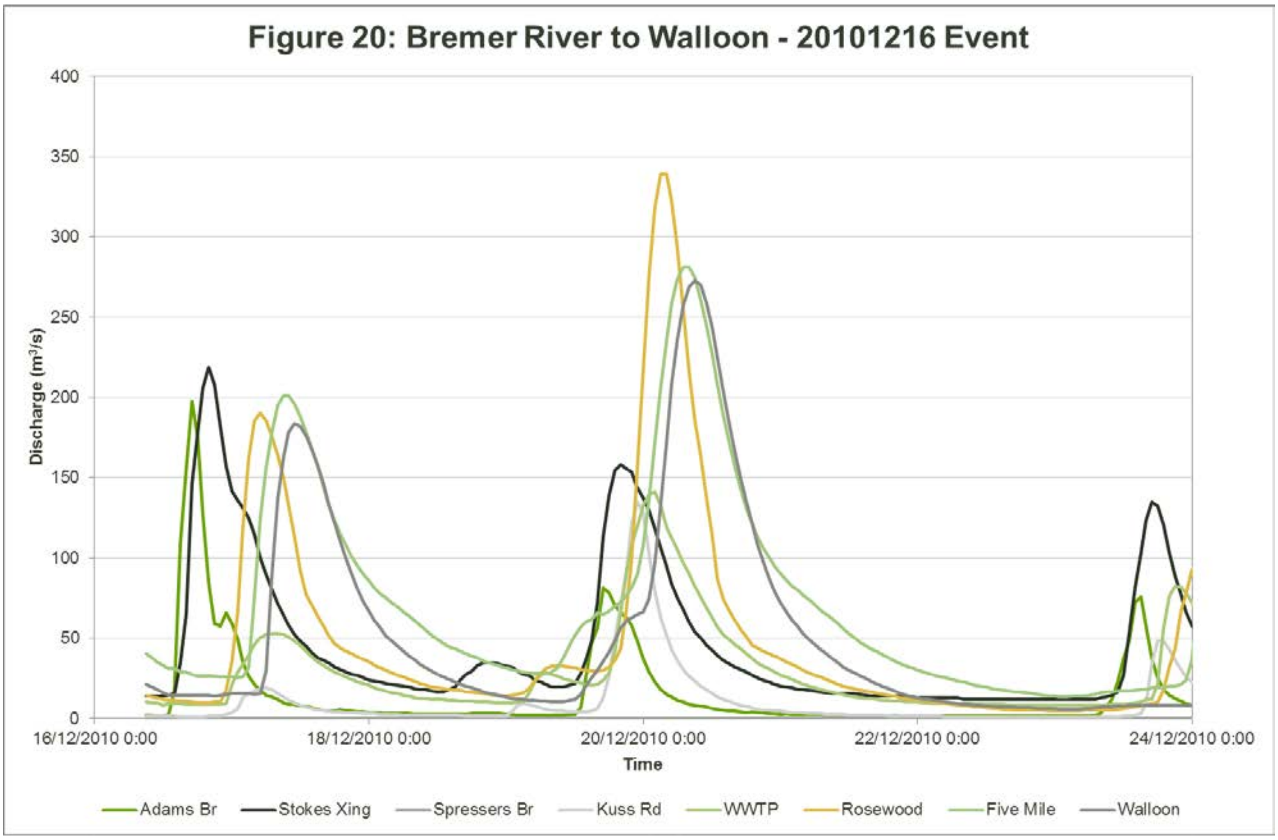


Figure 20: Bremer River to Walloon - 20101216 Event
Discharge (m³/s)
400
350
300
250
200
150
100
50
0
16/12/2010 0:00
18/12/2010 0:00
20/12/2010 0:00
22/12/2010 0:00
24/12/2010 0:00
Time
Adams Br
Stokes Xing
Spressers Br
Kuss Rd
WWTP
Rosewood
Five Mile
Walloon

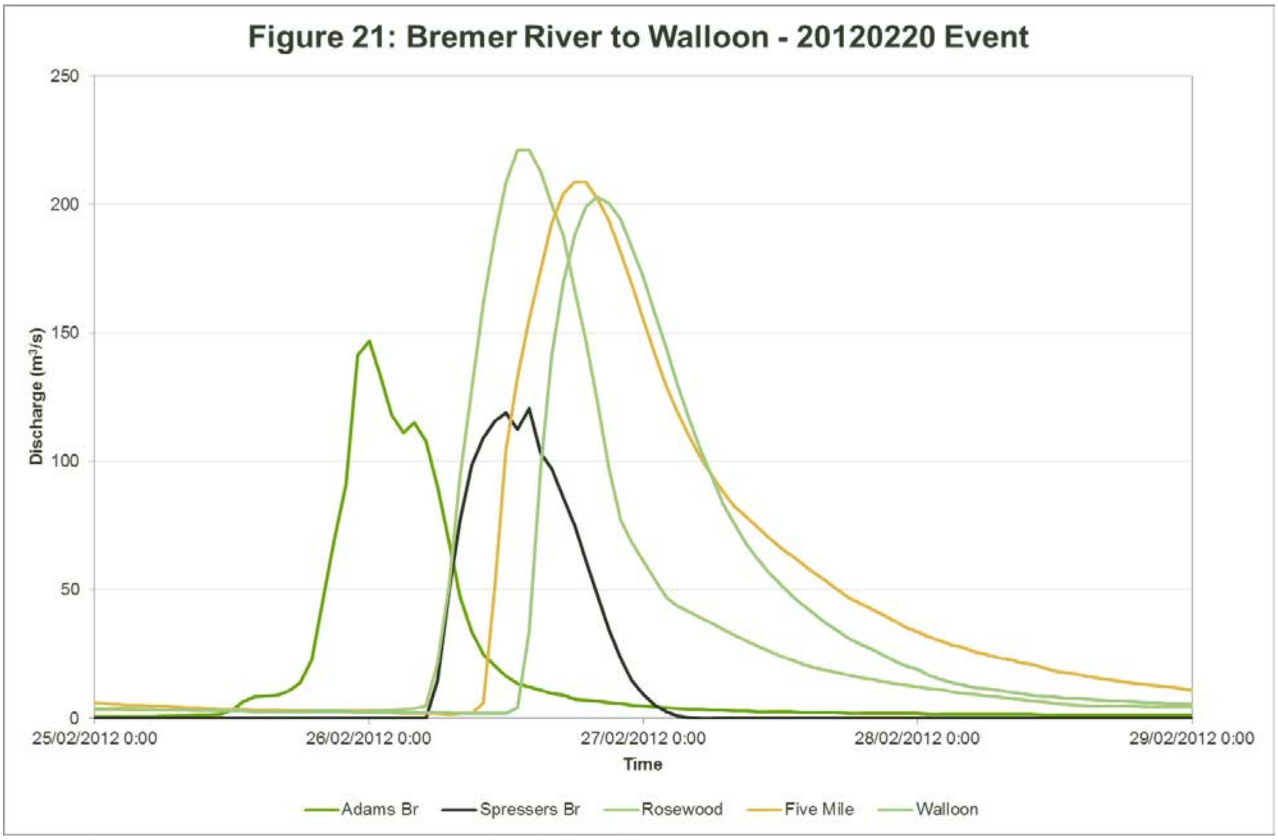


Figure 21: Bremer River to Walloon - 20120220 Event
Discharge (m3/s)
Time
Adams Br
Spressers Br
Rosewood
Five Mile
Walloon

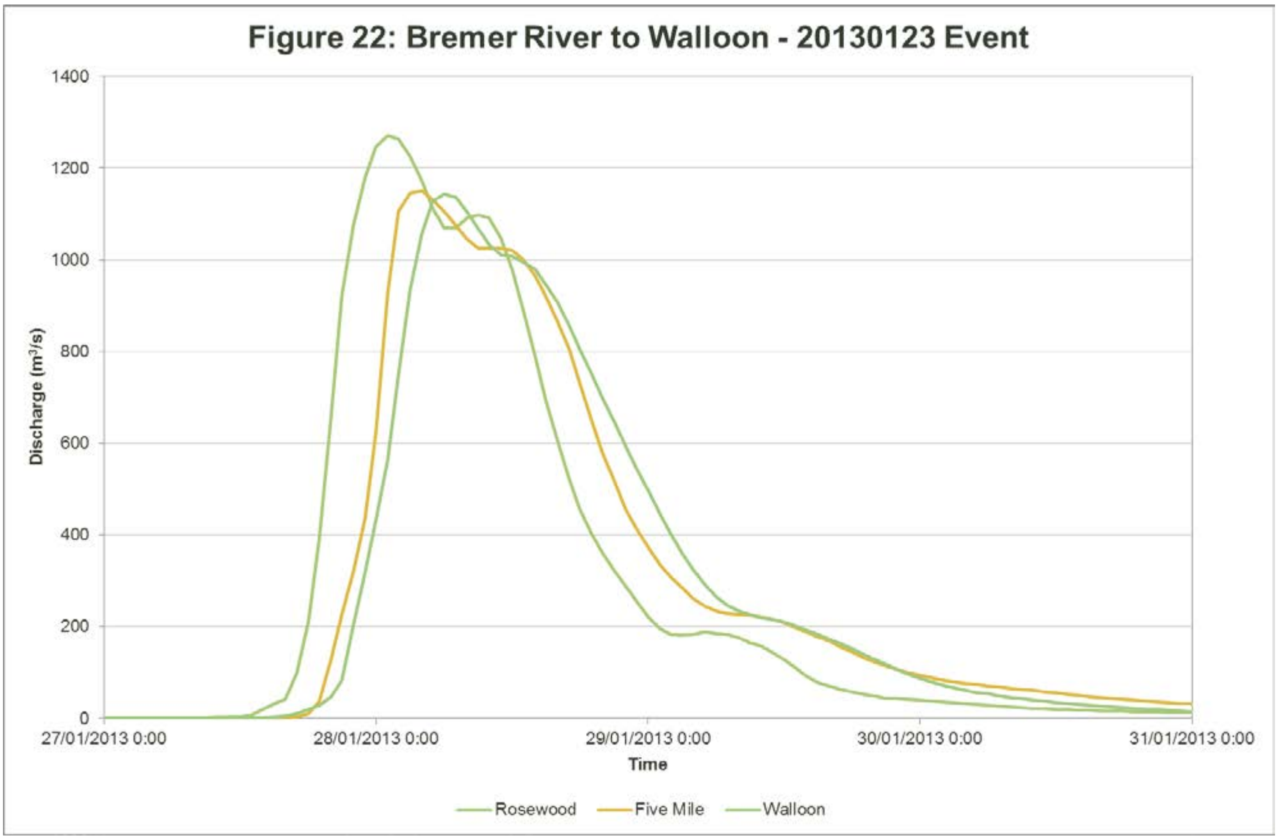


Figure 22: Bremer River to Walloon - 20130123 Event
Discharge (m3/s)
Time
Rosewood
Five Mile
Walloon

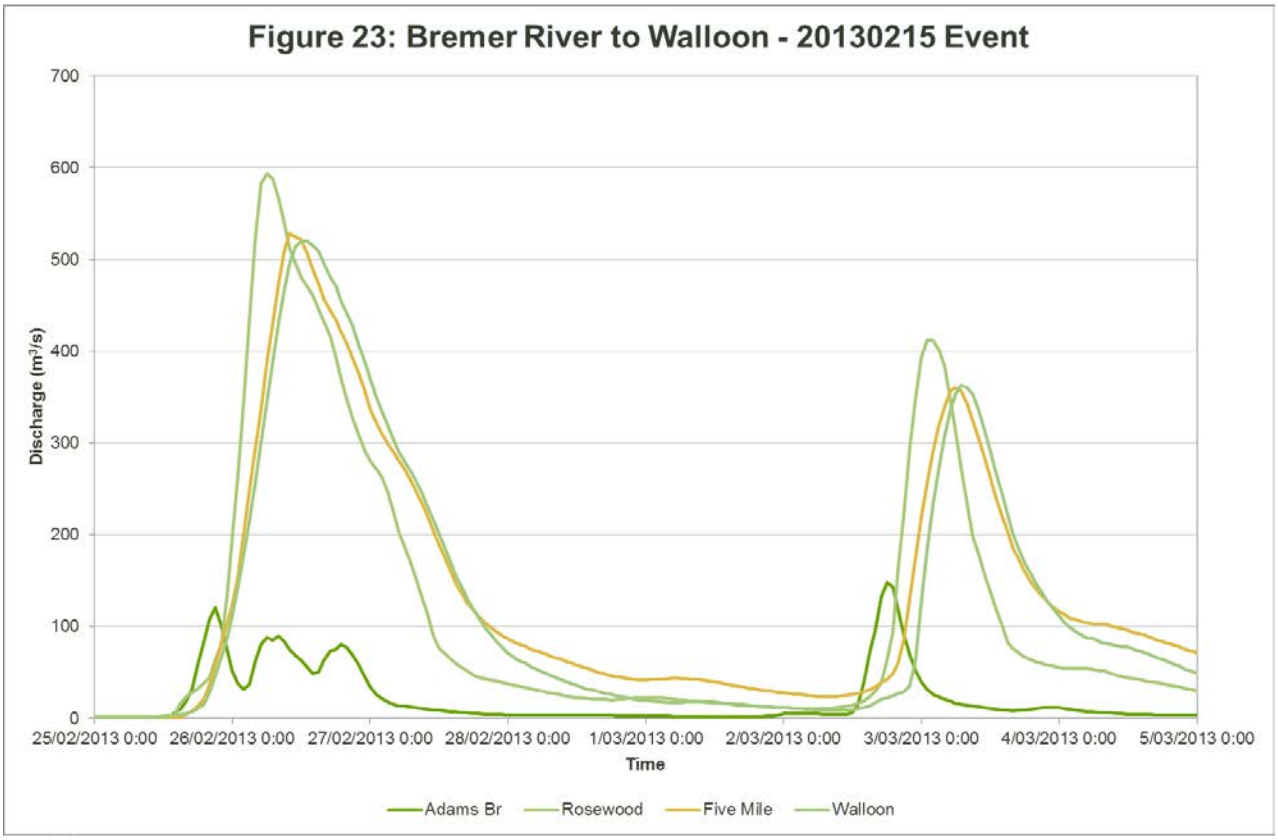


Figure 23: Bremer River to Walloon - 20130215 Event
700
600
500
400
300
200
100
0
Discharge (m3/s)
25/02/2013 0:00
26/02/2013 0:00
27/02/2013 0:00
28/02/2013 0:00
1/03/2013 0:00
2/03/2013 0:00
3/03/2013 0:00
4/03/2013 0:00
5/03/2013 0:00
Time
Adams Br
Rosewood
Five Mile
Walloon

Lockyer Creek

Table 4 Lockyer Creek to Glenore Grove and Lyons Bridge – Adopted Events and Values

Event	Upstream Peak Time	Downstream Peak Time	Rated Flow at Glenore Grove (m^3/s)	Travel Time	Peak Lag (hrs/km)
Helidon to Glenore Grove (46.8km)					
20101201	4/12/2010 21:00	5/12/2010 14:00	304	17	0.363
20101216-1	16/12/2010 22:00	17/12/2010 13:00	231	15	0.321
20101216-2	19/12/2010 21:00	20/12/2010 8:00	401	11	0.235
20101223	27/12/2010 16:00	27/12/2010 22:00	2568	6	0.128
US Gatton to Glenore Grove (19.9km)					
20100226-1	3/03/2010 5:00	3/03/2010 9:00	192	4	0.201
20100226-2	7/03/2010 6:00	7/03/2010 11:00	193	5	0.251
20101201	5/12/2010 8:00	5/12/2010 14:00	304	6	0.302
20101216-1	17/12/2010 8:00	17/12/2010 13:00	231	5	0.251
20101216-2	20/12/2010 3:00	20/12/2010 8:00	401	5	0.251
20101223	27/12/2010 19:00	27/12/2010 22:00	2568	3	0.151
Gatton to Glenore Grove (19.1km)					
19990207	9/02/1999 14:00	9/02/1999 17:00	494	3	0.157
20100226-1	3/03/2010 5:00	3/03/2010 9:00	192	4	0.209
20100226-2	7/03/2010 6:00	7/03/2010 11:00	193	5	0.262
Helidon to Lyons Bridge (69.0km)					
20101201	4/12/2010 21:00	6/12/2010 1:00	177	28	0.406
20101216-1	16/12/2010 22:00	17/12/2010 22:00	130	24	0.348
20101216-2	19/12/2010 21:00	20/12/2010 16:00	260	19	0.275
US Gatton to Lyons Bridge (42.1km)					
20100226-1	3/03/2010 5:00	3/03/2010 20:00	126	15	0.356
20100226-2	7/03/2010 6:00	7/03/2010 20:00	128	14	0.333
20101201	5/12/2010 8:00	6/12/2010 1:00	177	17	0.404
20101216-1	17/12/2010 8:00	17/12/2010 22:00	130	14	0.333
20101216-2	20/12/2010 3:00	20/12/2010 16:00	260	13	0.309
Gatton to Lyons Bridge (41.3km)					
19990207	9/02/1999 14:00	9/02/1999 22:00	394	8	0.194
20100226-1	3/03/2010 5:00	3/03/2010 20:00	126	15	0.363
20100226-2	7/03/2010 6:00	7/03/2010 20:00	128	14	0.339
Glenore Grove to Lyons Bridge (22.2km)					
19990207	9/02/1999 17:00	9/02/1999 22:00	394	5	0.225
20100226-1	3/03/2010 9:00	3/03/2010 20:00	126	11	0.495
20100226-2	7/03/2010 11:00	7/03/2010 20:00	128	9	0.405
20101201	5/12/2010 14:00	6/12/2010 1:00	177	11	0.495
20101216-1	17/12/2010 13:00	17/12/2010 22:00	130	9	0.405
20101216-2	20/12/2010 8:00	20/12/2010 16:00	260	8	0.360
20120220	26/02/2012 21:00	27/02/2012 6:00	52	9	0.405

Table 5 Laidley Creek to Warrego Highway – Adopted Events and Values

Event	Upstream Peak Time	Downstream Peak Time	Rated Flow at Warrego Highway (m^3/s)	Travel Time	Peak Lag (hrs/km)
Mulgowie to Warrego Highway (27.0km)					
20100226-2	6/03/2010 17:00	7/03/2010 11:00	48	18	0.667
20101006	11/10/2010 16:00	12/10/2010 6:00	51	14	0.519
20101216-1	16/12/2010 21:00	17/12/2010 13:00	34	16	0.593
20120220	26/02/2012 6:00	26/02/2012 18:00	65	12	0.444
Showgrounds to Warrego Highway (12.9km)					
19910205	8/02/1991 6:00	8/02/1991 14:00	131	8	0.620
20120220	26/02/2012 8:00	26/02/2012 18:00	65	10	0.775

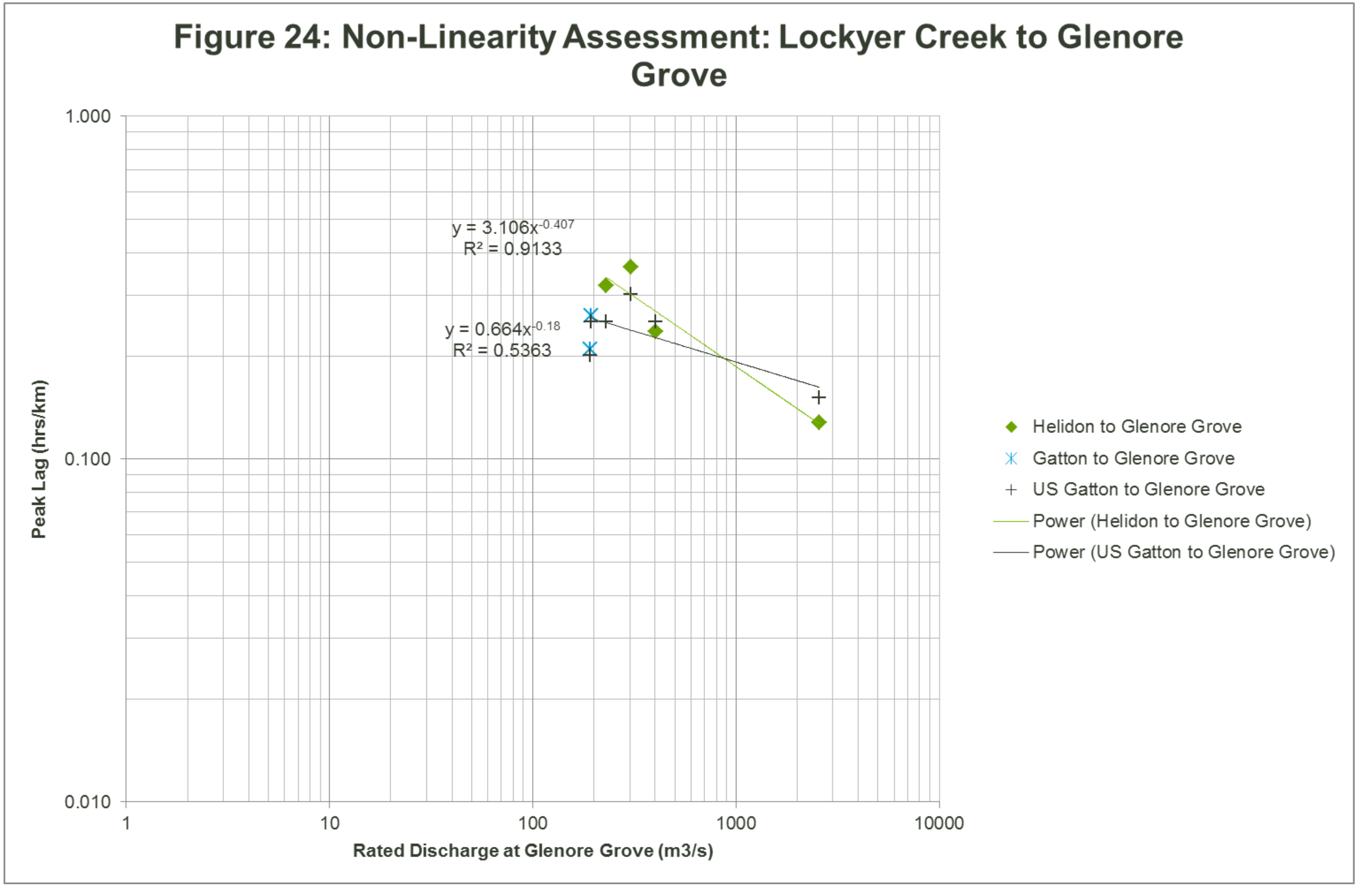


Figure 24: Non-Linearity Assessment: Lockyer Creek to Glenore Grove
1.000
0.100
0.010
1
10
100
1000
10000
Peak Lag (hrs/km)
Rated Discharge at Glenore Grove (m3/s)
y = 3.106x-0.407
R² = 0.9133
y = 0.664x-0.18
R² = 0.5363
Helidon to Glenore Grove
Gatton to Glenore Grove
US Gatton to Glenore Grove
Power (Helidon to Glenore Grove)
Power (US Gatton to Glenore Grove)

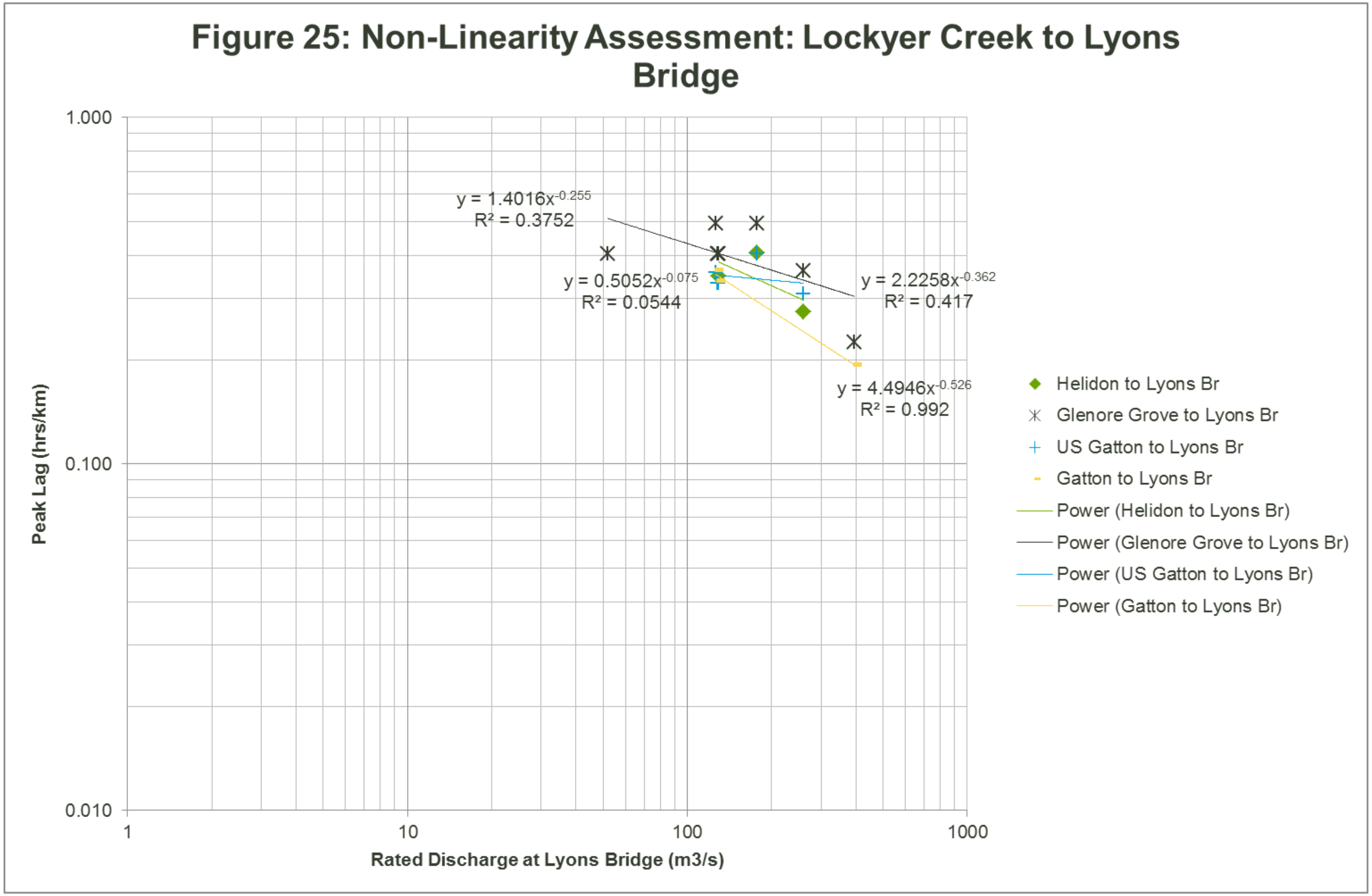


Figure 25: Non-Linearity Assessment: Lockyer Creek to Lyons Bridge
Peak Lag (hrs/km)
1.000
0.100
0.010
1
10
100
1000
Rated Discharge at Lyons Bridge (m3/s)
y = 1.4016x-0.255
R² = 0.3752
y = 0.5052x-0.075
R² = 0.0544
y = 2.2258x-0.362
R² = 0.417
y = 4.4946x-0.526
R² = 0.992
Helidon to Lyons Br
Glenore Grove to Lyons Br
US Gatton to Lyons Br
Gatton to Lyons Br
Power (Helidon to Lyons Br)
Power (Glenore Grove to Lyons Br)
Power (US Gatton to Lyons Br)
Power (Gatton to Lyons Br)

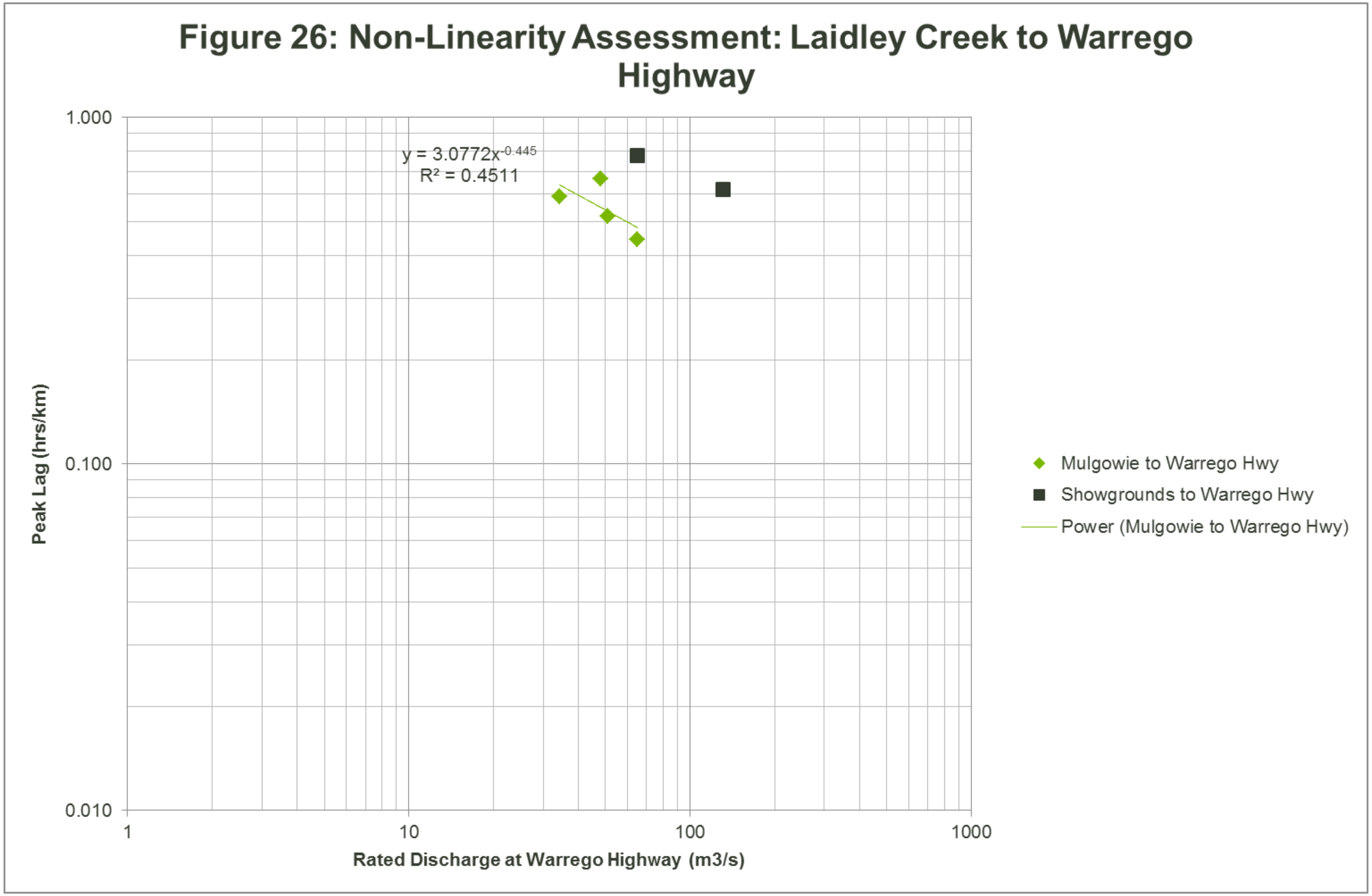


Figure 26: Non-Linearity Assessment: Laidley Creek to Warrego Highway
1.000
0.100
0.010
1
10
100
1000
y = 3.0772x^-0.445
R² = 0.4511
Peak Lag (hrs/km)
Rated Discharge at Warrego Highway (m3/s)
Mulgowie to Warrego Hwy
Showgrounds to Warrego Hwy
Power (Mulgowie to Warrego Hwy)

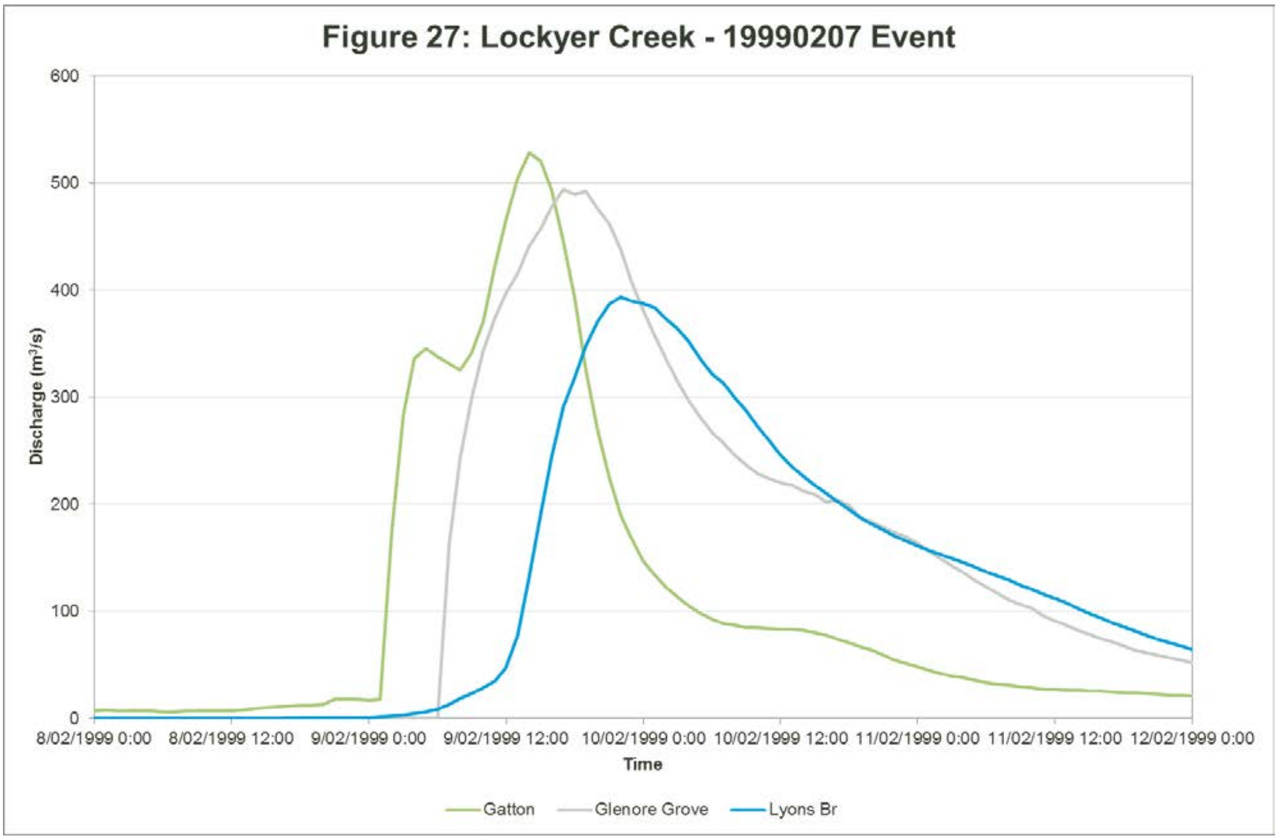


Figure 27: Lockyer Creek - 19990207 Event
Discharge (m³/s)
600
500
400
300
200
100
0
8/02/1999 0:00
8/02/1999 12:00
9/02/1999 0:00
9/02/1999 12:00
10/02/1999 0:00
10/02/1999 12:00
11/02/1999 0:00
11/02/1999 12:00
12/02/1999 0:00
Time
Gatton
Glenore Grove
Lyons Br

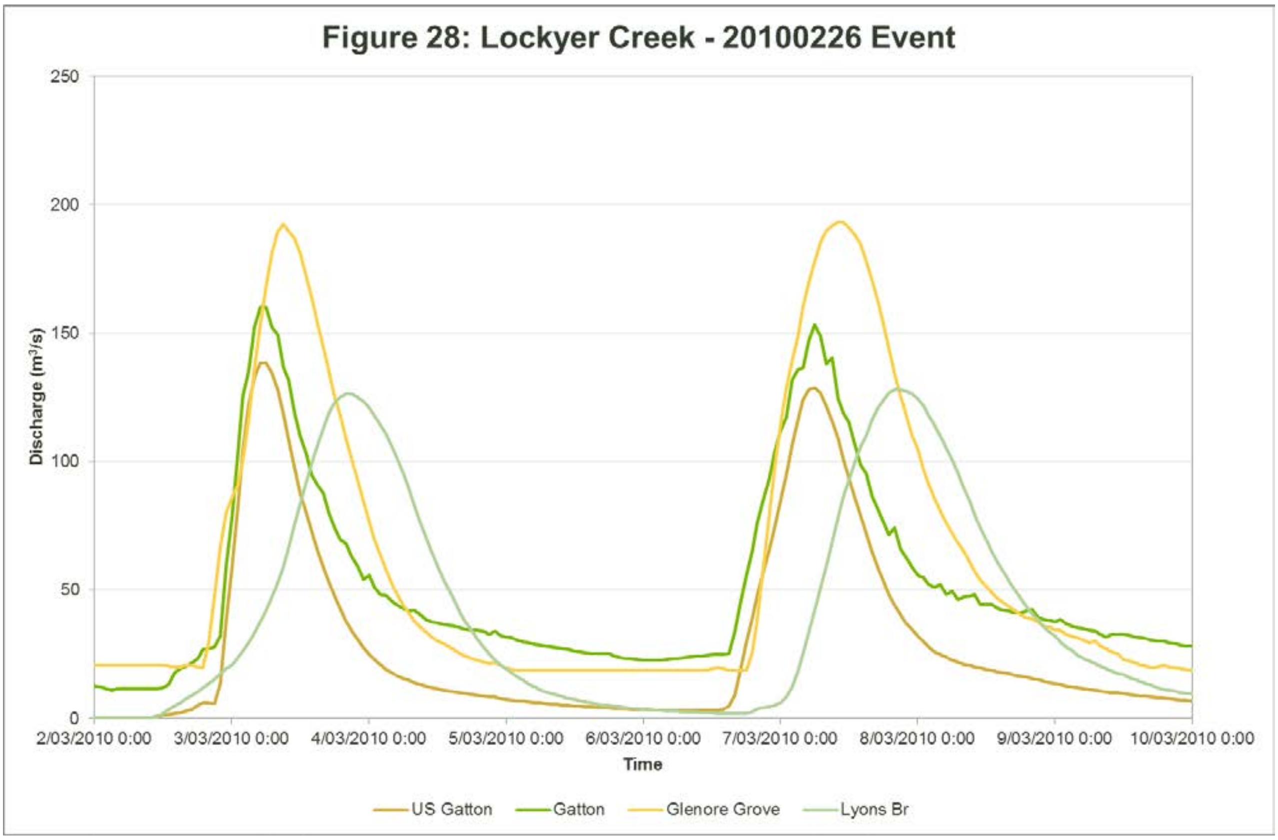


Figure 28: Lockyer Creek - 20100226 Event
Discharge (m³/s)
250
200
150
100
50
0
2/03/2010 0:00
3/03/2010 0:00
4/03/2010 0:00
5/03/2010 0:00
6/03/2010 0:00
7/03/2010 0:00
8/03/2010 0:00
9/03/2010 0:00
10/03/2010 0:00
Time
US Gatton
Gatton
Glenore Grove
Lyons Br

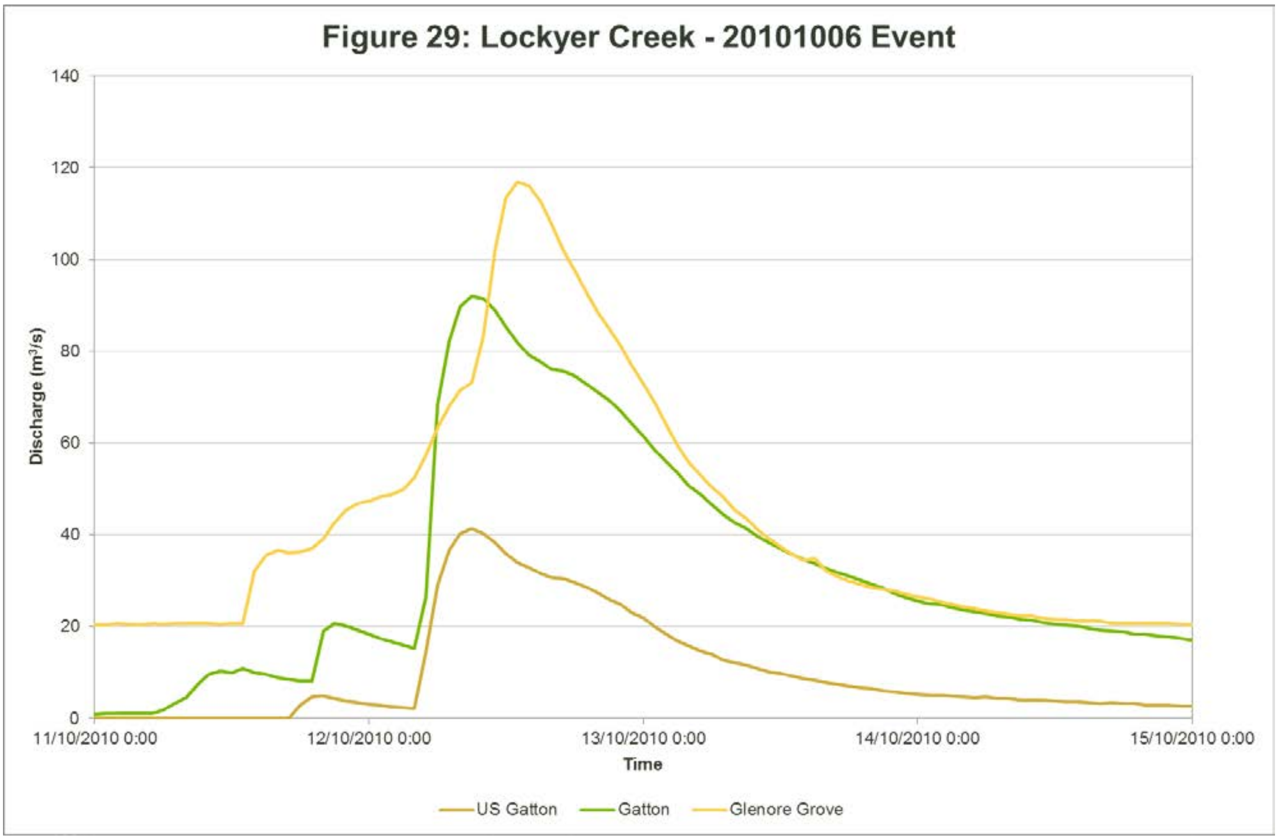


Figure 29: Lockyer Creek - 20101006 Event
Discharge (m³/s)
0
20
40
60
80
100
120
140
11/10/2010 0:00
12/10/2010 0:00
13/10/2010 0:00
14/10/2010 0:00
15/10/2010 0:00
Time
US Gatton
Gatton
Glenore Grove

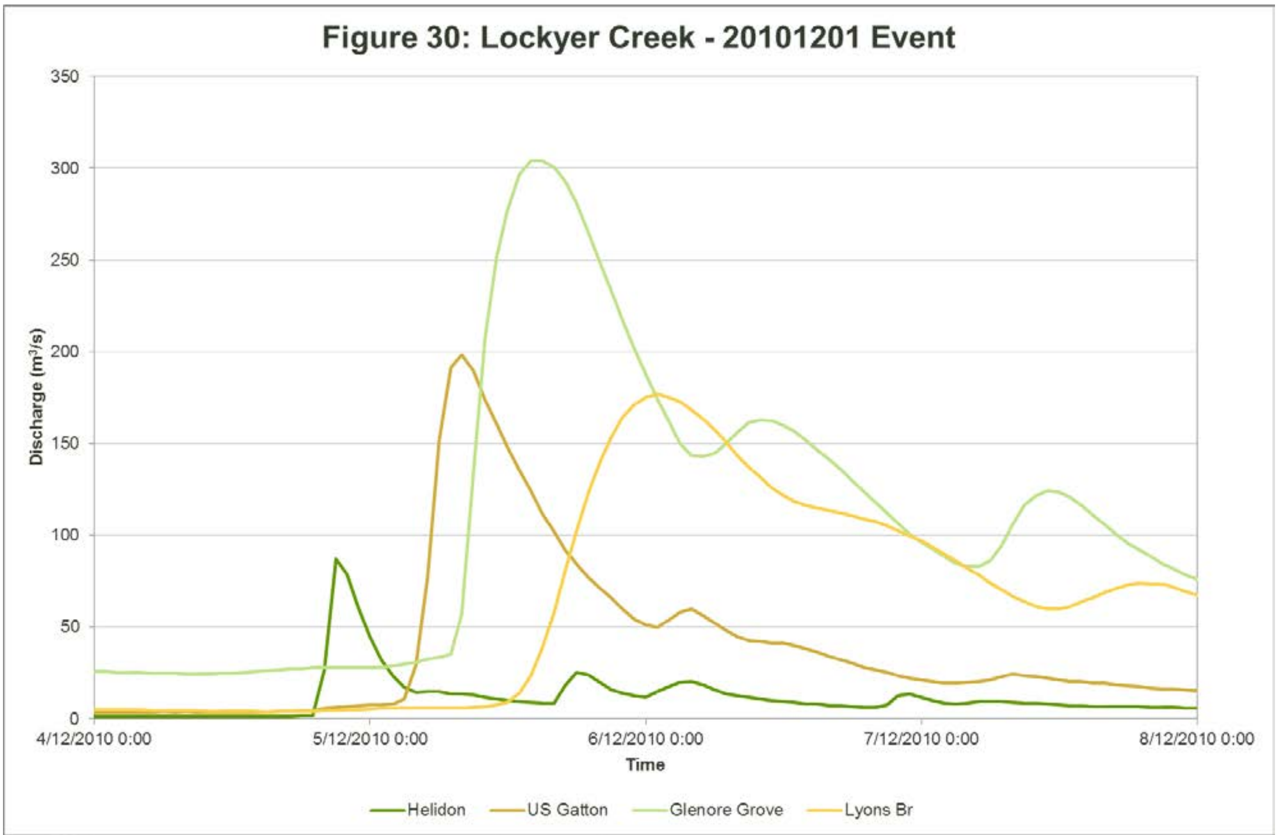


Figure 30: Lockyer Creek - 20101201 Event
Discharge (m³/s)
0
50
100
150
200
250
300
350
4/12/2010 0:00
5/12/2010 0:00
6/12/2010 0:00
7/12/2010 0:00
8/12/2010 0:00
Time
Helidon
US Gatton
Glenore Grove
Lyons Br

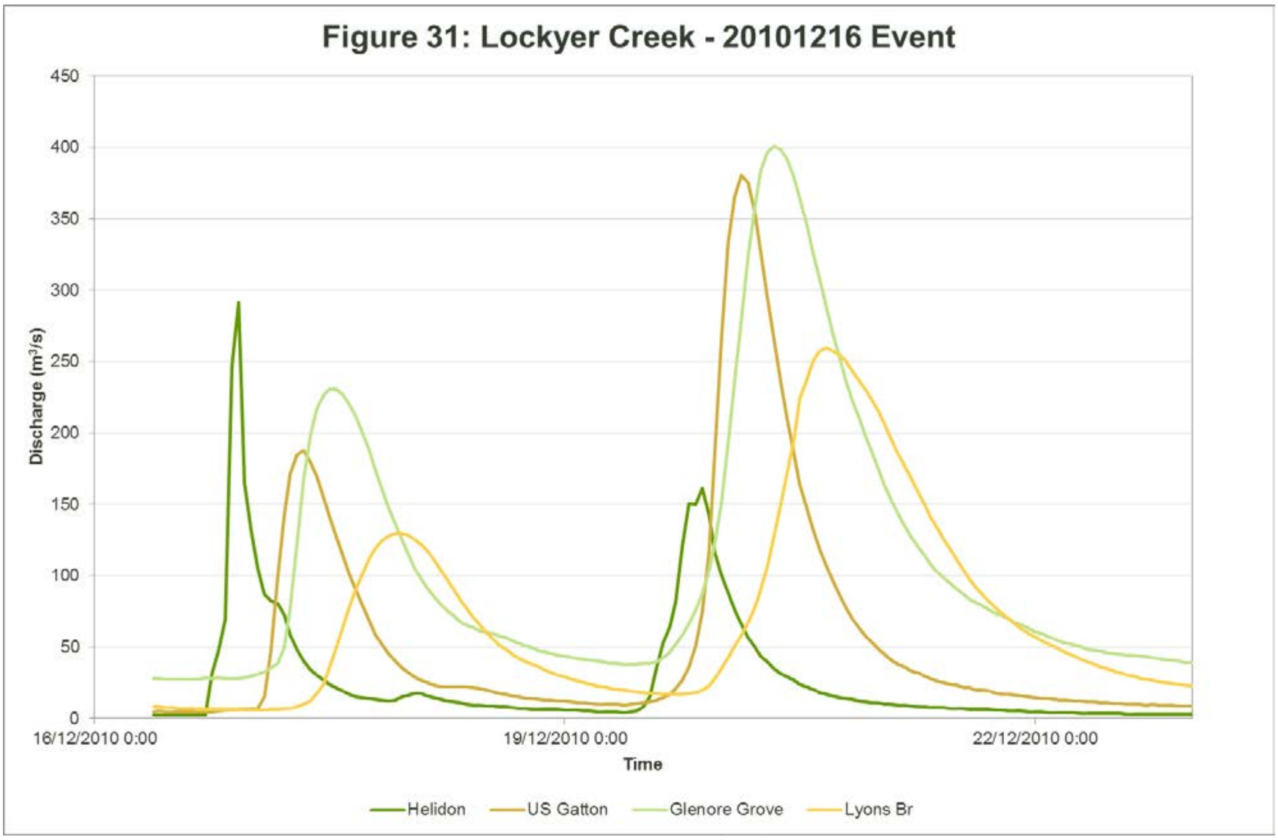


Figure 31: Lockyer Creek - 20101216 Event
450
400
350
300
250
200
150
100
50
0
Discharge (m3/s)
16/12/2010 0:00
19/12/2010 0:00
22/12/2010 0:00
Time
Helidon
US Gatton
Glenore Grove
Lyons Br

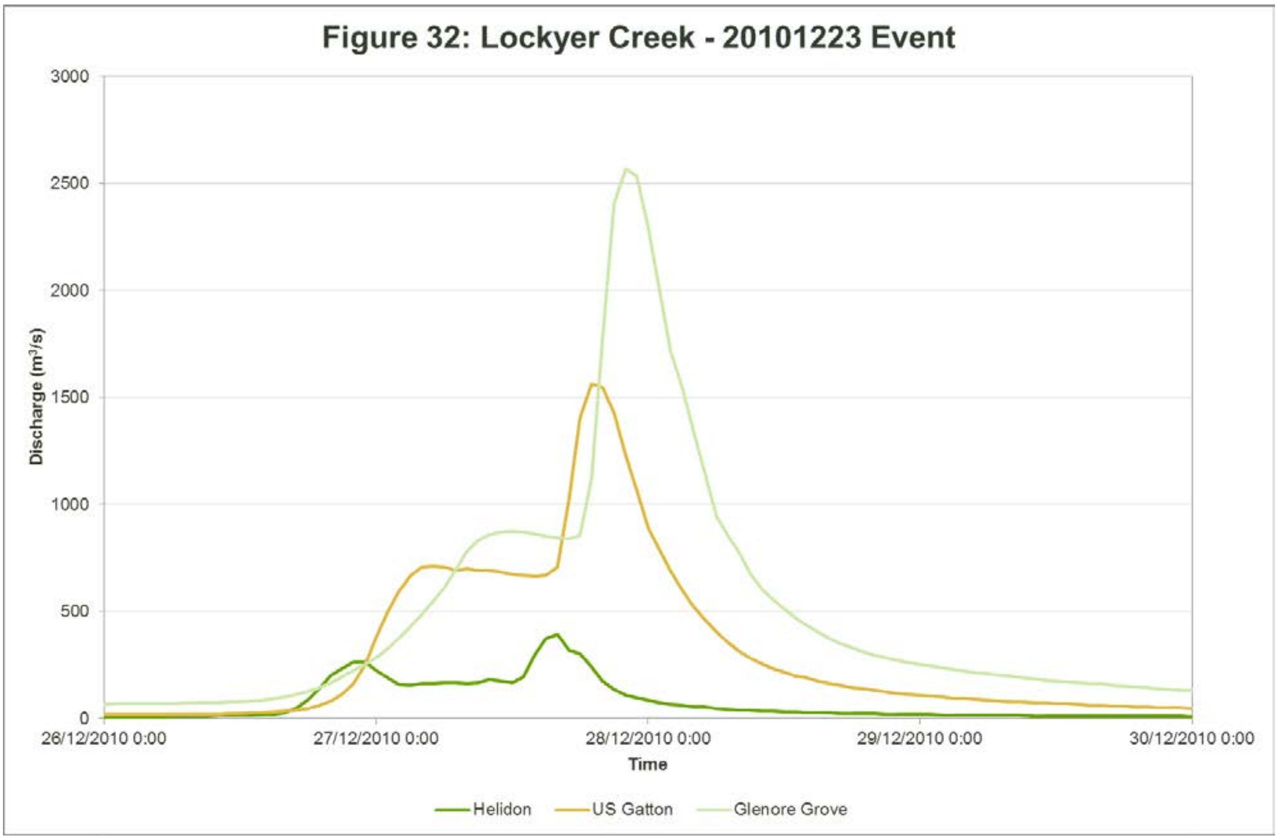


Figure 32: Lockyer Creek - 20101223 Event
3000
2500
2000
1500
1000
500
0
Discharge (m3/s)
26/12/2010 0:00
27/12/2010 0:00
28/12/2010 0:00
29/12/2010 0:00
30/12/2010 0:00
Time
Helidon
US Gatton
Glenore Grove

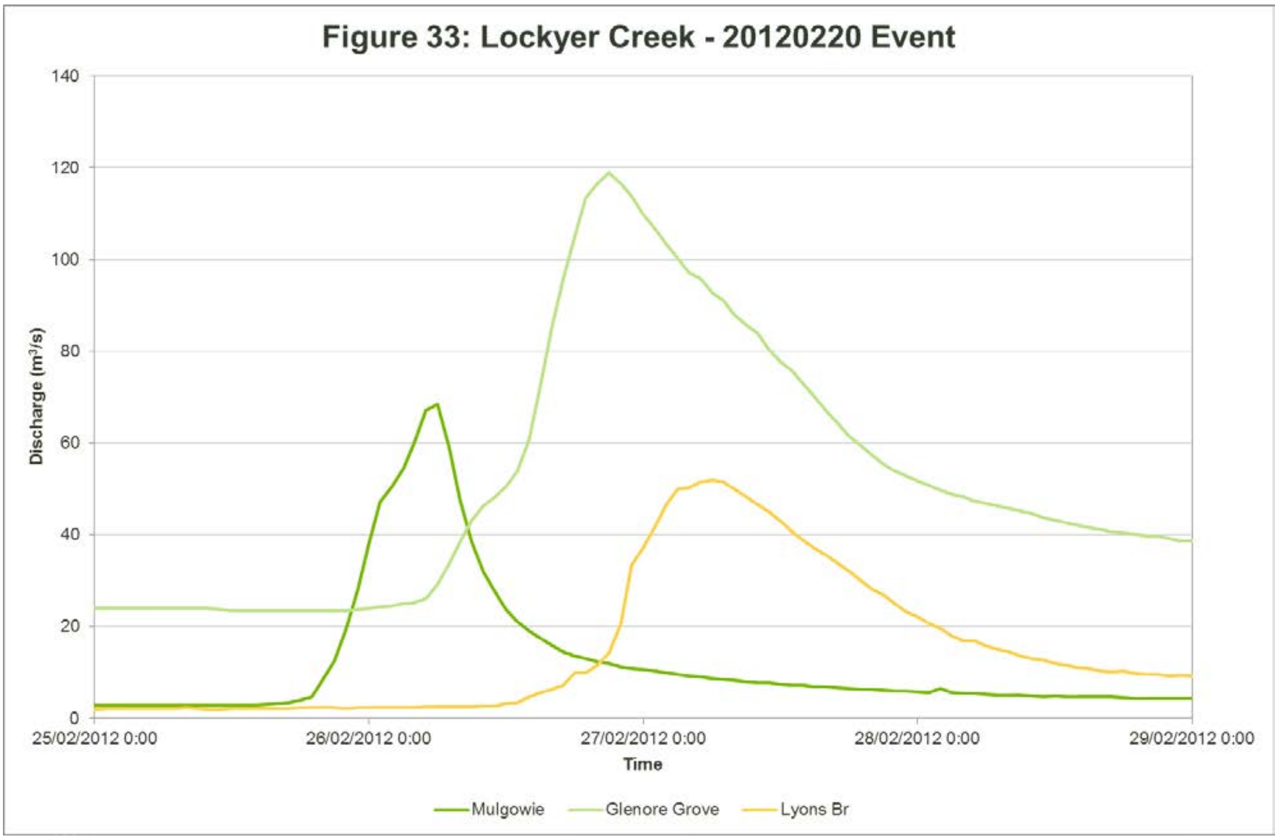


Figure 33: Lockyer Creek - 20120220 Event
Discharge (m³/s)
140
120
100
80
60
40
20
0
25/02/2012 0:00
26/02/2012 0:00
27/02/2012 0:00
28/02/2012 0:00
29/02/2012 0:00
Time
Mulgowie
Glenore Grove
Lyons Br

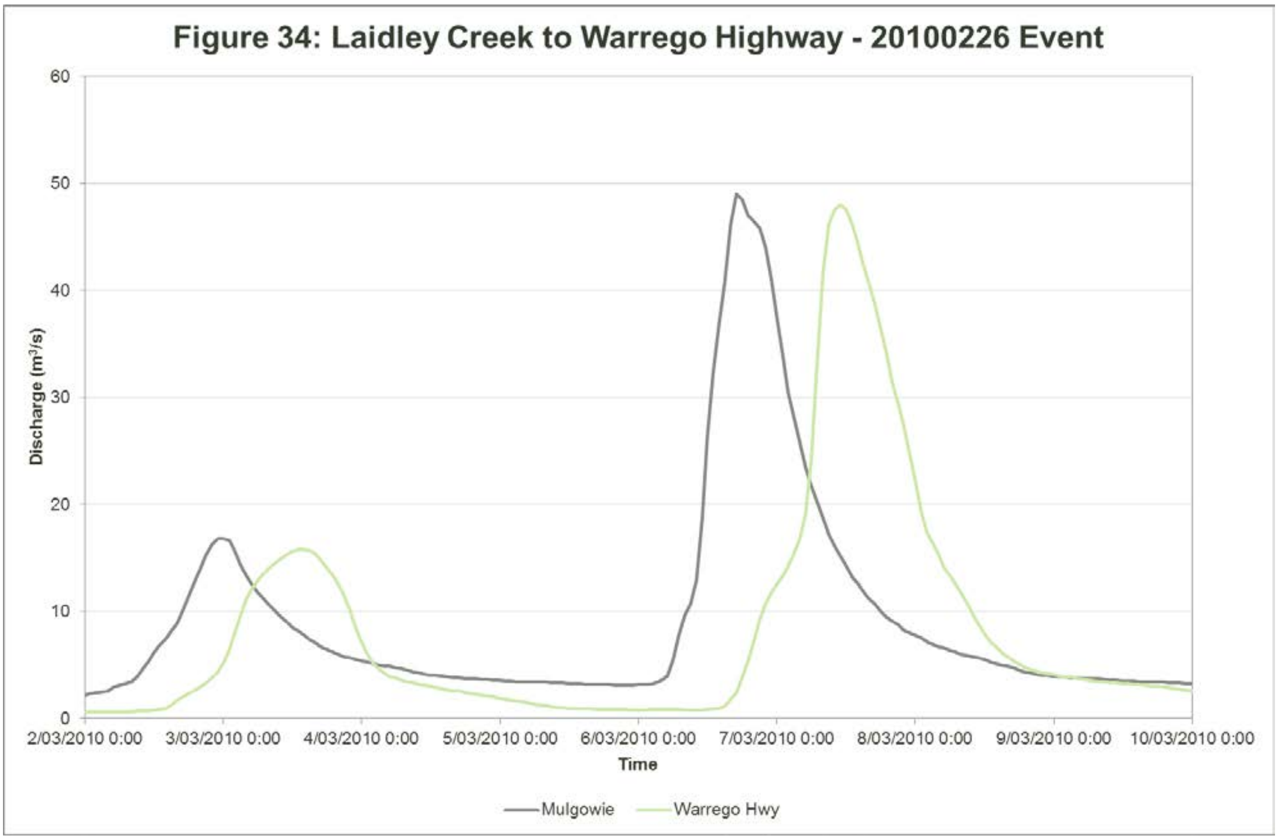


Figure 34: Laidley Creek to Warrego Highway - 20100226 Event
Discharge (m³/s)
60
50
40
30
20
10
0
2/03/2010 0:00
3/03/2010 0:00
4/03/2010 0:00
5/03/2010 0:00
6/03/2010 0:00
7/03/2010 0:00
8/03/2010 0:00
9/03/2010 0:00
10/03/2010 0:00
Time
Mulgowie
Warrego Hwy

