Cabbage Tree Creek Flood Study

Volume 1 of 2

Flood Study Report

Prepared by Brisbane City Council's, City Projects Office

August 2019

Flood Study Report Disclaimer

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Executive Summary

Introduction

Brisbane City Council is in the process of updating all of its creek flood studies to reflect the current conditions of the catchment and best practice flood modelling techniques. The most recent flood study of the Cabbage Tree Creek Catchment was completed by AECOM on behalf of BCC in 2013 / 2014. Since this time, there have been a number of significant changes within the catchment as well as to planning and policy documents.

The Cabbage Tree Creek Catchment is located approximately 14 km north of the Brisbane CBD and includes the suburbs of Ferny Hills, Arana Hills, Everton Hills, McDowall, Bridgeman Downs, Aspley, Carseldine, Fitzgibbon, Taigum, Bracken Ridge, Deagon, Boondall, Sandgate and Shorncliffe. The catchment has a total area of 43.2 km^2 and features two major creeks; namely Cabbage Tree Creek and Little Cabbage Tree Creek. There are several smaller creeks including Carseldine Channel and Taigum Channel as well as the minor tributaries of Fitzgibbon, Deagon and Sandgate.

Project Objectives

The primary objectives of the project are as follows:

- Update the Cabbage Tree Creek flood models (hydrologic and hydraulic) with the latest topographical data and incorporate the most recent major development / infrastructure works as well as the current planning scheme (City Plan 2014).
- Adequately calibrate and verify the flood models to recent historical storm events to confirm that the models are suitable for the purposes of simulating design flood events.
- Estimate design and rare / extreme flood magnitudes in accordance with AR&R 2019 and incorporating increased rainfall intensities due to projected climate variability effects.
- Determine flood levels for the design and rare / extreme events, accounting for the effects of Minimum Riparian Corridor (MRC) and floodplain development / filling in accordance with current planning policy.
- Produce flood extent mapping for the selected range of design and rare / extreme events.
- Quantify the differences in flood level as a result of sea-level increases due to projected climate variability effects.

Project Elements

The flood study consists of two main components, as follows:

Model Set-up and Calibration

Hydrologic and hydraulic models of the Cabbage Tree Creek Catchment have been developed using the URBS and TUFLOW modelling software, respectively.

The hydrologic model simulates the catchment rainfall-runoff and runoff-routing processes. The hydrologic model also utilises high-level channel routing to simulate the flow of floodwater in the major waterways within the catchment. The URBS model incorporated 78 sub-catchments and the delineation is essentially the same as the 2014 Flood Study URBS model, with the major differences being in the Fitzgibbon area, where changes were made to reflect recent development and infrastructure works.

The hydraulic model uses more sophisticated channel routing to simulate the movement of floodwater in order to predict flood levels, flood discharges and velocities. The hydraulic model incorporates the effects of the channel / floodplain topography, downstream tailwater conditions and hydraulic structures. The hydraulic model consists largely of a 1d / 2d linked schematisation, with the 1d domain modelled in ESTRY and the 2d domain in TUFLOW. The model incorporated Cabbage Tree Creek; Little Cabbage Tree Creek; Carseldine Channel; Taigum Channel; Deagon Tributary; Sandgate Tributary and Fitzgibbon Tributary.

Calibration is the process of refining the model parameters to achieve a good agreement between the modelled results and the historical / observed data. Calibration is achieved when the model simulates the historical event to within specified tolerances. Verification is then undertaken on additional flooding event(s) to confirm the calibrated model is suitable for use in simulating synthetic design storm events.

Calibration of the URBS and TUFLOW models was undertaken utilising two historical storms; namely, 1st May 2015 and 4th June 2016. Verification of the URBS and TUFLOW models utilised the 19th June 2016 historical storm event.

An acceptable correlation was achieved between the simulated and historical records for both calibration events. At the Maximum Height Gauges (MHGs), the simulated peak levels were generally within the specified tolerance of ± 0.3 m.

The verification was undertaken utilising the adopted parameters from the calibration process. Similar to the calibration, the verification achieved an acceptable correlation between the simulated and historical records.

Given the results of the calibration and verification process were quite reasonable, the URBS and TUFLOW models were considered acceptable for use in the second part of the flood study, in which design flood levels were estimated.

Design and Extreme Event Modelling

The calibrated hydrologic and hydraulic models were used to simulate a range of synthetic design flood events. Design, very rare and extreme flood magnitudes were estimated for the full range of events from 2-yr ARI (50 % AEP) to PMF. These analyses assumed ultimate catchment hydrological conditions in accordance with BCC City Plan 2014. A fixed tidal boundary was used at the downstream model extent to represent the tidal conditions in Moreton Bay.

Three waterway scenarios were considered, as follows:

- Scenario 1 – Existing Waterway Conditions: Based on the current waterway conditions. Some minor modifications were made to the TUFLOW model developed as part of the calibration / verification.
- Scenario 2 – Minimum Riparian Corridor (MRC): Includes an allowance for a riparian corridor along the edge of the channel.
- Scenario 3 – Ultimate Conditions: Includes an allowance for the minimum riparian corridor (as per Scenario 2) and also assumes development infill to the boundary of the “Modelled Flood Corridor” in order to simulate potential development.

The “Modelled Flood Corridor” is the greater extent of Flood Planning Areas (FPAs) 1, 2 and 3 and the Waterway Corridor.

The results from the TUFLOW modelling were used to determine / produce the following:

- Design flood discharges (Section 6.4.1)
- Design flood levels at 100 m intervals along the AMTD line (Appendices F, G, I and J)
- Scenario 1 design flood extent mapping (Volume 2 of 2)

A sea-level rise analysis for the 100-yr ARI (1 % AEP) event was undertaken to understand the differences in flood level. This involved increasing the downstream boundary level by 0.8 m to allow for the projected sea-level increase for the Year 2100 Planning Horizon

The results indicated that increased 100-yr ARI (1 % AEP) flood levels due to sea-level rise would propagate up the creeks and tributaries to the following extents:

- Cabbage Tree Creek – up to Chainage 5700 m, approximately 300 m upstream of Lemke Road.
- Little Cabbage Tree Creek – no impacts
- Carseldine Channel – up to Chainage 200 m, just upstream of the confluence with Cabbage Tree Creek.
- Taigum Channel – up to Chainage 700 m, approximately 500 m upstream of the Gateway Motorway.
- Deagon Tributary – entire modelled extent is subject to sea-level rise impacts.
- Sandgate Tributary – up to Board Street
- Fitzgibbon Tributary – no impacts

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Glossary of Terms

Term	Definition
2014 ALS Data	This dataset is part of the SEQ 2014 LiDAR capture project and covers an area of approximately 1392 km^2 over Brisbane City. This project was undertaken by Fugro Spatial Solutions Pty Ltd on behalf of the Queensland Government.
AHD	Australian Height Datum (AHD) is the reference level for defining reduced levels adopted by the National Mapping Council of Australia. The level of 0.0 mAHD is approximately mean sea level.
Annual Exceedance Probability(AEP)	The probability that a given rainfall total or flood flow will be exceeded in any one year.
AR&R Data Hub	The Australian Rainfall and Runoff Data Hub is a tool that allows for easy access to the design inputs required to undertake flood estimation in Australia. Background on the development and use of this data can be found in Australian Rainfall and Runoff (2019).
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrence of a flood as big as (or larger than) the selected event. For example, floods with a discharge as great as (or greater than) the 20 year ARI design flood will occur on average once every 20 years.
Brisbane Bar	Location at the mouth of the Brisbane River
Catchment	The area of land draining through the main stream (as well as tributary streams) to a particular site. It always relates to an area above a specific location.
Digital Elevation Model (DEM)	A three-dimensional model of the ground surface elevation.
Design Event, Design Storm	A hypothetical flood/storm representing a specific likelihood of occurrence (for example the 100 year ARI).
ESTRY	ESTRY is the 1d hydrodynamic engine used by TUFLOW.
Floodplain	Area of land subject to inundation by floods up to and including the Probable Maximum Flood (PMF) event.
Flood Frequency Analysis (FFA)	Method of predicting flood flows at a particular location by fitting observed values at the location to a standard statistical distribution.
Flood Planning Area (FPA)	Flood Planning Areas (FPAs) were introduced in BCC City Plan 2014 to better advise on the susceptibility of flooding.
HEC-RAS	Hydraulic modelling software package.
Hydrograph	A graph showing how the discharge or stage/flood level at any particular location varies with time during a flood.
Manning's 'n'	The Gauckler–Manning coefficient, used to represent hydraulic roughness in 1d / 2d flow equations.
MIKE11	Hydraulic modelling software package.

Glossary of Terms (cont)

Term	Definition
Minimum Riparian Corridor (MRC)	An area where future revegetation of the creek riparian zone has been assumed for modelling purposes. Modelled as dense vegetation (nominal Manning's n=0.15) and typically extending for a maximum of 15 m on either side of the low-flow channel.
Modelled Flood Corridor	The "Modelled Flood Corridor" is the greater extent of the Waterway Corridor (WC) and Flood Planning Areas (FPAs) 1, 2, 3 and represents a zone of assumed no filling.
Probable Maximum Flood (PMF)	An extreme flood deemed to be the largest flood that could conceivably occur at a specific location.
Probable Maximum Precipitation (PMP)	The theoretical greatest depth of precipitation that is physically possible over a particular catchment
TIN	Series of non-overlapping triangles from which the 3d vertices (x,y,z) are used as an approximation of the 3d surface.
URBS	Hydrologic modelling software package developed by Don Carroll

Adopted ARI to AEP Conversion

The use of the terms "*recurrence interval*" and "*return period*" has been criticised as leading to confusion in the minds of some decision-makers and members of the public. The recently updated AR&R 2019 utilises different terminology whereby for the larger flood magnitudes the term AEP (%) is now preferred to ARI.

The relationship between ARI and AEP can be expressed by the following equation:

AEP = 1 – exp (-1 / ARI)

Substituting the "Actual ARI" into this equation results in the "Actual AEP" as indicated in the table below. However, it is quite common within the industry to see *AEP = 1 / ARI (nominal)* used for simplicity.

Actual ARI (years)	Nominal ARI (years)	Actual AEP (%)
1.44	2	50
4.48	5	20
10	10	10
20	20	5
50	50	2
100	100	1
200	200	0.5
500	500	0.2
2000	2000	0.05

For the purpose of this study, the "Actual AEP" has been used in conjunction with the "Nominal ARI." The flood probability will be firstly expressed by the "Nominal ARI" and then secondly in brackets by the equivalent "Actual AEP."

List of Abbreviations

Abbreviation	Definition
1d	One dimensional, in the context of hydraulic modelling
2d	Two dimensional, in the context of hydraulic modelling
AMTD	Adopted Middle Thread Distance
ALS	Airborne Laser Scanning
AR&R 1987	Australian Rainfall and Runoff (1987)
AR&R 2019	Australian Rainfall and Runoff (2019)
BCC	Brisbane City Council
CBD	Central Business District
CL	Continuing rainfall loss (mm/hr)
DEA AR&R 1987	Design Event Approach Australian Rainfall and Runoff (1987)
DEA AR&R 2019	Design Event Approach Australian Rainfall and Runoff (2019)
DTMR	Department of Transport and Main Roads (Queensland)
FPA	Flood Planning Area
ICC	Ipswich City Council
IFD	Intensity Frequency Duration
IL	Initial rainfall loss (mm)
IL_s	Initial loss for the rainfall event (mm)
IL_b	Initial loss for the rainfall burst (mm)
IWL	Initial Water Level (mAHD)
LCC	Logan City Council
mAHD	metres above AHD
MBRC	Moreton Bay Regional Council
MHG	Maximum Height Gauge
MRC	Minimum Riparian Corridor
MSQ	Maritime Safety Queensland
POT	Peak Over Threshold
RCBC	Reinforced Concrete Box Culvert
RCP	Reinforced Concrete Pipe
RCP4.5	Representative Concentration Pathway 4.5
RCP8.5	Representative Concentration Pathway 8.5

Abbreviation	Definition
QUDM	Queensland Urban Drainage Manual (Draft 2013)
TIN	Triangular Irregular Network
WC	Waterway Corridor
WQA	Water Quantity Assessment

1.0 Introduction

1.1 Catchment Location

Cabbage Tree Creek Catchment is located approximately 14 km north of the Brisbane CBD and includes the suburbs of Ferny Hills, Arana Hills, Everton Hills, McDowall, Bridgeman Downs, Aspley, Carseldine, Fitzgibbon, Taigum, Bracken Ridge, Deagon, Boondall, Sandgate and Shorncliffe.

The catchment has a total area of 43.2 km^2 and features two major creeks; namely Cabbage Tree Creek and Little Cabbage Tree Creek. There are several smaller creeks including Carseldine Channel and Taigum Channel as well as the minor tributaries of Fitzgibbon, Deagon and Sandgate. The catchment extends from Ferny Hills in the upper reaches to its confluence with the mouth of Nundah Creek, where both waterways flow into Moreton Bay at Shorncliffe. The upper section of the catchment is located within Moreton Bay Regional Council (MBRC) and occupies approximately 14 % of the total catchment area.

Figure 1.1 indicates the locality of the catchment as well as the local government boundaries.

1.2 Study Background

A recent flood study of the Cabbage Tree Creek Catchment was completed by AECOM on behalf of BCC in 2013 / 2014.[1] Since this time, there have been a number of significant changes within the catchment as well as to planning and policy documents. These changes include:

- Development works in the Fitzgibbon area by Economic Development Queensland (EDQ)
- The upgrade of Telegraph Road and Lemke Road by BCC
- The Gateway Upgrade North (GUN) project by the Department of Transport and Main Roads (DTMR)
- 2014 Airborne Laser Scanning (ALS) data superseding the 2009 ALS data
- BCC City Plan 2014 superseding BCC City Plan 2000
- Australian Rainfall and Runoff 2019 (AR&R 2019)[2] superseding Australian Rainfall and Runoff 1987 (AR&R 1987)[3].

This flood study updates the work undertaken by AECOM with respect to the changes listed above. For the purpose of this report, the previous flood study by AECOM is termed the 2014 Flood Study. The methodology for this flood study is consistent with the current BCC Flood Study Procedure document.[4]

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[1] AECOM on behalf of Brisbane City Council - *Cabbage Tree Creek Flood Study, June 2014*

[2] Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) - *Australian Rainfall and Runoff: A Guide to Flood Estimation, © Commonwealth of Australia (Geoscience Australia), 2019.*

[3] Institution of Engineers, Australia – *Australian Rainfall and Runoff: A Guide to Flood Estimation (Volume 1), 1987.*

[4] Brisbane City Council, *Creek Flood Study Procedure Document Version 8.1, 2019.*

1.3 Study Objectives

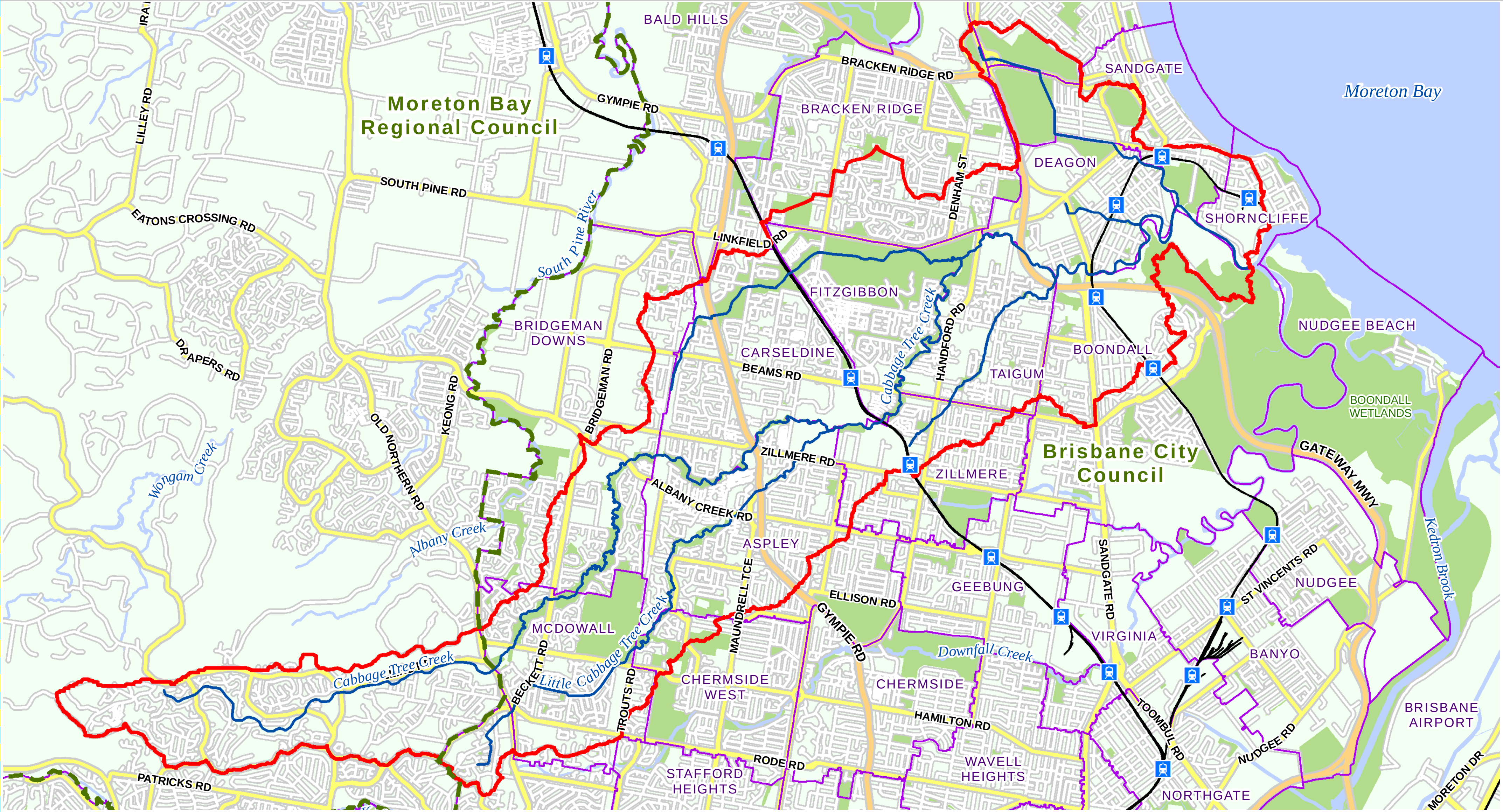
The primary objectives of the project are as follows:

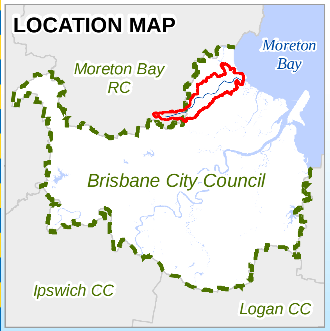
- Update the Cabbage Tree Creek flood models (hydrologic and hydraulic) with the latest topographical data and incorporate the most recent major development / infrastructure works as well as the current planning scheme (City Plan 2014).
- Adequately calibrate and verify the flood models to recent historical storm events to confirm that the models are suitable for the purposes of simulating design flood events.
- Estimate design and rare / extreme flood magnitudes in accordance with AR&R 2019 and incorporating increased rainfall intensities due to projected climate variability effects.
- Determine flood levels for the design and rare / extreme events, accounting for the effects of Minimum Riparian Corridor (MRC) and floodplain development / filling in accordance with current planning policy.
- Produce flood extent mapping for the selected range of design and rare / extreme events.
- Quantify the differences in flood level as a result of sea-level increases due to projected climate variability effects.

1.4 Scope of the Study

The following tasks were undertaken to achieve the project objectives as outlined in Section 1.3:

- Update the 2014 Flood Study URBS hydrologic model to incorporate the latest major development / infrastructure works and the current planning scheme (City Plan 2014).
- Update the 2014 Flood Study TUFLOW hydraulic model to incorporate the latest major development / infrastructure works and best available topographic data (2014 ALS).
- Calibrate the hydrologic and hydraulic models to the 1st May 2015 and 4th June 2016 historical flood events.
- Verify the hydrologic and hydraulic models against the 19th June 2016 historical flood event.
- Estimate the design, rare and extreme flood magnitudes for the full range of events from 2-yr ARI (50% AEP) to PMF.
- Simulate synthetic Australian Rainfall and Runoff (AR&R 2019) design storms for multiple ensembles and durations to determine the representative design flow at numerous locations within the catchment.
- Utilise the calibrated flood models to determine design flood levels for the design, rare and extreme events.
- Adjust the “Existing Condition” hydraulic model to simulate the impacts of MRC and filling outside the “Modelled Flood Corridor.”
- Produce flood extent mapping for the selected range of design, rare and extreme events.





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- Creek Centreline (Cabbage Tree Creek Catchment)
- Cabbage Tree Ck Catchment Area
- 2 Railway Station
- Railway Line
- Freeway/Highway
- Major Road
- Street
- Brisbane City Boundary
- Suburb Boundary
- Park
- Creek

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Figure 1.1: Locality Plan

Cabbage Tree Creek Flood Study

0 1 2 3 4
Kilometers

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1.5 Study Limitations

The results from this flood study are largely derived from the hydrologic and hydraulic models developed for this study. It is important to be aware of the limitations of these models, which includes (but is not limited to) the following:

The models have only been calibrated / verified at locations where Stream Gauge / MHG records exist. This should be taken into account when considering the accuracy of results outside the influence of the gauge locations. Refer to Figure 3.1 for the hydrometric gauge locations.

- These models are catchment scale and have been developed to simulate the flooding characteristics at a broad scale. As a result, smaller more localised flooding and drainage characteristics may not be apparent in the results.
- The 2014 ALS data has been used to represent the hydraulic model floodplain topography. Detailed checks have not been undertaken on the accuracy of the ALS data, it is assumed that the data is representative of the topography and “fit for purpose.”
- The accuracy of the model results is directly linked to the following:
  - The accuracy limits of the data used to develop the model (e.g. ALS, survey information, bridge data, etc.).
  - The accuracy and quality of the hydrometric data used to calibrate / verify the models.
  - The number of observed records, including MHG locations throughout the catchment.

2.0 Catchment Description

2.1 Catchment and Waterway Characteristics

2.1.1 General

Cabbage Tree Creek Catchment has an area of approximately 43.2 km^2 and is one of the largest catchments in the northern Brisbane area. The catchment is bounded by the Bald Hills Creek and Pine River catchments to the north, Nundah Creek and Kedron Brook catchments to the south, and Wongam Creek catchment to the west. The lower portion of the catchment is tidally dominated, which extends from just upstream of the Gateway Motorway to the catchment outlet at Moreton Bay.

Figure 2.1 indicates the major creeks and tributaries within the catchment, which include:

- Cabbage Tree Creek
- Little Cabbage Tree Creek
- Carseldine Channel
- Taigum Channel

The Cabbage Tree Creek Catchment typically drains in a north-easterly direction and can be generally split into three areas; upper, middle and lower. The Upper Catchment extends from the catchment headwaters to the confluence of Cabbage Tree Creek and Little Cabbage Tree Creek, approximately 9.5 km upstream of the catchment outlet at Shorncliffe. The middle catchment extends from the confluence of Cabbage Tree Creek and Little Cabbage Tree Creek to the boundary of the tidal limit, between Lemke Road and the Gateway Motorway. The lower catchment extends from the tidal limit of the catchment to the mouth of Cabbage Tree Creek at Shorncliffe.

The Upper Catchment is highly developed and is characterised by moderately steep slopes. The catchment is very elongated and is dominated by the north-easterly flowing Cabbage Tree and Little Cabbage Tree Creeks. Ground levels vary from 180 mAHD at the catchment headwaters to 10 mAHD in the creek bed at the confluence of Cabbage Tree Creek and Little Cabbage Tree Creek. The majority of the catchment area is utilised for residential purposes, in particular low-density residential. The largest urban centre in Cabbage Tree Creek Catchment is located close to the confluence of Cabbage Tree and Little Cabbage Tree Creeks in the Upper Catchment.

The Middle Catchment is highly developed with a significant proportion of low-medium density residential areas. The catchment is wider than the Upper Catchment and is dominated by Cabbage Tree Creek and Carseldine Channel. A significant man-made landform in this area is the former landfill site in Fitzgibbon, which divides Cabbage Tree Creek with the lower section of Carseldine Channel. The highest elevation in the middle catchment is approximately 52 mAHD on the ridge that forms the headwaters of the Carseldine Channel Catchment. The creek bed at the eastern boundary (close to Lemke Road) sits at an elevation of approximately 0 mAHD

The Lower Catchment is moderately developed and is characterised by generally flat slopes. The area is dominated by Lower Cabbage Tree Creek and Taigum Channel as well as some minor tributaries in the Deagon area. The development is this area is predominantly low density residential and there are also significant areas of open space / parkland, including the Deagon Racecourse, Boondall and Deagon Wetlands as well as the parkland around the Brisbane Entertainment Centre. Ground levels range from approximately 32 mAHD at the headwaters of the Taigum Channel to approximately 0 mAHD in the floodplain near the catchment outlet.

2.1.2 Cabbage Tree Creek

Cabbage Tree Creek flows in a north-easterly direction through the entire catchment from the headwaters in Ferny Hills to the confluence with Nundah Creek at Shorncliffe. The catchment headwaters rise to an elevation of approximately 180 mAHD in Ferny Hills.

The creek is approximately 23.3 km in length with the upper 6.2 km being located within MBRC area. Cabbage Tree Creek is an open waterway for its entire length and largely flows through an allocated creek corridor. The average bed slope over the entire creek length is 0.5 % and for the upper 13.8 km section to the confluence with Little Cabbage Tree Creek is 0.7 %.

The waterway is characterised by regular bridge / culvert crossings along its entire length. Major crossings of the creek include Old Northern Road, Beckett Road, Albany Creek Road, Gympie Road, North Coast Railway, Gateway Motorway and Sandgate Road.

2.1.3 Little Cabbage Tree Creek

Little Cabbage Tree Creek is approximately 8 km in length and joins Cabbage Tree Creek in Aspley, approximately 9.5 km upstream of the catchment outlet at Shorncliffe. The creeks flows in a north-easterly direction parallel to Cabbage Tree Creek for the majority of its length. The catchment headwaters rise to an elevation of approximately 89 mAHD in the suburb of Everton Park.

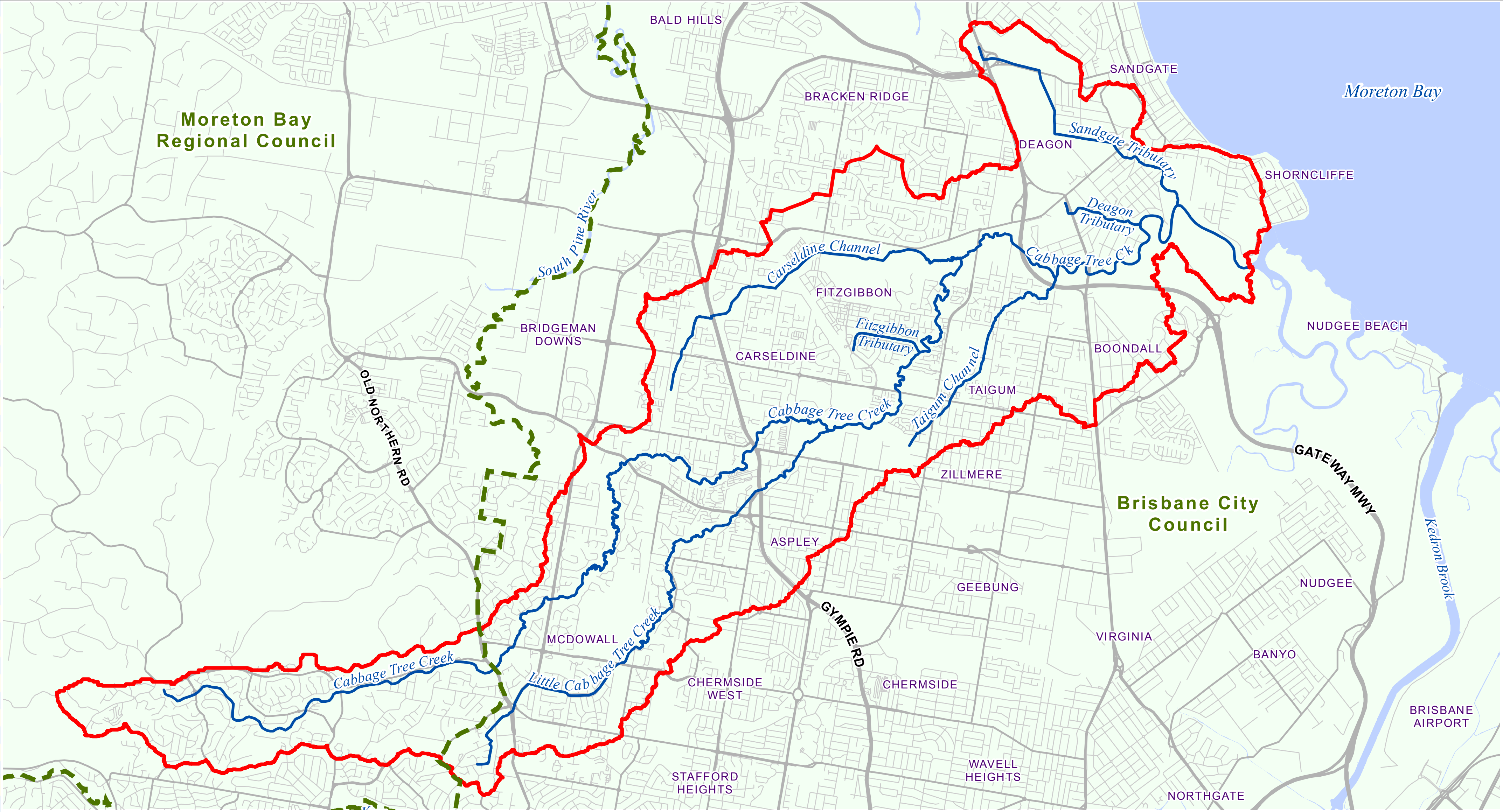
Little Cabbage Tree Creek is largely an open waterway for the 5.2 km length downstream of Hamilton Road, apart from a 250 m length that has been piped through the Aspley Hypermarket. Upstream of Hamilton Road, the creek is a mix of either (i) open waterway or (ii) low-flow pipe with high-flow channel or (iii) fully piped. The average bed slope over the entire creek length is 0.7 % and for the 5.2 km section downstream of Hamilton Road is 0.5 %.

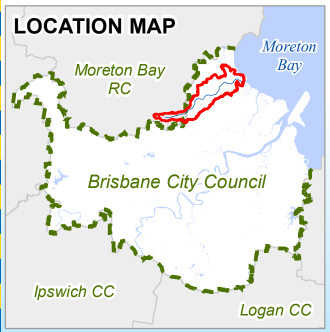
The waterway is characterised by regular bridge / culvert crossings along its entire length. Major crossings of the creek include Old Northern Road, Hamilton Road, Albany Creek Road, Gympie Road and Zillmere Road.

2.1.4 Carseldine Channel

Carseldine Channel is approximately 5.5 km in length and joins Cabbage Tree Creek in Carseldine, approximately 5.5 km upstream of the catchment outlet at Shorncliffe. The channel flows in a north-easterly / easterly direction and has been heavily modified in recent years in the Fitzgibbon area due to the development works by EDQ and the upgrade of Telegraph Road by BCC. As part of the Fitzgibbon Chase development by EDQ, two detention basins were constructed between Norris Road and the Fitzgibbon landfill area. For the purpose of this report, the northern basin is termed EDQ Detention Basin #1 and the southern basin EDQ Detention Basin #2. Further downstream, the channel passes between the two elevated landfill sites in the Fitzgibbon area, which tends to constrain the floodplain.

Carseldine Channel is an open waterway for its entire length and has an average bed slope of 0.8 %. The catchment headwaters rise to an elevation of approximately 52 mAHD in the suburbs of Bridgeman Downs / Carseldine.





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- Creek Centreline (Cabbage Tree Creek Catchment)
- Cabbage Tree Ck Catchment Area
- Brisbane City Boundary
- Freeway/Highway
- Major Road
- Street

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Figure 2.1: Major Creeks & Tributaries

Cabbage Tree Creek Flood Study

0 1 2 3 4
Kilometers

N W E S

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The channel has numerous waterway crossings; however, the regularity of crossings is not as significant as Cabbage Tree Creek and Little Cabbage Tree Creek. Major crossings of the channel include Gympie Road and the North Coast Railway.

2.1.5 Taigum Channel

Taigum Channel is approximately 3.3 km in length and joins Cabbage Tree Creek, approximately 4 km upstream of the catchment outlet at Shorncliffe. The channel flows in a north-easterly direction parallel to Cabbage Tree Creek for the majority of its length.

Taigum Channel is largely an open waterway for the 2.2 km length that extends from approximately 150 m downstream of Beams Road to the confluence with Cabbage Tree Creek. Upstream of Beams Road, the channel is a mix of either (i) open waterway or (ii) low-flow pipe with high-flow channel or (iii) fully piped. The catchment headwaters rise to an elevation of approximately 32 mAHD in the suburb of Zillmere. The average bed slope over the entire channel length is 0.5 % and for the 2.2 km section downstream of Beams Road is 0.4 %.

There are a number of waterway crossings of the channel, with the Gateway Motorway being the most significant. This crossing is located just upstream of the confluence with Cabbage Tree Creek.

2.2 Land Use

The Cabbage Tree Creek Catchment is largely developed with the predominant land use zoning being Low-density Residential. Figure 2.2 provides a breakdown of the catchment land use by percentage and Appendix C provides a map indicating the distribution of the land use throughout the catchment. The percentage figures indicated are relative to the catchment area within BCC (86 % of the total catchment) and are based upon City Plan 2014.

Residential areas occupy approximately 36.5 % of the catchment area with the next largest being Emerging Community (9.3 %). The “Emerging Community” zone is typically for land that would become urban development in the future. The Emerging Community areas are spread throughout the catchment, rather than being concentrated in the one area.

The largely pervious areas, which include Environmental Management and Conservation (7.2 %) and Sport and Recreation (5.8 %) are predominantly located in the lower catchment and include large areas such as the Deagon Racecourse, Boondall Wetlands and Deagon Wetlands.

The Fitzgibbon Priority Development Area (4 %) in the vicinity of the North Coast Railway and Norris Road is where the EDQ have been undertaking development works.

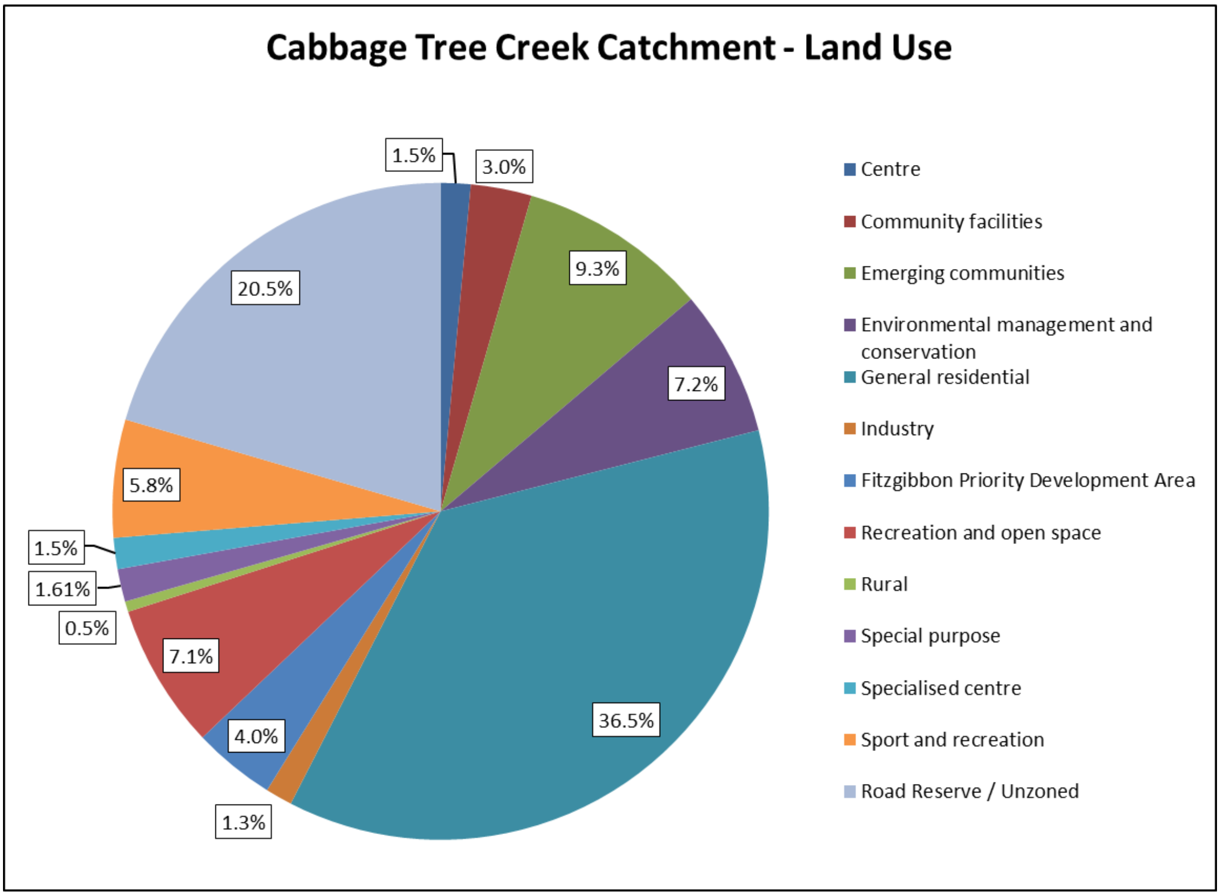


Figure 2.2: Cabbage Tree Creek Catchment Land Use

3.0 Hydrometric Data and Storm Selection

3.1 Selection of Historical Storm Events

As part of the 2014 Flood Study, calibration and verification was undertaken for the flooding events as listed below. These flooding events occurred prior to the major development in the Fitzgibbon area, which has occurred in recent years.

- Calibration
  - May 2009
  - October 2010
- Verification
  - March 2001
  - March 2004

For the purpose of this study, it was considered important to select recent flooding events that occurred around the time of the development works in the Fitzgibbon area. Another important consideration was that the flooding event occurred reasonably close to the capture of the updated LiDAR data for the catchment in October 2014.

Fortunately, there have been a number of flooding events since early 2015, with the 1st May 2015 event being one of the largest since records commenced. Table 3.1 indicates the recent events that have occurred in comparison to the events selected for the 2014 Flood Study. The table indicates the peak flood level in Cabbage Tree Creek at Beams Road (MHG 140), the number of recorded levels and the approximately size of the event.

Table 3.1 – Historical Peak Levels on Cabbage Tree Creek

Event	Observed Peak Flood Level (mAHD) MHG C140	Number of MHGs and/or recorded levels	Approximate Size of Event at MHG C140
March 2001	-	26	N/A
March 2004	7.89	18	50-yr ARI (2 % AEP)
May 2009	6.19	31	< 2-yr ARI (50 % AEP)
October 2010	7.85	36	20-yr ARI (5 % AEP) to 50-yr ARI (2 % AEP)
February 2015	7.27	35	5-yr ARI (20 % AEP) to 10-yr ARI (10 % AEP)
1st May 2015	8.16	38	> 100-yr ARI (1 % AEP)
4th June 2016	7.74	34	20-yr ARI (5 % AEP) to 50-yr ARI (2 % AEP)
19th June 2016	7.66	34	20-yr ARI (5 % AEP)
March 2017	7.42	34	5-yr ARI (20 % AEP) to 10-yr ARI (10 % AEP)

On the basis that the availability of rainfall records is similar for each event, the following storms were selected for the calibration and verification of the updated flood models.

- Calibration
  - 1st May 2015
  - 4th June 2016
- Verification
  - 19th June 2016

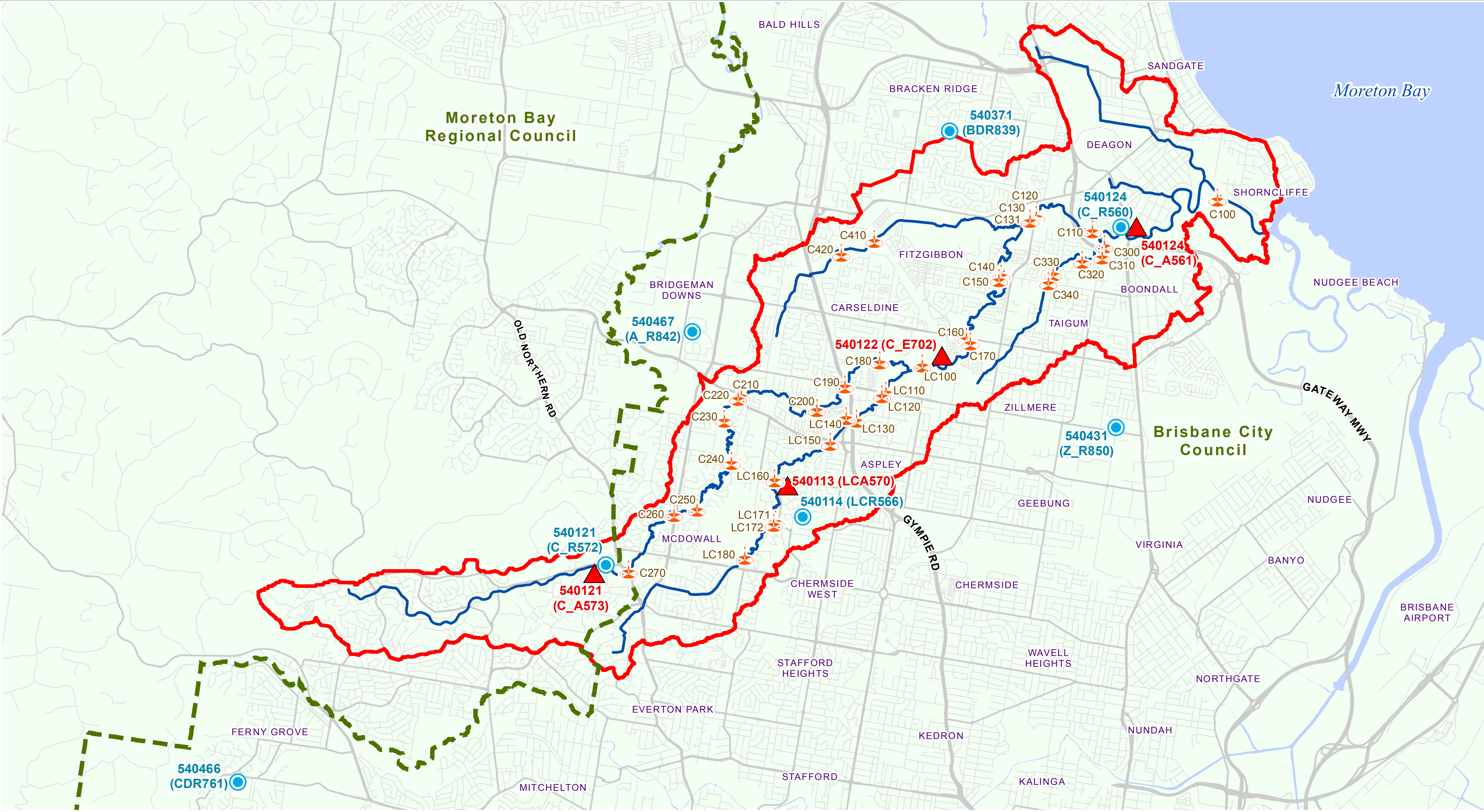
3.2 Availability of Historical Data for Selected Storms

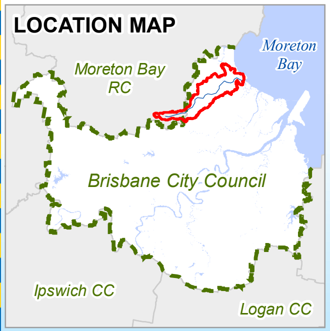
3.2.1 Continuous Recording Rainfall Stations

Seven rainfall stations were utilised for the calibration and verification events. Figure 3.1 and Table 3.2 indicate the location, details and availability of the rainfall station data for each of the selected storm events. For the selected storm events, all rainfall stations had data available.

Table 3.2 – Rainfall Station Records

Gauge ID	Old BCC ID	Location	Data Availability		
			1st May 2015	4th June 2016	19th June 2016
540114	LCR566	Aspley Reservoir, Aspley	✓	✓	✓
540121	C_R572	Collins Road, Everton Hills	✓	✓	✓
540124	C_R560	Burralong Street, Deagon	✓	✓	✓
540371	BDR839	Jude Street Reservoir, Bracken Ridge	✓	✓	✓
540431	Z_R850	Sleeman Park, Boondall	✓	✓	✓
540466	CDR761	Upper Kedron Recreation Reserve, Upper Kedron	✓	✓	✓
540467	A_R842	Pinnaroo Cemetery, Bridgeman Downs	✓	✓	✓





GIM - 190477 - 003

- Creek Centreline (Cabbage Tree Creek Catchment)
- Cabbage Tree Ck Catchment Area
- Maximum Height Gauge
- Pluviograph Station
- Continuous Recording Stream Gauge
- Brisbane City Boundary
- Road

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Figure 3.1: Catchment Map & Gauge Location

Cabbage Tree Creek Flood Study

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Prepared : 104515
Checked : JS
Revision : 3
Publication Date : 14 Jun 2019
Project Number : 190477

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3.2.2 Continuous Recording Stream Gauges

Continuous recording stream height gauges collect instantaneous water level information over time. They are important for calibration purposes as they provide important information on the timing of the flood peak as well as the total shape and volume of the flood hydrograph.

For the Cabbage Tree Creek Catchment, there are four operational continuous recording stream gauges. Three of these stream gauges are located in the BCC portion of the catchment and one in the MBRC portion of the catchment at Everton Hills.

Table 3.3 indicates the location, details and availability of the stream gauge data for each of the selected storm events. For the selected storm events, all stream gauges had data available.

Table 3.3 – Stream Gauge Records

Gauge ID	Old BCC ID	Owner	Start of Records	Location	Data Availability		
					1st May 2015	4th June 2016	19th June 2016
540113	LCA570	BCC	1994	Little Cabbage Tree Creek at Stringybark Drive, Aspley	✓	✓	✓
540121	C_A573	BCC	1994	Cabbage Tree Creek at Collins Road, Everton Hills	✓	✓	✓
540122	C_E702	BCC	1972	Cabbage Tree Creek at Pineapple Street, Carseldine	✓	✓	✓
540124	C_A561	BCC	1994	Cabbage Tree Creek at Burralong Street, Deagon	✓	✓	✓

3.2.3 Maximum Height Gauges (MHGs)

Maximum Height Gauges (MHGs) record the maximum water level experienced in a flooding event at the gauge location. MHG data is manually read by BCC staff following the flooding event. However, if the gauge has malfunctioned during the event and there is a nearby debris mark, then the recorded water level is typically based on this debris level.

There are 36 currently operating MHGs within the BCC portion of the catchment. The distribution of MHGs between the creeks / channels is as follows:

- Cabbage Tree Creek – 19 x MHGs
- Little Cabbage Tree Creek – 10 x MHGs
- Carseldine Channel – 2 x MHGs
- Taigum Channel - 5 x MHGs

Table 3.4 indicates the location, details and availability of the MHG records for each of the selected storm events.

Table 3.4 – Maximum Height Gauge Records

Creek / Channel	Gauge ID	Location	Data Availability		
			1st May 2015	4th June 2016	19th June 2016
Cabbage Tree	C100	1.2 km u/s of the creek mouth	✓	✗	✗
	C110	400 m d/s of Gateway Motorway	✓	✓	✓
	C120	d/s at Lemke Road	✓	✓	✓
	C130	u/s at Lemke Road	✓	✓	✓
	C131	100 m u/s of Lemke Road	✗	✗	✗
	C140	d/s at Roghan Road	✓	✓	✓
	C150	u/s at Roghan Road	✓	✓	✓
	C160	d/s at Beams Road	✓	✓	✓
	C170	u/s at Beams Road	✓ (d)	✓	✗ (O/T)
	C180	d/s at Dorville Road	✗ (O/T)	✓	✓
	C190	u/s at Gympie Road	✓	✓	✓
	C200	700 m u/s of Gympie Road	✓	✓	✓
	C210	d/s at Albany Creek Road	✓	✓	✓
	C220	u/s at Albany Creek Road	✓	✓	✓
	C230	500 m u/s of Albany Creek Road	✓	✓	✓
	C240	1.4 km u/s of Albany Creek Road	✓	✓	✓
	C250	300 m d/s of Beckett Road	✓	✓	✓
	C260	u/s at Beckett Road	✓	✓	✓
	C270	d/s at Old Northern Road	✓	✓	✓
Taigum	C300	d/s at Gateway Motorway	✓	✓	✓
	C310	u/s at Gateway Motorway	✓	✓	✓
	C320	300 m u/s of Gateway Motorway	✓	✗	✓
	C330	u/s at Church Road	✓	✓	✓
	C340	d/s at Roghan Road	✓	✓	✓
Carseldine	C410	u/s at North Coast Railway	✓	✓	✓
	C420	u/s at Lacey Road	✓	✓	✓
Little Cabbage Tree	LC100	Close to the Cabbage Tree – Little Cabbage Tree confluence	✓	✓	✓
	LC110	d/s at Zillmere Road	✓	✓	✓
	LC120	u/s at Zillmere Road	✓	✓	✓
	LC130	d/s at Gympie Road	✓	✓	✓
	LC140	u/s at Gympie Road	✓	✓	✓
	LC150	u/s at Albany Creek Road	✓	✗	✗
	LC160	u/s at Horn Road	✓ (d)	✗	✗
	LC171	d/s at Martindale Street	✓	✓	✓
	LC172	u/s at Martindale Street	✓	✓	✓
	LC180	u/s at Trouts Road	✓	✗	✗

(O/T) MHG Overtopped

(d) Reading from debris mark

The total number of MHGs available for each event is indicated below:

- May 2015 – 34 x MHGs
- 4th June 2016 – 30 x MHGs
- 19th June 2016 – 30 x MHGs

3.2.4 Miscellaneous Debris Marks

There were a number of debris marks recorded / surveyed as part of the post flood data collection for the 1st May 2015 event. Following a major flooding event, BCC Flood Management team members typically attend flood affected areas and identify flood debris marks. These debris marks are then surveyed to ascertain the approximate flood level. Table 3.5 indicates the location of the available debris marks for the 1st May 2015 event.

Table 3.5 – Recorded Debris Levels (1st May 2015 event)

Creek / Channel	Location	Coordinates (MGA)		Flood Level (m AHD)
		X	Y	
Cabbage Tree	Station Road, Deagon	506,860.6	6,977,165.1	2.28
	Upstream at Dorville Road, Aspley	502,078.1	6,974,507.5	16.74
	Zillmere Road, Aspley	501,755.4	6,974,177.9	18.33
Little Cabbage Tree	Augusta Street, Aspley	500,993.5	6,972,978.1	24.80
Carseldine	Telegraph Road at Enbrook Park Detention Basin, Bracken Ridge	502,984.0	6,976,841.2	8.93 (1)
	Macaranga Crescent, Carseldine	501,219.7	6,975,775.2	16.44
	Accolade Place, Carseldine	500.884.6	6,975,721.6	19.41
Taigum	50 m upstream of Quarrion Street, Taigum	504,558.9	6,975,232.4	7.11
Miscellaneous	Azalea Crescent, Fitzgibbon	503,651.3	6,975,475.6	10.42
	Odense Street, Fitzgibbon	503,215.3	6,975,595.0	10.36

(1) Estimated as part of the Telegraph Road Stage 1b Project

3.3 Characteristics of Historical Events

3.3.1 1st May 2015 event

This event was the largest in the lower section of the catchment since hydrometric records commenced and produced a flood level of 13.20 mAHD at 540122 (C_E702) Pineapple Street, Carseldine, approximately 700 m downstream of the confluence of Cabbage Tree Creek and Little Cabbage Tree Creek.

Table 3.6 indicates the flooding alert level, which was triggered at each of the four stream gauges. The flooding alert level relates to flooding impacts in lieu of flooding frequency. Flooding in the lower section of the catchment was amplified, as the flood peak from the creek coincided with the tidal peak.

Table 3.6 – Flood Alert Level (1st May 2015 event)

Gauge ID	Old BCC ID	Location	Flooding Alert Level
540113	LCA570	Little Cabbage Tree Creek at Stringybark Drive, Aspley	Minor
540121	C_A573	Cabbage Tree Creek at Collins Road, Everton Hills	Major
540122	C_E702	Cabbage Tree Creek at Pineapple Street, Carseldine	Moderate
540124	C_A561	Cabbage Tree Creek at Burralong Street, Deagon	Major

Rainfall occurred between 2:00 am on the 30th April until 8:00 pm on the 1st May 2015. The rainfall was typically more intense in the middle to lower catchment, with the most intense rainfall occurring in Bracken Ridge. The total event rainfall ranged from 238 mm at Upper Kedron to 353 mm at Bracken Ridge. Steady lead up rainfall occurred for the first 36 hours, where approximately 100 mm of rain fell throughout the catchment. The main storm burst occurred over six hours between 1:00 pm and 7:00 pm on the 1st May, where up to 258 mm of rainfall was recorded. The cumulative rainfall for each rainfall station is presented in Appendix A.

Table 3.7 indicates the 4-day and 14-day antecedent rainfall as well as statistics on the burst rainfall at the seven rainfall stations. The catchment experienced virtually no rainfall in the 4-day lead up to the event and from 6 to 23 mm in the 14-day lead up to the event.

Figure 3.2 provides a comparison of the IFD curve for the seven rainfall stations against the AR&R 2019 IFD curve generated at the catchment centroid.

The equivalent design rainfall ARI towards the middle of the catchment at Rainfall Station 540467 (A_R842) at Pinnaroo Cemetery, Bridgeman Downs, would have been as follows:

- 1-hour rainfall: 10-yr ARI (10 % AEP)
- 2-hour rainfall: > 100-yr ARI (1 % AEP)
- 3-hour rainfall: > 100-yr ARI (1 % AEP)
- 6-hour rainfall: > 100-yr ARI (1 % AEP)

Table 3.7 - Rainfall characteristics (May 2015 event)

Gauge ID	Old BCC ID	Location	Antecedent Rainfall (mm)		Burst Rainfall (mm)	
			14-day	4-day	Peak 1hr burst	Peak 6hr burst
540114	LCR566	Aspley Reservoir, Aspley	18	0	67	196
540121	C_R572	Collins Road, Everton Hills	18	0	63	182
540124	C_R560	Burralong Street, Deagon	8	0	86	220
540371	BDR839	Jude Street Reservoir, Bracken Ridge	8	0	92	258
540431	Z_R850	Sleeman Park, Boondall	6	0	77	205
540466	CDR761	Upper Kedron Recreation Reserve, Upper Kedron	9	0	48	144
540467	A_R842	Pinnaroo Cemetery, Bridgeman Downs	23	1	68	220

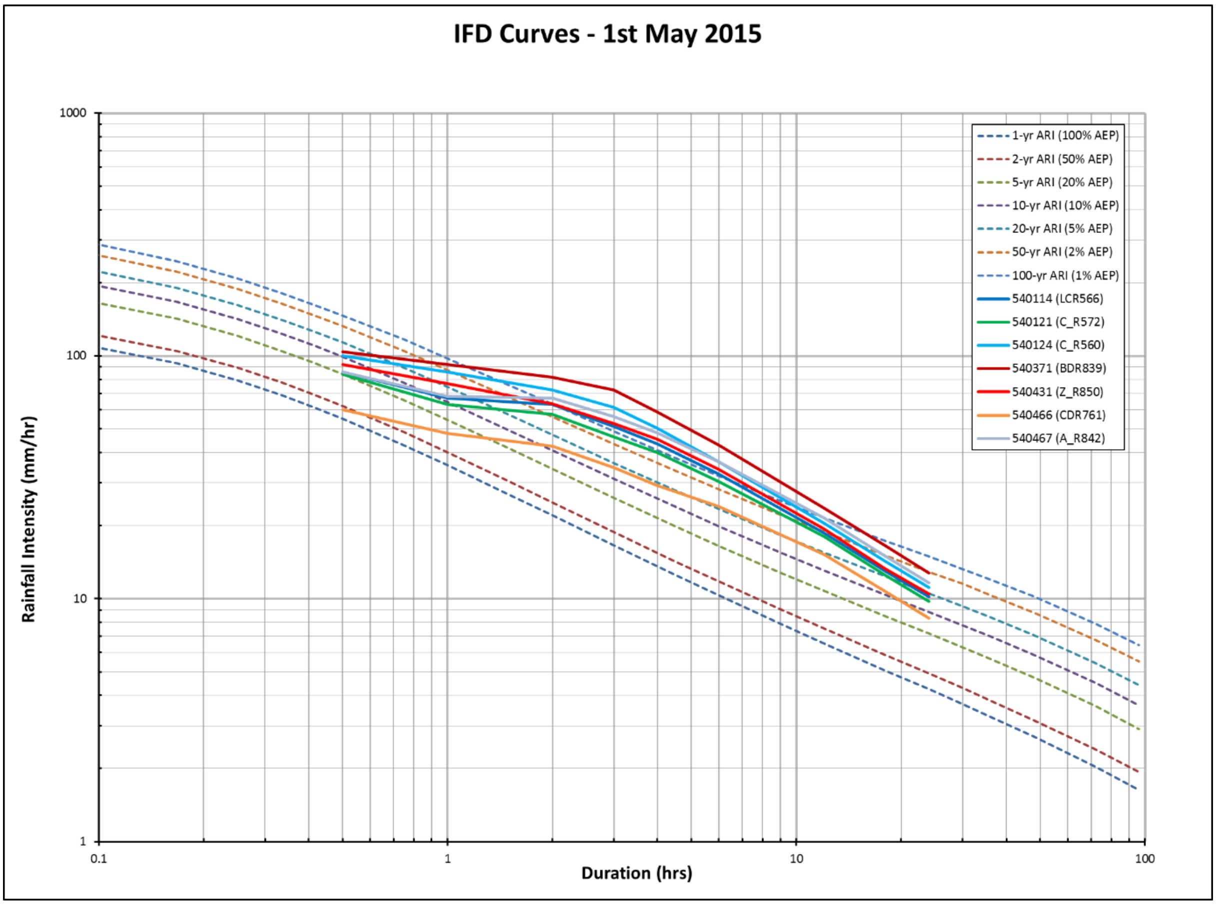

Figure 3.2: IFD Curve for May 2015 event.

3.3.2 4th June 2016 event

This event was minor to moderate in size and produced a flood level of 12.42 mAHD at 540122 (C_E702) Pineapple Street, Carseldine, approximately 700 m downstream of the confluence of Cabbage Tree Creek and Little Cabbage Tree Creek.

Table 3.8 indicates the flooding alert level, which was triggered at each of the four stream gauges. The flooding alert level relates to flooding impacts in lieu of flooding frequency. Flooding in the lower section of the catchment was lessened, as the flood peak from the creek coincided closely with the low tide in lieu of the high tide.

Table 3.8 – Flood Alert Level (4th June 2016 event)

Gauge ID	Old BCC ID	Location	Flooding Alert Level
540113	LCA570	Little Cabbage Tree Creek at Stringybark Drive, Aspley	Minor
540121	C_A573	Cabbage Tree Creek at Collins Road, Everton Hills	Major
540122	C_E702	Cabbage Tree Creek at Pineapple Street, Carseldine	Minor
540124	C_A561	Cabbage Tree Creek at Burralong Street, Deagon	Less than Minor

Rainfall occurred between 6:00 am on the 3rd June until 7:00 pm on the 4th June 2016. The rainfall was typically more intense in the upper to middle catchment, with the most intense rainfall occurring in Aspley and Everton Hills. The total event rainfall ranged from 96 mm at Boondall to 201 mm at Everton Hills. Steady lead up rainfall occurred for the first 6 hours, where approximately 25 mm of rain fell throughout the catchment. The main storm burst occurred over six hours between 5:00 am and 11:00 am on the 4th June, where up to 170 mm of rainfall was recorded. The cumulative rainfall for each rainfall station is presented in Appendix A.

Table 3.9 indicates the 4-day and 14-day antecedent rainfall as well as statistics on the burst rainfall at the seven rainfall stations. The catchment experienced from 2 to 6 mm in the 4-day lead up to the event and no rainfall in the 10 days prior. Figure 3.3 provides a comparison of the IFD curve for the seven rainfall stations against the AR&R 2019 IFD curve generated at the catchment centroid. The equivalent design rainfall ARI towards the middle of the catchment at Rainfall Station 540467 (A_R842) at Pinnaroo Cemetery, Bridgeman Downs, would have been as follows:

- 1-hour rainfall: 5-yr ARI (20 % AEP) to 10-yr ARI (10 % AEP)
- 2-hour rainfall: 20-yr ARI (5 % AEP)
- 3-hour rainfall: 20-yr ARI (5 % AEP)
- 6-hour rainfall: 20-yr ARI (5 % AEP)

Table 3.9 - Rainfall characteristics (4th June 2016 event)

Gauge ID	Old BCC ID	Location	Antecedent Rainfall (mm)		Burst Rainfall (mm)	
			14-day	4-day	Peak 1hr burst	Peak 6hr burst
540114	LCR566	Aspley Reservoir, Aspley	5	5	77	162
540121	C_R572	Collins Road, Everton Hills	5	5	63	170
540124	C_R560	Burralong Street, Deagon	4	4	21	63
540371	BDR839	Jude Street Reservoir, Bracken Ridge	2	2	61	130
540431	Z_R850	Sleeman Park, Boondall	4	4	28	68
540466	CDR761	Upper Kedron Recreation Reserve, Upper Kedron	6	6	57	141
540467	A_R842	Pinnaroo Cemetery, Bridgeman Downs	5	5	59	146

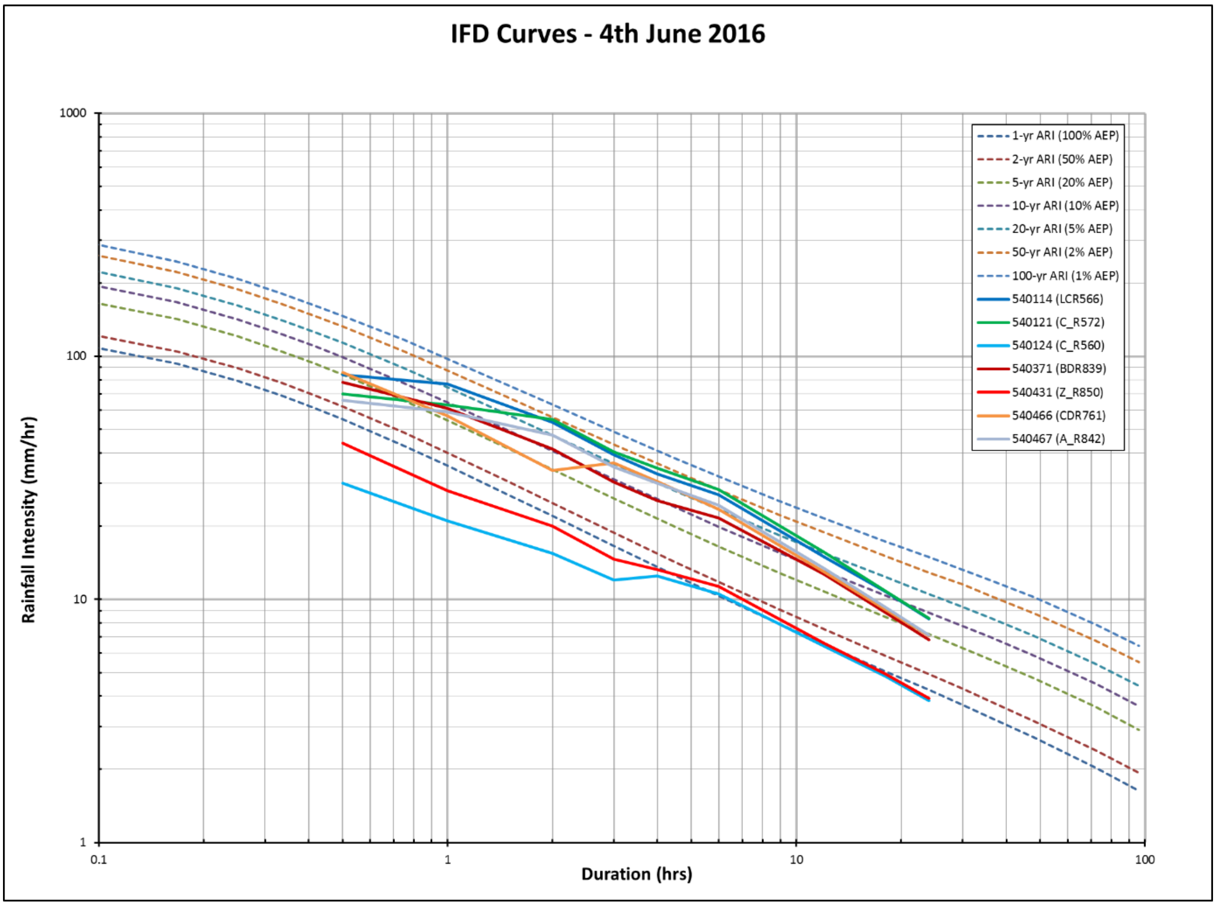

Figure 3.3: IFD Curve for 4th June 2016 event.

3.3.3 19th June 2016 event

This event was minor to moderate in size and produced a flood level of 12.62 mAHD at 540122 (C_E702) Pineapple Street, Carseldine, approximately 700 m downstream of the confluence of Cabbage Tree Creek and Little Cabbage Tree Creek.

Table 3.10 indicates the flooding alert level, which was triggered at each of the four stream gauges. The flooding alert level relates to flooding impacts in lieu of flooding frequency. Flooding in the lower section of the catchment was amplified, as the flood peak from the creek coincided with the tidal peak.

Table 3.10 – Flood Alert Level (19th June 2016 event)

Gauge ID	Old BCC ID	Location	Flooding Alert Level
540113	LCA570	Little Cabbage Tree Creek at Stringybark Drive, Aspley	Minor
540121	C_A573	Cabbage Tree Creek at Collins Road, Everton Hills	Major
540122	C_E702	Cabbage Tree Creek at Pineapple Street, Carseldine	Minor
540124	C_A561	Cabbage Tree Creek at Burralong Street, Deagon	Minor

Rainfall occurred between 2:30 am on the 19th June until 11:00 pm on the 19th June 2016. The rainfall was typically more intense in the upper to middle catchment, with the most intense rainfall occurring in Everton Hills. The total event rainfall ranged from 87 mm at Boondall to 180 mm at Everton Hills. Light intermittent lead up rainfall occurred for the first 12 hours, where up to 20 mm of rain fell throughout the catchment. The main storm burst occurred over three hours between 3:30 pm and 6:30 pm on the 19th June, where up to 150 mm of rainfall was recorded. The cumulative rainfall for each rainfall station is presented in Appendix A.

Table 3.11 indicates the 4-day and 14-day antecedent rainfall as well as statistics on the burst rainfall at the seven rainfall stations. The catchment experienced from 1 to 3 mm in the 4-day lead up to the event and from 4 to 8 mm in the 14-day lead to the event. However, 15 days prior to this event, the catchment experienced up to 200 mm of rainfall due to the storm event on the 4th June 2016.

Figure 3.4 provides a comparison of the IFD curve for the seven rainfall stations against the AR&R 2019 IFD curve generated at the catchment centroid. The equivalent design rainfall ARI towards the middle of the catchment at Rainfall Station 540467 (A_R842) at Pinnaroo Cemetery, Bridgeman Downs, would have been as follows:

- 1-hour rainfall: 5-yr ARI (20 % AEP)
- 2-hour rainfall: 5-yr ARI (20 % AEP)
- 3-hour rainfall: 5-yr ARI (20 % AEP) to 10-yr ARI (10 % AEP)
- 6-hour rainfall: 5-yr ARI (20 % AEP)

The rainfall which was recorded at 540121 (C_R572) Collins Road, Everton Hills is considerably higher than the other six rainfall stations.

Table 3.11 - Rainfall characteristics (19th June 2016 event)

Gauge ID	Old BCC ID	Location	Antecedent Rainfall (mm)		Burst Rainfall (mm)	
			14-day	4-day	Peak 1hr burst	Peak 6hr burst
540114	LCR566	Aspley Reservoir, Aspley	5	1	57	94
540121	C_R572	Collins Road, Everton Hills	5	2	63	165
540124	C_R560	Burralong Street, Deagon	8	3	51	75
540371	BDR839	Jude Street Reservoir, Bracken Ridge	7	3	55	81
540431	Z_R850	Sleeman Park, Boondall	4	1	52	78
540466	CDR761	Upper Kedron Recreation Reserve, Upper Kedron	7	2	48	114
540467	A_R842	Pinnaroo Cemetery, Bridgeman Downs	7	2	52	98

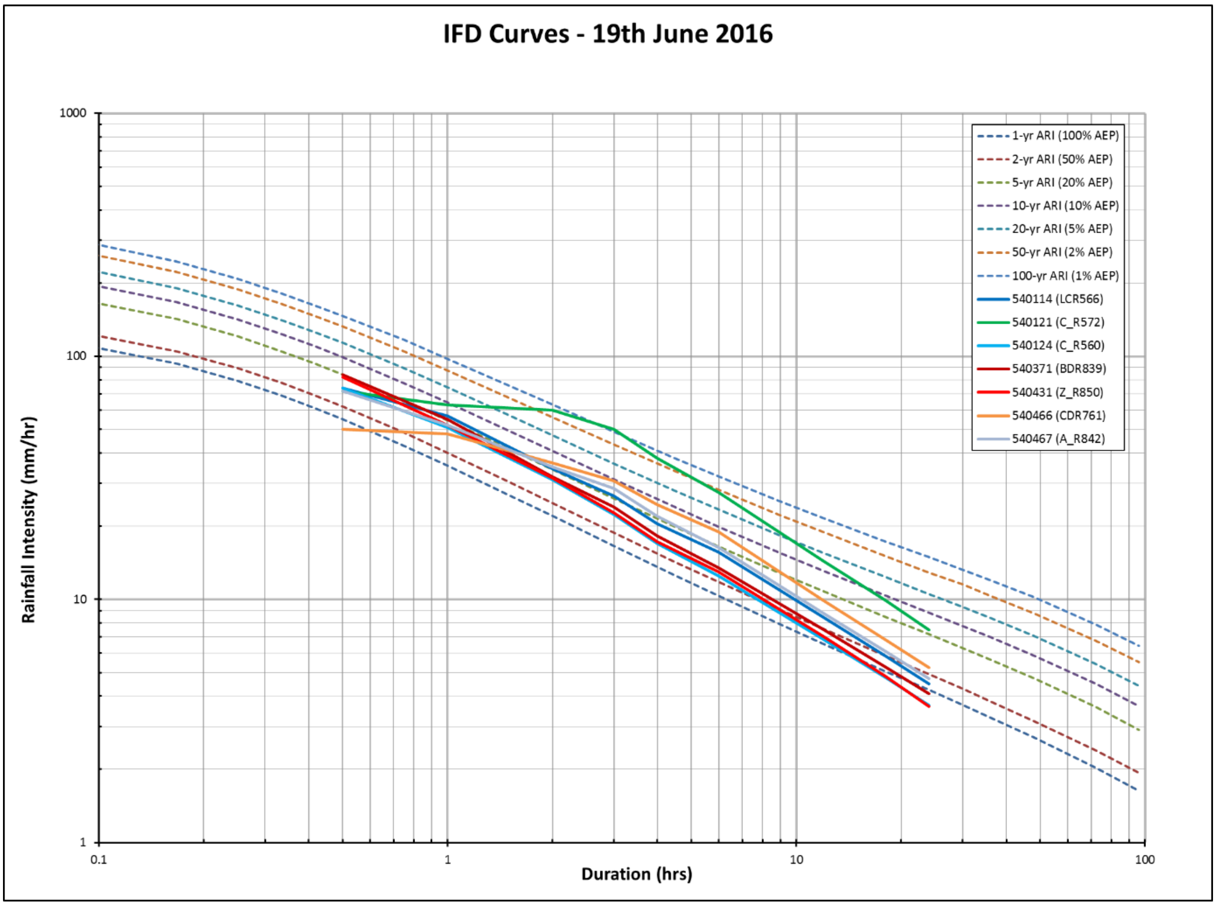

Figure 3.4: IFD Curve for 19th June 2016 event.

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4.0 Hydrologic Model Development and Calibration

4.1 Overview

The hydrologic model simulates the rainfall-runoff-routing process within the catchment. Hydrologic modelling for this study was performed using the URBS (version 6.34) software. URBS allows the effects of development / urbanisation to be assessed, which makes it suitable for largely urbanised catchments such as Cabbage Tree Creek. URBS also provides the option of modelling the sub-catchment and channel routing separately by selecting the “Split” modelling approach. This approach allows better compatibility with the hydraulic model, as the channel routing component can be matched to the hydraulic model, while varying the sub-catchment routing parameters to achieve calibration to recorded events.

Sub-catchment routing using the “Split” modelling approach is undertaken by routing through a non-linear reservoir, of which the storage-discharge relationship is based upon the following equation:

$$S_{catch} = \{\beta \sqrt{A}(1 + F)^2 / (1 + U)^2\}Q^m$$

where:

S_{catch} = catchment storage
β = catchment lag parameter
A = area of sub-catchment
U = fraction urbanisation of sub-catchment
F = fraction of sub-catchment forested
m = catchment non-linearity parameter
Q = outflow

Routing of all major open waterways and tributaries utilised the Muskingum methodology, which is based on the following equation:

$$S_{chnl} = \alpha f(\mathrm{n}L / \sqrt{S_c})(xQ_u + (1 - x)Q_d)^n$$

where:

S_{chnl} = channel storage
α = channel lag parameter
f = reach length factor
L = length of reach
S_c = slope of reach
Q_u = inflow at upstream end of the reach
Q_d = inflow at downstream end of the reach
x = Muskingum translation parameter
n = Muskingum non-linearity parameter
n = Manning’s ‘n’ or channel roughness

For further details on this modelling approach refer to the URBS User Manual.[5]

[5] *URBS A Rainfall Runoff Routing Model for Flood Forecasting and Design Version 6.00*, DG Carroll 2016

An URBS model was previously developed for the Cabbage Tree Creek Catchment as part of the 2014 Flood Study. This model comprised of 70 sub-catchments that utilised the land use information based upon BCC City Plan 2000 and did not include the extensive development works that have occurred in the Fitzgibbon area. The 2014 Flood Study URBS model was updated for this study to include:

- Changes to the sub-catchment land use and impervious areas to incorporate BCC City Plan 2014
- Changes to the sub-catchment delineation and land use because of the infrastructure and development works in the Fitzgibbon area.
- Further sub-catchment refinement increasing the total number of sub-catchments to 78.

4.2 URBS Sub-catchment Data

4.2.1 General

This section describes the sub-catchment information used in the URBS model. URBS allows the user to define the sub-catchment with differing levels of detail depending on the type of catchment and requirements for the study.

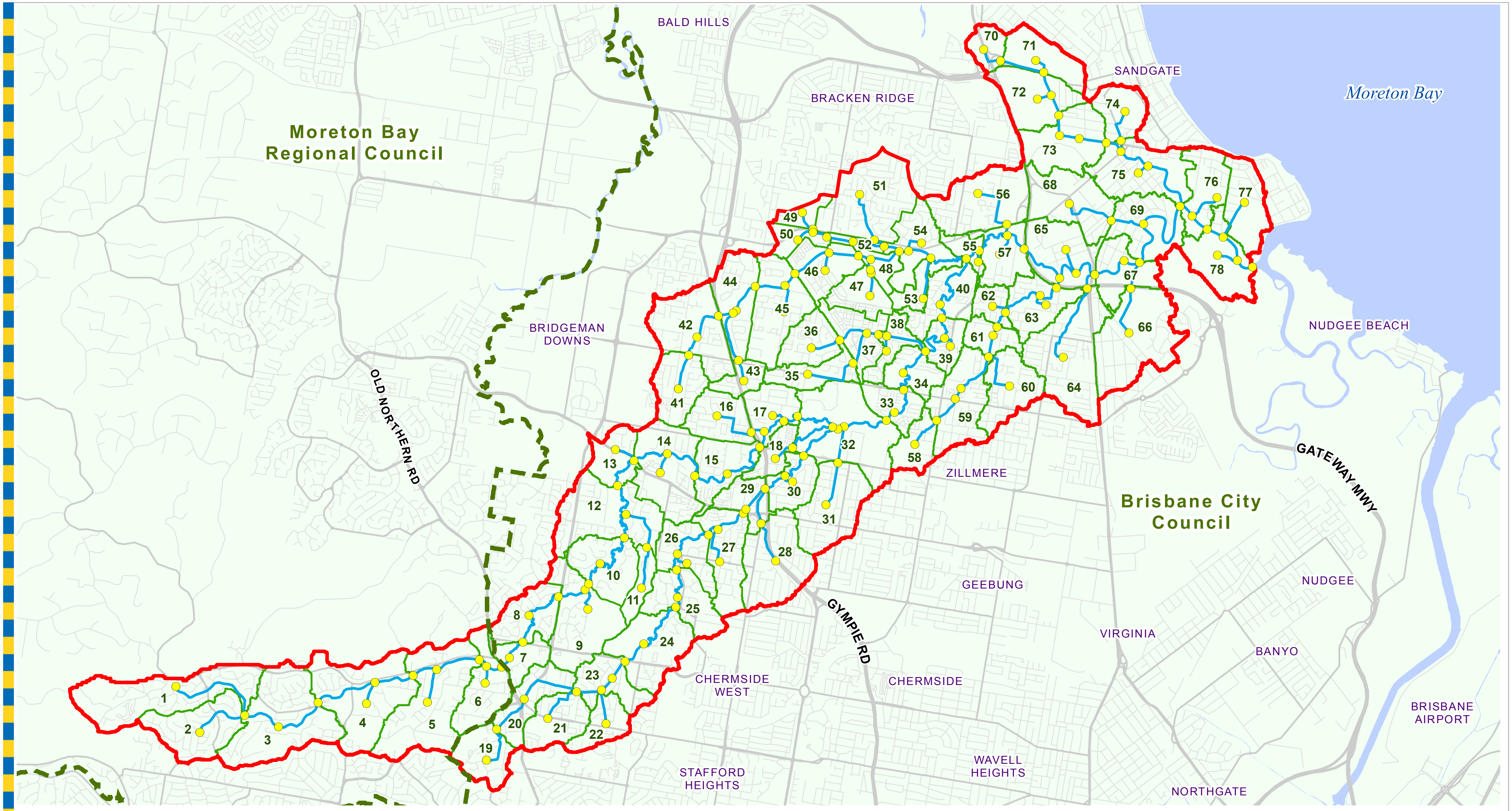
For this study, the following parameters were utilised:

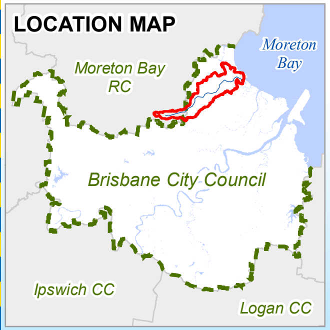
Area:	Sub-catchment area (mandatory)
UL:	Urban Low Density Index
UM:	Urban Medium Density Index
UH:	Urban High Density Index
UR:	Urban Rural Index
I:	Impervious Fraction

The adopted sub-catchment parameters for the calibration and verification events are presented in Appendix B. The same sub-catchment parameters have been used for all three historical events due to their close proximity and the minimal changes in catchment / channel topography and development during this 14 month period.

4.2.2 Sub-catchment Delineation

The URBS model was divided into 78 sub-catchments as indicated in Figure 4.1. Based on a total catchment area of 43.2 km^2, the average sub-catchment size was 0.55 km^2. The sub-catchment delineation is essentially the same as the 2014 Flood Study URBS model, with the major differences being in the Fitzgibbon area, where changes were required to reflect the recent development / infrastructure works.





URBS Node

URBS Link/Route

URBS Subcatchment (1 - 78)

Cabbage Tree Ck Catchment Area

Brisbane City Boundary

Road

GIM - 190477 - 004

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Figure 4.1: URBS Model Schematisation

Cabbage Tree Creek Flood Study

0 1 2 3 4

Kilometers

N W E S

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Prepared : 104515
Checked : JS
Revision : 2
Publication Date : 14 Jun 2019
Project Number : 190477

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File : G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\GIS\ESRI\Final_Maps_Feb_2019\GIM_190477_004_URBS_Fig_4_1.mxd

4.2.3 Land Use and Impervious Area

The effect of development / urbanisation is modelled in URBS using an Urbanisation Index (U) and Impervious Fraction (I). The Urbanisation Index (U) is used to determine the decrease in catchment lag and the Impervious Fraction (I) is used to determine the increase in runoff volume as a result of development. The Urbanisation Index (U) for each sub-catchment is determined with respect to the urbanisation indices; namely UL, UM, UH and UR for this study. These represent the fraction of the sub-catchment area occupied by that specific URBS urbanisation category. For example, a value of UL = 0.1 equates to 10 % of the sub-catchment area being occupied by the Urban Low Density (UL) urbanisation category.

To determine the value of UL, UM, UH and UR for each sub-catchment it was firstly required to adopt impervious fractions for each and secondly determine the total impervious area.

Impervious Fractions

The urbanisation indices were assigned the following impervious fractions: UL (0.15), UM (0.5), UH (0.9) and UR (0.0 - default). The threshold Urban Impervious Fraction (UI) was assigned the default value of 0.5.

Total Impervious Area

Using the catchment land use maps from BCC City Plan 2014 and the adopted land use percentage impervious (refer Appendix C); the total impervious area for the sub-catchment was able to be determined. The impervious fraction for the road reserve was assigned on a sub-catchment to sub-catchment basis to reflect the actual conditions. From this, the Impervious Fraction (I) for each sub-catchment was able to be determined.

Once the Impervious Fractions were assigned and the Total Impervious Area determined the following process was used to assign values to the urbanisation indices (UL, UM, UH and UR):

(i) Each BCC City Plan 2014 land use category within the catchment was assigned to the most appropriate urbanisation index (UL, UM, UH or UR) and the respective area of each determined.
(ii) The impervious area for each sub-catchment was calculated using the adopted fraction impervious for each urbanisation index.
(iii) This calculated impervious area was compared to the total impervious area for each sub-catchment.
(iv) The values of the urbanisation indices were adjusted (as required) so that this calculated impervious area matched the total impervious area for each sub-catchment.

4.3 URBS Channel Data

URBS allows the user to define the channel with differing levels of detail depending on the type of catchment and requirements for the study. For this study the following parameters were utilised:

L: Channel length (mandatory)
S_c: Channel slope

The channel length was determined using GIS software and the channel slope from channel survey or 2014 ALS (at locations where channel survey was not available).

4.4 Event Rainfall

4.4.1 Observed Rainfall

Recorded rainfall data from each calibration and verification event was incorporated into the URBS model at five minute intervals, noting that the rainfall gauge only records information when 1 mm or more of rain has fallen.

Thiessen Polygons were utilised for each event to enable the gauged rainfall to be apportioned to each of the sub-catchments in the URBS model. Those sub-catchments which fell totally within a polygon were fully assigned to the respective rainfall station. Those sub-catchments which bridged across two or more polygons were generally apportioned a weighted average of the total rainfall depth based on the respective rainfall gauges. The Thiessen Polygon distribution for the three events are presented in Appendix A for reference.

4.4.2 Rainfall Losses

The Initial Loss (IL) and Continuing Loss (CL) methodology was used to simulate the rainfall losses. For impervious areas, the URBS model assumes by default that there is no initial loss and 100 % runoff. Therefore, rainfall losses are only subtracted from the pervious portion of the sub-catchment.

The IL (mm) is known to be the amount of rainfall that occurs before the start of surface runoff. The initial loss comprises factors such as interception storage (e.g. tree leaves); depression storage (e.g. ditches, surface puddles, etc.) and the initial infiltration capacity of the soil, whereby a dry soil has a larger capacity than a saturated soil.

The CL (mm/hr) is assumed to be the average loss rate throughout the remainder of the rainfall event and is predominantly dependant on the underlying soil type and porosity.

4.5 Stream Gauge Rating Curve

In order to undertake the hydrological calibration, the following three stream gauges were utilised:

- 540113 (LCA570) - Little Cabbage Tree Creek at Stringybark Drive, Aspley.
- 540121 (C_A573) - Cabbage Tree Creek at Collins Road, Everton Hills.
- 540122 (C_E702) - Cabbage Tree Creek at Pineapple Street, Carseldine.

540124 (C_A561) was not used for the hydrologic calibration because the location is within the tidal limits of the catchment.

To convert gauged water levels into discharge, it was necessary to utilise a rating curve at the three stream gauge locations. BCC Hydrometrics does not keep records of rating curves for stream gauges, therefore, it was required to generate a rating curve at each location. This was typically done using the TUFLOW hydraulic model; for further discussions on the TUFLOW model refer to Section 5. Figures 4.2 to 4.4 indicate the rating curve used at 540113 (LCA570), 540121 (C_A573) and 540122 (C_E702) respectively.

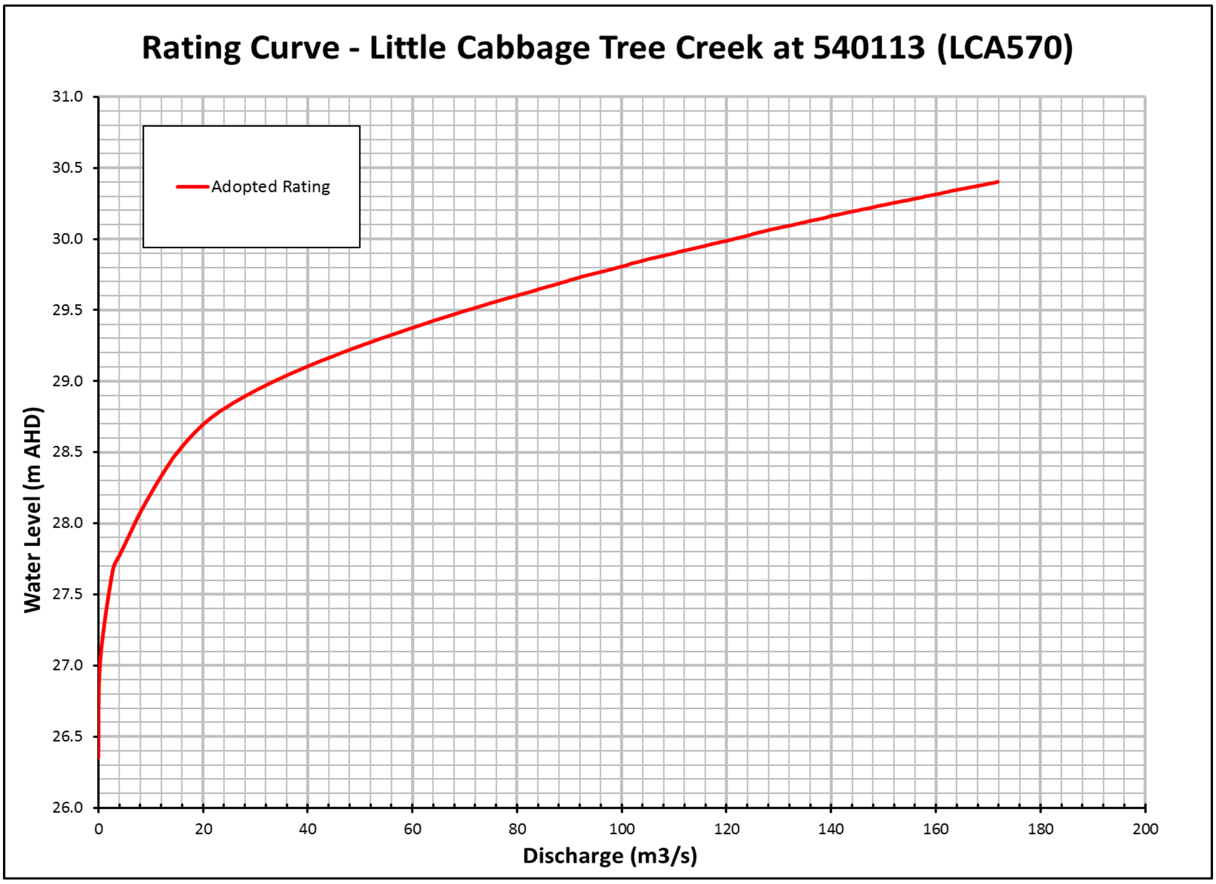


Figure 4.2: Rating Curve – Little Cabbage Tree Creek at Stringybark Drive, Aspley

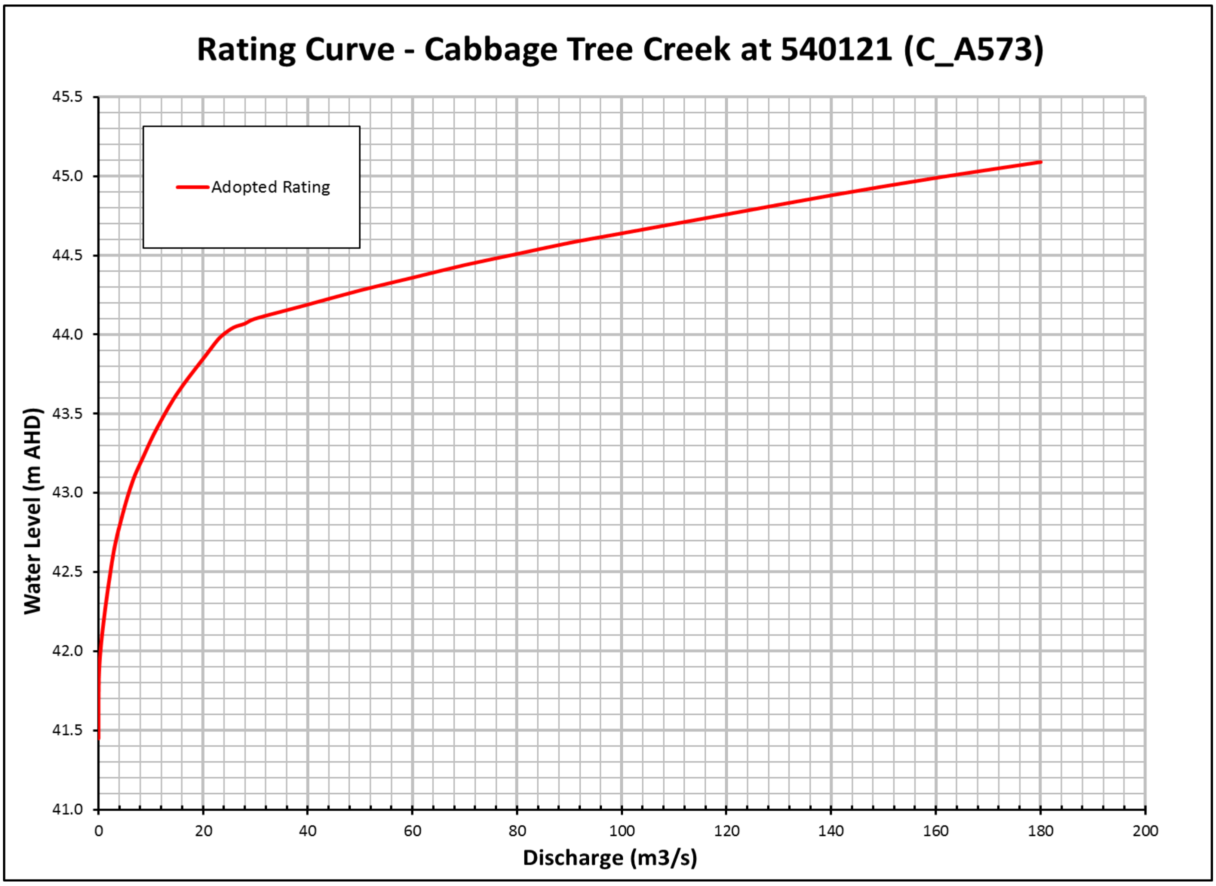


Figure 4.3: Rating Curve – Cabbage Tree Creek at Collins Road, Everton Hills

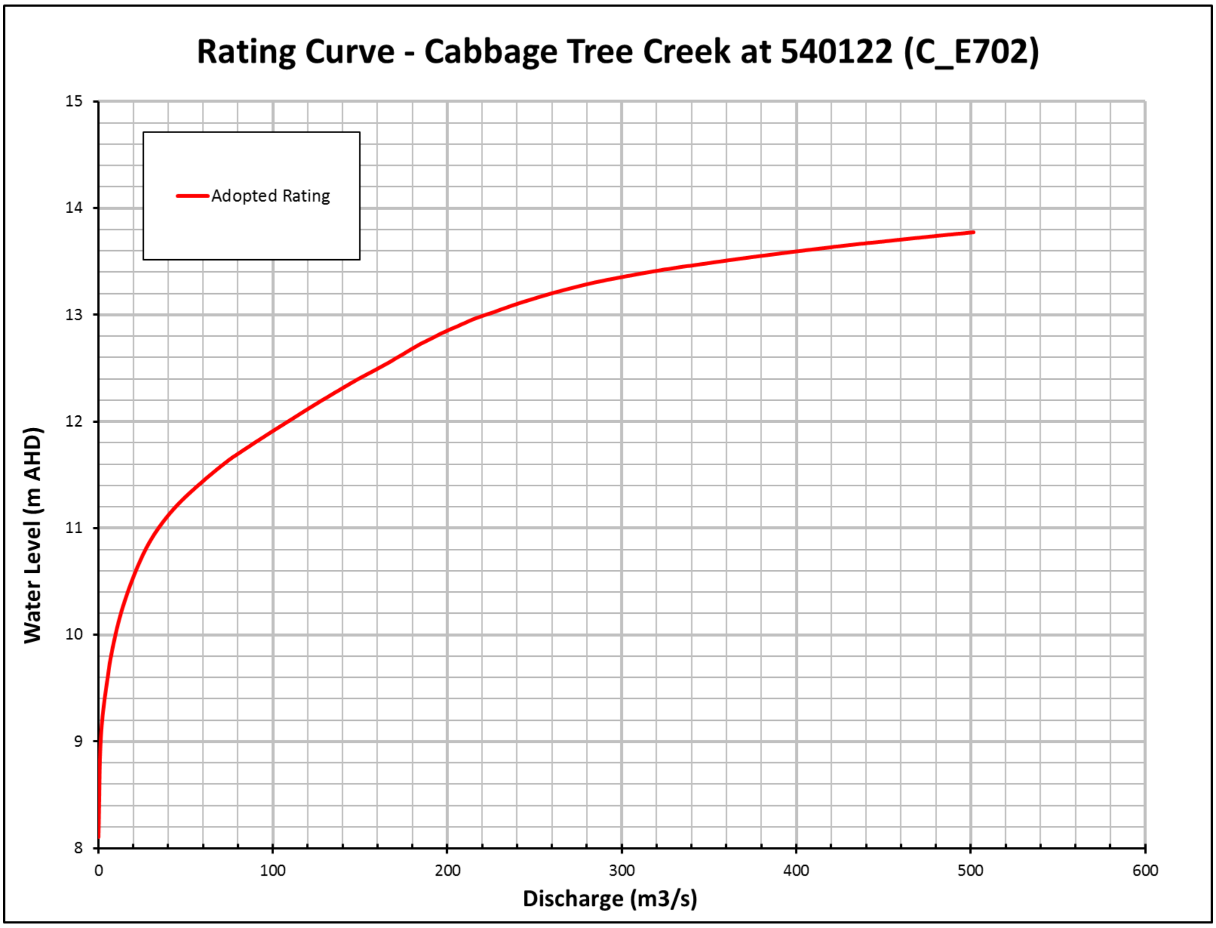


Figure 4.4: Rating Curve – Cabbage Tree Creek at Pineapple Street, Carseldine

4.6 Calibration and Verification Procedure

4.6.1 General

The calibration and verification process was adopted to suit the study objectives and requirements. The general requirements were to produce a hydrologic model sufficiently robust to accurately predict design discharges without the need to run the hydraulic model. This requirement meant that the approach adopted was to undertake a separate hydrologic calibration to ensure the URBS model was suitable to be used as a "standalone" model. The general approach adopted for the calibration and verification is indicated in Section 4.6.3.

4.6.2 Tolerances

The current BCC Flood Study Procedure document[4] is not prescriptive in relation to the ideal hydrologic calibration and verification tolerances. For the purposes of this study, the calibration and verification process has aimed to achieve the following tolerances:

- Volume - within +20 % to -10 %
- Peak Flow - within +25 % to -15 %
- Good replication of the hydrograph shape (especially the rising limb)
- Good replication of the timing of peaks and troughs.

4.6.3 Methodology

The methodology applied to the calibration and verification of the URBS model was as follows:

1) Input the observed rainfall data and apportion the rainfall to each sub-catchment. This was undertaken using the Thiessen Polygon methodology as described in Section 4.4.
2) Using the TUFLOW model, establish an appropriate rating curve at the three stream gauges and convert the stage recordings to flow. This was detailed in Section 4.5.
3) Run the calibration events (i.e. 1st May 2015 and 4th June 2016) through the URBS model and compare the simulated results against the observed (rated) flow records.
4) Iteratively adjust the model parameters (as required) and re-run the model to achieve the best possible fit with the observed data. The predominant model parameters adjusted included the IL (mm); CL (mm/hr); channel lag parameter (α); catchment lag parameter (β) and catchment non-linearity parameter (m).
5) Adopt a single set of model parameters (typically CL, α, β and m) based on the calibration results.
6) Run the verification event (i.e. 19th June 2016) through the calibrated URBS model and compare the simulated results against the observed (rated) flow records.
7) Adjust the initial loss (as required) to represent the event specific rainfall lost at the start of the verification event.
8) Repeat steps 2 to 7 (as necessary) following the results of the hydraulic model simulations. If required, adjust the reach length factor (f) to better replicate the results of the hydraulic model. Refer to Section 5 for more detail on the hydraulic modelling.

4.7 Simulation Parameters

Table 4.1 indicates the start and finish times of the hydrologic simulations as well as the time step used in the URBS model.

Table 4.1 – Hydrologic Simulation Parameters

Event	Start Time	Finish Time	Duration (hours)	Time Step (min)
1st May 2015	30/04/15 00:00	02/05/15 12:00	60	0.5
4th June 2016	03/06/16 12:00	05/06/16 00:00	36	0.5
19th June 2016	19/06/16 00:00	21/06/16 00:00	48	0.5

The 2014 Flood Study adopted the URBS parameters (indicated below) as part of the calibration / verification process. These parameters were initially adopted as part of the calibration and verification process for this current flood study

- Subcatchment Routing
  - Catchment lag parameter (β) = 6
  - Catchment non-linearity parameter (m) = 0.78
- Channel Routing
  - Channel lag parameter (α) = 0.01
  - Muskingum non-linearity parameter (n) = 0.95
  - Muskingum translation parameter (x) = 0.15
- Rainfall Losses
  - Impervious Area: IL = 0 mm, CL = 0 mm/hr (URBS default)
  - Pervious Area: IL = varies, CL = 0 mm/hr

4.8 Hydrologic Model Calibration Results

4.8.1 May 2015

Figure 4.5 to Figure 4.7 provide a comparison of the URBS results and the rated flow (established using the adopted rating curves) at the three stream gauges. The results typically indicate a good fit to the shape and timing of the peak flow at all three stream gauges. At all three stream gauges, the modelled peak flow is less than the rated observed peak flow, but largely within the ideal hydrologic calibration tolerances. The modelled flood volume at 540113 (LCA570) and 540121 (C_A573) is greater than the rated observed flood volume and at 540122 (C_E702) is less than the rated observed flood volume.

