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Milestone Report 2: Fast Model Development and Calibration

Comprehensive Hydraulic Assessment

Brisbane River Catchment Flood Study

DRAFT FINAL

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

April 2015

Comprehensive Hydraulic Assessment
as part of the
Brisbane River Catchment Flood Study

Milestone Report 2:
Fast Model Development and Calibration

Prepared for:	State of Queensland (acting through) Department of State Development, Infrastructure and Planning Department of Natural Resources and Mines
Prepared by:	BMT WBM Pty Ltd (Member of the BMT group of companies)

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Executive Summary

The State of Queensland, acting through the Department of State Development, Infrastructure and Planning (DSDIP), and project managed through the Department of Natural Resources and Mines, is undertaking a Comprehensive Hydraulic Assessment (this assessment) to deliver a fully calibrated hydraulic model that accurately defines the flood behaviour of the lower Brisbane River including major tributaries downstream of Wivenhoe Dam. This assessment is a component of a broader framework of the Brisbane River Catchment Floodplain Studies (BRCFS) currently being undertaken by the Queensland Government in response to the Queensland Floods Commission of Inquiry to provide a comprehensive plan to manage Brisbane River flood risk.

Milestone Report 2 (this report), titled “Fast Model Development and Calibration”, reports on the development of the Fast Model and its calibration and verification to the historical floods of 1974, 1996, 1999, 2011 and 2013. This report addresses the review comments and incorporates feedback provided by the Independent Panel of Experts (IPE) and Technical Working Group (TWG), both prior to and following Workshop 2. Workshop 2, held on Thursday 11 December 2014, focussed on presentation of the details of the Fast Model development and calibration. Outcomes and Actions from Workshop 2 are included in this report as Appendix A. Comments received from the IPE, BCC and Seqwater and the subsequent responses from BMT WBM are provided in Appendix B.

The report addresses the tasks below in Section 3.10 of the Brief:

- Section 3.10.4.1 – Model development and calibration; and
- Section 3.10.1.3 – Fast Model Quality Assurance and Reporting (part).

In undertaking the above tasks and preparing this report, the following Sections of the Brief are also relevant:

- Section 3.8 (Accuracy Requirements)
- Section 3.9.3 (Hydraulic Models)
- Section 3.10.4.3 (Fast Model Quality Assurance and Reporting).

The purpose of the Fast Model in the BRCFS is to simulate thousands of the Hydrologic Assessment’s Monte Carlo flood events through a hydraulic model to:

- Incorporate the hydraulic effects of conveyance, storage and inertia into the Monte Carlo Analysis, especially in tidal and backwater influenced areas; and
- Produce peak flood level and flow frequency curves at gauge sites and other locations along the rivers and creeks to fine-tune and value-add to the Hydrologic Assessment’s Monte Carlo Analysis.

The results of the Fast Model’s Monte Carlo Analysis will be analysed and used to derive a selection of approximately 50 of the Monte Carlo events that provide AEP ensemble event sets to be simulated in the Detailed Model.

The Fast Model also offers the opportunity to further review the rating curves at gauge locations developed by Seqwater and the Hydrologic Assessment (Aurecon et al, 2014c).

Executive Summary

Milestone Report 2: Fast Model Development and Calibration presents:

- An overview of the data used to develop the Fast Model, including the DEM (Digital Elevation Model), historical data such as individual flood height records and gauge recordings, land-uses used to guide model roughness parameters, and significant hydraulic structures.
- The update of the DMT hydraulic model used to help inform the development of the Fast Model.
- A description of the Fast Model schematisation and approach to model development and calibration.
- Presentation and discussion of the Fast Model calibration results for each of the calibration and verification events.
- Discussion on the confidence and limitations of the Fast Model for simulating Monte Carlo flood events, and for value adding to the Hydrologic Assessment's Monte Carlo Analysis.

The Fast Model has been developed as a 1D network hydraulic model comprised of approximately 2,350 channels interconnected to represent the in-bank and overland flowpaths. The use of the DMT Model, which was updated (known thereafter as the Updated DMT Model) to include recently acquired data sets and to incorporate the revised URBS modelling from the Hydrologic Assessment, was of significant benefit during the Fast Model construction.

The Fast Model was calibrated and verified to the floods of 1974, 1996, 1999, 2011 and 2013. Key observations during the model calibration/verification phase are:

- The conveyance dominated sections of the Brisbane River cannot be calibrated using solely a Manning's n approach. Additional form (energy) losses, particularly at sharp river bends, rock ledges and confluences are needed to reproduce the timing of the flood wave and the steep gradients along sections of the Brisbane River.
- The Manning's n values, with a minor allowance needed for the application of form losses to in-bank channels, are within the ranges used in the industry.
- The interaction and size of the Lockyer Valley floodplains has a significant influence on flood behaviour, most notably in the Lockyer Valley, but also on the Brisbane River.
- The calibration is more rigorous for:
  - Areas where there is more accurate in-bank topographic data, i.e. the tidal reaches where bathymetric surveys were carried out; and
  - The major floods of 1974 and 2011.

Additional extreme event simulations were undertaken for 1.5, 2, 5 and 8 times the 1974 event. The 1.5 times 1974 event is similar in flow magnitude to the 1893 flood event in Brisbane City. While these extreme event simulations were not undertaken as a calibration exercise, they are important in ensuring that the Fast Model is capable of modelling events of these magnitudes both in terms of model schematisation and stability.

In regard to the suitability of the Fast Model to be used for the Monte Carlo stage of the Hydraulic Assessment:

- The Fast Model has a run time of around 4 mins for an 8 day flood on a standard single CPU core[1]. This is within the 15 mins run time as stipulated by the Hydraulic Assessment brief. At this run time the model can feasibly be used to simulate the Monte Carlo events.
- The Fast Model has been calibrated and verified to tidal conditions, three minor floods (1996, 1999 and 2013) and two major floods (1974 and 2011). These floods vary substantially in their behaviour and size, and the Fast Model satisfactorily reproduces the flood behaviour across the wide range of events without the need to vary calibration parameters on an event by event basis.
- The Fast Model has been proofed against a range of extreme events and has demonstrated that overland flowpaths are defined appropriately and that the model is robust.

In conclusion, the Fast Model is considered sufficiently robust and accurate to simulate the selected Monte Carlo events from the Hydrologic Assessment leading to the selection of about 50 events for the Detailed Model's design flood simulation phase.

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[1] At the time of writing, the standard CPU core runs at 4.2GHz

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The various plots produced to present the Updated DMT Model calibration cross-check and the Fast Model's calibration and verification, along with a selection of sensitivity tests are collated in the Plot Addendum and are listed below in the order that they are compiled in the addendum.

Updated DMT Model

2011 UDMT Flood Calibration Check

2013 UDMT Flood Calibration Check

1974 UDMT Flood Calibration Check

Fast Model – Tidal and Minor Flood Calibration and Verification

2013 FM Flood and Tide Calibration

1996 FM Flood Calibration

1999 FM Flood Verification

Fast Model – Major Flood Calibration and Verification

2011 FM Flood Calibration

1974 FM Flood Verification

Fast Model – Longitudinal Profiles for all Calibration Events

Fast Model – Rating Curve Review

Fast & UDMT Model – Extreme Flood Proofing

Fast Model Sensitivity Tests

ST01 Fast Model General Manning’s n and Bend Loss Tests

ST02 Fast Model Manning’s n and Bend Loss Values ±10%

ST03 URBS Alpha Values ±10%

ST04 URBS Beta Values ±10%

ST05 Lowood-Fernvale Cross-Sections

List of Abbreviations

1D	One dimensional
2D	Two dimensional
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ALS	Aerial Laser Survey
ARI	Australian Rivers Institute
AWRC	Australian Water Resources Council
BCC	Brisbane City Council
BCC (CPO)	Brisbane City Council (City Projects Office)
BoM	Bureau of Meteorology
BRCFMP	Brisbane River Catchment Floodplain Management Plan
BRCFMS	Brisbane River Catchment Floodplain Management Study
BRCFS	Brisbane River Catchment Flood Study
CBD	Central Business District
CPU	Central Processing Unit
DCS	Data Collection Study
DEM	Digital Elevation Model - a fixed grid of elevations sampled from a DTM
DMT	Disaster Management Tool
DNRM	Department of Natural Resources and Mines
DPI	Department of Primary Industries (former)
DS	Downstream
DSDIP	Department of State Development, Infrastructure and Planning
DTM	Digital Terrain Model – a triangulation of raw elevation data points
DTMR	Department of Transport and Main Roads
FCoI	Floods Commission of Inquiry (Qld)
FEWS	Flood Early Warning System
FM	Fast Model
FOSM	Flood Operations Simulation Model
GIS	Geographic Information System
GPU	Graphics Processing Unit
H&H	Hydrologic and Hydraulic
HDD	Hard Disk Drive

ICC	Ipswich City Council
IPE	Independent Panel of Experts (for the current Study)
IRP	Independent Review Panel (commissioned by BCC in 2003)
LGA	Local Government Area
LiDAR	Light Detection and Ranging
LVRC	Lockyer Valley Regional Council
PMF	Probable Maximum Flood
PoB	Port of Brisbane
QGIS	Queensland Government Information Service
QR	Queensland Rail
RAM	Random Access Memory
SEQ	South East Queensland
SRC	Somerset Regional Council
SRTM	Shuttle Radar Topography Mission
TIN	Triangulated Irregular Network
TLPI	Temporary Local Planning Instrument
TWG	Technical Working Group
UDMT	Updated Disaster Management Tool
US	Upstream
WSDOS	Wivenhoe and Somerset Dams Optimisation Study

1 Introduction

1.1 Context

1.1.1 Brisbane River Catchment Floodplain Studies

The State of Queensland, acting through the Department of State Development, Infrastructure and Planning (DSDIP) and the Department of Natural Resources and Mines (DNRM) as project manager, is undertaking a Comprehensive Hydraulic Assessment (this assessment) to deliver a fully calibrated hydraulic model that accurately defines the flood behaviour of the lower Brisbane River including major tributaries downstream of Wivenhoe Dam.

This assessment is a component of a broader framework of the Brisbane River Catchment Floodplain Studies (shown in Figure 1-1) currently being undertaken by the Queensland Government in response to Recommendation 2.2 of the Queensland Floods Commission of Inquiry[2] to provide a comprehensive plan to manage Brisbane River flood risk.

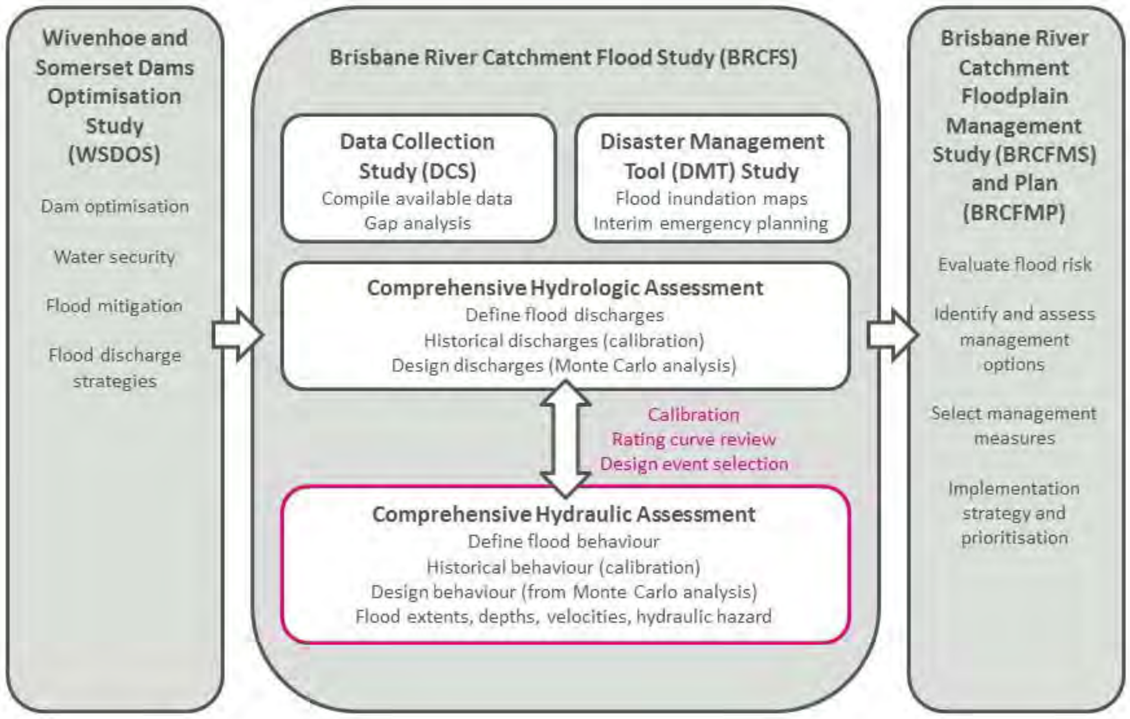

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Figure 1-1 Brisbane River Catchment Floodplain Studies

Recommendation 2.2 states that:

Brisbane City Council, Ipswich City Council and Somerset Regional Council and the Queensland Government should ensure that, as soon as practicable, a flood study of the Brisbane River

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[2] Final Report, Queensland Floods Commission of Inquiry, March 2012.

catchment is completed in accordance with the process determined by them under recommendation 2.5 and 2.6. The study should:

- Be comprehensive in terms of the methodologies applied and use different methodologies to corroborate results;
- Involve the collation, and creation where appropriate, of the following data:
    - Rainfall data including historical and design data and radar;
    - Streamflow data;
    - Tide levels;
    - Inundation levels and extents;
    - Data on the operation of Wivenhoe and Somerset dams;
    - River channel and floodplain characteristics including topography, bathymetry, development and survey data;
    - Involve determining the correlation between any of the data sets above;
- Produce suitable hydrologic models run in a Monte Carlo framework, taking account of variability over the following factors:
    - Spatial and temporal rainfall patterns;
    - Saturation of the catchment;
    - Initial water level in dams;
    - Effect of operating procedures;
    - Physical limitations on the operation of the dams;
    - Tidal conditions;
    - Closely occurring rainfall events;
- Validate hydrologic models to ensure they reproduce:
    - Observed hydrograph attenuation;
    - Probability distributions of observed values for total flood volume and peak flow;
    - Timing of major tributary flows;
    - Observed flood behaviour under no dams conditions and current conditions;
- Produce a suitable hydraulic model or models that:
    - Are able to determine flood heights, extents of inundation, velocities, rate of rise and duration of inundation for floods of different probabilities;
    - Are able to deal with movement of sediment and changes in river beds during floods;
    - Are able to assess historical changes to river bathymetry;
    - Are able to be run in a short time to allow detailed calibration and assessment work;

  - Characterise the backwater effect at the confluence of the Brisbane and Bremer rivers and other confluences as appropriate;
  - Involve analysis of the joint probability of floods occurring in the Brisbane and Bremer rivers (and any other pair of rivers if considered appropriate); and
  - Be iterative, and obtain a short-term estimate of the characteristics of floods of different probabilities in all significant locations in the catchment (at least Brisbane City, Ipswich City and at Wivenhoe Dam) in order to determine the priorities for the rest of the study.

This suite of studies follows the traditional and effective flood risk management framework endorsed as current best practice in Australia[3], which incorporates the following steps:

- A Flood Study: The **Brisbane River Catchment Flood Study (BRCFS)** is presently underway to define flood behaviour. The BRCFS comprises a Data Collection Study (DCS), Comprehensive Hydrologic Assessment and Comprehensive Hydraulic Assessment (see Section 1.1.2).
- A Floodplain Management Study: The **Brisbane River Catchment Floodplain Management Study (BRCFMS)** will subsequently evaluate flood risk based on the flood behaviour defined in the BRCFS and identify and assess a range of flood risk management options. Options that involve changes in hydrologic and/or hydraulic conditions will be assessed using the models developed for the BRCFS.
- A Floodplain Management Plan: The **Brisbane River Catchment Floodplain Management Plan (BRCFMP)** will select a range of flood risk management measures based on the options assessed in the BRCFMS to guide the current and future management of flood risk. This will include a prioritised strategy outlining how the measures are to be implemented (including funding, responsibilities, actions, timeframes etc.).

The **Wivenhoe and Somerset Dams Optimisation Study** (WSDOS) has also been carried out in response to the Queensland Floods Commission of Inquiry to investigate potential options to improve dam operations and flood mitigation, taking into consideration water supply security, dam safety and erosion.

1.1.2 Brisbane River Catchment Flood Study (BRCFS)

The Brisbane River Catchment Flood Study (BRCFS) comprises the following stages:

- **Data Collection Study (Aurecon *et al*, 2013):** The Data Collection Study (DCS) was completed by Aurecon in 2013 and identified, compiled and reviewed readily available data and metadata, including a gap analysis.
- **Comprehensive Hydrologic Assessment (Aurecon *et al*, 2014c):** The Hydrologic Assessment commenced in 2013 and is currently being reviewed by the Client. It will define flood flows for the Brisbane River catchment based on flood frequency analysis, design event analysis and hydrologic modelling using a Monte Carlo approach to cater for temporal and

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[3] Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia, Australian Emergency Management Handbook 7, Australian Government Attorney-General's Department, 2013.

spatial variations in rainfall patterns, operation of Wivenhoe Dam and other factors that affect catchment runoff. The Hydrologic Assessment also includes the configuration of a FEWS framework for data and simulation management.

- **Comprehensive Hydraulic Assessment:** The Hydraulic Assessment (this assessment) will define flood behaviour of the lower Brisbane River on the basis of, and in conjunction with, the Hydrologic Assessment. Specifically, this assessment will identify flood extents, depths, velocities and hydraulic hazard, across the full extent of the floodplain, for a range of events up to and including the PMF.

In addition to the above stages, the **Disaster Management Tool (DMT) Study** (BCC, 2014a) has been undertaken by Brisbane City Council (City Projects Office) (BCC (CPO)) for the BRCFS Steering Committee for the purposes of providing flood inundation maps for interim emergency planning. The DMT also provides significant and useful background for the development of the hydraulic models for this assessment.

1.1.3 BRCFS Hydraulic Assessment

Key elements of the Hydraulic Assessment include the development of an integrated suite of hydraulic models, rigorous and defendable calibration to historical events, and modelling of a comprehensive range of design events to define flood behaviour.

There has been close integration between the Hydraulic Assessment and the Hydrologic Assessment where they interact and overlap as shown in Figure 1-1; specifically adoption of rating curves and selection of design events from the Monte Carlo analysis.

The Hydraulic Assessment incorporates the following phases: data collation, site inspections, interfacing with the FEWS framework developed for the Hydrologic Assessment, modelling, reporting and workshops (shown in Figure 1-2). The calibration of the Fast Model has been undertaken outside of the FEWS framework as per the Hydrologic Assessment.

1.2 Fast Model Function

The primary purpose of the Fast Model is to simulate thousands of Monte Carlo events derived by the Hydrologic Assessment. The peak flows and peak water levels from these thousands of runs will be used to carry out flood frequency analyses (FFA) at 29 reporting locations along the main creeks and rivers. From these FFAs, preliminary flood level AEPs at the reporting locations will be derived, followed by selection of approximately 50 of the Monte Carlo events that give a reasonable representation of the flood level AEPs derived from the FFA.

The Fast Model is best viewed as a stepping stone to the selection of the 50 design flood events for the Detailed Model. The 50 events are to be selected from the thousands of Monte Carlo Events produced by the Hydrologic Assessment. The long run-times of the Detailed Model prohibit using the Detailed Model for the Monte Carlo analysis to derive peak water level AEPs.

For the Fast Model to meet these objectives, its run time, according to the study brief, is to be less than 15 minutes. The model must also be able to reliably reproduce the hydraulics of the Brisbane River Catchment downstream of Wivenhoe Dam, particularly along the main creeks and rivers where the reporting locations are located. Therefore, the model needs to be calibrated and verified to a range of historical events, and also shown to produce consistent results for extreme events through comparison with other models/analyses.

Importantly, the Fast Model is not intended to calculate the final peak water levels for different AEPs – this will be an output of the Detailed Model. The Fast Model is solely to be used to help select a small sub-set (~50) of the Monte Carlo events that give consistent results with the Monte Carlo FFA.

1.3 This Report

1.3.1 Purpose and Scope

This Milestone Report 2: Fast Model Development and Calibration is the second[4] in a series of milestone reports to be delivered as part of the BRCFS Hydraulic Assessment. The purpose of this report is to provide an overview of the development and calibration of the Fast Hydraulic Model, including data used, methodology adopted for model schematisation and calibration to historical events. This report was initially released as a Draft prior to the Workshop held on 11 December 2014, at which the findings outlined in this report were presented and discussed with the IPE and TWG members. Outcomes, key points and response to comments from the review and workshop are incorporated into this Draft Final report as Appendix A (Outcomes and Actions from Workshop 2) and Appendix B (comments received from IPE, BCC and Seqwater).

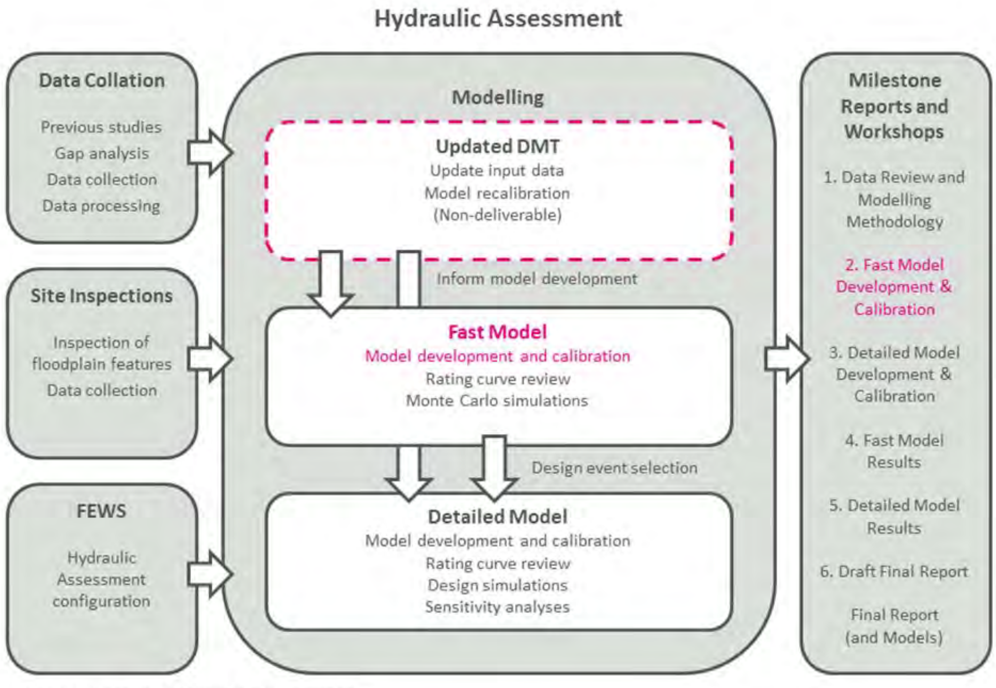

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Figure 1-2 BRCFS Hydraulic Assessment

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[4] The first report being BMT WBM (2014) - Milestone Report 1: Data Review and Modelling Methodology, BMT WBM for Department of State Development, Infrastructure and Planning, Draft Final - 29 October 2014.

1.3.2 Brief

This Milestone Report 2: Fast Model Development and Calibration, addresses the relevant components of the following tasks as outlined in the Brief (DSDIP, 2014):

3.10.4.1 Model Development, Calibration and Validation

A fast hydraulic model will be developed. The general requirements for the model are outlined in Section 3.9.3.

The topography for the model will be derived from a comprehensive DTM of the area, representing the current floodplain and river geometry, with accuracy suitable for hydraulic modelling of small to extreme flood events.

The model will be calibrated (or validated) against a wide range of representative flood events (small to large) in each of the model catchments including a sufficient number of significant events. Calibration will include matching modelled to observed peak levels, goodness of fit of height hydrographs, discharges, velocities, afflux at structures, maximum depths, timing of peaks, and extents of inundation. A calibration strategy similar to that for the calibration of the detailed model is recommended. It may be efficient to calibrate the fast and detailed models using the same observed data sets and in parallel.

The fast model should be able to simulate (within acceptable tolerances) the interaction of flood flows from tributaries with flood flows in the Brisbane River as measured against the results of the detailed model. The fast model should give results very similar to the results of the detailed model over a range of flood magnitudes at key locations[5]*.*

The consultant may propose alternative approaches and should outline in the proposal why such approaches may provide more efficient effort and better calibration outcomes.

3.10.4.3 Fast Model Quality Assurance and Reporting (part)

A comprehensive report on the development and calibration of the fast hydraulic model is to be prepared. The report should provide information on topographic data input, structures, schematisation, boundary conditions, modelling of interface between and river and floodplain, tests of robustness and stability, interfacing with the hydrology modelling component, ability of model to meet the objectives of the study, limitations of model, likely accuracy, and tolerances which should apply to model results.

A presentation to the client will be required to describe the model development and calibration.

Other sections relevant to the work undertaken as part of the Brief are as follows:

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[5] Comparison of the Fast Model and Detailed Model results is not possible in this Report as the Detailed Model calibration is not yet complete at the time of writing. The Detailed Model component of the assessment occurs later in the timeline than the Fast Model. Comparison of the results of both models was carried out during fine-tuning of the Fast Model in March 2015 when the initial results from the Detailed Model were available.

3.8 Accuracy Requirements[6]

In terms of water level estimates for specified annual exceedance probabilities, it would be desirable to achieve the following target tolerances:

- *Brisbane River downstream of Oxley Creek ± 0.15 m*

- *Brisbane River between Goodna and Oxley Creek ± 0.30 m*

- *Ipswich urban area± 0.30 m*

- *Brisbane River and tributaries upstream of Goodna (for non-urban areas), including Bremer River and Lockyer Creek ± 0.50 m*

While there is no independent way of confirming that these accuracies will have been achieved in the results, some indication of the likely accuracy might be obtained through consideration of:

- *the quality of the input (including tolerances of topographic data, currency of topographic and bathymetry data, and the quality of the flood height data and corresponding estimates of flow);*

- *river geomorphology;*

- *the quality of the calibration;*

- *the magnitude of the events used for model calibration, in comparison with the design events;*

- *the discretisation of the hydrodynamic model;*

- *specifications of hydraulic roughness and energy losses (note that consideration may need to be given to variable roughness relationship with depth, and possible careful separation of friction losses versus drag and turbulence losses);*

- *the height vs. flow (rating curve) characteristics;*

- *quality of the design flood hydrology;*

- *experience in recent hydraulic modelling work in the catchment;*

- *benchmarking tests for hydraulic models; and*

- *results of sensitivity analyses for the key model parameters.*

The Consultant is required to consider and address the above aspects which affect accuracy, and draw conclusions regarding the likely accuracy of the results. Based on the above considerations, the Consultant is required to nominate "tolerances" which should be applied to the estimated design flood levels. The theory of errors may be used to establish an 'error range' for final levels.

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[6] These tolerances for accuracy contained in the brief relate to the **design** water level estimates rather than the **calibration** water levels. However, these tolerances are used and discussed in this report in relation to recorded and modelled levels and their differences.

3.9.3.Hydraulic Models (part)

A fast hydraulic model of the lower Brisbane River is also to be developed. This model is to have the following properties.

- *The software platform will satisfy the requirements of the fast hydraulic model as described in Section 3.7 “Hydraulic Modelling Software Platform(s)”.*
- *The extent of the model will be in accord with description in the Section 3.6 “Model Extent”.*
- *The model configuration will reflect the existing or currently-approved development along the rivers and floodplains within the extent of the model.*
- *The run times will be short enough to simulate large numbers of storm and tide flood event scenarios as described in Section 3.7. Ideally run times should be shorter than 15 minutes.*
- *The model should simulate floodplain storage and channel breakthrough typically associated with large flow conditions (e.g. >8,000 m3/s).*
- *The hydraulic model will be calibrated against the best available data at the time of the study. Section 3.10.4.1 provides more information on the calibration process.*
- *Boundary conditions for the model will be supplied from the URBS runoff-routing model of the Brisbane River catchment developed as part of the Hydrology Study. An efficient interface between the two models is required. This is to be achieved through the Delft-FEWS framework.*
- *If the model run time is significantly longer than 15 minutes, the model will be configured to run using hot-start files to ensure efficient model run time.*

The hydraulic models will be handed over to the BRCFS Steering Committee at the end of the consultancy.

3.10.4.3 Fast Model Quality Assurance and reporting (part)

A comprehensive report on the development and calibration of the fast hydraulic model is to be prepared. The report should provide information on topographic data input, structures, schematisation, boundary conditions, modelling of interface between and river and floodplain, tests of robustness and stability, validation of the model against the detailed model results[5], interfacing with the hydrology modelling component, ability of model to meet the objectives of the study, limitations of model, likely accuracy, and tolerances which should apply to model results.

A presentation to the client will be required to describe the model development and calibration.

2 Data Inputs

2.1 Topographic Data

The relevance and priority of the available topographic datasets that were considered for use in the development of the Fast Model are discussed in this section. Topographic datasets used in the Updated DMT Model are discussed specifically in Section 3.1.2.

2.1.1 Disaster Management Tool DEM (DMT DEM)

As part of the Brisbane River Catchment Disaster Management Tool study ("DMT Study") completed by BCC in 2014 (BCC, 2014a), a DEM was developed across the full hydraulic model study area. This DEM is referred to as the DMT DEM. It was based on the latest floodplain LiDAR and bathymetry (post-2011 flood) information and represented the best information available at the time of the DMT study. Further details on the background and development of the DMT DEM are provided in BCC (2014a) and BCC (2014b). Additional discussion on the DMT DEM relating to technical matters and identified data gaps directly relevant to this study is provided in BMT WBM (2014). A Drawing showing the areas of LiDAR data utilised to form the DMT DEM is provided in BMT WBM (2014).

Since development of the DMT DEM, additional topographic and bathymetric data have become available and/or were deliberately sourced in order to fill the data gaps identified by BCC (2014b). It was not possible to incorporate the new data into that DEM[7], instead, the new data has been utilised on a priority basis by the hydraulic model in order to inform hydraulic model topography. Both the new data and other relevant data are described in the following sections. The priority order of all data sets used in the Fast Model is described in Section 2.1.5. The use and priority of datasets used in the Updated DMT Model is provided in Section 3.1.2.

2.1.2 Lower Brisbane River and Tributaries DEM (GHD)

For the purpose of the Coastal Plan Implementation Plan Study undertaken for BCC by GHD (GHD, 2014), a DEM of the Lower Brisbane River and tributaries was developed. This DEM was developed from BCC LiDAR data and various sources of bathymetric data. Of particular interest to this study are the bathymetric components of the DEM. The bathymetric data used to create the DEM includes:

- Cross-sectional data (BCC) extending up into some tributary creeks (for example, Norman and Oxley Creeks);
- Hydrographic survey data extending up into some tributary creeks (for example, Breakfast Creek and Bulimba Creek); and
- Other sources including Dredge Area MSL, Moreton Bay Channel data, MSQ and R plus L Bathymetry (naming of these sources was extracted directly from the explanatory text file that was received with the DEM).

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[7] Attempts were made to combine these new datasets with the DMT DEM into a single DEM and assistance was sought from the 12D developers and Peter Murray from BCC in this regard. However, due to the computing constraints imposed by the very large size of the DMT DEM it was not possible to incorporate the new data into the DEM.

The GHD data typically captures the lower reaches of some of the tidal tributaries that the DMT DEM did not. The original DMT Model modified the bathymetry at these locations using z shapes to lower the creek beds. Comparison of the GHD DTM and the DMT DEM shows very little difference in the overbank areas. In general, for the in-bank areas of the lower reaches of the Brisbane River (below Hamilton), the GHD DTM gives higher bed levels than both the DMT DEM and the 2014 Port of Brisbane bathymetry (refer to Section 2.1.4.1). We have not used the GHD DEM in these regions, instead giving priority to the 2014 PoB bathymetric survey.

Details on the prioritisation of this DEM for use in the hydraulic models are provided in Section 2.1.5.

2.1.3 Future LiDAR Data

Through discussions with stakeholders and DNRM, it is understood that a new LiDAR survey being flown in South East Queensland will cover the area of the Hydraulic Assessment except for the Lockyer Valley. It has been confirmed by DNRM that there is a delay in the delivery of this LiDAR and it is not possible to include this data within the Fast Model. There is a possibility that the future data may be available to include in the development of the Detailed Model. Further commentary on this future dataset is provided in BMT WBM (2014) with commentary updates anticipated in future BMT WBM Milestone Reports.

2.1.4 Bathymetric Data

Bathymetric data defines the shape of the ground surface below water level. This data can be collected as cross-sections or hydrographic survey. Cross-sections are typically perpendicular to the flow direction and may include components of above-water topography. Hydrographic survey is traditionally limited to the underwater ground surface and is typically provided as a closely spaced set of regularly spread points.

The location of the following bathymetric data sets are shown in Drawing 3.

2.1.4.1 PoB Lower Brisbane and Lower Bremer (2014)

In August 2014, the Port of Brisbane (PoB) (on behalf of the Qld DNRM) provided a 5m gridded DEM bathymetric data point set based on their hydrographic survey of the following areas:

- **Bremer River** - from West Ipswich downstream to the confluence with the Brisbane River;
- **Brisbane River** - from Parker Island (near the Gateway Bridge) downstream to Inner Bar; and
- **Brisbane River** - from Shafston Reach downstream to the Quarries Reach (near the Gateway Bridge) (completed as a part of the BCC Kingsford Smith Drive Stage 3 project).

BMT WBM used these points to create three DEMs: Lower Bremer, Lower Brisbane 1 and Lower Brisbane 2. The use of these DEMs is discussed in Section 2.1.5.

2.1.4.2 Mt Crosby Weir Pool (2007)

Seqwater commissioned a detailed hydrographic survey of the Mt Crosby weir pool in 2007, extending about 15km upstream from the Mt Crosby Weir to Pine Mountain. This survey was undertaken as a set of bathymetric cross-sections spaced at 25m. BMT WBM used these sections to create a bathymetric DEM of the Mt Crosby weir pool. The use of this DEM is discussed in Section 2.1.5.

2.1.4.3 Lowood-Fernvale Cross-Sections (2008)

As part of the Fernvale and Lowood Flood Study (BCC, 2009), cross-sections were surveyed on both the Brisbane River and Lockyer Creek in 2008. A total of 46 cross-sections were surveyed with 14 of these on Lockyer Creek and 32 on the Brisbane River, as shown in Drawing 3. The spacing between sections is approximately 500m. A comparison of these surveyed cross-section points with the DMT DEM data in this region revealed that the surveyed points are on average 0.42 m lower than the DMT DEM, with a standard deviation of 2.0 m. THE DMT DEM is primarily based on LiDAR in this region and it is typical for LiDAR to be higher than surveyed data due to the effects of vegetation and water.

When considering these cross-sections for use in the Fast Model, it was found that the cross-sections did not extend across the entire waterway and in some reaches they were at a spacing that was greater than desired. If these cross-sections were to be used for 1D modelling, they would need to be extended across the full waterway by merging the surveyed component with extracted DMT DEM sections. Given the limited timeframe available this was not a realistic option. Instead, two tests were undertaken to assess the suitability of using the DMT DEM to provide topographic/bathymetric data for the Fast Model in the Lowood Fernvale area:

(1) A model sensitivity test using the (unextended) Fernvale Lowood cross-sections for in-bank topography in the Fast Model compared with using the DMT DEM was carried out. This sensitivity test is documented in Section 4.15.5.

(2) Comparison of a Seqwater surveyed gauge cross-section (refer to Section 2.1.4.8) with the DMT DEM in this region. The DMT DEM compared very well with the surveyed cross-section and led to the understanding that BCC (2014b) undertook manual adjustment of the DMT DEM bathymetry using the invert levels from the Lowood Fernvale cross-sections in conjunction with aerial imagery to identify pools and riffles. Further details on the cross-section comparison and the manual adjustment are provided in Appendix E.

In summary, these results lead to the following conclusions:

- The DMT DEM in this area is suitable for use in informing the Fast Model topography due to comparable results being achieved in the Lowood-Fernvale cross-section sensitivity test.
- The DMT DEM in this area is based on more than just LiDAR data due to the fact that BCC (2014b) undertook manual adjustment of river sections below normal water level. Independent checks on the DMT DEM in this area using a Seqwater surveyed gauge-cross-section indicate the DMT DEM represents the cross-sectional area and river conveyance well.

As such, the DMT DEM was used in preference to the Lowood-Fernvale cross-sections to inform the Fast Model topography.

2.1.4.4 RUBICON Model Cross-Sections

In 1994, Qld DPI completed the Brisbane River and Pine River Flood Study (DPI, 1994) on behalf of the South East Queensland Water Board. RUBICON hydraulic modelling was undertaken using the following sources of in-bank topographic data:

- 40 cross sections of the Brisbane River surveyed by DPI (formerly the Queensland Water Resources Commission) in 1992 between Wivenhoe Dam and Colleges Crossing. A further 8 cross sections were available from a 1989 survey near Burtons Bridge;
- Cross sections of the Lockyer Creek surveyed by DPI in 1966;
- A hydrographic survey of the Brisbane River extending from the river mouth to just below Colleges Crossing from 1974; and
- A hydrographic survey of the Bremer River from its junction with the Brisbane River to the Basin Reserve in Ipswich by the Bremer River Trust Fund in 1988.

As shown in Drawing 3 these cross-sections are very widely spaced. In addition, some of the sections were surveyed many years ago, making their currency less certain. These two facts in combination make the cross-sections of limited value in the modelling undertaken for the current study. However, they have been used to provide further insights into in-bank topography on an as-required basis.

2.1.4.5 Ipswich City Council Cross-Sections

As shown in Drawing 3, the Ipswich City Council cross-sections cover some of the minor tributaries of the Bremer River. The locations of these sections are outside the extent the hydraulic models developed for the current study.

2.1.4.6 ARI Depth Soundings (2012)

Depth soundings of the Brisbane River were collected by the Australian Rivers Institute (ARI) in September/November 2012. The soundings extend from Wivenhoe downstream to the top end of the Mt Crosby weir pool (upstream of Mt Crosby), as shown in Drawing 3 and result in small overlaps with the Lowood-Fernvale Cross-Sections and the Mt Crosby pool data at the upstream and downstream ends respectively. Joe McMahon from ARI advised that the underwater ground surface elevation in AHD was estimated by linking the water level measured by ARI with the water level measured by LiDAR, flown in 2011. This allowed water depths measured by ARI to be converted to AHD. BMT WBM compared the ARI bathymetry with that found within the LiDAR dataset and found that ARI bathymetry values were 1.3m lower on average than LIDAR, with a standard deviation of 1.4. This seems reasonable given that the LIDAR does not extend below water level and that ARI data was collected from a canoe.

The ARI data was not suited for incorporation into the Fast Model due to its large spatial variance in the horizontal and it often not being perpendicular to the flow direction. It was therefore not used in the Fast Model but may assist in the development of the Detailed Model.

2.1.4.7 MIKE 11 Model Cross-Sections

The MIKE11 model of the Brisbane River has been reviewed and updated numerous times. It was initially developed by SKM (1998) using 197 surveyed cross-sections up to the extent of the BCC Council area (about 79km upstream and about 10km downstream of Colleges Crossing). The MIKE11 model was extended up into the Bremer River by SKM (2000) using surveyed cross-sections and photogrammetry of "questionable accuracy" to represent the modelled floodplain topography. In 2005, the SKM (2000) MIKE11 model was extended up to Wivenhoe Dam and into Lockyer Creek to assess the impacts of the Wivenhoe Dam upgrade (Wivenhoe Alliance, 2005). Cross-sections used to extend the model in 2005 were derived from:

- 5 m digital contours of Esk Shire Council area; and
- Cross sections surveyed for DNR for the 1994 study (DNR, 1994) – the "Rubicon Model Cross-Sections".

The most recent review and update of the MIKE11 model was undertaken by SKM (2011) for Seqwater. One significant key finding of this review was that the representation of cross-sections was not found to be appropriate for the magnitude of events relevant to that study.

More recent bathymetric survey now covers the majority of the rivers over which the surveyed MIKE11 cross-sections lie. For areas in which bathymetric survey is not available (e.g. upstream of the Mt Crosby weir pool surveyed section to the Lowood-Fernvale cross-sections), the MIKE11 cross-sections are based on the Rubicon model cross-sections. As previously mentioned in Section 2.1.4.4, these sections are too greatly spaced to be of use in the model topography. As such, the MIKE11 sections have not been used directly in the model but are used on an as-needed basis for checking purposes.

2.1.4.8 Seqwater Surveyed Cross-Sections at Gauge Sites

Cross-section information upstream and downstream of gauge sites is held by Seqwater and was supplied to BMT WBM in September 2014. The cross-sections are not suitable for use in the model but have been used to provide an indication of potential accuracy or otherwise of the LiDAR data used in the in-bank sections of the Fast Model. This is discussed further in Appendix E.

2.1.5 Priority Ranking of Topographic Datasets

For the purpose of the update to the DMT and the Fast Model development, each dataset has been given a priority ranking to ensure that the most suitable data is utilised within the relevant model area. This priority ranking is only applicable in areas where the datasets overlap. That is, in an area where only one dataset is available, then this dataset is the one used, regardless of its priority ranking. If datasets do not overlap, they may be assigned the same priority ranking as they are never in competition with each other. For example, there is no overlap between each Priority 1 dataset shown below for in-bank data. The Updated DMT Model datasets and priorities are discussed in Section 3.1.2.

Priority 1 Data (Highest Priority):

- Mt Crosby Weir Pool (2007)
- PoB Lower Brisbane and Lower Bremer (2014).

Priority 2 Data:

- Lower Brisbane River and Tributaries DEM (GHD).

Priority 3 Data (Lowest Priority):

- DMT DEM.

Checking as Required[8] (not directly incorporated within the model):

- ARI Cross-Sections (2012)
- RUBICON & MIKE11 Model Cross-Sections
- Lowood-Fernvale Cross-Sections (2008)
- Seqwater Surveyed Cross-Sections at Gauges (refer to Appendix E).

2.1.6 Breaklines

Breaklines are survey strings used to define continuous linear features. In relation to 2D modelling, they are used to define both the location and elevation of floodplain features such as levees and embankments that need to be specifically included in the DEM and/or the hydraulic model due to their ability to affect hydraulic behaviour.

Digital geo-referenced locations of railway lines and State carriageways were provided by Queensland Rail and DTMR respectively. However, neither of these digital datasets (breaklines) contained elevation data. In order to assign elevation data to these breaklines, automated procedures were developed that used the location of the breakline to search the 5m DEM for the series of high point elevations that best represented the longitudinal elevation of the linear feature for the purposes of hydraulic modelling.