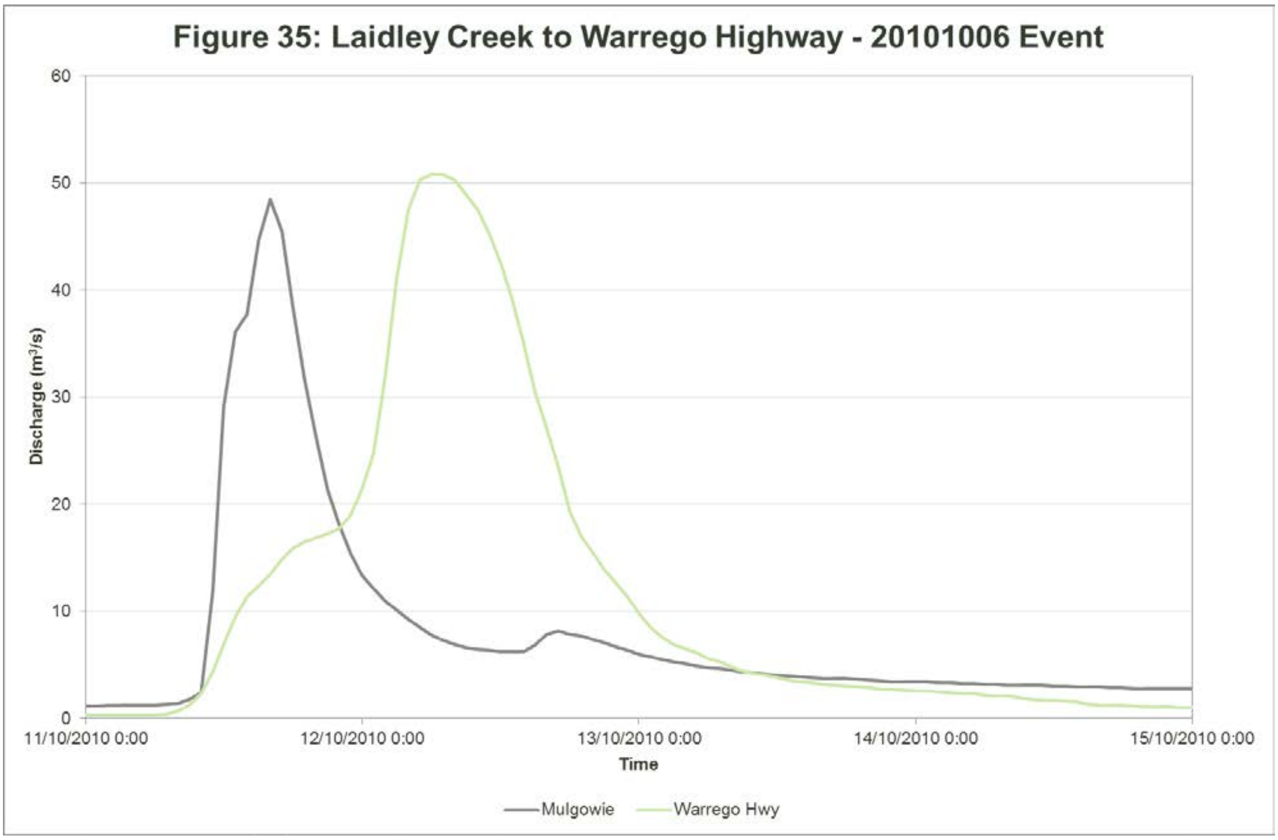


Figure 35: Laidley Creek to Warrego Highway - 20101006 Event
60
50
40
30
20
10
0
Discharge (m3/s)
11/10/2010 0:00
12/10/2010 0:00
13/10/2010 0:00
14/10/2010 0:00
15/10/2010 0:00
Time
Mulgowie
Warrego Hwy

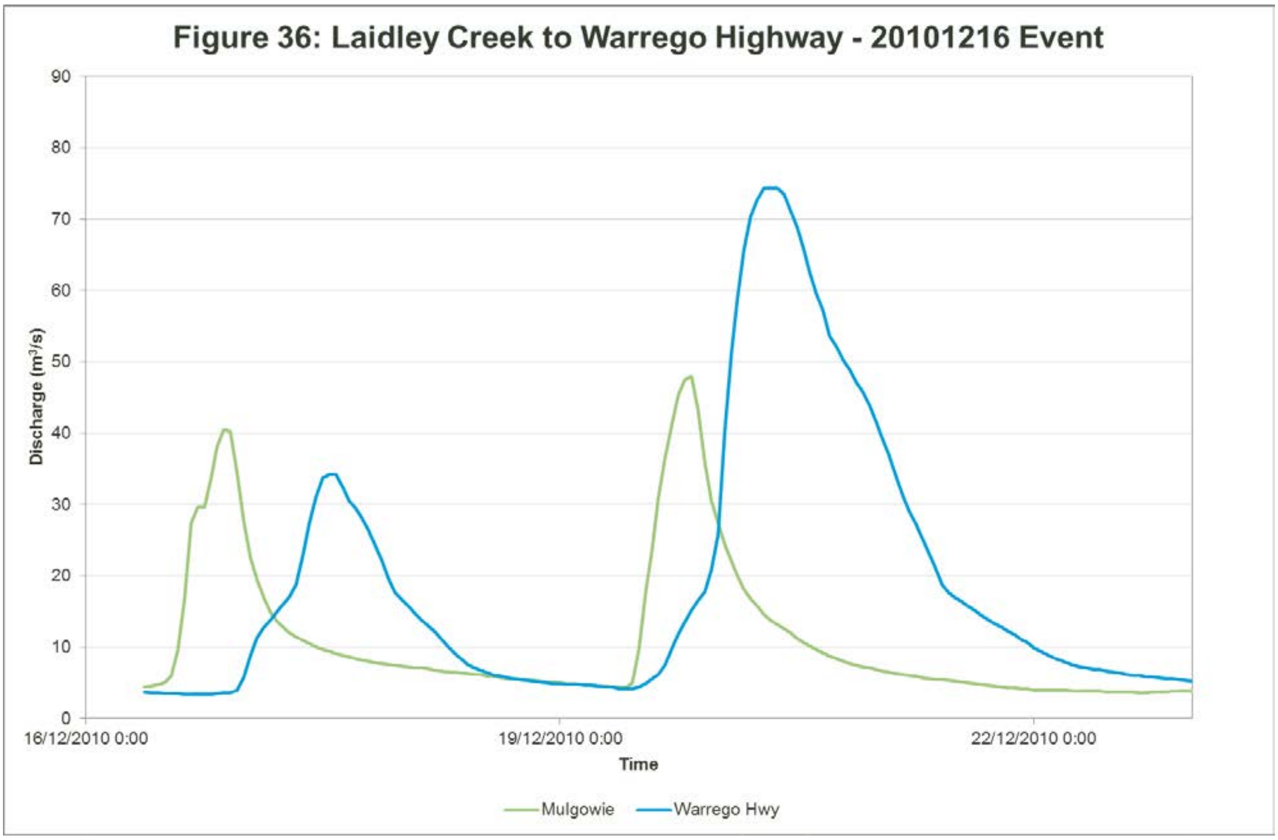


Figure 36: Laidley Creek to Warrego Highway - 20101216 Event
90
80
70
60
50
40
30
20
10
0
Discharge (m3/s)
16/12/2010 0:00
19/12/2010 0:00
22/12/2010 0:00
Time
Mulgowie
Warrego Hwy

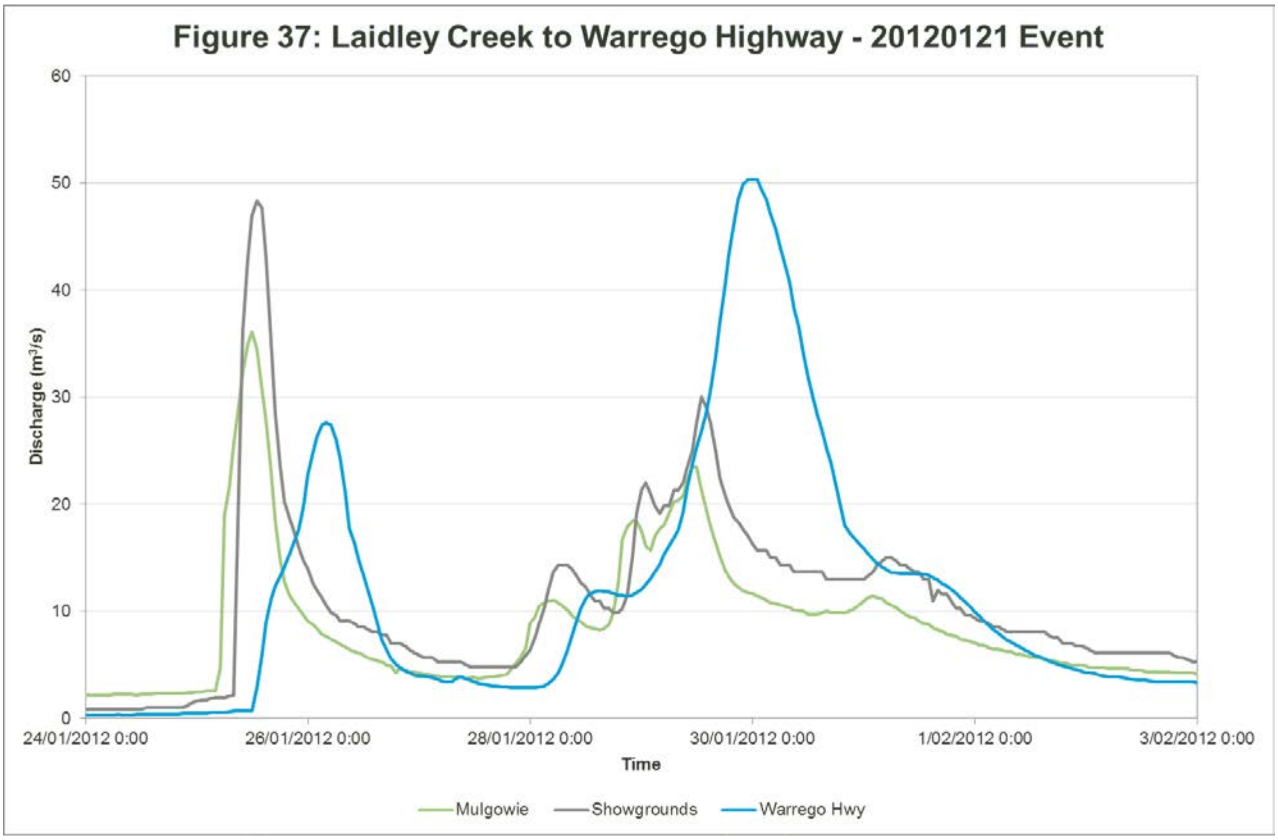


Figure 37: Laidley Creek to Warrego Highway - 20120121 Event
60
50
40
30
20
10
0
Discharge (m³/s)
24/01/2012 0:00
26/01/2012 0:00
28/01/2012 0:00
30/01/2012 0:00
1/02/2012 0:00
3/02/2012 0:00
Time
Mulgowie
Showgrounds
Warrego Hwy

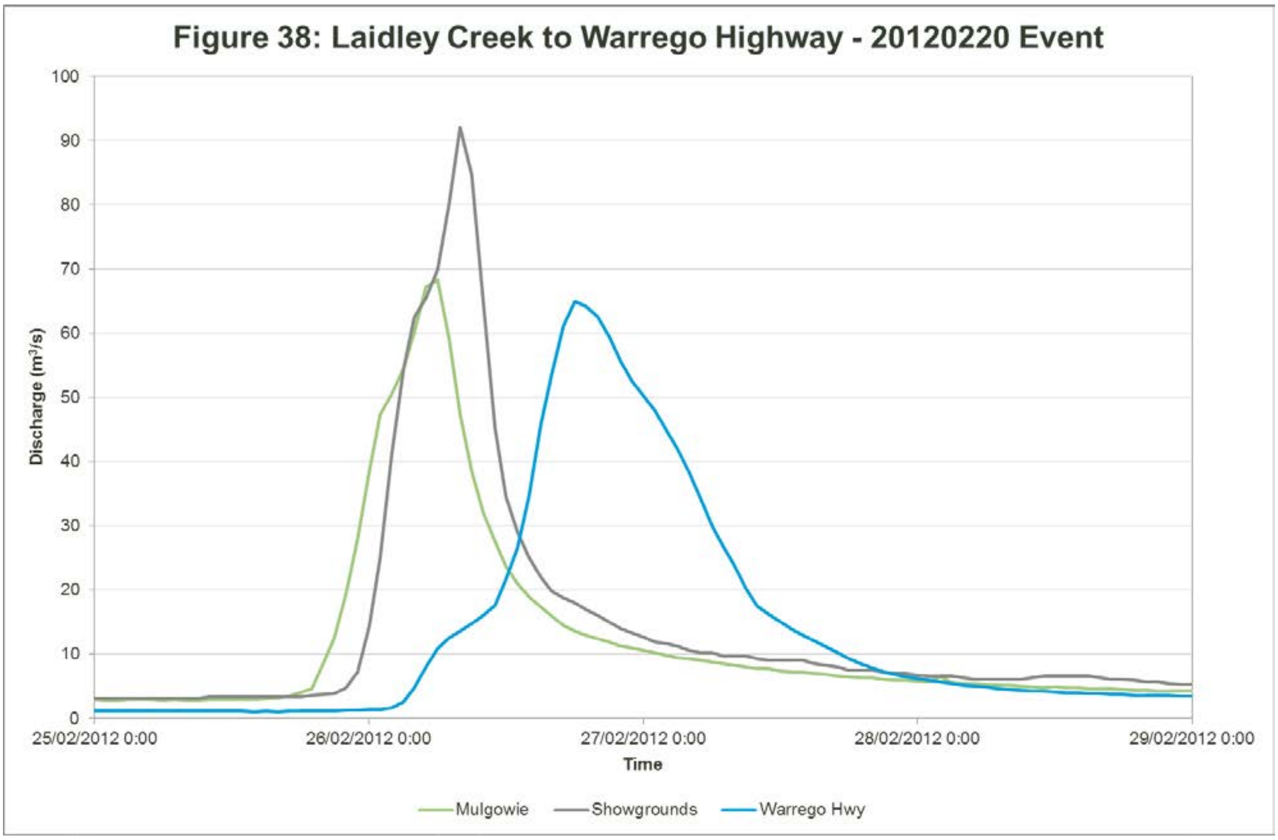


Figure 38: Laidley Creek to Warrego Highway - 20120220 Event
100
90
80
70
60
50
40
30
20
10
0
Discharge (m³/s)
25/02/2012 0:00
26/02/2012 0:00
27/02/2012 0:00
28/02/2012 0:00
29/02/2012 0:00
Time
Mulgowie
Showgrounds
Warrego Hwy

Purga Creek

Table 6 Purga Creek to Loamside – Adopted Events and Values

Event	Upstream Peak Time	Downstream Peak Time	Rated Flow at Loamside (m^3/s)	Travel Time	Peak Lag (hrs/km)
Peak Crossing to Loamside (15.3km)					
20040304	6/03/2004 6:00	6/03/2004 14:00	87	8	0.523
20110102	10/01/2011 15:00	10/01/2011 21:00	170	6	0.392
20120220	26/02/2012 4:00	26/02/2012 14:00	44	10	0.654

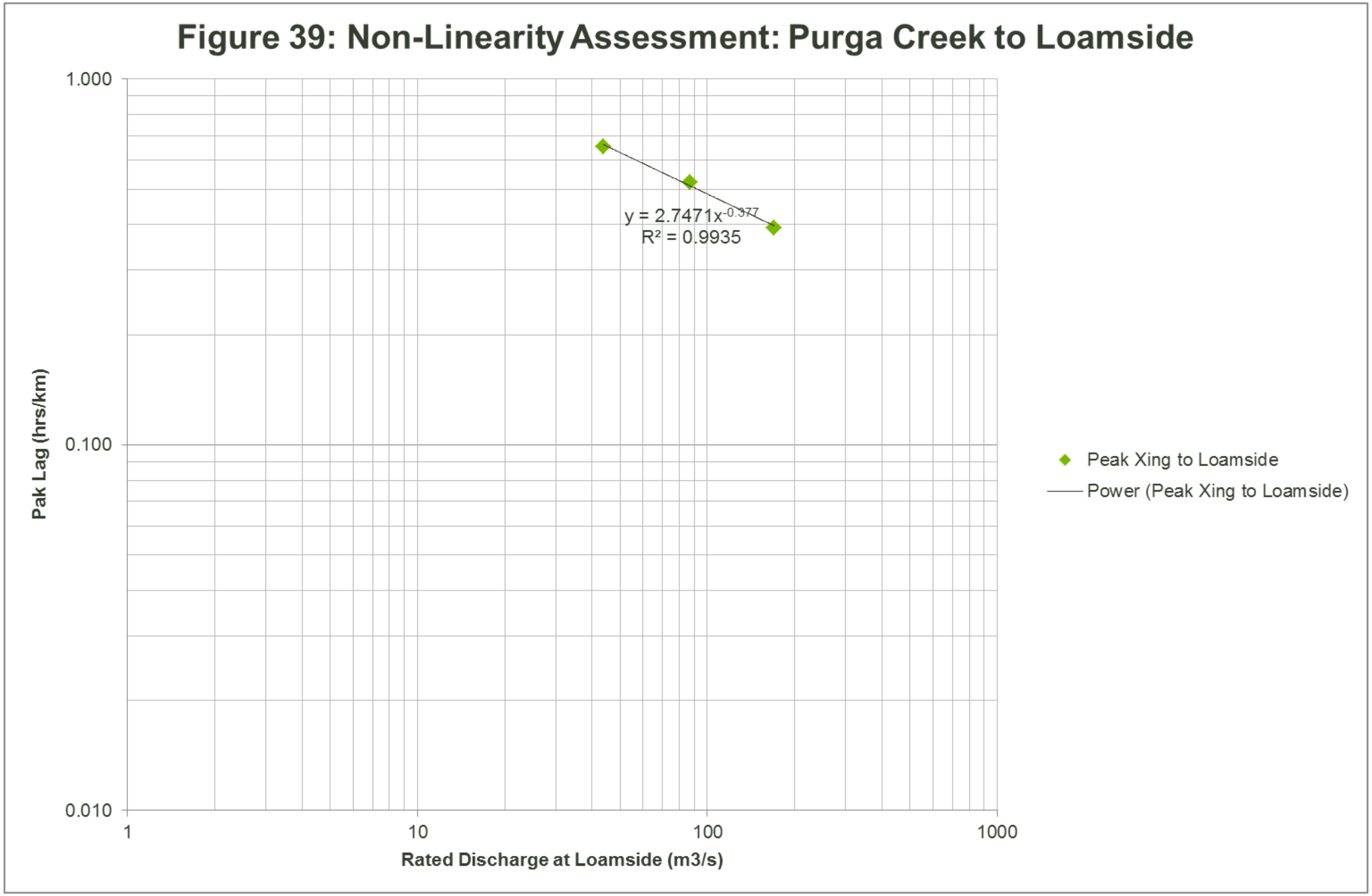


Figure 39: Non-Linearity Assessment: Purga Creek to Loamside
1.000
0.100
0.010
Pak Lag (hrs/km)
1
10
100
1000
Rated Discharge at Loamside (m3/s)
y = 2.7471x-0.377
R² = 0.9935
Peak Xing to Loamside
Power (Peak Xing to Loamside)

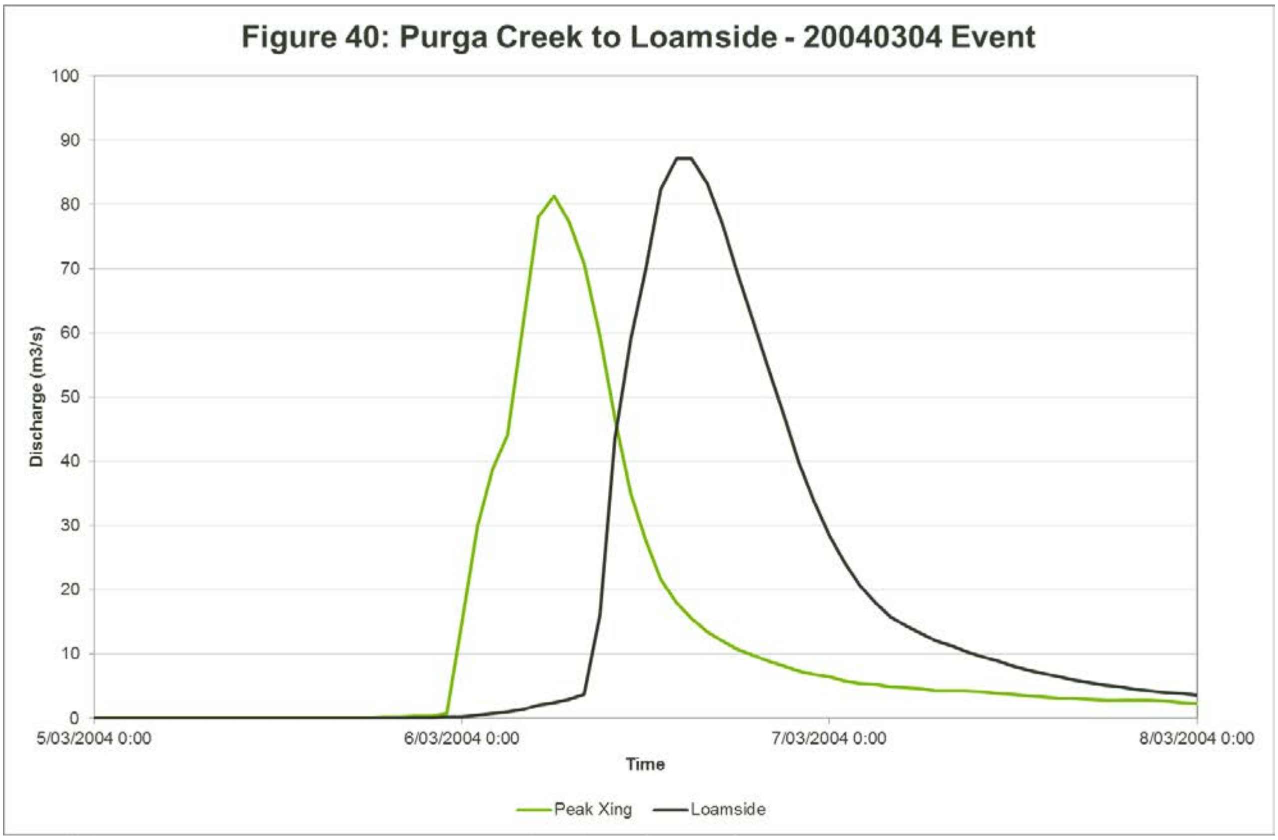


Figure 40: Purga Creek to Loamside - 20040304 Event
Discharge (m3/s)
100
90
80
70
60
50
40
30
20
10
0
5/03/2004 0:00
6/03/2004 0:00
7/03/2004 0:00
8/03/2004 0:00
Time
Peak Xing
Loamside

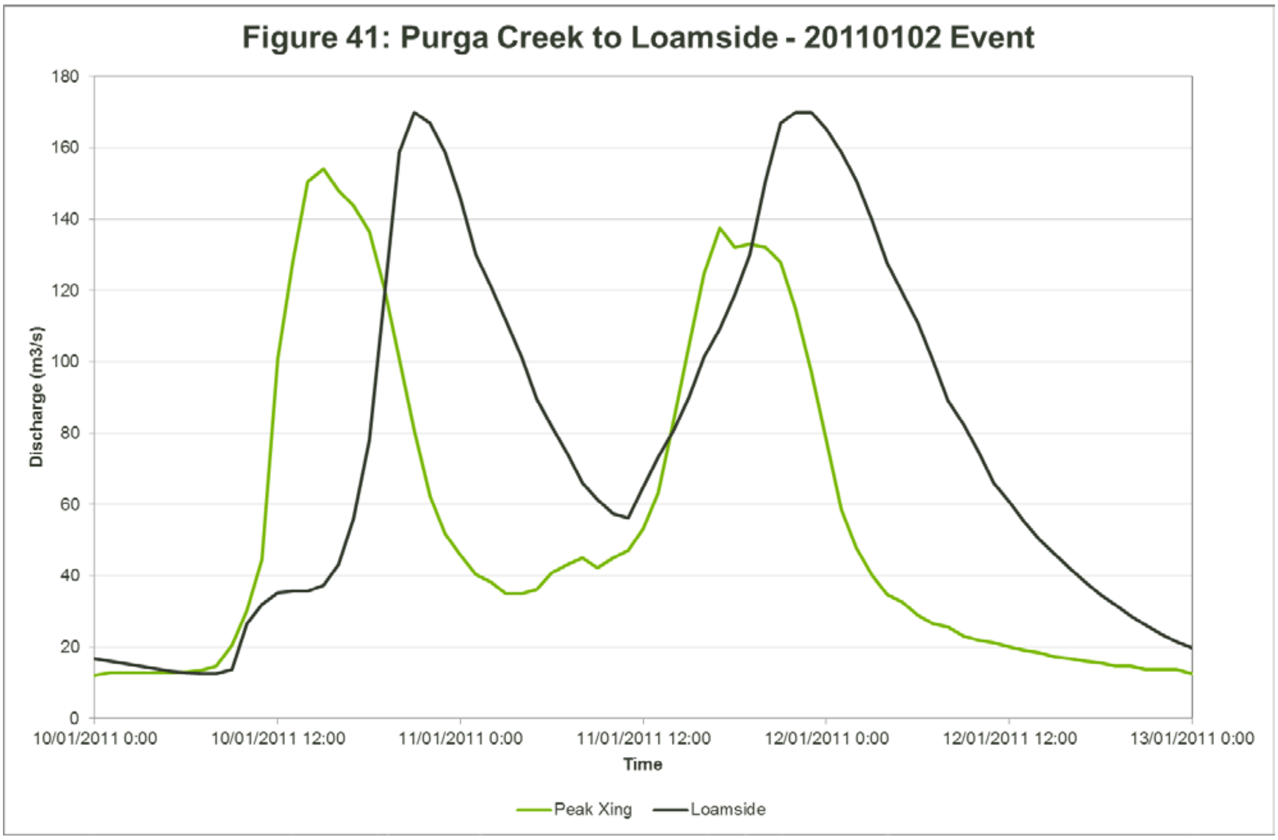


Figure 41: Purga Creek to Loamside - 20110102 Event
Discharge (m3/s)
180
160
140
120
100
80
60
40
20
0
10/01/2011 0:00
10/01/2011 12:00
11/01/2011 0:00
11/01/2011 12:00
12/01/2011 0:00
12/01/2011 12:00
13/01/2011 0:00
Time
Peak Xing
Loamside

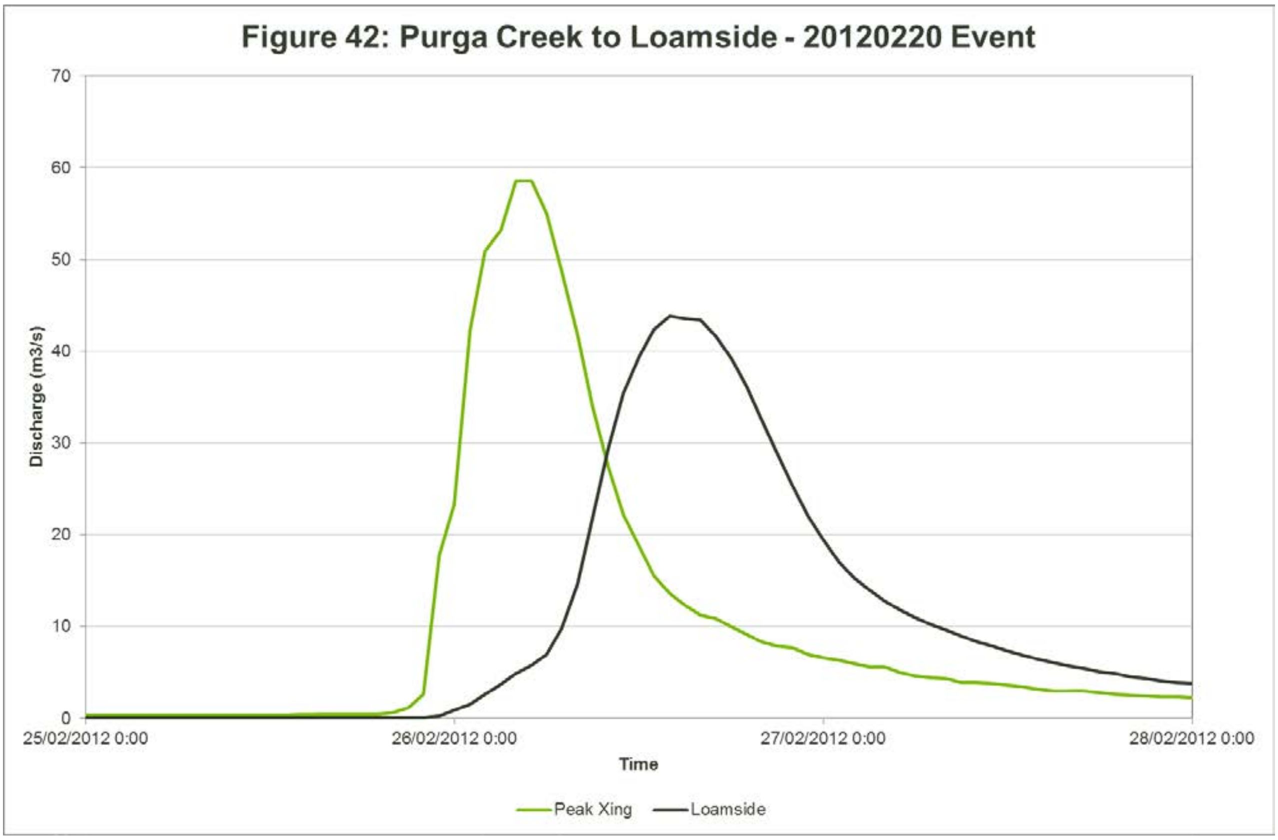


Figure 42: Purga Creek to Loamside - 20120220 Event
Discharge (m3/s)
70
60
50
40
30
20
10
0
25/02/2012 0:00
26/02/2012 0:00
27/02/2012 0:00
28/02/2012 0:00
Time
Peak Xing
Loamside

Lower Brisbane

Table 7 Lower Brisbane River to Mt Crosby Weir – Adopted Events and Values

Event	Upstream Peak Time	Downstream Peak Time	Rated Flow at Glenore Grove (m^3/s)	Travel Time	Peak Lag (hrs/km)
Lowood to Mt Crosby (49.4km)					
19680107	13/01/1968 21:00	14/01/1968 8:00	3775	11	0.223
19730705	9/07/1973 7:00	9/07/1973 20:00	2714	13	0.263
19740124	28/01/1974 2:00	28/01/1974 11:00	10375	9	0.182
20110102	12/01/2011 0:00	12/01/2011 10:00	9842	10	0.202
20130123	29/01/2013 0:00	29/01/2013 8:00	2250	8	0.162
Savages Crossing to Mt Crosby (39.6km)					
19590215	19/02/1959 10:00	19/02/1959 16:00	1881	6	0.152
19650718	21/07/1965 10:00	21/07/1965 19:00	1758	9	0.227
19670607	12/06/1967 5:00	12/06/1967 13:00	3036	8	0.202
19680107	13/01/1968 23:00	14/01/1968 8:00	3775	9	0.227
19720201	14/02/1972 14:00	14/02/1972 20:00	2086	6	0.152
19730705	9/07/1973 10:00	9/07/1973 20:00	2714	10	0.253
19740124	28/01/1974 1:00	28/01/1974 11:00	10375	10	0.253
19760119	22/01/1976 9:00	22/01/1976 19:00	1869	10	0.253
19760209	12/12/1976 18:00	12/12/1976 23:00	1010	5	0.126
19830620	24/06/1983 1:00	24/06/1983 6:00	1892	5	0.126
19890423	27/04/1989 7:00	27/04/1989 15:00	1508	8	0.202
20010130	4/02/2001 14:00	4/02/2001 23:00	511	9	0.227
20101006	14/10/2010 10:00	14/10/2010 20:00	1493	10	0.253
20110102	12/01/2011 2:00	12/01/2011 10:00	9842	8	0.202
20120121	29/01/2012 13:00	29/01/2012 19:00	536	6	0.152
20130123	29/01/2013 3:00	29/01/2013 8:00	2250	5	0.126

Table 8 Lower Brisbane River to Moggill – Adopted Events and Values

Event	Upstream Peak Time	Downstream Peak Time	Rated Flow at Glenore Grove (m^3/s)	Travel Time	Peak Lag (hrs/km)
Lowood to Moggill (68.2km)					
19680107	13/01/1968 21:00	14/01/1968 11:00	4877	14	0.205
19740124	28/01/1974 2:00	28/01/1974 12:00	11664	10	0.147
20110102	12/01/2011 0:00	12/01/2011 16:00	9580	16	0.235
Savages Crossing to Moggill (58.4km)					
19680107	13/01/1968 23:00	14/01/1968 11:00	4877	12	0.205
19740124	28/01/1974 2:00	28/01/1974 12:00	11664	10	0.171
20110102	12/01/2011 2:00	12/01/2011 16:00	9580	14	0.240

Table 9 Lower Brisbane River to Centenary Bridge – Adopted Events and Values

Event	Upstream Peak Time	Downstream Peak Time	Rated Flow at Glenore Grove (m^3/s)	Travel Time	Peak Lag (hrs/km)
Mt Crosby to Centenary Bridge (47.2km)					
19740124	28/01/1974 11:00	28/01/1974 20:00	11672	9	0.191
20110102	12/01/2011 10:00	12/01/2011 19:00	9483	9	0.191
Moggill to Centenary Bridge (28.4km)					
19740124	28/01/1974 12:00	28/01/1974 20:00	11672	8	0.282
20110102	12/01/2011 16:00	12/01/2011 19:00	9484	3	0.106

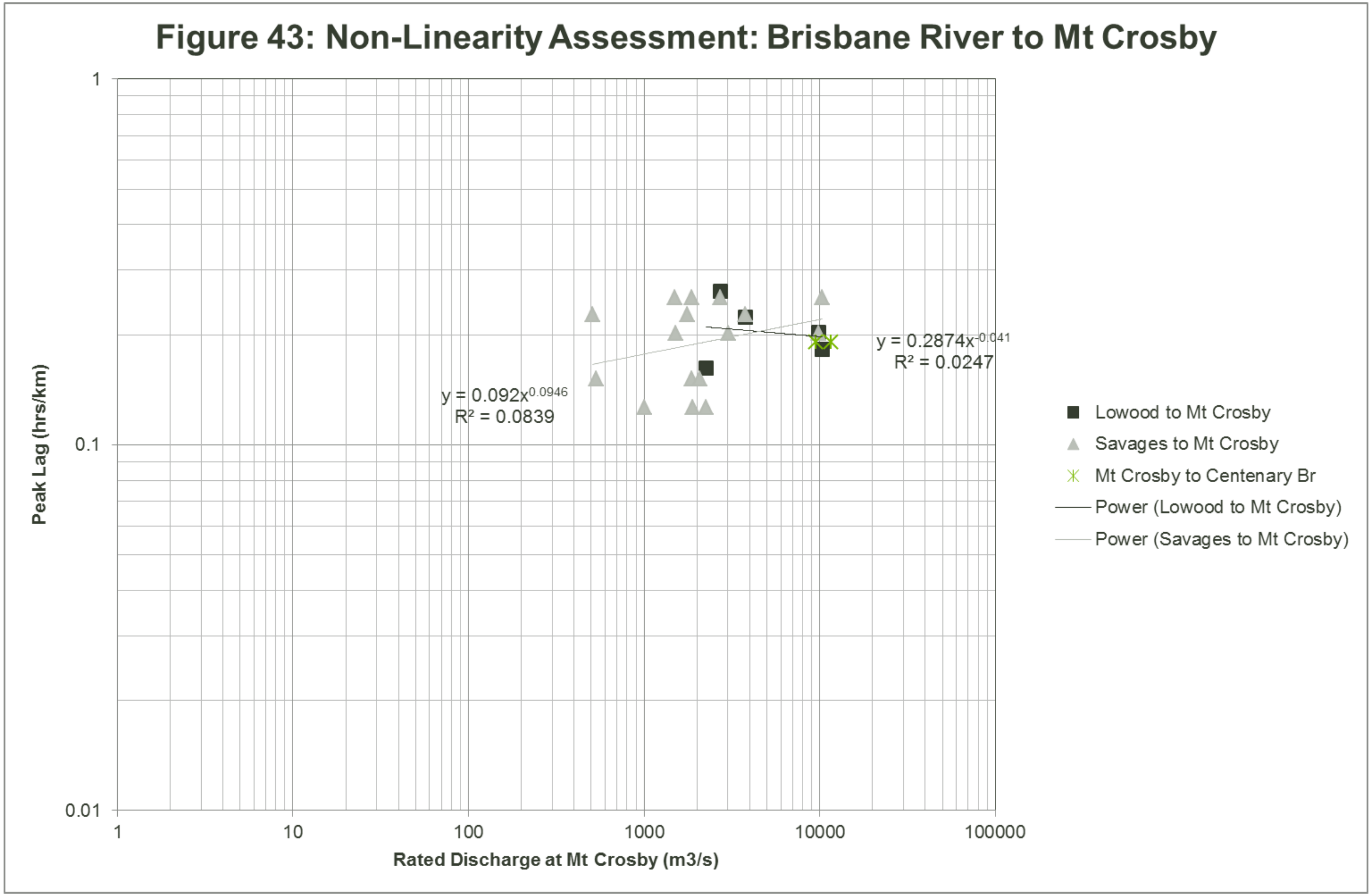


Figure 43: Non-Linearity Assessment: Brisbane River to Mt Crosby
Peak Lag (hrs/km)
1
0.1
0.01
1
10
100
1000
10000
100000
Rated Discharge at Mt Crosby (m3/s)
y = 0.092x^0.0946
R² = 0.0839
y = 0.2874x^-0.041
R² = 0.0247
Lowood to Mt Crosby
Savages to Mt Crosby
Mt Crosby to Centenary Br
Power (Lowood to Mt Crosby)
Power (Savages to Mt Crosby)

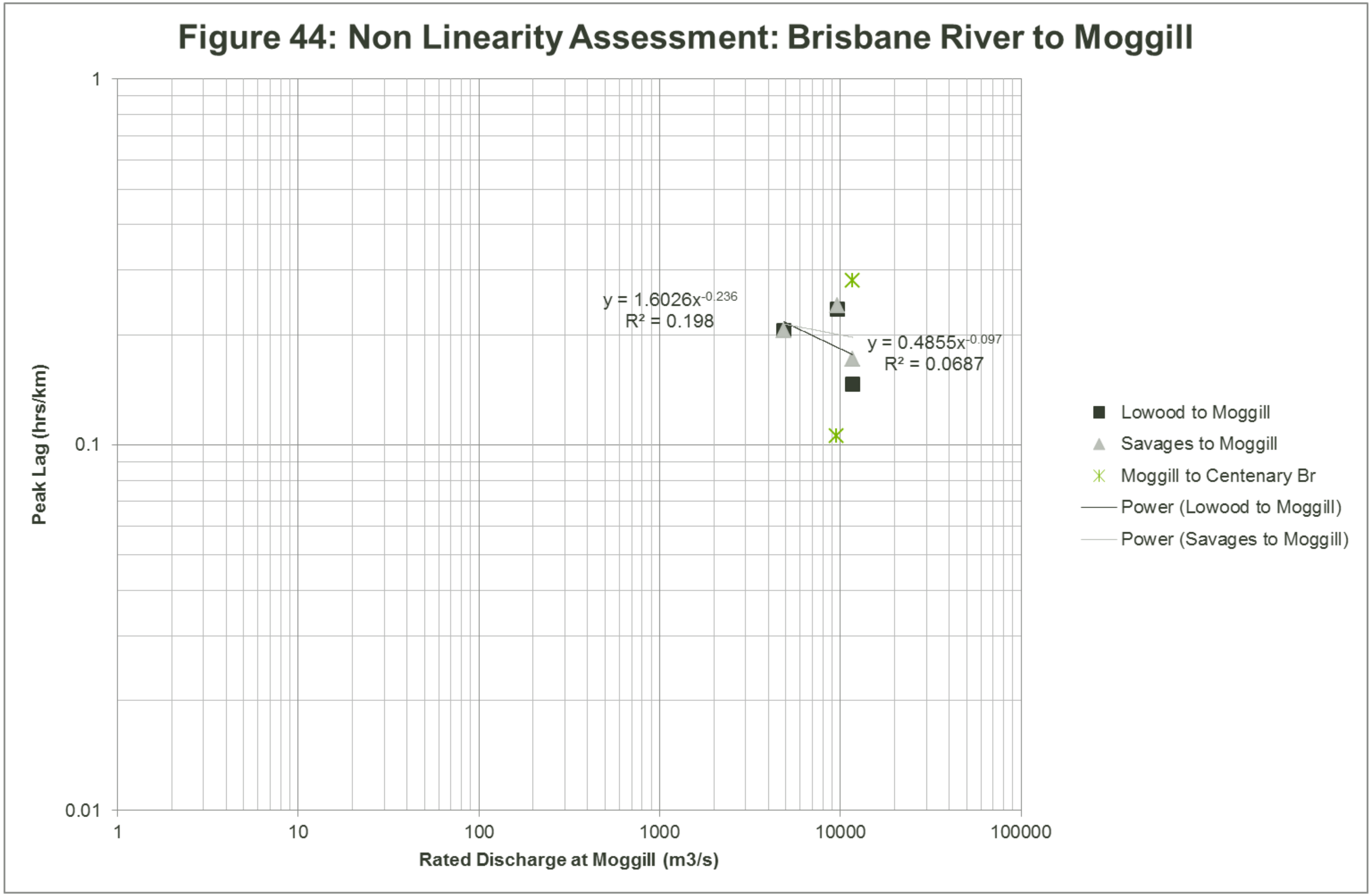


Figure 44: Non Linearity Assessment: Brisbane River to Moggill
Peak Lag (hrs/km)
1
0.1
0.01
1
10
100
1000
10000
100000
Rated Discharge at Moggill (m3/s)
y = 1.6026x-0.236
R² = 0.198
y = 0.4855x-0.097
R² = 0.0687
Lowood to Moggill
Savages to Moggill
Moggill to Centenary Br
Power (Lowood to Moggill)
Power (Savages to Moggill)

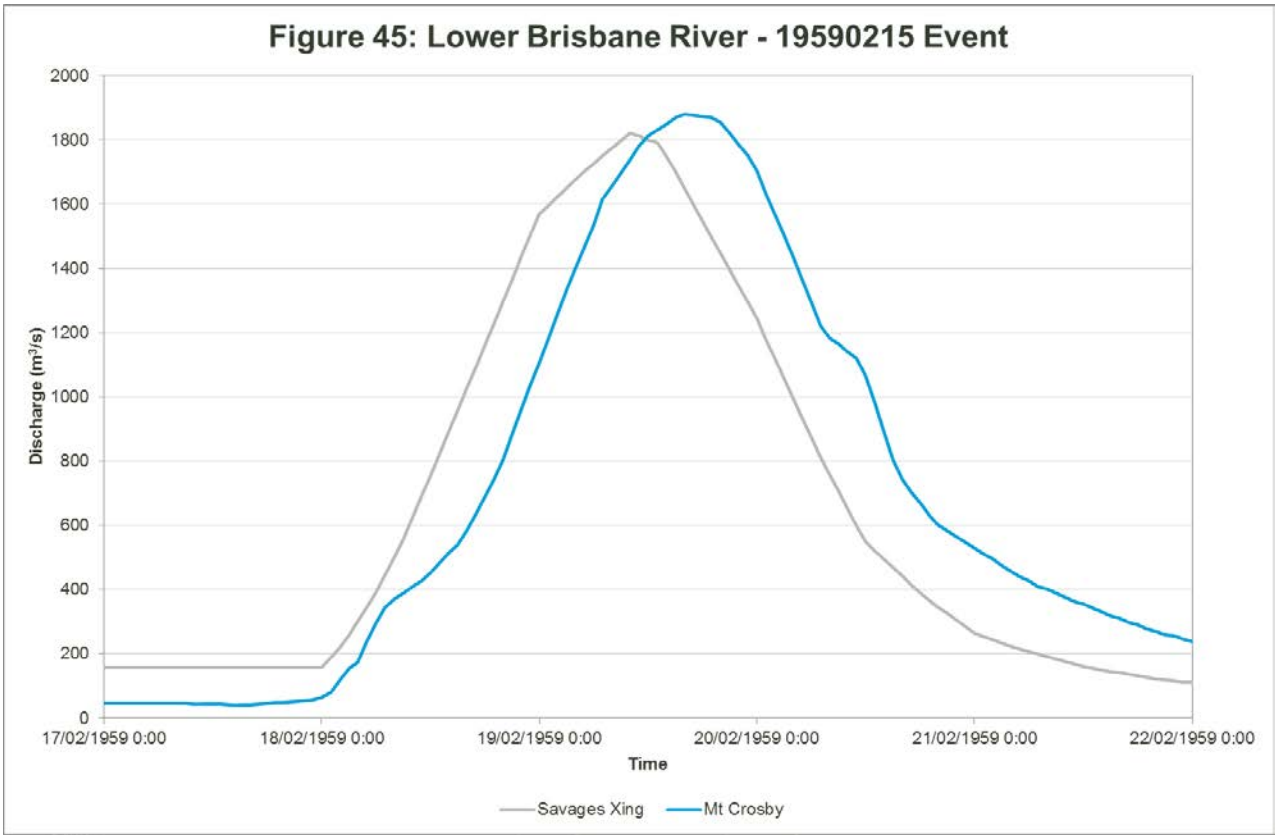


Figure 45: Lower Brisbane River - 19590215 Event
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Discharge (m3/s)
17/02/1959 0:00
18/02/1959 0:00
19/02/1959 0:00
20/02/1959 0:00
21/02/1959 0:00
22/02/1959 0:00
Time
Savages Xing
Mt Crosby

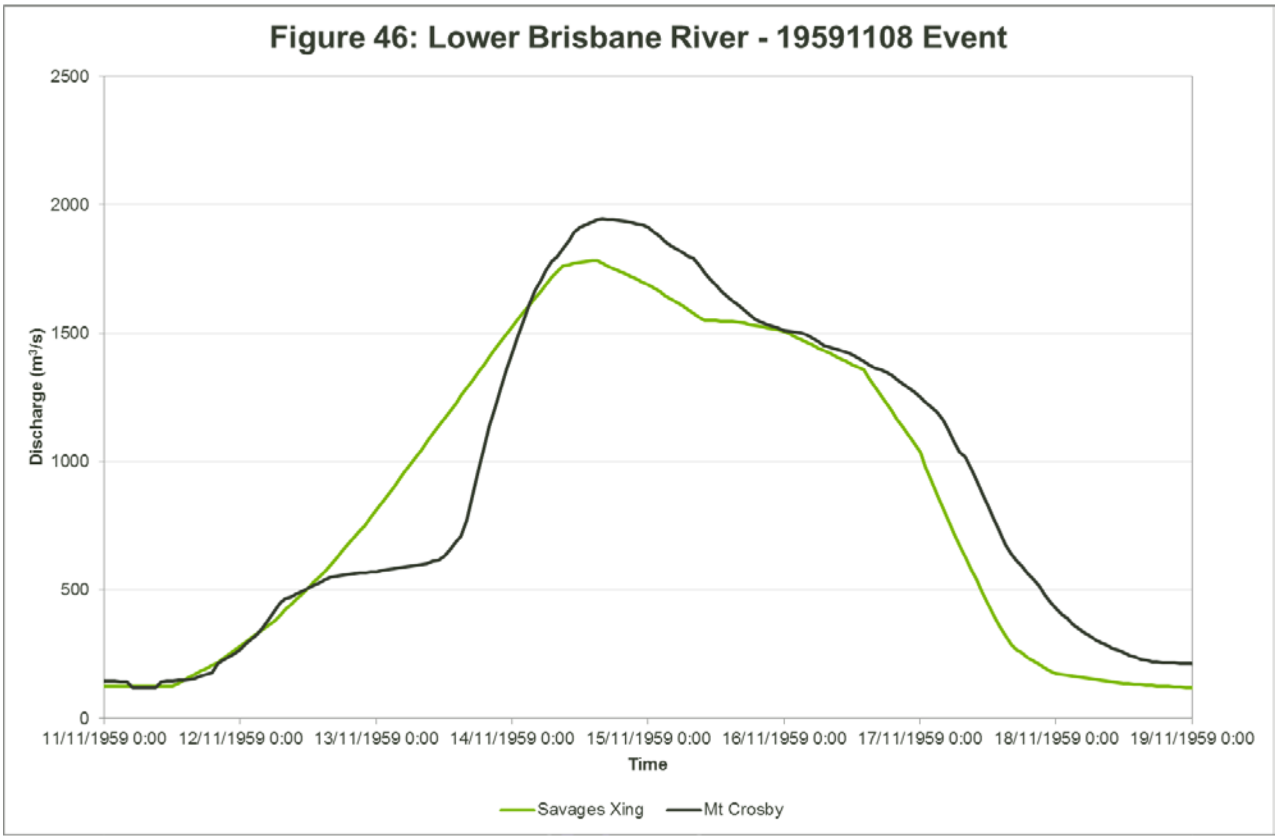


Figure 46: Lower Brisbane River - 19591108 Event
2500
2000
1500
1000
500
0
Discharge (m3/s)
11/11/1959 0:00
12/11/1959 0:00
13/11/1959 0:00
14/11/1959 0:00
15/11/1959 0:00
16/11/1959 0:00
17/11/1959 0:00
18/11/1959 0:00
19/11/1959 0:00
Time
Savages Xing
Mt Crosby

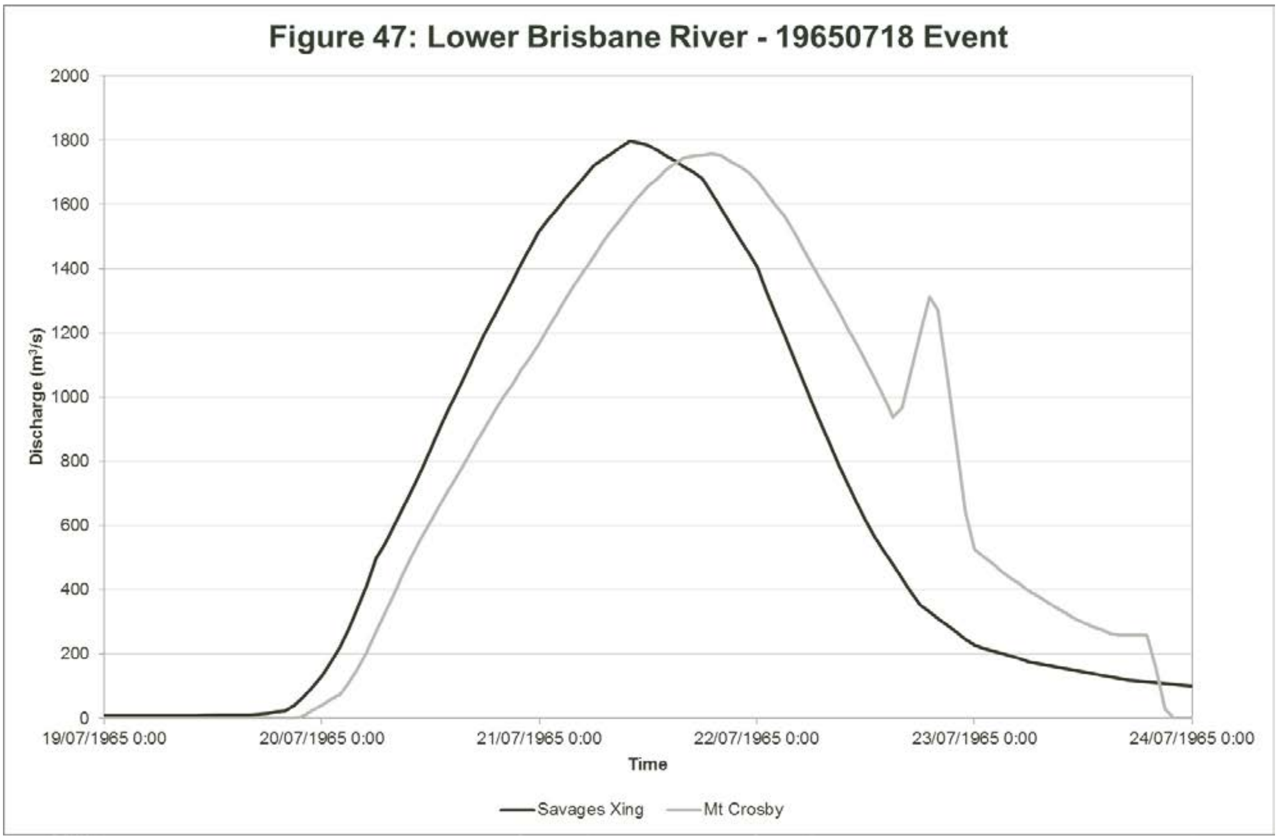


Figure 47: Lower Brisbane River - 19650718 Event
Discharge (m³/s)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
19/07/1965 0:00
20/07/1965 0:00
21/07/1965 0:00
22/07/1965 0:00
23/07/1965 0:00
24/07/1965 0:00
Time
Savages Xing
Mt Crosby

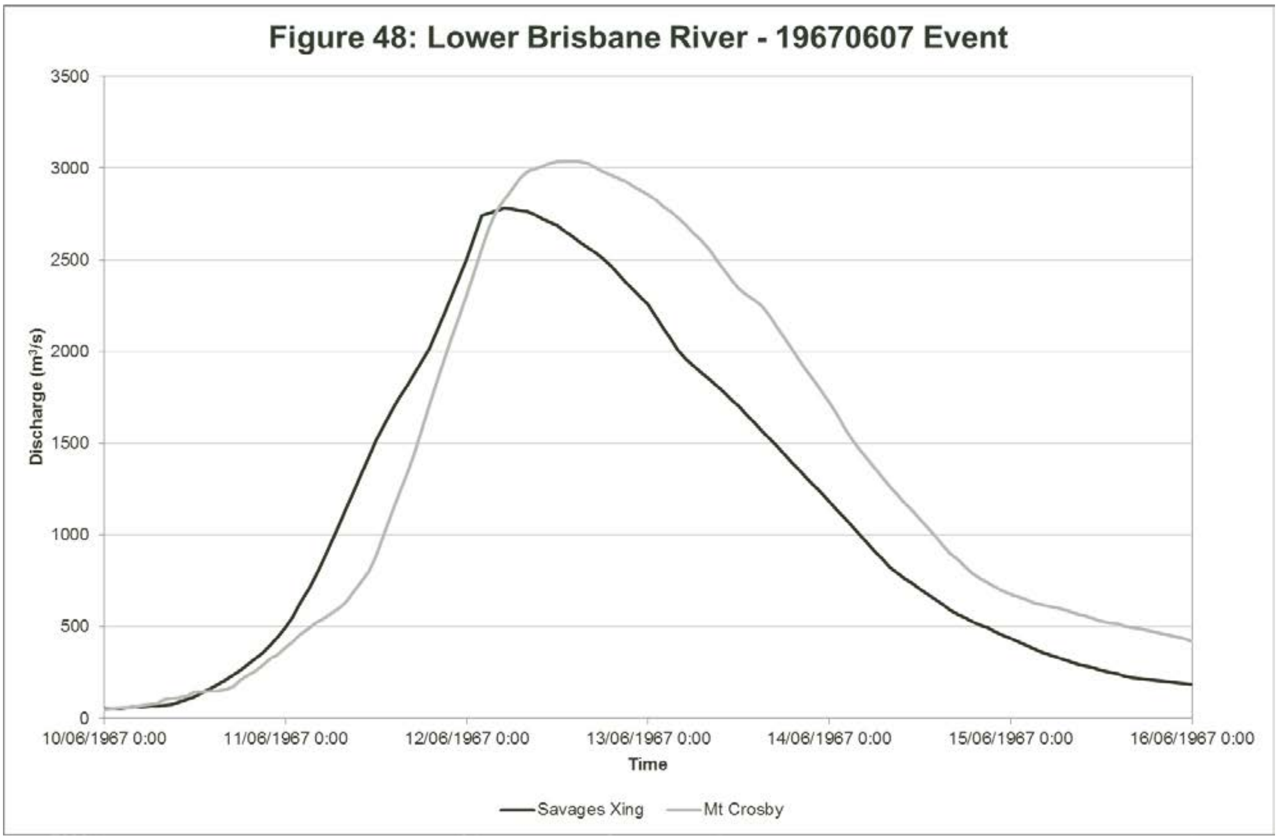


Figure 48: Lower Brisbane River - 19670607 Event
Discharge (m³/s)
3500
3000
2500
2000
1500
1000
500
0
10/06/1967 0:00
11/06/1967 0:00
12/06/1967 0:00
13/06/1967 0:00
14/06/1967 0:00
15/06/1967 0:00
16/06/1967 0:00
Time
Savages Xing
Mt Crosby