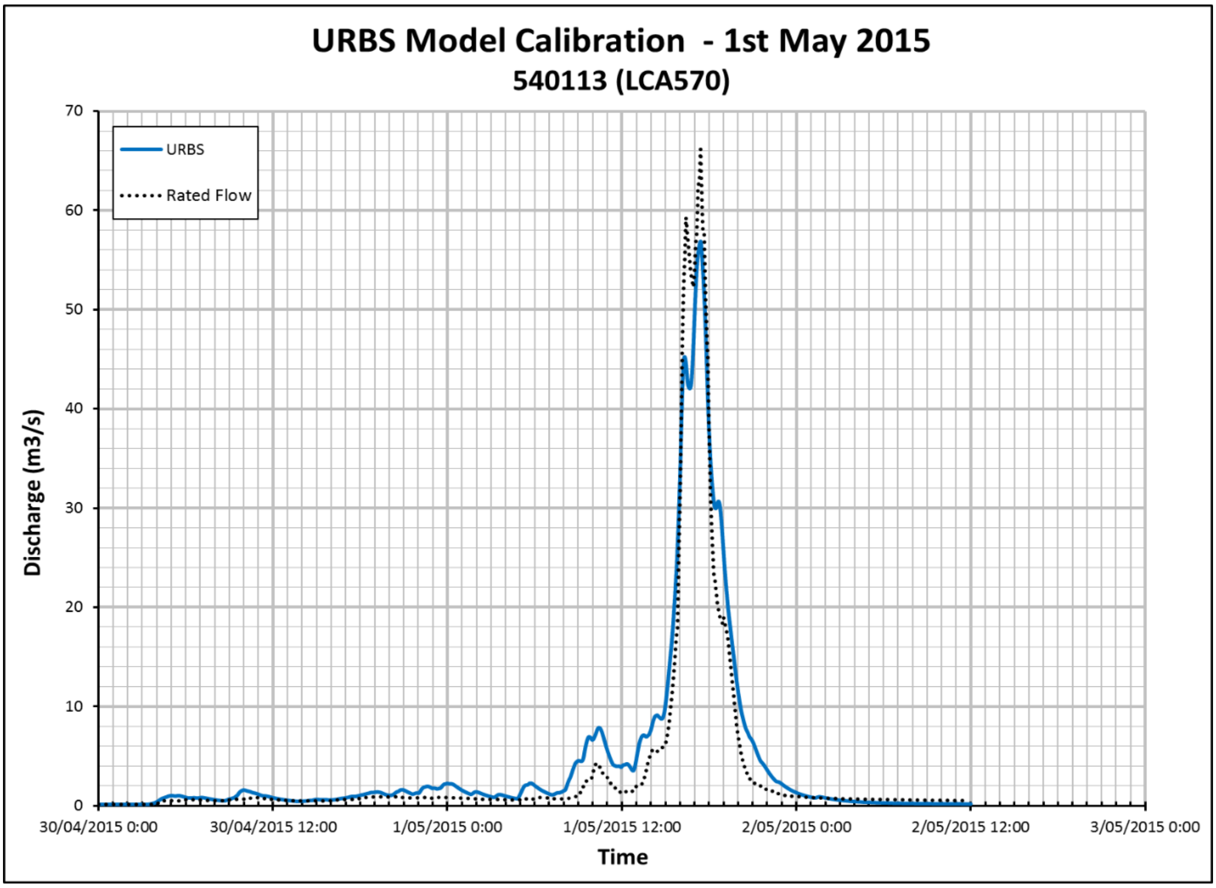


Figure 4.5: May 2015 URBS Model Calibration - Little Cabbage Tree Creek at 540113 (LCA570)

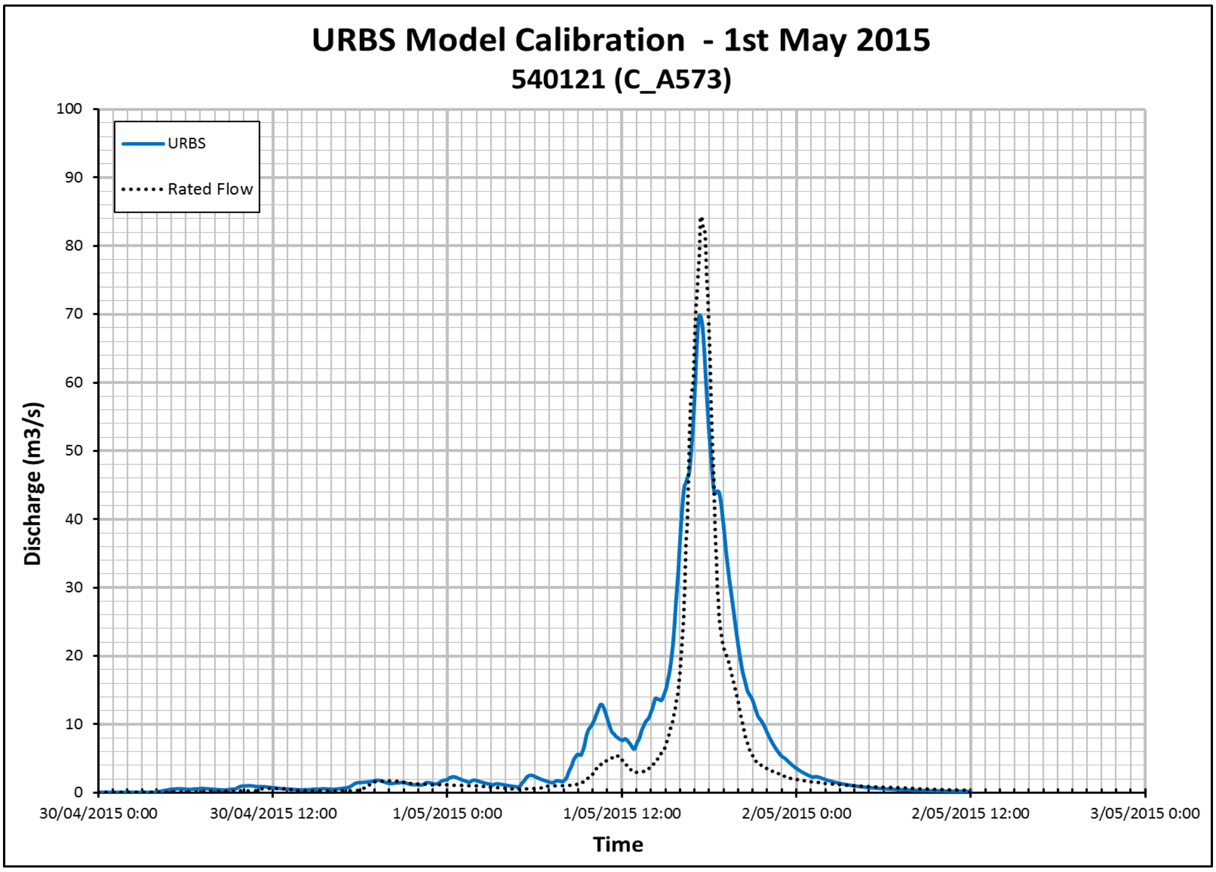


Figure 4.6: May 2015 URBS Model Calibration - Cabbage Tree Creek at 540121 (C_A573)

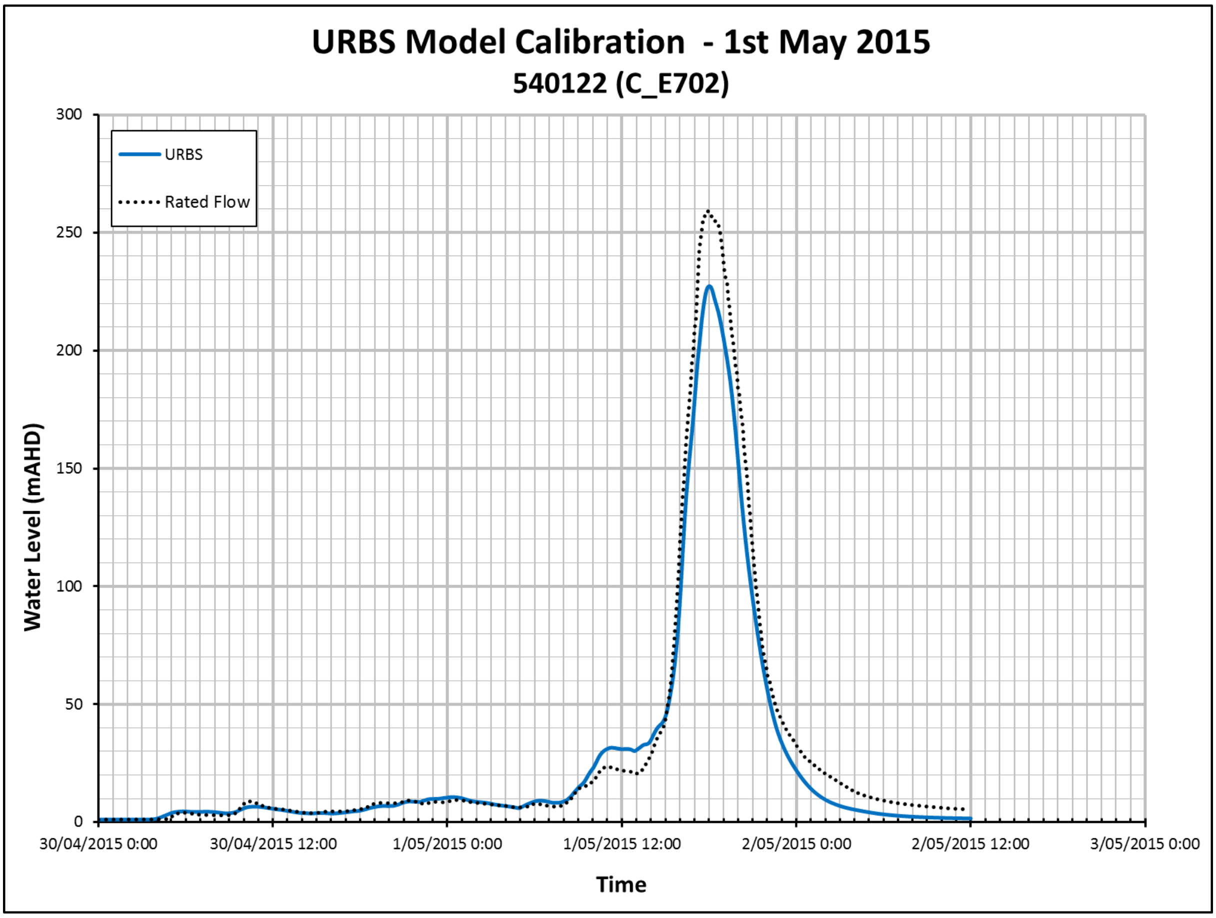


Figure 4.7: May 2015 URBS Model Calibration - Cabbage Tree Creek at 540122 (C_E702)

The adopted URBS parameters as part of the calibration of this event are as indicated below. These parameters are consistent with the 2014 Flood Study, apart from the Channel lag parameter (*α*), which was changed from 0.01 to 0.008 as the typical range of this parameter is between 0.003 and 0.008.

- Subcatchment Routing
  - Catchment lag parameter (*β*) = 6
  - Catchment non-linearity parameter (*m*) = 0.78
- Channel Routing
  - Channel lag parameter (*α*) = 0.008
  - Muskingum non-linearity parameter (*n*) = 0.95
  - Muskingum translation parameter (*x*) = 0.15
- Rainfall Losses
  - Impervious Area: IL = 0 mm, CL = 0 mm/hr (URBS default)
  - Pervious Area: IL = 40, CL = 0 mm/hr

Further results from the calibration are provided in Section 5.4 and a discussion on the overall calibration / verification results is provided in Section 5.8.

4.8.2 4th June 2016

Figure 4.8 to

Figure 4.10 provide a comparison of the URBS results and the rated flow (established using the adopted rating curve) at the three stream gauges. The results typically indicate a good fit to the shape and timing of the peak flow at all three stream gauges.

The modelled peak flow at 540113 (LCA570) matches the rated peak flow very well. At 540121 (C_A573), the modelled peak flow is approximately 9 % lower than the rated peak flow, whereas at 540122 (C_E702), the modelled peak flow is approximately 19 % higher than the rated peak flow. Flood volumes are greater than the rated observed flood volume at all three stream gauges.

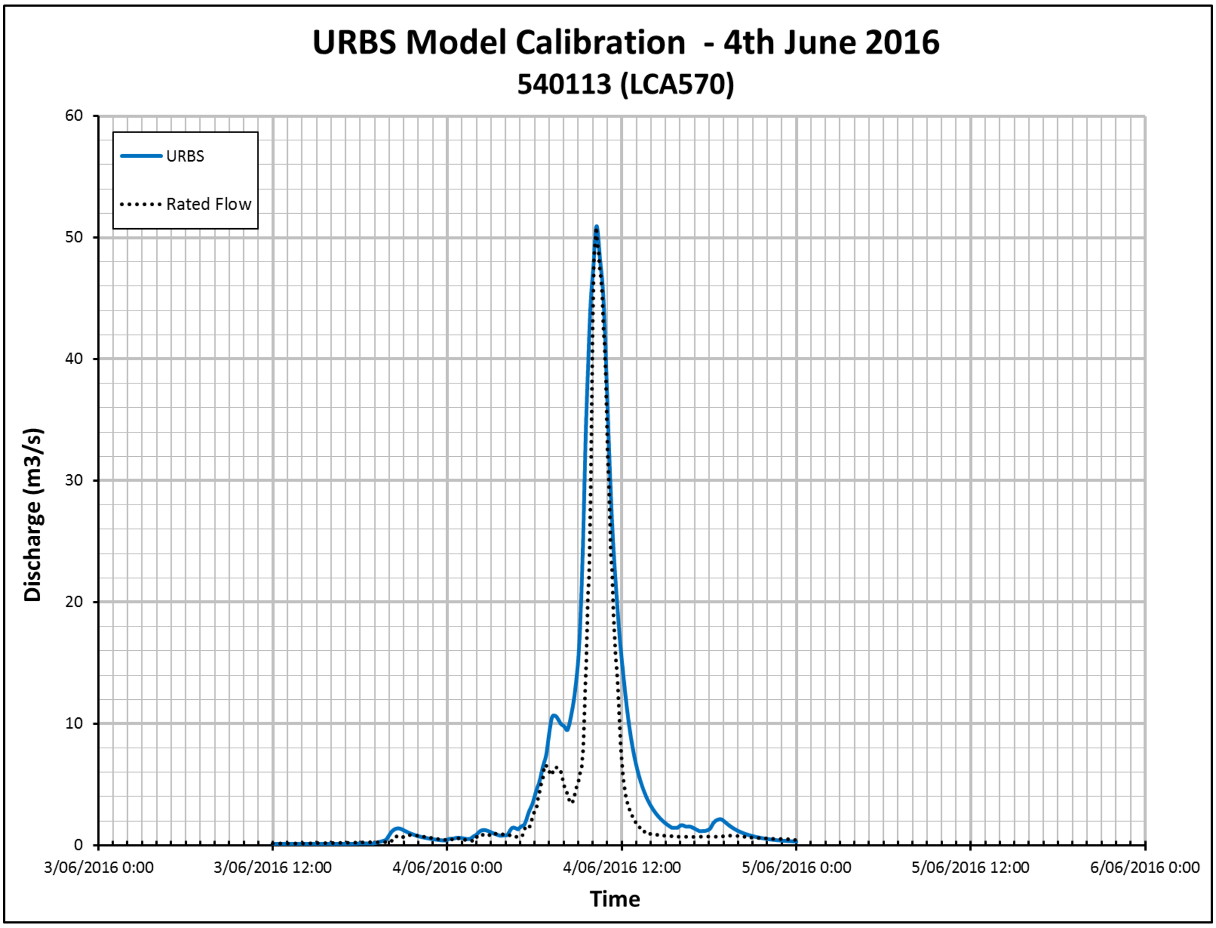


Figure 4.8: 4th June 2016 URBS Model Calibration - Little Cabbage Tree Creek at 540113 (LCA570)

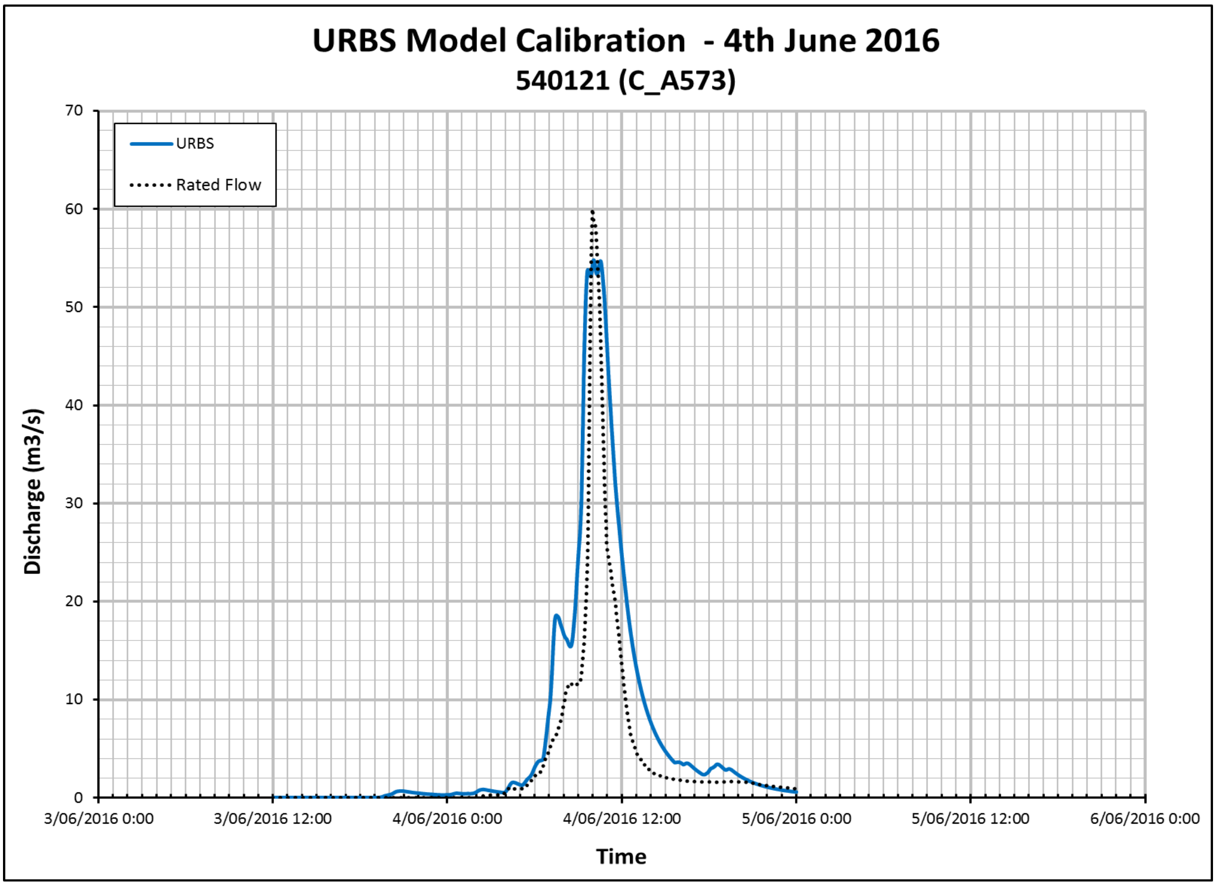


Figure 4.9: 4th June 2016 URBS Model Calibration - Cabbage Tree Creek at 540121 (C_A573)

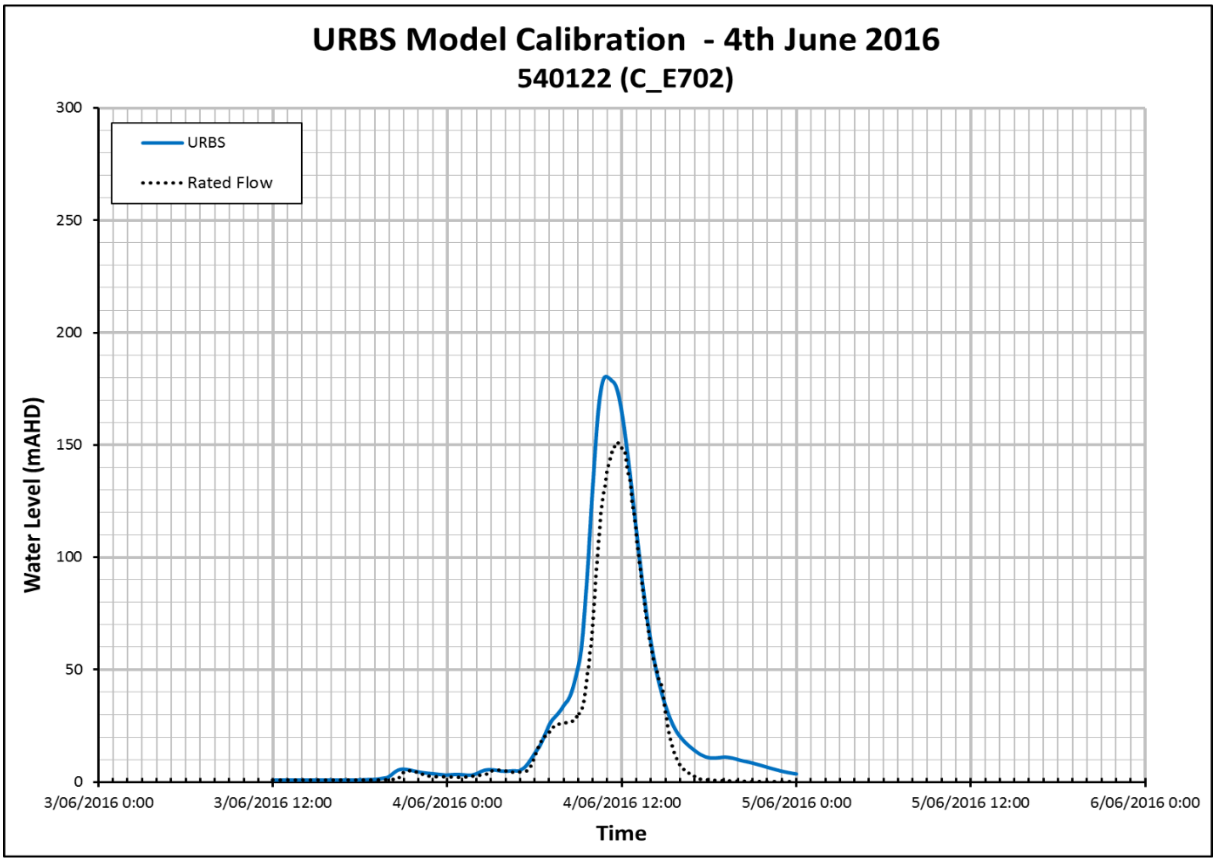


Figure 4.10: 4th June 2016 URBS Model Calibration - Cabbage Tree Creek at 540122 (C_E702)

The adopted URBS parameters as part of the calibration of this event are as indicated below. These parameters are consistent with the 2014 Flood Study, apart from the Channel lag parameter (*α*), which was changed from 0.01 to 0.008 as the typical range of this parameter is between 0.003 and 0.008.

- Subcatchment Routing
  - Catchment lag parameter (*β*) = 6
  - Catchment non-linearity parameter (*m*) = 0.78
- Channel Routing
  - Channel lag parameter (*α*) = 0.008
  - Muskingum non-linearity parameter (*n*) = 0.95
  - Muskingum translation parameter (*x*) = 0.15
- Rainfall Losses
  - Impervious Area: IL = 0 mm, CL = 0 mm/hr (URBS default)
  - Pervious Area: IL = 50, CL = 0 mm/hr

4.9 Hydrologic Model Verification Results

Table 4.2 indicates the parameters adopted from the hydrologic calibration of the two historical events. These parameters were used to verify the URBS model to the one verification event (i.e. 19th June 2016).

Table 4.2 – Adopted URBS parameters

Parameter	Description	Adopted Value
Imp CL	Impervious Area Continuing Loss (mm/hr)	0
Perv CL	Pervious Area Continuing Loss (mm/hr)	0
β	Catchment lag parameter	6
m	Catchment non-linearity parameter	0.78
α	Channel lag parameter	0.008
n	Muskingum non-linearity parameter	0.95
x	Muskingum translation parameter	0.15

Using the adopted model parameters, the 19th June 2016 event was simulated in URBS. Figure 4.11 to Figure 4.13 provide a comparison of the URBS results and the rated flows (established using the adopted rating curves) at the three stream gauges. The results typically indicate a good fit to the overall hydrograph at all three stream gauges.

The modelled peak flow at 540113 (LCA570) again matches the rated peak flow very well. At 540121 (C_A573), the modelled peak flow is approximately 3 % lower than the rated peak flow and at 540122 (C_E702), the modelled peak flow is also approximately 3 % lower than the rated peak flow. The modelled flood volume at 540113 (LCA570) and 540121 (C_A573) is greater than the rated observed flood volume and at 540122 (C_E702) is slightly less than the rated observed flood volume.

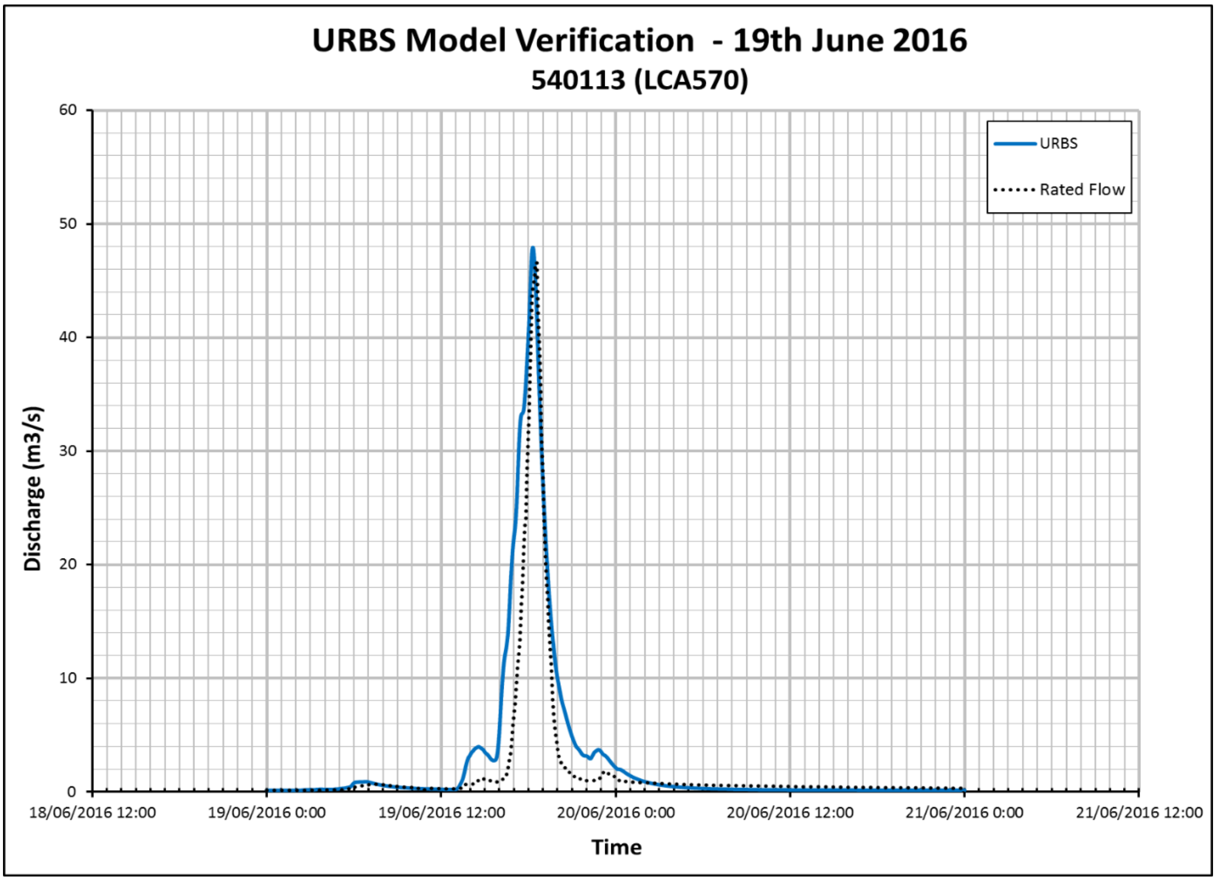


Figure 4.11:19th June 2016 URBS Model Verification - Little Cabbage Tree Creek at 540113 (LCA570)

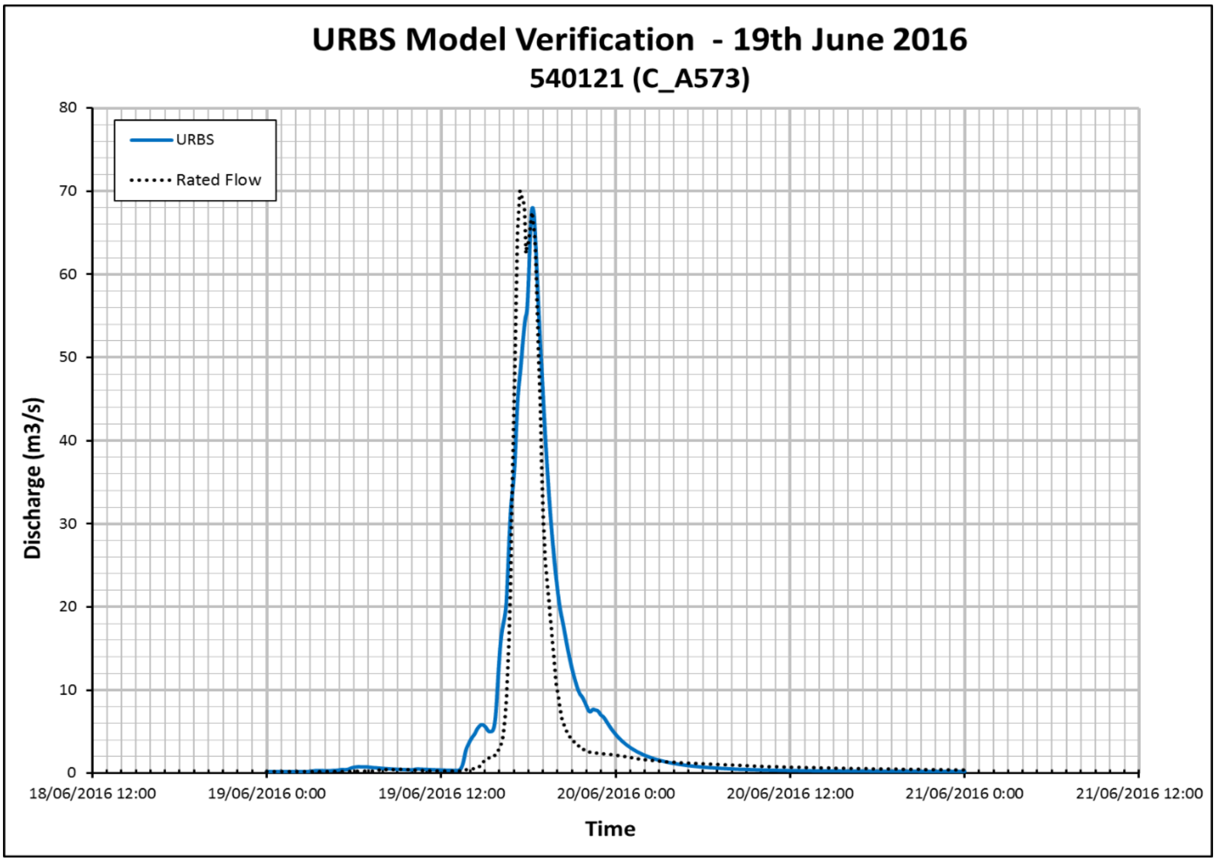


Figure 4.12: 19th June 2016 URBS Model Verification - Cabbage Tree Creek at 540121 (C_A573)

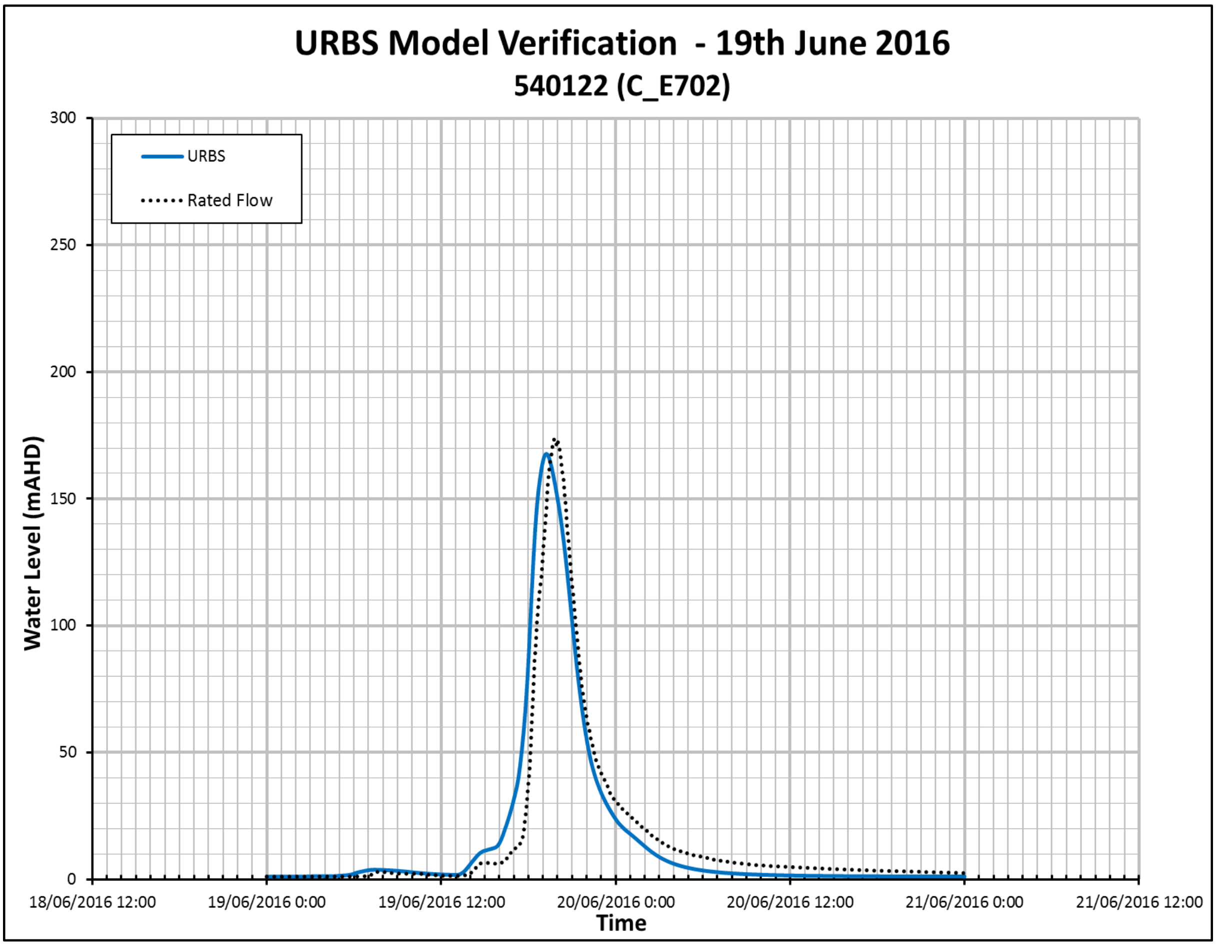


Figure 4.13: 19th June 2016 URBS Model Verification - Cabbage Tree Creek at 540122 (C_E702)

The adopted URBS rainfall loss parameters adopted for this simulation were as follows:

- Impervious Area: IL = 0 mm, CL = 0 mm/hr (URBS default)
- Pervious Area: IL = 10 mm, CL = 0 mm/hr

Further results from the calibration / verification are provided in Section 5.4 and a discussion on the overall calibration / verification results is provided in Section 5.8.

4.10 URBS Model Consistency Checks (Historical Events)

As noted previously, the results of the hydrologic – hydraulic model consistency checks are presented in Section 5.7. As part of these consistency checks, the URBS model channel routing was adjusted in order to better replicate the shape and timing of the TUFLOW model hydrograph.

This was undertaken by using one of the following means:

- Increasing the reach length factor (*f*); or
- Using Level-pool (reservoir) routing in lieu of Muskingum channel routing

There were four areas for which level-pool routing was used in lieu of Muskingum channel routing to better represent the storage effects. For these four areas, the stage–storage relationship was derived using the 2014 ALS data and the stage–discharge relationship from the TUFLOW model results. These areas were as follows:

- URBS Sub-catchment #45 (Carseldine Channel) – between Lacey Road and the North Coast Railway.
- URBS Sub-catchment #46 (Carseldine Channel) – between the North Coast Railway and Norris Road.
- URBS Sub-catchment #46 (Carseldine Channel) – EDQ Detention Basin #1 between Norris Road and the Bill Brown Sports Fields.
- URBS Sub-catchment #47 (Carseldine Channel) – EDQ Detention Basin #2.

The reach length factor was increased to better match the TUFLOW routing for the majority of the waterways as indicated in Table 4.3.

Table 4.3 – Adopted Reach Length Factor (*f*)

Creek	Adopted Value
Cabbage Tree Creek	1.0 to 2.0
Little Cabbage Tree Creek	1.0 to 2.0
Carseldine Channel	1.0 to 3.0
Taigum Channel	1.0

5.0 Hydraulic Model Development and Calibration

5.1 Overview

The 2014 Flood Study TUFLOW model forms the basis of the TUFLOW model developed for this study. The updates made to the TUFLOW model as part of this study are detailed in Section 5.2. TUFLOW version 2018-03-AB-iSP-w64 has been used for this study, whereas the 2014 Flood Study used TUFLOW version 2012-05-AE-iSP-w64.

5.2 Model Development

5.2.1 Model Schematisation

Figure 5.1 indicates the extent of the TUFLOW model, as well as the inflow locations and the hydraulic structures included in the model. The model consists largely of a 1d / 2d linked schematisation, with the 1d domain modelled in ESTRY and the 2d domain in TUFLOW.

The extents of the model are essentially the same as the TUFLOW model developed for the 2014 Flood Study, apart from at the upstream extent of Cabbage Tree Creek, in the vicinity of Old Northern Road. The TUFLOW model used for the calibration / verification was extended approximately 550 m upstream of Old Northern Road to assist in the development of a rating curve at 540121 (C_A573) on Cabbage Tree Creek at Collins Road, Everton Hills. The rating curve was required to convert the recorded stream levels into an equivalent flow.

5.2.2 Topography

<u>1d Domain</u>

The 1d open channel bathymetry was essentially the same as the TUFLOW model developed for the 2014 Flood Study, apart from the following changes:

- Carseldine Channel in the Fitzgibbon area
    - Between the North Coast Railway and the Bill Brown Sports Fields, the channel was changed from 1d to 2d to better represent the EDQ detention basins, which were constructed as part of the initial EDQ development works in mid-2010.
    - At the downstream end of the Bill Brown Sports Fields, a 200 m section of the Carseldine Channel was realigned to allow for the widening of Telegraph Road, as part of the Stage 2 works in late 2017. This update was incorporated into the design TUFLOW model.
- Cabbage Tree Creek between Lemke Road and the Gateway Motorway – the 1d channel alignment was modified to more accurately represent the meandering of the creek channel.
- Cabbage Tree Creek at Old Northern Road - the extension of the calibration TUFLOW model approximately 550 m upstream of Old Northern Road included the creek channel being represented in 1d. The 1d channel cross-sections were typically from 2014 ALS data with the cross-section at the stream gauge being from field survey undertaken in 2012.

- Sandgate and Deagon Tributaries – these two tributaries were previously represented in 2d as part of the 2014 Flood Study TUFLOW model. As these channels are quite small and typically less than two grids cells wide, they were changed to 1d. The 1d channel cross-sections were typically from a mix of design drawings and 2014 ALS data.

Cabbage Tree Creek has a number of large meander bends in the lower section from downstream of the Gateway Motorway. To capture the bend head-loss, an additional form loss has been applied to the 1d channel in a number of locations. The methodology used to determine the bend-loss coefficient is as outlined in Section 9.3.6 of the Queensland Urban Drainage Manual. [6]

The loss coefficient is a function of the bend radius and channel width as follows:

$$k_b = 2B/R_c$$

where:

k_b = bend loss coefficient
B = channel width
R_c = centreline radius of bend

2d Domain – Base Terrain

The base 2d terrain consisted of a 4 m grid which was created from a 1 m ASCII grid file (MGA Zone 56) of the 2014 ALS data. The 2d grid was rotated at an angle of 30 degrees (to the horizontal) to better align with the north-easterly flow direction of the major creeks. The grid cell size and rotation angle are the same as the 2014 Flood Study, with the major difference being the use of 2014 ALS in lieu of 2009 ALS.

The 2014 ALS data was captured as part of the SEQ 2014 LiDAR Capture Project, undertaken by Fugro Spatial Solutions Pty Ltd on behalf of the Queensland Government. The ALS data was acquired from a fixed wing aircraft flying over Brisbane City on the 28th October 2014.

The SEQ 2014 LiDAR Capture Project's technical processes and specifications were designed to achieve the following data accuracies:

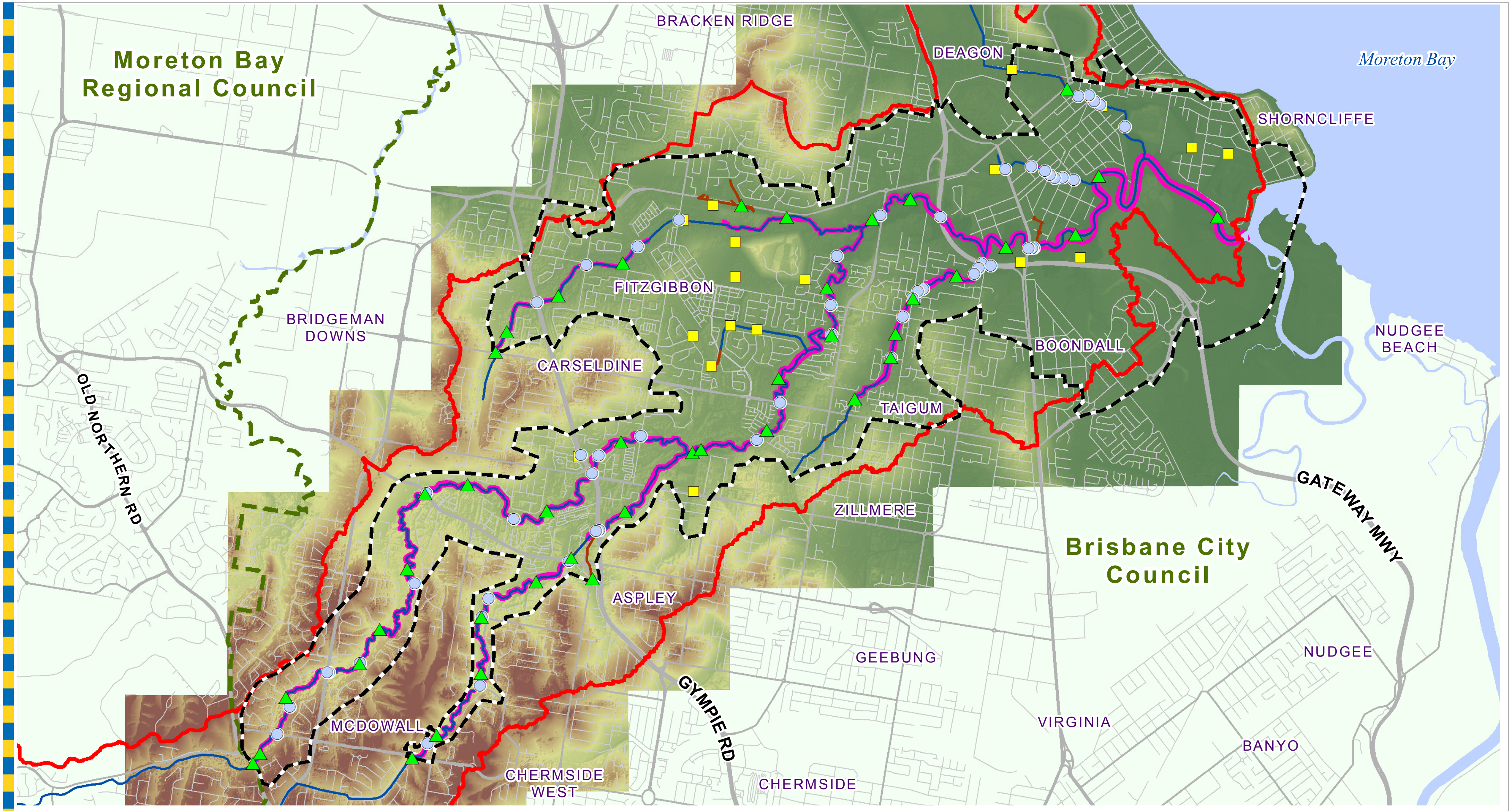
- Vertical data: 0.3 m @ 95 % threshold accuracy
- Horizontal data: 0.8 m @ 95 % threshold accuracy

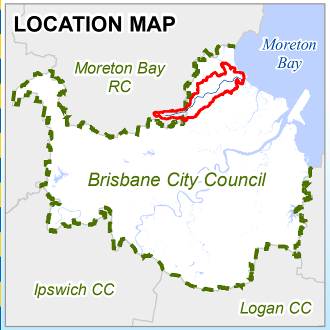
Detailed validation checks have not been undertaken on the accuracy of the 2014 ALS data as part of this flood study. It is assumed that the data is representative of the topography and "fit for purpose."

2d Domain – Major Terrain Modifications

There have been numerous changes within the 2d domain since the base ALS data was captured in October 2014. The majority of these changes have been in the Fitzgibbon area due to the EDQ development works and the upgrade of Telegraph Road / Lemke Road. As a result, the 2d domain was modified with data from a number of sources, which included:

[6] Institute of Public Works Engineering Australasia, QLD Division 2016, *Queensland Urban Drainage Manual*





Hydraulic Structure

1d Inflow Location

2d Inflow Location

1d Piped Drainage

1d Channel Boundary

Model Boundary

Creek Centreline (Cabbage Tree Ck Catchment)

Cabbage Tree Ck Catchment Area

Elevation: 100 m, 50 m, 0 m

Brisbane City Boundary

Road

GIM - 190477 - 005

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Figure 5.1: TUFLOW Model Schematisation

Cabbage Tree Creek Flood Study

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Checked : JS
Revision : 3
Publication Date : 17 Jun 2019
Project Number : 190477

Dedicated to a better Brisbane

- Northern Development Pad Design TIN (Carseldine Channel) – this area was constructed circa mid-2015 and includes the raised development pad between the North Coast Railway and Norris Road; north of Carseldine Channel and south of Telegraph Road. This data was acquired from the EDQ TUFLOW model developed by WRM Consultants.
- 2016 BCC Topographic Survey TIN (Cabbage Tree Creek and Carseldine Channel) – topographic survey was acquired circa February 2016 along the Telegraph Road and Lemke Road alignments in preparation for the Telegraph Road Stage 2 project. This data was acquired from the BCC Telegraph Road Stage 2 TUFLOW model.
- Telegraph Road Stage 1b Design TIN (Cabbage Tree Creek and Carseldine Channel) – BCC Design TIN of the proposed Telegraph Road Stage 1b Alignment (dated 04/12/2015) acquired from the BCC Telegraph Road Stage 1b TUFLOW model. These road works were constructed in 2017.
- Telegraph Road Stage 2 Design TIN (Cabbage Tree Creek and Carseldine Channel) – BCC Design TIN of the proposed Telegraph Road Stage 2 Alignment acquired from the BCC Telegraph Road Stage 2 TUFLOW model. These road works are currently being constructed.
- Carseldine Channel Realignment Design TIN - BCC Design TIN of the proposed realignment of Carseldine Channel due to the Telegraph Road Stage 2 works. This data was acquired from the BCC Telegraph Road Stage 2 TUFLOW model and the channel works were constructed late in 2017.
- 2018 BCC Topographic Survey TIN (Cabbage Tree Creek and Carseldine Channel) – topographic survey was acquired circa February 2018 in the area downstream of the Fitzgibbon Landfill and upstream of Lemke Road, between Carseldine Channel / Cabbage Tree Creek and Telegraph Road.
- 2018 BCC Topographic Survey TIN (Carseldine Channel) – topographic survey was acquired circa March 2018 in the area between the Bill Brown Sports Fields and Telegraph Road, which included the modified Telegraph Road Drain (constructed in 2017).
- Lemke Road Design TIN (Cabbage Tree Creek) – BCC Design TIN of the proposed Lemke Road Alignment acquired from the BCC Telegraph Road Stage 2 TUFLOW model. These road works are currently being constructed.

In the Fitzgibbon area, topographic survey was undertaken (February 2019) as part of this study to accurately define the embankment crests of EDQ Detention Basin #1 and EDQ Detention Basin #2.

5.2.3 Land Use and Hydraulic Roughness

Manning's 'n' roughness values in the 2d section of the TUFLOW model were updated from those used in the 2014 Flood Study TUFLOW model. The assignment of suitable roughness values to the land use / topographical feature was undertaken utilising a combination of aerial photography, BCC City Plan 2014, experience with similar studies and relevant hydraulic literature. Table 5.1 indicates the typical values that were adopted within the 2d section of the TUFLOW model.

Table 5.1 – Adopted TUFLOW roughness parameters

Topographical feature / Land Use	Adopted Manning's 'n'
Land Use BCC City Plan 2014	
Low Density Residential	0.12
Low – Medium Density Residential	0.15
Medium Density Residential	0.15
Neighbourhood Centre	0.15
District Centre	0.15
Low Impact Industry	0.12
Industry (General Industry A,B and C)	0.15
Industry Investigation	0.12
Sport And Recreation	0.04
Open Space	0.04
Environmental Management and Conservation	0.08
Emerging Communities	0.06
Extractive Industry	0.10
Rural Residential	0.06
Community Facilities (Major Health Care)	0.06
Community Facilities (Cemetery)	0.04
Community Facilities (Community Purposes)	0.10
Community Facilities (Education Purposes)	0.10
Community Facilities (Emergency Services)	0.15
Specialised Centre (Major Education and Research)	0.12
Specialised Centre (Large Format Retail)	0.12
Specialised Centre (Mixed Industry and Business)	0.12
Special Purpose (Detention Facility)	0.08
Special Purpose (Transport Infrastructure)	0.04
Special Purpose (Utility Services)	0.04
Additional Roughness	
Road pavement	0.02
Road verge	0.03
Channel – concrete lined	0.015
Vegetation – light to high density	0.035 to 0.15
Minimum Riparian Corridor (MRC)	0.15

Manning's 'n' values in the 1d section of the TUFLOW model were typically not changed from those values used in the 2014 Flood Study TUFLOW model, only some minor adjustments were made as part of the calibration process. The 2014 Flood Study used differing techniques to represent the hydraulic roughness within the 1d cross-section. In the majority of areas, a single composite Manning's 'n' value was used, whereas in other areas, the Manning's 'n' values were varied horizontally across the 1d cross-section. Whilst the use of a single composite Manning's 'n' value is not considered best practice, this approach was typically not changed for this study, unless to make local adjustments to improve the calibration. Typically, where adjustments to the cross-section hydraulic roughness were undertaken, the approach adopted was consistent with the methodology used in the 2014 Flood Study.

5.2.4 Hydraulic Structures – Culverts and Bridges

The major bridge and culvert structures within the model extents were represented in the TUFLOW model. These structures generally consisted of the waterway crossing from motorways, railways, local roads and footbridges. Table 5.2 indicates the location and details of the structures as well as the modelling approach used. The majority of the structures are the same as represented in the TUFLOW model developed for the 2014 Flood Study. However, there were a number of structures upgraded as part of this study, of which the majority are listed below:

Sandgate Road / Shorncliffe Railway / Pedestrian Bridge (S1 to S3) – Cabbage Tree Creek

These three structures were modelled as the one structure in the 2014 Flood Study. As part of this study, these structures were modelled separately using the 1d bridge / 1d weir approach for each structure.

Gateway Motorway (S4) – Cabbage Tree Creek

The former bridge structure was removed and two new four span bridges were constructed in 2013 / 2014. These two parallel bridges were modelled as one bridge and represented in the model using the 1d bridge / 1d weir approach.

Lemke Road (S5) – Cabbage Tree Creek

The new Lemke Road Bridge is currently being constructed as part of the Telegraph Road Stage 2 project. This bridge was represented in 2d as part of the design TUFLOW model using the 2d layered flow constriction methodology in TUFLOW.

North Coast Railway (S10) – Cabbage Tree Creek

These dual bridge structures were updated to reflect the as-constructed conditions. These two structures were modelled as one structure (based on the smaller upstream bridge) and included in the model using the 1d bridge / 1d weir approach.

Albany Creek Road (S15) – Cabbage Tree Creek

This culvert was changed from 6 / 3 x 3 m RCBCs to 5 / 3 x 3 m RCBCs to reflect the as-constructed conditions.

401A Church Road (S26) – Taigum Channel

This culvert was changed from 2 / 1.8 x 0.6 m RCBCs to 2 / 1.725 m dia RCPs to reflect the as-constructed conditions.

Table 5.2 – Hydraulic Structures represented in the TUFLOW model

Creek	Structure ID	AMTD	Structure location	Structure details	Modelled structure representation	Origin of Structure Coding
Cabbage Tree	S1	3490	Blackwood Road	Three span bikeway bridge	1d bridge / 1d weir	Design drawings
	S2	3510	Shorncliffe Railway	Dual seven span rail bridges	1d bridge / 1d weir	QLD Rail design drawings + 2010 KBR Gateway Upgrade North + engineering judgement
	S3	3550	Sandgate Road	Dual four span road bridges	1d bridge / 1d weir	DTMR design drawings
	S4	4570	Gateway Motorway	Dual four span road bridges	1d bridge / 1d weir	DTMR design drawings
	S5	5350	Lemke Road	Three span road bridge	2d bridge / 2d weir	BCC TUFLOW model for Telegraph Road Stage 2
	S6	5960	Cambridge Crescent	Bikeway bridge	Not modelled	N/A
	S7	6580	Roghan Road	Two span road bridge	1d bridge / 1d weir	2014 Flood Study
	S8	6900	Jasmine Circuit	Bikeway bridge	Not modelled	N/A
	S9	8190	Beams Road	5 / 3.6 x 1.8 m RCBCs + 4 / 3.6 x 3.6 m RCBCs + 1 / 3.6 x 2.7 m RCBC	1d culvert / 1d weir	2014 Flood Study
	S10	8710	North Coast Railway	Dual multiple span bridges	1d bridge / 1d weir	QLD Rail design drawings
	S11	9990	Dorville Road	5 / 3.6 x 3.6 m RCBCs	1d culvert / 1d weir	2014 Flood Study
	S12	10510	Kahli Place	Bikeway bridge	Not modelled	N/A
	S13a	10720	Gympie Road	Dual two span road bridges	1d bridge / 1d weir	2014 Flood Study
	S13b	10720	Gympie Road	4 / 0.9 m dia RCPs	1d culvert / 1d weir	2014 Flood Study
	S14	11940	Livingstone Circuit	Bikeway bridge	Not modelled	N/A

Creek	Structure ID	AMTD	Structure location	Structure details	Modelled structure representation	Origin of Structure Coding
Cabbage Tree	S15	13080	Albany Creek Road	5 / 3 x 3 m RCBCs	1d culvert / 1d weir	1996 Flood Study (culvert) + 2014 Flood Study (weir)
	S16	14380	Bangalow Street	Bikeway bridge	Not modelled	N/A
	S17	15480	Costner Place	Bikeway bridge	Not modelled	N/A
	S18	15800	Beckett Road	Two span bikeway bridge	Not modelled	N/A
	S19	15820	Beckett Road	4 / 3.3 x 3.3 m RCBCs	1d culvert / 2d weir	2014 Flood Study
	S20	16350	Streisand Drive	2 / 1.35 m dia RCPs	1d culvert / 1d weir	
	S21	16670	Hamilton Road	5 / 3.6 x 2.7 m RCBCs	1d culvert / 2d weir	
Taigum	S22a	200	Gateway Motorway	2 / 2.4 x 1.9 m RCBCs + 4 / 2.4 x 2.1 m RCBCs + 1 / 2.4 x 2.5 m RCBC	1d culvert / 2d weir	
	S22b			3 / 1.5 x 1.5 m RCBCs	1d culvert / 2d weir	
	S23	270	350 Muller Road	1 / 1.725 m dia RCP + 1 / 1.65 m dia RCP	1d culvert / 2d weir	
	S24	330	334 Muller Road	2 / 1.825 m dia RCP + 1 / 1.825 m dia RCP + 1 / 1.425 m dia RCP	1d culvert / 2d weir	
	S25	915	401 Church Road	Single span bridge	1d bridge / 1d weir	
	S26	970	401A Church Road	2 / 1.725 m dia RCPs	1d culvert / 1d weir	2012 Taigum Channel Flood Study
	S27	1080	Church Road	4 / 3.3 x 1.5 m RCBCs	1d culvert / 1d weir	2014 Flood Study
	S28	1275	Roghan Road	3 / 3.6 x 1.5 m RCBCs	1d culvert / 1d weir	
	S29	1690	Quarrion Street	4 / 3.6 x 1.5 m RCBCs	1d culvert / 1d weir	

Creek	Structure ID	AMTD	Structure location	Structure details	Modelled structure representation	Origin of Structure Coding
Carseldine	S30	1925	Norris Road	15 / 1.8 x 0.9 m RCBCs	1d culvert / 2d weir	EDQ TUFLOW model developed by WRM Consultants
	S31	2460	North Coast Railway	3 / 3.45 x 2.4 m RCBCs	1d culvert / 2d weir	2014 Flood Study
	S32	3080	Lacey Road	4 / 3.3 x 1.5 m RCBCs + 1 / 3.3 x 1.8 m RCBC	1d culvert / 2d weir	
	S33	5630	Gympie Road	5 / 1.5 x 0.9 m RCBCs	1d culvert / 2d weir	
Little Cabbage Tree	S34	570	Zillmere Road	5 / 3.6 x 2.4 m RCBCs	1d culvert / 1d weir	Design drawings (culvert) + 2014 Flood Study (weir)
	S35	1270	Gympie Road	3 / 2.05 x 1.8 m RCBCs + 3 / 2 m dia RCPs	1d culvert / 1d weir	1996 Flood Study (culvert) + 2014 Flood Study (weir)
	S36	1300	Gayford Street	4 / 4 x 2 m RCBCs	1d culvert / 1d weir	2014 Flood Study
	S37	1685	Albany Creek Road	3 / 4.6 x 2.33 m RCBCs to 6 / 2.13 x 2.33 m RCBCs to 3 / 4.6 x 2.33 m RCBCs	1d culvert / 2d weir	
	S38	2600	Hawera Street	Bikeway bridge	Not modelled	N/A
	S39	2795	Horn Road	Single span bikeway bridge	1d bridge / 1d weir	2014 Flood Study
	S40	3510	Martindale Street	5 / 3.6 x 3 m RCBCs	1d culvert / 2d weir	
	S41	4305	31 Walker Street	Timber bikeway bridge	Not modelled	N/A
Sandgate Tributary	S42	475	Bungama Street	Bikeway bridge	Not modelled	N/A
	S43	890	Bridge Street	4 / 2.1 x 1.5 m RCBCs	1d culvert / 2d weir	Design drawings + 2014 ALS
	S44	960	Shorncliffe Railway	2 / 2.24 x 1.52 m RCBCs + 2 / 1.5 m dia RCPs	1d culvert / 2d weir	Design drawings + 2014 ALS
	S45	1040	Barclay Street	2 / 3.3 x 1.5 m RCBCs	1d culvert / 2d weir	Design drawings + 2014 ALS

Creek	Structure ID	AMTD	Structure location	Structure details	Modelled structure representation	Origin of Structure Coding
Sandgate Tributary	S46	1150	Coward Street	2 / 2.24 x 1.52 m RCBCs	1d culvert / 2d weir	Design drawings + 2014 ALS
Deagon Tributary	S47	265	Finnie Road	2 / 3 x 1.8 m RCBCs	1d culvert / 2d weir	Design drawings + 2014 ALS
	S48	375	Blackwood Road	2 / 3 x 1.8 m RCBCs	1d culvert / 2d weir	Design drawings + 2014 ALS
	S49	460	Shorncliffe Railway	2 / 2.4 x 1.5 m RCBCs	1d culvert / 2d weir	QR Advice + Engineering Judgement + 2014 ALS
	S50	520	Smith Street	2 / 2.7 x 1.2 m RCBCs	1d culvert / 2d weir	Design drawings + 2014 ALS
	S51	580	Esther Street	2 / 2.7 x 1.2 m RCBCs	1d culvert / 2d weir	Design drawings + 2014 ALS
	S52	730	Loftus Street	2 / 2.1 x 1.2 m RCBCs	1d culvert / 2d weir	Design drawings + 2014 ALS
	S53	1010	Braun Street	4 / 1.2 m dia RCPs	1d culvert / 2d weir	BCC Records + Engineering Judgement + 2014 ALS

Norris Road (S30) – Carseldine Channel

The upgrade of Norris Road was undertaken as part of the EDQ works in Fitzgibbon. The new culvert (constructed circa April 2014) was represented in both the calibration and design TUFLOW models as 1d culvert / 2d weir.

Zillmere Road (S34) – Little Cabbage Tree Creek

This culvert was changed from [5 / 3.6 x 2.4 m RCBCs + 1 / 1.8 m dia RCP] to 5 / 3.6 x 2.4 m RCBCs to reflect the as-constructed conditions.

Gympie Road (S35) – Little Cabbage Tree Creek

This culvert was changed from [1 / 3.35 x 2.45 m RCBCs + 2 / 2.3 x 2.45 m RCBCs + 3 / 2 m dia RCPs] to [3 / 2.05 x 1.8 m RCBCs + 3 / 2 m dia RCPs] to reflect the as-constructed conditions.

S43 to S46 – Sandgate Tributary

These four culvert structures were changed from 2d layered flow constrictions to 1d culverts to better model the hydraulics of the structures.

S47 to S53 – Deagon Tributary

These seven culvert structures were changed from 2d layered flow constrictions to 1d culverts to better model the hydraulics of the structures.

5.2.5 Piped Drainage

A number of piped drainage reaches were modelled as part of the 2014 Flood Study. The coding of these piped drainage reaches in TUFLOW has typically not been changed from the 2014 Flood Study. However, there were a number of additional piped drainage reaches modelled as part of this study, as follows:

Enbrook Park Detention Basin – Carseldine Channel

The Enbrook Park Detention Basin is adjacent to Bracken Ridge Plaza, close to the intersection of Telegraph Road and Norris Road. The outlet pipework for this detention basin was included in the TUFLOW model to better represent the hydraulics of the detention basin and the greater Carseldine Channel.

The calibration TUFLOW model uses the pipework configuration prior to the upgrade as part of the Telegraph Road Stage 1b project. The design TUFLOW model uses the pipework configuration upgraded as part of the Telegraph Road Stage 1b project.

Carseldine Railway Station

The culvert crossing of the North Coast Railway, immediately north of Carseldine Railway Station, consists of 3 / 1.5 m dia RCPs. When development works occurred downstream of this culvert in mid-2011, the open waterway was piped for 150 m downstream. This 150 m length of pipework was included in the TUFLOW model.

Blackwood Road at Deagon

This 260 m length of pipework conveys runoff from upstream of the Shorncliffe Railway embankment (intersection of Musgrave and Bowen Streets) via Blackwood Street to its outfall downstream of the railway embankment at Cabbage Tree Creek. This pipework was included to better represent the flooding upstream of the railway embankment in large events.

Sandgate Tributary at Board Street

The 130 m long piped section of this tributary between Kempster Street and the open waterway downstream of Board Street was included in the TUFLOW model. This section consists of 3 / 1.35 m dia RCPs connecting into a 2-cell box culvert, which in turn flows underneath Board Street.

5.2.6 Boundary Conditions

Inflow Boundaries

Inflows to the TUFLOW hydraulic model were taken from the URBS hydrologic model. All inflows were represented as a discharge versus time (Q-T) relationship, with the inflow locations as indicated in Figure 5.1. The inflow locations were generally adopted to match the URBS model sub-catchment schematisation.

Downstream Boundary

A varying water level versus time (H-T) boundary was used to represent the downstream boundary conditions at the mouth of Cabbage Tree Creek. As there is no stream gauge at the mouth of Cabbage Tree Creek, the H-T boundary was derived based on the recorded levels at the Brisbane Bar. At the mouth of Cabbage Tree Creek, the 2019 QLD Tide Tables [7] recommend factoring the recorded level at the Brisbane Bar by 0.96.

5.2.7 Run Parameters

Time Step

The 1d ESTRY component was run using a 0.5 second time step and 2d TUFLOW component using a 1 second time step.

Eddy Viscosity

The Smagorinsky method was used for specifying the eddy viscosity in the 2d domain. This method is recommended in the TUFLOW manual and the default approach, in lieu of the Constant method. The method uses the Smagorinsky formula with a “Constant Coefficient” of 0.1 and “Smagorinsky Coefficient” of 0.2. This method has been successfully used on other similar BCC flood studies.

[7] Maritime Safety Queensland – Queensland Tide Tables Standard Port Tide Times 2019

5.3 Calibration Procedure

5.3.1 Tolerances

BCC flood studies aim to achieve the following tolerances with regard to the hydraulic model calibration / verification:

- Continuous recording stream gauges - within ± 0.15 m of the peak flood level
- MHGs - within ± 0.30 m of the peak flood level
- Debris marks - within ± 0.40 m of the peak flood level
- Good replication of the timing of peaks and troughs.

5.3.2 Methodology

The methodology applied to the calibration and verification of the TUFLOW model was as follows:

1) Run a large slowing increasing flow through the TUFLOW model to enable hydraulic structure head-loss checks to be undertaken against the HEC-RAS model(s).
2) Iteratively adjust the bridge loss parameters (as required) and re-run the model to establish a reasonable correlation with the HEC-RAS model(s).
3) Using the flow inputs from the URBS model, run the calibration events through the TUFLOW model and compare the simulated results against the observed flood levels at both the stream gauge and the MHGs.
4) Iteratively adjust the TUFLOW model parameters and re-run the model with the aim of achieving a good fit with the observed data. The predominant model parameters adjusted included Manning's 'n' and the hydraulic structure losses.
5) Adopt model parameters based on the calibration results.
6) Using the flow inputs from the URBS model, run the single verification event through the calibrated TUFLOW model and compare the simulated results against the observed flood levels at the stream gauge and the MHGs.

The exact same TUFLOW model set-up has been used for all three historical events. This set-up represents the catchment and waterway conditions circa 2015 / 2016.

5.4 Hydraulic Model Calibration Results

5.4.1 May 2015

The 1st May 2015 flood was simulated in TUFLOW for 60 hours from 12 am on the 30th April 2015 to 12 pm on the 2nd May 2015. Figure 5.2 to Figure 5.4 provide a comparison between the TUFLOW (and URBS) results and the gauged flood level at the three stream gauges within the BCC area.

Table 5.3 provides a comparison between the TUFLOW results and the recorded peak flood levels at the MHGs and Table 5.4 provides a comparison between the TUFLOW results and the peak flood levels at the debris marks.

From review of the peak level / MHG results, it was apparent that at 30 out of 33 locations the desired peak flood level tolerance of ± 0.30 m was able to be achieved. At most locations, the simulated flood level was slightly lower than the observed, with the average difference being -0.13 m. The reading at MHG C170 was disregarded as it appears to be in error, as the recorded flood level was over 0.4 m lower than the recorded flood level at the downstream MHG C160.

From review of the debris level results, it was apparent that at 8 out of 10 locations the desired peak flood level tolerance of ± 0.40 m was able to be achieved.

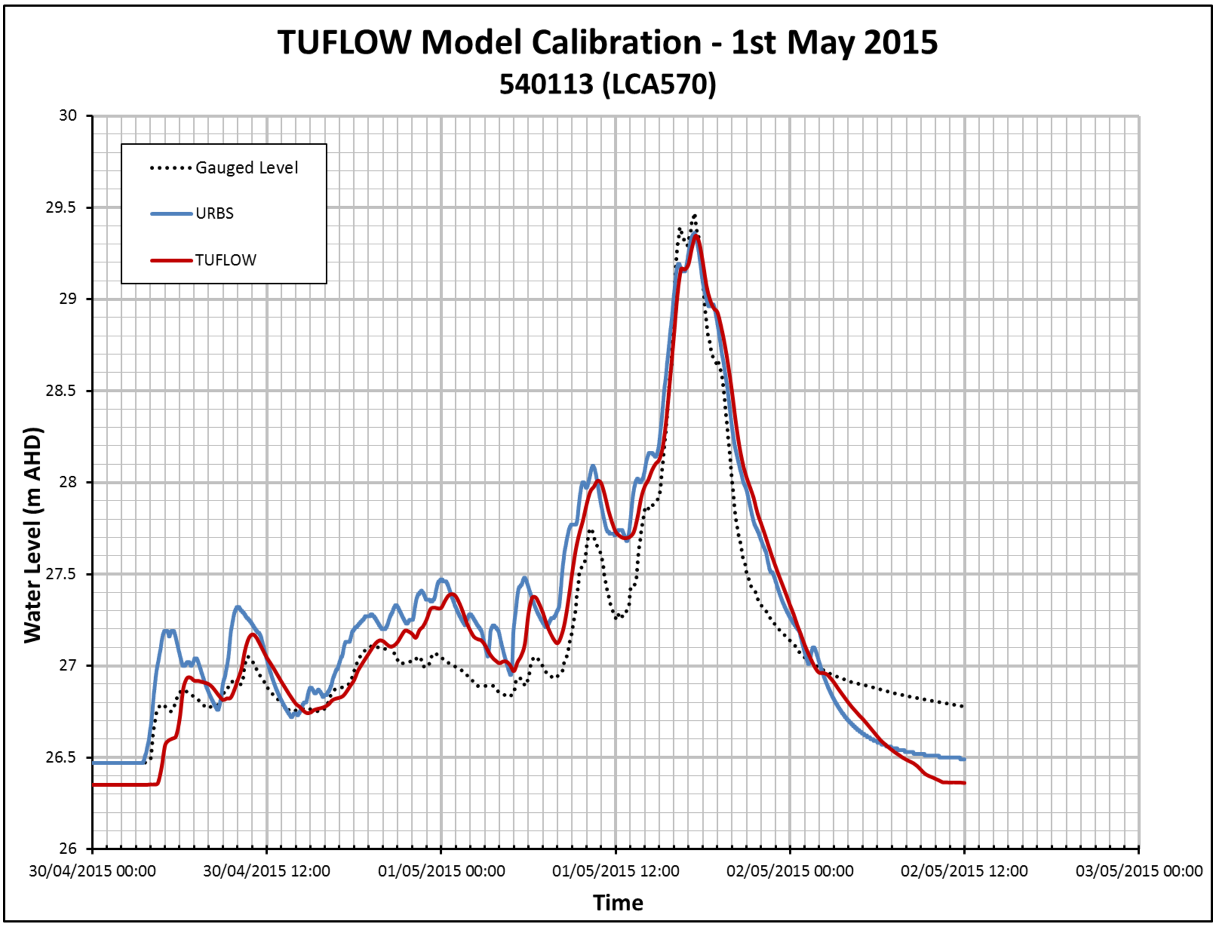

Figure 5.2: May 2015 TUFLOW Model Calibration - Little Cabbage Tree Creek at 540113 (LCA570)

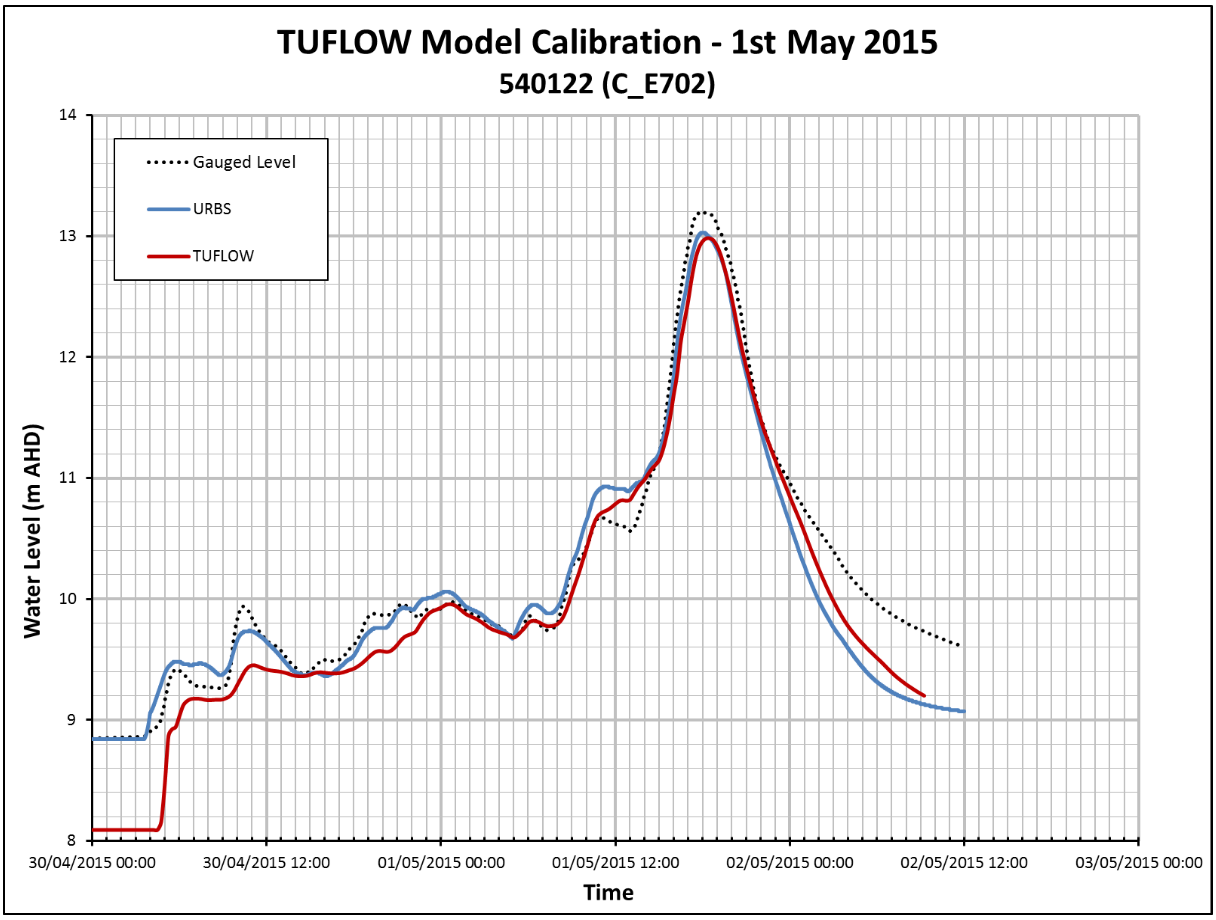

Figure 5.3: May 2015 TUFLOW Model Calibration - Cabbage Tree Creek at 540122 (C_E702)

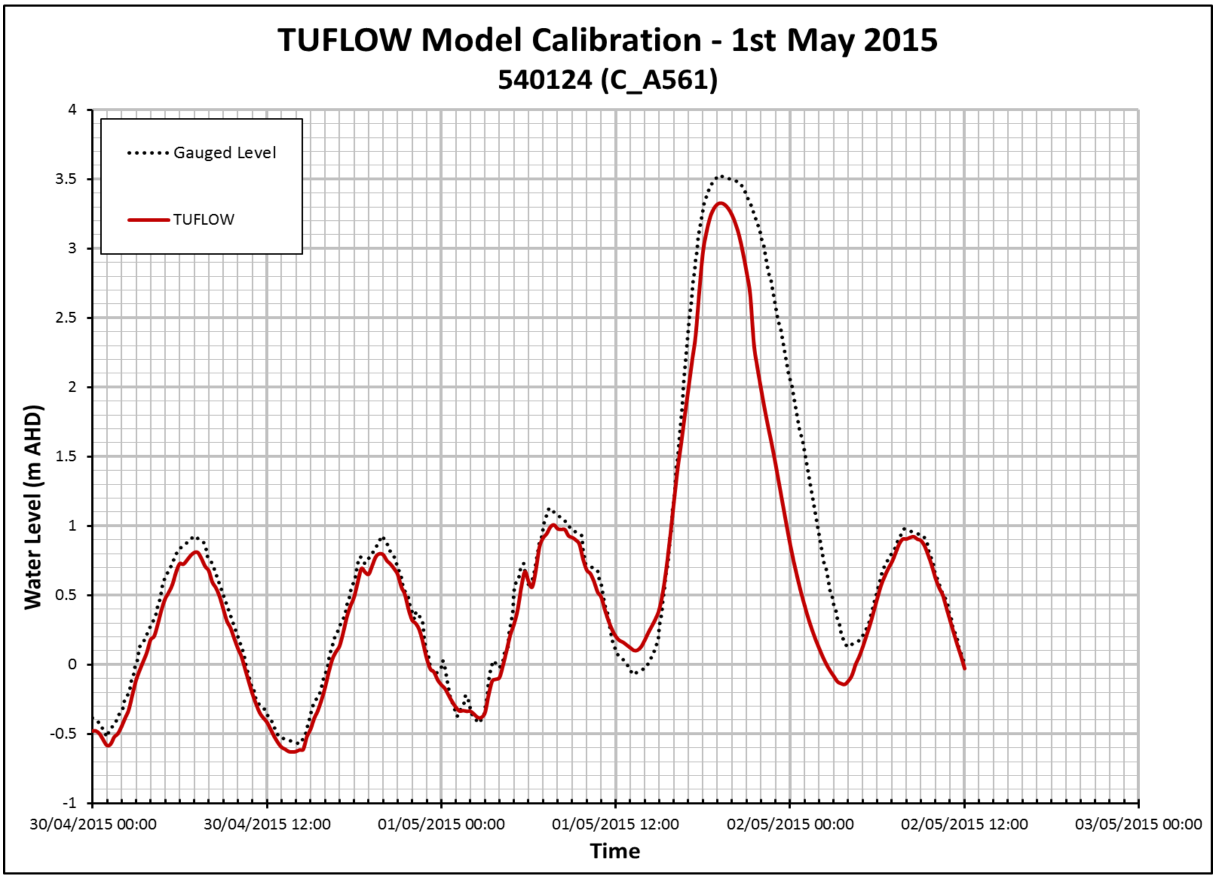

Figure 5.4: May 2015 TUFLOW Model Calibration - Cabbage Tree Creek at 540124 (C_A561)

Table 5.3 – Calibration to Peak Flood Level Data (1st May 2015)

Creek / Channel	Gauge ID	Location	Recorded Peak WL (mAHD)	Simulated Peak WL (mAHD)	Difference (m)
Cabbage Tree	C100	1.2 km u/s of the creek mouth	1.60	1.46	-0.15
	540124	Stream Gauge	3.53	3.31	-0.22
	C110	400 m d/s of Gateway Motorway	4.02	3.71	-0.31
	C120	d/s at Lemke Road	4.62	4.23	-0.39
	C130	u/s at Lemke Road	4.98	4.53	-0.45
	C140	d/s at Roghan Road	8.16	8.15	-0.01
	C150	u/s at Roghan Road	8.62	8.36	-0.26
	C160	d/s at Beams Road	12.23	12.15	-0.08
	C170	u/s at Beams Road	~~11.80~~	~~12.35~~	~~0.55~~
	540122	Stream Gauge	13.20	13.00	-0.20
	C190	u/s at Gympie Road	19.18	19.23	0.05
	C200	700 m u/s of Gympie Road	20.91	20.78	-0.13
	C210	d/s at Albany Creek Road	25.73	25.63	-0.10
	C220	u/s at Albany Creek Road	26.00	25.94	-0.06
	C230	500 m u/s of Albany Creek Road	27.52	27.46	-0.06
	C240	1.4 km u/s of Albany Creek Road	31.32	31.37	0.05
	C250	300 m d/s of Beckett Road	35.00	34.80	-0.20
	C260	u/s at Beckett Road	37.40	37.14	-0.26
	C270	d/s at Old Northern Road	42.11	42.35	0.24
Taigum	C300	d/s at Gateway Motorway	3.88	3.58	-0.30
	C310	u/s at Gateway Motorway	3.88	3.65	-0.23
	C320	300 m u/s of Gateway Motorway	3.92	3.71	-0.21
	C330	u/s at Church Road	5.37	5.18	-0.19
	C340	d/s at Roghan Road	5.80	5.78	-0.02
Carseldine	C410	u/s at North Coast Railway	11.93	11.70	-0.23
	C420	u/s at Lacey Road	13.31	13.33	0.02
Little Cabbage Tree	LC100	Close to the Cabbage Tree – Little Cabbage Tree confluence	14.66	14.43	-0.23
	LC110	d/s at Zillmere Road	16.71	16.47	-0.24
	LC120	u/s at Zillmere Road	16.87	16.69	-0.18
	LC130	d/s at Gympie Road	19.31	19.09	-0.22
	LC140	u/s at Gympie Road	20.00	19.86	-0.14
	LC150	u/s at Albany Creek Road	21.78	21.74	-0.04
	LC160	u/s at Horn Road	28.30 (d)	28.60	0.30
	540113	Stream Gauge	29.47	29.38	-0.09
	LC171	d/s at Martindale Street	31.72	31.61	-0.11
	LC172	u/s at Martindale Street	32.07	31.96	-0.11
	LC180	u/s at Trouts Road	36.05	36.27	0.22

(d) Reading from debris mark

Table 5.4 – Calibration to Debris Levels (1st May 2015 event)

Creek / Channel	Location	Recorded Peak WL (mAHD)	Simulated Peak WL (mAHD)	Difference (m)
Cabbage Tree	Station Road, Deagon	2.28	1.76 (1)	-0.52
	Upstream at Dorville Road, Aspley	16.74	16.87	0.13
	Zillmere Road, Aspley	18.33	18.33	0.00
Little Cabbage Tree	Augusta Street, Aspley	24.80	24.93	0.13
Carseldine	Telegraph Road at Enbrook Park Detention Basin, Bracken Ridge	8.93	8.93	0.00
	Macaranga Crescent, Carseldine	16.44	16.30 (1)	-0.13
	Accolade Place, Carseldine	19.41	19.34	-0.07
Taigum	50 m upstream of Quarrion Street, Taigum	7.11	6.66 (1)	-0.45
Miscellaneous	Azalea Crescent, Fitzgibbon	10.42	10.73	0.31
	Odense Street, Fitzgibbon	10.36	10.73	0.37

(1) Dry ground – closest flood level used

At Stream Gauge 540113 (Stringybark Drive, Aspley), the simulated peak flood level was within the desired ± 0.15 m tolerance. The overall shape of the hydrograph and the timing of the flood peak achieved a good fit with the observed, however the simulated falling limb generally did not recede as quickly as the observed.

At Stream Gauge 540122 (Pineapple Street, Carseldine), the simulated peak flood level was 0.20 m lower than the observed, which is just outside the desired ± 0.15 m tolerance. The simulated rising limb achieved a good fit with the recorded hydrograph, however, the simulated falling limb generally receded quicker than the observed.

At Stream Gauge 540124 (Burralong Street, Deagon), the simulated peak flood level was 0.22 m lower than the observed, which is just outside the desired ± 0.15 m tolerance. The timing of the simulated peak and troughs achieved a good fit with the recorded hydrograph.

5.4.2 4th June 2016

The 4th June 2016 flood was simulated in TUFLOW for 36 hours from 12 pm on the 3rd June 2016 to 12 am on the 5th June 2016. Figure 5.5 to Figure 5.7 provide a comparison between the TUFLOW (and URBS) results and the gauged flood level at the three stream gauges within the BCC area.

Table 5.5 provides a comparison between the TUFLOW results and the recorded peak flood levels at the MHGs for which records were available.

From review of the peak level / MHG results, it was apparent that at 26 out of 29 locations the desired peak flood level tolerance of ± 0.30 m was able to be achieved. At most locations, the simulated flood level was slightly higher than the observed, with the average difference being 0.1 m. The reading at MHG C170 was disregarded as it appears to be in error, as the recorded flood level was over 0.6 m lower than the recorded flood level at the downstream MHG C160.

At Stream Gauge 540113 (Stringybark Drive, Aspley), the simulated peak flood level was within the desired ± 0.15 m tolerance. The overall shape of the simulated hydrograph achieved a reasonable fit and the timing of the flood peak matched well with the observed, however, the simulated falling limb generally did not recede as quickly as the observed.

At Stream Gauge 540122 (Pineapple Street, Carseldine), the simulated peak flood level was 0.28 m higher than the observed, which is outside the desired ± 0.15 m tolerance. The simulated rising limb was slightly earlier than the observed and the simulated falling limb generally did not recede as quickly as the observed.

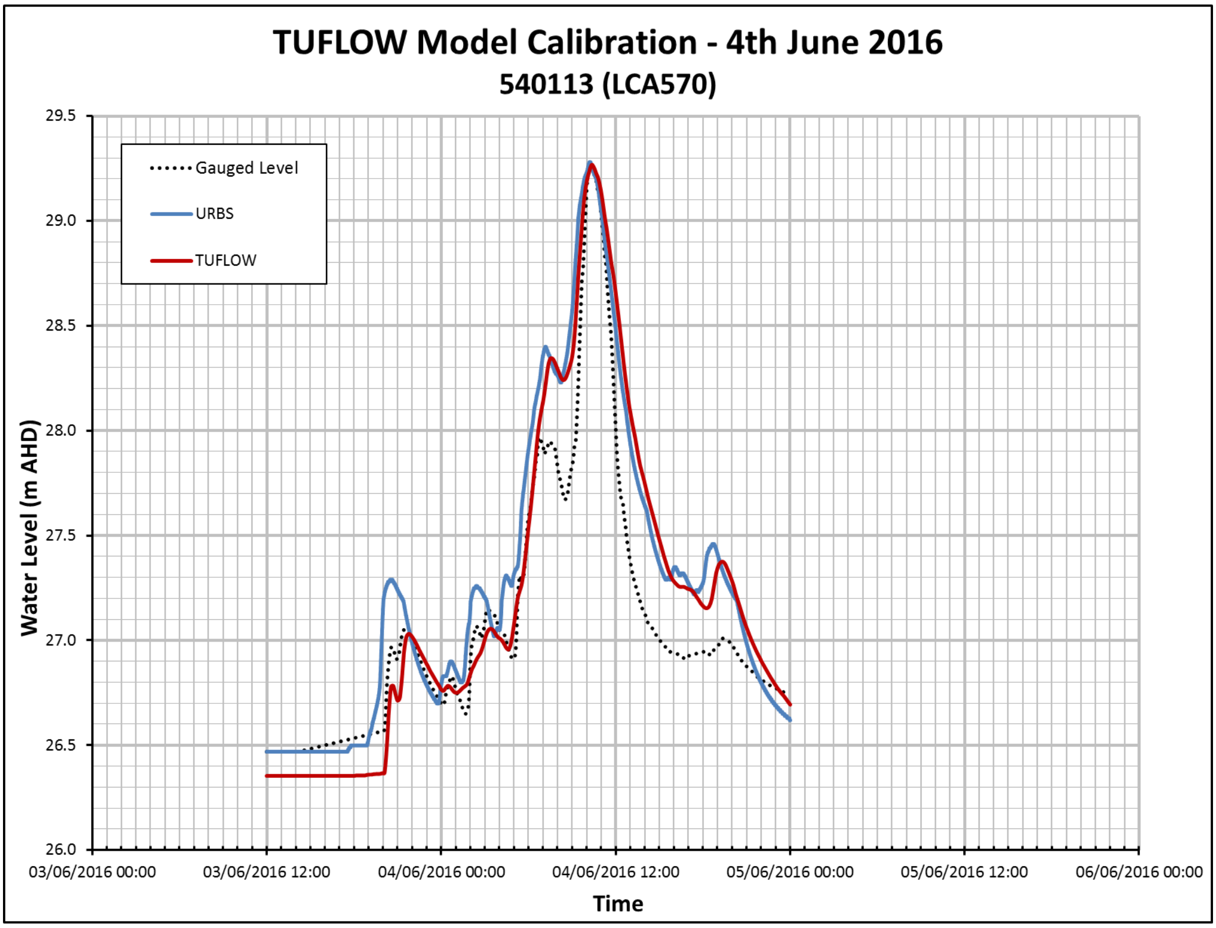

Figure 5.5: 4th June 2016 TUFLOW Model Calibration - Little CTC at 540113 (LCA570)

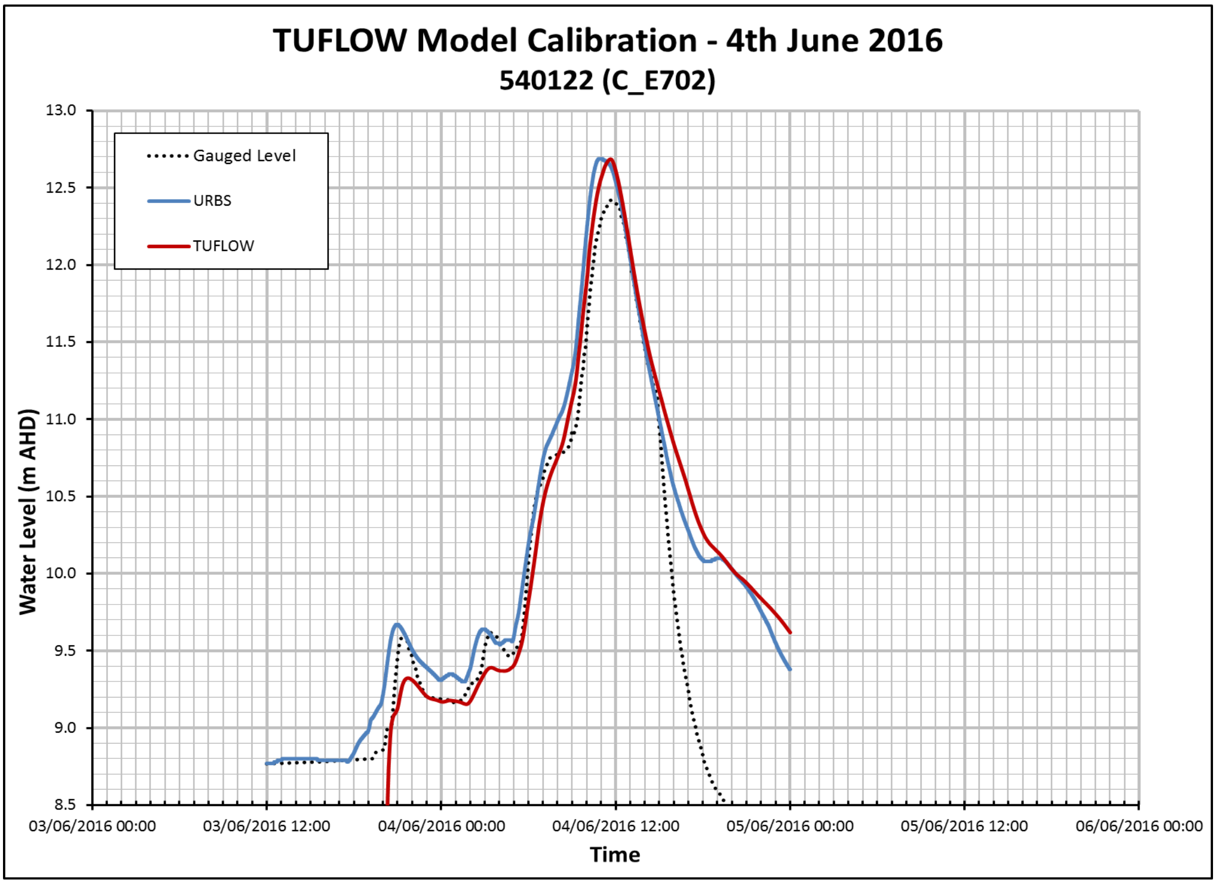

Figure 5.6: 4th June 2016 TUFLOW Model Calibration - Cabbage Tree Creek at 540122 (C_E702)

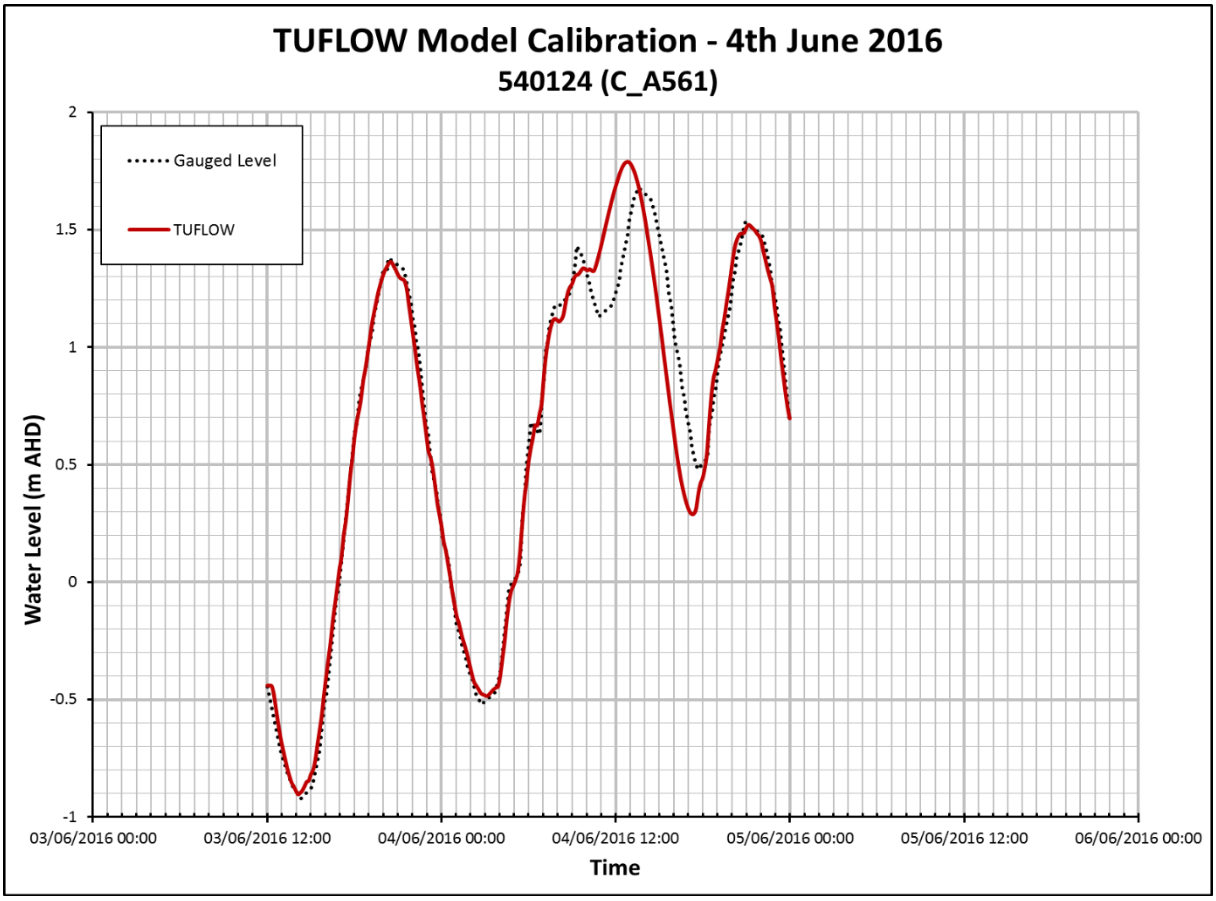

Figure 5.7: 4th June 2016 TUFLOW Model Calibration - Cabbage Tree Creek at 540124 (C_A561)

At Stream Gauge 540124 (Burralong Street, Deagon), the simulated peak flood level was within the desired ± 0.15 m tolerance. The simulated flood shape achieved a reasonable fit, however the simulated flood peak occurred approximately 1-hour before the observed and the simulated hydrograph was unable to replicate the trough, which occurred approximately 3-hours before the flood peak.

Table 5.5 – Calibration to Peak Flood Level Data (4th June 2016)

Creek / Channel	Gauge ID	Location	Recorded Peak WL (mAHD)	Simulated Peak WL (mAHD)	Difference (m)
Cabbage Tree	540124	Stream Gauge	1.68	1.79	0.11
	C110	400 m d/s of Gateway Motorway	2.60	2.81	0.21
	C120	d/s at Lemke Road	3.62	3.77	0.15
	C130	u/s at Lemke Road	3.90	4.17	0.27
	C140	d/s at Roghan Road	7.74	7.82	0.08
	C150	u/s at Roghan Road	7.72	7.96	0.24
	C160	d/s at Beams Road	11.43	11.91	0.48
	C170	u/s at Beams Road	~~10.78 [d]~~	~~12.06~~	~~1.28~~
	540122	Stream Gauge	12.42	12.69	0.27
	C180	d/s at Dorville Road	16.31	16.49	0.18
	C190	u/s at Gympie Road	18.82	18.99	0.17
	C200	700 m u/s of Gympie Road	20.53	20.63	0.10
	C210	d/s at Albany Creek Road	25.58	25.54	-0.04
	C220	u/s at Albany Creek Road	25.61	25.80	0.19
	C230	500 m u/s of Albany Creek Road	27.39	27.41	0.02
	C240	1.4 km u/s of Albany Creek Road	31.34	31.32	-0.02
	C250	300 m d/s of Beckett Road	34.86	34.73	-0.13
	C260	u/s at Beckett Road	37.04	36.90	-0.14
	C270	d/s at Old Northern Road	42.06	42.24	0.18
Taigum	C300	d/s at Gateway Motorway	2.46	2.62	0.16
	C310	u/s at Gateway Motorway	2.40	2.71	0.31
	C330	u/s at Church Road	4.53	4.28	-0.25
	C340	d/s at Roghan Road	5.28	5.00	-0.28
Carseldine	C410	u/s at North Coast Railway	11.53	11.28	-0.25
	C420	u/s at Lacey Road	13.11	13.29	0.18
Little Cabbage Tree	LC100	Close to the Cabbage Tree – Little Cabbage Tree confluence	13.85	14.17	0.32
	LC110	d/s at Zillmere Road	16.18	16.32	0.14
	LC120	u/s at Zillmere Road	16.26	16.52	0.26
	LC130	d/s at Gympie Road	18.92	19.00	0.08
	LC140	u/s at Gympie Road	19.55	19.77	0.22
	540113	Stream Gauge	29.27	29.31	0.04
	LC171	d/s at Martindale Street	31.54	31.54	0.00
	LC172	u/s at Martindale Street	31.82	31.87	0.05

5.5 Hydraulic Model Verification Results

5.5.1 19th June 2016

The 19th June 2016 flood was simulated in TUFLOW for 48 hours from 12 am on the 19th June 2016 to 12 am on the 21st June 2016. Figure 5.8 to Figure 5.10 provide a comparison between the TUFLOW (and URBS) results and the gauged flood level at the three stream gauges within the BCC area.

Table 5.6 provides a comparison of the TUFLOW results and the recorded peak flood levels at the MHGs for which records were available

From review of the peak level / MHG results, it was apparent that at 30 out of 30 locations the desired peak flood level tolerance of ± 0.30 m was able to be achieved. The simulated flood levels were both higher and lower than the observed, with no obvious trend being apparent and reflected by an average difference of 0 m.

At Stream Gauge 540113 (Stringybark Drive, Aspley), the simulated peak flood level was within the desired ± 0.15 m tolerance. The overall shape of the simulated hydrograph was reasonable and the timing of the flood peak achieved a good fit with the observed,

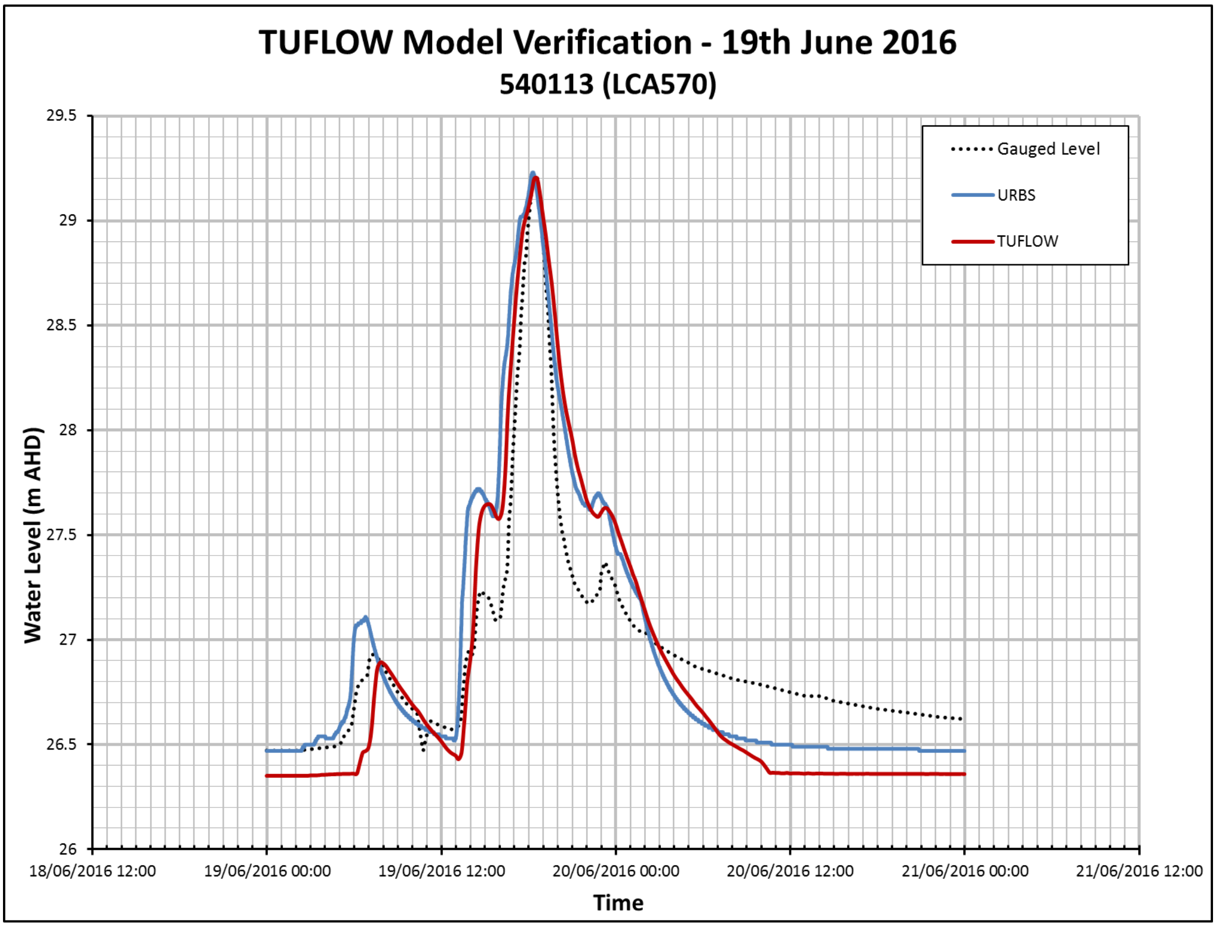

Figure 5.8: 19th June 2016 TUFLOW Model Calibration - Little CTC at 540113 (LCA570)

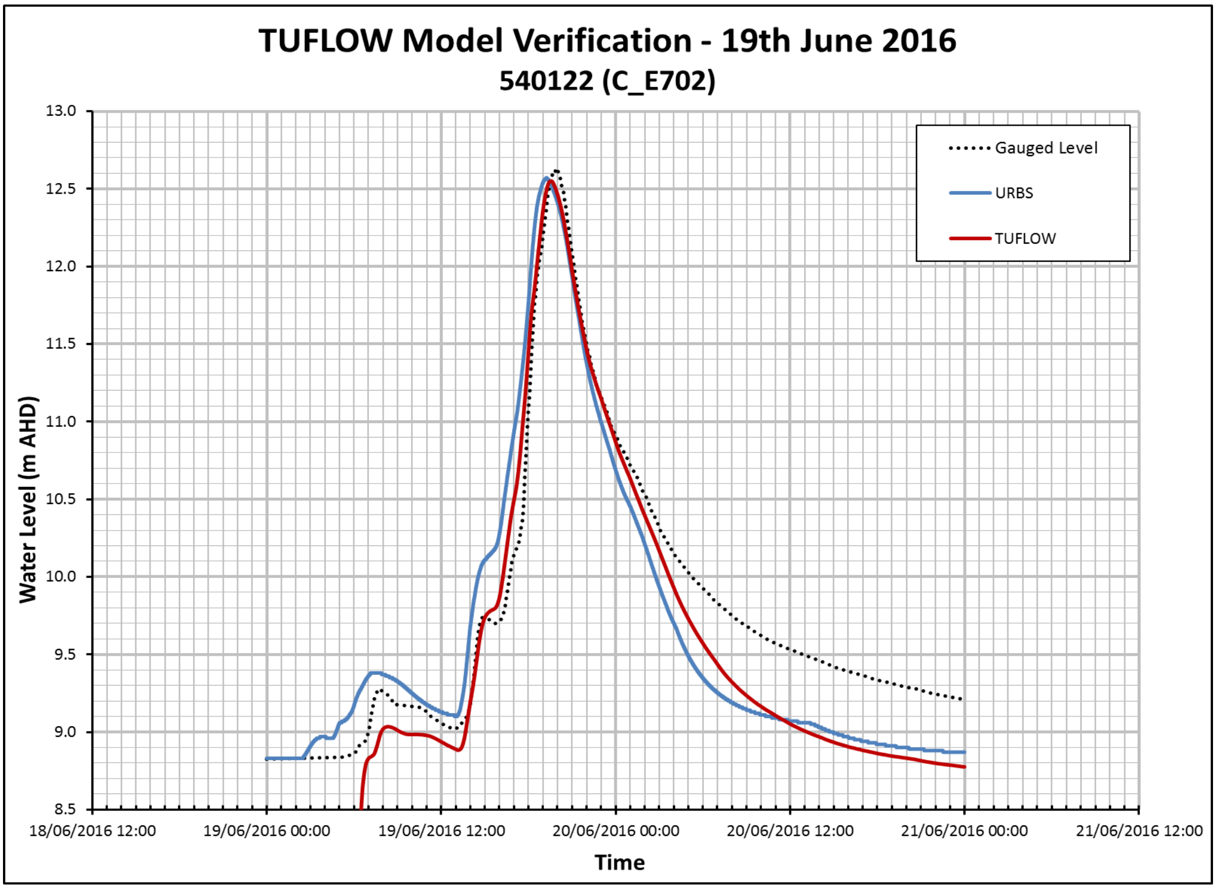

Figure 5.9: 19th June 2016 TUFLOW Model Calibration - Cabbage Tree Creek at 540122 (C_E702)

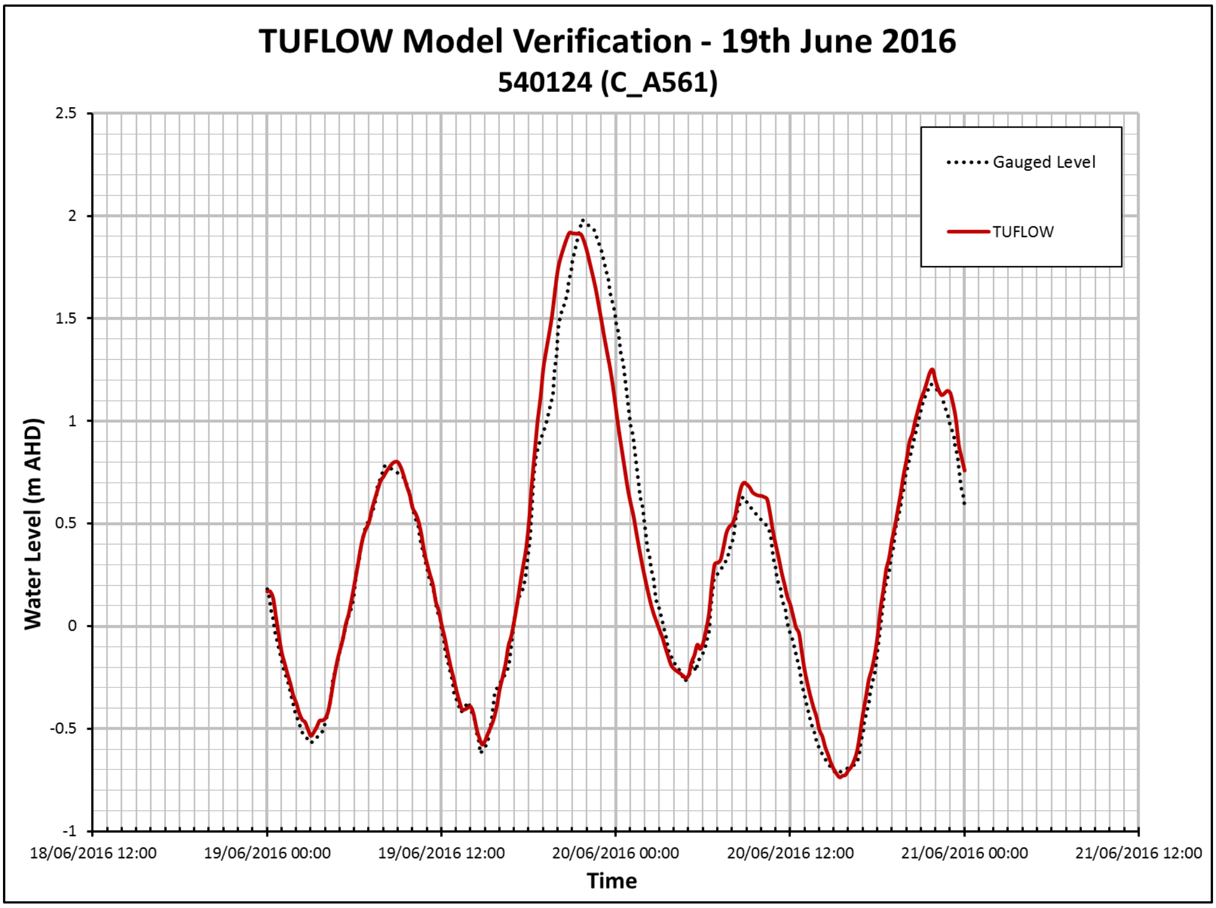

Figure 5.10: 19th June 2016 TUFLOW Model Calibration - Cabbage Tree Creek at 540124 (C_A561)

Table 5.6 – Calibration to Peak Flood Level Data (19th June 2016)

Creek / Channel	Gauge ID	Location	Recorded Peak WL (mAHD)	Simulated Peak WL (mAHD)	Difference (m)
Cabbage Tree	540124	Stream Gauge	1.98	1.90	-0.08
	C110	400 m d/s of Gateway Motorway	2.65	2.70	0.05
	C120	d/s at Lemke Road	3.50	3.69	0.19
	C130	u/s at Lemke Road	3.90	4.07	0.17
	C140	d/s at Roghan Road	7.66	7.68	0.02
	C150	u/s at Roghan Road	7.76	7.82	0.06
	C160	d/s at Beams Road	11.71	11.79	0.08
	540122	Stream Gauge	12.62	12.57	-0.05
	C180	d/s at Dorville Road	16.39	16.48	0.09
	C190	u/s at Gympie Road	19.18	18.99	-0.19
	C200	700 m u/s of Gympie Road	20.92	20.62	-0.30
	C210	d/s at Albany Creek Road	25.74	25.55	-0.19
	C220	u/s at Albany Creek Road	26.12	25.82	-0.30
	C230	500 m u/s of Albany Creek Road	27.61	27.42	-0.19
	C240	1.4 km u/s of Albany Creek Road	31.40	31.35	-0.05
	C250	300 m d/s of Beckett Road	34.71	34.78	0.07
	C260	u/s at Beckett Road	37.13	37.09	-0.04
	C270	d/s at Old Northern Road	42.19	42.34	0.15
Taigum	C300	d/s at Gateway Motorway	2.56	2.53	-0.03
	C310	u/s at Gateway Motorway	2.65	2.61	-0.04
	C320	300 m u/s of Gateway Motorway	2.91	2.99	0.08
	C330	u/s at Church Road	4.93	4.90	-0.03
	C340	d/s at Roghan Road	5.35	5.49	0.14
Carseldine	C410	u/s at North Coast Railway	11.36	11.16	-0.20
	C420	u/s at Lacey Road	13.08	13.26	0.18
Little Cabbage Tree	LC100	Close to the Cabbage Tree – Little Cabbage Tree confluence	14.12	14.07	-0.05
	LC110	d/s at Zillmere Road	16.00	16.07	0.07
	LC120	u/s at Zillmere Road	16.06	16.24	0.18
	LC130	d/s at Gympie Road	18.82	18.80	-0.02
	LC140	u/s at Gympie Road	19.36	19.48	0.12
	540113	Stream Gauge	29.21	29.25	0.04
	LC171	d/s at Martindale Street	31.59	31.52	-0.07
	LC172	u/s at Martindale Street	31.76	31.86	0.10

At Stream Gauge 540122 (Pineapple Street, Carseldine), the simulated peak flood level was within the desired ± 0.15 m tolerance. The simulated flood shape achieved a good fit, however the flood peak occurred approximately 30-minutes before the observed. The simulated falling limb generally receded quicker than the observed.