Digital locations of other breakline features such as farm levees, dam walls and minor roads were not available. Instead, these features, where likely to be hydraulically influential, were manually digitised using the DEM and aerial imagery. The Updated DMT Model results were used to limit the extent of manual digitisation required by only considering locations in high velocity x depth areas, as it is these areas that will potentially have the greatest impact on model results. Once the

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[8] The “checking as required” sections upstream of Mt Crosby weir pool were used in a number of ways to check that the topography/bathymetry actually used in this area (LiDAR and other data from the DMT DEM) reasonably represented the topography/bathymetry for the purposes of the Fast Model. For example, a sensitivity test was undertaken to test the significance of the difference between the datasets in the Fernvale Lowood area by assessing the difference in model results when using either the DMT DEM or the cross-sections. This sensitivity test (refer to Section 4.15.5 and Section 2.1.4.3) demonstrated that model results were comparable. In summary, this is an example of what is meant by “checking as required”.

location of these breaklines had been digitised, the same automated procedure as used for railway lines and state carriageways was used to assign high point elevations along each linear feature.

Slim flow obstructions include noise barriers, fences and hand railings. These features may have an impact upon hydraulic behaviour depending upon their location and elevation. Breakline data on slim flow obstructions was not provided for this assessment. Unlike “wider” features like roads and levees that are possible to see on an aerial photograph and whose elevations are reflected in the LiDAR data, slim flow obstructions cannot be seen on an aerial photograph and elevations are not detected by LiDAR due to their “slim” nature. Thus, it was not possible to incorporate these features into the Fast Model, simply because the data was not available and not able to be extracted from any existing dataset.

2.1.7 Historical Topographic Data

Topography of floodplains and channels can change over time. In particular, large events can have a major impact on in-bank channel form and vegetative condition. These parameters can then impact upon channel conveyance. For example, significant changes to river conveyance (in-bank bathymetry and roughness) occurred within the Brisbane River catchment due to damage to channels and stripping of vegetation caused by the 2011 event floodwaters. The area downstream of Savages crossing was particularly affected. Michel Raymond from Seqwater (pers.comm., Nov 2014) noted that the impacts of this damage resulted in a general drop in water levels at Mt Crosby and Savages Crossing.

Ideally, channels and floodplains would be surveyed periodically to ensure that changes to topography were recorded and that the relevant topographic dataset could be used in a hydraulic model during calibration to a particular historic event. However, this would be a costly exercise and has not been carried out for the Brisbane River catchment. Accounting for historical changes in channel and floodplain roughness within the hydraulic model is possible by sensitivity testing Manning’s n values in areas where anecdotal or other evidence indicates that these changes have occurred. However, accounting for changes in topography is more difficult unless reasonable topographic surveys are available.

2.2 Hydrographic Data

2.2.1 Historical River Gauge Data

River gauges record water levels with flows derived from the recorded water levels using a rating curve. As part of the calibration process for a hydraulic model, the recorded water levels are compared to modelled water levels for each calibration event. A summary of the river gauges available for each calibration event is provided in Table 2-1. Gauges that are indicated as having data of questionable quality are discussed further in Appendix A.

The location of the river gauges is provided in Drawing 1. As the GIS coordinates supplied with the gauge data generally indicate the position of the gauge hut/electronics rather than the pressure sensor (where the water level is actually measured), Seqwater (personal communication, Oct 2014) provided advice on the exact positioning of the pressure sensor for a number of critical gauge sites. This allowed the GIS point of measurement for each gauge to be moved from an out-of-bank location to the more correct in-bank main channel location. While some uncertainty remains on the precise location of some of these pressure sensors; the updated dataset is considered an improvement over that used previously.

Table 2-1 Historical Availability of River Gauge Data for Calibration Events

BoM Gauge No.	AWRC Gauge No.	Gauge Name	System	Historical Calibration Data				
				1974	1996	1999	2011	2013
540495	143891	Whyte Island Tide AL	Moreton Bay	x	x	x	Yes	Yes
40647	143935	Brisbane bar Tide TM	Moreton Bay	Yes	Yes	Yes	Yes	Yes
540129	143847	Hemmant AL	Lower Brisbane	x	x	x	Yes	?
MSQ: R046047A.86		Gateway Bridge	Lower Brisbane	x	Yes	Yes	Yes	x
540286	143877	Breakfast Creek Mouth Al	Lower Brisbane	x	x	x	Yes	Yes
540130	143851	Bowen Hills Alert	Lower Brisbane	x	x	x	Yes	Yes
540198	143838	City Gauge	Lower Brisbane	Yes	Yes	Yes	Yes	Yes
540274	143872	Oxley Ck Mouth AL	Lower Brisbane	x	x	x	Yes	Yes
540132	143848	East Brisbane Alert	Lower Brisbane	x	x	x	Yes	Yes
540192	143832	Jindalee Alert	Lower Brisbane	Yes	x	?	Yes	Yes
41472	-	Centenary Bridge	Lower Brisbane	Yes	x	x	Yes	x
540200	143924	Moggill Alert	Lower Brisbane	Yes	Yes	?	?	Yes
-		Clarence Rd	Lower Brisbane	Yes	x	x	x	x
-		Dutton Park Cemetery	Lower Brisbane	Yes	x	x	x	x
-		Highgate Hill - Paradise St	Lower Brisbane	Yes	x	x	x	x
-		Tennyson Powerhouse	Lower Brisbane	Yes	x	x	x	x
-		Sandy Creek	Lower Brisbane	Yes	x	x	x	x
-		St Lucia Ferry	Lower Brisbane	?	x	x	x	x
-		OxleyCkCorinda	Lower Brisbane	Yes	x	x	x	x
-		Yeronga St	Lower Brisbane	Yes	x	x	x	x
-		Tennyson	Lower Brisbane	Yes	x	x	x	x
540063	143868	Colleges Crossing Alert	Mid Brisbane	x	x	x	?	?
540199	143839	Mt Crosby AL	Mid Brisbane	Yes	Yes	Yes	Yes	Yes
540256	143864	Kholo Bridge AL	Mid Brisbane	x	x	x[11]	?	Yes
540606	143049	Lake Manchester HW TM	Mid Brisbane	x	x	x	Yes	Yes
540257	143856	Burtons Bridge	Mid Brisbane	x	x	x[11]	?	Yes
540066	143001C	Savages Crossing TM	Mid Brisbane	Yes	Yes	Yes	Yes	Yes
540182	143001A	Lowood Alert-B	Mid Brisbane	Yes	x	Yes	Yes	Yes
540178	143823	Wivenhoe Dam TW Alert-P	Mid Brisbane	x	x	?	?	Yes
40831	143954	Ipswich Alert	Bremer River	Yes	Yes	x	Yes	Yes
540250	143852	Brassall (Hancocks Bridge)	Bremer River	x	x	x	?	?

BoM Gauge No.	AWRC Gauge No.	Gauge Name	System	Historical Calibration Data				
				1974	1996	1999	2011	2013
40836	14953	One Mile Bridge Alert	Bremer River	x	x	Yes	Yes	Yes
540550	143114	Berry's Lagoon Alert	Bremer River	x	x	x	?	Yes
40838	143956	Three Mile Bridge AL	Bremer River	x	x	Yes	?	?
540504	143896	Walloon AL	Bremer River	x	Yes	?	Yes	Yes
540249	143854	Bundamba (Hanlon St) Al	Bundamba Ck	x	x	x	Yes	?
-	143114	Mary St	Bundamba Ck	Yes	x	x	x	x
540248	143857	Churchill Alert	Deebing Ck	x	x	x	Yes	Yes
540062	143983	Loamside Alert	Purga Creek	x	x	Yes	Yes	Yes
540210	143113	Loamside TM	Purga Creek	Yes	Yes	x	x	x
40816	143108	Amberley (DNRM) TM	Warrill Creek	Yes	Yes	Yes	Yes	Yes
540180	143825	Amberley-P (Greens Road)	Warrill Creek	x	Yes	Yes	Yes	x[13a]
40874	143962	Brisbane Road Alert	Woogaroo Creek	x	x	x	Yes	?
540051	143207	O'Reilly's Weir AL	Lockyer Creek	x	?	Yes	Yes	x[13a]
540544	143700	Rifle Range Rd Alert -P	Lockyer Creek	x	Yes	Yes	Yes	Yes
540174	143819	Lyons Bridge Alert-P	Lockyer Creek	Yes	x	Yes	?	x[13a]
540149	143808	Glenore Grove Alert	Lockyer Creek	Yes	x	Yes	Yes	Yes

Yes	Data available and of sufficient quality for use in calibration
x	Data not available or gauge identified as erroneous by Seqwater
?	Data available but of questionable quality. Discussed in Appendix A.

13a – Assessment validated by Seqwater (2013a)
13b – Assessment validated by Seqwater (2013b)
11 – Assessment validated by Seqwater (2011)

2.2.2 Historical Flood Mark Levels

Historical flood mark records exist for the 1974, 2011 and 2013 flood events. These marks are considered to be peak flood levels at spot locations. Locations of these spot levels across the hydraulic model area are contained within Drawing 4 to Drawing 6 for the 1974, 2011 and 2013 flood events respectively. These flood marks were surveyed after the event and are typically based on debris marks or watermarks. It is important to realise that debris and watermarks can be inaccurate for a number of reasons including:

- Dynamic hydraulic effects such as waves, eddies, pressure surges, bores or transient effects, which may not be accounted for in the model. For example, if the debris mark is located within a region of fast flowing floodwater it is possible that the floodwater has pushed the debris up against an obstacle, lodging it at a higher level than the surrounding flood level.

- Lodgement of debris at a level lower than the peak flood level. The reason for this is that for debris to be deposited, it needs to have somewhere to lodge and this elevation is not always at the peak flood level. For example, debris lodged in the fork of a tree or on the strands of a barb-wire fence may have been carried there by floodwater that went *higher* than the tree fork or fence wire, but this was not apparent after the event due to the lack of higher lodging places.

2.2.3 Flow Gauging at Centenary Bridge

Flow gauging carried out on the downstream side of Centenary Bridge during the 1974, 2011 and 2013 floods provides valuable data on the flows close to the peaks of these floods. For the 2011 and 2013 floods, flows were also measured during the "steady-state" post flood Wivenhoe Dam releases, once again providing a check on discharges during controlled releases from Wivenhoe Dam. Of note is that the 1974 flow measurements are considered to be of lesser accuracy due to the use of older technology. Water levels off the downstream side were also recorded whilst the flow measurements were taken.

2.3 Hydraulic Structure Information

Hydraulic structure information was sourced from a variety of agencies and was received in a number of formats, including plans and existing hydraulic model representations. Further details on the collection of this data and other associated information is provided in BMT WBM (2014). Table 2-2 contains a summary of the historical presence of hydraulic structures that has guided their inclusion in the Fast Model. The location of each of these structures is shown in Drawing 7, labelled with the ID shown in Table 2-2.

Some hydraulic structures have very little impact on hydraulic behaviour (eg the Gateway Bridge), nonetheless they are incorporated into the model.

Table 2-2 Historical Presence of Hydraulic Structures

ID	Description	River Crossing	1974	1996	1999	2011	2013
ICC_056	Three Mile Bridge	Bremer River	Yes	Yes	Yes	Yes	Yes
ICC_057	One Mile Bridge	Bremer River	Yes	Yes	Yes	Yes	Yes
ICC_058	Hancock Bridge	Bremer River	Yes	Yes	Yes	Yes	Yes
QR_025	Railway Workshop Bridge	Bremer River	Yes	Yes	Yes	Yes	Yes
QR_103	Wulkuraka Rail Bridge	Bremer River	Yes	Yes	Yes	Yes	Yes
TMR_037	Warrego Hwy	Bremer River	Yes	Yes	Yes	Yes	Yes
TMR_043	David Trumpy Bridge	Bremer River	Yes	Yes	Yes	Yes	Yes
BCC_006	Story Bridge	Brisbane River	Yes	Yes	Yes	Yes	Yes
BCC_008	Goodwill Bridge	Brisbane River	x	x	x	Yes	Yes
BCC_009	Victoria Bridge	Brisbane River	Yes	Yes	Yes	Yes	Yes
BCC_010	Kurilpa Bridge	Brisbane River	x	x	x	Yes	Yes
BCC_011	William Jolly Bridge	Brisbane River	Yes	Yes	Yes	Yes	Yes

ID	Description	River Crossing	1974	1996	1999	2011	2013
BCC_012	Go Between Bridge	Brisbane River	x	x	x	Yes	Yes
BCC_019	Green Bridge	Brisbane River	x	x	x	Yes	Yes
BCC_020	Walter Taylor Bridge	Brisbane River	Yes	Yes	Yes	Yes	Yes
BCC_021	Jack Pesch Bridge	Brisbane River	x	x	Yes	Yes	Yes
BCC_076	Kholo Rd Bridge	Brisbane River	Yes	Yes	Yes	Yes	Yes
BCC_077	Mt Crosby Weir	Brisbane River	Yes	Yes	Yes	Yes	Yes
QR_083	Albert Bridge	Brisbane River	Yes	Yes	Yes	Yes	Yes
QR_087	Merivale St Bridge	Brisbane River	x	Yes	Yes	Yes	Yes
SRC_073	Twin Bridges	Brisbane River	Yes	Yes	Yes	Yes	Yes
SRC_074	Savages Crossing	Brisbane River	Yes	Yes	Yes	Yes	Yes
SRC_075	Burtons Bridge	Brisbane River	Yes[9]	Yes[9]	Yes[9]	Yes	Yes
TMR_001	New Gateway Mtwy	Brisbane River	x	Yes	Yes	Yes	Yes
TMR_038	Captain Cook Bridge	Brisbane River	Yes	Yes	Yes	Yes	Yes
TMR_039	Centenary Hwy	Brisbane River	Yes	Yes	Yes	Yes	Yes
TMR_050	Brisbane Valley Highway	Brisbane River	x	Yes	Yes	Yes	Yes
TMR_078	Colleges Crossing - Mt Crosby Rd	Brisbane River	Yes	Yes	Yes	Yes	Yes
QR_065	Brisbane Valley Rail Trail near Mahons Rd	Lockyer Ck	Yes	Yes	Yes	Yes	Yes
SRC_063	Lyons Bridge	Lockyer Ck	Yes	Yes	Yes	Yes	Yes
SRC_064	Watsons Bridge	Lockyer Ck	x	Yes	Yes	Yes	Yes
SRC_070	Pointings Bridge	Lockyer Ck	x	x	x	Yes	Yes
SRC_071	O'Reilly's Weir	Lockyer Ck	Yes	Yes	Yes	Yes	Yes
BCC_023	Pamphlet Bridge - Graceville Ave	Oxley Ck	Yes	Yes	Yes	Yes	Yes
TMR_049	Cunningham Highway	Purga Ck	x	Yes	Yes	Yes	Yes
TMR_048	Cunningham Highway	Warrill Ck	x	Yes	Yes	Yes	Yes

x = not yet constructed

Note: A unique structure ID has been developed by BMT WBM for each structure. The ID reflects the owner of the structure, followed by a number unique to that owner. Owner abbreviations are: **BCC** – Brisbane City Council; **DPW** – Department of Housing and Public Works; **ICC** – Ipswich City Council; **QR** – Queensland Rail; **SEQw** – Seqwater; **SRC** – Somerset Regional Council; **TMR** – Department of Transport and Main Roads.

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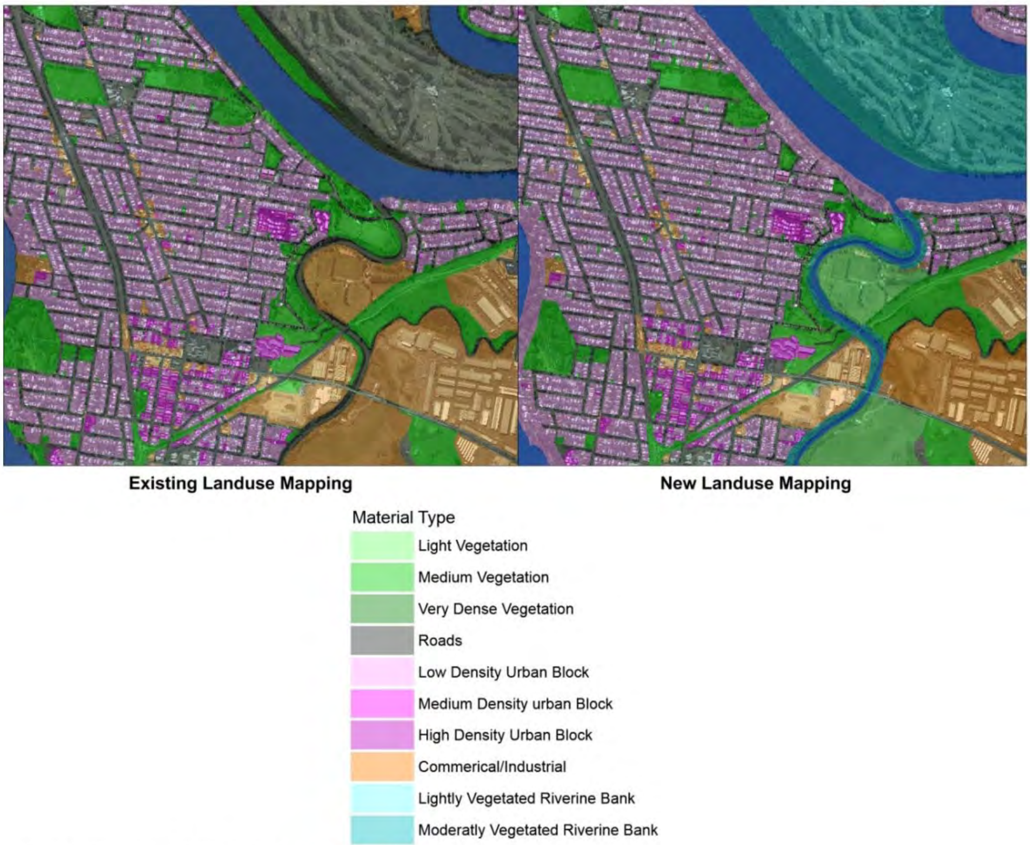
[9] The survey drawing for Burtons Bridge (prepared in 2000) indicates that a new bridge was constructed around this time with the old bridge being removed. The design drawings for the old bridge were not provided and were not able to be sourced. As such, the model contains the new bridge data for all events, in lieu of the old data.

2.4 Land Use Data

Spatial land use data is used to assist in determining the spatial extent of model roughness values. The digital land use layers received for this study (collected by Aurecon *et al*. (2013)) were not of sufficient spatial accuracy to allow direct application of model roughness parameters based on land use extents. Land use extents were updated by manual digitisation using aerial photographs to locate the land-use layer polygon more accurately. An example of the improvement in land use delineation following the manual digitisation process is provided in Figure 2-1; note in particular the inclusion of waterways and refinement of commercial/industrial areas.

Roughness parameters for each land use area are discussed and provided in Section 3.1.3 for the Updated DMT Model and Section 4.14 for the Fast Model.



"B:\B20702 BRCFS Hydraulics\60_Mapping\DRG\MR2\FLD_010_Landuse_Upgrade.wor"

Figure 2-1 Example of the Improved Spatial Differentiation of Land Uses

2.5 Inflows

Model inflows are extracted from the calibrated URBS models provided by Aurecon from the Aurecon *et al* (2014a, c) Hydrologic Assessment. Aurecon *et al* (2014a, c) for the purpose of the BRCFS refined the URBS models developed and calibrated by Seqwater. A comparison of the Aurecon and Seqwater URBS parameters is given in Table 2-3 with comparisons of the volume outputs and loss parameters given in Table 2-4. These values were taken directly from the .q URBS model output files. Note that Aurecon *et al* (2014) adopted a different (non-linear) URBS model channel routing exponent ‘n’ for the Lockyer, Bremer, and Purga models, compared to the (linear) exponent ‘n’ adopted by Seqwater in the original URBS model calibration. This means that the α value adopted by Seqwater cannot be directly compared to the α value adopted by Aurecon.

Volume outputs provided in Table 2-4 generally demonstrate that the Aurecon URBS model outputs flows of greater volume than the Seqwater URBS model, with the exception of the smaller events of 1996 and 1999. This is of interest to the current study as the previous DMT Model study undertaken by BCC (BCC, 2014a) found the need to use multipliers on the Seqwater URBS model flows to achieve an acceptable calibration. BCC (2014a) contains further details on the rationale and application of the multipliers. However, the current study has found that the flows output from the Aurecon URBS model produce an acceptable calibration without the need for multipliers. This is related, in part, to the generally greater flow volumes output from the Aurecon URBS model for the larger historical events (refer to Table 2-4). URBS parameters presented in Table 2-3 and Table 2-4 are provided to give background as to the source of the difference in volume outputs between the Aurecon URBS and Seqwater URBS models. They also provide background to scenarios considered when modelling the 1974 flood event, as discussed in Section 4.10. Further detail and discussion on URBS parameters is provided in Aurecon *et al.* (2014a).

In order to produce the total and local flow hydrographs needed to provide inflows to the Fast Model, BMT WBM ran the URBS calibration models for each event. No changes were made to the URBS models other than to ensure output of the needed hydrographs. Locations at which primary periphery inflows were applied to the Fast Model using URBS model flows are shown in Table 2-5 and in Drawing 9. Table 2-5 also lists the peak inflows for each calibration event to provide a relative indication of event magnitude at the primary inflow locations. Figure 2-2 to Figure 2-9 compare the inflow hydrographs at the primary periphery inflow locations for each calibration event to allow the relative importance and timing of each inflow to be understood.

During the use of the Aurecon URBS model (Aurecon *et al*, 2014a) to produce the total and local flows, it was noted that the 5 sub-catchments representing Kedron Brook had been removed from the URBS model. Aurecon confirmed that Kedron Brook was removed from their URBS model as Kedron Brook is not a tributary of the Brisbane River. Future users of the URBS model may note 5 redundant URBS .r files (lower 110 to lower 114) that have been confirmed by Aurecon as being a legacy of the removal of Kedron Brook (pers. comm. Rob Ayre, Aurecon, 21 Jan 2015). It was agreed with the Client that the removal of Kedron Brook from the URBS model will have negligible to no impact on the outcomes of this hydraulic assessment, other than that there will be no inflows from Kedron Brook. In extreme events, there is a potential for flood flows from Kedron Brook to breakout across the Kedron Brook floodplain towards the Brisbane River. However, as the potential breakout of floodwater from Kedron Brook will precede the time of the peak flows in the Brisbane River, it is unlikely that Kedron Brook flows will impact upon peak flood levels in the Brisbane River. In small to large events, Kedron Brook flows do not enter the Brisbane River and thus will have no impact on Brisbane River flood behaviour.

Outflows from Wivenhoe Dam were included in the Fast Model as an upstream boundary condition. Wivenhoe dam outflow hydrographs were provided by Aurecon for each calibration event, or in the case of the 1974 flood were calculated by the URBS model.

Table 2-3 URBS Catchment and Routing Parameters

	Alpha[1]		Beta	
Catchment	**Seqwater[2]**	**Aurecon**	**Seqwater[2]**	**Aurecon**
Stanley	0.1 to 0.15	0.11	4.1 to 8.0	5.7
Upper Brisbane	0.1 to 0.14	0.12	2.0 to 3.25	2.8
Lockyer	0.15 to 0.3	0.49	3.0	3.1
Bremer	0.25 to 0.4	0.79	2.5 to 3.5	2.8
Warrill	0.7 to 0.9	0.79	1.5 to 4	2.5
Purga	0.15 to 0.8	0.93	3.0 to 4.0	3.8
Lower Brisbane	0.13 to 0.2	0.30	2.5 to 3.0	4.0

[1] Note that Aurecon et al (2014) adopted a different (non-linear) URBS model channel routing exponent ‘n’ for the Lockyer, Bremer, and Purga models, compared to the (linear) exponent ‘n’ adopted by Seqwater in the original URBS model calibration. This means that the α value adopted by Seqwater cannot be directly compared to the α value adopted by Aurecon.

[2] For the Seqwater WSDOS URBS modelling the Alpha and Beta parameters varied between events

Table 2-4 URBS Volume and Loss Comparisons for Each Calibration Event

1974						
	Volume (GL)				**Losses (IL/CL)**	
Catchment	**Seqwater**	**Aurecon**	**Change**	**% increase**	**Seqwater**	**Aurecon**
Lockyer	567	690	123	22%	50 / 2.5	40 / 1.8
Bremer	250	348	98	39%	65 / 2.0	30 / 0.3
Purga	70	98	28	40%	80 / 2.5	40 / 0.8
Warrill	294	411	117	40%	79 / 2.0	8 / 0.5
Upper Brisbane	1541	1441	-100	-6%	45 / 1.2	50 / 1.5
Lower (Brisbane Bar)	3525	3995	470	13%	50 / 2.0	24 / 0.24
1996						
	Volume (GL)				**Losses (IL/CL)**	
Catchment	**Seqwater**	**Aurecon**	**Change**	**% increase**	**Seqwater**	**Aurecon**
Lockyer (O'Reillys)	565	595	30	5%	130 / 1.5	180 / 0.7
Bremer (Walloon)	175	200	25	14%	100 / 1.5	100 / 1
Purga	56	54	-2	-4%	55 / 0.5	90 / 0.3
Warrill	117	99	-18	-15%	79 / 1.5	129 / 1.3
Wivenhoe (outflow)	0	0	0	0%	N/A	N/A
Lower (Brisbane Bar)	1538	1693	155	10%	60 / 2.0	138 / 0.2
1999						
	Volume (GL)				**Losses (IL/CL)**	
Catchment	**Seqwater**	**Aurecon**	**Change**	**% increase**	**Seqwater**	**Aurecon**
Lockyer (O'Reillys)	139	62	-77	-55%	95 / 3.0	135 / 1.5
Bremer (Walloon)	56	55	-1	-2%	50 / 1.0	50 / 0.8
Purga	10	9	-1	-10%	25 / 1.5	45 / 0.7
Warrill	34	33	-1	-3%	50 / 0.7	45 / 0.7
Wivenhoe (outflow)	809	809	0	0%	N/A	N/A
Lower (Brisbane Bar)	1225	1075	-150	-12%	20 /1.5	97 / 0.4

2011						
	Volume (GL)				Losses (IL/CL)	
Catchment	Seqwater	Aurecon	Change	% increase	Seqwater	Aurecon
Lockyer (O'Reillys)	574	761	187	33%	50 / 3.0	60 / 1.1
Bremer (Walloon)	212	201	-11	-5%	30 / 2.0	35 / 2.0
Purga	36	35	-1	-3%	40 / 0.5	40 / 0.5
Warrill	224	219	-5	-2%	35 / 1.1	40 / 1.0
Wivenhoe (outflow)	2692	2692	0	0%	N/A	N/A
Lower (Brisbane Bar)	4085	4405	320	8%	15 / 2.5	33 / 2.0
2013						
	Volume (GL)				**Losses (IL/CL)**	
Catchment	**Seqwater**	**Aurecon**	**Change**	**% increase**	**Seqwater**	**Aurecon**
Lockyer (O'Reillys)	326	373	47	14%	175 / 4.0	190 / 3.0
Bremer (Walloon)	120	119	-1	-1%	175 / 3.0	160 / 3.5
Purga	11	9	-2	-18%	180 / 7.5	180 / 9.0
Warrill	183	209	26	14%	179 / 5.0	149 / 4.5
Wivenhoe (outflow)	866	862	-4	0%	N/A	N/A
Lower (Brisbane Bar)	1740	1843	103	6%	150 / 2.5	122 / 2.4

Note: Losses are catchment average losses and therefore Warrill and Lower catchments are adjusted by URBS for impervious areas

Table 2-5 Fast Model Primary Periphery Inflows from URBS Model

	Peak Flow (m^3/s)				
Periphery Inflows	**1974**	**1996**	**1999**	**2011**	**2013**
Wivenhoe Dam Outfall	7115	0	1804	7471	1817
Lockyer Creek near Tenthill Creek	2866	1659	401	2490	1798
Laidley Creek near Forest Hill	257	96	2	346	109
Spring Creek 1 near Moreton Vale	122	121	26	206	98
Buaraba Creek U/S of Atkinson Dam	560	379	261	356	644
Spring Creek 2 near Beutel Road	110	53	30	129	24
England Creek Wivenhoe Somerset Rd	110	68	70	294	31
Banks Creek near Savages Crossing	37	28	11	122	2
Black Snake Creek near Burtons Bridge	276	133	43	510	22
Sandy Creek near Russels Road	154	86	39	223	31
Lake Manchester Outfall	335	172	83	201	242
Bremer River near Amberley	2145	1026	430	2013	1195
Warrill Creek near Amberley Gauge	1971	377	169	683	1084
Purga Creek near Loamside	795	269	68	166	120
Bundamba Creek near Brisbane Road	496	153	17	72	170
Six Mile Creek near Ipswich Motorway	186	67	10	37	62
Goodna Creek at Ipswich Motorway	343	96	11	33	134
Watson Creek at Wacol Station Road	111	49	20	32	62
Pullen Pullen Creek at Moggill Road	124	53	14	24	66
Moggill Creek at Rafting Ground Road	346	141	44	102	162
Oxley Creek near Ipswich Motorway	974	450	94	132	374
Norman Creek near Stanley Street	198	141	61	65	167
Enoggera Creek at Enoggera Road	402	156	96	84	140
Bulimba Creek near Enoggera Reserve	507	219	57	72	375