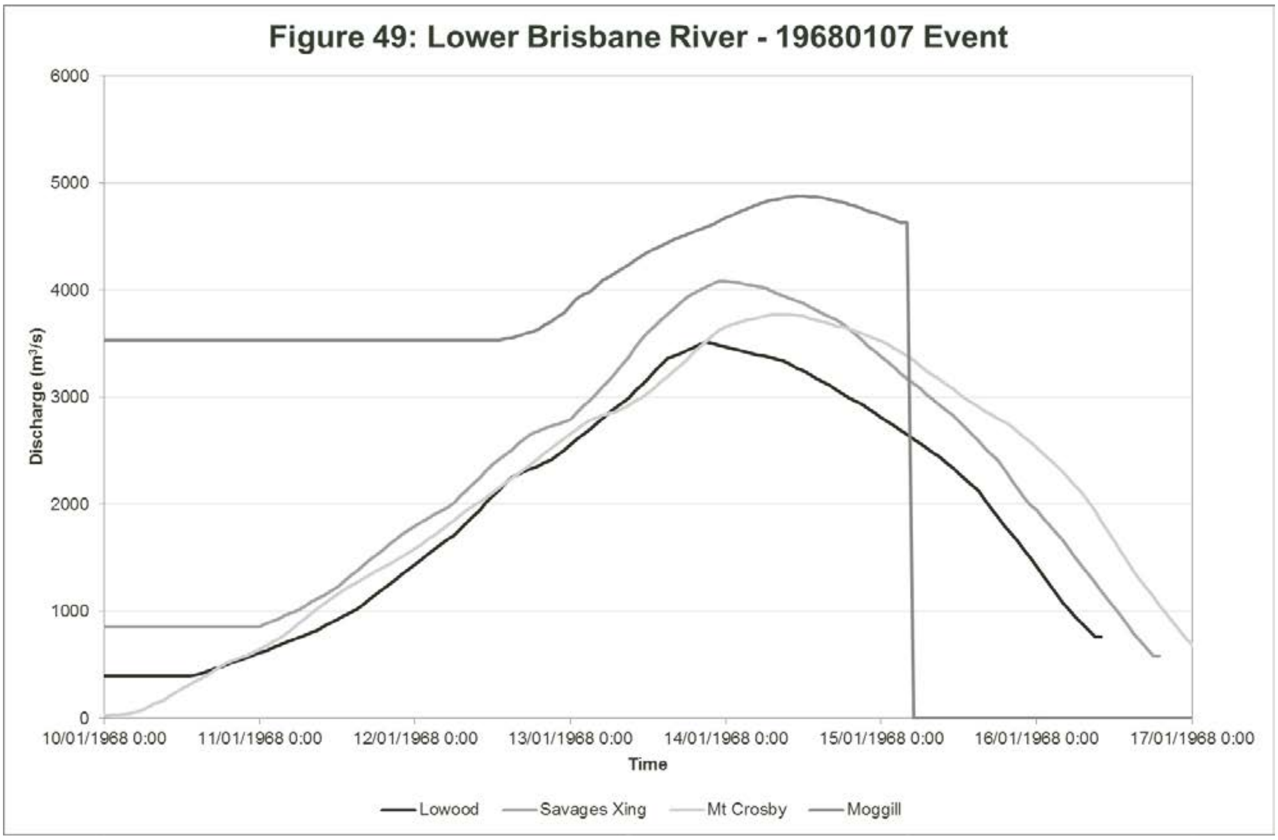


Figure 49: Lower Brisbane River - 19680107 Event
Discharge (m3/s)
6000
5000
4000
3000
2000
1000
0
10/01/1968 0:00
11/01/1968 0:00
12/01/1968 0:00
13/01/1968 0:00
14/01/1968 0:00
15/01/1968 0:00
16/01/1968 0:00
17/01/1968 0:00
Time
Lowood
Savages Xing
Mt Crosby
Moggill

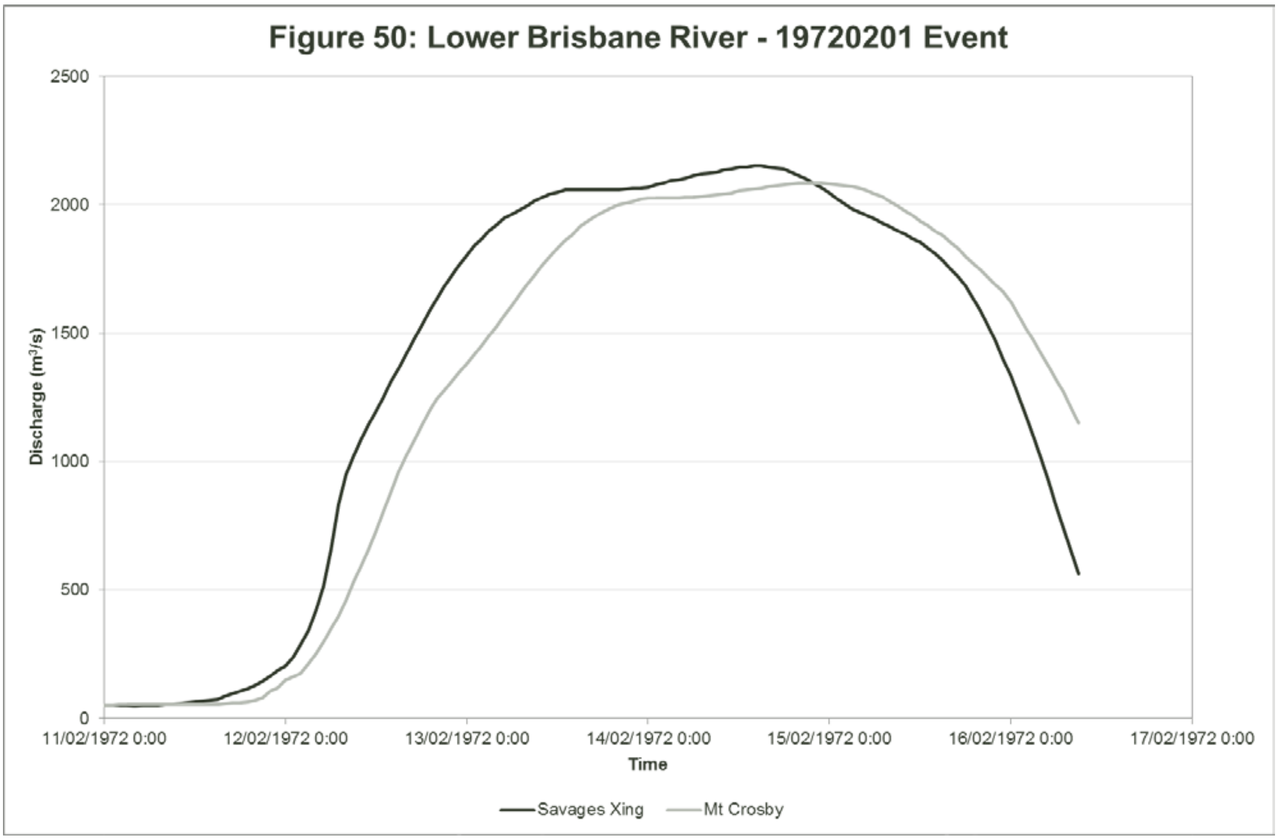


Figure 50: Lower Brisbane River - 19720201 Event
Discharge (m3/s)
2500
2000
1500
1000
500
0
11/02/1972 0:00
12/02/1972 0:00
13/02/1972 0:00
14/02/1972 0:00
15/02/1972 0:00
16/02/1972 0:00
17/02/1972 0:00
Time
Savages Xing
Mt Crosby

Figure 51: Lower Brisbane River - 19730705 Event

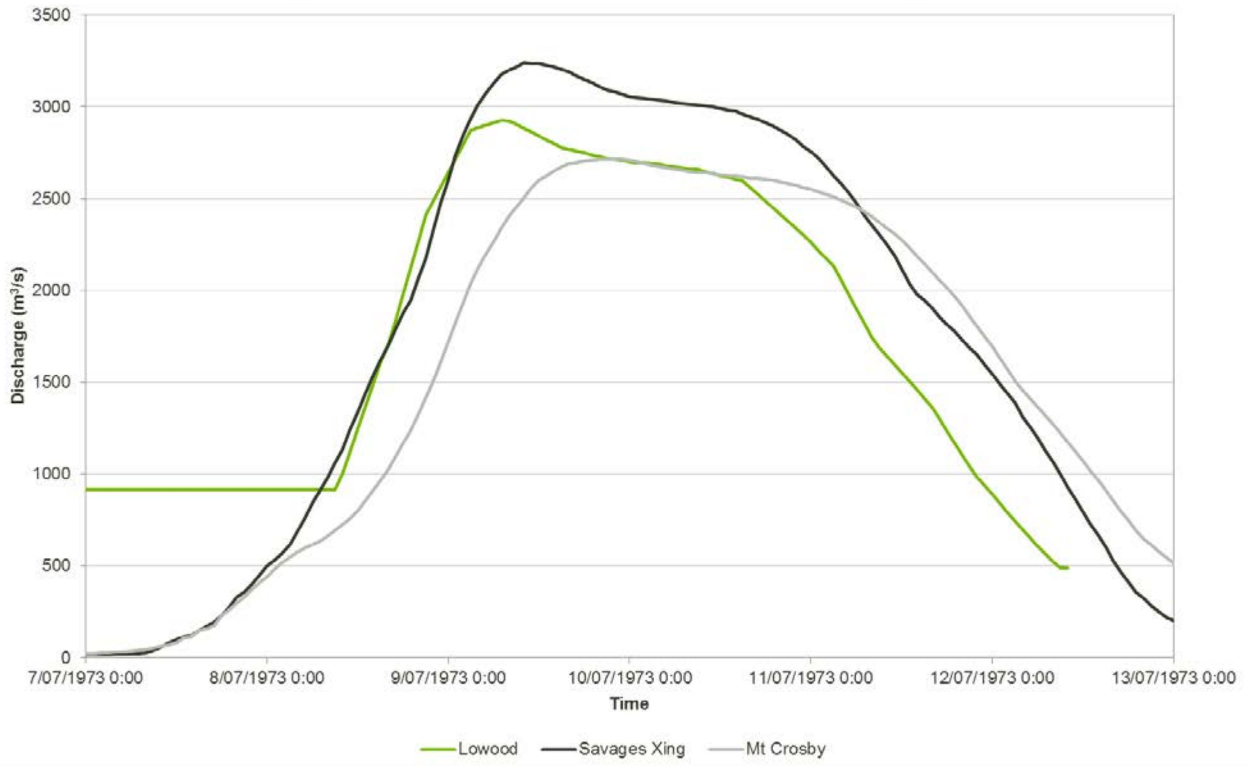
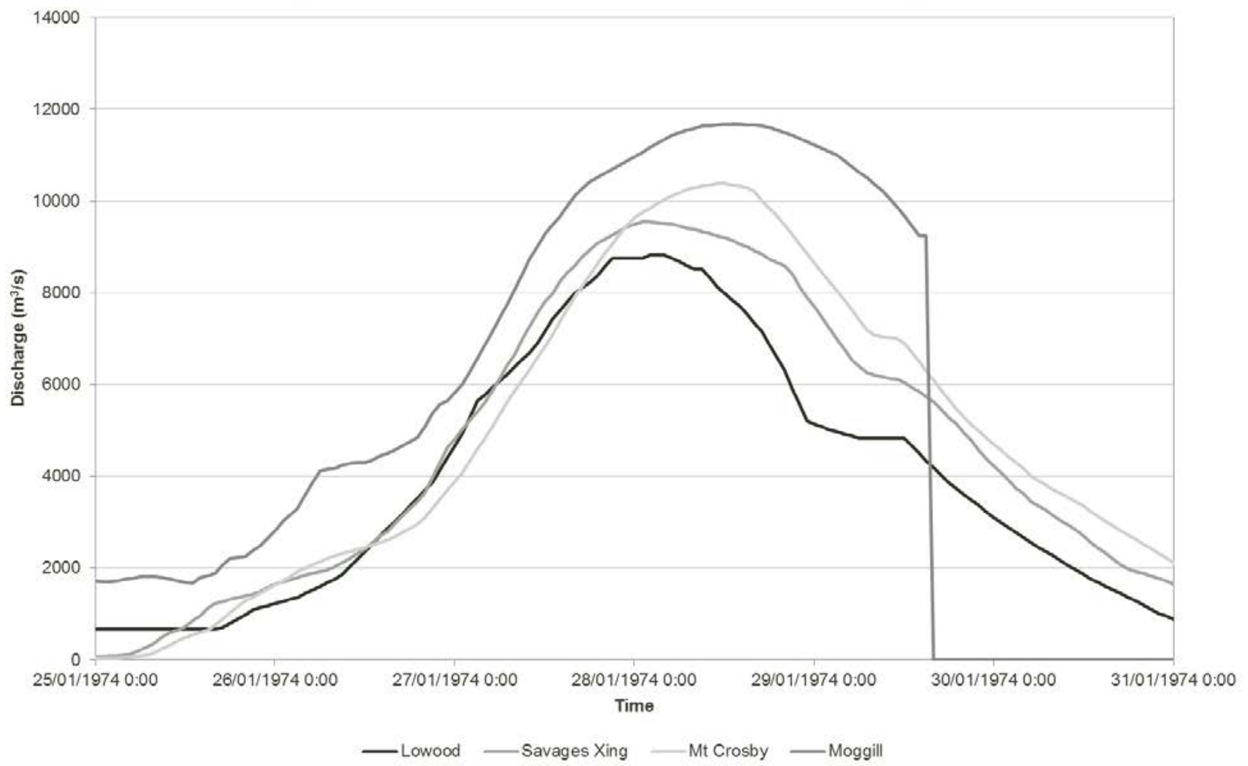


Figure 52: Lower Brisbane River - 19740124 Event



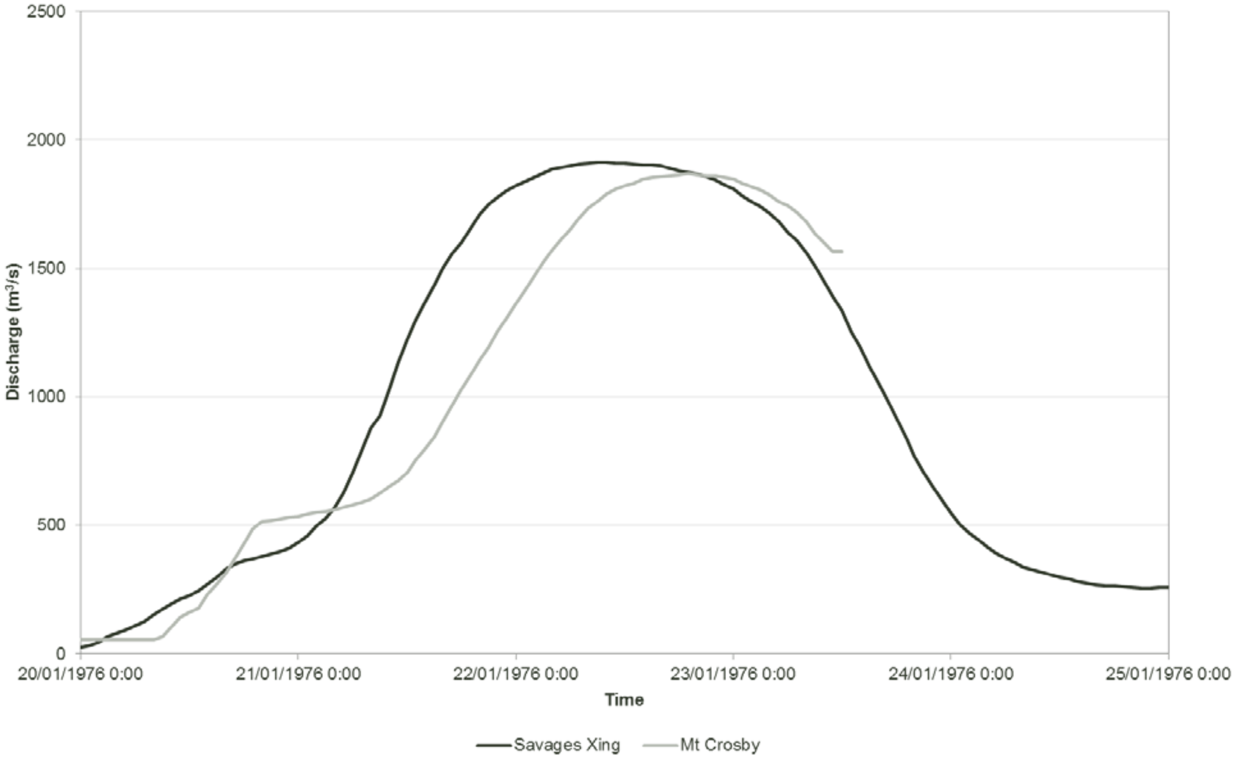


Figure 53: Lower Brisbane River - 19760119 Event

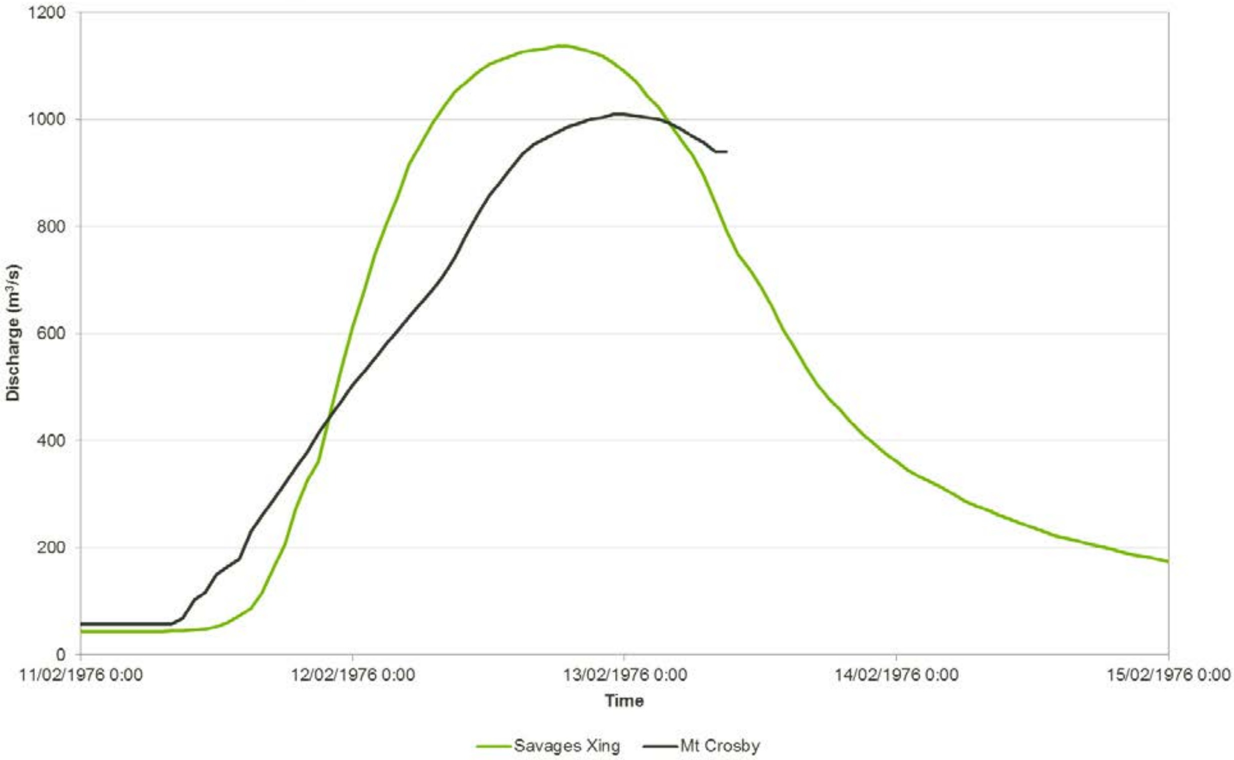


Figure 54: Lower Brisbane River - 19760209 Event

Figure 55: Lower Brisbane River - 19830620 Event

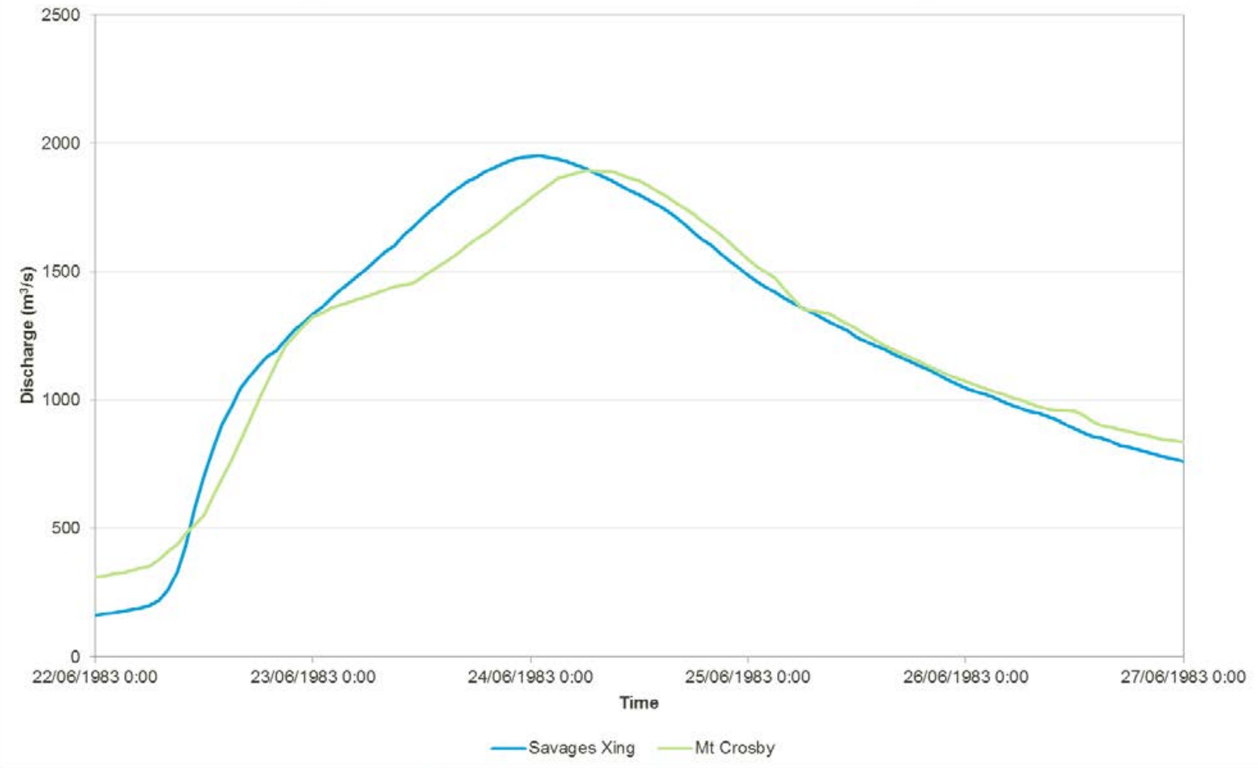
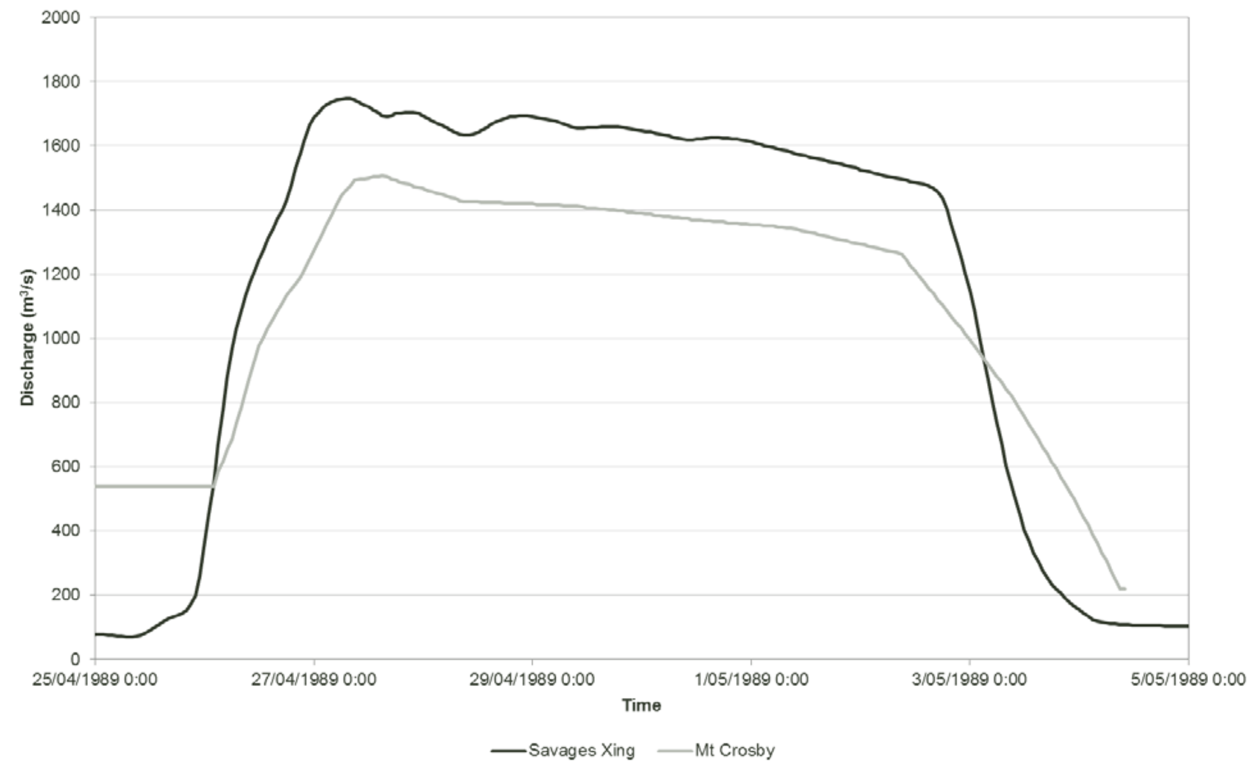


Figure 56: Lower Brisbane River - 19890401 Event



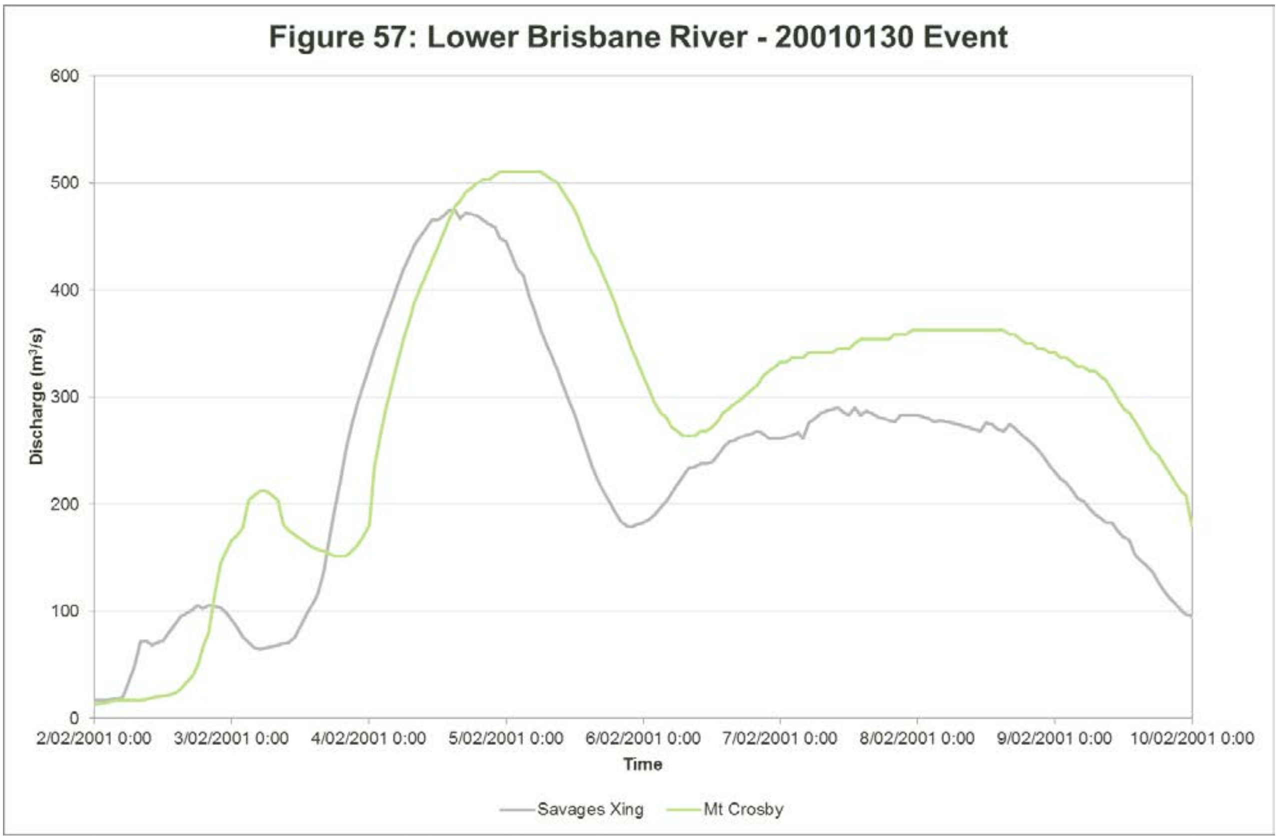


Figure 57: Lower Brisbane River - 20010130 Event
Discharge (m3/s)
600
500
400
300
200
100
0
2/02/2001 0:00
3/02/2001 0:00
4/02/2001 0:00
5/02/2001 0:00
6/02/2001 0:00
7/02/2001 0:00
8/02/2001 0:00
9/02/2001 0:00
10/02/2001 0:00
Time
Savages Xing
Mt Crosby

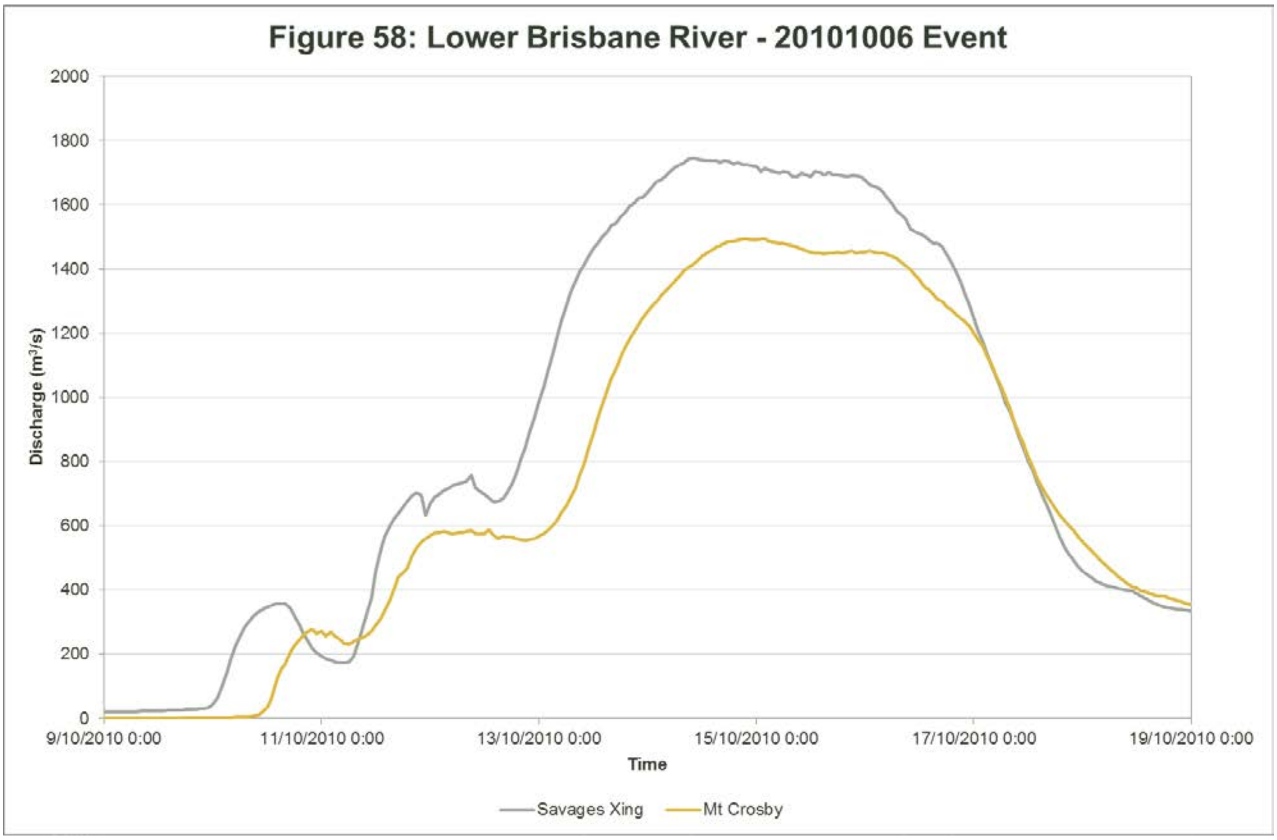


Figure 58: Lower Brisbane River - 20101006 Event
Discharge (m3/s)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
9/10/2010 0:00
11/10/2010 0:00
13/10/2010 0:00
15/10/2010 0:00
17/10/2010 0:00
19/10/2010 0:00
Time
Savages Xing
Mt Crosby

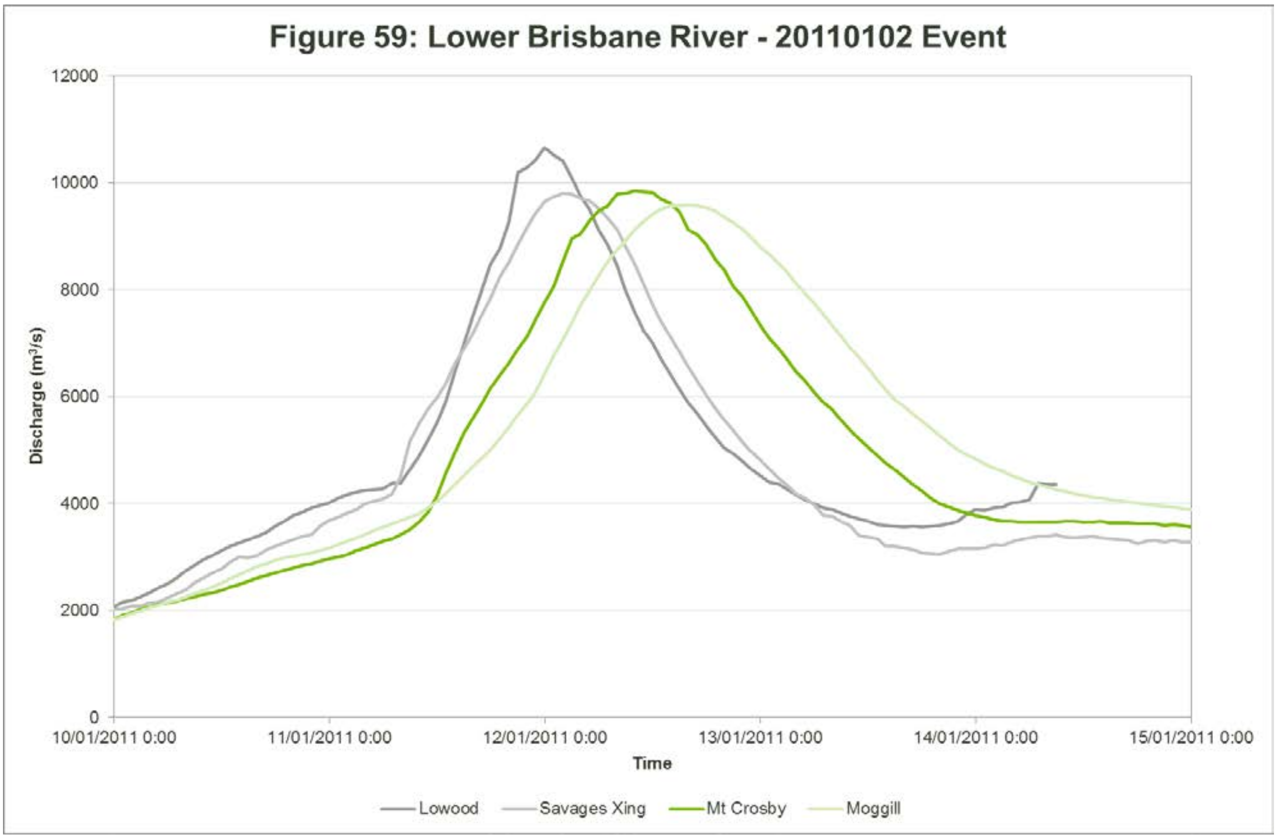


Figure 59: Lower Brisbane River - 20110102 Event
12000
10000
8000
6000
4000
2000
0
Discharge (m³/s)
10/01/2011 0:00
11/01/2011 0:00
12/01/2011 0:00
13/01/2011 0:00
14/01/2011 0:00
15/01/2011 0:00
Time
Lowood
Savages Xing
Mt Crosby
Moggill

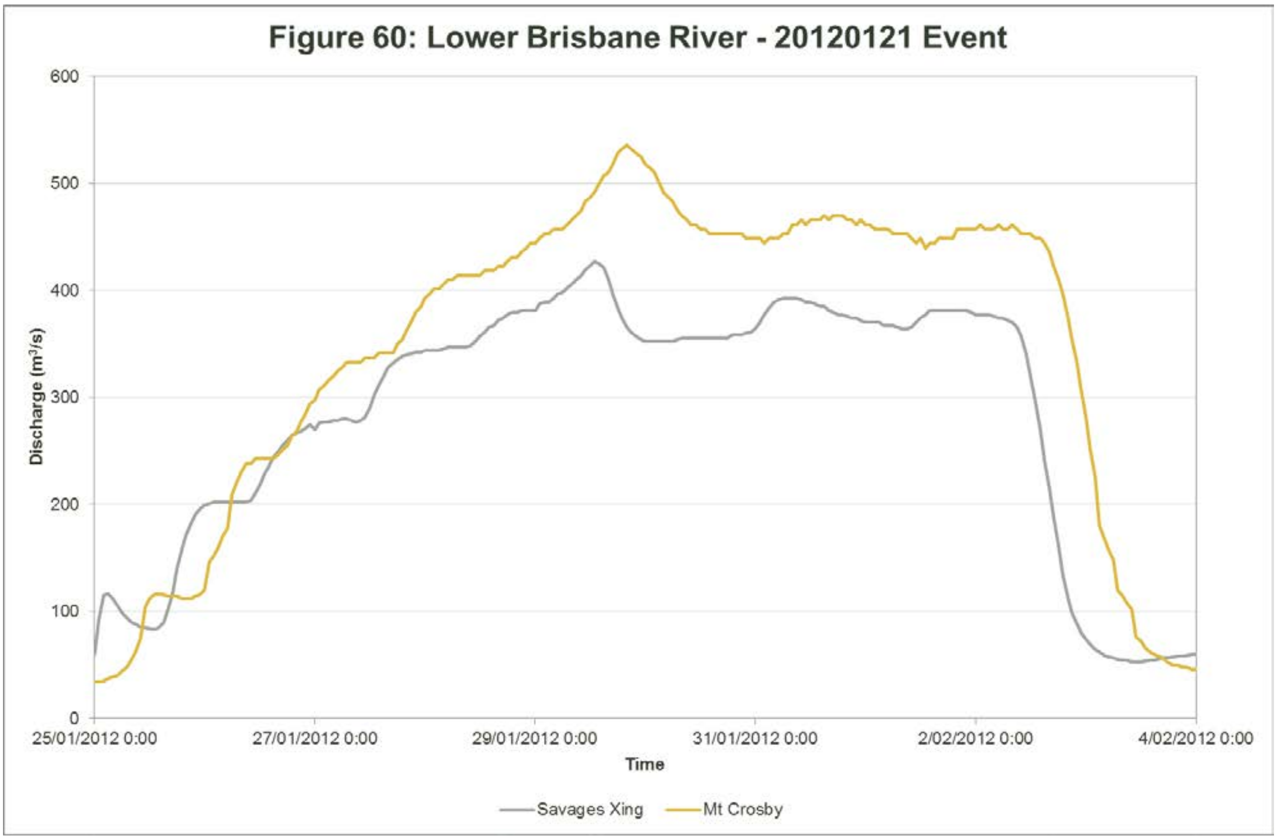


Figure 60: Lower Brisbane River - 20120121 Event
600
500
400
300
200
100
0
Discharge (m³/s)
25/01/2012 0:00
27/01/2012 0:00
29/01/2012 0:00
31/01/2012 0:00
2/02/2012 0:00
4/02/2012 0:00
Time
Savages Xing
Mt Crosby

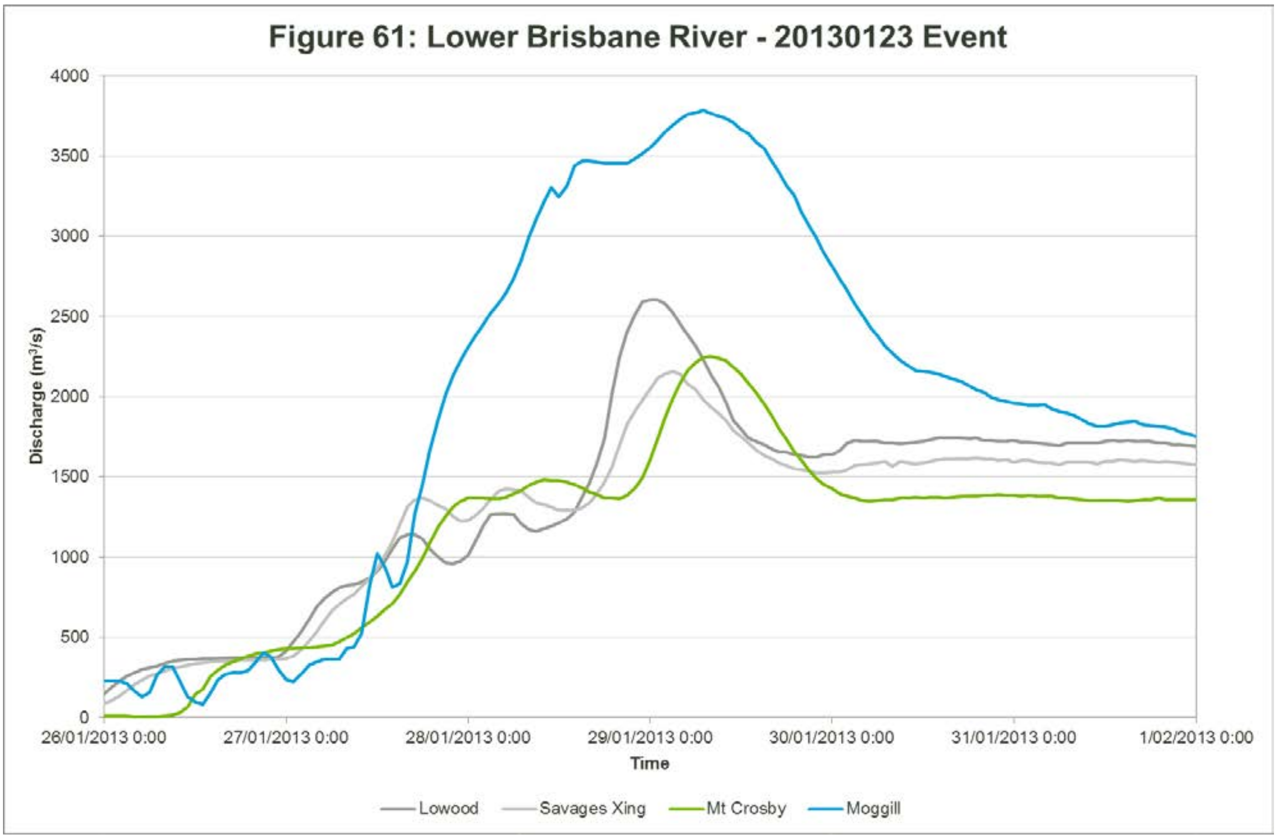


Figure 61: Lower Brisbane River - 20130123 Event
4000
3500
3000
2500
2000
1500
1000
500
0
Discharge (m³/s)
26/01/2013 0:00
27/01/2013 0:00
28/01/2013 0:00
29/01/2013 0:00
30/01/2013 0:00
31/01/2013 0:00
1/02/2013 0:00
Time
Lowood
Savages Xing
Mt Crosby
Moggill

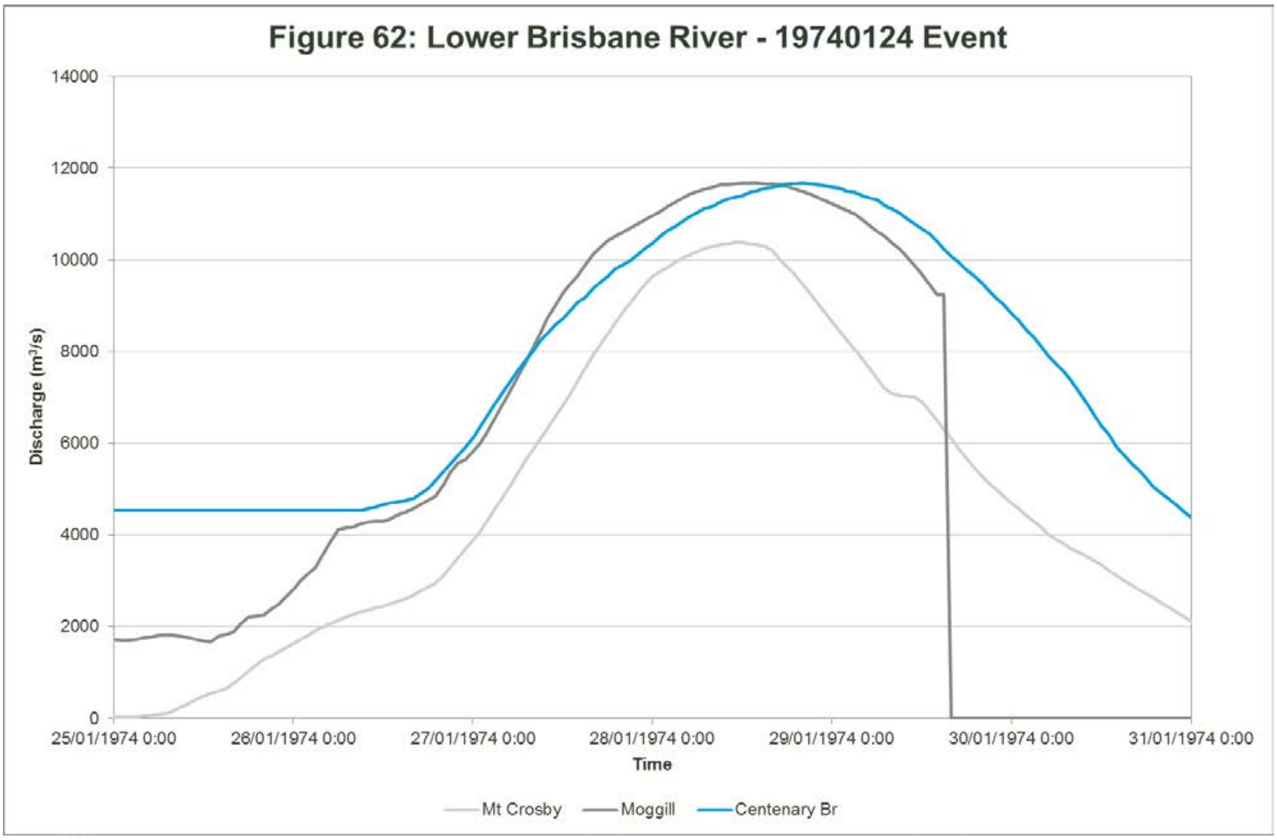
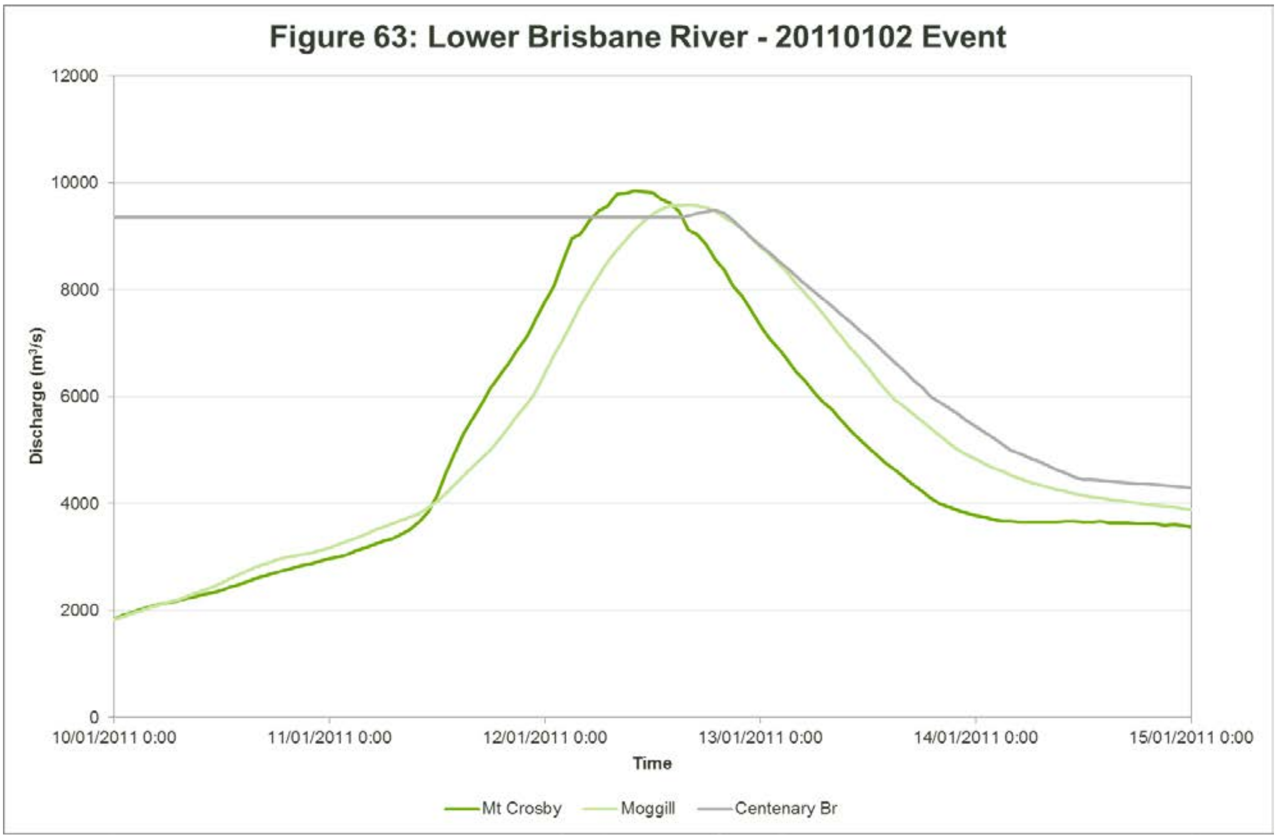


Figure 62: Lower Brisbane River - 19740124 Event
14000
12000
10000
8000
6000
4000
2000
0
Discharge (m³/s)
25/01/1974 0:00
26/01/1974 0:00
27/01/1974 0:00
28/01/1974 0:00
29/01/1974 0:00
30/01/1974 0:00
31/01/1974 0:00
Time
Mt Crosby
Moggill
Centenary Br



URBS Test

Further to the assessment of actual data, an assessment of the impacts of non-linearity parameters on the URBS model predictions was carried out. This process included the following steps:

- Modify n to 0.8 for each catchment (except Warrill Creek)
- Recalibrate the 1974 event in each catchment to obtain similar results to the models using the recommended parameters by modifying the alpha and beta values
- Run the model with double the 1974 event flows using n = 1 and the recommended parameters
- Run the model with double the 1974 event flows using n = 0.8 and the revised parameters

Table 10 Non-Linearity Assessment: Adopted Model Parameters

Catchment	Recommended Alpha	Recommended Beta	Revised Alpha	Revised Beta
Stanley	0.16	4.3	1.5	2.7
Upper Brisbane	0.13	2.8	1.5	2.7
Lockyer	0.30	3.0	1.6	3.3
Bremer	0.35	3.0	0.6	4.1
Purga	0.40	3.4	0.7	2.4
Lower Brisbane	0.15	3.0	1.0	2.0

Figures 64 to 87 present the results of this assessment. The Lower Brisbane River results have been included although the results are unstable as a result of the conceptual storages in this model.