At Stream Gauge 540124 (Burralong Street, Deagon), the simulated peak flood level was within the desired ± 0.15 m tolerance. The simulated flood shape and timing of the peak and troughs achieved a good fit with the observed hydrograph, however the flood peak of approximately 2 m AHD occurred approximately 45-minutes before the observed.

5.6 Hydraulic Structure Verification

5.6.1 General

The TUFLOW manual recommends confirming the head-loss across hydraulic structures as follows:

It is strongly recommended that the losses through a structure be validated through:

- *Calibration to recorded information (if available).*
- *Cross-checked using desktop calculations based on theory and/or standard publications (e.g. Hydraulics of Bridge Waterways, US FHA 1973).*
- *Cross-checked with results using other hydraulic software.*

5.6.2 HEC-RAS Checks

It is common practice in BCC flood studies to cross-check structure head-losses against results from the HEC-RAS hydraulic modelling software. Generally, HEC-RAS is regarded as one of the better hydraulic modelling packages when it comes to more accurately representing hydraulic structures such as bridges. The majority of the hydraulic structures within the catchment(s) are culverts, for which the TUFLOW and HEC-RAS algorithms would be reasonably similar. Therefore, it was considered more important to check the head-loss at a number of the bridge structures.

Head-loss checks for the major bridge structures were undertaken as part of the 2014 Flood Study. As most of the bridge structures have not been changed, HEC-RAS checks were only undertaken for the following Cabbage Tree Creek bridge structures which were updated:

- S1 to S3 – Bikeway / Shorncliffe Railway / Sandgate Road
- S4 – Gateway Motorway
- S10 – North Coast Railway

Table 5.7 provides a comparison of the head-loss across the structure between TUFLOW and the HEC-RAS model. Generally, the TUFLOW head-losses for those bridge structures checked were within ± 0.3 m of the HEC-RAS values for the full range of flows considered. This is considered a good result and gives credence to the TUFLOW results.

The TUFLOW results are outside the ± 0.3 m tolerance for Structure S10 at flows of around 300 m^3/s. Based on the 2014 Flood Study, the 100-yr ARI (1 % AEP) flow at this location is around 220 m^3/s, meaning that a flow of 300 m^3/s is likely to have a magnitude of around 500-yr ARI (0.2 % AEP). Given that the comparative results are only slightly outside (0.06 m) of the ideal ± 0.3 m tolerance for such a large event, it was not considered warranted to expend more effort in trying to match the HEC-RAS results. This is in the context that the structure is quite complex (two parallel structures) and because of this complexity it is considered that there is no guarantee that the HEC-RAS head-loss results are any more accurate than the TUFLOW head-loss results.

Table 5.7 – HEC-RAS Bridge Head-loss Checks

Flow (m^3/s)	HEC-RAS Head-loss (m)	TUFLOW Head-loss (m)	Difference (m)
Structures S1 to S3 – Bikeway / Shorncliffe Railway / Sandgate Road (Cabbage Tree Creek)			
50.3	0.01	0.03	0.02
99.2	0.04	0.05	0.01
203.6	0.11	0.08	-0.03
401.8	0.85	0.81	-0.04
600.6	0.66	0.57	-0.09
Structures S4 – Gateway Motorway (Cabbage Tree Creek)			
48.7	0.00	0.01	0.01
100.3	0.02	0.01	-0.01
203.9	0.05	0.03	-0.02
399.4	0.11	0.03	-0.08
600.8	0.19	0.24	0.05
Structures S10 – North Coast Railway (Cabbage Tree Creek)			
49.5	0.20	0.14	-0.06
106.1	0.29	0.19	-0.10
151.1	0.37	0.23	-0.14
201.1	0.44	0.27	-0.17
250.4	0.57	0.33	-0.24
300.5	0.75	0.39	-0.36

5.7 Hydrologic-Hydraulic Model Consistency Checks (Historical Events)

5.7.1 General

Comparison checks were undertaken between the URBS and TUFLOW models to understand how closely the hydrologic and hydraulic models were matching and as a means of confirming whether the URBS model was adequately calibrated. The locations where comparative plots were undertaken are as follows:

(i) Cabbage Tree Creek – MHG 240
(ii) Cabbage Tree Creek – North Coast Railway
(iii) Cabbage Tree Creek – Gateway Motorway
(iv) Little Cabbage Tree Creek – MHG LC172
(v) Little Cabbage Tree Creek – MHG LC150
(vi) Carseldine Channel – North Coast Railway
(vii) Carseldine Channel – Downstream end of Fitzgibbon Landfill
(viii) Taigum Channel – MHG C340

Figure 5.11 to Figure 5.16 provide comparative plots for the three historical events at (i) MHG C240 (Cabbage Tree Creek) and (ii) North Coast Railway (Cabbage Tree Creek). The remainder of the comparative plots are provided in Appendix D. Table 5.8 provides a comparison of the peak flows at these eight locations.

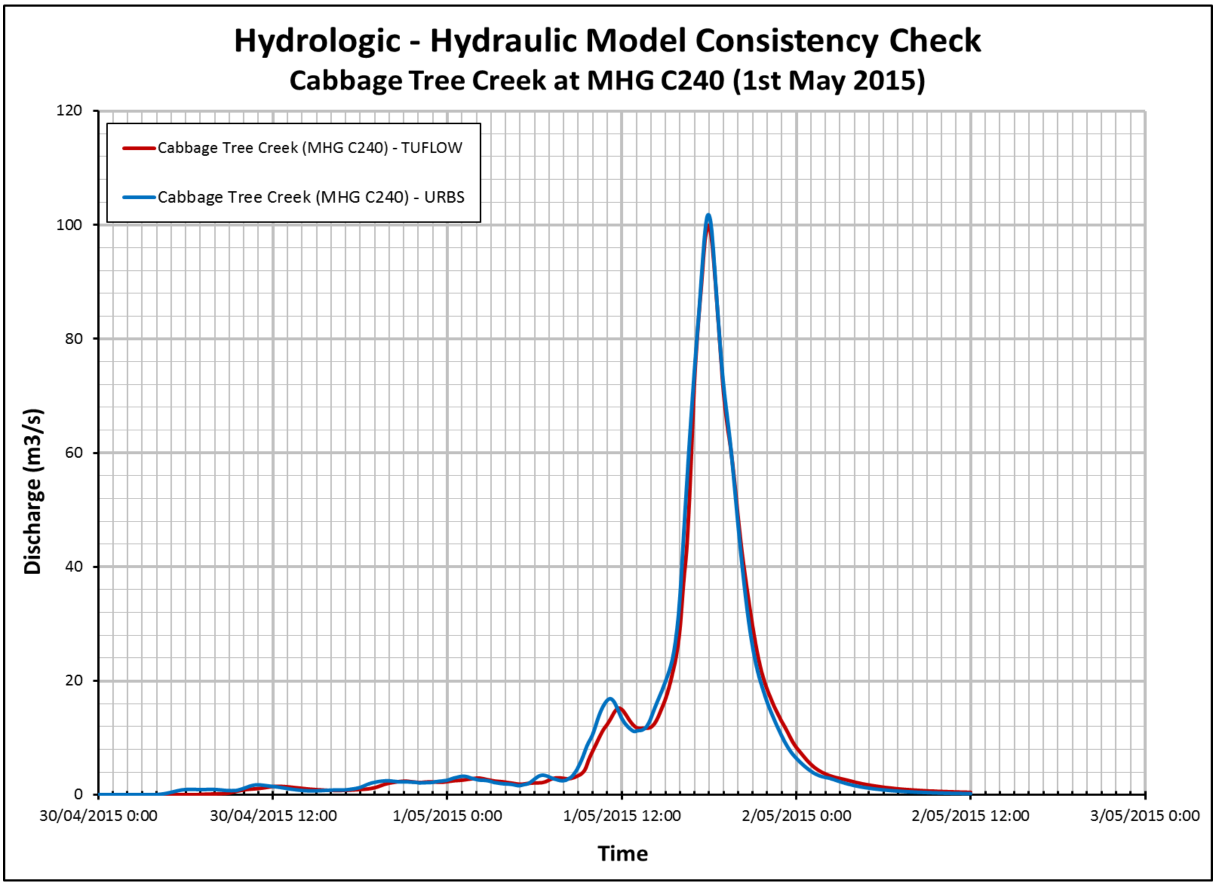

Figure 5.11: Model Comparison for 1st May 2015 - Cabbage Tree Creek at MHG C240

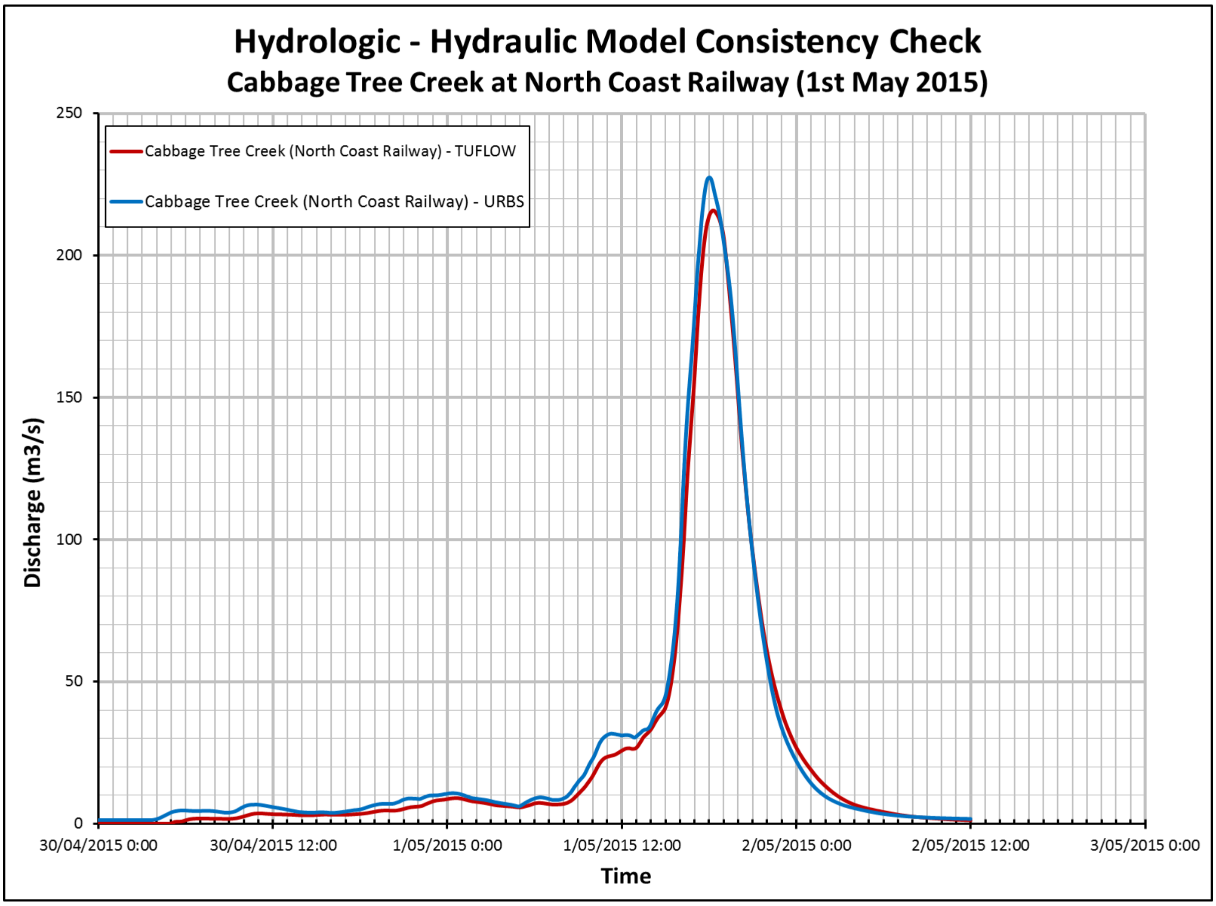

Figure 5.12: Model Comparison for 1st May 2015 - Cabbage Tree Creek at North Coast Railway

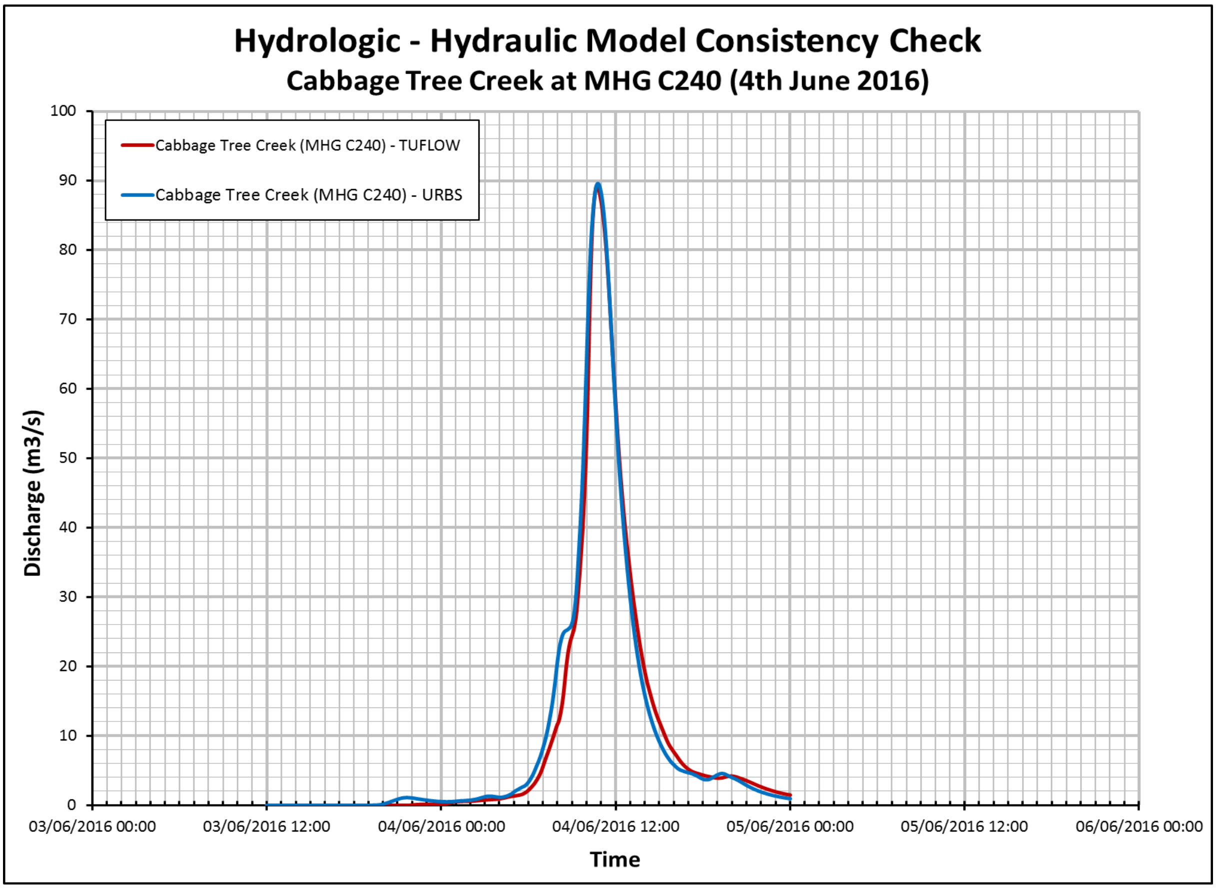

Figure 5.13: Model Comparison for 4th June 2016 - Cabbage Tree Creek at MHG C240

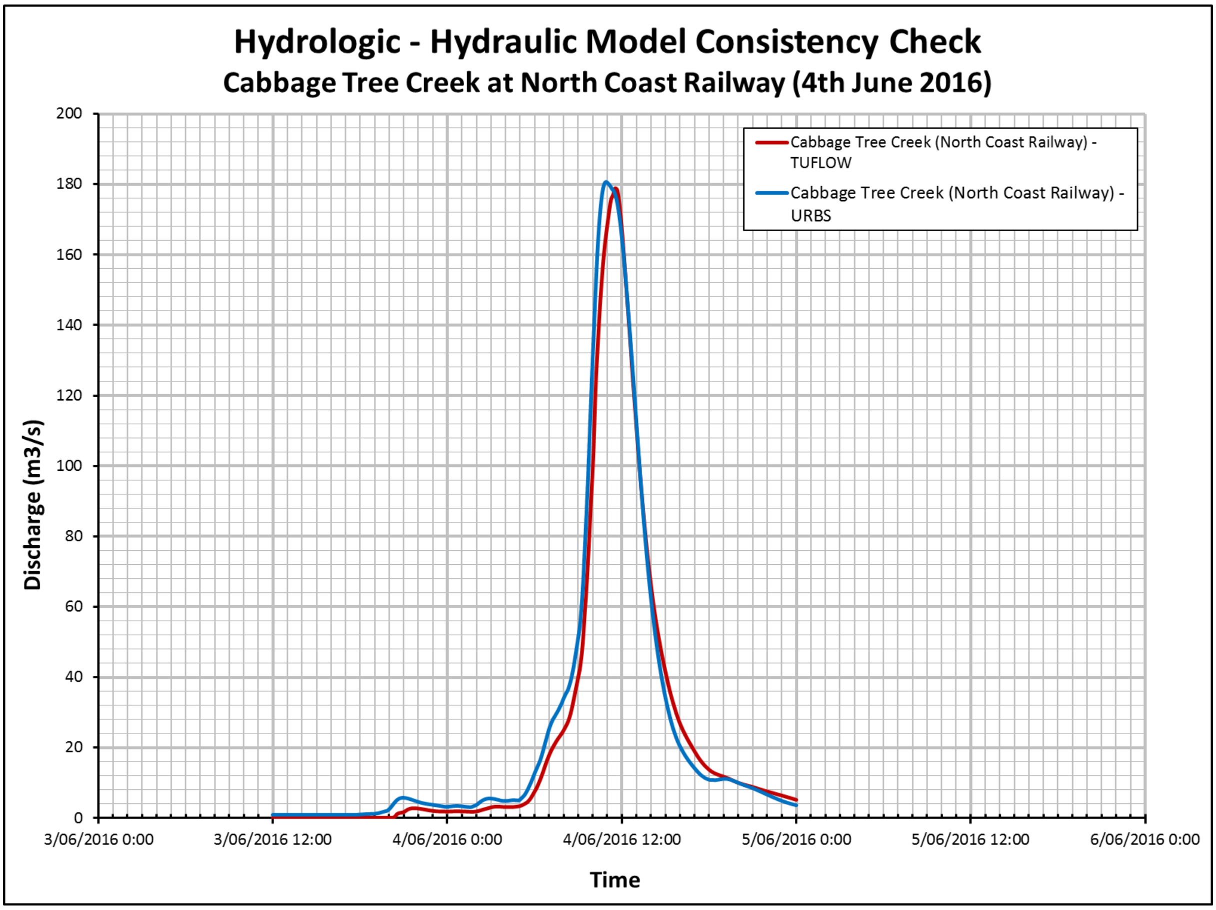

Figure 5.14: Model Comparison for 4th June 2016 - Cabbage Tree Creek at North Coast Railway

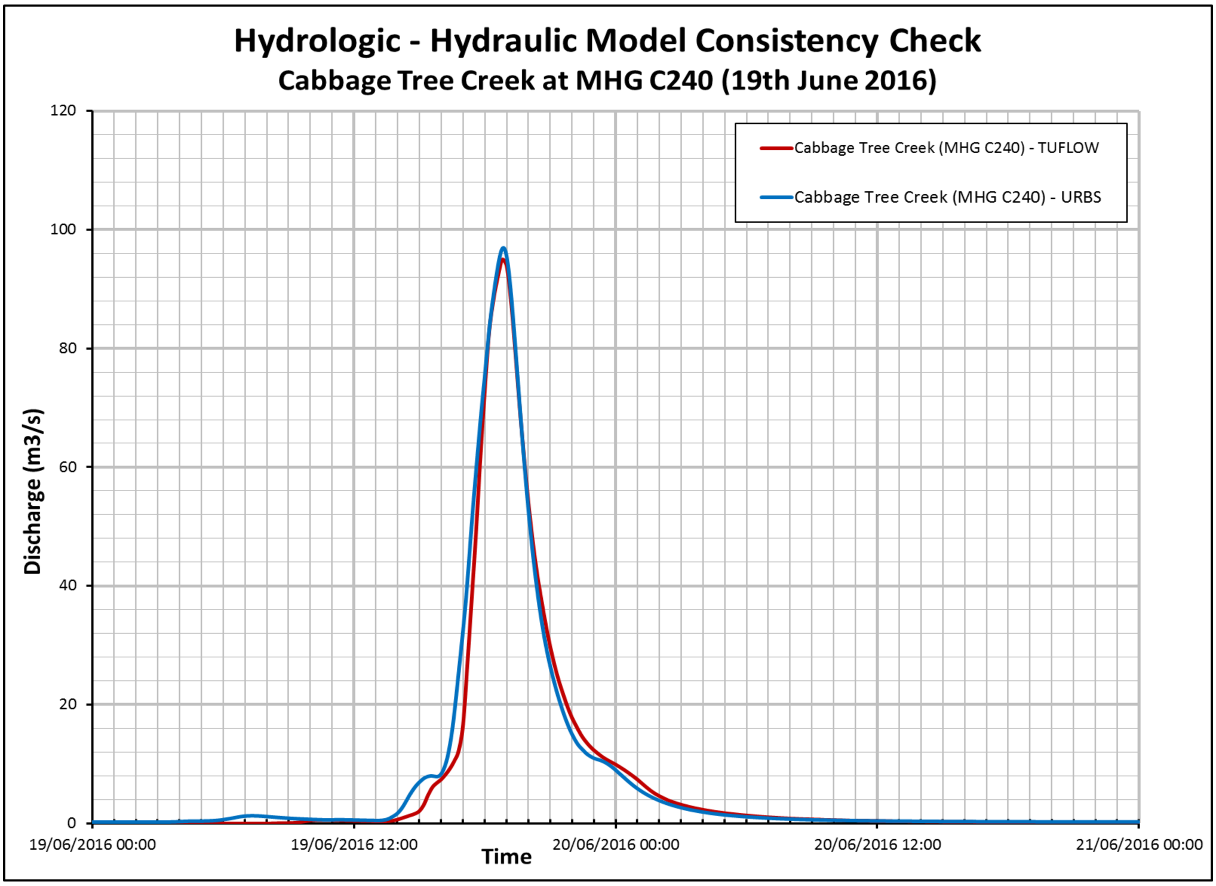

Figure 5.15: Model Comparison for 19th June 2016 - Cabbage Tree Creek at MHG C240

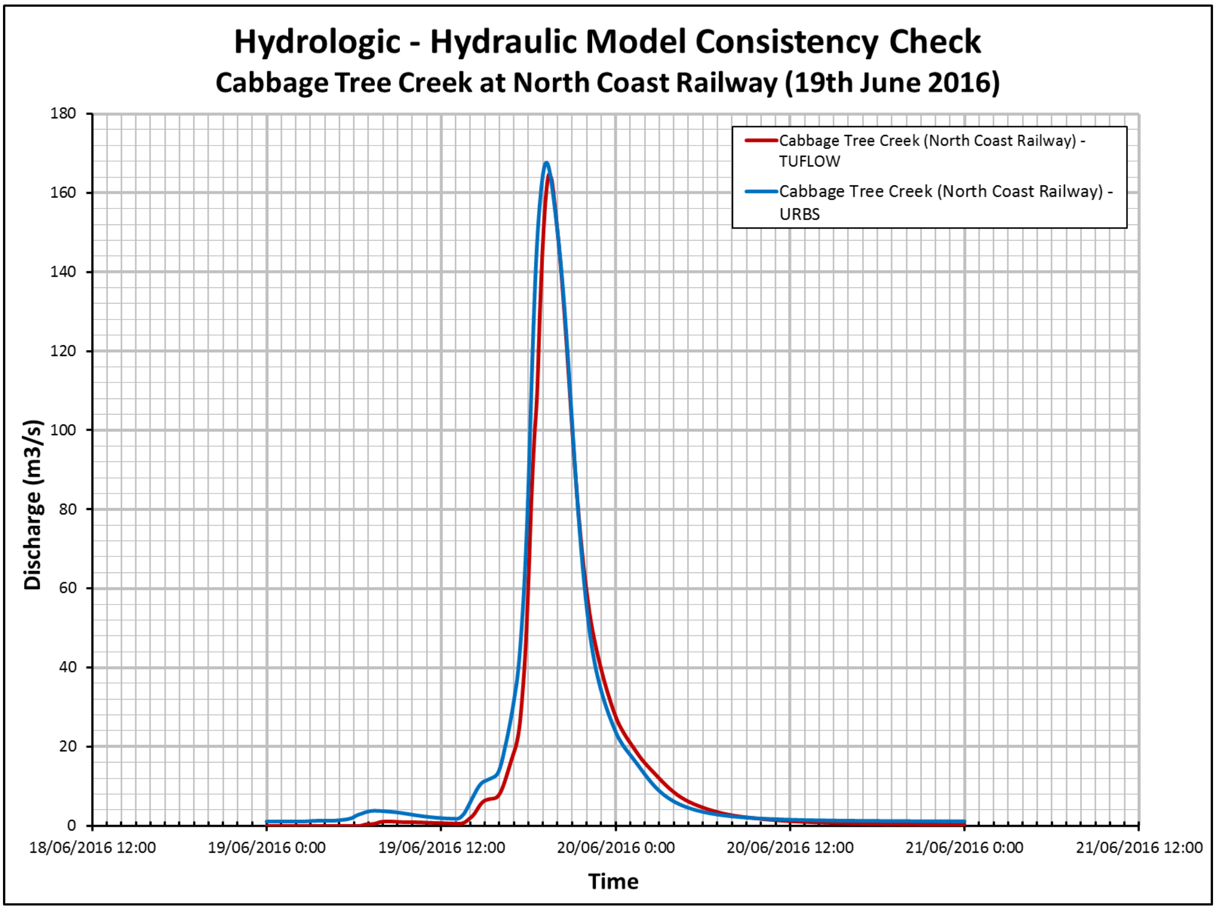

Figure 5.16: Model Comparison for 19th June 2016 - Cabbage Tree Creek at North Coast Railway

Table 5.8 – Peak Flow Comparison, URBS and TUFLOW

Location	Model	Peak Flow (m^3/s)		
		May 2015	4th June 2016	19th June 2016
Cabbage Tree Creek at MHG 240	URBS	101.8	89.5	97.0
	TUFLOW	99.9	89	95.0
Cabbage Tree Creek at North Coast Railway	URBS	227.3	180.6	167.7
	TUFLOW	215.8	178.9	165.6
Cabbage Tree Creek at Gateway Motorway	URBS	335.8	231.9	205.5
	TUFLOW	311.8	206.6	179.1
Little Cabbage Tree Creek at MHG LC172	URBS	47.8	42.6	42.0
	TUFLOW	47.3	42.0	41.4
Little Cabbage Tree Creek at MHG LC150	URBS	71.6	65.5	56.3
	TUFLOW	69.0	62.8	53.1
Carseldine Channel at North Coast Railway	URBS	46.7	31.4	27.2
	TUFLOW	48.4	30.7	26.0
Carseldine Channel at downstream end of Fitzgibbon Landfill	URBS	92.8	41.7	32.7
	TUFLOW	87.3	39.5	28.6
Taigum Channel at MHG C340	URBS	34.9	11.2	23.0
	TUFLOW	32.9	10.4	20.8

The results of the comparison indicate that the URBS and TUFLOW models show a good correlation with peak flow and hydrograph timing / shape throughout the model. Based on the good correlation between URBS and TUFLOW, it is considered that the URBS model would be suitable for use as a 'standalone' hydrology model.

5.8 Discussion on Calibration and Verification

The results of the calibration and verification are quite reasonable and there is confidence that the hydrologic and hydraulic models would be suitable for producing accurate flood levels for the full range of design floods.

The replication of peak flood levels to within the desired tolerance at the MHGs was very good with the following being achieved:

- 1st May 2015 – successful replication at 30 out of 33 MHGs (average difference -0.13 m)
- 4th June 2016 – successful replication at 26 out of 29 MHGs (average difference 0.1 m)
- 19th June 2016 – successful replication at 30 out of 30 MHGs (average difference 0 m)

The 1st May 2015 peak flood levels were on average slightly lower than the observed and the 4th June 2016 peak flood levels on average slightly higher than the observed. The 19th June 2016 peak flood levels produced an excellent fit with the observed peak flood levels, indicated by an average difference of 0 m.

The shape and timing of the simulated flood hydrographs at the stream gauges was generally quite good with an acceptable replication of the observed results.

At Stream Gauge 540113 (LCA570), the observed peak flood level is typically well replicated for all three events. However, at flood levels between 27 m AHD and 28.5 m AHD when the flood is largely contained within the channel, the modelled results consistently over predict the observed results for all three events. From review of the model setup, this is likely to be a result of the channel hydraulic roughness being represented by a single composite Manning's 'n' value in lieu of the more accurate technique of varying the roughness across the channel section. The single composite Manning's 'n' value approach, whilst producing an accurate result at bank full levels and above, would be over predicting flood levels for lower in-channel flows. This would also affect the in-channel rating curve, which in turn would be contributing to lower observed flood volumes than in reality. This is likely to be contributing to the simulated flood volumes being greater than the observed flood volumes, as discussed below.

The simulated flood volumes were greater than the observed at 540113 (LCA570) and 540121 (C_A573), which are located in the upper catchment. At 540122 (C_E702) in the middle catchment, the simulated flood volumes were typically lower than the observed, apart from the 4th June 2016 event, which was higher. These simulated flood volumes were obtained using a CL of 0 mm/hr, which was also successfully used for the four calibration / verification events as part of the 2014 Flood Study. Given that across the catchment that the simulated flood volumes were both higher and lower than observed flood volumes, it was not considered appropriate to increase the CL value from 0 mm/hr to obtain a better result in the upper catchment areas, as this would in turn produce an inferior result in the middle catchment.

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6.0 Design Event Analysis

6.1 Design Event Scenarios

Table 6.1 indicates the three scenarios utilised in the modelling of the design events, noting that all design event scenarios were modelled using ultimate hydrological conditions.

For the purpose of this report, the term "design events" refers to the following events:

- Frequent: 2-yr ARI (50 % AEP) and 5-yr ARI (20 % AEP), and
- Intermediate: 10-yr ARI (10 % AEP) and 20-yr ARI (5 % AEP), and
- Rare: 50-yr ARI (2 % AEP) and 100-yr ARI (1 % AEP)

Table 6.1 – Design Event Scenarios

Event	Scenario 1	Scenario 2	Scenario 3
2-yr ARI (50 % AEP)	✓	✗	✓
5-yr ARI (20 % AEP)	✓	✗	✓
10-yr ARI (10 % AEP)	✓	✗	✓
20-yr ARI (5 % AEP)	✓	✗	✓
50-yr ARI (2 % AEP)	✓	✗	✓
100-yr ARI (1 % AEP)	✓	✓	✓

The following describes the design event scenarios:

Scenario 1: Existing Waterway Conditions
Scenario 1 is based on the current waterway conditions. Some minor modifications were made to the TUFLOW model developed as part of the calibration / verification; refer to Section 6.3 for further details.

Scenario 2: Minimum Riparian Corridor (MRC)
Scenario 2 includes an allowance for a Minimum Riparian Corridor (MRC) along the edge of the channel. The MRC is typically a 30 m wide corridor (with a default Manning's 'n' roughness value of 0.15) which extends 15 m each side from the low flow channel.

Representing the MRC within the TUFLOW model typically involves adjusting the Manning's 'n' roughness in 1d cross-section and creating a new 2d materials layer with the default Manning's 'n' roughness value of 0.15. From review of the 2014 Flood Study TUFLOW model, it was apparent that adjustments to the Manning's 'n' roughness in the 1d cross-sections were not undertaken and only the 2d materials layer with the default Manning's 'n' roughness of 0.15 was used. The MRC corridor was applied in the 2d domain only at each side of the 1d cross-section for a width of 15 m. This method is not strictly correct, as in many cases the 1d cross-section includes overbank areas that would typically include the MRC. It appears that the previous study applied this methodology because in most areas only a single composite Manning's 'n' value was used to represent the hydraulic roughness within the 1d cross-section, as previously discussed in Section 5.2.3.

As the methodology for representing the hydraulic roughness in the 1d cross-section was largely not changed for this study, it meant that the same methodology to represent the MRC (as used in the 2014 Flood Study TUFLOW model) had to be used. Whilst this is not ideal, it is considered that this methodology would be slightly more conservative than the more correct method of also adjusting the hydraulic roughness in the 1d cross-section (where applicable).

Scenario 3: Filling to the Modelled Flood Corridor + Minimum Riparian Corridor (MRC)
The "Modelled Flood Corridor" is the greater extent of the Waterway Corridor (WC) and Flood Planning Areas (FPAs) 1, 2 and 3. Figure 6.1 indicates the "Modelled Flood Corridor" for all creeks.

Scenario 3 assumes filling to the "Modelled Flood Corridor" boundary to represent potential development. In the design events, 2-yr ARI (50 % AEP) to 100-yr ARI (1 % AEP), the filling acts as a barrier and the "Modelled Flood Corridor" can be modelled simplistically as a glass-wall of infinite height. This is a simple and conservative assumption used to develop design planning levels. It does not necessarily reflect allowable development assumptions under BCC City Plan.

6.2 Design Event Hydrology

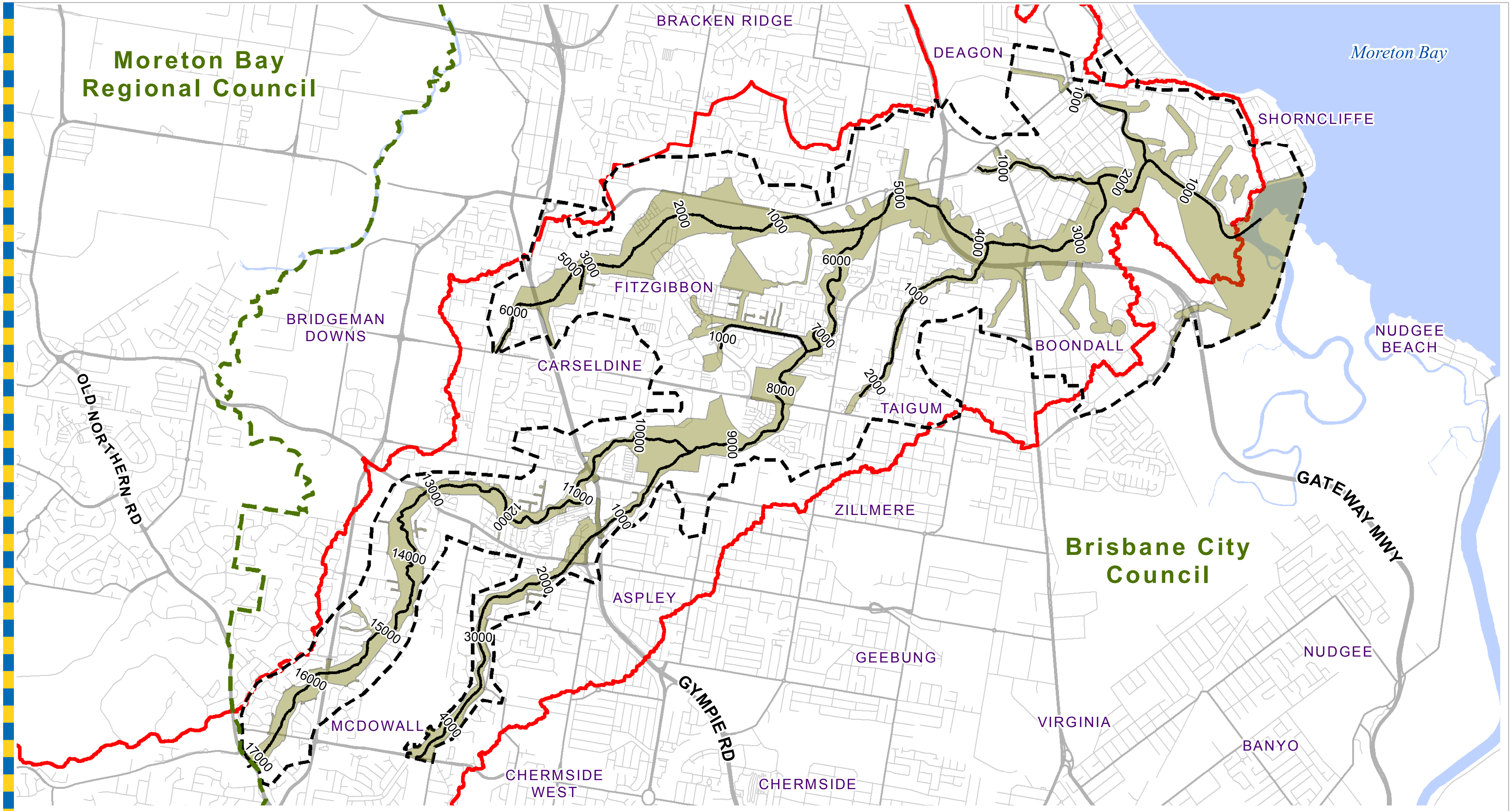
6.2.1 Background

The recent update of Australian Rainfall and Runoff (AR&R 2019) has resulted in significant changes with respect to the hydrological methods when compared to the previous version (AR&R 1987). This study utilises the AR&R 2019 approach for design flood estimation, which is detailed in the following sections.

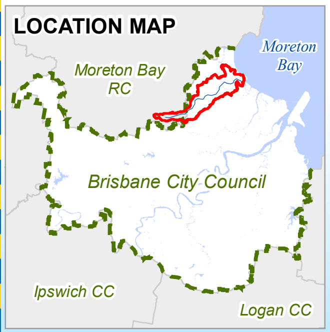
6.2.2 Suitability of Flood Frequency Analysis

Design flood estimation is generally best determined by undertaking some form of flood frequency analysis (FFA) of annual maximum and / or peak over threshold (POT) series from observed long-term stream flow records. If FFA is not suitable, then the other established method used to estimate the design flood is the rainfall (event) based design storm concept, common to both AR&R 1987 and AR&R 2019.

Stream Gauge 540122 (C_E702) at Pineapple Street was installed in 1972, resulting in approximately 46 years of records. The other three stream gauges were installed around 1994, resulting in approximately 24 years of records. A requirement of FFA is that the catchment is homogeneous and has not undergone change, for example development / urbanisation. From review of the historical aerial photography, it is apparent that the catchment urbanisation has been steadily increasing from 1972 to date. Whilst there is likely to have been some statutory development controls applied to the catchment development to reduce the urbanised runoff (e.g. detention basins), it is considered that if the same storm occurred in 1972 and 2018 that the resultant flooding would not be the same due to the degree of urbanisation which has taken place within this period.



LOCATION MAP



- AMTD
- Flood Corridor
- Model Boundary
- Cabbage Tree Ck Catchment Area
- Brisbane City Boundary
- Freeway/Highway
- Major Road
- Street

GIM - 190477 - 009

For Information Only - Not Council Policy

Figure 6.1: Modelled Flood Corridor

Cabbage Tree Creek Flood Study

0 1 2 3
Kilometers

N
W E
S

Brisbane City Council
City Projects Office
GPO Box 1434
Brisbane Qld 4001

For more information
visit www.brisbane.qld.gov.au
or call (07) 3403 8888

Prepared : 104515
Checked : JS
Revision : 2
Publication Date : 18 Jun 2019
Project Number : 190477

Dedicated to a better Brisbane

File : G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\GIS\ESRI\Final_Maps_Feb_2019\GIM_190477_009_Flood_Corridor_Fig_6_1.mxd

For this reason, it was not considered suitable to undertake FFA based on recorded floods within the catchment. The MHG records are not suitable for statistical analysis due to the random nature of the sampling interval, which could range from numerous times a year during a wet year to many years apart during times of drought. Manual reading at each MHG is also discretionary and not dependent on, for example, exceeding a nominated flood level. Regional Flood Frequency Estimation was not considered, as the catchment is deemed unsuitable because of the high degree of urbanisation.

6.2.3 Rainfall (Event) Based Flood Estimation

The use of event-based approaches to derive design floods is common to both AR&R 1987 and AR&R 2019 and most overseas countries. A major difference between AR&R 1987 and AR&R 2019 is the move away from a 'simple' event based approach to the more complex 'ensemble' and 'monte-carlo' methods. Figure 6.2 (from AR&R 2019) illustrates the major differences between these approaches.

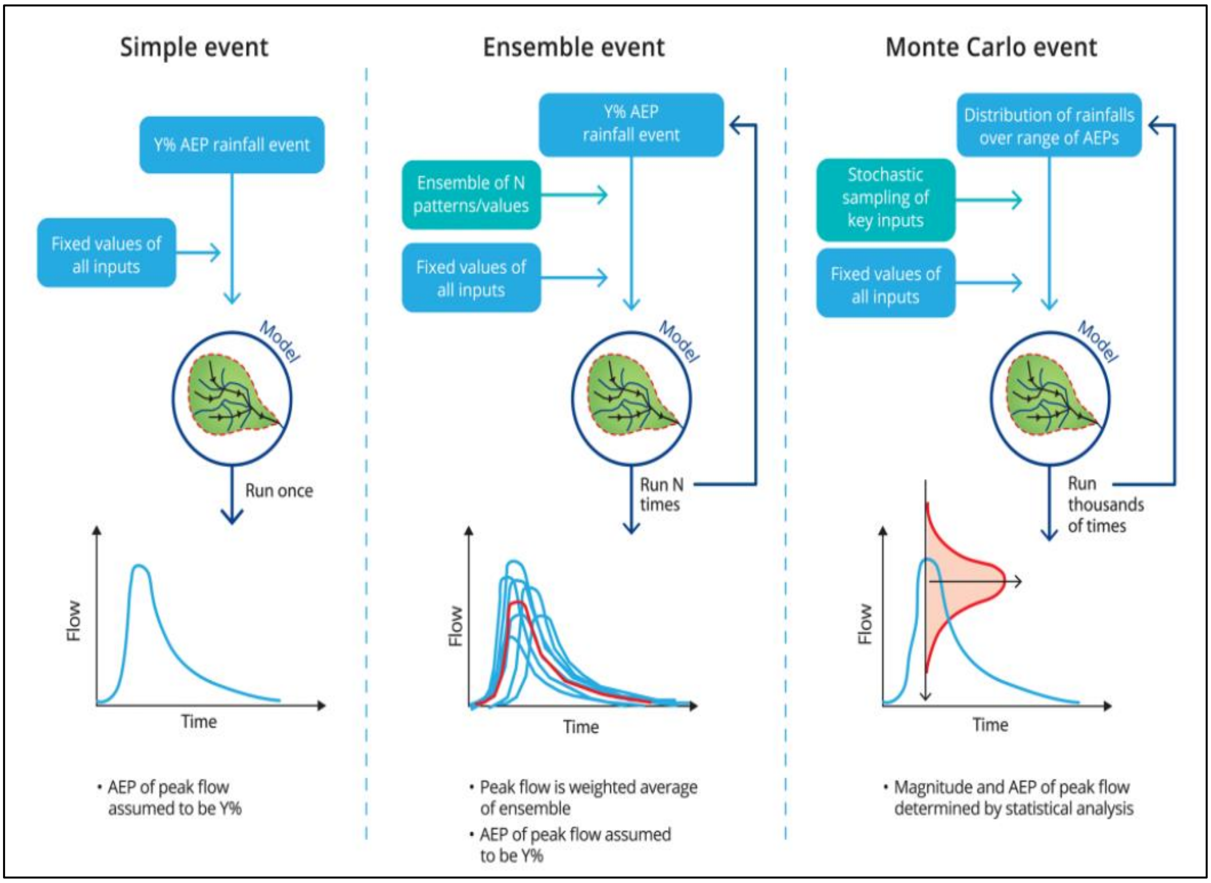


Figure 6.2: Differing Hydrological Methods

For the purpose of this flood study, the AR&R 2019 Ensemble Design Event Approach (DEA AR&R 2019) was adopted for use. This is consistent with the current BCC Flood Study Procedure document.[4]

6.2.4 Major Differences between DEA AR&R 2019 and AR&R 1987

The DEA AR&R 2019 represents a significant change from the DEA AR&R 1987 with the move from a single event to an ensemble event approach. The major changes are listed below:

- Pre-burst Rainfall – new as part of AR&R 2019 and used to reduce the Storm Burst Initial Loss (IL_b) to account for pre-burst rainfall occurring prior to the main storm burst.
- Temporal Patterns – updated as part of AR&R 2019 with the most significant change being that there are now 10 patterns (ensembles) per duration for each of the four temporal pattern ranges; namely frequent, intermediate, rare and very rare. At this time, the very rare temporal patterns are still to be finalised. AR&R 1987 used one temporal pattern per duration for ARI ≤ 30 years and one temporal pattern per duration for ARI > 30 years.
- Areal Reduction Factor (ARF) – updated as part of AR&R 2019 with the recommendation to apply to catchments greater than 1 km^2. AR&R 1987 advocated the use of ARFs, however there was little supporting practitioner guidance.
- Rainfall Losses – updated as part of AR&R 2019 with distinction now provided between the Storm Event Initial Loss (IL_s) and the Burst Initial Loss (IL_b). Generic values for the IL_s and the Continuing Loss (CL) are now provided for most geographic regions in Australia (refer to AR&R Data Hub: http://data.arr-software.org/). However, the AR&R Data Hub states that these loss values are only for rural use and not for use in urban areas.
- Baseflow – updated as part of AR&R 2019 with the recommendation to consider the inclusion of baseflow for rural catchments. AR&R 1987 guidance was non-prescriptive with regard to the inclusion of baseflow.
- IFD Data – new IFD data was released as part of AR&R 2019. This data supersedes both the 2013 Interim and AR&R 1987 IFD data.

6.2.5 Adopted Methodology for the DEA AR&R 2019

AR&R 2019 (Book 1, Table 1.3.2) recommends the use of a simple average (or median value) to represent the flood magnitude at a location within the catchment. AR&R 2019 (Book 2 Section 5.9.2) also advises that "*it is not recommended that the temporal pattern that represents the worst (or best) case be used itself for design*." The methodology used for undertaking the design hydrology for this study is as follows:

- Obtain the relevant URBS input data from the AR&R Data Hub, using the catchment centroid coordinates
- Populate the URBS model from the Data Hub information. This is an automated process undertaken within URBS. Refer to Section 6.2.6 for further details on the URBS parameters used.
- Run the ten ensembles in URBS for durations 30 minutes to 9 hours and ARIs (AEPs) 2-yr (50 %) to 100-yr (1 %).
- Select the representative design flow at the location of interest. For this analysis, the representative design flow was adopted as the median flow from the ten ensembles for the critical duration at the location of interest.

6.2.6 URBS Model Set-up

The calibrated URBS model was used to simulate the design storm rainfall-runoff and sub-catchment routing process. The following describes the parameters used and the adjustments made to the calibration model in order to simulate the design events.

Catchment Development

The design events were modelled using ultimate catchment hydrological conditions. These conditions assume that the state of development within the catchment is at its ultimate condition, with reference to the current adopted planning scheme. Depending on the developed state of the catchment, an increase in development will typically increase the impervious land use factors. The ultimate hydrological conditions assume negligible attenuation effects resulting from any statutory development controls applied to catchment development to reduce the urbanised runoff (e.g. detention basins).

Appendix B presents the URBS catchment parameters that were adopted for the design event modelling scenarios. The current adopted version of BCC City Plan (2014) was used to establish the ultimate catchment hydrological conditions. The adopted land use for the ultimate catchment development is shown on a catchment map in Appendix C.

Design IFD Data

Table 6.2 indicates the adopted design IFD data, which was obtained from the Bureau of Meteorology (BOM) website (based on AR&R 2019) and factored up by 9.8 % to allow for increased rainfall intensity due to projected climate variability effects.

Table 6.2 – Adopted Design Event IFD Data

Duration (hrs)	Rainfall Intensity (mm/hr) (1)					
	2-yr ARI (50 % AEP)	5-yr ARI (20 % AEP)	10-yr ARI (10 % AEP)	20-yr ARI (5 % AEP)	50-yr ARI (2 % AEP)	100-yr ARI (1 % AEP)
0.5	68.30	92.56	108.92	125.17	146.03	161.41
1	44.03	60.06	71.04	81.80	96.29	107.49
1.5	33.38	45.79	54.24	62.81	74.33	83.34
2	27.34	37.55	44.80	51.94	61.71	69.39
3	20.64	28.55	34.15	39.75	47.54	53.69
4.5	15.59	21.85	26.24	30.63	36.89	41.72
6	12.96	18.12	21.85	25.69	30.96	35.14
9	9.93	14.05	17.02	20.09	24.38	27.78

(1) Includes 9.8 % increase in rainfall intensity due to projected climate variability effects.

Following the release of AR&R 2019, there is now a recommendation to consider whether it is applicable to incorporate the effects of climate change into the design rainfall. The decision on whether to include climate change effects into the design rainfall is based on a six-step process, which is detailed in AR&R 2019 (Book1, Chapter 6). This analysis was undertaken as a separate exercise to this flood study and concluded that increased rainfall intensities should be incorporated into the design rainfall.

The 9.8 % factor is representative of RCP4.5 at Climate Future Year 2100. At present, the AR&R Data Hub only provides guidance on rainfall intensity increases as far as Year 2090, therefore in order to obtain a value for Year 2100, a linear extrapolation was undertaken based on the values of Year 2080 and Year 2090.

The BOM rainfall data was obtained at the centroid of the total catchment. Checks were undertaken at some selected locations around the catchment, from which it was ascertained that there was only a small variation in design rainfall depth throughout the catchment. On this basis, it was deemed appropriate to adopt a consistent design rainfall depth throughout the catchment.

Burst Initial Loss (IL_b)
The Burst Initial Loss (IL_b) = Storm Initial Loss (IL_s) – pre-burst rainfall.

- IL_b (impervious area) – a value of 0 mm was adopted for the impervious areas within the catchment, which is the URBS default value.
- IL_b (pervious areas) – AR&R Data Hub provides a Storm Event Initial Loss (IL_s) value of 13 mm as being representative for the geographical region in which this catchment is located. However, the AR&R Data Hub advises that this loss value is only for rural use and not for use in urban areas. AR&R 2019 (Book 5, Section 3.5.3.3) recommends to adopt the losses for urban pervious areas from the loss values for rural catchments, taken from the AR&R Data Hub in the absence of better information. As there is some uncertainty regarding the appropriate IL_b (pervious) value to use, a comparative analysis was undertaken to understand the sensitivity of this selection on the results; which is presented in Section 6.2.7.

Continuing Loss (CL)
The following values were adopted for the Continuing Loss:

- CL (impervious area) – a value of 0 mm/hr was adopted for the impervious areas within the catchment, which is the URBS default value.
- CL (pervious area) – AR&R Data Hub provides a CL (pervious) value of 2.2 mm/hr as being representative for the geographical region in which this catchment is located. However, this was replaced by a value of 0 mm/hr from the results of the calibration and verification process.

Areal Reduction Factor
The advice from AR&R 2019 is that Areal Reduction Factors (ARFs) should be considered for catchments with an area of at least 1 km^2. The following formula is appropriate for catchments between 10 km^2 and 1000 km^2.

The determination of ARFs is primarily a function of catchment area, storm event duration and to a lesser extent, ARI (AEP). The issue with ARFs for catchments such as Cabbage Tree Creek (where a significant proportion of the catchment is the study area and there are numerous tributaries of various sizes) is that there is not a single catchment area that can be applied for calculating an ARF that is representative over the entire study area. For this reason and for simplicity, BCC has chosen to adopt an ARF of 1, as documented in the current version of the BCC Flood Study Procedure document.[4]

$$ARF = Min\left[1, 1 - 0.287\left(Area^{0.265} - 0.439\log_{10}(Duration)\right).Duration^{-0.36} + 2.26 \text{ x } 10^{-3} \text{ x } Area^{0.226} .Duration^{0.125}\,(0.3 + \log_{10}(AEP)) + 0.0141 \text{ x } Area^{0.213} \text{ x } 10^{-0.021\frac{(Duration-180)^2}{1440}}\,(0.3 + \log_{10}(AEP))\right]$$

Baseflow

AR&R 2019 (Book 5, Section 4.2) advises the following with regard to the suitability of the AR&R 2019 baseflow methodology to urban catchments:

"*the approach and catchments considered in development of the method were selected to represent rural conditions, therefore the approach is not applicable to urban catchments (flood estimation for urban catchments is covered in Book 9). Baseflow is typically a small contribution to the flows.*"

Given that this catchment is highly urbanised, baseflow has not been included. This is consistent with the current version of the BCC Flood Study Procedure document.[4]

6.2.7 Sensitivity of IL_b (Pervious) Value

Historically, many BCC flood studies have typically adopted an IL_b of 0 mm for both the impervious and pervious areas of the catchment, with the understanding that the IL_b (pervious) value is conservative, especially for the smaller design events. The AR&R Data Hub provides a Storm Event Initial Loss (IL_s) value of 13 mm, with the caveat that it is only applicable for rural use and not for urban areas. The AR&R Data Hub also provides pre-burst rainfall loss values to account for the rainfall lost before the main storm burst.

To understand how sensitive the URBS peak flow values are to the selection of the IL_b (pervious) value, a comparative analysis was undertaken considering two IL options:

- Option 1 – IL_b (pervious) = 0 mm
- Option 2 – IL_b (pervious) = IL_s (pervious) minus the AR&R 2019 pre-burst rainfall losses, where IL_s (pervious) = 13 mm.

Table 6.3 indicates the differences in design flow when using the two initial loss options. The results indicate that at most locations the design flows are identical when considering events between 5-yr ARI (20 % AEP) and 100-yr ARI (1 % AEP). In the 2-yr ARI (50 % AEP) event, there are very small differences in flow. On this basis, it was decided to adopt the Option 1 approach (i.e. IL_b (pervious) = 0 mm) for this study. It is considered that using this approach maintains some consistency with historical BCC flood studies and provides a somewhat standardised approach that can be adopted for future flood studies.

Table 6.3 – Sensitivity of Initial Loss Selection

Location	Initial Loss Option	URBS Design Flow (m^3/s) (1)					
		ARI (AEP)					
		2-yr (50 %)	5-yr (20 %)	10-yr (10 %)	20-yr (5 %)	50-yr (2 %)	100-yr (1 %)
Cabbage Tree Creek							
Old Northern Road	1	40.6	58.4	69.5	81.8	97.6	110.8
	2	39.2	57.9	69.5	81.8	96.5	109.9
MHG C240	1	47.9	69.3	82.4	97.2	117.6	133.8
	2	45.4	69.3	82.4	97.2	117.6	132.3
540122 (Pineapple Street)	1	85.1	121.2	151.6	178.8	207.9	237.0
	2	81.4	121.2	151.6	178.8	207.9	237.0
Lemke Road	1	106.2	154.5	194.9	231.3	273.6	311.9
	2	104.0	154.5	194.9	231.3	273.6	311.9
Catchment Outlet	1	133.5	193.0	235.2	279.4	330.9	378.4
	2	131.7	193.0	235.2	279.4	330.9	378.4
Little Cabbage Tree Creek							
Hamilton Road	1	20.0	28.5	32.3	38.1	46.0	51.7
	2	18.8	27.5	31.6	37.2	45.4	51.3
Gympie Road	1	39.3	55.8	67.4	79.4	93.9	106.5
	2	37.8	55.8	67.4	79.4	93.9	106.0
Carseldine Channel							
Gympie Road	1	11.3	16.1	18.5	21.7	25.8	29.3
	2	10.5	15.5	18.1	21.4	25.6	29.1
Norris Road	1	19.2	26.9	32.1	37.0	42.8	47.8
	2	18.4	26.9	32.1	37.0	42.8	47.8
Fitzgibbon Land-fill	1	19.6	30.6	40.4	48.4	58.1	67.8
	2	19.3	30.6	40.4	48.4	58.1	67.8
Taigum Channel							
Church Road	1	16.3	23.2	26.5	31.0	37.1	42.0
	2	15.3	22.5	25.9	30.6	36.9	41.8

(1) Includes increased design rainfall due to projected climate variability effects.

6.3 Design Event Hydraulic Modelling

6.3.1 Overview

The TUFLOW model was used to determine design flows and flood levels for those scenarios as detailed in Table 6.1 for the 2-yr ARI (50 % AEP) to the 100-yr ARI (1 % AEP) events. These events were simulated for durations from 30 minutes to 9.0 hours using the DEA AR&R 2019 as discussed in the previous section.

6.3.2 Methodology

The number of hydraulic model simulations required to run all ensembles would be 80 runs / ARI (AEP), which equates to a total number of 480 runs. In order to reduce this significant number of simulations, the following approach was undertaken:

- Select a number of locations within the hydraulic model extents from which to determine the critical duration and the representative design flow.
- At each location, extract the URBS peak flow for each ensemble and rank from Rank 10 (highest) to Rank 1 (lowest), for each duration. Identify the critical duration and adopt the Rank 6 ensemble (median) as being the representative design flow for each ARI (AEP).
- Identify the ensemble (E1 to E10) which corresponds to Rank 6 and Rank 5 flow at each of the chosen locations. For each of the three temporal pattern groups (i.e. frequent, intermediate and rare), select up to two ensembles (per duration) which correspond to those which occur the most frequently as Rank 6 and Rank 5 flow.
- Check the URBS results to ensure that the chosen ensembles for other selected locations do not produce a higher flow than the adopted ensemble at that specific location.
- Run the chosen ensemble(s) through the URBS model for each of the 30-minute to 9-hour storm events for the 2-yr ARI (50 % AEP) to 100-yr ARI (1 % AEP) events to create inflow hydrographs for the TUFLOW model.
- Run the TUFLOW model with the URBS inflow hydrographs, extract the results and undertake a peak flood level analysis for each ARI (AEP). Adopt the peak flood level as the design flood level.

6.3.3 Locations for Selecting Design Ensembles

Table 6.4 indicates the thirteen locations chosen from which to select the ensembles for use in the hydraulic modelling. The locations chosen are based on the layout of the hydraulic model and are considered sufficient to capture the full range of critical storm durations within the hydraulic model extents.

Table 6.4 – Locations for Selecting Design Ensembles

Creek	Location	Contributing Catchment Area (km^2)
Taigum Channel	Fernwood Place (U/S TUFLOW extent)	1.1
	Church Road	1.9
Carseldine Channel	Beams Road (U/S TUFLOW extent)	0.5
	Gympie Road	1.3
	Norris Road	3.4
	Fitzgibbon Land-fill	6.0
Little Cabbage Tree Creek	Hamilton Road (U/S TUFLOW extent)	2.2
	Gympie Road	5.8
Cabbage Tree Creek	Old Northern Road (U/S TUFLOW extent)	6.0
	MHG C240	8.2
	540122 (Pineapple Street)	20.4
	Lemke Road	29.6
	Catchment Outlet	43.2

6.3.4 Selected Ensembles for Hydraulic Modelling

Table 6.5 indicates the median ranking(s) as well as the critical duration for the full range of ARIs (AEPs) at each of the 13 locations. These results are from the URBS hydrologic analysis. Based on the methodology presented in the previous sections, the ensembles selected for the hydraulic analysis using the TUFLOW model are as follows:

- 30-minute storm duration
  - Intermediate: [10-yr ARI (10 % AEP) and 20-yr ARI (5 % AEP)] - Ensemble 3 (of 10)
  - Rare: [50-yr ARI (2 % AEP) and 100-yr ARI (1 % AEP)] - Ensemble 7 (of 10)
- 1-hour storm duration
  - Frequent: [2-yr ARI (50 % AEP) and 5-yr ARI (20 % AEP)] - Ensemble 4 (of 10)
  - Intermediate: [10-yr ARI (10 % AEP) and 20-yr ARI (5 % AEP)] - Ensemble 8 (of 10)
  - Rare: [50-yr ARI (2 % AEP) and 100-yr ARI (1 % AEP)] - Ensemble 4 (of 10)
- 1.5-hour storm duration
  - Frequent: [2-yr ARI (50 % AEP) and 5-yr ARI (20 % AEP)] - Ensemble 2 (of 10)
  - Intermediate: [10-yr ARI (10 % AEP) and 20-yr ARI (5 % AEP)] - Ensemble 6 (of 10)
  - Rare: [50-yr ARI (2 % AEP) and 100-yr ARI (1 % AEP)] - Ensemble 5 (of 10)
- 2-hour storm duration
  - Frequent: [2-yr ARI (50 % AEP) and 5-yr ARI (20 % AEP)] - Ensemble 8 (of 10)
  - Intermediate: [10-yr ARI (10 % AEP) and 20-yr ARI (5 % AEP)] - Ensemble 10 (of 10)

- Rare: [50-yr ARI (2 % AEP) and 100-yr ARI (1 % AEP)] - Ensemble 1 (of 10)

- 3-hour storm duration
  - Frequent: [2-yr ARI (50 % AEP) and 5-yr ARI (20 % AEP)] - Ensembles 1 & 8 (of 10)
  - Intermediate: [10-yr ARI (10 % AEP) and 20-yr ARI (5 % AEP)] - Ensemble 8 (of 10)
  - Rare: [50-yr ARI (2 % AEP) and 100-yr ARI (1 % AEP)] - Ensemble 4 (of 10)

- 4.5-hour storm duration
  - Frequent: [2-yr ARI (50 % AEP) and 5-yr ARI (20 % AEP)] - Ensemble 4 (of 10)
  - Intermediate: [10-yr ARI (10 % AEP) and 20-yr ARI (5 % AEP)] - Ensemble 5 (of 10)
  - Rare: [50-yr ARI (2 % AEP) and 100-yr ARI (1 % AEP)] - Ensemble 3 (of 10)

- 6-hour storm duration
  - Frequent: [2-yr ARI (50 % AEP) and 5-yr ARI (20 % AEP)] - Ensemble 3 (of 10)
  - Intermediate: [10-yr ARI (10 % AEP) and 20-yr ARI (5 % AEP)] - Ensembles 3 & 10 (of 10)
  - Rare: [50-yr ARI (2 % AEP) and 100-yr ARI (1 % AEP)] - Ensemble 6 (of 10)

The tabulated results in Appendix E (highlighted in yellow) indicate where the selected ensemble is ranked (as well as the discharge) for all durations and ARIs (AEPs) at the 13 selected locations. Also shown (highlighted in light pink) is the ranking (and discharge) as a result of the ensemble(s) chosen for other locations.

Table 6.5 – Critical Duration and Ensemble Ranking (Design Events)

Location	Statistics	Ensemble # (Critical Duration)					
		Frequent		Intermediate		Rare	
		2-yr (50 %)	5-yr (20 %)	10-yr (10 %)	20-yr (5 %)	50-yr (2 %)	100-yr (1 %)
Taigum Channel at Fernwood Place	Rank 6 (max)	4 (1-hr)	4 (1-hr)	8 (1-hr)	8 (1-hr)	7 (0.5-hr)	7 (0.5-hr)
	Rank 5 (max)	1 (1-hr)	1 (1-hr)	6 (0.5-hr)	6 (0.5-hr)	10 (0.5-hr)	7 (1-hr)
Taigum Channel at Church Road	Rank 6 (max)	4 (1-hr)	4 (1-hr)	5 (1-hr)	5 (1-hr)	5 (1-hr)	4 (1-hr)
	Rank 5 (max)	5 (1-hr)	5 (1-hr)	8 (1-hr)	8 (1-hr)	4 (1-hr)	5 (1-hr)
Carseldine Channel at Beams Road	Rank 6 (max)	1 (1-hr)	1 (1-hr)	3 (0.5-hr)	3 (0.5-hr)	8 (0.5-hr)	8 (0.5-hr)
	Rank 5 (max)	4 (1-hr)	4 (1-hr)	4 (0.5-hr)	4 (0.5-hr)	4 (0.5-hr)	4 (0.5-hr)
Carseldine Channel at Gympie Road	Rank 6 (max)	4 (1-hr)	4 (1-hr)	8 (1-hr)	8 (1-hr)	4 (1-hr)	4 (1-hr)
	Rank 5 (max)	5 (1-hr)	1 (1-hr)	5 (1-hr)	5 (1-hr)	10 (1-hr)	10 (1-hr)
Carseldine Channel at Norris Road	Rank 6 (max)	1 (3-hr)	1 (3-hr)	8 (2-hr)	4 (3-hr)	5 (1.5-hr)	1 (2-hr)
	Rank 5 (max)	8 (2-hr)	8 (2-hr)	10 (2-hr)	8 (3-hr)	8 (2-hr)	8 (2-hr)

Location	Statistics	Ensemble # (Critical Duration)					
		Frequent		Intermediate		Rare	
		2-yr (50 %)	5-yr (20 %)	10-yr (10 %)	20-yr (5 %)	50-yr (2 %)	100-yr (1 %)
Carseldine Channel at Fitzgibbon Landfill	Rank 6 (max)	4 (4.5-hr)	9 (4.5-hr)	10 (6-hr)	10 (6-hr)	2 (4.5-hr)	2 (4.5-hr)
	Rank 5 (max)	6 (4.5-hr)	6 (4.5-hr)	5 (4.5-hr)	8 (3-hr)	7 (3-hr)	7 (3-hr)
Little Cabbage Tree Creek at Hamilton Road	Rank 6 (max)	4 (1-hr)	7 (1-hr)	6 (0.5-hr)	6 (0.5-hr)	7 (0.5-hr)	7 (0.5-hr)
	Rank 5 (max)	1 (1-hr)	4 (1-hr)	3 (0.5-hr)	3 (0.5-hr)	10 (0.5-hr)	10 (0.5-hr)
Little Cabbage Tree Creek at Gympie Road	Rank 6 (max)	9 (3-hr)	9 (3-hr)	9 (1.5-hr)	9 (1.5-hr)	9 (1.5-hr)	9 (1.5-hr)
	Rank 5 (max)	5 (1.5-hr)	2 (3-hr)	6 (1-hr)	5 (1-hr)	5 (1.5-hr)	5 (1.5-hr)
Cabbage Tree Creek at Old Northern Road	Rank 6 (max)	1 (1-hr)	1 (1-hr)	10 (2-hr)	10 (2-hr)	5 (1-hr)	5 (1-hr)
	Rank 5 (max)	5 (1-hr)	5 (1-hr)	9 (1-hr)	9 (1-hr)	10 (1-hr)	10 (1-hr)
Cabbage Tree Creek at MHG C240	Rank 6 (max)	1 (3-hr)	1 (3-hr)	6 (1.5-hr)	6 (1.5-hr)	3 (1.5-hr)	3 (1.5-hr)
	Rank 5 (max)	2 (1.5-hr)	2 (1.5-hr)	10 (2-hr)	10 (2-hr)	5 (1.5-hr)	5 (1.5-hr)
Cabbage Tree Creek at 540122 (Pineapple Street)	Rank 6 (max)	8 (3-hr)	8 (3-hr)	1 (3-hr)	1 (3-hr)	4 (3-hr)	4 (3-hr)
	Rank 5 (max)	3 (3-hr)	3 (3-hr)	8 (3-hr)	8 (3-hr)	6 (3-hr)	6 (3-hr)
Cabbage Tree Creek at Lemke Road	Rank 6 (max)	4 (4.5-hr)	9 (4.5-hr)	10 (6-hr)	10 (6-hr)	3 (4.5-hr)	3 (4.5-hr)
	Rank 5 (max)	1 (4.5-hr)	4 (4.5-hr)	3 (6-hr)	3 (6-hr)	7 (4.5-hr)	7 (4.5-hr)
Cabbage Tree Creek at Catchment Outlet	Rank 6 (max)	6 (6-hr)	5 (6-hr)	3 (6-hr)	3 (6-hr)	6 (6-hr)	6 (6-hr)
	Rank 5 (max)	3 (6-hr)	3 (6-hr)	5 (6-hr)	5 (6-hr)	1 (6-hr)	8 (6-hr)

Table 6.6 indicates a summary of the locations where the adopted ensemble did not produce the Rank 5 / 6 (median) flow and the respective differences. At locations where the adopted ensemble(s) did not produce the Rank 5 / 6 (median) flow, there is typically not a large difference (%) in flow. Considering the 2-yr ARI (50 % AEP) to 100-yr ARI (1 % AEP) events, the adopted ensemble(s) produced the Rank 5 / 6 (median) flow 56 out of 78 times. For those 22 times when the Rank 5 / 6 (median) flow was not produced, the flow differences when compared to the Rank 6 (median) flow are quite small as indicated in Table 6.6.

Table 6.6 – Differences from Median Flow

Location	Rank 5 / 6 flow not produced	Difference (%) from Rank 6 Flow		
		Average	Maximum	Minimum
Taigum Channel at Fernwood Place	2 out of 6	0.50	2.26	0.00
Taigum Channel at Church Road	2 out of 6	0.10	1.51	-0.48
Carseldine Channel at Beams Road	3 out of 6	0.73	2.14	0.00
Carseldine Channel at Gympie Road	2 out of 6	0.37	1.87	0.00
Carseldine Channel at Norris Road	-	-0.15	0.00	-0.46
Carseldine Channel at Fitzgibbon Landfill	3 out of 6	-0.37	0.49	-2.12
Little Cabbage Tree Creek at Hamilton Road	2 out of 6	0.15	0.91	-0.06
Little Cabbage Tree Creek at Gympie Road	4 out of 6	0.55	1.47	-0.54
Cabbage Tree Creek at Old Northern Road	4 out of 6	0.69	2.60	-0.01
Cabbage Tree Creek at MHG C240	-	-0.44	0.00	-1.37
Cabbage Tree Creek at 540122	-	-0.06	0.00	-0.20
Cabbage Tree Creek at Lemke Road	-	-0.00	0.00	-0.01
Cabbage Tree Creek at Catchment Outlet	-	-0.78	0.00	-2.39

6.3.5 TUFLOW Model Set-up

TUFLOW model extents

The Scenario 1, 2 and 3 TUFLOW model extents were the essentially the same as the TUFLOW model developed for the calibration and verification events. The only difference being that the upstream extent of the design TUFLOW model for Cabbage Tree Creek was Old Northern Road.

TUFLOW model roughness

The hydraulic roughness in the calibrated TUFLOW model was updated (as required) to represent the ultimate catchment conditions; which included MRC for Scenarios 2 and 3.

TUFLOW model boundaries

Design Inflows

The design inflow (Q-T) boundaries to the TUFLOW model were taken from the URBS model for each ARI (AEP) and duration. The inflow locations were typically the same as for the TUFLOW model developed for the calibration and verification events.

Design Tailwater Boundary

The design event TUFLOW model utilised a fixed Mean High Water Springs (MHWS) water level (H-T) boundary as the downstream model boundary. At this location the value of MHWS is 0.77 mAHD.

6.4 Results and Mapping

6.4.1 Design Discharge Results

A full range of durations (30 minute to 6 hour) were simulated for the 2-yr ARI (50 % AEP) to 100-yr ARI (1 % AEP) events. Table 6.7 provides design flow results at selected major waterway crossings for the Scenario 1 conditions. This information is from the TUFLOW hydraulic model.

Table 6.7 – Design Discharge at Selected Major Waterway Crossings (Scenario 1)

Location	Design Discharge (m^3/s) (1)					
	2-yr ARI (50 % AEP)	5-yr ARI (20 % AEP)	10-yr ARI (10 % AEP)	20-yr ARI (5 % AEP)	50-yr ARI (2 % AEP)	100-yr ARI (1 % AEP)
Cabbage Tree Creek						
Old Northern Road	40.6	58.4	69.5	81.8	96.1	109.0
Beckett Road (S19)	41.1	60.3	74.1	86.7	104.9	120.0
Albany Creek Road (S15)	46.8	69.9	87.9	104.5	126.2	144.6
Gympie Road (S13a)	46.9	70.5	88.4	104.7	123.7	138.2
North Coast Railway (S10)	70.9	108.9	139.0	169.3	199.5	220.5
Gateway Motorway (S4)	92.1	133.1	180.0	211.7	251.4	283.7

Location	Design Discharge (m³/s) (1)					
	2-yr ARI (50 % AEP)	5-yr ARI (20 % AEP)	10-yr ARI (10 % AEP)	20-yr ARI (5 % AEP)	50-yr ARI (2 % AEP)	100-yr ARI (1 % AEP)
Sandgate Road (S3)	102.1	148.5	188.3	224.2	270.9	293.5
Little Cabbage Tree Creek						
Hamilton Road	20.0	28.3	32.3	38.0	46.0	51.7
Gympie Road (S35)	32.9	49.7	57.8	69.1	80.6	92.0
Carseldine Channel						
Gympie Road (S33)	11.3	15.6	17.5	19.5	22.2	26.2
North Coast Railway (S31)	16.9	24.6	29.4	33.4	38.2	42.6
Taigum Channel						
Roghan Road (S28)	15.2	21.7	24.8	29.1	35.0	39.8
Gateway Motorway (S22a)	15.3	21.1	26.3	31.7	38.4	43.4

(1) Includes increased design rainfall due to projected climate variability effects.

6.4.2 Design Flood Levels

Tabulated design flood level results for the 2-yr ARI (50 % AEP) to 100-yr ARI (1 % AEP) events are provided at the following locations for all creeks:

- Scenario 1: 2-yr ARI (50 % AEP) to 100-yr ARI (1 % AEP) events – Appendix F
- Scenario 3: 2-yr ARI (50 % AEP) to 100-yr ARI (1 % AEP) events – Appendix G

The design flood levels are the maximum flood level when considering the selected ensembles used for the hydraulic modelling as previously indicated in Section 6.3.4. The design flood levels are extracted along the current AMTD line for all creeks. Where there was no AMTD line, an assumed line was drawn to enable flood levels to be extracted. At some locations, the current AMTD line did not intersect the flood surface, which resulted in a null value (indicated by N/R).

6.4.3 Return Periods of Historic Events

Table 6.8 indicates the estimated magnitude of the calibration / verification events (expressed as ARI / AEP) at selected locations within the catchment. The estimated magnitude was extracted from the flood frequency curves as indicated in Figure 6.3 and Figure 6.4. These flood frequency curves are based on the results of the Scenario 1 modelling using present day design rainfall (i.e. no future climate variability allowance).

Table 6.8 – Estimated Magnitude of Historical Events

Location	Event Magnitude		
	1st May 2015	4th June 2016	19th June 2016
Cabbage Tree Creek			
MHG C260 Becket Road	50-yr to 100-yr ARI (2 % to 1 % AEP)	20-yr to 50-yr ARI (5 % to 2 % AEP)	20-yr to 50-yr ARI (5 % to 2 % AEP)
MHG C190 Gympie Road	50-yr to 100-yr ARI (2 % to 1 % AEP)	20-yr to 50-yr ARI (5 % to 2 % AEP)	50-yr to 100-yr ARI (2 % to 1 % AEP)
540122 (C_E702) North Coast Railway	200-yr to 500-yr ARI (0.5 % to 0.2 % AEP)	10-yr to 20-yr ARI (10 % to 5 % AEP)	20-yr to 50-yr ARI (5 % to 2 % AEP)
MHG C110 Gateway Motorway	500-yr to 2000-yr ARI (0.2 % to 0.05 % AEP)	5-yr to 10-yr ARI (20 % to 10 % AEP)	10-yr to 20-yr ARI (10 % to 5 % AEP)
Little Cabbage Tree Creek			
MHG LC180 Trouts Road	5-yr to 10-yr ARI (20 % to 10 % AEP)	No data	No data
MHG LC140 Gympie Road	200-yr to 500-yr ARI (0.5 % to 0.2 % AEP)	20-yr to 50-yr ARI (5 % to 2 % AEP)	10-yr to 20-yr ARI (10 % to 5 % AEP)
Carseldine Channel			
MHG C410 North Coast Railway	500-yr to 2000-yr ARI (0.2 % to 0.05 % AEP)	50-yr to 100-yr ARI (2 % to 1 % AEP)	20-yr to 50-yr ARI (5 % to 2 % AEP)
Taigum Channel			
MHG C330 Church Road	500-yr ARI (0.2 % AEP)	< 2-yr ARI (50 % AEP)	10-yr ARI (10 % AEP)

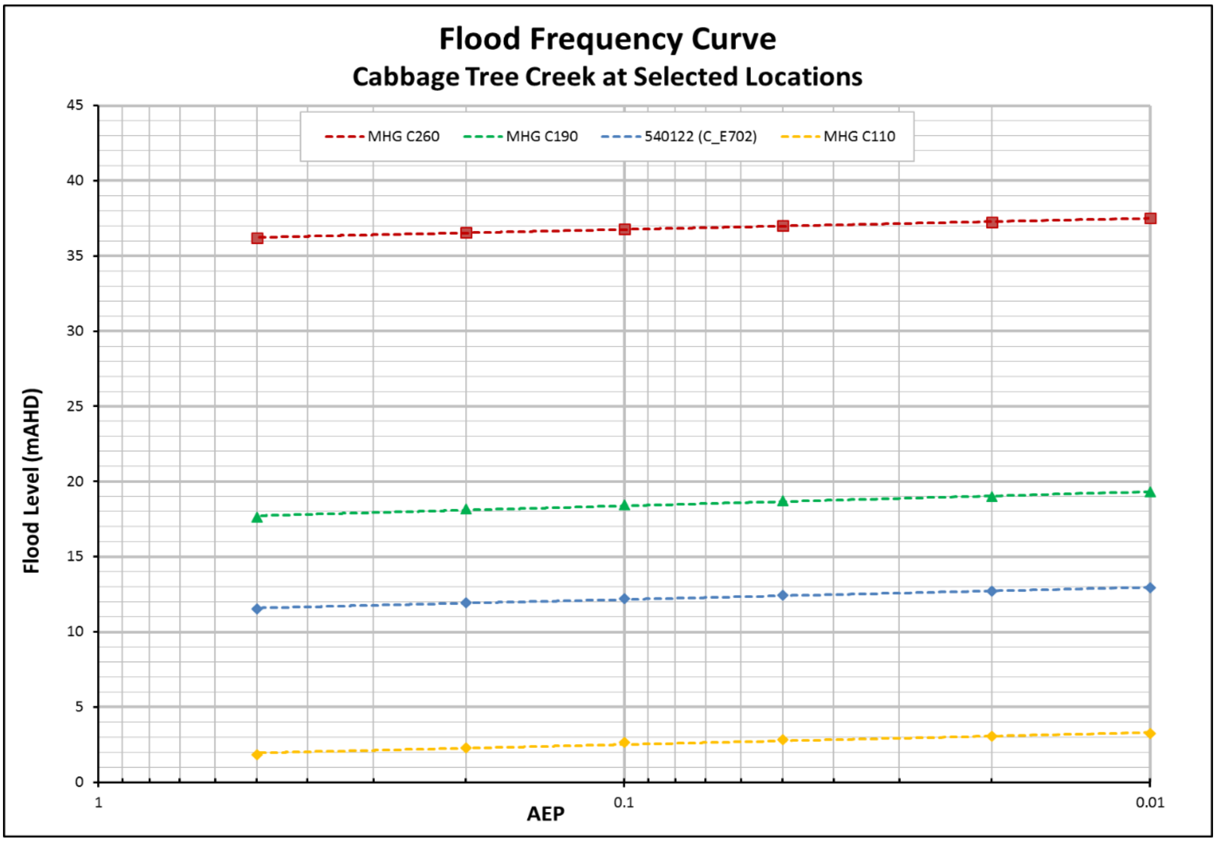


Figure 6.3: Flood Frequency Curves at Selected Locations on Cabbage Tree Creek

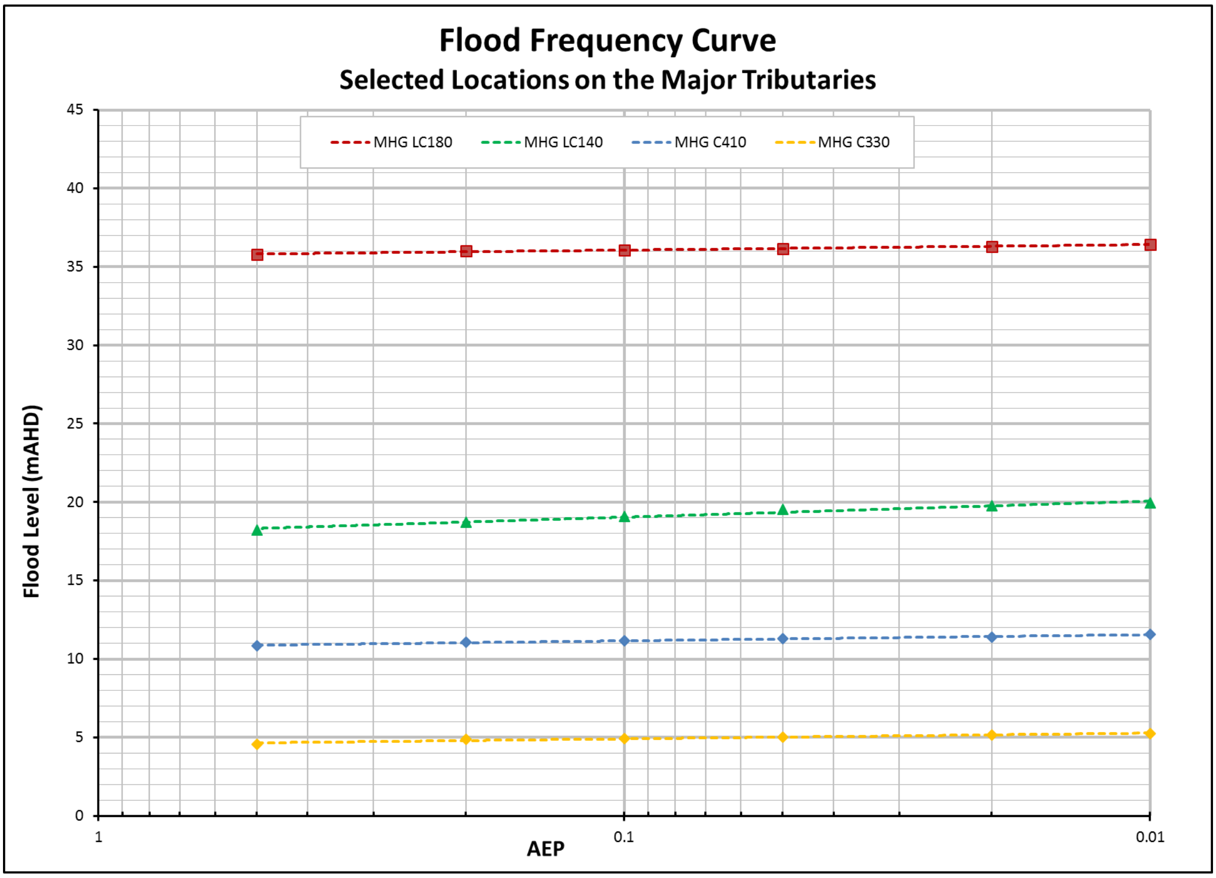


Figure 6.4: Flood Frequency Curves at Selected Locations on the Major Tributaries

6.4.4 Rating Curves

Rating curves (H-Q) have been derived at a number of locations within the catchment and are provided in Appendix L. These locations are generally in the vicinity of hydraulic structures and include:

- Beckett Road (S19) – Cabbage Tree Creek
- Albany Creek Road (S15) – Cabbage Tree Creek
- Gympie Road (S13a) – Cabbage Tree Creek
- North Coast Railway (S10) – Cabbage Tree Creek
- Gateway Motorway (S4) – Cabbage Tree Creek
- Sandgate Road (S2) – Cabbage Tree Creek
- Gympie Road (S35) – Little Cabbage Tree Creek
- Gympie Road (S33) – Carseldine Channel
- North Coast Railway (S31) – Carseldine Channel
- Roghan Road (S28) – Taigum Channel

The rating curves were developed using the PMF simulation, with a constant tailwater level of HAT (1.31 mAHD) at the downstream model boundary. Typically, the adopted rating curve lies between the rising limb rating curve and the falling limb rating curve of the hydrograph. In the lower reaches of the catchment, care should be taken if utilising the rating curves, as they have the potential to change depending on the tidal conditions in Moreton Bay.

6.4.5 Comparison with AR&R 1987 for the 100-yr ARI (1 % AEP)

In order to understand the differences between the AR&R 2019 and AR&R 1987 methodologies, a comparison was undertaken for the 100-yr ARI (1 % AEP) design flows. This comparison was undertaken using the DEA AR&R 2019 and the DEA AR&R 1987 methodologies, using similar URBS routing and rainfall loss parameters. The DEA AR&R 2019 used the 2019 IFD data and adopted the Rank 6 (median) flow as the design flow. To allow an equivalent comparison, the 2019 IFD data did not include increased rainfall intensity due to projected climate variability effects. The DEA AR&R 1987 used the 1987 IFD data and adopted the maximum flow as the design flow.

Table 6.9 indicates the 100-yr ARI (1 % AEP) design flows at selected locations from the URBS results for both methods. The results indicate that the AR&R 1987 methodology produces considerably higher design flows at all locations across the catchment. The differences in flow range from 8.8 % at the catchment outlet to 25.2 % at Hamilton Road on Little Cabbage Tree Creek.

Table 6.9 – Comparison of 100-yr ARI (1 % AEP) Design Flow

Location	URBS Design Flow (m^3/s) (1) 100-yr ARI (1 % AEP)		
	AR&R 1987	**AR&R 2019**	**Difference (%)**
Cabbage Tree Creek			
Old Northern Road	119.2	99.5	19.8%
MHG C240	141.9	120.4	17.9%
540122 (Pineapple Street)	243.5	214.3	13.6%
Lemke Road	308.1	282.2	9.2%
Catchment Outlet	373.0	342.7	8.8%
Little Cabbage Tree Creek			
Hamilton Road	58.1	46.4	25.2%
Gympie Road	117.3	96.1	22.1%
Carseldine Channel			
Beams Road	13.6	11.3	20.4%
Gympie Road	32.4	26.3	23.2%
Norris Road	51.4	43.7	17.6%
Fitzgibbon Land-fill	67.5	59.9	12.7%
Taigum Channel			
Fernwood Place	26.7	21.8	22.5%
Church Road	47.3	37.8	25.1%

(1) Does not include increased design rainfall due to projected climate variability effects

A review of the 2019 IFD and 1987 IFD rainfall intensities for the 100-yr ARI (1 % AEP) indicates that the 1987 IFD values are between 4.4 % (6-hour storm) and 12.5 % (1.5-hour storm) higher than the 2019 IFD values at the catchment centroid. These IFD differences would contribute to a higher flow for the AR&R 1987 methodology, however, given that some differences in flow are up the 25 %, it is considered that the AR&R 1987 methodology would still produce higher flows at the majority of locations across the catchment, even if the IFD values were the same.

6.4.6 Comparison of Design Flood Levels with the Full Ensemble Method

As a means of verifying the simplified ensemble methodology used in this flood study, checking of flood level results was undertaken against the full ensemble method for both the 10-yr ARI (10 % AEP) and the 100-yr ARI (1 % AEP) events.

The full ensemble method consisted of running 10 ensembles for each of seven durations (0.5, 1, 1.5, 2, 3, 4.5 and 6 hours) for each design ARI (AEP) event; which totalled 70 hydraulic model runs per design ARI (AEP) event. The median flood level for each duration was determined (seven in total) and the design flood level was adopted as the maximum of these seven median flood levels.

Table 6.10 – Summary of Flood Level Compaison Results

Creek	ARI (AEP)	Average Difference (m)	Maximum Positive Difference (m)	Maximum Negative Difference (m)
Cabbage Tree	10-yr (10 %)	0.00	0.02	0.02
	100-yr (1 %)	0.01	0.06	0.00
Little Cabbage Tree	10-yr (10 %)	0.00	0.02	0.02
	100-yr (1 %)	0.00	0.03	0.09
Carseldine Channel	10-yr (10 %)	0.00	0.04	0.03
	100-yr (1 %)	0.01	0.04	0.02
Taigum Channel	10-yr (10 %)	0.00	0.01	0.01
	100-yr (1 %)	0.01	0.05	0.01
Fitzgibbon Tributary	10-yr (10 %)	0.00	0.00	0.00
	100-yr (1 %)	0.01	0.01	0.00
Deagon Tributary	10-yr (10 %)	0.01	0.02	0.00
	100-yr (1 %)	0.01	0.02	0.00
Sandgate Tributary	10-yr (10 %)	0.00	0.01	0.01
	100-yr (1 %)	0.00	0.02	0.00
Full Model	10-yr (10 %)	0.00	0.04	0.03
	100-yr (1 %)	0.01	0.06	0.09

The flood level results / differences from this comparison are presented in Appendix H and a summary of the results in Table 6.10. The results indicate that the simplified ensemble approach compares very well with the full ensemble method. The average flood level difference across the catchment is 0.00 m for the 10-yr ARI (10 % AEP) and only 0.01 m for the 100-yr ARI (1 % AEP) event. Those few locations where the larger differences occur are upstream of hydraulic structures where it would appear that the water level is sensitive to small changes in flow.

6.4.7 Hydrologic-Hydraulic Model Consistency Check (Design Events)

Comparison checks on flow were undertaken between the URBS and TUFLOW models for the 5-yr ARI (20 % AEP), 20-yr ARI (5 % AEP) and 100-yr ARI (1 % AEP) events at selected locations to understand how closely the hydrologic and hydraulic models were matching. Comparisons were undertaken for the 120-minute duration storm utilising the following: 5-yr ARI (Ensemble #8), 20-yr ARI (Ensemble #10) and 100-yr ARI (Ensemble #1).

The locations where comparative plots were undertaken are as follows:

(i) Cabbage Tree Creek – MHG C240
(ii) Cabbage Tree Creek – North Coast Railway
(iii) Cabbage Tree Creek – Gateway Motorway
(iv) Little Cabbage Tree Creek – MHG LC172
(v) Little Cabbage Tree Creek – MHG LC150
(vi) Carseldine Channel – North Coast Railway
(vii) Carseldine Channel – downstream end of Fitzgibbon Landfill
(viii) Taigum Channel – MHG C340
(ix) Cabbage Tree Creek – Catchment Outlet

Figure 6.5 to Figure 6.10 provide comparative plots at six of the nine locations. The remainder of the comparative plots are provided in Appendix D. Table 6.11 provides a comparison of the peak flows at these nine locations.

Table 6.11 – Peak Flow Comparison, URBS and TUFLOW

Location	Model	120-minute Duration Peak Flow (m^3/s)		
		5-yr ARI (20 % AEP)	20-yr ARI (5 % AEP)	100-yr ARI (1 % AEP)
Cabbage Tree Creek at MHG C240	URBS	65.4	96.2	127.7
	TUFLOW	64.7	96.4	131.2
Cabbage Tree Creek at North Coast Railway	URBS	112.3	161.6	222.5
	TUFLOW	97.1	149.2	207.5
Cabbage Tree Creek at Gateway Motorway	URBS	141.6	205.3	280.3
	TUFLOW	113.1	169.9	236.3
Little Cabbage Tree Creek at MHG LC172	URBS	28.7	44.7	60.8
	TUFLOW	28.3	44.0	59.4

Location	Model	120-minute Duration Peak Flow (m^3/s)		
		5-yr ARI (20 % AEP)	20-yr ARI (5 % AEP)	100-yr ARI (1 % AEP)
Little Cabbage Tree Creek at MHG LC150	URBS	41.5	61.8	81.5
	TUFLOW	38.7	58.6	77.7
Carseldine Channel at North Coast Railway	URBS	25.1	35.0	44.8
	TUFLOW	24.2	33.9	42.9
Carseldine Channel at downstream end of Fitzgibbon Landfill	URBS	26.0	39.9	56.5
	TUFLOW	19.8	31.5	45.3
Taigum Channel at MHG C340	URBS	19.1	30.2	41.0
	TUFLOW	18.7	28.5	38.2
Cabbage Tree Creek at Catchment Outlet	URBS	150.0	214.9	293.7
	TUFLOW	131.5	195.0	272.8

At the majority of locations, there is a reasonably good comparison between the URBS and TUFLOW models. In the upper and middle sections of the catchment, there is a very good comparison between the URBS and TUFLOW hydrographs for all three events. However, towards the bottom of the catchment, the differences between URBS and TUFLOW tend to increase, with the URBS model typically exceeding the TUFLOW peak flow values. For example, at the Gateway Motorway crossing of Cabbage Tree Creek, the URBS model exceeds the TUFLOW peak flow values by 18 % to 25 %. These differences are likely to be a result of the superior modelling of the floodplain storage by the hydraulic model in the lower sections of the catchment.

The other location where there is a considerable difference between the URBS and TUFLOW results is on Carseldine Channel at Fitzgibbon, immediately downstream of the landfill areas. At this location, the URBS model exceeds the TUFLOW peak flow values by 25 % to 31 %. The reasons for these differences include:

- The TUFLOW model is better representing the considerable storage effects, which characterise this channel in the middle to lower reaches.
- The Enbrook Park Detention Basin, adjacent to the Bracken Ridge Plaza (north of Telegraph Road), has been comprehensively represented in TUFLOW model but only simplistically represented in the URBS model.
- A proportion of the flow within the Carseldine Channel diverts north of the Bill Brown Sports Fields, joining the Telegraph Road Drain. This complex flow pattern has been represented in the TUFLOW model, but not in the URBS model.