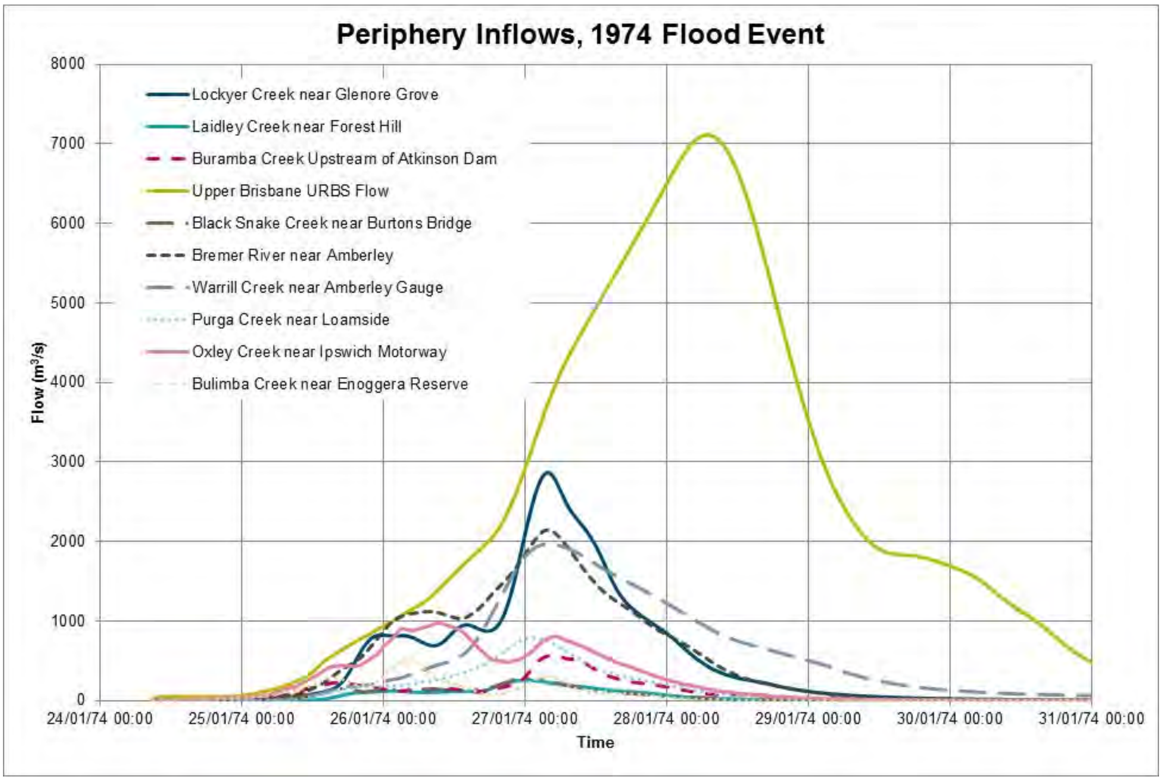


Figure 2-2 Periphery URBS Inflows, 1974 Flood Event

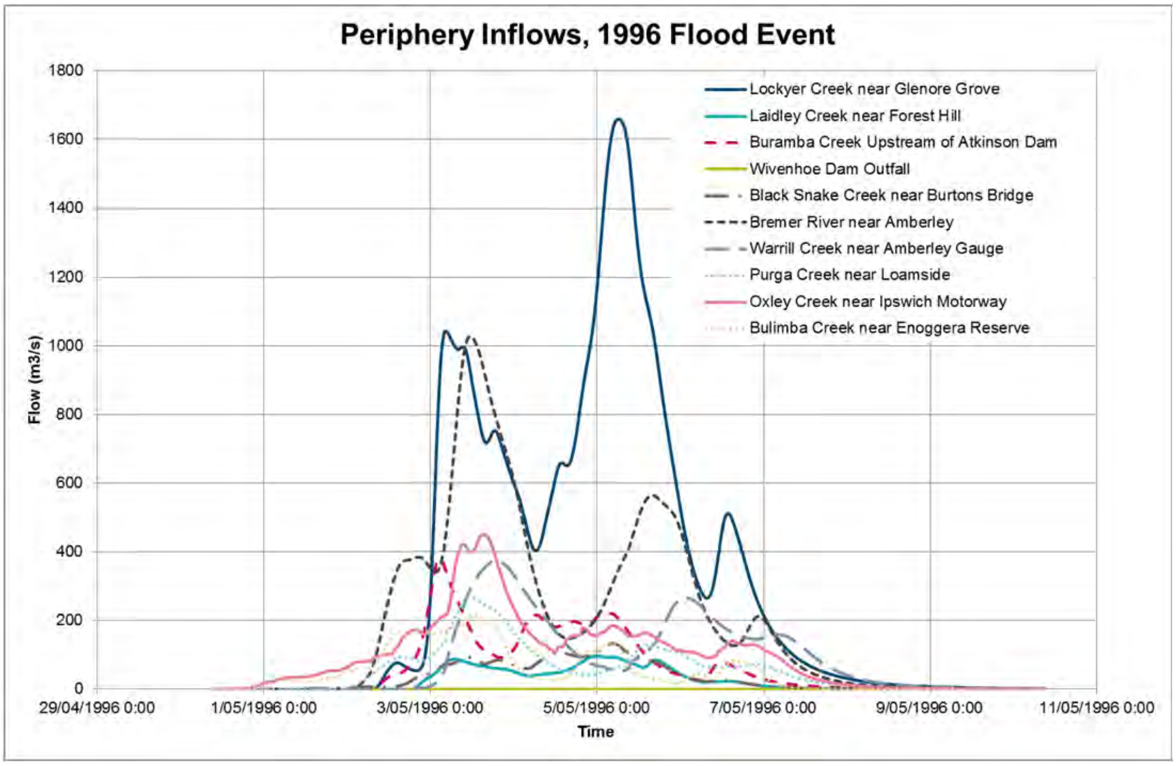


Figure 2-3 Periphery URBS Inflows, 1996 Flood Event

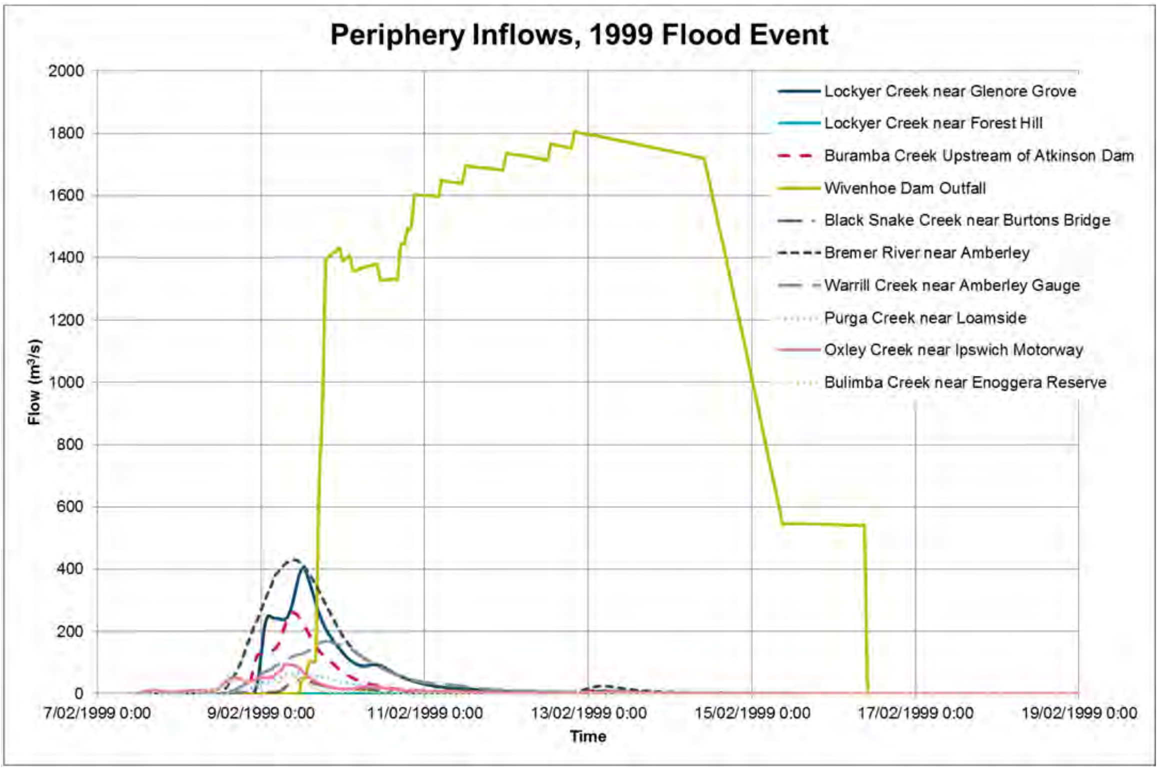


Figure 2-4 Periphery URBS Inflows, 1999 Flood Event

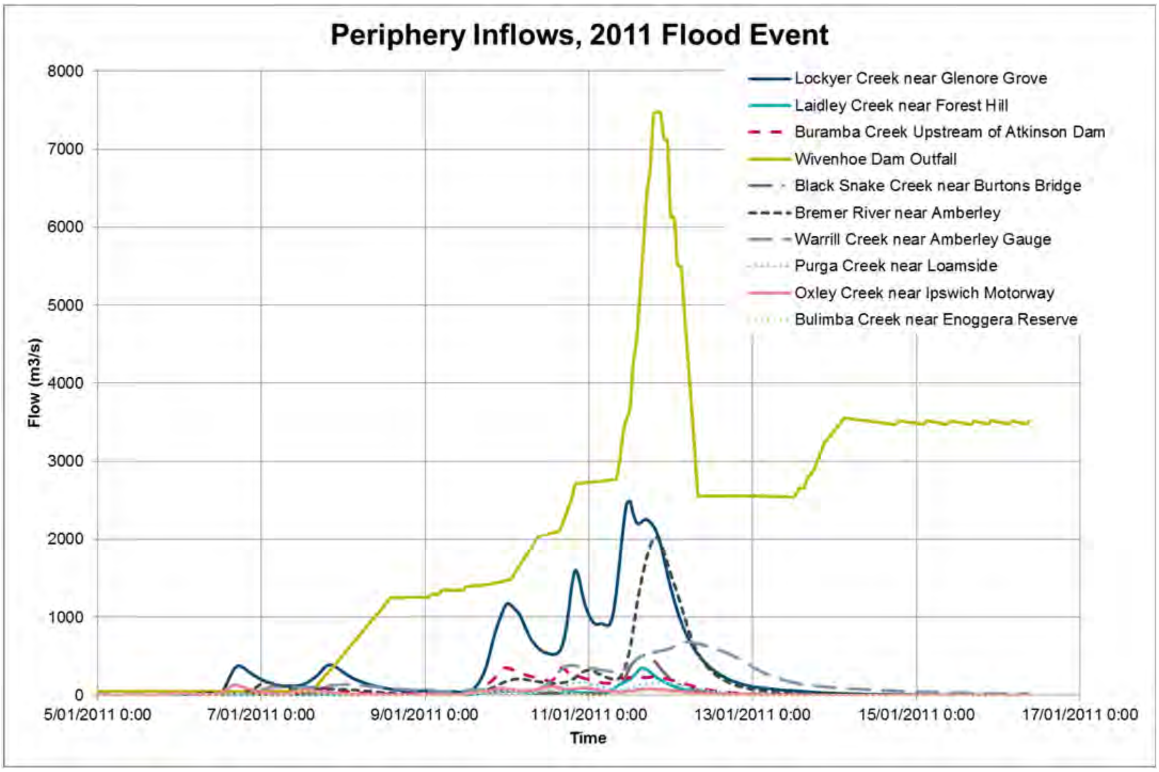


Figure 2-5 Periphery URBS Inflows, 2011 Flood Event

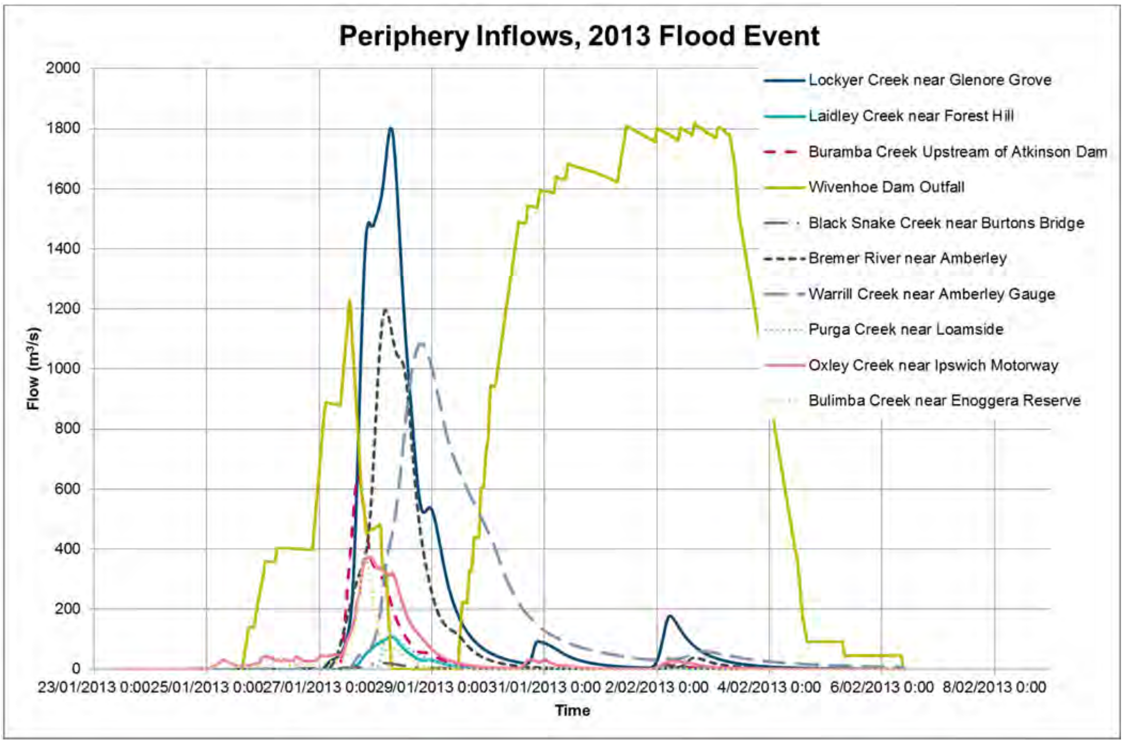


Figure 2-6 Periphery URBS Inflows, 2013 Flood Event

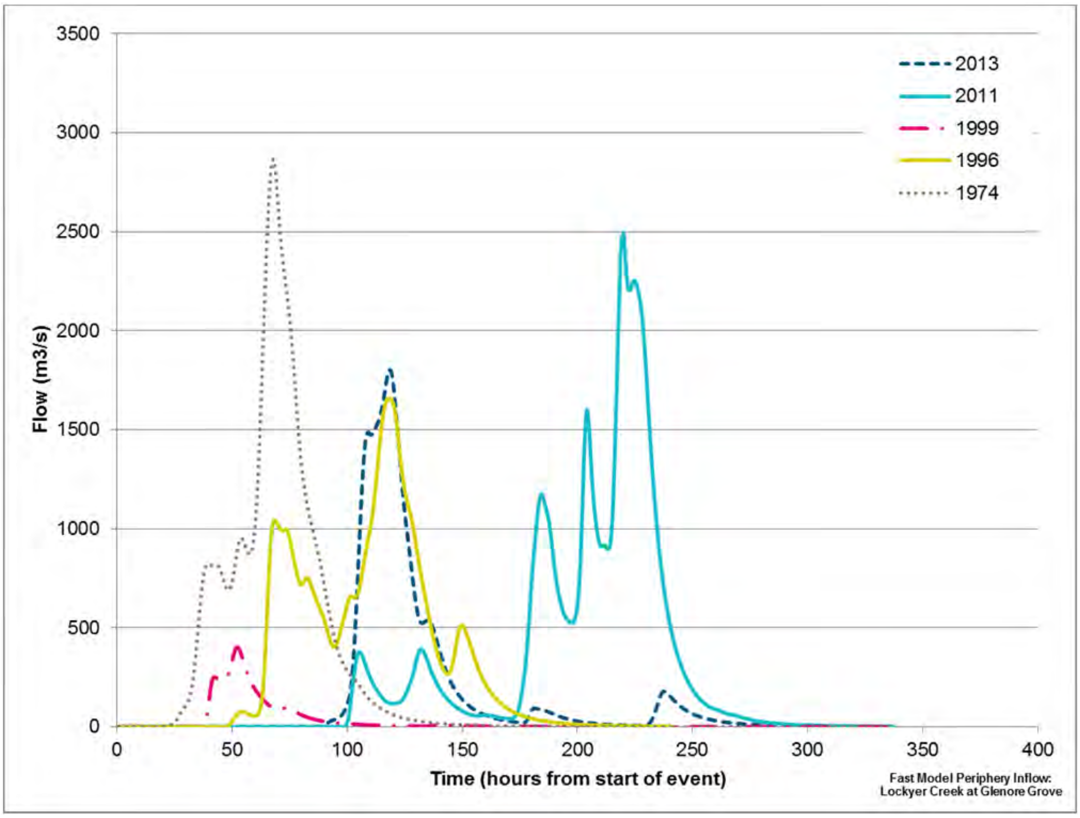


Figure 2-7 Periphery URBS Inflows at Glenore Grove All Flood Events

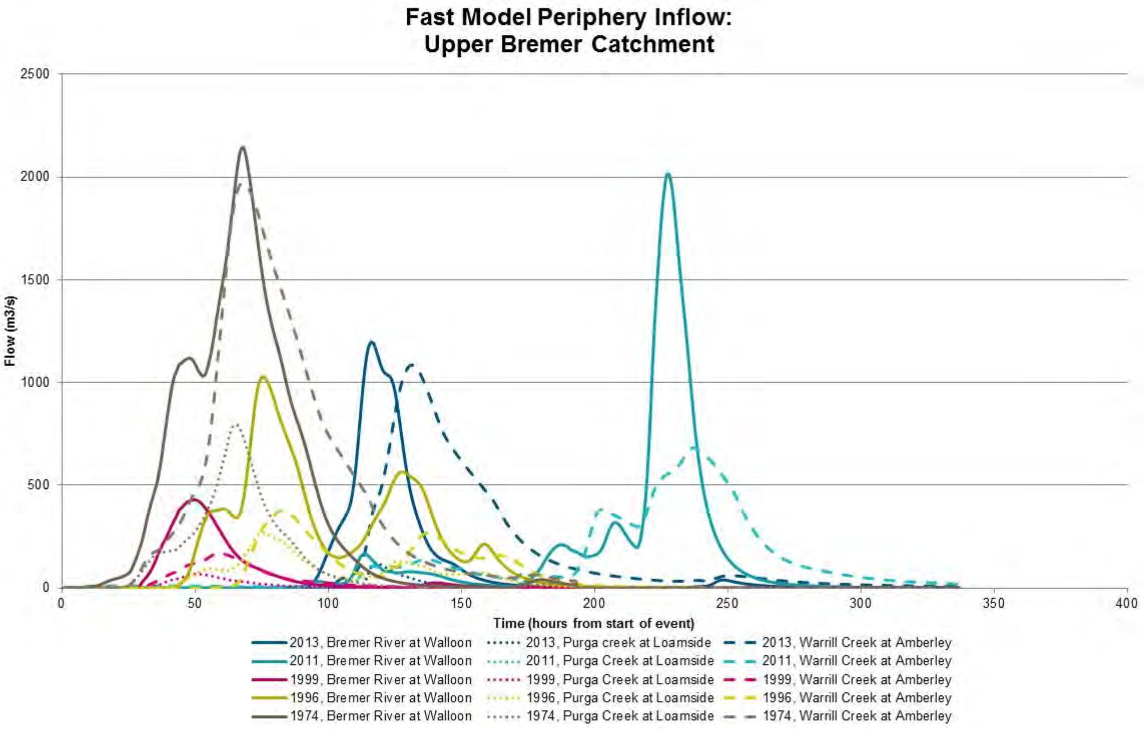


Figure 2-8 Periphery URBS Inflows at Walloon, Loamside and Amberley All Flood Events

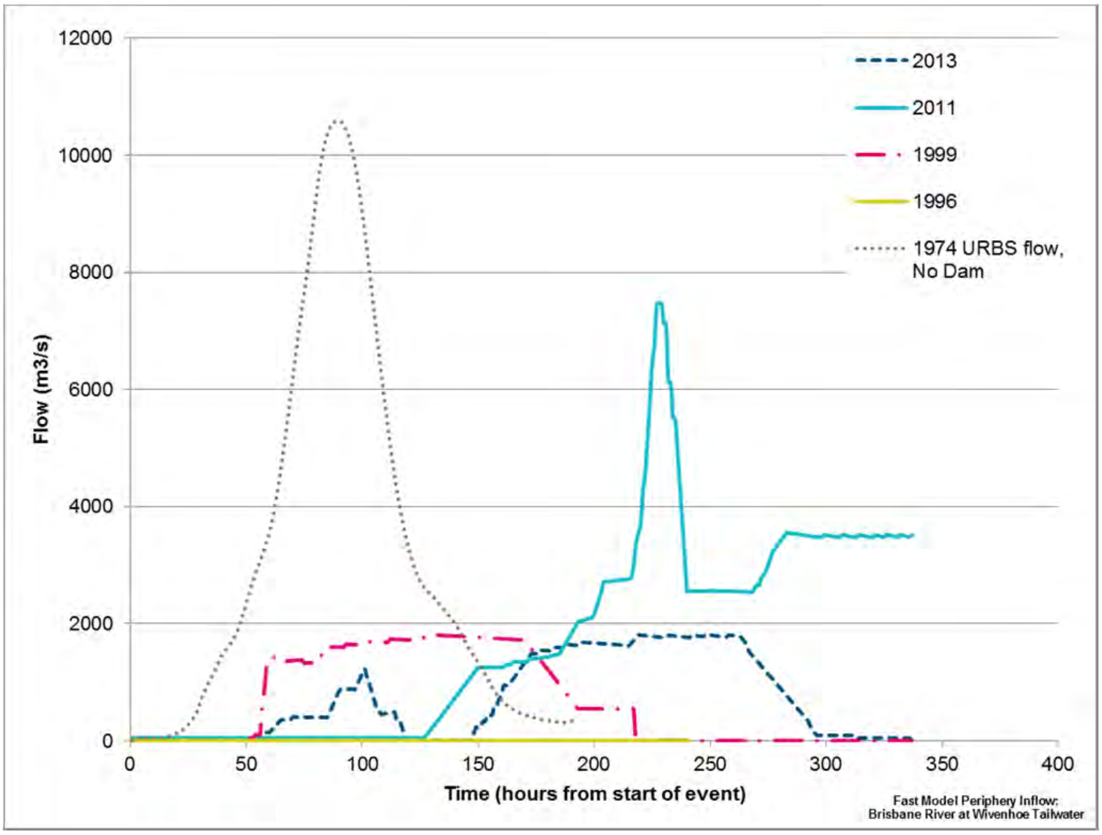


Figure 2-9 Periphery URBS Inflows at Wivenhoe Tailwater All Flood Events

3 Updated DMT Model

The Disaster Management Tool (DMT) model was developed by Brisbane City Council (BCC) for the Department of State Development Infrastructure and Planning and was finalised in June 2014 (BCC, 2014a). The model builds on an earlier assessment undertaken by BCC in 2009 entitled ‘Brisbane River Hydraulic Model to Probable Maximum Flood’ (BCC, 2009b) and is a broad-scale, fully 2D TUFLOW GPU model of the Brisbane River catchment downstream of Wivenhoe Dam including significant areas of the Lockyer and Bremer tributary catchments.

The purpose of the DMT Model was to provide a set of disaster management maps which could be used in the interim before the completion of the Brisbane River Catchment Flood Study (this report) in order to assist in the response to a flood emergency. A key feature of the DMT Model was the development of a Digital Elevation Model (DEM) that incorporated LiDAR, bathymetry and breaklines. The model adopted a 20m cell size and used hydrological URBS inflows derived by Seqwater for the Wivenhoe Somerset Dam Optimisation Study (WSDOS). The model was calibrated to the following three flood events:

- January 1974
- January 2011
- January 2013

The 1893 floods were used as a further verification of the model’s performance.

The calibrated model was then used to run various combinations of what was termed by BCC (2014a) as ‘notional flows’ through the Brisbane, Bremer and Lockyer lengths of the catchment resulting in the production of 106 maps.

This current study recognises the value of the DMT Model in informing the design of the BRCFS Fast Model and the DMT Model was updated with more recent data. Since the completion of the DMT Model, updated hydrology has become available as part of the BRCFS Hydrologic Assessment (Aurecon *et al*, 2014a, c). Furthermore, additional bathymetric survey has been captured and collated. This study has updated the DMT Model with these additional datasets along with other improvements detailed below in order to provide an up-to-date tool used for informing the Fast Model development. This updated model is termed hereafter as the Updated DMT Model.

3.1 Updates

3.1.1 Hydrology

Model inflows have been updated by using the recent URBS model calibration results from Aurecon *et al* (2014a). During calibration of the original DMT Model by BCC (2014a), it was found that, in general, the inflows derived from the original hydrologic model were not sufficient in volume to achieve a satisfactory calibration. To overcome this insufficiency, BCC (2014a) included a multiplier on the hydrologic inflows[10] (excluding flows from Wivenhoe Dam) in order to introduce

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[10] Refer to BCC (2014) for further details on application of the multiplier to the DMT Model inflows

greater volume into the model. In general, the recently revised hydrology (Aurecon *et al*, 2014a) produces a greater volume than that used previously (with the exception of the smaller 1996 and 1999 events). These multipliers were not used for the updated DMT modelling.

Local inflows are those that are generated from catchment runoff within the model extent as opposed to external inflows applied at the model boundaries. In the original DMT Model, local inflows were input into the model at appropriate localised area locations. Instead, the Updated DMT Model distributes inflows along digitised streamlines, avoiding any localised lumping of flows.

The streamline approach has the potential for double routing of flows. That is, the flows which have been routed through the hydrologic model are again routed or partially routed through the hydraulic model. Any effects of double routing are deemed to be minimal as:

(1) Double routing only has the potential to occur along streamlines digitised in the hydraulic model. Digitised streamlines only represent the main flow route/s through each sub-catchment. That is, they do not include the full network of minor drainage lines within a sub-catchment. Furthermore a relatively high density of sub-catchments is defined in the hydrologic model meaning that any one sub catchment is typically of small area relative to the overall catchment. Any double routing through these catchments would be along a short length of channel and therefore have minimal influence on results.

(2) URBS simulates two routing mechanisms: catchment routing and channel routing. The former represents routing associated with hillslope processes in the transfer of runoff to the main streamlines. The later routes the sub-catchment generated runoff along the main channels. Streamline inputs in the hydraulic model are typically ‘local’ inputs from URBS. The runoff response from these inputs, provided the catchment area is relatively small, is dominated by the catchment routing process rather than the channel routing process. Therefore, application of these local inputs, which are dominated by catchment routing, in the hydraulic model on a sub-catchment by sub-catchment basis would not result in any notable double routing.

(3) No evidence of double-routing was found during calibration when comparing modelled and recorded hydrographs.

3.1.2 Model Topography

The original DMT Model sampled base topography from the 10m DEM developed for the original DMT study. The Updated DMT Model samples from the 5m DEM also developed as part of the DMT study. Additional datasets, described in Section 2.1.3, were read into the Updated DMT Model, overlaying the base DTM in the following order of priority from **highest to lowest**. The same datasets with the same priority of use also inform the Fast Model topography:

- Bathymetry data of the lower Brisbane River (collected in 2014 by PoB and described in Section 2.1.4.1).
- Bathymetry data of the lower Bremer River (collected in 2014 by PoB and described in Section 2.1.4.1).

- Bathymetry data of the Mt Crosby Weir Pool (collected in 2007 by Seqwater and described in Section 2.1.4.2).
- Bathymetry data of lower local tidal creeks in the lower Brisbane River supplied by GHD from the Coastal Plan Implementation Study (GHD, 2014) (described in Section 2.1.2).

Inclusion of the lower Bremer bathymetry data allowed for the removal of an interim DMT Model file that lowered the bed levels through the tidal sections of the Bremer River.

3.1.3 Land Use

The original DMT Model adopted delineated land use extents from the earlier BCC (2009b) study. These in turn were based on the SEQ Catchments land cover layer from BCC. The original DMT study augmented the mapped extents with GIS derived streamlines for the major rivers and creeks. This study noted that the spatial extents did not always correspond with the widths of the channels and this may in turn impact on model performance. As described in Section 2.4, to provide a better definition of land use extents within the model area for the current study, these extents were updated using a combination of cadastre and manual digitisation. The manual digitisation was particularly focussed on areas of high conveyance, primarily the main channels and waterway corridors.

Manning’s ‘n’ values attributed to the land use categories were updated to reflect the change in land use classes used in the Updated DMT Model. Adopted values generally remained consistent with the original DMT study within bank but varied for out-of-bank areas.

Table 3-1 contains a general comparison of Manning’s ‘n’ values between the Updated DMT Model and the original DMT Model. Note that the spatial extents of each of the land-use categories vary between the Updated DMT Model and the original DMT Model.

Table 3-1 Comparison of Manning's 'n' values for the DMT Models

Land-Use Category	Updated DMT Model Manning's n	Original DMT Model Manning's n[1]
Waterway (tidal)	0.022	0.022
Waterway (non-tidal)	0.03	0.035
Low density riparian vegetation	0.04	Not Applicable[2]
Medium density riparian vegetation	0.06	Not Applicable[2]
High density riparian vegetation	0.08	Not Applicable[2]
Agricultural fields[3]	0.03	0.06
Vacant Urban Land (typically open space / light vegetation)	0.04	Not Applicable[2]
Very Dense Vegetation	0.15	0.07 (forest); 0.08 non-forest native vegetation
Low density urban	0.06	0.07 (non-vegetated)
Medium density urban	0.10	
High density urban	0.20	
Commercial/Industrial	0.10	
Roads / Car Parks	0.025	0.02

[1] The Original DMT Model (BCC, 2014a) used 18 roughness categories (plus 3 bend loss categories). The BCC (2014a) category names differ from the current study. Comparisons made in this table are done by aligning those categories that are most similar with the intent of demonstrating that Manning's n values are indeed similar for similar categories.

[2] The Original DMT Model did not use these categories and thus direct comparison between models is not applicable.

[3] The Agricultural fields' category has been equated to the original DMT Model category of "Irrigated Crop & Pasture", which may be different in terms of vegetation density and type.

3.1.4 Time Series Reporting Locations

A revised dataset of model gauge locations was prepared following discussions with Seqwater, as described in Section 2.2.1. The revised gauge locations were incorporated into the Updated DMT Model.

3.1.5 Model Structure

Other minor improvements/changes were made to the general structure of the original DMT Model in the process of updating. These include:

- Use of event files to specify the flood event to be modelled, thereby avoiding the need for multiple model control files.
- Disabling of localised model output areas as the focus of this exercise was the modelled area in its entirety.

3.2 Modelled Events

Simulations of the Updated DMT Model were undertaken for the 1974, 2011 and 2013 calibration events. This enabled a comparison of model performance against both recorded flood levels and the original DMT Model at key gauge locations. Three extreme events were also modelled: 2x1974, 5x1974 and 8x1974 flows. These were used to identify extreme event flow paths to include in the Fast Model.

3.3 Updated DMT Model Outputs

3.3.1 Comparison of Updated DMT Model with Gauge and Flow Records

Outputs from the Updated DMT were compared to gauge records to ensure that the model is capable of sufficiently reproducing the shape of these level hydrographs. Plots of the predicted water levels from both the Updated DMT and the original DMT model against recorded gauge levels are provided in plots as follows:

- 2011 - Plot 1 to Plot 4;
- 2013 - Plot 5 to Plot 8; and
- 1974 - Plot 9 to Plot 13.

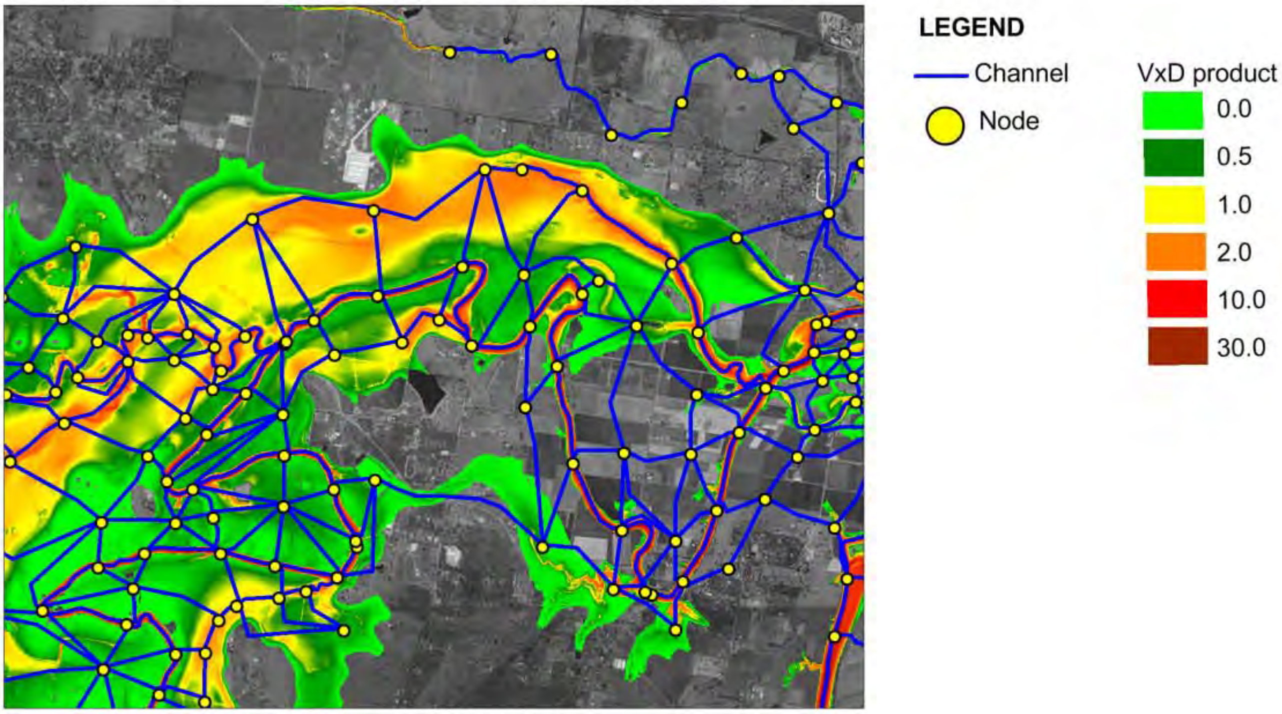
The differences between the original and Updated DMT Models are due to the updates described in the preceding sections, and some minor changes to the Manning’s n values.

Overall the performance of the Updated DMT Model remains comparable or better than the original model, and is considered suitable for informing the development of the Fast Model.

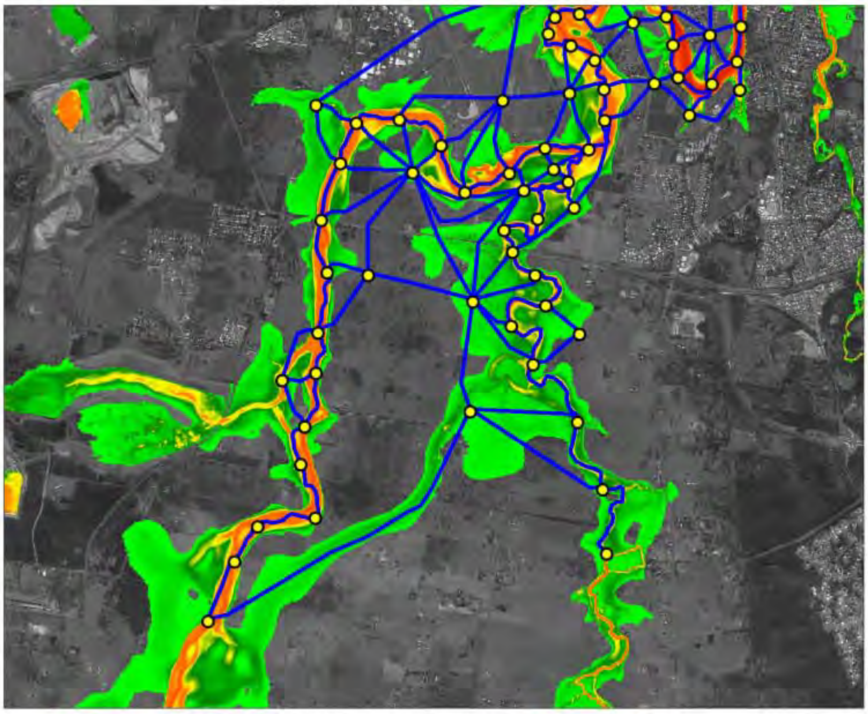
3.3.2 Velocity x Depth Mapping

The Updated DMT Model was used to produce mapping products to assist in the development of the Fast Model. Velocity x depth mapping of extreme hypothetical floods (2x1974, 5x1974 and 8x1974) allowed major and minor conveyance paths to be identified for the purpose of defining 1D channel locations and nodes for the Fast Model. Drawing 8 shows an example of the velocity x depth product map based on a hypothetical 2 x 1974 event for the full extent of the Updated DMT Model. In addition, Figure 3-1 shows localised examples of how the velocity x depth mapping was able to inform the Fast Model schematisation.

The Updated DMT Model meets the requirements for this investigation, which is to assist in the schematisation of the Fast and Detailed Models and provide an additional cross-check, in particular for helping test the Fast Model’s performance under extreme events. Should the Updated DMT Model be required for other purposes subsequent to this study, further refinements to the model might be required depending on the modelling objectives.



Lockyer River near Clarendon



Warrill Creek near Amberley

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Figure 3-1 Use of the Updated DMT Model in Development of the Fast Model

4 Fast Model Development and Calibration

4.1 Fast Model Development

The primary purpose of the Fast Model is to simulate thousands of Monte Carlo events derived by the Hydrologic Assessment. The peak flows and peak water levels from these thousands of runs will be used to carry out flood frequency analyses (FFA) at 29 reporting locations along the main creeks and rivers. From these FFAs, preliminary flood level AEPs at the reporting locations will be derived, followed by selection of approximately 50 of the Monte Carlo events that give a reasonable representation of the flood level AEPs derived from the FFA.

The Fast Model is best viewed as a stepping stone to the selection of the 50 design flood events for the Detailed Model. The 50 events are to be selected from the thousands of Monte Carlo Events produced by the Hydrologic Assessment. The long run-times of the Detailed Model prohibit using the Detailed Model for the Monte Carlo analysis to derive peak water level AEPs.

4.1.1 Hydraulic Characteristics of the Brisbane River Catchment

Hydraulically, the Brisbane River Valley is a mixture of conveyance and storage dominated reaches. Lockyer Creek, due to its flat wide topography is, in a large event, highly storage dominated, with substantial volumes of floodwaters being stored and conveyed on the floodplain with flood waters originating from its catchment or by backwater from the Brisbane River. Between Lockyer Creek and the Bremer River the Brisbane River is largely conveyance dominated, with relatively minor floodplains, and floodwaters largely confined to the river channel. The river experiences high velocities and steep gradients through these reaches.

The Bremer River and the Brisbane River downstream of Colleges Crossing are a mixture of storage and conveyance with both having significant floodplains that store and/or help convey the flood wave. The lower Brisbane River, unlike most large east coast Australian rivers, has few natural meanders, with many of the river's reaches controlled by the hilly terrain. The hydraulic consequence is that substantially higher velocities, driven by a steep gradient, develop along the lower Brisbane River during a flood. Consequently, the Brisbane River banks are sometimes rock, bends can literally be a sharp 180º (e.g. Kangaroo Point) and the entire flood flow is often solely confined between the river banks with relatively little or no overbank flowpaths.

4.1.2 Fast Model Construct

The Fast Model is based on the well-established hydraulic modelling approach of using a network of 1D channels and storage nodes that was commonplace prior to 2D flood modelling. The network of channels gives a quasi 2D effect by conveying water through flowpaths representing both the rivers/creeks and floodplains. Spill channels connect the river/creek and floodplain flowpaths. The Fast Model has some 2,350 channels or flow paths that are illustrated in Drawing 9.

Each channel's hydraulic conveyance properties are based on cross-sections. For rivers and creeks the cross-sections typically extend from bank to bank and are extracted at each end of the channel. For links between the river or creek and their floodplains the cross-section is typically based on the line of highest elevation (eg. along the top of the levee). For floodplain flowpaths, the cross-sections are taken at representative locations across the floodplain.

Cross-sections were extracted from the various DEMs, with higher priority given to the more accurate DEM where DEMs overlapped. Details of each dataset and the relative priorities assigned are provided in Section 2.1. The same datasets with the same priorities for use were used to inform the topography in the Updated DMT Model. In the final model topography, the in-bank surveyed cross-sections from prior modelling studies were not used for a variety of reasons described in Section 2.1.4 and summarised as follows:

- Sensitivity tests comparing results of using the Fernvale-Lowood sections with data extracted from the DMT DEM showed comparable Fast Model results, as discussed in Section 4.15.5. This gave confidence that the DMT DEM was suitable for use in informing model topography in this area. In order to use the Fernvale-Lowood surveyed sections, a merging of survey and LiDAR sections would be required, which was not an option within the timeframe available.
- The spatial distance between cross-sections surveyed for the Rubicon model (DPI, 1994) and other prior studies were too large and infrequent for that required for the Fast Model, therefore, so as to have a consistent underlying data set these sections were not used.
- The ARI river depth survey was found to be not practical to incorporate due to its large spatial variance in the horizontal, often not being perpendicular to the flow, and uncertainties over the vertical accuracy.
- Manning's n values were varied across the cross-sections by sampling the land-use GIS data at each ground elevation point.

The channels are hydraulically connected at nodes, which represent the storage of the system. Each node has a surface area versus height table defining the volume of water that a node can hold. For nodes connecting the in-bank river and creek channels, the storage is derived by multiplying the cross-section widths by half the in-bank channel lengths at varying heights. For nodes on the floodplain the storage is extracted from the DEM. Each overbank node is associated with a polygon that is used to extract the horizontal surface area from the DEM at different elevations. This approach ensures that the floodplain storage in the model is the same as that of the DEM. It is not an option to use the in-bank channel approach of multiplying cross-section width by channel length, as the floodplain storage can be grossly overestimated due to duplication or over-lapping of the calculated surface areas.

The extent of the model covers the area as required by the Hydraulic Assessment Brief (DSDIP, 2014), with some areas extended further upstream to reach a better boundary location such as the upper end of Lockyer Creek.

4.1.3 Cross-Section Conveyance Approach

Three approaches to calculating a cross-section’s conveyance are available in the TUFLOW software. These are:

- R1: Hydraulic Radius using a parallel channel analysis that divides the cross-section into separate parallel channels, with one parallel channel for each X (distance) value.
- R2: Hydraulic Radius using a parallel channel analysis that divides the cross-section into separate parallel channels wherever there is a change in bed resistance (Manning’s n).
- R3: Resistance Radius that only uses depth (does not use wetted perimeter).

Figure 4-1 illustrates how the cross-section is divided up for R1 and Figure 4-2 for R2. R3 is rarely used in the Australian industry, and is more suited to wide open channels where side friction is of minor importance. R1 and R3, due to their formulation, do not experience reducing conveyance with height issues, which can be a problem with the R2 approach where there is large increase in wetted perimeter with only a small increase in flow area.

Everything else being the same, the three different approaches will need slightly different Manning’s n values to give the same water level profile. R2 is the most restrictive and therefore requires a lower Manning’s n value (conveyance is inversely proportional to Manning’s n) when compared with R1 and R3. R3 is the least restrictive, primarily due to ignoring side friction, and therefore would have the highest Manning’s n when compared with R1 and R2. R1 lies in between R2 and R3, and typically would have an equivalent Manning’s n value around 10% higher than the Manning’s n for R2 in order to produce results similar to R2.

R1 is the default formulation used by TUFLOW and that adopted for the Fast Model.

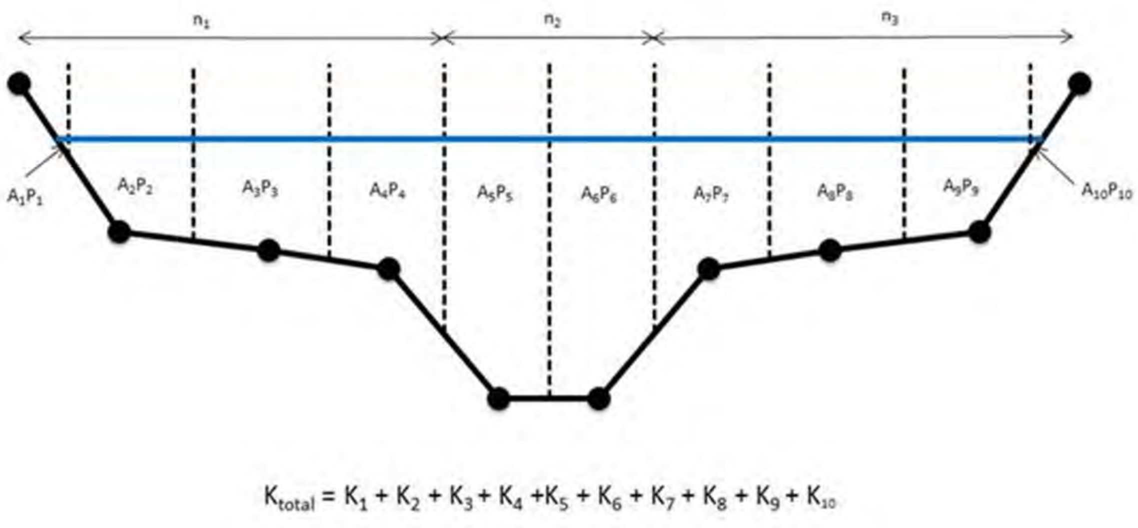

Figure 4-1 R1 Hydraulic Radius Formulation Approach

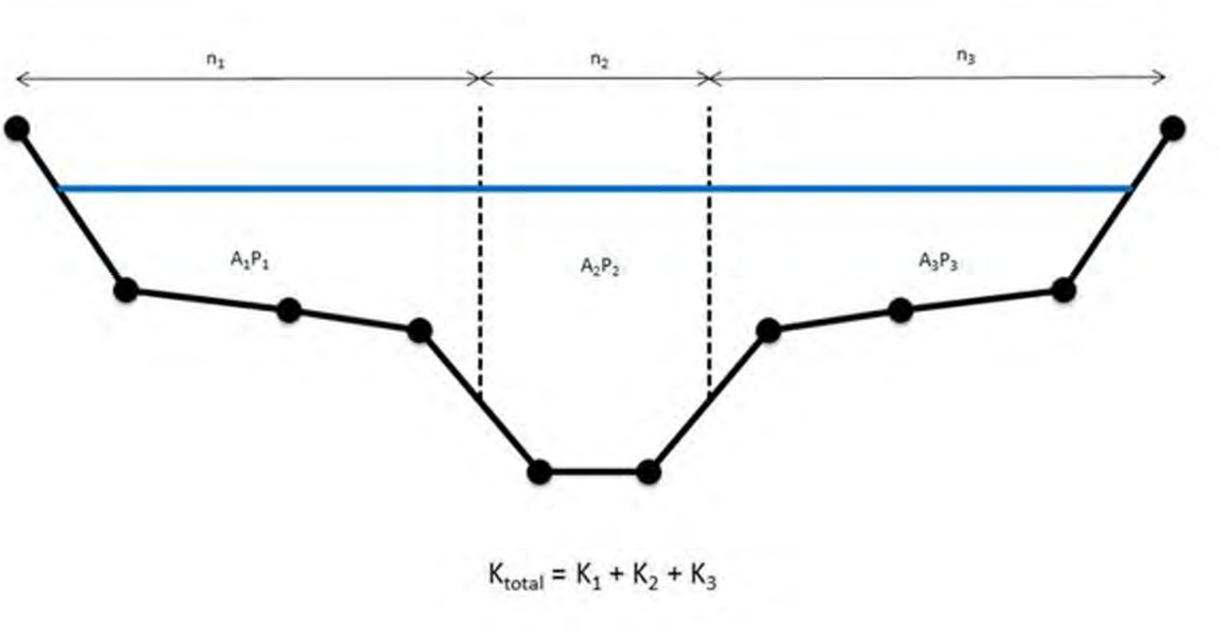

Figure 4-2 R2 Hydraulic Radius Formulation Approach

4.1.4 Fast Model Topography

The bathymetric and topographic data used to develop the Fast Model is described in detail in Section 2.1, with priorities assigned to particular datasets described in Section 2.1.5. These are the same datasets (with the same priorities) used to develop the Updated DMT Model (as described in Section 3.1.2). Due to the lack of historical topography, the same topography (and bathymetry) was used in the Fast Model for all calibration and extreme events modelled.

4.1.5 Hydraulic Structures

Hydraulic structures such as bridges, weirs and culverts are represented as special channels. Details of structures were obtained from supplied and/or sourced drawings and existing models. The representation of each structure within the model was then checked back against the source data as part of an internal review process.

Bridges are represented by a height versus width table of the under bridge waterway, automatically adjusted entrance and exit loss coefficients, bridge deck surcharge discharge coefficient, and a table of energy loss coefficients with height derived using AustRoads (1994)[11].

The losses associated with bridge piers, skew, and eccentricity were derived from AustRoads (1994)[11]. For the losses associated with the contraction and expansion of flow (entrance and exit losses), these are automatically adjusted according to the approach and departure velocities using industry standard equations (BMT WBM, 2010). This approach ensures that if a bridge causes little or no constriction that the contraction/expansion losses (excluding the losses associated with

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[11] Austroads have updated their publication series such that Austroads (2009) Guide to Bridge Technology Part 4 is seen as a replacement for the previous Austroads (1994) Waterway Design. However, Austroads (1994) still remains the most recent source of detailed technical guidance on application of losses to bridge structures, which is required to model hydraulic structures in a 1D model.

piers and the deck) are reduced to zero or close to zero, while for bridges with more substantial constrictions, usually associated with significant approach embankments) the losses will be larger.

For overtopping of the bridge a weir channel was used based on the cross-section of the bridge deck. These weirs are often flowing in a submerged (downstream controlled) state, for which the submergence curve developed by Bradley (FHWA, 1978) was used.

In-bank weirs are represented by a cross-section of the weir crest extending up either side of the river or creek banks.

The Mt Crosby weir was represented as a combination of zero-length rectangular culverts for the openings under the roadway, and a weir channel for flow over the overbridge. The small low flow culverts under the weir are understood to be blocked and even if fully operational would have negligible influence on flows/levels during flood events. They have not been included in the model.

Structures such as underpasses or large culverts through embankments within the floodplain are represented as circular, rectangular or irregular shaped culverts as appropriate.

Hydraulic Structure Reference Sheets have been developed for each mainstream hydraulic structure. These are contained in Appendix C. The sheets provide details of each structure's geometry, document how they are represented in the Fast Model and report on flow, velocity and afflux for all calibration and extreme events. These have been checked against the longitudinal profiles for each calibration event to verify model outputs.

Many hydraulic structures trap debris during a flood event. Debris can reduce hydraulic conveyance through and over the structure altering flow behaviour. Unless event specific evidence of significant debris build up was available, structures were assumed to be unblocked for the calibration events. It is important to note that the approach to blockage of hydraulic structures adopted for the calibration events may differ from that to be adopted during the design events. The methodology for assigning blockage factors to hydraulic structures for design events will be decided in advance of the design flood simulations in the Detailed Model.

4.1.6 Model Boundaries

The Fast Model boundaries consist of major river and creek inflows around the model's upstream periphery, localised internal inflows for URBS sub-catchments that fall within the model's extent and a tidal water level boundary at the mouth of the Brisbane River. On the Brisbane River the model starts immediately downstream of Wivenhoe Dam.

Table 2-5 lists the main periphery inflows and the peak flow values for each historical event based on the URBS models provided by the Hydrology Assessment (Aurecon *et al*, 2014a). Drawing 9 shows the Fast Model layout including locations of inflow boundaries.

For all calibration/verification events post Wivenhoe Dam (ie. 1996, 1999, 2011 and 2013) the flow estimates over the Wivenhoe Dam spillway are used as the inflow to the Fast Model (ie. URBS modelling upstream of Wivenhoe Dam is not used). For the 1974 event Wivenhoe Dam was not in existence and the model inflows are based on the URBS generated hydrograph at the Wivenhoe Dam site.

The hydrographs for all the inflows were generated by re-configuring URBS model hydrograph output locations and re-running the URBS models for each event. This was required as the output locations in the provided URBS models did not include any local hydrograph outputs, or outputs at the Fast Model's periphery inflow locations. Cross-checks were carried out on the re-configured URBS model by comparing total volume and outflow hydrographs at the Brisbane River mouth with the supplied model. This ensured that the reconfiguration of the URBS model did not change the URBS model's hydrologic calculations.

For each calibration event, the recorded water level hydrograph at the Brisbane Bar was applied in the Fast Model as the downstream boundary.

The Bremer, Warrill and Purga URBS models included a base flow component. These base flows were applied to the hydraulic models as additional flows. The Lockyer and Lower URBS models have no base flow hydrographs. Seqwater advised (verbal comm, Nov 2014) that Lockyer Creek exhibits a strong, but highly indeterminate and therefore difficult to estimate, base flow component. Consequently a good match in Lockyer Creek before the flood and on the flood recession would be difficult to achieve.

4.1.7 Solution Scheme

The TUFLOW 1D solver (ESTRY) was utilised to solve the 1D equations of free-surface fluid flow often referred to as the St Venant equations. The full momentum equation (ie. includes inertia) is applied at the channels and the mass balance equation at the nodes. Open channels can also automatically switch in and out of upstream controlled super-critical flow should this flow regime occur. For special channels such as bridges, weirs and culverts, the momentum equation is replaced by appropriate equations representing the flow through the structure. These equations cater for a range of upstream and downstream controlled flow regimes that can occur in the structure. For more details on the solution scheme refer to the TUFLOW software documentation (BMT WBM, 2010).

4.1.8 Quality Control Checks

During the course of the modelling, a number of quality control checks were undertaken:

- **Mass conservation within the hydraulic solution**. A table of the peak and final cumulative mass error for key TUFLOW model simulations is presented below in Table 4-1. For the calibration events and the extreme flood events (2, 5 and 8 times the 1974 flows) the peak mass balance in the model did not exceed 0.14% and, with the exception of the smaller 1999 calibration event, the final cumulative mass error was below 0.1%. While there are no industry standards, mass error should ideally be less than 1%.

Table 4-1 Summary of TUFLOW Model Mass Conservation

Simulation	Peak Cumulative Mass Error (%)	Final Cumulative Mass Error (%)
1974 Calibration	0.04	0.06
1996 Calibration	0.08	0.01
1999 Calibration	0.13	0.12
2011 Calibration	0.08	0.03
2013 Calibration	0.14	0.06
1974 x 2 Extreme	0.09	0.00
1974 x 5 Extreme	0.13	0.00
1974 x 8 Extreme	0.08	0.00

To ensure that flows from the hydrologic model were all included in the hydraulic model, checks on the flow volume in URBS and the flow volumes in TUFLOW were undertaken. In order to remove the influence of the tidal boundary on the model, the five calibration events were simulated with a fixed downstream boundary of 0.0mAHD. The total volume in the TUFLOW model is calculated as the change in volume in the model (final volume minus the initial volume) plus the volume leaving the model. This is compared to the reported volume leaving the URBS model at the Brisbane Bar as reported in the URBS .q output file. The comparisons are summarised in Table 4-2. The comparison is somewhat hampered in that URBS does not report the total model volume at the end of the simulation, only the volume leaving the model. Both the volumes in the TUFLOW model and the URBS model include baseflow.