Table 11 Peak Flow, Volume and Peak Level for 1974 Event, with n = 0.8 and Recalibration of Parameters

Catchment	Gauge	Recommended Parameters			With n = 0.8						With n = 0.8 and alpha and beta recalibrated					
		Peak Flow (m^3/s)	Volume (ML)	Peak Level (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)
Stanley	Peachester	336	60947	8.49	364	8.15%	60997	0.08%	8.6	0.11	335	-0.48%	60947	0.00%	8.49	0
	Woodford	654	145591	8.49	689	5.24%	145769	0.12%	8.64	0.15	649	-0.86%	145586	0.00%	8.46	-0.03
	Mt Kilcoy	270	35183	6.21	286	6.03%	35208	0.07%	6.28	0.07	272	0.76%	35144	-0.11%	6.22	0.01
	SD Inflow	3496	611462	-	3745	7.13%	612407	0.15%	-	-	3545	1.42%	611536	0.01%	-	-
Upper	Cooyar Ck	1120	162118	9.21	1249	11.56%	162282	0.10%	9.72	0.51	1086	-3.02%	162483	0.23%	9.08	-0.13
	Linville	2565	300068	8.87	2866	11.74%	300455	0.13%	9.28	0.41	2516	-1.90%	300551	0.16%	8.80	-0.07
	Devon Hills	2752	356165	10.04	3225	17.18%	356672	0.14%	10.71	0.67	2696	-2.06%	356638	0.13%	9.96	-0.08
	Boat Mt	1406	190310	9.52	1483	5.45%	190578	0.14%	9.74	0.22	1407	0.02%	190786	0.25%	9.52	0
	Gregor Ck	5284	760100	13.58	6199	17.31%	761341	0.16%	14.53	0.95	5214	-1.34%	761467	0.18%	13.51	-0.07
	Perserverance	5275	718366	-	6246	18.41%	718545	0.02%	-	-	5219	-1.06%	720089	0.24%	-	-
	Dam Site	179	25752	447.57	179	0.02%	25755	0.01%	447.57	0	186	3.72%	25793	0.16%	447.61	0.04
	Cressbrook	509	62174	285.26	521	2.30%	62182	0.01%	285.33	0.07	520	2.12%	62279	0.17%	285.33	0.07
	Rosentretters	753	89307	-	785	4.22%	89323	0.02%	-	-	761	1.07%	89505	0.22%	-	-
	SD Outflow	864	113475	7.60	907	4.99%	113573	0.09%	7.72	0.12	869	0.57%	113646	0.15%	7.61	0.01
	Caboonbah	6380	870362	17.12	7596	19.07%	870567	0.02%	18.28	1.16	6339	-0.63%	872329	0.23%	17.08	-0.04
	Middle Ck	991	238216	-	991	0.00%	238216	0.00%	-	-	991	0.00%	238216	0.00%	-	-
	WD Inflow	7142	1311191	16.67	9021	26.32%	1313827	0.20%	18.3	1.63	7260	1.66%	1312087	0.07%	16.78	0.11
	Cooyar Ck	7937	1455460	24.01	10498	32.26%	1459258	0.26%	27.65	3.64	8119	2.29%	1455823	0.02%	24.28	0.27
	Linville	8344	1609470	-	11228	34.56%	1615053	0.35%	-	-	8584	2.87%	1608625	-0.05%	-	-
Lockyer	Helidon	645	51007	6.68	692	7.28%	51013	0.01%	6.88	0.2	638	-1.16%	51100	0.18%	6.65	-0.03
	Brown Zirbels	262	17543	7.61	275	4.87%	17546	0.02%	7.73	0.12	258	-1.60%	17592	0.28%	7.58	-0.03
	Harms	442	36615	6.29	484	9.54%	36621	0.02%	6.49	0.2	428	-3.29%	36721	0.29%	6.22	-0.07
	Sandy Ck Rd	80	6564	4.78	83	3.98%	6565	0.02%	4.86	0.08	77	-4.34%	6579	0.23%	4.70	-0.08
	Grantham	1424	125971	-	1703	19.58%	125994	0.02%	-	-	1428	0.29%	126298	0.26%	-	-
	Tenthill	895	95132	8.48	948	5.96%	95140	0.01%	8.68	0.2	880	-1.67%	95262	0.14%	8.43	-0.05
	US Gatton	2331	237867	16.09	2809	20.51%	237900	0.01%	17.41	1.32	2304	-1.14%	238286	0.18%	16.01	-0.08
	Gatton	2331	237867	15.07	2809	20.51%	237900	0.01%	16.2	1.13	2304	-1.14%	238286	0.18%	15.00	-0.07
	Mulgowie	532	59733	9.08	553	3.87%	59739	0.01%	9.09	0.01	532	-0.07%	59811	0.13%	9.08	0
	Laidley	676	79073	14.08	720	6.51%	79082	0.01%	14.62	0.54	666	-1.53%	79200	0.16%	13.96	-0.12
	Showground	692	81323	9.88	739	6.84%	81332	0.01%	10.07	0.19	679	-1.87%	81452	0.16%	9.83	-0.05
	Forest Hill	226	26145	3.75	249	10.00%	26152	0.03%	3.8	0.05	205	-9.54%	26255	0.42%	3.71	-0.04
	Warrego Hwy	1123	138417	7.67	1278	13.78%	138441	0.02%	7.83	0.16	1088	-3.12%	138779	0.26%	7.64	-0.03
	Glenore Grove	3221	396845	14.89	4223	31.08%	396918	0.02%	15.37	0.48	3255	1.04%	397417	0.14%	14.91	0.02
	Lyons Br	3345	449740	16.84	4697	40.40%	449920	0.04%	17.38	0.54	3430	2.54%	449967	0.05%	16.87	0.03
	Rifle Range Rd	3355	470197	16.59	4835	44.12%	470418	0.05%	16.96	0.37	3473	3.53%	470172	-0.01%	16.62	0.03
	Buraba Ck	680	85236	-	891	31.08%	85289	0.06%	-	-	580	-14.60%	85657	0.49%	-	-
	O'Reillys Weir	3667	566551	18.04	5634	53.64%	567016	0.08%	20.81	2.77	3828	4.39%	565658	-0.16%	18.28	0.24
Bremer	Adams Br	405	47142	5.36	412	1.80%	47157	0.03%	5.39	0.03	416	2.68%	47173	0.07%	5.41	0.05
	Stokes Xing	565	67804	6.55	581	2.72%	67857	0.08%	6.63	0.08	574	1.51%	67881	0.11%	6.59	0.04
	Spressers Br	820	106807	7.40	939	14.45%	106974	0.16%	7.64	0.24	829	1.03%	106926	0.11%	7.42	0.02
	Grandchester	154	18139	4.89	158	2.35%	18144	0.03%	4.91	0.02	157	1.83%	18163	0.13%	4.91	0.02
	Kuss Rd	658	83594	7.95	727	10.48%	83680	0.10%	8.03	0.08	652	-0.92%	83744	0.18%	7.94	-0.01
	WWTP	760	98988	8.26	886	16.54%	99119	0.13%	8.39	0.13	742	-2.34%	99140	0.15%	8.24	-0.02

Catchment	Gauge	Recommended Parameters			With n = 0.8						With n = 0.8 and alpha and beta recalibrated					
	Rosewood	1637	216364	7.30	1931	17.97%	216713	0.16%	7.63	0.33	1631	-0.34%	216639	0.13%	7.29	-0.01
	Five Ml Br	1712	237620	9.22	2173	26.97%	238203	0.25%	10.15	0.93	1708	-0.18%	237650	0.01%	9.22	0
	Walloon	1744	249761	10.91	2314	32.66%	250534	0.31%	11.57	0.66	1742	-0.12%	249516	-0.10%	10.90	-0.01
Warrill	MD Inflow	627	62990	-	627	0.00%	62990	0.00%	-	-	627	0.00%	62990	0.00%	-	-
	Moogerah Dam	329	59738	158.34	329	0.00%	59738	0.00%	158.34	0	329	0.00%	59738	0.00%	158.34	0
	Toohills Xing	350	42751	6.14	350	0.00%	42751	0.00%	6.14	0	350	0.00%	42751	0.00%	6.14	0
	Junction Weir	847	151923	80.60	847	0.00%	151923	0.00%	80.6	0	847	0.00%	151923	0.00%	80.60	0
	Kalbar	808	124062	13.96	808	0.00%	124062	0.00%	13.96	0	808	0.00%	124062	0.00%	13.96	0
	Kalbar 2B	808	124062	13.96	808	0.00%	124062	0.00%	13.96	0	808	0.00%	124062	0.00%	13.96	0
	Harrisville	921	167767	6.07	921	0.00%	167767	0.00%	6.07	0	921	0.00%	167767	0.00%	6.07	0
	Churchbank	1512	246797	42.60	1512	0.00%	246797	0.00%	42.6	0	1512	0.00%	246797	0.00%	42.60	0
	Greens Rd	1667	288376	10.72	1667	0.00%	288376	0.00%	10.72	0	1667	0.00%	288376	0.00%	10.72	0
	Amberley	1688	293045	10.88	1688	0.00%	293045	0.00%	10.88	0	1688	0.00%	293045	0.00%	10.88	0
Purga	Peak Xing	520	50346	7.15	518	-0.40%	50400	0.11%	7.13	-0.02	518	-0.44%	50346	0.00%	7.13	-0.02
	Loamside	693	70245	9.10	757	9.25%	70390	0.21%	9.25	0.15	693	-0.04%	69991	-0.36%	9.10	0
Lower	WD Outflow	8344	1545346	-	11228	34.56%	1559981	0.95%	-	-	8584	2.87%	1539386	-0.39%	-	-
	O'Reillys Weir	3667	566551	18.04	5634	53.64%	567016	0.08%	20.81	2.77	3828	4.39%	565658	-0.16%	18.28	0.24
	Lowood	10189	2125268	23.13	11985	17.62%	2141188	0.75%	24.32	1.19	10141	-0.47%	2116889	-0.39%	23.09	-0.04
	Savages Xing	10218	2187458	24.54	12148	18.88%	2204613	0.78%	26.58	2.04	10172	-0.45%	2177362	-0.46%	24.49	-0.05
	Burtons Br	10223	2249409	19.50	12239	19.72%	2267825	0.82%	21.36	1.86	10177	-0.45%	2236733	-0.56%	19.46	-0.04
	Lake Manchester	10239	2324240	21.94	12413	21.23%	2344476	0.87%	25.65	3.71	10198	-0.39%	2306470	-0.76%	21.87	-0.07
	Kholo Br	10236	2329070	26.55	12414	21.28%	2349978	0.90%	28.81	2.26	10196	-0.40%	2308865	-0.87%	26.50	-0.05
	Mt Crosby Weir	10235	2330570	25.88	12421	21.36%	2351780	0.91%	28.48	2.60	10195	-0.39%	2309174	-0.92%	25.83	-0.05
	Colleges Xing	1744	249761	10.91	2314	32.66%	250534	0.31%	11.57	0.66	1742	-0.12%	249516	-0.10%	10.90	-0.01
	Walloon	1754	255459	25.40	2380	35.67%	256283	0.32%	27.56	2.16	1750	-0.22%	254976	-0.19%	25.39	-0.01
	Three Ml Br	1688	293045	10.88	1688	0.00%	293045	0.00%	10.88	0.00	1688	0.00%	293045	0.00%	10.88	0
	Amberley	693	70245	9.10	757	9.25%	70390	0.21%	9.25	0.15	693	-0.04%	69991	-0.36%	9.10	0
	Loamside	3628	623118	25.79	3762	3.70%	624400	0.21%	26.09	0.30	3633	0.14%	621896	-0.20%	25.80	0.01
	Berrys Lagoon	3633	625829	24.84	3774	3.88%	627290	0.23%	25.24	0.40	3636	0.10%	624225	-0.26%	24.85	0.01
	One Ml Br	3672	641816	23.48	3844	4.68%	643326	0.24%	24.01	0.53	3666	-0.16%	640150	-0.26%	23.47	-0.01
	Hancocks Br	3677	645201	21.34	3855	4.85%	646910	0.26%	25.73	4.39	3672	-0.12%	643116	-0.32%	21.44	0.1
	Ipswich	11524	3064791	19.78	14745	27.95%	3089608	0.81%	23.18	3.40	11705	1.57%	3033441	-1.02%	19.98	0.2
	Moggill	11526	3124368	18.86	14822	28.59%	3150349	0.83%	21.8	2.94	11707	1.57%	3090469	-1.08%	19.03	0.17
	Goodna	11379	3167487	14.73	14483	27.28%	3195324	0.88%	17.63	2.90	11519	1.23%	3128041	-1.25%	14.87	0.14
	Jindalee	11380	3215344	13.83	14518	27.57%	3243701	0.88%	16.66	2.83	11519	1.22%	3174900	-1.26%	13.96	0.13
	Centenary Br	11353	3362781	5.39	14560	28.25%	3396959	1.02%	6.72	1.33	11496	1.26%	3309368	-1.59%	5.44	0.05
	Brisbane	-	-	2.36	-	-	-	-	2.36	0.00	-	-	-	-	2.36	0

Table 12 Peak Flow, Volume and Peak Level for Double 1974 Event, with n = 0.8 and Recalibration of Parameters

Catchment	Gauge	1974 Event with Recommended Parameters			Double 1974 Flows With n = 0.8						Double 1974 Flows With n = 0.8 and alpha and beta recalibrated					
		Peak Flow (m^3/s)	Volume (ML)	Peak Level (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)
Stanley	Peachester	336	60947	8.49	773	129.87%	140239	130.10%	9.87	1.38	789	134.60%	140261	130.14%	9.91	1.42
	Woodford	654	145591	8.49	1377	110.35%	331637	127.79%	11.41	2.92	1384	111.41%	331637	127.79%	11.44	2.95
	Mt Kilcoy	270	35183	6.21	650	140.61%	87645	149.11%	7.47	1.26	667	146.91%	87583	148.94%	7.52	1.31
	SD Inflow	3496	611462	-	8081	131.19%	1363599	123.01%	-	-	8345	138.73%	1363912	123.06%	-	-
Upper	Cooyar Ck	1120	162118	9.21	2642	135.92%	422912	160.87%	14.13	4.92	2680	139.37%	423667	161.33%	14.23	5.02
	Linville	2565	300068	8.87	6066	136.48%	796563	165.46%	12.61	3.74	6227	142.74%	797878	165.90%	12.75	3.88
	Devon Hills	2752	356165	10.04	6497	136.03%	931517	161.54%	14.21	4.17	6688	142.96%	932830	161.91%	14.38	4.34
	Boat Mt	1406	190310	9.52	3233	129.90%	472979	148.53%	13.63	4.11	3341	137.58%	473722	148.92%	13.85	4.33
	Gregor Ck	5284	760100	13.58	12205	130.96%	1918821	152.44%	19.44	5.86	12684	140.02%	1921824	152.84%	19.77	6.19
	Fulham Vale	5275	718366	-	12171	130.73%	1810031	151.97%	-	-	12693	140.62%	1813230	152.41%	-	-
	Perserverance	179	25752	447.57	435	143.20%	65175	153.09%	448.67	1.10	451	152.19%	65245	153.36%	448.73	1.16
	Cressbrook	509	62174	285.26	1184	132.45%	157922	154.00%	288.82	3.56	1214	138.42%	158117	154.31%	288.96	3.70
	Tinton	753	89307	-	1724	129.02%	223475	150.23%	-	-	1759	133.64%	223847	150.65%	-	-
	Rosentretters	864	113475	7.60	1986	129.90%	282840	149.25%	10.23	2.63	2018	133.64%	283197	149.57%	10.30	2.70
	Watts Bridge	6380	870362	17.12	14648	129.59%	2182696	150.78%	25.06	7.94	15380	141.07%	2186303	151.19%	25.76	8.64
	SD Outflow	991	238216	-	1982	100.00%	476431	100.00%	-	-	1982	100.00%	476431	100.00%	-	-
	Caboonbah	7142	1311191	16.67	16346	128.89%	3139607	139.45%	23.21	6.54	17740	148.40%	3141900	139.62%	23.98	7.31
	Middle Ck	7937	1455460	24.01	18236	129.74%	3480665	139.15%	37.71	13.70	19793	149.37%	3481503	139.20%	39.73	15.72
	WD Inflow	8344	1609470	-	18983	127.50%	3804415	136.38%	-	-	20862	150.02%	3803479	136.32%	-	-
Lockyer	Helidon	645	51007	6.68	1645	154.93%	159512	212.73%	9.78	3.10	1677	160.02%	159653	213.00%	9.86	3.18
	Brown Zirbels	262	17543	7.61	680	159.72%	54384	210.00%	10.61	3.00	687	162.28%	54449	210.37%	10.65	3.04
	Harms	442	36615	6.29	1109	150.86%	107686	194.10%	9.43	3.14	1106	150.15%	107829	194.49%	9.42	3.13
	Sandy Ck Rd	80	6564	4.78	214	166.97%	22345	240.42%	7.29	2.51	211	162.50%	22377	240.90%	7.23	2.45
	Grantham	1424	125971	-	3651	156.35%	393406	212.30%	-	-	3787	165.92%	393783	212.60%	-	-
	Tenthill	895	95132	8.48	2196	145.42%	265980	179.59%	12.72	4.24	2210	146.98%	266164	179.78%	12.77	4.29
	US Gatton	2331	237867	16.09	5912	153.64%	712205	199.41%	25.85	9.76	6091	161.32%	712581	199.57%	26.34	10.25
	Gatton	2331	237867	15.07	5912	153.64%	712205	199.41%	22.79	7.72	6091	161.32%	712581	199.57%	23.17	8.10
	Mulgowie	532	59733	9.08	1235	132.21%	150175	151.41%	9.33	0.25	1250	135.06%	150283	151.59%	9.34	0.26
	Laidley	676	79073	14.08	1564	131.16%	198326	150.81%	24.86	10.78	1577	133.13%	198501	151.04%	25.02	10.94
	Showground	692	81323	9.88	1598	131.05%	204191	151.09%	13.51	3.63	1613	133.14%	204369	151.31%	13.57	3.69
	Forest Hill	226	26145	3.75	536	136.86%	69160	164.52%	4.37	0.62	510	125.59%	69321	165.14%	4.32	0.57
	Warrego Hwy	1123	138417	7.67	2647	135.69%	360336	160.33%	9.42	1.75	2672	137.92%	360881	160.72%	9.45	1.78
	Glenore Grove	3221	396845	14.89	8063	150.31%	1139367	187.11%	17.12	2.23	8589	166.62%	1140083	187.29%	17.36	2.47
	Lyons Br	3345	449740	16.84	8434	152.11%	1290221	186.88%	18.87	2.03	9198	174.95%	1290545	186.95%	19.18	2.34
	Rifle Range Rd	3355	470197	16.59	8476	152.65%	1344727	185.99%	17.87	1.28	9315	177.67%	1344508	185.95%	18.08	1.49
	Buraba Ck	680	85236	-	1651	142.90%	236136	177.04%	-	-	1572	131.28%	237071	178.13%	-	-
	O'Reillys Weir	3667	566551	18.04	9287	153.25%	1610119	184.20%	25.75	7.71	10472	185.58%	1609324	184.06%	27.35	9.31
Bremer	Adams Br	405	47142	5.36	917	126.55%	117788	149.86%	7.09	1.73	935	131.11%	117828	149.94%	7.15	1.79
	Stokes Xing	565	67804	6.55	1282	126.76%	168569	148.61%	9.72	3.17	1311	131.85%	168668	148.76%	9.84	3.29
	Spressers Br	820	106807	7.40	1847	125.18%	264070	147.24%	9.26	1.86	1935	135.82%	264260	147.42%	9.41	2.01
	Grandchester	154	18139	4.89	351	127.25%	45235	149.38%	5.70	0.81	359	132.59%	45268	149.56%	5.73	0.84
	Kuss Rd	658	83594	7.95	1486	125.82%	207556	148.29%	8.93	0.98	1514	130.04%	207767	148.54%	8.96	1.01

Catchment	Gauge	1974 Event with Recommended Parameters			Double 1974 Flows With n = 0.8						Double 1974 Flows With n = 0.8 and alpha and beta recalibrated					
	WWTP	760	98988	8.26	1715	125.61%	245534	148.04%	9.22	0.96	1767	132.47%	245764	148.28%	9.27	1.01
	Rosewood	1637	216364	7.30	3686	125.22%	535406	147.46%	9.41	2.11	3858	135.75%	535846	147.66%	9.59	2.29
	Five Ml Br	1712	237620	9.22	3858	125.41%	587676	147.32%	13.52	4.30	4070	137.78%	587786	147.36%	13.94	4.72
	Walloon	1744	249761	10.91	3930	125.32%	617751	147.34%	13.37	2.46	4157	138.32%	617435	147.21%	13.62	2.71
Warrill	MD Inflow	627	62990	-	1411	125.18%	157847	150.59%	-	-	1411	125.18%	157847	150.59%	-	-
	Moogerah Dam	329	59738	158.34	1068	224.15%	153656	157.22%	161.37	3.03	1068	224.15%	153656	157.22%	161.37	3.03
	Toohills Xing	350	42751	6.14	802	129.09%	106966	150.21%	7.49	1.35	802	129.09%	106966	150.21%	7.49	1.35
	Junction Weir	847	151923	80.60	2250	165.56%	390469	157.02%	82.30	1.70	2250	165.56%	390469	157.02%	82.30	1.70
	Kalbar	808	124062	13.96	2129	163.51%	317687	156.07%	24.53	10.57	2129	163.51%	317687	156.07%	24.53	10.57
	Kalbar 2B	808	124062	13.96	2129	163.51%	317687	156.07%	24.53	10.57	2129	163.51%	317687	156.07%	24.53	10.57
	Harrisville	921	167767	6.07	2417	162.56%	431611	157.27%	6.72	0.65	2417	162.56%	431611	157.27%	6.72	0.65
	Churchbank	1512	246797	42.60	3809	151.97%	637498	158.31%	43.74	1.14	3809	151.97%	637498	158.31%	43.74	1.14
	Greens Rd	1667	288376	10.72	4466	167.85%	749444	159.88%	16.02	5.3	4466	167.85%	749444	159.88%	16.02	5.30
	Amberley	1688	293045	10.88	4529	168.37%	761873	159.98%	14.03	3.15	4529	168.37%	761873	159.98%	14.03	3.15
Purga	Peak Xing	520	50346	7.15	1187	128.29%	129546	157.31%	11.60	4.45	1189	128.61%	129508	157.24%	11.61	4.46
	Loamside	693	70245	9.10	1587	129.11%	183389	161.07%	11.14	2.04	1649	138.02%	182878	160.34%	11.28	2.18
Lower	WD Outflow	8344	1545346	-	18570	122.55%	3449268	123.20%	-	-	20862	150.02%	3660778	136.89%	-	-
	O'Reillys Weir	3667	566551	18.04	9287	153.25%	1610119	184.20%	25.75	7.71	10472	185.58%	1609324	184.06%	27.35	9.31
	Lowood	10189	2125268	23.13	29432	188.85%	5096347	139.80%	33.22	10.09	34535	238.93%	5303205	149.53%	35.77	12.64
	Savages Xing	10218	2187458	24.54	27740	171.47%	5241479	139.62%	42.20	17.66	31494	208.21%	5445273	148.93%	45.96	21.42
	Burtons Br	10223	2249409	19.50	27261	166.67%	5393662	139.78%	33.33	13.83	31861	211.66%	5593542	148.67%	36.96	17.46
	Lake Manchester	10239	2324240	21.94	26894	162.67%	5574496	139.84%	48.29	26.35	31192	204.65%	5767381	148.14%	54.97	33.03
	Kholo Br	10236	2329070	26.55	26708	160.92%	5586952	139.88%	41.25	14.70	31006	202.90%	5776539	148.02%	44.90	18.35
	Mt Crosby Weir	10235	2330570	25.88	26735	161.22%	5590818	139.89%	45.56	19.68	31148	204.34%	5778802	147.96%	50.83	24.95
	Colleges Xing	1744	249761	10.91	3930	125.32%	617751	147.34%	13.37	2.46	4157	138.32%	617434	147.21%	13.62	2.71
	Walloon	1754	255459	25.40	3964	125.93%	631852	147.34%	31.86	6.46	4204	139.60%	631087	147.04%	32.48	7.08
	Three Ml Br	1688	293045	10.88	4529	168.37%	761873	159.98%	14.03	3.15	1688	0.00%	293045	0.00%	10.88	0.00
	Amberley	693	70245	9.10	1587	129.11%	183389	161.07%	11.14	2.04	1649	138.02%	182878	160.34%	11.28	2.18
	Loamside	3628	623118	25.79	9907	173.07%	1588431	154.92%	38.71	12.92	7494	106.57%	1119351	79.64%	33.79	8.00
	Berrys Lagoon	3633	625829	24.84	9727	167.79%	1595079	154.87%	40.19	15.35	7337	101.98%	1125649	79.87%	34.24	9.40
	One Ml Br	3672	641816	23.48	9816	167.32%	1634303	154.64%	41.61	18.13	7451	102.92%	1164857	81.49%	34.65	11.17
	Hancocks Br	3677	645201	21.34	9844	167.72%	1642550	154.58%	42.83	21.49	7536	104.95%	1172720	81.76%	47.43	26.09
	Ipswich	11524	3064791	19.78	30825	167.49%	7447299	143.00%	39.32	19.54	35286	206.20%	7156536	133.51%	43.79	24.01
	Moggill	11526	3124368	18.86	30782	167.06%	7584610	142.76%	33.88	15.02	35407	207.19%	7291081	133.36%	37.36	18.50
	Goodna	11379	3167487	14.73	30981	172.25%	7685500	142.64%	30.70	15.97	35320	210.38%	7386337	133.19%	34.06	19.33
	Jindalee	11380	3215344	13.83	30880	171.36%	7793845	142.40%	29.42	15.59	35435	211.39%	7493699	133.06%	32.95	19.12
	Centenary Br	11353	3362781	5.39	30540	169.01%	8137200	141.98%	13.12	7.73	35402	211.83%	7823781	132.66%	15.06	9.67
	Brisbane	-	-	2.36	-	-	-	-	2.36	0.00	-	-	-	-	2.36	0.00

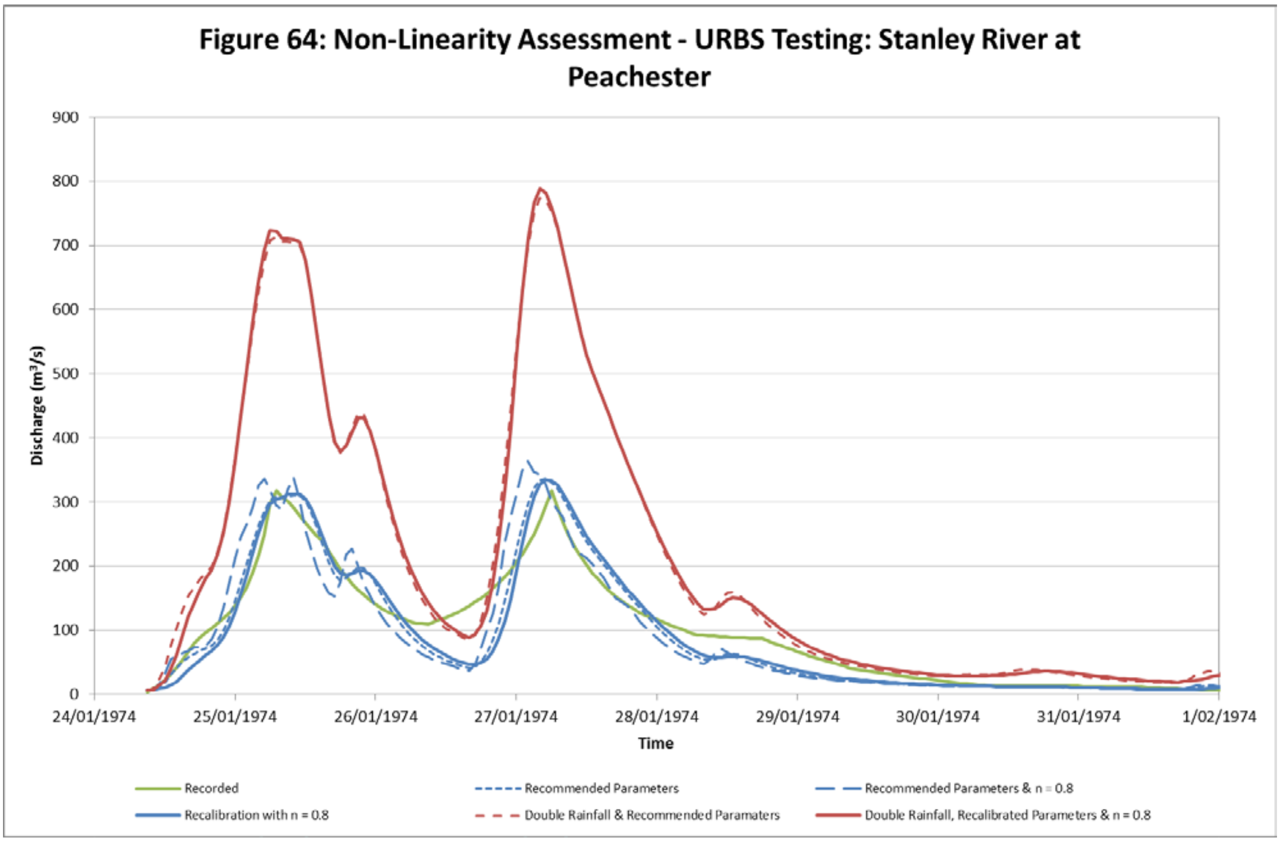


Figure 64: Non-Linearity Assessment - URBS Testing: Stanley River at Peachester
Discharge (m³/s)
0
100
200
300
400
500
600
700
800
900
24/01/1974
25/01/1974
26/01/1974
27/01/1974
28/01/1974
29/01/1974
30/01/1974
31/01/1974
1/02/1974
Time
Recorded
Recommended Parameters
Recommended Parameters & n = 0.8
Recalibration with n = 0.8
Double Rainfall & Recommended Paramaters
Double Rainfall, Recalibrated Parameters & n = 0.8

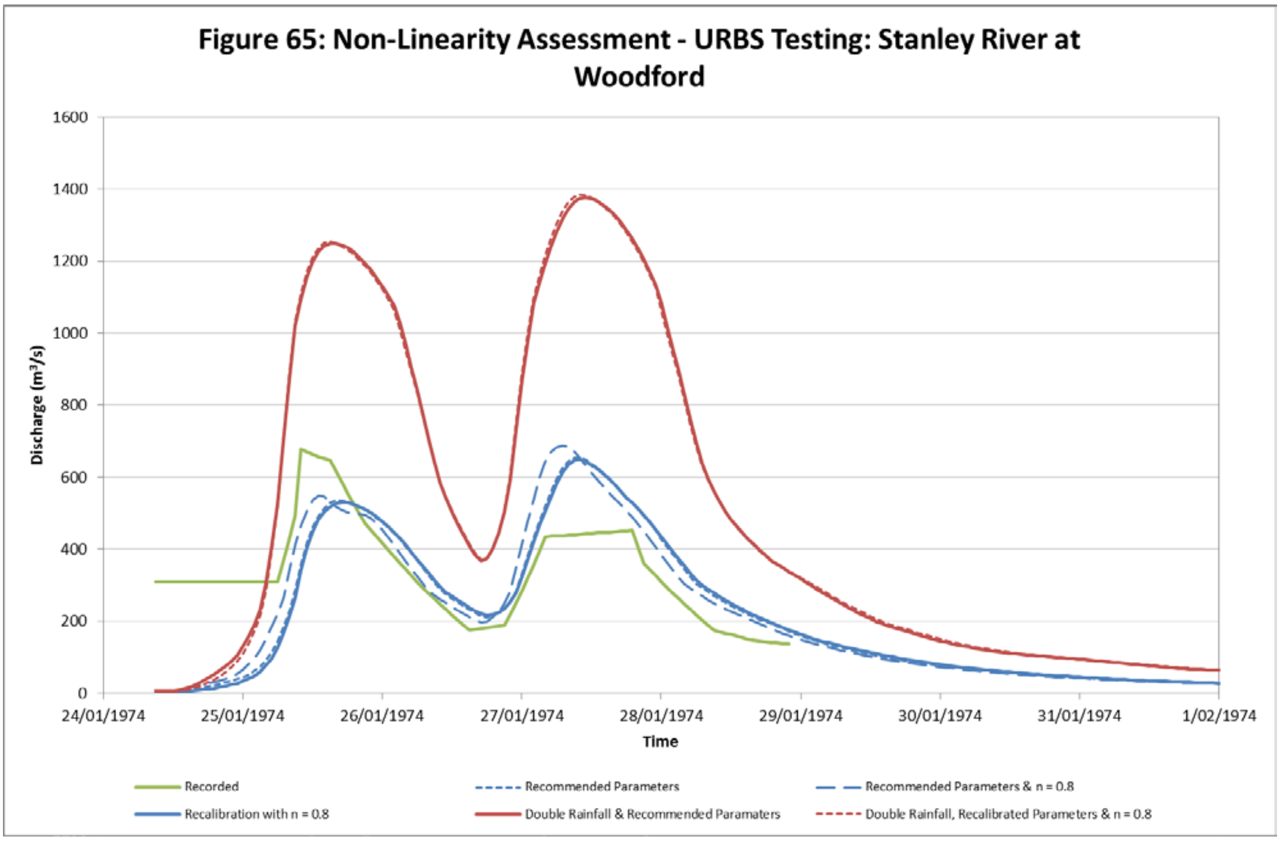


Figure 65: Non-Linearity Assessment - URBS Testing: Stanley River at Woodford
Discharge (m³/s)
0
200
400
600
800
1000
1200
1400
1600
24/01/1974
25/01/1974
26/01/1974
27/01/1974
28/01/1974
29/01/1974
30/01/1974
31/01/1974
1/02/1974
Time
Recorded
Recommended Parameters
Recommended Parameters & n = 0.8
Recalibration with n = 0.8
Double Rainfall & Recommended Paramaters
Double Rainfall, Recalibrated Parameters & n = 0.8

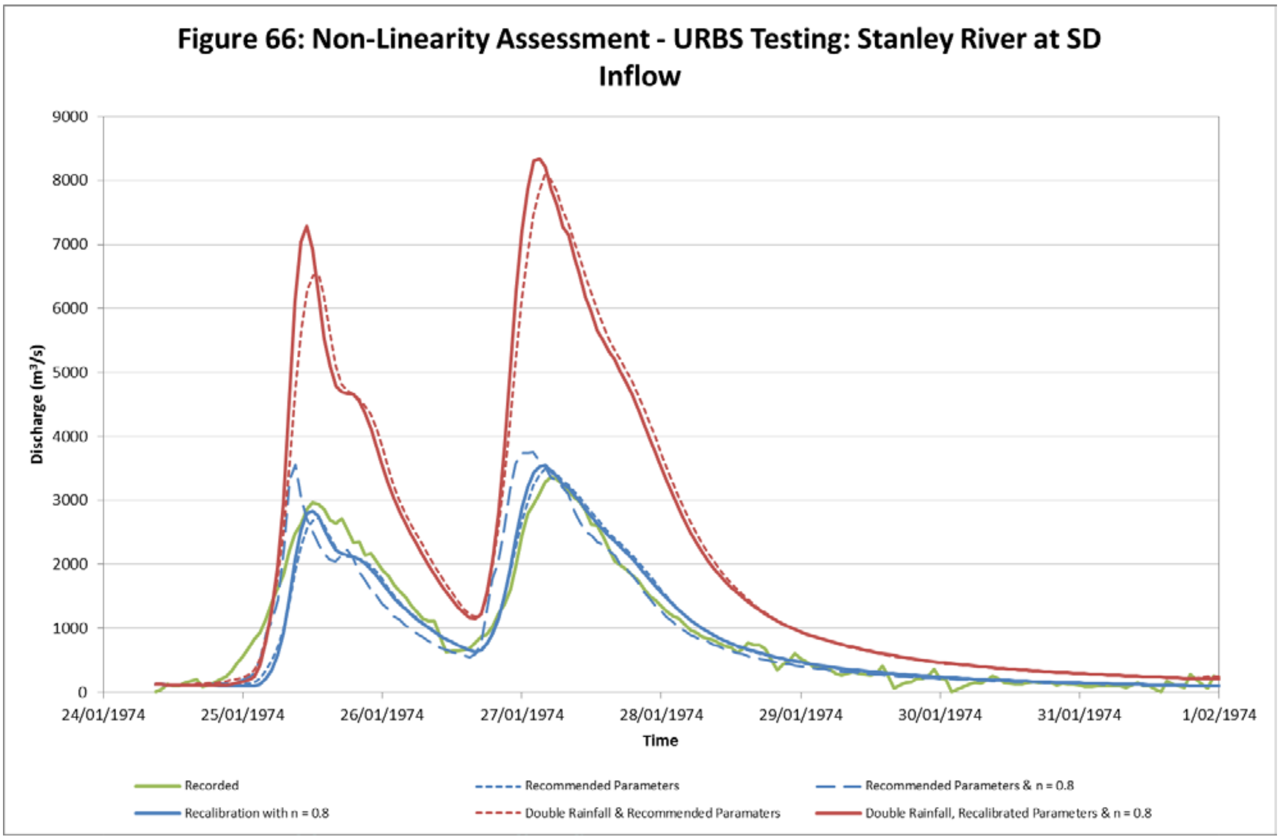


Figure 66: Non-Linearity Assessment - URBS Testing: Stanley River at SD Inflow
Discharge (m³/s)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
24/01/1974
25/01/1974
26/01/1974
27/01/1974
28/01/1974
29/01/1974
30/01/1974
31/01/1974
1/02/1974
Time
Recorded
Recommended Parameters
Recommended Parameters & n = 0.8
Recalibration with n = 0.8
Double Rainfall & Recommended Paramaters
Double Rainfall, Recalibrated Parameters & n = 0.8

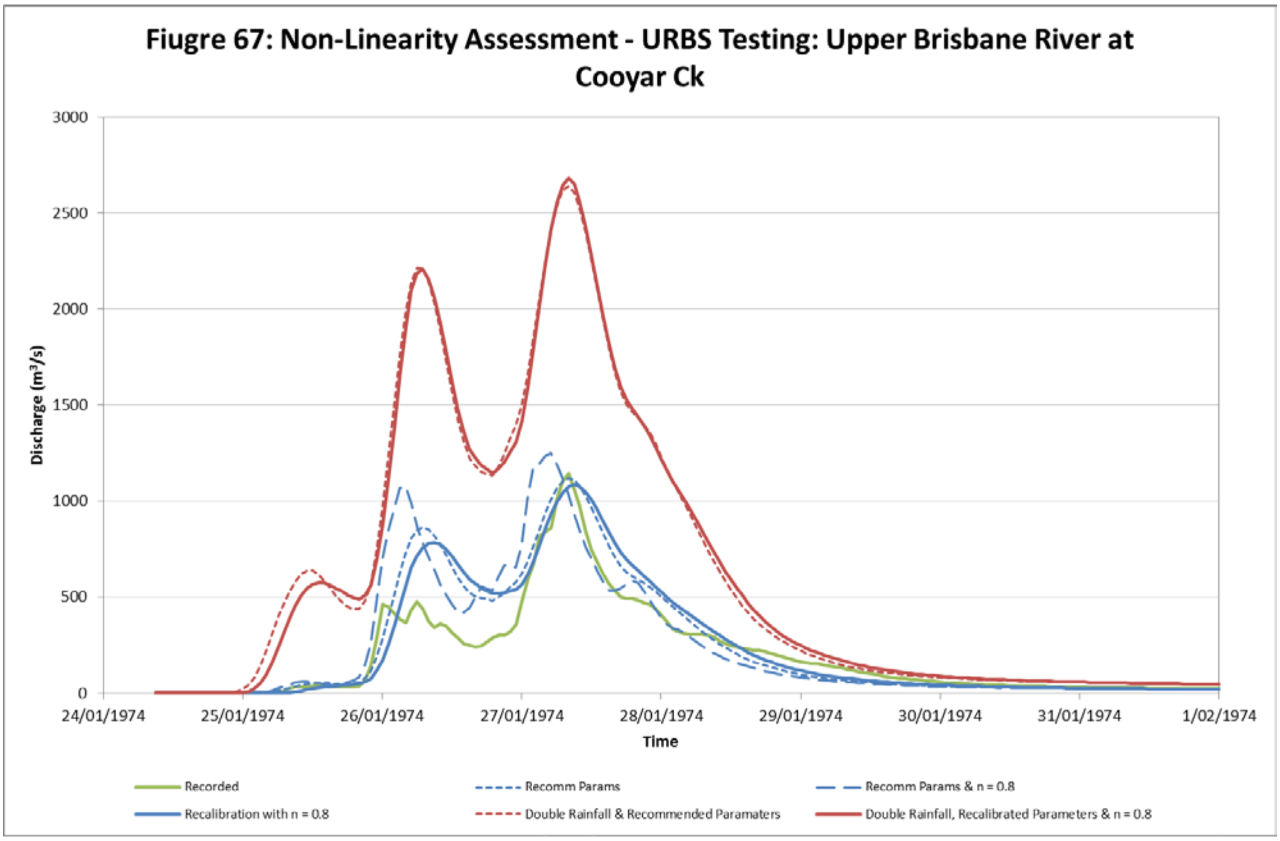
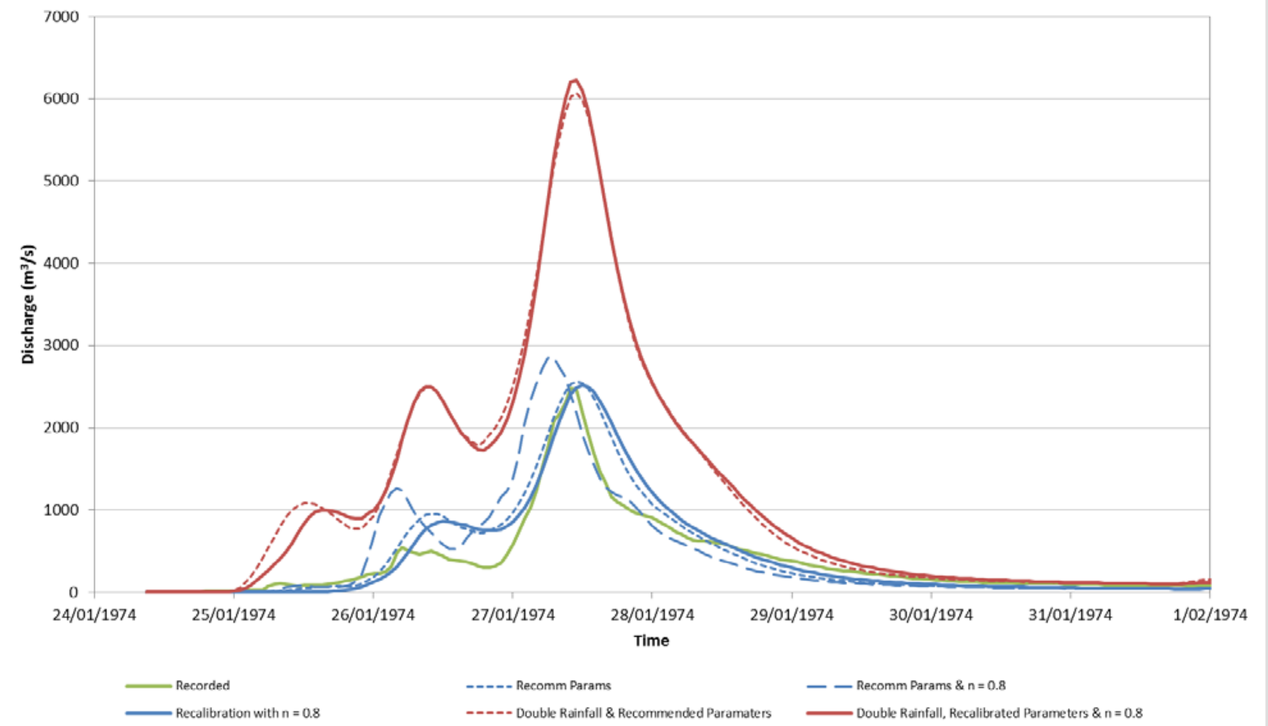
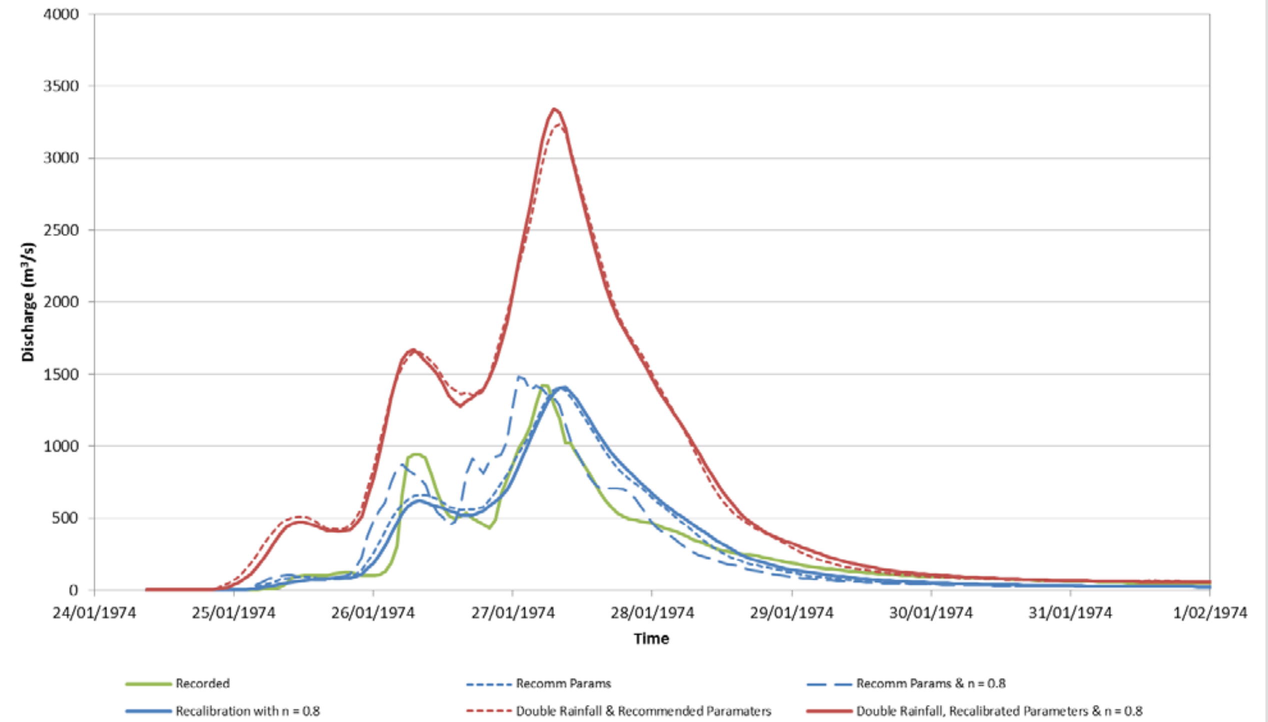

Fiugre 67: Non-Linearity Assessment - URBS Testing: Upper Brisbane River at Cooyar Ck
Discharge (m³/s)
3000
2500
2000
1500
1000
500
0
24/01/1974
25/01/1974
26/01/1974
27/01/1974
28/01/1974
29/01/1974
30/01/1974
31/01/1974
1/02/1974
Time
Recorded
Recomm Params
Recomm Params & n = 0.8
Recalibration with n = 0.8
Double Rainfall & Recommended Paramaters
Double Rainfall, Recalibrated Parameters & n = 0.8

Figure 68: Non-Linearity Assessment - URBS Testing: Upper Brisbane River at Linville



Figue 69: Non-Linearity Assessment - URBS Testing: Upper Brisbane River at Boat Mt



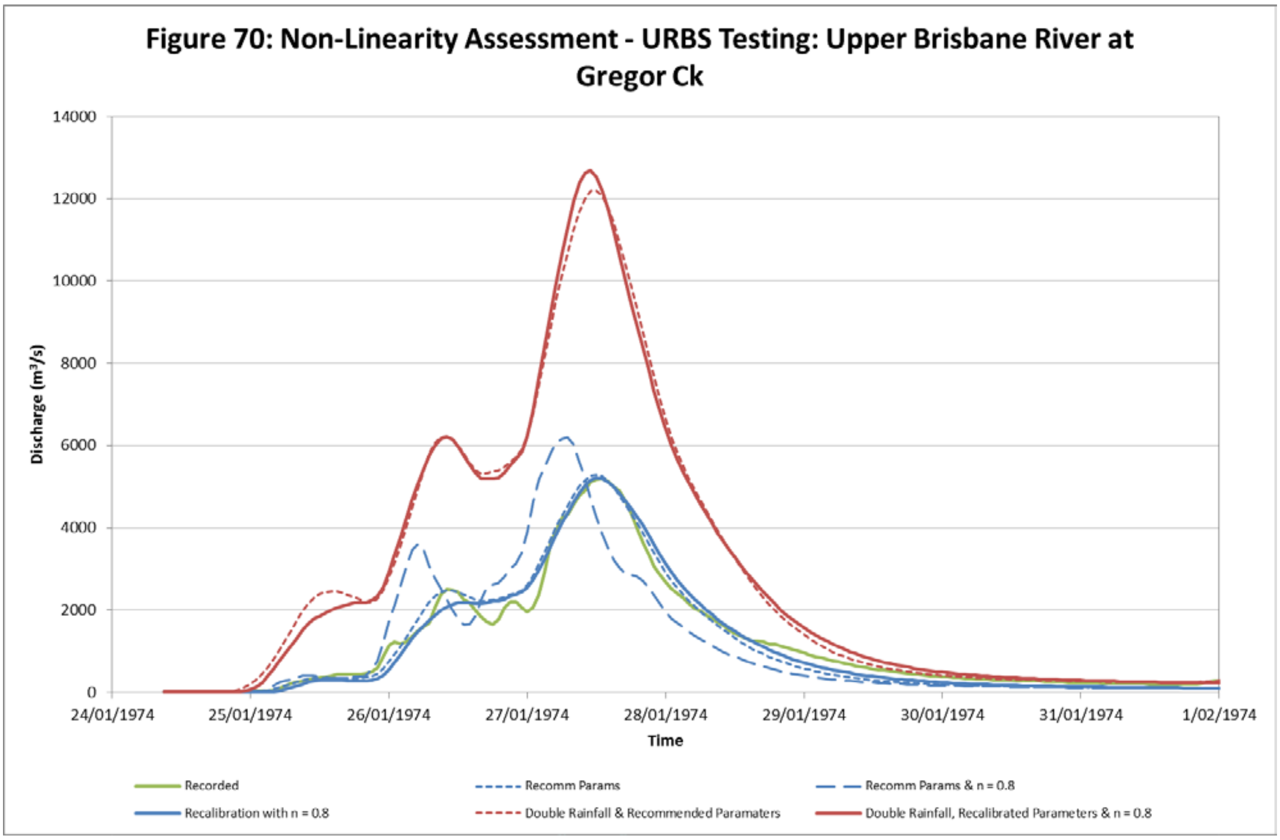


Figure 70: Non-Linearity Assessment - URBS Testing: Upper Brisbane River at Gregor Ck
Discharge (m³/s)
Time
Recorded
Recomm Params
Recomm Params & n = 0.8
Recalibration with n = 0.8
Double Rainfall & Recommended Paramaters
Double Rainfall, Recalibrated Parameters & n = 0.8

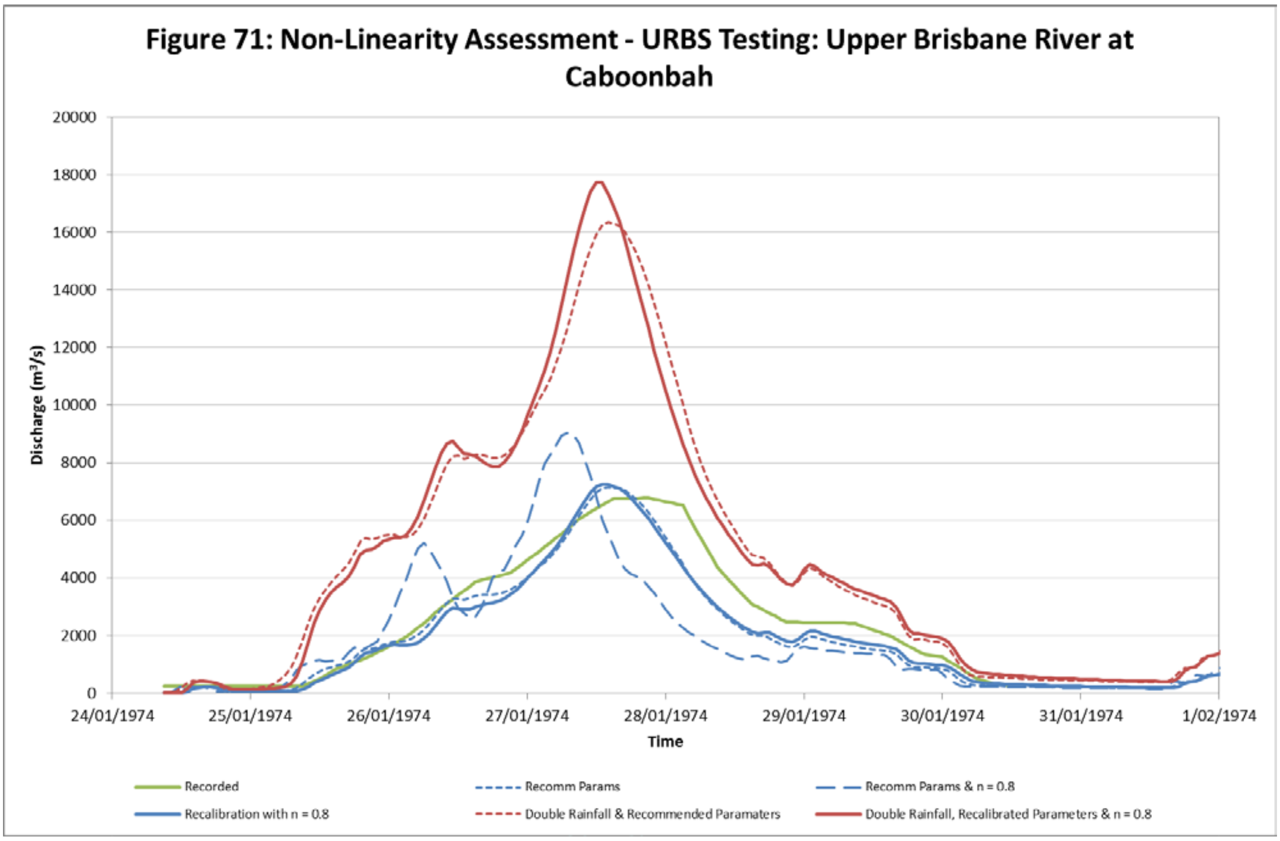


Figure 71: Non-Linearity Assessment - URBS Testing: Upper Brisbane River at Caboonbah
Discharge (m³/s)
Time
Recorded
Recomm Params
Recomm Params & n = 0.8
Recalibration with n = 0.8
Double Rainfall & Recommended Paramaters
Double Rainfall, Recalibrated Parameters & n = 0.8

Figure 72: Non-Linearity Assessment - URBS Testing: Lockyer Creek at Helidon

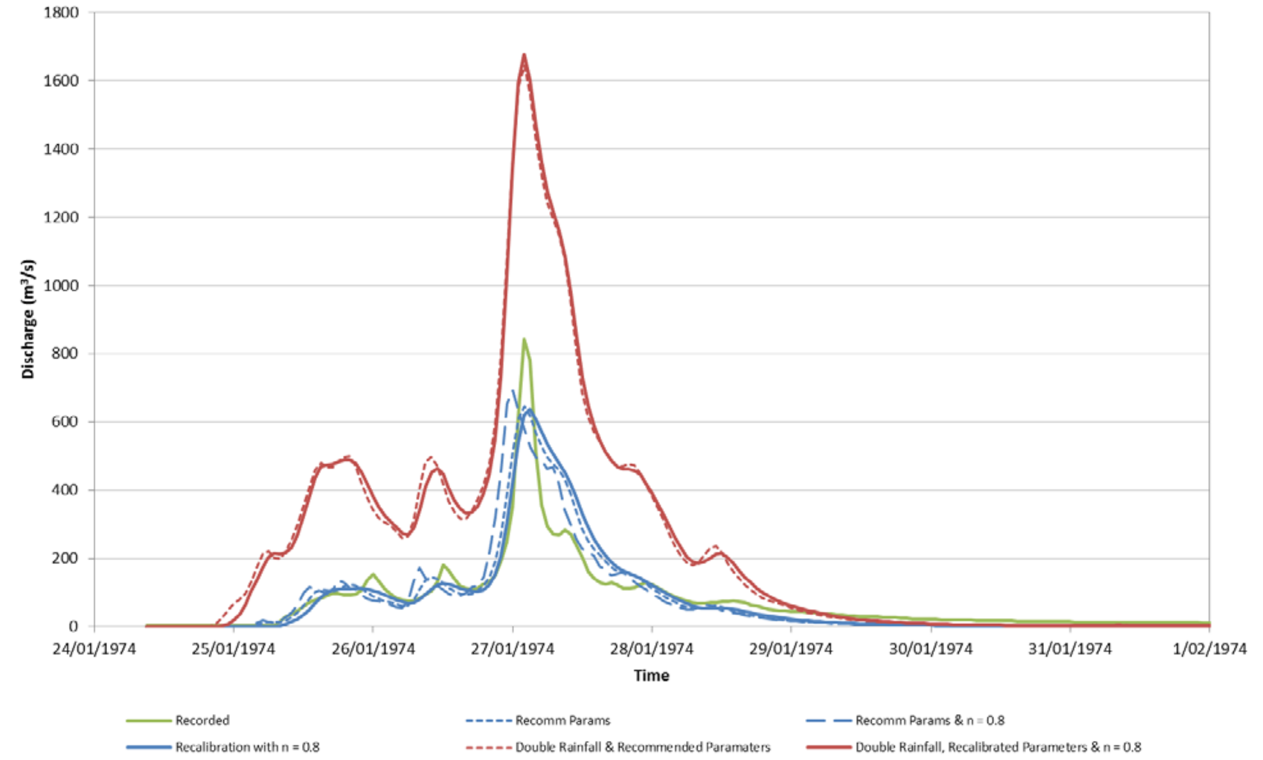
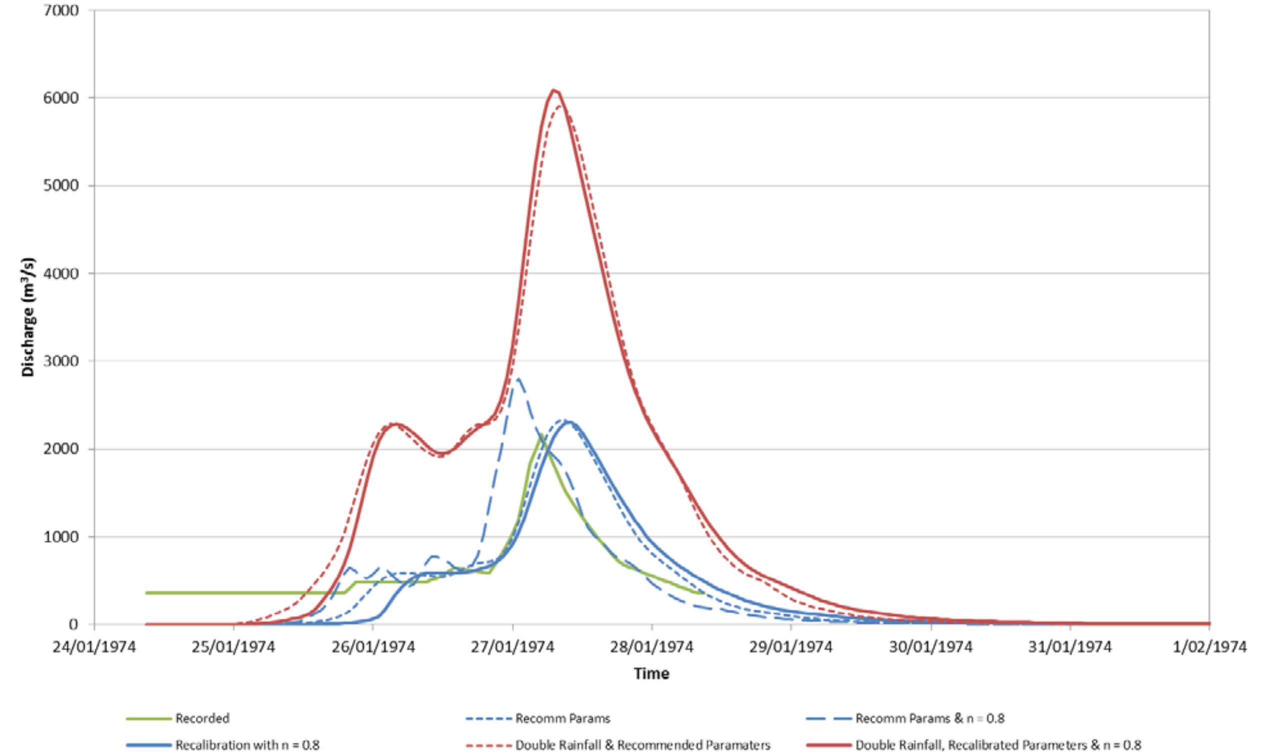


Figure 73: Non-Linearity Assessment - URBS Testing: Lockyer Creek at Gatton



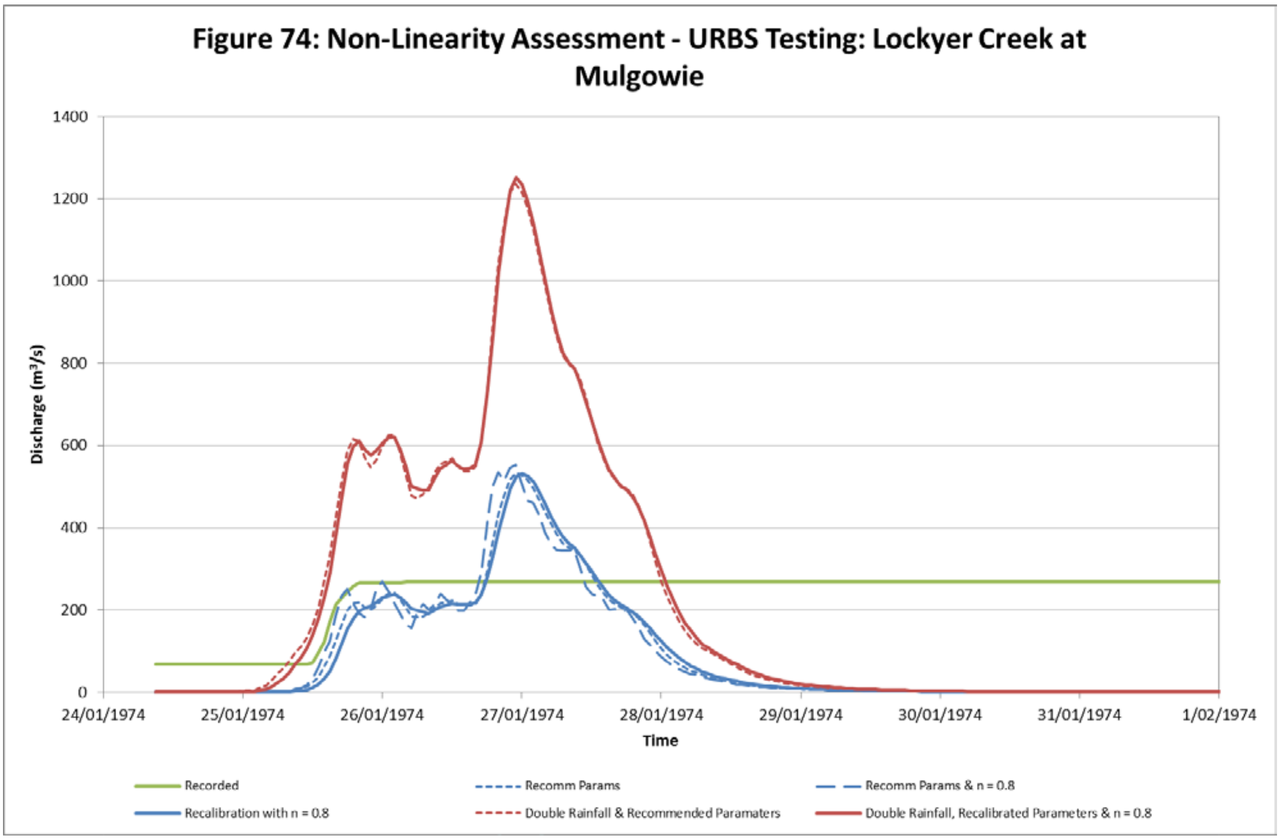


Figure 74: Non-Linearity Assessment - URBS Testing: Lockyer Creek at Mulgowie
Discharge (m³/s)
1400
1200
1000
800
600
400
200
0
24/01/1974
25/01/1974
26/01/1974
27/01/1974
28/01/1974
29/01/1974
30/01/1974
31/01/1974
1/02/1974
Time
Recorded
Recomm Params
Recomm Params & n = 0.8
Recalibration with n = 0.8
Double Rainfall & Recommended Paramaters
Double Rainfall, Recalibrated Parameters & n = 0.8