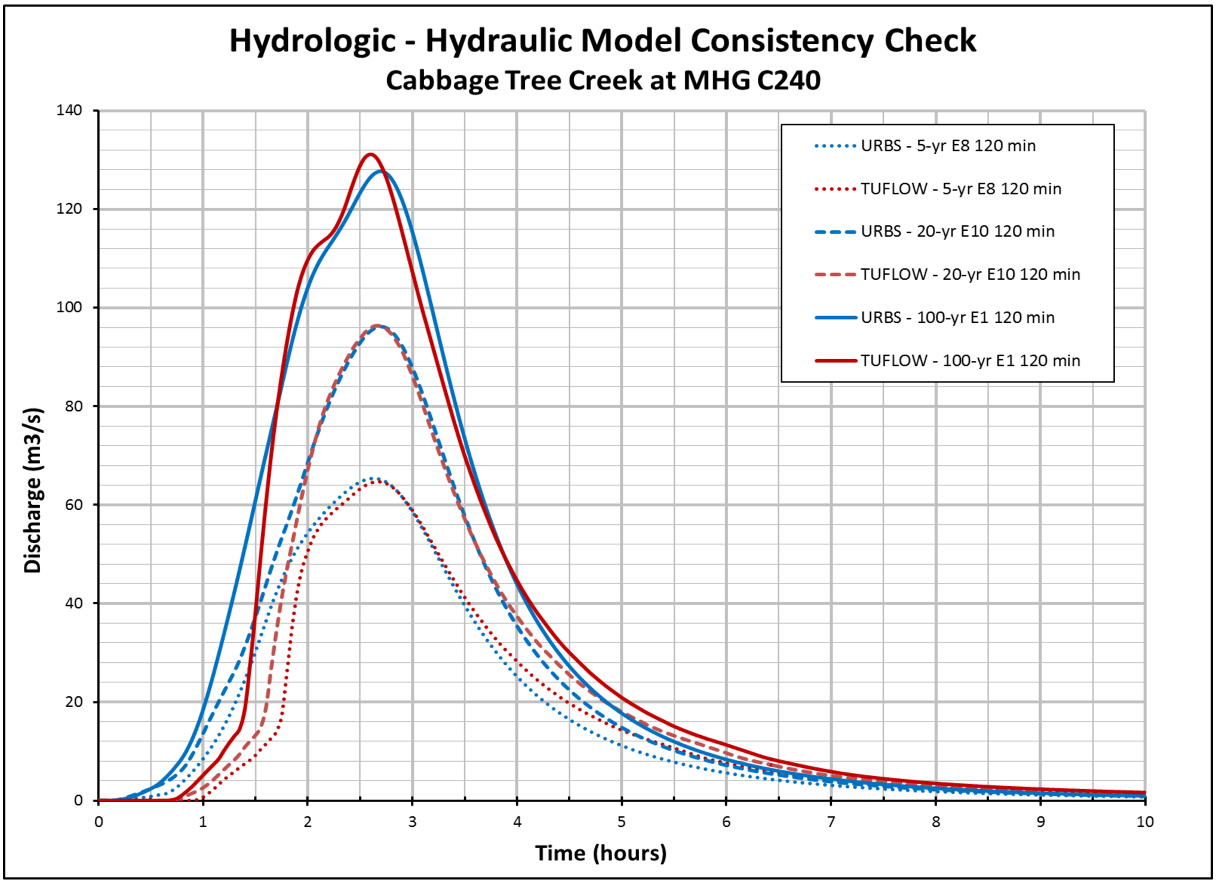


Figure 6.5: Model Comparison for Design Events - Cabbage Tree Creek at MHG C240

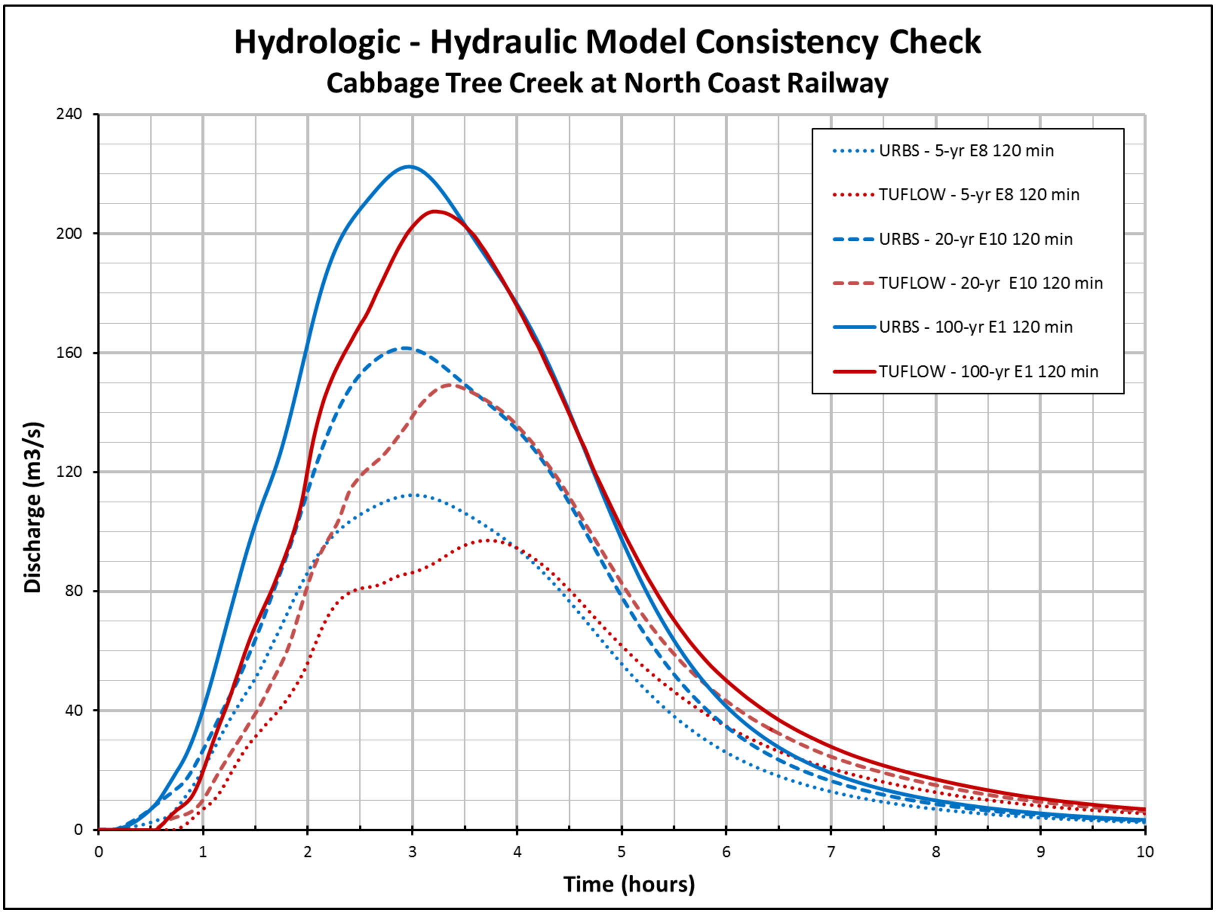


Figure 6.6: Model Comparison for Design Events - Cabbage Tree Creek at North Coast Railway

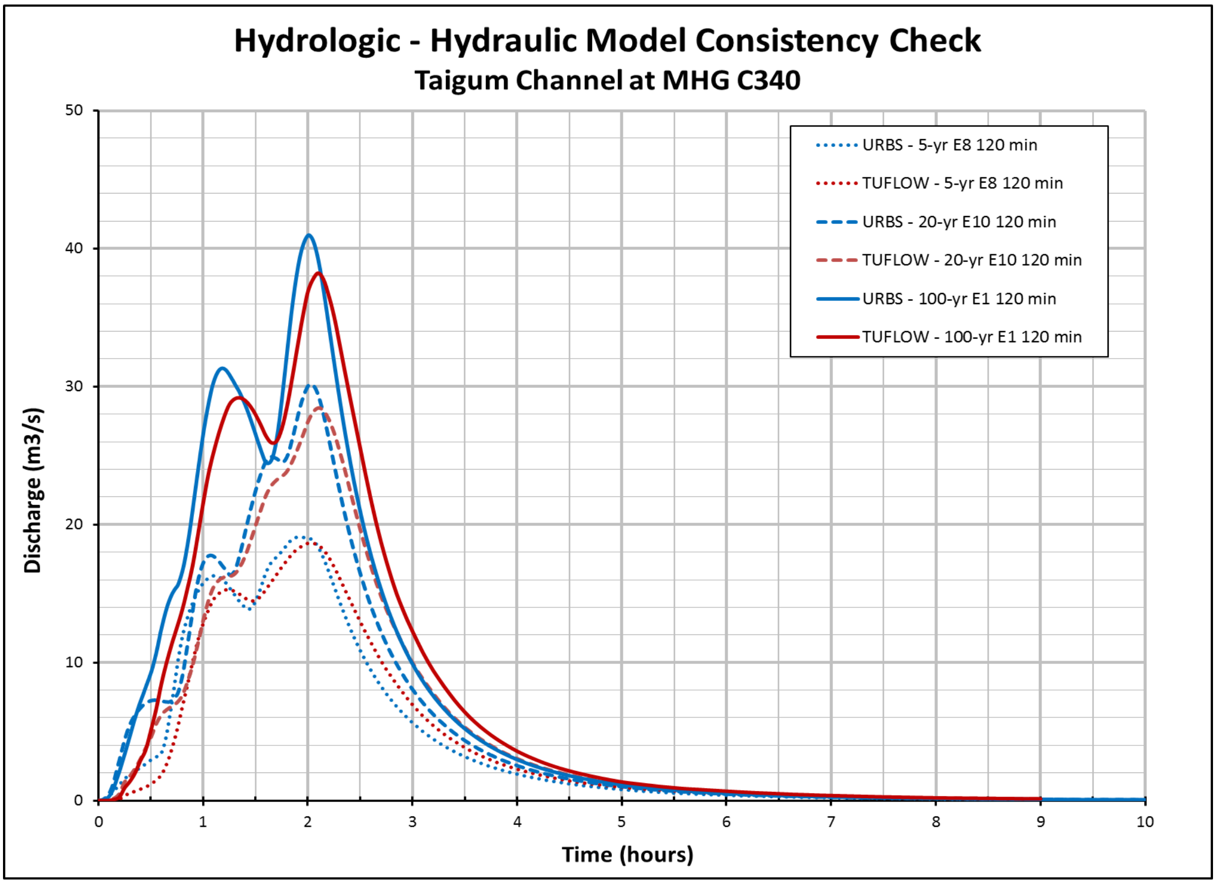


Figure 6.7: Model Comparison for Design Events - Taigum Channel at MHG C340

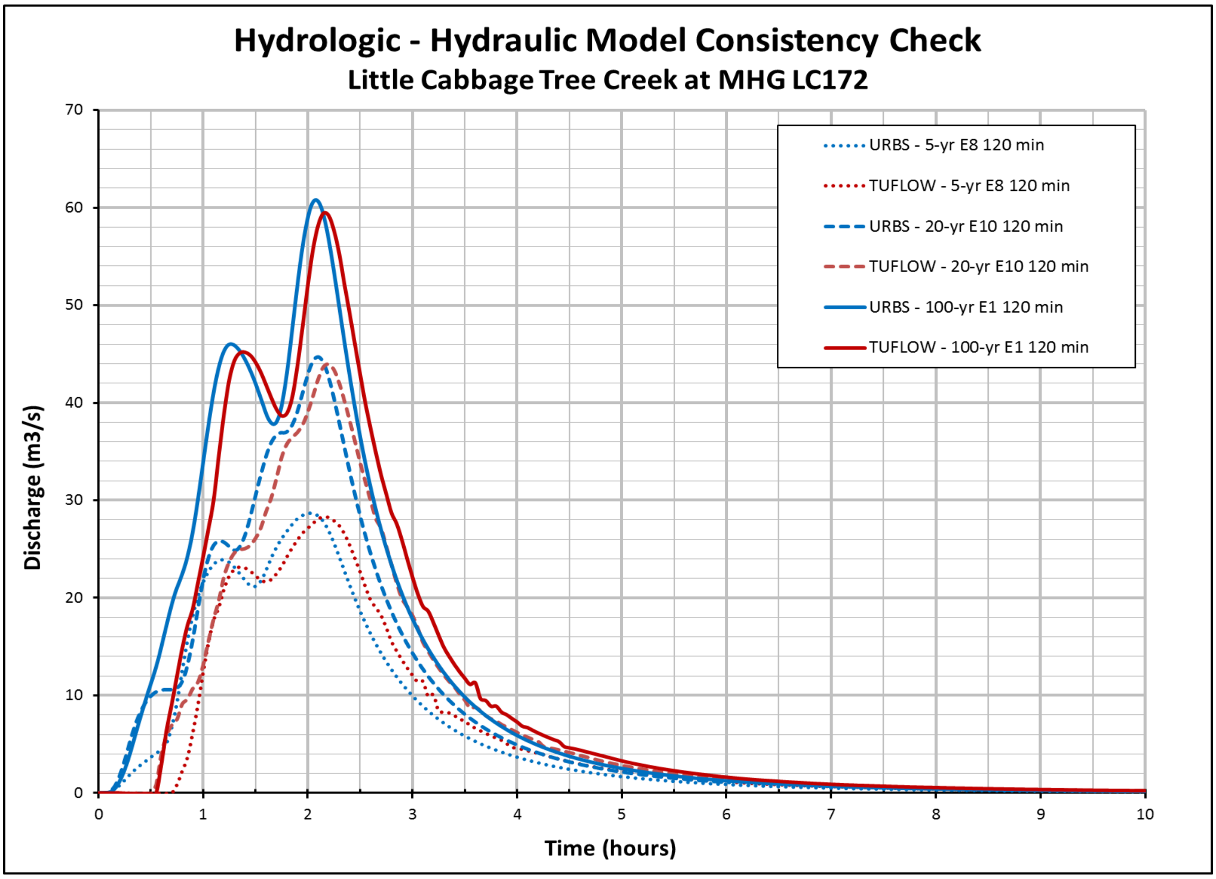


Figure 6.8: Model Comparison for Design Events - Little Cabbage Tree Creek at MHG LC172

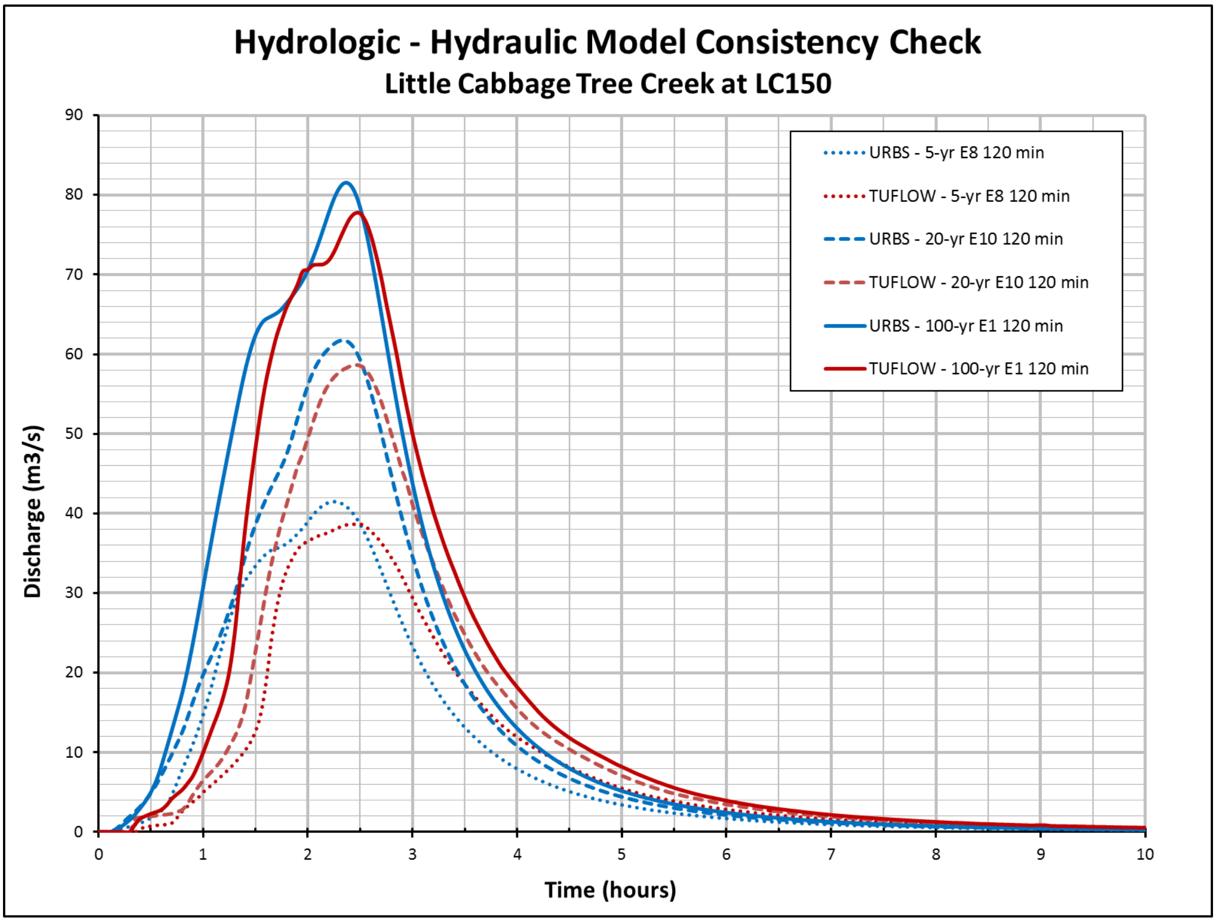


Figure 6.9: Model Comparison for Design Events - Little Cabbage Tree Creek at MHG LC150

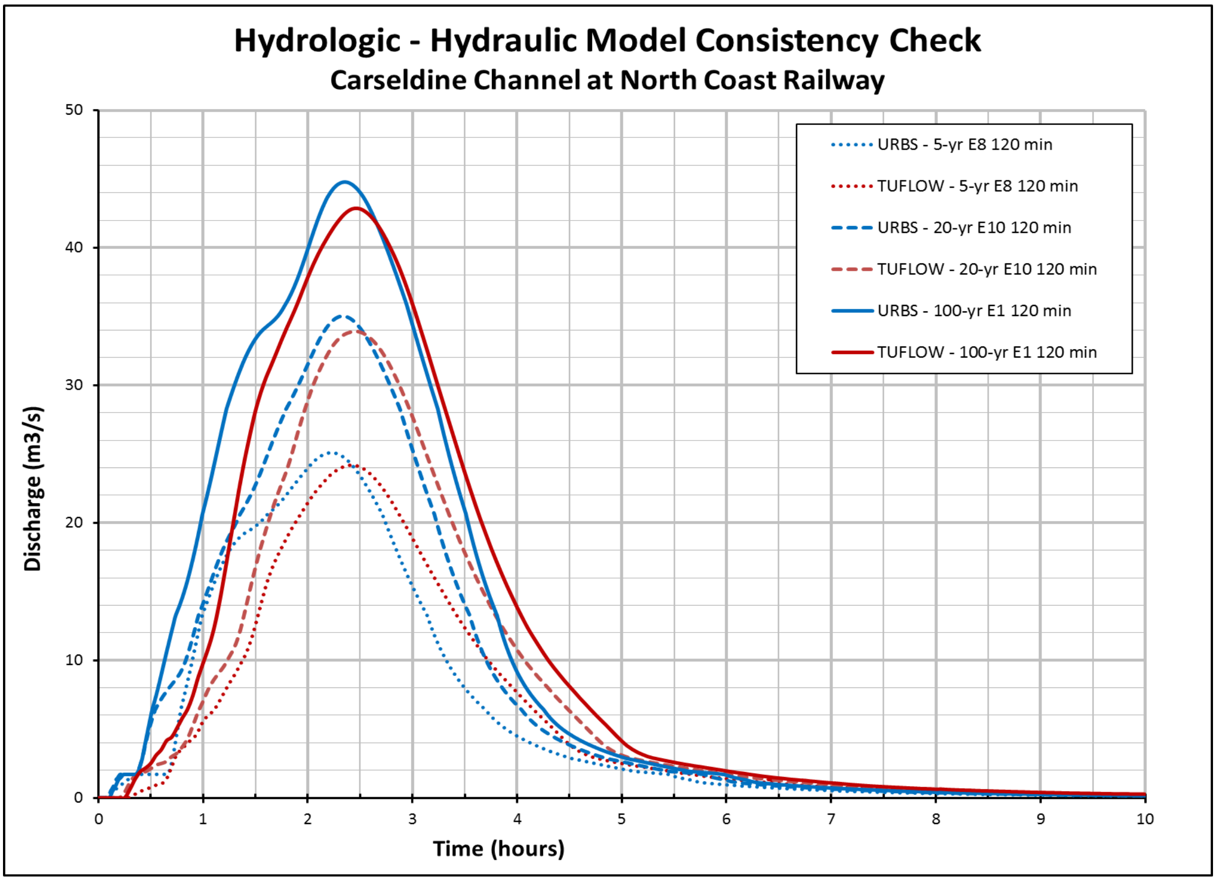


Figure 6.10: Model Comparison for Design Events - Carseldine Channel at North Coast Railway

6.4.8 Hydraulic Structure Reference Sheets

Details of flood level and flow data derived for the hydraulic structure crossings modelled are summarised in the Hydraulic Structure Reference Sheets and included in Appendix M. The flood levels and flow values are representative of present day conditions and as such do not include increases in rainfall intensity due to projected climate variability effects.

6.4.9 Flood Mapping

The flood mapping products are provided in Volume 2 and include the following:

- Scenario 1
    - Flood Extent Mapping: 2-yr ARI (50 % AEP) to 100-yr ARI (1 % AEP)

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7.0 Very Rare and Extreme Event Analysis

7.1 Very Rare and Extreme Event Scenarios

Table 7.1 indicates the events and scenarios modelled as part of the Very Rare and Extreme event analysis. These scenarios have been previously described in Section 6.1. All Very Rare and Extreme event modelling was undertaken using ultimate hydrological conditions.

Table 7.1 – Very Rare and Extreme Event Scenarios

Event	Scenario 1	Scenario 2	Scenario 3
200-yr ARI (0.5 % AEP)	✓	✗	✓
500-yr ARI (0.2 % AEP)	✓	✗	✓
2000-yr ARI (0.05 % AEP)	✓	✗	✗
PMF	✓	✗	✗

For the modelling of the Scenario 3 events, the fill height outside of the “Modelled Flood Corridor” is set to the Scenario 3 100-yr ARI (1 % AEP) flood level plus an additional height allowance of 0.3 m. The “100-yr ARI (1 % AEP) plus 0.3 m flood surface” is then required to be stretched, for which the methodology is detailed below.

7.2 Flood Extent Stretching Process

With the move to two-dimensional flood models, the production of flood levels, extents and depth-velocity products is inherent in simulating a model, i.e. a flood map is a direct output from a model simulation removing the requirement to apply a separate process. For the Scenario 1 “existing” simulations, the model is run and the direct output is able to be mapped or referenced in a GIS environment. In order to simulate the “ultimate” scenario, the model topography must be modified to represent filling associated with development. This in turn affects the resulting flood mapping with the flood extent limited to the edge of the filled floodplain. Post processing of the model output is required to represent the modelled flood levels against the current floodplain conditions.

In order to create the “stretched” flood surface(s), the Scenario 3 “ultimate” flood level surfaces were firstly required to be generated. As previously discussed in Section 6.1, the ultimate scenario involves modifying the flood model topography to represent a fully developed (filled) floodplain in accordance with BCC City Plan 2014 and in most instances making further allowances for a riparian corridor.

The WaterRIDE™ Flood Manager software was utilised for the purpose of stretching the Scenario 3 “ultimate” case results and producing the “stretched” flood surface(s). The WaterRIDE™ ‘buffer width’ tool was used, whereby the surface is extended by an equal number of grid cells (or TIN triangles) as a buffer around the current wet cells. A minimum depth threshold is used to determine what surrounding cells (within the buffer width) are considered ‘available’ for stretching. For this purpose, a value of 500 was used for the buffer width and -5 for the minimum depth threshold. Using these high values / tolerances ensured the flood surface was initially stretched far beyond the realistic limit of stretching. The stretched flood surface was then mapped onto the ground surface terrain grid to produce the mapped flood extents of the stretched flood surface.

From experience to date, it is known that there are inherent anomalies with the automated stretching process and some degree of manual intervention is typically required by an experienced / skilled practitioner to produce a more realistic stretched flood surface. To facilitate this process, a comparison of the mapped extent against the “existing” flooding extents (including larger events) was undertaken. In areas where there were obvious anomalies, some minor adjustments were made to the mapped extents of the stretched flood surface.

7.3 Very Rare and Extreme Event Hydrology

7.3.1 Overview

Very Rare and Extreme event flood hydrology was determined for the following events, as detailed further in Sections 7.3.2 to 7.3.3.

(i) 200-yr ARI (0.5 % AEP), 500-yr ARI (0.2 % AEP) and 2000-yr ARI (0.05 % AEP) events,

(ii) Probable Maximum Precipitation (PMP)

7.3.2 200-yr ARI (0.5 % AEP) to 2000-yr ARI (0.05 % AEP) Events

The DEA AR&R 2019 was used for the 200-yr ARI (0.5 % AEP), 500-yr ARI (0.2 % AEP) and 2000-yr ARI (0.05 % AEP) events, similar to previously detailed in Section 6.2.

Design rainfall depth / intensity data was obtained from the Bureau of Meteorology (BOM) website and factored up by 9.8 % to allow for increased rainfall intensity due to projected climate variability effects, as previously discussed in Section 6.2.6.

Table 7.2 indicates the adopted design rainfall intensities (catchment centroid) with comparison to the adopted 100-yr ARI (1 % AEP).

Table 7.2 – Adopted Rare and Very Rare Event IFD Data

Duration (hrs)	Rainfall Intensity (mm/hr) (1)			
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
0.5	161.41	182.27	213.01	264.62
1	107.49	120.78	141.64	176.78
1.5	83.34	93.99	109.80	137.25
2	69.39	78.18	91.57	114.19
3	53.69	60.39	70.49	87.51
4.5	41.72	46.77	54.57	67.53
6	35.14	39.31	45.68	56.44
9	27.78	31.07	36.01	44.47

(1) Includes 9.8 % increase in rainfall intensity due to projected climate variability effects.

7.3.3 Probable Maximum Precipitation (PMP)

In order to create a simplified PMP hyetograph that could be utilised across all BCC catchments, a simplified super-storm method was used. A 6-hr super-storm was developed to represent all storm durations up to 6 hours. The super-storm was developed in 30-minute blocks and incorporates the 0.5-hr, 1-hr, 1.5-hr, 2-hr and 3-hr storm bursts. Durations less than 30-minutes were not considered.

This methodology was documented in the memorandum "Technical Memorandum for Adopted Methodology – Extreme Events Modelling" from BCC Flood Management to BCC Natural Environment Water and Sustainability Branch (NEWS) on the 15th March 2013. This same methodology has also been used on other BCC flood studies recently undertaken. Table 7.3 indicates the adopted super-storm temporal pattern and hyetograph for the PMP.

Table 7.3 – Adopted Super-storm Hyetograph

Time (hr)	Cumulative Rainfall (%)	Rainfall (mm)	Time (hr)	Cumulative Rainfall (%)	Rainfall (mm)
0.00	0	0.00	3.17	58	75.08
0.17	1	9.92	3.33	70	75.08
0.33	3	9.92	3.50	75	38.25
0.50	4	9.92	3.67	77	27.63
0.67	5	9.92	3.83	80	27.63
0.83	6	9.92	4.00	82	27.63
1.00	8	9.92	4.17	84	18.42
1.17	9	13.46	4.33	86	18.42
1.33	10	13.46	4.50	89	18.42
1.50	11	13.46	4.67	90	13.46
1.67	14	18.42	4.83	91	13.46
1.83	16	18.42	5.00	92	13.46
2.00	18	18.42	5.17	94	9.92
2.17	20	27.63	5.33	95	9.92
2.33	23	27.63	5.50	96	9.92
2.50	25	27.63	5.67	97	9.92
2.67	30	38.25	5.83	99	9.92
2.83	34	38.25	6.00	100	9.92
3.00	46	75.08	**TOTAL**		**816**

The total PMP rainfall depth was derived from the 6-hr storm duration using the Generalised Short Duration Method (GSDM). For the tropical and sub-tropical coastal areas it is recommended that this method be used to estimate the PMP over areas up to 520 km^2 and for durations up to 6 hours. To apply a consistent methodology across the majority of BCC an average catchment size of 60 km^2 and moisture adjustment factor of 0.85 were adopted. The total rainfall depth of the super-storm was set equal to the 6-hr GSDM PMP rainfall depth, which was determined as 816 mm.

7.4 Very Rare and Extreme Event Hydraulic Modelling

7.4.1 General

The TUFLOW model was used to simulate the scenarios as detailed in Section 7.1 to enable design flood levels and flood mapping products to be determined / produced.

7.4.2 Methodology

The methodology used is similar to that discussed previously in Sections 6.3.2 and 6.3.3.

7.4.3 Selected Ensembles for Hydraulic Modelling

Table 7.4 indicates the median ranking(s) as well as the critical duration for the full range of ARIs (AEPs) at each of the seven locations. These results are from the URBS hydrologic analysis and based on the methodology presented in the previous sections, the ensembles selected for the hydraulic analysis using the TUFLOW model are as follows:

- 30-minute storm duration
  - Very Rare: [200-yr ARI (0.5 % AEP), 500-yr ARI (0.2 % AEP) and 2000-yr ARI (0.05 % AEP)] - Ensemble 7 (of 10)
- 1-hour storm duration
  - Very Rare: [200-yr ARI (0.5 % AEP), 500-yr ARI (0.2 % AEP) and 2000-yr ARI (0.05 % AEP)] - Ensemble 4 (of 10)
- 1.5-hour storm duration
  - Very Rare: [200-yr ARI (0.5 % AEP), 500-yr ARI (0.2 % AEP) and 2000-yr ARI (0.05 % AEP)] - Ensemble 5 (of 10)
- 2-hour storm duration
  - Very Rare: [200-yr ARI (0.5 % AEP), 500-yr ARI (0.2 % AEP) and 2000-yr ARI (0.05 % AEP)] - Ensemble 1 (of 10)
- 3-hour storm duration
  - Very Rare: [200-yr ARI (0.5 % AEP), 500-yr ARI (0.2 % AEP) and 2000-yr ARI (0.05 % AEP)] - Ensemble 4 (of 10)
- 4.5-hour storm duration
  - Very Rare: [200-yr ARI (0.5 % AEP), 500-yr ARI (0.2 % AEP) and 2000-yr ARI (0.05 % AEP)] - Ensemble 3 (of 10)
- 6-hour storm duration
  - Very Rare: [200-yr ARI (0.5 % AEP), 500-yr ARI (0.2 % AEP) and 2000-yr ARI (0.05 % AEP)] - Ensemble 6 (of 10)

The tabulated results in Appendix I (highlighted in yellow) indicate where the selected ensemble is ranked (as well as the discharge) for all durations and ARIs (AEPs) at the 13 selected locations. Also shown (highlighted in light pink) is the ranking (and discharge) as a result of the ensemble(s) chosen for other locations.

Table 7.4 – Critical Duration and Ensemble Ranking (Very Rare Events)

Location	Statistics	Ensemble # (Critical Duration)		
		200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
Taigum Channel at Fernwood Place	Rank 6 (max)	7 (0.5-hr)	7 (0.5-hr)	7 (0.5-hr)
	Rank 5 (max)	4 (0.5-hr)	4 (0.5-hr)	4 (0.5-hr)
Taigum Channel at Church Road	Rank 6 (max)	4 (1-hr)	4 (1-hr)	4 (1-hr)
	Rank 5 (max)	5 (1-hr)	5 (1-hr)	5 (1-hr)
Carseldine Channel at Beams Road	Rank 6 (max)	8 (0.5-hr)	8 (0.5-hr)	2 (0.5-hr)
	Rank 5 (max)	4 (0.5-hr)	4 (0.5-hr)	4 (0.5-hr)
Carseldine Channel at Gympie Road	Rank 6 (max)	4 (1-hr)	7 (0.5-hr)	7 (0.5-hr)
	Rank 5 (max)	5 (1-hr)	5 (1-hr)	10 (0.5-hr)
Carseldine Channel at Norris Road	Rank 6 (max)	1 (2-hr)	1 (2-hr)	7 (2-hr)
	Rank 5 (max)	8 (2-hr)	8 (2-hr)	2 (2-hr)
Carseldine Channel at Fitzgibbon Landfill	Rank 6 (max)	2 (4.5-hr)	4 (3-hr)	7 (3-hr)
	Rank 5 (max)	9 (3-hr)	7 (3-hr)	4 (3-hr)
Little Cabbage Tree Creek at Hamilton Road	Rank 6 (max)	7 (0.5-hr)	7 (0.5-hr)	7 (0.5-hr)
	Rank 5 (max)	10 (0.5-hr)	10 (0.5-hr)	10 (0.5-hr)
Little Cabbage Tree Creek at Gympie Road	Rank 6 (max)	9 (1.5-hr)	9 (1.5-hr)	9 (1.5-hr)
	Rank 5 (max)	5 (1.5-hr)	5 (1.5-hr)	5 (1.5-hr)
Cabbage Tree Creek at Old Northern Road	Rank 6 (max)	5 (1-hr)	5 (1-hr)	5 (1-hr)
	Rank 5 (max)	10 (1-hr)	10 (1-hr)	10 (1-hr)
Cabbage Tree Creek at	Rank 6 (max)	3 (1.5-hr)	3 (1.5-hr)	3 (1.5-hr)

Location	Statistics	Ensemble # (Critical Duration)		
		200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
MHG C240	Rank 5 (max)	5 (1.5-hr)	5 (1.5-hr)	5 (1.5-hr)
Cabbage Tree Creek at 540122	Rank 6 (max)	4 (3-hr)	4 (3-hr)	4 (3-hr)
	Rank 5 (max)	6 (3-hr)	6 (3-hr)	6 (3-hr)
Cabbage Tree Creek at Lemke Road	Rank 6 (max)	3 (4.5-hr)	3 (4.5-hr)	3 (4.5-hr)
	Rank 5 (max)	7 (3-hr)	7 (3-hr)	4 (3-hr)
Cabbage Tree Creek at Catchment Outlet	Rank 6 (max)	6 (6-hr)	6 (6-hr)	6 (6-hr)
	Rank 5 (max)	8 (6-hr)	8 (6-hr)	9 (6-hr)

7.4.4 TUFLOW Model Set-up

TUFLOW model extents

No changes were made from the design event TUFLOW model(s).

TUFLOW model roughness

No changes were made from the design event TUFLOW model(s).

TUFLOW channel representation

No changes were made from the design event TUFLOW model(s) for the 200-yr ARI (0.5 % AEP) to 2000-yr ARI (0.05 % AEP) simulations.

However, the simulation of the PMF required portions of the 1d channel within the Carseldine Channel to be changed to 2d representation, to overcome issues with model instabilities. Between Gympie Road and Lacey Road, a 300 m length of 1d channel was changed to 2d representation. In addition, between Lacey Road and the North Coast Railway, a 400 m length of 1d channel was changed to 2d representation. It is considered that these changes will have negligible effects on flood levels due to the magnitude of this event and the considerable proportion of floodplain flow.

TUFLOW model boundaries

Design Inflows

The Very Rare and Extreme event inflow (Q-T) boundaries to the TUFLOW model were taken from the results of the URBS model for each ARI and duration. The inflow locations did not change from the design event TUFLOW model(s).

Design Tailwater Boundary

The Very Rare and Extreme event TUFLOW model utilised a fixed Highest Astronomical Tide (HAT) water level (H-T) boundary as the downstream model boundary. At this location the value of HAT is 1.31 mAHD.

7.4.5 Hydraulic Structures

The Very Rare and Extreme event TUFLOW model utilised the same hydraulic structures as the design event TUFLOW model(s).

7.5 Results and Mapping

7.5.1 Peak Flood Levels

Tabulated peak flood level results for the Very Rare and Extreme events are provided at the following locations for all creeks:

- Scenario 1: 200-yr ARI (0.5 % AEP) to 2000-yr ARI (0.05 % AEP) events – Appendix J
- Scenario 3: 200-yr ARI (0.5 % AEP) and 500-yr ARI (0.2 % AEP) events – Appendix K

7.5.2 Flood Mapping

The flood mapping products are provided in Volume 2 and include the following:

- Scenario 1
    - Flood Extent Mapping: 200-yr ARI (0.5 % AEP), 500-yr ARI (0.2 % AEP) and 2000-yr ARI (0.05 % AEP)

7.5.3 Discussion of Results

A longitudinal plot of the Scenario 1 100-yr ARI (1 % AEP) to PMF flood profiles for the major creeks is provided in Figure 7.1 to Figure 7.5.

The flood profiles for the 200-yr ARI (0.5 % AEP), 500-yr ARI (0.2 % AEP) and 2000-yr ARI (0.05 % AEP) events are observed to follow a very similar trend when compared to the 100-yr ARI (1 % AEP) flood profile along all of the creeks.

Generally, as the bed slope (gradient) of the creek increases towards the head of the catchment, the relative differences in flood level between events decreases. This is also because the relative differences between the design flows are typically less towards the head of the catchment. The largest differences in relative flood level typically occur towards the lower section of the creeks, where the relative differences in design flow are greatest.

Table 7.5 indicates the average differences in flood level along the major creeks when compared to the 100-yr ARI (1 % AEP) flood profile. The results indicate the largest average differences are in Cabbage Tree Creek and the smallest in Taigum Channel.

In Cabbage Tree Creek, considerable head-losses are apparent for the 200-yr ARI (0.5 % AEP) to 2000-yr ARI (0.05 % AEP) events in the vicinity of Sandgate Road and the Shorncliffe Railway. Whereas the Gateway Motorway appears to create the largest head-losses in the PMF.

The results indicate there are considerable head-losses for all flood profiles at Albany Creek Road on Little Cabbage Tree Creek.

In the Carseldine Channel, there are considerable head-losses at Norris Road, the North Coast Railway and Lacey Road. The flood profiles are quite flat between Chainage 1500 and Lacey Road, reflecting the attenuation effects within this reach.

Table 7.5 – Average Increase in Flood Level

Event	Average Increase in Flood Level (m) with reference to the 100-yr ARI (1 % AEP) flood level [1]			
	Cabbage Tree Creek	Little Cabbage Tree Creek	Carseldine Channel	Taigum Channel
200-yr ARI (0.5 % AEP)	0.20	0.12	0.11	0.12
500-yr ARI (0.2 % AEP)	0.36	0.29	0.26	0.26
2000-yr ARI (0.05 % AEP)	0.61	0.52	0.50	0.46
PMF	1.89	1.60	1.58	1.43

(1) Includes increased design rainfall due to projected climate variability effects

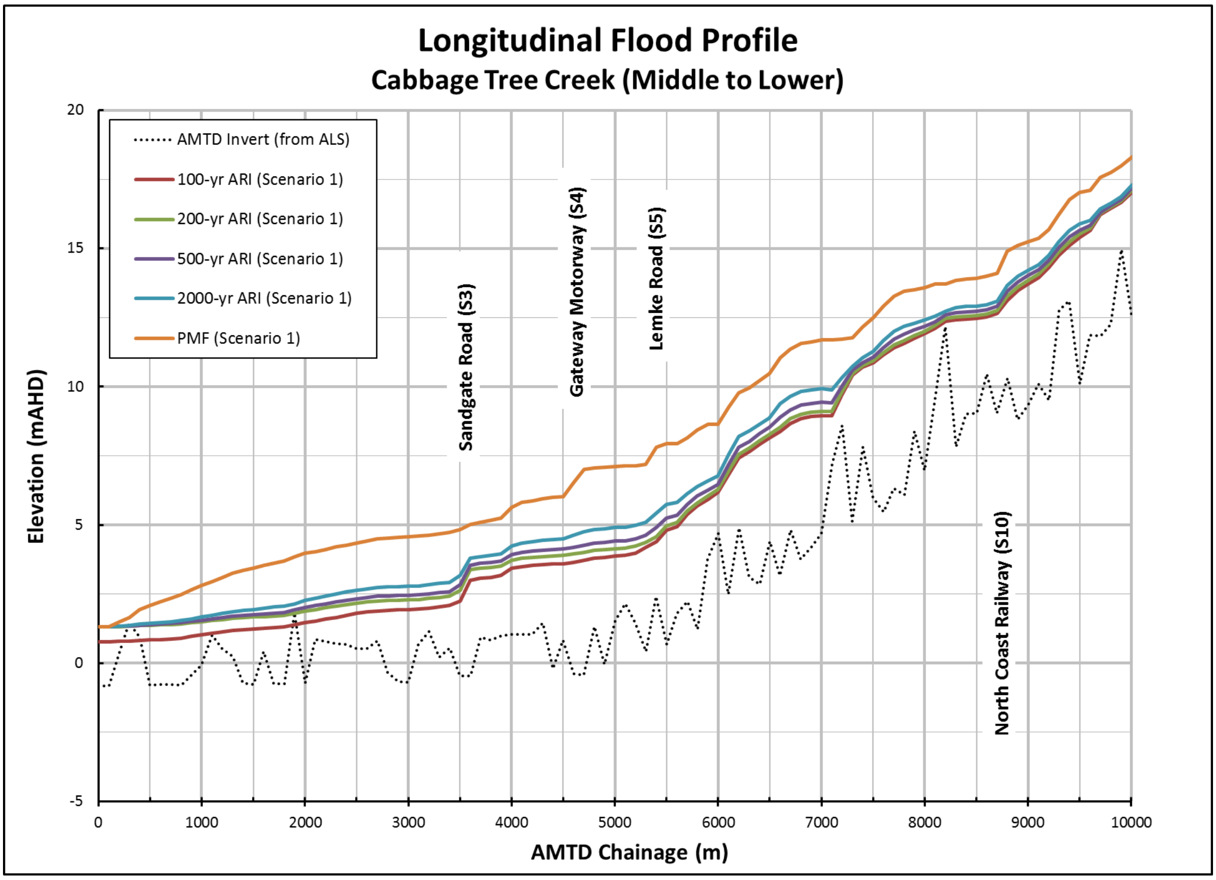

Figure 7.1: Longitudinal Flood Profile – Cabbage Tree Creek (Middle to Lower)

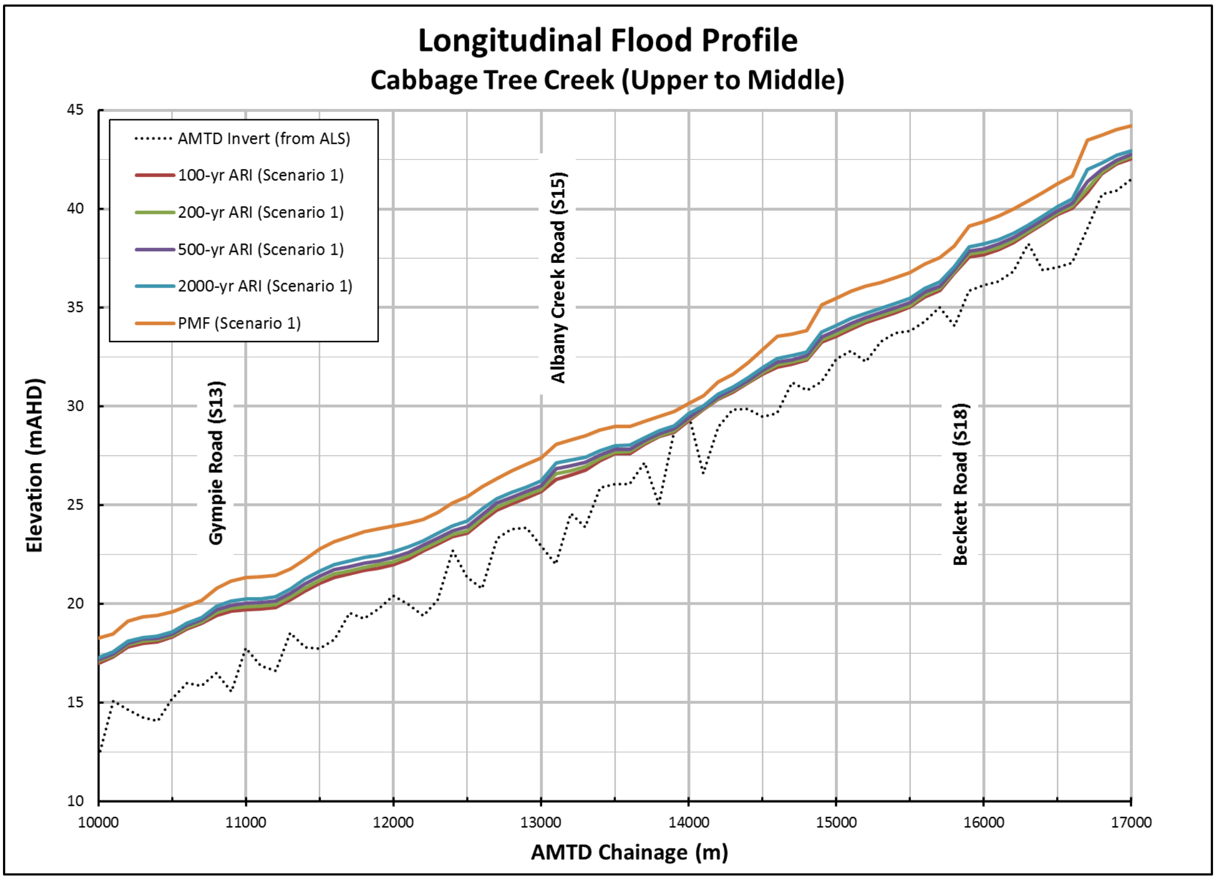

Figure 7.2: Longitudinal Flood Profile – Cabbage Tree Creek (Upper to Middle)

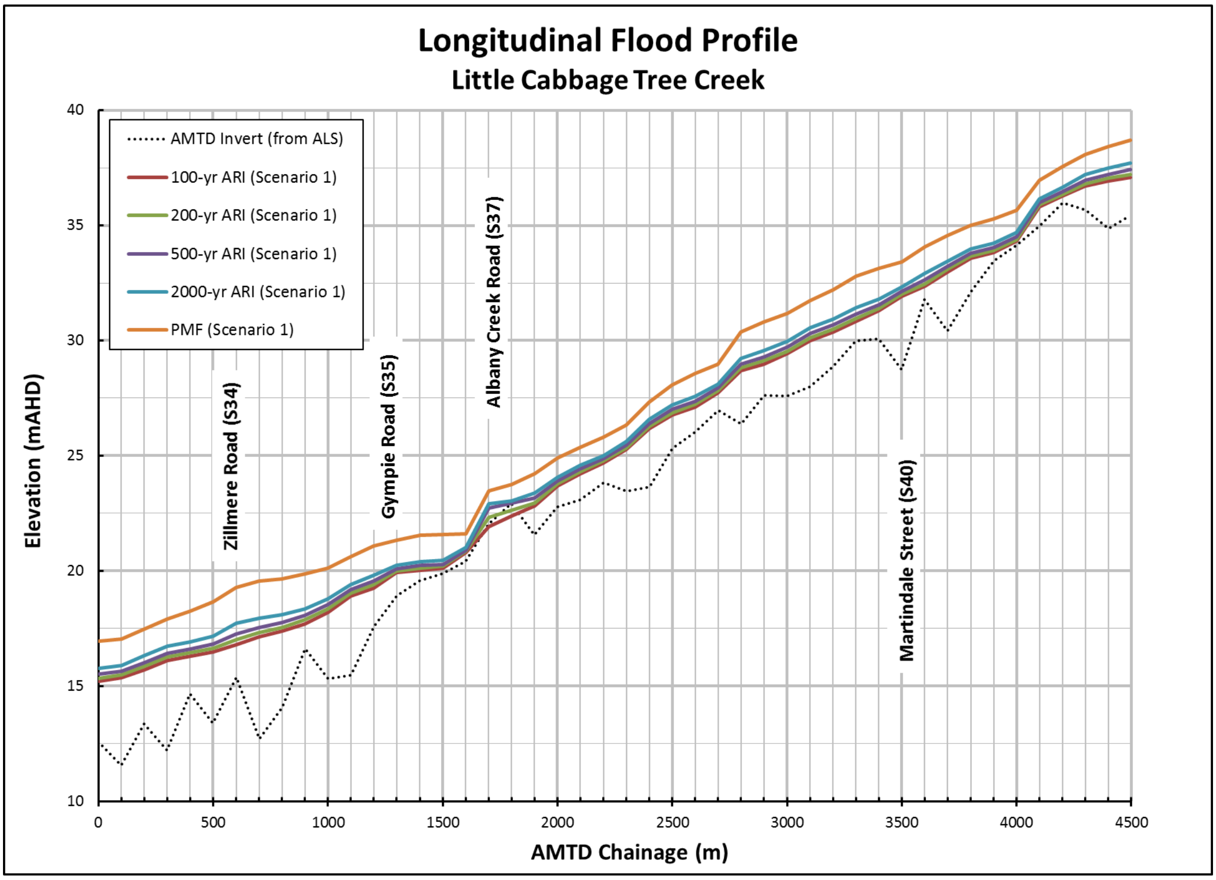

Figure 7.3: Longitudinal Flood Profile – Little Cabbage Tree Creek

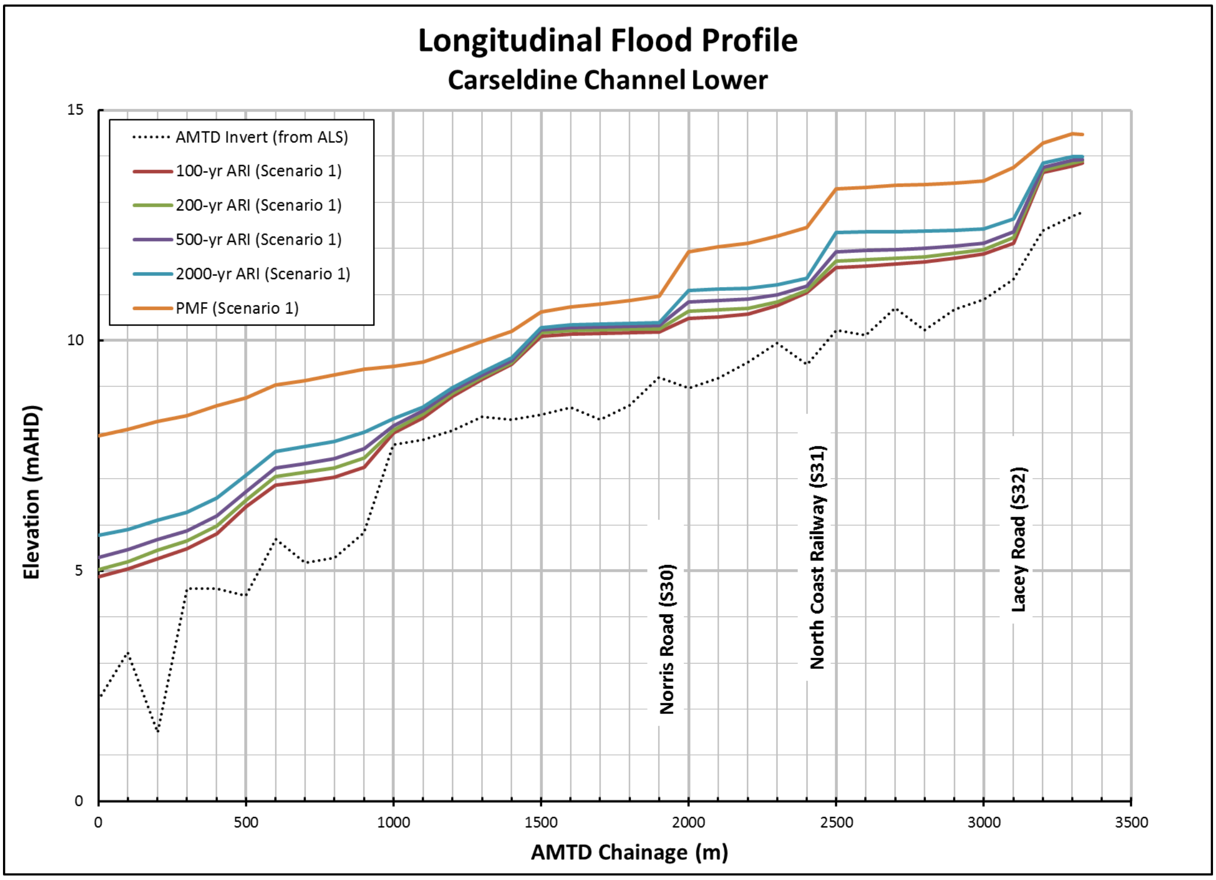

Figure 7.4: Longitudinal Flood Profile – Carseldine Channel Lower

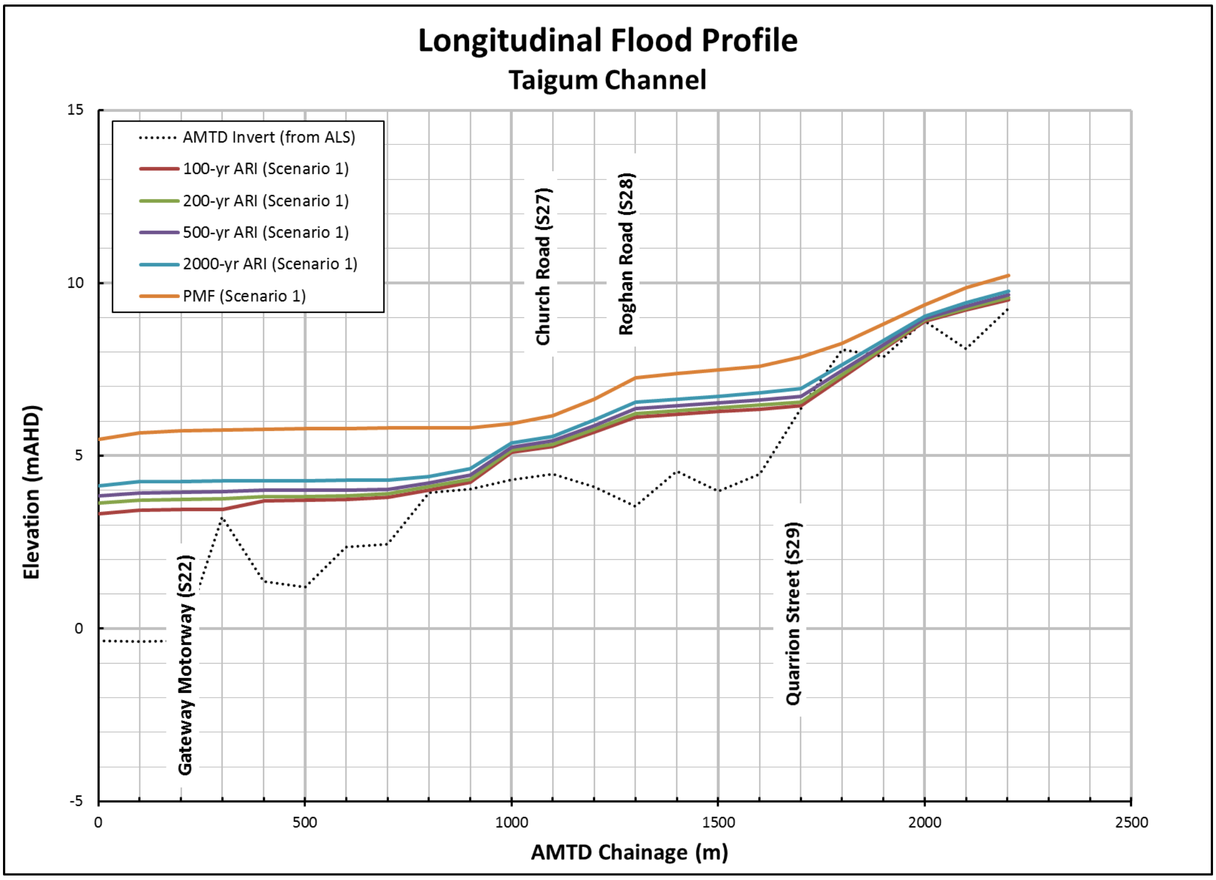

Figure 7.5: Longitudinal Flood Profile – Taigum Channel

8.0 Sensitivity Simulations

8.1 General

A requirement for the scope of this flood study is to undertake a sensitivity analysis on the effects of climate variability induced sea-level rise on design flood levels. Table 8.1 indicates the events and scenarios modelled as part of the sea-level rise sensitivity analysis. This modelling was undertaken for Scenario 1 and Scenario 3 using ultimate hydrological conditions and an increased downstream boundary due to sea-level rise. Scenarios 1 to 3 have been previously described in Section 6.1.

Table 8.1 – Sea-level Rise Scenarios

Event	Planning horizon	Tailwater Condition	Scenario 1	Scenario 2	Scenario 3
100-yr ARI (1 % AEP)	2100	MHWS + 0.8 m = 1.57 mAHD	✓	✗	✓

8.2 Selected Ensembles for Hydraulic Modelling

The same ensembles which were previous adopted in Section 6.3.4 (100-yr ARI (1 % AEP)) were used in the hydraulic modelling for the sea-level rise analysis.

8.3 Hydraulic Modelling

The TUFLOW model(s) used for the sea-level rise analysis incorporated the same model set-up as the design event TUFLOW model(s), apart from the downstream boundary condition, which was increased by 0.8 m to represent the anticipated sea-level rise for the Year 2100 Planning Horizon.

8.4 Impacts of Sea-level Rise

Table 8.2 provides a comparison of the peak Scenario 1 100-yr ARI (1 % AEP) flood levels, with and without sea-level rise. The flood level results are provided at selected locations along the major creeks within the middle and lower catchment. The results indicate that the greatest change in flood level is in the lower reaches downstream of Lemke Road.

The Scenario 1 100-yr ARI (1 % AEP) flood level differences (as a result of sea-level rise) propagate up the creeks and tributaries to the following extents:

- Cabbage Tree Creek – Chainage 5700 m, approximately 300 m upstream of Lemke Road
- Little Cabbage Tree Creek – no impacts
- Carseldine Channel – Chainage 200 m, just upstream of the confluence with Cabbage Tree Creek.
- Taigum Channel – Chainage 700 m, approximately 500 m upstream of the Gateway Motorway.
- Deagon Tributary – entire modelled extent is subject to sea-level rise impacts.

- Sandgate Tributary – Board Street
- Fitzgibbon Tributary – no impacts

Table 8.2 – 100-yr ARI (1 % AEP) SLR Impacts at Selected Locations (Scenario 1)

Location	100-yr ARI (1 % AEP) Peak Flood Level (m AHD) (1)		
	Existing	Sea-level Rise Included	Difference (m)
Cabbage Tree Creek			
540122 (Pineapple Street)	13.04	13.04	0.00
Beams Road	12.38	12.38	0.00
Roghan Road	8.37	8.37	0.00
Lemke Road	4.47	4.51	0.04
Gateway Motorway	3.63	3.77	0.14
Sandgate Road	2.98	3.24	0.26
Catchment Outlet	0.77	1.57	0.80
Carseldine Channel			
Norris Road	10.46	10.46	0.00
Taigum Channel			
Roghan Road	6.11	6.11	0.00
Church Road	5.27	5.27	0.00
Gateway Motorway	3.45	3.61	0.16
Deagon Tributary			
Braun Street	3.65	3.70	0.05
Finnie Road	1.75	2.14	0.39
Sandgate Tributary			
Board Street	4.09	4.09	0.00
Bridge Street	2.22	2.29	0.07

(1) Includes increased design rainfall due to projected climate variability effects

9.0 Summary of Study Findings

This flood study report details the calibration and verification, design event, very rare / extreme event and sensitivity modelling for the Cabbage Tree Creek Catchment. The major tributaries of Cabbage Tree Creek; Little Cabbage Tree Creek; Carseldine Channel and Taigum Channel as well as a number of minor tributaries are included. New hydrologic and hydraulic models have been developed for the study using the URBS and TUFLOW modelling software, respectively.

Hydrometric information was sourced from the available rainfall, stream and maximum height gauge records. Calibration of the URBS and TUFLOW models was undertaken for the 1st May 2015 and 4th June 2016 events. Verification of the URBS and TUFLOW models was undertaken for the 19th June 2016 event.

Cross-checks of the TUFLOW hydraulic structure head-losses were undertaken at selected structures using the HEC-RAS software, from which it was confirmed that the model was representing the structures adequately.

The results of the hydraulic calibration and verification indicated that the URBS and TUFLOW models were able to adequately replicate the historical flooding events to within the specified tolerances for the majority of areas. On this basis, it was concluded that the URBS and TUFLOW models were sufficiently robust to be used to accurately simulate the synthetic design flood events.

Design, very rare and extreme flood magnitudes were estimated for the full range of events from 2-yr ARI (50% AEP) to PMF. These analyses assumed hydrologic ultimate catchment development conditions in accordance with BCC City Plan 2014 and utilised the recently released AR&R 2019 methodology. The design rainfall intensities included an allowance for increased rainfall intensity due to projected climate variability effects. A fixed tidal boundary was used at the downstream model extent to represent the tidal conditions in Moreton Bay.

Three waterway scenarios were considered as follows:

- Scenario 1 is based on the current waterway conditions. Minor modifications were made to the TUFLOW model developed as part of the calibration / verification phase.
- Scenario 2 includes an allowance for a riparian corridor along the edge of the channel.
- Scenario 3 includes an allowance for the riparian corridor (as per Scenario 2) and also assumes filling to the “Modelled Flood Corridor” boundary to simulate potential development.

The results from the TUFLOW modelling were used to produce the following:

- Peak flood discharges at selected locations
- Peak flood levels at 100 m intervals along the AMTD line
- Peak flood extent mapping (Scenario 1 only)
- Hydraulic structure flood immunity data

A sea-level rise analysis for the 100-yr ARI (1 % AEP) event was undertaken to understand the differences in flood level. This involved increasing the downstream boundary level by 0.8 m to allow for the projected sea-level increase for the Year 2100 Planning Horizon

The results indicated that increased 100-yr ARI (1 % AEP) flood levels due to sea-level rise would propagate up the creeks and tributaries to the following extents:

- Cabbage Tree Creek – up to Chainage 5700 m, approximately 300 m upstream of Lemke Road.
- Little Cabbage Tree Creek – no impacts
- Carseldine Channel – up to Chainage 200 m, just upstream of the confluence with Cabbage Tree Creek.
- Taigum Channel – up to Chainage 700 m, approximately 500 m upstream of the Gateway Motorway.
- Deagon Tributary – entire modelled extent is subject to sea-level rise impacts.
- Sandgate Tributary – up to Board Street
- Fitzgibbon Tributary – no impacts

Hydraulic Structure Reference Sheets (HSRS) for all major crossings within the TUFLOW model area were also prepared. The HSRS provide data for each hydraulic structure and include data relating to the structure description, location, hydraulic performance and history.

APPENDICES

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Appendix A: Rainfall Distribution

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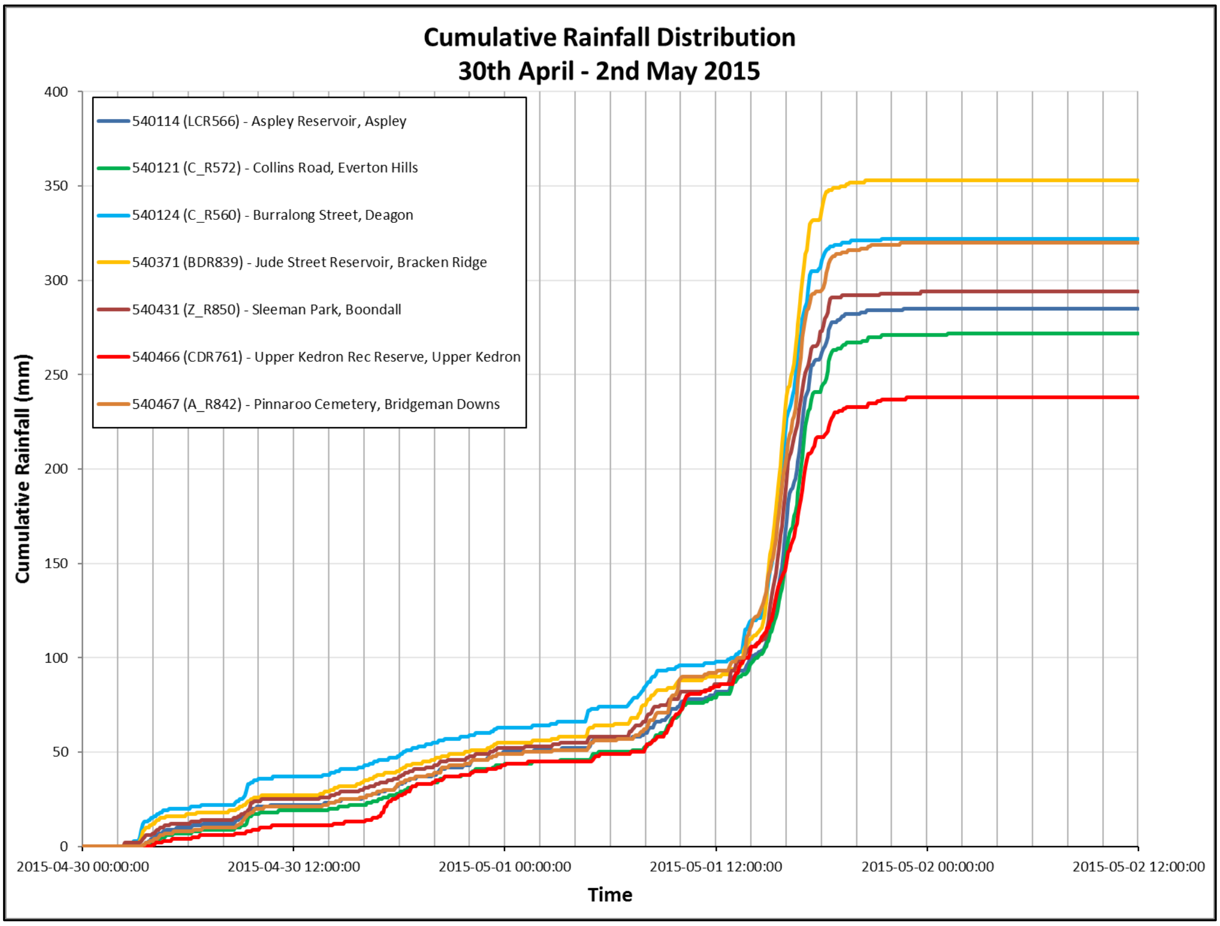
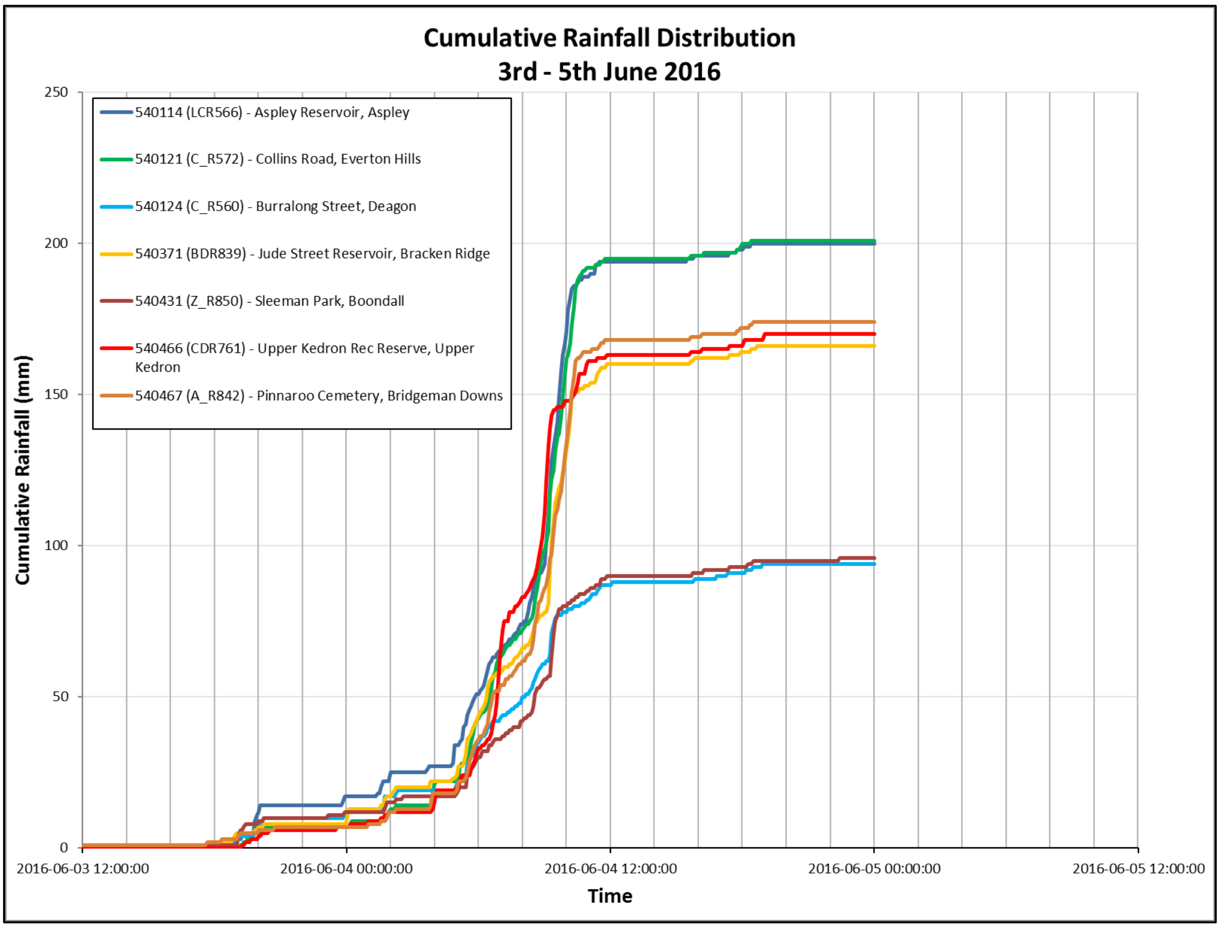
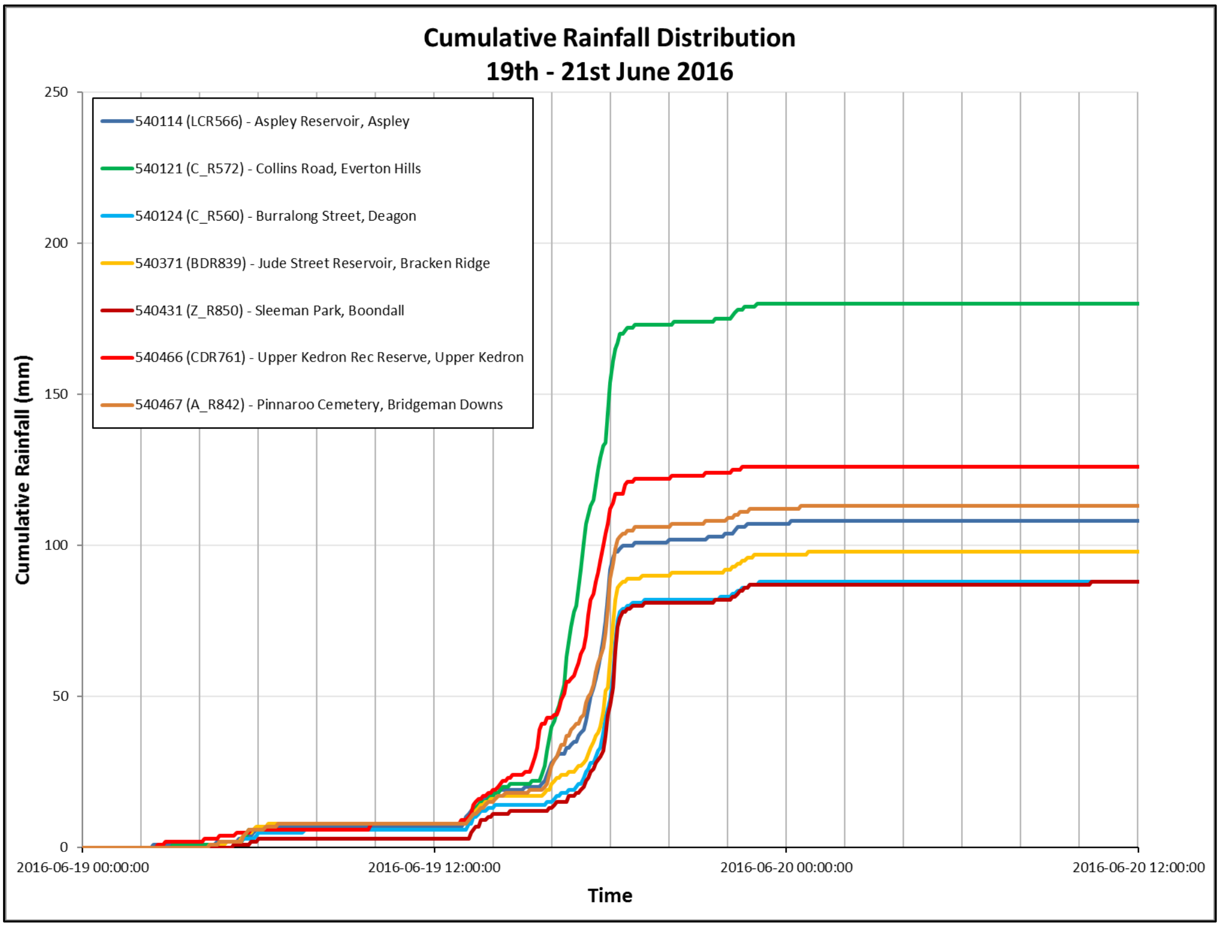


Cumulative Rainfall Distribution
30th April - 2nd May 2015
540114 (LCR566) - Aspley Reservoir, Aspley
540121 (C_R572) - Collins Road, Everton Hills
540124 (C_R560) - Burralong Street, Deagon
540371 (BDR839) - Jude Street Reservoir, Bracken Ridge
540431 (Z_R850) - Sleeman Park, Boondall
540466 (CDR761) - Upper Kedron Rec Reserve, Upper Kedron
540467 (A_R842) - Pinnaroo Cemetery, Bridgeman Downs
Cumulative Rainfall (mm)
0
50
100
150
200
250
300
350
400
2015-04-30 00:00:00
2015-04-30 12:00:00
2015-05-01 00:00:00
2015-05-01 12:00:00
2015-05-02 00:00:00
2015-05-02 12:00:00
Time



Cumulative Rainfall Distribution
3rd - 5th June 2016
540114 (LCR566) - Aspley Reservoir, Aspley
540121 (C_R572) - Collins Road, Everton Hills
540124 (C_R560) - Burralong Street, Deagon
540371 (BDR839) - Jude Street Reservoir, Bracken Ridge
540431 (Z_R850) - Sleeman Park, Boondall
540466 (CDR761) - Upper Kedron Rec Reserve, Upper Kedron
540467 (A_R842) - Pinnaroo Cemetery, Bridgeman Downs
Cumulative Rainfall (mm)
0
50
100
150
200
250
2016-06-03 12:00:00
2016-06-04 00:00:00
2016-06-04 12:00:00
2016-06-05 00:00:00
2016-06-05 12:00:00
Time



Cumulative Rainfall Distribution
19th - 21st June 2016
Cumulative Rainfall (mm)
250
200
150
100
50
0
540114 (LCR566) - Aspley Reservoir, Aspley
540121 (C_R572) - Collins Road, Everton Hills
540124 (C_R560) - Burralong Street, Deagon
540371 (BDR839) - Jude Street Reservoir, Bracken Ridge
540431 (Z_R850) - Sleeman Park, Boondall
540466 (CDR761) - Upper Kedron Rec Reserve, Upper Kedron
540467 (A_R842) - Pinnaroo Cemetery, Bridgeman Downs
2016-06-19 00:00:00
2016-06-19 12:00:00
2016-06-20 00:00:00
2016-06-20 12:00:00
Time

Figure A-1: Thiessen Polygons for Historical Events

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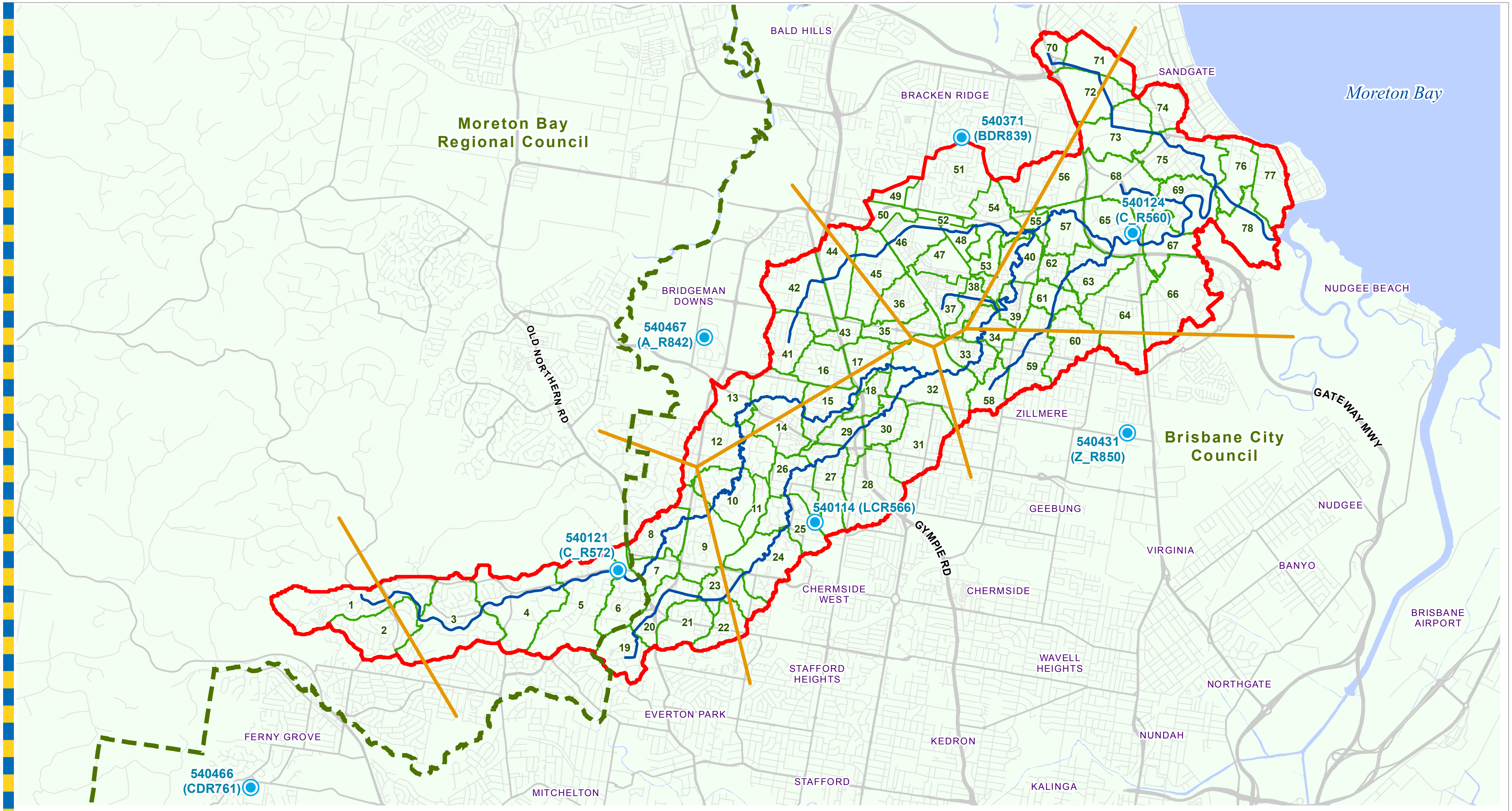

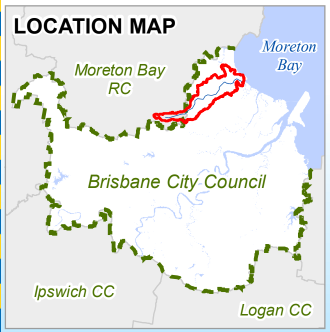

- Pluviograph Station
- Rainfall Distribution
- Creek Centreline (Cabbage Tree Creek Catchment)
- URBS Subcatchment (1 - 78)
- Cabbage Tree Ck Catchment Area
- Brisbane City Boundary
- Road

GIM - 190477 - 006

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Figure A.1: Thiessen Polygons

Cabbage Tree Creek Flood Study

0 1 2 3 4 5
Kilometers

N W E S

Brisbane City Council
City Projects Office
GPO Box 1434
Brisbane Qld 4001

For more information
visit www.brisbane.qld.gov.au
or call (07) 3403 8888

Prepared : 104515
Checked : JS
Revision : 2
Publication Date : 14 Jun 2019
Project Number : 190477

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File : G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\GIS\ESRI\Final_Maps_Feb_2019\GIM_190477_006_Thiessen_Fig_A_1.mxd

Appendix B: URBS Model Parameters

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URBS Calibration / Verification Event Sub-catchment Parameters

Sub-catchment	Area (km^2)	UL	UM	UH	UR	I
1	1.156	0.331	0.572	0.005	0.092	0.340
2	0.716	0.046	0.867	0.000	0.087	0.441
3	1.216	0.247	0.639	0.025	0.089	0.379
4	1.130	0.633	0.155	0.028	0.184	0.198
5	1.188	0.636	0.125	0.056	0.183	0.208
6	0.556	0.077	0.574	0.114	0.235	0.401
7	0.295	0.215	0.271	0.190	0.324	0.339
8	0.501	0.016	0.483	0.256	0.246	0.474
9	0.869	0.056	0.344	0.207	0.394	0.366
10	0.589	0.000	0.531	0.013	0.456	0.278
11	0.214	0.000	0.171	0.095	0.735	0.171
12	0.970	0.105	0.428	0.090	0.376	0.311
13	0.383	0.376	0.050	0.030	0.544	0.109
14	0.885	0.000	0.411	0.181	0.408	0.368
15	0.492	0.165	0.502	0.164	0.169	0.423
16	0.462	0.000	0.749	0.249	0.003	0.598
17	0.408	0.053	0.716	0.112	0.119	0.466
18	0.248	0.000	0.270	0.729	0.001	0.791
19	0.447	0.320	0.463	0.141	0.077	0.406
20	0.487	0.322	0.501	0.146	0.032	0.430
21	0.472	0.000	0.798	0.029	0.173	0.425
22	0.332	0.110	0.550	0.140	0.200	0.418
23	0.442	0.039	0.559	0.189	0.214	0.455
24	0.768	0.002	0.358	0.078	0.562	0.249
25	0.550	0.000	0.559	0.204	0.238	0.463
26	0.461	0.037	0.588	0.172	0.203	0.454
27	0.618	0.026	0.701	0.127	0.146	0.469
28	0.853	0.000	0.786	0.204	0.011	0.576
29	0.324	0.000	0.191	0.809	0.000	0.824
30	0.369	0.000	0.723	0.229	0.047	0.568
31	0.782	0.037	0.814	0.149	0.000	0.546
32	1.197	0.558	0.175	0.242	0.026	0.389
33	0.333	0.000	0.471	0.198	0.331	0.414

Sub-catchment	Area (km^2)	UL	UM	UH	UR	I
34	0.347	0.190	0.332	0.049	0.429	0.239
35	0.362	0.113	0.570	0.259	0.058	0.535
36	0.411	0.041	0.694	0.220	0.046	0.551
37	0.424	0.000	0.629	0.286	0.085	0.572
38	0.264	0.000	0.402	0.462	0.136	0.617
39	0.288	0.048	0.644	0.124	0.183	0.441
40	0.518	0.041	0.568	0.089	0.302	0.370
41	0.502	0.033	0.812	0.112	0.042	0.512
42	0.835	0.202	0.318	0.216	0.264	0.383
43	0.213	0.000	0.852	0.119	0.030	0.533
44	0.598	0.000	0.535	0.049	0.415	0.312
45	0.771	0.164	0.533	0.098	0.205	0.379
46	0.476	0.279	0.179	0.141	0.402	0.258
47	0.346	0.000	0.224	0.139	0.637	0.237
48	0.173	0.000	0.000	0.000	1.000	0.000
49	0.153	0.000	0.166	0.089	0.745	0.163
50	0.194	0.364	0.001	0.091	0.544	0.137
51	1.018	0.073	0.550	0.275	0.102	0.533
52	0.097	0.000	0.152	0.051	0.797	0.122
53	0.181	0.000	0.088	0.045	0.867	0.084
54	0.569	0.000	0.299	0.171	0.530	0.304
55	0.169	0.167	0.115	0.088	0.630	0.162
56	0.861	0.065	0.567	0.076	0.293	0.362
57	0.454	0.175	0.168	0.078	0.580	0.180
58	0.318	0.000	0.677	0.228	0.095	0.543
59	0.748	0.134	0.719	0.094	0.053	0.464
60	0.563	0.063	0.510	0.290	0.137	0.526
61	0.259	0.018	0.270	0.180	0.532	0.300
62	0.210	0.000	0.602	0.255	0.143	0.531
63	0.497	0.000	0.352	0.072	0.577	0.240
64	1.122	0.000	0.760	0.154	0.086	0.519
65	0.682	0.153	0.488	0.044	0.315	0.307
66	1.085	0.017	0.373	0.082	0.527	0.263
67	0.474	0.129	0.213	0.087	0.571	0.204

Sub-catchment	Area (km^2)	UL	UM	UH	UR	I
68	0.745	0.197	0.438	0.112	0.253	0.349
69	0.644	0.000	0.363	0.191	0.446	0.353
70	0.227	0.257	0.037	0.045	0.661	0.098
71	0.479	0.164	0.042	0.021	0.773	0.065
72	0.635	0.141	0.096	0.022	0.741	0.089
73	0.716	0.023	0.375	0.038	0.564	0.225
74	0.386	0.013	0.345	0.105	0.538	0.269
75	0.803	0.089	0.500	0.150	0.262	0.398
76	0.514	0.000	0.482	0.082	0.436	0.315
77	0.539	0.059	0.371	0.117	0.453	0.300
78	0.641	0.000	0.066	0.128	0.806	0.148

URBS Design Event Sub-catchment Parameters

Sub-catchment	Area (km^2)	UL	UM	UH	UR	I
1	1.156	0.000	0.903	0.005	0.092	0.546
2	0.716	0.000	0.913	0.000	0.087	0.548
3	1.216	0.000	0.886	0.025	0.089	0.554
4	1.130	0.000	0.788	0.028	0.184	0.498
5	1.188	0.000	0.760	0.057	0.183	0.508
6	0.556	0.000	0.653	0.112	0.235	0.493
7	0.295	0.000	0.405	0.394	0.201	0.558
8	0.501	0.000	0.457	0.297	0.246	0.496
9	0.869	0.000	0.354	0.252	0.394	0.404
10	0.589	0.000	0.417	0.127	0.456	0.323
11	0.214	0.000	0.203	0.128	0.669	0.217
12	0.970	0.001	0.534	0.388	0.076	0.616
13	0.383	0.259	0.373	0.287	0.081	0.483
14	0.885	0.039	0.489	0.366	0.106	0.580
15	0.492	0.165	0.465	0.215	0.155	0.451
16	0.462	0.000	0.654	0.344	0.003	0.636
17	0.408	0.000	0.544	0.364	0.092	0.600
18	0.248	0.033	0.196	0.770	0.001	0.796
19	0.447	0.000	0.572	0.406	0.022	0.651
20	0.487	0.000	0.548	0.436	0.017	0.666
21	0.472	0.000	0.567	0.405	0.028	0.648
22	0.332	0.000	0.578	0.403	0.019	0.651
23	0.442	0.000	0.563	0.355	0.082	0.601
24	0.768	0.051	0.310	0.232	0.407	0.372
25	0.550	0.072	0.473	0.294	0.162	0.512
26	0.461	0.000	0.542	0.303	0.155	0.543
27	0.618	0.000	0.542	0.313	0.144	0.553
28	0.853	0.000	0.624	0.376	0.000	0.650
29	0.324	0.000	0.191	0.809	0.000	0.824
30	0.369	0.000	0.558	0.394	0.047	0.634
31	0.782	0.037	0.592	0.371	0.000	0.635
32	1.197	0.340	0.144	0.491	0.026	0.564

Sub-catchment	Area (km^2)	UL	UM	UH	UR	I
33	0.333	0.000	0.394	0.431	0.175	0.585
34	0.347	0.000	0.519	0.292	0.189	0.522
35	0.362	0.000	0.553	0.389	0.058	0.627
36	0.411	0.000	0.630	0.347	0.023	0.627
37	0.424	0.000	0.399	0.516	0.085	0.664
38	0.264	0.000	0.385	0.479	0.136	0.624
39	0.288	0.000	0.514	0.303	0.183	0.529
40	0.518	0.153	0.483	0.215	0.150	0.458
41	0.502	0.004	0.750	0.240	0.006	0.591
42	0.835	0.065	0.462	0.447	0.026	0.643
43	0.213	0.000	0.570	0.400	0.030	0.645
44	0.598	0.000	0.330	0.309	0.361	0.443
45	0.771	0.000	0.468	0.363	0.169	0.560
46	0.476	0.000	0.201	0.257	0.542	0.332
47	0.346	0.000	0.162	0.212	0.627	0.272
48	0.173	0.911	0.018	0.070	0.000	0.209
49	0.153	0.000	0.192	0.138	0.669	0.220
50	0.194	0.000	0.367	0.246	0.387	0.405
51	1.018	0.000	0.540	0.367	0.093	0.600
52	0.097	0.574	0.090	0.336	0.000	0.433
53	0.181	0.764	0.121	0.115	0.000	0.278
54	0.569	0.493	0.240	0.239	0.028	0.409
55	0.169	0.522	0.358	0.062	0.059	0.313
56	0.861	0.000	0.495	0.379	0.126	0.589
57	0.454	0.018	0.610	0.088	0.284	0.387
58	0.318	0.000	0.264	0.640	0.095	0.708
59	0.748	0.000	0.544	0.415	0.041	0.646
60	0.563	0.000	0.478	0.473	0.050	0.664
61	0.259	0.000	0.530	0.417	0.052	0.641
62	0.210	0.000	0.557	0.359	0.084	0.602
63	0.497	0.056	0.495	0.412	0.037	0.626
64	1.122	0.020	0.571	0.374	0.035	0.625
65	0.682	0.000	0.553	0.132	0.315	0.395
66	1.085	0.000	0.298	0.540	0.163	0.634

Sub-catchment	Area (km^2)	UL	UM	UH	UR	I
67	0.474	0.000	0.354	0.074	0.571	0.244
68	0.745	0.225	0.332	0.416	0.028	0.574
69	0.644	0.000	0.304	0.249	0.446	0.377
70	0.227	0.196	0.037	0.106	0.661	0.156
71	0.479	0.000	0.075	0.152	0.773	0.174
72	0.635	0.013	0.132	0.127	0.728	0.183
73	0.716	0.455	0.120	0.293	0.132	0.392
74	0.386	0.013	0.187	0.262	0.538	0.331
75	0.803	0.215	0.335	0.350	0.100	0.515
76	0.514	0.331	0.198	0.365	0.105	0.477
77	0.539	0.419	0.191	0.371	0.019	0.492
78	0.641	0.007	0.133	0.251	0.608	0.294

Appendix C: Adopted Land Use

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Figure C-1: BCC City Plan 2014 Zones

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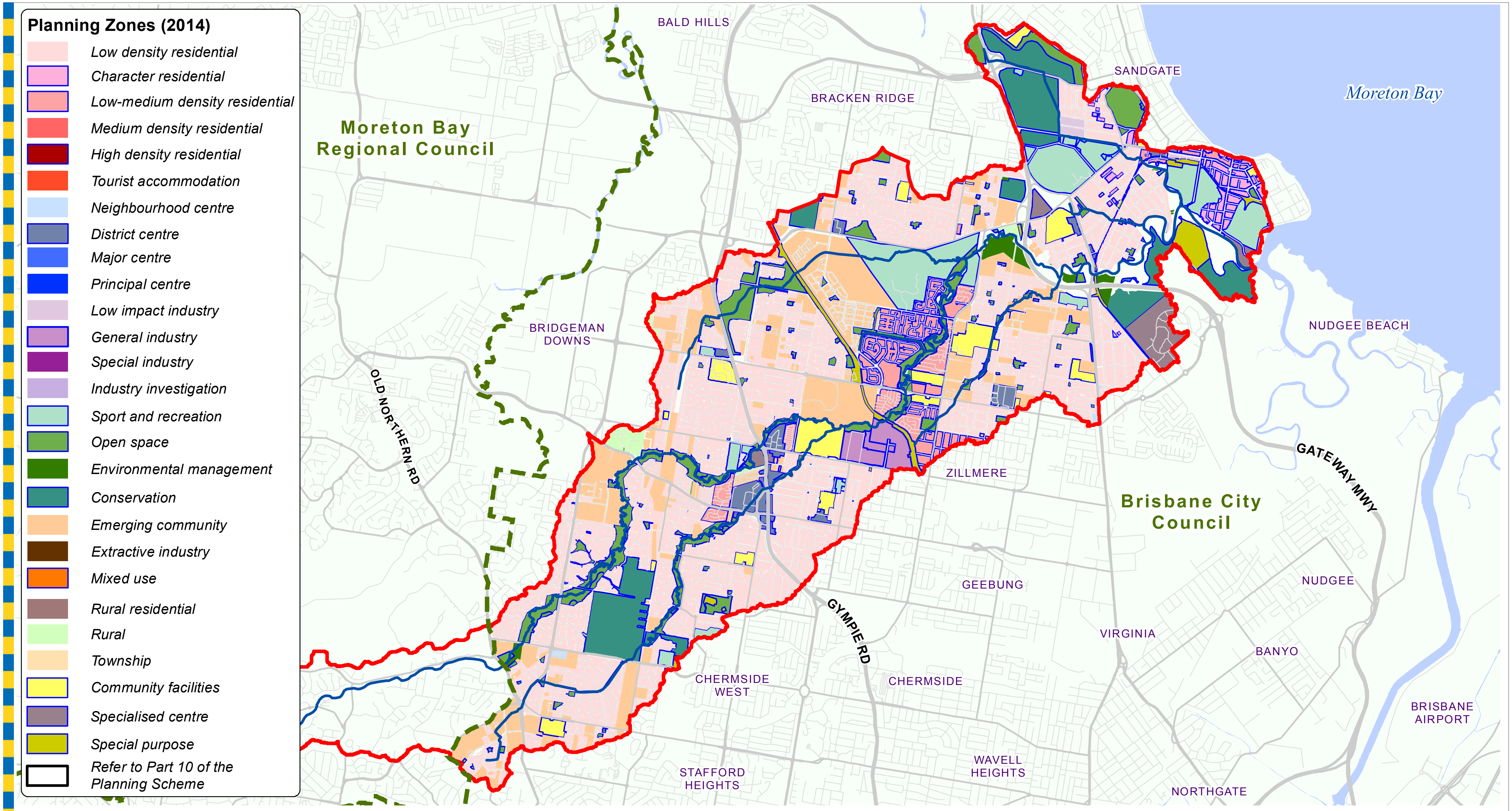

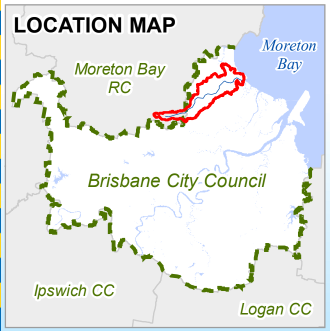

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Creek Centreline
(Cabbage Tree Creek Catchment)

Cabbage Tree Ck Catchment Area

Brisbane City Boundary

Road

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Figure C.1: City Planning Zones

Cabbage Tree Creek Flood Study

0 1 2 3 4
Kilometers

N W E S

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Prepared : 104515
Checked : JS
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BRISBANE CITY

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Figure C-2: May 2019 Aerial Photo

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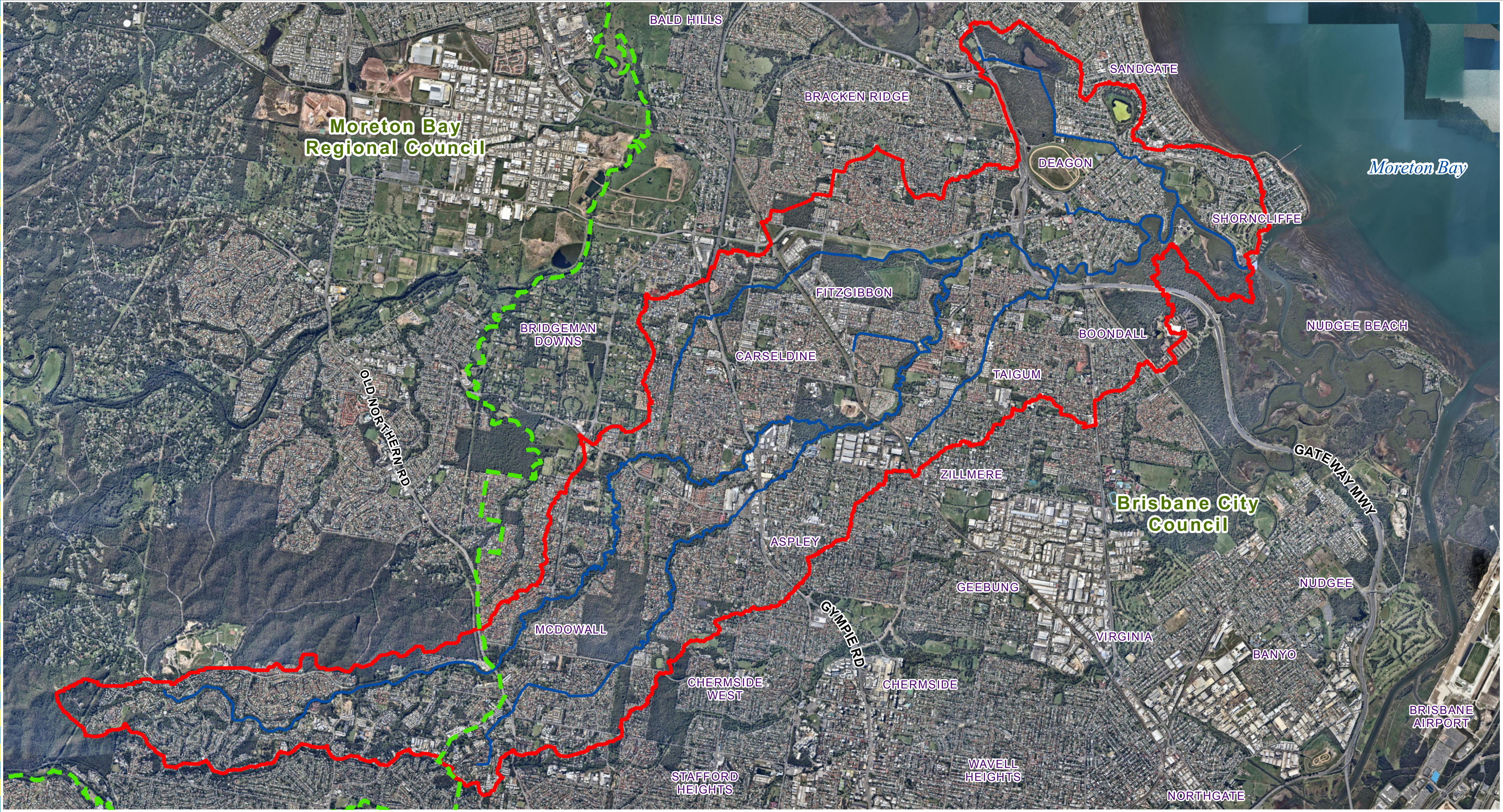

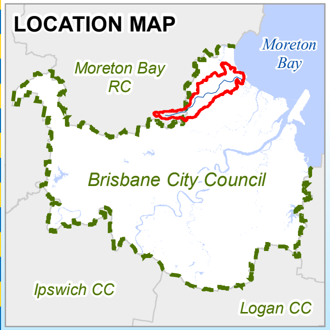

GIM - 190477 - 008

- Creek Centreline (Cabbage Tree Creek Catchment)
- Cabbage Tree Ck Catchment Area
- Brisbane City Boundary

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Figure C.2: Aerial Photograph

Source: NearMap 26/05/2019

Cabbage Tree Creek Flood Study

0 1 2 3 4
Kilometers

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Land Use Type	% Impervious
Low density residential	60
Character residential (Character)	70
Character residential (Infill housing)	70
Low-medium density residential (2 storey mix)	70
Low-medium density residential (2 or 3 storey mix)	70
Low-medium density residential (Up to 3 storeys)	70
Medium density residential	80
High density residential (Up to 8 storeys)	90
High density residential (Up to 15 storeys)	90
Tourist accommodation	80
Neighbourhood centre	90
District centre (District)	90
District centre (Corridor)	90
Major centre	90
Principal centre (City centre)	90
Principal centre (Regional centre)	90
Low impact industry	90
Industry (General industry A)	90
Industry (General industry B)	90
Industry (General industry C)	90
Special industry	90
Industry investigation	90
Sport and recreation	20
Sport and recreation (Local)	20
Sport and recreation (District)	20
Sport and recreation (Metropolitan)	20
Open space	5
Open space (Local)	5
Open space (District)	5
Open space (Metropolitan)	5
Environmental management	5
Conservation	0
Conservation (Local)	0
Conservation (District)	0
Conservation (Metropolitan)	0

Land Use Type	% Impervious
Emerging community	70
Extractive industry	5
Mixed use (Inner city)	90
Mixed use (Centre frame)	90
Mixed use (Corridor)	90
Rural	5
Rural residential	30
Township	80
Community facilities (Major health care)	50
Community facilities (Major sports venue)	60
Community facilities (Cemetery)	20
Community facilities (Community purposes)	70
Community facilities (Education purposes)	70
Community facilities (Emergency services)	70
Community facilities (Health care purposes)	50
Specialised centre (Major education and research facility)	50
Specialised centre (Entertainment and conference centre)	90
Specialised centre (Brisbane Markets)	90
Specialised centre (Large format retail)	90
Specialised centre (Mixed industry and business)	90
Specialised centre (Marina)	80
Special purpose (Defence)	80
Special purpose (Detention facility)	50
Special purpose (Transport infrastructure)	75
Special purpose (Utility services)	50
Special purpose (Airport)	60
Special purpose (Port)	60