Table 4-2 Model Volume Checks

Run ID	Event	Fast Model				URBS Volume at BAR (GL)*	Difference TUFLOW - URBS (GL)	Percentage difference (%)
		Initial Volume (m^3)	Final Volume (m^3)	Volume Leaving Model (m^3)	Total Volume (GL)			
0237_MB	1974	1.983E+08	3.022E+08	3.950E+09	4054	3992	62	1.6
0237_MB	1996	1.983E+08	2.594E+08	1.651E+09	1712	1693	19	1.1
0237_MB	1999	1.983E+08	2.204E+08	1.059E+09	1081	1075	6	0.6
0237_MB	2011	1.983E+08	3.266E+08	4.218E+09	4346	4274	72	1.7
0237_MB	2013	1.983E+08	2.502E+08	1.840E+09	1892	1843	49	2.7

*This does not include the volume remaining in the URBS model.

The comparison shows good agreement between the models with the Fast Model showing slightly higher total volumes. This is expected given that the URBS model does not output the volume remaining in the model at the end of the simulation, only that which reaches the Brisbane Bar output location.

- **Structure affluxes** were consistent with hand calculations and desktop checks using industry standard publications. Affluxes across structures were also visually assessed on the longitudinal profiles and compared to the affluxes contained in the Hydraulic Structure Reference Sheets (Appendix C).
- **Changes to the model were consistent with expectations**. For example, as part of the sensitivity test ST02, in which the Manning's values are increased throughout the model, we would expect that this change in the model would increase predicted flood levels. For this example, the change to the model creates results that are consistent with expectations. Should the change (whatever the change may be) not be inconsistent with expectations, further investigation is required to identify potential problems or errors.
- **Model file naming, version control and data management protocols** were adhered to. This was of particular importance given the thousand plus simulations carried out for the Fast Model calibration.

4.2 Fast Model Construction and Calibration / Verification Approach

The primary purpose of the Fast Model is to simulate thousands of Monte Carlo events so as to extend the Hydrologic Assessment's Monte Carlo analysis using a hydraulic model. This has the added benefit to the Monte Carlo Analysis of (a) better representing the tidally and backwater influenced areas, and (b) being able to produce more accurate peak flood level frequency curves at gauge sites and other locations along the rivers and creeks (i.e. the 29 reporting locations). The Fast Model calibration, therefore, primarily focuses on the model's performance at the river and creek water level gauges, any flow recordings, and the flood marks along the rivers and creeks.

Less importance was placed on the calibration to overbank flood marks well removed from the rivers and creeks.

The Fast Model was calibrated and verified using a staged approach as follows:

- Construct the tidal sections of the Brisbane River catchment and calibrate to the tidal signals in the lead up to the 2013 flood event.
- Extend the model to Mt Crosby and carry out a preliminary calibration using the URBS hydrograph at Mt Crosby Weir for the 2013 minor flood. This step was carried out whilst waiting for the final calibrated URBS model produced by the Hydrologic Assessment.
- Calibrate the model to the near “steady-state” flow conditions that occurred during post-flood releases from Wivenhoe Dam during 2011 and 2013. The flow during these releases was nearly entirely in-bank.
- Extend the model out onto the floodplain using results from the Updated DMT Model to guide the location of overland flowpaths as shown in Figure 3-1.
- Calibrate to the minor floods of 2013 and 1996.
- Verify the model against the minor flood of 1999.
- Calibrate to the major flood of 2011.
- Verify against the major flood of 1974.
- Proof the model against a range of extreme synthetic flood events to ensure the model schematisation is capable of effectively and realistically modelling such events. The extreme events used to undertake this proofing are: 2 x 1974, 5 x 1974, 8 x 1974 and 1.5 x 1974 (the latter provides a peak flow of 16,500m^3/s at Brisbane City, approximating one of the flood events of 1893).
- Compare the Fast Model results with the Hydrologic Assessment’s (Aurecon *et al*, 2014c) derived rating curves as a cross-check.
- During the fine-tuning of the Fast Model calibration post Workshop 2, preliminary results and flow behaviour from the Detailed Model calibration were used to further improve the Fast Model’s performance.

4.3 Fast Model Calibration Parameters

The primary hydraulic parameters available to calibrate the Fast Model are Manning’s n flow resistance values, and form losses (loss of kinetic energy which can also be referred to as an energy or bend loss). Where the flow is redirected by rock bends or ledges, or where major river/creek junctions occur, a more appropriate form of representing the losses can be to apply a form or energy loss, which is a proportion of the kinetic energy ($v^2/2g$) available.

Hydrologic parameters that can be varied during a traditional joint hydrologic and hydraulic model calibration exercise include the initial and continuing loss rates and the alpha and beta values of the URBS models. However, a joint calibration of the models was not an option in this assessment, and given the extensive work undertaken by Seqwater and the Hydrologic Assessment (Aurecon *et al.*, 2014c) on establishing URBS parameter sets for the five calibration/verification events, these URBS parameters have been left unchanged. However, some sensitivity tests varying the alpha and beta parameter values are provided so as to give some guidance as to the influence of these parameters (refer to Section 4.15.3 and 4.15.4).

4.4 Presentation of Calibration and Verification Plots and Table

The Fast Model's performance against the five calibration and verification floods is presented as a series of plots in the accompanying Plot Addendum. The plots consist of comparisons with the water level gauges, flow recordings off Centenary Bridge for the 1974, 2011 and 2013 events, and longitudinal profiles compared with flood marks within 100m and 500 m of the river/creek centreline for the 1974, 2011 and 2013 floods.

The plots are designed so that when viewing them in digital format they can be readily zoomed into so that a much closer inspection of the plots can be observed without losing image clarity.

The water level gauge plots are grouped by the three main waterways of Lockyer Creek, Bremer River and the Brisbane River downstream of Wivenhoe Dam. Where possible/practical the plots' water level axis scale and range have been kept similar to other nearby gauges to allow ease of comparison between the gauges.

Water level gauges that experienced a known or reported problem, or can be demonstrated to have a datum, scaling or quality control issue are shown in a light (cyan) blue instead of dark blue (see Table 2-1 and Appendix A). If no water level gauge existed or the gauge failed completely, the model results are still shown so as to provide a comparison with the other floods and maintain consistency.

Modelled longitudinal profiles of all calibration events are shown together in Plot 39 (Brisbane River) and Plot 40 (Lockyer Creek and Bremer River). These plots provide an indication as to the relative magnitude of each calibration event in throughout modelled sections of Lockyer Creek, Bremer River and the Brisbane River.

Some of the gauges in the upper sections of the model also include a plot of the largest URBS, Wivenhoe Dam or upstream modelled flow hydrograph so that the timing and magnitude of the flood wave entering that section of the model can be appreciated. This is of particular relevance in understanding the influence of Wivenhoe Dam discharges.

A comparison of peak modelled and recorded gauge levels is also provided in Table 4-3. This is placed in Section 4.11 to follow the calibration discussion.

4.5 Tidal and Preliminary In-Bank Calibration

4.5.1 Tidal Calibration

The tidal period prior to the 2013 flood arriving was used to carry out an initial calibration of the in-bank tidal waters Manning's n value. An n value of around 0.022 was found to produce the best reproduction of tidal wave propagation in the Brisbane River. This value is highly consistent with the many other tidal calibrations carried out using 1D and 2D schemes and is within the acceptable range for tidal reaches (0.02 to 0.04) provided in Australian Rainfall and Runoff (Babister & Barton, 2012).

4.5.2 Preliminary In-Bank Minor Flood Calibration Downstream of Mt Crosby

Whilst waiting for the final re-calibrated URBS model from the Hydrologic Assessment, a preliminary calibration to the in-bank Manning's n values was carried out using a 2013 flow hydrograph supplied by the Hydrologic Assessment at Mt Crosby Weir. Of particular note from this exercise was that an n value of around 0.022 for the tidal waters does not sufficiently reproduce the flood gradient.

To reach the peak level at Moggill, an n value of 0.038 with river bank n values varying from 0.05 to 0.10 was needed. It was also noted that an unsatisfactory match at other gauges between Moggill and the river mouth occurred. Increasing the n value also causes the tidal calibration to become substandard with too much attenuation and dampening of the tidal wave in upstream areas. This is discussed further throughout the following sections and is also detailed in Sensitivity Test ST01 (See Section 4.15.1).

4.5.3 Calibration to "Steady-State" Dam Releases after 2011 and 2013 Floods

The periods after the flood peaks of the 2011 and 2013 floods offer a good opportunity to calibrate the in-bank Manning's n values. During these periods a reasonably constant release over about four days was made from Wivenhoe Dam of around 1,700 to 1,800 m^3/s in the 2013 flood and 3,500 m^3/s for the 2011 flood. This has the effect of producing a near steady-state situation making the hydraulics solely a conveyance based problem (i.e. there would be negligible storage effects that can attenuate the flood flows).

For the 2013 post flood peak release of 1,700 to 1,800 m^3/s, it was found that an in-bank tidal water Manning's n of around 0.031 was needed to reproduce the water level at Moggill during this period. For the 2011 post flood peak discharges of 3,500 m^3/s it was found that a Manning's n value of 0.038 was needed. Also of interest was for the 2011 event flood peak to be reached at Moggill, the Manning's n value needed to be increased from 0.038 to 0.041. These simulations were repeated for Sensitivity Test ST01 as discussed in Section 4.15.1.

This exercise confirmed the preliminary findings from the 2013 calibration downstream of Mt Crosby discussed in the previous section that different in-bank Manning's n values maybe required to produce reasonable calibrations at different flood flow heights, with the general observation that Manning's n needs to increase with flow depth to match the recorded flood gradient. In summary, if the tidal n value of 0.022 is adopted, the timings are good but the flood gradient is too flat and the flood levels upstream are under-predicted. If higher n values are adopted the tidal signal becomes dampened and tidal propagation is not as well reproduced.

As a result of the above observations, sensitivity test simulations were carried out introducing form loss coefficients. Form loss coefficients were applied as both a constant (ie. to all in-bank channels), and targeted values at river bends, known rock outcrops (eg. Dutton Park and Seventeen Mile Rocks) and major river confluences. Using a tidal waters n value of 0.022, and non-tidal waters n value of 0.03, the form losses were applied in a variety of combinations. The pre-flood tidal period and post flood Wivenhoe Dam steady-state release for the 2011 and 2013 floods were used to evaluate the tests.

Constant in-bank form loss coefficients up to 0.3/km and bend losses typically varying from 0.25 for a slight bend up to 1.5 for a tight 180º bend were trialled. Form loss coefficients are discussed further in Section 4.14.

The tests showed that introducing form losses generally had little effect on the tidal calibration with an n of 0.022. The tidal signal and range/amplification throughout the tidal reaches is well represented. The form loss under tidal flows generally has little influence due to the much lower velocities and shallower depths.

Constant form loss coefficients of 0.3/km in the lower Brisbane (downstream of Mt Crosby Weir), and 0.2/km for all other in-bank channels were adopted. In combination with the targeted form losses at river bends, confluences and rock outcrops as illustrated in Drawing 10, and a Manning's n in the tidal reaches of the Brisbane River bed of 0.022, these values provided a better reproduction of the flood gradient during the post flood Wivenhoe Dam releases for 2011 and 2013. In addition, a much improved reproduction of water levels at all gauges was observed.

Based on these findings the detailed calibration of the Fast Model proceeded on the basis of using a combination of Manning's n values and form (bend) loss coefficients for the in-bank flowpaths. Section 4.14 contains more details on both Manning's n values and form loss coefficients.

4.6 2013 Tide / Minor Flood Calibration

The minor flood of 2013 largely remained in-bank, except for areas of the Lockyer Valley, which experienced a larger flood than elsewhere. The flow from Wivenhoe Dam was reduced to zero to coincide with peaks out of Lockyer Creek and Bremer River, thereby having a major effect on reducing the flows reaching Brisbane.

Plot 14, Plot 15 and Plot 16 show the Fast Model's calibration for the Lockyer Creek, Bremer River and Brisbane River gauges respectively. Plot 17 presents the water level and flow data recordings taken off Centenary Bridge. Plot 18 and Plot 19 show the longitudinal comparison of the calculated peak water levels with recorded flood marks within 100 and 500m of the creek/river centreline.

4.7 1996 Minor Flood Calibration

The minor flood of 1996 also largely remained in-bank, with some overtopping onto the Lockyer Creek floodplains. Of particular interest is that Wivenhoe Dam retained all inflows from the Brisbane and Stanley River catchments upstream, so the only catchments that contributed to inflows downstream of Wivenhoe Dam were those of Lockyer Creek and the Bremer River. Also of interest is the two peaks that entered the Lockyer system merge to become one peak prior to entering the Brisbane River.

Plot 20, Plot 21 and Plot 22 show the Fast Model's 1996 calibration for the Lockyer Creek, Bremer River and Brisbane River gauges respectively. The results show the two Lockyer flood peaks merging into one peak prior to reaching the Brisbane River.

The high URBS Initial Loss value of 180 mm for Lockyer Creek is delaying water entering the Fast Model. To better time the rising limb, a lower IL would be required.

4.8 1999 Minor Flood Verification

The minor flood of 1999 was used as a verification of the 1996 and 2013 minor flood calibrations.

Plot 23, Plot 24 and Plot 25 show the Fast Model's 1999 calibration for the Lockyer Creek, Bremer River and Brisbane River gauges respectively.

The model under-predicts the water level at Savages Crossing during the post flood peak steady-state release of around 1,800 m^3/s whereas the 2013 event, for the same post peak release flows of 1,800 m^3/s reproduces the level at Savages Crossing. This would indicate that there are some differences in the river topography and/or bed resistance/bank vegetation between 1999 and 2013.

4.9 2011 Major Flood Calibration

The major flood of 2011 caused extensive flooding throughout the floodplains of Lockyer Creek, Bremer River and Brisbane River. The releases from Wivenhoe Dam played an important role in the hydraulic behaviour of the flood. The flood storage compartment of Wivenhoe was used to help contain and delay the first flood wave upstream of Wivenhoe Dam. However, during the second flood wave into the dam, major releases from the dam were required, sending a short, sharp hydrograph downstream that combined with flood waves from the Lockyer and Bremer catchments.

Plot 26, Plot 27 and Plot 28 show the Fast Model's 2011 calibration for the Lockyer Creek, Bremer River and Brisbane River gauges respectively. The Updated DMT model results are included in these plots for interest.

Plot 29 presents the water level and flow data recordings taken off Centenary Bridge during the 2011 event. As can be seen, the levels and flows calculated by the Fast Model fall within the range of levels and flows recorded during the peak of the flood and afterwards during the post flood dam releases.

Plot 30 and Plot 31 show a comparison of the peak longitudinal flood profile with the water level gauge peaks and flood marks within 100m and 500 m of the river/creek centreline for the Brisbane and Bremer/Lockyer respectively. Modelled peak flood levels in the Bremer are shown to be in close agreement with both the 2011 recorded flood debris marks and the peak of the operational water level gauges. Modelled peak flood levels in the Lockyer are shown to provide a reasonable match to the peak level at the water level gauges. The Mid and Lower Brisbane profiles show good agreement between the modelled peak levels and the recorded peak levels at all operating water level gauges, with a maximum difference across all gauges (modelled minus recorded) of -0.09m. Good agreement is also noted between modelled and recorded flood debris marks for those marks within 100m of the Brisbane River centreline. Debris marks that are further out from the centreline show more scatter and are not always consistent with each other. However, in general, a reasonable agreement between these marks and the modelled peak levels is shown.

4.10 1974 Flood Verification

The major flood of 1974 is the largest flood recorded during the 1900s, but is smaller than the two floods of 1893. The 1974 flood caused extensive flooding throughout the floodplains of Lockyer Creek, Bremer River and Brisbane River producing flood levels typically 1 to 2 metres higher than the 2011 flood in Brisbane.

Wivenhoe Dam was not in existence in 1974, therefore the inflows to the model at the Wivenhoe Dam site were based on the URBS generated hydrographs from the Upper Brisbane and Stanley River catchments. These flow estimates have higher uncertainty than using the estimated discharges through Wivenhoe Dam for the other calibration/verification events. This is in part evidenced by the URBS flow hydrograph peak occurring after the recorded peaks at Lowood and Savages Crossing as shown in Plot 34.

Note that three scenarios are shown for the Fast Model results in all of the 1974 plots (Plot 32 to Plot 38). The scenarios are:

- **IL/CL Scenario 1 and IL/CL Scenario 2** – As presented in Section 2.5 (refer to Table 2-4), there is a significant difference between the Initial Loss (IL) / Continuing Loss (CL) used in the URBS modelling by Seqwater (Seqwater, 2013b) and the subsequent URBS modelling by Aurecon (Aurecon *et al,* 2014) for the 1974 URBS model calibration. Aurecon used smaller IL/CL values which resulted in larger flow volumes being predicted by the Aurecon URBS model compared to those predicted by the Seqwater URBS model for the Bremer catchment. The Aurecon flow volumes for the 1974 event are approximately 40% greater than the Seqwater flow volumes in the Bremer River catchment. During the hydraulic model verification to the 1974 event using the Aurecon URBS flow inputs, it was found that the Fast Model generally over-predicted peak flood levels in the Bremer River. While this over-prediction could be minimised using standard hydraulic model parameters (such as Manning's n and form loss), any such variation in these parameters produced poorer (lower water levels) calibration results in the 2011 and 2013 flood events. This led to the belief that the over-prediction of flood levels in the 1974 event using the Aurecon URBS flow inputs is potentially due to the higher inflow volumes. In order to test this belief, the 1974 flood event was simulated with two inflow scenarios: **IL/CL Scenario 1** using the higher Aurecon URBS inflows and **IL/CL Scenario 2** using inflows generated using the Seqwater IL/CL rates that produce lower URBS inflows. The results of these scenarios are presented in all plots and are discussed further in the following paragraphs.
- **Forcing at Savages –** As mentioned above, Wivenhoe Dam inflows into the Fast Model for the 1974 verification were provided by the URBS modelling, as Wivenhoe dam was not in existence in 1974. There were concerns expressed by stakeholders that the URBS modelling upstream of Wivenhoe Dam produces flows that are too low during the receding (falling) limb of the flood wave. To test the influence of these inflows on the downstream modelled water levels, a scenario was simulated in which these inflows were "neutralised" at Savages Crossing by

forcing the Fast Model to match the recorded water levels at Savages Crossing. This means the inflows above Savages crossing exit the model at this point, and new inflows are automatically generated at Savages crossing based on the forced water level and downstream hydraulic conditions (this is akin to how a tidal boundary works during an incoming tide). There are some limitations in using this approach as the inflows generated by the Fast Model at Savages Crossing are dependent on the hydraulic characteristics and behaviour of the Fast Model at that location (for example, higher Manning's n values will produce lower inflows). However, it does allow a general assessment and additional check on the calibration, particularly in terms of the model's ability to reproduce the shape of the flood wave from Savages Crossing to Moreton Bay. The results of this scenario is presented in all plots and are discussed further in the following paragraphs. Note that the Forcing at Savages Scenario uses the IL/CL Scenario 1 URBS inflows.

Plot 32, Plot 33 and Plot 34 show the Fast Model's 1974 verification (for all three scenarios) for the Lockyer Creek, Bremer River and Brisbane River gauges respectively. Additional recordings at a number of other gauges are shown in Plot 35 (note that a few additional gauge recordings are not shown as these data could not be sourced digitally).

IL/CL Scenarios

In Lockyer Creek (Plot 32), there is no noticeable difference between modelled water levels for the IL/CL Scenario 1 and 2 as these scenarios are focussed on changes in the Bremer River hydrology. In the Bremer River and tributaries (Plot 33), there is a noticeable difference between the scenarios. As expected, modelled water levels for the IL/CL Scenario 1 (higher inflow volumes) are higher than for IL/CL Scenario 2. The relevance of this difference to the recorded water levels is most evident in the Bremer River longitudinal profile presented in Plot 38. In general, this plot shows that peak debris level marks tend to lie between IL/CL Scenario 1 and 2 upstream of Ipswich, suggesting that the best estimate of the Bremer catchment inflows for 1974 should be somewhere between the two IL/CL scenarios. While downstream of Ipswich in the Bremer River, a good calibration is provided by the lower Seqwater flow volumes (IL/CL Scenario 2). This trend is continued in the lower portions of the Mid Brisbane (Plot 37), which is expected given the dominance of this section of the river in determining tailwater levels in the Bremer. Further downstream in the Lower Brisbane, the impact of the two IL/CL scenarios is still evident with the recorded peak gauge levels and debris marks generally lying between the two modelled peak profiles. In conclusion we believe that the best calibration would be achieved with IL/CL values in the Bremer River catchment being somewhere between the IL/CL Scenario 1 and IL/CL Scenario 2 values.

Forcing at Savages

The scenario in which the Fast Model is forced at Savages also shows no noticeable differences with the other two scenarios at the Lockyer gauges until the backwater effects of the Brisbane River have an influence (see O'Reilly's Weir, Plot 32). Similarly, in the Bremer catchment (Plot 33) until the backwater effects of the Brisbane River are felt, there are no differences. For the Brisbane River (Plot 34), the forcing at Savages causes the receding limb of the flood to generate higher flows (also see Plot 36 which shows the flows at Centenary Bridge for the three scenarios). This tends to over-predict (too high) water levels on the final stage of the flood recession, but does give a closer calibration at the Port Office Gauge. In conclusion, the forcing at Savages has potentially generated flows that are too high, which could be a consequence of the assumptions and uncertainties of using an upstream water level boundary, but it does demonstrate that the flows produced by the URBS modelling upstream of Wivenhoe Dam may under-predict the flows during the receding flood limb.

Plot 36 presents the water level and three flow data recordings taken off Centenary Bridge during the 1974 event. The technology used for the 1974 flow recordings is considered to be less accurate than that used for 2011 and 2013 (due to the more advanced ADCP technology used in 2011 and 2013). At present, only the day of the 1974 recordings has been able to be sourced, and on the assumption that the recordings were made during daylight hours, each flow and water level recording is shown as a line extending from 6am to 6pm.

Plot 37 and Plot 38 (already discussed in previous paragraphs) show a comparison of the peak flood level profile with the water level gauge peaks and flood marks within 100m and 500 m of the river/creek centreline. Of note is the significantly larger number of flood marks collected after the 1974 flood compared with that collected from the 2011 flood, thereby giving an excellent recorded profile that helps clearly identify changes in flood profile gradients due to sharp bends, meanders that are shortcut and rock ledges such as at Dutton Park.

4.11 Calibration & Verification Peak Level Comparison

Table 4-3 summarises the peak recorded and modelled flood level for all calibration events at each gauge location. A legend for this table is shown below the table in the bottom left corner. Accuracy tolerances for each area are provided in the second column. These accuracy tolerances are extracted directly from the Brief (DSDIP, 2014) where they are provided to guide accuracy of peak *design* flood levels. They are used here to provide an indication as to how the differences between peak recorded and modelled flood levels sit in relation to the accuracy tolerances. A difference between peak and modelled flood level that is within tolerance is shaded in green, a difference that is outside tolerance is shaded in red. This summary of peak flood levels should be considered in conjunction with the presentation of recorded and modelled level hydrographs in the calibration plots (Plot 14 through to Plot 38). Commentary on model performance relating to Table 4-3 is provided in the preceding sections of the report (Section 4.2 to Section 4.10). Note that the 1974 model results provided in this table are from IL/CL Scenario 1 which, as described in Section 4.10, over-predicts 1974 flood levels in the Bremer River and portions of the Mid and Lower Brisbane rivers. A better calibration to the 1974 event would be achieved with IL/CL values set at values between those used in Scenario 1 and Scenario 2. However, for simplicity and transparency, only the 1974 IL/CL Scenario 1 is presented in the Table 4-3.

Table 4-3 Fast Model Calibration and Verification Peak Level Comparison at Gauges

Location	Accuracy Tolerance	BoM Gauge No.	AWRC Gauge No.	Gauge Name	System	Node ID	Recorded and Modelled Peak Water Surface Levels														
							1974*			1996			1999			2011			2013		
							Recorded	Modelled	Difference	Recorded	Modelled	Difference	Recorded	Modelled	Difference	Recorded	Modelled	Difference	Recorded	Modelled	Difference
Brisbane River D/S of Oxley Creek	±0.15m	540495	143891	Whyte Island Tide AL	Moreton Bay	BR80_05727.2	x	1.50	x	x	1.33	x	x	1.32	x	1.63	1.68	0.05	1.79	1.87	0.08
		540286	143877	Breakfast Creek Mouth Al	Lower Brisbane	BK10_06373.2	x	3.07	x	x	1.63	x	x	1.40	x	2.50	2.56	0.06	2.12	2.10	-0.02
		540198	143838	Port Office / City Gauge	Lower Brisbane	BR60_00583.2	5.45	5.57	0.12	2.1	2.05	-0.05	1.44	1.46	0.02	4.46	4.44	-0.02	2.32	2.36	0.04
		-	-	Highgate Hill - Paradise St	Lower Brisbane	BR45_01058.2	8.36	8.60	0.24	x	2.89	x	x	1.65	x	x	7.14	x	x	2.92	x
		-	-	St Lucia Ferry	Lower Brisbane	BR45_00338.2	?	8.77	?	x	2.93	x	x	1.66	x	x	7.27	x	x	2.95	x
				Dutton Park Cemetery	Lower Brisbane	BR40_08587.2	9.57	9.59	0.02	x	3.21	x	x	1.73	x	x	8.01	x	x	3.15	x
		-	-	Sandy Creek	Lower Brisbane	BR40_06357.2	?	10.02	?	x	3.33	x	x	1.76	x	x	8.37	x	x	3.24	x
				Yeronga St	Lower Brisbane	BR40_03993.2	10.83	10.77	-0.06	x	3.57	x	x	1.82	x	x	9.03	x	x	3.42	x
		-	-	Tennyson Powerhouse	Lower Brisbane	BR40_03691.2	10.81	10.85	0.04	x	3.60	x	x	1.83	x	x	9.12	x	x	3.45	x
				Tennyson	Lower Brisbane	BR40_02716.2	11.04	10.96	-0.08	x	3.66	x	x	1.84	x	x	9.23	x	x	3.50	x
		540274	143872	Oxley Ck Mouth AL	Lower Brisbane	OX20.1	x	11.01	x	x	3.68	x	x	1.85	x	9.20	9.27	0.07	3.36	3.52	0.16
				OxleyCkCorinda	Lower Brisbane	OX10_06299.2	11	11.04	0.04	x	4.05	x	x	1.85	x	x	9.29	x	x	3.98	x
Brisbane River D/S of Goodna, U/S of Oxley Creek	±0.30m	-	-	Clarence Rd	Lower Brisbane	BR40_00000.2	11.2	11.34	0.14	x	3.85	x	x	1.91	x	x	9.58	x	x	3.69	x
		41472	-	Centenary Bridge	Lower Brisbane	BR30_00000.1	14.1	14.08	-0.02	x	4.98	x	x	2.28	x	12.07	12.13	0.06	x	4.77	x
		540192	143832	Jindalee Alert	Lower Brisbane	BR25_33331.2	?	14.91	?	x	5.33	x	?	2.49	?	12.90	12.86	-0.04	4.98	5.11	0.13
Brisbane River U/S of Goodna	±0.50m	540200	143840	Moggill Alert	Lower Brisbane	BR25_13670.2	19.91	20.45	0.54	7.1	8.32	1.22	?	4.78	?	18.17	18.23	0.06	7.97	8.27	0.30
		540063	143868	Colleges Crossing Alert	Mid Brisbane	BR20_03221.2	x	25.24	x	x	11.90	x	x	9.63	x	?	23.64	?	?	11.31	?
		540199	143839	Mt Crosby AL	Mid Brisbane	_BCC_077_RC.	26.7	27.56	0.86	14.1	14.04	-0.06	11.97	12.18	0.21	26.18	26.25	0.07	13.41	13.33	-0.08
		540256	143864	Kholo Bridge AL	Mid Brisbane	BR18_00000.2	x	29.89	x	x	16.49	x	x	14.66	x	?	28.88	?	16.62	15.65	-0.97
		540257	143856	Burtons Bridge	Mid Brisbane	BR12_12100.2	x	36.45	x	x	25.37	x	x	24.08	x	?	36.16	?	24.69	24.85	0.16
		540066	143001C	Savages Crossing TM	Mid Brisbane	BR10_03593.2	42.13	42.48	0.35	31.03	30.51	-0.52	29.83	29.11	-0.72	42.58	42.61	0.03	30.53	30.06	-0.47
		540182	143001A	Lowood Alert-B	Mid Brisbane	BR00_07861.2	44.76	45.96	1.20	34.99	34.49	-0.50	33.61	33.13	-0.48	46.29	46.28	-0.01	35.28	34.25	-1.03
		540178	143823	Wivenhoe Dam TW Alert-P	Mid Brisbane	BR00_00000.2	x	47.68	x	x	36.51	x	?	35.39	?	?	47.93	?	37.26	36.35	-0.91
Ipswich Urban Area	±0.30m	40831	143954	Ipswich Alert	Bremer River	BM48.2	20.72	21.49	0.77	11.31	12.28	0.97	6.58	6.57	-0.01	19.30	19.16	-0.14	13.90	13.06	-0.84
		540250	143852	Brassall (Hancocks Bridge)	Bremer River	BM40_01880.2	x	23.33	x	x	14.14	x	x	8.05	x	?	19.59	?	?	14.92	?
		40836	14953	One Mile Bridge Alert	Bremer River	WA15_11343.2	x	26.08	x	x	18.50	x	12.93	13.88	0.95	21.98	22.02	0.04	19.05	19.08	0.03
Bremer River, Non-Urban Area	±0.50m	540550	143114	Berry's Lagoon Alert	Bremer River	WA15_09155.2	x	26.52	x	x	19.79	x	x	15.33	x	?	22.82	?	20.07	20.34	0.27
		40838	143956	Three Mile Bridge AL	Bremer River	BM20_00000.1	x	26.88	x	x	21.13	x	17.26	17.33	0.07	?	23.68	?	?	21.47	?
		540504	143896	Walloon AL	Bremer River	BM10_05036.2	27.96	28.19	0.23	26.65	26.22	-0.43	?	24.15	?	27.68	27.70	0.02	26.25	26.41	0.16
		540062	143983	Loamside Alert	Purga Creek	PU10_00000.2	x	28.04	x	x	26.96	x	24.71	25.34	0.63	26.14	26.44	0.30	25.33	26.06	0.73
		540210	143113	Loamside TM	Purga Creek	PU10_00000.2	27.68	28.04	0.36	26.47	26.96	0.49	x	25.34	x	x	26.44	x	x	26.06	x
		40816	143108	Amberley (DNRM) TM	Warrill Creek	WA10_04293.2	28.69	28.49	-0.20	26.355	25.23	-1.12	23.83	23.62	-0.21	25.63	26.88	1.25	27.79	27.67	-0.12
		540180	143825	Amberley-P (Greens Road)	Warrill Creek	WA10_03014.2	x	30.44	x	26.62	27.19	0.57	25.21	25.63	0.42	27.99	28.52	0.53	?	29.37	?
Lockyer Creek	±0.50m	540051	143207	O'Reilly's Weir AL	Lockyer Creek	lo60_03917.2	?	47.38	?	39.472	39.73	0.26	36.29	35.52	-0.77	47.30	47.73	0.43	?	39.73	?
		540544	143700	Rifle Range Rd Alert -P	Lockyer Creek	lo30_01958.2	x	61.08	x	61.093	60.71	-0.39	56.69	54.96	-1.73	60.92	61.18	0.26	61.14	60.78	-0.36
		540174	143819	Lyons Bridge Alert-P	Lockyer Creek	lo20_02940.2	64.95	65.17	0.22	x	64.38	x	60.08	58.59	-1.49	?	65.34	?	63.93	64.57	0.64
		540149	143808	Glenore Grove Alert	Lockyer Creek	lo10_17895.2	82.05	82.31	0.26	81.41	81.65	0.24	77.79	76.58	-1.21	82.45	82.32	-0.13	82.21	82.02	-0.19

* Note 1: 1974 modelled peak flood levels are based on the model results from IL/CL Scenario 1. As described in Section 4.10, Scenario 1 over-predicts flood levels, particularly in the Bremer River. Hence, differences in peak flood level tabulated here show modelled peak flood levels that are too high in the Bremer and portions of the Mid and Lower Brisbane. A better calibration is provided with an IL/CL scenario that lies between IL/CL Scenario 1 and 2 (refer to Section 4.10).

Note 2: Differences between modelled and recorded peak levels that are outside tolerance are due to a number of factors and combinations thereof, including uncertainties in topography, hydrology, recorded levels and so on. These uncertainties are discussed in Section 4.16 and 4.17.

x	Gauge data not available
?	Gauge data questionable (e.g. gauge failure before peak)
0.12	Difference between recorded and measured within tolerance
0.34	Difference between recorded and measured outside tolerance
18.17	Moggill Gauge Peak Level in 2011 manually adjusted to 18.17m AHD (Seqwater, 2013c)

4.12 Extreme Event Proofing

In 1893, Brisbane experienced two major flood events, both of which were greater in flow magnitude in Brisbane than any other recorded event, including 1974 and 2011. As the Hydraulic Assessment is reliant on events produced by the Hydrologic Assessment (Aurecon *et al*. 2014) and the Hydrologic Assessment did not model the 1893 event, the Hydraulic Assessment is not able to specifically model this event. However, it is essential that the Fast Model be capable of running events larger than the calibration events, as the subsequent Monte-Carlo analysis will require this to be so. As such, the following events have been simulated: 2x1974, 5x1974, 8x1974 and 1.5x1974 (approximately an 1893 event).

4.12.1 Scaled 1974 events

To inform the further development of the Fast Model for extreme events, a simulation of the 2x1974, 5x1974 and 8x1974 events were undertaken in the Updated DMT Model. The Updated DMT Model was subject to the following checks, designed to firstly ensure that this model was capable of simulating these extreme events:

- Confirmation that the active area of the Updated DMT Model extended beyond the extreme event flood extents
- Robust results (no numerical instabilities).

The Updated DMT Model was found to satisfy the requirements of these checks and, as such, considered suitable to be used to further develop the Fast Model. New high-flow flowpaths predicted by the Updated DMT Model were incorporated into the Fast Model. An example of a high-flow flowpath that was subsequently added to the Fast Model to enable it to appropriately model the extreme events is shown in Figure 4-3. The circled flowpaths allow break out from the Brisbane River into Dutton Park / Woolloongabba to occur in extreme events.

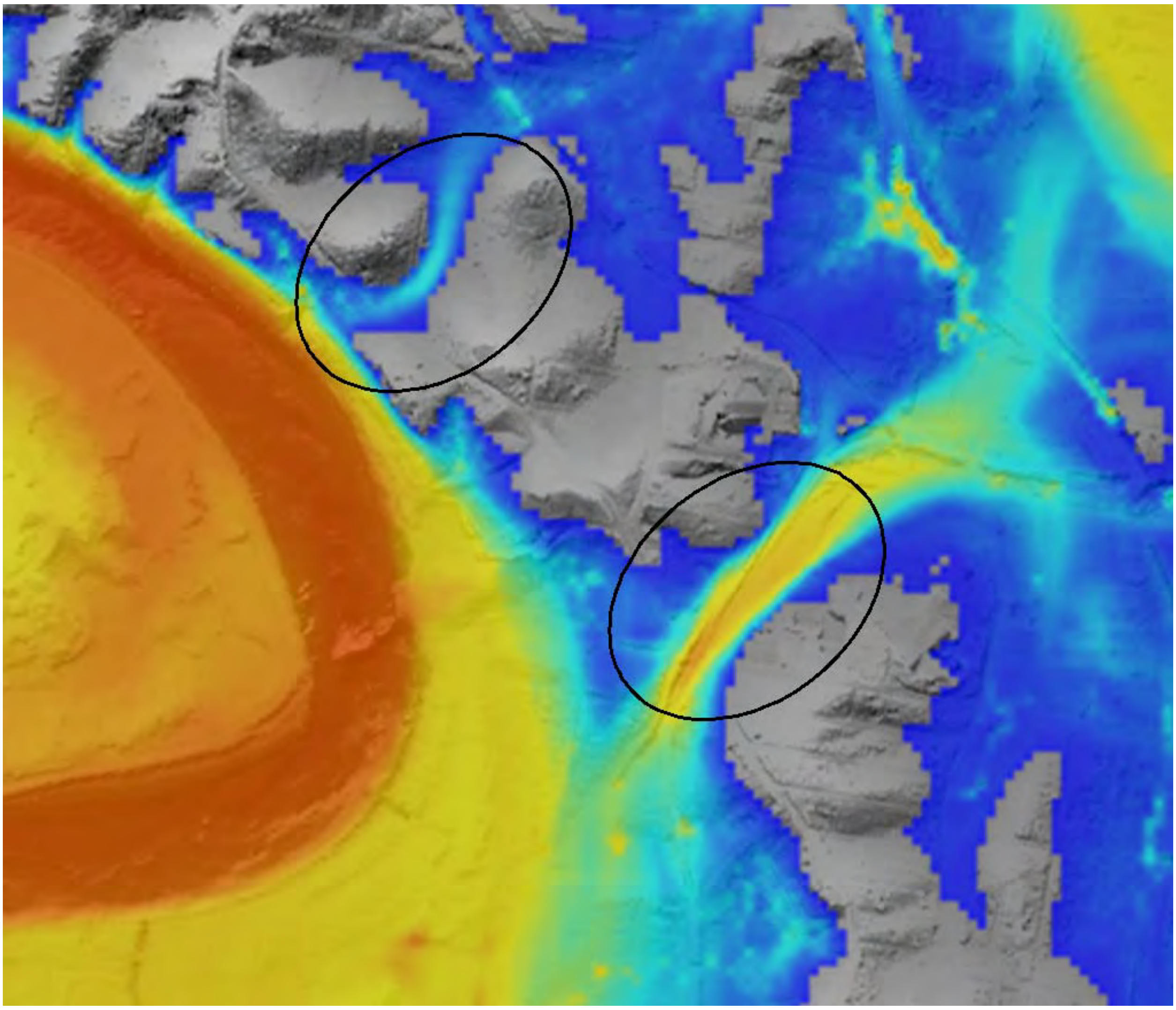

Figure 4-3 Example of New High-Flow Flowpath for the 8x1974 Event

Longitudinal peak level profiles for these extreme events are provided in Plot 43 and Plot 44 for the Lockyer Creek, Bremer River and the Brisbane River respectively. The Fast and Updated DMT Models produce similar, consistent profiles. The Fast Model's prediction of extreme flood levels is therefore considered reasonable for the purposes of selecting the ~50 design flood events. In reviewing the plots, please note:

(1) The Fast Model tends to produce a smoother profile as it does not have the fine resolution results produced by the Updated DMT Model (note that the apparent erratic nature of the Updated DMT Model profile is due to the significant changes in kinetic energy ($v^2/2g$) that occurs along the profile line).

(2) The Updated DMT Model does not have any representation of structures. This is particularly evident for the 2x1974 event where the bridges through the Brisbane CBD have a noticeable influence due to surcharging against the bridge decks. For the 5x1974 and 8x1974 the bridges have mostly drowned out and these afflux effects are not as apparent.

(3) The Updated DMT Model shows substantial water level drops at the Breakfast Creek and, to a lesser extent, Story Bridge river bends (the bend at Breakfast Creek essentially becomes the most significant hydraulic control in the 5x1974 and 8x1974 events).

(4) Some interesting significant head drops were noted in the Updated DMT Model where the flow across a meander became a dominant flow path (flow similar or greater than that in the river). The head drop occurs where the water is pouring back into the river and would be due to substantial energy loss associated with the remixing of river and meander flows (like that that would occur at a major confluence), and the change in direction of the meander flows as it realigns in the river direction. To achieve a similar effect in the Fast Model required adding form losses to the meander channel. This did not affect the calibration of the model.

(5) An unusual localised effect is noted in Lockyer Creek upstream of Lyons Road Bridge in Plot 43. A dip (a decrease in peak flood level in the upstream direction) in the modelled longitudinal profile is presented in this area for the 5 x 1974 magnitude event (green solid line). This is due to a significant flow entering Lockyer Creek upstream of the bridge from the southern tributary and floodplain. This causes a temporary reversal of flow in the creek at the peak of the event, which results in the dip in the profile as shown.

4.12.2 Psuedo-1893 Flood

Two very large flood events occurred in 1893, the first in January and the second in February with the January event resulting in higher observed levels in Brisbane City.

The Hydrologic Assessment did not model the 1893 flood events and therefore, flow boundary conditions were not available to model these events directly. However, given these are the largest observed floods on record, it was necessary to give some consideration to these events. There are three estimates of flow for the 1893 events:

- 16,000m^3/s at Indooroopilly Bridge (Seqwater, 2013b)
- 15,830m^3/s at Brisbane CBD (Aurecon, 2014c)
- 17,940m^3/s at Moggill (Aurecon, 2014c).

Given the lack of boundary data available to create a flood event with similar flows, the 1974 event flows were factored up by 1.5 to achieve a peak flow in the Brisbane CBD of approximately 16,500m^3/s and create a pseudo-1893 flood event. The tidal water level for the 1974 calibration event was used as a downstream boundary condition.

A summary of the observed peak water levels for the January and February events as well as the modelled water levels for the pseudo-1893 event is presented in Table 4-4. The modelled results generally agree well with the recorded peak water levels, particularly given the unknown accuracy of the recorded peak flood levels, the difference in the hydrograph shape and peak (derived from the 1974 event), and the historical changes to the river system and catchment (e.g. topography and vegetation) that are not considered in the model.

Table 4-4 1893 Peak Water Level Summary

Location	Observed Jan 1893 (m AHD)	Observed Feb 1893 (m AHD)	Modelled Pseudo-1893 (m AHD)
Lowood	50.07	-	48.3
Mt Crosby	32.00	31.28	32.2
Ipswich	24.50	23.60	24.9
Moggill	24.50	23.60	24.8
Centenary	17.90	16.60	16.4
Brisbane	8.35	8.09	8.5
Bar	1.33	1.26	1.5

4.13 Fast Model Rating Curve Review

The stage-discharge outputs calculated by the Fast Model for each calibration/verification event are presented in Plot 41. Where backwater or tidal effects occur, Fast Model results show a more pronounced hysteresis or looping, with the lower side of the loop (higher flows) occurring during the flood rise, and the higher side (lower flows) on the flood recession. The Brisbane City Gauge results show the strong effect of the ocean tide at the lower levels.

Overall there is good consistency between the Fast Model results and the rating curves derived by Seqwater and Aurecon (Aurecon *et al*, 2014c) (also shown on Plot 41), and on gaugings at Savages Crossing and Amberley. Plot 42 shows the same rating curve charts but for the extreme floods described in Section 4.12.