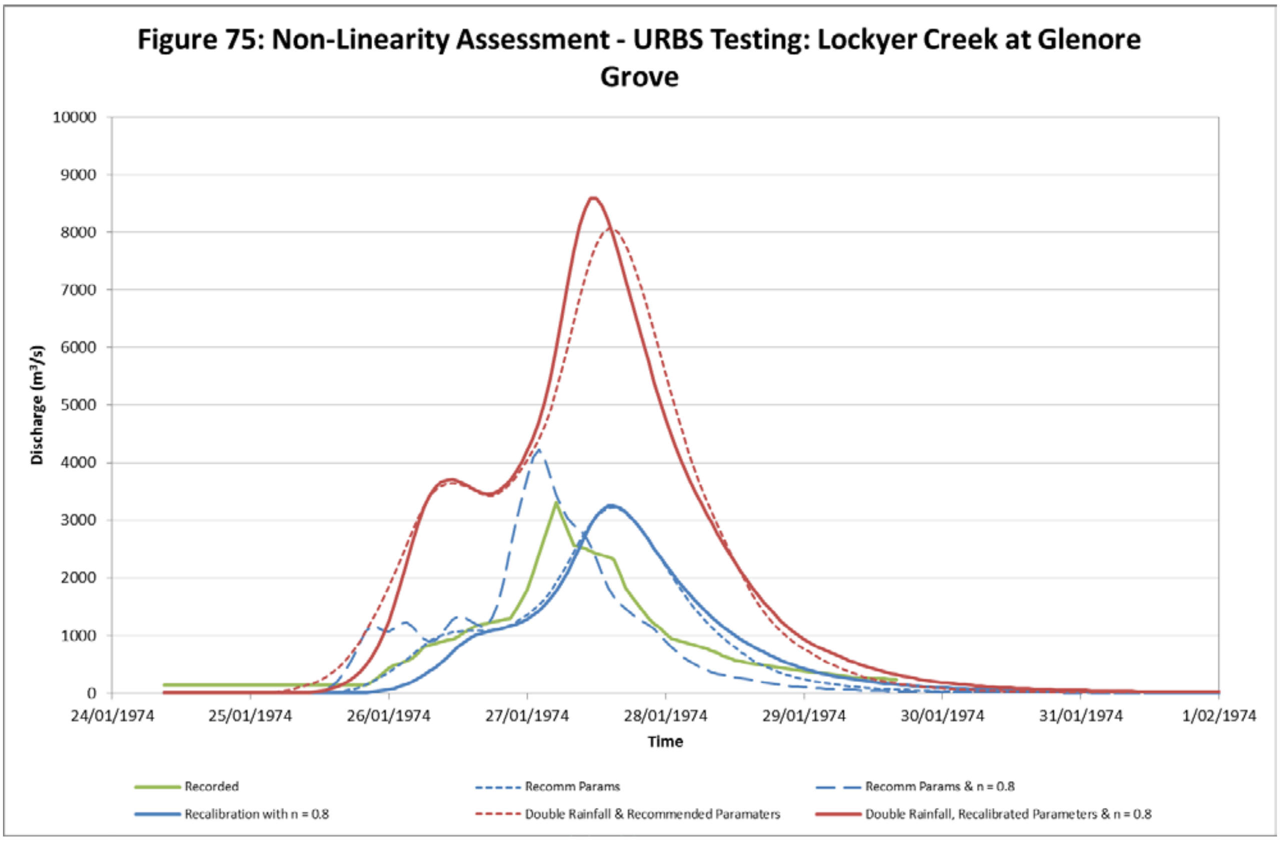


Figure 75: Non-Linearity Assessment - URBS Testing: Lockyer Creek at Glenore Grove
Discharge (m³/s)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
24/01/1974
25/01/1974
26/01/1974
27/01/1974
28/01/1974
29/01/1974
30/01/1974
31/01/1974
1/02/1974
Time
Recorded
Recomm Params
Recomm Params & n = 0.8
Recalibration with n = 0.8
Double Rainfall & Recommended Paramaters
Double Rainfall, Recalibrated Parameters & n = 0.8

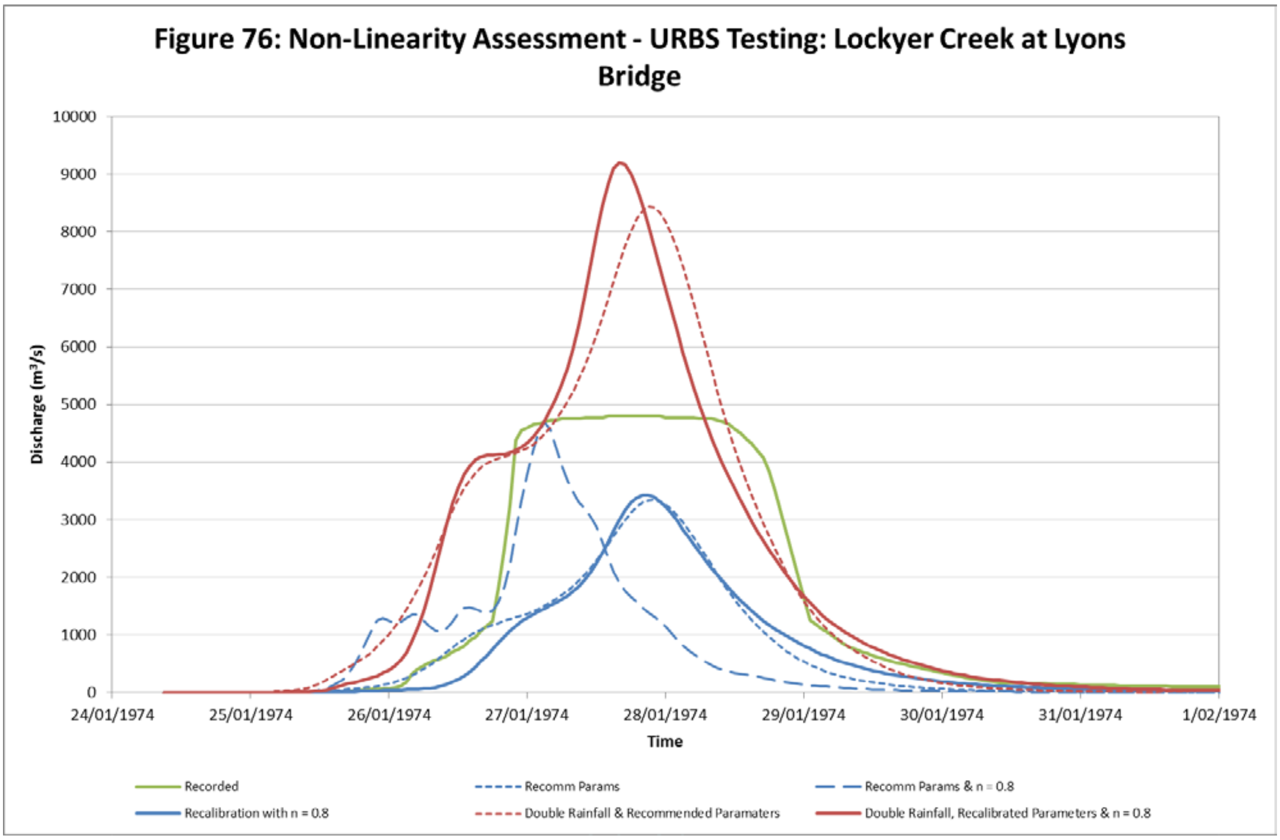


Figure 76: Non-Linearity Assessment - URBS Testing: Lockyer Creek at Lyons Bridge
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Discharge (m³/s)
24/01/1974
25/01/1974
26/01/1974
27/01/1974
28/01/1974
29/01/1974
30/01/1974
31/01/1974
1/02/1974
Time
Recorded
Recomm Params
Recomm Params & n = 0.8
Recalibration with n = 0.8
Double Rainfall & Recommended Paramaters
Double Rainfall, Recalibrated Parameters & n = 0.8

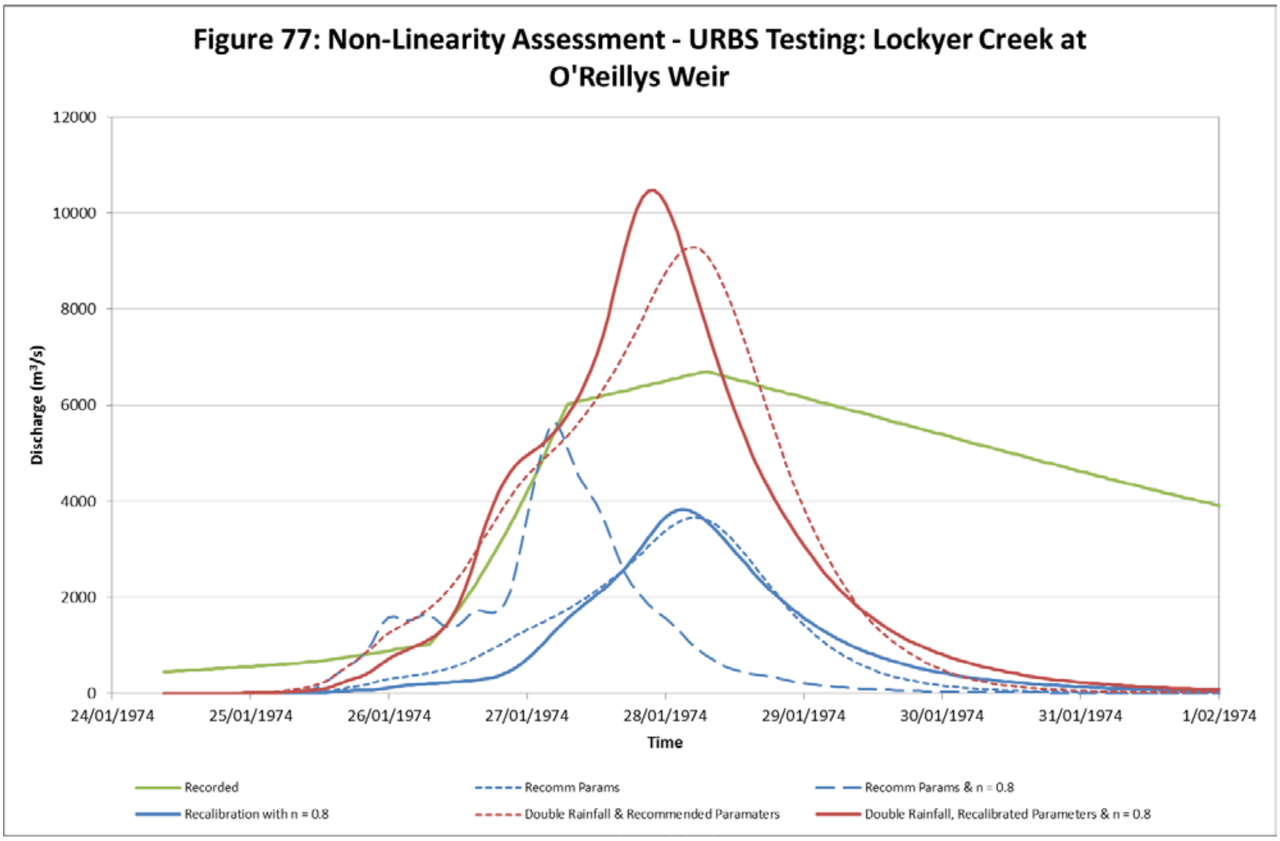


Figure 77: Non-Linearity Assessment - URBS Testing: Lockyer Creek at O'Reillys Weir
12000
10000
8000
6000
4000
2000
0
Discharge (m³/s)
24/01/1974
25/01/1974
26/01/1974
27/01/1974
28/01/1974
29/01/1974
30/01/1974
31/01/1974
1/02/1974
Time
Recorded
Recomm Params
Recomm Params & n = 0.8
Recalibration with n = 0.8
Double Rainfall & Recommended Paramaters
Double Rainfall, Recalibrated Parameters & n = 0.8

Figure 78: Non-Linearity Assessment - URBS Testing: Bremer River at Adams Bridge

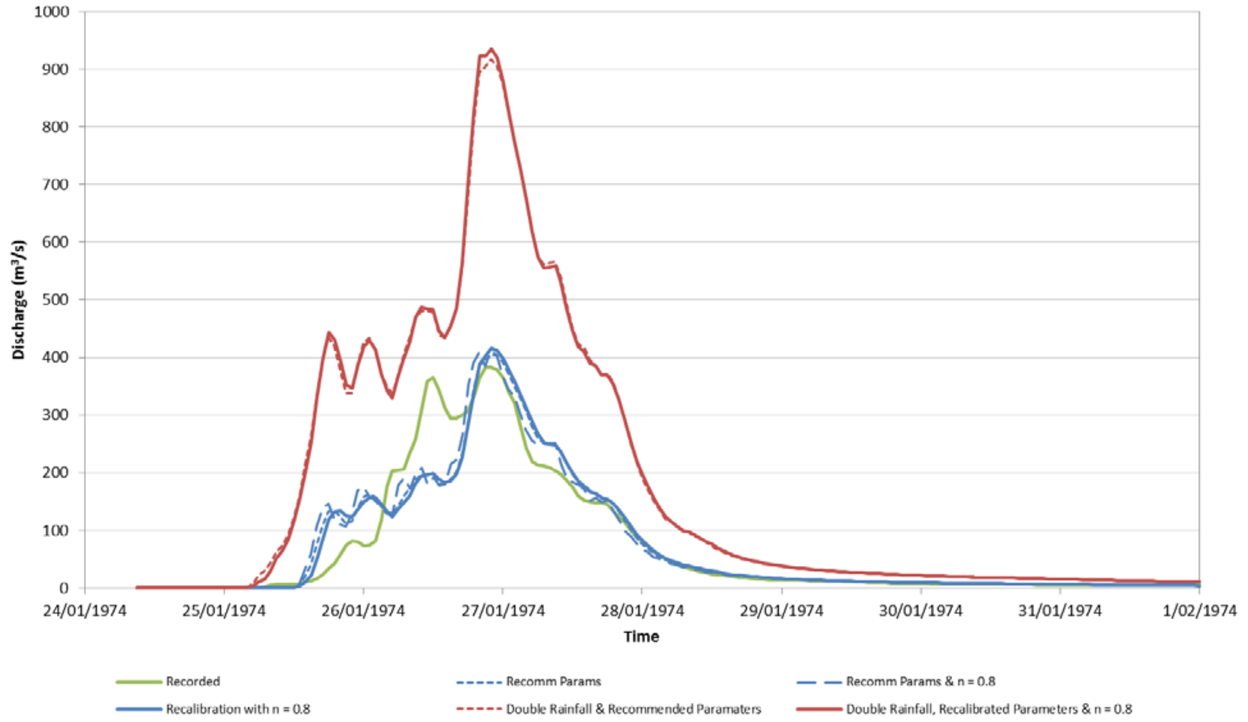


Figure 79: Non-Linearity Assessment - URBS Testing: Purga Ck at Loamside

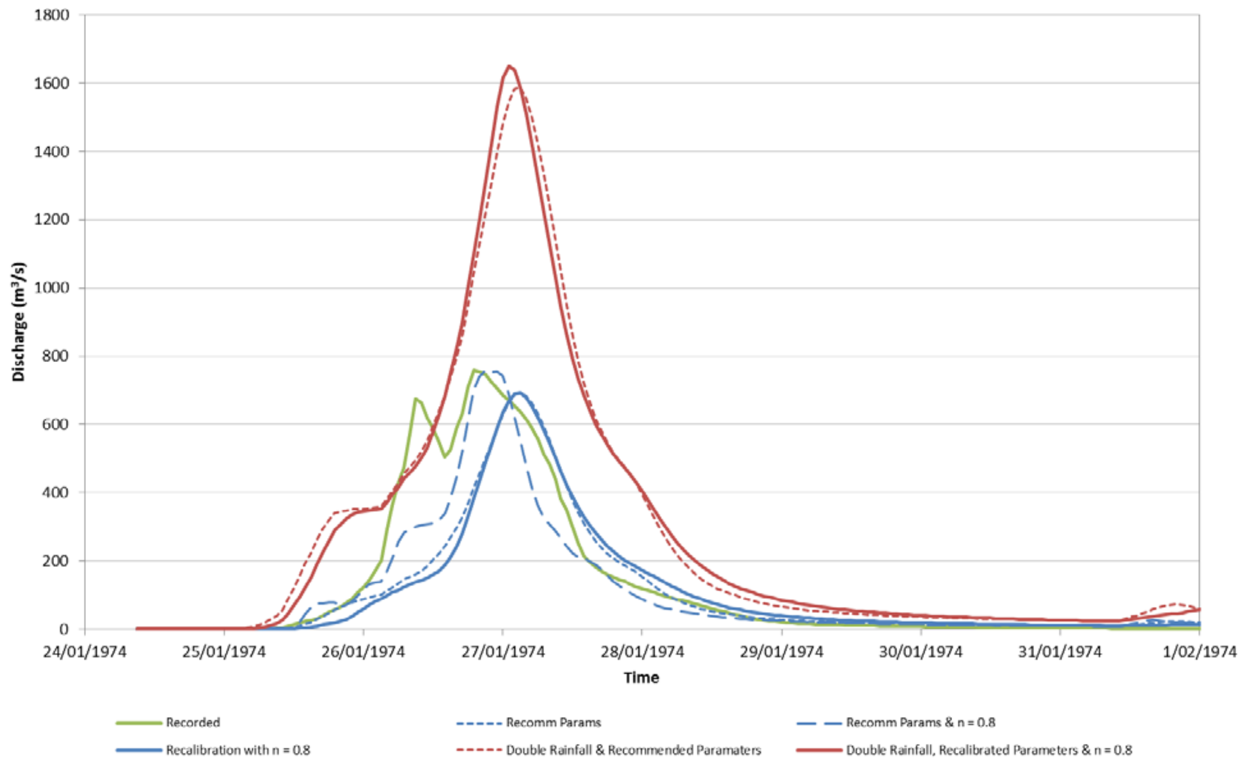


Figure 80: Non-Linearity Assessment - URBS Testing: Lower Brisbane River at Lowood

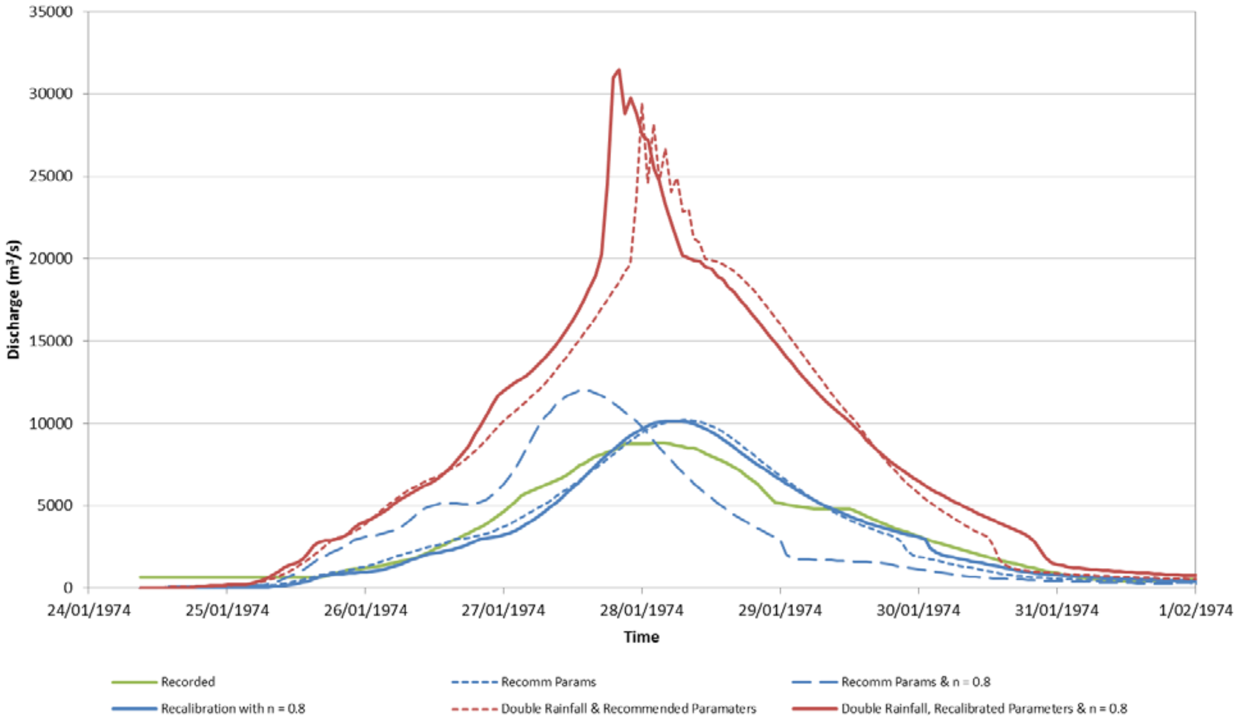
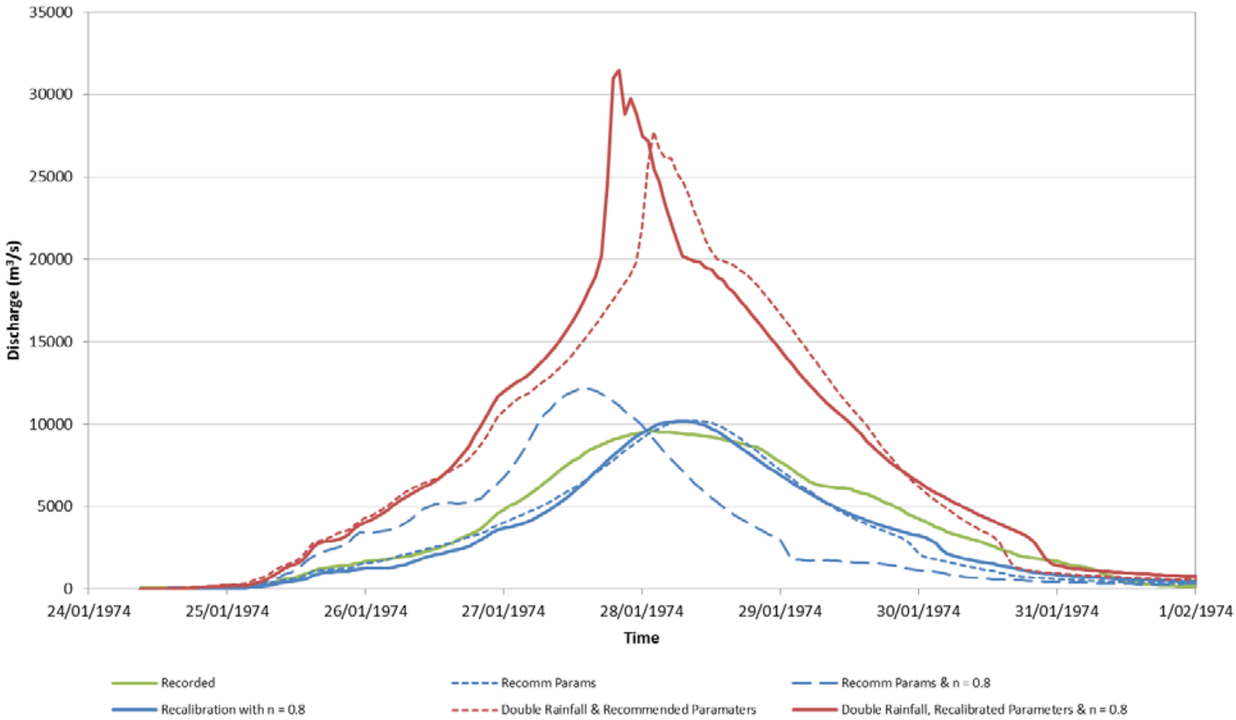


Figure 81: Non-Linearity Assessment - URBS Testing: Lower Brisbane River at Savages Crossing



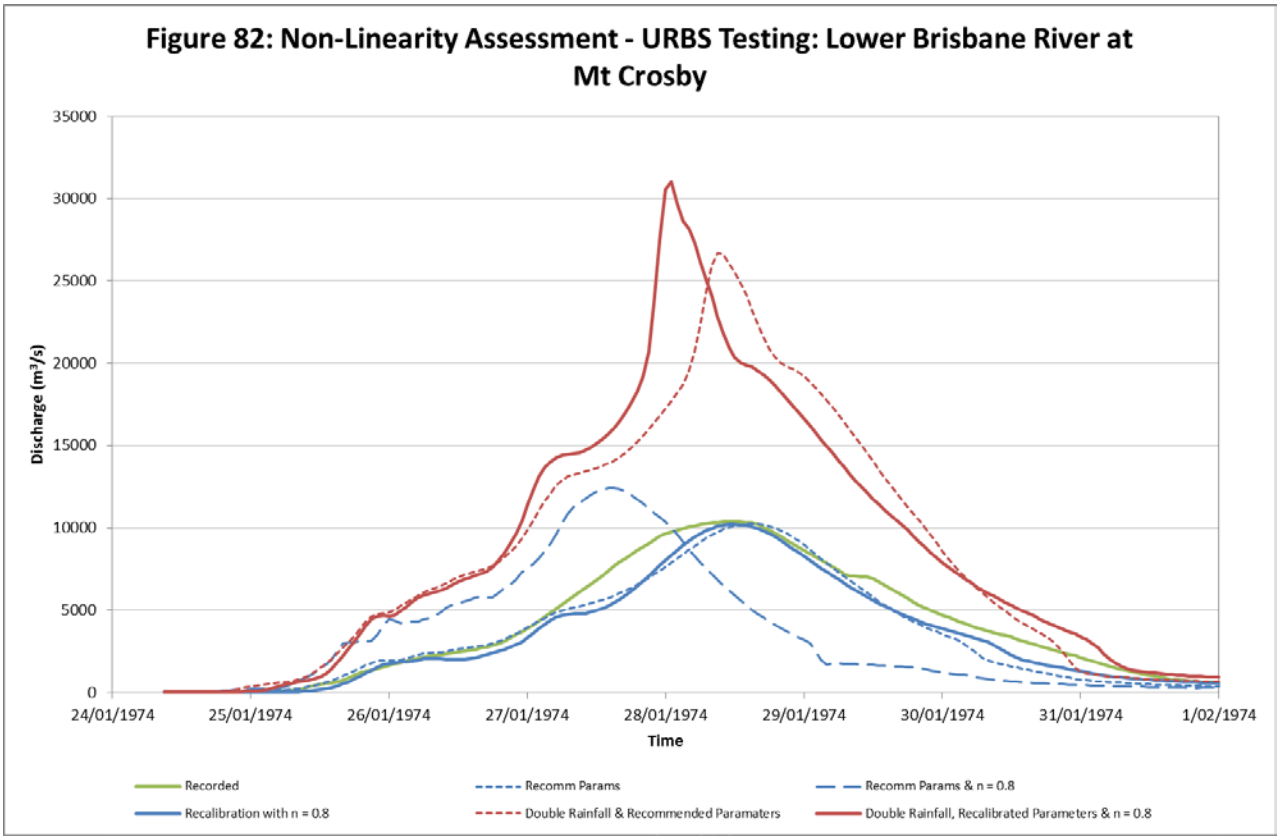


Figure 82: Non-Linearity Assessment - URBS Testing: Lower Brisbane River at Mt Crosby
35000
30000
25000
20000
15000
10000
5000
0
Discharge (m³/s)
24/01/1974
25/01/1974
26/01/1974
27/01/1974
28/01/1974
29/01/1974
30/01/1974
31/01/1974
1/02/1974
Time
Recorded
Recomm Params
Recomm Params & n = 0.8
Recalibration with n = 0.8
Double Rainfall & Recommended Paramaters
Double Rainfall, Recalibrated Parameters & n = 0.8

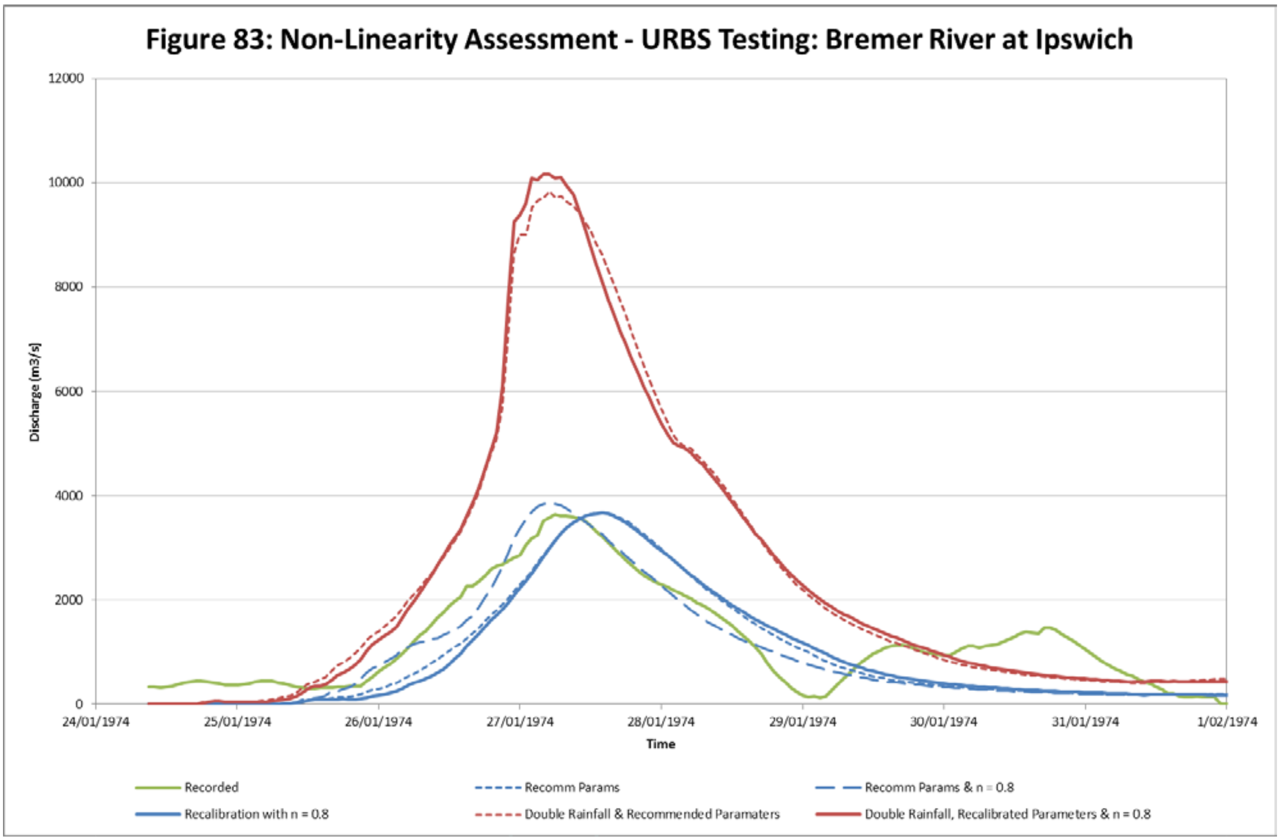


Figure 83: Non-Linearity Assessment - URBS Testing: Bremer River at Ipswich
12000
10000
8000
6000
4000
2000
0
Discharge (m3/s)
24/01/1974
25/01/1974
26/01/1974
27/01/1974
28/01/1974
29/01/1974
30/01/1974
31/01/1974
1/02/1974
Time
Recorded
Recomm Params
Recomm Params & n = 0.8
Recalibration with n = 0.8
Double Rainfall & Recommended Paramaters
Double Rainfall, Recalibrated Parameters & n = 0.8

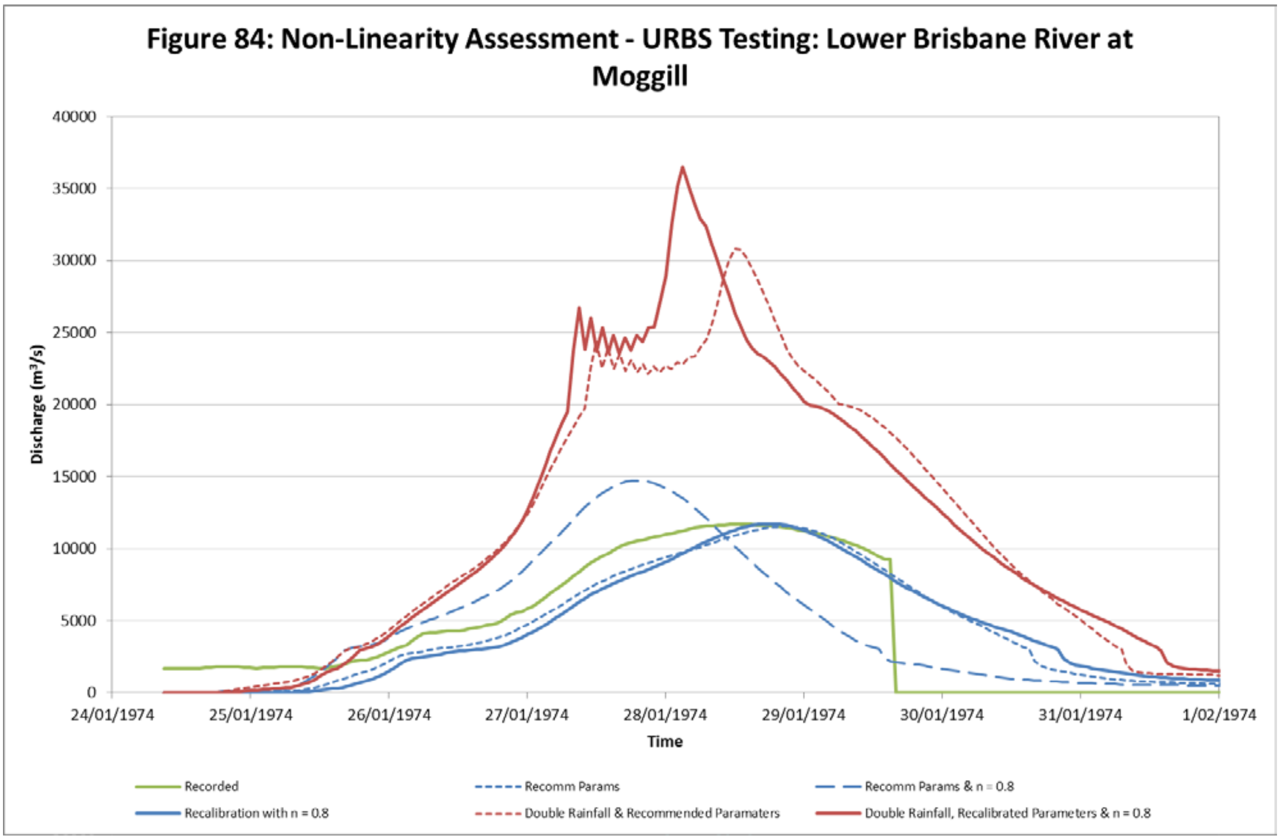


Figure 84: Non-Linearity Assessment - URBS Testing: Lower Brisbane River at Moggill
Discharge (m³/s)
40000
35000
30000
25000
20000
15000
10000
5000
0
24/01/1974
25/01/1974
26/01/1974
27/01/1974
28/01/1974
29/01/1974
30/01/1974
31/01/1974
1/02/1974
Time
Recorded
Recomm Params
Recomm Params & n = 0.8
Recalibration with n = 0.8
Double Rainfall & Recommended Paramaters
Double Rainfall, Recalibrated Parameters & n = 0.8

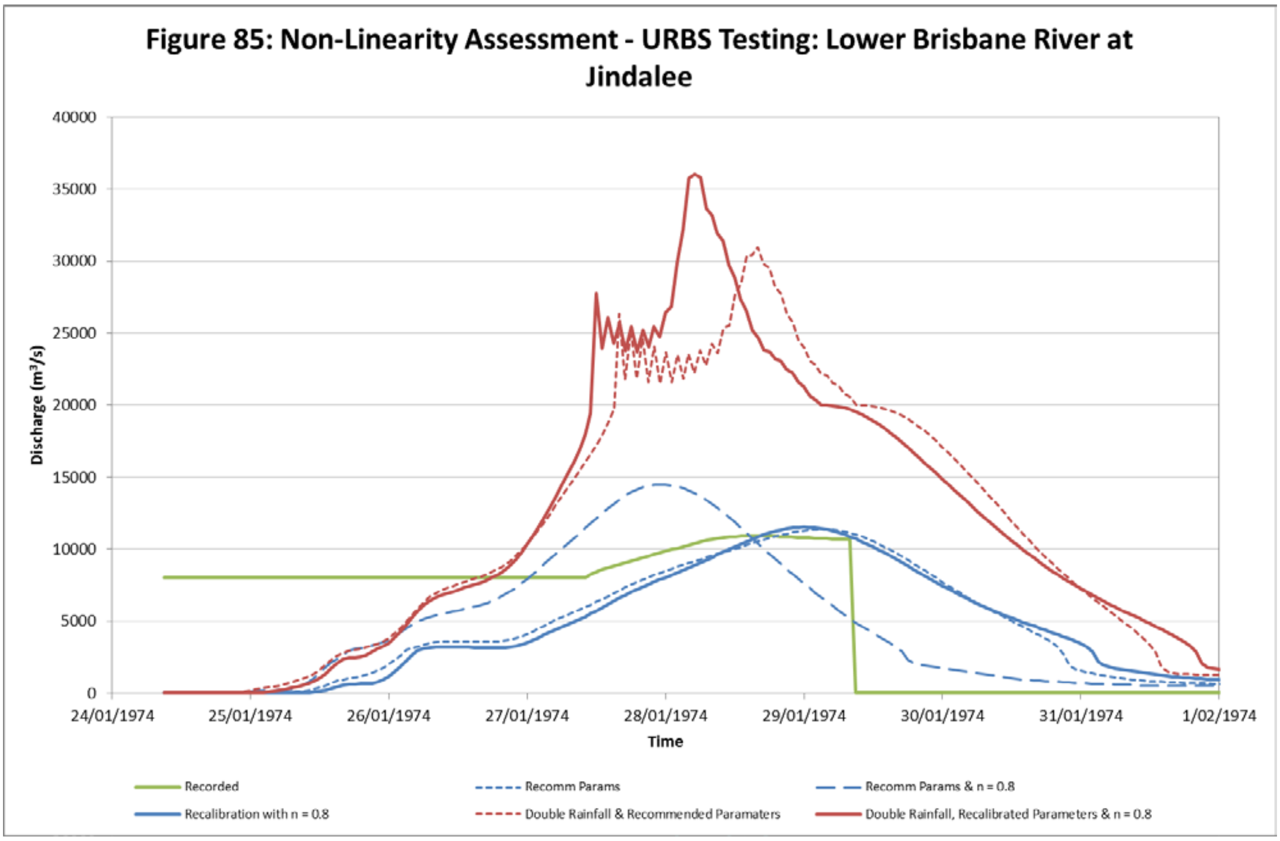


Figure 85: Non-Linearity Assessment - URBS Testing: Lower Brisbane River at Jindalee
Discharge (m³/s)
40000
35000
30000
25000
20000
15000
10000
5000
0
24/01/1974
25/01/1974
26/01/1974
27/01/1974
28/01/1974
29/01/1974
30/01/1974
31/01/1974
1/02/1974
Time
Recorded
Recomm Params
Recomm Params & n = 0.8
Recalibration with n = 0.8
Double Rainfall & Recommended Paramaters
Double Rainfall, Recalibrated Parameters & n = 0.8

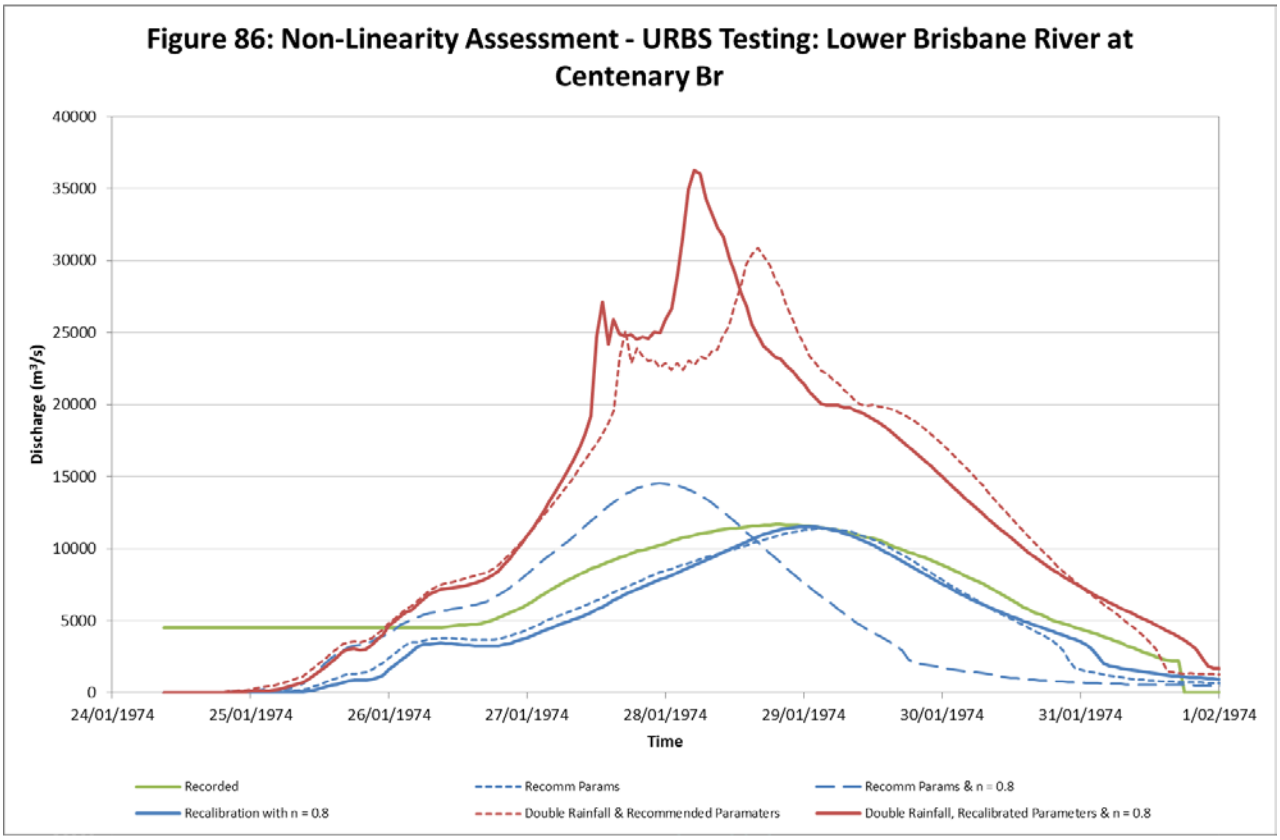


Figure 86: Non-Linearity Assessment - URBS Testing: Lower Brisbane River at Centenary Br
Discharge (m³/s)
Time
Recorded
Recomm Params
Recomm Params & n = 0.8
Recalibration with n = 0.8
Double Rainfall & Recommended Paramaters
Double Rainfall, Recalibrated Parameters & n = 0.8

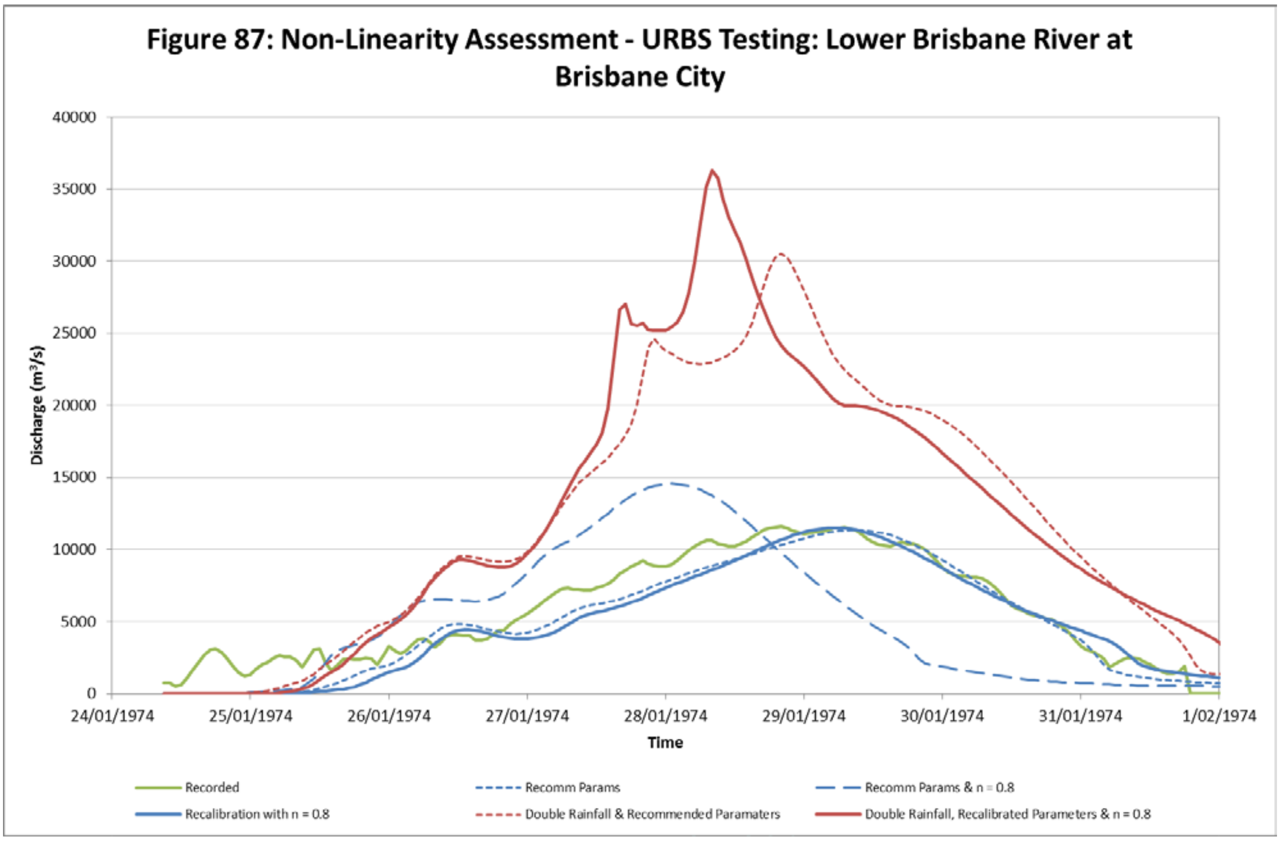
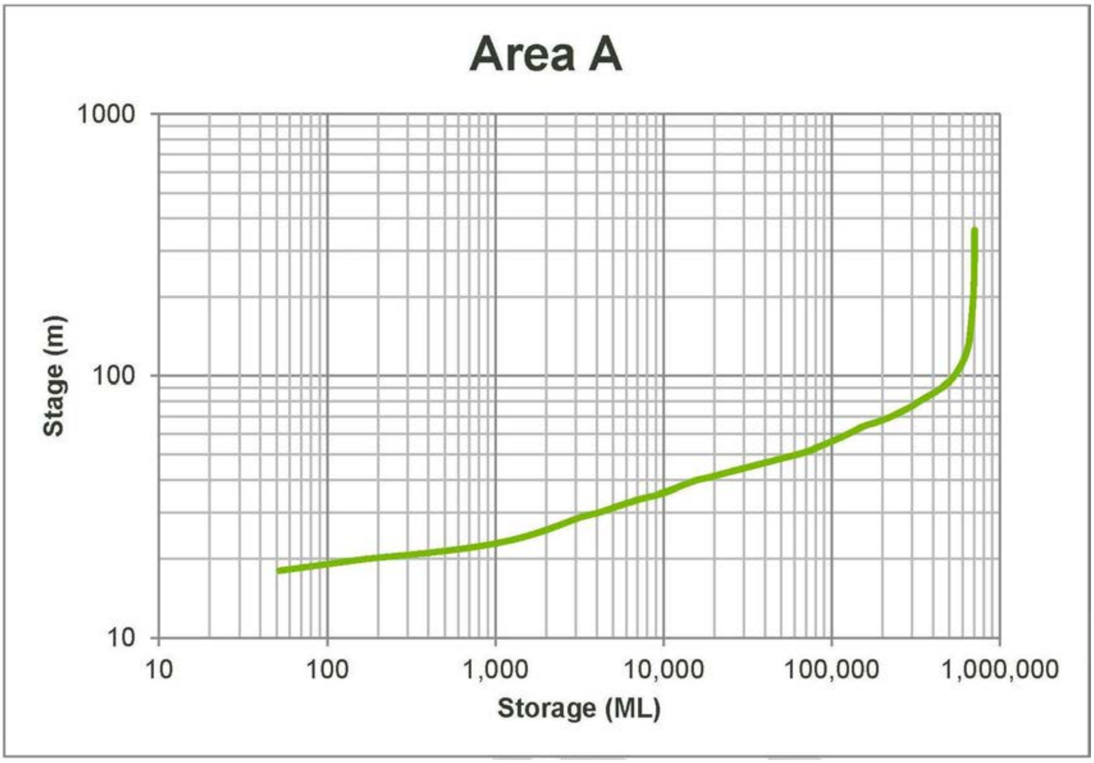


Figure 87: Non-Linearity Assessment - URBS Testing: Lower Brisbane River at Brisbane City
Discharge (m³/s)
Time
Recorded
Recomm Params
Recomm Params & n = 0.8
Recalibration with n = 0.8
Double Rainfall & Recommended Paramaters
Double Rainfall, Recalibrated Parameters & n = 0.8

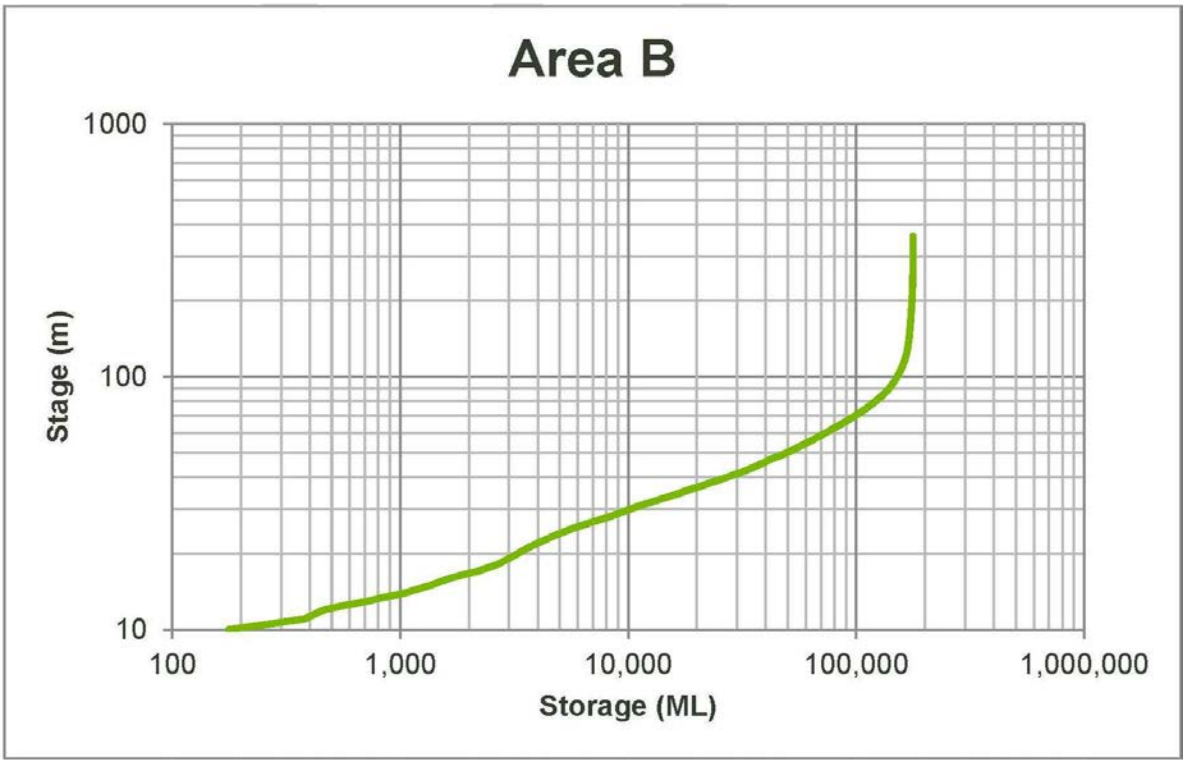
Appendix C
Conceptual storage assessment

Relationships derived from BCC DMT TUFLOW model

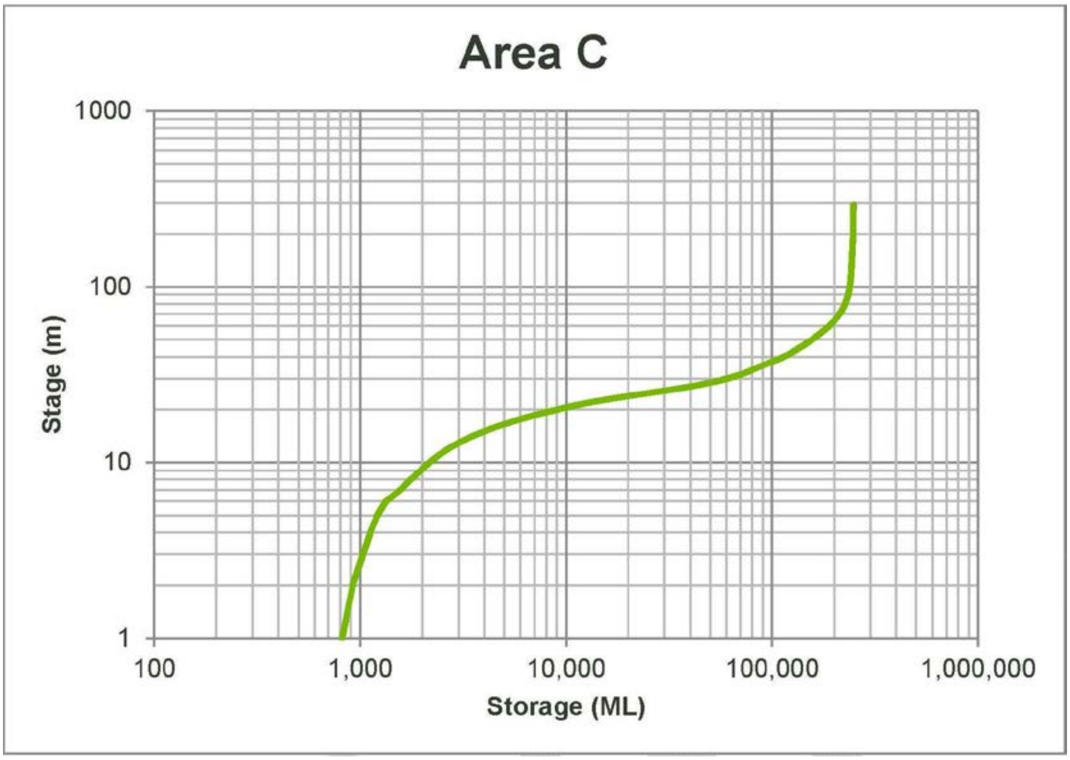
Stage – Storage relationships derived from BCC DMT 10m grid DEM



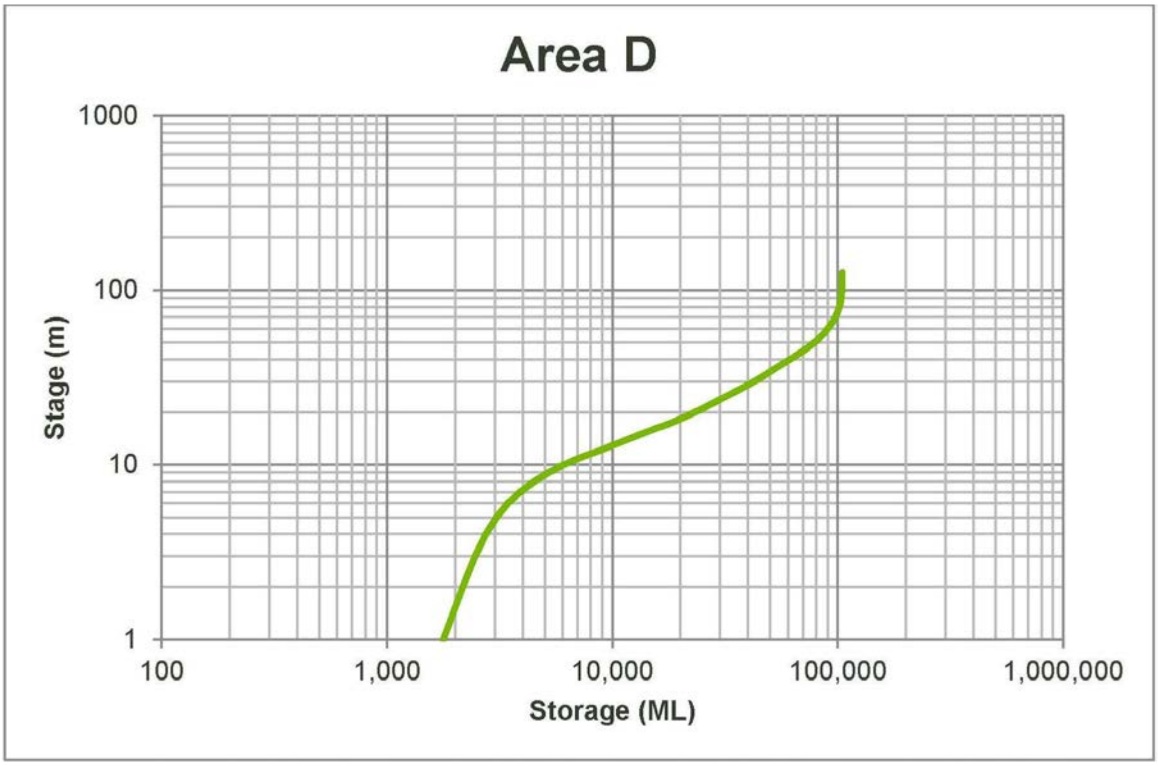
Area A Brisbane River upstream of Savages Crossing



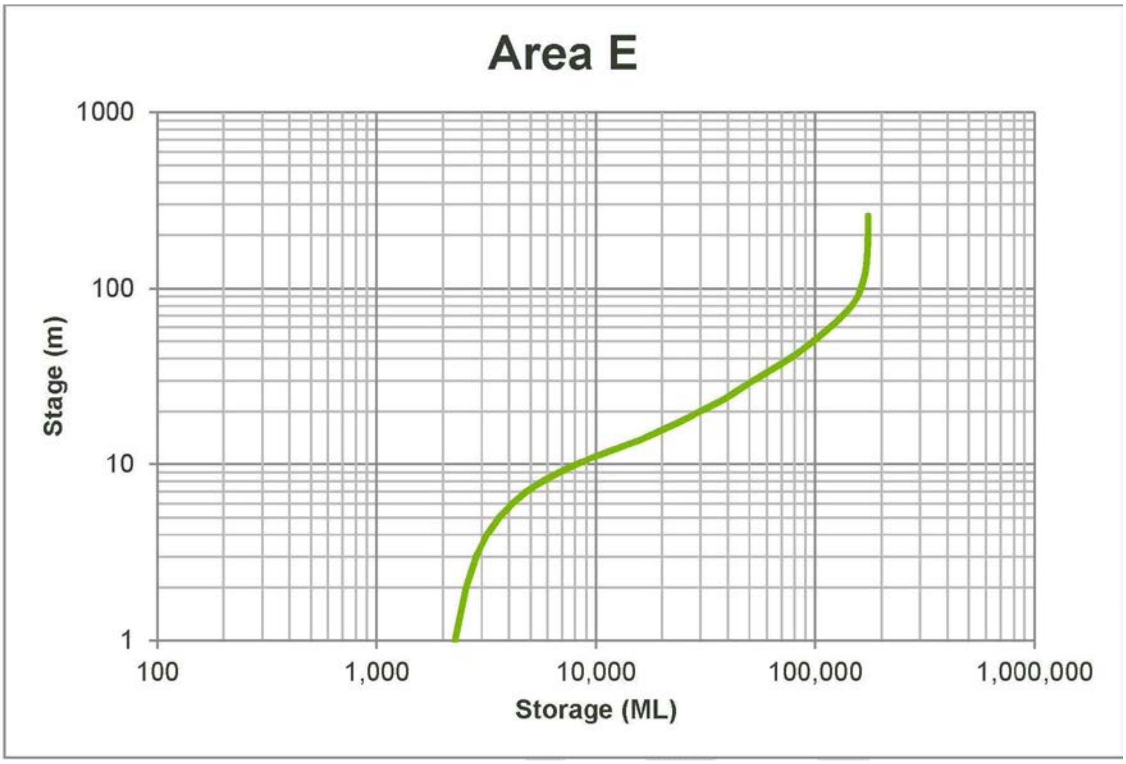
Area B Brisbane River upstream of Burtons Bridge