Appendix D: URBS – TUFLOW Comparative Plots

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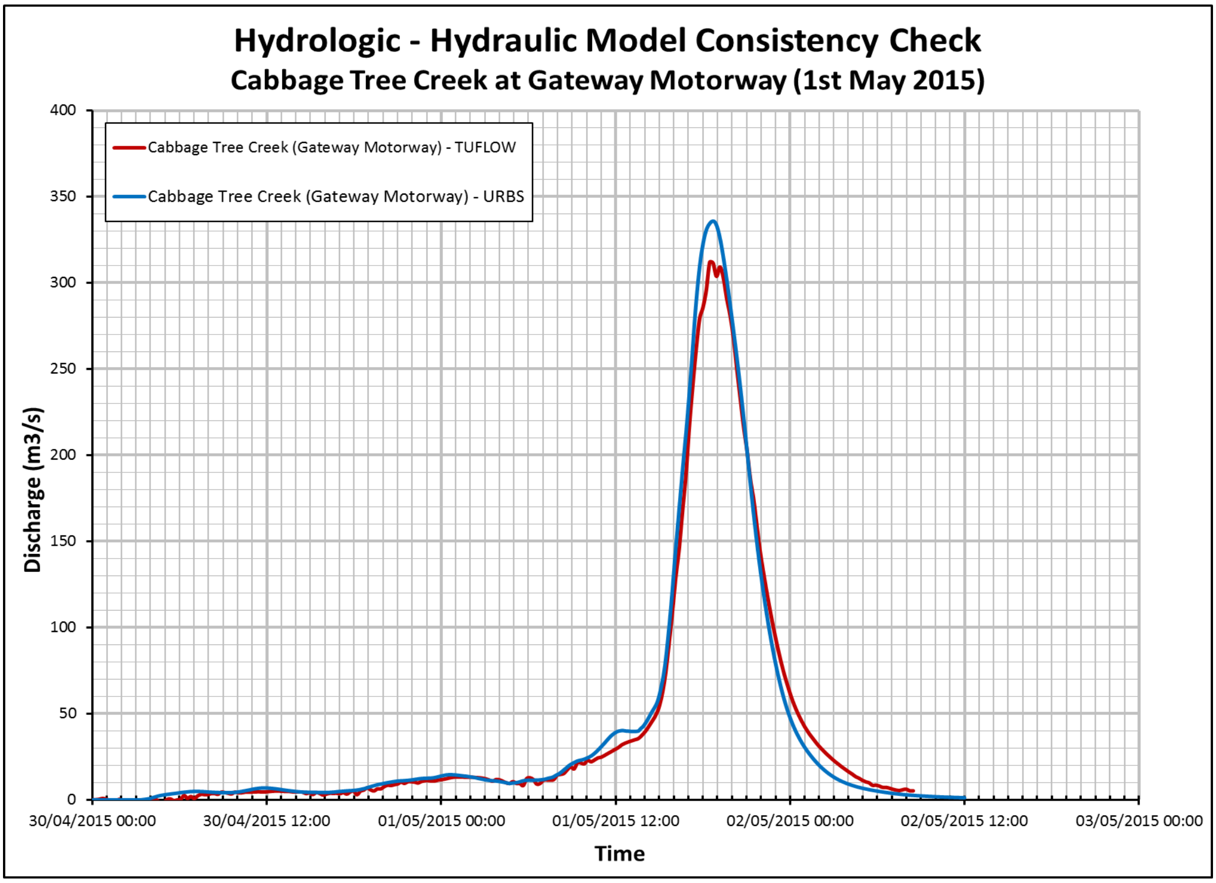
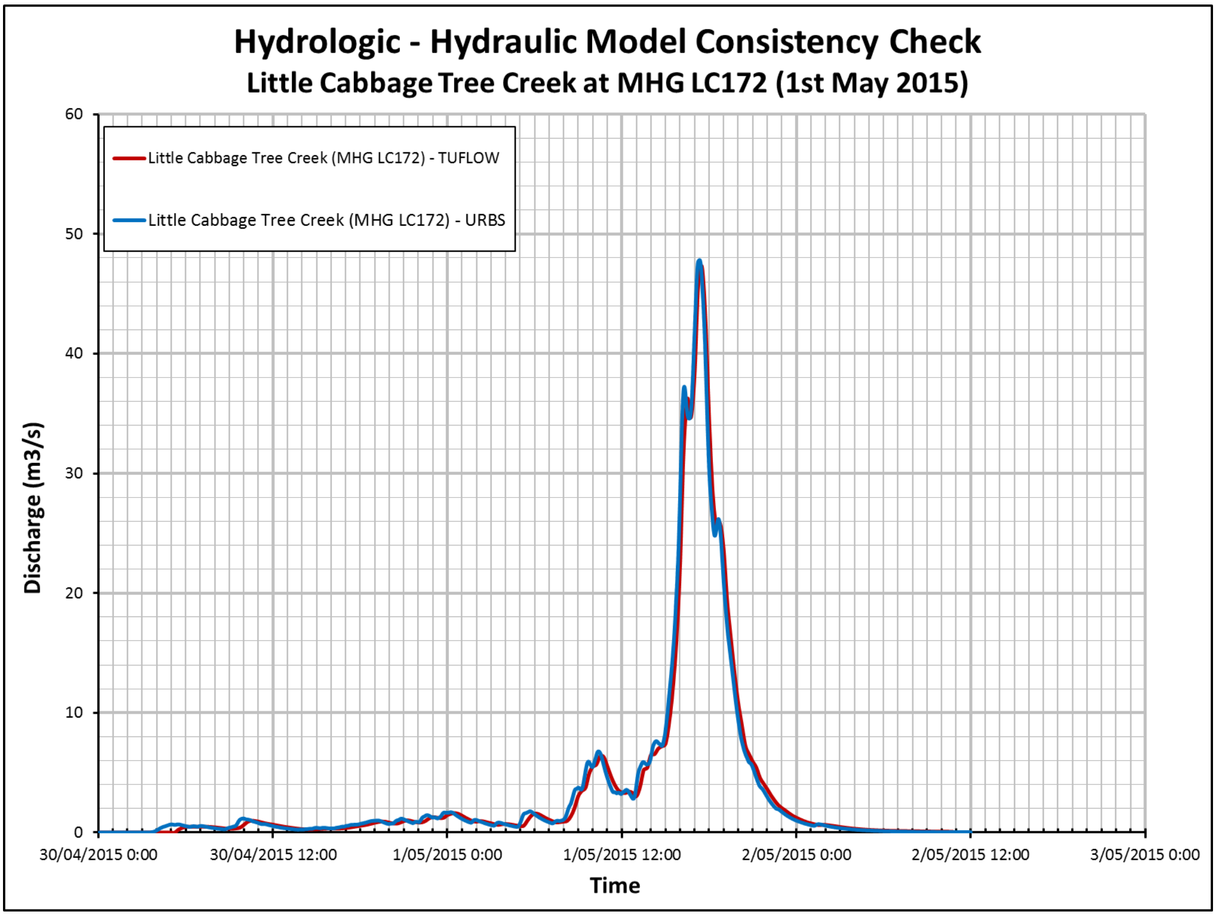
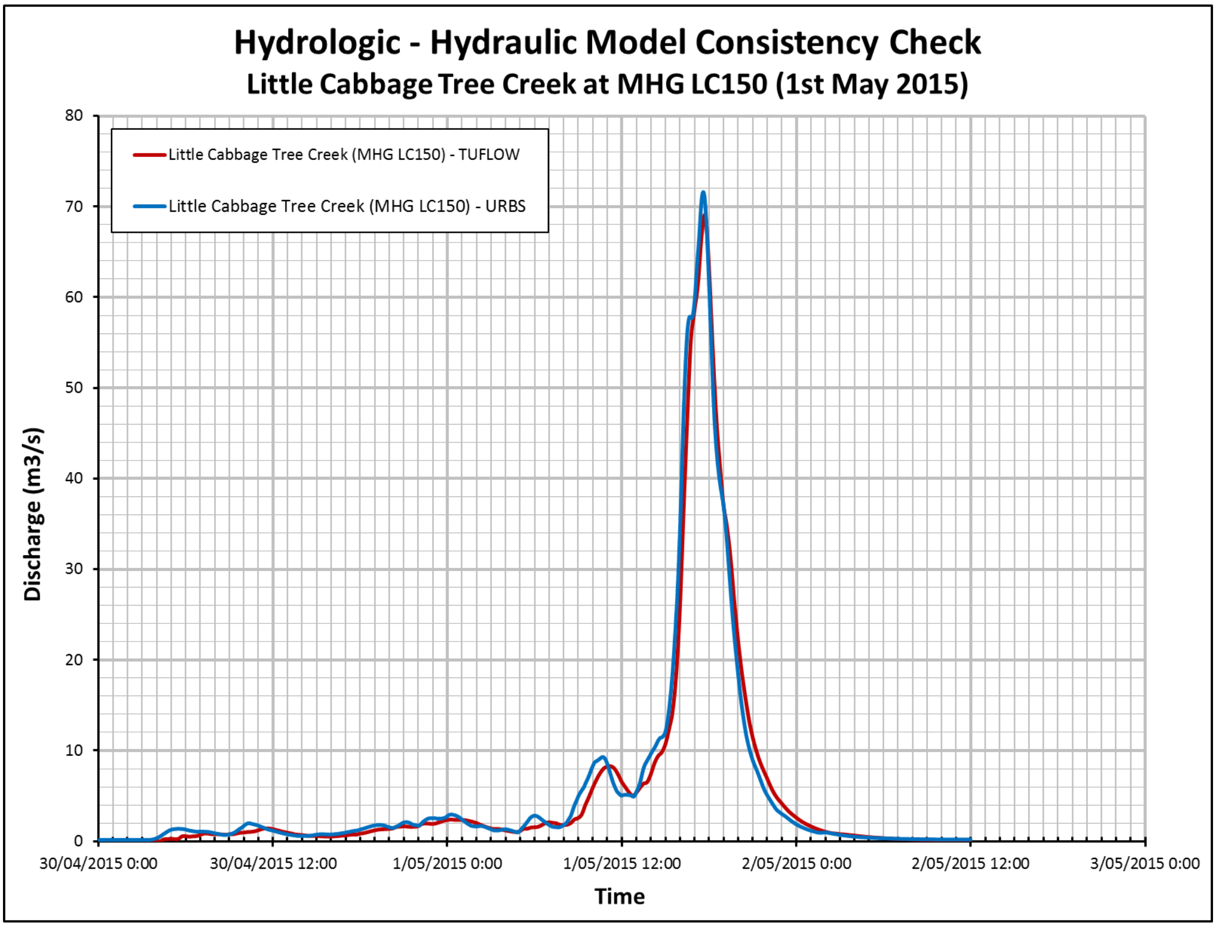
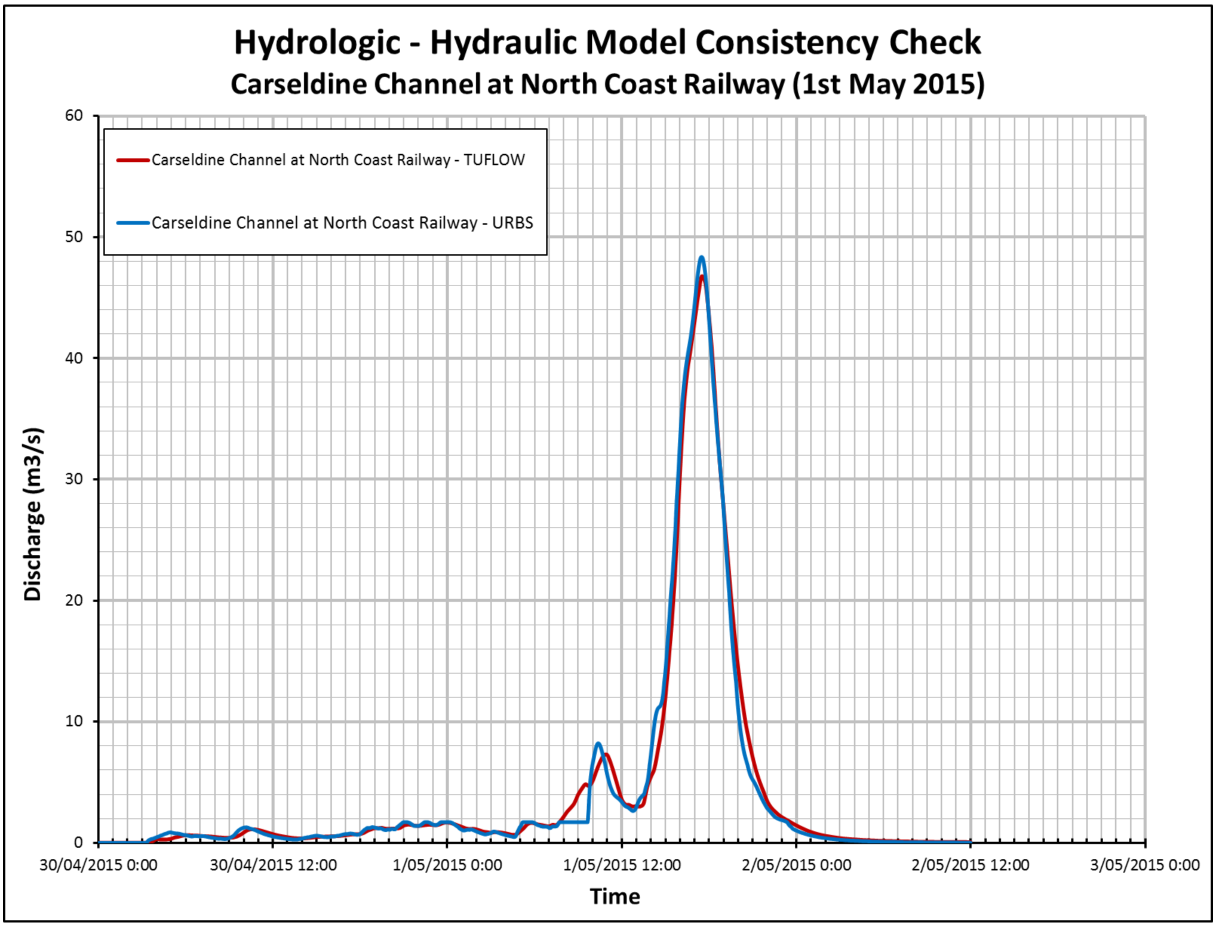
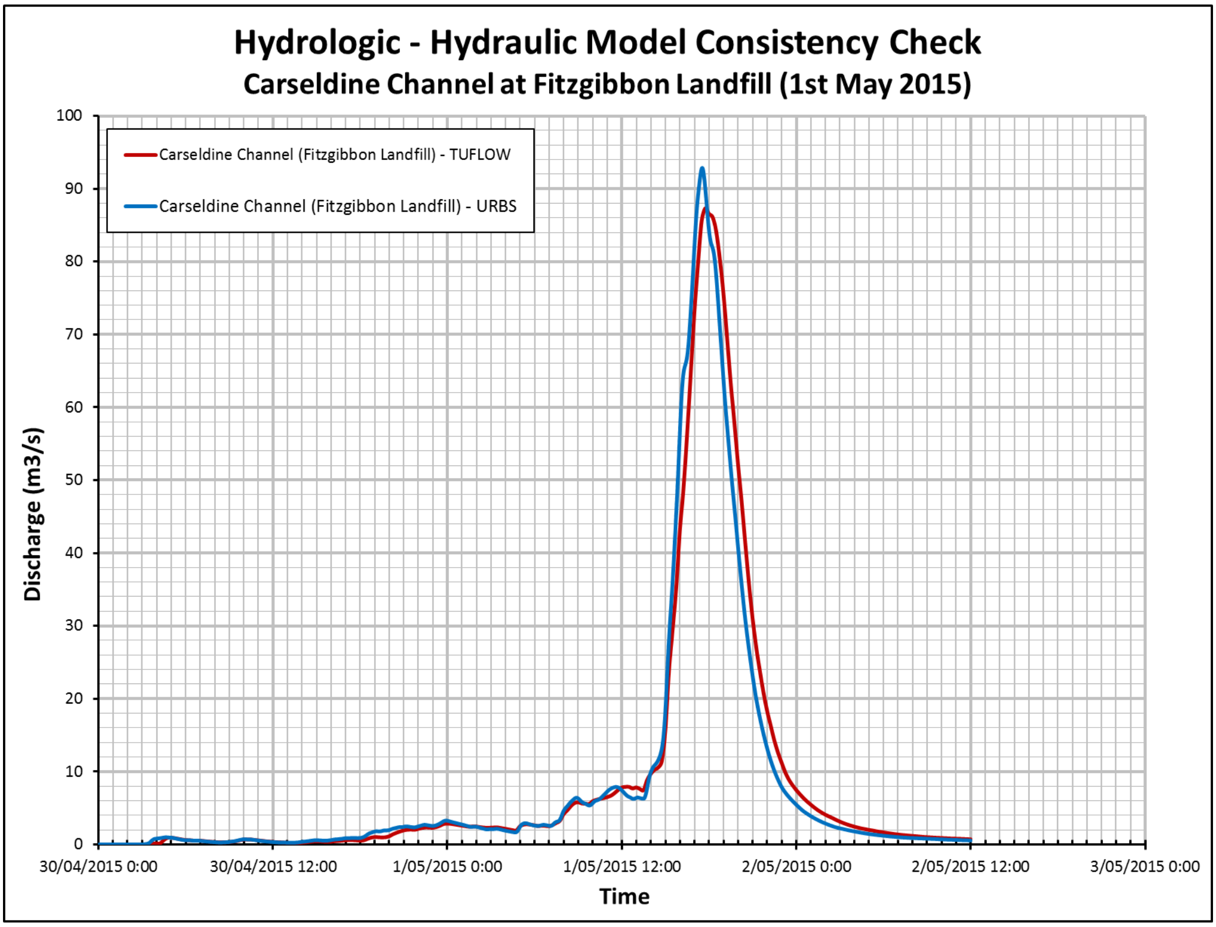
Historical Events



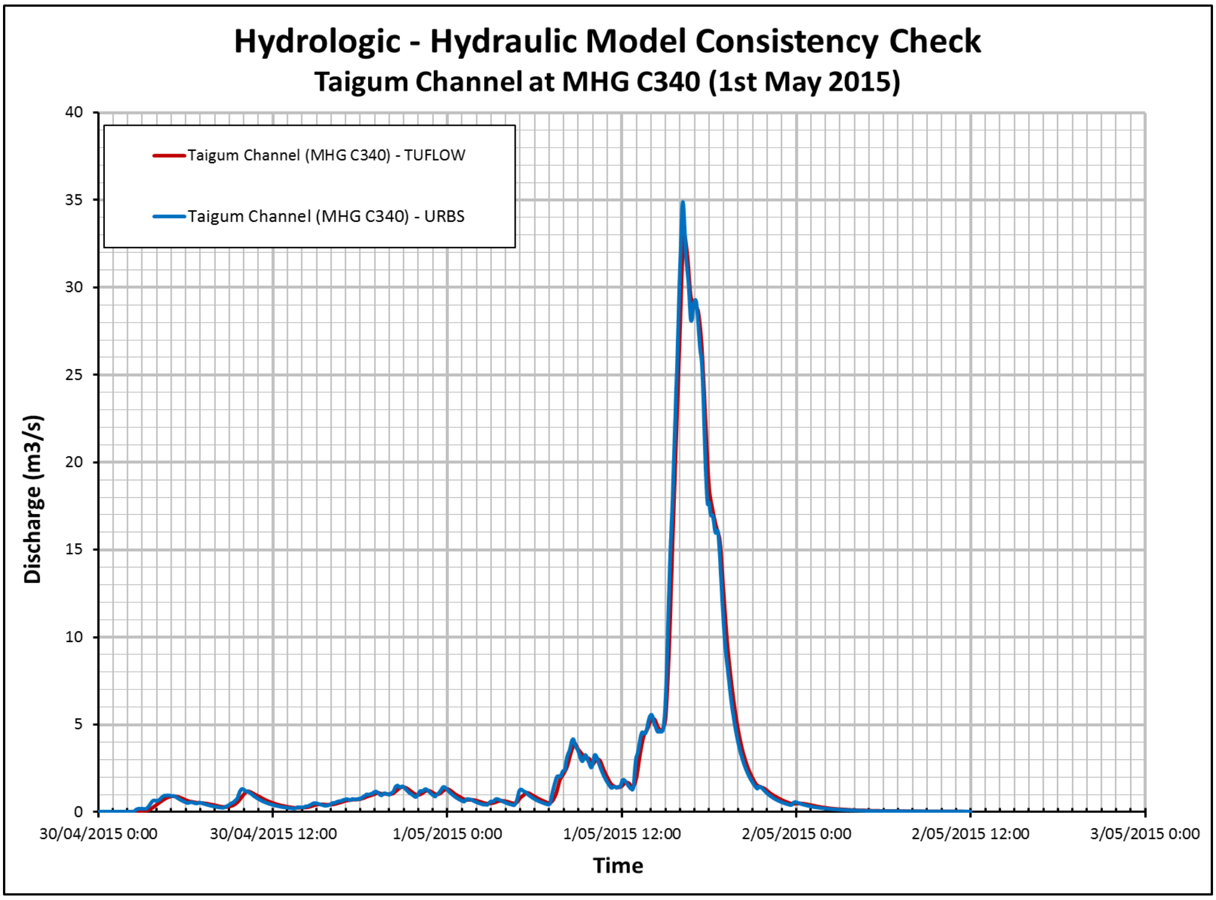



Hydrologic - Hydraulic Model Consistency Check
Little Cabbage Tree Creek at MHG LC150 (1st May 2015)
Little Cabbage Tree Creek (MHG LC150) - TUFLOW
Little Cabbage Tree Creek (MHG LC150) - URBS
Discharge (m3/s)
Time
0
10
20
30
40
50
60
70
80
30/04/2015 0:00
30/04/2015 12:00
1/05/2015 0:00
1/05/2015 12:00
2/05/2015 0:00
2/05/2015 12:00
3/05/2015 0:00

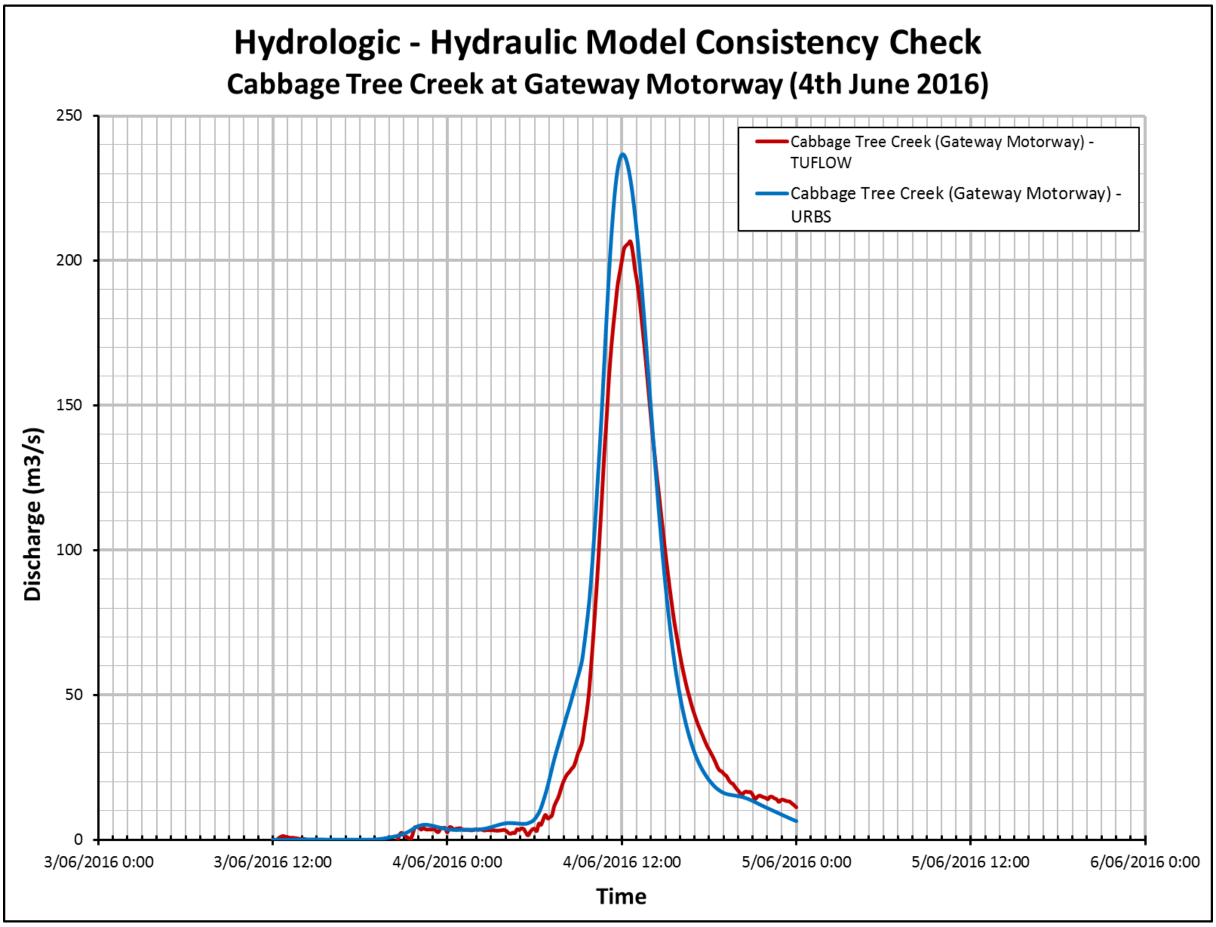

Hydrologic - Hydraulic Model Consistency Check
Carseldine Channel at North Coast Railway (1st May 2015)
Carseldine Channel at North Coast Railway - TUFLOW
Carseldine Channel at North Coast Railway - URBS
Discharge (m3/s)
Time
0
10
20
30
40
50
60
30/04/2015 0:00
30/04/2015 12:00
1/05/2015 0:00
1/05/2015 12:00
2/05/2015 0:00
2/05/2015 12:00
3/05/2015 0:00



Hydrologic - Hydraulic Model Consistency Check
Carseldine Channel at Fitzgibbon Landfill (1st May 2015)
Carseldine Channel (Fitzgibbon Landfill) - TUFLOW
Carseldine Channel (Fitzgibbon Landfill) - URBS
Discharge (m3/s)
100
90
80
70
60
50
40
30
20
10
0
30/04/2015 0:00
30/04/2015 12:00
1/05/2015 0:00
1/05/2015 12:00
2/05/2015 0:00
2/05/2015 12:00
3/05/2015 0:00
Time



Hydrologic - Hydraulic Model Consistency Check
Taigum Channel at MHG C340 (1st May 2015)
Taigum Channel (MHG C340) - TUFLOW
Taigum Channel (MHG C340) - URBS
Discharge (m3/s)
40
35
30
25
20
15
10
5
0
30/04/2015 0:00
30/04/2015 12:00
1/05/2015 0:00
1/05/2015 12:00
2/05/2015 0:00
2/05/2015 12:00
3/05/2015 0:00
Time



Hydrologic - Hydraulic Model Consistency Check
Cabbage Tree Creek at Gateway Motorway (4th June 2016)
Cabbage Tree Creek (Gateway Motorway) - TUFLOW
Cabbage Tree Creek (Gateway Motorway) - URBS
Discharge (m3/s)
0
50
100
150
200
250
3/06/2016 0:00
3/06/2016 12:00
4/06/2016 0:00
4/06/2016 12:00
5/06/2016 0:00
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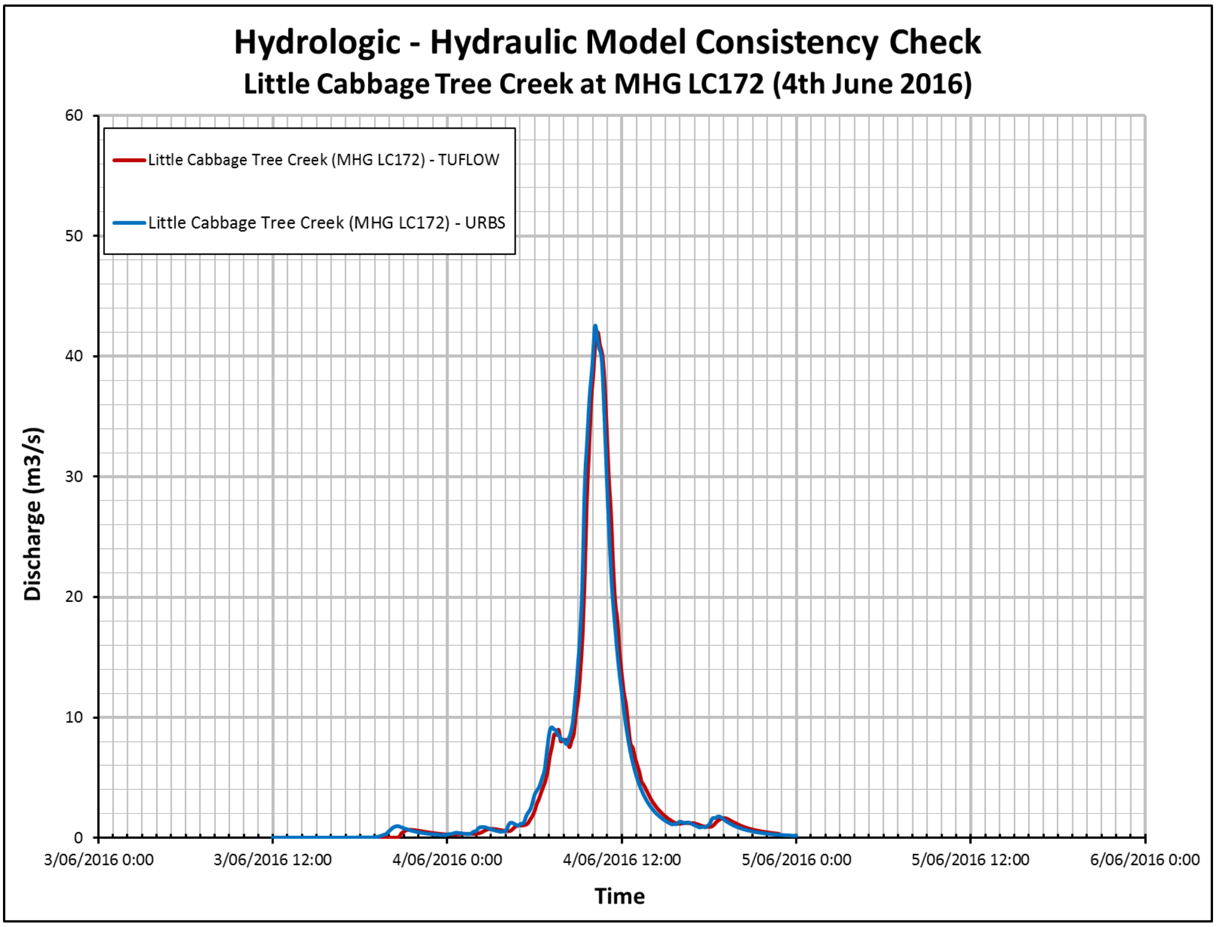
6/06/2016 0:00
Time



Hydrologic - Hydraulic Model Consistency Check
Little Cabbage Tree Creek at MHG LC172 (4th June 2016)
Little Cabbage Tree Creek (MHG LC172) - TUFLOW
Little Cabbage Tree Creek (MHG LC172) - URBS
Discharge (m3/s)
0
10
20
30
40
50
60
3/06/2016 0:00
3/06/2016 12:00
4/06/2016 0:00
4/06/2016 12:00
5/06/2016 0:00
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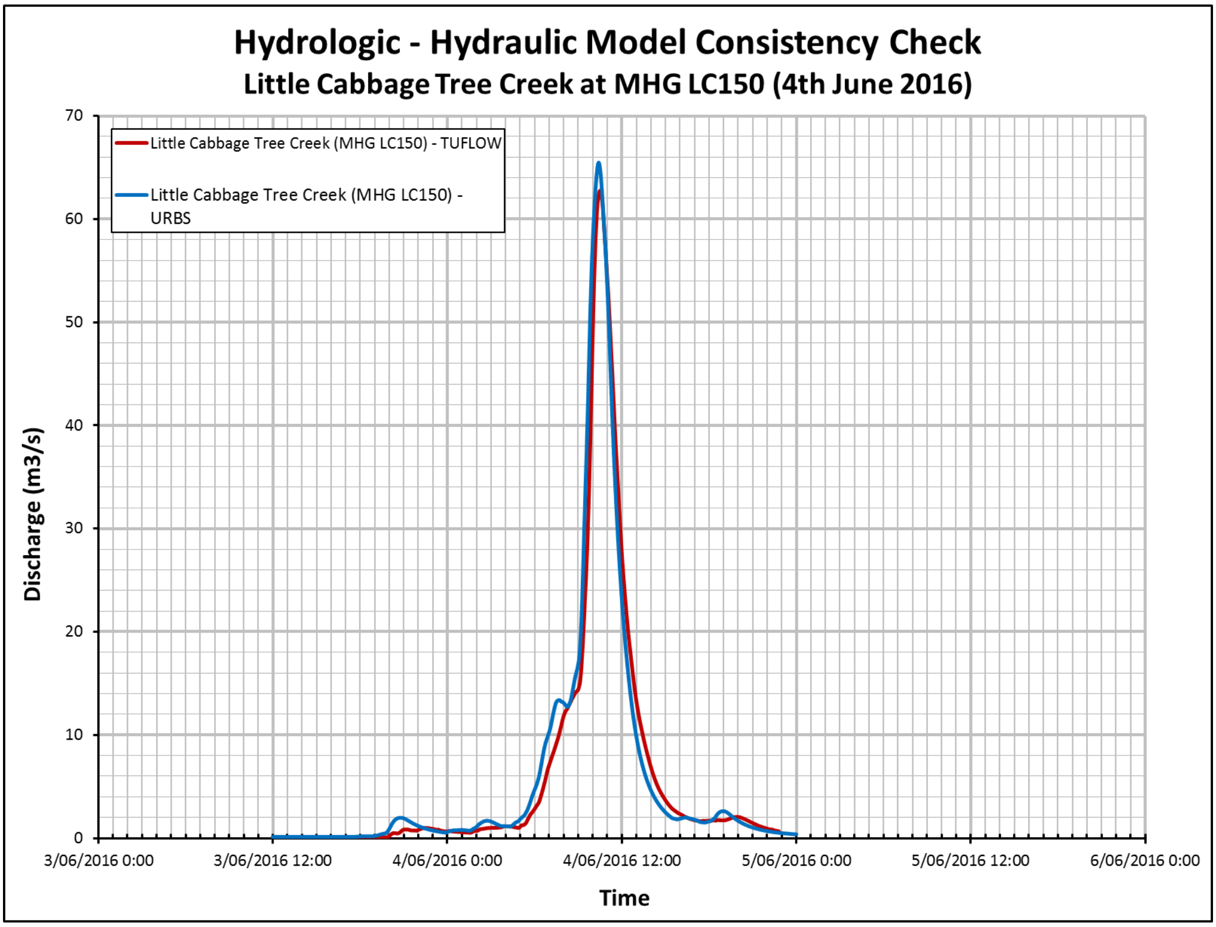
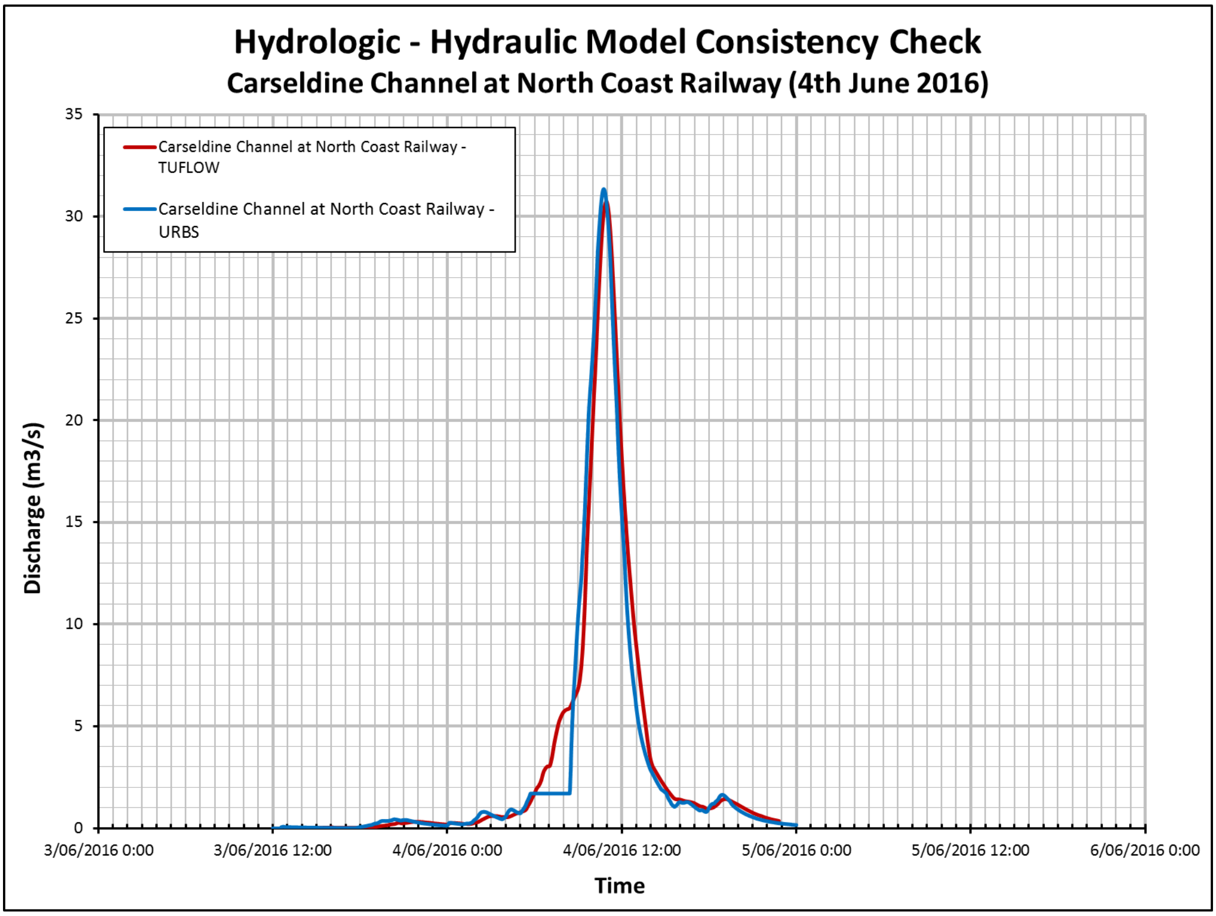
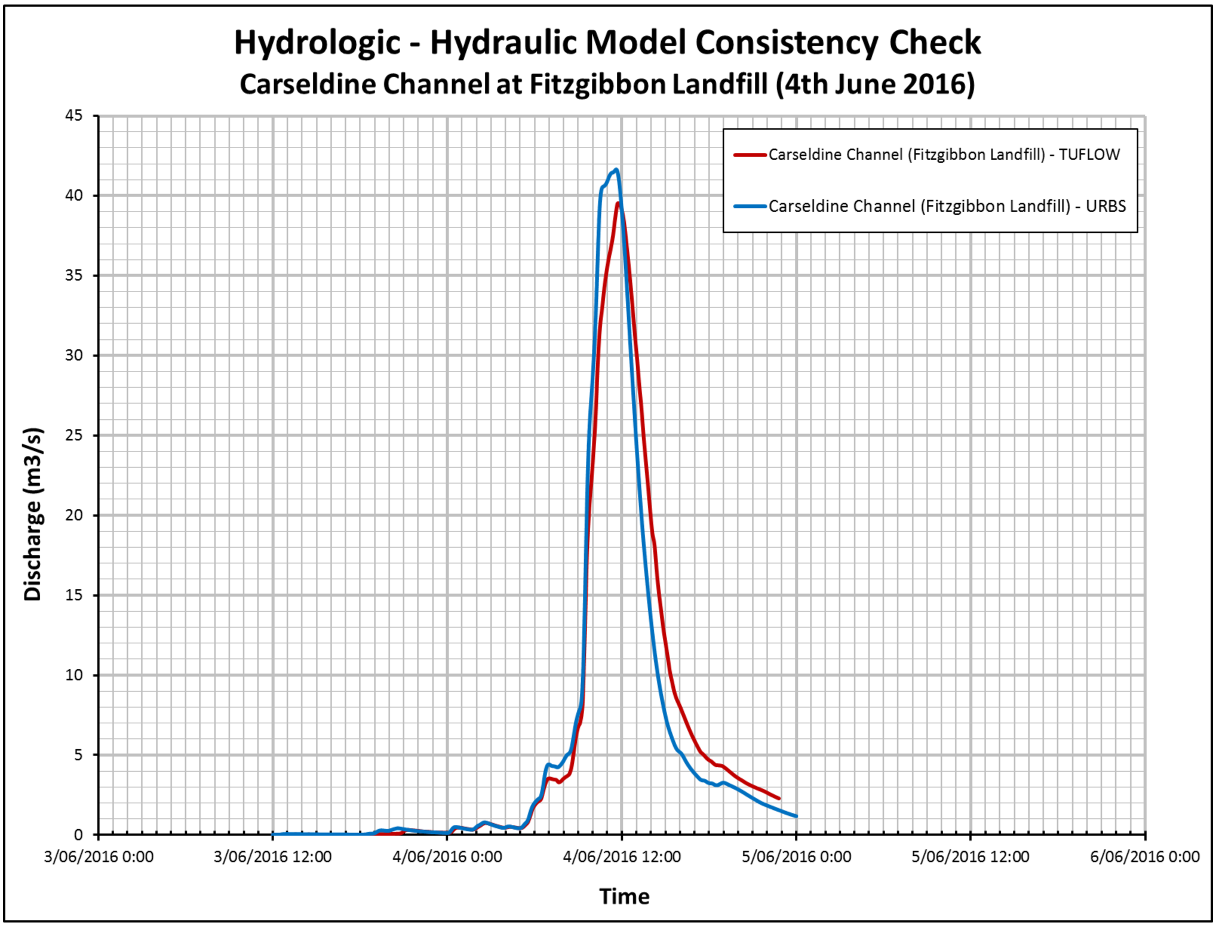
6/06/2016 0:00
Time

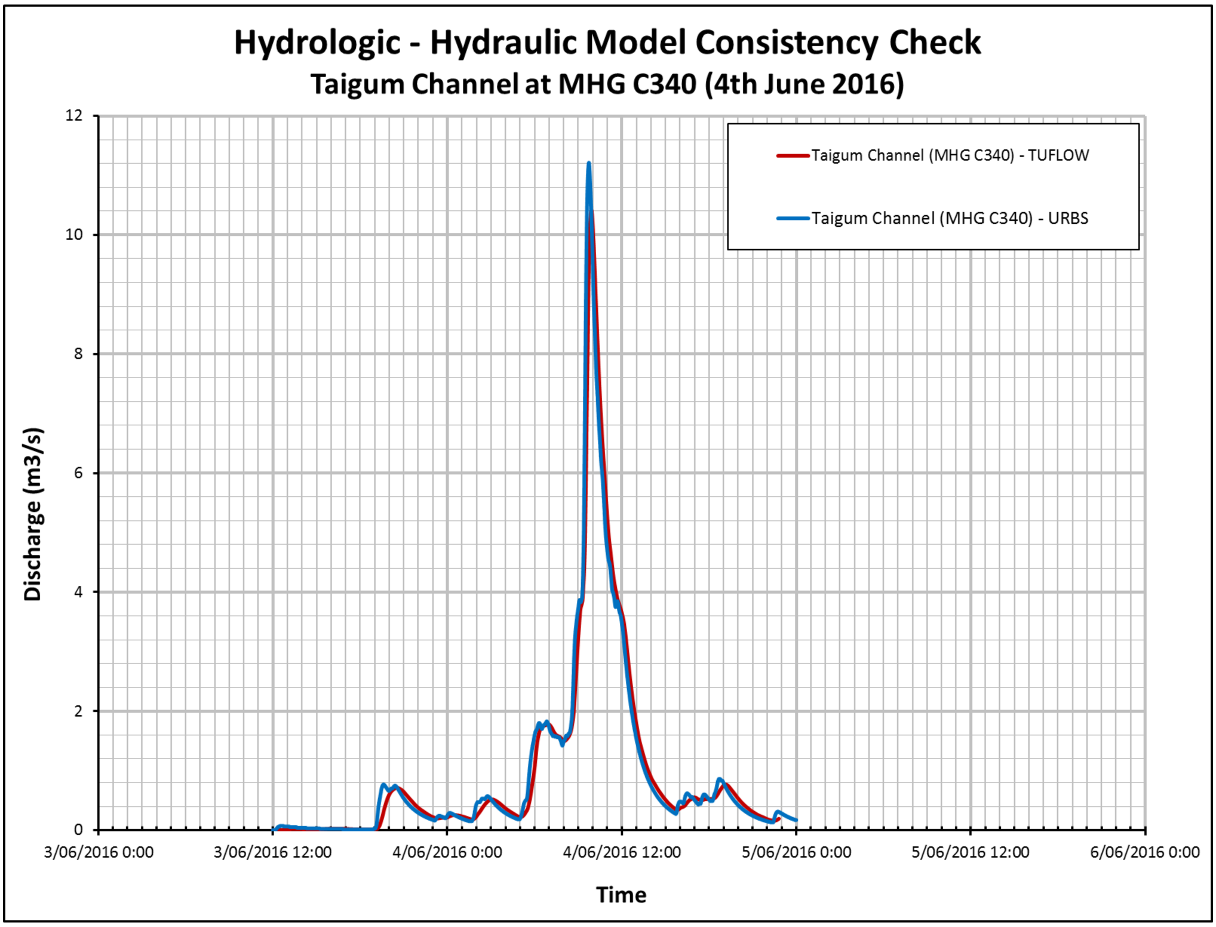


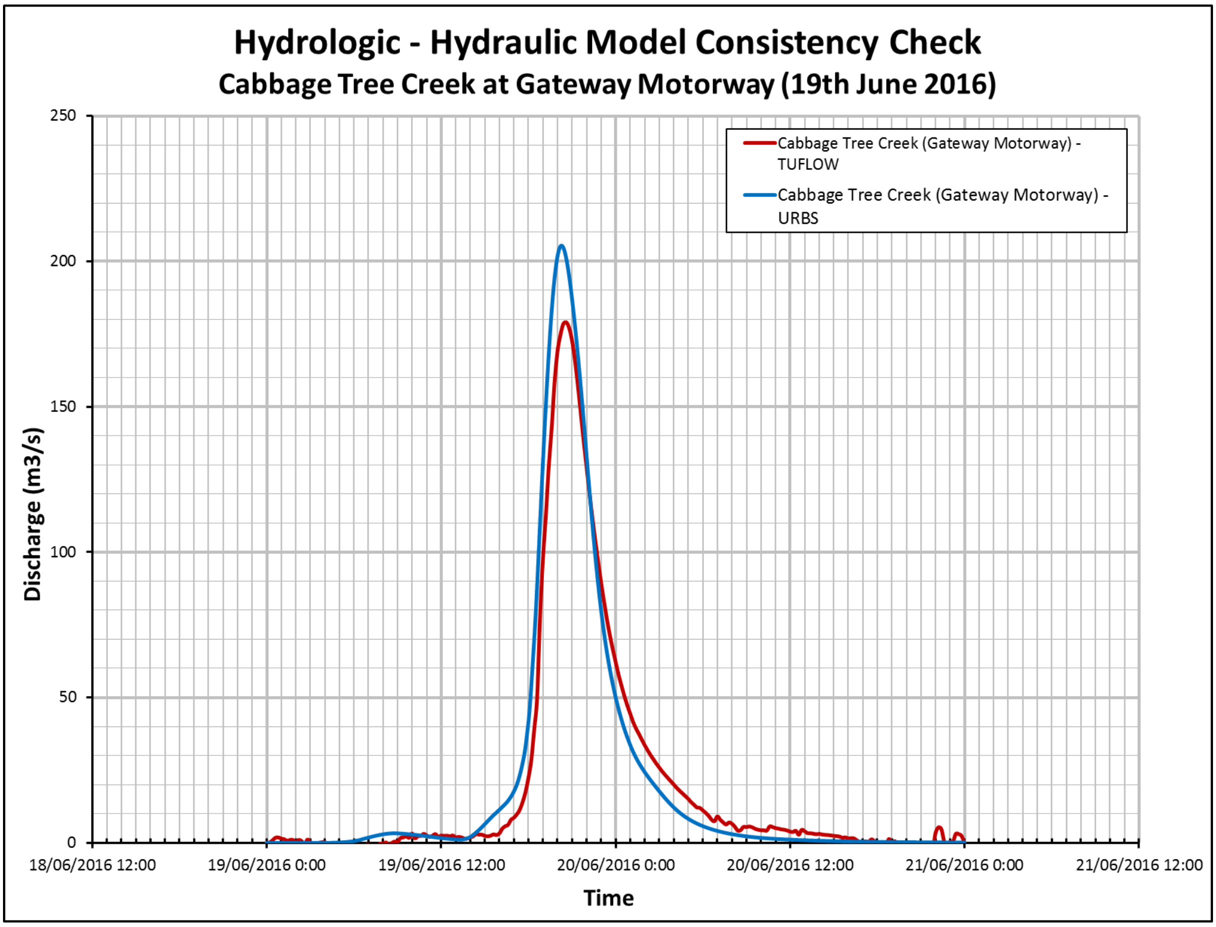
Hydrologic - Hydraulic Model Consistency Check
Little Cabbage Tree Creek at MHG LC150 (4th June 2016)
Little Cabbage Tree Creek (MHG LC150) - TUFLOW
Little Cabbage Tree Creek (MHG LC150) - URBS
Discharge (m3/s)
0
10
20
30
40
50
60
70
3/06/2016 0:00
3/06/2016 12:00
4/06/2016 0:00
4/06/2016 12:00
5/06/2016 0:00
5/06/2016 12:00
6/06/2016 0:00
Time



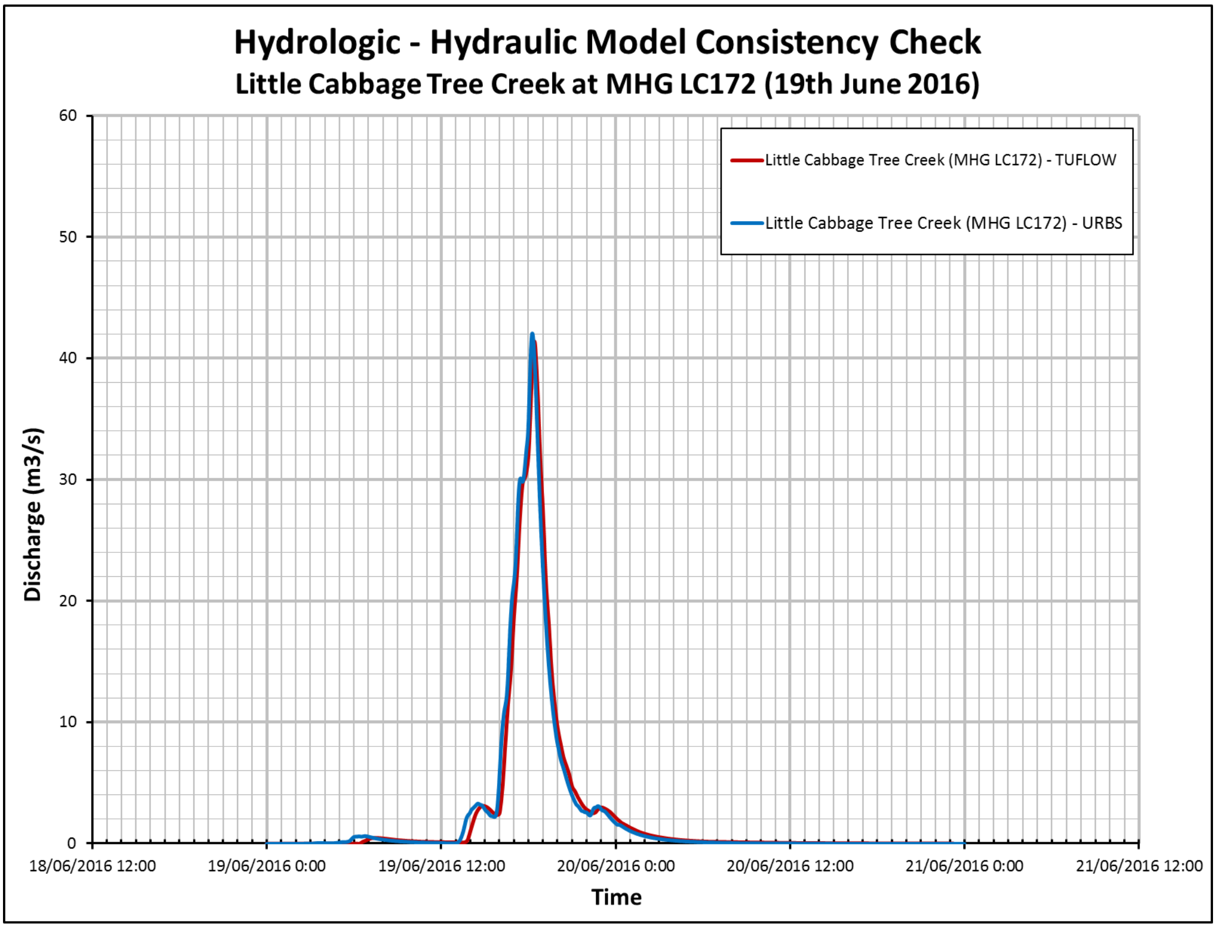
Hydrologic - Hydraulic Model Consistency Check
Carseldine Channel at North Coast Railway (4th June 2016)
Carseldine Channel at North Coast Railway - TUFLOW
Carseldine Channel at North Coast Railway - URBS
Discharge (m3/s)
0
5
10
15
20
25
30
35
3/06/2016 0:00
3/06/2016 12:00
4/06/2016 0:00
4/06/2016 12:00
5/06/2016 0:00
5/06/2016 12:00
6/06/2016 0:00
Time


Hydrologic - Hydraulic Model Consistency Check
Carseldine Channel at Fitzgibbon Landfill (4th June 2016)
Carseldine Channel (Fitzgibbon Landfill) - TUFLOW
Carseldine Channel (Fitzgibbon Landfill) - URBS
Discharge (m3/s)
0
5
10
15
20
25
30
35
40
45
3/06/2016 0:00
3/06/2016 12:00
4/06/2016 0:00
4/06/2016 12:00
5/06/2016 0:00
5/06/2016 12:00
6/06/2016 0:00
Time

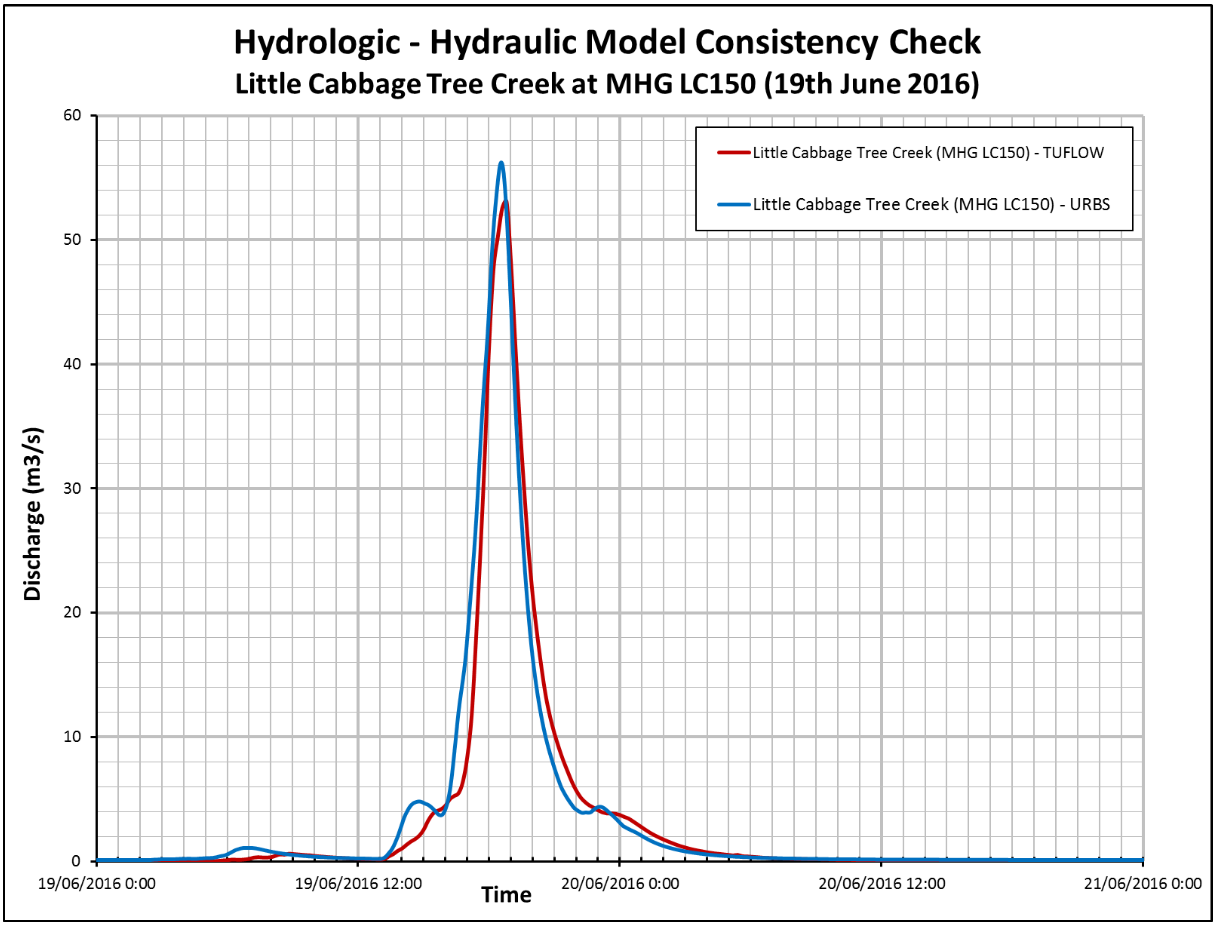

Hydrologic - Hydraulic Model Consistency Check
Taigum Channel at MHG C340 (4th June 2016)
Taigum Channel (MHG C340) - TUFLOW
Taigum Channel (MHG C340) - URBS
Discharge (m3/s)
0
2
4
6
8
10
12
3/06/2016 0:00
3/06/2016 12:00
4/06/2016 0:00
4/06/2016 12:00
5/06/2016 0:00
5/06/2016 12:00
6/06/2016 0:00
Time



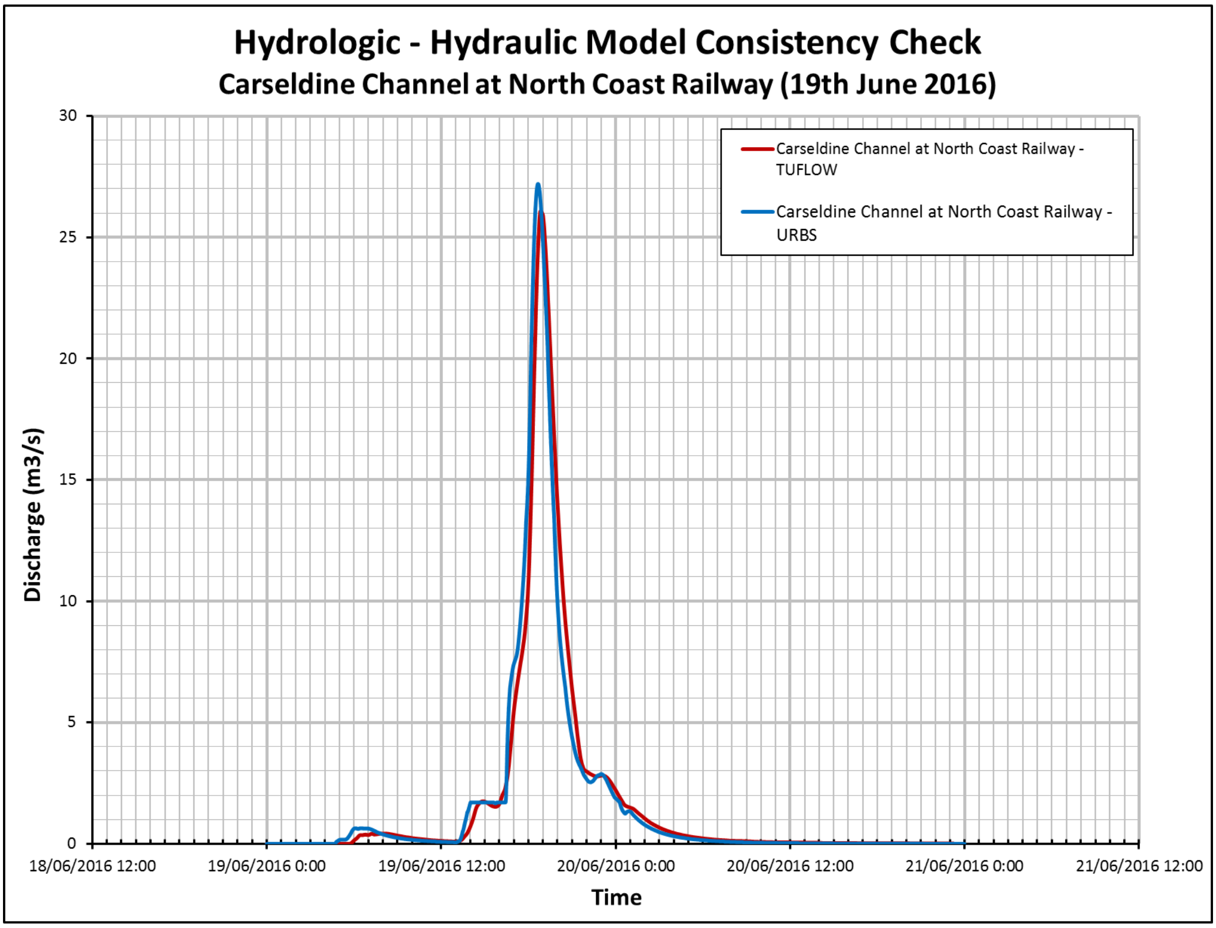
Hydrologic - Hydraulic Model Consistency Check
Cabbage Tree Creek at Gateway Motorway (19th June 2016)
Cabbage Tree Creek (Gateway Motorway) - TUFLOW
Cabbage Tree Creek (Gateway Motorway) - URBS
Discharge (m3/s)
250
200
150
100
50
0
18/06/2016 12:00
19/06/2016 0:00
19/06/2016 12:00
20/06/2016 0:00
20/06/2016 12:00
21/06/2016 0:00
21/06/2016 12:00
Time



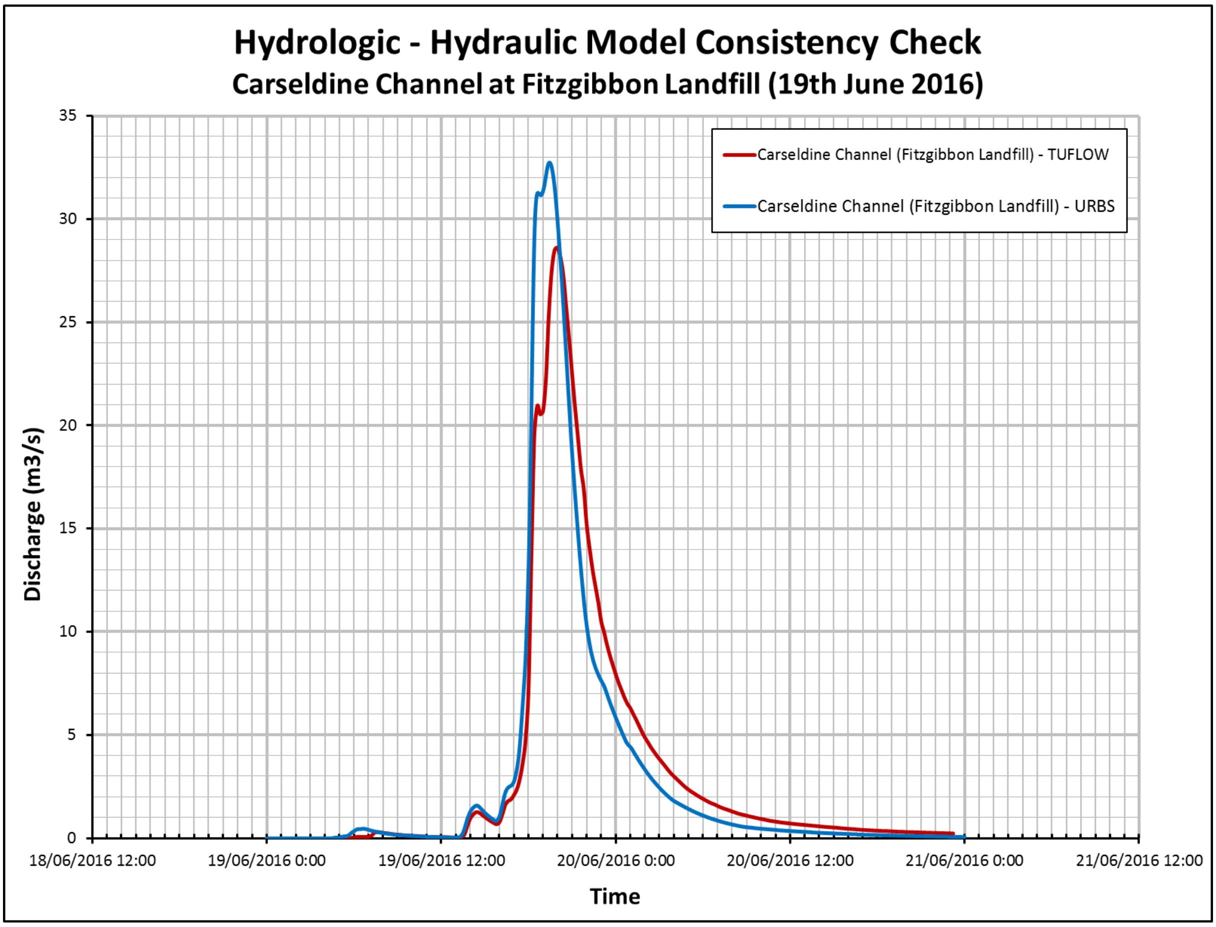
Hydrologic - Hydraulic Model Consistency Check
Little Cabbage Tree Creek at MHG LC172 (19th June 2016)
Little Cabbage Tree Creek (MHG LC172) - TUFLOW
Little Cabbage Tree Creek (MHG LC172) - URBS
Discharge (m3/s)
60
50
40
30
20
10
0
18/06/2016 12:00
19/06/2016 0:00
19/06/2016 12:00
20/06/2016 0:00
20/06/2016 12:00
21/06/2016 0:00
21/06/2016 12:00
Time

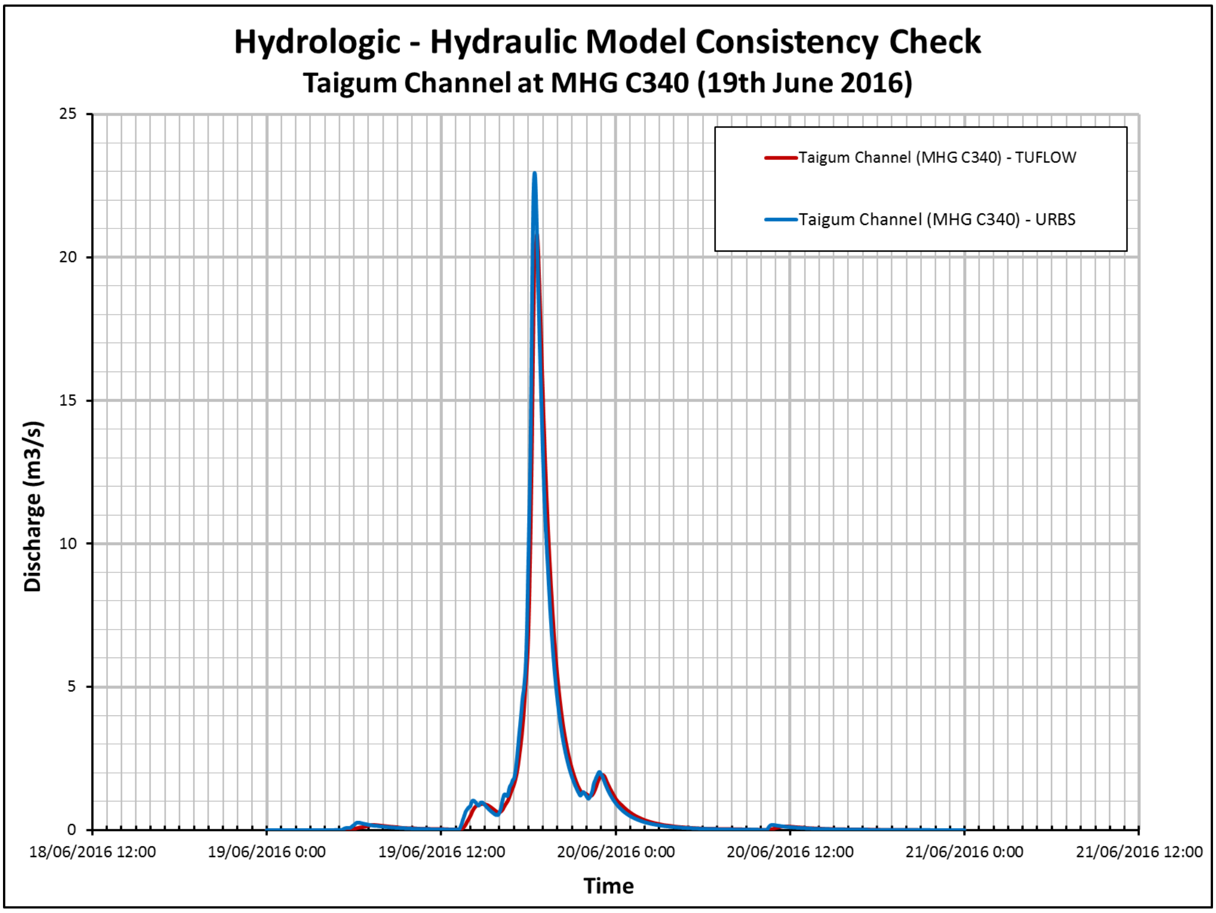


Hydrologic - Hydraulic Model Consistency Check
Little Cabbage Tree Creek at MHG LC150 (19th June 2016)
Little Cabbage Tree Creek (MHG LC150) - TUFLOW
Little Cabbage Tree Creek (MHG LC150) - URBS
Discharge (m3/s)
60
50
40
30
20
10
0
19/06/2016 0:00
19/06/2016 12:00
20/06/2016 0:00
20/06/2016 12:00
21/06/2016 0:00
Time

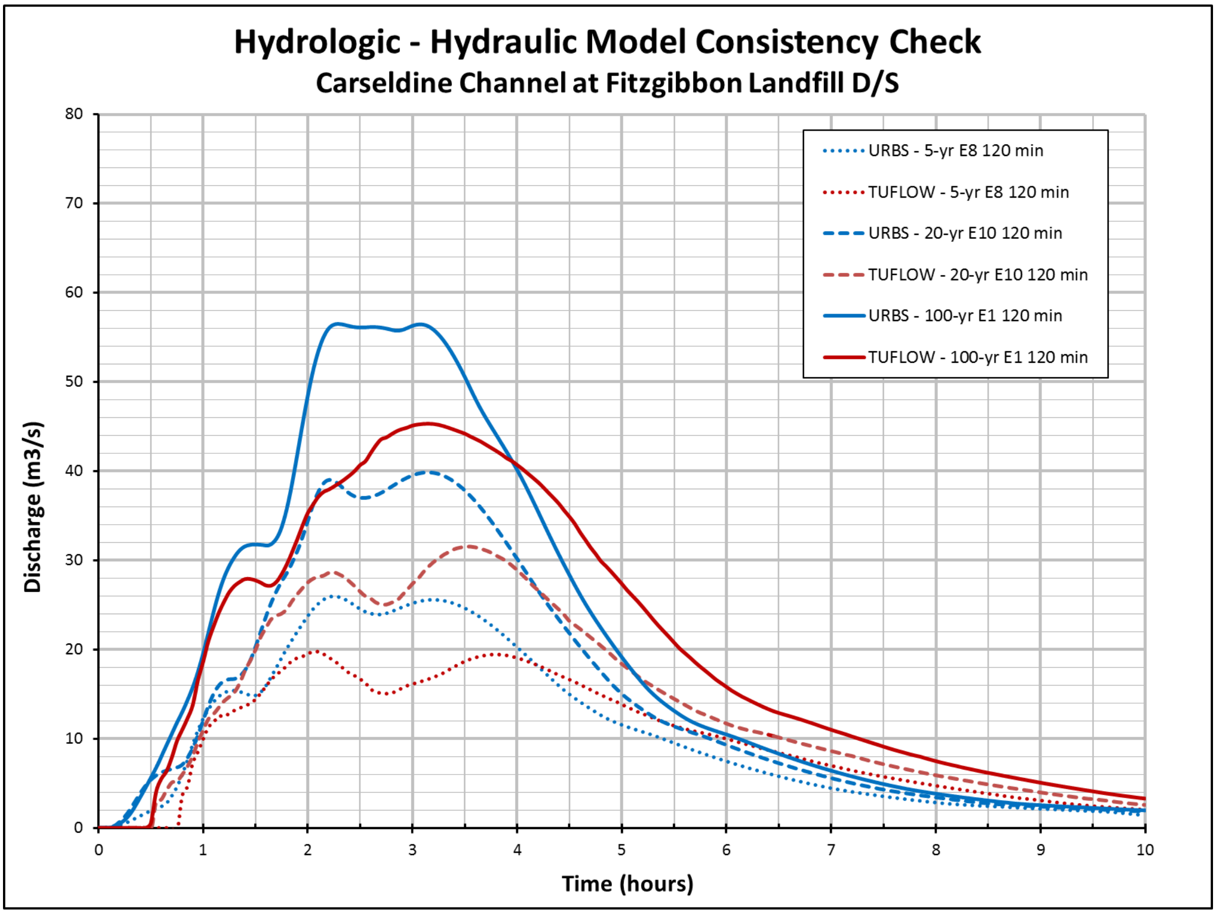


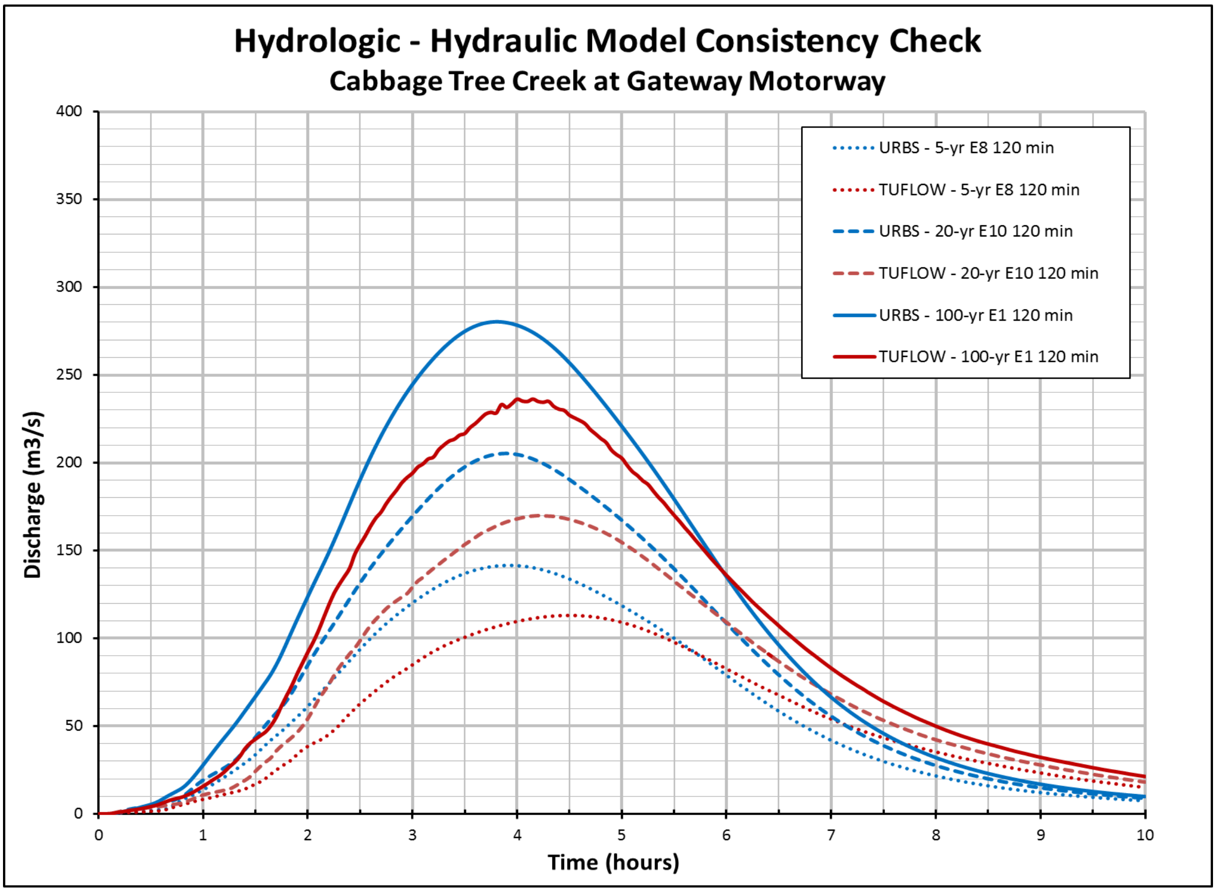
Hydrologic - Hydraulic Model Consistency Check
Carseldine Channel at North Coast Railway (19th June 2016)
Carseldine Channel at North Coast Railway - TUFLOW
Carseldine Channel at North Coast Railway - URBS
Discharge (m3/s)
30
25
20
15
10
5
0
18/06/2016 12:00
19/06/2016 0:00
19/06/2016 12:00
20/06/2016 0:00
20/06/2016 12:00
21/06/2016 0:00
21/06/2016 12:00
Time

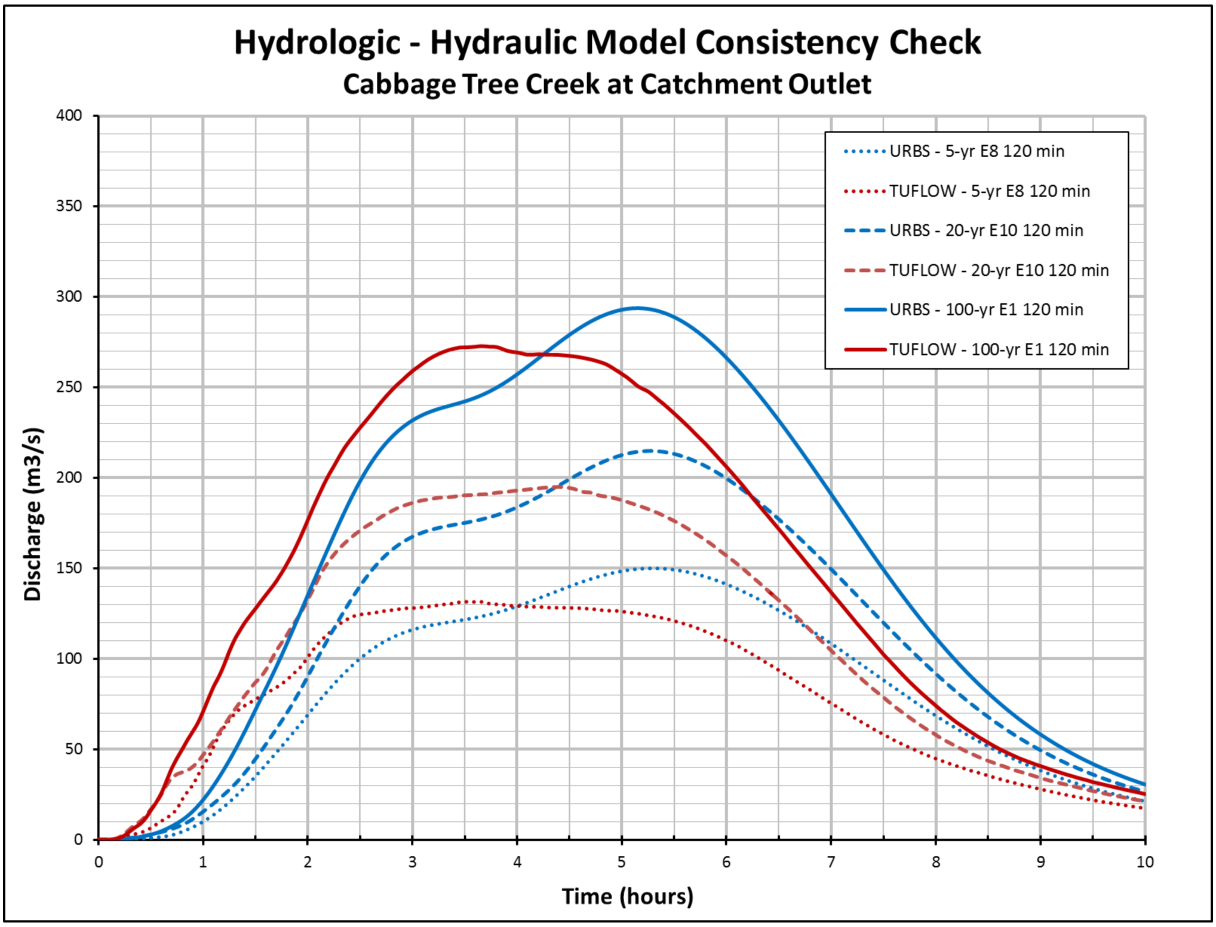

Hydrologic - Hydraulic Model Consistency Check
Carseldine Channel at Fitzgibbon Landfill (19th June 2016)
Carseldine Channel (Fitzgibbon Landfill) - TUFLOW
Carseldine Channel (Fitzgibbon Landfill) - URBS
Discharge (m3/s)
0
5
10
15
20
25
30
35
18/06/2016 12:00
19/06/2016 0:00
19/06/2016 12:00
20/06/2016 0:00
20/06/2016 12:00
21/06/2016 0:00
21/06/2016 12:00
Time


Hydrologic - Hydraulic Model Consistency Check
Taigum Channel at MHG C340 (19th June 2016)
Taigum Channel (MHG C340) - TUFLOW
Taigum Channel (MHG C340) - URBS
Discharge (m3/s)
0
5
10
15
20
25
18/06/2016 12:00
19/06/2016 0:00
19/06/2016 12:00
20/06/2016 0:00
20/06/2016 12:00
21/06/2016 0:00
21/06/2016 12:00
Time

Design Events







Hydrologic - Hydraulic Model Consistency Check
Cabbage Tree Creek at Catchment Outlet
Discharge (m3/s)
Time (hours)
URBS - 5-yr E8 120 min
TUFLOW - 5-yr E8 120 min
URBS - 20-yr E10 120 min
TUFLOW - 20-yr E10 120 min
URBS - 100-yr E1 120 min
TUFLOW - 100-yr E1 120 min

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Appendix E: URBS Ensemble Results – Design Events

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Notes on Table Content and Formatting

- The following tables indicate the ranking and discharge of all ten ensembles for each storm duration at the selected location within the catchment.
- The bold formatted rows indicate the critical storm duration for the selected location.
- The bold formatted columns indicate the median (Rank 5 / 6) peak discharge and corresponding ensemble number.
- The yellow highlighted peak discharge and ensemble number are those adopted from the simplified method as detailed in Section 6.3.4.
- The light pink highlighted peak discharge and ensemble number are those adopted from the simplified method for the other storm durations.

Taigum Channel at Fernwood Place – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	0.5	3	4	2	6	5	9	8	7	10	1
		8.33	8.41	8.43	8.48	8.7	8.77	8.78	8.84	8.88	9
	1	3	8	2	5	1	4	7	6	9	10
		8.14	8.54	8.65	9.07	9.09	9.32	9.47	9.79	10.04	10.15
	1.5	3	6	1	8	4	7	2	5	9	10
		7.58	7.63	7.9	7.96	8.08	8.29	8.55	9.87	10.24	10.28
	2	2	1	4	8	6	3	9	7	10	5
		6.32	6.77	7.49	7.72	7.9	8.03	8.44	8.47	8.89	9.74
	3	8	4	7	6	9	5	2	10	1	3
		6.19	6.36	6.53	7.29	7.89	8.6	8.98	9.37	9.39	10.44
	4.5	4	6	5	2	9	7	8	3	10	1
		5.74	6.29	6.48	6.49	6.93	7.05	7.1	7.43	7.53	9.22
	6	9	2	5	7	10	6	4	1	8	3
		4.67	4.69	5.6	5.84	5.84	6.01	6.17	6.31	6.97	7.45
	9	8	10	9	7	2	5	6	1	3	4
		4.14	4.69	4.86	5.09	5.47	6.13	6.76	7.08	8.05	8.13
5	0.5	3	4	2	6	5	8	9	7	10	1
		11.95	12.09	12.1	12.18	12.52	12.65	12.65	12.76	12.84	13.02
	1	3	8	2	5	1	4	7	6	9	10
		11.71	12.2	12.25	12.86	13.16	13.29	13.5	14.02	14.42	14.54
	1.5	6	3	1	8	4	7	2	5	10	9
		10.71	10.95	11.14	11.36	11.41	11.79	12.29	14.13	14.72	14.73
	2	2	1	4	8	6	3	9	7	10	5
		9.09	9.83	10.64	10.87	11.14	11.47	11.88	11.97	12.57	13.98
	3	8	4	7	6	9	5	2	10	1	3
		8.66	8.94	9.36	10.27	11.21	12.19	13.07	13.44	13.59	15.15
	4.5	4	6	5	2	9	7	8	10	3	1
		8.24	9.12	9.29	9.51	9.95	10.1	10.19	10.88	11.02	13.28
	6	9	2	5	10	7	6	1	4	8	3
		6.7	6.71	8.07	8.28	8.39	8.67	8.98	9.01	9.92	10.87
	9	8	10	9	7	2	5	6	1	4	3
		5.94	6.83	7.03	7.31	8	8.96	9.71	10.26	11.81	11.95
10	0.5	2	1	5	4	6	3	8	10	7	9
		14.5	14.63	14.92	15.06	15.07	15.1	15.42	15.57	15.59	15.62
	1	4	2	3	9	5	8	7	6	1	10
		13.08	14.04	14.56	14.75	14.94	15.25	16.06	16.55	17.86	18.85
	1.5	4	2	8	7	5	6	9	1	3	10

Taigum Channel at Fernwood Place – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		12.5	13.55	13.62	13.91	**14.49**	**14.5**	15.16	15.77	16.83	16.87
	2	3	6	9	7	**8**	**10**	2	4	1	5
		12.58	13.42	13.73	14.22	**14.55**	**14.72**	14.85	15.24	15.84	15.84
	3	5	3	2	6	**8**	**7**	9	4	10	1
		11.02	11.37	12.47	12.54	**13.11**	**14.14**	14.34	14.41	14.94	16.69
	4.5	5	2	8	7	**1**	**9**	10	4	6	3
		8.33	9	10.31	10.38	**10.48**	**12.96**	13.6	14.58	15.67	16.46
	6	6	4	10	3	**5**	**7**	8	9	2	1
		7.39	9.22	10.03	10.89	**11.09**	**11.67**	11.78	11.92	13.38	15.86
	9	6	10	8	4	**2**	**3**	9	7	1	5
		7.79	8	8.72	8.96	**9.24**	**9.51**	9.89	10.27	10.48	12.93
20	0.5	2	1	5	4	**6**	**3**	8	10	7	9
		17.08	17.25	17.6	17.77	**17.79**	**17.83**	18.21	18.4	18.43	18.47
	1	**4**	**2**	**3**	**9**	**5**	**8**	**7**	**6**	**1**	**10**
		15.24	**16.38**	**17.08**	**17.3**	**17.48**	**17.84**	**18.87**	**19.42**	**21.04**	**22.22**
	1.5	4	2	8	7	**6**	**5**	9	1	3	10
		14.63	15.87	15.96	16.31	**17.18**	**17.2**	17.82	18.64	19.85	19.87
	2	3	6	9	7	**8**	**10**	2	4	1	5
		14.73	15.79	16.15	16.71	**17.04**	**17.27**	17.42	18.14	18.63	18.68
	3	5	3	2	6	**8**	**7**	9	4	10	1
		12.92	13.36	14.72	14.74	**15.41**	**16.67**	16.9	17.09	17.59	19.95
	4.5	5	2	8	7	**1**	**9**	10	4	6	3
		9.74	10.71	12.11	12.17	**12.37**	**15.32**	15.99	17.27	18.56	19.68
	6	6	4	10	3	**5**	**7**	8	9	2	1
		8.72	10.93	11.93	13.05	**13.14**	**13.94**	13.95	14.16	16.11	18.92
	9	6	10	8	4	**2**	**3**	9	7	1	5
		9.23	9.49	10.41	10.78	**11.1**	**11.33**	11.73	12.28	12.44	15.52
50	**0.5**	**1**	**6**	**5**	**4**	**10**	**7**	**8**	**2**	**9**	**3**
		20.36	**20.36**	**20.75**	**21.23**	**21.23**	**21.59**	**21.67**	**21.73**	**21.77**	**22.26**
	1	8	9	5	10	**7**	**4**	6	3	1	2
		20.41	20.67	20.9	21.13	**21.19**	**21.36**	21.97	22.03	25.06	25.11
	1.5	1	7	4	8	**3**	**5**	6	2	10	9
		17.75	19.06	19.28	19.99	**20.04**	**20.39**	22.91	23.36	23.7	23.71
	2	7	8	4	2	**3**	**6**	5	1	9	10
		16.97	18.08	18.28	18.48	**18.72**	**19.78**	20.22	20.6	21.4	21.57
	3	7	9	5	2	**6**	**4**	3	8	1	10
		13.59	14.67	15.5	15.62	**15.93**	**16.68**	17.52	17.91	19	21.36

Taigum Channel at Fernwood Place – Peak Discharge (m³/s) and Ensemble Ranking

ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
	4.5	3	6	2	8	**4**	**7**	9	1	5	10
		13.87	14.01	14.22	14.4	**14.54**	**15.65**	16.62	16.98	17.06	18.61
	6	5	2	3	6	**4**	**10**	9	7	8	1
		12.15	12.62	13.37	14.27	**14.35**	**14.8**	16.31	18.83	23.06	27.06
	9	3	4	8	10	**9**	**2**	1	6	7	5
		8.6	9.35	10.87	12.51	**13.22**	**15.17**	15.24	20.15	23.81	26.58
100	**0.5**	**6**	**1**	**5**	**10**	4	**7**	**8**	**2**	**9**	**3**
		22.9	**22.91**	**23.35**	**23.9**	23.91	**24.33**	**24.41**	**24.47**	**24.54**	**25.11**
	1	8	9	5	10	**7**	**4**	6	3	1	2
		23.04	23.32	23.63	23.86	**23.95**	**24.19**	24.83	24.97	28.44	28.5
	1.5	1	7	4	8	**3**	**5**	6	2	9	10
		20.02	21.51	21.83	22.61	**22.85**	**23.12**	26.01	26.51	26.91	26.92
	2	7	8	4	2	**3**	**6**	5	1	9	10
		19.27	20.45	20.72	20.93	**21.36**	**22.45**	23.12	23.39	24.28	24.51
	3	7	9	5	2	**6**	**4**	3	8	1	10
		15.53	16.68	17.71	17.84	**18.24**	**19.08**	19.88	20.45	21.66	24.45
	4.5	3	6	2	8	**4**	**7**	9	1	5	10
		15.78	16.1	16.26	16.35	**16.66**	**17.82**	18.96	19.35	19.51	21.19
	6	5	2	3	6	**4**	**10**	9	7	8	1
		13.86	14.42	15.28	16.34	**16.49**	**16.92**	18.74	21.52	26.5	31.22
	9	3	4	8	10	**9**	**2**	1	6	7	5
		9.81	10.68	12.48	14.33	**15.25**	**17.44**	17.5	23.3	27.55	30.65

Taigum Channel at Church Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
2	0.5	4	3	2	6	**5**	**9**	7	8	10	1
		14.33	14.35	14.48	14.57	**14.86**	**14.93**	15.01	15.03	15.07	15.22
	1	**3**	**2**	**8**	**1**	**5**	**4**	**7**	**9**	**6**	**10**
		14.47	**14.94**	**15.23**	**15.88**	**16.06**	**16.27**	**16.28**	**17.04**	**17.3**	**17.48**
	1.5	3	6	1	8	**4**	**7**	2	5	10	9
		13.05	13.18	13.6	14.15	**14.39**	**14.51**	15.17	16.82	17.89	17.93
	2	2	1	4	6	**8**	**3**	7	9	10	5
		11.23	11.97	13.25	13.57	**13.59**	**14.11**	14.43	14.99	15.7	17.02
	3	8	4	7	6	**9**	**5**	2	1	10	3
		10.81	11.07	11.67	12.89	**14.07**	**15.18**	15.75	16.28	16.31	18.61
	4.5	4	6	5	2	**7**	**9**	8	3	10	1
		10.16	10.96	11.47	11.49	**12.24**	**12.36**	12.56	12.73	13.28	16.28
	6	9	2	5	7	**10**	**6**	4	1	8	3
		8.05	8.34	9.98	10.23	**10.35**	**10.53**	10.91	11.04	12.14	13.04
	9	8	10	9	7	**2**	**5**	6	1	4	3
		7.21	8.18	8.58	9.05	**9.63**	**10.81**	11.99	12.43	14.18	14.24
5	0.5	4	3	2	6	**5**	**9**	7	8	10	1
		20.53	20.56	20.77	20.9	**21.35**	**21.45**	21.58	21.61	21.69	21.92
	1	**3**	**2**	**8**	**5**	**1**	**4**	**7**	**9**	**6**	**10**
		20.77	**21.15**	**21.6**	**22.84**	**22.92**	**23.17**	**23.18**	**24.39**	**24.76**	**25.03**
	1.5	6	3	1	8	**4**	**7**	2	5	10	9
		18.46	19.01	19.13	20.22	**20.25**	**20.57**	21.82	24	25.59	25.7
	2	2	1	4	8	**6**	**3**	7	9	10	5
		16.07	17.36	18.98	19.06	**19.11**	**20.07**	20.33	21.1	22.19	24.38
	3	8	4	7	6	**9**	**5**	2	10	1	3
		15.1	15.55	16.67	18.19	**19.93**	**21.55**	22.88	23.37	23.52	26.89
	4.5	4	6	5	2	**7**	**9**	8	3	10	1
		14.57	15.83	16.42	16.78	**17.53**	**17.71**	18.03	18.8	19.12	23.46
	6	9	2	5	7	**10**	**6**	1	4	8	3
		11.52	11.95	14.35	14.65	**14.66**	**15.15**	15.68	15.95	17.26	18.98
	9	8	10	9	7	**2**	**5**	6	1	4	3
		10.33	11.91	12.37	13.02	**14.08**	**15.78**	17.24	17.98	20.6	21.06
10	0.5	1	2	5	3	**4**	**6**	8	10	7	9
		24.88	24.91	25.42	25.47	**25.5**	**25.66**	26.13	26.22	26.29	26.33
	1	**4**	**2**	**3**	**9**	**8**	**5**	**7**	**6**	**1**	**10**
		22.41	**24.55**	**25.94**	**26.07**	**26.33**	**26.45**	**28.46**	**28.5**	**30.47**	**32.45**
	1.5	4	2	8	7	**5**	**6**	9	1	3	10

Taigum Channel at Church Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
		22.08	22.96	23.68	24.31	25.1	25.36	26.69	27.51	29.57	29.8
	2	3	6	9	7	8	10	2	4	5	1
		21.87	23.75	24.25	24.63	25.44	25.58	26.07	26.59	27.35	27.78
	3	5	3	2	6	8	4	7	9	10	1
		18.7	19.58	21.89	22.31	22.94	24.53	24.9	25.11	26.01	28.39
	4.5	5	2	8	7	1	9	10	4	6	3
		14.68	15.97	18.05	18.21	18.31	22.3	23.82	25.3	27.66	29.08
	6	6	4	10	3	5	7	8	9	2	1
		13.08	15.95	17.7	18.87	19.6	20.59	20.72	20.87	23.43	27.99
	9	6	10	8	4	2	3	9	7	1	5
		13.63	14.16	15.23	15.8	15.94	16.83	17.5	18.17	18.59	22.33
20	0.5	1	2	5	3	4	6	8	10	7	9
		29.3	29.33	29.96	30.02	30.06	30.25	30.82	30.94	31.03	31.07
	1	**4**	**2**	**3**	**9**	**8**	**5**	**7**	**6**	**1**	**10**
		26.09	**28.65**	**30.48**	**30.58**	**30.81**	**30.96**	**33.43**	**33.45**	**35.83**	**38.23**
	1.5	4	2	8	7	5	6	9	1	3	10
		25.83	26.87	27.74	28.47	29.75	30	31.33	32.44	34.85	35.1
	2	3	6	9	7	8	10	2	4	5	1
		25.63	27.95	28.53	28.92	29.82	30	30.56	31.61	32.23	32.66
	3	5	3	2	6	8	4	7	9	10	1
		22.04	23.12	25.81	26.2	26.94	29.06	29.33	29.57	30.59	33.9
	4.5	5	2	8	7	1	9	10	4	6	3
		17.17	19	21.23	21.36	21.58	26.34	28.01	29.96	32.75	34.69
	6	6	4	10	3	5	8	7	9	2	1
		15.42	18.91	21.02	22.59	23.23	24.51	24.61	24.78	28.14	33.4
	9	6	10	8	4	2	3	9	7	1	5
		16.15	16.81	18.19	18.98	19.12	20.03	20.75	21.73	22.08	26.8
50	0.5	1	6	5	4	10	7	9	8	2	3
		34.28	34.7	35.38	35.85	36.02	36.32	36.59	36.8	36.92	37.29
	1	**7**	**9**	**8**	**10**	**4**	**5**	**6**	**3**	**1**	**2**
		36.19	**36.21**	**36.24**	**36.78**	**37.12**	**37.13**	**38.97**	**39.02**	**42.15**	**42.29**
	1.5	1	4	7	8	5	3	2	6	9	10
		31.47	32.71	33.63	35.14	35.51	35.54	40.17	40.23	40.61	41.51
	2	7	8	4	2	3	6	5	1	9	10
		29.58	31.8	31.96	32.38	33.14	34.27	35.15	35.89	37.37	37.88
	3	7	9	2	5	6	4	8	3	1	10
		23.94	25.96	27.27	27.53	27.8	29.65	30.01	30.56	33.06	37.53

Taigum Channel at Church Road – Peak Discharge (m^3/s) and Ensemble Ranking

ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
	4.5	3	6	2	8	**4**	**7**	9	5	1	10
		24.34	24.84	25.13	25.23	**25.87**	**27.44**	28.62	29.57	30.1	32.42
	6	2	5	3	6	**4**	**10**	9	7	8	1
		21.27	21.48	23.13	24.16	**25.32**	**25.89**	28.98	32.82	40.6	47.52
	9	3	4	8	10	**9**	**2**	1	6	7	5
		15.2	16.55	19.13	22.02	**23.13**	**26.55**	26.64	34.98	41.49	46.18
100	0.5	1	6	5	4	**10**	**7**	9	8	2	3
		38.52	39	39.79	40.33	**40.53**	**40.87**	41.18	41.43	41.57	41.99
	1	**9**	**7**	**8**	**10**	**5**	**4**	**6**	**3**	**1**	**2**
		40.87	**40.88**	**40.91**	**41.54**	**41.95**	**42.01**	**44.08**	**44.18**	**47.8**	**47.95**
	1.5	1	4	7	8	**5**	**3**	2	6	9	10
		35.49	37	37.97	39.76	**40.22**	**40.51**	45.55	45.63	46.08	47.12
	2	7	8	4	2	**3**	**6**	5	1	9	10
		33.58	35.96	36.21	36.68	**37.59**	**38.88**	40.2	40.73	42.42	42.97
	3	7	9	2	5	**6**	**4**	8	3	1	10
		27.35	29.52	31.12	31.42	**31.8**	**33.87**	34.22	34.67	37.65	42.9
	4.5	3	6	8	2	**4**	**7**	9	5	1	10
		27.68	28.58	28.63	28.69	**29.6**	**31.22**	32.65	33.79	34.28	36.88
	6	2	5	3	6	**4**	**10**	9	7	8	1
		24.27	24.51	26.41	27.64	**29.07**	**29.58**	33.27	37.46	46.63	54.79
	9	3	4	8	10	**9**	**2**	1	6	7	5
		17.35	18.89	21.96	25.22	**26.65**	**30.54**	30.59	40.44	47.95	53.25

Carseldine Channel at Beams Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
2	0.5	3	2	6	4	**5**	**8**	9	7	10	1
		4.29	4.36	4.39	4.44	**4.55**	**4.56**	4.64	4.72	4.77	4.94
	1	**3**	**8**	**2**	**5**	**4**	**1**	**7**	**6**	**10**	**9**
		4.11	**4.32**	**4.33**	**4.52**	**4.71**	**4.73**	**4.8**	**4.97**	**5.16**	**5.22**
	1.5	6	3	8	1	**4**	**7**	2	5	10	9
		3.75	3.93	3.94	3.97	**3.98**	**4.17**	4.3	5.12	5.16	5.22
	2	2	1	4	8	**6**	**3**	9	7	10	5
		3.19	3.45	3.69	3.78	**3.9**	**4.04**	4.14	4.28	4.35	4.91
	3	8	4	7	6	**9**	**5**	2	10	1	3
		2.97	3.07	3.24	3.51	**3.86**	**4.18**	4.57	4.67	4.74	5.31
	4.5	4	5	6	2	**9**	**7**	8	10	3	1
		2.78	3.17	3.19	3.25	**3.36**	**3.43**	3.45	3.75	3.88	4.5
	6	2	9	5	10	**7**	**6**	1	4	8	3
		2.28	2.31	2.75	2.82	**2.89**	**2.98**	3.07	3.07	3.38	3.75
	9	8	10	9	7	**2**	**5**	6	1	4	3
		1.99	2.31	2.37	2.44	**2.69**	**3.01**	3.24	3.46	3.97	4.09
5	0.5	3	2	6	4	**5**	**8**	9	7	10	1
		6.13	6.24	6.28	6.35	**6.52**	**6.54**	6.66	6.79	6.87	7.14
	1	**3**	**2**	**8**	**5**	**4**	**1**	**7**	**6**	**10**	**9**
		5.91	**6.1**	**6.17**	**6.43**	**6.69**	**6.82**	**6.82**	**7.11**	**7.35**	**7.46**
	1.5	6	1	3	4	**8**	**7**	2	5	10	9
		5.24	5.59	5.62	5.63	**5.63**	**5.93**	6.18	7.32	7.36	7.49
	2	2	1	4	8	**6**	**3**	9	7	10	5
		4.62	4.99	5.31	5.31	**5.49**	**5.74**	5.86	6.05	6.13	7.03
	3	8	4	7	6	**9**	**5**	2	10	1	3
		4.17	4.34	4.64	4.94	**5.48**	**5.9**	6.62	6.68	6.82	7.72
	4.5	4	5	6	2	**9**	**7**	8	10	3	1
		3.98	4.56	4.62	4.74	**4.82**	**4.9**	4.93	5.41	5.74	6.45
	6	2	9	5	10	**7**	**6**	1	4	8	3
		3.28	3.31	3.97	4	**4.15**	**4.29**	4.36	4.47	4.79	5.47
	9	8	10	9	7	**2**	**5**	6	1	4	3
		2.85	3.36	3.43	3.54	**3.91**	**4.39**	4.64	5.01	5.76	6.08
10	**0.5**	**2**	**1**	**5**	**6**	**4**	**3**	**8**	**7**	**9**	**10**
		7.43	**7.62**	**7.73**	**7.83**	**7.94**	**8.03**	**8.1**	**8.28**	**8.37**	**8.4**
	1	4	2	3	9	**5**	**8**	7	6	1	10
		6.48	6.89	7.29	7.33	**7.39**	**7.62**	8.05	8.3	9.35	9.78
	1.5	4	8	2	7	**6**	**5**	9	1	3	10

Carseldine Channel at Beams Road – Peak Discharge (m³/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		6.07	6.66	6.74	6.86	**7.38**	**7.43**	7.51	8.05	8.41	8.45
	2	3	6	9	8	**7**	**10**	2	1	4	5
		6.18	6.58	6.73	7.07	**7.1**	**7.23**	7.28	7.85	7.87	7.92
	3	5	3	6	2	**8**	**7**	9	4	10	1
		5.61	5.66	6.08	6.19	**6.4**	**6.92**	7.02	7.33	7.33	8.65
	4.5	5	2	8	7	**1**	**9**	10	4	6	3
		3.94	4.45	4.95	4.96	**5.14**	**6.45**	6.54	7.2	7.66	8.43
	6	6	4	10	5	**3**	**8**	7	9	2	1
		3.52	4.47	4.93	5.32	**5.45**	**5.67**	5.72	5.88	6.89	7.75
	9	6	10	8	4	**3**	**2**	9	1	7	5
		3.72	3.82	4.26	4.49	**4.61**	**4.62**	4.71	5	5.01	6.41
20	**0.5**	**2**	**1**	**5**	**6**	**4**	**3**	**8**	**7**	**9**	**10**
		8.73	**8.96**	**9.1**	**9.22**	**9.35**	**9.47**	**9.55**	**9.77**	**9.87**	**9.92**
	1	4	2	3	9	**5**	**8**	7	6	1	10
		7.55	8.03	8.57	8.57	**8.64**	**8.91**	9.45	9.72	11	11.53
	1.5	4	8	2	7	**6**	**5**	9	1	3	10
		7.09	7.79	7.89	8.03	**8.73**	**8.8**	8.82	9.51	9.92	9.96
	2	3	6	9	8	**7**	**10**	2	1	5	4
		7.24	7.72	7.92	8.27	**8.35**	**8.48**	8.53	9.23	9.32	9.35
	3	5	3	6	2	**8**	**7**	9	10	4	1
		6.71	6.72	7.15	7.29	**7.52**	**8.14**	8.26	8.61	8.69	10.31
	4.5	5	2	8	7	**1**	**9**	10	4	6	3
		4.61	5.27	5.81	5.82	**6.06**	**7.62**	7.69	8.52	9.05	10.07
	6	6	4	10	5	**3**	**8**	7	9	2	1
		4.15	5.3	5.86	6.3	**6.52**	**6.7**	6.82	6.99	8.3	9.23
	9	6	10	8	4	**3**	**2**	9	1	7	5
		4.41	4.52	5.08	5.4	**5.5**	**5.54**	5.58	5.93	5.98	7.68
50	**0.5**	**6**	**5**	**1**	**10**	**4**	**8**	**2**	**7**	**9**	**3**
		10.48	**10.67**	**10.85**	**11**	**11.15**	**11.23**	**11.24**	**11.46**	**11.65**	**12.13**
	1	8	9	5	10	**7**	**4**	6	3	1	2
		10.08	10.13	10.36	10.4	**10.59**	**10.75**	10.82	11.06	12.93	12.93
	1.5	1	7	4	8	**3**	**5**	6	2	9	10
		8.55	9.2	9.57	9.73	**10.12**	**10.16**	11.47	11.71	11.8	11.8
	2	7	8	2	4	**3**	**6**	1	5	9	10
		8.37	8.74	8.97	8.99	**9.43**	**9.78**	10.15	10.17	10.42	10.75
	3	7	9	5	2	**6**	**4**	3	8	1	10
		6.67	7.07	7.65	7.7	**8.07**	**8.29**	8.43	9.06	9.43	10.76

Carseldine Channel at Beams Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
	4.5	3	6	8	2	**4**	**7**	9	1	5	10
		6.78	6.93	6.95	6.99	**7.23**	**7.63**	8.11	8.27	8.46	9.12
	6	5	2	3	6	**4**	**10**	9	7	8	1
		5.82	6.23	6.55	7.06	**7.08**	**7.18**	8.08	9.22	11.33	13.46
	9	3	4	8	10	**9**	**2**	1	6	7	5
		4.07	4.44	5.25	6.01	**6.54**	**7.37**	7.4	10	11.94	13.04
100	**0.5**	**6**	**5**	**1**	**10**	**4**	**8**	**2**	**7**	**9**	**3**
		11.76	**11.99**	**12.2**	**12.36**	**12.54**	**12.63**	**12.64**	**12.9**	**13.12**	**13.67**
	1	8	9	5	10	**7**	**4**	6	3	1	2
		11.38	11.47	11.7	11.73	**11.95**	**12.15**	12.21	12.53	14.66	14.66
	1.5	1	7	4	8	**5**	**3**	6	2	9	10
		9.69	10.38	10.82	11	**11.51**	**11.53**	13.01	13.28	13.37	13.39
	2	7	8	2	4	**3**	**6**	1	5	9	10
		9.49	9.87	10.16	10.19	**10.75**	**11.1**	11.51	11.62	11.82	12.21
	3	7	9	5	2	**6**	**4**	3	8	1	10
		7.61	8.03	8.73	8.77	**9.23**	**9.49**	9.67	10.35	10.74	12.32
	4.5	3	8	6	2	**4**	**7**	9	1	5	10
		7.72	7.9	7.94	7.97	**8.28**	**8.68**	9.25	9.43	9.66	10.37
	6	5	2	3	6	**4**	**10**	9	7	8	1
		6.63	7.12	7.48	8.09	**8.12**	**8.2**	9.29	10.53	12.99	15.5
	9	3	4	8	10	**9**	**2**	1	6	7	5
		4.65	5.06	6.02	6.88	**7.54**	**8.46**	8.49	11.54	13.8	15.01