General observations are:

- The most noticeable differences occur during the in-bank stages of Glenore Grove and Rifle Range, and the higher stages of Loamside. For Glenore Grove and Rifle Range the in-bank differences could be due to the uncertainties associated with using LiDAR for in-bank areas and the inaccuracies associated with deriving the rating curves.
- There is some looping (hysteresis) effects at some gauges. Where this occurs the rating curves tend to match well with the rising limb of the flood (ie. with the lower side of the hysteresis curve).
- At gauges such as Mt Crosby and Moggill there is a noticeable difference between the major floods of 1974 and 2011, despite having similar peak flows at Mt Crosby. This is most likely due to the different flood shapes; the 2011 flood, due to the influence of Wivenhoe Dam, was a shorter, sharper shape with less volume than the 1974 event. The Bremer River flow entering at Moggill in 1974 was also greater than 2011 making 1974 larger than 2011 downstream of the rivers' confluence. This is aptly illustrated at the lower Brisbane gauges where the flood level was above 10 mAHD for around 3 days in 1974, but less than 2 days in 2011.

4.14 Calibration Parameters

4.14.1 Manning’s n Roughness Values

Roughness of the land surface over which the water flows is represented in the hydraulic model by Manning’s n values. Different roughness values across a cross-section are applied in the Fast Model. A number of methods for calculating conveyance and area can be applied in the TUFLOW engine for the processing of varying roughness across a section.

The Fast Model uses a parallel channel analysis at each coordinate across the section, this prevents decreases in conveyance with increasing height. Further discussion on this can be found in Section 4.1.3.

The cross-sectional area calculation has been set to use the effective area approach in TUFLOW. In this approach, the effective flow area is calculated based on the sum of the areas divided by the relative resistance factor. The wetted perimeter is adjusted to compensate for the change in flow area so as to produce the same conveyance as would occur for the total area. This effective area approach produces a velocity that applies to the main channel. Further information on this can be found in Section 4.6.8 of the TUFLOW manual (BMT WBM, 2010).

Manning’s n roughness values were initially set to typical values for each land use type. These values were then adjusted within acceptable bounds as part of the calibration exercise.

The final Manning’s n values adopted for the calibration and verification simulations are presented in Table 4-5. Discussion on the methodology by which the values were derived is provided in Sections 4.5 to 4.10.

Table 4-5 Manning's n Values (Used in Conjunction with Form Losses)

Landuse Category	Manning's n
Brisbane River	
Tidal Waterway	0.022
Non-Tidal Waterway	0.032
Riverbank Light Vegetation	0.05
Riverbank Medium Vegetation	0.07
Riverbank Dense Vegetation	0.09
Bremer River	
Tidal Waterway	0.03
Non-Tidal Waterway	0.08
Riverbank Light Vegetation	0.08
Riverbank Medium Vegetation	0.12
Riverbank Dense Vegetation	0.16
Lockyer Creek	
Non-Tidal Waterway	0.06
Riverbank Light Vegetation	0.08
Riverbank Medium Vegetation	0.12
Riverbank Dense Vegetation	0.16
Floodplains	
Roads / Carparks	0.025
Water bodies	0.03
Agricultural Fields	0.03
Vegetation Light	0.06
Vegetation Medium	0.09
Vegetation Dense	0.12
Grass (maintained)	0.03
Urban Low Density	0.05
Urban Medium Density	0.1
Urban High Density	0.2
Commercial / Industrial	0.2

4.14.2 Form Loss Coefficients

Hydraulic models aim to realistically represent flow behaviour. 1D hydraulic models rely on the one-dimensional cross-sectional depth and width-averaged equations of fluid motion. A 1D scheme therefore cannot represent complexities of hydraulic behaviour that occur in two or three dimensions where rapid changes to velocity occur, such as eddies and torsional vortexes. As such, energy losses associated with such hydraulic behaviour need to be manually accounted for within the 1D model.

The Manning's n equation is the most common approach that can be utilised to represent these losses, but usually has to be varied with height to do so. As discussed in Section 4.5.3, it was not possible to achieve a reasonable calibration using the same Manning's n value to post-flood constant discharges from Wivenhoe Dam for the 2011 and 2013 events. A much improved calibration was achieved through applying, in addition to the base tidal Manning's n value, a small general form loss along with targeted form losses at sharp, rock controlled, river bends and rock ledges (e.g. Dutton Park).

A form loss coefficient is applied to the model to simulate the energy losses associated with hydraulic behaviour not able to be represented explicitly in the hydraulic model. The form loss is applied as an energy loss based on the dynamic head equation below where ζ_a is the form loss value.

$$\Delta h = \zeta_a \frac{V^2}{2g}$$

As investigated in Sargent (1978), the Brisbane River is effectively a series of rock controlled steps/ledges with sharp bends and rock outcrops. The energy losses that result from these obstructions to flow are more closely approximated by the energy (form) loss equation, rather than the Manning's equation. Therefore, the application of additional energy losses through the use of form losses is readily justified, and has been shown to be a more satisfactory approach through the testing carried out during the calibration of the Fast Model, as calibration can be achieved through the use of a single, consistent set of parameters for all calibration events. This is a preferable approach to solely using the Manning's equation, which would require using different n values for different floods.

In addition to the Manning's n values, targeted form loss coefficients at sharp bends or rock outcrops are presented in Drawing 10 and Table 4-6 (Mid Brisbane), Table 4-7 (Lower Brisbane) and Table 4-8 (Lockyer Creek and Bremer River). A general form loss was also applied across the model in three sections as presented in Table 4-9.

Preliminary estimates of the targeted form loss were based on calculations, such as the sinuosity index and bend radius. However, it was found that a better calibration outcome was obtained based on manual estimation. Manual estimation considered geometry, bathymetry and recorded data. This allowed for similar bends to have a consistent value applied, for example a 180 degree bend was typically assigned a form-loss of 1.5, and a 90 degree bend a form loss value of 0.75. As part of the calibration process the values of form loss were varied to provide the most consistent match across the events.

The values for the general form loss, derived through the calibration process, are shown in Table 4-9 with the general form losses applied separately for the following three areas of the model:

- The lower sections of the Brisbane River, downstream of New Farm Park and the tidal areas of the Brisbane creeks (Oxley Creek, Breakfast Creek, Bulimba Creek, Norman Creek, Moggill Creek).
- Bremer River, Warrill Creek, Purga Creek and the Brisbane River from Mt Crosby to New Farm Park.
- Lockyer Creek and the Brisbane River from Wivenhoe Dam to Mt Crosby.

Different losses for these sections were considered reasonable due to the distinct bed formations across these three areas, with the higher sections of the system having a more irregular bed form.

Table 4-6 Targeted Form Losses Mid Brisbane River

River	Long. Profile Chainage	FLC* Value	Location	Suburb	Physical Feature
Mid Brisbane	9030	1.5	Wivenhoe Pocket	Lowood	Bend
Mid Brisbane	17240	1	England Creek	Fernvale	Bend
Mid Brisbane	18890	0.5	US Savages Crossing	Fernvale	Bend
Mid Brisbane	20550	0.5	DS Savages Crossing	Fernvale	Bend
Mid Brisbane	21800	0.5	Fernvale Bend 3	Fernvale	Bend
Mid Brisbane	22900	0.5	Frenvale Bend 2	Fernvale	Bend
Mid Brisbane	25290	0.75	Fernvale Bend 1	Fernvale	Bend
Mid Brisbane	29810	0.75	Black Snake Creek	Fairney View	Bend
Mid Brisbane	33290	0.5	Hills Crossing	Borallon	Bend
Mid Brisbane	35810	0.75	Near Sandy Creek	Pine Mountain	Bend
Mid Brisbane	38550	1	Quary	Pine Mountain	Bend
Mid Brisbane	44470	1.5	Near Kholo Road 2	Kholo	Bend
Mid Brisbane	46330	0.75	Near Skyline Drive	Kholo	Bend
Mid Brisbane	51500	1.5	Kholo Road Bridge	Muirlea	Bend
Mid Brisbane	56700	0.75	Near Kholo Road 1	Chuwar	Bend
Mid Brisbane	62820	1.5	Allawah Road	Chuwar	Bend
Mid Brisbane	64600	1	Colleges Crossing	Karana Downs	Bend
Mid Brisbane	66860	1	Johnsons Rocks	Karalee	Underwater Feature
Mid Brisbane	67500	0.5	Venus Pool	Karalee	Bend

River	Long. Profile Chainage	FLC* Value	Location	Suburb	Physical Feature
Mid Brisbane	69690	1.5	Kookaburra Park	Karana Downs	Bend
Mid Brisbane	71290	1.5	Taylors Nook	Karalee	Bend

*FLC = Form Loss Coefficient

Table 4-7 Targeted Form Losses Lower Brisbane River

River	Long. Profile Chainage	FLC* Value	Location	Suburb	Physical Feature
Lower Brisbane	35170	0.5	Long Pocket 2	Indooroopilly	Bend
Lower Brisbane	36640	0.75	Long Pocket 1	Indooroopilly	Bend
Lower Brisbane	37900	0.5	Six Mile Rocks	Yeronga	Underwater Feature
Lower Brisbane	39610	0.75	The Elbow	Yeronga	Bend
Lower Brisbane	39850	1	Dutton Park Rocks	Dutton Park	Underwater Feature
Lower Brisbane	43070	0.75	Kayes Rocks	West End	Bend
Lower Brisbane	46400	0.375	William Jolly Bridge	South Brisbane	Bend
Lower Brisbane	48350	1	Captain Cook Bridge	Woolloongabba	Bend
Lower Brisbane	50520	1	Story Bridge	Kangaroo Point	Bend
Lower Brisbane	52450	0.75	Kinellan Point	New Farm	Bend
Lower Brisbane	54150	0.75	Norris Point	New Farm	Bend
Lower Brisbane	57420	1.5	Bulimba Point	Bulimba	Bend

*FLC = Form Loss Coefficient

Table 4-8 Targeted Form Losses Bremer and Lockyer River

River	Long. Profile Chainage	FLC* Value	Location	Suburb	Physical Feature
Bremer	11310	1	Bremer / Warrill Confluence	Leichhardt	Bremer / Warrill Confluence
Bremer	13370	1.5	Berrys Lagoon	Leichhardt	Bend
Bremer	15380	1	Leichhardt Park	Leichhardt	Bend
Bremer	16370	1.5	Jim Finimore Sportsground	Leichhard	Bend
Bremer	16900	1.5	Gengemain Property	Leichhardt	Bend
Bremer	18960	1	Shapcott	Coalfalls	Bend
Bremer	20100	1	Woodend Nature Reserve	Woodend	Bend
Bremer	21010	1.5	Woodend Pocket	Woodend	Bend
Bremer	22380	1	Parnell Street	Woodend	Bend
Bremer	24250	1.5	Bob Gamble Park	East Ipswich	Bend
Bremer	25860	0.75	Tivoli Rocks	Tivoli	Underwater Feature
Bremer	27730	0.75	Moores Pocket 2	East Ipswich	Bend
Bremer	28790	1.5	Moores Pocket 1	North Booval	Bend
Bremer	30120	1	Waterstown Rocks	Tivoli	Underwater Feature
Bremer	34320	1.5	Motor Boat Bend	Bundamba	Bend
Bremer	35180	1	Warrego Highway	Chuwar	Bend
Bremer	36660	1.5	Devil's Elbow	Riverview	Bend
Bremer	40180	1	The Junction	Moggill	Confluence Bremer / Brisbane
Bremer	42000	1.5	Six Mile Creek	Riverview	Bend
Bremer	44660	0.75	Chemical Crossing	Redbank	Bend
Bremer	48880	1.5	Hospital Corner	Wolston	Bend
Bremer	53600	0.75	Wolston Creek Confluence	Moggill	Bend
Bremer	54400	0.75	Popes Reach	Riverhills	Bend
Bremer	55610	0.75	Hells Gate	Bellbowrie	Bend
Bremer	56810	0.75	Pullen Pullen Reach	Westlake	Bend
Bremer	59220	0.75	Mt Ommaney Reach	Mt Ommaney	Bend
Bremer	60330	0.75	Moggill Creek Confluence	Mt Ommaney	Bend
Bremer	63460	0.25	Seventeen Mile Rocks 2	Sinnamon Park	Underwater Feature
Bremer	64060	0.25	Seventeen Mile Rocks 1	Seventeen Mile Rocks	Underwater Feature
Bremer	64890	0.5	Rocks Riverside Park	Seventeen Mile Rocks	Bend

River	Long. Profile Chainage	FLC* Value	Location	Suburb	Physical Feature
Bremer	66150	0.75	Carrington Rocks	Corinda	Underwater Feature
Bremer	70530	1	Walter Taylor Bridge	Chelmer	Bend
Lockyer	19880	0.75	Glenore Grove	Glenore Grove	Bend
Lockyer	24020	0.5	Pomerenke Road	Lockrose	Bend
Lockyer	28740	0.5	Lynford	Lynford	Bend
Lockyer	34200	1.5	Brightview Pocket	Brightview	Bend
Lockyer	38870	0.5	Marschke Road	Brightview	Bend
Lockyer	40050	0.5	Radkes Lane	Brightview	Bend
Lockyer	41660	1.5	Rifle Range Road	Rifle Range	Bend
Lockyer	43770	0.5	Forest Hill Fernvale Road	Rifle Range	Bend
Lockyer	43770	0.75	Forest Hill Fernvale Road	Lockrose	Bend
Lockyer	46520	1.5	Mt Tarampa Pocket	Mt Tarampa	Bend
Lockyer	50210	0.5	Watsons Bridge	Clarendon	Bend
Lockyer	51630	0.5	Clarendon Station	Clarendon	Bend
Lockyer	53410	1.5	Clarendon Pocket	Clarendon	Bend
Lockyer	58560	1	Mahon Road 2	Patrick Estate	Bend
Lockyer	60850	1.5	Mahon Road 1	Patrick Estate	Bend
Lockyer	64320	1.5	Lowood Patrick Estate Road 2	Lowood	Bend
Lockyer	65260	1.5	Lowood Patrick Estate Road 1	Lowood	Bend
Lockyer	70630	1	Confluence Lockyer/Brisbane River	Wivenhoe Pocket	Confluence

*FLC = Form Loss Coefficient

Table 4-9 General Form Losses

River Section	General Form Loss	Physical Features
Bremer River, Warrill Creek, Purga Creek, Brisbane River from Mt Crosby to New Farm Park	0.3/km	Irregular bed formations; general energy losses.
Lockyer Creek, Brisbane River from Wivenhoe Dam to Mt Crosby	0.2/km	General energy losses.
Brisbane River from New Farm Park to the mouth, Oxley Creek, Breakfast Creek, Bulimba Creek, Norman Creek, Moggill Creek	0/km	Smooth bed formation and backwater-affected creeks

4.15 Sensitivity Assessments

General sensitivity tests were carried out to help understand the influence of key hydrologic and hydraulic primary calibration parameters. For these tests, the 2011 flood was chosen given its magnitude, period of steady-state discharges at minor flood levels after the flood peak, and critical timing of flood waves down the three major catchments.

The sensitivity tests presented are listed in Table 4-10 and are discussed in the following sections.

Table 4-10 General Sensitivity Tests on the Primary Calibration Parameters

Sensitivity Test	Description and Plots
ST01	Manning’s n only approach, with no general form losses along the river and no targeted form losses at bends, rock ledges and major confluences.
ST02	Increase and decrease all Manning’s n values and form losses by ±10%.
ST03	Increase and decrease the URBS alpha parameter by ±20%.
ST04	Increase and decrease the URBS beta parameter by ±20%.
ST05	Use Fernvale to Lowood Cross Sections

4.15.1 ST01 – No Form Losses Sensitivity Tests

To demonstrate the impact of not using any form (bend) losses, the 2011 flood was simulated with the general form losses and all targeted form losses set to zero. The in-bank Manning’s n values were set based on the following two scenarios based on initial calibration testing as discussed in Section 4.5.3:

- **ST01A Moggill Post Flood.** A scenario that uses an in-bank tidal Manning’s n of 0.038 to approximately match the flood level at Moggill for the post flood peak discharge of 3,500 m^3/s from Wivenhoe Dam – see dark green line in Figure 4-4.
- **ST01B Moggill Peak.** A scenario that uses an in-bank tidal Manning’s n of 0.041 to approximately match the peak flood level at Moggill at over 10,500 m^3/s – see orange line in Figure 4-4.

Plot 45 compares the results for the Brisbane River gauges, Plot 46 the water level profiles and Plot 48 the effect on the Centenary Bridge flows. Of note is that:

- The timing of the flood peak is too early for the two Manning’s n only cases resulting in a poor reproduction of the flood wave shape.
- The profile along the Brisbane River shows a poor representation compared with the recorded levels, with the flood levels at Brisbane CBD and Breakfast Creek substantially too high.
- The peak flow at Centenary Bridge is significantly overestimated for both Manning’s n scenarios.

- The combination of Manning's n and form losses is able to reproduce both peak flow and post peak flows using the same set of parameters (see red line in Figure 4-4) compared with a Manning's n only approach.

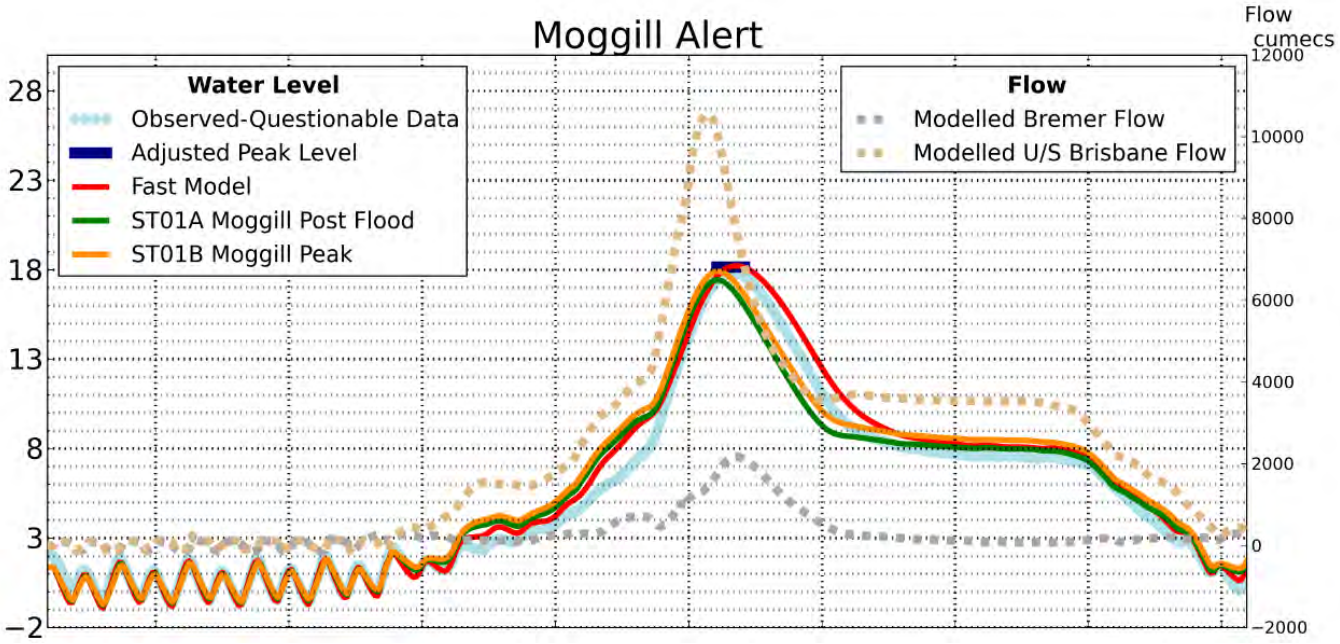

Figure 4-4 ST01 - No Bend Losses Sensitivity Tests Moggill Gauge

4.15.2 ST02 – Increase/Decrease Manning's n and Form Loss Values by ±10%

ST02 shows the effect of applying a general decrease and increase of ±10% to all Manning's n and form loss values. Plot 49 to Plot 54 compare results for the 2011 flood. As would be expected, decreasing the values tends to reduce flood levels and increase flows, whilst increasing the values raises levels and reduces the peak flow at Centenary Bridge.

4.15.3 ST03 – Increase/Decrease URBS Alpha Values by ±20%

ST03 shows the effect of applying a general decrease and increase of ±20% to the URBS Alpha values for catchments downstream of Wivenhoe Dam. Plot 55 to Plot 60 compare the results for the 2011 flood. Due to the dominance of the Wivenhoe Dam releases (which are not effected by varying Alpha) during the peak of the flood and post flood releases, there is little change along the Brisbane River. For the Lockyer and Bremer catchments minor changes occur with no demonstrable benefit in calibration outcomes, except for a slight improvement in matching the peak levels in the Bremer around Three Mile Bridge using a reduced Alpha.

4.15.4 ST04 – Increase/Decrease URBS Beta Values by ±20%

ST04 shows the effect of applying a general decrease and increase of ±20% to the URBS Beta values for catchments downstream of Wivenhoe Dam. Plot 61 to Plot 66 compare the results for the 2011 flood. As for the Alpha value test, due to the dominance of the Wivenhoe Dam releases (which are not affected by varying Beta) there is little change along the Brisbane River. For the

Lockyer and Bremer the outcomes are similar to ST03 with no significant effect on the Fast Model calibration.

4.15.5 ST05 – Use Lowood-Fernvale Surveyed Cross-Sections

As described in Section 2.1.4.3 the Lowood-Fernvale survey were not used in the development of the Fast Model as these sections did not cover the entire waterway, and were too coarsely spaced along the length of the river than desired. Sensitivity Test ST05 was carried out to ascertain the effect on the Fast Model's results if these cross-sections were used in preference to those based on the DMT DEM.

Plot 67 to Plot 72 show the results of ST05 using the 2011 flood event. In the area of the changed cross-sections the predicted water levels are comparable for both scenarios, with greater deviations at very shallow flows and at/near the flood peak. The differences in peak water levels are due to the Fernvale-Lowood sections not extending to above the flood peak causing higher flood levels. This is due to the DMT DEM cross-sections extending well above the peak flood levels, whilst the Lowood-Fernvale cross-sections in some instances do not extend above the peak flood level causing these cross-sections to have a lower conveyance at high flows. In areas away from the changed cross-sections negligible or no measureable change in flood levels occurred.

Note that the Lowood-Fernvale cross-sections not extending above peak flood levels was not an issue with the previous modelling undertaken in this area (Fernvale and Lowood Flood Study by BCC, 2009), as this modelling used a dynamically linked 1D/2D model with the conveyance at higher elevations (not included in the cross-sections) being modelled in 2D.

It was found that while the DMT DEM is based on LiDAR data in the Lowood-Fernvale area, BCC (2014b) undertook manual adjustment of the DMT DEM bathymetry. This adjustment was achieved with a graded stream centreline derived using the Lowood-Fernvale cross-sections invert levels in conjunction with identification of riffle structures from aerial photographs. This is discussed in detail in Appendix E. The manual adjustment was successful in providing a reasonable representation of the Lowood-Fernvale area bathymetry as evidenced by the comparisons in Appendix E.

ST05 concluded that cross-sections extracted from the DMT DEM through the Lowood-Fernvale cross-section survey extent were suitable for use in the Fast Model.

4.16 Model Uncertainty and Limitations

The uncertainties associated with the Fast Model based on observations during the model development and calibration phase are:

(1) The storage of the model can be considered to have low uncertainty given the extent and quality of the topographic survey data available, and that the Fast Model's storage is directly derived from the DEM.

(2) The in-bank cross-sections within the extents of the bathymetric surveys (all tidal reaches excluding local creeks) can be considered excellent and of low uncertainty. The spatial resolution between cross-sections is fine (approximately every 300 to 600 m), and the

manual selection of cross-section locations to ensure representative sections are extracted, is sufficiently high to incorporate the effects of changes in river conveyance. The model's spatial discretisation is considered sufficiently fine to not affect any uncertainties associated with the model schematisation.

(3) For non-tidal in-bank cross-sections, there are likely to be some uncertainty that will be more significant for the smaller flood events in terms of flood heights. The in-bank sections where bathymetry surveys were not available relied on using LiDAR that may have a positive bias (ie. ground levels are too high) based on comparisons presented in the Milestone Report 1 and the effects of ponded water at the time of the LiDAR survey.

(4) The spill levels and cross-sections used to transfer water between in-bank and overbank were located along the natural or artificial levees. Elevations along these cross-sections were resampled by taking the highest elevation in the DEM within a search distance. This is of particular importance in the Lockyer Valley floodplains where there are numerous levees along the creek banks and floodplains. The accuracy of the representation of the crest levels along the man-made levees is difficult to ascertain without ground survey, and the likelihood that these levees will change over time and possibly fail during a flood is high. It was certainly evident during the numerous simulations undertaken to investigate the complex hydraulic behaviour of Lockyer Creek that the representation and presence (or not) of a major levee can have a significant effect on flood behaviour in the Lockyer Valley.

(5) The Fast Model is a 1D network model using the 1D St Venant flow equations as described in Section 4.1.7. There are a number of limitations and associated uncertainty with this approach as follows:

  (a) The solution assumes that the water level is constant in height across a cross-section, therefore, the effects of superelevation at river bends and variations in water level between the centre of the river (high velocity head, lower water surface) and river bank (low velocity head, higher water surface) are not reproduced.

  (b) Some characteristics of free-surface fluid flow are either not represented or need to be approximated such as: the effects of superelevation at river bends; transfer of momentum to the floodplain; energy losses at river bends; and representation of complex flow patterns in the horizontal and vertical.

  (c) The transfer of water between river/creek and floodplain is simplistic and where the flow over the floodplain has a variable and complex behaviour the representation may be very approximate.

  (d) Where the flow behaviour is in a backwater location and is storage dominated (eg. Oxley Creek basin at the height of a major flood) the Fast Model would adequately reproduce these effects.

  (e) Flowpaths have to be pre-defined in a 1D network model, therefore any areas on the floodplain that display a strong 2D flow behaviour (ie. water flows in a variety of directions during the course of the flood) will only be approximately represented.

(f) Bridge affluxes are modelled using energy loss versus height tables based on coefficients derived from industry standard publications. Cross-checks with the model results indicate the affluxes calculated by the Fast Model are consistent with the publications, and the affluxes can be considered as being reasonably represented and of low uncertainty. Any effects of blockages due to debris were not included due to lack of information.

(g) Due to the simplistic nature of the Fast Model, and of the equations used, the output from the model except possibly for in-bank sections is not suited for detailed flood mapping or flood hazard categorisation.

4.17 Model Accuracy and Confidence Limits

The accuracy of the calibrated Fast Model is considered to be as follows:

- The accuracy of flood levels and flows is driven by the greatest uncertainties, which are considered to be:
  - The in-bank topographic data where the cross-sections are reliant on LiDAR. These areas are notably:
    - Lockyer Creek
    - Between Wivenhoe Dam and Kholo Bridge
    - Downstream of Mt Crosby Weir to the start of the bathymetric survey
    - Non-tidal reaches of Bremer, Warrill and Purga Creeks.
  - The hydrologic modelling, rainfall distribution and rainfall loss representation.
  - The coarse representation of the complexity of Lockyer Creek floodplains, and the effect of the numerous levees, especially for minor floods that just overtop the creek banks.
  - Where there is a significant variation in water level across the river/creek causing superelevation such as that that would occur at a sharp river bend.
- The model demonstrates a good reproduction of the travel time and shape of the flood wave after accounting for any bias carried through from the hydrologic modelling.
- Backwater and tidal effects are well represented.

Importantly, in regard to the suitability of the Fast Model for the Monte Carlo stage of the Hydraulic Assessment, and the deriving of approximately 50 events for the Detailed Model the following information is provided:

(1) The model has a run time of around 4 mins for an 8 day flood on a standard single CPU core. This is within the 15 mins run time as stipulated by the Hydraulic Assessment brief. At this run time the model, with sufficient computing resources and time, can feasibly be used to simulate hundreds to tens of thousands of Monte Carlo events.

(2) The Fast Model has been calibrated to tidal conditions, two minor floods (1996 and 2013) and a major flood (2011), and verified to a minor flood (1999) and a major flood (1974).

These floods vary significantly in behaviour and size, and the ability of a hydraulic model to reproduce such a wide range of events without varying parameters provides confidence.

(3) Whilst the Fast Model will not be used during the Hydraulic Assessment for any other purpose besides the selection of ~50 of the Monte Carlo events, it does have potential other uses such as for Seqwater’s dam operations, and as a quick online flood forecasting and warning tool. Specific refinements to the model may be required to suit the purpose if the model is used outside the current assessment.

5 Conclusion

The Fast Model has been developed as a 1D network hydraulic model comprised of approximately 2,350 channels interconnected to represent the in-bank and overland flowpaths. The use of the DMT Model, which was updated to include recently acquired data sets and to incorporate the revised URBS modelling from the Hydrologic Assessment, was of significant benefit during the Fast Model construction.

The Fast Model was calibrated and verified to the floods of 1974, 1996, 1999, 2011 and 2013. A pseudo-1893 flood event was simulated by the Fast Model and comparisons made to peak 1893 flood levels. The Fast Model was proofed for the three extreme events: 2x1974, 5x1974 and 8x1974. Key observations during the model calibration/verification phase are:

- The conveyance dominated sections of the Brisbane River cannot be calibrated using solely a Manning's n approach. Additional form (energy) losses, particularly at sharp river bends, rock ledges and confluences are needed to reproduce the timing of the flood wave and the steep gradients along sections of the Brisbane River.
- The Manning's n values, with a minor allowance needed for the application of form losses to in-bank channels, are within the ranges used in the industry.
- The interaction and size of the Lockyer Valley floodplains has a significant influence on flood behaviour, most notably in the Lockyer Valley, but also on the Brisbane River.
- The calibration is more rigorous for:
    - Areas where there is more accurate in-bank topographic data, ie. the tidal reaches where bathymetric surveys were carried out; and
    - The major floods of 1974 and 2011.

In regard to the suitability of the Fast Model to be used for the Monte Carlo stage of the Hydraulic Assessment:

- The model has a run time of around 4 mins for an 8 day flood on a standard single CPU core. This is within the 15 mins run time as stipulated by the Hydraulic Assessment brief. At this run time the model can feasibly be used to simulate the Monte Carlo events.
- The Fast Model has been calibrated and verified to tidal conditions, three minor floods (1996, 1999 and 2013) and two major floods (1974 and 2011). These floods vary substantially in their behaviour and size, and the Fast Model satisfactorily reproduces this wide range of events without needing to vary calibration parameters.
- A pseudo-1893 event has been simulated to assess flood behaviour of this event against recorded peak levels. In addition, three extreme events (2x1974, 5x1974 and 8x1974) have been simulated to proof the model for events of these magnitudes. It has been demonstrated that the Fast Model is capable of running these extreme events accounting for major breakout flow routes.

In conclusion, the Fast Model is considered sufficiently robust and accurate to simulate the selected Monte Carlo events from the Hydrologic Assessment leading to the selection of about 50 events for the Detailed Model's design flood simulation phase.

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Appendix A Outcomes and Actions from Workshop 2

Memorandum

Workshop 2 **Summary of Outcomes/Actions**: Fast Model Development and Calibration

To:	DNRM (Wai Tong Wong)	From:	BMT WBM (Bill Syme & Cathie Barton)
Date:	19 December 2014		
Subject:	B20702-80 Brisbane River Catchment Flood Study Hydraulic Assessment – IPE/TWG Workshop 2 held on 11 December 2014 Fast Model Development and Calibration		

ATTENDEES

Hydraulics IPE (Independent Panel of Experts)

- Mark Babister (Chair) (WMA) [MB]
- Em Prof Colin Apelt [CA]
- Dr John Macintosh [JM]

TWG (Technical Working Group)

- BCC: James Charalambous [JC], Evan Caswell [EC] and Ouswatta Perera [OP]
- SRC: Tony Jacobs [TJ]
- ICC: Hoy Sung Yau [HSY]
- Seqwater: Michael Raymond [MR] & Lindsay Millard [LM]
- DSITIA: John Ruffini [JR]
- DNRM: Wai-Tong Wong (Client PM for the Hydraulic Assessment) [WTW]
- DNRM: Pushpa Onta (Client PM for the Hydrologic Assessment) [PO]
- DSDIP: Roger Brewster [RB]
- DEWS: Russell Cuerel [RC]

BMT WBM Facilitator

- Jo Tinnion (BMT WBM Project Communications Officer) [JET]

BMT WBM BRCFS Hydraulic Assessment Team

- Bill Syme (Project Manager) [WJS]
- Cathie Barton (Project Coordinator) [CLB] (afternoon session)
- Barry Rodgers [BR]
- Philip Ryan [PAR]
- Rachel Jensen [REJ]

This summary was prepared during and following the BRCFS Hydraulic Assessment Workshop 2: Fast Model Development and Calibration, held at the office of BMT WBM 11 December 2014. A set of presentations are available separately.

ISSUE	WORKSHOP DISCUSSION	OUTCOMES	ACTIONS
Actions from previous Workshop No.1 - 49 Outcomes and 25 Action Items - **All Action Items implemented except for the 2014 LiDAR (now termed 2015 LiDAR)** - **DNRM Mapping advised a delay in the delivery of the 2015 LiDAR dataset from the contractor, data is now expected in Jan/Feb 2015. DNRM needs to validate the data thereafter and process them into a single DEM. The new DEM will be assessed and considered for the Detailed Model.**			
U.1 Data sets for UDMT model			
1. Updated Hydrology	Comparison of inflows from original Seqwater URBS model and updated Aurecon flows from hydrology study. Assessment of the impact of the new Hydrology using the UDMT model, particularly on the Bremer/Mid Brisbane confluence.	1.1 Acknowledgements of change in model results largely attributed to changed hydrological inflows.	**1.1 – BMT WBM** to amend hydrograph plots for all events in the lower Brisbane to include flow from Bremer and Lockyer. **DONE**
2. Updated Topography	Updated topography including breaklines from DTMR, QR and DTM embankments and bathymetry for the Bremer, lower Brisbane , upstream of Mt Crosby and local creeks	2.1 No further topographic data sets raised	none
3. Updated Landuse and Manning's 'n' variables	Table 3-1 and figure 2-1 in MR1 showing change in Manning's 'n' and improved spatial differentiation of landuse	3.1 Acknowledgement that Manning's 'n' not significantly changed 3.2 Request for further comparison of spatial differentiation of land use	**3.1 – BMT WBM** to revise Table 3-1 to remove Original DMT values and add text to state n values not significantly changed. A comparison map was not considered practical due to complexity of satellite imagery, use of different land-use categories and map scale. **CLARIFICATION PROVIDED IN TABLE AND TEXT** **3.2 – BMT WBM** to update the drawing from MR1 showing land-use categories to include

ISSUE	WORKSHOP DISCUSSION	OUTCOMES	ACTIONS
			additional data sets acquired or digitised since Workshop 1, and add this drawing to MR2. **DONE**
4. Calibration cross-check between original and UDMT	Plots within plot addendum illustrating change in hydrograph for modelled calibration events presented	4.1 Request from the TWG for further information of comparison to be provided, particularly within Lockyer and Bremer Catchments 4.2 No further calibration cross check issues raised	**4.1 – BMT WBM** to include in the plot addendum, the hydrograph calibration plots for the Updated DMT model for the Lockyer and Bremer Catchments. **DONE** **4.2 – BMT WBM** to amend current 2011 hydrograph plots with original DMT output for comparison. **DONE**
5. Influence of the Bremer and mid Brisbane on Lower Brisbane	Commentary on the importance of the Bremer and Lockyer flows on the lower Brisbane catchment and how this is represented in the hydrological modelling		**5.1 – BMT WBM** to add Bremer and Mid Brisbane flows to lower Brisbane plots as per Action 1.1. **DONE**
F.1 Fast Model Development			
6. Storage and conveyance network within Fast Model	Drawing 8 and GIS workspace of Fast Model nodes and channels presented. Discussion on the derivation of storage/height relationships for overbank areas.	6.1 No issues raised in regards to methodology for derivation of storage/height relationships 6.2 Seqwater requested checking of model storage/discharge relationships by river reach. BMT WBM advised that storage/discharge relationships by river reach is not an output	**6.1 – BMT WBM** to tabulate whole of model volumes in/out and residual for each calibration event. **DONE**

ISSUE	WORKSHOP DISCUSSION	OUTCOMES	ACTIONS
		presently available from the model or software. Agreed that Seqwater could discuss this output option with BMT WBM outside of the BRCFS framework.	
7. Structure Modelling methodology	Methodology for modelling of hydraulic structures, including fixed and adjustable losses, piers and decks. Cunningham highway bridges over Bremer River and Warrill Creek were included in the model.	7.1 Agreement that methodology for blockage of rails should be 30% blockage at centreline. This is relevant for the Detailed Model. 7.2 Request for more information regarding structure performance	**7.1 - BMT WBM** to provide further details on main hydraulic structures in the report (including key ones on the floodplain if available) **DONE**
8. Fast Model Boundaries	Discussion of the Fast Model boundaries, in particular, the URBS inflows. The URBS models were altered to extract local flows at 99 locations within the model extent. Total flows were applied at the model upstream boundaries and local URBS flows within the Fast Model domain.	none	none
9. Suitability of the model for simulating extreme events	Discussion on potential limitations when modelling extreme events due to extents of digitised channels and storages	9.1 Agreed that a flood of around 8x1974 should provide an upper limit. 9.2 A 1.5x1974 event was run "live" during the workshop to approximate the estimated 1893 flood flow of 16,000m^3/s at Port Office. This event produced similar levels to 1893 flood peaks.	**9.1 – BMT WBM** to add extreme flood flow paths and forward results prior to Christmas 2014. **DONE** **9.2** – **BMT WBM** to add the approximated 1893 flood flow assessment to MR2, along with the 2x1974, 5x1974 and 8x1974 extreme flood proofing. **DONE**

ISSUE	WORKSHOP DISCUSSION	OUTCOMES	ACTIONS
10. Fast Model health	The mass balance error of the Fast Model is typically less than 0.1% and reaches a peak of less than 0.3%. The model requires double precision for accuracy due to incremental changes in large storage volumes.	none	none

ISSUE	WORKSHOP DISCUSSION	OUTCOMES	ACTIONS
F.2 Fast Model Calibration			
11. Use of form losses in conjunction with Manning's 'n' as calibration parameter due to a Manning's n only approach not being adequate to achieve calibration	Discussion on appropriateness of form losses as part of calibration. General form loss of 0.0 to 0.2 trialled to account for channel irregularity, targeted form loss at bends of up to 1.5 with constant Manning's n material roughness. Discussion on methodology to calculate form loss and literature available. Questions on the inner and outer radius of bends and impact on super elevations in the Detailed Model.	11.1. Consensus that form loss is appropriate and has circumstantial evidence in Brisbane (JR experience at Dutton Park Rocks in 2011) 11.2 Questions over scalability of form losses for large events and deep backwaters. 11.3 No objections raised to methodology to calculate form loss but further description required in reporting	**11.1 – BMT WBM** to expand on section 4.12 and Table 4.1 of MR2 **DONE**
12. Profile plots for Brisbane River above Moggill and for Lockyer Ck and addition of energy grade lines	BMT WBM advised that profile plots above Moggill can be added (they were omitted due to only limited number of flood marks available within close proximity of the river/creek line). Discussion on presenting energy grade lines for long sections to show magnitude of losses	12.1 Agreement that due to averaging of 1D velocities upstream and downstream of a water level computational point that energy grade lines would be approximation and potentially misleading if presented.	**12.1 – BMT WBM** to include profile plots for 1974 and 2011 for Brisbane River above Moggill and for Lockyer Ck. **DONE**
13. Rating Curve Review	Discussion on rating curve comparisons with Fast Model calculations. Seqwater Amberley gauge rating includes the breakout upstream and has many gauged recordings.		**13.1 – BMT WBM** to add gauged recordings for calibration events if available and include upstream breakout flow to Amberley rating curve comparison. **DONE**
14. Rating Curve Calibration in the	Rating curves in the Bremer Catchment not as consistent as elsewhere in the model. It is	14.1 Seqwater advised that the high alpha values in the Bremer catchment are due to	none

ISSUE	WORKSHOP DISCUSSION	OUTCOMES	ACTIONS
Bremer Catchment	proposed by BMT WBM that the high alpha value in the catchment from the URBS model over attenuates the hydrograph thereby requiring Manning's n values on the high side to compensate and produce a reasonable calibration. Sensitivity tests ST03 and ST04 in MR2 corroborate this.	use of different non-linearity parameters in the URBS model for these catchments, and that the high alpha values were applied to account for the different non-linearity values.	
15. Comparison of Fast model ratings with UDMT	Comparison between the Fast Model and the UDMT via rating cures would assist in assessing the performance of the Fast Model, particularly at upstream gauges and larger order events		**15.1** – **BMT WBM** to add UDMT results to rating curve plots with a focus on large events and upstream gauges, and/or provide as a separate plot if the large number of items on the rating curve plots are too numerous to differentiate **DONE**
16. Momentum transfer/preservation	General discussion requested by IPE on momentum transfer and preservation between 1D/2D links. Question posed "was this an issue of importance?"	No objections raised to the way TUFLOW currently handles momentum transfer, given the challenges and uncertainties in applying momentum transfer across a 1D/2D interface.	none

Appendix B Comments from the IPE

BRCFS Comprehensive Hydraulic Assessment Phase - IPE Comments on BMT WBM Draft Milestone Report 2: Fast Model Development and Calibration 5 December 2014

Introduction

This report provides detailed description of the development and calibration of the Fast Hydraulic Model that is required to calculate the flow and height hydrographs corresponding to the large group of stochastically generated floods that have been one of the outputs of the MCS in the BRCFS Comprehensive Hydrology Assessment Phase. These hydrographs are required at specified reporting locations throughout the Brisbane River Catchment and for the full range of AEP from 50% up to the PMP.

The comments below are based on the Draft Milestone Report 2, cited above, and on modelling results from the Fast Model, that were produced during the Workshop #2 on 11 December 2014, and provided peak level profiles and rating curves for floods produced by twice the rainfalls that caused the 2011 flood and the 1974 flood.

The comments that follow are made in the context of the purpose for which the Fast Hydraulic Model has been developed; viz., to provide sufficiently accurate results of the modelling of a large number of flood events derived from the MCS for the full range of AEP of interest up to the PMP so that a small number of design events (approximately 50) can be selected with confidence for more accurate modelling with the Detailed Hydraulic Model.

Some of the topics covered by these comments were discussed at the Workshop #2 on 11 December 2014 and may have since been dealt with by BMT WBM. However, all have been included here for completeness.

The numbering of following sections reflects the headings of the BMT WBM report.

2.17 Breaklines

This section would benefit from some discussion on how hand railings, noise barriers and other slim flow obstructions are treated as they are unlikely to be captured by LIDAR.

3.1.2 Model Topography

Sources for the bathymetry used in the updated DMT are detailed. The bathymetry used for the lower Brisbane River in that model is from 2014.