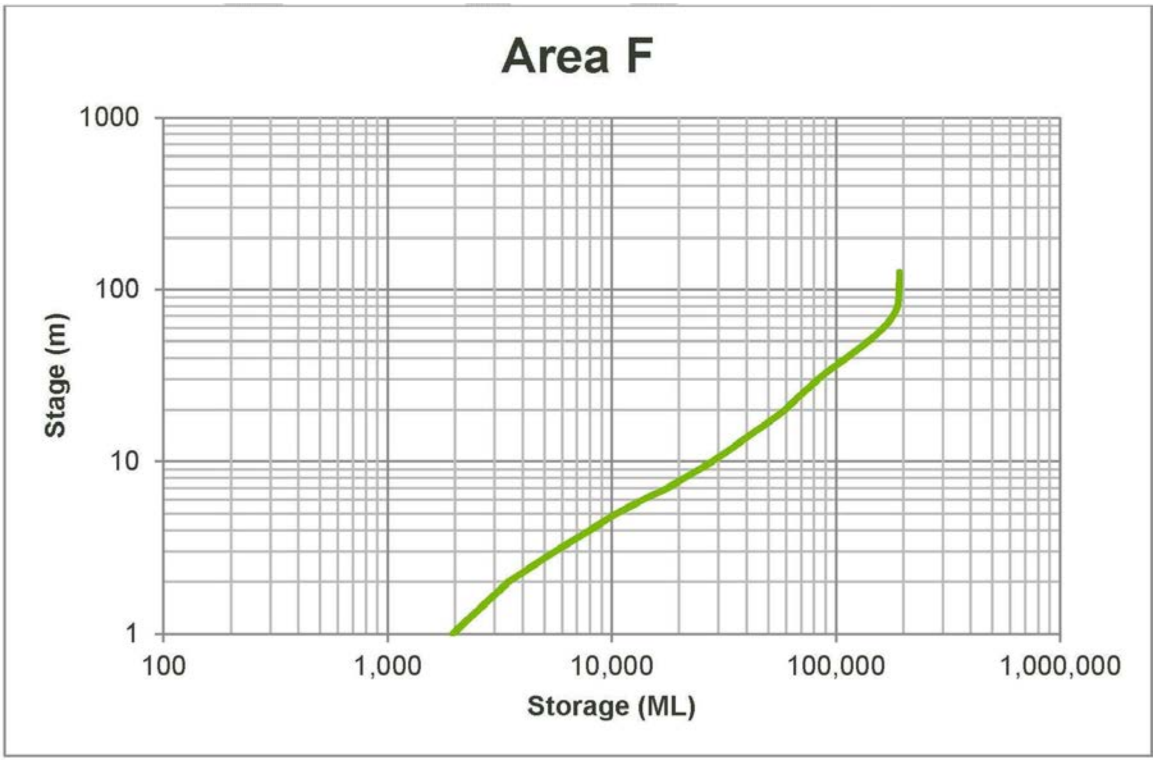
Area C Bremer River upstream of Berrys Lagoon



Area D Brisbane river upstream of Moggill



Area E Brisbane River upstream of Jindalee

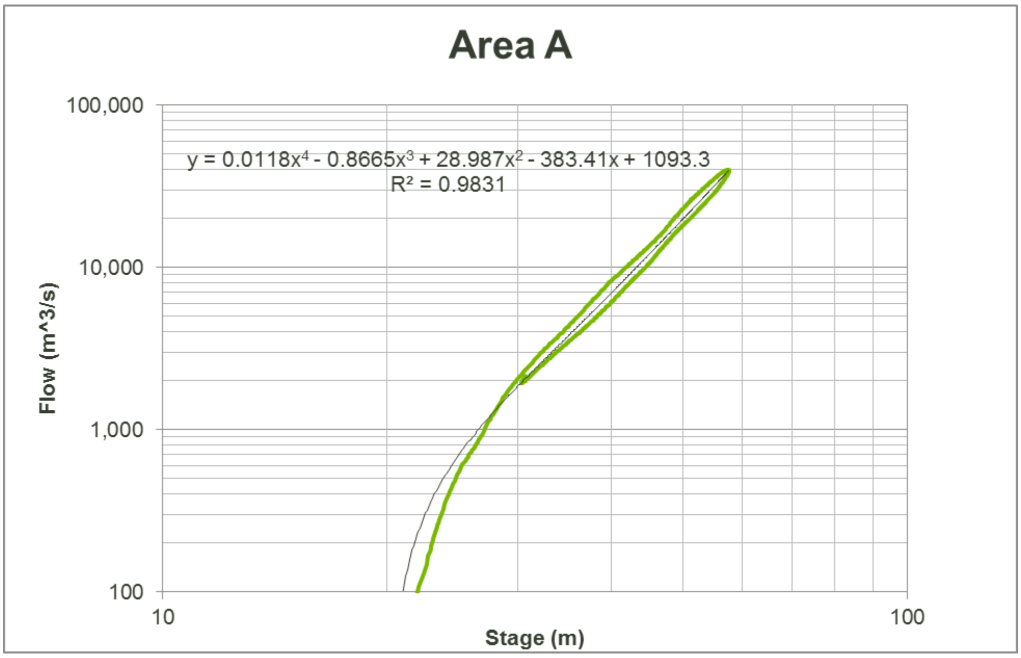


Area F Brisbane River and Oxley Creek junction

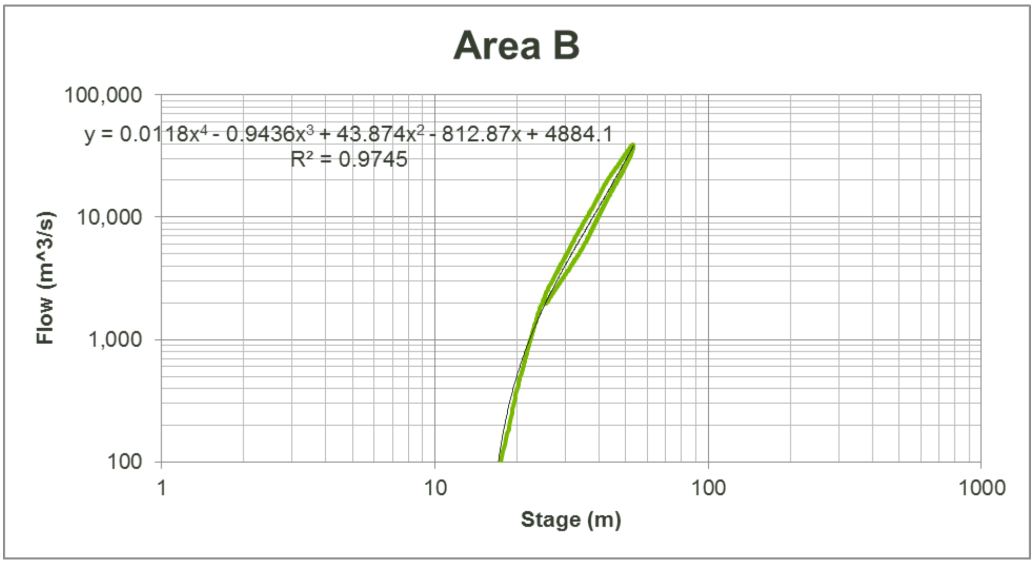
Discharge – Stage relationships

Derived from BCC DMT Tuflow model simulations:

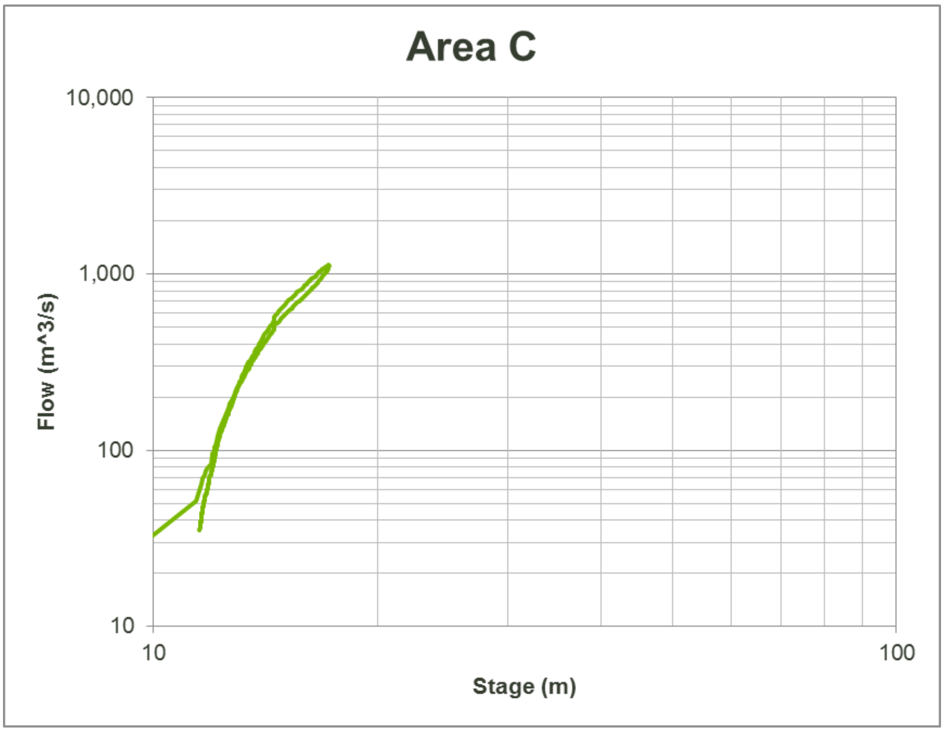
- br_prf_WDOF0.5TWL1.5_r2_GPU+20m_PO
- br_prf_WDOF1TWL1.75_r2_GPU+20m_PO
- br_prf_WDOF2.5TWL2.25_r2_GPU+20m_PO
- br_prf_WDOF2TWL2.25_r2_GPU+20m_PO
- br_prf_WDOF4TWL2.75_r2_GPU+20m_PO
- br_prf_WDOF6TWL3_r2_GPU+20m_PO



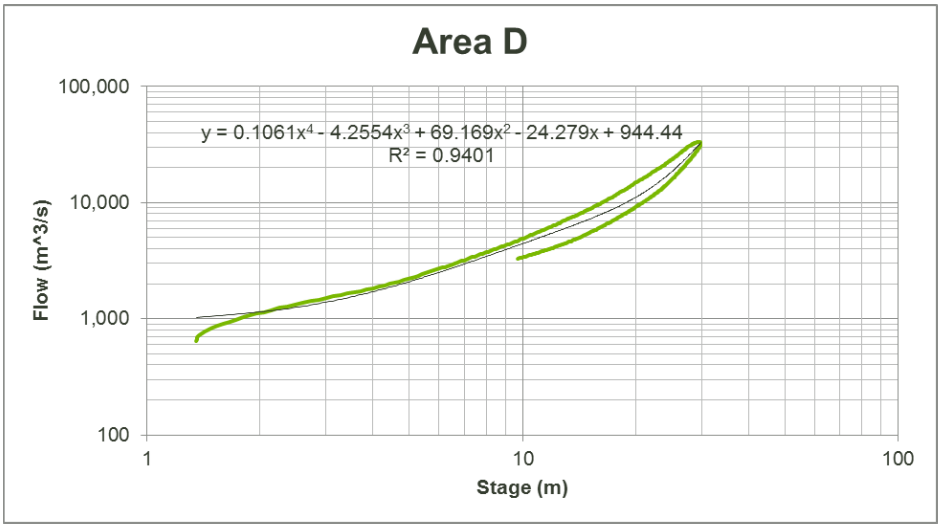
Area A Brisbane River upstream of Savages Crossing



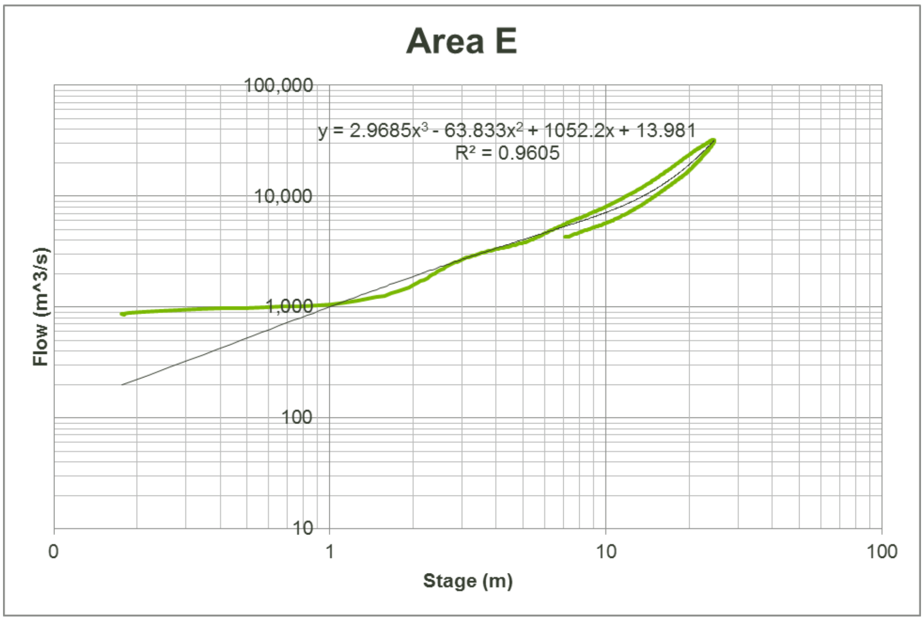
Area B Brisbane River upstream of Burtons Bridge



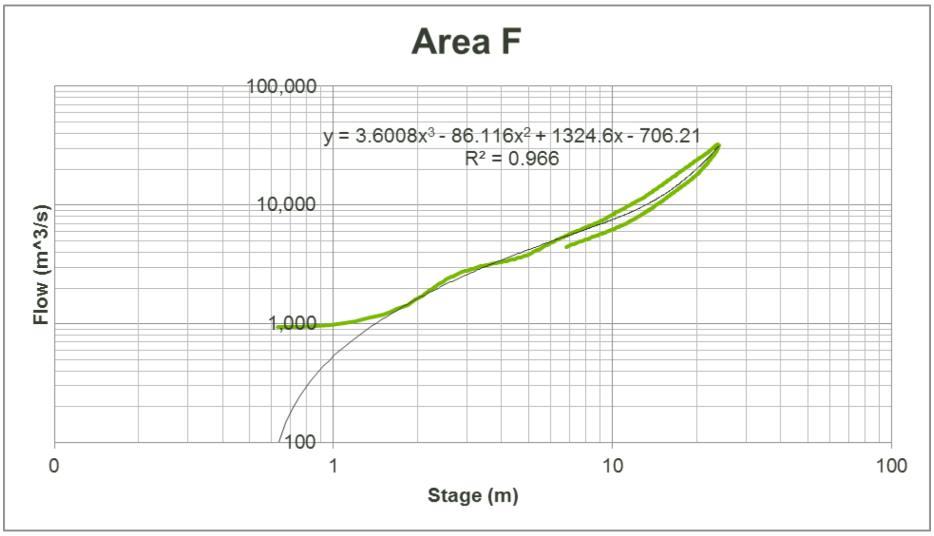
Area C Bremer River upstream of Berrys Lagoon



Area D Brisbane River upstream of Moggill

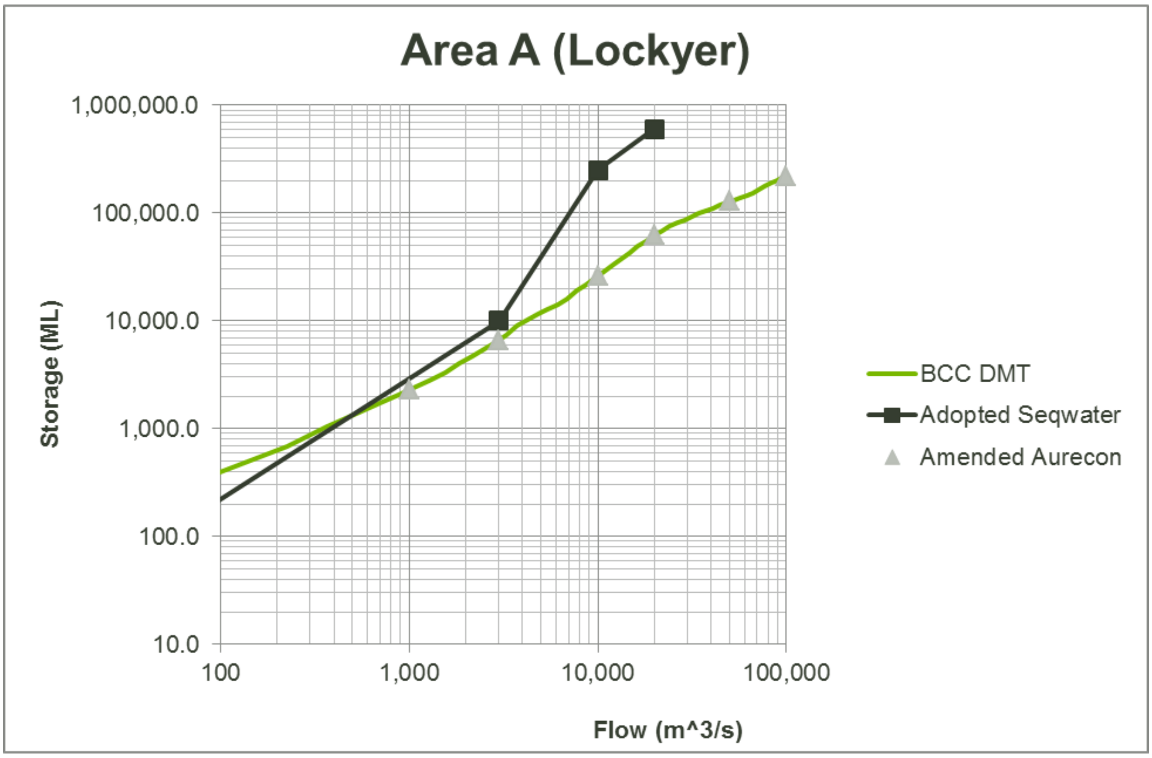


Area E Brisbane River upstream of Jindalee

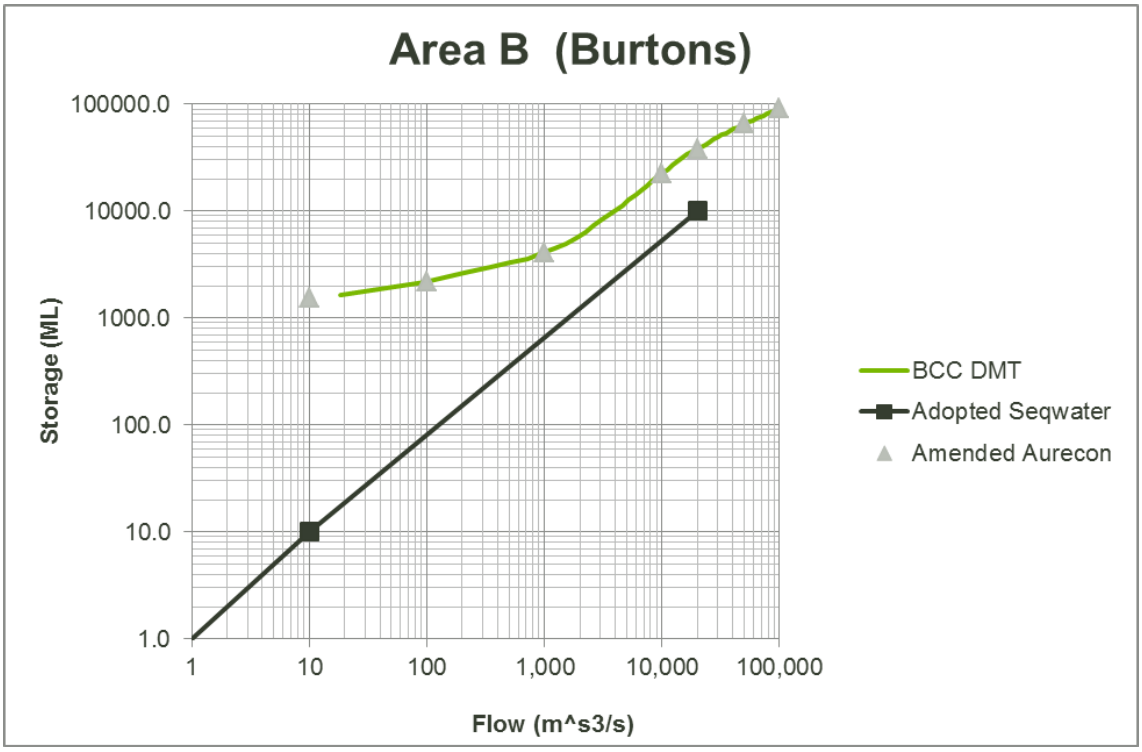


Area F Brisbane River and Oxley creek junction

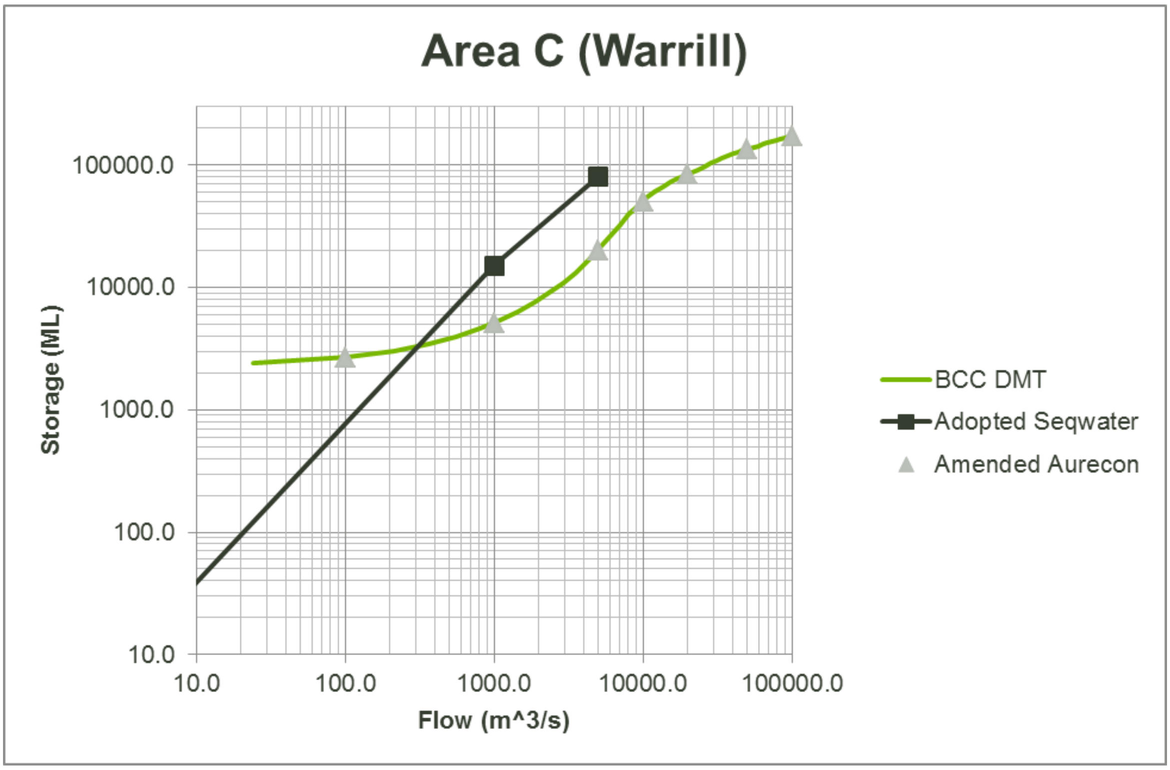
Storage – Discharge relationships



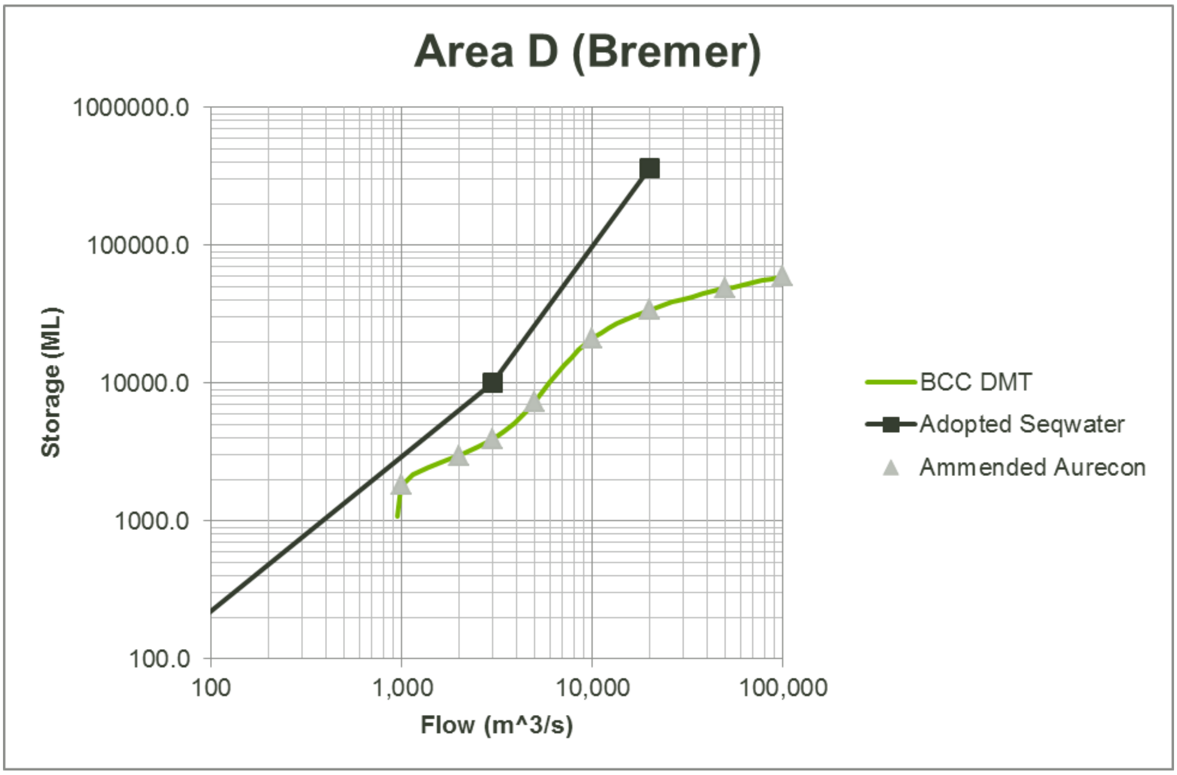
Area A Brisbane river upstream of Savages Crossing



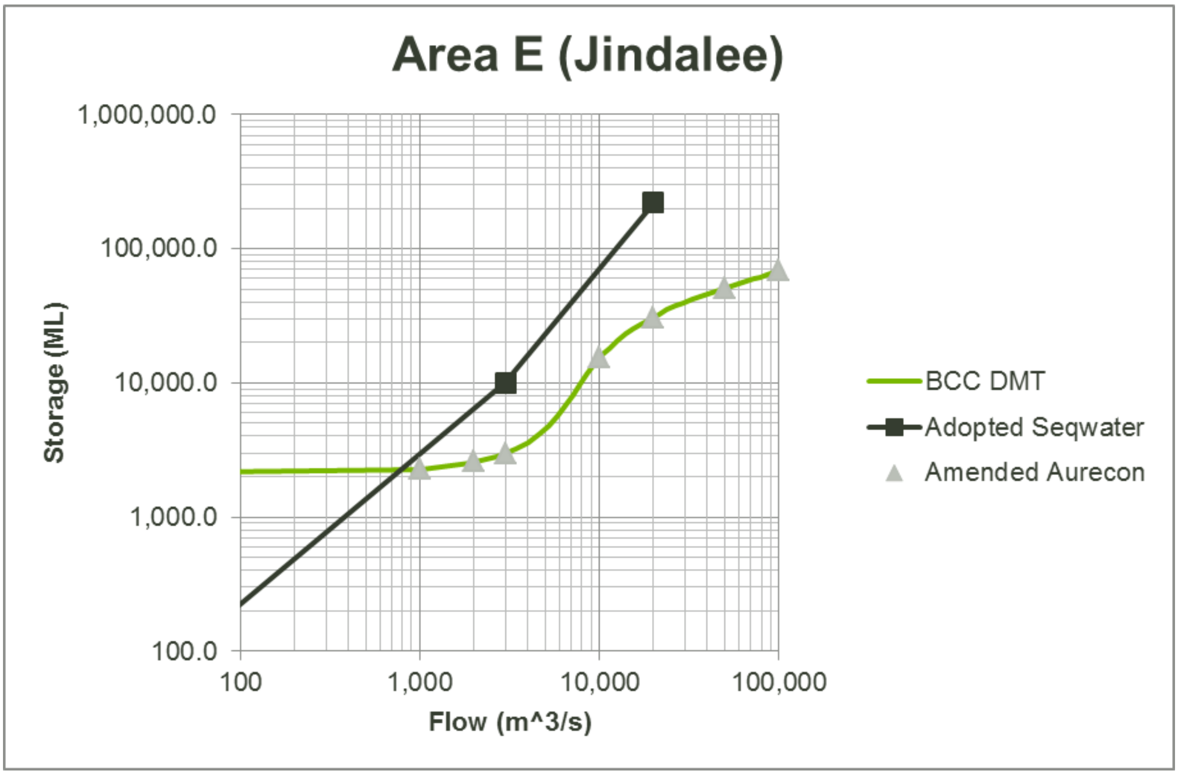
Area B Brisbane River upstream of Burtons Bridge



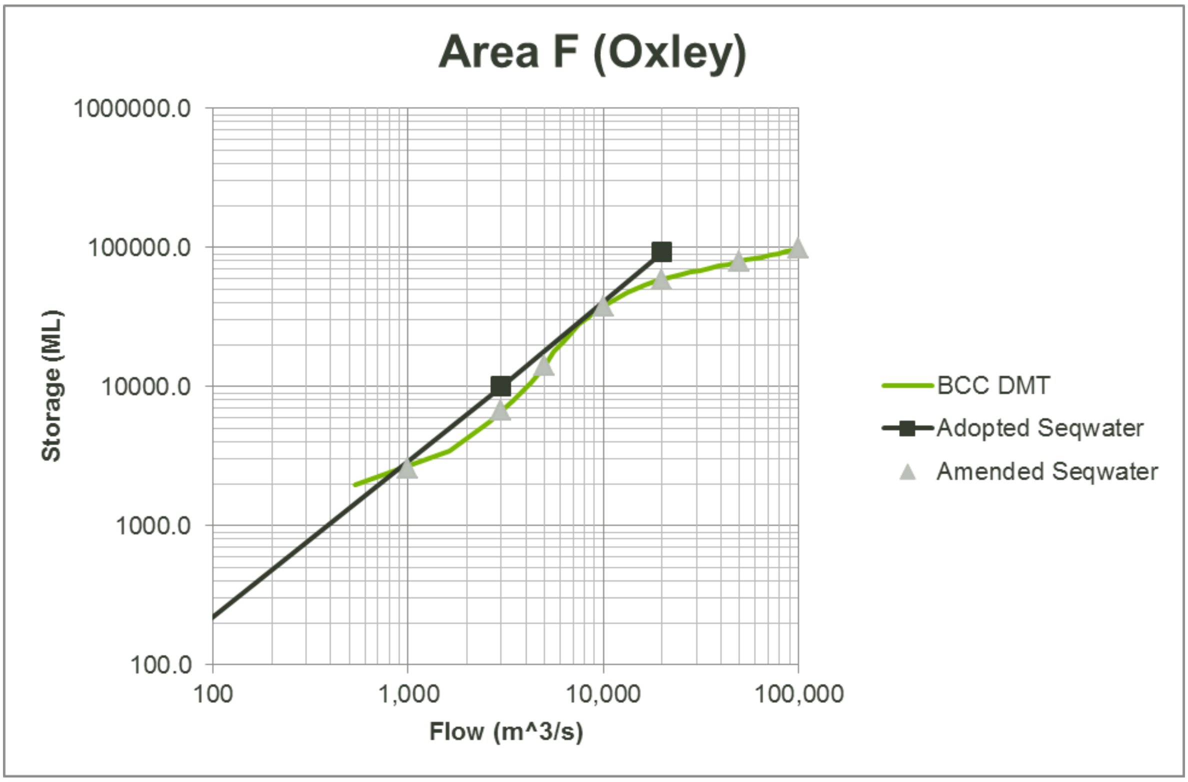
Area C Bremer River upstream of Berrys Lagoon



Area D Brisbane River upstream of Moggill



Area E Brisbane River upstream of Jindalee



Area F Brisbane River and Oxley Creek junction

URBS model assessments

Three cases were assessed:

- Storages modified based on BCC TUFLOW model
- Storages A, C, D, E & F with high flow volumes reduced 10%
- Storages A, C, D, E & F with high flow volumes reduced 10%

For each case, the URBS model was run with α = 0.15. The α value was then modified until the best match of peaks across all events and locations occurred.

Adopted α values were:

- α = 0.5 for storages modified based on BCC TUFLOW model
- α = 0.18 for storages A, C, D, E & F with high flow volumes reduced 10%
- α = 0.19 for storages A, C, D, E & F with high flow volumes reduced 10%

Only six of the larger events were assessed:

- March 1955
- January 1968
- January 1974
- May 1996
- January 1996
- January 2013

The following tables present the peak flows, volumes and peak water levels for each of the three modelled cases respectively. These tables also present the differences in flow, volume and water level. Figures 1 to 6 present the modelled hydrographs at the Brisbane City Gauge for the six events respectively.

Peak flow, volume and peak level for storages modified based on BCC TUFLOW model – With and without modification to Alpha

Event	Location	Recommended Parameters			All Storages Modified based on BCC TUFLOW Model						With Alpha Increased to 0.5					
		Peak Flow (m^3/s)	Volume (ML)	Peak Level (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)
Mar-55	Mt Crosby Weir	7367	1532146	23.06	8853	20.16%	1534762	0.17%	24.92	1.86	7495	1.73%	1525491	-0.43%	23.23	0.17
	Colleges Crossing	7366	1530863	22.16	8851	20.15%	1533500	0.17%	24.17	2.01	7495	1.75%	1523757	-0.46%	22.34	0.18
	Ipswich	1260	162937	16.61	1386	10.03%	163086	0.09%	19.5	2.89	1287	2.19%	162919	-0.01%	16.73	0.12
	Moggill	7716	1696905	15.66	10092	30.80%	1702018	0.30%	18.2	2.54	7907	2.47%	1687828	-0.53%	15.89	0.23
	Goodna	7717	1702117	14.7	10096	30.84%	1707242	0.30%	17.41	2.71	7904	2.42%	1692265	-0.58%	14.93	0.23
	Jindalee	7520	1702860	10.64	10097	34.27%	1710343	0.44%	13.48	2.84	7760	3.19%	1691629	-0.66%	10.92	0.28
	Centenary Bridge	7521	1710119	9.95	10108	34.40%	1717607	0.44%	12.69	2.74	7761	3.19%	1698587	-0.67%	10.22	0.27
	Brisbane City	7486	1724354	3.84	10095	34.85%	1734360	0.58%	4.82	0.98	7725	3.19%	1709670	-0.85%	3.79	-0.05
Jan-68	Mt Crosby Weir	3832	1385105	17.4	3840	0.20%	1384705	-0.03%	17.41	0.01	3852	0.51%	1384570	-0.04%	17.44	0.04
	Colleges Crossing	3831	1385606	16.2	3840	0.22%	1385177	-0.03%	16.22	0.02	3850	0.49%	1385034	-0.04%	16.24	0.04
	Ipswich	725	226584	10.65	728	0.33%	226569	-0.01%	10.65	0.00	728	0.42%	226563	-0.01%	10.66	0.01
	Moggill	4036	1637264	8.61	4030	-0.15%	1636673	-0.04%	8.59	-0.02	4043	0.16%	1636474	-0.05%	8.63	0.02
	Goodna	4038	1653840	9.16	4031	-0.16%	1653189	-0.04%	9.15	-0.01	4044	0.15%	1652969	-0.05%	9.17	0.01
	Jindalee	4016	1670356	5.24	4010	-0.14%	1669592	-0.05%	5.22	-0.02	4024	0.20%	1669334	-0.06%	5.26	0.02
	Centenary Bridge	4017	1688214	4.84	4011	-0.14%	1687426	-0.05%	4.82	-0.02	4025	0.19%	1687159	-0.06%	4.85	0.01
	Brisbane City	4013	1745388	2.39	4007	-0.16%	1744331	-0.06%	2.37	-0.02	4020	0.16%	1743973	-0.08%	2.37	-0.02
Jan-74	Mt Crosby Weir	10236	2329070	26.55	10298	0.60%	2327107	-0.08%	26.61	0.06	10384	1.45%	2326446	-0.11%	26.7	0.15
	Colleges Crossing	10235	2330570	25.88	10298	0.62%	2328476	-0.09%	25.95	0.07	10380	1.42%	2327767	-0.12%	26.05	0.17
	Ipswich	3677	645201	21.34	3725	1.31%	644988	-0.03%	21.34	0.00	3773	2.60%	644916	-0.04%	21.45	0.11
	Moggill	11524	3064791	19.78	11478	-0.39%	3061403	-0.11%	19.73	-0.05	11532	0.07%	3060233	-0.15%	19.78	0.00
	Goodna	11526	3124368	18.86	11481	-0.39%	3120515	-0.12%	18.81	-0.05	11533	0.06%	3119178	-0.17%	18.86	0.00
	Jindalee	11379	3167487	14.73	11354	-0.23%	3162650	-0.15%	14.71	-0.02	11422	0.38%	3160967	-0.21%	14.77	0.04
	Centenary Bridge	11380	3215344	13.83	11354	-0.23%	3210305	-0.16%	13.81	-0.02	11423	0.38%	3208547	-0.21%	13.87	0.04
	Brisbane City	11353	3362781	5.39	11325	-0.25%	3355307	-0.22%	5.44	0.05	11395	0.37%	3352673	-0.30%	5.47	0.08
May-96	Mt Crosby Weir	2657	757857	14.54	2634	-0.86%	757788	-0.01%	14.47	-0.07	2627	-1.12%	757764	-0.01%	14.46	-0.08
	Colleges Crossing	2662	759583	13.56	2639	-0.86%	759507	-0.01%	13.5	-0.06	2634	-1.04%	759481	-0.01%	13.49	-0.07
	Ipswich	1534	371191	11.52	1553	1.25%	371133	-0.02%	11.52	0.00	1574	2.60%	371113	-0.02%	11.59	0.07
	Moggill	3301	1193932	6.75	3237	-1.93%	1193672	-0.02%	6.59	-0.16	3220	-2.46%	1193581	-0.03%	6.55	-0.20
	Goodna	3379	1223892	7.85	3325	-1.60%	1223577	-0.03%	7.74	-0.11	3308	-2.11%	1223467	-0.03%	7.7	-0.15
	Jindalee	3448	1257998	4.26	3384	-1.86%	1257566	-0.03%	4.15	-0.11	3367	-2.37%	1257412	-0.05%	4.12	-0.14
	Centenary Bridge	3576	1296663	4.12	3494	-2.29%	1296207	-0.04%	3.99	-0.13	3471	-2.93%	1296045	-0.05%	3.95	-0.17
	Brisbane City	3729	1389388	2.17	3641	-2.36%	1388600	-0.06%	2.18	0.01	3617	-3.01%	1388312	-0.08%	2.18	0.01
Jan-11	Mt Crosby Weir	7662	3450461	23.44	7720	0.75%	3448559	-0.06%	23.51	0.07	7794	1.73%	3447910	-0.07%	23.61	0.17
	Colleges Crossing	7664	3450368	22.58	7718	0.70%	3448280	-0.06%	22.65	0.07	7793	1.68%	3447560	-0.08%	22.76	0.18

Event	Location	Recommended Parameters			All Storages Modified based on BCC TUFLOW Model						With Alpha Increased to 0.5					
		Peak Flow (m^3/s)	Volume (ML)	Peak Level (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)
	Ipswich	2437	479756	19.62	2484	1.90%	479343	-0.09%	19.52	-0.10	2531	3.84%	479210	-0.11%	19.6	-0.02
	Moggill	9252	3951405	17.35	9313	0.66%	3947529	-0.10%	17.41	0.06	9433	1.95%	3946307	-0.13%	17.53	0.18
	Goodna	9253	3961490	16.5	9314	0.66%	3957263	-0.11%	16.57	0.07	9435	1.96%	3955995	-0.14%	16.7	0.20
	Jindalee	9029	3969394	12.37	9120	1.01%	3965237	-0.10%	12.48	0.11	9270	2.66%	3963906	-0.14%	12.64	0.27
	Centenary Bridge	9029	3987292	11.59	9124	1.06%	3983062	-0.11%	11.69	0.10	9270	2.68%	3981655	-0.14%	11.84	0.25
	Brisbane City	8990	4018337	4.55	9079	1.00%	4010009	-0.21%	4.5	-0.05	9228	2.65%	4006314	-0.30%	4.56	0.01
Jan-13	Mt Crosby Weir	2589	1251744	14.35	2579	-0.38%	1251423	-0.03%	14.32	-0.03	2574	-0.59%	1251315	-0.03%	14.31	-0.04
	Colleges Crossing	2588	1252293	13.37	2577	-0.41%	1251950	-0.03%	13.35	-0.02	2574	-0.51%	1251836	-0.04%	13.34	-0.03
	Ipswich	1844	318735	12.91	1876	1.74%	318699	-0.01%	13.01	0.10	1909	3.53%	318687	-0.02%	13.14	0.23
	Moggill	3581	1599659	7.45	3502	-2.21%	1599128	-0.03%	7.26	-0.19	3466	-3.23%	1598950	-0.04%	7.16	-0.29
	Goodna	3582	1611717	8.27	3502	-2.23%	1611124	-0.04%	8.11	-0.16	3467	-3.23%	1610924	-0.05%	8.03	-0.24
	Jindalee	3526	1625266	4.39	3456	-1.98%	1624552	-0.04%	4.28	-0.11	3429	-2.73%	1624305	-0.06%	4.23	-0.16
	Centenary Bridge	3526	1642465	4.04	3457	-1.95%	1641723	-0.05%	3.93	-0.11	3429	-2.74%	1641464	-0.06%	3.89	-0.15
	Brisbane City	3516	1686176	2.46	3447	-1.96%	1684893	-0.08%	2.38	-0.08	3421	-2.71%	1684391	-0.11%	2.36	-0.10

Peak flow, volume and peak level for storages A, C, D, E & F reduced 10% - With and without modification to Alpha

Event	Location	Recommended Parameters			Storages A, C, D, E & F Reduced 10%						With Alpha Increased to 0.18					
		Peak Flow (m^3/s)	Volume (ML)	Peak Level (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)
Mar-55	Mt Crosby Weir	7367	1532146	23.06	7441	1.01%	1532146	0.00%	23.16	0.1	7426	0.80%	1527165	-0.33%	23.14	0.08
	Colleges Crossing	7366	1530863	22.16	7442	1.03%	1530863	0.00%	22.27	0.11	7425	0.80%	1525542	-0.35%	22.24	0.08
	Ipswich	1260	162937	16.61	1273	1.05%	162937	0.00%	16.81	0.20	1273	1.02%	162923	-0.01%	16.59	-0.02
	Moggill	7716	1696905	15.66	7869	1.99%	1696905	0.00%	15.84	0.18	7783	0.87%	1690101	-0.40%	15.74	0.08
	Goodna	7717	1702117	14.7	7870	1.99%	1702116	0.00%	14.89	0.19	7781	0.83%	1694731	-0.43%	14.78	0.08
	Jindalee	7520	1702860	10.64	7694	2.30%	1702860	0.00%	10.84	0.20	7612	1.22%	1694440	-0.49%	10.75	0.11
	Centenary Bridge	7521	1710119	9.95	7696	2.33%	1710119	0.00%	10.14	0.19	7614	1.24%	1701476	-0.51%	10.05	0.10
	Brisbane City	7486	1724354	3.84	7662	2.35%	1724354	0.00%	3.98	0.14	7576	1.20%	1713349	-0.64%	3.73	-0.11
Jan-68	Mt Crosby Weir	3832	1385105	17.4	3845	0.34%	1385105	0.00%	17.43	0.03	3840	0.20%	1384705	-0.03%	17.41	0.01
	Colleges Crossing	3831	1385606	16.2	3845	0.36%	1385606	0.00%	16.23	0.03	3840	0.22%	1385177	-0.03%	16.22	0.02
	Ipswich	725	226584	10.65	725	0.00%	226584	0.00%	10.66	0.01	728	0.33%	226569	-0.01%	10.65	0.00
	Moggill	4036	1637264	8.61	4055	0.48%	1637264	0.00%	8.67	0.06	4030	-0.15%	1636673	-0.04%	8.59	-0.02
	Goodna	4038	1653840	9.16	4057	0.47%	1653840	0.00%	9.2	0.04	4031	-0.16%	1653189	-0.04%	9.15	-0.01
	Jindalee	4016	1670356	5.24	4037	0.51%	1670356	0.00%	5.28	0.04	4010	-0.14%	1669592	-0.05%	5.22	-0.02
	Centenary Bridge	4017	1688214	4.84	4037	0.50%	1688214	0.00%	4.88	0.04	4011	-0.14%	1687426	-0.05%	4.82	-0.02
	Brisbane City	4013	1745388	2.39	4034	0.52%	1745388	0.00%	2.4	0.01	4007	-0.16%	1744331	-0.06%	2.37	-0.02

Event	Location	Recommended Parameters			Storages A, C, D, E & F Reduced 10%						With Alpha Increased to 0.18					
		Peak Flow (m^3/s)	Volume (ML)	Peak Level (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)
Jan-74	Mt Crosby Weir	10236	2329070	26.55	10315	0.76%	2329071	0.00%	26.63	0.08	10298	0.60%	2327107	-0.08%	26.61	0.06
	Colleges Crossing	10235	2330570	25.88	10316	0.79%	2330570	0.00%	25.97	0.09	10298	0.62%	2328476	-0.09%	25.95	0.07
	Ipswich	3677	645201	21.34	3728	1.38%	645200	0.00%	21.5	0.16	3725	1.31%	644988	-0.03%	21.34	0.00
	Moggill	11524	3064791	19.78	11621	0.84%	3064792	0.00%	19.88	0.10	11478	-0.39%	3061403	-0.11%	19.73	-0.05
	Goodna	11526	3124368	18.86	11624	0.85%	3124368	0.00%	18.95	0.09	11481	-0.39%	3120515	-0.12%	18.81	-0.05
	Jindalee	11379	3167487	14.73	11498	1.04%	3167487	0.00%	14.85	0.12	11354	-0.23%	3162650	-0.15%	14.71	-0.02
	Centenary Bridge	11380	3215344	13.83	11498	1.04%	3215344	0.00%	13.95	0.12	11354	-0.23%	3210305	-0.16%	13.81	-0.02
	Brisbane City	11353	3362781	5.39	11476	1.08%	3362783	0.00%	5.39	0.00	11325	-0.25%	3355307	-0.22%	5.44	0.05
May-96	Mt Crosby Weir	2657	757857	14.54	2657	0.00%	757857	0.00%	14.54	0.00	2634	-0.86%	757788	-0.01%	14.47	-0.07
	Colleges Crossing	2662	759583	13.56	2662	0.00%	759583	0.00%	13.56	0.00	2639	-0.86%	759507	-0.01%	13.5	-0.06
	Ipswich	1534	371191	11.52	1555	1.39%	371191	0.00%	11.6	0.08	1553	1.25%	371133	-0.02%	11.52	0.00
	Moggill	3301	1193932	6.75	3303	0.06%	1193932	0.00%	6.76	0.01	3237	-1.93%	1193672	-0.02%	6.59	-0.16
	Goodna	3379	1223892	7.85	3379	-0.01%	1223892	0.00%	7.85	0.00	3325	-1.60%	1223577	-0.03%	7.74	-0.11
	Jindalee	3448	1257998	4.26	3457	0.24%	1257998	0.00%	4.28	0.02	3384	-1.86%	1257566	-0.03%	4.15	-0.11
	Centenary Bridge	3576	1296663	4.12	3588	0.36%	1296663	0.00%	4.14	0.02	3494	-2.29%	1296207	-0.04%	3.99	-0.13
	Brisbane City	3729	1389388	2.17	3743	0.38%	1389388	0.00%	2.16	-0.01	3641	-2.36%	1388600	-0.06%	2.18	0.01
Jan-11	Mt Crosby Weir	7662	3450461	23.44	7751	1.16%	3450459	0.00%	23.55	0.11	7720	0.75%	3448559	-0.06%	23.51	0.07
	Colleges Crossing	7664	3450368	22.58	7751	1.14%	3450370	0.00%	22.7	0.12	7718	0.70%	3448280	-0.06%	22.65	0.07
	Ipswich	2437	479756	19.62	2484	1.93%	479756	0.00%	19.79	0.17	2484	1.90%	479343	-0.09%	19.52	-0.10
	Moggill	9252	3951405	17.35	9429	1.91%	3951404	0.00%	17.53	0.18	9313	0.66%	3947529	-0.10%	17.41	0.06
	Goodna	9253	3961490	16.5	9430	1.91%	3961491	0.00%	16.7	0.20	9314	0.66%	3957263	-0.11%	16.57	0.07
	Jindalee	9029	3969394	12.37	9228	2.20%	3969395	0.00%	12.6	0.23	9120	1.01%	3965237	-0.10%	12.48	0.11
	Centenary Bridge	9029	3987292	11.59	9229	2.22%	3987292	0.00%	11.8	0.21	9124	1.06%	3983062	-0.11%	11.69	0.10
	Brisbane City	8990	4018337	4.55	9190	2.23%	4018335	0.00%	4.65	0.10	9079	1.00%	4010009	-0.21%	4.5	-0.05
Jan-13	Mt Crosby Weir	2589	1251744	14.35	2589	0.00%	1251744	0.00%	14.35	0.00	2579	-0.38%	1251423	-0.03%	14.32	-0.03
	Colleges Crossing	2588	1252293	13.37	2588	0.00%	1252293	0.00%	13.37	0.00	2577	-0.41%	1251950	-0.03%	13.35	-0.02
	Ipswich	1844	318735	12.91	1875	1.71%	318735	0.00%	13.02	0.11	1876	1.74%	318699	-0.01%	13.01	0.10
	Moggill	3581	1599659	7.45	3576	-0.15%	1599659	0.00%	7.44	-0.01	3502	-2.21%	1599128	-0.03%	7.26	-0.19
	Goodna	3582	1611717	8.27	3577	-0.15%	1611717	0.00%	8.26	-0.01	3502	-2.23%	1611124	-0.04%	8.11	-0.16
	Jindalee	3526	1625266	4.39	3530	0.13%	1625266	0.00%	4.4	0.01	3456	-1.98%	1624552	-0.04%	4.28	-0.11
	Centenary Bridge	3526	1642465	4.04	3531	0.15%	1642465	0.00%	4.05	0.01	3457	-1.95%	1641723	-0.05%	3.93	-0.11
	Brisbane City	3516	1686176	2.46	3523	0.19%	1686176	0.00%	2.46	0.00	3447	-1.96%	1684893	-0.08%	2.38	-0.08

Peak flow, volume and peak level for storages A, C, D, E & F reduced 10% - With and without modification to Alpha

Event	Location	Recommended Parameters			Storages A, C, D, E & F Reduced 20%						With Alpha Increased to 0.19					
		Peak Flow (m^3/s)	Volume (ML)	Peak Level (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)
Mar-55	Mt Crosby Weir	7367	1532146	23.06	7521	2.08%	1532146	0.00%	23.26	0.2	7495	1.73%	1525491	-0.43%	23.23	0.17
	Colleges Crossing	7366	1530863	22.16	7518	2.06%	1530863	0.00%	22.37	0.21	7495	1.75%	1523757	-0.46%	22.34	0.18
	Ipswich	1260	162937	16.61	1287	2.20%	162937	0.00%	17.02	0.41	1287	2.19%	162919	-0.01%	16.73	0.12
	Moggill	7716	1696905	15.66	8026	4.02%	1696904	0.00%	16.03	0.37	7907	2.47%	1687828	-0.53%	15.89	0.23
	Goodna	7717	1702117	14.7	8027	4.02%	1702117	0.00%	15.08	0.38	7904	2.42%	1692265	-0.58%	14.93	0.23
	Jindalee	7520	1702860	10.64	7875	4.72%	1702860	0.00%	11.04	0.40	7760	3.19%	1691629	-0.66%	10.92	0.28
	Centenary Bridge	7521	1710119	9.95	7876	4.73%	1710119	0.00%	10.34	0.39	7761	3.19%	1698587	-0.67%	10.22	0.27
	Brisbane City	7486	1724354	3.84	7848	4.83%	1724354	0.00%	4.12	0.28	7725	3.19%	1709670	-0.85%	3.79	-0.05
Jan-68	Mt Crosby Weir	3832	1385105	17.4	3858	0.68%	1385105	0.00%	17.46	0.06	3852	0.51%	1384570	-0.04%	17.44	0.04
	Colleges Crossing	3831	1385606	16.2	3859	0.72%	1385606	0.00%	16.26	0.06	3850	0.49%	1385034	-0.04%	16.24	0.04
	Ipswich	725	226584	10.65	725	0.00%	226584	0.00%	10.67	0.02	728	0.42%	226563	-0.01%	10.66	0.01
	Moggill	4036	1637264	8.61	4075	0.97%	1637264	0.00%	8.73	0.12	4043	0.16%	1636474	-0.05%	8.63	0.02
	Goodna	4038	1653840	9.16	4077	0.96%	1653840	0.00%	9.23	0.07	4044	0.15%	1652969	-0.05%	9.17	0.01
	Jindalee	4016	1670356	5.24	4059	1.06%	1670356	0.00%	5.33	0.09	4024	0.20%	1669334	-0.06%	5.26	0.02
	Centenary Bridge	4017	1688214	4.84	4060	1.06%	1688214	0.00%	4.93	0.09	4025	0.19%	1687159	-0.06%	4.85	0.01
	Brisbane City	4013	1745388	2.39	4056	1.08%	1745388	0.00%	2.41	0.02	4020	0.16%	1743973	-0.08%	2.37	-0.02
Jan-74	Mt Crosby Weir	10236	2329070	26.55	10409	1.68%	2329071	0.00%	26.73	0.18	10384	1.45%	2326446	-0.11%	26.7	0.15
	Colleges Crossing	10235	2330570	25.88	10409	1.71%	2330570	0.00%	26.08	0.20	10380	1.42%	2327767	-0.12%	26.05	0.17
	Ipswich	3677	645201	21.34	3782	2.86%	645201	0.00%	21.66	0.32	3773	2.60%	644916	-0.04%	21.45	0.11
	Moggill	11524	3064791	19.78	11718	1.69%	3064791	0.00%	19.99	0.21	11532	0.07%	3060233	-0.15%	19.78	0.00
	Goodna	11526	3124368	18.86	11722	1.70%	3124369	0.00%	19.05	0.19	11533	0.06%	3119178	-0.17%	18.86	0.00
	Jindalee	11379	3167487	14.73	11617	2.08%	3167486	0.00%	14.96	0.23	11422	0.38%	3160967	-0.21%	14.77	0.04
	Centenary Bridge	11380	3215344	13.83	11617	2.08%	3215344	0.00%	14.06	0.23	11423	0.38%	3208547	-0.21%	13.87	0.04
	Brisbane City	11353	3362781	5.39	11597	2.15%	3362783	0.00%	5.45	0.06	11395	0.37%	3352673	-0.30%	5.47	0.08
May-96	Mt Crosby Weir	2657	757857	14.54	2657	0.00%	757857	0.00%	14.54	0.00	2627	-1.12%	757764	-0.01%	14.46	-0.08
	Colleges Crossing	2662	759583	13.56	2662	0.00%	759583	0.00%	13.56	0.00	2634	-1.04%	759481	-0.01%	13.49	-0.07
	Ipswich	1534	371191	11.52	1579	2.92%	371191	0.00%	11.68	0.16	1574	2.60%	371113	-0.02%	11.59	0.07
	Moggill	3301	1193932	6.75	3307	0.17%	1193933	0.00%	6.77	0.02	3220	-2.46%	1193581	-0.03%	6.55	-0.20
	Goodna	3379	1223892	7.85	3381	0.05%	1223892	0.00%	7.86	0.01	3308	-2.11%	1223467	-0.03%	7.7	-0.15
	Jindalee	3448	1257998	4.26	3466	0.52%	1257998	0.00%	4.29	0.03	3367	-2.37%	1257412	-0.05%	4.12	-0.14
	Centenary Bridge	3576	1296663	4.12	3602	0.74%	1296664	0.00%	4.16	0.04	3471	-2.93%	1296045	-0.05%	3.95	-0.17
	Brisbane City	3729	1389388	2.17	3757	0.76%	1389388	0.00%	2.16	-0.01	3617	-3.01%	1388312	-0.08%	2.18	0.01
Jan-11	Mt Crosby Weir	7662	3450461	23.44	7843	2.37%	3450458	0.00%	23.67	0.23	7794	1.73%	3447910	-0.07%	23.61	0.17
	Colleges Crossing	7664	3450368	22.58	7840	2.29%	3450369	0.00%	22.82	0.24	7793	1.68%	3447560	-0.08%	22.76	0.18

Event	Location	Recommended Parameters			Storages A, C, D, E & F Reduced 20%						With Alpha Increased to 0.19					
		Peak Flow (m^3/s)	Volume (ML)	Peak Level (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)
	Ipswich	2437	479756	19.62	2537	4.08%	479756	0.00%	19.96	0.34	2531	3.84%	479210	-0.11%	19.6	-0.02
	Moggill	9252	3951405	17.35	9615	3.92%	3951405	0.00%	17.72	0.37	9433	1.95%	3946307	-0.13%	17.53	0.18
	Goodna	9253	3961490	16.5	9616	3.92%	3961490	0.00%	16.9	0.40	9435	1.96%	3955995	-0.14%	16.7	0.20
	Jindalee	9029	3969394	12.37	9434	4.48%	3969395	0.00%	12.81	0.44	9270	2.66%	3963906	-0.14%	12.64	0.27
	Centenary Bridge	9029	3987292	11.59	9437	4.52%	3987292	0.00%	12.01	0.42	9270	2.68%	3981655	-0.14%	11.84	0.25
	Brisbane City	8990	4018337	4.55	9395	4.51%	4018335	0.00%	4.74	0.19	9228	2.65%	4006314	-0.30%	4.56	0.01
Jan-13	Mt Crosby Weir	2589	1251744	14.35	2589	0.00%	1251744	0.00%	14.35	0.00	2574	-0.59%	1251315	-0.03%	14.31	-0.04
	Colleges Crossing	2588	1252293	13.37	2588	0.00%	1252293	0.00%	13.37	0.00	2574	-0.51%	1251836	-0.04%	13.34	-0.03
	Ipswich	1844	318735	12.91	1906	3.36%	318735	0.00%	13.15	0.24	1909	3.53%	318687	-0.02%	13.14	0.23
	Moggill	3581	1599659	7.45	3568	-0.39%	1599659	0.00%	7.42	-0.03	3466	-3.23%	1598950	-0.04%	7.16	-0.29
	Goodna	3582	1611717	8.27	3568	-0.39%	1611717	0.00%	8.24	-0.03	3467	-3.23%	1610924	-0.05%	8.03	-0.24
	Jindalee	3526	1625266	4.39	3530	0.14%	1625266	0.00%	4.4	0.01	3429	-2.73%	1624305	-0.06%	4.23	-0.16
	Centenary Bridge	3526	1642465	4.04	3532	0.17%	1642465	0.00%	4.05	0.01	3429	-2.74%	1641464	-0.06%	3.89	-0.15
	Brisbane City	3516	1686176	2.46	3525	0.25%	1686176	0.00%	2.46	0.00	3421	-2.71%	1684391	-0.11%	2.36	-0.10