Carseldine Channel at Gympie Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
2	0.5	3	4	2	6	**5**	**9**	8	7	10	1
		9.92	9.99	10.03	10.08	**10.33**	**10.4**	10.42	10.48	10.53	10.68
	1	**3**	**2**	**8**	**1**	**5**	**4**	**7**	**6**	**9**	**10**
		9.85	**10.42**	**10.42**	**10.92**	**11.04**	**11.27**	**11.35**	**11.88**	**11.98**	**12.16**
	1.5	3	6	1	8	**4**	**7**	2	5	10	9
		9.16	9.3	9.66	9.7	**9.96**	**10.11**	10.37	11.87	12.4	12.42
	2	2	1	4	8	**6**	**3**	7	9	10	5
		7.71	8.18	9.22	9.47	**9.62**	**9.75**	10.26	10.39	10.88	11.8
	3	8	4	7	6	**9**	**5**	2	1	10	3
		7.66	7.83	8.02	9.01	**9.74**	**10.56**	10.83	11.31	11.36	12.72
	4.5	4	6	2	5	**9**	**7**	8	3	10	1
		7.08	7.71	7.9	8.01	**8.58**	**8.64**	8.74	8.9	9.26	11.3
	6	9	2	5	7	**10**	**6**	4	1	8	3
		5.71	5.81	6.9	7.17	**7.25**	**7.36**	7.49	7.78	8.57	9.04
	9	8	10	9	7	**2**	**5**	6	1	3	4
		5.12	5.73	6.02	6.32	**6.68**	**7.51**	8.38	8.72	9.81	9.94
5	0.5	3	4	2	6	**5**	**9**	8	7	10	1
		14.25	14.35	14.41	14.48	**14.88**	**15**	15.02	15.11	15.2	15.43
	1	**3**	**8**	**2**	**5**	**1**	**4**	**7**	**6**	**9**	**10**
		14.17	**14.77**	**14.79**	**15.72**	**15.8**	**16.08**	**16.21**	**17**	**17.19**	**17.46**
	1.5	6	3	1	8	**4**	**7**	2	5	10	9
		13.06	13.12	13.63	13.86	**14.03**	**14.39**	14.94	17	17.77	17.85
	2	2	1	4	8	**6**	**3**	7	9	10	5
		11	11.88	12.99	13.35	**13.58**	**13.92**	14.5	14.63	15.41	16.95
	3	8	4	7	6	**9**	**5**	2	10	1	3
		10.72	11.01	11.49	12.72	**13.83**	**15.01**	15.77	16.32	16.38	18.45
	4.5	4	6	5	2	**9**	**7**	8	3	10	1
		10.17	11.16	11.48	11.58	**12.3**	**12.39**	12.57	13.19	13.38	16.33
	6	9	2	5	10	**7**	**6**	4	1	8	3
		8.18	8.31	9.94	10.29	**10.3**	**10.61**	10.96	11.08	12.2	13.2
	9	8	10	9	7	**2**	**5**	6	1	4	3
		7.34	8.35	8.69	9.09	**9.79**	**10.98**	12.07	12.63	14.47	14.55
10	0.5	2	1	5	4	**6**	**3**	8	10	7	9
		17.26	17.37	17.72	17.83	**17.87**	**17.92**	18.26	18.43	18.46	18.49
	1	**4**	**2**	**3**	**9**	**5**	**8**	**7**	**6**	**1**	**10**
		15.8	**17.04**	**17.75**	**17.92**	**18.28**	**18.47**	**19.51**	**19.91**	**21.43**	**22.71**
	1.5	4	2	8	7	**5**	**6**	9	1	3	10

Carseldine Channel at Gympie Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		15.4	16.41	16.66	17.03	**17.38**	**17.54**	18.54	19.08	20.5	20.66
	2	3	6	9	7	**8**	**10**	2	4	5	1
		15.5	16.42	16.82	17.39	**17.83**	**18.08**	18.21	18.41	19.18	19.4
	3	5	3	2	6	**8**	**4**	7	9	10	1
		13.44	13.89	15.27	15.53	**16.12**	**17.34**	17.36	17.57	18.29	19.84
	4.5	5	2	8	7	**1**	**9**	10	4	6	3
		10.4	10.98	12.75	12.87	**12.9**	**15.81**	16.78	17.73	19.2	19.99
	6	6	4	10	3	**5**	**7**	8	9	2	1
		9.22	11.31	12.4	13.18	**13.74**	**14.28**	14.59	14.7	16.25	19.43
	9	6	10	8	4	**2**	**3**	9	7	1	5
		9.67	9.95	10.69	10.95	**11.24**	**11.79**	12.31	12.62	13.03	15.68
20	0.5	2	1	5	4	**6**	**3**	8	10	7	9
		20.34	20.47	20.9	21.04	**21.08**	**21.15**	21.56	21.78	21.81	21.85
	1	**4**	**2**	**3**	**9**	**5**	**8**	**7**	**6**	**1**	**10**
		18.42	**19.91**	**20.86**	**21.04**	**21.4**	**21.65**	**22.94**	**23.39**	**25.24**	**26.79**
	1.5	4	2	8	7	**5**	**6**	9	1	3	10
		18.02	19.23	19.53	19.97	**20.63**	**20.77**	21.8	22.56	24.18	24.34
	2	3	6	9	7	**8**	**10**	2	4	5	1
		18.18	19.34	19.8	20.45	**20.91**	**21.22**	21.38	21.91	22.64	22.84
	3	5	3	2	6	**8**	**7**	4	9	10	1
		15.76	16.33	18.03	18.25	**18.95**	**20.46**	20.56	20.71	21.53	23.71
	4.5	5	2	8	7	**1**	**9**	10	4	6	3
		12.16	13.07	15	15.1	**15.21**	**18.68**	19.74	21.02	22.75	23.89
	6	6	4	10	3	**5**	**7**	8	9	2	1
		10.88	13.41	14.74	15.8	**16.29**	**17.08**	17.27	17.47	19.55	23.21
	9	6	10	8	4	**2**	**3**	9	7	1	5
		11.46	11.81	12.77	13.17	**13.48**	**14.04**	14.61	15.11	15.48	18.83
50	0.5	1	6	5	4	**10**	**7**	9	8	2	3
		24.17	24.21	24.67	25.14	**25.17**	**25.55**	25.76	25.77	25.8	26.36
	1	**8**	**9**	**7**	**5**	10	4	**6**	**3**	**1**	**2**
		25	**25.24**	**25.56**	**25.58**	25.61	25.82	**26.8**	**26.85**	**29.88**	**29.92**
	1.5	1	4	7	3	**8**	**5**	6	2	9	10
		22.01	23.36	23.54	24.37	**24.57**	**24.86**	27.99	28.32	28.64	28.93
	2	7	8	4	2	**3**	**6**	5	1	9	10
		20.76	22.36	22.53	22.78	**23.02**	**24.25**	24.41	25.33	26.29	26.44
	3	7	9	5	2	**6**	**4**	8	3	1	10
		16.62	18.12	19.06	19.07	**19.42**	**20.48**	21.63	21.66	23.33	26.14

Carseldine Channel at Gympie Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
	4.5	6	3	2	4	**8**	**7**	9	5	1	10
		17.05	17.17	17.48	17.85	**17.86**	**19.32**	20.31	20.77	21.06	22.95
	6	5	2	3	6	**4**	**10**	9	7	8	1
		15.07	15.38	16.45	17.34	**17.58**	**18.24**	20.05	23.24	28.19	32.84
	9	3	4	8	10	**9**	**2**	1	6	7	5
		10.75	11.68	13.4	15.49	**16.17**	**18.61**	18.74	24.39	28.94	32.35
100	0.5	1	6	5	4	**10**	**7**	8	9	2	3
		27.19	27.23	27.76	28.3	**28.34**	**28.78**	29.03	29.03	29.07	29.72
	1	**8**	**9**	**7**	**5**	**10**	**4**	**6**	**3**	**1**	**2**
		28.25	**28.51**	**28.89**	**28.93**	**28.94**	**29.25**	**30.32**	**30.43**	**33.92**	**33.96**
	1.5	1	4	7	3	**8**	**5**	6	2	9	10
		24.83	26.45	26.59	27.8	**27.82**	**28.19**	31.79	32.15	32.53	32.86
	2	7	8	4	2	**3**	**6**	5	1	9	10
		23.59	25.3	25.54	25.82	**26.13**	**27.52**	27.94	28.75	29.85	29.99
	3	7	9	5	2	**6**	**4**	3	8	1	10
		19	20.62	21.77	21.78	**22.24**	**23.43**	24.58	24.68	26.59	29.91
	4.5	3	6	2	8	**4**	**7**	9	5	1	10
		19.54	19.61	19.99	20.29	**20.45**	**22**	23.16	23.76	23.98	26.13
	6	5	2	3	6	**4**	**10**	9	7	8	1
		17.2	17.56	18.79	19.85	**20.2**	**20.85**	23.04	26.55	32.4	37.9
	9	3	4	8	10	**9**	**2**	1	6	7	5
		12.26	13.34	15.39	17.75	**18.65**	**21.41**	21.53	28.23	33.48	37.34

Carseldine Channel at Norris Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	0.5	4	3	2	6	7	5	9	1	10	8
		15.02	15.08	15.1	15.13	15.13	15.14	15.14	15.15	15.15	15.2
	1	3	2	9	7	8	5	4	10	1	6
		17.91	17.96	18.21	18.25	18.33	18.44	18.46	18.55	18.67	18.81
	1.5	3	1	6	7	2	8	4	5	9	10
		16.33	18.37	18.54	18.67	18.99	19.21	19.26	19.42	19.92	20.41
	2	1	2	6	3	8	7	4	9	10	5
		17.04	17.45	17.84	18.26	19.01	19.12	19.5	19.98	20.05	20.74
	3	4	8	7	6	2	1	9	10	5	3
		16.31	16.99	17.21	17.88	18.23	19.23	20.23	20.37	20.49	21.55
	4.5	4	3	6	5	2	7	9	8	10	1
		14.91	15.75	15.9	16.14	16.75	16.8	17.81	17.97	18.7	21.89
	6	2	9	7	5	4	6	3	10	1	8
		12.92	13.45	14.63	14.72	14.8	14.96	16.13	16.76	16.79	17.79
	9	8	10	2	9	7	5	6	1	3	4
		11.44	12.74	13.33	13.52	14.85	15.56	18.11	18.36	18.41	19.43
5	0.5	4	3	2	9	6	5	1	7	10	8
		20.39	20.48	20.51	20.55	20.56	20.57	20.58	20.58	20.58	20.64
	1	3	2	9	7	8	4	5	10	1	6
		24.73	24.75	25.02	25.13	25.25	25.39	25.39	25.51	25.7	25.86
	1.5	3	1	6	7	2	8	4	5	9	10
		22.83	25.55	25.77	25.89	26.42	26.69	26.71	26.87	27.44	28.18
	2	1	2	6	3	8	7	4	9	10	5
		23.82	24.38	24.74	25.5	26.42	26.59	27.15	27.65	27.69	28.67
	3	4	8	7	6	2	1	9	10	5	3
		22.85	23.83	24.16	24.87	25.48	26.92	28.18	28.5	28.6	30.01
	4.5	4	6	3	5	7	2	9	8	10	1
		20.91	22.34	22.35	22.62	23.64	23.86	25.02	25.38	26.41	30.89
	6	2	9	7	5	4	6	3	10	1	8
		18.16	18.63	20.27	20.64	20.77	20.92	22.78	23.7	23.74	25.1
	9	8	10	2	9	7	5	6	3	1	4
		16.08	18	18.86	18.9	20.98	22.05	25.83	26.13	26.14	27.66
10	0.5	1	3	4	5	2	7	10	6	9	8
		24.1	24.11	24.17	24.19	24.2	24.22	24.23	24.24	24.24	24.29
	1	4	2	8	6	3	9	5	1	7	10
		28.79	29.58	29.74	29.86	29.93	29.96	29.97	30.28	30.4	30.7
	1.5	8	2	4	5	7	6	9	1	10	3

Carseldine Channel at Norris Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
		29.87	30.31	30.34	31.01	31.17	31.98	32.16	32.45	32.51	32.6
	2	3	4	7	6	10	8	9	1	5	2
		28.45	29.72	30.57	31.88	31.92	32.06	32.09	32.5	33.18	33.2
	3	1	5	3	2	8	4	6	9	7	10
		27.45	27.53	28.65	29.77	31.86	31.97	32.72	32.97	33.48	33.89
	4.5	2	5	8	1	7	9	4	3	10	6
		23.66	24.82	26	26.22	28.73	28.94	31.23	32.64	32.93	34.51
	6	6	4	3	7	2	10	5	9	8	1
		22.21	22.81	25.1	25.74	26.61	27.08	28.91	29.84	31.85	34.83
	9	4	8	2	6	10	3	7	5	9	1
		21.22	21.45	21.7	22.33	22.58	25.5	26.32	26.75	27.31	28.38
20	0.5	1	3	4	5	2	7	9	10	6	8
		27.76	27.76	27.83	27.87	27.88	27.9	27.91	27.91	27.93	27.98
	1	4	2	8	6	3	9	5	1	7	10
		33.02	33.86	34.02	34.14	34.25	34.26	34.27	34.6	34.76	35.09
	1.5	8	2	4	5	7	6	9	1	10	3
		34.36	34.88	34.91	35.71	35.85	36.84	37.05	37.39	37.43	37.55
	2	3	4	7	10	6	8	9	1	2	5
		32.97	34.56	35.19	36.76	36.77	36.94	36.98	37.46	38.33	38.36
	3	1	5	3	2	8	4	6	9	7	10
		32.17	32.18	33.5	34.64	36.82	36.99	37.91	38.16	38.81	39.25
	4.5	2	5	8	1	9	7	4	3	10	6
		27.73	29.02	30.52	30.67	33.5	33.52	36.18	37.95	38.17	40.09
	6	6	4	3	7	2	10	5	9	8	1
		26.1	26.68	29.62	30.34	31.32	31.93	33.8	34.84	37.16	40.72
	9	4	8	2	6	10	3	7	5	9	1
		25.08	25.25	25.49	26.34	26.6	30.12	31.26	31.58	32.28	33.42
50	0.5	1	6	7	4	5	9	10	3	8	2
		32.03	32.27	32.33	32.34	32.34	32.35	32.37	32.39	32.47	32.51
	1	7	1	10	4	8	9	5	2	3	6
		39.08	39.6	39.7	39.87	39.87	39.89	39.96	39.99	40.4	40.56
	1.5	4	8	1	7	9	5	3	2	10	6
		40.03	41.73	42	42.3	42.64	42.83	43.36	43.45	43.62	44.3
	2	6	2	4	7	8	1	9	5	3	10
		41.42	41.57	41.71	41.94	42.65	42.72	43.2	43.36	43.38	44.97
	3	2	8	5	6	7	9	4	1	3	10
		34.92	36.99	37.62	38.02	38.16	38.64	39.48	42	43.48	45.34

Carseldine Channel at Norris Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
	4.5	4	3	9	6	**5**	**2**	7	8	1	10
		34.88	36.15	36.21	36.32	**37.65**	**39.73**	39.73	39.78	41.25	46.33
	6	2	6	5	3	**4**	**9**	10	7	8	1
		31.8	32.45	32.75	34.07	**34.83**	**35.89**	37.68	47.09	49.78	53.44
	9	3	8	4	9	**10**	**2**	1	6	7	5
		26.03	27.36	28.01	31.42	**33.78**	**34.42**	37.01	39.45	49.18	49.73
100	0.5	1	6	7	4	**5**	**9**	10	3	8	2
		35.24	35.51	35.56	35.58	**35.59**	**35.6**	35.62	35.63	35.72	35.77
	1	7	1	10	8	**4**	**9**	5	2	3	6
		43.36	43.91	44.04	44.24	**44.25**	**44.26**	44.33	44.36	44.83	45.01
	1.5	4	8	1	7	**9**	**5**	3	2	10	6
		44.66	46.56	46.87	47.2	**47.51**	**47.78**	48.45	48.51	48.71	49.54
	2	**6**	**2**	**4**	**7**	**8**	**1**	**9**	**5**	**3**	**10**
		46.38	**46.55**	**46.7**	**46.96**	**47.75**	**47.83**	**48.35**	**48.67**	**48.68**	**50.52**
	3	2	8	5	6	**7**	**9**	4	1	3	10
		39.36	41.74	42.4	42.88	**43.03**	**43.56**	44.34	47.14	49.04	51.18
	4.5	4	9	3	6	**5**	**7**	2	8	1	10
		39.42	40.83	40.92	41.18	**42.38**	**44.69**	44.75	44.79	46.33	52.45
	6	2	6	5	3	**4**	**9**	10	7	8	1
		35.85	36.56	37.08	38.55	**39.49**	**40.57**	42.51	53.51	56.52	60.51
	9	3	8	4	9	**10**	**2**	1	6	7	5
		29.71	31.33	32	35.56	**38.33**	**39.11**	41.99	44.66	55.99	56.66

Carseldine Channel at Fitzgibbon Landfill – Peak Discharge (m³/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
2	0.5	4	3	2	6	**5**	**9**	7	8	10	1
		12.85	12.9	12.97	13.03	**13.18**	**13.21**	13.25	13.29	13.29	13.37
	1	3	2	8	1	**5**	**7**	4	9	6	10
		13.51	14.46	14.79	15.2	**15.31**	**15.37**	15.41	15.78	16.15	16.17
	1.5	2	8	6	4	**1**	**7**	3	5	9	10
		15.01	15.45	15.56	15.79	**15.83**	**16.05**	16.37	16.75	17.09	17.16
	2	5	4	3	9	**2**	**8**	1	7	10	6
		16.88	17.11	17.35	17.36	**17.43**	**17.56**	17.66	17.84	17.96	18.03
	3	3	1	5	10	**2**	**7**	9	4	8	6
		18.63	18.7	18.83	18.89	**18.94**	**19.28**	19.66	19.84	19.85	20.23
	4.5	**1**	**2**	**8**	**3**	**6**	**4**	**10**	**9**	**5**	**7**
		18.12	**18.21**	**18.73**	**18.78**	**19.47**	**19.64**	**19.96**	**21**	**21.01**	**21.73**
	6	2	7	3	6	**9**	**5**	1	4	8	10
		17.2	18.12	18.26	18.4	**18.87**	**19.09**	19.15	19.9	20.72	21.44
	9	2	3	8	10	**9**	**5**	7	6	4	1
		15.26	16.52	16.58	17.57	**18.32**	**18.33**	18.95	19.66	20.78	22.16
5	0.5	4	3	2	6	**5**	**9**	7	10	8	1
		18.51	18.57	18.7	18.79	**19.02**	**19.07**	19.14	19.19	19.2	19.32
	1	3	2	8	1	**5**	**7**	4	9	6	10
		19.67	20.98	21.17	21.81	**21.98**	**22.07**	22.12	22.72	23.28	23.31
	1.5	6	2	4	8	**1**	**7**	3	5	10	9
		23.09	23.14	23.21	23.21	**23.48**	**23.64**	24.39	24.91	25.17	25.73
	2	2	1	3	4	**8**	**9**	5	7	10	6
		25.24	25.55	25.69	25.91	**25.96**	**26.17**	26.23	26.5	26.67	26.71
	3	4	6	9	2	**8**	**1**	3	7	10	5
		28.9	29.13	29.2	29.28	**29.43**	**29.88**	29.93	30.03	30.11	30.64
	4.5	**3**	**2**	**1**	**8**	**6**	**9**	**4**	**5**	**7**	**10**
		27.43	**28.43**	**29.61**	**29.79**	**30.25**	**30.6**	**30.75**	**31.34**	**33.02**	**33.08**
	6	2	7	3	6	**9**	**5**	1	4	8	10
		24.21	25.63	26.96	28	**28.66**	**28.95**	29.47	30.31	33.18	34.36
	9	2	8	3	5	**10**	**9**	7	6	4	1
		23.21	24.28	25.68	25.76	**25.87**	**27.68**	28.71	31.85	32.6	35.46
10	0.5	1	2	3	5	**4**	**6**	8	10	7	9
		22.52	22.6	22.8	22.86	**22.88**	**23.01**	23.27	23.28	23.32	23.35
	1	4	3	2	9	**5**	**8**	6	7	1	10
		24.74	25.15	25.23	25.78	**26.09**	**26.1**	27.22	27.3	28.4	29.76
	1.5	2	4	8	7	**5**	**6**	9	1	3	10

Carseldine Channel at Fitzgibbon Landfill – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
		29.31	29.34	29.47	29.53	29.57	29.75	29.79	29.89	30.49	30.84
	2	3	4	8	10	7	9	6	2	1	5
		32.42	32.77	32.85	32.94	32.96	33.03	33.2	33.35	33.63	33.68
	3	1	3	9	10	8	4	7	6	5	2
		37.12	37.33	37.55	37.76	37.89	37.97	37.99	38.09	38.13	38.22
	4.5	2	4	3	1	5	8	7	9	10	6
		31.3	35.41	37.09	37.26	38.12	38.88	39.77	41.09	41.78	41.81
	6	4	6	2	3	7	10	5	1	8	9
		33.31	33.73	33.92	37.62	37.73	40.44	40.78	42.22	42.28	42.5
	9	8	7	6	4	5	10	9	2	3	1
		28.8	31.22	32.03	32.3	33.59	33.83	34.88	35.42	37.56	39.59
20	0.5	1	2	3	5	4	6	8	10	7	9
		26.58	26.68	26.93	27	27.03	27.19	27.51	27.52	27.57	27.61
	1	4	2	9	3	5	8	7	6	1	10
		30.37	30.53	30.67	30.69	30.94	30.95	32.18	32.37	33.57	35.16
	1.5	8	2	4	7	5	6	9	3	1	10
		35.67	35.97	36	36.2	36.29	36.47	36.5	36.56	36.6	36.79
	2	7	3	10	8	1	9	4	6	2	5
		39.37	39.52	39.86	39.91	40.09	40.13	40.21	40.38	40.53	40.99
	3	9	1	10	3	8	4	7	6	5	2
		45.65	45.7	45.71	45.84	46.03	46.24	46.27	46.55	46.75	46.76
	4.5	2	4	1	3	5	8	7	9	6	10
		36.73	43.02	44.45	45.19	45.41	46.83	47.88	49.47	50.25	51.17
	6	4	6	2	3	7	10	5	1	9	8
		39.53	40.51	40.72	45.96	45.96	48.36	48.98	51.05	51.36	51.6
	9	8	4	7	6	5	10	2	9	3	1
		34.41	38.56	38.97	39.37	39.88	40.53	42.34	43.4	45.1	47.79
50	0.5	1	6	5	4	10	7	9	8	2	3
		31.32	31.73	32.16	32.39	32.52	32.63	32.79	32.98	33.08	33.17
	1	7	10	9	4	5	8	3	6	2	1
		38.04	38.17	38.26	38.27	38.27	38.27	38.39	38.46	40.53	40.61
	1.5	4	8	1	7	2	10	5	9	6	3
		44.16	44.6	44.73	44.75	44.88	44.89	44.95	45.02	45.05	45.11
	2	9	1	6	2	4	8	10	7	3	5
		48.67	48.97	49.02	49.05	49.22	49.26	49.38	49.42	50.12	50.24
	3	2	6	9	5	7	4	1	8	10	3
		56.3	56.63	56.89	56.97	57.08	57.81	58.3	58.73	58.97	59.25

Carseldine Channel at Fitzgibbon Landfill – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
	4.5	**5**	**4**	**7**	**6**	**3**	**2**	**8**	**9**	**1**	**10**
		50.47	**51.59**	**53.52**	**55.09**	**56.5**	**58.14**	**59.24**	**60.1**	**60.24**	**66.51**
	6	9	4	2	5	**3**	**6**	10	8	1	7
		45.07	50.21	52.89	52.96	**53.64**	**55.24**	55.34	55.96	61.36	69.37
	9	8	9	3	2	**4**	**6**	1	10	5	7
		38.81	38.81	41.7	44.08	**44.15**	**46.74**	48.95	48.95	52.56	61.78
100	0.5	1	6	5	4	**10**	**7**	9	8	2	3
		35.26	35.75	36.24	36.5	**36.65**	**36.78**	36.97	37.18	37.31	37.4
	1	7	10	8	5	**9**	**4**	3	6	2	1
		43.57	43.67	43.75	43.76	**43.76**	**43.78**	43.86	43.88	46.27	46.36
	1.5	4	8	7	1	**5**	**2**	10	3	9	6
		50.25	50.46	50.61	50.65	**51**	**51.19**	51.27	51.39	51.56	51.74
	2	9	1	8	4	**7**	**2**	6	3	5	10
		56.35	56.5	56.67	57.04	**57.15**	**57.19**	57.47	57.91	58.02	58.24
	3	6	2	5	9	**7**	**4**	8	1	3	10
		64.2	64.63	64.67	64.69	**64.87**	**66.33**	67.64	67.89	68.71	69.13
	4.5	5	4	7	6	**3**	**2**	8	9	1	10
		58.04	58.97	61.49	62.95	**64.1**	**67.77**	68.3	68.48	69	77.85
	6	9	4	5	2	**3**	**10**	6	8	1	7
		51.3	57.76	59.91	60.01	**60.79**	**62.69**	63.02	67.5	73.76	82.22
	9	8	9	3	4	**2**	**6**	10	1	5	7
		44.71	45.7	47.73	50.67	**50.77**	**53.91**	56.2	56.54	64.06	74.35

Little Cabbage Tree Creek at Hamilton Road – Peak Discharge (m³/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	0.5	3	4	2	6	5	9	8	7	10	1
		17.97	18.06	18.19	18.29	18.78	18.91	18.98	19.05	19.16	19.43
	1	3	2	8	5	1	4	7	6	9	10
		17.77	18.23	18.44	19.52	19.81	19.95	20.07	21.22	21.3	21.7
	1.5	6	3	1	4	8	7	2	5	10	9
		15.77	16.35	16.47	17.09	17.1	17.58	18.54	20.77	21.88	22
	2	2	1	4	8	6	3	7	9	10	5
		13.66	14.78	16.04	16.17	16.4	17.07	17.51	17.79	18.78	20.83
	3	8	4	7	6	9	5	2	10	1	3
		12.71	13.11	13.97	15.25	16.69	18.09	19.35	19.78	19.97	22.61
	4.5	4	6	5	2	7	9	8	3	10	1
		12.06	13.22	13.58	13.92	14.6	14.61	14.91	15.87	15.88	19.42
	6	9	2	5	10	7	6	1	4	8	3
		9.67	9.87	11.88	12.14	12.22	12.64	13.06	13.25	14.39	15.86
	9	8	10	9	7	2	5	6	1	4	3
		8.5	9.8	10.14	10.62	11.55	12.94	14.08	14.77	16.95	17.3
5	0.5	3	4	2	6	5	9	8	7	10	1
		25.7	25.85	26.03	26.19	26.96	27.18	27.27	27.4	27.57	28
	1	3	2	8	5	4	7	1	6	9	10
		25.5	25.72	26.33	27.65	28.34	28.51	28.59	30.3	30.45	31
	1.5	6	1	3	4	8	7	2	5	10	9
		22.19	23.12	23.79	24.09	24.35	24.91	26.62	29.6	31.21	31.51
	2	2	1	8	4	6	3	7	9	10	5
		19.72	21.39	22.68	22.95	23.07	24.24	24.67	25.14	26.47	29.8
	3	8	4	7	6	9	5	2	10	1	3
		17.73	18.41	19.96	21.47	23.65	25.58	28.06	28.29	28.77	32.71
	4.5	4	6	5	2	7	9	8	10	3	1
		17.26	19.12	19.47	20.31	20.91	20.96	21.35	22.88	23.42	27.89
	6	9	2	5	10	7	6	1	4	8	3
		13.85	14.15	17.08	17.2	17.5	18.16	18.53	19.3	20.43	23.08
	9	8	10	9	7	2	5	6	1	4	3
		12.18	14.27	14.64	15.34	16.84	18.86	20.19	21.36	24.58	25.61
10	0.5	2	1	5	4	3	6	8	10	7	9
		31.09	31.25	31.98	32.2	32.28	32.3	33.06	33.36	33.42	33.49
	1	4	2	3	9	5	8	7	6	1	10
		27.13	29.39	31.52	31.64	31.9	32.13	34.68	35.02	37.98	40.55
	1.5	4	2	8	7	5	6	9	1	3	10

Little Cabbage Tree Creek at Hamilton Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		26.2	27.94	28.41	29.11	**31.1**	**31.17**	32.06	33.61	35.91	36.05
	2	3	6	9	7	**8**	**10**	2	4	5	1
		26.28	28.48	29.1	29.77	**30.33**	**30.78**	31.12	33.08	33.33	33.46
	3	5	3	2	6	**8**	**7**	9	4	10	1
		23.04	23.82	26.25	26.32	**27.25**	**29.71**	30.01	30.14	31.07	35.54
	4.5	5	2	8	7	**1**	**9**	10	4	6	3
		17.05	19.28	21.33	21.35	**21.79**	**26.86**	28.12	30.51	33.1	35.53
	6	6	4	10	3	**5**	**8**	7	9	2	1
		15.22	18.95	20.99	22.94	**23.07**	**24.35**	24.74	24.82	28.67	33.48
	9	6	10	8	4	**2**	**3**	9	7	1	5
		15.95	16.55	18.16	19.06	**19.32**	**19.83**	20.42	21.61	21.75	27.04
20	**0.5**	**2**	**1**	**5**	**4**	**3**	**6**	**8**	**10**	**7**	**9**
		36.57	**36.77**	**37.66**	**37.92**	**38.03**	**38.05**	**38.98**	**39.36**	**39.44**	**39.51**
	1	4	2	3	9	**5**	**8**	7	6	1	10
		31.96	34.24	37	37.06	**37.27**	**37.55**	40.71	41.05	44.64	47.75
	1.5	4	2	8	7	**5**	**6**	9	1	3	10
		30.6	33.06	33.25	34.06	**36.85**	**36.86**	37.61	39.67	42.29	42.41
	2	3	6	9	7	**8**	**10**	2	5	4	1
		30.79	33.47	34.19	34.95	**35.51**	**36.07**	36.45	39.24	39.3	39.31
	3	5	3	6	2	**8**	**7**	9	4	10	1
		27.51	28.29	30.9	30.93	**31.99**	**34.97**	35.31	35.69	36.53	42.4
	4.5	5	2	7	8	**1**	**9**	10	4	6	3
		19.93	22.9	25.02	25.07	**25.68**	**31.72**	33.04	36.09	39.14	42.39
	6	6	4	10	5	**3**	**8**	9	7	2	1
		17.94	22.46	24.93	27.32	**27.43**	**28.79**	29.48	29.55	34.44	39.9
	9	6	10	8	4	**2**	**3**	9	1	7	5
		18.89	19.64	21.69	22.89	**23.17**	**23.61**	24.19	25.81	25.81	32.42
50	**0.5**	**1**	**6**	**5**	**4**	**10**	**7**	**9**	**8**	**2**	**3**
		43.16	**43.34**	**44.28**	**45.19**	**45.28**	**45.98**	**46.41**	**46.46**	**46.56**	**47.54**
	1	8	9	7	10	**5**	**4**	6	3	1	2
		43.47	43.6	44.21	44.34	**44.7**	**45.31**	46.97	47.4	52.62	52.69
	1.5	1	4	7	8	**5**	**3**	6	2	9	10
		37.01	39.65	39.81	42	**42.78**	**43.39**	48.54	48.82	49.48	50.27
	2	7	8	4	2	**3**	**6**	1	5	9	10
		35.51	37.55	38.09	38.52	**39.51**	**41.23**	43.14	43.25	44.83	45
	3	7	9	2	5	**6**	**4**	3	8	1	10
		28.68	30.63	32.7	32.87	**33.7**	**35.51**	36.01	36.64	39.55	45.27

Little Cabbage Tree Creek at Hamilton Road – Peak Discharge (m^3/s) and Ensemble Ranking

ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
	4.5	3	8	2	6	**4**	**7**	9	1	5	10
		28.76	29.62	29.95	30.14	**30.98**	**32.46**	34.31	35.52	35.59	38.45
	6	5	2	3	6	**4**	**10**	9	7	8	1
		25.2	25.52	27.51	29.14	**30.34**	**30.65**	34.63	38.89	48.68	57.69
	9	3	4	8	10	**9**	**1**	2	6	7	5
		17.65	19.23	22.62	25.88	**27.76**	**31.61**	31.61	42.43	50.32	55.57
100	**0.5**	**1**	**6**	**5**	**4**	**10**	**7**	**9**	**8**	**2**	**3**
		48.49	**48.67**	**49.76**	**50.82**	**50.92**	**51.74**	**52.23**	**52.27**	**52.4**	**53.55**
	1	8	9	7	10	**5**	**4**	6	3	1	2
		49.05	49.15	49.9	50.01	**50.48**	**51.24**	53.08	53.64	59.67	59.7
	1.5	1	4	7	8	**5**	**3**	6	2	9	10
		41.74	44.83	44.9	47.49	**48.41**	**49.44**	55.02	55.32	56.09	57.02
	2	7	8	4	2	**3**	**6**	1	5	9	10
		40.28	42.43	43.13	43.61	**45**	**46.76**	48.93	49.42	50.84	51.04
	3	7	9	2	5	**6**	**4**	3	8	1	10
		32.73	34.8	37.28	37.5	**38.54**	**40.57**	40.86	41.8	45.03	51.75
	4.5	3	8	2	6	**4**	**7**	9	1	5	10
		32.72	33.61	34.19	34.62	**35.46**	**36.92**	39.13	40.45	40.64	43.73
	6	5	2	3	6	**4**	**10**	9	7	8	1
		28.73	29.14	31.42	33.36	**34.81**	**35**	39.75	44.4	55.84	66.45
	9	3	4	8	10	**9**	**1**	2	6	7	5
		20.14	21.95	25.95	29.62	**31.97**	**36.28**	36.3	49	58.14	64

Little Cabbage Tree Creek at Gympie Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
2	0.5	4	3	2	6	9	5	7	10	1	8
		30.94	31.19	31.29	31.43	31.51	31.52	31.57	31.6	31.66	31.75
	1	2	3	9	7	8	4	5	10	1	6
		36.04	37.23	37.38	37.43	37.78	37.9	38.17	38.8	39.17	39.56
	1.5	3	1	7	6	5	4	2	8	9	10
		29.27	36.22	36.22	36.81	38.42	38.58	38.71	39.11	40.85	42.04
	2	1	2	6	7	8	3	4	9	10	5
		30.92	32.06	33.21	35.78	35.94	36.36	37.88	39.47	39.52	42.39
	3	**4**	**8**	**7**	**6**	**2**	**9**	**1**	**5**	**10**	**3**
		29.13	**30.58**	**32.76**	**33.51**	**37.82**	**39.26**	**39.3**	**39.98**	**40.27**	**44.78**
	4.5	4	6	5	7	3	2	9	8	10	1
		27.28	29.4	29.48	30.57	31.38	31.97	33.9	34.14	35.43	43.65
	6	2	9	7	5	6	4	10	1	3	8
		22.82	23.54	26.59	27.5	27.73	28.53	29.87	30.4	31.94	32.93
	9	8	10	9	2	7	5	6	1	3	4
		20	21.89	24.21	25.1	26.89	29.61	33.86	34.25	37.01	37.11
5	0.5	4	3	2	6	9	5	7	10	1	8
		44.02	44.41	44.56	44.78	44.9	44.91	44.98	45.02	45.12	45.27
	1	2	9	7	3	8	4	5	10	1	6
		51.23	53.12	53.22	53.23	53.9	53.96	54.41	55.3	56.04	56.49
	1.5	3	7	1	6	5	4	2	8	9	10
		41.75	51.31	51.5	52.35	54.52	55.05	55.27	55.79	58.28	60.06
	2	1	2	6	7	8	3	4	9	10	5
		43.28	45.18	46.83	50.55	50.73	51.77	53.76	56.12	56.12	60.39
	3	**4**	**8**	**7**	**6**	**2**	**9**	**1**	**5**	**10**	**3**
		40.91	**42.87**	**46.55**	**47.46**	**54.81**	**55.81**	**56.56**	**57.16**	**57.72**	**64.6**
	4.5	4	5	6	7	3	2	9	8	10	1
		39.12	42.16	42.22	43.65	45.76	46.2	48.71	49.12	50.82	63.48
	6	2	9	7	5	6	4	10	1	3	8
		32.55	33.2	38.03	39.53	39.73	41.55	42.2	43.25	46.35	47.11
	9	8	10	9	2	7	5	6	1	4	3
		28.64	31.44	34.81	36.99	38.66	43.07	49.08	49.4	53.88	54.52
10	0.5	1	3	2	4	5	6	10	7	9	8
		53.32	53.38	53.8	53.8	53.88	54.18	54.23	54.28	54.35	54.46
	1	4	8	2	5	6	9	3	1	7	10
		61.22	63.48	63.74	64.71	64.77	65.12	65.5	66.68	67.3	69.38
	1.5	**8**	**4**	**2**	**7**	**5**	**9**	**6**	**1**	**10**	**3**

Little Cabbage Tree Creek at Gympie Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		58.3	**59.86**	**61.16**	**63.98**	**64.32**	**67.44**	**68.39**	**69.69**	**69.96**	**69.97**
	2	3	7	4	10	**6**	**8**	1	9	2	5
		51.72	58.74	61.51	63.88	**64.21**	**64.48**	66.14	66.73	68.31	68.63
	3	5	3	2	1	**8**	**4**	6	9	7	10
		50.26	54.58	58.08	61.32	**61.47**	**63.11**	63.35	66.09	67.12	68.22
	4.5	2	5	8	1	**7**	**9**	4	10	3	6
		42.39	43.82	46.31	49.9	**52**	**55.28**	63.54	65.96	70.93	72.13
	6	6	4	3	10	**7**	**5**	9	2	8	1
		38.73	43.25	48.6	50.39	**52.15**	**54.61**	55.87	55.94	58.69	72.91
	9	6	2	8	10	**4**	**3**	7	9	1	5
		38.62	39.88	40.63	40.79	**42.17**	**48.05**	51.14	51.3	53.22	54.24
20	0.5	1	3	4	2	**5**	**6**	10	7	9	8
		62.61	62.67	63.18	63.19	**63.29**	**63.65**	63.71	63.76	63.85	63.99
	1	4	8	2	6	**5**	**9**	3	1	7	10
		71.9	74.52	74.87	75.94	**75.96**	**76.47**	76.97	78.23	79.05	81.5
	1.5	**8**	**4**	**2**	**7**	**5**	**9**	**6**	**1**	**3**	**10**
		68.36	**70.18**	**71.82**	**75.29**	**75.53**	**79.44**	**80.61**	**82.13**	**82.39**	**82.39**
	2	3	7	4	10	**6**	**8**	1	9	2	5
		60.42	68.82	72.83	75.13	**75.51**	**75.78**	77.7	78.45	80.4	80.66
	3	5	3	2	8	**1**	**4**	6	9	7	10
		58.85	64.4	68.5	72.3	**73.01**	**74.32**	74.48	77.8	78.99	80.37
	4.5	2	5	8	1	**7**	**9**	4	10	3	6
		50.33	51.3	54.37	58.71	**61.11**	**65.14**	75.26	77.92	84.45	85.5
	6	6	4	3	10	**7**	**5**	9	2	8	1
		45.69	51.39	58.02	59.65	**62.28**	**64.76**	66.2	67.02	69.5	87.1
	9	6	2	8	10	**4**	**3**	9	7	1	5
		45.74	47.57	48.45	48.47	**50.61**	**57.18**	61.06	61.11	63.41	65.04
50	0.5	1	6	5	4	**7**	**10**	9	3	8	2
		73.3	74.78	75.34	75.37	**75.46**	**75.68**	75.69	76.04	76.29	76.57
	1	7	10	8	1	**9**	**4**	5	2	3	6
		84.86	89.19	90.36	90.47	**90.64**	**90.67**	90.93	91.72	93.6	94.44
	1.5	**4**	**8**	**1**	**7**	**5**	**9**	**2**	**3**	**10**	**6**
		79.84	**86.73**	**89.97**	**90.88**	**93.44**	**93.89**	**95.23**	**96.11**	**97.56**	**100.04**
	2	2	4	6	7	**1**	**8**	3	9	5	10
		80.54	80.84	81	83.7	**84.45**	**86.12**	90.74	90.93	91.89	95.18
	3	7	8	6	2	**9**	**5**	4	3	1	10
		68.27	68.49	69.13	72.62	**73.17**	**74.46**	80.45	82.69	83.59	94.71

Little Cabbage Tree Creek at Gympie Road – Peak Discharge (m^3/s) and Ensemble Ranking

ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
	4.5	6	3	9	4	**2**	**8**	7	5	1	10
		64.75	66.02	68.96	70.21	**71.88**	**71.91**	75.29	77.09	79.98	89.99
	6	2	6	5	3	**4**	**10**	9	7	8	1
		56.58	57.86	60.84	61.43	**69.4**	**72.34**	75.36	91.26	109.15	121.99
	9	3	4	8	9	**10**	**2**	1	6	7	5
		45.25	49.13	52.41	61.84	**62.57**	**69.93**	71.84	85.86	107.42	113.62
100	0.5	1	6	5	4	**7**	**10**	9	3	8	2
		82.21	83.91	84.56	84.59	**84.69**	**84.95**	84.96	85.36	85.65	85.97
	1	7	10	1	8	**4**	**9**	5	2	3	6
		95.95	100.96	102.34	102.36	**102.68**	**102.73**	102.97	103.77	106.05	107.03
	1.5	**4**	**8**	**1**	**7**	**5**	9	**2**	**3**	**10**	**6**
		90.34	**98.21**	**101.95**	**103.09**	**105.91**	**106.48**	**108.08**	**109.12**	**110.72**	**113.68**
	2	2	4	6	7	**1**	**8**	3	9	5	10
		91.21	91.52	91.74	94.87	**95.66**	**97.63**	103.26	103.28	104.66	108.17
	3	7	8	6	2	**9**	**5**	4	3	1	10
		77.28	77.77	78.85	83.07	**83.24**	**84.83**	91.85	93.85	95.12	108.06
	4.5	6	3	9	4	**8**	**2**	7	5	1	10
		73.42	74.95	78.48	80.31	**81.58**	**81.74**	85.66	88.2	90.96	102.28
	6	2	6	5	3	**4**	**10**	9	7	8	1
		64.36	65.95	69.58	69.94	**79.58**	**82.53**	86.57	104.08	125.34	140.37
	9	3	4	8	9	**10**	**2**	1	6	7	5
		51.65	56.11	60.33	71.14	**71.67**	**80.66**	82.46	99.3	123.89	131.43

Cabbage Tree Creek at Old Northern Road – Peak Discharge (m³/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	0.5	4	3	2	6	5	9	7	10	8	1
		33.55	33.74	33.91	34.08	34.37	34.43	34.52	34.6	34.67	34.76
	1	3	2	8	7	5	1	4	9	10	6
		36.13	38.25	39.43	40.45	40.57	40.59	40.63	41.28	42.4	42.59
	1.5	3	6	1	8	2	7	4	5	9	10
		33.6	36.43	36.55	37.61	38.27	38.96	39.27	42.57	45.07	45.39
	2	2	1	6	3	4	8	7	9	10	5
		31.96	32.61	36.69	36.95	37.27	38.07	38.84	41.22	42.38	43.53
	3	4	8	7	6	2	9	1	5	10	3
		31.84	31.9	32.06	36.4	39.59	39.75	41.12	41.55	42.98	47.31
	4.5	4	6	2	3	5	7	8	9	10	1
		28.56	30.71	30.94	31.23	32.67	34.44	35.26	35.34	36.98	44.32
	6	2	9	5	7	6	4	10	1	3	8
		23.74	24.34	27.78	28.68	29.03	29.2	30.49	31.92	34.11	34.73
	9	8	10	9	2	7	5	6	1	3	4
		21.29	23.3	25.06	25.7	27.11	29.88	34.78	35.45	37.92	39.28
5	0.5	4	3	2	6	5	9	7	10	8	1
		48.29	48.59	48.86	49.13	49.59	49.67	49.8	49.93	50.05	50.19
	1	3	2	8	7	5	1	4	9	10	6
		51.76	54.7	56.55	58.11	58.31	58.37	58.38	59.4	61.15	61.44
	1.5	3	6	1	8	2	7	4	5	9	10
		47.63	51.7	51.88	53.46	55.37	55.62	56.02	61.13	65.05	65.48
	2	2	1	6	4	3	8	7	9	10	5
		44.79	45.84	52.03	52.74	53.13	53.98	55.12	58.74	60.54	62.67
	3	8	4	7	6	9	2	5	1	10	3
		44.89	44.97	45.94	51.76	56.62	57.85	59.66	59.89	62.02	69
	4.5	4	6	2	3	5	7	9	8	10	1
		41.25	44.14	44.68	46.28	46.92	49.48	50.91	50.99	53.46	64.7
	6	2	9	5	7	4	6	10	1	8	3
		33.97	34.34	40.17	41.25	41.65	41.96	43.44	45.6	49.77	49.93
	9	8	10	9	2	7	5	6	1	3	4
		30.56	33.45	36.12	38.08	38.97	43.71	50.47	51.44	56.02	57.45
10	0.5	1	2	3	4	5	6	10	8	7	9
		58.8	59.16	59.34	59.65	59.65	60.05	60.53	60.61	60.65	60.72
	1	4	2	3	8	9	5	6	7	1	10
		60.76	65.71	67.18	67.76	68.43	68.78	71.39	72.48	74.31	77.76
	1.5	4	5	2	8	7	6	9	1	3	10

Cabbage Tree Creek at Old Northern Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
		61.84	62.02	62.33	64.44	66.52	67.31	71.82	72.88	76.93	77.23
	2	**3**	**4**	**6**	**9**	**7**	**10**	**8**	**5**	**2**	**1**
		60.03	**64.02**	**64.34**	**65.01**	**66.8**	**69.46**	**70.13**	**71.25**	**72.06**	**74.18**
	3	5	3	2	4	6	8	1	7	9	10
		53.71	54.9	60.07	63.41	64.35	65.26	67.85	69.53	69.63	72.61
	4.5	2	5	8	1	7	9	4	10	3	6
		43.14	45.28	52.31	52.48	54.06	62.01	67.87	68.63	74.5	75.44
	6	6	4	3	10	7	5	9	2	8	1
		39.97	45.98	49.31	50.92	55.42	57.17	60.04	60.37	60.94	76.32
	9	6	10	4	8	2	3	7	9	1	5
		41.12	42.28	42.75	42.92	43.34	49.68	50.92	52.22	54.85	59.26
20	0.5	1	2	3	4	5	6	10	8	7	9
		69.42	69.86	70.07	70.45	70.45	70.94	71.53	71.63	71.68	71.76
	1	4	2	3	8	9	5	6	7	1	10
		71.18	77.19	79.01	79.66	80.5	80.91	84.1	85.44	87.64	91.87
	1.5	4	2	5	8	7	6	9	1	3	10
		72.66	73.22	73.63	75.83	78.28	79.21	84.72	86.1	90.99	91.35
	2	**3**	**6**	**4**	**9**	**7**	**10**	**8**	**5**	**2**	**1**
		70.5	**75.88**	**76.29**	**76.8**	**78.64**	**81.77**	**82.59**	**84.31**	**84.88**	**87.52**
	3	5	3	2	4	6	8	1	7	9	10
		63	64.75	71.11	75.26	75.8	76.89	81.24	82.13	82.25	85.68
	4.5	2	5	8	1	7	9	4	10	3	6
		50.77	53.04	61.58	61.86	63.61	73.25	80.71	81.03	89.15	89.62
	6	6	4	3	10	7	5	9	8	2	1
		47.22	54.58	59.3	60.53	66.4	67.89	71.33	72.32	72.71	91.4
	9	6	10	8	4	2	3	7	9	1	5
		48.8	50.29	51.3	51.44	51.93	59.11	61.08	62.18	65.38	71.38
50	0.5	1	6	5	4	10	7	9	8	3	2
		81.66	83.02	84.03	84.43	84.83	84.91	85.28	85.87	86.11	86.19
	1	**7**	**9**	**8**	**4**	**10**	**5**	**3**	**6**	**1**	**2**
		93.69	**95.67**	**95.99**	**96.05**	**96.47**	**97.64**	**100.87**	**101.45**	**103.26**	**104.02**
	1.5	4	1	7	3	5	8	2	9	6	10
		88.48	90.07	94.39	95.08	95.82	96.05	105.58	105.88	107.39	108.86
	2	7	5	4	8	2	3	6	1	9	10
		85.15	88.37	89.63	90.85	90.94	92.38	93.58	97.63	101.71	104.5
	3	7	6	2	9	5	4	8	3	1	10
		69.7	74.16	74.44	74.62	76.02	81.49	81.59	89.22	93.28	101.46

Cabbage Tree Creek at Old Northern Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
	4.5	6	4	3	2	**8**	**7**	9	5	1	10
		67.37	70.94	71.25	73.93	**75.38**	**79.38**	80.2	80.26	86.64	94.13
	6	2	5	3	6	**4**	**10**	9	7	8	1
		61.37	62.91	67.14	67.97	**69.72**	**74.98**	79.33	95.59	110.21	124.03
	9	3	4	8	9	**10**	**2**	1	6	7	5
		47.04	50.79	54.29	63.81	**64.84**	**73.73**	75.82	91.12	110.69	123.26
100	0.5	1	6	5	4	**10**	**7**	9	8	3	2
		91.94	93.51	94.69	95.14	**95.6**	**95.68**	96.12	96.81	97.08	97.18
	1	**7**	**9**	**8**	**4**	**10**	**5**	**3**	**6**	**1**	**2**
		106.18	**108.46**	**108.85**	**108.95**	**109.41**	**110.77**	**114.54**	**115.2**	**117.34**	**118.2**
	1.5	4	1	7	3	**5**	**8**	2	9	6	10
		100.31	102.04	107.08	108.14	**108.89**	**109.06**	120.1	120.51	122.21	123.96
	2	7	5	4	8	**2**	**3**	6	1	9	10
		96.49	101.25	101.76	103.1	**103.29**	**105.2**	106.38	111.05	115.79	118.95
	3	7	6	9	2	**5**	**8**	4	3	1	10
		79.01	85.04	85.09	85.24	**87.04**	**92.97**	93.28	101.47	106.35	116.24
	4.5	6	3	4	2	**8**	**7**	9	5	1	10
		76.47	81.11	81.35	83.96	**85.69**	**90.56**	91.47	92.04	98.79	107.23
	6	2	5	3	6	**4**	**10**	9	7	8	1
		69.94	71.99	76.67	77.66	**80.21**	**85.76**	91.36	109.25	127	143.34
	9	3	4	8	9	**10**	**2**	1	6	7	5
		53.7	58.06	62.59	73.66	**74.43**	**85.16**	87.29	105.78	128.15	142.84

Cabbage Tree Creek at MHG C240 – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
2	0.5	4	3	2	6	**9**	**5**	7	10	1	8
		35.61	35.76	35.82	35.9	**35.96**	**35.97**	36	36.01	36.05	36.1
	1	3	2	9	7	**8**	**4**	5	1	10	6
		43.52	43.82	44.88	44.94	**44.94**	**45.36**	45.41	45.91	45.95	46.52
	1.5	3	1	6	7	**2**	**8**	4	5	9	10
		38.64	44.14	44.9	45.61	**46.51**	**46.79**	47.12	48	49.63	50.84
	2	1	2	6	3	**7**	**8**	4	9	10	5
		40.56	41.61	43.32	45.27	**45.98**	**46.06**	47.26	49.17	49.51	51.39
	3	**4**	**8**	**7**	**6**	**2**	**1**	**9**	**5**	**10**	**3**
		39.15	**40.48**	**41.8**	**43.68**	**44.83**	**47.87**	**49.58**	**50.47**	**51.36**	**54.08**
	4.5	4	3	5	6	**2**	**7**	9	8	10	1
		36.24	38.12	39.09	39.1	**40.43**	**40.87**	43.68	44.16	46.33	53.94
	6	2	9	7	5	**4**	**6**	3	1	10	8
		30.72	32	34.95	35.29	**35.46**	**36.26**	39.58	40.62	40.67	43.62
	9	8	10	2	9	**7**	**5**	6	1	3	4
		26.85	30.21	31.62	32.55	**35.48**	**37.43**	44.35	45.15	45.36	48.18
5	0.5	4	3	2	6	**5**	**9**	7	10	1	8
		50.92	51.15	51.25	51.38	**51.47**	**51.47**	51.53	51.55	51.6	51.69
	1	3	2	9	7	**8**	**4**	5	1	10	6
		62.24	62.62	64.25	64.35	**64.37**	**64.99**	65.08	65.88	65.91	66.8
	1.5	3	1	6	7	**2**	**8**	4	5	9	10
		54.45	62.79	64.02	65.06	**66.76**	**66.96**	67.4	68.71	71.27	73.11
	2	1	2	6	3	**7**	**8**	4	9	10	5
		57.11	58.99	61.31	64.73	**65.15**	**65.37**	67.32	70.15	70.66	73.63
	3	**4**	**8**	**7**	**6**	**2**	**1**	**9**	**5**	**10**	**3**
		55.19	**57.08**	**59.74**	**62.02**	**65.28**	**69.34**	**70.83**	**72.48**	**73.83**	**78.47**
	4.5	4	3	5	6	**7**	**2**	9	8	10	1
		52.12	55.81	55.94	56.08	**58.44**	**58.73**	62.9	63.78	66.72	78.88
	6	2	9	7	5	**4**	**6**	3	10	1	8
		44	45.22	50.15	50.97	**51.41**	**52.19**	57.67	57.8	58.07	62.43
	9	8	10	2	9	**7**	**5**	6	1	3	4
		38.45	43.27	46.68	46.77	**51.26**	**54.66**	64.45	65.37	66.94	70.32
10	0.5	1	3	2	4	**5**	**6**	10	7	9	8
		61.75	61.8	62.03	62.05	**62.1**	**62.29**	62.33	62.35	62.4	62.47
	1	4	2	8	3	**9**	**5**	6	1	7	10
		73	76.41	77.15	77.69	**77.98**	**78**	78.38	80.02	80.08	81.92
	1.5	**2**	**8**	**4**	**5**	**7**	**6**	**9**	**1**	**10**	**3**

Cabbage Tree Creek at MHG C240 – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		74.82	**75.33**	**75.9**	**77.85**	**79.48**	**82.4**	**83.72**	**85.11**	**86.33**	**86.39**
	2	3	4	7	6	**10**	**9**	8	1	2	5
		69.8	74.52	77.03	81.23	**81.72**	**82.01**	82.52	84.75	85.93	86.17
	3	5	3	1	2	**4**	**8**	6	9	7	10
		66.33	70.86	71.87	75.29	**80.62**	**80.64**	82.65	85.11	86.25	87.62
	4.5	2	5	8	1	**7**	**9**	4	10	3	6
		56.81	60.24	63.21	65.72	**70.53**	**73.24**	80.51	84.29	86.2	91.14
	6	6	4	3	7	**10**	**2**	5	9	8	1
		54.01	56.42	61.87	66.23	**66.98**	**68.5**	72.82	74.96	79.12	92.12
	9	4	2	8	6	**10**	**3**	7	9	5	1
		52.59	52.86	53.44	53.61	**55.64**	**63.19**	65.62	67.49	68.88	71
20	0.5	1	3	2	4	**5**	**6**	10	7	9	8
		72.67	72.74	73.02	73.04	**73.11**	**73.33**	73.38	73.4	73.47	73.56
	1	4	2	8	3	**9**	**5**	6	1	7	10
		85.67	89.81	90.69	91.38	**91.72**	**91.73**	92.19	94.18	94.26	96.5
	1.5	**2**	**8**	**4**	**5**	**7**	**6**	**9**	**1**	**10**	**3**
		87.92	**88.58**	**89.31**	**91.86**	**93.63**	**97.22**	**98.79**	**100.5**	**101.98**	**102.04**
	2	3	4	7	6	**10**	**9**	8	1	2	5
		81.78	88.13	90.51	95.75	**96.18**	**96.65**	97.16	99.87	101.28	101.82
	3	5	3	1	2	**8**	**4**	6	9	7	10
		77.72	83.46	85.77	88.99	**95.01**	**95.13**	97.46	100.46	101.82	103.43
	4.5	2	5	8	1	**7**	**9**	4	10	3	6
		66.9	70.67	74.27	77.41	**83.01**	**86.36**	95.68	99.59	102.83	108.16
	6	6	4	3	7	**10**	**2**	5	9	8	1
		63.82	66.92	74.09	79.14	**79.34**	**82.32**	86.42	88.89	93.98	110.2
	9	2	4	6	8	**10**	**3**	7	9	5	1
		63.06	63.23	63.6	63.78	**66.14**	**75.23**	78.71	80.54	82.82	84.65
50	0.5	1	6	5	4	**7**	**10**	9	3	8	2
		86.1	87.02	87.38	87.42	**87.48**	**87.61**	87.63	87.85	88.01	88.18
	1	7	10	8	9	**4**	**5**	1	2	3	6
		106.07	109.07	109.52	109.54	**109.57**	**110.25**	110.48	111.77	112.43	113.1
	1.5	**4**	**1**	**8**	**7**	**5**	**3**	**9**	**2**	**10**	**6**
		103.16	**111.35**	**111.65**	**113.39**	**116.08**	**117.6**	**118.4**	**120.16**	**121.92**	**123.54**
	2	2	4	6	7	**8**	**1**	5	3	9	10
		107.21	107.38	107.9	107.94	**110.84**	**112.42**	114.19	115.87	117.49	122.15
	3	2	8	7	6	**5**	**9**	4	3	1	10
		91.05	93.39	93.83	94.29	**96.66**	**97.76**	103.18	109.83	110.54	122.84

Cabbage Tree Creek at MHG C240 – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
	4.5	6	4	3	9	**2**	**5**	8	7	1	10
		88.89	89.92	91.18	92.7	**98.22**	**98.61**	99.27	101.11	107.56	120.01
	6	2	6	5	3	**4**	**9**	10	7	8	1
		76.38	79.82	82.07	85.52	**89.36**	**95.07**	96.79	122.05	136.64	150
	9	3	8	4	9	**10**	**2**	1	6	7	5
		63.67	68.59	68.66	80.07	**84.83**	**89.52**	95.44	106.78	135.48	141.3
100	0.5	1	6	5	4	**7**	**10**	9	3	8	2
		96.76	97.81	98.24	98.29	**98.36**	**98.5**	98.53	98.78	98.96	99.16
	1	7	10	8	9	**4**	**5**	1	2	3	6
		120.16	123.66	124.19	124.21	**124.26**	**125.04**	125.3	126.8	127.58	128.36
	1.5	**4**	**1**	**8**	**7**	**5**	**3**	**9**	**2**	**10**	**6**
		116.85	**126.44**	**126.72**	**128.76**	**131.97**	**133.8**	**134.62**	**136.63**	**138.69**	**140.59**
	2	2	4	6	7	**8**	**1**	5	3	9	10
		121.66	121.86	122.48	122.59	**125.88**	**127.69**	130.02	131.95	133.66	139.02
	3	2	8	7	6	**5**	**9**	4	3	1	10
		104.33	106.11	106.53	107.06	**110.52**	**111.37**	117.97	124.9	125.92	140.39
	4.5	6	4	3	9	**2**	**8**	5	7	1	10
		101.1	103	103.63	105.46	**111.82**	**112.83**	113.09	115.34	122.52	136.71
	6	2	6	5	3	**4**	**9**	10	7	8	1
		86.9	90.94	93.87	97.46	**102.67**	**109.41**	110.65	139.49	157.42	173.01
	9	3	4	8	9	**10**	**2**	1	6	7	5
		72.69	78.48	79.08	92.28	**97.35**	**103.4**	109.81	123.76	156.49	163.71

Cabbage Tree Creek at 540122 – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
2	0.5	4	3	2	6	**5**	**9**	7	10	1	8
		50.33	50.46	50.5	50.57	**50.61**	**50.61**	50.63	50.64	50.67	50.73
	1	3	2	8	7	**9**	**4**	5	1	10	6
		63.96	64.03	64.91	64.93	**64.93**	**65.17**	65.27	65.69	65.7	66.1
	1.5	2	6	1	8	**4**	**7**	3	5	9	10
		71.04	71.21	71.37	71.43	**71.97**	**72.12**	72.54	73.06	74.34	74.45
	2	3	2	4	1	**8**	**6**	7	9	5	10
		77.55	78	78.16	78.71	**78.96**	**79.13**	79.28	79.62	79.83	80.22
	3	**1**	**2**	**7**	**4**	**3**	**8**	**5**	**6**	**10**	**9**
		83.06	**83.3**	**83.75**	**84.15**	**84.78**	**85.11**	**85.49**	**85.66**	**87.09**	**87.72**
	4.5	3	2	6	4	**5**	**9**	8	1	7	10
		71.65	79.58	79.62	81.2	**81.25**	**83.05**	83.67	83.73	87.88	89.13
	6	2	7	3	9	**6**	**5**	1	4	8	10
		65.35	69.48	72.14	73.38	**75.96**	**77.04**	82.83	82.99	88.67	89.79
	9	8	5	10	2	**9**	**7**	3	6	4	1
		59.23	66.07	67.26	68.74	**71.31**	**72.22**	76.64	85.5	90.25	91.44
5	0.5	4	3	2	6	**9**	**5**	7	10	1	8
		71.23	71.44	71.51	71.61	**71.67**	**71.68**	71.7	71.72	71.76	71.86
	1	2	3	9	7	**8**	**4**	5	10	1	6
		90.85	90.88	92.18	92.2	**92.24**	**92.6**	92.75	93.38	93.45	94.03
	1.5	6	2	1	8	**4**	**7**	3	5	9	10
		101.16	101.26	101.37	101.76	**102.45**	**102.61**	103.1	104.06	106.07	106.27
	2	3	2	4	1	**8**	**6**	7	9	5	10
		109.88	110.67	111.01	111.78	**112.27**	**112.47**	112.76	113.39	113.86	114.32
	3	**1**	**2**	**7**	**4**	**3**	**8**	**5**	**6**	**10**	**9**
		117.96	**118.2**	**119.13**	**119.74**	**120.5**	**121.19**	**121.95**	**122.07**	**124.65**	**125.4**
	4.5	3	2	6	4	**5**	**9**	8	1	7	10
		101.13	113.6	113.83	115.78	**116.06**	**119.1**	120.82	121.8	126.06	128.21
	6	2	7	3	9	**6**	**5**	4	1	8	10
		93.8	99.64	101.5	103.79	**107.42**	**108.63**	118.52	118.85	126.77	127.99
	9	8	5	10	2	**9**	**7**	3	6	4	1
		84.84	95.28	96.56	99.76	**102.13**	**103.43**	112.8	124.19	131.5	132.28
10	0.5	1	3	4	2	**5**	**6**	10	7	9	8
		85.85	85.86	86.08	86.09	**86.13**	**86.27**	86.28	86.31	86.34	86.41
	1	4	2	8	3	**5**	**9**	6	1	7	10
		107.84	110.27	110.66	111.27	**111.32**	**111.38**	111.7	112.76	112.92	114.27
	1.5	5	4	2	7	**6**	**8**	9	1	3	10

Cabbage Tree Creek at 540122 – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		121.15	122.34	122.48	123.25	**124.03**	**124.06**	125.14	125.97	127.2	127.6
	2	5	6	4	9	**3**	**10**	8	2	7	1
		133.43	134.33	135.66	135.77	**135.96**	**137.21**	137.38	137.53	137.81	138.93
	3	**5**	**3**	**2**	**4**	**8**	**1**	**6**	**9**	**10**	**7**
		146.63	**147.18**	**147.92**	**150.04**	**151.25**	**151.56**	**152.52**	**153.76**	**154.27**	**154.32**
	4.5	2	8	4	1	**5**	**3**	9	7	6	10
		123.44	135.36	135.96	137.31	**138.22**	**145.59**	148	150.73	154.38	156.31
	6	4	6	2	7	**10**	**3**	5	1	9	8
		117.13	124.88	128.53	141.4	**143.94**	**145.41**	150.8	155.93	157.59	159.44
	9	8	4	10	7	**5**	**6**	2	9	3	1
		103.1	112.43	122.25	123.07	**124.39**	**124.42**	125.11	132.35	134.44	142.71
20	0.5	1	3	4	2	**5**	**6**	10	7	9	8
		100.57	100.57	100.85	100.86	**100.9**	**101.08**	101.08	101.12	101.16	101.24
	1	4	2	8	3	**5**	**9**	6	1	7	10
		126.32	129.22	129.67	130.44	**130.47**	**130.55**	130.89	132.18	132.4	134.02
	1.5	5	4	2	7	**8**	**6**	9	1	3	10
		142.39	143.88	144.04	145.01	**145.98**	**146.07**	147.33	148.38	149.85	150.33
	2	5	6	4	9	**3**	**10**	8	2	7	1
		156.93	158.13	159.61	159.94	**159.97**	**161.59**	161.8	162.02	162.3	163.7
	3	**5**	**3**	**2**	**4**	**8**	**1**	**6**	**9**	**10**	**7**
		172.89	**173.46**	**174.35**	**177.15**	**178.53**	**178.8**	**180.12**	**181.66**	**182.24**	**182.35**
	4.5	2	8	4	1	**5**	**3**	9	7	6	10
		145.88	159.41	160.07	161.42	**162.49**	**171.95**	174.34	177.65	182.66	184.64
	6	4	6	2	7	**10**	**3**	5	1	9	8
		138.55	147.65	152.14	167.52	**170.44**	**172.6**	178.76	185.96	186.86	189.54
	9	8	4	10	7	**5**	**6**	2	9	3	1
		122.45	133.7	145.13	147.12	**147.19**	**148.21**	148.58	157.89	159.88	169.96
50	0.5	1	6	4	5	**7**	**9**	10	3	8	2
		119.06	119.82	120.1	120.1	**120.13**	**120.24**	120.26	120.39	120.56	120.71
	1	7	10	8	9	**4**	**5**	1	2	3	6
		153.26	155.55	155.94	156	**156.03**	**156.45**	156.85	157.44	158.1	158.62
	1.5	1	7	4	5	**3**	**8**	2	9	6	10
		173.01	174.66	175.13	175.18	**175.58**	**175.84**	178.8	179.94	180.28	180.28
	2	3	5	7	8	**4**	**2**	1	6	10	9
		189.7	190.53	192.6	193.48	**194.46**	**195.41**	195.49	196.14	196.85	196.92
	3	**2**	**8**	**9**	**5**	**6**	**4**	**7**	**10**	**1**	**3**
		200.35	**202.47**	**205.53**	**205.91**	**207.64**	**207.93**	**208.4**	**214.14**	**214.52**	**215.4**

Cabbage Tree Creek at 540122 – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
	4.5	5	4	7	6	**3**	**9**	2	8	1	10
		182.99	186.53	200.58	201.79	**205.67**	**205.96**	218.1	218.8	221.93	239.39
	6	9	2	4	6	**10**	**5**	3	8	1	7
		159.05	182.75	183.86	188.54	**193.55**	**193.62**	195.37	208.78	224.64	245.95
	9	8	9	3	2	**4**	**6**	10	1	5	7
		147.03	150.23	150.86	157.66	**160.15**	**174.87**	178.62	184.89	205.95	225.92
100	0.5	1	6	4	5	**7**	**9**	10	3	8	2
		133.36	134.24	134.55	134.56	**134.59**	**134.72**	134.75	134.9	135.1	135.26
	1	7	10	8	9	**4**	**5**	1	2	3	6
		173.26	175.94	176.41	176.48	**176.52**	**176.99**	177.41	178.09	178.91	179.51
	1.5	1	7	4	5	**3**	**8**	2	9	10	6
		196.25	198.18	198.71	198.87	**199.4**	**199.55**	203	204.34	204.74	204.77
	2	3	5	7	8	**4**	**2**	1	6	10	9
		215.7	216.63	219.08	220.1	**221.25**	**222.35**	222.45	223.2	224.09	224.14
	3	**2**	**8**	**9**	**5**	**6**	**4**	**7**	**10**	**1**	**3**
		228.07	**230.56**	**234.24**	**234.65**	**236.74**	**237**	**237.61**	**244.51**	**244.75**	**245.75**
	4.5	5	4	7	6	**3**	**9**	2	8	1	10
		207.65	212.42	229.08	230.29	**233.95**	**234.38**	248.34	249.22	252.88	273.26
	6	9	2	4	6	**5**	**10**	3	8	1	7
		181.72	208.33	209.96	214.83	**220.65**	**221.07**	222.62	240.07	258.44	281.53
	9	8	3	9	2	**4**	**6**	10	1	5	7
		168.23	172.14	173.16	180.65	**183.09**	**201.44**	204.03	212.89	238.09	260.58

Cabbage Tree Creek at Lemke Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
2	0.5	4	3	2	7	6	9	1	5	10	8
		60.71	60.79	60.82	60.84	60.85	60.85	60.86	60.86	60.86	60.94
	1	3	2	9	7	8	4	5	10	1	6
		79.31	79.39	79.72	79.78	79.87	80.03	80.03	80.17	80.31	80.5
	1.5	3	1	6	2	7	8	4	5	9	10
		87.13	88.63	88.91	89.26	89.26	89.62	89.79	90.16	90.85	91.26
	2	3	2	1	6	7	8	4	9	10	5
		95.21	95.3	95.31	96.33	97.2	97.21	97.36	98.3	98.7	99.11
	3	2	1	4	7	8	6	3	5	10	9
		101.43	102.35	104.19	104.58	105.24	105.66	106.02	108.42	109.14	109.24
	4.5	**3**	**6**	**5**	**2**	**1**	**4**	**9**	**8**	**7**	**10**
		96.42	**102.96**	**104.21**	**105.75**	**106.02**	**106.18**	**106.21**	**109.38**	**110.21**	**113.21**
	6	2	7	3	9	5	6	1	4	8	10
		85.46	92.76	97.87	98.37	103.85	103.9	106.53	106.61	116.27	116.88
	9	8	5	2	10	3	9	7	6	4	1
		78.79	86.13	88.57	89.3	94.44	97.63	98.77	108.79	115.99	119.79
5	0.5	4	3	2	6	9	5	7	10	1	8
		85.75	85.86	85.89	85.94	85.94	85.96	85.96	85.96	85.97	86.05
	1	3	2	9	7	8	5	4	10	1	6
		113.1	113.24	113.84	113.92	114.02	114.26	114.27	114.5	114.71	115.03
	1.5	3	1	6	7	2	8	4	5	9	10
		125.18	128.29	128.76	129.25	129.42	129.97	130.23	130.75	131.95	132.66
	2	1	2	3	6	7	8	4	9	10	5
		137.19	137.34	137.58	138.94	140.4	140.44	141.01	142.69	142.95	143.93
	3	2	1	4	7	8	6	3	5	9	10
		145.47	147.83	150.49	151.34	152.16	152.9	154.53	157.73	158.79	159.83
	4.5	**3**	**6**	**5**	**2**	**4**	**9**	**1**	**8**	**7**	**10**
		138.42	**149.43**	**151.25**	**152.94**	**154.48**	**154.5**	**157.24**	**159.37**	**160.41**	**166.44**
	6	2	7	3	9	6	5	4	1	8	10
		123.56	131.81	139.78	140.96	148.6	148.85	154.38	155.07	168.96	169.13
	9	8	5	10	2	9	3	7	6	4	1
		113.53	125.79	129.25	129.52	141.21	141.4	143.46	161.47	171.27	175.01
10	0.5	1	3	4	2	5	7	10	6	9	8
		103.31	103.31	103.4	103.43	103.43	103.48	103.48	103.49	103.49	103.56
	1	4	2	8	3	6	9	5	1	7	10
		136.99	138.42	138.73	139.02	139.12	139.12	139.13	139.84	139.97	140.62
	1.5	2	8	4	5	7	6	9	1	3	10

Cabbage Tree Creek at Lemke Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
		155.5	155.75	155.81	156.62	157.62	158.91	159.48	160.08	160.58	160.62
	2	4	3	7	6	10	9	8	5	1	2
		167.17	167.43	170.73	172.05	172.9	173.09	173.25	173.57	174.3	174.86
	3	5	1	3	2	8	4	6	9	7	10
		184.47	185.5	185.88	186.61	192.01	192.4	193.78	194.27	195.45	195.6
	4.5	2	8	4	1	5	3	9	7	10	6
		163.62	174.72	181.18	181.71	184.63	186.78	191.83	200.17	201.39	207.78
	6	**4**	**2**	**6**	**7**	**3**	**10**	**5**	**9**	**1**	**8**
		153.87	**166.44**	**174.69**	**191.8**	**194.16**	**194.88**	**200.67**	**207.59**	**209.64**	**211.28**
	9	8	4	7	6	10	2	5	3	9	1
		138.81	145.33	159.77	164.89	167.99	168.29	170.9	177.3	179.25	196.59
20	0.5	1	3	4	5	2	10	7	9	6	8
		122.12	122.13	122.23	122.27	122.28	122.32	122.33	122.33	122.35	122.43
	1	4	2	8	3	5	9	6	1	7	10
		161.48	163.24	163.6	164	164.09	164.09	164.11	164.98	165.15	165.96
	1.5	2	8	4	5	7	6	9	1	3	10
		183.81	184	184.18	185.35	186.43	188.1	188.73	189.47	190.09	190.11
	2	4	3	7	6	10	9	8	5	1	2
		197.14	197.32	201.42	203.23	204.17	204.49	204.62	205.23	205.87	206.63
	3	5	1	3	2	8	4	6	9	7	10
		217.73	218.88	219.52	220.51	226.99	227.51	229.09	229.65	231.1	231.16
	4.5	2	8	4	1	5	3	9	7	10	6
		191.87	205.9	213.26	214.06	217.68	220.68	226.03	236.47	237.57	245.79
	6	**4**	**2**	**6**	**7**	**3**	**10**	**5**	**9**	**1**	**8**
		181.89	**197.6**	**206.5**	**227.33**	**230.69**	**231.32**	**237.96**	**246.25**	**249.83**	**251.11**
	9	8	4	7	6	2	10	5	3	9	1
		164.79	172.77	192.12	197.05	199.57	199.79	202.62	211.02	213.55	233.91
50	0.5	1	6	4	5	7	9	10	3	8	2
		146.19	146.58	146.71	146.71	146.71	146.74	146.78	146.8	146.95	147.01
	1	7	10	1	8	4	9	5	2	3	6
		195.85	197.27	197.56	197.57	197.58	197.6	197.84	198.21	198.84	199.15
	1.5	4	8	1	7	5	3	9	2	10	6
		220.48	224.18	224.23	225.11	226.21	226.96	227.3	228.12	228.8	229.73
	2	2	4	7	6	5	8	3	1	9	10
		242.66	242.68	242.8	242.9	243.48	244.25	244.35	244.74	247.14	249.23
	3	2	8	5	6	4	7	9	1	3	10
		250.8	256.59	260.48	262.04	263.05	263.05	263.09	269.66	272.81	278.01

Cabbage Tree Creek at Lemke Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
	4.5	**5**	**6**	**4**	**9**	**7**	**3**	**1**	**8**	**2**	**10**
		249.03	**262.21**	**262.69**	**263.35**	**265.15**	**273.56**	**285.97**	**288.87**	**289.06**	**306.27**
	6	9	2	10	6	**4**	**3**	5	8	1	7
		224.71	244.53	253.95	254.62	**257.45**	**266.25**	266.74	273.23	293.45	316.64
	9	9	8	2	3	**6**	**4**	1	10	5	7
		195.87	202.1	206.91	213.64	**223.2**	**224.37**	240.8	251.13	263.84	295.57
100	0.5	1	6	4	7	**5**	**9**	10	3	8	2
		164.5	164.96	165.1	165.1	**165.13**	**165.16**	165.2	165.23	165.38	165.47
	1	7	10	1	8	**4**	**9**	5	2	3	6
		221.57	223.19	223.51	223.53	**223.57**	**223.58**	223.84	224.25	224.99	225.35
	1.5	4	8	1	7	**5**	**9**	3	2	10	6
		249.59	254.01	254.27	255.33	**256.85**	**257.86**	257.93	259.14	259.96	261.33
	2	2	4	6	7	**5**	**8**	1	3	9	10
		275.7	275.87	275.92	276.35	**278.13**	**278.23**	278.6	279.04	281.71	284.58
	3	2	8	5	6	**7**	**4**	9	1	3	10
		285.02	292.17	296.96	298.78	**300.07**	**300.21**	300.48	308.39	312.01	318.07
	4.5	**5**	**6**	**9**	**4**	**7**	**3**	**1**	**2**	**8**	**10**
		282.95	**298.47**	**299.2**	**299.39**	**301.29**	**311.94**	**327.15**	**329.81**	**330.06**	**349.47**
	6	9	2	10	6	**4**	**3**	5	8	1	7
		255.13	278.48	290.02	290.38	**294.37**	**303.14**	303.94	315.03	338.05	362.22
	9	9	8	2	3	**4**	**6**	1	10	5	7
		226.06	231.6	237.15	243.95	**256.72**	**257.05**	276.65	287.7	306.17	341.02

Cabbage Tree Creek at Catchment Outlet – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
2	0.5	4	7	1	3	**10**	**2**	5	9	6	8
		64.59	64.62	64.63	64.63	**64.63**	**64.64**	64.64	64.64	64.65	64.68
	1	2	3	9	7	**8**	**10**	5	4	1	6
		84.94	84.94	84.98	85.03	**85.14**	**85.16**	85.17	85.21	85.33	85.37
	1.5	3	1	6	7	**2**	**4**	5	8	9	10
		94.82	96.26	96.33	96.39	**96.64**	**96.76**	96.79	96.79	96.97	97.33
	2	1	6	2	3	**8**	**7**	9	4	10	5
		103.58	103.78	104	104.63	**105.09**	**105.26**	105.45	105.53	105.71	106.23
	3	4	2	6	8	**7**	**1**	9	10	5	3
		114.15	114.5	114.66	115.39	**115.86**	**116.52**	117.68	118.12	118.78	118.87
	4.5	9	6	5	7	**3**	**4**	10	2	8	1
		119.59	120.1	121.82	123.75	**124.19**	**125.17**	125.49	127.34	128.29	131.13
	6	**2**	**7**	**4**	**9**	**3**	**6**	**5**	**10**	**1**	**8**
		125.87	**128.99**	**129.28**	**129.38**	**130.46**	**133.5**	**133.54**	**134.95**	**135.04**	**138.28**
	9	3	8	5	10	**2**	**7**	9	6	1	4
		101.47	108.91	113.9	114.08	**117.31**	**126.35**	127.72	129.05	135.81	139.31
5	0.5	4	1	2	3	**7**	**9**	10	5	6	8
		90.42	90.46	90.47	90.47	**90.47**	**90.47**	90.47	90.48	90.48	90.51
	1	3	2	9	7	**8**	**5**	10	4	1	6
		119.68	119.69	119.82	119.9	**120.01**	**120.07**	120.08	120.11	120.31	120.39
	1.5	3	1	6	7	**2**	**5**	4	8	9	10
		134.67	137.16	137.29	137.38	**137.82**	**138.03**	138.04	138.04	138.45	139.01
	2	1	6	2	3	**8**	**7**	4	9	10	5
		147.63	147.89	148.34	149.34	**149.96**	**150.27**	150.78	150.88	150.98	151.93
	3	4	2	6	8	**7**	**1**	9	10	5	3
		163.46	164.26	164.29	165.56	**166.48**	**167.59**	169.12	170.7	170.93	171.25
	4.5	9	6	5	7	**3**	**4**	10	2	8	1
		172.24	172.88	175.9	179.16	**179.68**	**181.56**	183.24	185.29	186.7	191.21
	6	**2**	**7**	**9**	**4**	**3**	**5**	**6**	**1**	**10**	**8**
		179.81	**185.35**	**185.39**	**185.48**	**188.37**	**192.99**	**193.01**	**195.03**	**195.53**	**200.05**
	9	3	8	10	5	**2**	**7**	9	6	1	4
		149.47	155.49	162.73	163.32	**168.91**	**182.23**	183.04	185.07	198.2	202.46
10	0.5	1	3	4	7	**5**	**9**	10	2	6	8
		108.22	108.22	108.24	108.24	**108.25**	**108.25**	108.25	108.26	108.27	108.28
	1	4	2	8	6	**3**	**9**	5	1	7	10
		144.34	144.87	144.98	145.03	**145.14**	**145.16**	145.17	145.36	145.46	145.63
	1.5	8	2	4	5	**7**	**6**	9	10	1	3

Cabbage Tree Creek at Catchment Outlet – Peak Discharge (m^3/s) and Ensemble Ranking

ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		165.17	165.66	165.72	166.32	166.43	167.15	167.32	167.54	167.59	167.64
	2	3	7	4	10	8	9	6	1	2	5
		178.98	181.13	181.14	182.46	182.58	182.87	183	183.06	184.11	184.35
	3	5	1	3	2	8	4	9	6	10	7
		200.29	201.33	203.38	204.61	205.49	205.75	205.96	206.9	206.9	207.44
	4.5	8	1	9	5	2	10	7	4	3	6
		209.21	214.54	215.92	217.42	218.14	218.69	227.32	227.42	228.29	235.18
	6	**4**	**2**	**6**	**10**	**5**	**3**	**7**	**9**	**8**	**1**
		213.19	**218.46**	**229.57**	**230.25**	**233.53**	**235.15**	**237.88**	**238.68**	**249.12**	**249.91**
	9	4	7	8	6	3	10	2	9	1	5
		187.55	187.88	194.95	200.66	212.59	216.78	223.57	227	236.98	238.07
20	0.5	1	3	4	9	7	10	5	2	6	8
		126.74	126.74	126.76	126.76	126.77	126.77	126.78	126.8	126.8	126.82
	1	4	2	8	6	3	9	5	1	7	10
		169.11	169.75	169.89	169.99	170.09	170.09	170.1	170.36	170.46	170.7
	1.5	8	2	4	5	7	6	9	10	1	3
		194.43	195.05	195.12	195.87	195.99	196.87	197.06	197.35	197.38	197.47
	2	3	7	4	10	8	9	6	1	2	5
		210.64	213.22	213.32	214.85	214.99	215.34	215.51	215.56	216.87	217.17
	3	5	1	3	2	8	4	9	10	6	7
		236.39	237.64	240.17	241.68	242.54	242.84	243.06	244.16	244.21	244.89
	4.5	8	1	9	5	10	2	7	4	3	6
		247.79	254.57	256.15	257.63	258.04	258.15	269.11	269.5	270.27	278.39
	6	**4**	**2**	**6**	**10**	**5**	**3**	**7**	**9**	**8**	**1**
		253.13	**258.61**	**272.97**	**274.33**	**278.4**	**279.4**	**283.35**	**284.55**	**296.38**	**297.5**
	9	7	4	8	6	3	10	2	9	5	1
		222.18	222.65	231.89	239.54	254.02	257.18	265.45	270.99	282.48	282.54
50	0.5	1	6	9	3	4	7	5	10	8	2
		150.77	150.9	150.91	150.92	150.92	150.92	150.94	150.95	151.01	151.02
	1	7	1	10	8	9	4	5	2	3	6
		203.19	203.68	203.74	203.9	203.9	203.91	203.98	204.02	204.37	204.48
	1.5	4	8	1	7	9	5	3	2	10	6
		233.53	235.47	235.75	236.07	236.32	236.65	237.14	237.23	237.41	238.03
	2	6	2	4	7	1	9	8	5	3	10
		257.03	257.4	257.68	258.08	258.63	258.72	258.78	259.93	259.97	261.45
	3	2	8	7	6	5	1	9	4	3	10
		281.46	281.74	287.11	287.34	287.99	288	288.47	290.28	292.89	296.76

Cabbage Tree Creek at Catchment Outlet – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
	4.5	9	1	5	3	**6**	**4**	8	7	2	10
		318.15	318.27	318.89	319.13	**321.14**	**323.99**	327	327.76	330.08	331.96
	6	**10**	**2**	**9**	**8**	**1**	**6**	**4**	**3**	**5**	**7**
		316.6	**318.73**	**327.42**	**328.63**	**329.02**	**330.85**	**333.6**	**335.68**	**341.64**	**348.65**
	9	6	8	2	9	**5**	**1**	3	4	7	10
		245.82	256.18	263.81	267.92	**273.18**	**288.01**	301.21	308.22	313.4	346.51
100	0.5	1	6	7	4	**9**	**3**	5	10	8	2
		168.77	168.93	168.94	168.95	**168.95**	**168.96**	168.98	168.99	169.05	169.08
	1	7	1	10	8	**9**	**4**	5	2	3	6
		229.43	230	230.05	230.22	**230.23**	**230.26**	230.33	230.38	230.78	230.9
	1.5	4	8	1	7	**9**	**5**	3	2	10	6
		264.28	266.52	266.89	267.26	**267.55**	**267.98**	268.57	268.67	268.89	269.67
	2	6	2	4	7	**1**	**9**	8	5	3	10
		291.76	292.22	292.55	293.07	**293.74**	**293.86**	293.93	295.4	295.44	297.22
	3	8	2	7	6	**5**	**1**	9	4	3	10
		320.68	321.45	327.23	327.51	**328.35**	**328.46**	328.92	331.2	334.41	338.94
	4.5	1	9	3	5	**6**	**4**	8	7	2	10
		363.13	363.79	364.14	364.34	**365.95**	**369.82**	373.62	374.03	377.34	379.16
	6	**10**	**2**	**9**	**1**	**8**	**6**	**4**	**3**	**5**	**7**
		362.09	**364.21**	**374.35**	**374.44**	**375.83**	**378.4**	**381.02**	**383.83**	**390.38**	**399.29**
	9	6	8	2	9	**5**	**1**	3	4	7	10
		283.05	294.82	301.5	306.18	**315.37**	**330.41**	343.86	352.74	361.36	396.7

Appendix F: Design Events (Scenario 1) - Peak Flood Levels

The flood level data presented in this Appendix has been extracted (in part) from the results of a 2-dimensional flood model. Levels presented have been extracted generally at selected points along the centreline of the waterway with the intent of demonstrating general flood characteristics. The applicability of this data to locations on the floodplains adjacent should be determined by a suitably qualified professional. It is recommended for any detailed assessment of flood risk associated with the waterway that complete flood model results be accessed and interrogated.

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AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
Cabbage Tree Creek						
0	0.77	0.77	0.77	0.77	0.77	0.77
100	0.77	0.77	0.77	0.77	0.77	0.77
200	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
300	0.77	0.78	0.78	0.79	0.79	0.80
400	0.78	0.78	0.79	0.80	0.82	0.82
500	0.78	0.79	0.80	0.81	0.83	0.84
600	0.78	0.79	0.81	0.82	0.84	0.86
700	0.78	0.80	0.82	0.84	0.86	0.88
800	0.79	0.81	0.83	0.85	0.88	0.90
900	0.80	0.83	0.86	0.90	0.94	0.97
1000	0.81	0.85	0.89	0.94	0.99	1.02
1100	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
1200	0.82	0.88	0.95	1.01	1.08	1.12
1300	0.83	0.90	0.98	1.05	1.13	1.17
1400	0.84	0.91	1.00	1.07	1.16	1.21
1500	0.85	0.93	1.01	1.10	1.19	1.24
1600	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
1700	0.86	0.94	1.04	1.13	1.23	1.29
1800	0.86	0.95	1.05	1.15	1.25	1.31
1900	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
2000	0.89	1.01	1.14	1.26	1.39	1.46
2100	0.90	1.03	1.17	1.30	1.45	1.52
2200	0.92	1.06	1.22	1.36	1.51	1.59
2300	0.94	1.10	1.27	1.41	1.58	1.66
2400	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	1.74
2500	0.98	1.17	1.36	1.53	1.71	1.80
2600	0.99	1.19	1.40	1.57	1.75	1.85
2700	1.01	1.22	1.43	1.61	1.79	1.89
2800	1.02	1.23	1.45	1.63	1.82	1.91
2900	1.02	1.24	1.46	1.64	1.82	1.92
3000	1.03	1.24	1.46	1.64	1.83	1.93
3100	1.03	1.26	1.48	1.66	1.85	1.95

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
3200	1.05	1.28	1.51	1.70	1.89	1.99
3300	1.07	1.31	1.55	1.74	1.93	2.04
3400	1.09	1.34	1.59	1.78	1.97	2.08
Structure S1 – Blackwood Road Bikeway Bridge						
3500	1.13	1.40	1.65	1.87	2.12	2.25
Structure S2 – Shorncliffe Railway						
Structure S3 – Sandgate Road						
3600	1.13	1.40	1.65	1.87	2.12	2.25
3700	1.20	1.48	1.76	1.99	2.24	2.99
3800	1.33	1.65	1.95	2.17	2.41	3.07
3900	1.40	1.74	2.05	2.26	2.49	3.10
4000	1.50	1.88	2.21	2.42	2.64	3.18
4100	1.83	2.29	2.65	2.87	3.06	3.42
4200	1.93	2.39	2.75	2.97	3.17	3.50
4300	1.96	2.42	2.78	3.00	3.20	3.53
4400	1.99	2.45	2.81	3.03	3.24	3.56
4500	2.00	2.47	2.82	3.06	3.26	3.58
Structure S4 – Gateway Motorway						
4600	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
4700	2.12	2.60	2.95	3.19	3.40	3.71
4800	2.25	2.71	3.06	3.28	3.51	3.79
4900	2.42	2.80	3.12	3.34	3.56	3.82
5000	2.62	2.94	3.22	3.41	3.62	3.87
5100	2.75	3.02	3.26	3.45	3.65	3.89
5200	2.99	3.22	3.42	3.58	3.77	3.98
5300	3.29	3.53	3.71	3.85	4.02	4.17
Structure S5 – Lemke Road						
5400	3.38	3.65	3.87	4.02	4.21	4.39
5500	3.73	4.06	4.28	4.44	4.64	4.80
5600	3.92	4.26	4.48	4.64	4.81	4.95
5700	4.15	4.57	4.84	5.03	5.24	5.39
5800	4.39	4.83	5.11	5.31	5.53	5.68
5900	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) [(2)]					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
6000	5.13	5.55	5.76	5.90	6.07	6.18
6100	5.56	6.03	6.28	6.46	6.68	6.83
6200	6.09	6.53	6.80	7.00	7.25	7.41
6300	6.50	6.85	7.09	7.28	7.51	7.66
6400	6.72	7.09	7.34	7.53	7.76	7.92
6500	6.88	7.27	7.54	7.74	7.98	8.14
Structure S7 – Roghan Road						
6600	7.00	7.40	7.68	7.90	8.18	8.38
6700	7.22	7.68	7.98	8.21	8.49	8.67
6800	7.37	7.85	8.16	8.40	8.67	8.85
6900	7.42	7.90	8.21	8.45	8.73	8.91
7000	7.46	7.93	8.24	8.48	8.76	8.94
7100	7.81	8.12	8.35	8.55	8.80	8.96
7200	N/R [(1)]	N/R [(1)]	N/R [(1)]	N/R [(1)]	N/R [(1)]	N/R [(1)]
7300	9.21	9.71	9.96	10.17	10.33	10.42
7400	9.41	9.97	10.23	10.45	10.61	10.70
7500	9.51	10.07	10.35	10.57	10.76	10.86
7600	9.67	10.26	10.56	10.81	11.02	11.14
7700	9.82	10.44	10.77	11.03	11.26	11.41
7800	9.99	10.60	10.94	11.19	11.43	11.57
7900	10.20	10.79	11.13	11.39	11.62	11.75
8000	10.44	11.00	11.33	11.58	11.79	11.92
8100	10.72	11.23	11.55	11.79	12.00	12.12
Structure S9 – Beams Road						
8200	N/R [(1)]	N/R [(1)]	N/R [(1)]	N/R [(1)]	12.24	12.37
8300	10.84	11.37	11.72	12.00	12.26	12.41
8400	10.89	11.41	11.75	12.03	12.29	12.44
8500	10.94	11.43	11.77	12.05	12.31	12.46
8600	11.05	11.52	11.84	12.11	12.36	12.51
8700	11.32	11.71	12.00	12.24	12.49	12.64
Structure S10 – North Coast Railway						
8800	11.75	12.15	12.43	12.69	12.96	13.13
8900	12.15	12.56	12.83	13.08	13.33	13.49

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
9000	12.46	12.86	13.11	13.34	13.56	13.72
9100	12.76	13.16	13.39	13.60	13.81	13.96
9200	13.06	13.50	13.75	13.97	14.17	14.31
9300	13.31	13.81	14.10	14.37	14.60	14.76
9400	13.58	14.10	14.42	14.71	14.95	15.10
9500	13.92	14.47	14.77	15.04	15.26	15.39
9600	14.30	14.86	15.12	15.34	15.54	15.64
9700	14.85	15.41	15.69	15.93	16.12	16.21
9800	15.08	15.63	15.92	16.17	16.36	16.45
9900	15.29	15.85	16.13	16.37	16.56	16.66
Structure S11 – Dorville Road						
10010	15.42	16.01	16.34	16.63	16.88	17.04
10100	15.63	16.25	16.59	16.89	17.16	17.32
10200	16.17	16.74	17.09	17.39	17.66	17.82
10300	16.47	16.98	17.30	17.58	17.84	18.01
10400	16.69	17.16	17.44	17.69	17.93	18.08
10500	17.09	17.55	17.80	18.01	18.20	18.33
10600	17.44	17.92	18.18	18.41	18.59	18.73
10700	17.65	18.15	18.43	18.67	18.87	19.01
Structure S13a – Gympie Road						
10800	17.87	18.42	18.71	18.98	19.22	19.42
10900	18.19	18.68	18.95	19.21	19.45	19.64
11000	18.49	18.86	19.01	19.31	19.53	19.71
11100	18.61	18.94	19.07	19.36	19.56	19.74
11200	18.80	19.08	19.23	19.47	19.66	19.82
11300	19.20	19.52	19.68	19.88	20.06	20.22
11400	19.61	19.97	20.15	20.34	20.51	20.66
11500	19.95	20.33	20.54	20.72	20.90	21.05
11600	20.16	20.57	20.80	21.00	21.18	21.35
11700	20.33	20.74	20.97	21.16	21.34	21.51
11800	20.66	21.01	21.21	21.38	21.55	21.70
11900	20.96	21.24	21.39	21.54	21.68	21.82
12000	21.26	21.50	21.62	21.74	21.87	22.00

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
12100	21.50	21.78	21.91	22.04	22.17	22.30
12200	21.81	22.14	22.29	22.42	22.55	22.66
12300	22.11	22.50	22.65	22.79	22.93	23.05
12400	22.36	22.79	22.96	23.11	23.26	23.39
12500	22.54	22.96	23.13	23.28	23.44	23.58
12600	22.99	23.45	23.66	23.84	24.04	24.20
12700	23.45	23.94	24.17	24.38	24.59	24.75
12800	23.94	24.39	24.59	24.76	24.95	25.08
12900	24.44	24.81	24.97	25.10	25.25	25.37
13000	24.84	25.15	25.30	25.43	25.57	25.68
Structure S15 – Albany Creek Road						
13100	25.01	25.41	25.62	25.82	26.08	26.31
13200	25.26	25.69	25.89	26.08	26.31	26.51
13300	25.74	26.12	26.29	26.43	26.61	26.77
13400	26.52	26.79	26.90	27.01	27.14	27.24
13500	27.02	27.22	27.31	27.40	27.51	27.60
13600	27.08	27.26	27.34	27.43	27.53	27.62
13700	27.60	27.77	27.84	27.92	28.01	28.08
13800	28.01	28.18	28.25	28.32	28.40	28.46
13900	N/R (1)	N/R (1)	N/R (1)	N/R (1)	28.62	28.70
14000	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
14100	29.55	29.66	29.70	29.75	29.81	29.85
14200	30.03	30.14	30.19	30.25	30.31	30.36
14300	30.44	30.53	30.58	30.62	30.69	30.73
14400	30.87	30.97	31.02	31.07	31.13	31.18
14500	31.19	31.34	31.40	31.47	31.56	31.63
14600	31.46	31.63	31.71	31.80	31.92	32.00
14700	31.62	31.78	31.86	31.94	32.05	32.14
14800	31.89	32.04	32.11	32.18	32.28	32.36
14900	32.57	32.79	32.90	33.00	33.14	33.25
15000	32.90	33.10	33.20	33.31	33.45	33.55
15100	33.30	33.49	33.58	33.68	33.82	33.92
15200	33.71	33.88	33.96	34.05	34.16	34.26

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
15300	33.97	34.13	34.21	34.30	34.41	34.50
15400	34.19	34.36	34.45	34.54	34.66	34.76
15500	34.50	34.66	34.74	34.83	34.93	35.02
15600	34.94	35.14	35.24	35.33	35.45	35.54
15700	35.35	35.51	35.59	35.68	35.79	35.87
15800	36.06	36.31	36.43	36.55	36.67	36.74
Structure S19 – Beckett Road						
15900	36.45	36.81	37.00	37.23	37.45	37.58
16000	36.61	36.96	37.14	37.34	37.56	37.69
16100	37.13	37.37	37.50	37.65	37.82	37.94
16200	37.64	37.88	37.97	38.07	38.20	38.29
16300	38.23	38.39	38.46	38.56	38.67	38.76
16400	38.75	38.92	38.99	39.07	39.16	39.24
16500	39.18	39.36	39.43	39.52	39.62	39.70
16600	39.44	39.66	39.75	39.85	39.96	40.05
16700	39.83	40.16	40.30	40.47	40.66	40.83
16800	41.34	41.46	41.52	41.60	41.69	41.76
16900	41.82	41.97	42.03	42.11	42.21	42.29
17000	42.01	42.18	42.26	42.36	42.46	42.55
17035	42.08	42.27	42.35	42.45	42.56	42.65
Sandgate Tributary						
0	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
100	0.85	0.93	1.02	1.11	1.21	1.26
200	0.86	0.94	1.04	1.13	1.23	1.28
300	0.86	0.95	1.05	1.14	1.24	1.30
400	0.86	0.95	1.05	1.15	1.25	1.31
500	0.88	0.98	1.09	1.20	1.31	1.38
600	0.95	1.05	1.17	1.30	1.40	1.51
700	1.07	1.23	1.34	1.44	1.58	1.65
800	1.21	1.36	1.47	1.57	1.69	1.78
Structure S43 – Bridge Street						
900	1.42	1.60	1.74	1.94	2.10	2.22
Structure S44 – Shorncliffe Railway						

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
1000	1.57	1.75	1.90	2.16	2.39	2.64
Structure S45 – Barclay Street						
1100	1.67	1.86	2.04	2.31	2.55	2.74
Structure S46 – Coward Street						
1200	2.01	2.24	2.42	2.69	2.87	2.96
1288	N/R (1)	N/R (1)	2.71	2.88	3.00	3.07
Deagon Tributary						
0	0.94	1.10	1.28	1.42	1.59	1.67
100	0.95	1.11	1.29	1.44	1.60	1.69
200	0.95	1.11	1.29	1.44	1.60	1.69
Structure S47 – Finnie Road						
300	1.01	1.15	1.33	1.48	1.65	1.76
Structure S48 – Blackwood Road						
400	1.13	1.30	1.39	1.53	1.70	1.80
Structure S49 – Shorncliffe Railway						
500	1.25	1.44	1.53	1.64	1.78	1.91
Structure S50 – Smith Street						
Structure S51 – Esther Street						
600	1.41	1.64	1.76	1.87	2.03	2.13
700	1.58	1.78	1.88	1.98	2.13	2.23
Structure S52 – Loftus Street						
800	1.76	1.99	2.13	2.27	2.46	2.60
900	1.89	2.11	2.23	2.35	2.51	2.64
989	2.09	2.23	2.33	2.45	2.58	2.70
Structure S53 – Braun Street						
1100	2.65	2.89	3.01	3.23	3.45	3.66
1200	2.72	2.94	3.05	3.25	3.47	3.68
1300	N/R (1)	N/R (1)	N/R (1)	3.25	3.47	3.68
Taigum Channel						
0	1.65	2.09	2.45	2.67	2.88	3.31
100	1.76	2.25	2.63	2.86	3.06	3.42
200	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
Structure S22a – Gateway Motorway						

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
Structure S23 – 350 Muller Road						
300	N/R (1)	N/R (1)	2.78	2.99	3.18	3.46
Structure S24 – 334 Muller Road						
400	2.70	3.09	3.30	3.47	3.61	3.70
500	2.72	3.10	3.31	3.48	3.63	3.72
600	2.74	3.11	3.32	3.49	3.64	3.74
700	2.95	3.23	3.41	3.56	3.71	3.80
800	3.39	3.57	3.67	3.79	3.91	4.00
900	3.63	3.83	3.90	4.01	4.14	4.22
Structure S25 – 401 Church Road						
Structure S26 – 401A Church Road						
1000	4.51	4.75	4.82	4.92	5.03	5.10
Structure S27 – Church Road						
1100	4.68	4.93	5.01	5.10	5.21	5.27
1200	5.13	5.34	5.41	5.50	5.61	5.68
Structure S28 – Roghan Road						
1300	5.38	5.64	5.74	5.87	6.02	6.12
1400	5.45	5.72	5.82	5.95	6.10	6.20
1500	5.54	5.81	5.90	6.03	6.18	6.28
1600	5.65	5.89	5.98	6.11	6.25	6.35
Structure S29 – Quarrion Street						
1700	5.77	5.99	6.09	6.20	6.34	6.45
1800	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
1900	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
2000	N/R (1)	N/R (1)	N/R (1)	N/R (1)	8.88	8.90
2100	8.86	9.01	9.05	9.12	9.18	9.22
2203	N/R (1)	N/R (1)	N/R (1)	9.40	9.47	9.52
Carseldine Channel						
0	3.83	4.16	4.38	4.54	4.72	4.88
100	3.99	4.30	4.53	4.69	4.87	5.04
200	4.84	5.02	5.07	5.14	5.18	5.27
300	5.14	5.30	5.34	5.39	5.44	5.47
400	5.19	5.37	5.41	5.48	5.61	5.80

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) [(2)]					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
500	5.36	5.62	5.90	6.08	6.22	6.39
600	5.66	6.02	6.33	6.53	6.69	6.89
700	N/R [(1)]	N/R [(1)]	N/R [(1)]	N/R [(1)]	N/R [(1)]	N/R [(1)]
800	5.80	6.17	6.51	6.71	6.86	7.08
900	6.07	6.42	6.72	6.92	7.07	7.29
1000	7.86	7.90	7.93	7.94	7.96	8.00
1100	8.05	8.11	8.14	8.18	8.23	8.32
1200	8.43	8.52	8.59	8.65	8.72	8.79
1300	8.80	8.93	9.01	9.06	9.10	9.16
1400	9.09	9.24	9.33	9.39	9.44	9.48
1500	9.60	9.78	9.91	9.98	10.04	10.10
1600	9.62	9.80	9.94	10.02	10.09	10.15
1700	9.62	9.81	9.95	10.04	10.10	10.16
1800	9.63	9.82	9.96	10.04	10.11	10.17
1900	9.63	9.82	9.96	10.05	10.12	10.18
Structure S30 – Norris Road						
2000	9.71	9.95	10.14	10.28	10.37	10.49
2100	9.77	9.99	10.17	10.31	10.40	10.52
2200	10.02	10.15	10.27	10.39	10.47	10.57
2300	10.46	10.54	10.59	10.64	10.70	10.76
2400	10.75	10.85	10.90	10.94	10.99	11.04
Structure S31 – North Coast Railway						
2500	10.91	11.12	11.24	11.35	11.47	11.58
2600	10.99	11.18	11.29	11.40	11.51	11.62
2700	11.14	11.28	11.37	11.46	11.56	11.66
2800	11.26	11.39	11.47	11.54	11.62	11.71
2900	11.43	11.54	11.60	11.65	11.72	11.79
3000	11.58	11.68	11.72	11.77	11.82	11.88
Structure S32 – Lacey Road						
3100	11.67	11.92	11.96	12.00	12.05	12.12
3200	13.43	13.53	13.56	13.58	13.61	13.65
3300	13.54	13.64	13.68	13.72	13.76	13.80
Upstream of Lacey Road - AMTD Chainage commences at 5000 m						

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
5000	11.63	11.81	11.87	11.94	12.00	12.08
5100	13.85	13.91	13.93	13.95	13.97	14.00
5200	14.11	14.16	14.18	14.20	14.23	14.26
5300	N/R (1)	N/R (1)	14.58	14.59	14.60	14.62
5400	15.54	15.58	15.59	15.61	15.62	15.64
5500	16.21	16.26	16.28	16.30	16.31	16.33
5600	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
Structure S33 – Gympie Road						
5700	17.32	17.63	17.77	17.90	17.99	18.05
5800	17.74	17.96	18.06	18.18	18.28	18.34
5900	18.84	18.99	19.04	19.12	19.19	19.23
6000	19.69	19.88	19.94	20.02	20.10	20.16
6100	21.33	21.43	21.46	21.51	21.56	21.59
6200	22.46	22.56	22.60	22.65	22.70	22.73
6300	N/R (1)	N/R (1)	N/R (1)	N/R (1)	23.97	24.02
6350	24.04	24.26	24.37	24.47	24.60	24.68
Fitzgibbon Tributary						
0	9.45	10.00	10.27	10.49	10.66	10.75
100	9.44	10.00	10.28	10.49	10.65	10.75
200	9.44	10.00	10.28	10.49	10.65	10.75
300	9.44	10.00	10.28	10.49	10.65	10.75
400	9.44	10.01	10.28	10.49	10.65	10.75
500	9.45	10.01	10.28	10.49	10.65	10.75
600	9.45	10.01	10.28	10.49	10.65	10.75
700	9.45	10.01	10.28	10.49	10.65	10.75
800	9.45	10.01	10.28	10.49	10.65	10.75
900	N/R (1)	10.01	10.28	10.49	10.65	10.75
1000	9.45	10.01	10.28	10.49	10.65	10.75
1103	N/R (1)	10.01	10.28	10.50	10.65	10.75
Little Cabbage Tree Creek						
0	13.67	14.19	14.52	14.81	15.05	15.20
100	13.80	14.36	14.71	14.99	15.22	15.36
200	N/R (1)	14.75	15.11	15.40	15.56	15.71

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
300	14.72	15.24	15.52	15.78	15.95	16.12
400	15.11	15.53	15.74	15.97	16.15	16.32
500	15.30	15.71	15.90	16.13	16.32	16.50
Structure S34 – Zillmere Road						
600	15.46	15.89	16.09	16.34	16.58	16.79
700	15.87	16.31	16.49	16.72	16.95	17.14
800	16.09	16.55	16.74	16.97	17.19	17.37
900	N/R (1)	16.87	17.07	17.30	17.53	17.71
1000	16.95	17.45	17.62	17.83	18.04	18.21
1100	17.87	18.28	18.43	18.60	18.77	18.92
1200	18.26	18.64	18.78	18.96	19.12	19.26
Structure S35 – Gympie Road						
Structure S36 – Gayford Street						
1400	N/R (1)	N/R (1)	N/R (1)	19.79	19.95	20.04
1500	N/R (1)	N/R (1)	19.91	19.97	20.06	20.13
1600	N/R (1)	20.44	20.58	20.69	20.77	20.81
Structure S37 – Albany Creek Road						
1700	N/R (1)	N/R (1)	N/R (1)	21.59	21.76	21.94
1800	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
1900	22.22	22.44	22.53	22.63	22.73	22.84
2000	23.02	23.26	23.36	23.48	23.59	23.68
2100	23.64	23.84	23.93	24.04	24.15	24.23
2200	24.26	24.40	24.46	24.54	24.62	24.69
2300	N/R (1)	N/R (1)	N/R (1)	N/R (1)	25.20	25.27
2400	25.64	25.82	25.90	26.00	26.10	26.18
2500	26.17	26.37	26.45	26.56	26.67	26.76
2600	26.58	26.75	26.82	26.92	27.03	27.12
2700	27.28	27.43	27.50	27.58	27.67	27.74
Structure S39 – Horn Road Bikeway Bridge						
2800	27.82	28.13	28.26	28.41	28.56	28.68
2900	28.16	28.45	28.56	28.69	28.86	28.98
3000	28.74	28.98	29.06	29.18	29.33	29.43
3100	29.23	29.50	29.59	29.72	29.88	29.99

AMTD (m)	Design Events – Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
3200	29.57	29.84	29.94	30.08	30.25	30.37
3300	30.12	30.36	30.45	30.56	30.73	30.84
3400	30.70	30.91	30.98	31.08	31.21	31.30
3500	31.37	31.58	31.65	31.74	31.86	31.93
Structure S40 – Martindale Street						
3600	N/R (1)	31.96	32.03	32.14	32.27	32.36
3700	32.37	32.62	32.69	32.78	32.91	33.00
3800	32.87	33.22	33.29	33.39	33.50	33.58
3900	N/R (1)	33.51	33.56	33.64	33.73	33.81
4000	N/R (1)	34.17	34.18	34.21	34.26	34.32
4100	35.41	35.53	35.58	35.66	35.75	35.82
4200	N/R (1)	35.92	35.98	36.06	36.19	36.26
4300	35.95	36.23	36.32	36.44	36.60	36.70
4400	36.12	36.41	36.50	36.64	36.80	36.92
4494	36.25	36.55	36.64	36.78	36.96	37.08

(1) N/R = no result, typically because the AMTD line does not intersect the flood surface.