Questions

1. Is the bathymetry used in developing the Fast Hydraulic Model the same as that used for the updated DMT?
2. Is the same bathymetry used for all of the calibration runs of the Fast Model and for the later modelling of extreme events?

4.1.5 Quality Control Checks

The quality control checks used in the Fast Model development and in its use are described briefly. More information should be provided on

1. Mass conservation check
    - provide details of the test case(s)

  - provide details of the history of the check result throughout the test.

2. Changes to the model - it is suggested that some examples are given to provide background to the statement *"Changes to the model were consistent with expectations"*?

4.5 to 4.12 Calibration and Verification of Fast Model

The results for calibration (C) and validation (V) of the Fast Model for the historical flood events of 2013(C), 1996(C), 1999(V), 2011(C), and 1974(V) are presented in Sections 4.5 to 4.12

General Comment The calibration and validation of the Fast Hydraulic Model with these historical flood events are considered satisfactory in the context of the purpose for which the Fast Model has been developed. This assessment is based on the information provided, viz., the peak level profiles and the rating curves. Some detailed comments are given below for particular cases.

4.9 2011 Major Flood Calibration

- Overall the calibration is good.
- The Bremer modelled peak level profile is lower than observations by approx 0.5 m downstream from 3 Mile Bridge (but by less at the junction with the Brisbane River).
- What is the evidence for the statement, *"The calibration indicated that there is potentially a need for some additional flow into the Bremer catchment."?*

4.10 1974 Flood Verification

- The validation is good at many locations; it is of varied quality at some locations, but is considered acceptable overall.
- The validation is good at Ipswich, Moggill, Jindalee and the Port Office (around the peak).
- The receding flood level is modelled as falling faster than observations at Savages Crossing, Mt Crosby, Port Office and also Tennyson, Yeronga, Sandy Creek. (The UMDT modelled results are similar in this respect).
- The modelled peak profile is quite good for the Brisbane River but high for the Bremer River by about 1m, upstream from Ipswich.

4.11 Fast Model Rating Curve Review

All comparisons that follow are related to the Aurecon rating curves. The first four comments relate to the Fast Model rating curves for floods used in the calibration and verification of the Fast Model up to the 1974 event.

- For sites along the Brisbane River the correlation with the Aurecon rating curves is reasonably good and any differences are explained satisfactorily
- The Fast Model rating curves are higher for Walloon (Bremer), Amberley (Warrill) and Loamside (Purga).
- The Fast Model rating curves differ substantially for Glenore Grove and Rifle Range Road (both on Lockyer). The Fast Model curves are lower for smaller flows then cross over to be higher at flows a little larger than 1000m^3/s.
- In all cases the data from the Fast Model for all events appear to be self-consistent.

At Workshop #2, two more cases were modelled with the Fast Model and its rating curves were extended up for floods produced by twice the rainfall that caused the 2011 flood and the 1974 flood. Peak level profiles were provided and the rating curves were extended. Such large floods may have properties that differ from those of the 1974 flood, so comparison between rating curves needs to be treated with caution. At a ‘broad brush level’, the extensions of the Fast Model rating curves beyond those from the calibration events appear reasonable.

- The extensions of the rating curves for Moggill, the Port Office are close to the Aurecon ratings and that for Centenary Bridge is somewhat higher.
- The extensions for Savages Crossing and Mt Crosby Weir are above the curves by Aurecon and Seqwater but closer to the latter.
- The extensions for Loamside, Amberley and Walloon are strongly affected by the extensive backwater effects from the very large flows in the Brisbane River.
- The extensions of the rating curves for Glenore Grove and Rifle Range Road are self-consistent with those for the calibration events.

4.12 Calibration Parameters

The description of the flow resistance modelling in the Fast Model in Section 4.12 and its Table 4-1 needs to be expanded substantially along the lines of the discussion between members of the IPE and Bill Syme of BMT WBM at the Workshop #2 on 11 December. This should include information on how the 'segmental' resistances due to different values of roughness across a cross-section are combined to produce the effective n value for a cross section, including the effects of the reach form loss; and how the section is projected above bank full level. It is suggested that plots of overall n value versus water level, including the effect of channel form loss, be given for a couple of lower Brisbane River locations.

While it constitutes a different kind of flow resistance, it is important that the details of how exchanges of momentum between the 1D channel and overbank flows are modelled are documented in some detail. The report would benefit plotting the energy surface on the main profiles.

There is evidence that substantial bed movement is mobilised in larger floods. It is likely that large bed forms move with the flood waters but at a different pace - and sometimes even in the opposite direction. An unknown factor concerning flow resistance is to what extend bed movement could be contributing to the energy losses, both from the energy involved in the bed movement itself and from the varying bed forms causing increased flow resistance (form loss). Unfortunately, there appears to be insufficient data to estimate these effects. However, they should be noted as contributing to the uncertainty in the results of calibration and modelling, particularly for extreme events.

Overall Comment on Calibration - Reconsider Verification with 1893 Flood

The IPE noted in its comments of 21 September 2014 on the Milestone #1 Report its concern that a suite of only 5 calibration/verification events is rather limiting and concerning for a system as important and complex as the Brisbane River. As discussed below, the Fast Model has been shown to be able to model extreme events but the assessment of the quality of the results has to be based on their overall plausibility and consistency.

The IPE has come to the conclusion that it is highly desirable that the Fast Model be used to model the January 1893 flood, the largest historic flood event for which there is sufficient data. It is recognised that the data is limited but there is sufficient for that flood event to be run through both Fast and Detailed Hydraulic models as a gross check. In the WSDOS study, SEQwater modelled the January 1893 flood event in URBS, using a very simplified temporal pattern based on daily rainfall data with adjustments to the losses to account for the approximate temporal pattern (Ref 1). Allowance would need to be made for the ‘no dams’ situation.

Comments on Extreme Event Modelling

Results of modelling extreme events with the Fast Model and with the UDMT were provided on 24 December 2014 for floods produced by twice, five times and eight times the rainfall that caused the 1974 flood. These results are compared with those from modelling the 1974 flood, as provided in the draft Milestone #2 Report. The first of these extreme events was modelled during the Workshop #2 on 11 December 2014 and the results were shown there as discussed above under Section 4.11. The results from modelling a flood produced by twice the 2011 flood rainfall event were also produced and were shown at the Workshop #2.

Comparison between the results from the two models, as provided by Bill Syme, has provided insights into aspects of the hydraulic phenomena and, in some cases, has indicated the need for some adjustments to the Fast Model while generally providing mutual support for the results from both models. However, only the results from the Fast Model are discussed here.

- The draft Aurecon overall study report estimated the PMP peak flow in the lower Brisbane River at between 64,000 m^3/s (Moggill) and 61,000 m^3/s (Brisbane) for the 'no dams' scenario and between 59,000 and 55,000 m^3/s for the 'with dams' scenario.
- The SKM (2013) estimate of the 1974 peak flow at Brisbane is 13,700 m^3/s for the 'no dams' scenario.
- It is assumed that the BMT WBM cases of '5x1974' and '8x1974' refer to the rainfall inputs; in that case the peak flows at Brisbane for the 'no dams' scenario would be of order 68,000 m^3/s (about the PMP peak flow) and 110,000 m^3/s (much greater than the PMP flood).
- The Bremer River at Ipswich is swamped by backwater from Brisbane River floods at 1x1974 and greater.
- The Lockyer at Lyons Bridge Alert is swamped by backwater from Brisbane River only for floods greater than the 5x1974. There are backwater effects at the downstream end from the 1974 flood and these effects move progressively upstream as the flood increases in magnitude.
- The Fast Model results for extreme events are broadly consistent with those for the modelled historical flood events. This appraisal is given without condition for the modelling of the 2x2011 and 2x1974 flood events for which the Fast Model rating curves have been seen. It remains conditional for the modelling of extreme events larger than these until the extensions of the Fast Model rating curves have been seen.
- Extensions of the Fast Model rating curves with the results of the largest two floods have not been provided - this should be done in the final Milestone #2 report.
- It is recommended that the peak energy profiles are shown as well as the peak level profile.

Conclusions

The IPE is satisfied with the work carried out on the fast model. The comments in the review generally relate to desire for more information on the model development and the calibration. While the figures are of suitable quality for a draft report the clarity of the figures should be improved for the final.

Reference

Seqwater (2013) Brisbane River Flood Hydrology Models, December 2013.

12 January 2015

M K Babister C J Apelt J.C. Macintosh

Mark Babister
WMAwater

Colin Apelt
UniQuest Pty Ltd

John Macintosh
Water Solutions

Memorandum
Milestone Report 2: Fast Model Development and Calibration
IPE Comments and BMT WBM Responses

From:	Cathie Barton, Bill Syme	To:	Dr Wai-Tong Wong
Date:	11 February 2015	CC:	Pushpa Onta
Subject:	B20702-50 BRCFS Hydraulic Assessment Milestone Report 2 Comments from IPE and Responses by BMT WBM		

The following table contains comments received from the Hydraulics IPE (Mark Babister, Colin Apelt and John Macintosh). These comments were received by email on 10th December 2014 (John Mac), 14th December 2014 (Colin Apelt), and 13 January 2015 (IPE).

Comments from IPE **Responses from BMT WBM**	
I1	Taking up BMT WBM's offer, the IPE would like them to undertake another sensitivity case for the Thursday meeting: say hypothetical at 2x ^{1}74 flood (or similar) using their recommended calibration parameter set. Results should be longitudinal profile overlaid against the other calibration / verification events, inclusion of the Q / WL point on the Plot 29 rating curves, plus hydrography at both Savages Crossing and Moggill. **BMT WBM Response:** 2x1974 was carried out and presented at the MR2 Workshop. Extreme flood sensitivity tests are documented in the report in the new Section “Extreme Flood Proofing” and several related new plots are also produced.
I2	The description of the flow resistance modelling in the fast model in Section 4.12 *Calibration Parameters* and its Table 4-1 of the draft Milestone 2 Report needs to be expanded substantially along the lines of the discussion between members of the IPE and Bill Syme at the workshop on 11 Dec. This should include information on how the 'segmental' resistances due to different roughnesses across a cross-section are combined. **BMT WBM Response:** Agree. Additional details are provided in the Section 4.13 on “Calibration Parameters”.
I3	Significantly more information on the the use of the form loss instead of just manning n values. a) This will need to include the methodology used to select the bend loss for the sharper bends and why different bends have different coefficients. This section would also benefit from a table that listed location, bend loss and physical features b) the use of the general form loss and how this interacts with Manning's n and what is the resulting the equivalent total resistance. This could be produced for several typical sections. **BMT WBM Response:** A new sub-section has been added to Section 4.13 (“Calibration Parameters”) in the report. Additional information on the rationale & methodology for adding form loss is provided. Some examples are provided for specific areas.

Comments from IPE **Responses from BMT WBM**	
I4	More information on how sensitive those areas without bathymetric data is likely to be. **BMT WBM Response:** This is very difficult to quantify without knowing the degree of uncertainty or inaccuracy that the missing bathymetric data causes. As presented at the workshop, a sensitivity test comparing LiDAR vs the Fernvale to Lowood cross-section survey was carried out, noting that the Fernvale to Lowood data set is not ideal as it is somewhat coarsely spaced and does not extend far enough up the river banks in some locations. However, the comparison is a worthwhile exercise and a summary is presented in Section 4.14.
I5	Specific documentation on how the factored up events compare to 1893 levels or better still how SEQ's best estimate of the 1893 event performs **BMT WBM Response:** Further information on a factored-up version of 1893 and other more extreme events is provided in the new Section "Extreme Flood Proofing". This includes the discussion and plots provided on 24 Dec but also provides further detail.
I6	**2.17 Breaklines**. This section would benefit from some discussion on how hand railings, noise barriers and other slim flow obstructions are treated as they are unlikely to be captured by LIDAR. **BMT WBM Response:** Data on slim flow obstructions such as noise barriers and hand railings is not available. As discussed at Workshop 1, the Data Collection Phase did not collect any information on breaklines of any type. Clearly visible obstructions in the DEM have now been digitised (eg. farm levees), and road/rail alignments have been used to extract high points from the DEM, however, slim obstructions will be poorly or not represented in the DEM and therefore unable to be included in the hydraulic models. This clarification is added to the Section 2.1.7 on Breaklines.
I7	**3.1.2 Model Topography** Sources for the bathymetry used in the updated DMT are detailed. The bathymetry used for the lower Brisbane River in that model is from 2014. Questions 1. Is the bathymetry used in developing the Fast Hydraulic Model the same as that used for the updated DMT? 2. Is the same bathymetry used for all of the calibration runs of the Fast Model and for the later modelling of extreme events? **BMT WBM Response:** **1.** Yes - The bathymetry used for both the Updated DMT and Fast Models is the same. This is clarified in the report through the addition of sub-section 4.1.3 "Fast Model Topography". **2.** Yes – The same bathymetry is used for all simulations. This is also clarified in the new sub-section. Note that whole the bathymetry remains the same, noting that some hydraulic structures change between calibration events.
I8	**4.1.5 Quality Control Checks** The quality control checks used in the Fast Model development and in its use are described briefly. More information should be provided on 1. Mass conservation check • provide details of the test case(s) • provide details of the history of the check result throughout the test. 2. Changes to the model - it is suggested that some examples are given to provide background to the statement "Changes to the model were consistent with expectations"? **BMT WBM Response:** Agree. More details are provided in this section of the report.
I9	**4.5 to 4.12 Calibration and Verification of Fast Model** The results for calibration (C) and validation (V) of the Fast Model for the historical flood events of 2013(C), 1996(C), 1999(V), 2011(C), and 1974(V) are presented in Sections 4.5 to 4.12.

Comments from IPE **Responses from BMT WBM**	
	General Comment The calibration and validation of the Fast Hydraulic Model with these historical flood events are considered satisfactory in the context of the purpose for which the Fast Model has been developed. This assessment is based on the information provided, viz., the peak level profiles and the rating curves. Some detailed comments are given below for particular cases. **BMT WBM Response:** Noted.
I10	**4.9 2011 Major Flood Calibration** • Overall the calibration is good. • The Bremer modelled peak level profile is lower than observations by approx 0.5 m downstream from 3 Mile Bridge (but by less at the junction with the Brisbane River). • What is the evidence for the statement, “The calibration indicated that there is potentially a need for some additional flow into the Bremer catchment.”? **BMT WBM Response:** The suggestion that additional flow may be required in the Bremer is driven by the modelled peak level being consistently about 0.5m lower than the recorded peak levels for the 2011 event from Three Mile Bridge to downstream of Ipswich. This is best demonstrated by the Longitudinal Profile for 2011. The modelled peak levels closer to the Bremer-Brisbane confluence are also higher than the recorded levels but not by as much. Comparison of recorded and modelled peak levels in the Brisbane River below the Bremer confluence does not reveal a consistent trend. Thus, lower modelled peak flood levels are confined to the Bremer. This is the basis of our comment. These additional explanations are added to the report in the 2011 Calibration Section.
I11	**4.10 1974 Flood Verification** • The validation is good at many locations; it is of varied quality at some locations, but is considered acceptable overall. • The validation is good at Ipswich, Moggill, Jindalee and the Port Office (around the peak). • The receding flood level is modelled as falling faster than observations at Savages Crossing, Mt Crosby, Port Office and also Tennyson, Yeronga, Sandy Creek. (The UMDT modelled results are similar in this respect). • The modelled peak profile is quite good for the Brisbane River but high for the Bremer River by about 1m, upstream from Ipswich. **BMT WBM Response:** The modelled peak flood levels upstream of Ipswich are on average about 0.5m to 1m higher than the recorded flood levels. This is in contrast to the 2011 event which are lower as per the previous item. The most likely explanation is uncertainties in the modelling, especially in the rainfall and runoff from the hydrologic modelling.
I12	**4.11 Fast Model Rating Curve Review** All comparisons that follow are related to the Aurecon rating curves. The first four comments relate to the Fast Model rating curves for floods used in the calibration and verification of the Fast Model up to the 1974 event. • For sites along the Brisbane River the correlation with the Aurecon rating curves is reasonably good and any differences are explained satisfactorily • The Fast Model rating curves are higher for Walloon (Bremer), Amberley (Warrill) and Loamside (Purga). • The Fast Model rating curves differ substantially for Glenore Grove and Rifle Range Road (both on Lockyer). The Fast Model curves are lower for smaller flows then cross over to be higher at flows a little larger than 1000m3/s. • In all cases the data from the Fast Model for all events appear to be self-consistent. At Workshop #2, two more cases were modelled with the Fast Model and its rating curves were extended up for floods produced by twice the rainfall that caused the 2011 flood and the 1974 flood. Peak level profiles were provided and the rating curves were extended. Such large floods may have properties that differ from those of the 1974 flood, so comparison between rating curves

Comments from IPE Responses from BMT WBM	
	needs to be treated with caution. At a ‘broad brush level’, the extensions of the Fast Model rating curves beyond those from the calibration events appear reasonable. • The extensions of the rating curves for Moggill, the Port Office are close to the Aurecon ratings and that for Centenary Bridge is somewhat higher. • The extensions for Savages Crossing and Mt Crosby Weir are above the curves by Aurecon and Seqwater but closer to the latter. • The extensions for Loamside, Amberley and Walloon are strongly affected by the extensive backwater effects from the very large flows in the Brisbane River. • The extensions of the rating curves for Glenore Grove and Rifle Range Road are self-consistent with those for the calibration events. **BMT WBM Response:** Agree.
I13	**4.12 Calibration Parameters** The description of the flow resistance modelling in the Fast Model in Section 4.12 and its Table 4-1 needs to be expanded substantially along the lines of the discussion between members of the IPE and Bill Syme of BMT WBM at the Workshop #2 on 11 December. This should include information on how the 'segmental' resistances due to different values of roughness across a cross-section are combined to produce the effective n value for a cross section, including the effects of the reach form loss; and how the section is projected above bank full level. It is suggested that plots of overall n value versus water level, including the effect of channel form loss, be given for a couple of lower Brisbane River locations. **BMT WBM Response:** Agree. This is discussed in Comment I2. While it constitutes a different kind of flow resistance, it is important that the details of how exchanges of momentum between the 1D channel and overbank flows are modelled are documented in some detail. The report would benefit plotting the energy surface on the main profiles. **BMT WBM Response:** The 1D solution scheme uses the momentum equation over a staggered (link-node) spatial discretisation that is difficult to produce a reliable profile of energy levels. At water level computation points (nodes), the velocity is not known or calculated, and therefore needs to be interpolated from upstream and downstream channels. This becomes particularly difficult when the upstream or downstream channel is a structure, or there are multiple channels feeding into the node. At these nodes it is not feasible or is very difficult to determine a velocity to calculate the kinetic energy component. We agree that energy is a useful output, however, this would require coming up with a reliable approach that does not give misleading results. The approach would also need to be coded into the TUFLOW software. We have considered this issue before, and if possible we will try to revisit, but unfortunately there is not a simple solution to this one! There is evidence that substantial bed movement is mobilised in larger floods. It is likely that large bed forms move with the flood waters but at a different pace - and sometimes even in the opposite direction. An unknown factor concerning flow resistance is to what extend bed movement could be contributing to the energy losses, both from the energy involved in the bed movement itself and from the varying bed forms causing increased flow resistance (form loss). Unfortunately, there appears to be insufficient data to estimate these effects. However, they should be noted as contributing to the uncertainty in the results of calibration and modelling, particularly for extreme events. **BMT WBM Response:** Agree. We will add further discussion on this issue in the Section on “Model Uncertainty”.
I14	The IPE noted in its comments of 21 September 2014 on the Milestone #1 Report its concern that a suite of only 5 calibration/verification events is rather limiting and concerning for a system as important and complex as the Brisbane River. As discussed below, the Fast Model has been shown to be able to model extreme events but the assessment of the quality of the results has to

Comments from IPE
Responses from BMT WBM

be based on their overall plausibility and consistency.

The IPE has come to the conclusion that it is highly desirable that the Fast Model be used to model the January 1893 flood, the largest historic flood event for which there is sufficient data. It is recognised that the data is limited but there is sufficient for that flood event to be run through both Fast and Detailed Hydraulic models as a gross check. In the WSDOS study, SEQwater modelled the January 1893 flood event in URBS, using a very simplified temporal pattern based on daily rainfall data with adjustments to the losses to account for the approximate temporal pattern (Ref 1). Allowance would need to be made for the 'no dams' situation.

BMT WBM Response: We agree that it would be beneficial to include the 1893 flood given that it's the largest on record, however, we were constrained to the 5 calibration/verification events used by the Hydrologic Assessment. These 5 events fortunately cover a wide range of flows and different flood patterns, and include two major events, so they represent a good spectrum of events and also cover most of the events in recent times for which good calibration data exists. However, the 1893 flood does provide an opportunity to test the model at higher flows than 1974, therefore, we have included the findings of the comparison to the several 1893 flood levels made during the workshop using a scaled up 1974 event that showed the Fast Model satisfactorily reproduced the recorded 1893 levels. We have also added far more detail on proofing the model for extreme events in Section 4.11.

I15 **Comments on Extreme Event Modelling**

Results of modelling extreme events with the Fast Model and with the UDMT were provided on 24 December 2014 for floods produced by twice, five times and eight times the rainfall that caused the 1974 flood. These results are compared with those from modelling the 1974 flood, as provided in the draft Milestone #2 Report. The first of these extreme events was modelled during the Workshop #2 on 11 December 2014 and the results were shown there as discussed above under Section 4.11. The results from modelling a flood produced by twice the 2011 flood rainfall event were also produced and were shown at the Workshop #2.

Comparison between the results from the two models, as provided by Bill Syme, has provided insights into aspects of the hydraulic phenomena and, in some cases, has indicated the need for some adjustments to the Fast Model while generally providing mutual support for the results from both models. However, only the results from the Fast Model are discussed here.

- The draft Aurecon overall study report estimated the PMP peak flow in the lower Brisbane River at between 64,000 m3/s (Moggill) and 61,000 m3/s (Brisbane) for the 'no dams' scenario and between 59,000 and 55,000 m3/s for the 'with dams' scenario.
- The SKM (2013) estimate of the 1974 peak flow at Brisbane is 13,700 m3/s for the 'no dams' scenario.
- It is assumed that the BMT WBM cases of '5x1974' and '8x1974' refer to the rainfall inputs; in that case the peak flows at Brisbane for the 'no dams' scenario would be of order 68,000 m3/s (about the PMP peak flow) and 110,000 m3/s (much greater than the PMP flood).

BMT WBM Response: Agree - this needs clarifying in the report. A table has been added quantifying peak flow at various locations for each of the extreme events simulated.

- The Bremer River at Ipswich is swamped by backwater from Brisbane River floods at 1x1974 and greater.
- The Lockyer at Lyons Bridge Alert is swamped by backwater from Brisbane River only for floods greater than the 5x1974. There are backwater effects at the downstream end from the 1974 flood and these effects move progressively upstream as the flood increases in magnitude.
- The Fast Model results for extreme events are broadly consistent with those for the modelled historical flood events. This appraisal is given without condition for the modelling of the 2x2011 and 2x1974 flood events for which the Fast Model rating curves have been seen. It remains conditional for the modelling of extreme events larger than these until the extensions of the Fast Model rating curves have been seen.
- Extensions of the Fast Model rating curves with the results of the largest two floods have not been provided - this should be done in the final Milestone #2 report.

BMT WBM Response: The extreme event results (5x & 8x 1974) have been added to the rating

Comments from IPE Responses from BMT WBM	
	curves. Two separate figures are provided for each of the rating curves: one that has an x- & y-scale chosen to focus on the magnitude of the calibration events, and one that has an x- & y-scale chosen to show the full suite of events out to the largest magnitude event simulated. • It is recommended that the peak energy profiles are shown as well as the peak level profile. **BMT WBM Response:** Please refer to Comment I13.
I16	**Conclusions** The IPE is satisfied with the work carried out on the fast model. The comments in the review generally relate to desire for more information on the model development and the calibration. While the figures are of suitable quality for a draft report the clarity of the figures should be improved for the final. **BMT WBM Response:** Thank you. The plots have been reworked so that they are suitable for both digital viewing/zooming and printing at A3 page scale.

Appendix C Hydraulic Structure Reference Sheets

Sir Leo Hielscher Bridges (TMR_001) Structure

Structure Name	Sir Leo Hielscher Bridges		
Structure ID	TMR_001		
Owner	TMR	**Waterway**	Brisbane River
Date of Construction	1986	**AMTD**	9940
Date of significant modification	2010	**Co-ordinates (GDA 56)**	509982.86E 6964316.4N
Source of Structure Information	Hydraulic Structure Reference Sheet (SKM 1999) As-Constructed Drawings (2010)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\TMR_001 New Gateway Bridge\		

Description	Concrete Arch Bridge. Piers and Abutments modelled only, deck sufficiently above Q2000 year ARI water surface level		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	-mAHD	**Number of Barrels**	-
Number of Piers in Waterway	2	**Dimensions**	-
Pier Width	19m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	-mAHD		
Rail height	-m		
Span Length	584m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Gateway Motorway and Sir Leo Hielscher Bridges, looking upstream
Image Source	https://www.leightoncontractors.com.au/assets/Large_project_738x361_GUP1-738x361.jpg
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\TMR_001 Sir Leo Hielscher\New Gateway Bridge-45777(N239)\Image2.JPG

Sir Leo Hielscher Bridges (TMR_001) Characteristics

Structure Name	Sir Leo Hielscher Bridges
Structure ID	TMR_001
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	-	-	-	-	-	-	-	-	-	-	-	-
1996	3444	0	3444	3087	0	3087	1.1	0.0	1.1	1.46	1.44	0.02
1999	544	0	544	3054	0	3054	0.2	0.0	0.2	1.37	1.37	0.00
2011	9046	0	9046	3139	0	3139	2.9	0.0	2.9	1.65	1.55	0.10
2013	2416	0	2416	3317	0	3317	0.7	0.0	0.7	1.98	1.97	0.01
1.5 x 1974 (1893 Approx.)	16080	0	16080	3620	0	3620	4.4	0.0	4.4	2.79	2.61	0.18
2 x 1974	22520	0	22520	4226	0	4226	5.3	0.0	5.3	4.00	3.78	0.23
5 x 1974	54324	0	54324	8126	0	8126	6.7	0.0	6.7	7.82	7.71	0.11
8 x 1974	80665	0	80665	10399	0	10399	7.8	0.0	7.8	9.90	9.75	0.15

* At time of peak water level

Story Bridge (BCC_006) Structure

Structure Name	Story Bridge		
Structure ID	BCC_006		
Owner	TMR	**Waterway**	Brisbane River
Date of Construction	1940	**AMTD**	21740
Date of significant modification	-	**Co-ordinates (GDA 56)**	503498.12E 6962171.33N
Source of Structure Information	Hydraulic Structure Reference Sheet (SKM 1999) Structural Design Drawings (1938)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_006 Storey Bridge\		

Description	Suspension Bridge, Steel truss superstructure		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	29.8mAHD	**Number of Barrels**	-
Number of Piers in Waterway	2	**Dimensions**	-
Pier Width	9.6m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	33.5mAHD		
Rail height	1.1*m		
Span Length	82-281m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	HW and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Story Bridge, looking upstream
Image Source	http://de.wikipedia.org/wiki/Story_Bridge#mediaviewer/File:Story_Bridge_Panorama.jpg
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_006 Story Bridge\Story_Bridge_Panorama.jpg

Story Bridge (BCC_006) Characteristics

Structure Name	Story Bridge
Structure ID	BCC_006
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	11082	0	11082	3138	0	3138	3.5	0.0	3.5	5.1	5.0	0.10
1996	3556	0	3556	2349	0	2349	1.5	0.0	1.5	1.96	1.94	0.02
1999	746	0	746	2233	0	2233	0.3	0.0	0.3	1.44	1.44	0.01
2011	8960	0	8960	2862	0	2862	3.1	0.0	3.1	4.10	4.03	0.07
2013	2726	0	2726	2432	0	2432	1.1	0.0	1.1	2.30	2.29	0.01
1.5 x 1974 (1893 Approx.)	15621	0	15621	4092	0	4092	3.8	0.0	3.8	7.89	7.77	0.12
2 x 1974	19549	0	19549	5200	0	5200	3.8	0.0	3.8	10.65	10.56	0.09
5 x 1974	32342	0	32342	9773	0	9773	3.3	0.0	3.3	20.17	20.06	0.11
8 x 1974	39205	0	39205	11829	0	11829	3.3	0.0	3.3	25.00	24.83	0.18

* At time of peak water level

Captain Cook Bridge (TMR_038) Structure

Structure Name	Captain Cook Bridge		
Structure ID	TMR_038		
Owner	TMR	**Waterway**	Brisbane River
Date of Construction	1972	**AMTD**	24090
Date of significant modification		**Co-ordinates (GDA 56)**	502861.51E 6960260.23N
Source of Structure Information	Hydraulic Structure Reference Sheet (SKM 1999) Structural Design Drawings (1970)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\TMR_038 Capitain Cook Bridge\		

Description	Concrete Arch Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	10.4mAHD	**Number of Barrels**	-
Number of Piers in Waterway	3	**Dimensions**	-
Pier Width	6m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	9.8mAHD		
Rail height	1.5*m		
Span Length	73-183m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	HW and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Captain Cook Bridge, looking downstream
Image Source	http://static.panoramio.com/photos/large/6976034.jpg
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\TMR_038 Captain Cook Bridge\Image2.jpg

Captain Cook Bridge (TMR_038) Characteristics

Structure Name	Captain Cook Bridge
Structure ID	TMR_038
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	11093	0	11093	3499	0	3499	3.2	0.0	3.2	6.2	6.1	0.13
1996	3571	0	3571	2327	0	2327	1.5	0.0	1.5	2.18	2.15	0.03
1999	1295	0	1295	2152	0	2152	0.6	0.0	0.6	1.49	1.48	0.01
2011	8961	0	8961	3104	0	3104	2.9	0.0	2.9	4.97	4.86	0.11
2013	2759	0	2759	2398	0	2398	1.2	0.0	1.2	2.44	2.42	0.02
1.5 x 1974 (1893 Approx.)	16337	0	16337	4459	0	4459	3.7	0.0	3.7	9.38	9.20	0.18
2 x 1974	22191	484	22675	5191	188	5379	4.3	2.6	4.2	12.52	12.24	0.28
5 x 1974	15782	11385	27167	5612	3468	9080	2.8	3.3	3.0	21.94	21.69	0.25
8 x 1974	11545	16205	27749	5612	6642	12254	2.1	2.4	2.3	26.88	26.77	0.11

* At time of peak water level

Goodwill Bridge (BCC_008) Structure

Structure Name	Goodwill Bridge		
Structure ID	BCC_008		
Owner	TMR	**Waterway**	Brisbane River
Date of Construction	2001	**AMTD**	24260
Date of significant modification		**Co-ordinates (GDA 56)**	502674.14E 6960341.25N
Source of Structure Information	Structural Design Drawings (1999)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_008 Goodwill Bridge\		

Description	Concrete and Steel Arch Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	6.1mAHD	**Number of Barrels**	-
Number of Piers in Waterway	8	**Dimensions**	-
Pier Width	23m, 0.8m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	7.3mAHD		
Rail height	1.6*m		
Span Length	19.7 - 112m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	HW and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Goodwill Bridge, looking upstream
Image Source	http://citycattour.com/chapter-c/landmarks/goodwill-bridge.html
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_008 Goodwill Bridge\Image1.JPG

Goodwill Bridge (BCC_008) Characteristics

Structure Name	Goodwill Bridge
Structure ID	BCC_008
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-
2011	8960	0	8960	3773	0	3774	2.4	0.7	2.4	5.13	5.10	0.04
2013	2760	0	2760	2889	0	2889	1.0	0.0	1.0	2.47	2.46	0.02
1.5 x 1974 (1893 Approx.)	16193	143	16336	5152	314	5466	3.1	0.5	3.0	9.59	9.59	0.00
2 x 1974	21985	698	22684	5970	960	6930	3.7	0.7	3.3	12.79	12.78	0.01
5 x 1974	18785	8410	27194	6283	4821	11104	3.0	1.7	2.4	22.11	22.05	0.06
8 x 1974	16064	11684	27749	6283	7042	13325	2.6	1.7	2.1	27.01	26.96	0.05

* At time of peak water level

Victoria Bridge (BCC_009) Structure

Structure Name	Victoria Bridge		
Structure ID	BCC_009		
Owner	TMR	**Waterway**	Brisbane River
Date of Construction	1865	**AMTD**	25305
Date of significant modification	1897, 1969	**Co-ordinates (GDA 56)**	502072.36E 6961236.33N
Source of Structure Information	Hydraulic Structure Reference Sheet (SKM 1999) Structural Design Drawings (1966)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_009 Victoria Bridge\		

Description	Concrete Arch Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	8.2mAHD	**Number of Barrels**	-
Number of Piers in Waterway	2	**Dimensions**	-
Pier Width	4m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	9.2mAHD		
Rail height	1.5*m		
Span Length	136, 85.3m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	HW and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Victoria bridge, looking downstream
Image Source	http://www.marysrosaries.com/collaboration/index.php?title=File:Victoria-Bridge_Brisbane.jpg
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_009 Victoria Bridge\Victoria-Bridge_Brisbane.jpg

Victoria Bridge (BCC_009) Characteristics

Structure Name	Victoria Bridge
Structure ID	BCC_009
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	11098	0	11098	3279	0	3279	3.4	0.0	3.4	6.7	6.6	0.09
1996	3584	0	3584	2184	0	2184	1.6	0.0	1.6	2.32	2.29	0.03
1999	1317	0	1317	1996	0	1996	0.7	0.0	0.7	1.52	1.51	0.01
2011	8962	0	8962	2946	0	2946	3.0	0.0	3.0	5.41	5.33	0.08
2013	2822	0	2822	2239	0	2239	1.3	0.0	1.3	2.53	2.51	0.02
1.5 x 1974 (1893 Approx.)	15708	0	15708	3855	0	3855	4.1	0.0	4.1	10.21	9.86	0.35
2 x 1974	17992	426	18417	4074	136	4210	4.4	3.1	4.4	13.77	13.06	0.72
5 x 1974	16543	11266	27808	4083	2520	6602	4.1	4.5	4.2	22.74	22.23	0.51
8 x 1974	17226	19162	36388	4083	4101	8183	4.2	4.7	4.4	27.63	27.15	0.49

* At time of peak water level

Kurilpa Bridge (BCC_010) Structure

Structure Name	Kurilpa Bridge		
Structure ID	BCC_010		
Owner	TMR	**Waterway**	Brisbane River
Date of Construction	2009	**AMTD**	25705
Date of significant modification		**Co-ordinates (GDA 56)**	501765.75E 6961559.1N
Source of Structure Information	Structural Design Drawings (2007)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_010 Kurilpa Bridge\		

Description	Tensegrity Cable Stay Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	9.5mAHD	**Number of Barrels**	-
Number of Piers in Waterway	2	**Dimensions**	-
Pier Width	10*m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	10.4mAHD		
Rail height	1.6*m		
Span Length	115m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	HW and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Kurilpa Bridge, looking upstream
Image Source	http://rcp.net.au/rcp/wp-content/blogs.dir/2/files/2013/03/03-kurilpa-bridge-5678.jpg
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_010 Kurilpa Bridge\Image_3.JPG

Kurilpa Bridge (BCC_010) Characteristics

Structure Name	Kurilpa Bridge
Structure ID	BCC_010
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-
2011	8951	0	8951	3514	0	3514	2.5	0.0	2.5	5.55	5.53	0.02
2013	2778	0	2778	2852	0	2852	1.0	0.0	1.0	2.56	2.55	0.01
1.5 x 1974 (1893 Approx.)	13244	4	13248	4642	8	4650	2.9	0.4	2.8	10.43	10.43	0.00
2 x 1974	10250	85	10334	5255	218	5472	2.0	0.4	1.9	13.98	13.98	0.00
5 x 1974	8290	1628	9918	5477	2400	7877	1.5	0.7	1.3	22.97	22.96	0.01
8 x 1974	8725	2895	11620	5477	3919	9395	1.6	0.7	1.2	27.91	27.90	0.01

* At time of peak water level

William Jolly Bridge (BCC_011) Structure

Structure Name	William Jolly Bridge		
Structure ID	BCC_011		
Owner	TMR	**Waterway**	Brisbane River
Date of Construction	1932	**AMTD**	26035
Date of significant modification		**Co-ordinates (GDA 56)**	501537.64E 6961628.46N
Source of Structure Information	Hydraulic Structure Reference Sheet (SKM 1999) Structural Design Drawings (1927)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_011 William Jolly\		

Description	Concrete Arch Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	13.5mAHD	**Number of Barrels**	-
Number of Piers in Waterway	3	**Dimensions**	-
Pier Width	6.6m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	14.3mAHD		
Rail height	1.5*m		
Span Length	72.5m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	HW and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	William Jolly Bridge, looking downstream
Image Source	http://engineerbarbie.com/server/home/brisbane/2007_07_blog13/2007_07_21_Mum2%20017c.jpg
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_011 William Jolly\image.jpg

William Jolly Bridge (BCC_011) Characteristics

Structure Name	William Jolly Bridge
Structure ID	BCC_011
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	10993	0	10993	3935	0	3935	2.8	0.0	2.8	7.1	7.0	0.04
1996	3582	0	3582	2864	0	2864	1.3	0.0	1.3	2.39	2.38	0.01
1999	1324	0	1324	2679	0	2679	0.5	0.0	0.5	1.54	1.53	0.01
2011	8952	0	8952	3621	0	3621	2.5	0.0	2.5	5.70	5.67	0.03
2013	2816	0	2816	2908	0	2908	1.0	0.0	1.0	2.59	2.58	0.01
1.5 x 1974 (1893 Approx.)	13248	0	13248	4742	0	4742	2.8	0.0	2.8	10.64	10.58	0.06
2 x 1974	10334	0	10334	5400	0	5400	1.9	0.0	1.9	14.14	14.05	0.09
5 x 1974	6933	2983	9916	5400	1987	7387	1.3	1.5	1.3	23.04	22.99	0.04
8 x 1974	6530	5089	11619	5400	3557	8957	1.2	1.4	1.3	27.97	27.94	0.04

* At time of peak water level

Merivale St Bridge (QR_087) Structure

Structure Name	Merivale St Bridge		
Structure ID	QR_087		
Owner	QR	**Waterway**	Brisbane River
Date of Construction	1978	**AMTD**	26290
Date of significant modification		**Co-ordinates (GDA 56)**	501306.22E 6961566.52N
Source of Structure Information	Hydraulic Structure Reference Sheet (SKM 1999) As-Construcuted Drawings (1974)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\QR_087 Merivale Street Rail\		

Description	Through Arch Bridge with Concrete Deck and Cable Stay Arch		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	14.1mAHD	**Number of Barrels**	-
Number of Piers in Waterway	4	**Dimensions**	-
Pier Width	max 13.4m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	15.1mAHD		
Rail height	-m		
Span Length	33.4-132.9m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Merivale St Bridge, looking upstream
Image Source	http://commons.wikimedia.org/wiki/File:Merivale_Bridge.jpg
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\QR_087 Merivale Street Rail\Image.JPG

Merivale St Bridge Hydraulic Structure Reference Sheet
Brisbane River

Merivale St Bridge (QR_087) Characteristics

Structure Name	Merivale St Bridge
Structure ID	QR_087
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	-	-	-	-	-	-	-	-	-	-	-	-
1996	3598	0	3598	1691	0	1691	2.1	0.0	2.1	2.51	2.41	0.11
1999	1331	0	1331	1522	0	1522	0.9	0.0	0.9	1.56	1.54	0.02
2011	8956	0	8956	2434	0	2434	3.7	0.0	3.7	6.01	5.75	0.27
2013	2862	0	2862	1728	0	1728	1.7	0.0	1.7	2.66	2.60	0.07
1.5 x 1974 (1893 Approx.)	14739	0	14739	3546	0	3546	4.2	0.0	4.2	10.83	10.70	0.12
2 x 1974	18156	0	18156	4220	0	4220	4.3	0.0	4.3	14.35	14.20	0.15
5 x 1974	19405	5968	25374	4318	1911	6229	4.5	3.1	4.1	23.31	23.08	0.22
8 x 1974	20027	10561	30589	4318	3119	7437	4.6	3.4	4.1	28.26	28.02	0.24

* At time of peak water level

Go Between Bridge (BCC_012) Structure

Structure Name	Go Between Bridge		
Structure ID	BCC_012		
Owner	TMR	**Waterway**	Brisbane River
Date of Construction	2010	**AMTD**	29380
Date of significant modification		**Co-ordinates (GDA 56)**	501204.81E 6961523.39N
Source of Structure Information	As-Construcuted Drawings (2010)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_012 Go Between Bridge\		

Description	Concrete Arch Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	6.7mAHD	**Number of Barrels**	-
Number of Piers in Waterway	2	**Dimensions**	-
Pier Width	8.9m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	7.5mAHD		
Rail height	1.3m		
Span Length	78.5-117 m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	HW and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Go Between Bridge, looking upstream
Image Source	http://upload.wikimedia.org/wikipedia/commons/f/fe/Go_between_bridge.jpg
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_012 Go Between Bridge\Image.JPG

Go Between Bridge Hydraulic Structure Reference Sheet
Brisbane River

Go Between Bridge (BCC_012) Characteristics

Structure Name	Go Between Bridge
Structure ID	BCC_012
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-
2011	8956	0	8956	3397	0	3397	2.6	0.0	2.6	6.05	6.03	0.02
2013	2873	0	2873	2470	0	2470	1.2	0.0	1.2	2.68	2.66	0.01
1.5 x 1974 (1893 Approx.)	14677	61	14739	4497	93	4590	3.3	0.7	3.2	10.85	10.85	0.01
2 x 1974	17338	817	18155	4846	499	5345	3.6	1.6	3.4	14.42	14.36	0.06
5 x 1974	17495	7878	25373	4846	2881	7727	3.6	2.7	3.3	23.46	23.32	0.14
8 x 1974	17555	13032	30587	4846	4253	9099	3.6	3.1	3.4	28.46	28.28	0.18

* At time of peak water level

Eleanor Schonell (Green) Bridge (BCC_019) Structure

Structure Name	Eleanor Schonell (Green) Bridge		
Structure ID	BCC_019		
Owner	BCC	**Waterway**	Brisbane River
Date of Construction	2006	**AMTD**	35100
Date of significant modification		**Co-ordinates (GDA 56)**	502036.19E 6958442.67N
Source of Structure Information	As-Construcuted Drawings (2005)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_019 Green Bridge\		