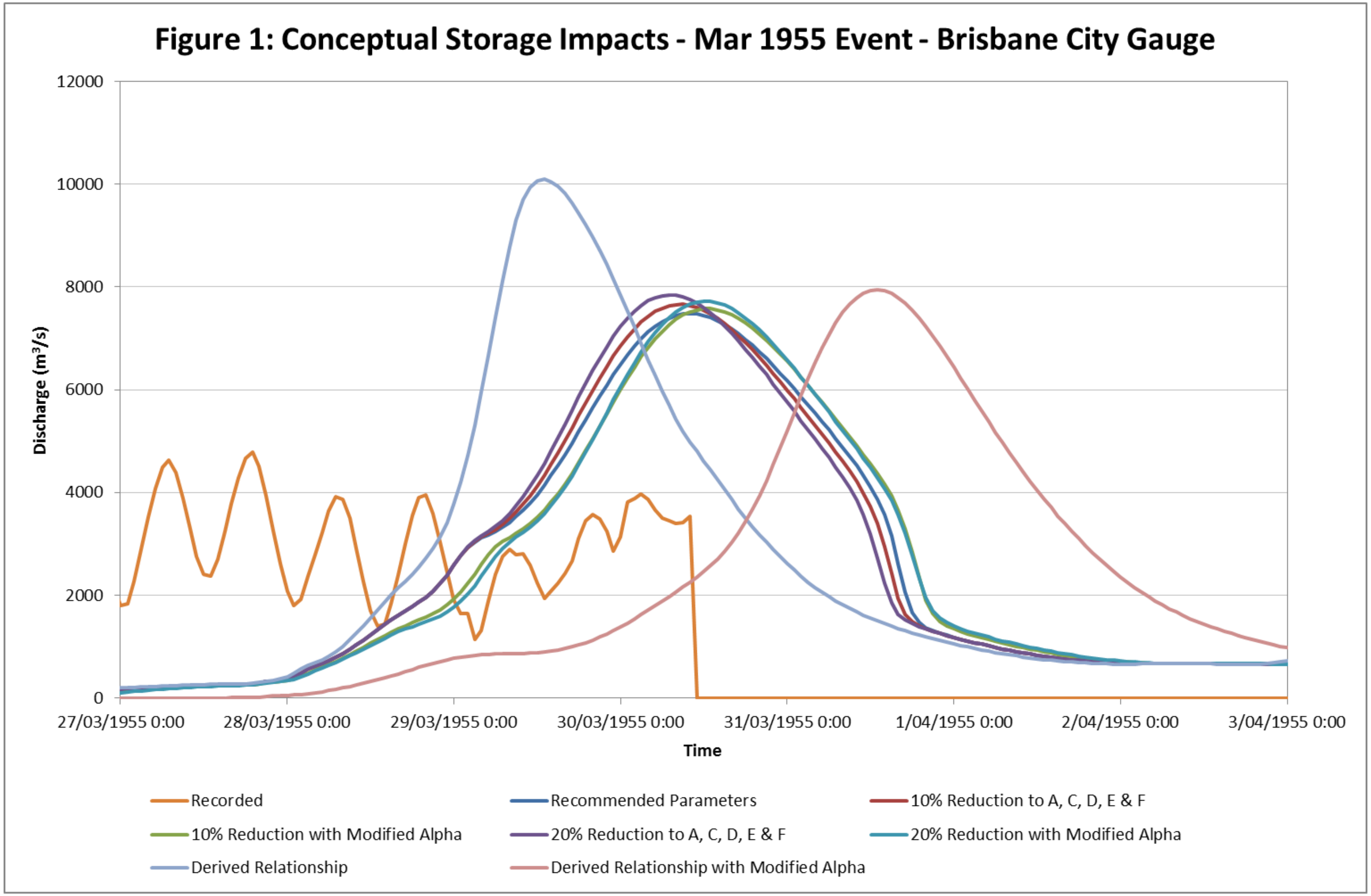


Figure 1: Conceptual Storage Impacts - Mar 1955 Event - Brisbane City Gauge
12000
10000
8000
6000
4000
2000
0
Discharge (m³/s)
27/03/1955 0:00
28/03/1955 0:00
29/03/1955 0:00
30/03/1955 0:00
31/03/1955 0:00
1/04/1955 0:00
2/04/1955 0:00
3/04/1955 0:00
Time
Recorded
Recommended Parameters
10% Reduction to A, C, D, E & F
10% Reduction with Modified Alpha
20% Reduction to A, C, D, E & F
20% Reduction with Modified Alpha
Derived Relationship
Derived Relationship with Modified Alpha

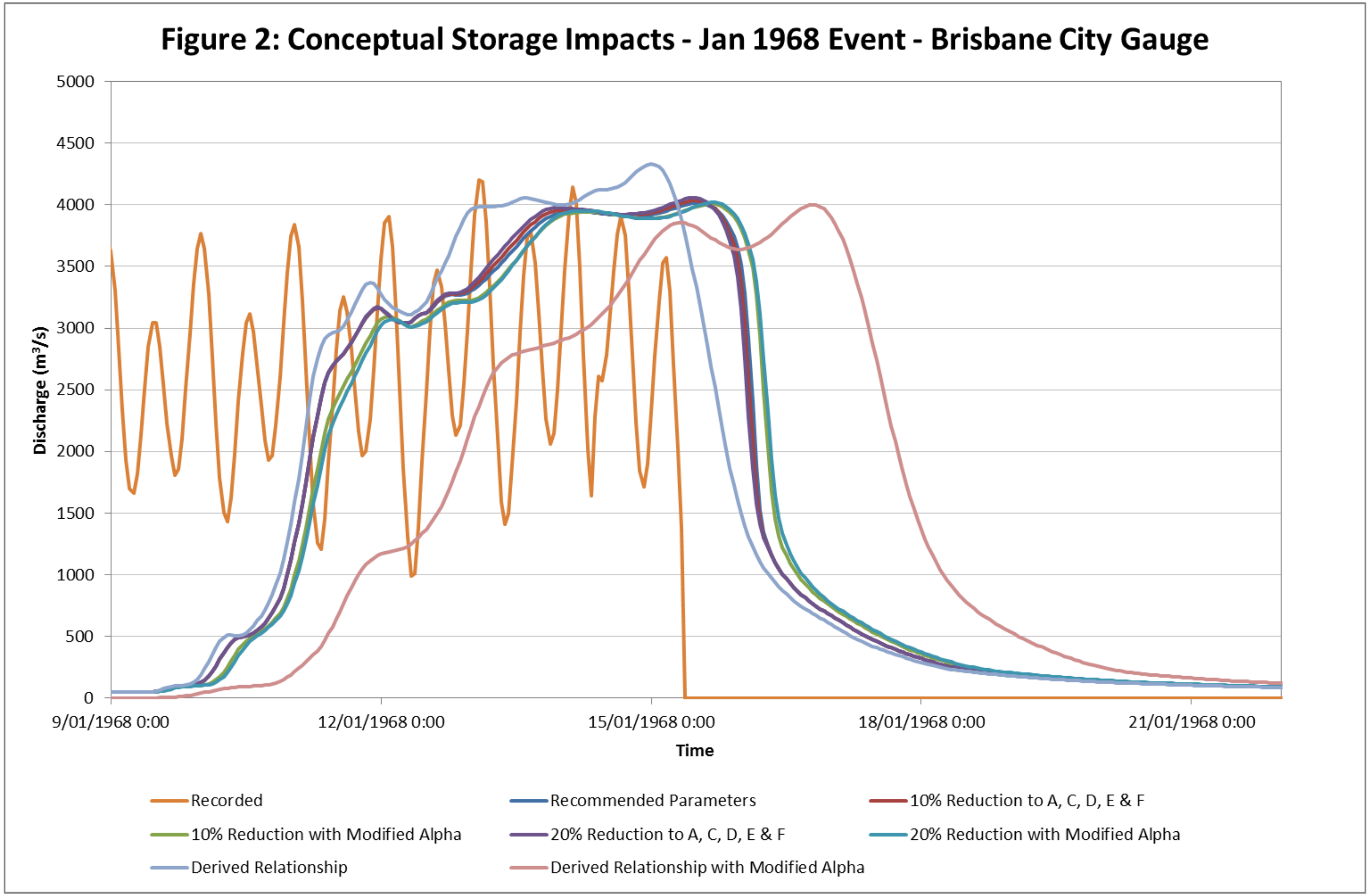


Figure 2: Conceptual Storage Impacts - Jan 1968 Event - Brisbane City Gauge
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Discharge (m³/s)
9/01/1968 0:00
12/01/1968 0:00
15/01/1968 0:00
18/01/1968 0:00
21/01/1968 0:00
Time
Recorded
Recommended Parameters
10% Reduction to A, C, D, E & F
10% Reduction with Modified Alpha
20% Reduction to A, C, D, E & F
20% Reduction with Modified Alpha
Derived Relationship
Derived Relationship with Modified Alpha

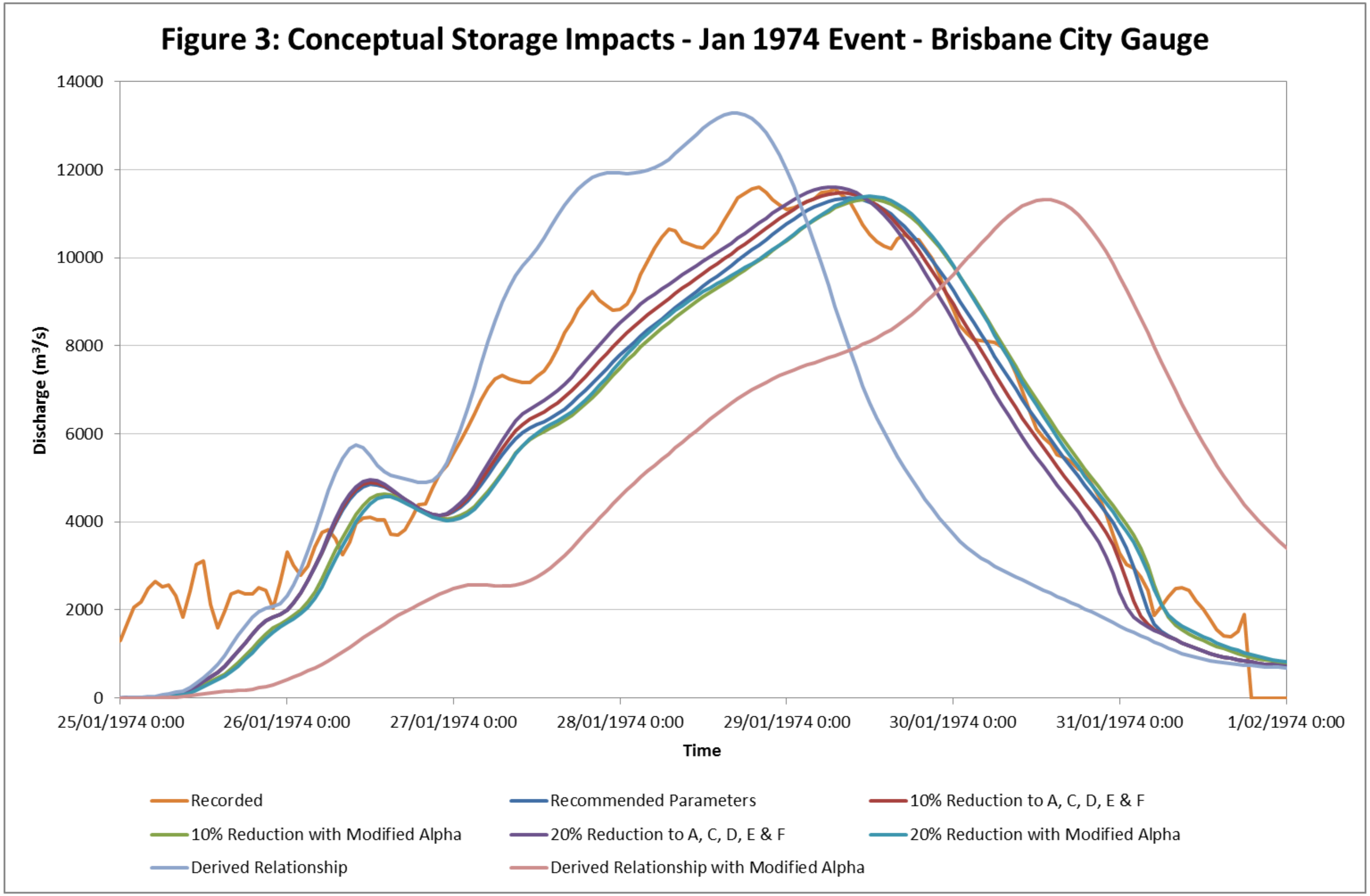


Figure 3: Conceptual Storage Impacts - Jan 1974 Event - Brisbane City Gauge
14000
12000
10000
8000
6000
4000
2000
0
Discharge (m³/s)
25/01/1974 0:00
26/01/1974 0:00
27/01/1974 0:00
28/01/1974 0:00
29/01/1974 0:00
30/01/1974 0:00
31/01/1974 0:00
1/02/1974 0:00
Time
Recorded
Recommended Parameters
10% Reduction to A, C, D, E & F
10% Reduction with Modified Alpha
20% Reduction to A, C, D, E & F
20% Reduction with Modified Alpha
Derived Relationship
Derived Relationship with Modified Alpha

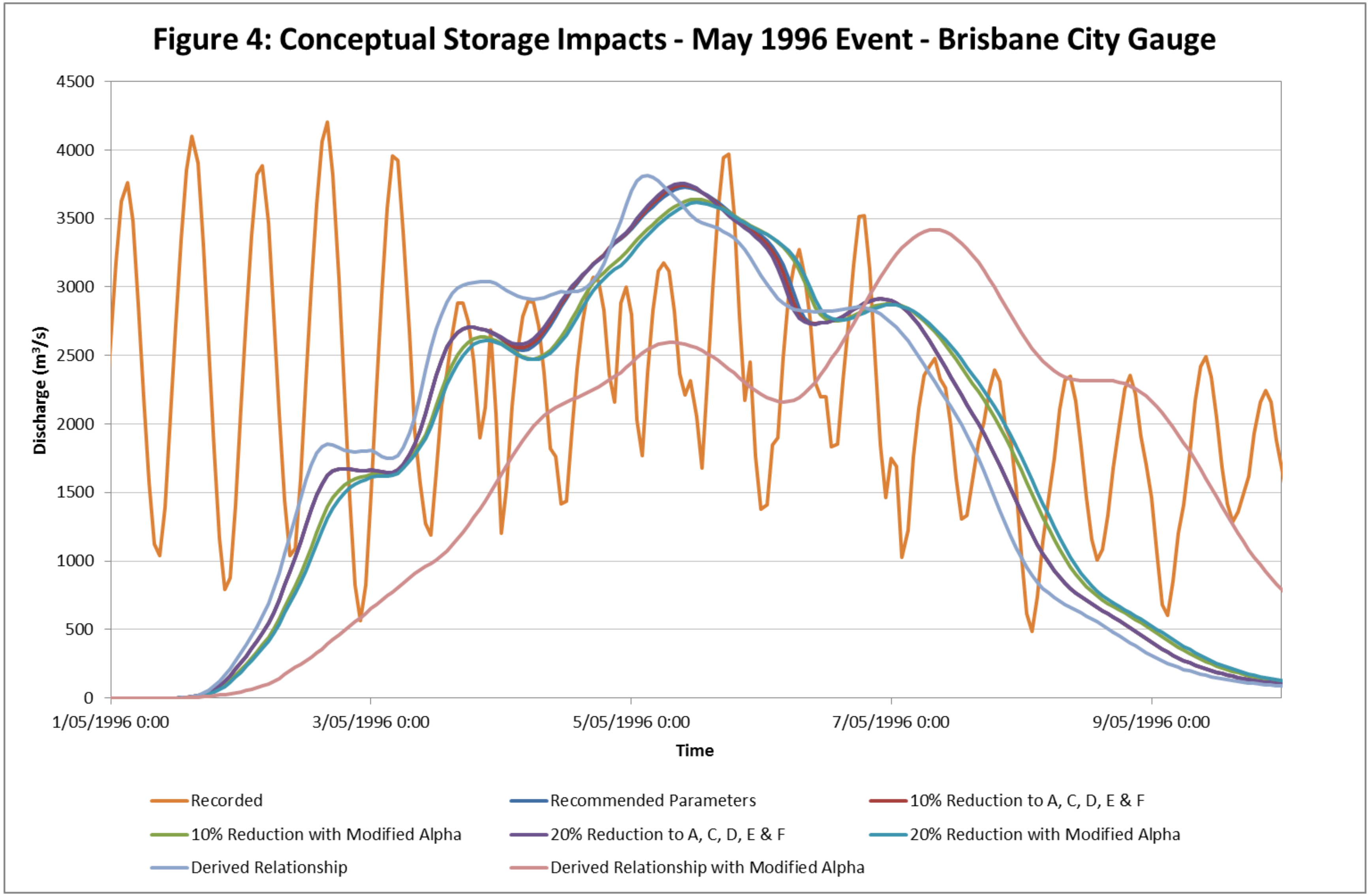


Figure 4: Conceptual Storage Impacts - May 1996 Event - Brisbane City Gauge
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Discharge (m³/s)
1/05/1996 0:00
3/05/1996 0:00
5/05/1996 0:00
7/05/1996 0:00
9/05/1996 0:00
Time
Recorded
Recommended Parameters
10% Reduction to A, C, D, E & F
10% Reduction with Modified Alpha
20% Reduction to A, C, D, E & F
20% Reduction with Modified Alpha
Derived Relationship
Derived Relationship with Modified Alpha

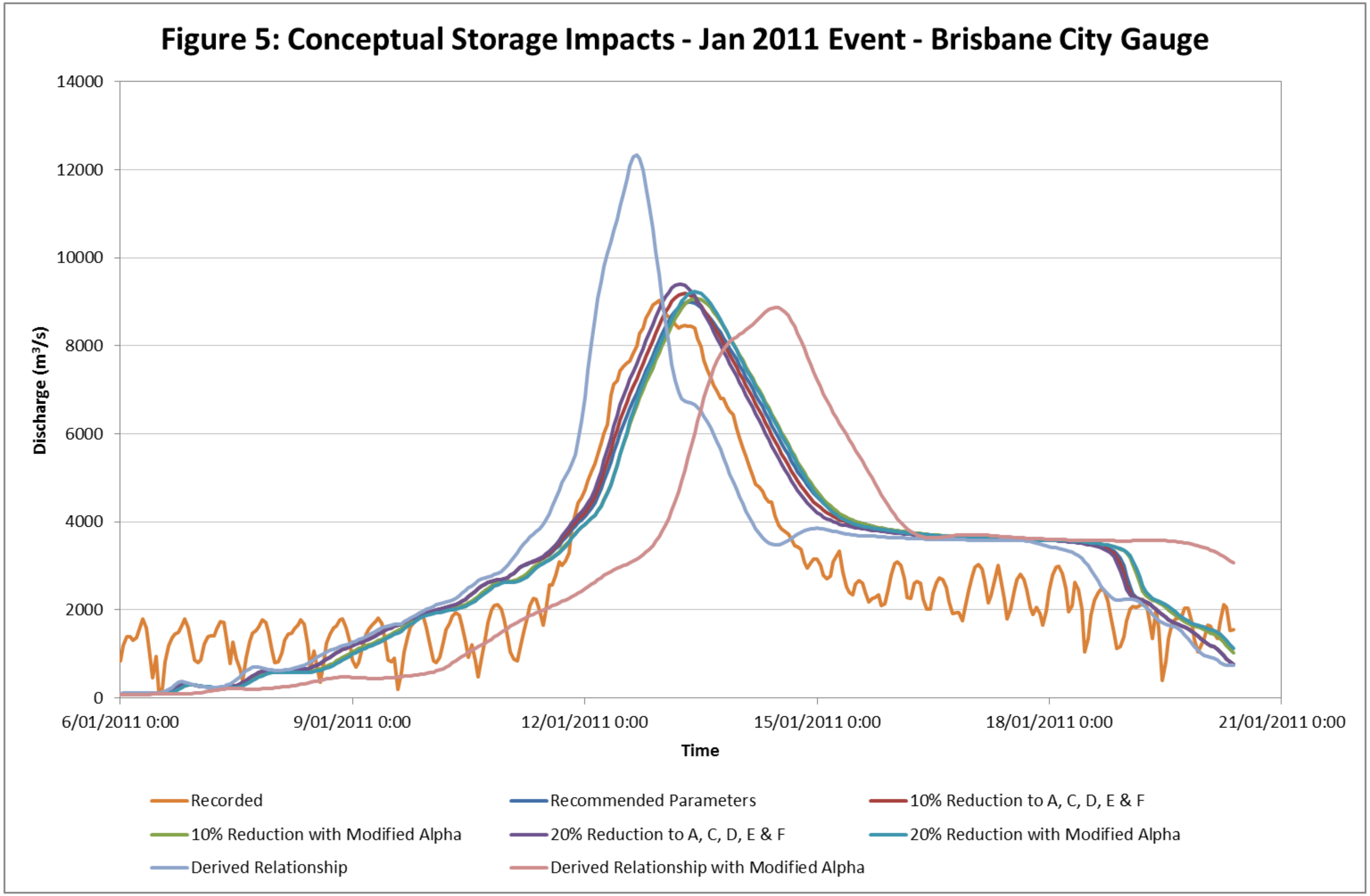


Figure 5: Conceptual Storage Impacts - Jan 2011 Event - Brisbane City Gauge
Discharge (m³/s)
14000
12000
10000
8000
6000
4000
2000
0
6/01/2011 0:00
9/01/2011 0:00
12/01/2011 0:00
15/01/2011 0:00
18/01/2011 0:00
21/01/2011 0:00
Time
Recorded
Recommended Parameters
10% Reduction to A, C, D, E & F
10% Reduction with Modified Alpha
20% Reduction to A, C, D, E & F
20% Reduction with Modified Alpha
Derived Relationship
Derived Relationship with Modified Alpha

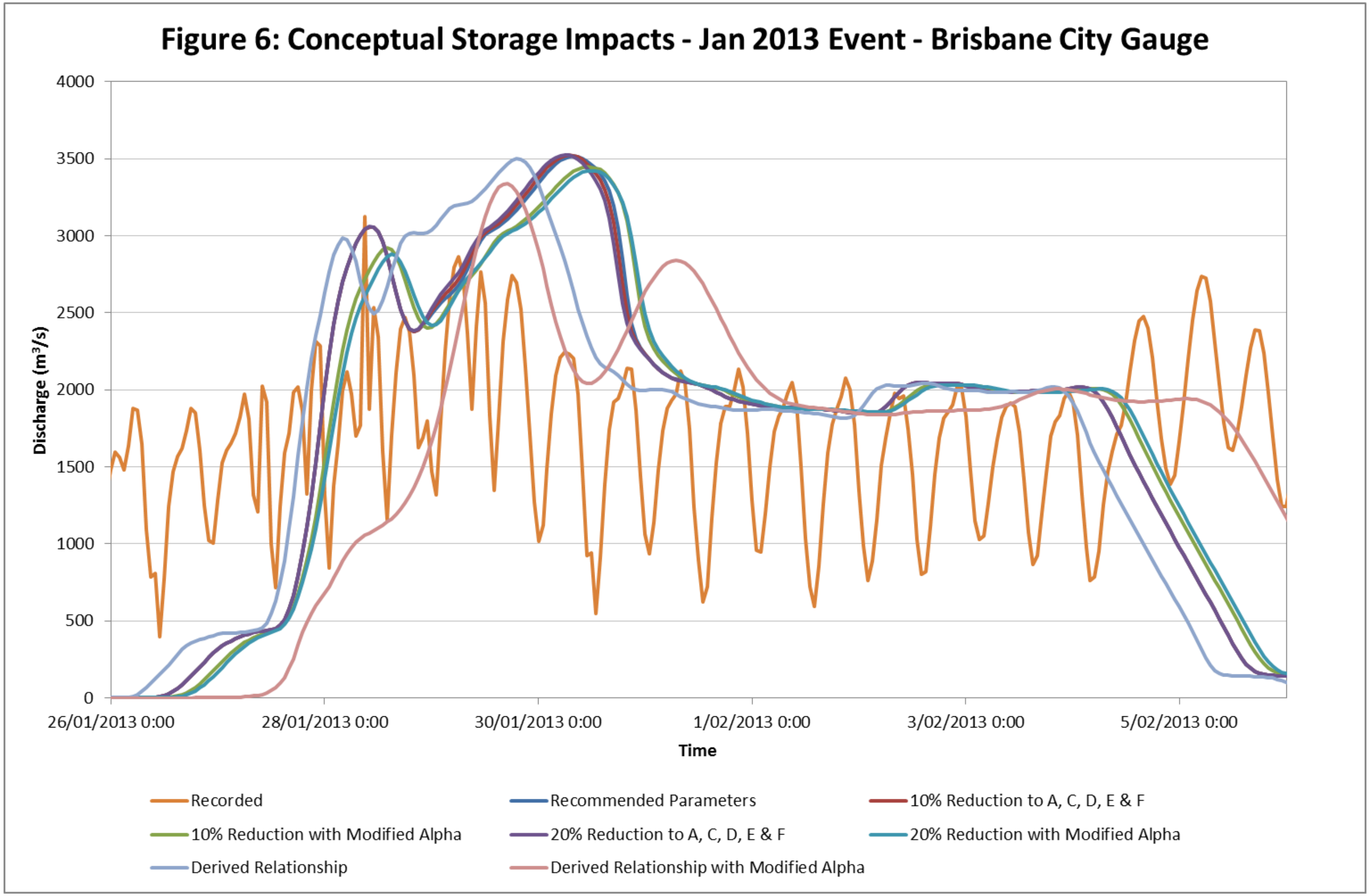


Figure 6: Conceptual Storage Impacts - Jan 2013 Event - Brisbane City Gauge
4000
3500
3000
2500
2000
1500
1000
500
0
Discharge (m³/s)
26/01/2013 0:00
28/01/2013 0:00
30/01/2013 0:00
1/02/2013 0:00
3/02/2013 0:00
5/02/2013 0:00
Time
Recorded
Recommended Parameters
10% Reduction to A, C, D, E & F
10% Reduction with Modified Alpha
20% Reduction to A, C, D, E & F
20% Reduction with Modified Alpha
Derived Relationship
Derived Relationship with Modified Alpha

Appendix D
Sensitivity analysis – infiltration capacity

Two cases were assessed:

- Infiltration limit set to 350 mm
- Infiltration limit set to 350 mm and continuing loss value modified until event peaks matched those of the recommended parameters model

Only the May 1996 event was assessed.

For the continuing loss, a best fit value was selected to provide an overall match across each of the catchments. The adopted continuing loss values are as follows:

	Seqwater recommended continuing loss (mm/hr)	Modified continuing loss value (mm/hr)
Stanley	1.6	3.9
Upper	3.5	20.0*
Lockyer	1.5	3.7
Bremer	1.5	2.5
Purga	0.5	0.6
Warrill	1.5	3.0
Lower	2.0	8.0*

* The peaks for these events are higher than those with the recommended continuing loss rates. It was considered that these loss values are unrealistic and therefore the loss value was not modified further

The table below presents the URBS calculated peak flow, volume and peak water level for each reporting location in each of the seven models. It presents this data for the recommended parameters as well as the two infiltration limit scenarios. It also presents the differences in flow, volume and water level. Figures 1 to 10 show the hydrographs at key locations throughout the system.

Catchment	Location	Recommended Parameters			With 350mm Infiltration Limit						With 350mm Infiltration Limit and Additional Continuing Loss					
		Peak Flow (m^3/s)	Volume (ML)	Peak Level (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)
Stanley	Peachester	212	15727	7.84	233	10.14%	21025	33.69%	8.00	0.16	204	-3.60%	18782	19.43%	7.77	-0.07
	Woodford	349	47710	6.93	413	18.39%	61612	29.14%	7.29	0.36	347	-0.32%	54964	15.20%	6.92	-0.01
	Mt Kilcoy	11	978	1.94	33	205.69%	5710	483.84%	3.12	1.18	29	168.41%	5373	449.39%	2.94	1.00
	SD Inflow	1753	189181	-	2024	15.45%	254291	34.42%	-	-	1765	0.68%	224870	18.87%	-	-
Upper	Cooyar Ck	76	7094	3.44	236	209.29%	38196	438.43%	5.05	1.61	174	127.94%	34027	379.66%	4.54	1.10
	Linville	74	7186	2.00	303	306.83%	60318	739.38%	3.44	1.44	243	226.69%	56071	680.28%	3.11	1.11
	Devon Hills	87	11707	2.48	336	285.51%	72475	519.07%	4.28	1.80	273	213.22%	65943	463.28%	3.94	1.46
	Boat Mt	339	29671	5.17	566	66.62%	75437	154.24%	6.46	1.29	334	-1.66%	59684	101.15%	5.13	-0.04
	GregorCk	615	73898	5.71	1252	103.56%	222160	200.63%	7.52	1.81	845	37.44%	183348	148.11%	6.45	0.74
	Perserverance	102	10186	447.12	199	95.38%	22894	124.76%	447.68	0.56	89	-12.34%	17567	72.46%	447.04	-0.08
	Dam Site	0	0	0.00	30	-	7109	-	1.94	1.94	0	-	0	-	0.00	0.00
	Cressbrook	0	0	280.00	30	-	7109	-	280.88	0.88	0	-	0	-	280.00	0.00
	Rosentretters	149	12186	4.32	213	42.23%	33472	174.68%	4.81	0.49	123	-17.42%	21026	72.54%	4.08	-0.24
	SD Outflow	0	0	-	0	-	0	-	-	-	0	-	0	-	-	-
	Caboonbah	953	137913	7.44	1742	82.68%	354773	157.24%	9.48	2.04	1189	24.71%	284418	106.23%	8.13	0.69
	Middle Ck	1417	196815	10.00	2363	66.77%	448529	127.89%	13.08	3.08	1608	13.47%	359966	82.90%	10.69	0.69
	WD Inflow	1627	269271	-	2643	62.48%	553365	105.50%	-	-	1842	13.25%	452854	68.18%	-	-
Lockyer	Helidon	837	88760	7.43	903	7.83%	114495	28.99%	7.66	0.23	811	-3.14%	100624	13.37%	7.33	-0.10
	Brown Zirbels	177	21035	6.77	205	16.25%	30313	44.11%	7.10	0.33	167	-5.30%	25168	19.65%	6.66	-0.11
	Harms	204	21933	4.93	245	19.81%	34455	57.09%	5.21	0.28	186	-9.11%	27827	26.87%	4.75	-0.18
	Sandy Ck Rd	108	15401	5.42	119	10.22%	19200	24.67%	5.65	0.23	107	-1.13%	16691	8.38%	5.39	-0.03
	Grantham	1156	186146	-	1326	14.66%	248678	33.59%	-	-	1140	-1.38%	213415	14.65%	-	-
	Tenthill	342	59323	5.74	415	21.44%	87290	47.14%	6.27	0.53	359	5.06%	71863	21.14%	5.90	0.16
	US Gatton	1359	266832	12.83	1637	20.49%	364766	36.70%	13.87	1.04	1377	1.34%	309495	15.99%	12.91	0.08
	Gatton	1359	266832	12.22	1637	20.49%	364766	36.70%	13.14	0.92	1377	1.34%	309495	15.99%	12.28	0.06
	Mulgowie	251	37159	8.38	287	14.04%	49452	33.08%	8.83	0.45	260	3.48%	42262	13.73%	8.49	0.11
	Laidley	281	47189	9.29	325	15.57%	63071	33.66%	9.81	0.52	293	4.27%	53736	13.87%	9.43	0.14
	Showground	284	49117	7.84	329	15.85%	65569	33.50%	8.12	0.28	297	4.42%	55885	13.78%	7.92	0.08
	Forest Hill	111	19153	3.52	128	15.39%	25993	35.71%	3.56	0.04	102	-8.15%	21978	14.75%	3.50	-0.02
	Warrego Hwy	457	101681	6.64	538	17.64%	135116	32.88%	6.84	0.20	433	-5.30%	115212	13.31%	6.58	-0.06
	Glenore Grove	1806	402265	14.00	2164	19.78%	543385	35.08%	14.23	0.23	1793	-0.76%	462015	14.85%	13.99	-0.01
	Lyons Br	1904	461404	16.26	2289	20.25%	621414	34.68%	16.42	0.16	1895	-0.48%	528441	14.53%	16.26	0.00
	Rifle Range Rd	1933	479167	16.23	2331	20.61%	645251	34.66%	16.33	0.10	1928	-0.22%	548651	14.50%	16.23	0.00
	BurabaCk	334	78307	-	395	18.18%	104633	33.62%	-	-	334	0.10%	89368	14.13%	-	-
	O'Reillys Weir	2078	565246	15.26	2520	21.28%	761083	34.65%	16.11	0.85	2086	0.37%	647188	14.50%	15.27	0.01

Catchment	Location	Recommended Parameters			With 350mm Infiltration Limit						With 350mm Infiltration Limit and Additional Continuing Loss					
		Peak Flow (m^3/s)	Volume (ML)	Peak Level (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)	Peak Flow (m^3/s)	% Difference	Volume (ML)	% Difference	Peak Level (m)	Difference (m)
Bremer	Adams Br	200	36546	4.40	220	9.87%	44898	22.85%	4.52	0.12	201	0.52%	41089	12.43%	4.41	0.01
	Stokes Xing	287	49740	4.79	312	8.82%	61102	22.84%	4.98	0.19	287	0.04%	55956	12.50%	4.79	0.00
	Spressers Br	422	73425	6.40	461	9.10%	90774	23.63%	6.52	0.12	422	-0.14%	82899	12.90%	6.40	0.00
	Grandchester	84	13922	4.34	91	8.16%	17249	23.90%	4.41	0.07	83	-0.76%	15714	12.87%	4.33	-0.01
	Kuss Rd	334	62349	7.57	365	9.28%	77467	24.25%	7.61	0.04	332	-0.70%	70587	13.21%	7.57	0.00
	WWTP	419	73961	7.87	457	8.85%	91952	24.32%	7.93	0.06	416	-0.71%	83704	13.17%	7.86	-0.01
	Rosewood	861	153478	6.28	939	9.13%	190574	24.17%	6.39	0.11	857	-0.44%	173625	13.13%	6.27	-0.01
	Five Ml Br	909	166264	7.62	995	9.49%	207078	24.55%	7.79	0.17	906	-0.35%	188374	13.30%	7.61	-0.01
	Walloon	932	175396	9.29	1023	9.68%	218487	24.57%	9.53	0.24	930	-0.27%	198759	13.32%	9.29	0.00

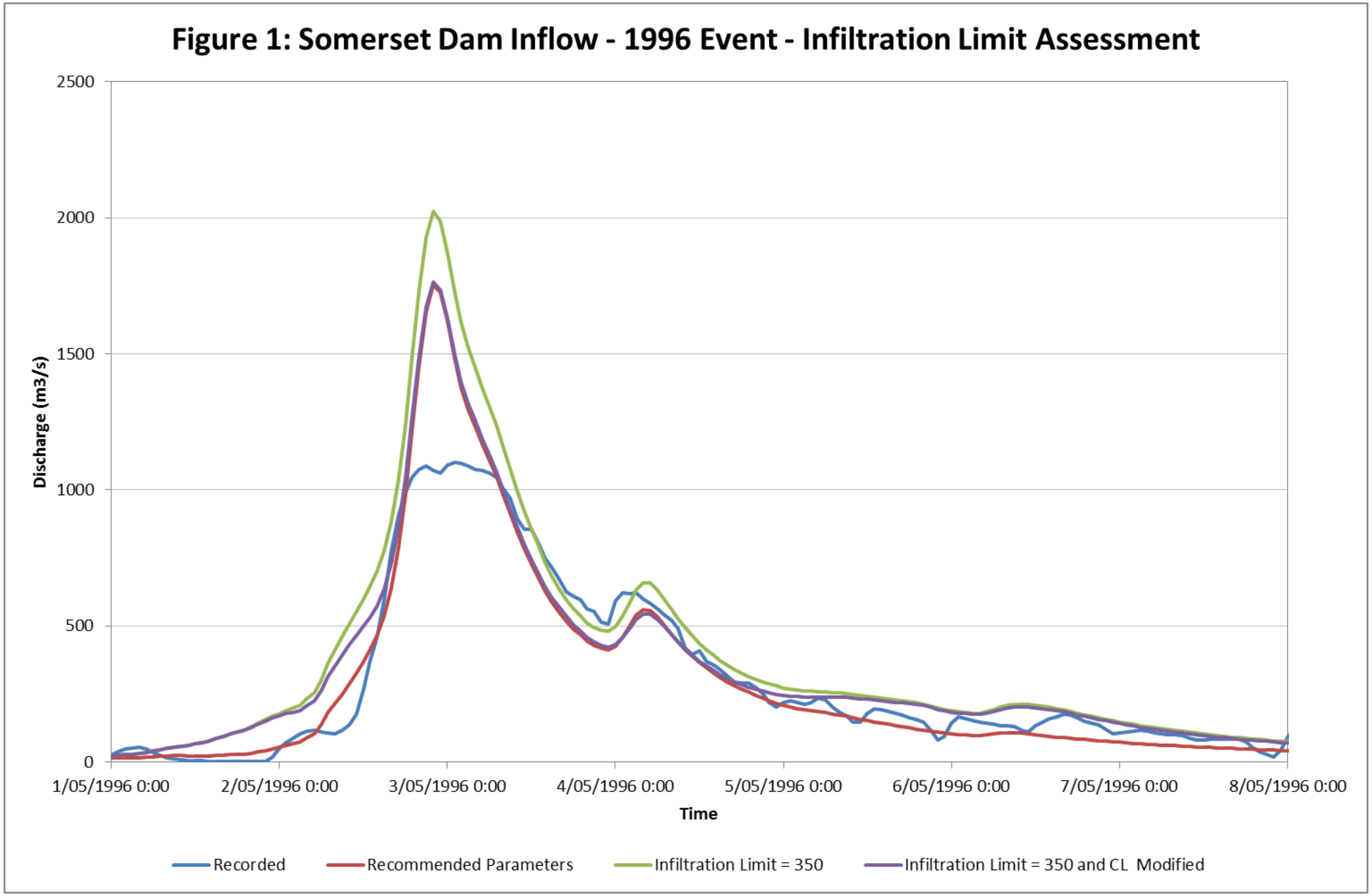


Figure 1: Somerset Dam Inflow - 1996 Event - Infiltration Limit Assessment
Discharge (m3/s)
2500
2000
1500
1000
500
0
1/05/1996 0:00
2/05/1996 0:00
3/05/1996 0:00
4/05/1996 0:00
5/05/1996 0:00
6/05/1996 0:00
7/05/1996 0:00
8/05/1996 0:00
Time
Recorded
Recommended Parameters
Infiltration Limit = 350
Infiltration Limit = 350 and CL Modified

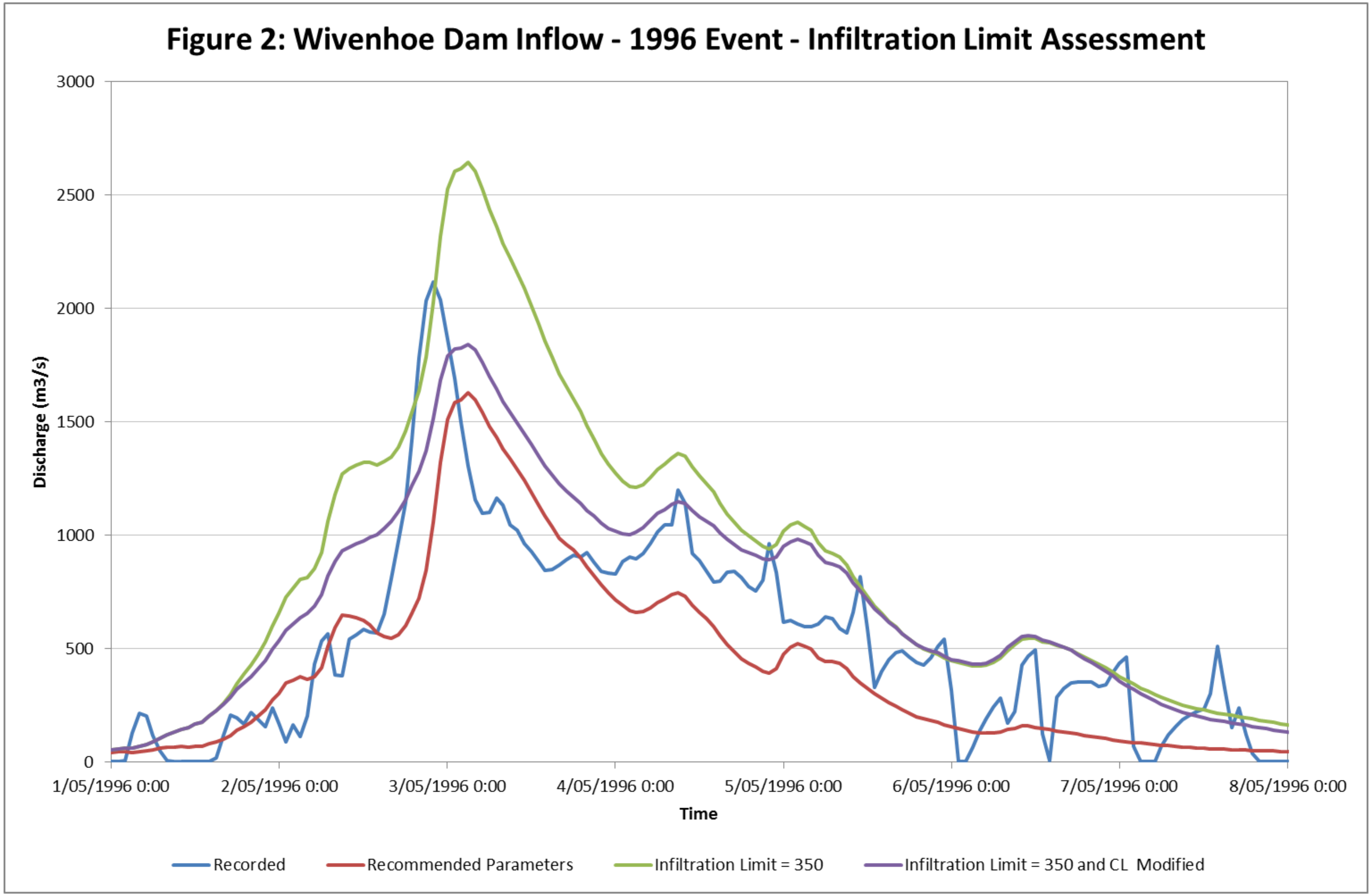


Figure 2: Wivenhoe Dam Inflow - 1996 Event - Infiltration Limit Assessment
3000
2500
2000
1500
1000
500
0
Discharge (m3/s)
1/05/1996 0:00
2/05/1996 0:00
3/05/1996 0:00
4/05/1996 0:00
5/05/1996 0:00
6/05/1996 0:00
7/05/1996 0:00
8/05/1996 0:00
Time
Recorded
Recommended Parameters
Infiltration Limit = 350
Infiltration Limit = 350 and CL Modified

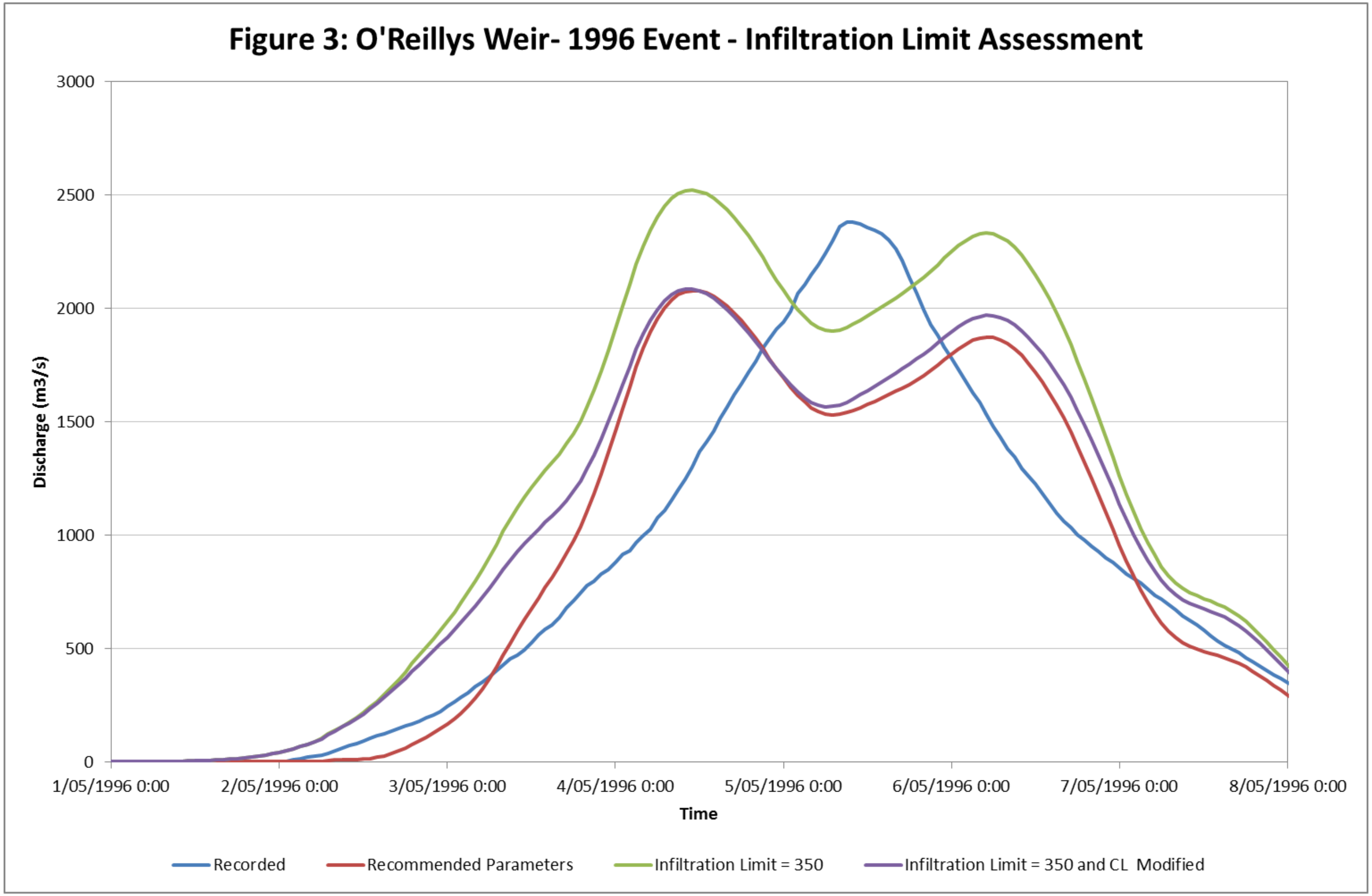


Figure 3: O'Reillys Weir- 1996 Event - Infiltration Limit Assessment
3000
2500
2000
1500
1000
500
0
Discharge (m3/s)
1/05/1996 0:00
2/05/1996 0:00
3/05/1996 0:00
4/05/1996 0:00
5/05/1996 0:00
6/05/1996 0:00
7/05/1996 0:00
8/05/1996 0:00
Time
Recorded
Recommended Parameters
Infiltration Limit = 350
Infiltration Limit = 350 and CL Modified

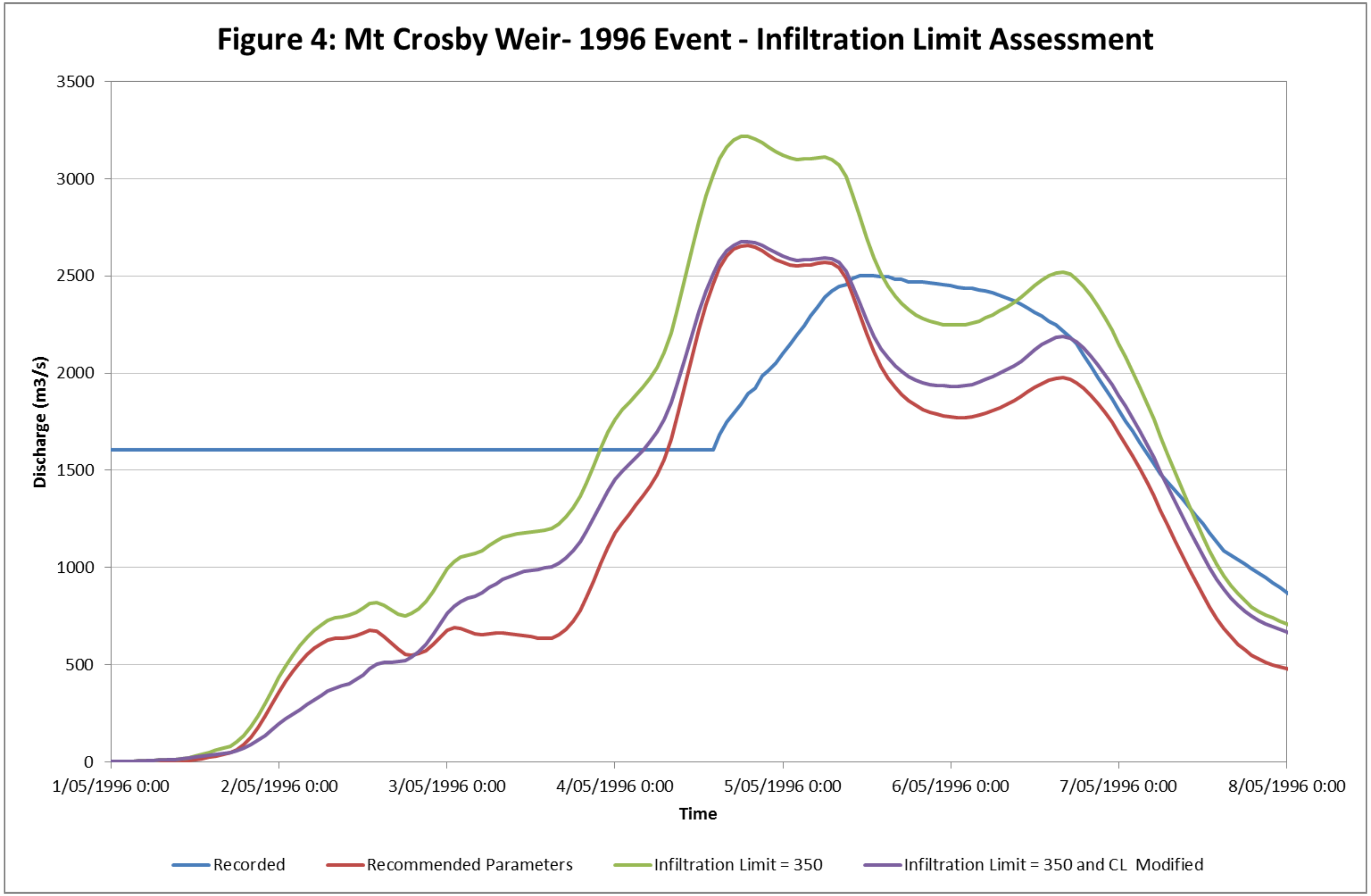


Figure 4: Mt Crosby Weir- 1996 Event - Infiltration Limit Assessment
Discharge (m3/s)
3500
3000
2500
2000
1500
1000
500
0
1/05/1996 0:00
2/05/1996 0:00
3/05/1996 0:00
4/05/1996 0:00
5/05/1996 0:00
6/05/1996 0:00
7/05/1996 0:00
8/05/1996 0:00
Time
Recorded
Recommended Parameters
Infiltration Limit = 350
Infiltration Limit = 350 and CL Modified

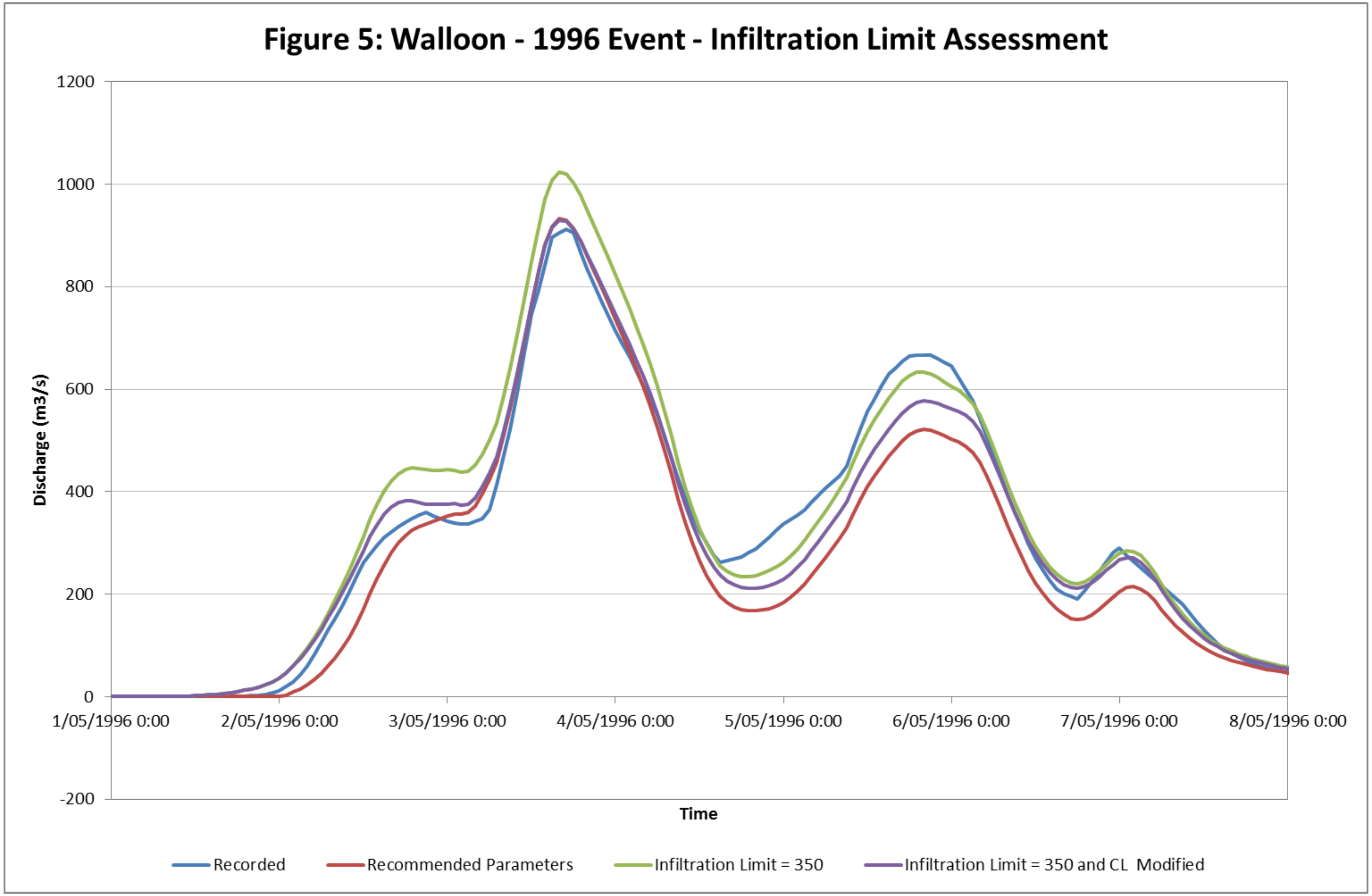


Figure 5: Walloon - 1996 Event - Infiltration Limit Assessment
1200
1000
800
600
400
200
0
-200
Discharge (m3/s)
1/05/1996 0:00
2/05/1996 0:00
3/05/1996 0:00
4/05/1996 0:00
5/05/1996 0:00
6/05/1996 0:00
7/05/1996 0:00
8/05/1996 0:00
Time
Recorded
Recommended Parameters
Infiltration Limit = 350
Infiltration Limit = 350 and CL Modified

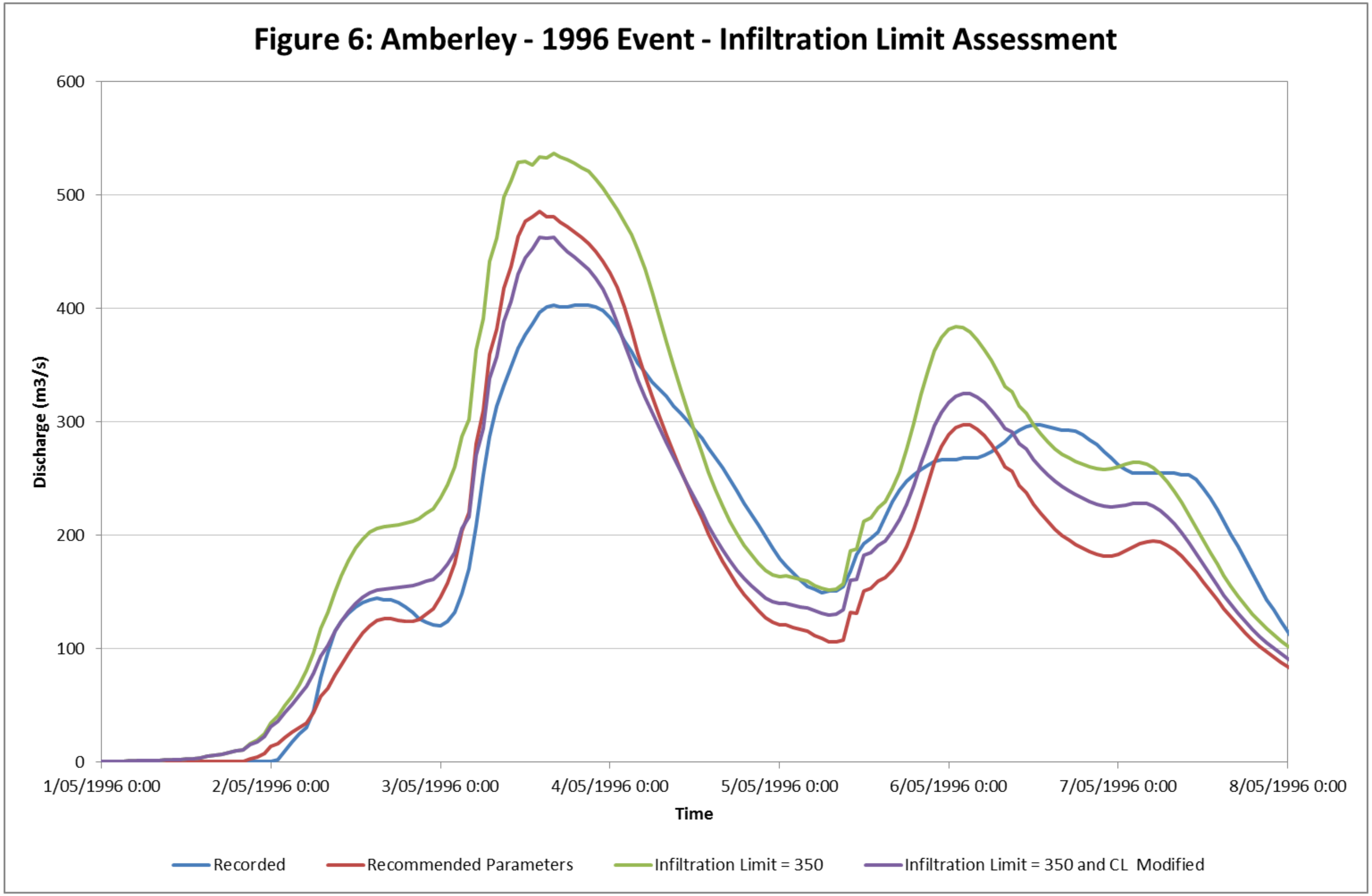


Figure 6: Amberley - 1996 Event - Infiltration Limit Assessment
Discharge (m3/s)
600
500
400
300
200
100
0
1/05/1996 0:00
2/05/1996 0:00
3/05/1996 0:00
4/05/1996 0:00
5/05/1996 0:00
6/05/1996 0:00
7/05/1996 0:00
8/05/1996 0:00
Time
Recorded
Recommended Parameters
Infiltration Limit = 350
Infiltration Limit = 350 and CL Modified