(2) Flood levels are inclusive of a 9.8% increase in rainfall intensity due to projected climate variability effects.

Appendix G: Design Events (Scenario 3) - Peak Flood Levels

The flood level data presented in this Appendix has been extracted (in part) from the results of a 2-dimensional flood model. Levels presented have been extracted generally at selected points along the centreline of the waterway with the intent of demonstrating general flood characteristics. The applicability of this data to locations on the floodplains adjacent should be determined by a suitably qualified professional. It is recommended for any detailed assessment of flood risk associated with the waterway that complete flood model results be accessed and interrogated.

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AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
Cabbage Tree Creek						
0	0.77	0.77	0.77	0.77	0.77	0.77
100	0.77	0.77	0.77	0.77	0.77	0.77
200	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
300	0.77	0.78	0.78	0.79	0.79	0.80
400	0.78	0.78	0.79	0.80	0.81	0.82
500	0.78	0.79	0.80	0.81	0.83	0.84
600	0.78	0.79	0.81	0.82	0.84	0.86
700	0.78	0.80	0.81	0.83	0.86	0.88
800	0.79	0.80	0.82	0.85	0.88	0.90
900	0.80	0.82	0.86	0.89	0.93	0.96
1000	0.80	0.84	0.88	0.93	0.98	1.02
1100	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
1200	0.82	0.87	0.93	0.99	1.07	1.12
1300	0.83	0.89	0.96	1.03	1.12	1.17
1400	0.84	0.91	0.98	1.05	1.15	1.20
1500	0.84	0.92	1.00	1.08	1.17	1.23
1600	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
1700	0.85	0.94	1.02	1.11	1.22	1.28
1800	0.86	0.94	1.03	1.12	1.23	1.30
1900	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
2000	0.88	1.00	1.11	1.23	1.37	1.44
2100	0.90	1.02	1.15	1.27	1.42	1.50
2200	0.91	1.05	1.19	1.32	1.48	1.56
2300	0.93	1.08	1.23	1.38	1.55	1.63
2400	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	1.70
2500	0.97	1.15	1.33	1.49	1.68	1.76
2600	0.98	1.17	1.36	1.53	1.72	1.81
2700	1.00	1.20	1.39	1.57	1.76	1.85
2800	1.01	1.21	1.41	1.59	1.79	1.88
2900	1.01	1.22	1.42	1.59	1.80	1.89
3000	1.01	1.22	1.42	1.60	1.80	1.89
3100	1.02	1.23	1.44	1.62	1.82	1.92

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
3200	1.04	1.26	1.47	1.65	1.86	1.95
3300	1.06	1.29	1.51	1.70	1.90	2.00
3400	1.08	1.32	1.54	1.73	1.94	2.04
Structure S1 – Blackwood Road Bikeway Bridge						
3500	1.12	1.37	1.61	1.80	2.05	2.26
Structure S2 – Shorncliffe Railway						
Structure S3 – Sandgate Road						
3600	1.18	1.46	1.71	1.92	2.17	2.92
3700	1.31	1.63	1.90	2.11	2.35	3.00
3800	1.38	1.72	2.00	2.20	2.44	3.04
3900	1.47	1.86	2.16	2.37	2.60	3.12
4000	1.81	2.26	2.59	2.82	3.03	3.38
4100	1.90	2.36	2.69	2.92	3.13	3.46
4200	1.93	2.38	2.72	2.95	3.16	3.49
4300	1.96	2.41	2.75	2.99	3.20	3.52
4400	1.97	2.43	2.77	3.01	3.22	3.54
4500	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	3.56
Structure S4 – Gateway Motorway						
4600	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
4700	2.09	2.56	2.90	3.14	3.36	3.67
4800	2.26	2.68	3.02	3.25	3.47	3.76
4900	2.41	2.78	3.08	3.30	3.51	3.79
5000	2.64	2.93	3.19	3.39	3.59	3.85
5100	2.79	3.03	3.26	3.45	3.63	3.88
5200	3.03	3.25	3.44	3.60	3.77	3.99
5300	3.35	3.60	3.79	3.94	4.09	4.25
Structure S5 – Lemke Road						
5400	3.49	3.80	4.03	4.22	4.41	4.58
5500	3.85	4.20	4.45	4.62	4.81	4.96
5600	4.10	4.49	4.73	4.88	5.04	5.18
5700	4.33	4.78	5.06	5.25	5.43	5.56
5800	4.53	4.99	5.28	5.48	5.67	5.80
5900	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
6000	5.17	5.63	5.85	6.02	6.19	6.30
6100	5.60	6.08	6.35	6.55	6.76	6.91
6200	6.12	6.56	6.85	7.07	7.31	7.47
6300	6.53	6.90	7.15	7.36	7.58	7.73
6400	6.74	7.12	7.39	7.60	7.82	7.98
6500	6.92	7.33	7.62	7.85	8.08	8.25
Structure S7 – Roghan Road						
6600	7.04	7.48	7.79	8.04	8.31	8.51
6700	7.25	7.74	8.06	8.32	8.61	8.80
6800	7.40	7.91	8.24	8.51	8.79	8.99
6900	7.47	7.98	8.31	8.58	8.86	9.06
7000	7.53	8.04	8.37	8.63	8.92	9.12
7100	7.96	8.32	8.58	8.80	9.05	9.23
7200	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
7300	9.21	9.71	9.99	10.18	10.36	10.47
7400	9.40	9.94	10.24	10.44	10.63	10.74
7500	9.50	10.06	10.37	10.58	10.78	10.91
7600	9.65	10.23	10.56	10.80	11.03	11.16
7700	9.80	10.40	10.76	11.01	11.26	11.41
7800	9.99	10.59	10.95	11.21	11.45	11.60
7900	10.19	10.79	11.15	11.41	11.64	11.78
8000	10.44	11.02	11.38	11.64	11.85	11.98
8100	10.77	11.30	11.64	11.89	12.09	12.21
Structure S9 – Beams Road						
8200	N/R (1)	N/R (1)	N/R (1)	12.06	12.31	12.43
8300	10.90	11.45	11.82	12.10	12.35	12.49
8400	10.95	11.49	11.86	12.14	12.39	12.53
8500	11.01	11.53	11.90	12.18	12.43	12.58
8600	11.14	11.64	11.99	12.27	12.52	12.67
8700	11.41	11.85	12.16	12.42	12.67	12.82
Structure S10 – North Coast Railway						
8800	11.78	12.20	12.52	12.79	13.06	13.23
8900	12.16	12.59	12.89	13.15	13.41	13.57

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
9000	12.47	12.89	13.16	13.39	13.64	13.79
9100	12.77	13.18	13.43	13.64	13.87	14.02
9200	13.06	13.51	13.78	14.00	14.23	14.36
9300	13.30	13.81	14.12	14.38	14.65	14.80
9400	13.58	14.11	14.44	14.72	15.00	15.17
9500	13.92	14.47	14.78	15.05	15.30	15.44
9600	14.30	14.87	15.14	15.37	15.57	15.68
9700	14.87	15.45	15.75	16.00	16.17	16.26
9800	15.13	15.70	16.01	16.27	16.44	16.54
9900	15.34	15.90	16.21	16.46	16.64	16.75
Structure S11 – Dorville Road						
10010	15.46	16.05	16.39	16.69	16.94	17.12
10100	15.65	16.26	16.62	16.93	17.20	17.39
10200	16.17	16.76	17.12	17.43	17.71	17.93
10300	16.47	17.00	17.34	17.63	17.91	18.12
10400	16.70	17.18	17.47	17.73	17.99	18.19
10500	17.08	17.53	17.80	18.02	18.23	18.40
10600	17.42	17.89	18.17	18.40	18.61	18.80
10700	17.63	18.12	18.41	18.66	18.89	19.09
Structure S13a – Gympie Road						
10800	17.86	18.39	18.70	18.98	19.26	19.52
10900	18.28	18.76	19.05	19.32	19.58	19.82
11000	18.63	19.08	19.36	19.61	19.86	20.08
11100	18.74	19.16	19.42	19.67	19.92	20.13
11200	18.88	19.25	19.50	19.74	19.97	20.18
11300	19.25	19.62	19.85	20.07	20.29	20.48
11400	19.65	20.03	20.25	20.46	20.66	20.84
11500	19.98	20.38	20.60	20.81	21.02	21.19
11600	20.19	20.63	20.87	21.10	21.31	21.49
11700	20.36	20.80	21.04	21.26	21.46	21.64
11800	20.70	21.07	21.28	21.47	21.66	21.82
11900	21.02	21.32	21.48	21.64	21.80	21.95
12000	21.35	21.60	21.73	21.86	22.01	22.15

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) [(2)]					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
12100	21.58	21.89	22.04	22.19	22.33	22.48
12200	21.87	22.23	22.39	22.54	22.68	22.81
12300	22.14	22.54	22.71	22.86	23.00	23.13
12400	22.38	22.82	22.99	23.15	23.31	23.44
12500	22.58	23.01	23.20	23.37	23.54	23.69
12600	23.01	23.48	23.69	23.89	24.10	24.28
12700	23.45	23.94	24.18	24.40	24.62	24.80
12800	23.93	24.39	24.61	24.80	24.99	25.14
12900	24.44	24.85	25.03	25.18	25.34	25.48
13000	24.84	25.21	25.37	25.52	25.68	25.82
Structure S15 – Albany Creek Road						
13100	25.02	25.46	25.67	25.89	26.16	26.42
13200	25.26	25.72	25.93	26.14	26.39	26.61
13300	25.72	26.13	26.31	26.48	26.69	26.86
13400	26.49	26.79	26.91	27.04	27.19	27.31
13500	27.03	27.25	27.35	27.46	27.59	27.68
13600	27.19	27.38	27.47	27.57	27.69	27.79
13700	27.69	27.88	27.96	28.04	28.15	28.23
13800	28.09	28.28	28.36	28.45	28.54	28.62
13900	N/R [(1)]	N/R [(1)]	28.70	28.81	28.93	29.02
14000	N/R [(1)]	N/R [(1)]	N/R [(1)]	N/R [(1)]	N/R [(1)]	N/R [(1)]
14100	29.58	29.72	29.77	29.83	29.90	29.95
14200	30.07	30.20	30.26	30.32	30.39	30.45
14300	30.53	30.68	30.74	30.81	30.89	30.96
14400	30.94	31.06	31.12	31.19	31.27	31.33
14500	31.25	31.40	31.48	31.57	31.67	31.75
14600	31.52	31.71	31.81	31.91	32.04	32.14
14700	31.71	31.91	32.01	32.11	32.24	32.34
14800	32.02	32.22	32.32	32.43	32.56	32.66
14900	32.62	32.86	32.98	33.10	33.26	33.38
15000	32.97	33.19	33.30	33.42	33.58	33.70
15100	33.36	33.56	33.66	33.78	33.93	34.05
15200	33.72	33.89	33.99	34.09	34.22	34.32

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
15300	34.00	34.17	34.26	34.35	34.47	34.57
15400	34.25	34.44	34.53	34.63	34.76	34.86
15500	34.56	34.74	34.83	34.92	35.04	35.14
15600	34.96	35.17	35.27	35.38	35.51	35.61
15700	35.36	35.54	35.63	35.73	35.84	35.93
15800	36.10	36.38	36.50	36.63	36.74	36.82
Structure S19 – Beckett Road						
15900	36.48	36.86	37.07	37.29	37.49	37.62
16000	36.64	37.02	37.21	37.41	37.61	37.74
16100	37.16	37.42	37.55	37.71	37.88	37.99
16200	37.66	37.91	38.01	38.11	38.24	38.34
16300	38.24	38.40	38.48	38.58	38.69	38.78
16400	38.78	38.96	39.04	39.13	39.24	39.32
16500	39.22	39.41	39.49	39.59	39.69	39.78
16600	39.49	39.72	39.82	39.93	40.05	40.15
16700	39.85	40.18	40.33	40.50	40.71	40.87
16800	41.38	41.51	41.57	41.64	41.73	41.80
16900	41.91	42.09	42.16	42.25	42.36	42.45
17000	42.10	42.31	42.41	42.52	42.64	42.74
17035	42.17	42.39	42.49	42.61	42.74	42.84
Sandgate Tributary						
0	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
100	0.85	0.92	1.01	1.09	1.19	1.25
200	0.85	0.93	1.02	1.11	1.21	1.29
300	0.86	0.94	1.03	1.12	1.22	1.30
400	0.86	0.94	1.04	1.13	1.24	1.32
500	0.88	0.97	1.09	1.19	1.30	1.39
600	0.95	1.06	1.19	1.30	1.41	1.51
700	1.07	1.24	1.39	1.53	1.63	1.70
800	1.23	1.39	1.55	1.68	1.80	1.89
Structure S43 – Bridge Street						
900	1.43	1.65	1.91	2.12	2.27	2.37
Structure S44 – Shorncliffe Railway						

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) [(2)]					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
1000	1.57	1.80	2.10	2.38	2.63	2.86
Structure S45 – Barclay Street						
1100	1.68	1.91	2.24	2.53	2.76	2.96
Structure S46 – Coward Street						
1200	2.01	2.27	2.64	2.86	3.03	3.18
1288	N/R [(1)]	2.61	2.86	3.01	3.14	3.26
Deagon Tributary						
0	0.93	1.09	1.24	1.39	1.56	1.64
100	0.94	1.09	1.25	1.40	1.58	1.65
200	0.94	1.09	1.25	1.40	1.58	1.66
Structure S47 – Finnie Road						
300	1.01	1.15	1.31	1.44	1.62	1.75
Structure S48 – Blackwood Road						
400	1.13	1.29	1.38	1.50	1.66	1.80
Structure S49 – Shorncliffe Railway						
500	1.25	1.44	1.53	1.64	1.75	1.88
Structure S50 – Smith Street						
Structure S51 – Esther Street						
600	1.41	1.64	1.75	1.87	2.02	2.13
700	1.58	1.78	1.87	1.98	2.13	2.23
Structure S52 – Loftus Street						
800	1.76	1.98	2.12	2.26	2.45	2.60
900	1.89	2.11	2.23	2.36	2.51	2.65
989	2.09	2.27	2.36	2.48	2.61	2.72
Structure S53 – Braun Street						
1100	2.65	2.90	3.02	3.24	3.47	3.69
1200	2.72	2.95	3.06	3.27	3.49	3.70
1300	N/R [(1)]	N/R [(1)]	N/R [(1)]	3.27	3.49	3.70
Taigum Channel						
0	1.62	2.07	2.40	2.63	2.85	3.27
100	1.73	2.22	2.58	2.82	3.03	3.38
200	N/R [(1)]	N/R [(1)]	N/R [(1)]	N/R [(1)]	N/R [(1)]	N/R [(1)]
Structure S22a – Gateway Motorway						

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
Structure S23 – 350 Muller Road						
300	N/R (1)	N/R (1)	2.77	2.99	3.21	3.44
Structure S24 – 334 Muller Road						
400	2.71	3.10	3.34	3.57	3.77	3.90
500	2.73	3.13	3.36	3.58	3.79	3.93
600	2.75	3.14	3.38	3.60	3.81	3.94
700	2.96	3.26	3.46	3.67	3.87	4.01
800	3.39	3.59	3.70	3.85	4.02	4.16
900	3.63	3.84	3.92	4.05	4.19	4.31
Structure S25 – 401 Church Road						
Structure S26 – 401A Church Road						
1000	4.51	4.75	4.83	4.93	5.06	5.13
Structure S27 – Church Road						
1100	4.68	4.95	5.03	5.13	5.25	5.33
1200	5.14	5.38	5.46	5.56	5.69	5.78
Structure S28 – Roghan Road						
1300	5.38	5.68	5.78	5.93	6.10	6.24
1400	5.46	5.75	5.86	6.00	6.18	6.31
1500	5.55	5.83	5.94	6.08	6.25	6.38
1600	5.65	5.91	6.01	6.15	6.31	6.44
Structure S29 – Quarrion Street						
1700	5.77	6.01	6.11	6.24	6.39	6.52
1800	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
1900	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
2000	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	8.90
2100	8.86	9.02	9.08	9.15	9.23	9.28
2203	N/R (1)	N/R (1)	9.35	9.43	9.52	9.58
Carseldine Channel						
0	3.97	4.34	4.58	4.74	4.91	5.06
100	4.06	4.40	4.65	4.82	5.00	5.17
200	4.85	5.03	5.08	5.15	5.20	5.38
300	5.13	5.30	5.34	5.39	5.44	5.58
400	5.19	5.38	5.43	5.55	5.73	5.91

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
500	5.36	5.63	5.93	6.12	6.30	6.49
600	5.65	6.02	6.35	6.55	6.74	6.95
700	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
800	5.79	6.18	6.53	6.73	6.93	7.16
900	6.06	6.42	6.74	6.94	7.13	7.36
1000	7.88	7.92	7.95	7.97	7.99	8.02
1100	8.08	8.14	8.18	8.21	8.26	8.33
1200	8.42	8.51	8.57	8.63	8.71	8.79
1300	8.80	8.93	9.01	9.07	9.11	9.18
1400	9.08	9.24	9.34	9.40	9.44	9.49
1500	9.62	9.79	9.92	9.99	10.06	10.15
1600	9.63	9.81	9.95	10.03	10.11	10.19
1700	9.64	9.82	9.96	10.04	10.12	10.20
1800	9.64	9.82	9.97	10.05	10.13	10.21
1900	9.64	9.83	9.97	10.06	10.14	10.22
Structure S30 – Norris Road						
2000	9.73	9.96	10.15	10.30	10.39	10.52
2100	9.78	10.00	10.19	10.33	10.42	10.55
2200	10.04	10.16	10.29	10.41	10.50	10.61
2300	10.47	10.55	10.61	10.66	10.72	10.79
2400	10.77	10.87	10.93	10.97	11.03	11.08
Structure S31 – North Coast Railway						
2500	10.92	11.13	11.25	11.37	11.50	11.62
2600	11.01	11.20	11.32	11.43	11.55	11.67
2700	11.16	11.31	11.41	11.50	11.61	11.72
2800	11.29	11.43	11.51	11.58	11.67	11.77
2900	11.45	11.57	11.63	11.70	11.77	11.86
3000	11.62	11.73	11.78	11.83	11.90	11.98
Structure S32 – Lacey Road						
3100	11.84	11.96	12.00	12.04	12.12	12.19
3200	13.45	13.55	13.57	13.60	13.65	13.70
3300	13.51	13.62	13.65	13.68	13.74	13.80
Upstream of Lacey Road - AMTD Chainage commences at 5000 m						

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
5000	11.55	11.72	11.79	11.87	11.97	12.08
5100	13.90	13.96	13.98	14.00	14.04	14.07
5200	14.14	14.20	14.22	14.25	14.29	14.32
5300	N/R (1)	N/R (1)	14.57	14.58	14.61	14.65
5400	15.56	15.60	15.62	15.64	15.66	15.68
5500	16.24	16.31	16.33	16.34	16.37	16.39
5600	N/R (1)	N/R (1)	N/R (1)	N/R (1)	16.97	17.00
Structure S33 – Gympie Road						
5700	17.32	17.69	17.81	17.94	18.05	18.12
5800	17.74	18.00	18.09	18.22	18.33	18.42
5900	18.84	19.02	19.09	19.17	19.26	19.33
6000	19.70	19.91	19.98	20.08	20.20	20.28
6100	21.35	21.48	21.52	21.59	21.66	21.72
6200	22.47	22.59	22.64	22.69	22.74	22.78
6300	N/R (1)	N/R (1)	N/R (1)	N/R (1)	23.98	24.03
6350	24.04	24.26	24.36	24.48	24.61	24.69
Fitzgibbon Tributary						
0	9.44	9.99	10.29	10.50	10.69	10.80
100	9.43	9.98	10.28	10.48	10.67	10.78
200	9.43	9.98	10.28	10.48	10.67	10.78
300	9.43	9.98	10.28	10.48	10.67	10.78
400	9.43	9.98	10.28	10.48	10.67	10.78
500	9.43	9.98	10.28	10.48	10.67	10.78
600	9.43	9.98	10.28	10.48	10.67	10.78
700	9.43	9.98	10.28	10.48	10.67	10.78
800	9.43	9.98	10.28	10.48	10.67	10.78
900	N/R (1)	9.98	10.28	10.48	10.67	10.78
1000	9.44	9.98	10.28	10.48	10.67	10.78
1103	N/R (1)	9.98	10.28	10.48	10.67	10.78
Little Cabbage Tree Creek						
0	13.67	14.20	14.54	14.82	15.11	15.27
100	13.78	14.36	14.71	15.00	15.27	15.42
200	N/R (1)	14.71	15.06	15.37	15.59	15.75

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
300	14.69	15.21	15.47	15.75	15.96	16.16
400	15.11	15.55	15.76	16.00	16.21	16.41
500	15.31	15.74	15.93	16.17	16.40	16.60
Structure S34 – Zillmere Road						
600	15.45	15.91	16.11	16.36	16.64	16.89
700	15.85	16.29	16.48	16.71	16.98	17.22
800	16.07	16.53	16.71	16.96	17.23	17.47
900	N/R (1)	16.85	17.04	17.29	17.58	17.82
1000	16.92	17.42	17.58	17.81	18.06	18.28
1100	17.84	18.26	18.38	18.58	18.79	18.97
1200	18.24	18.64	18.76	18.96	19.16	19.33
Structure S35 – Gympie Road						
Structure S36 – Gayford Street						
1400	N/R (1)	N/R (1)	N/R (1)	19.77	19.97	20.07
1500	N/R (1)	N/R (1)	19.90	19.96	20.06	20.13
1600	N/R (1)	N/R (1)	20.55	20.67	20.76	20.81
Structure S37 – Albany Creek Road						
1700	N/R (1)	N/R (1)	N/R (1)	21.52	21.72	21.89
1800	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)	N/R (1)
1900	22.21	22.45	22.56	22.69	22.82	22.94
2000	23.09	23.32	23.44	23.56	23.70	23.80
2100	23.66	23.88	23.98	24.10	24.22	24.31
2200	24.30	24.46	24.54	24.63	24.74	24.82
2300	N/R (1)	N/R (1)	25.14	25.25	25.36	25.45
2400	25.67	25.87	25.97	26.08	26.19	26.28
2500	26.22	26.43	26.52	26.64	26.76	26.86
2600	26.64	26.82	26.91	27.02	27.15	27.25
2700	27.37	27.55	27.64	27.73	27.85	27.94
Structure S39 – Horn Road Bikeway Bridge						
2800	27.86	28.20	28.36	28.54	28.74	28.88
2900	28.18	28.49	28.62	28.78	28.97	29.11
3000	28.75	29.01	29.11	29.24	29.41	29.53
3100	29.25	29.53	29.63	29.77	29.94	30.06

AMTD (m)	Design Events – Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)					
	2-yr ARI (50% AEP)	5-yr ARI (20% AEP)	10-yr ARI (10% AEP)	20-yr ARI (5% AEP)	50-yr ARI (2% AEP)	100-yr ARI (1% AEP)
3200	29.59	29.87	29.98	30.12	30.30	30.42
3300	30.12	30.38	30.47	30.60	30.77	30.89
3400	30.70	30.92	30.99	31.10	31.24	31.34
3500	31.37	31.61	31.69	31.80	31.93	32.01
Structure S40 – Martindale Street						
3600	N/R (1)	32.01	32.10	32.22	32.36	32.46
3700	32.38	32.68	32.77	32.88	33.02	33.12
3800	32.93	33.25	33.34	33.44	33.57	33.66
3900	N/R (1)	33.57	33.63	33.72	33.84	33.94
4000	N/R (1)	34.17	34.18	34.21	34.29	34.38
4100	35.53	35.69	35.76	35.85	35.96	36.05
4200	35.87	36.09	36.17	36.27	36.42	36.52
4300	36.05	36.34	36.43	36.56	36.72	36.84
4400	36.19	36.48	36.58	36.72	36.89	37.02
4494	36.30	36.60	36.70	36.85	37.03	37.16

(1) N/R = no result, typically because the AMTD line does not intersect the flood surface.

(2) Flood levels are inclusive of a 9.8% increase in rainfall intensity due to projected climate variability effects.

Appendix H: Comparison of Flood Levels using the Simplified Ensemble Method and the Full Ensemble Method

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AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1 [2]					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
Cabbage Tree Creek						
0	0.77	0.77	0.00	0.77	0.77	0.00
100	0.77	0.77	0.00	0.77	0.77	0.00
200	N/R [1]	N/R [1]	0.00	N/R [1]	N/R [1]	0.00
300	0.78	0.78	0.00	0.80	0.80	0.00
400	0.79	0.79	0.00	0.82	0.82	0.00
500	0.80	0.80	0.00	0.84	0.84	0.00
600	0.81	0.81	0.00	0.86	0.86	0.00
700	0.82	0.82	0.00	0.88	0.88	0.00
800	0.83	0.83	0.00	0.90	0.90	0.00
900	0.86	0.86	0.00	0.97	0.97	0.00
1000	0.89	0.89	0.00	1.02	1.02	0.00
1100	N/R [1]	N/R [1]	0.00	N/R [1]	N/R [1]	0.00
1200	0.95	0.95	0.00	1.12	1.12	0.00
1300	0.98	0.98	0.00	1.17	1.17	0.00
1400	1.00	1.00	0.00	1.21	1.21	0.00
1500	1.01	1.01	0.00	1.24	1.24	0.00
1600	N/R [1]	N/R [1]	0.00	N/R [1]	N/R [1]	0.00
1700	1.04	1.04	0.00	1.29	1.29	0.00
1800	1.05	1.05	0.00	1.31	1.30	0.00
1900	N/R [1]	N/R [1]	0.00	N/R [1]	N/R [1]	0.00
2000	1.14	1.14	0.00	1.46	1.45	0.01
2100	1.17	1.17	0.00	1.52	1.51	0.01
2200	1.22	1.22	0.00	1.59	1.58	0.01
2300	1.27	1.27	0.00	1.66	1.65	0.01
2400	N/R [1]	N/R [1]	0.00	1.74	1.73	0.01
2500	1.36	1.36	0.00	1.80	1.78	0.01
2600	1.40	1.40	0.00	1.85	1.83	0.01
2700	1.43	1.43	0.00	1.89	1.87	0.01
2800	1.45	1.45	0.00	1.91	1.90	0.01
2900	1.46	1.46	0.00	1.92	1.91	0.01
3000	1.46	1.46	0.00	1.93	1.92	0.02

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1 [(2)]					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
3100	1.48	1.48	0.00	1.95	1.94	0.02
3200	1.51	1.51	0.00	1.99	1.97	0.02
3300	1.55	1.55	0.00	2.04	2.02	0.02
3400	1.59	1.59	0.00	2.08	2.06	0.02
Structure S1 – Blackwood Road Bikeway Bridge						
3500	1.65	1.65	0.00	2.25	2.25	0.00
Structure S2 – Shorncliffe Railway						
Structure S3 – Sandgate Road						
3600	1.76	1.76	0.00	2.99	2.94	0.05
3700	1.95	1.95	0.00	3.07	3.02	0.05
3800	2.05	2.05	0.00	3.10	3.06	0.04
3900	2.21	2.21	0.00	3.18	3.14	0.04
4000	2.65	2.65	0.00	3.42	3.40	0.03
4100	2.75	2.75	0.00	3.50	3.48	0.02
4200	2.78	2.78	0.00	3.53	3.50	0.02
4300	2.81	2.81	0.00	3.56	3.54	0.02
4400	2.82	2.82	0.00	3.58	3.56	0.02
4500	N/R [(1)]	N/R [(1)]	0.00	3.60	3.58	0.02
Structure S4 – Gateway Motorway						
4600	N/R [(1)]	N/R [(1)]	0.00	N/R [(1)]	N/R [(1)]	0.00
4700	2.95	2.95	0.00	3.71	3.69	0.02
4800	3.06	3.06	0.00	3.79	3.78	0.01
4900	3.12	3.12	0.00	3.82	3.81	0.01
5000	3.22	3.22	0.00	3.87	3.86	0.01
5100	3.26	3.26	0.00	3.89	3.88	0.01
5200	3.42	3.42	0.00	3.98	3.98	0.00
5300	3.71	3.71	0.00	4.17	4.17	0.00
Structure S5 – Lemke Road						
5400	3.87	3.87	0.00	4.39	4.39	0.00
5500	4.28	4.29	0.00	4.80	4.80	0.00
5600	4.48	4.49	0.00	4.95	4.95	0.00
5700	4.84	4.84	0.00	5.39	5.39	0.00

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1 [(2)]					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
5800	5.11	5.12	0.00	5.68	5.68	0.00
5900	N/R [(1)]	N/R [(1)]	0.00	N/R [(1)]	N/R [(1)]	0.00
6000	5.76	5.76	0.00	6.18	6.18	0.00
6100	6.28	6.29	0.00	6.83	6.83	0.00
6200	6.80	6.80	0.00	7.41	7.41	0.00
6300	7.09	7.10	0.00	7.66	7.66	0.00
6400	7.34	7.34	0.00	7.92	7.92	0.00
6500	7.54	7.54	0.00	8.14	8.14	0.00
Structure S7 – Roghan Road						
6600	7.68	7.68	0.00	8.38	8.38	0.00
6700	7.98	7.98	0.00	8.67	8.67	0.00
6800	8.16	8.16	0.00	8.85	8.85	0.00
6900	8.21	8.21	0.00	8.91	8.91	0.00
7000	8.24	8.24	0.00	8.94	8.94	0.00
7100	8.35	8.36	0.00	8.96	8.96	0.00
7200	N/R [(1)]	N/R [(1)]	0.00	N/R [(1)]	N/R [(1)]	0.00
7300	9.96	9.96	0.00	10.42	10.42	0.00
7400	10.23	10.23	0.00	10.70	10.70	0.00
7500	10.35	10.35	0.00	10.86	10.86	0.00
7600	10.56	10.56	0.00	11.14	11.14	0.00
7700	10.77	10.77	0.00	11.41	11.41	0.00
7800	10.94	10.94	0.00	11.57	11.57	0.00
7900	11.13	11.13	0.00	11.75	11.75	0.00
8000	11.33	11.33	0.00	11.92	11.92	0.00
8100	11.55	11.55	0.00	12.12	12.12	0.00
Structure S9 – Beams Road						
8200	N/R [(1)]	N/R [(1)]	0.00	12.37	12.37	0.00
8300	11.72	11.72	0.00	12.41	12.41	0.00
8400	11.75	11.75	0.00	12.44	12.44	0.00
8500	11.77	11.77	0.00	12.46	12.46	0.00
8600	11.84	11.84	0.00	12.51	12.51	0.00
8700	12.00	12.00	0.00	12.64	12.64	0.00

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1 (2)					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
Structure S10 – North Coast Railway						
8800	12.43	12.43	0.00	13.13	13.13	0.00
8900	12.83	12.83	0.00	13.49	13.49	0.00
9000	13.11	13.11	0.00	13.72	13.72	0.00
9100	13.39	13.39	0.00	13.96	13.96	0.00
9200	13.75	13.75	0.00	14.31	14.31	0.00
9300	14.10	14.10	0.00	14.76	14.76	0.00
9400	14.42	14.42	0.00	15.10	15.10	0.00
9500	14.77	14.78	0.00	15.39	15.38	0.01
9600	15.12	15.13	-0.01	15.64	15.63	0.01
9700	15.69	15.70	-0.01	16.21	16.20	0.01
9800	15.92	15.93	-0.01	16.45	16.44	0.01
9900	16.13	16.14	-0.01	16.66	16.65	0.01
Structure S11 – Dorville Road						
10010	16.34	16.35	-0.01	17.04	17.02	0.02
10100	16.59	16.60	-0.02	17.32	17.29	0.02
10200	17.09	17.10	-0.01	17.82	17.80	0.03
10300	17.30	17.32	-0.01	18.01	17.98	0.03
10400	17.44	17.45	-0.01	18.08	18.06	0.03
10500	17.80	17.81	-0.01	18.33	18.30	0.02
10600	18.18	18.20	-0.02	18.73	18.71	0.02
10700	18.43	18.45	-0.02	19.01	19.00	0.01
Structure S13a – Gympie Road						
10800	18.71	18.73	-0.02	19.42	19.41	0.01
10900	18.95	18.98	-0.03	19.64	19.64	0.01
11000	19.01	19.06	-0.04	19.71	19.70	0.01
11100	19.07	19.10	-0.03	19.74	19.74	0.01
11200	19.23	19.25	-0.02	19.82	19.82	0.01
11300	19.68	19.70	-0.02	20.22	20.21	0.00
11400	20.15	20.18	-0.02	20.66	20.66	0.00
11500	20.54	20.56	-0.02	21.05	21.05	0.00
11600	20.80	20.82	-0.03	21.35	21.35	0.00

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1 [2]					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
11700	20.97	20.99	-0.02	21.51	21.51	0.00
11800	21.21	21.23	-0.02	21.70	21.70	0.00
11900	21.39	21.41	-0.02	21.82	21.82	0.00
12000	21.62	21.63	-0.01	22.00	22.00	0.00
12100	21.91	21.93	-0.02	22.30	22.30	0.00
12200	22.29	22.31	-0.02	22.66	22.66	0.00
12300	22.65	22.68	-0.02	23.05	23.05	0.00
12400	22.96	22.98	-0.02	23.39	23.39	0.00
12500	23.13	23.16	-0.02	23.58	23.58	0.00
12600	23.66	23.68	-0.03	24.20	24.20	0.00
12700	24.17	24.20	-0.03	24.75	24.75	0.00
12800	24.59	24.61	-0.02	25.08	25.08	0.00
12900	24.97	24.99	-0.02	25.37	25.37	0.00
13000	25.30	25.31	-0.02	25.68	25.68	0.00
Structure S15 – Albany Creek Road						
13100	25.62	25.64	-0.02	26.31	26.31	0.00
13200	25.89	25.91	-0.02	26.51	26.51	0.00
13300	26.29	26.30	-0.02	26.77	26.77	0.00
13400	26.90	26.92	-0.01	27.24	27.24	0.00
13500	27.31	27.32	-0.01	27.60	27.60	0.00
13600	27.34	27.35	-0.01	27.62	27.62	0.00
13700	27.84	27.85	-0.01	28.08	28.08	0.00
13800	28.25	28.26	-0.01	28.46	28.46	0.00
13900	N/R [1]	N/R [1]	0.00	28.70	28.70	0.00
14000	N/R [1]	N/R [1]	0.00	N/R [1]	N/R [1]	0.00
14100	29.70	29.71	-0.01	29.85	29.85	0.00
14200	30.19	30.21	-0.01	30.36	30.36	0.00
14300	30.58	30.58	0.00	30.73	30.73	0.00
14400	31.02	31.02	0.00	31.18	31.18	0.00
14500	31.40	31.40	0.00	31.63	31.63	0.00
14600	31.71	31.71	0.00	32.00	32.00	0.00
14700	31.86	31.86	0.00	32.14	32.14	0.00

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1 (2)					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
14800	32.11	32.11	0.00	32.36	32.36	0.00
14900	32.90	32.90	0.00	33.25	33.25	0.00
15000	33.20	33.20	0.00	33.55	33.55	0.00
15100	33.58	33.58	0.00	33.92	33.92	0.00
15200	33.96	33.96	0.00	34.26	34.26	0.00
15300	34.21	34.21	0.00	34.50	34.50	0.00
15400	34.45	34.45	0.00	34.76	34.76	0.00
15500	34.74	34.74	0.00	35.02	35.02	0.00
15600	35.24	35.24	0.00	35.54	35.54	0.00
15700	35.59	35.59	0.00	35.87	35.87	0.00
15800	36.43	36.43	0.00	36.74	36.74	0.00
Structure S19 – Beckett Road						
15900	37.00	37.00	0.00	37.58	37.58	0.00
16000	37.14	37.14	0.00	37.69	37.69	0.00
16100	37.50	37.50	0.00	37.94	37.94	0.00
16200	37.97	37.97	0.00	38.29	38.29	0.00
16300	38.46	38.46	0.00	38.76	38.76	0.00
16400	38.99	38.99	0.00	39.24	39.24	0.00
16500	39.43	39.43	0.00	39.70	39.70	0.00
16600	39.75	39.75	0.00	40.05	40.05	0.00
16700	40.30	40.30	0.00	40.83	40.83	-0.01
16800	41.52	41.52	0.00	41.76	41.76	0.00
16900	42.03	42.03	0.00	42.29	42.29	0.00
17000	42.26	42.26	0.00	42.55	42.55	0.00
17035	42.35	42.35	0.00	42.65	42.65	0.00
Sandgate Tributary						
0	N/R (1)	N/R (1)	0.00	N/R (1)	N/R (1)	0.00
100	1.02	1.02	0.00	1.26	1.26	0.00
200	1.04	1.04	0.00	1.28	1.28	0.00
300	1.05	1.04	0.00	1.30	1.30	0.00
400	1.05	1.05	0.00	1.31	1.31	0.00
500	1.09	1.08	0.01	1.38	1.39	-0.01

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1 [2]					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
600	1.17	1.17	0.00	1.51	1.52	-0.01
700	1.34	1.34	0.00	1.65	1.65	0.00
800	1.47	1.47	0.00	1.78	1.78	0.00
Structure S43 – Bridge Street						
900	1.74	1.74	0.00	2.22	2.22	0.00
Structure S44 – Shorncliffe Railway						
1000	1.90	1.92	-0.01	2.64	2.62	0.02
Structure S45 – Barclay Street						
1100	2.04	2.05	-0.01	2.74	2.72	0.02
Structure S46 – Coward Street						
1200	2.42	2.44	-0.02	2.96	2.97	0.00
1288	2.71	2.73	-0.01	3.07	3.07	0.00
Deagon Tributary						
0	1.28	1.28	0.00	1.67	1.66	0.01
100	1.29	1.29	0.00	1.69	1.67	0.01
200	1.29	1.29	0.00	1.69	1.68	0.01
Structure S47 – Finnie Road						
300	1.33	1.33	0.00	1.76	1.76	0.00
Structure S48 – Blackwood Road						
400	1.39	1.38	0.00	1.80	1.80	0.00
Structure S49 – Shorncliffe Railway						
500	1.53	1.53	0.00	1.91	1.91	0.00
Structure S50 – Smith Street						
Structure S51 – Esther Street						
600	1.76	1.76	0.00	2.13	2.13	0.00
700	1.88	1.88	0.00	2.23	2.23	0.00
Structure S52 – Loftus Street						
800	2.13	2.13	0.00	2.60	2.60	0.00
900	2.23	2.23	0.00	2.64	2.64	0.00
989	2.33	2.33	0.00	2.70	2.70	0.00
Structure S53 – Braun Street						
1100	3.01	3.01	0.00	3.66	3.67	0.00

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1 (2)					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
1200	3.05	3.05	0.00	3.68	3.68	0.00
1300	N/R (1)	N/R (1)	0.00	3.68	3.68	0.00
Taigum Channel						
0	2.45	2.45	0.00	3.31	3.28	0.03
100	2.63	2.63	0.00	3.42	3.39	0.03
200	N/R (1)	N/R (1)	0.00	N/R (1)	N/R (1)	0.00
Structure S22a – Gateway Motorway						
Structure S23 – 350 Muller Road						
300	2.78	2.75	0.03	3.46	3.42	0.04
Structure S24 – 334 Muller Road						
400	3.30	3.30	0.00	3.70	3.70	0.00
500	3.31	3.31	0.00	3.72	3.72	0.00
600	3.32	3.32	0.00	3.74	3.74	0.00
700	3.41	3.41	0.00	3.80	3.80	0.00
800	3.67	3.67	0.00	4.00	4.00	0.00
900	3.90	3.91	-0.01	4.22	4.23	0.00
Structure S25 – 401 Church Road						
Structure S26 – 401A Church Road						
1000	4.82	4.83	-0.01	5.10	5.10	-0.01
Structure S27 – Church Road						
1100	5.01	5.02	-0.01	5.27	5.28	-0.01
1200	5.41	5.42	-0.01	5.68	5.69	-0.01
Structure S28 – Roghan Road						
1300	5.74	5.75	-0.01	6.12	6.13	-0.01
1400	5.82	5.83	-0.01	6.20	6.21	-0.01
1500	5.90	5.91	-0.01	6.28	6.29	-0.01
1600	5.98	5.99	-0.01	6.35	6.37	-0.01
Structure S29 – Quarrion Street						
1700	6.09	6.09	-0.01	6.45	6.46	-0.01
1800	N/R (1)	N/R (1)	0.00	N/R (1)	N/R (1)	0.00
1900	N/R (1)	N/R (1)	0.00	N/R (1)	N/R (1)	0.00
2000	N/R (1)	N/R (1)	0.00	8.90	8.90	0.00

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1 [2]					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
2100	9.05	9.05	0.00	9.22	9.22	0.00
2203	N/R [1]	N/R [1]	0.00	9.52	9.52	0.00
Carseldine Channel						
0	4.38	4.39	0.00	4.88	4.88	0.00
100	4.53	4.53	0.00	5.04	5.04	0.00
200	5.07	5.06	0.01	5.27	5.30	-0.04
300	5.35	5.37	-0.02	5.47	5.47	0.00
400	5.41	5.43	-0.03	5.80	5.78	0.02
500	5.90	5.86	0.03	6.39	6.37	0.02
600	6.33	6.31	0.03	6.89	6.87	0.03
700	N/R [1]	N/R [1]	0.00	N/R [1]	N/R [1]	0.00
800	6.51	6.49	0.02	7.08	7.05	0.03
900	6.72	6.71	0.02	7.29	7.27	0.02
1000	7.93	7.93	0.00	8.00	8.00	0.00
1100	8.14	8.14	0.00	8.33	8.33	0.00
1200	8.59	8.59	0.00	8.79	8.79	0.00
1300	9.01	9.01	0.00	9.16	9.17	-0.01
1400	9.33	9.33	0.00	9.48	9.48	0.00
1500	9.91	9.91	0.00	10.10	10.10	0.00
1600	9.94	9.94	0.00	10.15	10.15	0.00
1700	9.95	9.95	0.00	10.16	10.16	0.00
1800	9.96	9.96	0.00	10.17	10.17	0.00
1900	9.96	9.96	0.00	10.18	10.18	0.00
Structure S30 – Norris Road						
2000	10.14	10.14	0.00	10.49	10.49	0.00
2100	10.17	10.18	0.00	10.52	10.51	0.00
2200	10.27	10.27	0.00	10.57	10.57	0.00
2300	10.59	10.59	0.00	10.76	10.75	0.00
2400	10.90	10.90	0.00	11.04	11.04	0.00
Structure S31 – North Coast Railway						
2500	11.24	11.24	0.00	11.58	11.58	0.00
2600	11.29	11.30	0.00	11.62	11.62	0.00

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1 [(2)]					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
2700	11.37	11.37	0.00	11.66	11.66	0.00
2800	11.47	11.47	0.00	11.71	11.71	0.00
2900	11.60	11.60	0.00	11.79	11.79	0.00
3000	11.72	11.72	0.00	11.88	11.88	0.00
Structure S32 – Lacey Road						
3100	11.96	11.96	0.00	12.12	12.13	-0.02
3200	13.56	13.56	0.00	13.65	13.65	0.00
3300	13.68	13.69	0.00	13.80	13.80	0.00
Upstream of Lacey Road - AMTD Chainage commences at 5000 m						
5000	11.87	11.87	0.00	12.08	12.08	0.00
5100	13.93	13.93	0.00	14.00	14.00	0.00
5200	14.18	14.18	0.00	14.26	14.26	0.00
5300	14.58	14.58	0.00	14.62	14.63	-0.01
5400	15.59	15.59	0.00	15.64	15.64	0.00
5500	16.28	16.28	0.00	16.33	16.34	0.00
5600	N/R [(1)]	N/R [(1)]	0.00	N/R [(1)]	N/R [(1)]	0.00
Structure S33 – Gympie Road						
5700	17.77	17.78	-0.01	18.05	18.05	0.00
5800	18.06	18.06	0.00	18.34	18.34	0.00
5900	19.04	19.04	0.00	19.23	19.23	0.00
6000	19.94	19.94	0.00	20.16	20.16	0.00
6100	21.46	21.46	0.00	21.59	21.59	0.00
6200	22.60	22.60	0.00	22.73	22.73	0.00
6300	N/R [(1)]	N/R [(1)]	0.00	24.02	24.02	0.00
6350	24.37	24.37	0.00	24.68	24.67	0.01
Fitzgibbon Tributary						
0	10.27	10.27	0.00	10.75	10.75	0.00
100	10.28	10.28	0.00	10.75	10.75	0.00
200	10.28	10.28	0.00	10.75	10.75	0.00
300	10.28	10.28	0.00	10.75	10.75	0.00
400	10.28	10.28	0.00	10.75	10.75	0.00
500	10.28	10.28	0.00	10.75	10.75	0.00

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1 [2]					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	Full Ensemble Method	Difference (m)	Simplified Ensemble Method	Full Ensemble Method	Difference (m)
600	10.28	10.28	0.00	10.75	10.75	0.00
700	10.28	10.28	0.00	10.75	10.75	0.00
800	10.28	10.28	0.00	10.75	10.75	0.00
900	10.28	10.28	0.00	10.75	10.75	0.00
1000	10.28	10.28	0.00	10.75	10.75	0.00
1103	10.28	10.28	0.00	10.75	10.75	0.00
Little Cabbage Tree Creek						
0	14.52	14.52	0.00	15.20	15.20	0.00
100	14.71	14.71	0.00	15.36	15.36	0.00
200	15.11	15.11	0.00	15.71	15.71	0.00
300	15.52	15.54	-0.02	16.12	16.12	0.00
400	15.74	15.77	-0.03	16.32	16.32	0.00
500	15.90	15.94	-0.03	16.50	16.50	0.00
Structure S34 – Zillmere Road						
600	16.09	16.13	-0.04	16.79	16.79	0.00
700	16.49	16.53	-0.03	17.14	17.14	0.00
800	16.74	16.77	-0.03	17.37	17.37	0.00
900	17.07	17.10	-0.03	17.71	17.71	0.00
1000	17.62	17.64	-0.02	18.21	18.21	0.00
1100	18.43	18.43	-0.01	18.92	18.92	0.00
1200	18.78	18.79	-0.01	19.26	19.26	0.00
Structure S35 – Gympie Road						
Structure S36 – Gayford Street						
1400	N/R [1]	N/R [1]	0.00	20.04	20.04	0.00
1500	19.91	19.91	0.00	20.13	20.15	-0.02
1600	20.58	20.58	0.00	20.81	20.82	-0.01
Structure S37 – Albany Creek Road						
1700	N/R [1]	N/R [1]	0.00	21.94	22.11	-0.17
1800	N/R [1]	N/R [1]	0.00	N/R [1]	N/R [1]	0.00
1900	22.53	22.53	0.00	22.84	22.87	-0.03
2000	23.36	23.36	0.00	23.68	23.71	-0.03
2100	23.93	23.93	0.00	24.23	24.24	-0.01

AMTD (m)	Comparison of Peak Water Levels (mAHD) – Scenario 1 (2)					
	10-yr ARI (10% AEP)			100-yr ARI (1% AEP)		
	Simplified Ensemble Method	**Full Ensemble Method**	**Difference (m)**	**Simplified Ensemble Method**	**Full Ensemble Method**	**Difference (m)**
2200	24.46	24.46	0.00	24.69	24.70	-0.01
2300	N/R (1)	N/R (1)	0.00	25.27	25.28	-0.01
2400	25.90	25.90	0.00	26.18	26.19	-0.01
2500	26.45	26.45	0.00	26.76	26.77	-0.01
2600	26.82	26.82	0.00	27.12	27.13	-0.01
2700	27.50	27.50	0.00	27.74	27.75	-0.01
Structure S39 – Horn Road Bikeway Bridge						
2800	28.26	28.26	0.00	28.68	28.69	-0.01
2900	28.56	28.56	-0.01	28.98	28.99	-0.01
3000	29.06	29.07	-0.01	29.43	29.44	-0.01
3100	29.59	29.60	-0.01	29.99	30.00	-0.01
3200	29.94	29.96	-0.02	30.37	30.37	-0.01
3300	30.45	30.46	-0.01	30.84	30.85	-0.01
3400	30.98	30.99	-0.01	31.30	31.30	-0.01
3500	31.65	31.66	-0.01	31.93	31.94	-0.01
Structure S40 – Martindale Street						
3600	32.03	32.04	-0.01	32.36	32.37	-0.01
3700	32.69	32.70	-0.01	33.00	33.00	-0.01
3800	33.29	33.30	-0.01	33.58	33.59	-0.01
3900	33.56	33.57	-0.01	33.81	33.82	-0.01
4000	34.18	34.18	0.00	34.32	34.32	0.00
4100	35.58	35.59	-0.01	35.82	35.82	0.00
4200	35.98	35.99	-0.01	36.26	36.27	0.00
4300	36.32	36.32	-0.01	36.70	36.70	0.00
4400	36.50	36.50	-0.01	36.92	36.92	0.00
4494	36.64	36.65	0.00	37.08	37.08	0.00

(1) N/R = no result, typically because the AMTD line does not intersect the flood surface.

(2) Flood levels are inclusive of a 9.8% increase in rainfall intensity due to projected climate variability effects.

Appendix I: URBS Ensemble Results – Rare Events

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Notes on Table Content and Formatting

- The following tables indicate the ranking and discharge of all ten ensembles for each storm duration at the selected location within the catchment.
- The bold formatted rows indicate the critical storm duration for the selected location.
- The bold formatted columns indicate the median (Rank 5 / 6) peak discharge and corresponding ensemble number.
- The yellow highlighted peak discharge and ensemble number are those adopted from the simplified method as detailed in Section 7.4.3.
- The light pink highlighted peak discharge and ensemble number are those adopted from the simplified method for the other storm durations.

Taigum Channel at Fernwood Place – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
200	**0.5**	**6**	**1**	**5**	**10**	**4**	**7**	**8**	**2**	**9**	**3**
		26.39	**26.44**	**26.92**	**27.59**	**27.61**	**28.12**	**28.2**	**28.27**	**28.37**	**29.06**
	1	8	9	5	10	**7**	**4**	6	3	1	2
		26.2	26.48	26.9	27.13	**27.25**	**27.59**	28.27	28.5	32.52	32.58
	1.5	1	7	4	8	**3**	**5**	6	2	9	10
		22.71	24.42	24.86	25.73	**26.24**	**26.38**	29.72	30.28	30.74	30.77
	2	7	8	4	2	**3**	**6**	5	1	9	10
		21.93	23.18	23.53	23.75	**24.42**	**25.54**	26.49	26.6	27.59	27.91
	3	7	9	5	2	**6**	**4**	3	8	1	10
		17.66	18.88	20.15	20.27	**20.79**	**21.73**	22.45	23.24	24.58	27.85
	4.5	3	6	2	8	**4**	**7**	9	1	5	10
		17.8	18.3	18.4	18.4	**18.9**	**20.1**	21.42	21.84	22.1	23.89
	6	5	2	3	6	**4**	**10**	9	7	8	1
		15.58	16.22	17.2	18.42	**18.65**	**19.04**	21.19	24.21	29.96	35.41
	9	3	4	8	10	**9**	**2**	1	6	7	5
		10.99	11.97	14.04	16.1	**17.23**	**19.65**	19.71	26.38	31.21	34.61
500	**0.5**	**6**	**1**	**5**	**10**	**4**	**7**	**8**	**2**	**9**	**3**
		31.65	**31.75**	**32.3**	**33.14**	**33.18**	**33.84**	**33.9**	**33.99**	**34.15**	**35.03**
	1	8	9	5	10	**7**	**4**	6	3	1	2
		31.23	31.49	32.12	32.3	**32.5**	**33.01**	33.72	34.15	39.04	39.09
	1.5	1	7	4	8	**5**	**3**	6	2	9	10
		26.71	28.75	29.4	30.39	**31.25**	**31.37**	35.29	35.92	36.48	36.55
	2	7	8	4	2	**3**	**6**	1	5	9	10
		26.02	27.35	27.83	28.08	**29.14**	**30.28**	31.55	31.7	32.68	33.12
	3	7	9	5	2	**6**	**4**	3	8	1	10
		20.89	22.22	23.85	23.96	**24.69**	**25.76**	26.34	27.51	29.02	33.06
	4.5	3	8	2	6	**4**	**7**	9	1	5	10
		20.93	21.57	21.74	21.75	**22.41**	**23.63**	25.26	25.71	26.12	28.1
	6	5	2	3	6	**4**	**10**	9	7	8	1
		18.2	19	20.15	21.63	**21.98**	**22.3**	24.99	28.35	35.28	41.9
	9	3	4	8	10	**9**	**2**	1	6	7	5
		12.76	13.9	16.4	18.77	**20.23**	**22.98**	23.03	31.06	36.78	40.61
2000	**0.5**	**6**	**1**	**5**	**10**	**4**	**7**	**8**	**2**	**9**	**3**
		40.7	**40.92**	**41.61**	**42.74**	**42.85**	**43.75**	**43.77**	**43.9**	**44.21**	**45.41**
	1	8	9	5	10	**7**	**4**	6	3	1	2
		39.83	40.02	41.06	41.12	**41.47**	**42.31**	43.03	43.86	50.28	50.33
	1.5	1	7	4	8	**5**	**3**	6	2	9	10

Taigum Channel at Fernwood Place – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		34	36.32	37.39	38.56	**39.83**	**40.51**	45.12	45.87	46.59	46.77
	2	7	8	4	2	**3**	**6**	1	5	9	10
		33	34.44	35.18	35.45	**37.27**	**38.41**	40.02	40.69	41.36	42.05
	3	7	9	5	2	**6**	**4**	3	8	1	10
		26.41	27.87	30.17	30.24	**31.39**	**32.68**	33.05	34.82	36.6	41.98
	4.5	3	8	2	6	**4**	**7**	9	1	5	10
		26.18	26.87	27.35	27.57	**28.33**	**29.55**	31.71	32.22	32.89	35.15
	6	5	2	3	6	**4**	**10**	9	7	8	1
		22.64	23.73	25.19	27.13	**27.66**	**27.84**	31.49	35.4	44.37	53.03
	9	3	4	8	10	**9**	**2**	1	6	7	5
		15.8	17.22	20.45	23.35	**25.44**	**28.74**	28.77	39.18	46.49	50.99

Taigum Channel at Church Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
200	0.5	1	6	5	4	**10**	**7**	9	8	2	3
		44.37	44.93	45.86	46.52	**46.74**	**47.17**	47.53	47.81	47.99	48.5
	1	**9**	**7**	**8**	**10**	**5**	**4**	**6**	**3**	**1**	**2**
		46.44	**46.49**	**46.5**	**47.23**	**47.74**	**47.88**	**50.22**	**50.39**	**54.6**	**54.76**
	1.5	1	4	7	8	**5**	**3**	2	6	9	10
		40.24	42.1	43.13	45.26	**45.84**	**46.47**	51.96	52.07	52.61	53.82
	2	7	8	4	2	**3**	**6**	5	1	9	10
		38.19	40.74	41.09	41.62	**42.72**	**44.19**	46.06	46.31	48.24	48.82
	3	7	9	2	5	**6**	**4**	8	3	1	10
		31.08	33.42	35.33	35.69	**36.2**	**38.52**	38.84	39.16	42.68	48.81
	4.5	3	8	2	6	**4**	**7**	9	5	1	10
		31.2	32.2	32.44	32.53	**33.55**	**35.19**	36.89	38.23	38.67	41.56
	6	2	5	3	6	**4**	**10**	9	7	8	1
		27.28	27.54	29.71	31.15	**32.85**	**33.27**	37.58	42.12	52.7	62.13
	9	3	4	8	10	**9**	**2**	1	6	7	5
		19.43	21.17	24.72	28.33	**30.08**	**34.41**	34.42	45.78	54.27	60.15
500	0.5	1	6	5	4	**10**	**7**	9	8	2	3
		53.16	53.84	55.01	55.82	**56.11**	**56.64**	57.1	57.46	57.68	58.32
	1	**9**	**8**	**7**	**10**	**5**	**4**	**6**	**3**	**1**	**2**
		55.28	**55.38**	**55.41**	**56.28**	**56.95**	**57.22**	**59.98**	**60.27**	**65.45**	**65.61**
	1.5	1	4	7	8	**5**	**3**	2	6	9	10

Taigum Channel at Church Road – Peak Discharge (m^3/s) and Ensemble Ranking

ARI	Duration (hr)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
		47.32	49.73	50.82	53.49	54.25	55.48	61.57	61.74	62.42	63.89
	2	7	8	4	2	3	6	1	5	9	10
		45.26	48.06	48.59	49.21	50.59	52.37	54.89	55.15	57.18	57.81
	3	7	9	2	5	6	4	8	3	1	10
		36.77	39.32	41.74	42.19	42.92	45.6	45.89	45.95	50.32	57.83
	4.5	3	8	2	6	4	7	9	5	1	10
		36.65	37.72	38.29	38.74	39.71	41.34	43.5	45.14	45.51	48.83
	6	2	5	3	6	4	10	9	7	8	1
		31.91	32.18	34.77	36.54	38.67	38.95	44.24	49.27	62.05	73.5
	9	3	4	8	10	9	1	2	6	7	5
		22.56	24.59	28.87	33.01	35.29	40.22	40.26	53.89	63.87	70.61
2000	0.5	1	6	5	4	10	7	9	8	2	3
		68.32	69.2	70.79	71.91	72.3	73.05	73.67	74.15	74.43	75.35
	1	9	8	7	10	5	4	6	3	1	2
		70.35	70.56	70.64	71.72	72.71	73.23	76.75	77.28	84.18	84.32
	1.5	1	4	7	8	5	3	2	6	9	10
		60.39	63.15	64.25	67.94	69.01	71.5	78.5	78.75	79.71	81.65
	2	7	8	4	2	3	6	1	5	9	10
		57.33	60.47	61.35	62.13	64.32	66.34	69.55	70.84	72.45	73.13
	3	7	9	2	5	6	4	8	3	1	10
		46.46	49.33	52.62	53.28	54.41	57.71	57.97	58.11	63.35	73.25
	4.5	3	8	2	6	4	7	9	5	1	10
		45.8	46.94	48.09	49.26	50.09	51.62	54.63	56.74	56.95	60.99
	6	2	5	3	6	10	4	9	7	8	1
		39.8	40.06	43.41	45.77	48.61	48.62	55.65	61.42	78.03	93.06
	9	3	4	8	10	9	1	2	6	7	5
		27.92	30.46	36.03	41.07	44.31	50.21	50.37	67.98	80.58	88.7

Carseldine Channel at Beams Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
200	0.5	6	5	1	10	4	8	2	7	9	3
		13.53	13.8	14.06	14.24	14.45	14.55	14.57	14.88	15.15	15.81
	1	8	9	5	10	7	4	6	3	2	1
		12.93	13.14	13.31	13.31	13.58	13.84	13.87	14.28	16.73	16.74
	1.5	1	7	4	8	5	3	6	2	9	10
		11.1	11.77	12.31	12.51	13.11	13.24	14.84	15.14	15.25	15.28
	2	7	8	2	4	3	6	1	5	9	10
		10.79	11.18	11.53	11.57	12.27	12.61	13.09	13.3	13.43	13.88
	3	7	9	5	2	6	4	3	8	1	10
		8.64	9.08	9.92	9.95	10.52	10.8	11.04	11.77	12.19	14.03
	4.5	3	8	2	6	4	7	9	1	5	10
		8.71	8.88	9.02	9.04	9.4	9.79	10.45	10.65	10.92	11.7
	6	5	2	3	6	4	10	9	7	8	1
		7.44	8.02	8.42	9.12	9.17	9.22	10.5	11.85	14.66	17.55
	9	3	4	8	10	9	2	1	6	7	5
		5.2	5.67	6.76	7.72	8.51	9.52	9.55	13.05	15.62	16.93
500	0.5	6	5	1	10	4	8	2	7	9	3
		16.18	16.52	16.86	17.06	17.34	17.46	17.48	17.87	18.2	19.04
	1	8	9	10	5	7	4	6	3	2	1
		15.39	15.81	15.81	15.86	16.16	16.51	16.55	17.08	20.03	20.05
	1.5	1	7	4	8	5	3	6	2	9	10
		13.21	13.85	14.55	14.77	15.51	15.82	17.6	17.93	18.06	18.12
	2	7	8	2	4	3	6	1	9	5	10
		12.78	13.17	13.63	13.7	14.61	14.94	15.51	15.9	15.91	16.46
	3	7	9	5	2	6	4	3	8	1	10
		10.2	10.67	11.73	11.74	12.48	12.8	13.13	13.93	14.38	16.65
	4.5	3	8	2	6	4	7	9	1	5	10
		10.25	10.41	10.64	10.79	11.14	11.5	12.31	12.55	12.89	13.75
	6	5	2	3	6	4	10	9	7	8	1
		8.69	9.39	9.87	10.71	10.79	10.79	12.38	13.87	17.23	20.71
	9	3	4	8	10	9	2	1	6	7	5
		6.04	6.59	7.89	8.99	9.98	11.11	11.14	15.33	18.38	19.82
2000	0.5	6	5	1	10	4	2	8	7	9	3
		20.75	21.2	21.69	21.92	22.32	22.48	22.5	23.05	23.49	24.65
	1	8	10	5	9	7	4	6	3	2	1
		19.58	20.13	20.21	20.44	20.56	21.1	21.27	21.91	25.71	25.77
	1.5	1	7	4	8	5	3	6	2	9	10

Carseldine Channel at Beams Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		16.95	17.46	18.47	18.73	19.72	20.44	22.44	22.85	23.01	23.13
	2	7	8	2	4	3	6	1	9	5	10
		16.17	16.56	17.2	17.32	18.62	18.93	19.64	20.12	20.41	20.86
	3	7	9	2	5	6	4	3	8	1	10
		12.85	13.35	14.78	14.8	15.85	16.22	16.73	17.64	18.13	21.12
	4.5	3	8	2	6	4	7	9	1	5	10
		12.83	12.96	13.35	13.77	14.07	14.36	15.45	15.75	16.19	17.19
	6	5	2	3	6	10	4	9	7	8	1
		10.79	11.74	12.34	13.44	13.45	13.54	15.6	17.31	21.6	26.12
	9	3	4	8	10	9	2	1	6	7	5
		7.47	8.15	9.82	11.17	12.53	13.86	13.9	19.28	23.18	24.82

Carseldine Channel at Gympie Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
200	0.5	1	6	5	4	10	7	8	9	2	3
		31.36	31.39	32.03	32.67	32.72	33.25	33.55	33.55	33.59	34.37
	1	**8**	**9**	**7**	**10**	**5**	**4**	**6**	**3**	**1**	**2**
		32.14	**32.41**	**32.89**	**32.93**	**32.95**	**33.38**	**34.56**	**34.74**	**38.79**	**38.82**
	1.5	1	4	7	8	3	5	6	2	9	10
		28.17	30.13	30.22	31.69	31.93	32.16	36.32	36.71	37.17	37.55
	2	7	8	4	2	3	6	5	1	9	10
		26.86	28.69	29.01	29.32	29.72	31.3	32.04	32.7	33.96	34.08
	3	7	9	2	5	6	4	3	8	1	10
		21.61	23.36	24.75	24.76	25.35	26.67	27.78	28.04	30.17	34.08
	4.5	3	6	2	8	4	7	9	5	1	10
		22.03	22.33	22.62	22.83	23.2	24.82	26.17	26.91	27.06	29.46
	6	5	2	3	6	4	10	9	7	8	1
		19.34	19.74	21.14	22.37	22.85	23.47	26.05	29.87	36.65	43.01
	9	3	4	8	10	9	2	1	6	7	5
		13.74	14.94	17.33	19.95	21.08	24.14	24.25	31.98	37.94	42.2
500	**0.5**	**1**	**6**	**5**	**4**	**10**	**7**	**8**	**9**	**2**	**3**
		37.64	**37.66**	**38.45**	**39.27**	**39.32**	**40.0**	**40.36**	**40.37**	**40.41**	**41.41**
	1	8	9	10	7	5	4	6	3	1	2
		38.33	38.61	39.25	39.26	39.34	39.94	41.29	41.61	46.59	46.59
	1.5	1	7	4	8	5	3	6	2	9	10

Carseldine Channel at Gympie Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		33.15	35.63	35.64	37.48	**38.12**	**38.16**	43.13	43.56	44.15	44.62
	2	7	8	4	2	**3**	**6**	5	1	9	10
		31.87	33.86	34.33	34.69	**35.24**	**37.11**	38.41	38.77	40.28	40.41
	3	7	9	2	5	**6**	**4**	3	8	1	10
		25.59	27.51	29.28	29.32	**30.1**	**31.63**	32.61	33.15	35.61	40.44
	4.5	3	6	2	8	**4**	**7**	9	5	1	10
		25.91	26.59	26.73	26.77	**27.51**	**29.2**	30.87	31.83	31.86	34.65
	6	5	2	3	6	**4**	**10**	9	7	8	1
		22.61	23.11	24.76	26.25	**26.93**	**27.49**	30.72	34.97	43.2	50.93
	9	3	4	8	10	**9**	**2**	1	6	7	5
		15.95	17.36	20.26	23.26	**24.75**	**28.27**	28.35	37.69	44.7	49.57
2000	**0.5**	**6**	**1**	**5**	**4**	**10**	**7**	**8**	**9**	**2**	**3**
		48.48	**48.49**	**49.56**	**50.69**	**50.75**	**51.68**	**52.17**	**52.19**	**52.23**	**53.64**
	1	8	9	10	7	**5**	**4**	6	3	2	1
		48.91	49.19	50.06	50.15	**50.29**	**51.23**	52.83	53.44	60	60.04
	1.5	1	7	4	8	**5**	**3**	6	2	9	10
		41.85	45.08	45.33	47.64	**48.6**	**49.26**	55.13	55.64	56.45	57.1
	2	7	8	4	2	**3**	**6**	1	5	9	10
		40.44	42.67	43.42	43.85	**45.08**	**47.06**	49.17	49.4	51.07	51.3
	3	7	9	2	5	**6**	**4**	3	8	1	10
		32.39	34.55	36.99	37.1	**38.25**	**40.12**	40.8	41.92	44.89	51.34
	4.5	3	8	2	6	**4**	**7**	9	1	5	10
		32.4	33.34	33.63	33.8	**34.78**	**36.51**	38.77	39.92	40.09	43.34
	6	5	2	3	6	**4**	**10**	9	7	8	1
		28.16	28.84	30.93	32.9	**33.92**	**34.33**	38.71	43.65	54.4	64.56
	9	3	4	8	10	**9**	**2**	1	6	7	5
		19.75	21.51	25.31	28.96	**31.12**	**35.4**	35.43	47.6	56.49	62.35

Carseldine Channel at Norris Road – Peak Discharge (m³/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
200	0.5	1	6	7	4	**5**	**9**	10	3	8	2
		39.58	39.87	39.93	39.95	**39.96**	**39.97**	39.99	40	40.11	40.15
	1	7	1	10	4	**8**	**9**	5	2	3	6
		48.52	49.15	49.33	49.58	**49.58**	**49.59**	49.68	49.69	50.28	50.48
	1.5	4	8	1	7	**9**	**5**	3	2	10	6
		50.37	52.6	52.94	53.34	**53.68**	**54**	54.72	54.79	54.99	55.89
	2	**6**	**2**	**4**	**7**	**8**	**1**	**9**	**5**	**3**	**10**
		52.36	**52.58**	**52.75**	**53.02**	**53.93**	**54.04**	**54.52**	**54.87**	**54.88**	**56.93**
	3	2	8	5	6	**7**	**9**	4	1	3	10
		43.99	46.74	47.51	48.2	**48.39**	**48.96**	49.84	53.11	55.18	57.48
	4.5	4	9	3	6	**5**	**7**	2	8	1	10
		43.96	45.56	45.67	46.03	**47.3**	**50.12**	50.22	50.27	52.01	58.73
	6	2	6	5	3	**4**	**9**	10	7	8	1
		40.15	40.92	41.5	43.03	**43.94**	**45.09**	47.26	59.75	63.11	65.62
	9	3	8	4	9	**10**	**2**	1	6	7	5
		33.2	34.85	35.6	39.7	**42.7**	**43.46**	46.71	49.89	62.42	62.9
500	0.5	1	6	7	4	**5**	**9**	10	3	8	2
		45.84	46.18	46.23	46.25	**46.27**	**46.28**	46.31	46.32	46.44	46.49
	1	7	1	10	8	**4**	**9**	2	5	3	6
		56.96	57.61	57.84	58.11	**58.12**	**58.13**	58.22	58.22	58.88	59.11
	1.5	4	8	1	7	**9**	**5**	10	2	6	3
		58.86	61.36	61.72	62.18	**62.53**	**62.92**	63.22	63.26	63.67	63.83
	2	**6**	**2**	**4**	**7**	**8**	**1**	**9**	**5**	**3**	**10**
		61.31	**61.53**	**61.71**	**62**	**63.06**	**63.21**	**63.73**	**64.2**	**64.21**	**65.06**
	3	2	8	5	6	**7**	**9**	4	1	3	10
		51.27	54.82	55.5	56.29	**56.54**	**57.09**	58.12	61.9	64.33	66.76
	4.5	4	3	9	6	**5**	**7**	2	8	1	10
		51.24	53.31	53.32	53.84	**55.28**	**58.45**	58.52	58.59	60.58	67.43
	6	2	6	5	3	**4**	**9**	10	8	7	1
		46.44	47.34	48.09	49.93	**50.98**	**52.31**	54.88	67.25	67.82	68.09
	9	3	8	4	9	**10**	**2**	1	6	5	7
		38.33	40.31	41.27	45.64	**49.33**	**50.24**	54.18	57.77	66.15	67.52
2000	0.5	1	6	7	4	**5**	**9**	3	10	8	2
		56.85	57.28	57.35	57.37	**57.4**	**57.4**	57.45	57.46	57.61	57.69
	1	1	2	6	3	**7**	**10**	5	8	9	4
		65.06	65.17	65.38	65.39	**65.41**	**65.41**	65.42	65.48	65.48	65.5
	1.5	9	10	2	6	**4**	**8**	5	7	3	1

Carseldine Channel at Norris Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		67.52	67.72	67.86	67.89	**67.92**	**67.97**	68.06	68.09	68.16	68.17
	2	**9**	**6**	**3**	**5**	**2**	**7**	**4**	**1**	**8**	**10**
		68.82	**69.16**	**69.2**	**69.24**	**69.44**	**69.45**	**69.47**	**69.49**	**69.58**	**69.66**
	3	2	8	5	4	**6**	**9**	7	1	10	3
		63.54	67	67.48	67.93	**68.61**	**68.81**	68.96	69.5	70.17	70.82
	4.5	4	9	3	5	**6**	**7**	2	8	1	10
		63.25	65.88	65.9	66.2	**66.68**	**68.41**	69.22	69.22	69.28	71.66
	6	2	6	5	3	**4**	**9**	10	8	1	7
		57.42	58.67	59.33	61.56	**62.78**	**64.35**	67.24	70.7	71.54	71.9
	9	3	8	4	9	**10**	**2**	6	1	5	7
		47.17	49.48	50.85	56.29	**60.71**	**61.88**	66.47	66.61	69.8	70.74

Carseldine Channel at Fitzgibbon Landfill – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
200	0.5	1	6	5	4	**10**	**7**	9	8	2	3
		40.72	41.29	41.87	42.19	**42.38**	**42.52**	42.74	43.01	43.15	43.27
	1	7	10	8	9	**4**	**5**	3	6	2	1
		49.4	49.74	49.91	49.91	**49.94**	**49.96**	50.25	50.33	53.16	53.29
	1.5	4	8	9	1	**7**	**5**	2	10	3	6
		59.41	60.69	61	61.01	**61.15**	**61.63**	61.74	61.8	62.05	62.31
	2	2	9	4	1	**6**	**7**	8	10	3	5
		67	67.12	67.15	67.42	**67.47**	**67.59**	67.76	69.14	69.36	69.53
	3	2	6	5	7	**9**	**8**	1	4	3	10
		73.1	75.53	75.96	75.98	**76.22**	**76.64**	77.69	77.84	79.82	82.05
	4.5	**5**	**4**	**7**	**6**	**3**	**2**	**9**	**8**	**1**	**10**
		65.44	**65.67**	**72.04**	**72.57**	**73.53**	**76.95**	**77.12**	**78.81**	**79.51**	**90.72**
	6	9	4	2	5	**3**	**10**	6	8	1	7
		57.79	65.55	67.03	67.96	**69.02**	**70.54**	70.62	79.64	84.37	94.44
	9	8	9	3	4	**2**	**10**	6	1	5	7
		50.54	52.27	53.56	56.51	**57.01**	**63.06**	63.11	64.87	75.16	87.24
500	0.5	1	6	5	4	**10**	**7**	9	8	2	3
		48.93	49.65	50.39	50.79	**51.02**	**51.21**	51.49	51.81	51.99	52.15
	1	7	10	8	9	**4**	**5**	3	2	6	1
		63.3	63.67	63.84	63.85	**63.87**	**63.88**	64.15	64.22	64.24	64.43
	1.5	4	8	9	6	**10**	**1**	7	2	5	3

Carseldine Channel at Fitzgibbon Landfill – Peak Discharge (m^3/s) and Ensemble Ranking

ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		74.5	76.08	76.41	76.52	**76.54**	**76.56**	76.71	76.77	77.31	77.91
	2	6	9	2	4	**1**	**7**	8	10	3	5
		83.46	84.11	84.14	84.56	**84.68**	**85.22**	85.23	85.46	87.64	87.88
	3	**2**	**6**	**5**	**9**	**7**	**4**	**8**	**1**	**3**	**10**
		87.79	**90.7**	**90.86**	**91.72**	**91.77**	**93.5**	**93.63**	**94.99**	**99.98**	**101.74**
	4.5	5	4	3	7	**6**	**9**	2	8	1	10
		75	80.63	86.43	87.3	**87.77**	**91.67**	93.04	94.25	95.36	109.99
	6	9	5	4	2	**3**	**6**	10	8	1	7
		67.84	79.19	79.46	79.7	**80.88**	**83**	85.22	91.64	94.59	112.43
	9	8	9	3	4	**2**	**10**	6	1	5	7
		58.89	61.38	61.97	66.15	**66.24**	**75.49**	77.16	78.77	84.7	101.58
2000	0.5	1	6	5	4	**10**	**7**	9	8	2	3
		63.26	64.14	65.15	65.7	**66.02**	**66.28**	66.66	67.11	67.36	67.58
	1	6	3	5	9	**8**	**4**	10	7	2	1
		78.69	78.95	79.62	79.78	**79.8**	**79.83**	79.92	80.73	83.42	83.79
	1.5	6	10	2	9	**3**	**5**	7	8	1	4
		90.86	91.64	92.15	92.7	**92.87**	**93.68**	94.42	95.12	95.15	97.97
	2	10	5	3	9	**1**	**8**	7	4	6	2
		106.53	107.85	108.01	108.05	**111.62**	**111.72**	112.31	113.07	113.78	113.82
	3	**2**	**5**	**6**	**9**	**4**	**7**	**8**	**10**	**1**	**3**
		109.89	**112.57**	**112.83**	**113.36**	**113.38**	**115.52**	**119.6**	**120.25**	**126.04**	**128.48**
	4.5	5	4	3	7	**6**	**9**	8	2	1	10
		92.36	102.58	107.73	110	**111.13**	**114.89**	117.41	117.57	121.42	132.7
	6	9	5	2	4	**3**	**6**	8	10	1	7
		88.7	98.33	99.94	100.14	**101.94**	**103.8**	109.13	109.3	112.54	134.61
	9	8	3	9	4	**2**	**6**	10	5	1	7
		73.64	78.46	82.06	82.77	**85.3**	**96.66**	96.68	99.96	103.12	120.37

Little Cabbage Tree Creek at Hamilton Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
200	**0.5**	**1**	**6**	**5**	**4**	**10**	**7**	**9**	**8**	**2**	**3**
		55.83	**56.01**	**57.32**	**58.58**	**58.7**	**59.68**	**60.26**	**60.31**	**60.46**	**61.86**
	1	8	9	7	10	**5**	**4**	6	3	1	2
		55.72	55.77	56.71	56.79	**57.41**	**58.36**	60.4	61.15	68.13	68.13
	1.5	1	7	4	8	**5**	**3**	6	2	9	10
		47.73	50.93	51	54.01	**55.14**	**56.71**	62.76	63.06	64	65.08
	2	7	8	4	2	**3**	**6**	1	5	9	10
		45.77	48.04	48.94	49.47	**51.36**	**53.14**	55.6	56.58	57.77	58
	3	7	9	2	5	**6**	**4**	3	8	1	10
		37.16	39.36	42.28	42.58	**43.87**	**46.13**	46.55	47.48	51.05	58.88
	4.5	3	8	2	6	**4**	**7**	9	1	5	10
		36.88	37.8	38.64	39.35	**40.18**	**41.59**	44.21	45.64	45.94	49.28
	6	5	2	3	6	**4**	**10**	9	7	8	1
		32.26	32.78	35.36	37.6	**39.31**	**39.36**	44.91	49.92	63.04	75.29
	9	3	4	8	10	**9**	**1**	2	6	7	5
		22.55	24.59	29.17	33.26	**36.08**	**40.81**	40.87	55.41	65.78	72.21
500	**0.5**	**1**	**6**	**5**	**4**	**10**	**7**	**9**	**8**	**2**	**3**
		66.86	**67.06**	**68.67**	**70.24**	**70.4**	**71.65**	**72.39**	**72.43**	**72.58**	**74.38**
	1	9	8	7	10	**5**	**4**	6	3	2	1
		66.25	66.29	67.5	67.51	**68.41**	**69.66**	72.02	73.11	81.6	81.64
	1.5	1	7	4	8	**5**	**3**	6	2	9	10
		56.76	59.91	60.23	63.76	**65.18**	**67.67**	74.34	74.66	75.86	77.17
	2	7	8	4	2	**3**	**6**	1	5	9	10
		54.2	56.62	57.84	58.45	**61.15**	**62.93**	65.85	67.66	68.4	68.7
	3	7	9	2	5	**6**	**4**	3	8	1	10
		43.89	46.26	49.89	50.31	**51.99**	**54.61**	55.24	56.14	60.21	69.76
	4.5	3	8	2	6	**4**	**7**	9	1	5	10
		43.34	44.28	45.56	46.77	**47.56**	**48.84**	52.12	53.71	54.2	57.89
	6	5	2	3	6	**10**	**4**	9	7	8	1
		37.66	38.37	41.4	44.14	**46.06**	**46.24**	52.87	58.38	74.12	88.96
	9	3	4	8	10	**9**	**1**	2	6	7	5
		26.17	28.56	34.03	38.73	**42.31**	**47.64**	47.76	65.13	77.37	84.63
2000	**0.5**	**1**	**6**	**5**	**4**	**10**	**7**	**9**	**8**	**2**	**3**
		85.88	**86.04**	**88.22**	**90.42**	**90.6**	**92.35**	**93.34**	**93.36**	**93.58**	**96.11**
	1	9	8	10	7	**5**	**4**	6	3	2	1
		84.25	84.33	85.78	85.92	**87.23**	**89.02**	92.09	93.65	104.76	104.9
	1.5	1	7	4	8	**5**	**3**	6	2	9	10

Little Cabbage Tree Creek at Hamilton Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		72.73	75.56	76.43	80.85	**82.78**	**87.19**	94.73	95.06	96.72	98.48
	2	7	8	4	2	**3**	**6**	1	9	5	10
		68.56	71.16	73.01	73.76	**77.94**	**79.68**	83.38	86.55	86.78	86.98
	3	7	9	2	5	**6**	**4**	3	8	1	10
		55.34	57.96	62.8	63.48	**65.89**	**69.09**	70.16	70.98	75.81	88.37
	4.5	3	8	2	6	**4**	**7**	9	1	5	10
		54.18	55.09	57.18	59.42	**59.99**	**60.95**	65.46	67.26	68.04	72.3
	6	5	2	3	6	**10**	**4**	9	7	8	1
		46.82	47.9	51.7	55.33	**57.44**	**58.07**	66.5	72.79	93.01	112.4
	9	3	4	8	10	**9**	**1**	2	6	7	5
		32.39	35.36	42.4	48.15	**53.1**	**59.43**	59.62	81.98	97.55	106.1

Little Cabbage Tree Creek at Gympie Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
200	0.5	1	6	5	4	**7**	**9**	10	3	8	2
		94.48	96.5	97.26	97.29	**97.41**	**97.72**	97.72	98.2	98.54	98.93
	1	7	10	1	8	**4**	**9**	5	2	3	6
		109.33	115.12	116.58	116.8	**117.12**	**117.28**	117.46	118.23	121.02	122.18
	1.5	**4**	**8**	**1**	**7**	**5**	**9**	**2**	**3**	**10**	**6**
		102.83	**111.91**	**116.24**	**117.66**	**120.77**	**121.52**	**123.48**	**124.7**	**126.44**	**130.03**
	2	2	4	6	7	**1**	**8**	9	3	5	10
		103.48	103.79	104.09	107.73	**108.55**	**110.86**	117.55	117.73	119.43	123.17
	3	7	8	6	9	**2**	**5**	4	3	1	10
		87.1	87.93	89.52	94.27	**94.58**	**96.2**	104.37	106.04	107.76	122.71
	4.5	6	3	9	4	**8**	**2**	7	5	1	10
		82.69	84.3	88.49	90.95	**91.7**	**92.26**	96.52	99.96	102.49	115.15
	6	2	6	5	3	**4**	**10**	9	7	8	1
		72.14	74.06	78.35	78.45	**89.82**	**92.74**	97.84	116.91	141.65	158.9
	9	3	4	8	9	**10**	**2**	1	6	7	5
		57.86	62.89	68.05	80.21	**80.51**	**91.15**	92.79	112.47	139.96	148.88
500	0.5	1	6	5	4	**7**	**9**	10	3	8	2
		112.87	115.41	116.34	116.36	**116.51**	**116.89**	116.9	117.48	117.92	118.4
	1	7	10	1	8	**4**	**9**	5	2	3	6
		130.76	137.7	139.25	139.86	**140.14**	**140.54**	140.57	141.26	144.91	146.39
	1.5	**4**	**8**	**1**	**7**	**5**	**9**	**2**	**3**	**10**	**6**

Little Cabbage Tree Creek at Gympie Road – Peak Discharge (m³/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
		121.48	132.44	137.6	139.51	143.07	144.1	146.68	148.16	150.07	154.62
	2	2	4	6	7	1	8	9	3	5	10
		122.28	122.57	123.03	127.44	128.38	131.12	139.52	140.02	142.21	146.27
	3	7	8	6	9	2	5	4	3	1	10
		101.92	103.33	105.76	111.01	112.12	113.61	123.45	124.47	126.95	145.01
	4.5	6	3	9	8	4	2	7	5	1	10
		98.11	98.79	104.07	107.35	107.55	108.61	113.38	118.44	120.39	135.11
	6	2	6	3	5	4	10	9	7	8	1
		84.04	86.49	91.51	91.84	105.58	108.4	115.23	136.56	166.83	187.56
	9	3	4	8	10	9	2	1	6	7	5
		67.18	73.07	79.75	93.83	93.93	107.06	108.38	132.49	164.32	175.44
2000	0.5	1	6	5	4	7	9	10	3	8	2
		144.5	147.95	149.2	149.22	149.39	149.91	149.95	150.71	151.31	151.97
	1	7	10	1	8	4	5	9	2	3	6
		167.83	176.61	178.14	179.61	179.77	180.39	180.7	180.79	186.08	188.17
	1.5	**4**	**8**	**1**	**7**	**5**	**9**	**2**	**3**	**10**	**6**
		154.12	**168.53**	**175.08**	**177.95**	**182.45**	**183.91**	**187.78**	**189.76**	**191.76**	**198.17**
	2	2	4	6	7	1	8	9	3	5	10
		154.28	154.5	155.29	161.01	162.3	165.6	177.21	178.24	181.3	185.81
	3	7	8	6	9	2	5	3	4	1	10
		127.42	129.48	133.48	139.42	142.13	143.63	155.61	156.01	159.6	183.07
	4.5	3	6	9	8	4	2	7	5	1	10
		122.98	124.18	130.22	133.41	135.51	136.01	141.53	149.84	150.34	168.41
	6	2	6	3	5	4	10	9	7	8	1
		104.19	107.65	113.76	114.82	132.48	135.01	144.98	169.88	209.98	236.79
	9	3	4	8	10	9	2	1	6	7	5
		83.19	90.57	100	116.76	117.64	134.7	135.29	167.39	206.57	221.81

Cabbage Tree Creek at Old Northern Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
200	0.5	1	6	5	4	**10**	**7**	9	8	3	2
		106.14	108.02	109.42	109.96	**110.52**	**110.61**	111.13	111.95	112.27	112.39
	1	**7**	**9**	**8**	**4**	**10**	**5**	**3**	**6**	**1**	**2**
		121.19	**123.84**	**124.3**	**124.48**	**124.98**	**126.57**	**131.01**	**131.78**	**134.32**	**135.31**
	1.5	4	1	7	3	**5**	**8**	2	9	6	10
		114.42	116.32	122.22	123.79	**124.54**	**124.6**	137.48	138.04	139.95	142.05
	2	7	4	5	8	**2**	**3**	6	1	9	10
		109.52	115.74	116.25	117.21	**117.51**	**120.02**	121.17	126.54	132.08	135.64
	3	7	9	6	2	**5**	**8**	4	3	1	10
		89.26	96.58	97.05	97.14	**99.18**	**105.46**	106.29	114.87	120.71	132.54
	4.5	6	3	4	2	**8**	**7**	9	5	1	10
		86.12	91.47	92.36	94.46	**96.49**	**102.31**	103.34	104.49	111.59	120.99
	6	2	5	3	6	**4**	**10**	9	7	8	1
		78.54	81.11	86.21	87.39	**90.8**	**96.59**	103.5	122.95	143.95	162.9
	9	3	4	8	9	**10**	**2**	1	6	7	5
		60.17	65.1	70.69	83.29	**83.75**	**96.32**	98.46	120.19	145.27	162.02
500	0.5	1	6	5	4	**10**	**7**	9	8	3	2
		127.54	129.93	131.68	132.34	**133.05**	**133.16**	133.8	134.85	135.25	135.41
	1	**7**	**9**	**8**	**4**	**10**	**5**	**3**	**6**	**1**	**2**
		145.12	**148.36**	**148.96**	**149.26**	**149.81**	**151.81**	**157.37**	**158.29**	**161.49**	**162.69**
	1.5	4	1	7	3	**8**	**5**	2	9	6	10
		135.57	137.67	144.91	147.39	**147.94**	**148.06**	163.65	164.44	166.65	169.33
	2	7	4	8	2	**5**	**3**	6	1	9	10
		129.47	137.23	138.85	139.39	**139.58**	**142.86**	143.92	150.41	157.18	161.36
	3	7	9	2	6	**5**	**8**	4	3	1	10
		104.74	114.05	115.3	115.41	**117.7**	**124.48**	126.15	135.18	142.52	157.43
	4.5	6	3	4	2	**8**	**7**	9	5	1	10
		101.25	107.56	109.6	110.7	**113.24**	**120.57**	121.85	123.95	131.5	142.36
	6	2	5	3	6	**4**	**10**	9	7	8	1
		91.72	95.12	100.88	102.37	**107.17**	**113.24**	122.27	143.99	170.2	193.31
	9	3	4	8	10	**9**	**2**	1	6	7	5
		69.88	75.71	82.96	97.82	**97.9**	**113.26**	115.38	142.16	171.33	191.21
2000	0.5	1	6	5	4	**10**	**7**	9	8	3	2
		164.62	167.9	170.31	171.19	**172.18**	**172.31**	173.18	174.62	175.16	175.39
	1	**7**	**9**	**8**	**4**	**10**	**5**	**3**	**6**	**1**	**2**
		186.28	**190.53**	**191.42**	**191.94**	**192.58**	**195.29**	**202.86**	**204.06**	**208.5**	**210.06**
	1.5	4	1	7	8	**3**	**5**	2	9	6	10

Cabbage Tree Creek at Old Northern Road – Peak Discharge (m³/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		172.79	175.14	184.83	189.1	**189.34**	**189.63**	209.93	211.23	213.91	217.7
	2	7	4	8	2	**5**	**3**	6	1	9	10
		163.37	173.92	175.75	176.77	**180.08**	**182.05**	182.88	191.3	200.23	205.43
	3	7	9	2	6	**5**	**8**	4	3	1	10
		130.92	143.8	146.39	146.92	**149.41**	**156.93**	160.21	169.63	179.71	200.13
	4.5	6	3	2	4	**8**	**7**	9	5	1	10
		127.71	134.5	137.73	138.77	**141.17**	**151.16**	152.99	156.78	164.94	178.15
	6	2	5	3	6	**4**	**10**	9	7	8	1
		114.13	118.98	125.84	127.94	**135.27**	**141.63**	154.52	179.79	215.33	245.86
	9	3	4	8	10	**9**	**2**	1	6	7	5
		86.56	93.92	104.2	122.08	**123.3**	**142.66**	144.64	180.61	216.8	242.1

Cabbage Tree Creek at MHG C240 – Peak Discharge (m³/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
200	0.5	1	6	5	4	**7**	**10**	9	3	8	2
		111.46	112.72	113.22	113.28	**113.36**	**113.54**	113.57	113.87	114.09	114.32
	1	7	10	8	9	**4**	**5**	1	2	3	6
		137.09	141.22	141.85	141.87	**141.95**	**142.84**	143.15	144.89	145.84	146.74
	1.5	**4**	**1**	**8**	**7**	**5**	**3**	**9**	**2**	**10**	**6**
		133.16	**144.48**	**144.73**	**147.15**	**150.99**	**153.21**	**154.02**	**156.35**	**158.79**	**161.02**
	2	2	4	6	7	**8**	**1**	5	3	9	10
		138.3	138.54	139.29	139.49	**143.21**	**145.31**	148.35	150.56	152.35	158.51
	3	2	8	7	6	**5**	**9**	4	3	1	10
		118.98	120.03	120.4	121	**125.78**	**126.3**	134.26	141.4	142.78	159.68
	4.5	6	3	4	9	**2**	**8**	5	7	1	10
		113.9	116.69	116.81	118.87	**126.11**	**127.05**	128.39	130.31	138.24	154.25
	6	2	6	5	3	**4**	**9**	10	7	8	1
		97.42	102.06	105.71	109.42	**116.08**	**123.87**	124.56	156.97	178.39	196.28
	9	3	4	8	9	**10**	**2**	1	6	7	5
		81.42	88	89.31	104.19	**109.53**	**116.98**	123.82	140.42	177.03	185.68
500	0.5	1	6	5	4	**7**	**10**	9	3	8	2
		133.58	135.16	135.79	135.86	**135.96**	**136.18**	136.22	136.59	136.87	137.16
	1	7	10	8	9	**4**	**5**	1	2	3	6
		164.09	169.25	170.05	170.07	**170.2**	**171.28**	171.65	173.8	175.01	176.13
	1.5	**4**	**1**	**8**	**7**	**5**	**3**	**9**	**2**	**10**	**6**

Cabbage Tree Creek at MHG C240 – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		157.56	**171.59**	**171.76**	**174.77**	**179.62**	**182.47**	**183.23**	**186.02**	**189.05**	**191.8**
	2	2	4	6	7	**8**	**1**	5	3	9	10
		163.85	164.13	165.09	165.48	**169.84**	**172.38**	176.65	179.24	181.14	188.54
	3	8	2	7	6	**9**	**5**	4	3	1	10
		141.12	141.36	141.36	142.07	**148.98**	**149.09**	159.09	166.37	168.39	189.08
	4.5	6	3	4	9	**2**	**8**	5	7	1	10
		133.75	136.93	138.39	139.71	**148.3**	**149.08**	152.32	153.58	162.68	181.5
	6	2	6	5	3	**4**	**10**	9	7	8	1
		113.49	119.13	123.91	127.73	**136.78**	**145.93**	146.23	183.81	210.86	232.34
	9	3	4	8	9	**10**	**2**	1	6	7	5
		94.55	102.32	104.8	122.25	**127.9**	**137.58**	145	165.81	208.25	219.13
2000	0.5	1	6	5	4	**7**	**10**	9	3	8	2
		171.78	173.93	174.78	174.88	**175.02**	**175.31**	175.36	175.87	176.25	176.66
	1	7	10	8	9	**4**	**5**	1	2	3	6
		210.54	217.55	218.66	218.69	**218.92**	**220.32**	220.8	223.68	225.39	226.91
	1.5	**4**	**8**	**1**	**7**	**5**	**3**	**9**	**2**	**10**	**6**
		200.41	**219.41**	**219.47**	**223.52**	**230.3**	**234.37**	**234.89**	**238.49**	**242.65**	**246.34**
	2	2	4	6	7	**8**	**1**	5	3	9	10
		207.41	207.77	209.14	209.94	**215.31**	**218.62**	225.34	228.48	230.47	240
	3	7	8	6	2	**9**	**5**	4	3	1	10
		176.78	176.92	178.4	179.76	**187.59**	**188.95**	201.56	208.69	211.96	239.3
	4.5	6	3	9	4	**2**	**8**	7	5	1	10
		166.88	170.73	174.63	174.81	**185.42**	**185.82**	192.57	192.75	203.64	227.1
	6	2	6	5	3	**4**	**10**	9	7	8	1
		140.69	148.12	154.9	158.81	**172.25**	**182.35**	184.6	229.45	266.69	294.48
	9	3	4	8	9	**10**	**2**	1	6	7	5
		117.09	126.92	131.66	153.56	**159.6**	**173.38**	181.62	210.18	262.56	277.51

Cabbage Tree Creek at 540122 – Peak Discharge (m³/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
200	0.5	1	6	4	5	**7**	**9**	10	3	8	2
		153.02	154.07	154.44	154.45	**154.48**	**154.63**	154.67	154.84	155.08	155.27
	1	7	10	8	9	**4**	**5**	1	2	3	6
		197.26	200.43	201.01	201.09	**201.14**	**201.67**	202.1	202.9	203.91	204.62
	1.5	1	7	4	5	**3**	**8**	2	9	10	6
		224.04	226.31	226.91	227.2	**227.9**	**227.93**	231.95	233.54	234.01	234.08
	2	3	5	7	8	**4**	**2**	1	6	10	9
		245.75	246.82	249.69	250.89	**252.24**	**253.52**	253.63	254.5	255.61	255.63
	3	**2**	**8**	**9**	**5**	**6**	**4**	**7**	**10**	**1**	**3**
		258.44	**261.38**	**265.74**	**266.18**	**268.67**	**268.9**	**269.67**	**277.9**	**277.97**	**279.08**
	4.5	5	4	7	6	**3**	**9**	2	8	1	10
		233.43	239.62	259.1	260.29	**263.61**	**264.23**	280.1	281.18	285.39	308.91
	6	9	2	4	6	**5**	**10**	3	8	1	7
		204.69	233.93	236.12	241.12	**247.68**	**248.67**	249.89	271.63	292.54	317.26
	9	8	3	9	2	**4**	**6**	10	1	5	7
		188.8	192.76	195.55	203.01	**205.32**	**227.38**	228.96	240.2	269.56	294.45
500	0.5	1	6	4	5	**7**	**9**	10	3	8	2
		182.48	183.78	184.24	184.26	**184.28**	**184.47**	184.52	184.73	185.03	185.27
	1	7	10	8	9	**4**	**5**	1	2	3	6
		235.46	239.43	240.19	240.3	**240.36**	**240.99**	241.41	242.4	243.77	244.65
	1.5	1	7	4	5	**8**	**3**	2	9	10	6
		265.78	268.57	269.29	269.8	**270.57**	**270.78**	275.49	277.46	278.03	278.18
	2	3	5	7	8	**4**	**2**	1	6	9	10
		292.1	293.34	296.9	298.35	**300.02**	**301.59**	301.73	302.79	304.22	304.25
	3	**2**	**8**	**9**	**5**	**6**	**4**	**7**	**1**	**10**	**3**
		304.53	**308.2**	**313.59**	**314.09**	**317.21**	**317.41**	**318.41**	**328.52**	**328.75**	**329.81**
	4.5	5	4	7	6	**3**	**9**	2	8	1	10
		273.28	281.94	305.92	307.01	**309.6**	**310.57**	329.42	330.85	335.93	364.46
	6	9	2	4	6	**5**	**10**	3	8	1	7
		241.22	273.17	276.34	281.4	**289.1**	**291.08**	291.69	320.41	345.27	372.25
	9	8	3	9	2	**4**	**6**	10	1	5	7
		219.75	223.75	229.49	236.76	**238.76**	**266.7**	267.03	281.57	317.41	345.84
2000	0.5	1	6	4	5	**7**	**9**	10	3	8	2
		233.04	234.82	235.42	235.45	**235.47**	**235.72**	235.8	236.07	236.48	236.81
	1	7	10	8	9	**4**	**5**	1	2	3	6
		301.03	306.46	307.56	307.73	**307.8**	**308.58**	308.95	310.28	312.31	313.51
	1.5	1	7	4	5	**8**	**3**	2	9	10	6

Cabbage Tree Creek at 540122 – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		339.48	343.22	344.18	345.08	**345.95**	**346.62**	352.45	355.15	355.89	356.19
	2	3	5	7	8	**4**	**2**	1	6	9	10
		371.67	373.19	377.95	379.84	**382.09**	**384.17**	384.33	385.74	387.7	387.84
	3	**2**	**8**	**9**	**5**	**6**	**4**	**7**	**1**	**10**	**3**
		382.87	**387.92**	**395.08**	**395.68**	**399.9**	**400.07**	**401.47**	**414.78**	**415.62**	**416.39**
	4.5	5	4	7	6	**3**	**9**	2	8	1	10
		339.49	352.93	384.66	385.46	**386.39**	**388.11**	412.01	414.06	420.56	457.76
	6	9	2	4	6	**5**	**3**	10	8	1	7
		303.92	339.75	345.04	349.67	**359.29**	**362.61**	363.3	404.12	435.81	466.05
	9	8	3	9	2	**4**	**10**	6	1	5	7
		272.93	276.89	288.4	294.98	**296.16**	**332.77**	334.89	353.22	400.77	435.12

Cabbage Tree Creek at Lemke Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
200	0.5	1	6	4	7	**5**	**9**	10	3	8	2
		189.45	190.01	190.18	190.18	**190.2**	**190.25**	190.29	190.33	190.52	190.6
	1	7	10	1	8	**4**	**9**	5	2	3	6
		252.03	254.13	254.43	254.61	**254.64**	**254.65**	254.99	255.42	256.46	256.92
	1.5	4	8	1	7	**5**	**9**	3	2	10	6
		285.58	291.21	291.9	293	**294.87**	**295.64**	296.31	297.27	298.16	299.97
	2	2	4	6	7	**8**	**1**	5	3	9	10
		314.1	314.34	314.36	315.02	**317.17**	**317.48**	317.59	318.5	321.2	324.53
	3	2	8	5	6	**7**	**4**	9	1	3	10
		323.63	332.02	337	339.08	**340.58**	**340.62**	341.11	349.97	354.06	361.3
	4.5	**5**	**4**	**6**	**9**	**7**	**3**	**1**	**2**	**8**	**10**
		318.32	**336.71**	**337**	**338.72**	**339.48**	**352.2**	**369.39**	**372.17**	**372.49**	**394.69**
	6	9	2	6	10	**4**	**5**	3	8	1	7
		285.67	312.6	326.12	326.92	**330.34**	**341.31**	341.41	356.72	380.61	407.93
	9	9	8	2	3	**4**	**6**	1	10	5	7
		254.94	260.35	266.48	273.37	**287.67**	**292.04**	312.79	322.24	346.51	384.98
500	0.5	1	6	4	7	**5**	**9**	10	3	8	2
		226.05	226.73	226.92	226.93	**226.96**	**227.02**	227.07	227.13	227.35	227.45
	1	7	10	1	8	**4**	**9**	5	2	3	6
		302.95	305.58	305.65	306.21	**306.28**	**306.28**	306.63	306.97	308.45	309.04
	1.5	4	8	1	7	**5**	**9**	2	3	10	6

Cabbage Tree Creek at Lemke Road – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		338.29	345.35	346.88	348	**350.55**	**350.63**	352.49	352.72	353.23	355.3
	2	2	6	4	7	**8**	**1**	5	3	9	10
		371.78	372.08	372.22	373.4	**376.1**	**376.18**	377.81	378.53	380.86	383.58
	3	2	8	5	6	**7**	**4**	9	1	3	10
		381.18	391.45	397.1	399.49	**401.38**	**401.55**	402.29	412.72	417.75	426.49
	4.5	**5**	**4**	**6**	**9**	**7**	**3**	**1**	**2**	**8**	**10**
		373.79	**395.52**	**396.54**	**398.03**	**398.9**	**414.31**	**435.03**	**437.74**	**438.31**	**463.75**
	6	9	2	6	10	**4**	**5**	3	8	1	7
		332.23	366.42	381.79	382.84	**385.74**	**398.64**	398.88	414.6	441.09	476.4
	9	9	8	2	3	**4**	**6**	1	10	5	7
		299.51	303.72	310.93	317.32	**335.42**	**343.43**	366.25	374.77	401.43	447.06
2000	0.5	1	6	4	7	**5**	**9**	10	3	8	2
		290.17	291.19	291.47	291.48	**291.54**	**291.6**	291.7	291.75	292.08	292.26
	1	7	1	10	8	**9**	**4**	2	5	3	6
		382.53	384.88	385.24	385.94	**386.02**	**386.07**	386.25	386.29	388.05	388.62
	1.5	4	8	1	7	**9**	**5**	2	3	10	6
		424.9	431.8	433.91	434.71	**437.42**	**437.52**	439.54	439.77	440.55	443.23
	2	2	4	6	7	**1**	**8**	5	3	9	10
		464.14	464.54	464.62	465.81	**467.98**	**468.11**	469.91	470.77	473.48	476.41
	3	2	8	5	6	**4**	**7**	9	1	3	10
		479.26	491.38	499.38	502	**503.59**	**504.08**	505.21	512.16	516.96	526.6
	4.5	**5**	**4**	**7**	**6**	**9**	**3**	**1**	**2**	**8**	**10**
		465.57	**493.5**	**496.23**	**496.48**	**498.22**	**518.41**	**539.32**	**545.76**	**545.88**	**569.91**
	6	9	2	6	10	**4**	**5**	3	8	1	7
		410.92	456.88	476.09	477.31	**480.03**	**495.92**	496.78	509.9	542.93	583.9
	9	9	8	2	3	**4**	**6**	1	10	5	7
		375.67	377.81	387.63	393.98	**416.85**	**427.88**	457.93	465.2	494.41	549.77

Cabbage Tree Creek at Catchment Outlet – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
200	0.5	1	6	7	4	**9**	**3**	5	10	8	2
		193.39	193.57	193.6	193.61	**193.61**	**193.62**	193.63	193.65	193.72	193.74
	1	7	1	10	8	**9**	**4**	5	2	3	6
		260.47	261.17	261.23	261.44	**261.44**	**261.47**	261.57	261.62	262.11	262.26
	1.5	4	8	1	7	**9**	**5**	3	2	10	6
		301.41	304.14	304.61	305.04	**305.35**	**305.9**	306.62	306.69	306.94	307.91
	2	6	2	4	7	**1**	**9**	8	5	3	10
		332.24	332.79	333.2	333.83	**334.56**	**334.68**	334.8	336.62	336.64	338.61
	3	8	2	7	6	**1**	**5**	9	4	3	10
		364.33	365.15	371.82	372.2	**372.91**	**373.31**	373.81	376.52	379.86	385.08
	4.5	1	9	5	3	**6**	**4**	8	7	2	10
		410.68	411.51	411.89	412.07	**413.65**	**418.47**	422.89	423.08	427.23	428.79
	6	**10**	**2**	**1**	**9**	**8**	**6**	**4**	**3**	**5**	**7**
		407.64	**409.43**	**418.77**	**421.42**	**423.03**	**425.61**	**428.14**	**431.9**	**439.75**	**450.26**
	9	6	8	2	9	**5**	**1**	3	4	7	10
		319.96	332.46	338.26	343.32	**356.25**	**371.86**	385.23	395.53	407.96	445.23
500	0.5	1	6	4	7	**9**	**5**	3	10	8	2
		229.85	230.07	230.1	230.1	**230.12**	**230.14**	230.15	230.16	230.26	230.28
	1	7	1	10	8	**9**	**4**	5	2	3	6
		310.49	311.36	311.47	311.73	**311.74**	**311.77**	311.88	311.93	312.57	312.78
	1.5	4	8	1	7	**9**	**5**	2	10	3	6
		357.1	360.38	361.05	361.54	**361.85**	**362.6**	363.1	363.22	363.54	364.01
	2	6	2	4	7	**1**	**9**	8	3	5	10
		394.25	394.93	395.44	396.26	**397.06**	**397.17**	397.39	399.77	399.79	400.83
	3	8	2	7	6	**1**	**5**	9	4	3	10
		430.63	433.04	439.4	439.95	**440.32**	**441.47**	441.83	445.23	448.73	454.81
	4.5	1	5	9	3	**6**	**4**	7	8	2	10
		485.14	486.03	487.02	487.16	**487.41**	**494.44**	499	499.69	504.89	505.19
	6	**10**	**2**	**1**	**8**	**9**	**6**	**4**	**3**	**5**	**7**
		477.48	**478.77**	**484.81**	**491.68**	**492.38**	**499.14**	**500.72**	**506.71**	**515.78**	**527.9**
	9	6	8	2	9	**5**	**1**	3	4	7	10
		375.95	388.93	393.21	399.13	**413.46**	**434.43**	447.11	460.54	474.89	518.87
2000	0.5	1	6	4	7	**9**	**5**	3	10	8	2
		291.87	292.19	292.25	292.27	**292.29**	**292.31**	292.33	292.36	292.47	292.52
	1	7	1	10	2	**8**	**9**	4	5	3	6
		391.65	392.02	392.23	392.32	**392.38**	**392.38**	392.43	392.44	392.77	392.82
	1.5	4	8	9	1	**7**	**5**	2	10	3	6

Cabbage Tree Creek at Catchment Outlet – Peak Discharge (m^3/s) and Ensemble Ranking											
ARI	Duration (hr)	R1	R2	R3	R4	**R5**	**R6**	R7	R8	R9	R10
		450.28	452.4	453.06	453.18	**453.33**	**454.12**	454.39	454.51	454.69	455.38
	2	6	2	4	9	**1**	**7**	8	3	5	10
		494.11	494.97	495.54	495.73	**496.29**	**496.39**	496.95	499.21	499.28	499.82
	3	8	2	1	7	**6**	**9**	5	3	4	10
		543.3	549.12	549.57	553.55	**554.41**	**555.91**	556.55	558.72	559.1	563.73
	4.5	5	1	6	3	**9**	**4**	7	10	8	2
		608.75	610.23	610.48	613.34	**614.22**	**621.35**	623.15	625.98	626.86	632.84
	6	**1**	**10**	**2**	**8**	**9**	**4**	**6**	**3**	**5**	**7**
		596.07	**596.39**	**598.35**	**606.04**	**612.86**	**623.62**	**624.56**	**634.32**	**644.82**	**656.77**
	9	6	2	8	9	**5**	**1**	3	4	7	10
		469.22	486.9	487.1	494.05	**510.41**	**541.73**	554.74	572.73	585.55	645.08

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Appendix J: Rare Events (Scenario 1) - Peak Flood Levels

The flood level data presented in this Appendix has been extracted (in part) from the results of a 2-dimensional flood model. Levels presented have been extracted generally at selected points along the centreline of the waterway with the intent of demonstrating general flood characteristics. The applicability of this data to locations on the floodplains adjacent should be determined by a suitably qualified professional. It is recommended for any detailed assessment of flood risk associated with the waterway that complete flood model results be accessed and interrogated.