Description	Harp Cable Stay Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	11.5mAHD	**Number of Barrels**	-
Number of Piers in Waterway	2	**Dimensions**	-
Pier Width	6.2-9.5m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	12.4mAHD		
Rail height	1.17m		
Span Length	73-184.4m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	HW and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Eleanor Schonell (Green) Bridge, looking upstream
Image Source	http://en.wikipedia.org/wiki/File:Eleanor_Schonell_Bridge,_Brisbane,_2007-01-31.jpg
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_019 Green Bridge\Image_3.jpg

Eleanor Schonell (Green) Bridge (BCC_019) Characteristics

Structure Name	Eleanor Schonell (Green) Bridge
Structure ID	BCC_019
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-
2011	8972	0	8972	4894	0	4894	1.8	0.0	1.8	7.48	7.47	0.01
2013	2988	0	2988	3507	0	3507	0.9	0.0	0.9	3.00	3.00	0.01
1.5 x 1974 (1893 Approx.)	13526	1	13527	6721	1	6722	2.0	0.4	2.0	12.71	12.70	0.00
2 x 1974	15512	115	15627	7534	292	7826	2.1	0.4	2.0	16.28	16.28	0.00
5 x 1974	20602	4065	24668	7748	3418	11166	2.7	1.2	2.2	26.35	26.32	0.03
8 x 1974	22485	8018	30503	7748	5208	12956	2.9	1.5	2.4	31.94	31.90	0.04

* At time of peak water level

Jack Pesch Bridge (BCC_021) Structure

Structure Name	Jack Pesch Bridge		
Structure ID	BCC_021		
Owner	BCC	**Waterway**	Brisbane River
Date of Construction	1998	**AMTD**	41550
Date of significant modification		**Co-ordinates (GDA 56)**	497452.41E 6957523.98N
Source of Structure Information	As-Construcuted Drawings (1997)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_021 Walter Taylor Pedestrian Bridge\		

Description	Steel Cable Stay Bridge. NB: Jack Pesch, Indooroopilly Rail (2) and Walter Taylor Bridges modelled as one.		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	15.5*mAHD	**Number of Barrels**	-
Number of Piers in Waterway	0	**Dimensions**	-
Pier Width	-m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	18.4mAHD		
Rail height	1.8*m		
Span Length	167.5m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	See BCC_020
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Aerial image of the four Indooroopilly bridges, looking upstream. Jack Pesch Bri
Image Source	http://structurae.net/photos/66157-jack-pesch-bridge-walter-taylor-bridge-albert-bridge-brisbane
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_020 Walter Taylor Bridge\ImageAerial.jpg

Jack Pesch Bridge (BCC_021) Characteristics

Structure Name	Jack Pesch Bridge
Structure ID	BCC_021
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-
1999	1588	0	1588	1651	0	1651	1.0	0.0	1.0	1.94	1.93	0.01
2011	9173	0	9173	3029	0	3029	3.0	0.0	3.0	9.84	9.79	0.06
2013	3557	0	3557	1934	0	1934	1.8	0.0	1.8	3.79	3.76	0.03
1.5 x 1974 (1893 Approx.)	14844	0	14844	4087	0	4087	3.6	0.0	3.6	15.59	15.24	0.35
2 x 1974	13607	641	14248	4087	267	4354	3.3	2.4	3.3	18.70	18.39	0.32
5 x 1974	4552	3999	8551	4087	2837	6924	1.1	1.4	1.2	27.73	27.70	0.04
8 x 1974	3119	4567	7685	4087	4390	8477	0.8	1.0	0.9	33.18	33.16	0.02

* At time of peak water level

Indooroopilly Railway Bridges (QR_083) Structure

Structure Name	Indooroopilly Railway Bridges		
Structure ID	QR_083		
Owner	QR	**Waterway**	Brisbane River
Date of Construction	1957	**AMTD**	41550
Date of significant modification		**Co-ordinates (GDA 56)**	497432.65E 6957535.32N
Source of Structure Information	Hydraulic Structure Reference Sheet (SKM 1999) Structural Design Drawings (1951)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\QR_083 Indooroopilly Rail\		

Description	Two steel suspension bridges. Albert Bridge with arched superstructure. NB: Jack Pesch, Indooroopilly Rail (2) and Walter Taylor Bridges modelled as one.		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	15.5*mAHD	**Number of Barrels**	-
Number of Piers in Waterway	1	**Dimensions**	-
Pier Width	7.3m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	16.5mAHD		
Rail height	-m		
Span Length	104.2m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	See BCC_020
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Aerial image of the four Indooroopilly bridges, looking upstream. Indooroopilly Ra
Image Source	http://structurae.net/photos/66157-jack-pesch-bridge-walter-taylor-bridge-albert-bridge-brisbane
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_020 Walter Taylor Bridge\ImageAerial.jpg

Indooroopilly Railway Bridges (QR_083) Characteristics

Structure Name	Indooroopilly Railway Bridges
Structure ID	QR_083
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	11180	0	11180	3383	0	3383	3.3	0.0	3.3	11.6	11.6	0.06
1996	3663	0	3663	1960	0	1960	1.9	0.0	1.9	3.95	3.92	0.03
1999	1588	0	1588	1651	0	1651	1.0	0.0	1.0	1.94	1.93	0.01
2011	9173	0	9173	3029	0	3029	3.0	0.0	3.0	9.84	9.79	0.06
2013	3557	0	3557	1934	0	1934	1.8	0.0	1.8	3.79	3.76	0.03
1.5 x 1974 (1893 Approx.)	14844	0	14844	4087	0	4087	3.6	0.0	3.6	15.59	15.24	0.35
2 x 1974	13607	641	14248	4087	267	4354	3.3	2.4	3.3	18.70	18.39	0.32
5 x 1974	4552	3999	8551	4087	2837	6924	1.1	1.4	1.2	27.73	27.70	0.04
8 x 1974	3119	4567	7685	4087	4390	8477	0.8	1.0	0.9	33.18	33.16	0.02

* At time of peak water level

Walter Taylor Bridge (BCC_020) Structure

Structure Name	Walter Taylor Bridge		
Structure ID	BCC_020		
Owner	BCC	**Waterway**	Brisbane River
Date of Construction	1936	**AMTD**	41550
Date of significant modification		**Co-ordinates (GDA 56)**	497399.96E 6957559.5N
Source of Structure Information	Hydraulic Structure Reference Sheet (SKM 1999) Structural Design Drawings (1934)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_020 Walter Taylor Bridge\		

Description	Concrete Bridge with Steel Suspension. NB: Jack Pesch, Indooroopilly Rail (2) and Walter Taylor Bridges modelled as one.		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	15.5*mAHD	**Number of Barrels**	-
Number of Piers in Waterway	0	**Dimensions**	-
Pier Width	10.1*m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	16.5mAHD		
Rail height	1.8*m		
Span Length	152.4m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Aerial image of the four Indooroopilly bridges, looking upstream. Walter Taylor or
Image Source	http://structurae.net/photos/66157-jack-pesch-bridge-walter-taylor-bridge-albert-bridge-brisbane
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_020 Walter Taylor Bridge\ImageAerial.jpg

Walter Taylor Bridge (BCC_020) Characteristics

Structure Name	Walter Taylor Bridge
Structure ID	BCC_020
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	11180	0	11180	3383	0	3383	3.3	0.0	3.3	11.6	11.6	0.06
1996	3663	0	3663	1960	0	1960	1.9	0.0	1.9	3.95	3.92	0.03
1999	1588	0	1588	1651	0	1651	1.0	0.0	1.0	1.94	1.93	0.01
2011	9173	0	9173	3029	0	3029	3.0	0.0	3.0	9.84	9.79	0.06
2013	3557	0	3557	1934	0	1934	1.8	0.0	1.8	3.79	3.76	0.03
1.5 x 1974 (1893 Approx.)	14844	0	14844	4087	0	4087	3.6	0.0	3.6	15.59	15.24	0.35
2 x 1974	13607	641	14248	4087	267	4354	3.3	2.4	3.3	18.70	18.39	0.32
5 x 1974	4552	3999	8551	4087	2837	6924	1.1	1.4	1.2	27.73	27.70	0.04
8 x 1974	3119	4567	7685	4087	4390	8477	0.8	1.0	0.9	33.18	33.16	0.02

* At time of peak water level

Centenary Bridge (TMR_039) Structure

Structure Name	Centenary Bridge		
Structure ID	TMR_039		
Owner	TMR	**Waterway**	Brisbane River
Date of Construction	1964	**AMTD**	49990
Date of significant modification	1985	**Co-ordinates (GDA 56)**	494771.63E 6955108.12N
Source of Structure Information	Hydraulic Structure Reference Sheet (SKM 1999) Structural Design Drawings, Duplication of Bridge (1985)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\TMR_039 Centenary Bridge\		

Description	Concrete Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	13.2mAHD	**Number of Barrels**	-
Number of Piers in Waterway	4	**Dimensions**	-
Pier Width	0.7m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	11.1mAHD		
Rail height	1.3m		
Span Length	42.3-48.3 m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	HW and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Centenary Bridge, seen from Jindalee looking downstream
Image Source	http://upload.wikimedia.org/wikipedia/commons/thumb/0/01/Centenary_Bridge_03.2014_03.JPG/1280px-Centenary_Bridge_03.2014_03.JPG
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\TMR_039 Centenary Bridge\Image_2014.JPG

Centenary Bridge (TMR_039) Characteristics

Structure Name	Centenary Bridge
Structure ID	TMR_039
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	9890	906	10795	3317	410	3727	3.0	2.2	2.9	14.2	14.1	0.12
1996	3714	0	3714	1722	0	1722	2.2	0.0	2.2	5.05	4.98	0.07
1999	2117	0	2117	1256	0	1256	1.7	0.0	1.7	2.33	2.28	0.05
2011	9241	136	9377	3143	79	3222	2.9	1.7	2.9	12.25	12.13	0.12
2013	3559	0	3559	1685	0	1685	2.1	0.0	2.1	4.84	4.77	0.07
1.5 x 1974 (1893 Approx.)	8020	4795	12815	3318	1788	5106	2.4	2.7	2.5	18.12	17.96	0.16
2 x 1974	7238	8091	15329	3318	3232	6549	2.2	2.5	2.3	21.06	20.93	0.13
5 x 1974	7334	19659	26993	3318	7587	10904	2.2	2.6	2.5	29.20	29.07	0.13
8 x 1974	7387	27512	34899	3318	10414	13732	2.2	2.6	2.5	34.43	34.30	0.13

* At time of peak water level

Colleges Crossing (TMR_078) Structure

Structure Name	Colleges Crossing		
Structure ID	TMR_078		
Owner	TMR	**Waterway**	Brisbane River
Date of Construction	1894	**AMTD**	85890
Date of significant modification		**Co-ordinates (GDA 56)**	480670.33E 6951875.09N
Source of Structure Information	Structural Design Drawings (1981)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\TMR_078 Colleges\		

Description	Concrete Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	2.2mAHD	**Number of Barrels**	-
Number of Piers in Waterway	2	**Dimensions**	-
Pier Width	0.6m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	2.6mAHD		
Rail height	0.3m		
Span Length	14m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Colleges Crossing, looking upstream
Image Source	BMT WBM, 2014
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\TMR_078 Colleges\Image2014.jpg

Colleges Crossing (TMR_078) Characteristics

Structure Name	Colleges Crossing
Structure ID	TMR_078
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	58	9535	9592	59	8165	8224	1.0	1.2	1.2	25.1	25.1	0.03
1996	53	2546	2599	59	2408	2467	0.9	1.1	1.1	11.81	11.79	0.02
1999	59	1874	1933	59	1587	1646	1.0	1.2	1.2	9.52	9.49	0.03
2011	61	9204	9266	59	7422	7481	1.0	1.2	1.2	23.54	23.51	0.03
2013	50	2191	2240	59	2192	2251	0.8	1.0	1.0	11.23	11.22	0.02
1.5 x 1974 (1893 Approx.)	65	13638	13702	59	10439	10498	1.1	1.3	1.3	30.02	29.99	0.03
2 x 1974	70	16983	17054	59	11913	11972	1.2	1.4	1.4	33.11	33.07	0.04
5 x 1974	90	29596	29686	59	16280	16339	1.5	1.8	1.8	42.04	41.98	0.06
8 x 1974	102	38895	38997	59	18907	18966	1.7	2.1	2.1	47.18	47.10	0.08

* At time of peak water level

Mt Crosby Weir (BCC_077) Structure

Structure Name	Mt Crosby Weir		
Structure ID	BCC_077		
Owner	Seqwater	**Waterway**	Brisbane River
Date of Construction	1894	**AMTD**	90320
Date of significant modification	1897, 1927	**Co-ordinates (GDA 56)**	480042.24E 6954038.38N
Source of Structure Information	Brief Archival Record (Converge 2013 for SEQwater)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_077 Mt Crosby Weir\		

Description	Multi-cell weir with concrete overbridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	11.2mAHD	**Number of Barrels**	-
Number of Piers in Waterway	21	**Dimensions**	-
Pier Width	0.91m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	12.5mAHD		
Rail height	1.5*m		
Span Length	7.6m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	18xRectangular culverts with v
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Mt Crosby Weir, looking upstream from west bank
Image Source	BMT WBM, 2014
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_077 Mt Crosby Weir\Image5.jpg

Mt Crosby Weir (BCC_077) Characteristics

Structure Name	Mt Crosby Weir
Structure ID	BCC_077
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	1726	7870	9596	509	3285	3793	3.4	2.4	2.5	27.6	27.5	0.11
1996	2008	605	2613	509	290	799	3.9	2.1	3.3	14.04	13.62	0.42
1999	1899	0	1899	473	0	473	4.0	0.0	4.0	12.18	11.33	0.85
2011	1812	7557	9369	509	2990	3498	3.6	2.5	2.7	26.25	26.13	0.12
2013	2011	231	2243	509	151	660	4.0	1.5	3.4	13.33	12.87	0.46
1.5 x 1974 (1893 Approx.)	1875	11593	13469	509	4463	4971	3.7	2.6	2.7	32.78	32.66	0.13
2 x 1974	1890	13999	15888	509	5130	5638	3.7	2.7	2.8	35.74	35.60	0.14
5 x 1974	1773	19685	21459	509	7048	7557	3.5	2.8	2.8	44.25	44.11	0.14
8 x 1974	1725	23554	25279	509	8223	8732	3.4	2.9	2.9	49.46	49.31	0.15

* At time of peak water level

Kholo Rd Bridge (BCC_076) Structure

Structure Name	Kholo Rd Bridge		
Structure ID	BCC_076		
Owner	BCC	**Waterway**	Brisbane River
Date of Construction	1970	**AMTD**	99090
Date of significant modification		**Co-ordinates (GDA 56)**	475036.12E 6950949.91N
Source of Structure Information	Structural Design Drawings (1969)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_076 Kholo Rd Bridge\		

Description	Concrete Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	11.2mAHD	**Number of Barrels**	-
Number of Piers in Waterway	8	**Dimensions**	-
Pier Width	0.8m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	11.7mAHD		
Rail height	0.6m		
Span Length	12.7m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	HW and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Kholo Rd Bridge, looking downstream
Image Source	http://hoverservices.com.au/html/brisbane.htm
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\BCC_076 Kholo Rd Bridge\image1.JPG

Kholo Rd Bridge (BCC_076) Characteristics

Structure Name	Kholo Rd Bridge
Structure ID	BCC_076
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	**Discharge (m^3/s)***			**Area (m^2)***			**Velocity (m/s)***			**Peak Water Surface Level* (mAHD)**		**Max Afflux (m)**
	Under Deck	**Over Deck**	**Total**	**Under Deck**	**Over Deck**	**Total**	**Under Deck**	**Over Deck**	**Total**	**US**	**DS**	
1974	730	8084	8813	414	3897	4311	1.8	2.1	2.0	30.2	30.1	0.08
1996	716	1891	2607	414	977	1391	1.7	1.9	1.9	16.78	16.70	0.08
1999	768	1177	1945	414	580	993	1.9	2.0	2.0	14.95	14.84	0.11
2011	771	8042	8812	414	3685	4098	1.9	2.2	2.2	29.20	29.11	0.09
2013	719	1530	2249	414	791	1204	1.7	1.9	1.9	15.92	15.84	0.08
1.5 x 1974 (1893 Approx.)	658	9509	10167	414	5047	5461	1.6	1.9	1.9	35.45	35.39	0.07
2 x 1974	590	9812	10402	414	5738	6151	1.4	1.7	1.7	38.62	38.57	0.05
5 x 1974	369	8672	9042	414	7803	8216	0.9	1.1	1.1	48.09	48.07	0.02
8 x 1974	323	8936	9259	414	9071	9485	0.8	1.0	1.0	53.91	53.89	0.02

* At time of peak water level

Burtons Bridge (SRC_075) Structure

Structure Name	Burtons Bridge		
Structure ID	SRC_075		
Owner	SRC	**Waterway**	Brisbane River
Date of Construction	?	**AMTD**	119090
Date of significant modification	2000	**Co-ordinates (GDA 56)**	469361.11E 6958199.51N
Source of Structure Information	Structural Design Drawings (2000)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\SRC_075 Burtons Bridge\		

Description	Concrete Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	18.1*mAHD	**Number of Barrels**	-
Number of Piers in Waterway	5	**Dimensions**	-
Pier Width	1-1.2*m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	19.8mAHD		
Rail height	1.1*m		
Span Length	14.3m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Burtons Bridge, looking downstream
Image Source	BMT WBM, 2014
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\SRC_075 Burtons Bridge\Image.jpg

Burtons Bridge (SRC_075) Characteristics

Structure Name	Burtons Bridge
Structure ID	SRC_075
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	**Discharge (m^3/s)***			**Area (m^2)***			**Velocity (m/s)***			**Peak Water Surface Level* (mAHD)**		**Max Afflux (m)**
	Under Deck	**Over Deck**	**Total**	**Under Deck**	**Over Deck**	**Total**	**Under Deck**	**Over Deck**	**Total**	**US**	**DS**	
1974	271	7982	8253	232	5644	5876	1.2	1.4	1.4	36.5	36.4	0.04
1996	369	2121	2490	232	1124	1356	1.6	1.9	1.8	25.37	25.30	0.07
1999	383	1556	1939	232	803	1036	1.6	1.9	1.9	24.08	23.99	0.09
2011	285	8192	8477	232	5501	5733	1.2	1.5	1.5	36.16	36.12	0.04
2013	379	1890	2268	232	987	1219	1.6	1.9	1.9	24.85	24.76	0.09
1.5 x 1974 (1893 Approx.)	235	9629	9864	232	7793	8025	1.0	1.2	1.2	40.79	40.76	0.03
2 x 1974	148	7254	7402	232	9381	9613	0.6	0.8	0.8	43.97	43.96	0.01
5 x 1974	77	9070	9147	232	14911	15144	0.3	0.6	0.6	55.06	55.05	0.01
8 x 1974	76	11347	11424	232	18743	18976	0.3	0.6	0.6	62.74	62.73	0.01

* At time of peak water level

Savages Crossing (SRC_074) Structure

Structure Name	Savages Crossing		
Structure ID	SRC_074		
Owner	SRC	**Waterway**	Brisbane River
Date of Construction	?	**AMTD**	85990
Date of significant modification		**Co-ordinates (GDA 56)**	467394.57E 6964416.65N
Source of Structure Information	Cottrell Cameron and Steen Survey (2008) for Esk-Lowood Flood Study		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\SRC_074 Savages Crossing\		

Description	Concrete Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	20.5mAHD	**Number of Barrels**	-
Number of Piers in Waterway	5	**Dimensions**	-
Pier Width	0.5-0.6m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	21.31mAHD		
Rail height	0.97m		
Span Length	12.3-12.6m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Savages Crossing, looking downstream
Image Source	BMT WBM, 2014
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\SRC_074 Savages Crossing\Image.jpg

Savages Crossing (SRC_074) Characteristics

Structure Name	Savages Crossing
Structure ID	SRC_074
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	88	9421	9509	64	5819	5883	1.4	1.6	1.6	42.4	42.3	0.05
1996	75	2333	2408	64	1692	1756	1.2	1.4	1.4	30.37	30.34	0.04
1999	74	1849	1923	64	1363	1427	1.2	1.4	1.3	28.97	28.93	0.03
2011	89	9704	9793	64	5868	5932	1.4	1.7	1.7	42.47	42.42	0.05
2013	76	2207	2283	64	1584	1648	1.2	1.4	1.4	29.92	29.88	0.04
1.5 x 1974 (1893 Approx.)	75	10642	10717	64	7654	7718	1.2	1.4	1.4	46.67	46.64	0.04
2 x 1974	76	12360	12436	64	8712	8776	1.2	1.4	1.4	49.11	49.08	0.04
5 x 1974	81	19901	19982	64	13200	13264	1.3	1.5	1.5	59.25	59.21	0.04
8 x 1974	82	25275	25357	64	16674	16738	1.3	1.5	1.5	66.83	66.79	0.04

* At time of peak water level

Brisbane Valley Highway (TMR_050) Structure

Structure Name	Brisbane Valley Highway		
Structure ID	TMR_050		
Owner	TMR	**Waterway**	Brisbane River
Date of Construction	1993	**AMTD**	123290
Date of significant modification		**Co-ordinates (GDA 56)**	464368.59E 6965778.14N
Source of Structure Information	Structural Design Drawings (1993)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\TMR_050 Brisbane Valley Hway\		

Description	Concrete Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	31.1mAHD	**Number of Barrels**	-
Number of Piers in Waterway	6	**Dimensions**	-
Pier Width	2m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	33.6mAHD		
Rail height	0.8m		
Span Length	31m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Brisbane Valley Highway, looking downstream
Image Source	BMT WBM, 2014
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\TMR_050 Brisbane Valley Hway\Image2014.jpg

Brisbane Valley Highway (TMR_050) Characteristics

Structure Name	Brisbane Valley Highway
Structure ID	TMR_050
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	-	-	-	-	-	-	-	-	-	-	-	-
1996	2349	0	2349	1438	0	1438	1.6	0.0	1.6	32.15	32.09	0.07
1999	1872	0	1872	1349	0	1349	1.4	0.0	1.4	30.78	30.77	0.01
2011	816	1703	2519	1438	2353	3791	0.6	0.7	0.7	43.48	43.47	0.01
2013	2286	0	2286	1438	0	1438	1.6	0.0	1.6	31.79	31.73	0.06
1.5 x 1974 (1893 Approx.)	733	1721	2454	1438	3289	4727	0.5	0.5	0.5	47.34	47.33	0.01
2 x 1974	678	1967	2645	1438	3882	5320	0.5	0.5	0.5	49.77	49.77	0.01
5 x 1974	560	2938	3498	1438	6341	7779	0.4	0.5	0.5	59.90	59.89	0.00
8 x 1974	481	3460	3941	1438	8174	9612	0.3	0.4	0.4	67.44	67.43	0.00

* At time of peak water level

Twin Bridges (SRC_073) Structure

Structure Name	Twin Bridges		
Structure ID	SRC_073		
Owner	SRC	**Waterway**	Brisbane River
Date of Construction	1900	**AMTD**	124390
Date of significant modification	?	**Co-ordinates (GDA 56)**	463779.36E 6965122.41N
Source of Structure Information	Cottrell Cameron and Steen Survey (2008) for Esk-Lowood Flood Study		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\SRC_073 Twin Bridges\		

Description	2 Concrete Causeways		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	23.3mAHD	**Number of Barrels**	-
Number of Piers in Waterway	14	**Dimensions**	-
Pier Width	0.4m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	23.7mAHD		
Rail height	-m		
Span Length	3m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	2 banks of culverts
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Twin Bridges, looking downstream
Image Source	BMT WBM, 2014
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\SRC_073 Twin Bridges\Image.jpg

Twin Bridges (SRC_073) Characteristics

Structure Name	Twin Bridges
Structure ID	SRC_073
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	69	5094	5162	58	7062	7120	1.2	0.7	0.7	43.4	43.3	0.01
1996	124	2226	2350	58	1965	2023	2.1	1.1	1.2	32.51	32.48	0.02
1999	122	1755	1877	58	1560	1618	2.1	1.1	1.2	31.19	31.16	0.02
2011	69	5149	5217	58	7137	7194	1.2	0.7	0.7	43.51	43.50	0.01
2013	127	2165	2292	58	1862	1919	2.2	1.2	1.2	32.18	32.15	0.03
1.5 x 1974 (1893 Approx.)	39	4992	5031	58	9037	9094	0.7	0.6	0.6	47.35	47.34	0.01
2 x 1974	33	5370	5403	58	10241	10299	0.6	0.5	0.5	49.78	49.78	0.01
5 x 1974	23	7195	7218	58	15245	15303	0.4	0.5	0.5	59.90	59.90	0.00
8 x 1974	17	8154	8171	58	18973	19031	0.3	0.4	0.4	67.44	67.44	0.00

* At time of peak water level

Warrego Hwy (TMR_037) Structure

Structure Name	Warrego Hwy		
Structure ID	TMR_037		
Owner	TMR	**Waterway**	Bremer River
Date of Construction	1953	**AMTD**	5310
Date of significant modification	1990	**Co-ordinates (GDA 56)**	481697.09E 6948960.68N
Source of Structure Information	Structural Design Drawings (1990)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRM\TMR_037 Bremer river Warrego Hwy 18A\		

Description	Dual Concrete Bridges with debris fender system, modelled as single structure		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	14.5*mAHD	**Number of Barrels**	-
Number of Piers in Waterway	11	**Dimensions**	-
Pier Width	1.5*m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	15.8mAHD		
Rail height	1.3*m		
Span Length	30-37m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Aerial Imagery of dual bridges, flow direction bottom to top
Image Source	Imagery provided by ICC
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRM\TMR_037 Bremer river Warrego Hwy 18A\Capture.JPG

Warrego Hwy (TMR_037) Characteristics

Structure Name	Warrego Hwy
Structure ID	TMR_037
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	80	424	504	1868	1377	3245	0.0	0.3	0.2	21.1	21.1	0.00
1996	1031	0	1031	937	0	937	1.1	0.0	1.1	9.03	9.02	0.01
1999	324	0	324	551	0	551	0.6	0.0	0.6	5.08	5.07	0.01
2011	233	345	578	1868	791	2659	0.1	0.4	0.2	18.89	18.89	0.00
2013	1626	0	1626	1001	0	1001	1.6	0.0	1.6	9.54	9.52	0.02
1.5 x 1974 (1893 Approx.)	13	423	436	1868	2518	4385	0.0	0.2	0.1	25.48	25.48	0.00
2 x 1974	13	536	549	1868	3184	5051	0.0	0.2	0.1	28.01	28.01	0.00
5 x 1974	17	986	1002	1868	5436	7304	0.0	0.2	0.1	36.52	36.52	0.00
8 x 1974	20	1323	1343	1868	6789	8656	0.0	0.2	0.2	41.59	41.59	0.00

* At time of peak water level

David Trumpy Bridge (TMR_043) Structure

Structure Name	David Trumpy Bridge		
Structure ID	TMR_043		
Owner	TMR	**Waterway**	Bremer River
Date of Construction	1965	**AMTD**	16720
Date of significant modification		**Co-ordinates (GDA 56)**	476469.74E 6945831.92N
Source of Structure Information	Structural Design Drawings (1961)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRM\TMR_043 Bremer river Warrego connection\		

Description	Concrete Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	20.9mAHD	**Number of Barrels**	-
Number of Piers in Waterway	4	**Dimensions**	-
Pier Width	0.5m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	24.5*mAHD		
Rail height	1.6m		
Span Length	40.8-50.3m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	David Trumpy Bridge 1974, looking upstream
Image Source	http://www.queenslandplaces.com.au/exhibit/postcard-folder/pc0986 (Centre for the Government of Queesnaldn MS)
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRM\TMR_043 Bremer river Warrego connection\Image_1974.jpg

David Trumpy Bridge (TMR_043) Characteristics

Structure Name	David Trumpy Bridge
Structure ID	TMR_043
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	2615	0	2615	3114	0	3114	0.8	0.0	0.8	21.5	21.5	0.01
1996	1662	0	1662	1132	0	1132	1.5	0.0	1.5	12.28	12.27	0.01
1999	687	0	687	465	0	465	1.5	0.0	1.5	6.57	6.56	0.01
2011	1361	0	1361	2520	0	2520	0.5	0.0	0.5	19.16	19.15	0.00
2013	1789	0	1789	1254	0	1254	1.4	0.0	1.4	13.06	13.06	0.01
1.5 x 1974 (1893 Approx.)	1839	252	2091	3536	370	3905	0.5	0.7	0.5	25.59	25.57	0.01
2 x 1974	1928	778	2706	3536	1097	4633	0.5	0.7	0.6	28.11	28.10	0.01
5 x 1974	1579	2369	3948	3536	3544	7080	0.4	0.7	0.6	36.61	36.60	0.01
8 x 1974	639	2481	3120	3536	5001	8537	0.2	0.5	0.4	41.67	41.66	0.01

* At time of peak water level

Railway Workshop Bridge (QR_025) Structure

Structure Name	Railway Workshop Bridge		
Structure ID	QR_025		
Owner	QR	**Waterway**	Bremer River
Date of Construction	1895	**AMTD**	17000
Date of significant modification	?	**Co-ordinates (GDA 56)**	476213.02E 6945933.83N
Source of Structure Information	Structural Design Drawings (1895)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRM\QR_025 Riverlink Shopping Centre Rail\		

Description	Steel Truss Supported Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	20.6*mAHD	**Number of Barrels**	-
Number of Piers in Waterway	2	**Dimensions**	-
Pier Width	2.2*m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	21.1mAHD		
Rail height	1.7*m		
Span Length	45.57m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Railway Bridge, Ipswich, looking usptream
Image Source	http://en.wikipedia.org/wiki/File:Bremer_R.JPG
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRM\QR_025 Riverlink Shopping Centre Rail\Image.jpg

Railway Workshop Bridge (QR_025) Characteristics

Structure Name	Railway Workshop Bridge
Structure ID	QR_025
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	2688	0	2688	2331	0	2331	1.2	0.0	1.2	21.5	21.5	0.03
1996	1662	0	1662	1105	0	1105	1.5	0.0	1.5	12.33	12.32	0.01
1999	687	0	687	507	0	507	1.4	0.0	1.4	6.62	6.61	0.01
2011	1359	0	1359	2116	0	2116	0.6	0.0	0.6	19.17	19.16	0.01
2013	1789	0	1789	1203	0	1203	1.5	0.0	1.5	13.11	13.10	0.01
1.5 x 1974 (1893 Approx.)	2148	638	2786	2331	597	2927	0.9	1.1	1.0	25.61	25.59	0.02
2 x 1974	2442	1306	3748	2331	1060	3391	1.0	1.2	1.1	28.14	28.11	0.03
5 x 1974	2539	3462	6001	2331	2615	4946	1.1	1.3	1.2	36.64	36.61	0.03
8 x 1974	1722	3222	4943	2331	3538	5868	0.7	0.9	0.8	41.68	41.67	0.02

* At time of peak water level

Hancock Bridge (ICC_058) Structure

Structure Name	Hancock Bridge		
Structure ID	ICC_058		
Owner	ICC	**Waterway**	Bremer River
Date of Construction	1895	**AMTD**	20420
Date of significant modification	?	**Co-ordinates (GDA 56)**	474756.37E 6946775.98N
Source of Structure Information	Survey taken as part of Bremer River Flood Study, Reports 1 and 2		
Link to data source	K:\B20702.k.saw_Brisbane_River\10 Data Management\10-05_Structures\Structure_Details\BRI\BRM\		

Description	Concrete Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	11*mAHD	**Number of Barrels**	-
Number of Piers in Waterway	3	**Dimensions**	-
Pier Width	0.8*m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	14.8*mAHD		
Rail height	1.2*m		
Span Length	18.3m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	HW and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Hancock Bridge, Bremer River flow left to right
Image Source	Imagery provided by ICC
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRM\ICC_058\Image1.JPG

Hancock Bridge (ICC_058) Characteristics

Structure Name	Hancock Bridge
Structure ID	ICC_058
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	1324	3179	4502	750	1569	2319	1.8	2.0	1.9	23.3	23.2	0.08
1996	1669	0	1669	750	0	750	2.2	0.0	2.2	14.14	14.01	0.13
1999	690	0	690	362	0	362	1.9	0.0	1.9	8.05	8.04	0.01
2011	799	876	1674	750	705	1456	1.1	1.2	1.2	19.59	19.56	0.03
2013	1794	3	1797	750	6	757	2.4	0.4	2.4	14.92	14.77	0.15
1.5 x 1974 (1893 Approx.)	905	3358	4263	750	2357	3108	1.2	1.4	1.4	26.04	26.01	0.04
2 x 1974	838	4108	4946	750	3099	3849	1.1	1.3	1.3	28.52	28.48	0.03
5 x 1974	1058	9461	10519	750	5650	6400	1.4	1.7	1.6	37.02	36.97	0.05
8 x 1974	1168	13231	14399	750	7157	7907	1.6	1.8	1.8	42.04	41.98	0.06

* At time of peak water level

Wulkuraka Rail Bridge (QR_103) Structure

Structure Name	Wulkuraka Rail Bridge		
Structure ID	QR_103		
Owner	QR	**Waterway**	Bremer River
Date of Construction	1895	**AMTD**	22300
Date of significant modification	?	**Co-ordinates (GDA 56)**	474327.63E 6945513.17N
Source of Structure Information	Structural Design Drawings (1895)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRM\QR_103 DIxon St\		

Description	Steel Truss Supported Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	25.5mAHD	**Number of Barrels**	-
Number of Piers in Waterway	8	**Dimensions**	-
Pier Width	1.2m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	28.1*mAHD		
Rail height	2.2*m		
Span Length	46.5m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Wulkuraka Rail Bridge, Aerial Imagery
Image Source	Imagery provided by ICC
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRM\QR_103 DIxon St\Aerial.JPG

Wulkuraka Rail Bridge Hydraulic Structure Reference Sheet
Bremer River

Wulkuraka Rail Bridge (QR_103) Characteristics

Structure Name	Wulkuraka Rail Bridge
Structure ID	QR_103
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	4550	0	4550	2310	0	2310	2.0	0.0	2.0	24.8	24.8	0.01
1996	1665	0	1665	901	0	901	1.8	0.0	1.8	16.02	16.01	0.01
1999	686	0	686	366	0	366	1.9	0.0	1.9	10.70	10.70	0.01
2011	2325	0	2325	1444	0	1444	1.6	0.0	1.6	20.46	20.46	0.01
2013	1801	0	1801	978	0	978	1.8	0.0	1.8	16.70	16.69	0.01
1.5 x 1974 (1893 Approx.)	6573	0	6573	2625	0	2625	2.5	0.0	2.5	27.73	27.55	0.18
2 x 1974	7810	814	8624	2625	388	3013	3.0	2.1	2.9	29.70	29.43	0.27
5 x 1974	7252	7300	14551	2625	2334	4959	2.8	3.1	2.9	37.75	37.54	0.21
8 x 1974	5924	9297	15221	2625	3482	6107	2.3	2.7	2.5	42.50	42.36	0.14

* At time of peak water level

One Mile Bridge (ICC_057) Structure

Structure Name	One Mile Bridge		
Structure ID	ICC_057		
Owner	ICC	**Waterway**	Bremer River
Date of Construction	1936	**AMTD**	24230
Date of significant modification	2004	**Co-ordinates (GDA 56)**	475079.71E 6944381.61N
Source of Structure Information	Structural Design Drawings, Upgrade (2004)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRM\ICC_057\		

Description	Concrete bridge on Bremer River downstream of Deebing Creek confluence		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	15.43mAHD	**Number of Barrels**	-
Number of Piers in Waterway	3	**Dimensions**	-
Pier Width	1.2m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	17.43mAHD		
Rail height	1.4m		
Span Length	29.7-30.0m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	One Mile Bridge, looking from downstream
Image Source	BMT WBM, 2015
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRM\ICC_057\P4133343.JPG

One Mile Bridge (ICC_057) Characteristics

Structure Name	One Mile Bridge
Structure ID	ICC_057
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	1051	3453	4504	1095	3036	4131	1.0	1.1	1.1	25.9	25.9	0.02
1996	1597	74	1671	1095	52	1147	1.5	1.4	1.5	18.08	18.03	0.05
1999	685	0	685	709	0	709	1.0	0.0	1.0	13.45	13.44	0.01
2011	1089	1364	2453	1095	1179	2274	1.0	1.2	1.1	21.73	21.70	0.03
2013	1616	189	1805	1095	123	1218	1.5	1.5	1.5	18.67	18.61	0.06
1.5 x 1974 (1893 Approx.)	1069	4988	6057	1095	4299	5394	1.0	1.2	1.1	28.74	28.71	0.02
2 x 1974	1134	6431	7566	1095	5222	6317	1.0	1.2	1.2	30.80	30.78	0.03
5 x 1974	950	9535	10486	1095	8871	9966	0.9	1.1	1.1	38.96	38.94	0.02
8 x 1974	454	7039	7493	1095	10772	11867	0.4	0.7	0.6	43.21	43.20	0.01

* At time of peak water level

Three Mile Bridge (ICC_056) Structure

Structure Name	Three Mile Bridge		
Structure ID	ICC_056		
Owner	ICC	**Waterway**	Bremer River
Date of Construction	1970	**AMTD**	29310
Date of significant modification	2004	**Co-ordinates (GDA 56)**	473160.25E 6943533.27N
Source of Structure Information	Structural Design Drawings (2006)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRM\ICC_056\		

Description	Concrete bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	16.7mAHD	**Number of Barrels**	-
Number of Piers in Waterway	2	**Dimensions**	-
Pier Width	0.55m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	19.2mAHD		
Rail height	1.3*m		
Span Length	25m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Three Mile Bridge, looking form upstream
Image Source	BMT WBM, 2015
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRM\ICC_056\P4133317.JPG

Three Mile Bridge (ICC_056) Characteristics

Structure Name	Three Mile Bridge
Structure ID	ICC_056
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	45	1029	1074	257	2094	2352	0.2	0.5	0.5	26.9	26.9	0.00
1996	349	685	1033	257	408	665	1.4	1.7	1.6	21.19	21.13	0.06
1999	465	0	465	257	0	257	1.8	0.0	1.8	17.45	17.33	0.12
2011	244	1346	1591	257	1123	1380	1.0	1.2	1.2	23.70	23.68	0.03
2013	249	596	845	257	485	742	1.0	1.2	1.1	21.50	21.46	0.04
1.5 x 1974 (1893 Approx.)	18	1032	1050	257	2836	3093	0.1	0.4	0.3	29.31	29.31	0.00
2 x 1974	11	1054	1065	257	3424	3681	0.0	0.3	0.3	31.23	31.23	0.00
5 x 1974	1	973	974	257	5833	6090	0.0	0.2	0.2	39.11	39.11	0.00
8 x 1974	0	375	375	257	7108	7365	0.0	0.1	0.1	43.28	43.28	0.00

* At time of peak water level

Cunningham Hwy (TMR_048) Structure

Structure Name	Cunningham Hwy		
Structure ID	TMR_048		
Owner	TMR	**Waterway**	Warrill Ck
Date of Construction	1991	**AMTD**	7630
Date of significant modification		**Co-ordinates (GDA 56)**	470262.48E 6940695.99N
Source of Structure Information	Structural Design Drawings (1991)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\WAR\TMR_048 Cunningham Hwy\		

Description	Flat Deck Concrete Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	25.6mAHD	**Number of Barrels**	-
Number of Piers in Waterway	6	**Dimensions**	-
Pier Width	0.7m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	27mAHD		
Rail height	0.75m		
Span Length	14m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Cunningham hwy over Warrill Creek
Image Source	BMT WBM, 2015
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\WAR\TMR_048 Cunningham Hwy\P4133311.JPG

Cunningham Hwy (TMR_048) Characteristics

Structure Name	Cunningham Hwy
Structure ID	TMR_048
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	-	-	-	-	-	-	-	-	-	-	-	-
1996	266	0	266	268	0	268	1.0	0.0	1.0	23.45	23.44	0.02
1999	68	0	68	110	0	110	0.6	0.0	0.6	20.88	20.87	0.01
2011	106	0	106	302	0	302	0.4	0.0	0.4	23.94	23.94	0.01
2013	95	0	95	238	0	238	0.4	0.0	0.4	22.98	22.98	0.01
1.5 x 1974 (1893 Approx.)	163	341	504	513	714	1227	0.3	0.5	0.4	29.37	29.37	0.00
2 x 1974	107	479	586	513	1406	1919	0.2	0.3	0.3	31.26	31.26	0.00
5 x 1974	68	898	966	513	5371	5884	0.1	0.2	0.2	39.12	39.12	0.00
8 x 1974	74	1328	1402	513	7931	8443	0.1	0.2	0.2	43.30	43.30	0.00

* At time of peak water level

Cunningham Hwy (TMR_049) Structure

Structure Name	Cunningham Hwy		
Structure ID	TMR_049		
Owner	TMR	**Waterway**	Purga Ck
Date of Construction	1991	**AMTD**	2290
Date of significant modification		**Co-ordinates (GDA 56)**	472413.14E 6940314.45N
Source of Structure Information	Structural Design Drawings (1991)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\PRG\TMR_049 Cunningham Hwy\		

Description	Flat Deck Concrete Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	25.3mAHD	**Number of Barrels**	-
Number of Piers in Waterway	3	**Dimensions**	-
Pier Width	0.7m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	26.8mAHD		
Rail height	0.75m		
Span Length	16m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Cunningham hwy over Purga Creek
Image Source	Imagery provided by ICC
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\PRG\TMR_049 Cunningham Hwy\Image1.JPG

Cunningham Hwy (TMR_049) Characteristics

Structure Name	Cunningham Hwy
Structure ID	TMR_049
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	**Discharge (m^3/s)***			**Area (m^2)***			**Velocity (m/s)***			**Peak Water Surface Level* (mAHD)**		**Max Afflux (m)**
	Under Deck	**Over Deck**	**Total**	**Under Deck**	**Over Deck**	**Total**	**Under Deck**	**Over Deck**	**Total**	**US**	**DS**	
1974	-	-	-	-	-	-	-	-	-	-	-	-
1996	408	0	408	297	0	297	1.4	0.0	1.4	24.56	24.55	0.01
1999	187	0	187	150	0	150	1.3	0.0	1.3	22.86	22.85	0.01
2011	771	0	771	471	0	471	1.6	0.0	1.6	26.31	26.25	0.06
2013	1063	19	1082	544	32	576	2.0	0.6	1.9	27.13	26.99	0.14
1.5 x 1974 (1893 Approx.)	480	687	1167	544	952	1496	0.9	0.7	0.8	29.46	29.44	0.01
2 x 1974	186	700	886	544	1743	2287	0.3	0.4	0.4	31.26	31.26	0.00
5 x 1974	106	1523	1629	544	5179	5723	0.2	0.3	0.3	39.12	39.12	0.00
8 x 1974	124	2352	2476	544	7003	7547	0.2	0.3	0.3	43.29	43.29	0.00