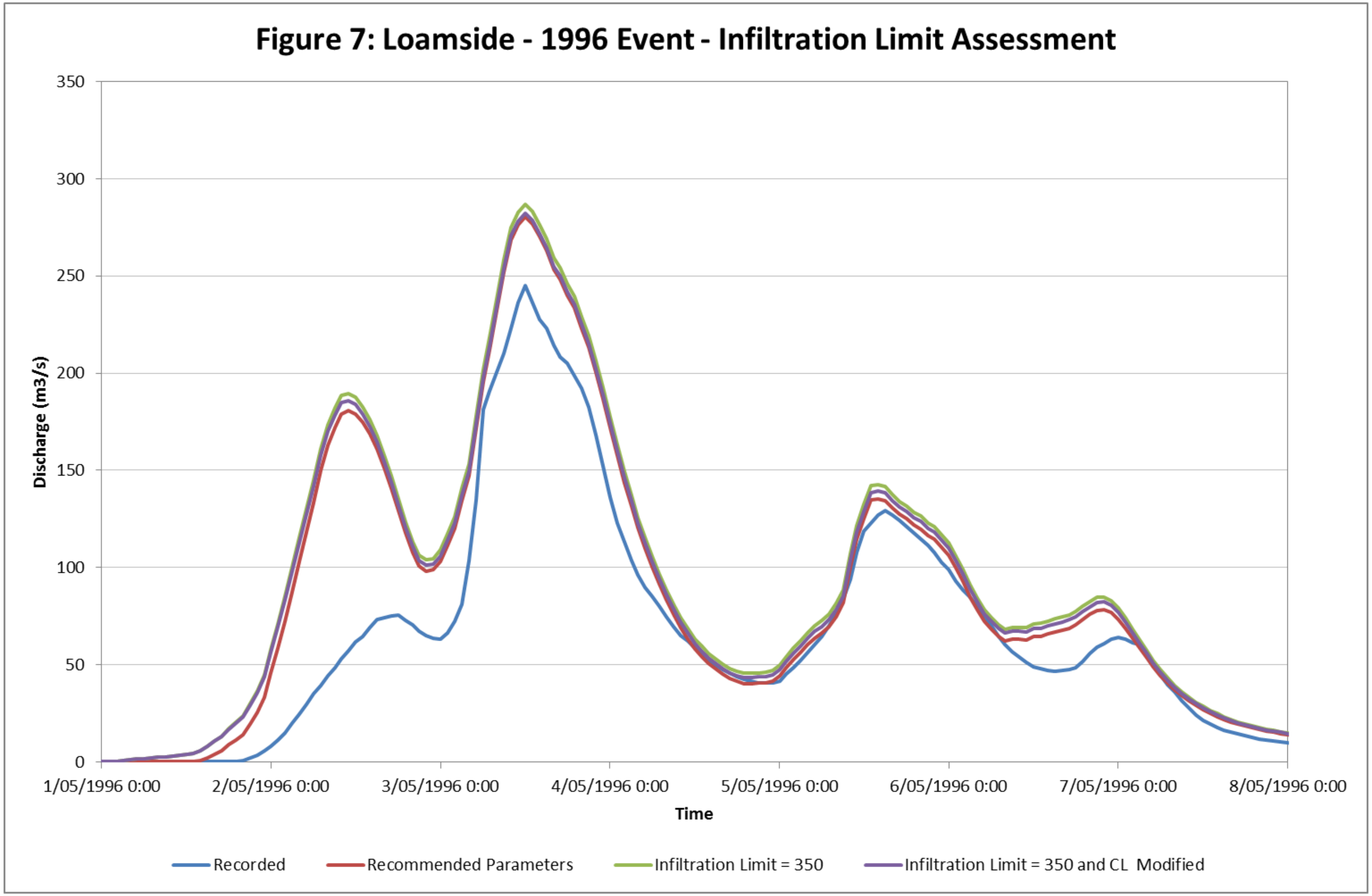


Figure 7: Loamside - 1996 Event - Infiltration Limit Assessment
Discharge (m3/s)
350
300
250
200
150
100
50
0
1/05/1996 0:00
2/05/1996 0:00
3/05/1996 0:00
4/05/1996 0:00
5/05/1996 0:00
6/05/1996 0:00
7/05/1996 0:00
8/05/1996 0:00
Time
Recorded
Recommended Parameters
Infiltration Limit = 350
Infiltration Limit = 350 and CL Modified

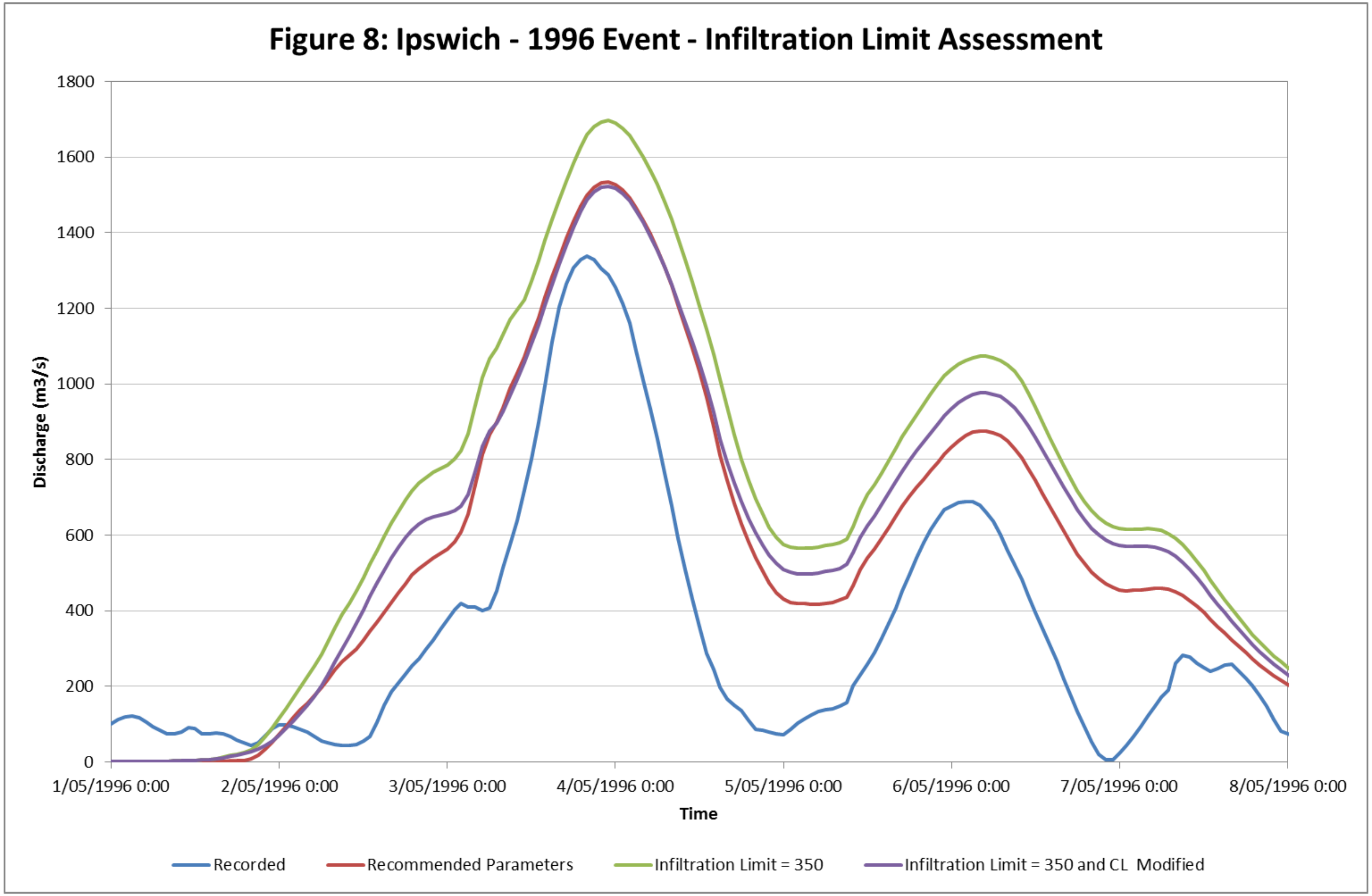


Figure 8: Ipswich - 1996 Event - Infiltration Limit Assessment
1800
1600
1400
1200
1000
800
600
400
200
0
Discharge (m3/s)
1/05/1996 0:00
2/05/1996 0:00
3/05/1996 0:00
4/05/1996 0:00
5/05/1996 0:00
6/05/1996 0:00
7/05/1996 0:00
8/05/1996 0:00
Time
Recorded
Recommended Parameters
Infiltration Limit = 350
Infiltration Limit = 350 and CL Modified

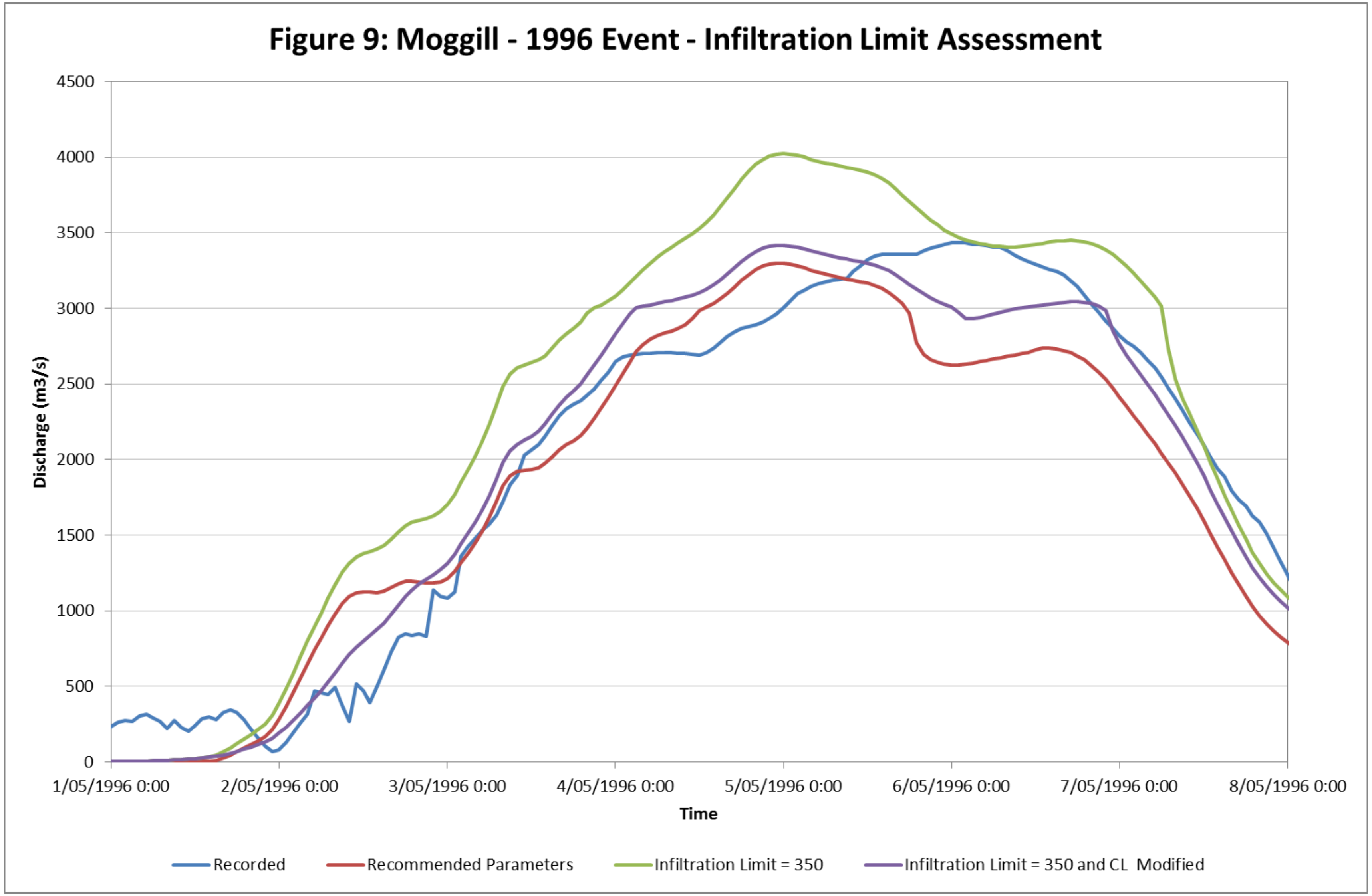


Figure 9: Moggill - 1996 Event - Infiltration Limit Assessment
Discharge (m3/s)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
1/05/1996 0:00
2/05/1996 0:00
3/05/1996 0:00
4/05/1996 0:00
5/05/1996 0:00
6/05/1996 0:00
7/05/1996 0:00
8/05/1996 0:00
Time
Recorded
Recommended Parameters
Infiltration Limit = 350
Infiltration Limit = 350 and CL Modified

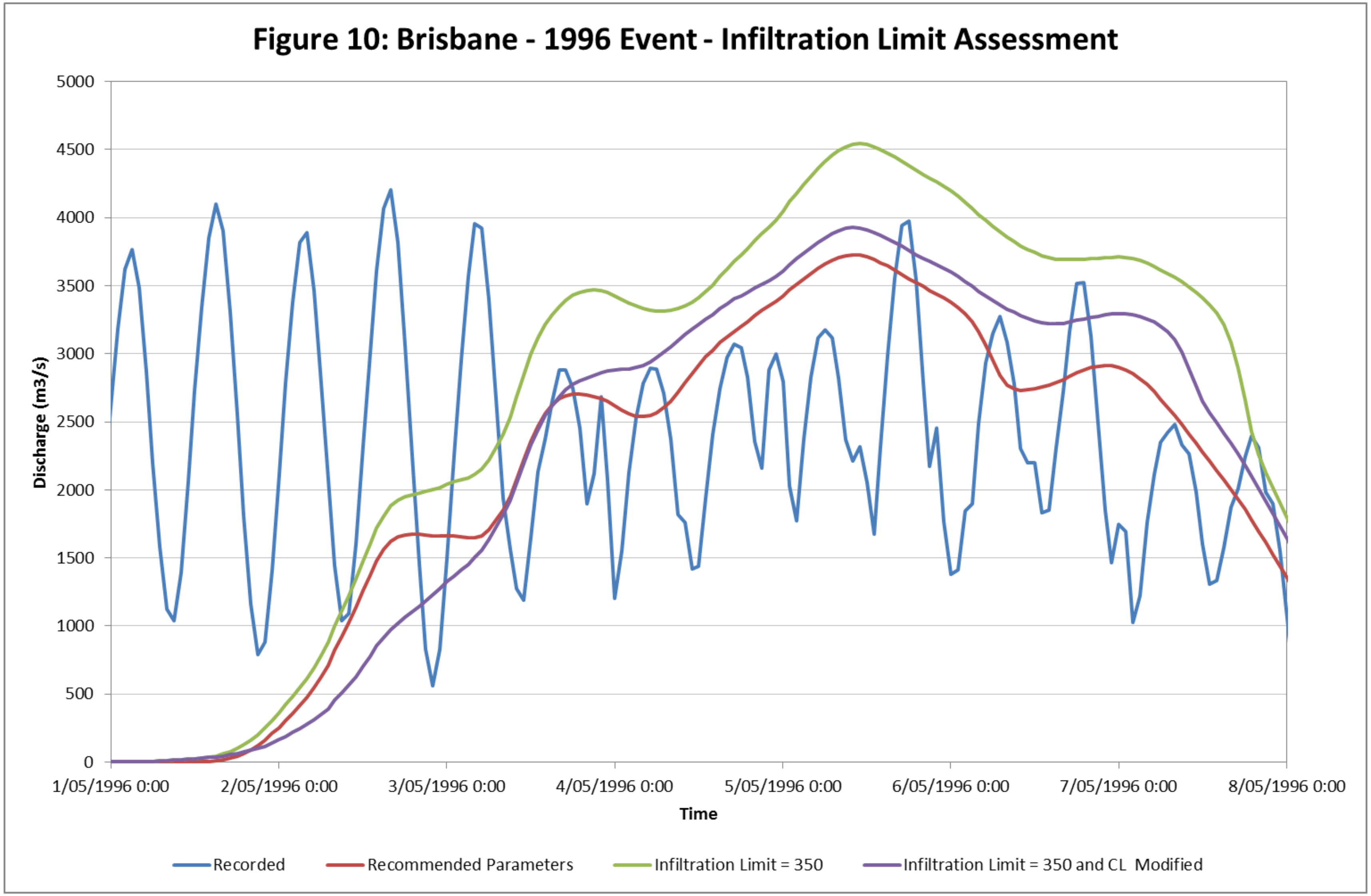


Figure 10: Brisbane - 1996 Event - Infiltration Limit Assessment
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Discharge (m3/s)
1/05/1996 0:00
2/05/1996 0:00
3/05/1996 0:00
4/05/1996 0:00
5/05/1996 0:00
6/05/1996 0:00
7/05/1996 0:00
8/05/1996 0:00
Time
Recorded
Recommended Parameters
Infiltration Limit = 350
Infiltration Limit = 350 and CL Modified

Appendix E
Sensitivity analysis – base flow assessment

The base flow parameters assessment was carried out on the Bremer River model.

Initially, a number of Bc values for each of the two Bm cases were assessed. The base flow index values for each of these runs were compared to that of the recommended parameters model. The values with the best overall match were selected. The adopted values are:

- Bm = 0.5 and Bc = 0.5
- Bm = 0.75 and Bc = 0.18

This process was carried out based on a number of events:

- July 1965
- January 1974
- April 1988
- February 1999
- January 2001
- March 2004
- December 2010
- January 2011
- January 2013

The tables below present the base flow index values for the recommended parameters model, and the two sets of modified parameters. Average values are included in these tables for comparison purposes. Figures 1 to 9 show the calculated hydrographs at Adams Bridge and Walloon for each of the modelled events.

Base flow index values for recommended parameters model

	Adams Br	5 Mile Br	Kuss Rd	Rosewood	Walloon	Average
Jul-65	0.093	0.090	0.094	0.092	0.089	0.092
Jan-74	0.108	0.105	0.107	0.106	0.105	0.106
Apr-88	0.102	0.098	0.101	0.100	0.097	0.100
Feb-99	0.117	0.116	0.117	0.117	0.116	0.117
Jan-01	0.122	0.121	0.121	0.121	0.121	0.121
Mar-04	0.095	0.091	0.095	0.093	0.091	0.093
Dec-10	0.115	0.115	0.114	0.114	0.115	0.115
Jan-11	0.113	0.114	0.110	0.113	0.115	0.113
Jan-13	0.119	0.118	0.119	0.119	0.118	0.119
Average	0.109	0.108	0.109	0.108	0.107	0.108

Base flow index values with B = 0.5 and Bc = 0.5

	Adams Br	5 Mile Br	Kuss Rd	Rosewood	Walloon	Average
Jul-65	0.157	0.087	0.136	0.089	0.087	0.111
Jan-74	0.086	0.042	0.068	0.044	0.041	0.056
Apr-88	0.119	0.065	0.105	0.068	0.063	0.084
Feb-99	0.212	0.097	0.141	0.101	0.095	0.129
Jan-01	0.203	0.119	0.165	0.124	0.118	0.146
Mar-04	0.245	0.122	0.162	0.125	0.121	0.155
Dec-10	0.157	0.087	0.136	0.089	0.087	0.111
Jan-11	0.137	0.065	0.094	0.066	0.065	0.085
Jan-13	0.091	0.065	0.113	0.066	0.066	0.080
Average	0.156	0.083	0.124	0.086	0.083	0.106

Base flow index values with B = 0.75 and Bc = 0.18

	Adams Br	5 Mile Br	Kuss Rd	Rosewood	Walloon	Average
Jul-65	0.125	0.088	0.109	0.091	0.086	0.100
Jan-74	0.106	0.073	0.094	0.075	0.072	0.084
Apr-88	0.118	0.087	0.11	0.089	0.085	0.098
Feb-99	0.17	0.114	0.137	0.117	0.113	0.130
Jan-01	0.166	0.128	0.151	0.13	0.127	0.140
Mar-04	0.167	0.115	0.134	0.117	0.114	0.129
Dec-10	0.144	0.108	0.133	0.109	0.108	0.120
Jan-11	0.132	0.091	0.106	0.092	0.092	0.103
Jan-13	0.11	0.094	0.123	0.094	0.094	0.103
Average	0.138	0.100	0.122	0.102	0.099	0.112

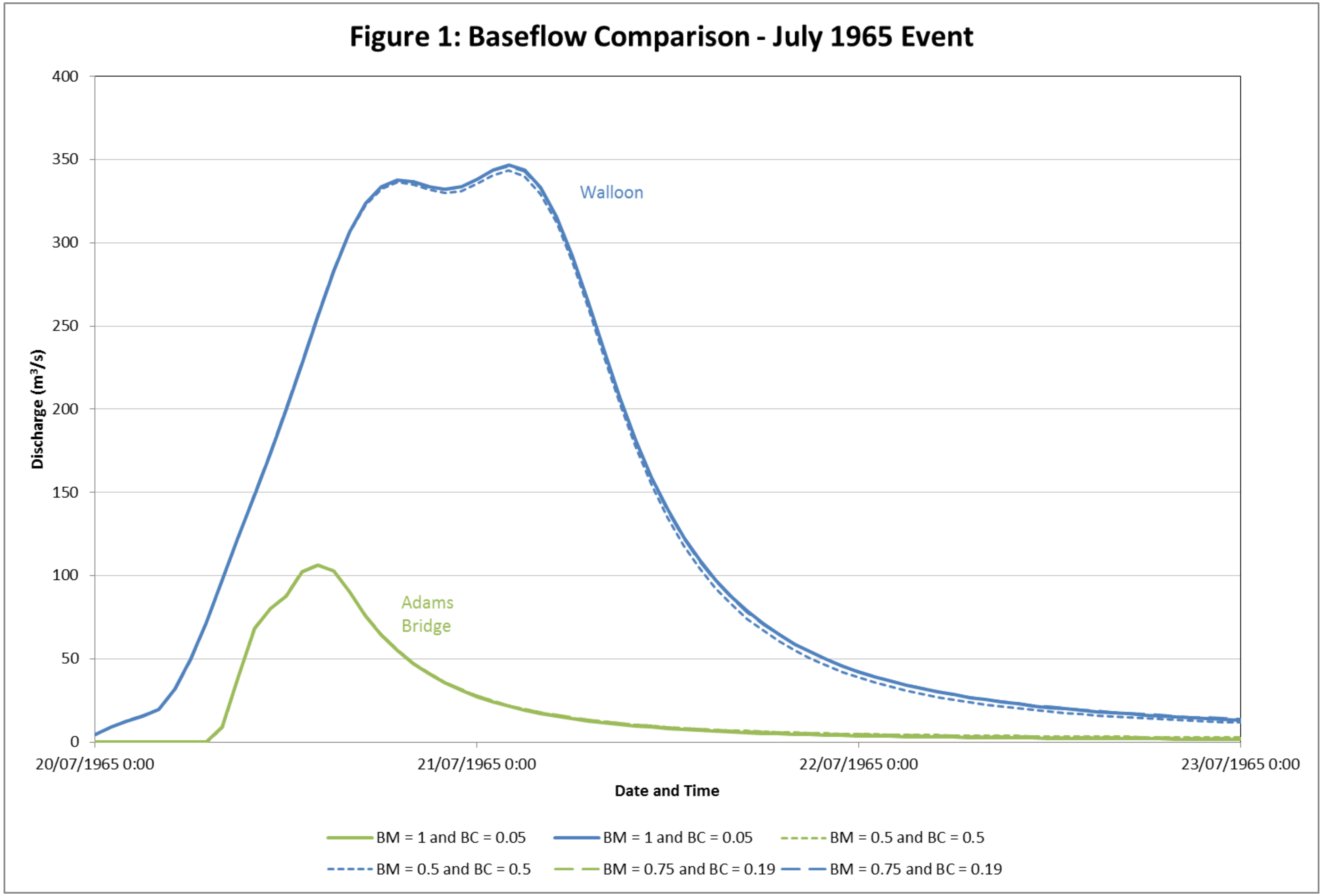


Figure 1: Baseflow Comparison - July 1965 Event
400
350
300
250
200
150
100
50
0
Discharge (m³/s)
Walloon
Adams
Bridge
20/07/1965 0:00
21/07/1965 0:00
22/07/1965 0:00
23/07/1965 0:00
Date and Time
BM = 1 and BC = 0.05
BM = 1 and BC = 0.05
BM = 0.5 and BC = 0.5
BM = 0.5 and BC = 0.5
BM = 0.75 and BC = 0.19
BM = 0.75 and BC = 0.19

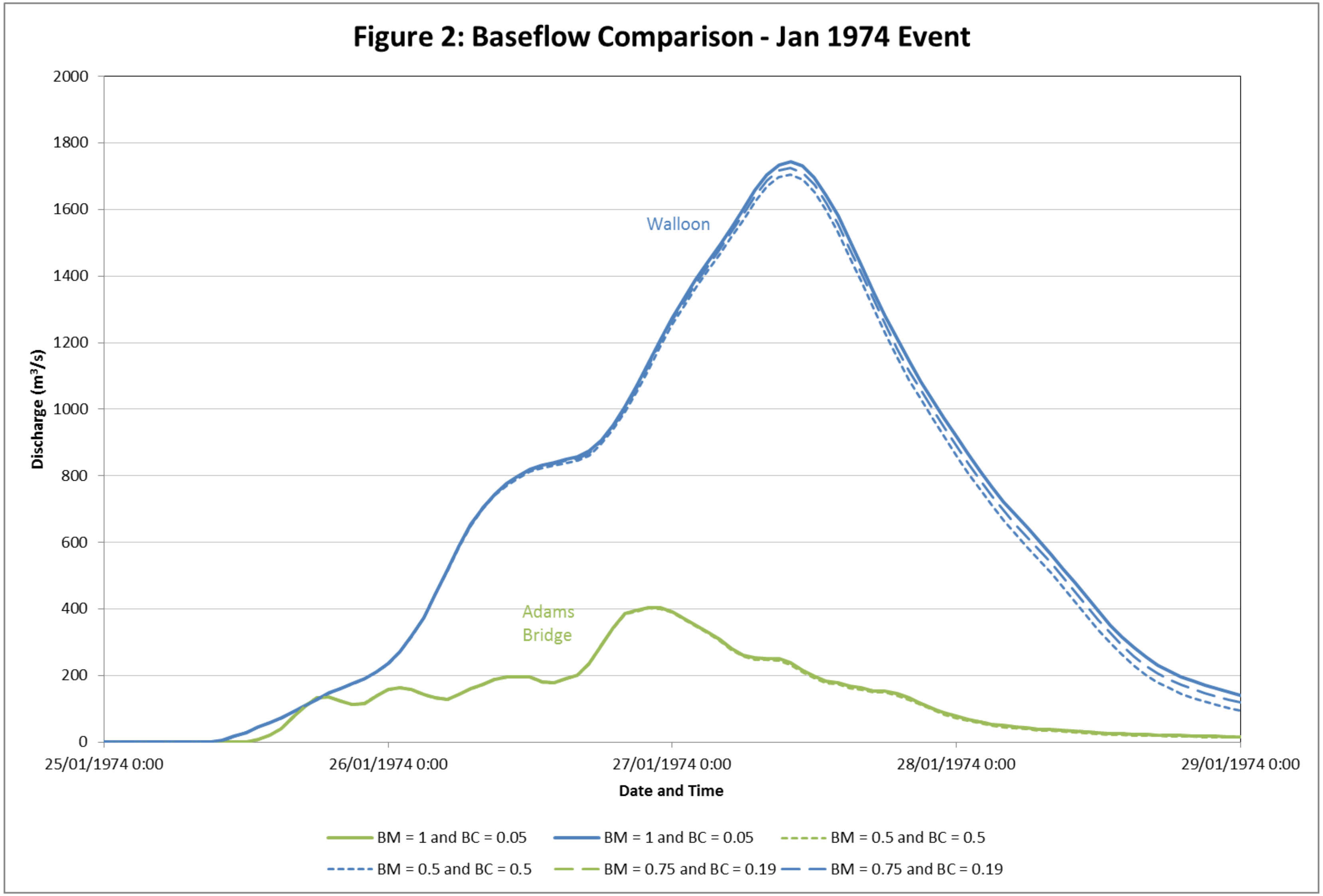


Figure 2: Baseflow Comparison - Jan 1974 Event
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Discharge (m³/s)
Walloon
Adams
Bridge
25/01/1974 0:00
26/01/1974 0:00
27/01/1974 0:00
28/01/1974 0:00
29/01/1974 0:00
Date and Time
BM = 1 and BC = 0.05
BM = 1 and BC = 0.05
BM = 0.5 and BC = 0.5
BM = 0.5 and BC = 0.5
BM = 0.75 and BC = 0.19
BM = 0.75 and BC = 0.19

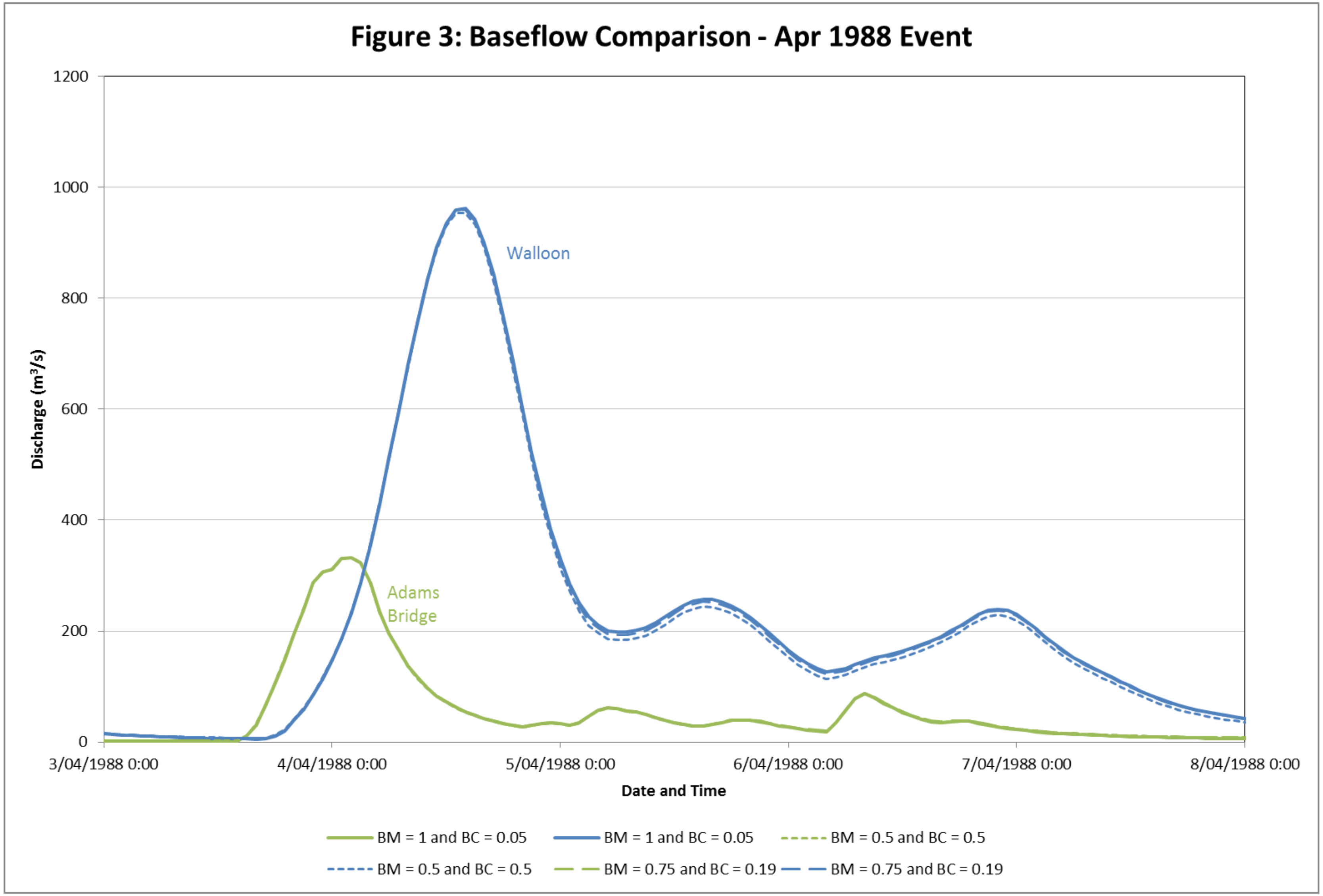


Figure 3: Baseflow Comparison - Apr 1988 Event
1200
1000
800
600
400
200
0
Discharge (m³/s)
Walloon
Adams
Bridge
3/04/1988 0:00
4/04/1988 0:00
5/04/1988 0:00
6/04/1988 0:00
7/04/1988 0:00
8/04/1988 0:00
Date and Time
BM = 1 and BC = 0.05
BM = 1 and BC = 0.05
BM = 0.5 and BC = 0.5
BM = 0.5 and BC = 0.5
BM = 0.75 and BC = 0.19
BM = 0.75 and BC = 0.19

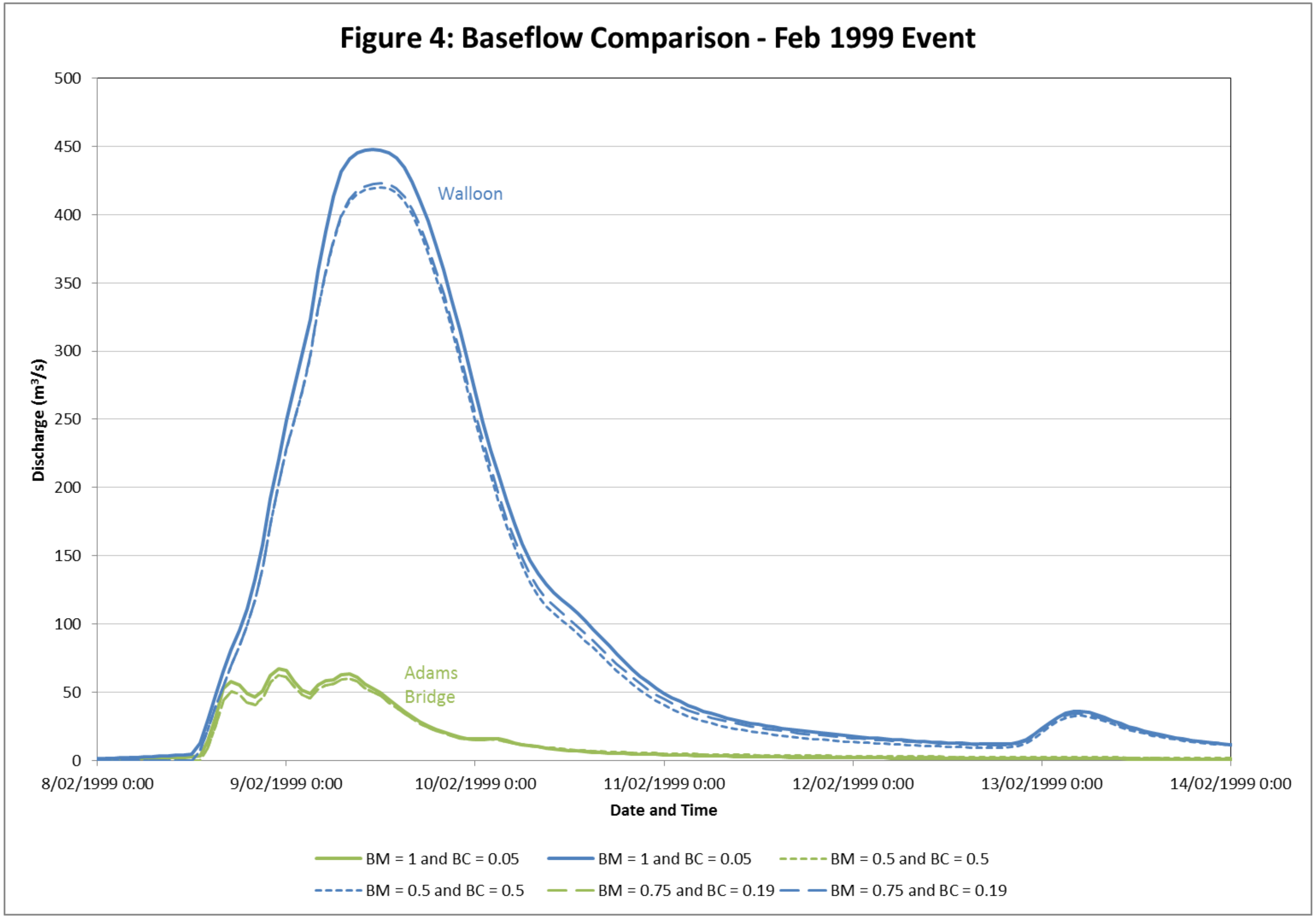


Figure 4: Baseflow Comparison - Feb 1999 Event
500
450
400
350
300
250
200
150
100
50
0
Discharge (m³/s)
Walloon
Adams
Bridge
8/02/1999 0:00
9/02/1999 0:00
10/02/1999 0:00
11/02/1999 0:00
12/02/1999 0:00
13/02/1999 0:00
14/02/1999 0:00
Date and Time
BM = 1 and BC = 0.05
BM = 1 and BC = 0.05
BM = 0.5 and BC = 0.5
BM = 0.5 and BC = 0.5
BM = 0.75 and BC = 0.19
BM = 0.75 and BC = 0.19

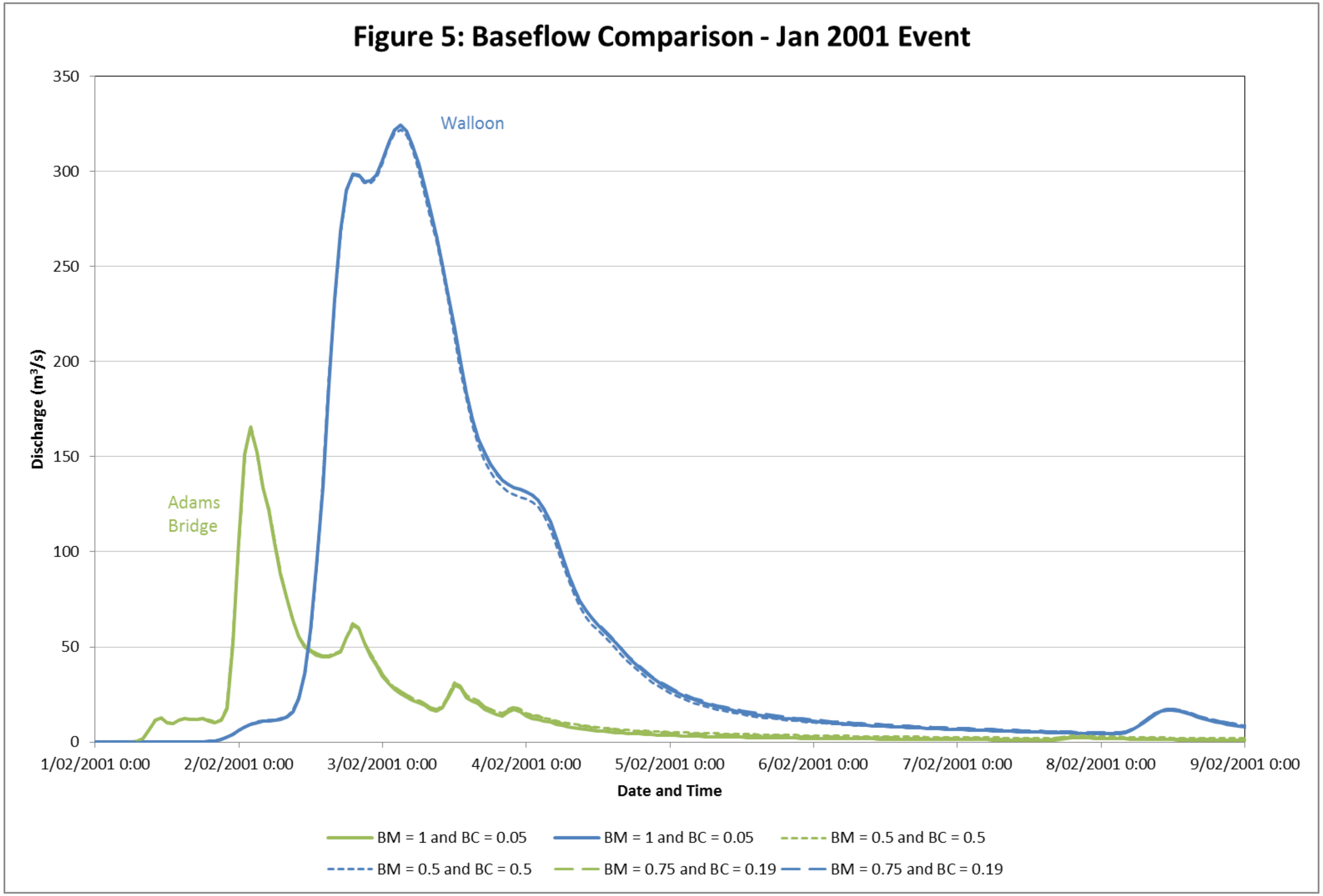
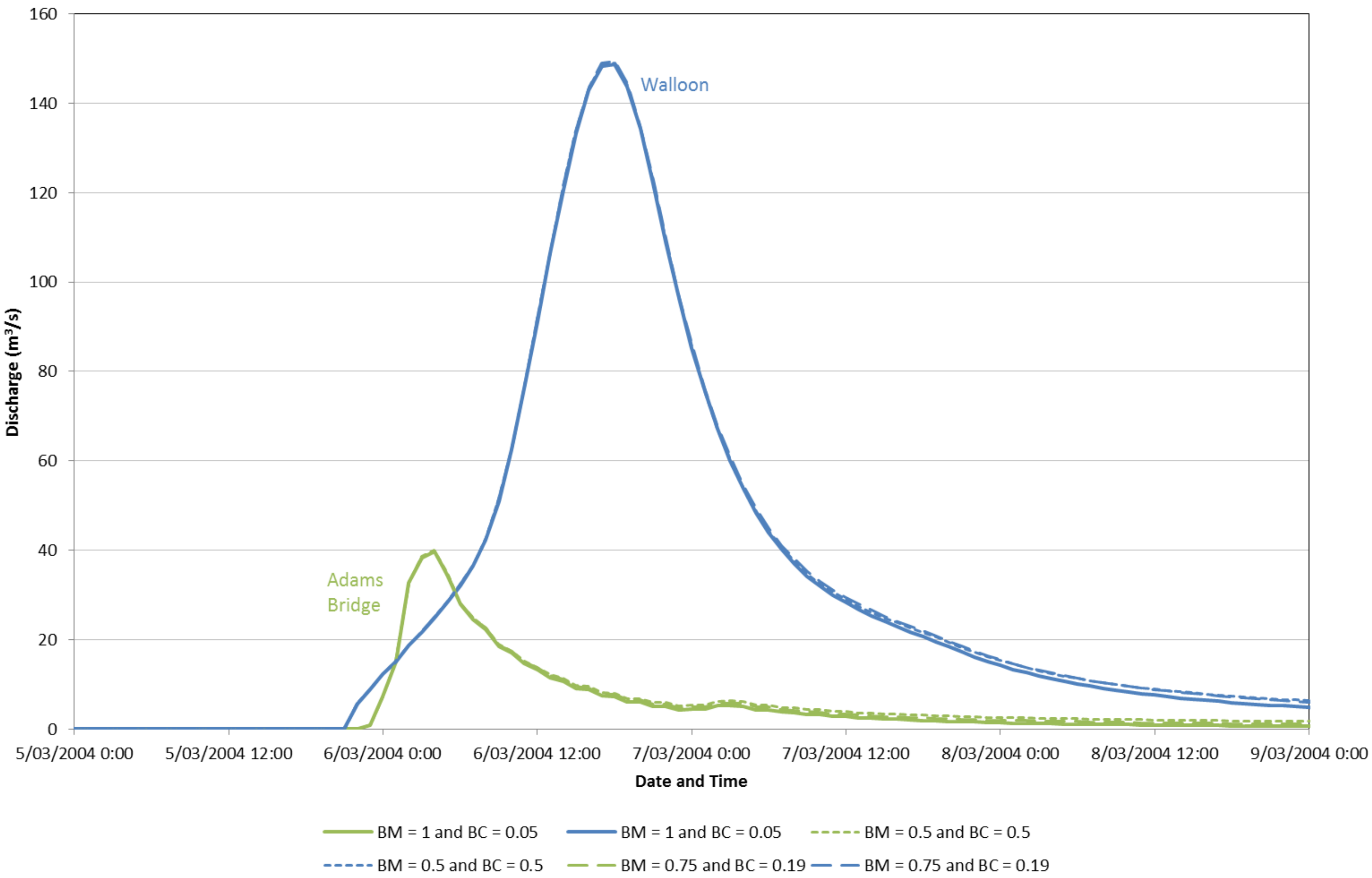


Figure 5: Baseflow Comparison - Jan 2001 Event
350
300
250
200
150
100
50
0
Discharge (m³/s)
Walloon
Adams
Bridge
1/02/2001 0:00
2/02/2001 0:00
3/02/2001 0:00
4/02/2001 0:00
5/02/2001 0:00
6/02/2001 0:00
7/02/2001 0:00
8/02/2001 0:00
9/02/2001 0:00
Date and Time
BM = 1 and BC = 0.05
BM = 1 and BC = 0.05
BM = 0.5 and BC = 0.5
BM = 0.5 and BC = 0.5
BM = 0.75 and BC = 0.19
BM = 0.75 and BC = 0.19

Figure 6: Baseflow Comparison - Mar 2004 Event



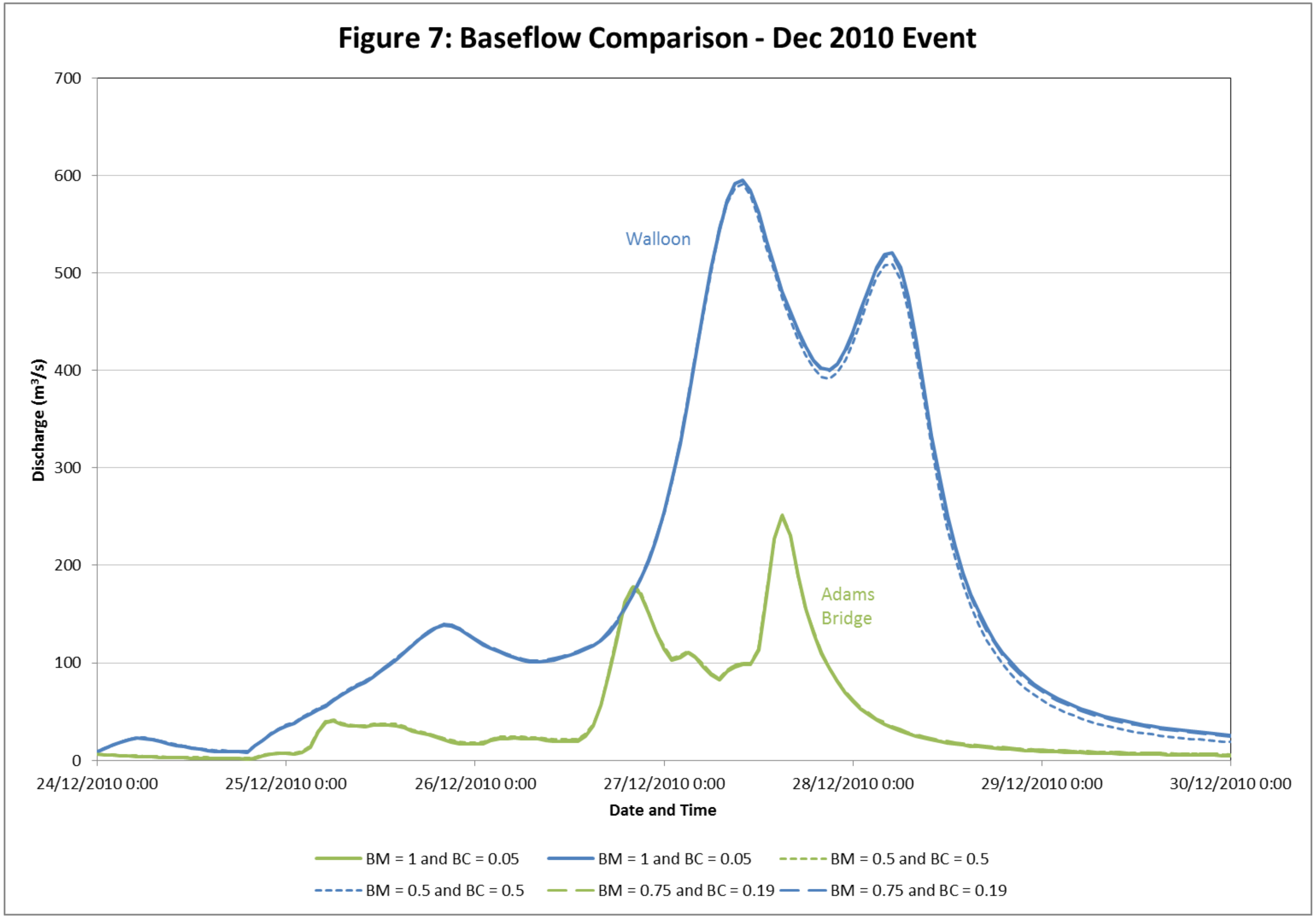


Figure 7: Baseflow Comparison - Dec 2010 Event
700
600
500
400
300
200
100
0
Discharge (m³/s)
Walloon
Adams Bridge
24/12/2010 0:00
25/12/2010 0:00
26/12/2010 0:00
27/12/2010 0:00
28/12/2010 0:00
29/12/2010 0:00
30/12/2010 0:00
Date and Time
BM = 1 and BC = 0.05
BM = 1 and BC = 0.05
BM = 0.5 and BC = 0.5
BM = 0.5 and BC = 0.5
BM = 0.75 and BC = 0.19
BM = 0.75 and BC = 0.19

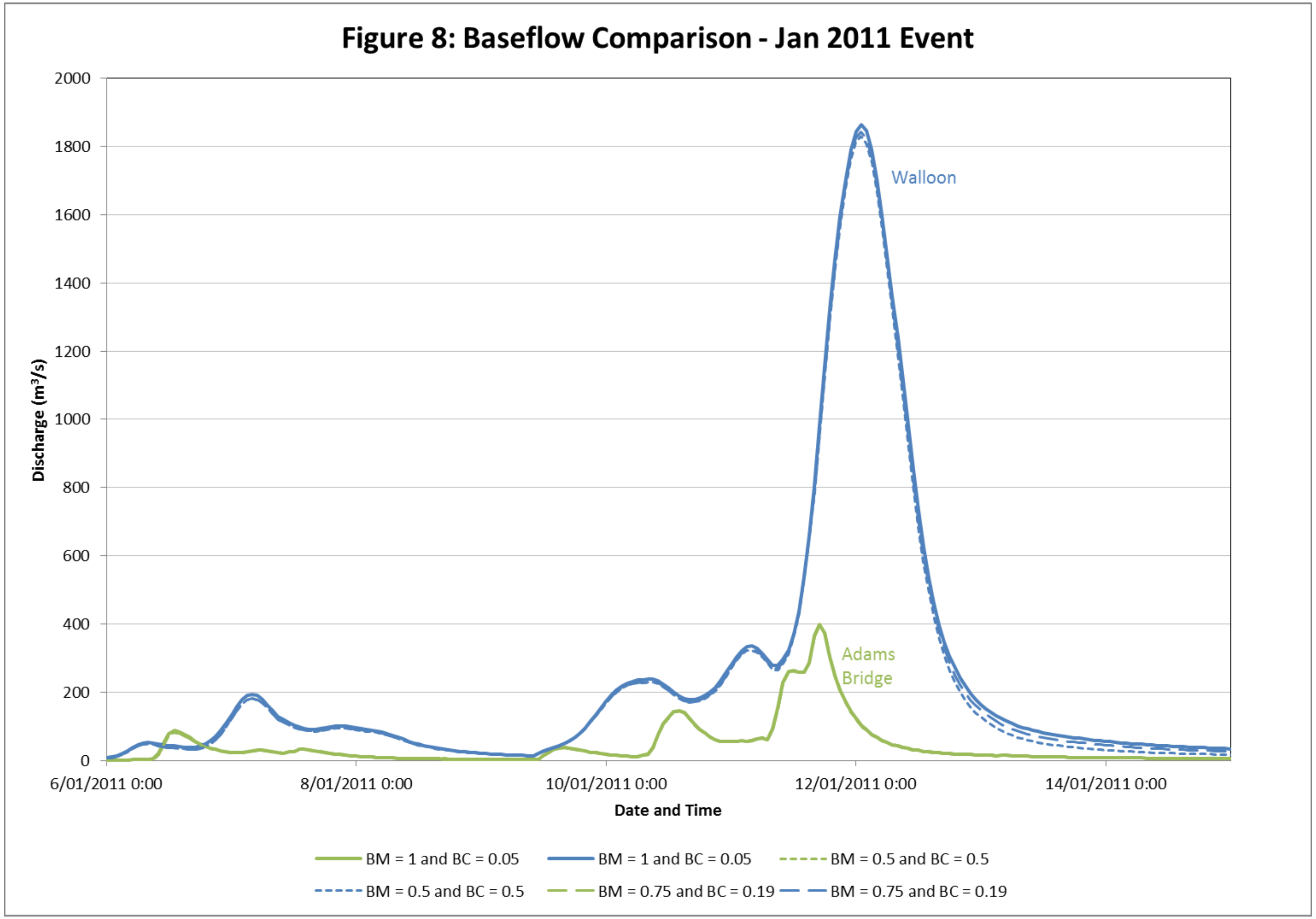


Figure 8: Baseflow Comparison - Jan 2011 Event
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Discharge (m³/s)
Walloon
Adams Bridge
6/01/2011 0:00
8/01/2011 0:00
10/01/2011 0:00
12/01/2011 0:00
14/01/2011 0:00
Date and Time
BM = 1 and BC = 0.05
BM = 1 and BC = 0.05
BM = 0.5 and BC = 0.5
BM = 0.5 and BC = 0.5
BM = 0.75 and BC = 0.19
BM = 0.75 and BC = 0.19

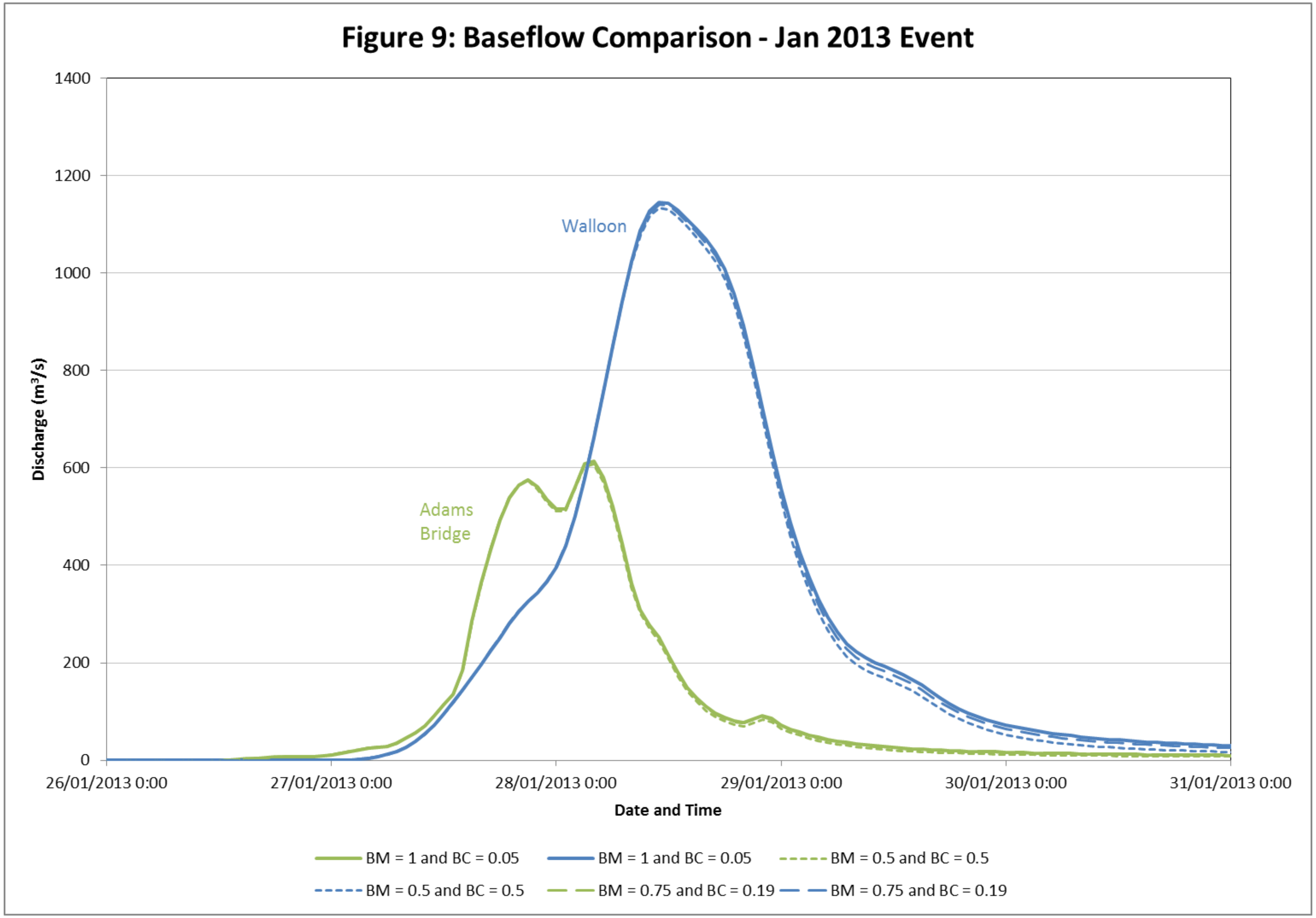


Figure 9: Baseflow Comparison - Jan 2013 Event
1400
1200
1000
800
600
400
200
0
Discharge (m³/s)
Walloon
Adams Bridge
26/01/2013 0:00
27/01/2013 0:00
28/01/2013 0:00
29/01/2013 0:00
30/01/2013 0:00
31/01/2013 0:00
Date and Time
BM = 1 and BC = 0.05
BM = 1 and BC = 0.05
BM = 0.5 and BC = 0.5
BM = 0.5 and BC = 0.5
BM = 0.75 and BC = 0.19
BM = 0.75 and BC = 0.19

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