* At time of peak water level

O'Reilly's Weir (SRC_071) Structure

Structure Name	O'Reilly's Weir		
Structure ID	SRC_071		
Owner	SEQw	**Waterway**	Lockyer Ck
Date of Construction	1951	**AMTD**	1480
Date of significant modification		**Co-ordinates (GDA 56)**	459557.06E 6967166.25N
Source of Structure Information	Various As-Constructed and Maintenance Plans (1951)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\LKY\SRC_071\		

Description	Concrete single-cell weir		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	-mAHD	**Number of Barrels**	-
Number of Piers in Waterway	-	**Dimensions**	-
Pier Width	-m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	31.1mAHD		
Rail height	-m		
Span Length	27.6m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	Weir Channel
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	O'Reilly's Weir, looking upstream
Image Source	BMT WBM, 2014
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\LKY\SRC_071\Image_2014.jpg

O'Reilly's Weir (SRC_071) Characteristics

Structure Name	O'Reilly's Weir
Structure ID	SRC_071
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	0	-1126	-1126	0	2071	2071	0.0	-0.5	-0.5	47.4	47.4	-0.01
1996	0	2334	2334	0	746	746	0.0	3.1	3.1	39.73	39.51	0.22
1999	0	519	519	0	267	267	0.0	1.9	1.9	35.52	35.44	0.08
2011	0	-595	-595	0	2150	2150	0.0	-0.3	-0.3	47.73	47.74	0.00
2013	0	2377	2377	0	746	746	0.0	3.2	3.2	39.73	39.50	0.23
1.5 x 1974 (1893 Approx.)	0	-1257	-1257	0	2492	2492	0.0	-0.5	-0.5	49.24	49.24	0.00
2 x 1974	0	-1766	-1766	0	2759	2759	0.0	-0.6	-0.6	50.42	50.43	-0.01
5 x 1974	0	-1789	-1789	0	4925	4925	0.0	-0.4	-0.4	59.99	59.99	0.00
8 x 1974	0	-2023	-2023	0	6624	6624	0.0	-0.3	-0.3	67.50	67.50	0.00

* At time of peak water level

Pointings Bridge (SRC_070) Structure

Structure Name	Pointings Bridge		
Structure ID	SRC_070		
Owner	SRC	**Waterway**	Lockyer Ck
Date of Construction	?	**AMTD**	3930
Date of significant modification	2010	**Co-ordinates (GDA 56)**	457621.09E 6964188.17N
Source of Structure Information	As-Construcuted Drawings (2009)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\LKY\SRC_070\		

Description	Concrete Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	38.7mAHD	**Number of Barrels**	-
Number of Piers in Waterway	2	**Dimensions**	-
Pier Width	1.05m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	40.2mAHD		
Rail height	1.2*m		
Span Length	29.9, 30m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Pointings Bridge, looking downstream
Image Source	BMT WBM, 2014
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\LKY\SRC_070\IMG_4972.JPG

Pointings Bridge (SRC_070) Characteristics

Structure Name	Pointings Bridge
Structure ID	SRC_070
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-
2011	666	931	1597	407	418	825	1.6	2.2	1.9	48.55	48.46	0.10
2013	946	563	1509	407	217	623	2.3	2.6	2.4	44.53	44.36	0.17
1.5 x 1974 (1893 Approx.)	625	779	1404	407	464	871	1.5	1.7	1.6	49.48	49.42	0.06
2 x 1974	316	474	789	407	512	919	0.8	0.9	0.9	50.44	50.42	0.02
5 x 1974	30	243	273	407	990	1396	0.1	0.2	0.2	59.99	59.99	0.00
8 x 1974	23	240	262	407	1365	1772	0.1	0.2	0.1	67.50	67.50	0.00

* At time of peak water level

Brisbane Valley Rail Trail, Mahons Rd (QR_065) Structure

Structure Name	Brisbane Valley Rail Trail, Mahons Rd		
Structure ID	QR_065		
Owner	QR	**Waterway**	Lockyer Ck
Date of Construction	1926	**AMTD**	13510
Date of significant modification		**Co-ordinates (GDA 56)**	453580.13E 6966961.39N
Source of Structure Information	Structural Design Drawings (1926)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\BRI\QR_065\		

Description	Wooden Railway Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	51.5mAHD	**Number of Barrels**	-
Number of Piers in Waterway	2	**Dimensions**	-
Pier Width	0.85m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	52.5mAHD		
Rail height	-m		
Span Length	6.7m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Brisbane Valley Rail Trail bridge
Image Source	http://www.railtrail.com/qld/bvrt_linville_blackbutt/07.jpg
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\LKY\QR_065\Image.jpg

Brisbane Valley Rail Trail, Mahons Rd (QR_065) Characteristics

Structure Name	Brisbane Valley Rail Trail, Mahons Rd
Structure ID	QR_065
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	1716	230	1946	825	125	951	2.1	1.8	2.0	53.8	53.6	0.18
1996	1304	106	1410	825	75	900	1.6	1.4	1.6	53.25	53.13	0.11
1999	547	0	547	522	0	522	1.0	0.0	1.0	47.75	47.74	0.01
2011	1729	234	1962	825	127	952	2.1	1.8	2.1	53.77	53.59	0.18
2013	1317	112	1429	825	77	903	1.6	1.5	1.6	53.27	53.16	0.12
1.5 x 1974 (1893 Approx.)	2253	413	2666	825	184	1009	2.7	2.2	2.6	54.34	54.03	0.31
2 x 1974	2601	633	3234	825	244	1069	3.2	2.6	3.0	54.94	54.52	0.42
5 x 1974	455	689	1144	825	755	1580	0.6	0.9	0.7	60.05	60.03	0.02
8 x 1974	40	539	579	825	1501	2326	0.0	0.4	0.2	67.51	67.50	0.00

* At time of peak water level

Watsons Bridge (SRC_064) Structure

Structure Name	Watsons Bridge		
Structure ID	SRC_064		
Owner	SRC	**Waterway**	Lockyer Ck
Date of Construction	?	**AMTD**	18460
Date of significant modification	1982	**Co-ordinates (GDA 56)**	454415.25E 6964784.8N
Source of Structure Information	Structural Design Drawings (1982)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\LKY\SRC_064\		

Description	Concrete Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	52.3mAHD	**Number of Barrels**	-
Number of Piers in Waterway	3	**Dimensions**	-
Pier Width	0.5m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	53mAHD		
Rail height	0.3m		
Span Length	18m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Watsons Bridge, looking upstream
Image Source	BMT WBM, 2014
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\LKY\SRC_064\IMG_4962.JPG

Watsons Bridge (SRC_064) Characteristics

Structure Name	Watsons Bridge
Structure ID	SRC_064
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	-	-	-	-	-	-	-	-	-	-	-	-
1996	713	388	1101	575	275	850	1.2	1.4	1.3	56.56	56.52	0.04
1999	367	0	367	493	0	493	0.7	0.0	0.7	51.08	51.07	0.01
2011	826	483	1309	575	299	874	1.4	1.6	1.5	56.86	56.81	0.05
2013	727	401	1128	575	279	854	1.3	1.4	1.3	56.61	56.57	0.04
1.5 x 1974 (1893 Approx.)	1293	265	1558	575	312	887	2.2	0.8	1.8	57.03	57.01	0.01
2 x 1974	1474	349	1823	575	334	908	2.6	1.0	2.0	57.29	57.27	0.02
5 x 1974	66	212	278	575	554	1129	0.1	0.4	0.2	60.05	60.05	0.01
8 x 1974	6	246	252	575	1151	1726	0.0	0.2	0.1	67.51	67.51	0.00

* At time of peak water level

Lyons Bridge (SRC_063) Structure

Structure Name	Lyons Bridge		
Structure ID	SRC_063		
Owner	SRC	**Waterway**	Lockyer Ck
Date of Construction	1955	**AMTD**	27480
Date of significant modification	?	**Co-ordinates (GDA 56)**	453585.31E 6961344.89N
Source of Structure Information	Site photographs		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\LKY\SRC_063\		

Description	Concrete Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	60.5mAHD	**Number of Barrels**	-
Number of Piers in Waterway	4	**Dimensions**	-
Pier Width	0.8m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	61mAHD		
Rail height	0.5m		
Span Length	30m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Lyons Bridge, looking upstream
Image Source	BMT WBM, 2014
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\LKY\SRC_063\IMG_4959.JPG

Lyons Bridge (SRC_063) Characteristics

Structure Name	Lyons Bridge
Structure ID	SRC_063
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	1218	797	2016	734	364	1098	1.7	2.2	1.8	65.1	65.0	0.11
1996	974	474	1448	734	283	1017	1.3	1.7	1.4	64.33	64.27	0.06
1999	372	0	372	501	0	501	0.7	0.0	0.7	58.32	58.32	0.01
2011	1272	877	2149	734	382	1115	1.7	2.3	1.9	65.32	65.19	0.13
2013	1017	541	1558	734	303	1037	1.4	1.8	1.5	64.53	64.46	0.07
1.5 x 1974 (1893 Approx.)	1360	1052	2412	734	421	1155	1.9	2.5	2.1	65.71	65.56	0.15
2 x 1974	1380	1186	2565	734	451	1184	1.9	2.6	2.2	66.01	65.83	0.17
5 x 1974	1570	1643	3212	734	548	1281	2.1	3.0	2.5	66.98	66.74	0.23
8 x 1974	503	704	1207	734	616	1349	0.7	1.1	0.9	67.66	67.64	0.02

* At time of peak water level

Lyons Bridge Hydraulic Structure Reference Sheet
Lockyer Ck

Pamphlet Bridge (BCC_023) Structure

Structure Name	Pamphlet Bridge		
Structure ID	BCC_023		
Owner	BCC	**Waterway**	Oxley Ck
Date of Construction	1964	**AMTD**	150
Date of significant modification		**Co-ordinates (GDA 56)**	499513.94E 6955446.4N
Source of Structure Information	Hydraulic Structure Reference Sheet (Aurecon 2013)		
Link to data source	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\OXL\BCC_023 Pamphlet Bridge\		

Description	Flat Deck Concrete Bridge		
BRIDGES		**CULVERTS**	
Lowest Point of Deck Soffit	7.1mAHD	**Number of Barrels**	-
Number of Piers in Waterway	3	**Dimensions**	-
Pier Width	0.7m	**Length**	-
		Upstream invert	-
		Downstream Invert	-
Lowest point of Deck/Embankment	8.1mAHD		
Rail height	0.8*m		
Span Length	16.7m - 21.3m		

*estimated

Included in Fast Model (FM)	Yes	**FM Representation**	XZ and LC table
Included in Detailed Model (DM)	TBC	**DM Representation**	

Image Description	Pamphlet Bridge, looking from downstream
Image Source	BMT WBM, 2015
Image Location	B:\B20702 BRCFS Hydraulics\10_Data Management\10_03_Structures\Structure_Details\OXL\BCC_023 Pamphlet Bridge\P4133295.JPG

Pamphlet Bridge (BCC_023) Characteristics

Structure Name	Pamphlet Bridge
Structure ID	BCC_023
Link to model data	B:\B20702 BRCFS Hydraulics\50_Hydraulic_Models\200_Calibration_S2\TUFLOW\F\model\bg\CSV

FAST MODEL

Event	Discharge (m^3/s)*			Area (m^2)*			Velocity (m/s)*			Peak Water Surface Level* (mAHD)		Max Afflux (m)
	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	Under Deck	Over Deck	Total	US	DS	
1974	411	241	652	506	226	731	0.8	1.1	0.9	11.0	11.0	0.02
1996	34	0	34	279	0	279	0.1	0.0	0.1	3.68	3.68	0.00
1999	-29	0	-29	170	0	170	-0.2	0.0	-0.2	1.85	1.85	0.00
2011	262	64	326	506	91	597	0.5	0.7	0.5	9.28	9.27	0.01
2013	218	0	218	269	0	269	0.8	0.0	0.8	3.52	3.51	0.01
1.5 x 1974 (1893 Approx.)	283	510	793	506	529	1035	0.6	1.0	0.8	14.92	14.84	0.08
2 x 1974	363	821	1184	506	763	1269	0.7	1.1	0.9	18.01	17.99	0.02
5 x 1974	287	1328	1615	506	1502	2008	0.6	0.9	0.8	27.60	27.59	0.01
8 x 1974	333	1987	2319	506	1926	2432	0.7	1.0	1.0	33.11	33.09	0.02

* At time of peak water level

Appendix D River Gauge Data of Questionable Quality

Seqwater (2011, 2013a, 2013b) identified gauge data that was erroneous and of insufficient quality for use. In the course of the current study, additional gauge data have been identified as having questionable quality. This Appendix provides further discussion on these datasets. A summary of gauges and the availability of data is provided in Table 2-1.

1996 Event

Aside from that gauge data already identified as erroneous or missing, no additional gauges were found to have questionable data in the 1996 event.

1999 Event

In 1999 the Moggill gauge failed around the time of the peak as shown in Figure D-1. The Jindalee gauge does not appear to fail but it is likely that the raw gauge data does not include the peak of the flood event, as shown in Figure D-1. These recordings are presented in the time series plots but are not included in Table 4-3, which compares peak recorded with peak modelled flows.

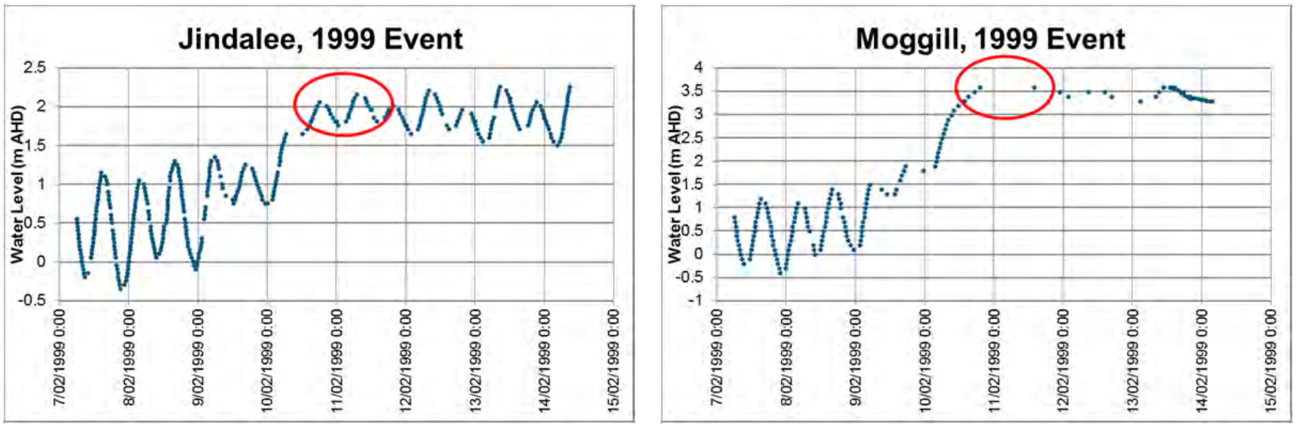

Figure D-1 Questionable 1999 Event Hydrographs, Jindalee & Moggill

The Walloon gauge on the Bremer River appears to have a datum error in recorded levels for the 1999 event. As shown in Figure D-2, the recorded level hydrograph consistently lies about 2m below the modelled level hydrograph. The recorded flood level prior to the arrival of the flood event at the gauge is about 15.8m AHD, however gauge zero for this gauge is 16.4m AHD. Thus, the gauge record is providing a level below gauge zero, which is not possible. Hence, it is believed that the Walloon gauge data for the 1999 event is questionable.

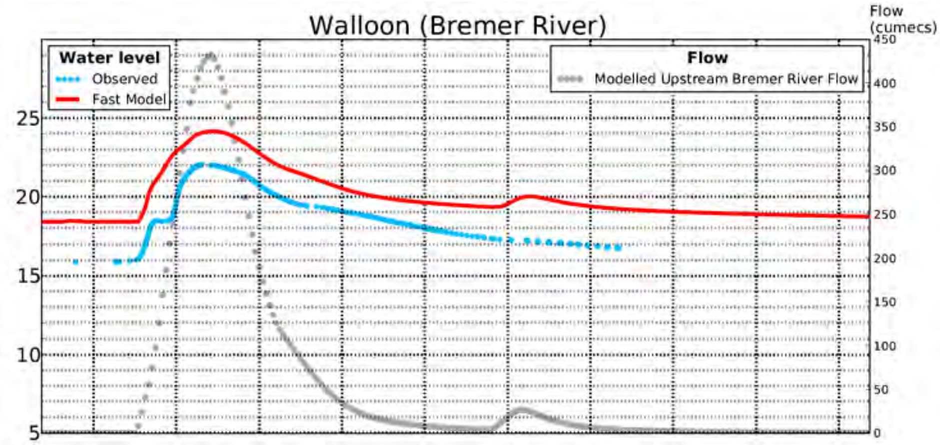

Figure D-2 Questionable 1999 Event Hydrograph, Walloon

2011 Event

The Brisbane River Moggill gauge records for the 2011 event have been investigated by BoM and found to be approximately 0.3m too low (Seqwater, 2013c)[12]. This conclusion was reached based on photographic evidence (reproduced in Figure D-3) taken of the manual gauge board just a few hours before the peak. The automatic gauge records for the Moggill gauge in 2011 are also provided in Figure D-3 with the corrected peak level of 18.17m AHD shown. This correction is reflected in all discussion and plots relating to the Moggill Gauge in the 2011 event within this current report.

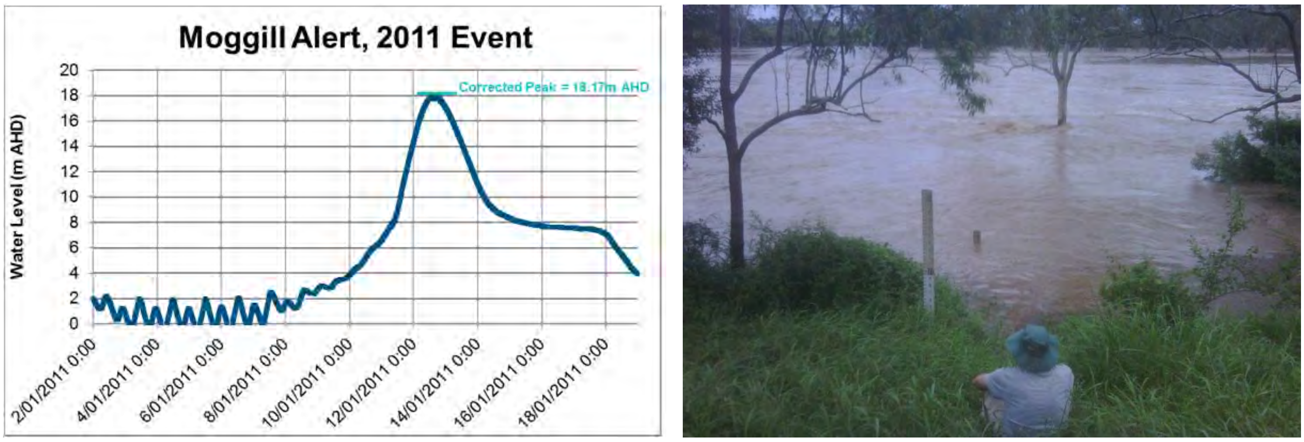

Photo of Moggill Gauge Board (courtesy of Shapland Family via Seqwater (2103c))

Figure D-3 Moggill Gauge in 2011 Flood Event

Several other gauges also experienced issues during this event. Wivenhoe Dam Tailwater, Colleges Crossing and Kholo Bridge all missed the peak of the event. The gauge hydrographs are shown Figure D-4.

The Hancock Bridge gauge on the Bremer River appears to have a datum error for the 2011 event. The hydrograph for this gauge (see below) has a tidal signal that is too high and the flood hydrograph peaks at a similar level to the upstream One Mile Bridge gauge peak (see Plot 27). It is suggested that a datum shift of between 1.5m and 2m needs to be applied (i.e. reduce the recorded levels by this amount).

Three Mile Bridge Gauge is located on the Bremer River, as shown in Figure D-4. In the 2011 event, the recorded level hydrograph at the gauge appears to be complete as shown below. However, the peak level recorded at the gauge for the 2011 event (27.05m AHD) is significantly higher than surrounding flood mark level records. This is demonstrated in Figure D-4, comparing flood mark levels with the peak gauge level. As the surrounding flood mark levels are sufficient in number and consistency to create confidence in their accuracy, the Three Mile Bridge gauge data for the 2011 event must be regarded as erroneous. This was confirmed in discussions with James Charalambous from BCC (personal communication, Dec 2014). As such, the 2011 gauge data has not been used in the calibration of the models.

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[12] This was reported in Seqwater (2013c) Supplementary Digital Data within an email from Peter Baddiley (BoM) to the authors of that report and others.

The Ipswich Gauge appears to have a high tidal signal before and after the flood event compared to surrounding gauges and previous record. However, the peak correlates relatively well with surrounding debris marks. It is suggested that the gauge datum and scaling factor is in error. This hydrograph has been used in the calibration of the models but with less confidence.

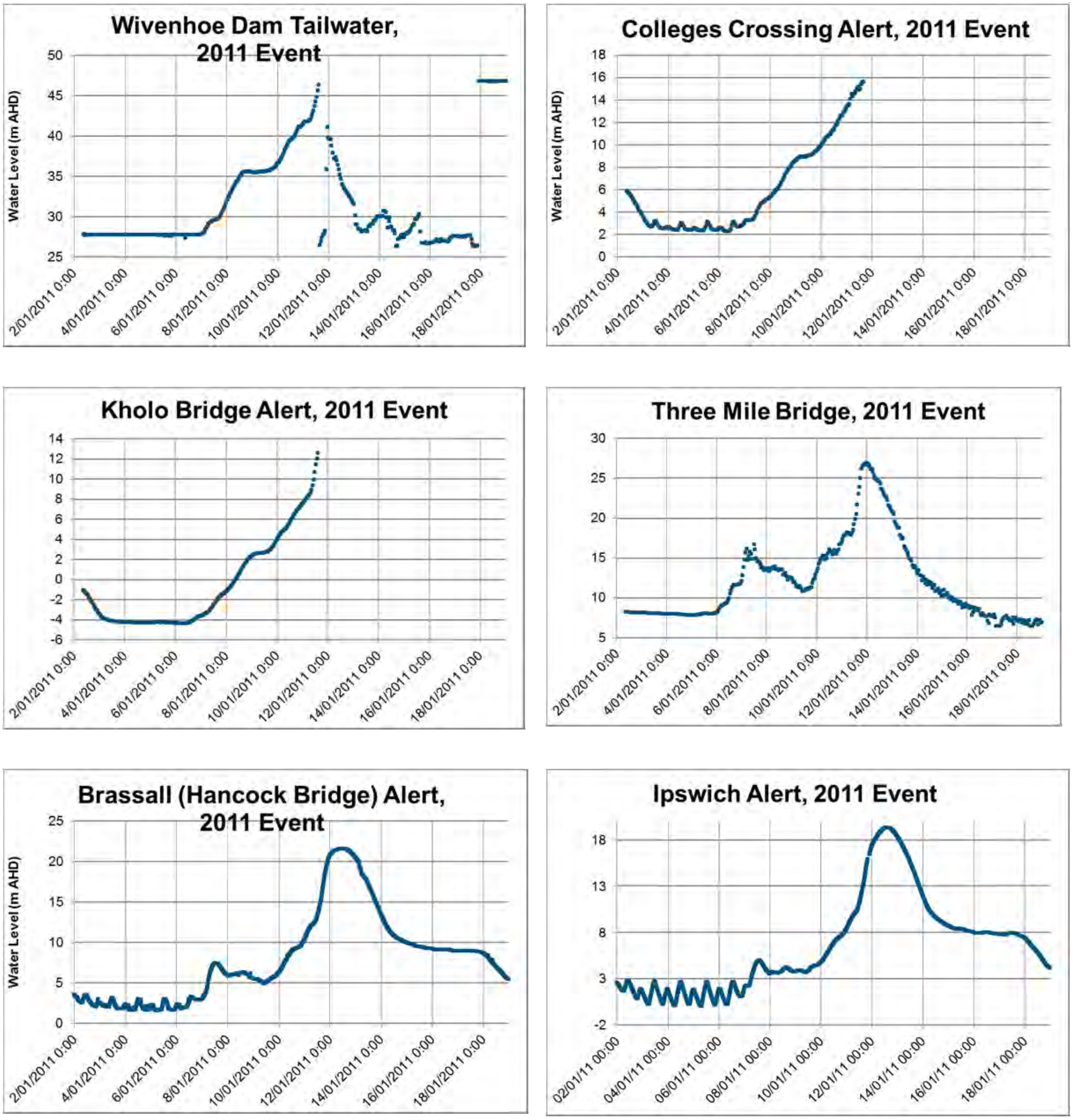

Figure D-4 Questionable 2011 Event Hydrographs

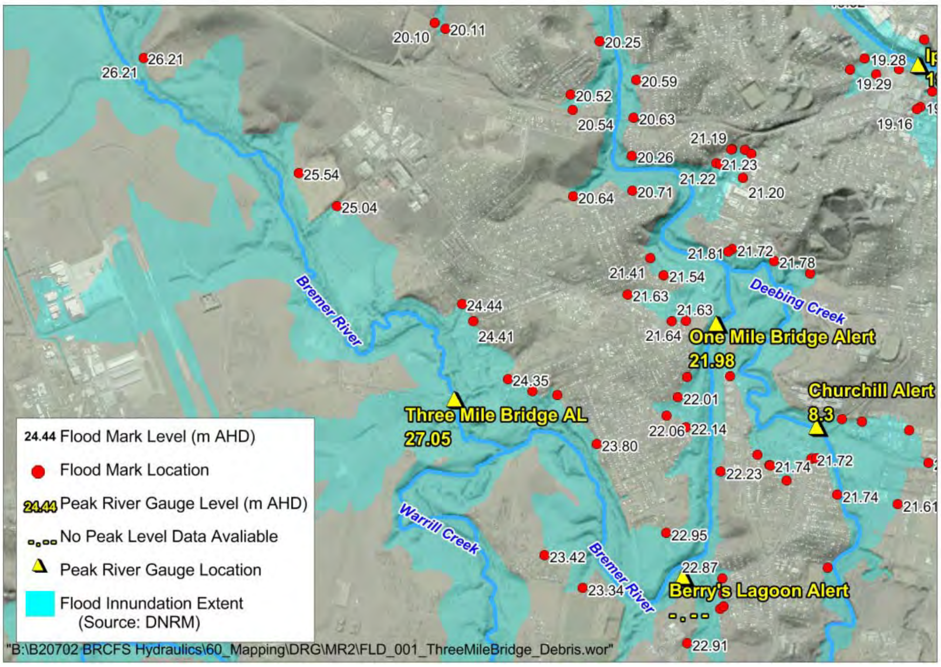

Figure D-5 Comparison of Three Mile Bridge Peak Level to Flood Marks – 2011 Event

2013 Event

Several gauges were identified as providing questionable data for the 2013 event in addition to those already identified by Seqwater (2013a). Amberley (Greens Road) and Brisbane Rd miss the rising limb and peak of the flood hydrograph. Amberley is shown below, while Brisbane Rd recorded one level of 2.72m AHD on 28 January 2013 at 8:24am. This assessment of Amberley is in agreement with Seqwater (2013a), who reported that this gauge “reported suspect readings”.

Colleges Crossing, Bundamba and Brassal (Hancock Bridge) all have scaling issues. Colleges and Bundamba show very little range of levels across the event as shown below. Hancock Bridge is not in agreement with the surrounding flood marks.

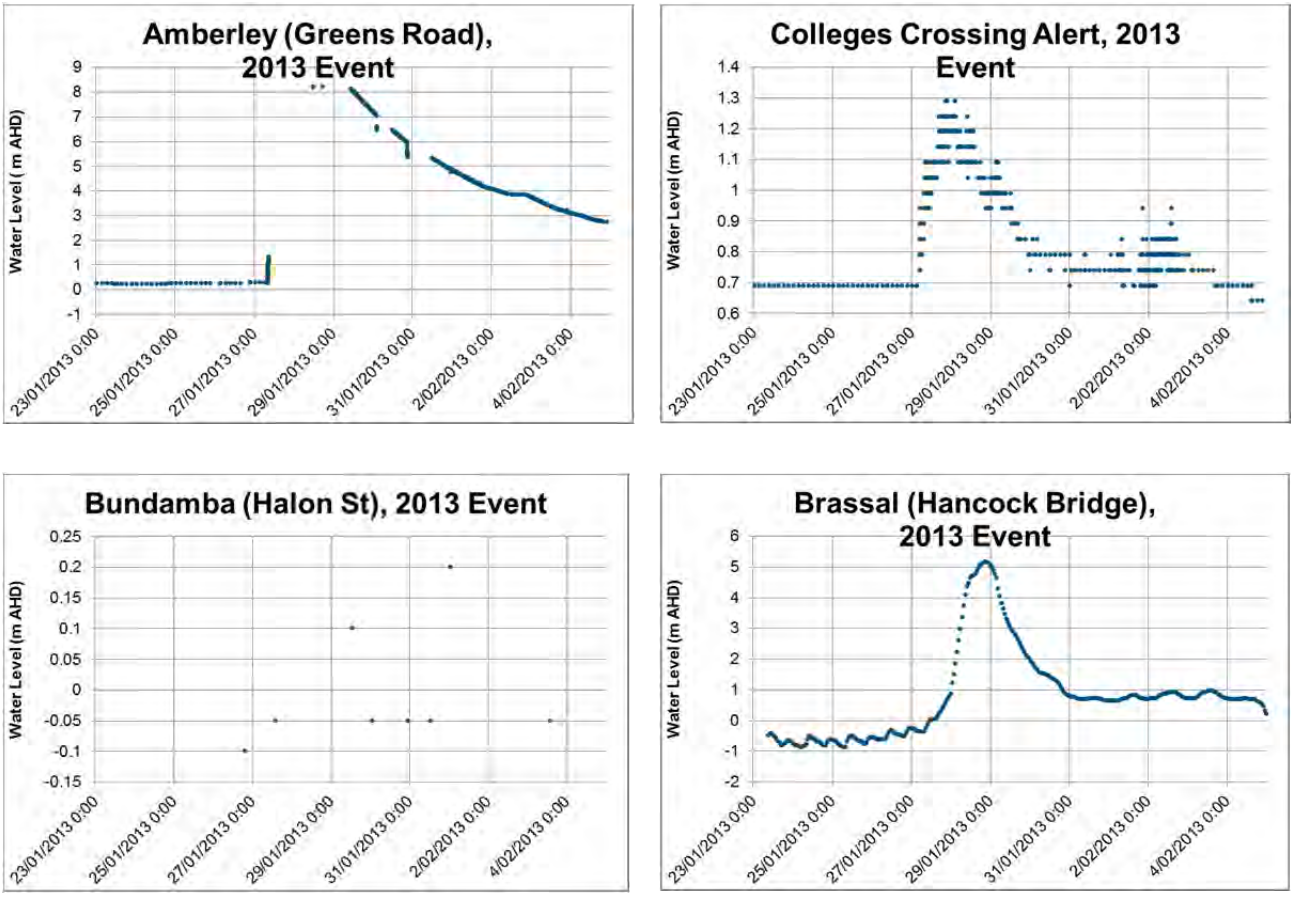

Figure D-6 Questionable 2013 Event Hydrographs

Appendix E Comparison of Gauge Cross-Sections with LiDAR Data

Cross-section information upstream and downstream of gauge sites is held by Seqwater and was supplied to BMT WBM in September 2014. The cross-sections have been used to provide an indication of potential accuracy or otherwise of the LiDAR data used in the in-bank sections of the Fast Model. Only three of the cross-sections provided satisfied the two requirements for comparison:

- Located in an area of the Fast Model that relies on LiDAR data to describe the in-bank channel sections; and
- Survey points had an Easting and Northing (to enable them to be located in a GIS environment over the LiDAR DEM).

A cross-section comparison was undertaken at these 3 locations as described below. In all cases the surveyed cross-sections compared favourably with the LiDAR DEM data. While this cannot be described as a rigorous widespread testing, the comparison does provide some assurance that the accuracy of the LiDAR DEM makes this data fit for the purpose of hydraulic modelling.

Glenore Grove

The surveyed cross-section at Glenore Grove compares reasonably well to the LiDAR data in that area as shown in Figure E-1. The minimum invert level of the survey cross-section is 0.8m higher than the LiDAR DEM data and the cross-sectional area of the survey cross-section is marginally smaller. However, neither of these differences will have a great influence on hydraulic model results.

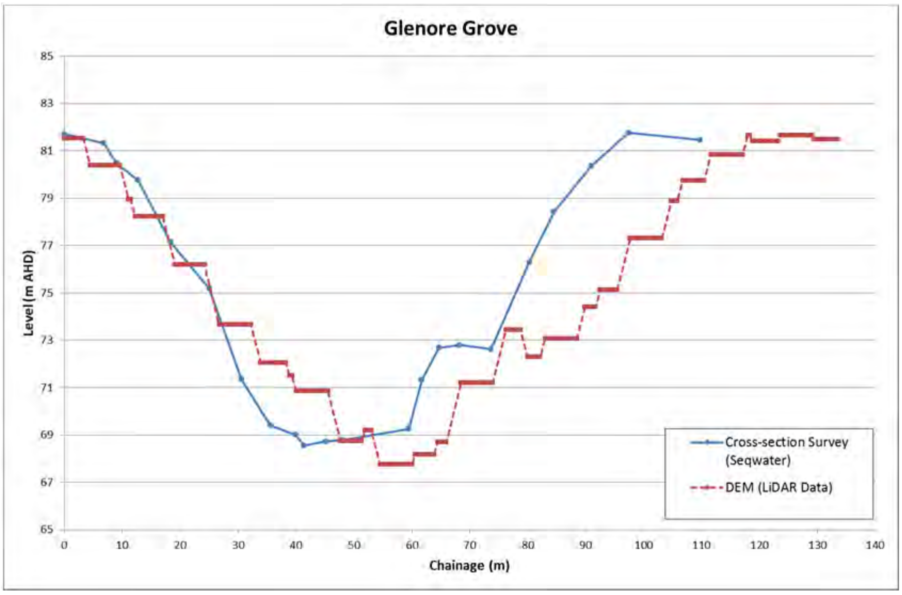

Figure E-1 Comparison of Survey Cross-Section with LiDAR DEM Data at Glenore Grove Lowood

At Lowood, the Seqwater surveyed cross-section compares well with the DTM DEM section as shown in Figure E-2. The reasonable result of this comparison was unexpected as it was believed that the DTM DEM was based solely on LiDAR data in this region. As LiDAR is unable to provide data below the water surface, it was expected that the bathymetry would not be defined at all. However, further investigation revealed that the DTM DEM was manually altered to better reflect the gradient of the river bed through this region. According to BCC (2014b), "*a very basic river bed centreline level was graded using riffles (identified by aerial imagery) and low points of sections taken in the 2008 study in the Lowood Fernvale area*". This graded centreline was used to alter the DMT DEM, thus providing some representation of the bathymetry in the Lowood Fernvale area. This explains the better than expected comparison with the surveyed cross-section.

The minimum invert level of the survey cross-section is 0.3m lower than the LiDAR DEM data and the cross-sectional area of the survey cross-section is marginally smaller. These differences are not expected to significantly impact upon results.

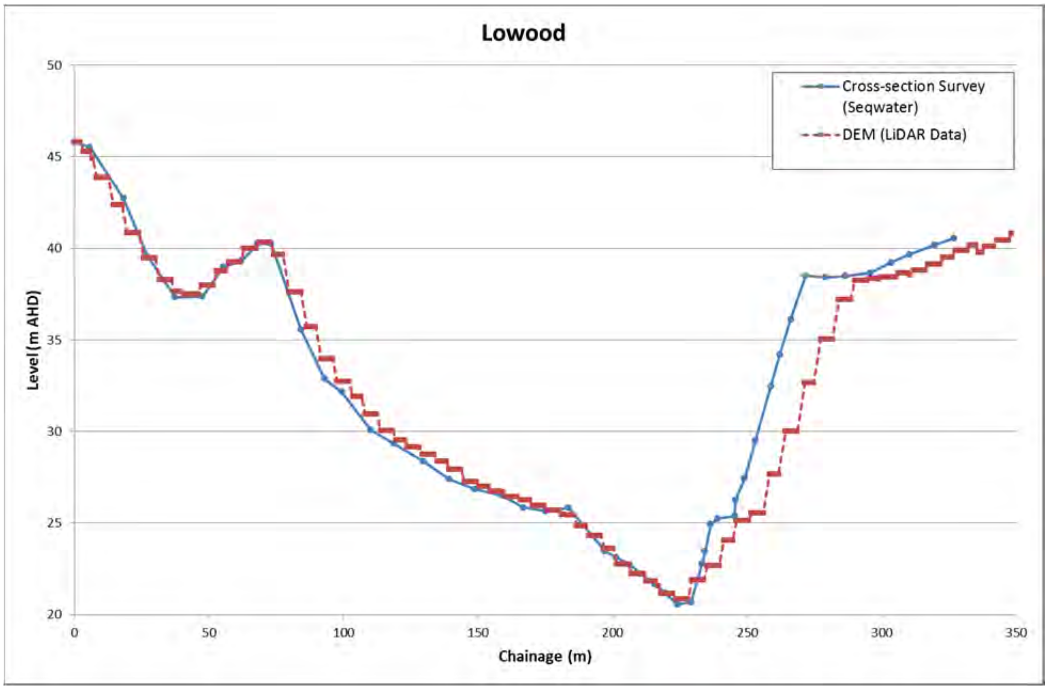

Figure E-2 Comparison of Survey Cross-Section with LiDAR DEM Data at Lowood

Jindalee

Bathymetric data used in the DEM at Jindalee is not based on LiDAR data but rather includes bathymetric survey collected post-2011 flood by MSQ (refer to BCC (2014a,b) and BMT WBM (2014) for further details). Regardless, it is still of interest to compare this with the surveyed Seqwater section. Figure E-3 shows that the surveyed cross-section at Jindalee is in good agreement with the DEM bathymetry. The noticeable difference appears to be due to a horizontal datum shift in either dataset, which will be of no consequence in the Fast Model schematisation. The minimum invert level of the surveyed cross-section is 0.1m lower than the DEM bathymetric data and the cross-sectional area to top of bank of both sections is very similar. A significant difference is noted out-of-bank on the left bank, with the surveyed cross-section rising above the DEM (LiDAR in this region of the section) by up to about 20m. Figure E-4 demonstrates that the surveyed cross-section points (in red) appear to cross Moggill Creek but the creek is obviously not present in the surveyed cross-section points. Without further information it is believed that the easting and northings of the surveyed cross-section points on the left bank are incorrect. As it is the in-bank portions of the cross-sections that is the focus of this comparison, the comparison shows that the in-bank portions of the DEM bathymetry is of comparable accuracy to the surveyed section and suitable for use in the Fast Model.

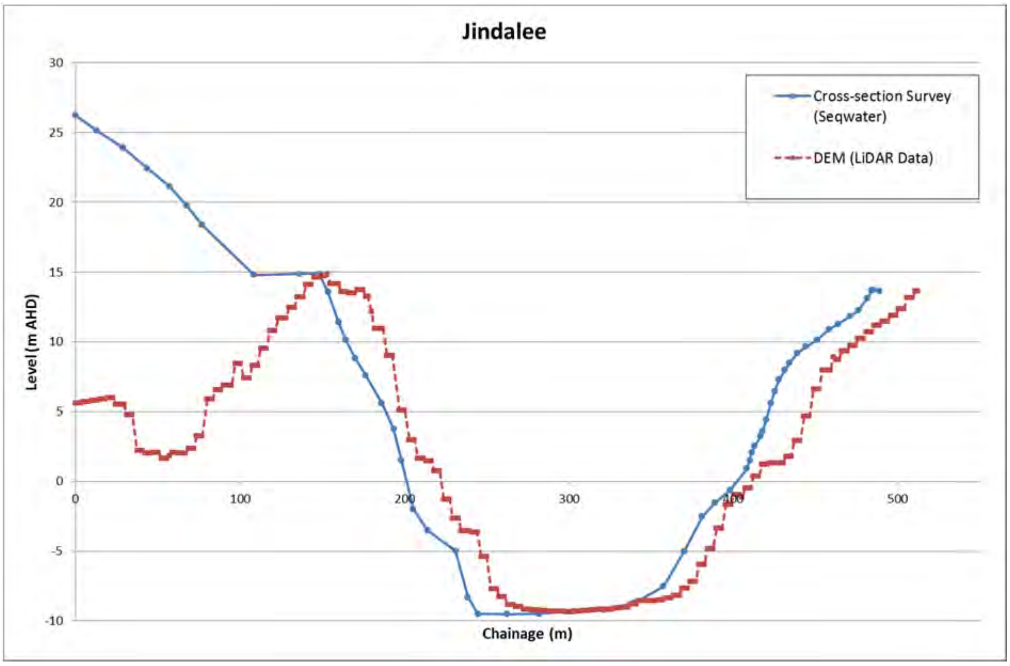

Figure E-3 Comparison of Survey Cross-Section with LiDAR DEM Data at Lowood

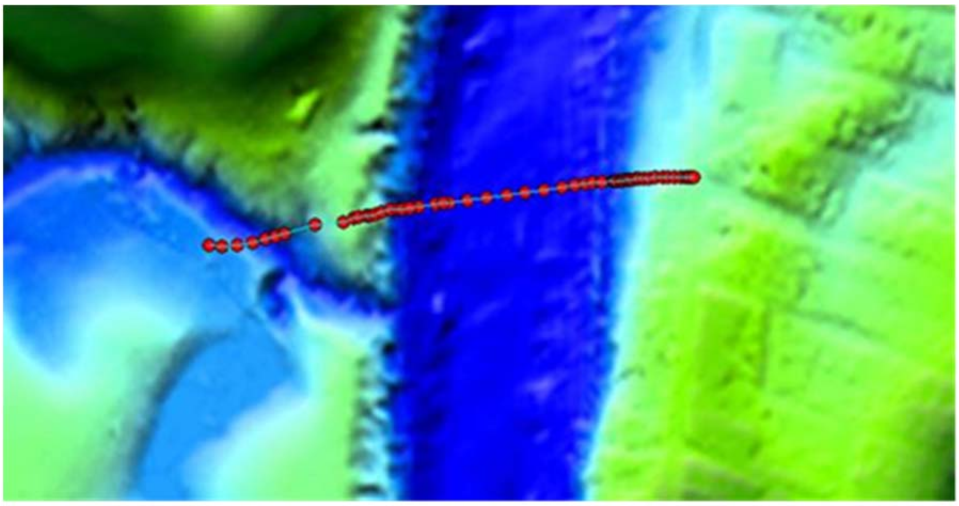

Figure E-4 DEM Overlain with Location of Surveyed Cross-Section Points (in red)