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AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) (2)		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
Cabbage Tree Creek			
0	1.31	1.31	1.31
100	1.31	1.31	1.31
200	N/R (1)	N/R (1)	N/R (1)
300	1.33	1.34	1.36
400	1.36	1.37	1.41
500	1.37	1.39	1.44
600	1.38	1.41	1.47
700	1.40	1.43	1.50
800	1.42	1.46	1.54
900	1.46	1.51	1.61
1000	1.50	1.55	1.68
1100	1.53	1.60	1.73
1200	1.57	1.64	1.80
1300	1.61	1.69	1.86
1400	1.64	1.72	1.90
1500	1.66	1.75	1.94
1600	N/R (1)	N/R (1)	N/R (1)
1700	1.71	1.81	2.03
1800	1.73	1.84	2.06
1900	N/R (1)	N/R (1)	2.15
2000	1.88	2.01	2.28
2100	1.94	2.08	2.36
2200	2.00	2.14	2.43
2300	2.06	2.21	2.50
2400	2.12	2.28	2.57
2500	2.17	2.33	2.63
2600	2.21	2.37	2.68
2700	2.25	2.41	2.73
2800	2.27	2.44	2.76
2900	2.28	2.45	2.77
3000	2.29	2.45	2.78
3100	2.31	2.48	2.80

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) [2]		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
3200	2.34	2.51	2.84
3300	2.38	2.55	2.88
3400	2.42	2.59	2.92
Structure S1 – Blackwood Road Bikeway Bridge			
3500	2.64	2.84	3.18
Structure S2 – Shorncliffe Railway			
Structure S3 – Sandgate Road			
3600	3.37	3.55	3.79
3700	3.43	3.61	3.86
3800	3.46	3.64	3.89
3900	3.52	3.70	3.96
4000	3.73	3.93	4.24
4100	3.80	4.02	4.35
4200	3.82	4.05	4.39
4300	3.86	4.09	4.44
4400	3.88	4.11	4.47
4500	3.89	4.13	4.48
Structure S4 – Gateway Motorway			
4600	N/R [1]	N/R [1]	N/R [1]
4700	4.00	4.25	4.75
4800	4.08	4.34	4.84
4900	4.11	4.37	4.86
5000	4.15	4.41	4.90
5100	4.16	4.42	4.92
5200	4.23	4.50	4.98
5300	4.38	4.64	5.09
Structure S5 – Lemke Road			
5400	4.59	4.90	5.44
5500	4.97	5.25	5.74
5600	5.08	5.35	5.81
5700	5.51	5.75	6.14
5800	5.80	6.04	6.39
5900	N/R [1]	N/R [1]	N/R [1]

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) [2]		
	200-yr ARI (0.5 % AEP)	**500-yr ARI (0.2 % AEP)**	**2000-yr ARI (0.05 % AEP)**
6000	6.28	6.47	6.78
6100	6.95	7.18	7.54
6200	7.54	7.80	8.19
6300	7.79	8.03	8.40
6400	8.04	8.29	8.64
6500	8.27	8.52	8.88
Structure S7 – Roghan Road			
6600	8.55	8.89	9.39
6700	8.83	9.17	9.66
6800	9.01	9.34	9.82
6900	9.07	9.40	9.88
7000	9.10	9.44	9.93
7100	9.11	9.42	9.88
7200	N/R [1]	N/R [1]	N/R [1]
7300	10.48	10.59	10.74
7400	10.76	10.87	11.04
7500	10.93	11.07	11.28
7600	11.23	11.42	11.67
7700	11.51	11.73	12.01
7800	11.67	11.90	12.18
7900	11.84	12.04	12.30
8000	12.00	12.18	12.40
8100	12.20	12.35	12.54
Structure S9 – Beams Road			
8200	12.46	12.59	12.74
8300	12.51	12.67	12.86
8400	12.55	12.71	12.90
8500	12.57	12.73	12.92
8600	12.62	12.78	12.97
8700	12.75	12.91	13.10
Structure S10 – North Coast Railway			
8800	13.26	13.45	13.67
8900	13.62	13.79	14.00

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) (2)		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
9000	13.84	14.01	14.20
9100	14.07	14.22	14.41
9200	14.42	14.57	14.75
9300	14.88	15.04	15.25
9400	15.25	15.42	15.66
9500	15.51	15.66	15.88
9600	15.73	15.84	16.01
9700	16.26	16.31	16.43
9800	16.50	16.55	16.65
9900	16.72	16.78	16.86
Structure S11 – Dorville Road			
10010	17.14	17.21	17.30
10100	17.41	17.48	17.56
10200	17.92	18.01	18.11
10300	18.11	18.21	18.31
10400	18.18	18.27	18.38
10500	18.41	18.49	18.58
10600	18.82	18.90	19.01
10700	19.11	19.20	19.32
Structure S13a – Gympie Road			
10800	19.55	19.70	19.89
10900	19.78	19.93	20.13
11000	19.85	20.02	20.23
11100	19.88	20.05	20.27
11200	19.96	20.13	20.34
11300	20.35	20.54	20.77
11400	20.80	21.00	21.25
11500	21.20	21.41	21.68
11600	21.51	21.72	22.00
11700	21.67	21.87	22.16
11800	21.86	22.07	22.36
11900	21.97	22.18	22.48
12000	22.14	22.34	22.63

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) [2]		
	200-yr ARI (0.5 % AEP)	**500-yr ARI (0.2 % AEP)**	**2000-yr ARI (0.05 % AEP)**
12100	22.43	22.62	22.88
12200	22.78	22.95	23.19
12300	23.17	23.35	23.58
12400	23.51	23.70	23.95
12500	23.71	23.91	24.19
12600	24.35	24.54	24.80
12700	24.90	25.09	25.33
12800	25.22	25.40	25.64
12900	25.50	25.67	25.91
13000	25.81	25.97	26.21
Structure S15 – Albany Creek Road			
13100	26.58	26.84	27.13
13200	26.74	26.99	27.29
13300	26.95	27.17	27.44
13400	27.36	27.53	27.76
13500	27.69	27.82	28.02
13600	27.71	27.84	28.03
13700	28.15	28.26	28.41
13800	28.53	28.62	28.75
13900	28.78	28.89	29.04
14000	N/R [1]	N/R [1]	29.65
14100	29.90	29.96	30.05
14200	30.42	30.49	30.60
14300	30.79	30.86	30.97
14400	31.24	31.31	31.44
14500	31.71	31.81	31.97
14600	32.10	32.23	32.44
14700	32.23	32.36	32.56
14800	32.44	32.56	32.75
14900	33.36	33.52	33.76
15000	33.67	33.83	34.08
15100	34.04	34.20	34.44
15200	34.36	34.50	34.73

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) [(2)]		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
15300	34.60	34.73	34.95
15400	34.86	35.00	35.22
15500	35.12	35.25	35.46
15600	35.64	35.78	35.99
15700	35.97	36.10	36.30
15800	36.82	36.92	37.08
Structure S19 – Beckett Road			
15900	37.70	37.86	38.08
16000	37.82	37.98	38.21
16100	38.06	38.21	38.44
16200	38.40	38.54	38.75
16300	38.85	38.98	39.18
16400	39.33	39.45	39.64
16500	39.78	39.90	40.10
16600	40.15	40.28	40.49
16700	41.01	41.37	42.00
16800	41.84	41.98	42.33
16900	42.37	42.48	42.70
17000	42.63	42.75	42.95
17035	42.73	42.85	43.05
Sandgate Tributary			
0	N/R [(1)]	N/R [(1)]	N/R [(1)]
100	1.68	1.78	1.98
200	1.70	1.80	2.00
300	1.71	1.81	2.01
400	1.71	1.82	2.02
500	1.75	1.86	2.07
600	1.83	1.95	2.18
700	1.92	2.06	2.29
800	2.01	2.16	2.39
Structure S43 – Bridge Street			
900	2.33	2.41	2.56
Structure S44 – Shorncliffe Railway			

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) (2)		
	200-yr ARI (0.5 % AEP)	**500-yr ARI (0.2 % AEP)**	**2000-yr ARI (0.05 % AEP)**
1000	2.87	3.03	3.16
Structure S45 – Barclay Street			
1100	2.93	3.10	3.24
Structure S46 – Coward Street			
1200	3.08	3.25	3.41
1288	3.16	3.29	3.46
Deagon Tributary			
0	2.07	2.22	2.51
100	2.08	2.23	2.53
200	2.09	2.24	2.53
Structure S47 – Finnie Road			
300	2.13	2.30	2.61
Structure S48 – Blackwood Road			
400	2.15	2.32	2.62
Structure S49 – Shorncliffe Railway			
500	2.24	2.41	2.80
Structure S50 – Smith Street			
Structure S51 – Esther Street			
600	2.33	2.48	2.82
700	2.40	2.52	2.84
Structure S52 – Loftus Street			
800	2.80	2.95	3.13
900	2.82	2.97	3.14
989	2.86	3.00	3.17
Structure S53 – Braun Street			
1100	3.92	4.21	4.61
1200	3.92	4.22	4.61
1300	3.92	4.22	4.61
Taigum Channel			
0	3.63	3.83	4.12
100	3.72	3.93	4.24
200	N/R (1)	N/R (1)	N/R (1)
Structure S22a – Gateway Motorway			

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) (2)		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
Structure S23 – 350 Muller Road			
300	3.76	3.97	4.27
Structure S24 – 334 Muller Road			
400	3.81	4.00	4.28
500	3.82	4.01	4.28
600	3.84	4.01	4.29
700	3.90	4.03	4.30
800	4.10	4.22	4.40
900	4.32	4.44	4.62
Structure S25 – 401 Church Road			
Structure S26 – 401A Church Road			
1000	5.16	5.24	5.36
Structure S27 – Church Road			
1100	5.34	5.43	5.56
1200	5.76	5.87	6.03
Structure S28 – Roghan Road			
1300	6.23	6.37	6.55
1400	6.31	6.45	6.64
1500	6.38	6.53	6.72
1600	6.46	6.61	6.81
Structure S29 – Quarrion Street			
1700	6.56	6.71	6.94
1800	N/R (1)	N/R (1)	N/R (1)
1900	N/R (1)	N/R (1)	N/R (1)
2000	8.93	8.97	9.03
2100	9.27	9.33	9.42
2203	9.58	9.66	9.77
Carseldine Channel			
0	5.03	5.30	5.77
100	5.20	5.46	5.90
200	5.44	5.68	6.10
300	5.65	5.87	6.27
400	5.98	6.19	6.58

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) (2)		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
500	6.54	6.72	7.08
600	7.05	7.23	7.59
700	N/R (1)	N/R (1)	N/R (1)
800	7.23	7.43	7.82
900	7.45	7.66	8.01
1000	8.06	8.16	8.31
1100	8.39	8.47	8.56
1200	8.85	8.91	8.97
1300	9.20	9.26	9.32
1400	9.52	9.57	9.62
1500	10.17	10.24	10.29
1600	10.21	10.28	10.34
1700	10.23	10.30	10.36
1800	10.24	10.31	10.38
1900	10.25	10.32	10.39
Structure S30 – Norris Road			
2000	10.64	10.84	11.09
2100	10.66	10.86	11.11
2200	10.70	10.89	11.14
2300	10.84	10.99	11.21
2400	11.09	11.18	11.35
Structure S31 – North Coast Railway			
2500	11.72	11.93	12.34
2600	11.75	11.95	12.36
2700	11.79	11.98	12.37
2800	11.82	12.00	12.38
2900	11.89	12.05	12.40
3000	11.97	12.11	12.42
Structure S32 – Lacey Road			
3100	12.23	12.36	12.64
3200	13.69	13.75	13.85
3300	13.86	13.92	13.99
Upstream of Lacey Road - AMTD Chainage commences at 5000 m			

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) [(2)]		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
5000	12.22	12.36	12.66
5100	14.04	14.08	14.15
5200	14.30	14.35	14.43
5300	14.65	14.70	14.77
5400	15.66	15.68	15.72
5500	16.36	16.39	16.43
5600	17.00	17.05	17.12
Structure S33 – Gympie Road			
5700	18.10	18.18	18.29
5800	18.41	18.50	18.63
5900	19.29	19.36	19.46
6000	20.24	20.33	20.47
6100	21.64	21.69	21.77
6200	22.77	22.82	22.90
6300	24.06	24.11	24.20
6350	24.76	24.85	24.94
Fitzgibbon Tributary			
0	10.82	10.93	11.12
100	10.81	10.92	11.11
200	10.81	10.92	11.12
300	10.81	10.92	11.12
400	10.81	10.92	11.12
500	10.81	10.92	11.12
600	10.81	10.92	11.12
700	10.81	10.92	11.12
800	10.81	10.92	11.12
900	10.81	10.92	11.12
1000	10.81	10.93	11.16
1103	10.82	10.96	11.25
Little Cabbage Tree Creek			
0	15.35	15.53	15.78
100	15.49	15.65	15.89
200	15.85	16.01	16.34

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) (2)		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
300	16.27	16.42	16.73
400	16.46	16.62	16.93
500	16.65	16.82	17.17
Structure S34 – Zillmere Road			
600	17.01	17.26	17.73
700	17.33	17.56	17.95
800	17.55	17.76	18.12
900	17.87	18.06	18.35
1000	18.36	18.53	18.79
1100	19.05	19.19	19.41
1200	19.40	19.57	19.81
Structure S35 – Gympie Road			
Structure S36 – Gayford Street			
1400	20.13	20.23	20.40
1500	20.20	20.29	20.45
1600	20.86	20.91	21.03
Structure S37 – Albany Creek Road			
1700	22.33	22.74	22.93
1800	N/R (1)	N/R (1)	23.03
1900	22.96	23.17	23.38
2000	23.78	23.90	24.08
2100	24.32	24.43	24.59
2200	24.77	24.87	25.01
2300	25.35	25.46	25.61
2400	26.27	26.40	26.57
2500	26.87	27.01	27.20
2600	27.22	27.37	27.59
2700	27.83	27.95	28.12
Structure S39 – Horn Road Bikeway Bridge			
2800	28.81	28.98	29.23
2900	29.11	29.30	29.57
3000	29.55	29.72	29.98
3100	30.12	30.30	30.55

AMTD (m)	Scenario 1 (Existing Waterway Conditions) Peak Water Levels (mAHD) (2)		
	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)	2000-yr ARI (0.05 % AEP)
3200	30.50	30.68	30.94
3300	30.97	31.16	31.43
3400	31.41	31.56	31.80
3500	32.02	32.15	32.34
Structure S40 – Martindale Street			
3600	32.47	32.63	32.92
3700	33.09	33.24	33.46
3800	33.67	33.79	33.97
3900	33.90	34.03	34.22
4000	34.39	34.51	34.70
4100	35.90	36.00	36.16
4200	36.35	36.47	36.64
4300	36.81	36.97	37.19
4400	37.04	37.22	37.48
4494	37.22	37.42	37.71

(1) N/R = no result, typically because the AMTD line does not intersect the flood surface

(2) Flood levels are inclusive of a 9.8% increase in rainfall intensity due to projected climate variability effects.

Appendix K: Rare Events (Scenario 3) - Peak Flood Levels

The flood level data presented in this Appendix has been extracted (in part) from the results of a 2-dimensional flood model. Levels presented have been extracted generally at selected points along the centreline of the waterway with the intent of demonstrating general flood characteristics. The applicability of this data to locations on the floodplains adjacent should be determined by a suitably qualified professional. It is recommended for any detailed assessment of flood risk associated with the waterway that complete flood model results be accessed and interrogated.

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AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
Cabbage Tree Creek			
0	0.77	1.31	1.31
100	0.77	1.31	1.31
200	N/R (1)	N/R (1)	N/R (1)
300	0.80	1.33	1.34
400	0.82	1.35	1.37
500	0.84	1.37	1.39
600	0.86	1.38	1.41
700	0.88	1.40	1.43
800	0.90	1.42	1.45
900	0.96	1.46	1.50
1000	1.02	1.49	1.55
1100	N/R (1)	1.52	1.59
1200	1.12	1.56	1.64
1300	1.17	1.60	1.68
1400	1.20	1.62	1.71
1500	1.23	1.65	1.74
1600	N/R (1)	N/R (1)	N/R (1)
1700	1.28	1.70	1.80
1800	1.30	1.71	1.82
1900	N/R (1)	N/R (1)	N/R (1)
2000	1.44	1.86	2.00
2100	1.50	1.92	2.06
2200	1.56	1.97	2.13
2300	1.63	2.03	2.19
2400	1.70	2.10	2.26
2500	1.76	2.14	2.31
2600	1.81	2.18	2.35
2700	1.85	2.22	2.39
2800	1.88	2.25	2.42
2900	1.89	2.25	2.43
3000	1.89	2.26	2.43
3100	1.92	2.28	2.46

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
3200	1.95	2.31	2.49
3300	2.00	2.35	2.53
3400	2.04	2.39	2.57
Structure S1 – Blackwood Road Bikeway Bridge			
3500	2.26	2.62	2.83
Structure S2 – Shorncliffe Railway			
Structure S3 – Sandgate Road			
3600	2.92	3.35	3.54
3700	3.00	3.41	3.60
3800	3.04	3.43	3.63
3900	3.12	3.49	3.69
4000	3.38	3.70	3.92
4100	3.46	3.77	4.00
4200	3.49	3.80	4.03
4300	3.52	3.83	4.06
4400	3.54	3.85	4.09
4500	3.56	3.87	4.11
Structure S4 – Gateway Motorway			
4600	N/R (1)	N/R (1)	N/R (1)
4700	3.67	3.97	4.22
4800	3.76	4.05	4.31
4900	3.79	4.08	4.34
5000	3.85	4.13	4.38
5100	3.88	4.15	4.40
5200	3.99	4.24	4.49
5300	4.25	4.44	4.70
Structure S5 – Lemke Road			
5400	4.58	4.78	5.08
5500	4.96	5.13	5.40
5600	5.18	5.32	5.57
5700	5.56	5.69	5.92
5800	5.80	5.92	6.13

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) [(2)]		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
5900	N/R [(1)]	N/R [(1)]	N/R [(1)]
6000	6.30	6.41	6.60
6100	6.91	7.03	7.27
6200	7.47	7.60	7.86
6300	7.73	7.86	8.10
6400	7.98	8.11	8.36
6500	8.25	8.38	8.64
Structure S7 – Roghan Road			
6600	8.51	8.68	9.01
6700	8.80	8.97	9.30
6800	8.99	9.16	9.49
6900	9.06	9.23	9.57
7000	9.12	9.29	9.62
7100	9.23	9.38	9.69
7200	N/R [(1)]	N/R [(1)]	N/R [(1)]
7300	10.47	10.56	10.74
7400	10.74	10.83	11.02
7500	10.91	11.01	11.22
7600	11.16	11.29	11.53
7700	11.41	11.55	11.81
7800	11.60	11.75	12.00
7900	11.78	11.92	12.15
8000	11.98	12.11	12.32
8100	12.21	12.32	12.50
Structure S9 – Beams Road			
8200	12.43	12.55	12.71
8300	12.49	12.63	12.83
8400	12.53	12.67	12.89
8500	12.58	12.72	12.95
8600	12.67	12.82	13.05
8700	12.82	12.97	13.22
Structure S10 – North Coast Railway			

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
8800	13.23	13.41	13.71
8900	13.57	13.73	14.01
9000	13.79	13.94	14.20
9100	14.02	14.14	14.37
9200	14.36	14.47	14.65
9300	14.80	14.92	15.08
9400	15.17	15.29	15.45
9500	15.44	15.55	15.68
9600	15.68	15.76	15.86
9700	16.26	16.31	16.37
9800	16.54	16.60	16.67
9900	16.75	16.83	16.91
Structure S11 – Dorville Road			
10010	17.12	17.23	17.35
10100	17.39	17.52	17.66
10200	17.93	18.09	18.27
10300	18.12	18.29	18.49
10400	18.19	18.35	18.54
10500	18.40	18.55	18.72
10600	18.80	18.96	19.12
10700	19.09	19.25	19.44
Structure S13a – Gympie Road			
10800	19.52	19.75	19.98
10900	19.82	20.02	20.24
11000	20.08	20.27	20.49
11100	20.13	20.32	20.54
11200	20.18	20.36	20.58
11300	20.48	20.65	20.88
11400	20.84	21.00	21.23
11500	21.19	21.35	21.57
11600	21.49	21.65	21.88
11700	21.64	21.80	22.03
11800	21.82	21.98	22.21

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
11900	21.95	22.11	22.32
12000	22.15	22.30	22.51
12100	22.48	22.63	22.83
12200	22.81	22.95	23.14
12300	23.13	23.28	23.46
12400	23.44	23.59	23.79
12500	23.69	23.85	24.06
12600	24.28	24.46	24.67
12700	24.80	24.97	25.17
12800	25.14	25.30	25.50
12900	25.48	25.62	25.81
13000	25.82	25.97	26.16
Structure S15 – Albany Creek Road			
13100	26.42	26.69	26.94
13200	26.61	26.86	27.10
13300	26.86	27.05	27.28
13400	27.31	27.44	27.62
13500	27.68	27.78	27.93
13600	27.79	27.87	28.02
13700	28.23	28.30	28.41
13800	28.62	28.69	28.78
13900	29.02	29.11	29.23
14000	N/R (1)	29.65	29.73
14100	29.95	30.01	30.09
14200	30.45	30.51	30.60
14300	30.96	31.02	31.11
14400	31.33	31.40	31.49
14500	31.75	31.84	31.95
14600	32.14	32.25	32.39
14700	32.34	32.45	32.59
14800	32.66	32.77	32.92
14900	33.38	33.52	33.71
15000	33.70	33.85	34.04

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
15100	34.05	34.19	34.38
15200	34.32	34.44	34.61
15300	34.57	34.68	34.84
15400	34.86	34.96	35.11
15500	35.14	35.25	35.39
15600	35.61	35.71	35.85
15700	35.93	36.03	36.17
15800	36.82	36.89	36.99
Structure S19 – Beckett Road			
15900	37.62	37.75	37.90
16000	37.74	37.87	38.04
16100	37.99	38.12	38.28
16200	38.34	38.45	38.60
16300	38.78	38.88	39.02
16400	39.32	39.42	39.55
16500	39.78	39.87	40.00
16600	40.15	40.25	40.39
16700	40.87	41.11	41.48
16800	41.80	41.89	42.05
16900	42.45	42.54	42.66
17000	42.74	42.84	42.99
17035	42.84	42.95	43.11
Sandgate Tributary			
0	N/R (1)	N/R (1)	N/R (1)
100	1.25	1.67	1.77
200	1.29	1.68	1.79
300	1.30	1.69	1.79
400	1.32	1.70	1.80
500	1.39	1.74	1.86
600	1.51	1.82	1.95
700	1.70	1.97	2.10
800	1.89	2.10	2.23
Structure S43 – Bridge Street			

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
900	2.37	2.49	2.65
Structure S44 – Shorncliffe Railway			
1000	2.86	3.05	3.26
Structure S45 – Barclay Street			
1100	2.96	3.14	3.34
Structure S46 – Coward Street			
1200	3.23	3.56	3.68
1288	3.34	3.66	3.76
Deagon Tributary			
0	1.64	2.04	2.20
100	1.65	2.06	2.21
200	1.66	2.06	2.22
Structure S47 – Finnie Road			
300	1.75	2.11	2.28
Structure S48 – Blackwood Road			
400	1.80	2.14	2.31
Structure S49 – Shorncliffe Railway			
500	1.88	2.22	2.40
Structure S50 – Smith Street			
Structure S51 – Esther Street			
600	2.13	2.32	2.48
700	2.23	2.40	2.52
Structure S52 – Loftus Street			
800	2.60	2.80	2.96
900	2.65	2.84	2.99
989	2.72	2.89	3.03
Structure S53 – Braun Street			
1100	3.69	3.95	4.24
1200	3.70	3.96	4.25
1300	3.70	3.96	4.25
Taigum Channel			
0	3.27	3.61	3.82
100	3.38	3.70	3.92

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
200	N/R (1)	N/R (1)	N/R (1)
Structure S22a – Gateway Motorway			
Structure S23 – 350 Muller Road			
300	3.44	3.76	3.99
Structure S24 – 334 Muller Road			
400	3.90	4.03	4.16
500	3.93	4.06	4.19
600	3.94	4.08	4.22
700	4.01	4.15	4.30
800	4.16	4.29	4.45
900	4.31	4.44	4.60
Structure S25 – 401 Church Road			
Structure S26 – 401A Church Road			
1000	5.13	5.21	5.32
Structure S27 – Church Road			
1100	5.33	5.42	5.54
1200	5.78	5.90	6.04
Structure S28 – Roghan Road			
1300	6.24	6.38	6.59
1400	6.31	6.46	6.66
1500	6.38	6.52	6.72
1600	6.44	6.58	6.77
Structure S29 – Quarrion Street			
1700	6.52	6.66	6.86
1800	N/R (1)	N/R (1)	N/R (1)
1900	N/R (1)	N/R (1)	N/R (1)
2000	8.90	8.92	8.97
2100	9.28	9.34	9.43
2203	9.58	9.64	9.74
Carseldine Channel			
0	5.06	5.21	5.48
100	5.17	5.34	5.61
200	5.38	5.56	5.84

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
300	5.58	5.77	6.05
400	5.91	6.12	6.41
500	6.49	6.70	6.98
600	6.95	7.13	7.39
700	N/R (1)	N/R (1)	N/R (1)
800	7.16	7.32	7.60
900	7.36	7.54	7.81
1000	8.02	8.08	8.19
1100	8.33	8.41	8.49
1200	8.79	8.87	8.94
1300	9.18	9.24	9.30
1400	9.49	9.54	9.59
1500	10.15	10.20	10.24
1600	10.19	10.24	10.29
1700	10.20	10.25	10.31
1800	10.21	10.26	10.32
1900	10.22	10.27	10.33
Structure S30 – Norris Road			
2000	10.52	10.68	10.89
2100	10.55	10.71	10.91
2200	10.61	10.75	10.95
2300	10.79	10.88	11.04
2400	11.08	11.13	11.23
Structure S31 – North Coast Railway			
2500	11.62	11.77	11.98
2600	11.67	11.81	12.02
2700	11.72	11.85	12.05
2800	11.77	11.89	12.07
2900	11.86	11.96	12.12
3000	11.98	12.06	12.20
Structure S32 – Lacey Road			
3100	12.19	12.27	12.41
3200	13.70	13.74	13.80

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
3300	13.80	13.81	13.89
Upstream of Lacey Road - AMTD Chainage commences at 5000 m			
5000	12.08	12.21	12.38
5100	14.07	14.12	14.17
5200	14.32	14.39	14.45
5300	14.65	14.71	14.77
5400	15.68	15.70	15.73
5500	16.39	16.42	16.45
5600	17.00	17.04	17.10
Structure S33 – Gympie Road			
5700	18.12	18.19	18.30
5800	18.42	18.51	18.64
5900	19.33	19.41	19.51
6000	20.28	20.39	20.53
6100	21.72	21.80	21.91
6200	22.78	22.84	22.91
6300	24.03	24.07	24.12
6350	24.69	24.77	24.85
Fitzgibbon Tributary			
0	10.80	10.90	11.09
100	10.78	10.87	11.06
200	10.78	10.87	11.06
300	10.78	10.87	11.06
400	10.78	10.87	11.06
500	10.78	10.87	11.06
600	10.78	10.87	11.06
700	10.78	10.87	11.05
800	10.78	10.87	11.05
900	10.78	10.87	11.05
1000	10.78	10.87	11.06
1103	10.78	10.87	11.06
Little Cabbage Tree Creek			
0	15.27	15.39	15.55

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) [(2)]		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
100	15.42	15.53	15.68
200	15.75	15.89	16.05
300	16.16	16.33	16.49
400	16.41	16.59	16.75
500	16.60	16.79	16.97
Structure S34 – Zillmere Road			
600	16.89	17.15	17.43
700	17.22	17.47	17.73
800	17.47	17.72	17.98
900	17.82	18.05	18.30
1000	18.28	18.50	18.73
1100	18.97	19.15	19.34
1200	19.33	19.52	19.71
Structure S35 – Gympie Road			
Structure S36 – Gayford Street			
1400	20.07	20.18	20.29
1500	20.13	20.22	20.32
1600	20.81	20.86	20.89
Structure S37 – Albany Creek Road			
1700	21.89	22.27	22.70
1800	N/R [(1)]	N/R [(1)]	N/R [(1)]
1900	22.94	23.08	23.31
2000	23.80	23.91	24.05
2100	24.31	24.41	24.53
2200	24.82	24.90	25.03
2300	25.45	25.54	25.66
2400	26.28	26.38	26.51
2500	26.86	26.97	27.11
2600	27.25	27.36	27.52
2700	27.94	28.04	28.19
Structure S39 – Horn Road Bikeway Bridge			
2800	28.88	29.03	29.24
2900	29.11	29.26	29.47

AMTD (m)	Scenario 3 (Ultimate Waterway Conditions) Peak Water Levels (mAHD) (2)		
	100-yr ARI (1 % AEP)	200-yr ARI (0.5 % AEP)	500-yr ARI (0.2 % AEP)
3000	29.53	29.66	29.86
3100	30.06	30.19	30.37
3200	30.42	30.56	30.74
3300	30.89	31.03	31.23
3400	31.34	31.46	31.63
3500	32.01	32.11	32.26
Structure S40 – Martindale Street			
3600	32.46	32.57	32.76
3700	33.12	33.23	33.39
3800	33.66	33.76	33.91
3900	33.94	34.04	34.20
4000	34.38	34.48	34.64
4100	36.05	36.14	36.28
4200	36.52	36.61	36.77
4300	36.84	36.96	37.13
4400	37.02	37.15	37.33
4494	37.16	37.30	37.50

(1) N/R = no result, typically because the AMTD line does not intersect the flood surface.

(2) Flood levels are inclusive of a 9.8% increase in rainfall intensity due to projected climate variability effects.

Appendix L: Rating Curves

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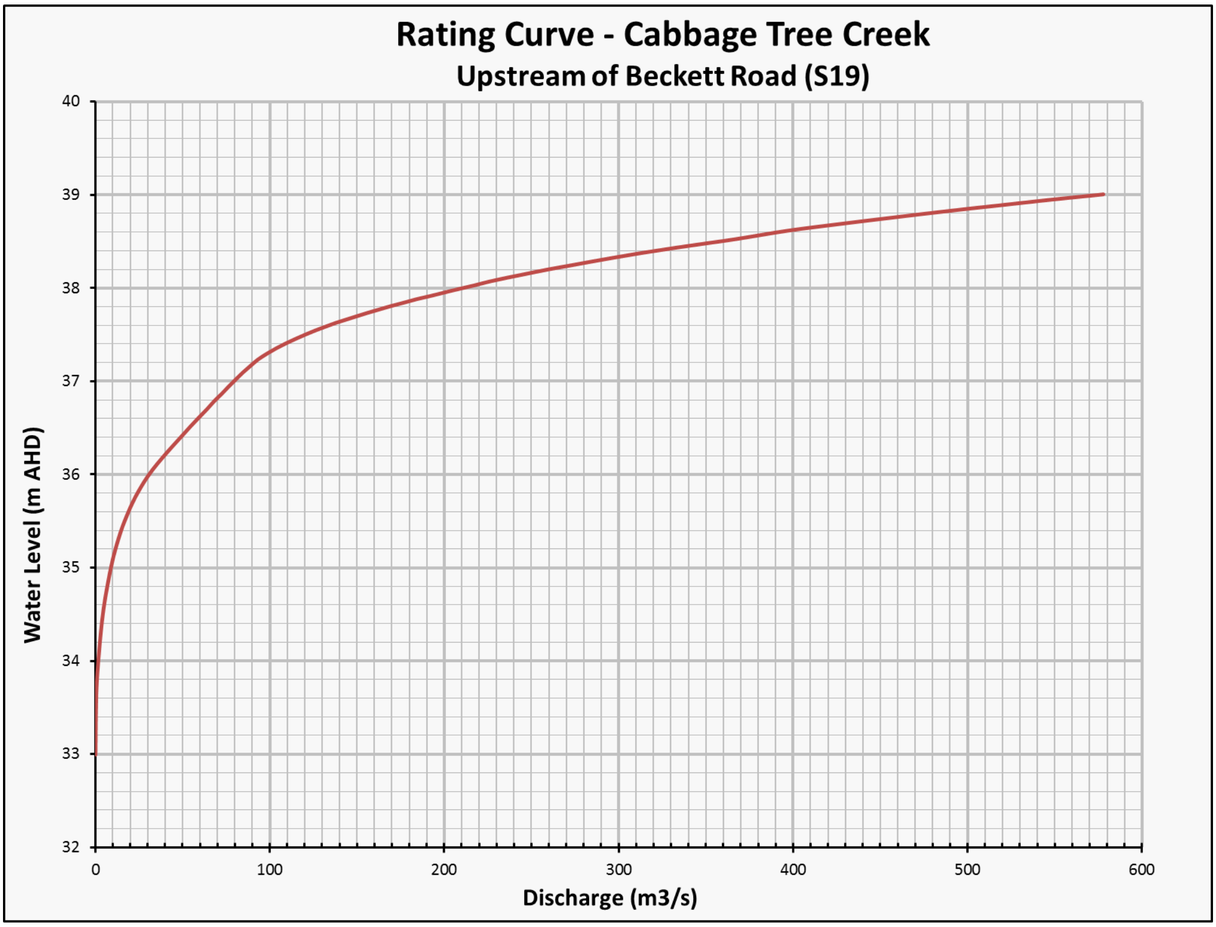
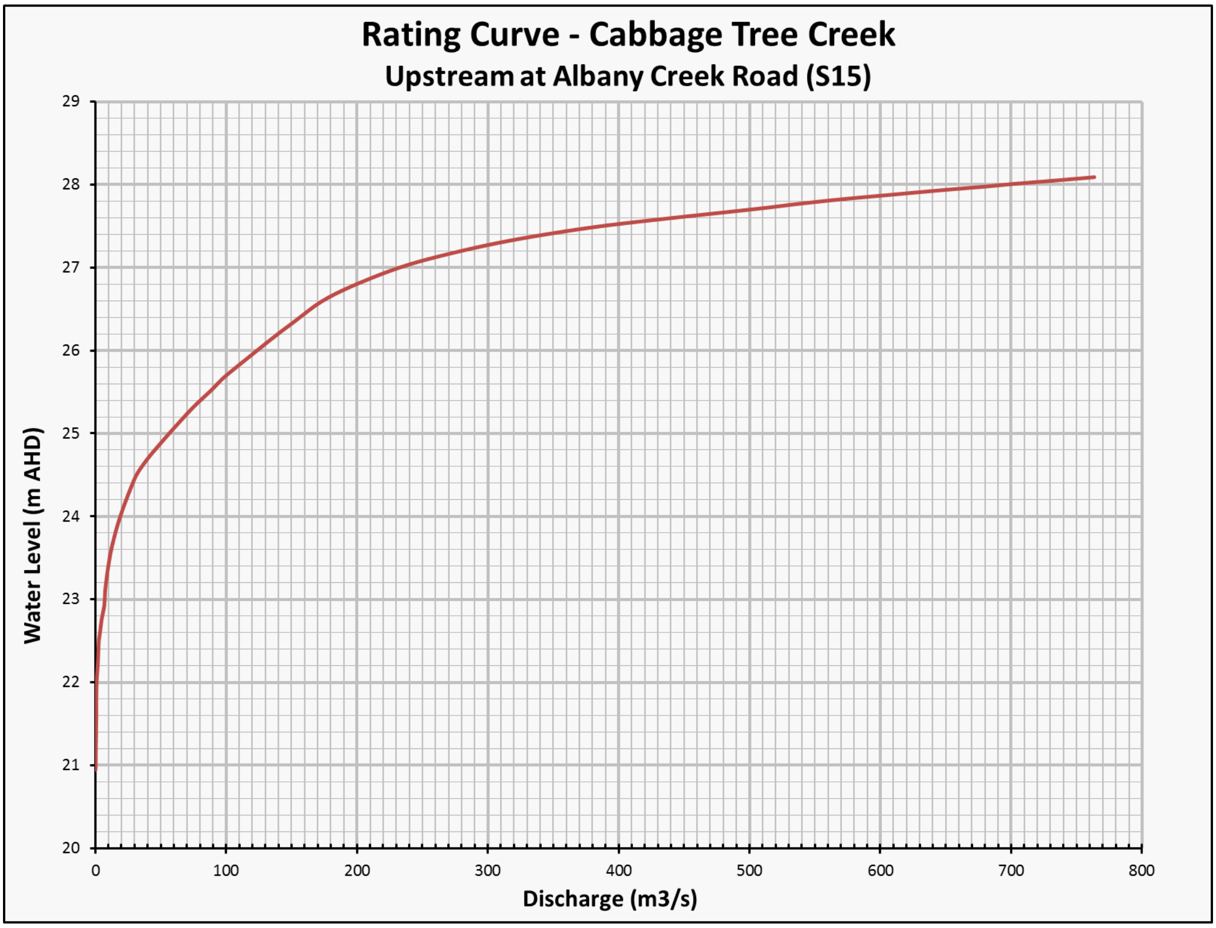
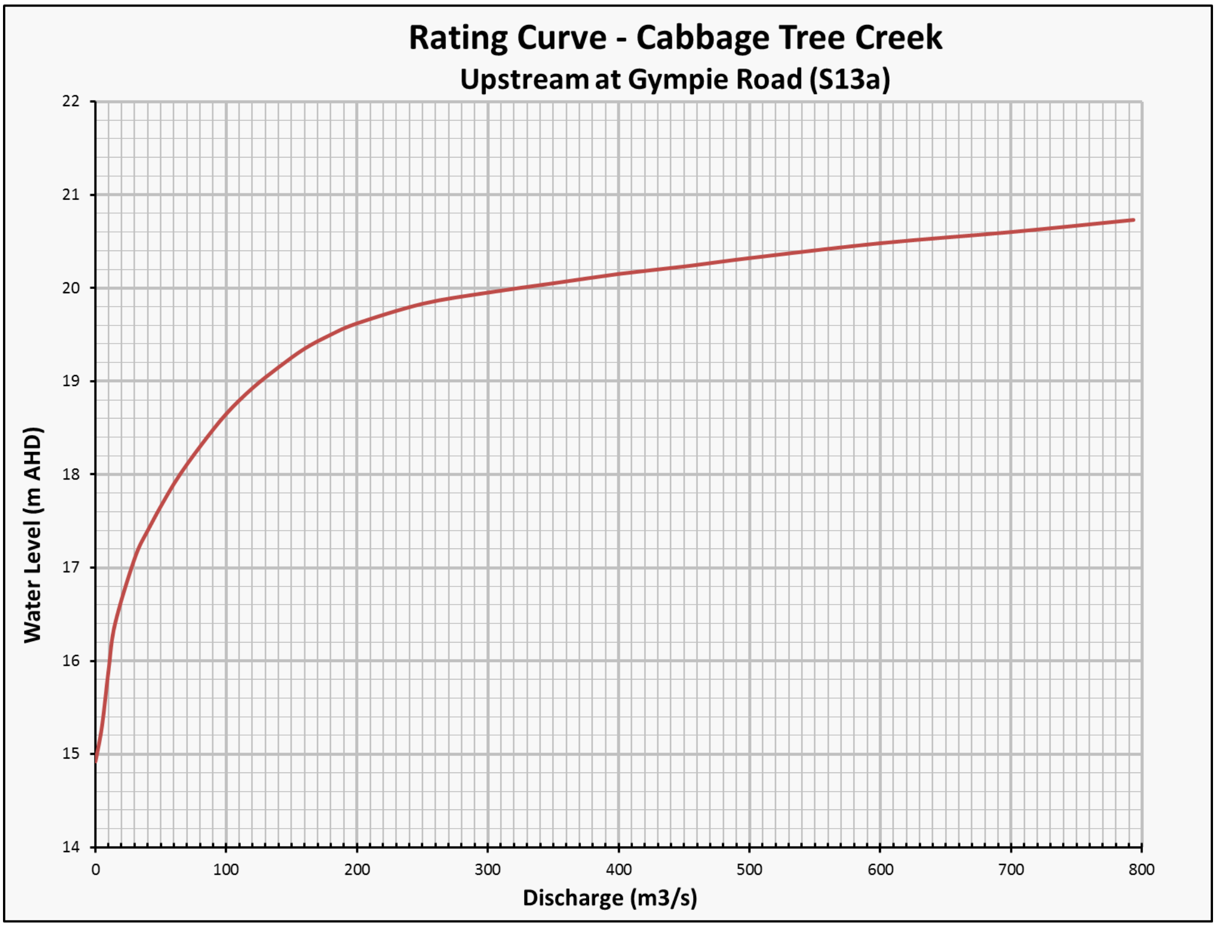
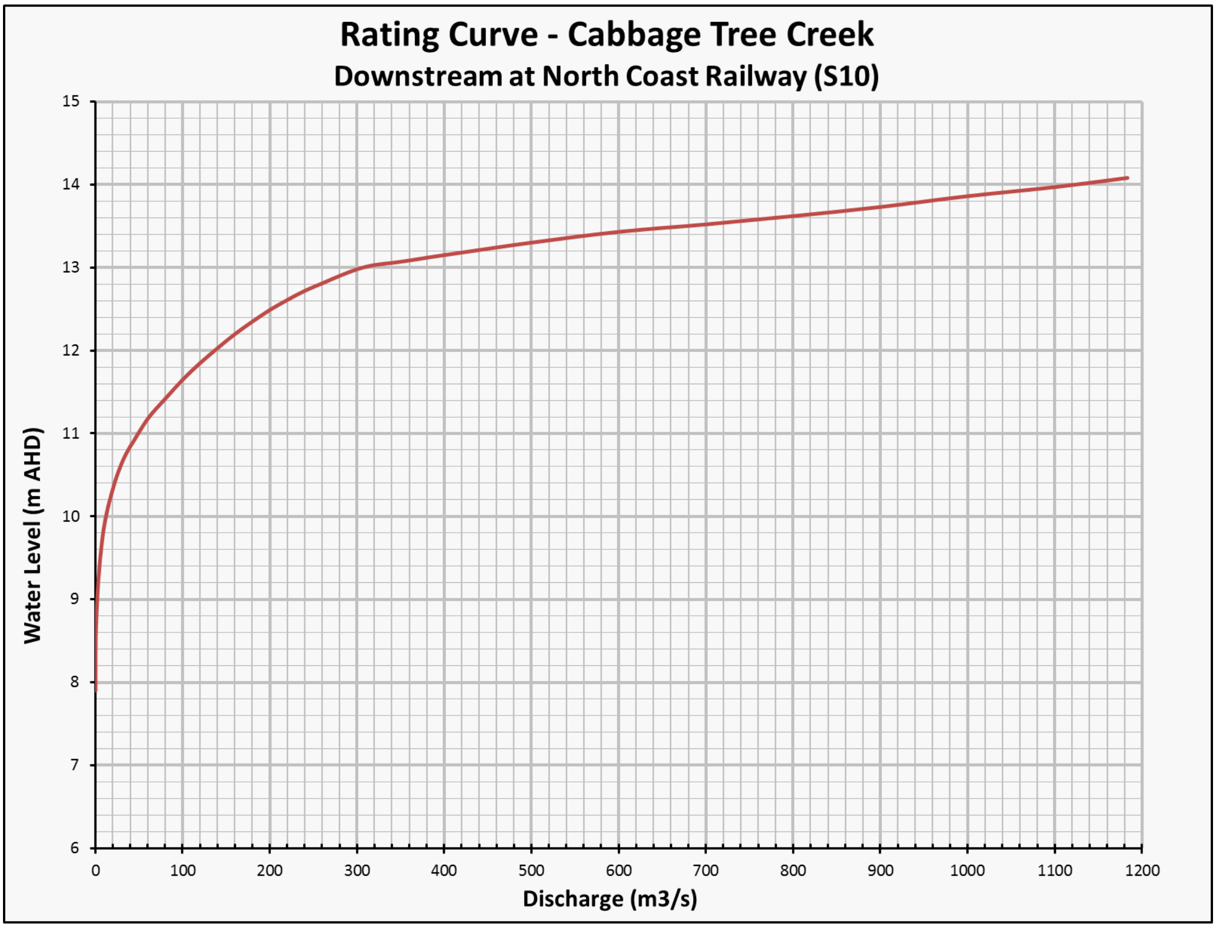
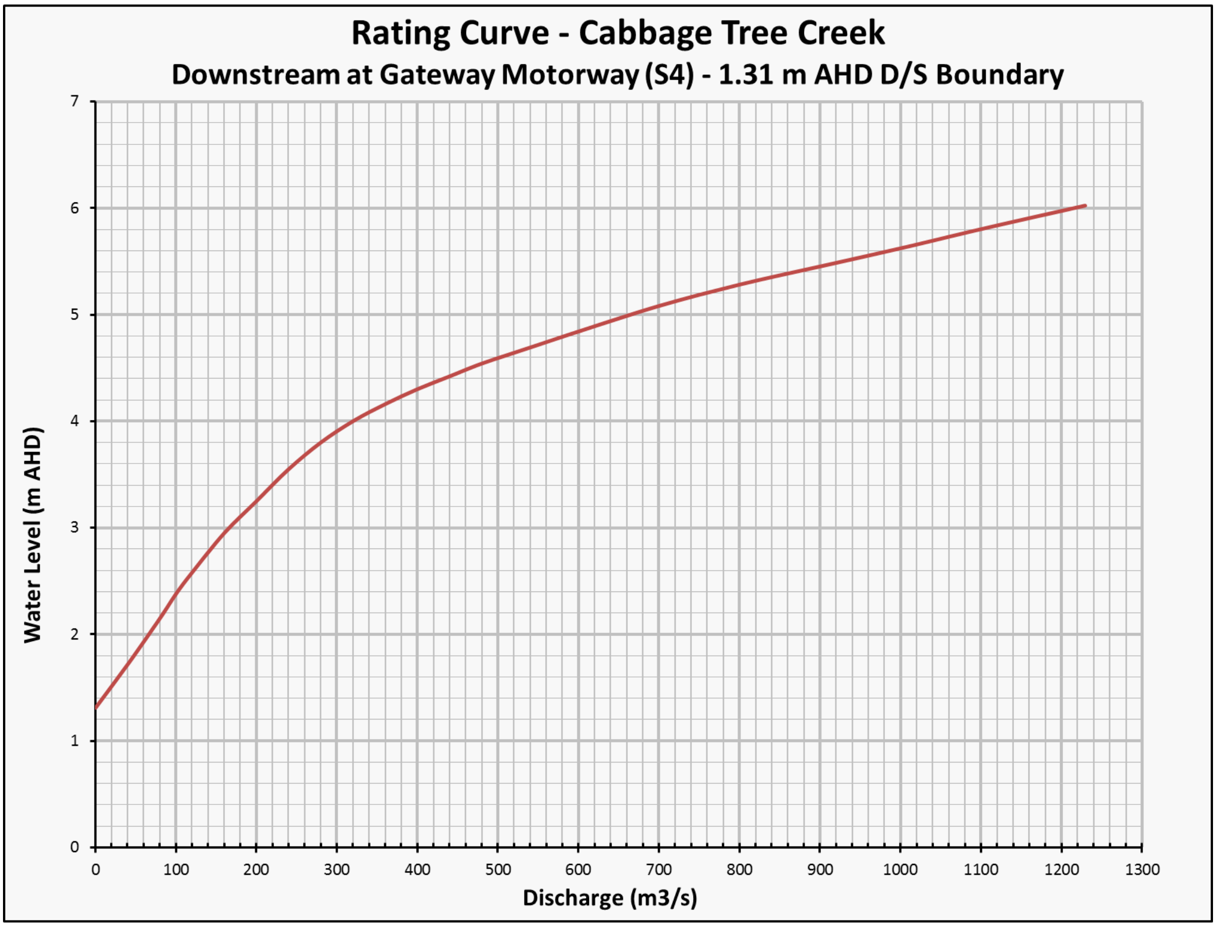

Rating Curve - Cabbage Tree Creek
Upstream of Beckett Road (S19)
Water Level (m AHD)
Discharge (m3/s)
40
39
38
37
36
35
34
33
32
0
100
200
300
400
500
600

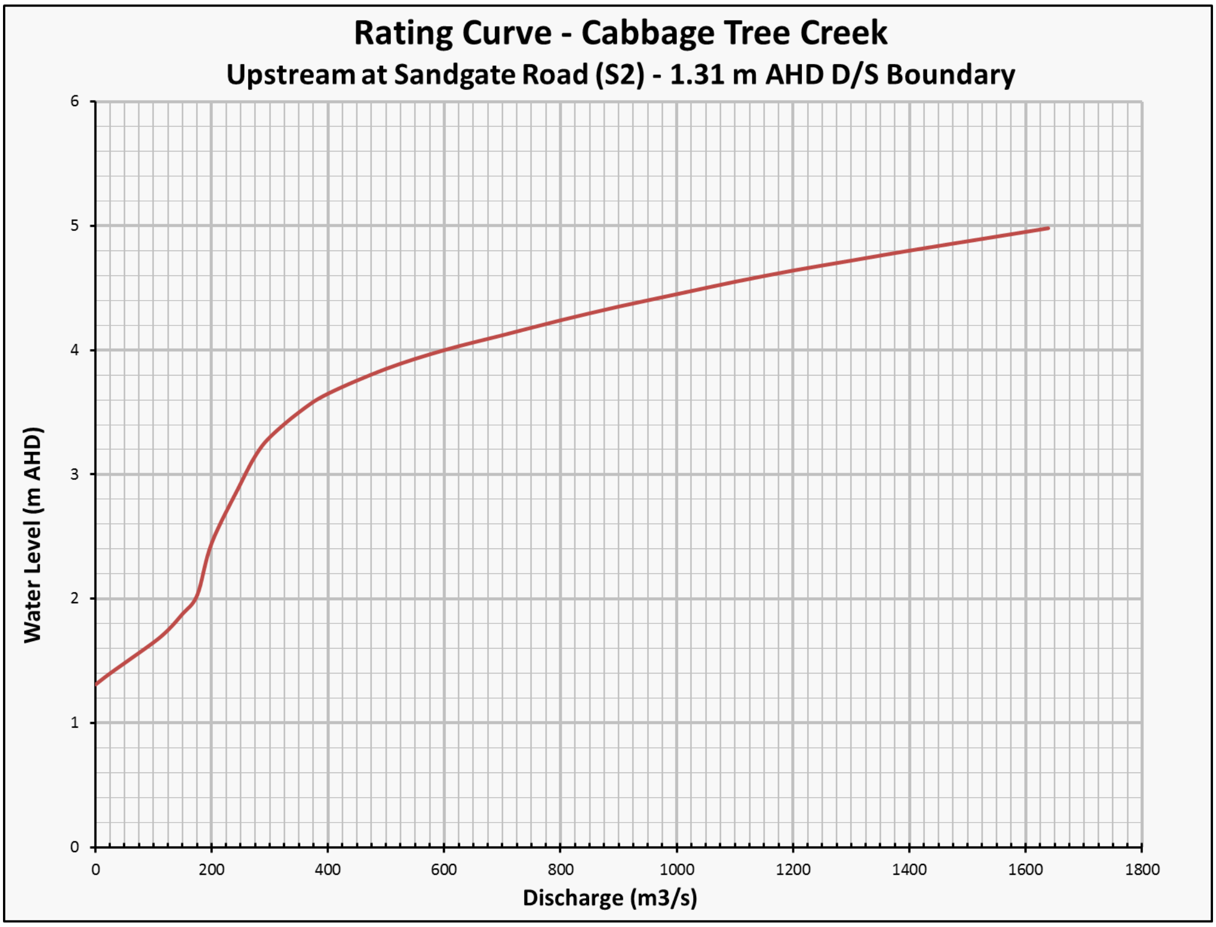

Rating Curve - Cabbage Tree Creek
Upstream at Albany Creek Road (S15)
Water Level (m AHD)
Discharge (m3/s)
29
28
27
26
25
24
23
22
21
20
0
100
200
300
400
500
600
700
800


Rating Curve - Cabbage Tree Creek
Upstream at Gympie Road (S13a)
Water Level (m AHD)
22
21
20
19
18
17
16
15
14
0
100
200
300
400
500
600
700
800
Discharge (m3/s)

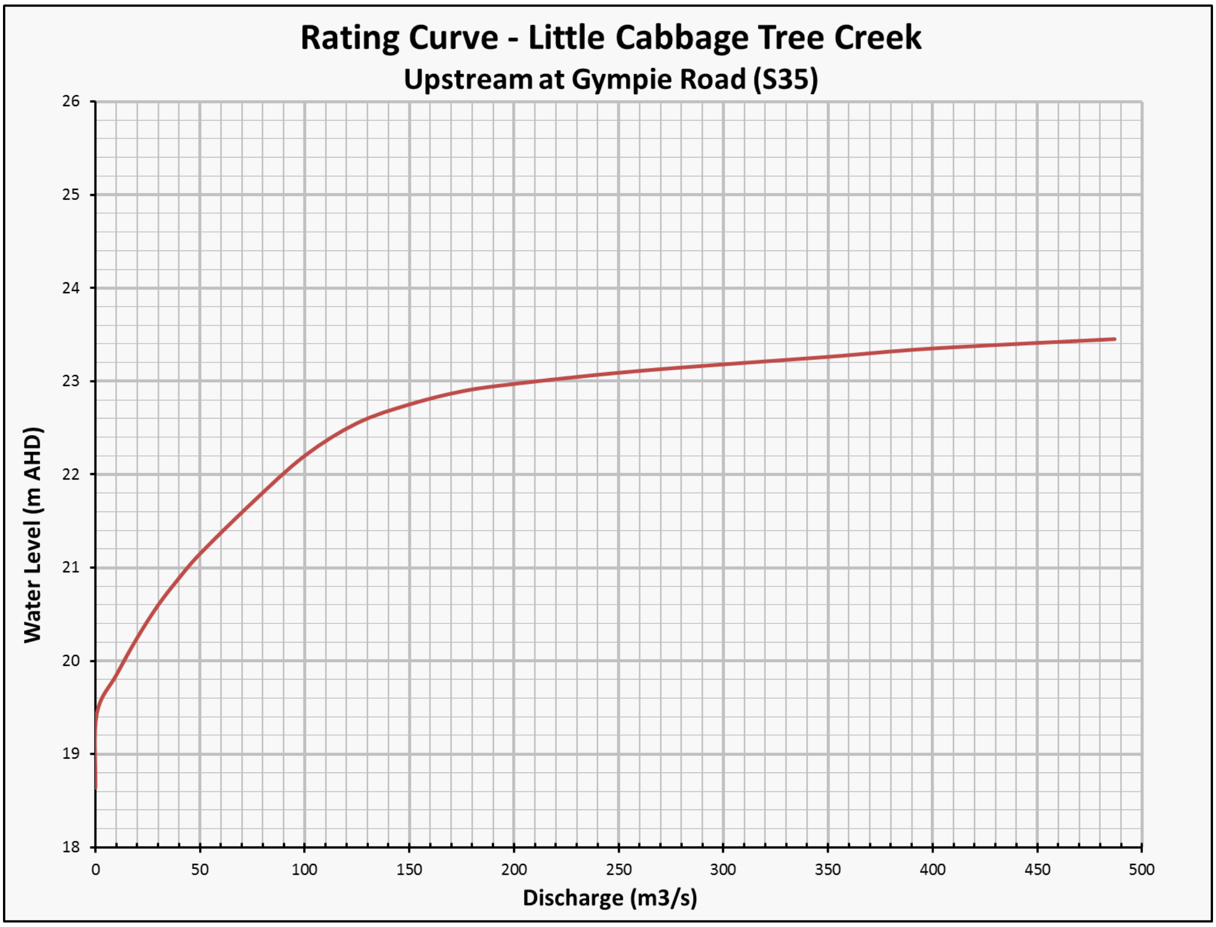

Rating Curve - Cabbage Tree Creek
Downstream at North Coast Railway (S10)
Water Level (m AHD)
15
14
13
12
11
10
9
8
7
6
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
Discharge (m3/s)

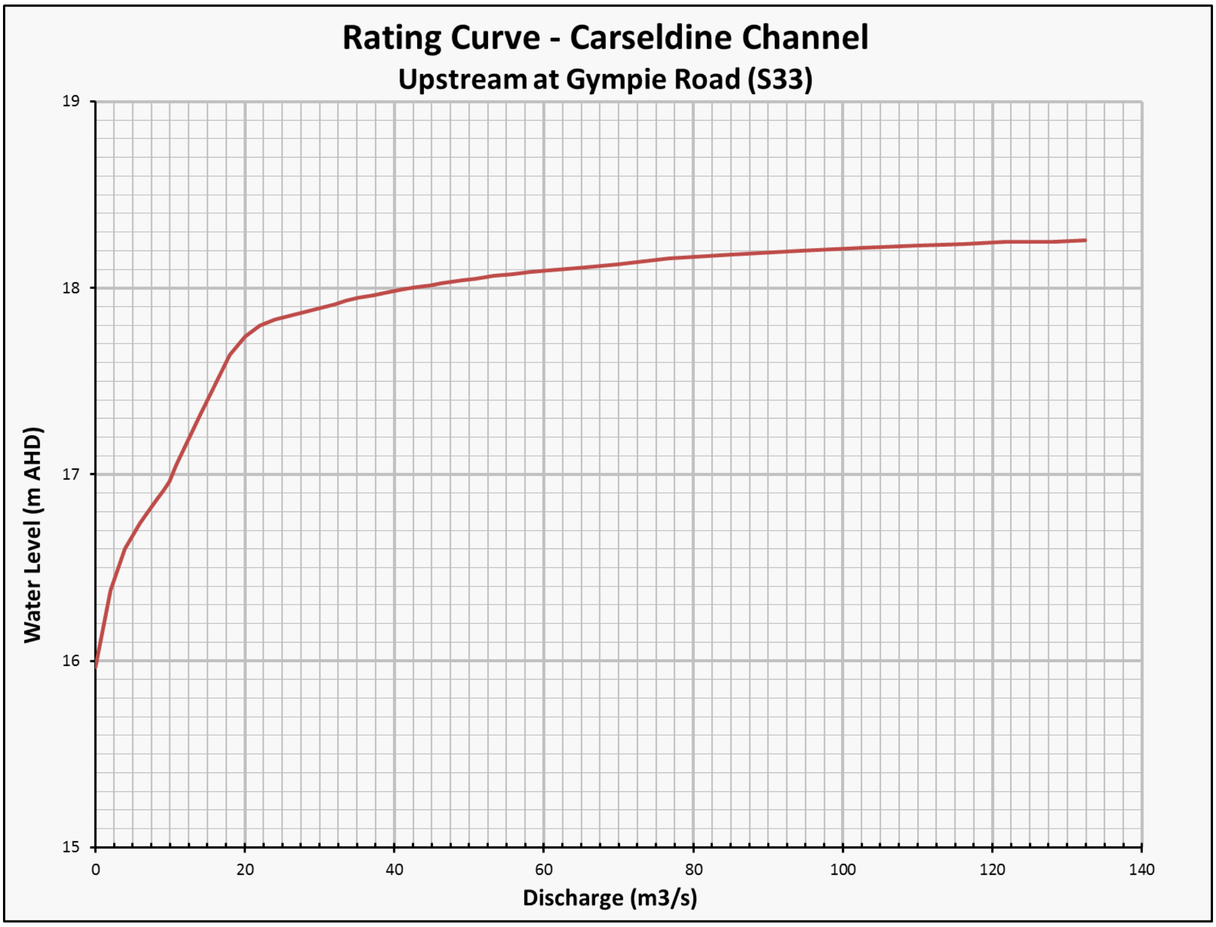


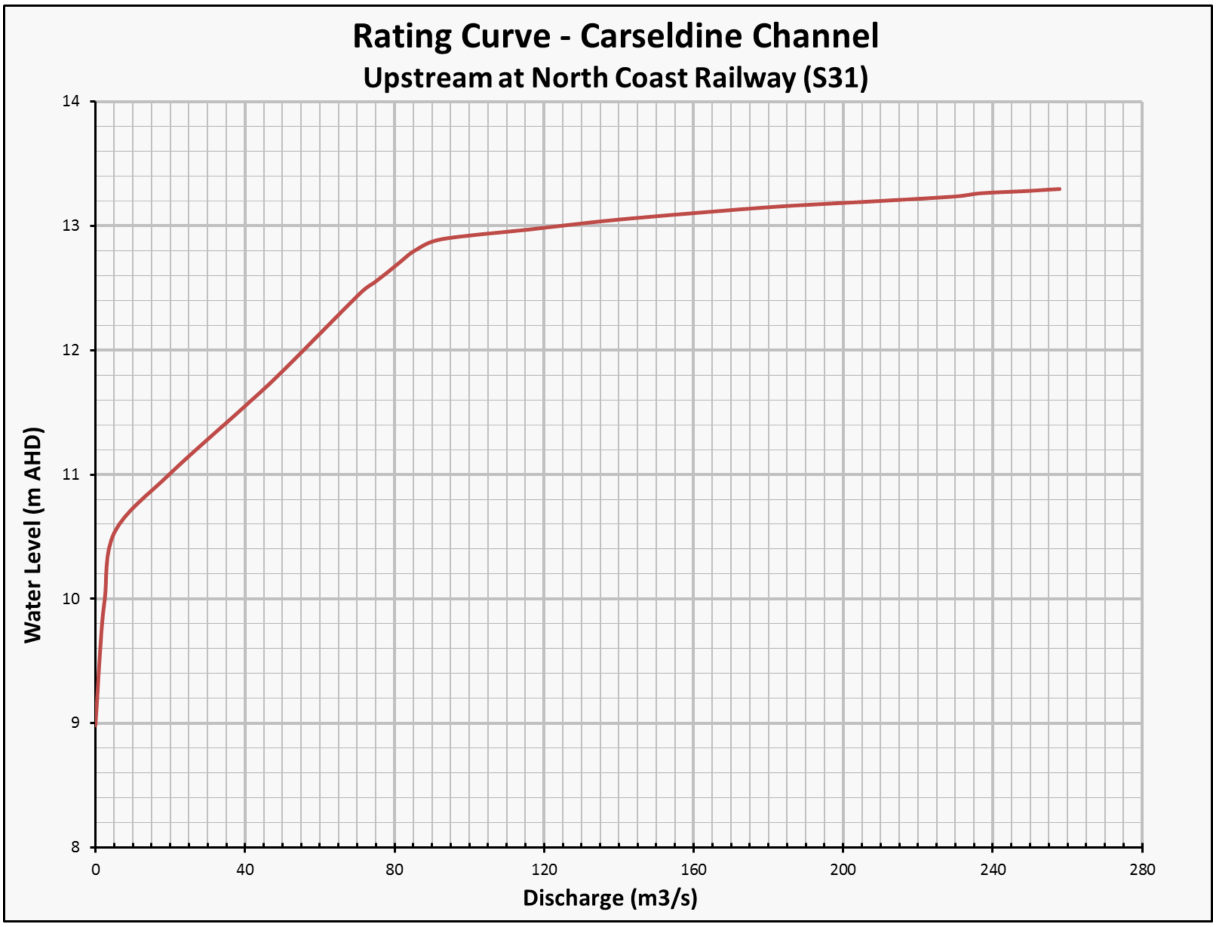
Rating Curve - Cabbage Tree Creek
Downstream at Gateway Motorway (S4) - 1.31 m AHD D/S Boundary
Water Level (m AHD)
Discharge (m3/s)
0
1
2
3
4
5
6
7
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300

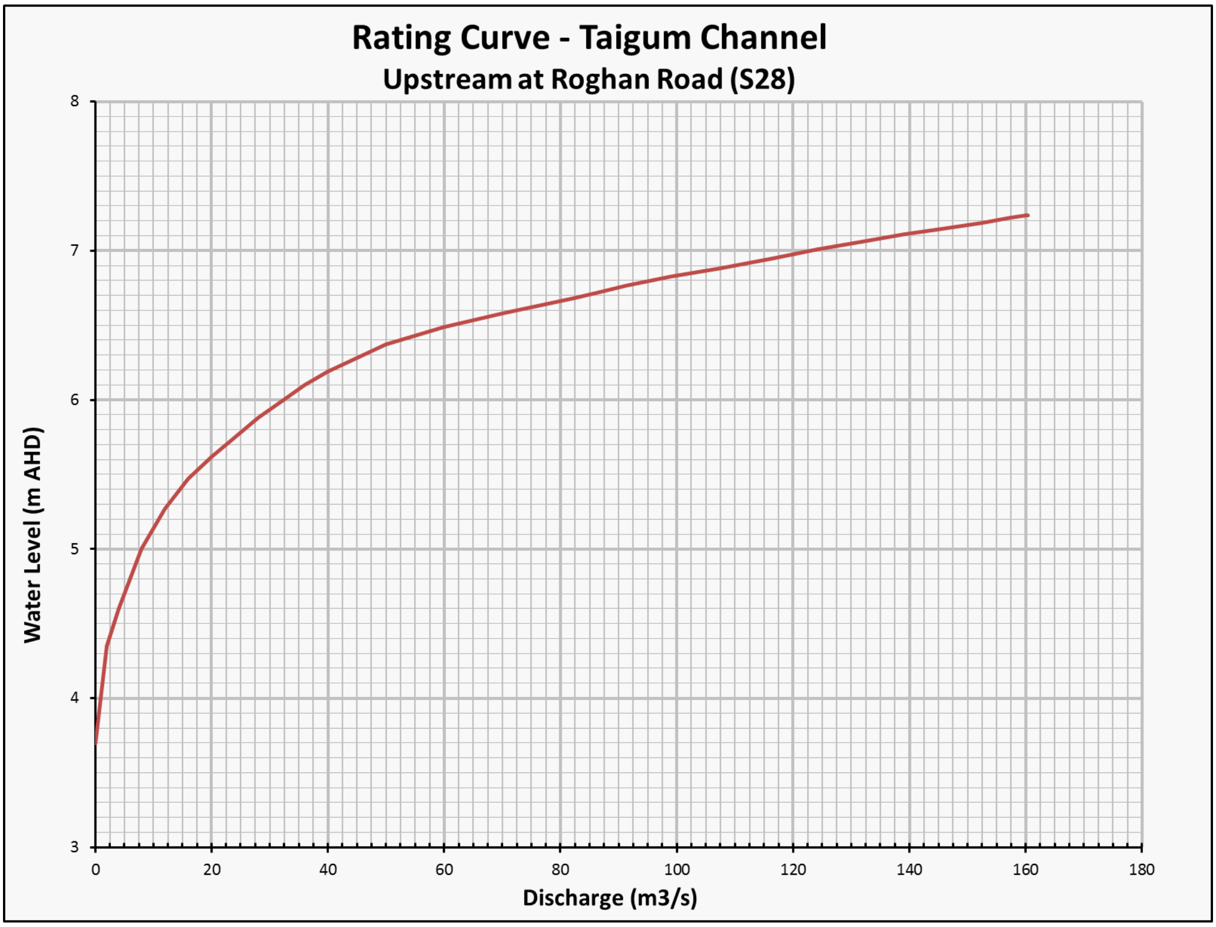


Rating Curve - Cabbage Tree Creek
Upstream at Sandgate Road (S2) - 1.31 m AHD D/S Boundary
Water Level (m AHD)
Discharge (m3/s)
0
1
2
3
4
5
6
0
200
400
600
800
1000
1200
1400
1600
1800


Rating Curve - Little Cabbage Tree Creek
Upstream at Gympie Road (S35)
Water Level (m AHD)
Discharge (m3/s)
26
25
24
23
22
21
20
19
18
0
50
100
150
200
250
300
350
400
450
500


Rating Curve - Carseldine Channel
Upstream at Gympie Road (S33)
Water Level (m AHD)
Discharge (m3/s)
19
18
17
16
15
0
20
40
60
80
100
120
140





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Appendix M: Hydraulic Structure Reference Sheets

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Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Blackwood Road Bikeway Bridge

BCC Asset ID	B1245	Tributary Name	Cabbage Tree Creek
Owner	BCC	AMTD (m)	3490
Year of Construction	2001	Coordinates (GDA94)	E 505955 N 6976370
Year of Significant Modification	N/A	Hydraulic Model ID	S1
Source of Structure Information	Design drawings	Flood Model Representation	1d bridge / 1d weir
Link to Data Source	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Data\Structures\Cabbage Tree Creek\S1 to S3 - Sandgate Road_Shorncliffe Rail		

Structure Description		Three span concrete bikeway bridge	
Bridges		**Culverts**	
Number of Spans	3	Number of Barrels	N/A
Number of Piers in Waterway	2	Dimensions (m)	N/A
Pier shape and Width (m)	0.6 circular	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	-1.72	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 3.6	
Span Length (m)		9.8 / 20.0 / 19.8 m	
Lowest Level of Deck Soffit (m AHD)		~ 1.6	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		2.05	
Average Handrail Height (m)		1.05	

Image Description	Looking Upstream
Date	23rd February 2017
Source	BCC Asset Management Records

Image Description	Looking Upstream
Date	23rd February 2017
Source	BCC Asset Management Records

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				50-yr ARI (2 % AEP)				
AEP (%)	Total Discharge (m^3/s)[8]	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	472.5	296.2	3.04	2.81	0.23	2.1	1.6	4.5
0.2	367.2	293.5	2.71	2.52	0.19	2.1	1.2	6
1	282.7	269.5	2.16	2.06	0.10	2.1	0	6
2	245.0	238.3	1.95	1.89	0.06	1.9	0	6
5	211.4	208.9	1.73	1.71	0.02	1.8	0	6
10	176.2	175.4	1.54	1.52	0.02	1.7	0	6
20	134.0	133.8	1.31	1.30	0.01	1.4	0	6
50	92.1	92.0	1.08	1.07	0.01	1.1	0	6

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

[8]*Total flow upstream of Sandgate Road*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Shorncliffe Rail Bridge

BCC Asset ID	N/A	Tributary Name	Cabbage Tree Creek
Owner	QLD Rail	AMTD (m)	3510
Year of Construction	Unknown	Coordinates (GDA94)	E 505935 , N 6976368
Year of Significant Modification	Unknown	Hydraulic Model ID	S2
Source of Structure Information	QLD Rail design drawings + 2010 KBR Gateway Upgrade North + engineering judgement	Flood Model Representation	1d bridge / 1d weir
Link to Data Source	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Data\Structures\Cabbage Tree Creek\S1 to S3 - Sandgate Road_Shorncliffe Rail		

Structure Description		Seven span railway bridge	
Bridges		**Culverts**	
Number of Spans	7	Number of Barrels	N/A
Number of Piers in Waterway	6	Dimensions (m)	N/A
Pier shape and Width (m)	~ 0.3 circular	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	-1.72	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 6.5	
Span Length (m)		~ 2 x 6.1 m, 4 x 7.98 m, 1 x 6.1 m	
Lowest Level of Deck Soffit (m AHD)		~ 2.16 (assumed)	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 3.16 (at bridge)	
Average Handrail Height (m)		Not modelled	

Image Description	Looking Downstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Image Description	Looking Upstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				500-yr ARI (0.2 % AEP)				
AEP (%)	Total Discharge (m^3/s)[8]	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	472.5	332.8	3.44	3.04	0.40	2.4	0.9	4.5
0.2	367.2	328.3	3.16	2.71	0.45	2.4	0	6
1	282.7	282.7	2.51	2.18	0.33	2.1	0	6
2	245.0	245.0	1.98	1.95	0.03	1.9	0	6
5	211.4	211.4	1.77	1.74	0.03	1.8	0	6
10	176.2	176.2	1.57	1.55	0.02	1.7	0	6
20	134.0	134.0	1.34	1.32	0.02	1.4	0	6
50	92.1	92.1	1.10	1.08	0.02	1.1	0	6

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

[8]*Total flow upstream of Sandgate Road*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Sandgate Road Bridge

BCC Asset ID	N/A	Tributary Name	Cabbage Tree Creek
Owner	QLD DTMR	AMTD (m)	3550
Year of Construction	~ 1969	Coordinates (GDA94)	E 505900, N 6976369
Year of Significant Modification	N/A	Hydraulic Model ID	S3
Source of Structure Information	DTMR design drawings	Flood Model Representation	1d culvert / 1d weir
Link to Data Source	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Data\Structures\Cabbage Tree Creek\S1 to S3 - Sandgate Road_Shorncliffe Rail		

Structure Description		Four span concrete road bridge	
Bridges		**Culverts**	
Number of Spans	4	Number of Barrels	N/A
Number of Piers in Waterway	3	Dimensions (m)	N/A
Pier shape and Width (m)	0.4 circular	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	-2.8	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 25	
Span Length (m)		~ 4 x 10.6	
Lowest Level of Deck Soffit (m AHD)		2.32	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 3.00	
Average Handrail Height (m)		1.2	

Image Description	Looking Downstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Image Description	Looking Upstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				100-yr ARI (1 % AEP)				
AEP (%)	Total Discharge (m^3/s)[8]	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	472.5	295.3	3.68	3.44	0.24	2.2	1.4	4.5
0.2	367.2	284.0	3.43	3.16	0.27	2.1	1.1	6
1	282.7	282.7	2.36	2.30	0.06	2.3	0	6
2	245.0	245.0	2.04	1.99	0.05	2.0	0	6
5	211.4	211.4	1.82	1.77	0.05	1.9	0	6
10	176.2	176.2	1.62	1.58	0.04	1.7	0	6
20	134.0	134.0	1.38	1.34	0.04	1.4	0	6
50	92.1	92.1	1.13	1.10	0.03	1.1	0	6

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

[8]*Total flow upstream of Sandgate Road*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Gateway Motorway Bridges

BCC Asset ID	N/A	Tributary Name	Cabbage Tree Creek
Owner	DTMR	AMTD (m)	4570
Year of Construction	2014	Coordinates (GDA94)	E 505035, N 6976679
Year of Significant Modification	N/A	Hydraulic Model ID	S4
Source of Structure Information	DTMR design drawings	Flood Model Representation	1d bridge / 1d weir
Link to Data Source	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Data\Structures\Cabbage Tree Creek\S4 - Gateway Motorway Bridge and Footbridge		

Structure Description		Four span concrete road bridge	
Bridges		**Culverts**	
Number of Spans	4	Number of Barrels	N/A
Number of Piers in Waterway	3	Dimensions (m)	N/A
Pier shape and Width (m)	0.55 octagonal	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	-1.31	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 44 (perpendicular to road)	
Span Length (m)		~ 4 x 26 (unskewed)	
Lowest Level of Deck Soffit (m AHD)		4.35	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 7.6 (at bridge)	
Average Handrail Height (m)		Multiple concrete safety barriers with varying heights	

Image Description	Looking Downstream through opening
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Image Description	Looking Downstream through opening
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	449.7	449.7	4.37	4.34	0.04	1.4	0	4.5
0.2	343.0	343.0	3.99	3.96	0.03	1.1	0	4.5
1	260.2	260.2	3.36	3.33	0.03	1.0	0	4.5
2	224.0	224.0	3.16	3.14	0.02	0.9	0	6
5	192.5	192.5	2.96	2.95	0.01	0.8	0	6
10	161.4	161.4	2.72	2.71	0.01	0.8	0	6
20	122.8	122.8	2.34	2.33	0.01	0.7	0	4.5
50	83.1	83.1	1.91	1.90	0.01	0.5	0	6

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Lemke Road Bridge

BCC Asset ID	B1240	Tributary Name	Cabbage Tree Creek
Owner	BCC	AMTD (m)	5350
Year of Construction	New bridge under construction	Coordinates (GDA94)	E 504445, N 6976689
Year of Significant Modification	N/A	Hydraulic Model ID	S5
Source of Structure Information	BCC TUFLOW model for Telegraph Road Stage 2	Flood Model Representation	2d bridge / 2d weir
Link to Data Source	G:\BI\CD\Proj16\160311_Telegraph_Rd_Stage_2_Layout\Design-Calc\Flood Management		

Structure Description		Three span concrete road bridge	
Bridges		**Culverts**	
Number of Spans	3	Number of Barrels	N/A
Number of Piers in Waterway	2	Dimensions (m)	N/A
Pier shape and Width (m)	1.2 circular	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	-0.28	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 30 (from HEC-RAS Telegraph Road Stage 2)	
Span Length (m)		2 x 22, 1 x 30	
Lowest Level of Deck Soffit (m AHD)		~ 5.5 (from TUFLOW Telegraph Road Stage 2)	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 7.2 (from TUFLOW Telegraph Road Stage 2)	
Average Handrail Height (m)		~ 1.7 (from TUFLOW Telegraph Road Stage 2)	

Image Description	Looking Downstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Image Description	Looking Upstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	443.7	443.7	5.28	4.91	0.37	N/A	N/A	4.5
0.2	332.7	332.7	4.77	4.50	0.28	N/A	N/A	4.5
1	255.8	255.8	4.32	4.06	0.26	N/A	N/A	4.5
2	220.7	220.7	4.16	3.91	0.25	N/A	N/A	4.5
5	189.4	189.4	4.00	3.76	0.24	N/A	N/A	6
10	159.9	159.9	3.84	3.62	0.22	N/A	N/A	6
20	121.9	121.9	3.63	3.43	0.20	N/A	N/A	4.5
50	81.6	81.6	3.37	3.21	0.16	N/A	N/A	6

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level. Taken approximately 50 m upstream and downstream of the bridge*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Roghan Road Bridge

BCC Asset ID	B9976	Tributary Name	Cabbage Tree Creek
Owner	BCC	AMTD (m)	6580
Year of Construction	1997	Coordinates (GDA94)	E 503956, N 6975807
Year of Significant Modification	N/A	Hydraulic Model ID	S7
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d bridge / 1d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Cabbage Tree Creek		

Structure Description		Two span concrete road bridge	
Bridges		**Culverts**	
Number of Spans	2	Number of Barrels	N/A
Number of Piers in Waterway	1	Dimensions (m)	N/A
Pier shape and Width (m)	0.6 circular	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	2.96	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 15	
Span Length (m)		2 x 17	
Lowest Level of Deck Soffit (m AHD)		~ 7.7	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 8.7	
Average Handrail Height (m)		~ 1	

Image Description	Looking Upstream
Date	21st September 2016
Source	BCC Asset Management Records

Image Description	Looking Downstream
Date	28th January 2016
Source	BCC Asset Management Records

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				500-yr ARI (0.2 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	336.2	315.4	9.17	8.80	0.37	2.5	0	3
0.2	254.6	251.2	8.63	8.41	0.22	2.0	0	4.5
1	203.0	201.3	8.22	8.09	0.14	1.9	0	4.5
2	177.8	177.1	8.00	7.90	0.10	1.9	0	4.5
5	150.5	150.5	7.76	7.69	0.07	1.7	0	6
10	127.6	127.6	7.54	7.49	0.05	1.7	0	6
20	100.0	100.0	7.26	7.22	0.04	1.8	0	4.5
50	67.3	67.3	6.88	6.85	0.03	1.8	0	4.5

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Beams Road Culvert

BCC Asset ID	C0113B	Tributary Name	Cabbage Tree Creek
Owner	BCC	AMTD (m)	8200
Year of Construction	~1996	Coordinates (GDA94)	E 503458, N 6974849
Year of Significant Modification	N/A	Hydraulic Model ID	S9
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d culvert / 1d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Cabbage Tree Creek		

Structure Description		Multiple cell concrete rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	10
Number of Piers in Waterway	N/A	Dimensions (m)	* 5 / 3.6 x 1.8 m RCBCs + ** 4 / 3.6 x 3.6 m RCBCs + *** 1 / 3.6 x 2.7 m RCBC
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	* 9.2 ** 7.4 *** 8.7
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	* 9.1 ** 7.26 *** 8.58
Structure Length (m) (in direction of flow)		Varies ~ 24 to 25	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 11.9	
Average Handrail Height (m)		~ 1	

Image Description	Looking Downstream
Date	March 2015
Source	BCC Asset Management Records

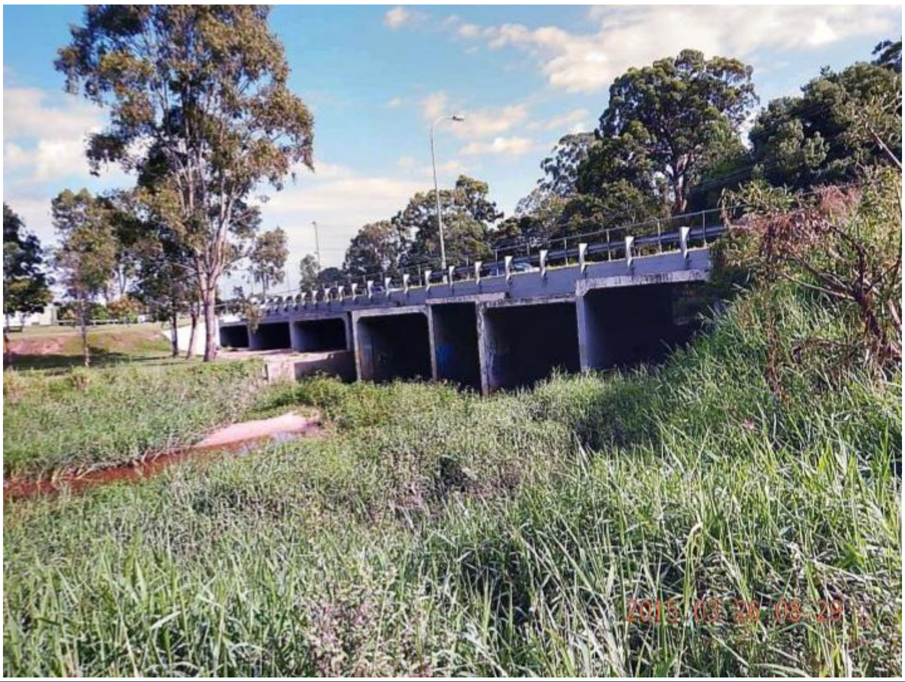


Image Description	Looking Upstream
Date	March 2015
Source	BCC Asset Management Records

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				20-yr ARI (5 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	292.9	233.9	12.74	12.56	0.18	Varies	0	3
0.2	259.7	223.0	12.55	12.37	0.18	Varies	0	3
1	213.0	198.0	12.27	12.13	0.14	Varies	0	4.5
2	187.0	179.2	12.09	11.98	0.11	Varies	0	4.5
5	153.6	151.1	11.81	11.74	0.07	Varies	0	6
10	127.5	126.1	11.53	11.49	0.04	Varies	0	6
20	100.6	100.0	11.19	11.17	0.02	Varies	0	4.5
50	71.6	71.6	10.67	10.67	0.01	Varies	0	4.5

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

North Coast Railway Bridge

BCC Asset ID	N/A	Tributary Name	Cabbage Tree Creek
Owner	QLD Rail	AMTD (m)	8710
Year of Construction	U/S bridge: ~1960 D/S bridge: ~1999	Coordinates (GDA94)	E 503229, N 6974486
Year of Significant Modification	Unknown	Hydraulic Model ID	S10
Source of Structure Information	QLD Rail design drawings	Flood Model Representation	1d bridge / 1d weir
Link to Data Source	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Data\Structures\Cabbage Tree Creek\S10 - North Coast Railway		

Structure Description		Inline Bridges – two span + four span	
Bridges		**Culverts**	
Number of Spans	U/S bridge: 2 D/S bridge: 4	Number of Barrels	N/A
Number of Piers in Waterway	U/S bridge: 1 D/S bridge: 3	Dimensions (m)	N/A
Pier shape and Width (m)	U/S bridge: varies D/S bridge: 1.2 circular	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	~ 7.9	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 14 (combined)	
Span Length (m)		U/S bridge: 2 x 12.6 D/S bridge: 2 x 9.3 / 2 x 10.3	
Lowest Level of Deck Soffit (m AHD)		U/S bridge: ~ 13.5 D/S bridge: ~ 13.5	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		14.3	
Average Handrail Height (m)		N/A	

Image Description	Looking Upstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	294.0	294.0	13.36	13.01	0.35	3.7	0	3
0.2	256.0	256.0	13.12	12.81	0.31	3.5	0	3
1	205.7	205.7	12.77	12.53	0.24	3.1	0	4.5
2	181.1	181.1	12.57	12.35	0.22	2.9	0	4.5
5	150.4	150.4	12.28	12.10	0.19	2.7	0	6
10	125.2	125.2	12.03	11.86	0.16	2.6	0	6
20	99.3	99.3	11.73	11.59	0.14	2.4	0	4.5
50	63.9	63.9	11.31	11.22	0.10	2.0	0	4.5

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Dorville Road Culvert

BCC Asset ID	C0020B	Tributary Name	Cabbage Tree Creek
Owner	BCC	AMTD (m)	9990
Year of Construction	Unknown	Coordinates (GDA94)	E 502092, N 6974524
Year of Significant Modification	N/A	Hydraulic Model ID	S11
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d culvert / 1d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Cabbage Tree Creek		

Structure Description		Multiple cell concrete box culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	5
Number of Piers in Waterway	N/A	Dimensions (m)	3.6 w x 3.6 h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	12.37
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	12.35
Structure Length (m) (in direction of flow)		15	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 16.7	
Average Handrail Height (m)		1.15	

Image Description	Looking Upstream
Date	November 2014
Source	BCC Asset Management Records

Image	Looking Downstream
Date	August 2015
Source	BCC Asset Management Records

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				50-yr ARI (2 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Culvert (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Culvert Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	172.7	152.7	17.24	16.97	0.27	2.4	0.7	3
0.2	151.9	148.1	17.15	16.90	0.25	2.3	0.4	3
1	129.4	129.4	16.90	16.72	0.18	2.0	0	3
2	114.7	114.7	16.70	16.57	0.13	1.8	0	3
5	97.4	97.4	16.42	16.34	0.08	1.5	0	3
10	81.9	81.9	16.15	16.09	0.06	1.4	0	3
20	66.3	66.3	15.83	15.79	0.04	1.4	0	3
50	44.5	44.5	15.23	15.21	0.02	1.2	0	3

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Gympie Road Bridge

BCC Asset ID	N/A	Tributary Name	Cabbage Tree Creek
Owner	QLD DTMR	AMTD (m)	10720
Year of Construction	~ 1986	Coordinates (GDA94)	E 501609, N 6974154
Year of Significant Modification	N/A	Hydraulic Model ID	S13a
Source of Structure Information	2014 Flood Study from previous MIKE11 model	Flood Model Representation	1d bridge / 1d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Cabbage Tree Creek		

Structure Description		Dual two span concrete road bridges	
Bridges		**Culverts**	
Number of Spans	2	Number of Barrels	N/A
Number of Piers in Waterway	1	Dimensions (m)	N/A
Pier shape and Width (m)	Varies	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	14.92	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 30	
Span Length (m)		2 x 14.35	
Lowest Level of Deck Soffit (m AHD)		~ 18.8	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 19.7	
Average Handrail Height (m)		1.2	

Image Description	Looking Downstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Image Description	Looking Upstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				20-yr ARI (5 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	205.9	169.3	19.74	19.28	0.46	1.6	0	2
0.2	167.0	153.4	19.53	19.16	0.37	1.4	0	2
1	133.3	128.5	19.18	18.92	0.26	1.2	0	3
2	118.3	114.6	18.96	18.75	0.21	1.1	0	3
5	99.3	98.0	18.71	18.53	0.18	1.0	0	3
10	83.1	82.1	18.44	18.29	0.15	0.9	0	3
20	68.2	66.5	18.13	18.00	0.13	0.8	0	3
50	45.1	44.3	17.62	17.53	0.09	0.7	0	3

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Albany Creek Road Culvert

BCC Asset ID	N/A	Tributary Name	Cabbage Tree Creek
Owner	QLD DTMR	AMTD (m)	13080
Year of Construction	~1993	Coordinates (GDA94)	E 499980, N 6973964
Year of Significant Modification	N/A	Hydraulic Model ID	S15
Source of Structure Information	1996 Flood Study (culvert) + 2014 Flood Study (weir)	Flood Model Representation	1d culvert / 1d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Cabbage Tree Creek		

Structure Description		Multiple cell concrete box culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	5
Number of Piers in Waterway	N/A	Dimensions (m)	3 w x 3 h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	20.95
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	20.84
Structure Length (m) (in direction of flow)		28.1	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 26.3	
Average Handrail Height (m)		~ 1.15	

Image Description	Looking Downstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Image Description	Looking Upstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				50-yr ARI (2 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	240.2	180.7	27.02	26.36	0.66	4.0	0.3	1.5
0.2	188.3	169.1	26.69	26.13	0.56	3.8	0	1.5
1	143.5	143.5	26.31	25.93	0.38	3.2	0	1.5
2	112.8	112.8	25.91	25.71	0.20	2.5	0	1.5
5	93.7	93.7	25.67	25.56	0.11	2.1	0	1.5
10	78.5	78.5	25.47	25.40	0.07	1.7	0	2
20	62.0	62.0	25.23	25.19	0.04	1.4	0	1.5
50	41.6	41.6	24.84	24.83	0.01	0.9	0	2

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Beckett Road Culvert

BCC Asset ID	C0116B	Tributary Name	Cabbage Tree Creek
Owner	BCC	AMTD (m)	15820
Year of Construction	1987	Coordinates (GDA94)	E 499005, N 6972198
Year of Significant Modification	N/A	Hydraulic Model ID	S19
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Cabbage Tree Creek		

Structure Description		Multiple cell concrete box culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	4
Number of Piers in Waterway	N/A	Dimensions (m)	3.3 w x 3.3 h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	33.02
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	32.91
Structure Length (m) (in direction of flow)		25.6	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 37.3	
Average Handrail Height (m)		0.7 (Armco)	

Image Description	Looking Downstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Image Description	Looking Upstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				50-yr ARI (2 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	188.0	111.7	37.90	37.27	0.63	2.6	N/A	1.5
0.2	147.4	106.4	37.68	37.12	0.56	2.4	N/A	1.5
1	120.0	101.0	37.50	36.99	0.51	2.3	N/A	1.5
2	93.8	91.2	37.24	36.83	0.41	2.1	N/A	1.5
5	78.4	78.6	36.98	36.68	0.30	1.8	N/A	2
10	66.7	66.7	36.76	36.54	0.22	1.5	N/A	2
20	52.8	52.8	36.49	36.35	0.14	1.2	N/A	1.5
50	36.0	36.0	36.13	36.06	0.07	0.9	N/A	1.5

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Hamilton Road Culvert

BCC Asset ID	C0150B	Tributary Name	Cabbage Tree Creek
Owner	BCC	AMTD (m)	16670
Year of Construction	1995	Coordinates (GDA94)	E 498516, N 6971589
Year of Significant Modification	N/A	Hydraulic Model ID	S21
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Cabbage Tree Creek		

Structure Description		Multiple cell concrete rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	5
Number of Piers in Waterway	N/A	Dimensions (m)	3.6 w x 2.7 h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	37.7
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	37.6
Structure Length (m) (in direction of flow)		21.6	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 41.4	
Average Handrail Height (m)		0.7 (Armco)	

Image Description	Looking Downstream
Date	December 2017
Source	BCC Asset Management Records

Image Description	Looking Upstream
Date	December 2017
Source	BCC Asset Management Records

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				500-yr ARI (0.2 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	186.0	177.9	41.68	40.58	1.10	3.7	N/A	1
0.2	139.9	139.9	41.04	40.36	0.68	2.9	N/A	1
1	114.0	114.0	40.67	40.19	0.48	2.4	N/A	1.5
2	90.4	90.4	40.36	40.02	0.34	2.1	N/A	1.5
5	74.9	74.9	40.15	39.89	0.26	2.1	N/A	1.5
10	63.7	63.7	39.99	39.78	0.21	2.0	N/A	1.5
20	54.0	54.0	39.84	39.67	0.17	2.1	N/A	1
50	37.0	37.0	39.54	39.44	0.10	2.0	N/A	1

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Gateway Motorway Culvert

BCC Asset ID	N/A	Tributary Name	Taigum Channel
Owner	QLD DMTR	AMTD (m)	200
Year of Construction	Unknown	Coordinates (GDA94)	E 505441 N 6976218
Year of Significant Modification	In late 2012 the culvert was lengthened	Hydraulic Model ID	S22a
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Taigum Channel		

Structure Description		Multiple cell concrete rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	5
Number of Piers in Waterway	N/A	Dimensions (m)	* 2 / 2.4 x 2.1 m RCBCs + ** 2 / 2.4 x 1.9 m RCBCs + *** 1 / 2.4 x 2.5 m RCBC
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	* -0.5 ** -0.5 *** -0.8
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	* -1.12 ** -1.12 *** -1.12
Structure Length (m) (in direction of flow)		~ 52.3	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 5	
Average Handrail Height (m)		Multiple concrete safety barriers with varying heights	

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)[8]	Discharge through Structure (m^3/s)[1&8]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	25.4	25.4	4.15	4.14	0.01	1.0	N/A	6
0.2	21.5	21.5	3.84	3.83	0.01	0.9	N/A	6
1	20.6	20.6	3.19	3.16	0.03	0.8	N/A	6
2	20.0	20.0	3.01	2.97	0.04	0.8	N/A	6
5	19.7	19.7	2.80	2.78	0.02	0.8	N/A	6
10	18.3	18.3	2.55	2.53	0.01	0.7	N/A	6
20	16.7	16.7	2.17	2.15	0.02	0.7	N/A	6
50	12.0	12.0	1.69	1.68	0.01	0.5	N/A	6

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

[8]Structure subject to backwater from Cabbage Tree Creek. The discharge value is from the storm duration that produces the peak flood level (i.e. critical duration in Cabbage Tree Creek) not the peak flow.

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Gateway Motorway Culvert

BCC Asset ID	N/A	Tributary Name	Taigum Channel
Owner	QLD DMTR	AMTD (m)	200
Year of Construction	Unknown	Coordinates (GDA94)	E 505532 N 6976196
Year of Significant Modification	In late 2012 the culvert was lengthened	Hydraulic Model ID	S22b
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Taigum Channel		

Structure Description		Multiple cell concrete box culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	3
Number of Piers in Waterway	N/A	Dimensions (m)	1.5 w x 1.5 h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	-0.22
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	-1.12
Structure Length (m) (in direction of flow)		~ 50	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 5.5	
Average Handrail Height (m)		Multiple concrete safety barriers with varying heights	

Image	Looking Downstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Image	Looking Upstream at Bikeway Culvert (not modelled)
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)[8]	Discharge through Structure (m^3/s)[1&8]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	7.0	7.0	4.14	4.06	0.08	1.0	N/A	6
0.2	6.2	6.2	3.83	3.77	0.06	0.9	N/A	6
1	5.8	5.8	3.18	3.09	0.09	0.9	N/A	6
2	5.4	5.4	2.99	2.91	0.08	0.8	N/A	6
5	4.6	4.6	2.78	2.72	0.06	0.7	N/A	6
10	3.0	3.0	2.52	2.49	0.03	0.4	N/A	6
20	0.2	0.2	2.13	2.13	0.00	0.03	N/A	6
50	0.1	0.1	1.66	1.66	0.00	0.01	N/A	6

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

[8]*Structure subject to backwater from Cabbage Tree Creek. The discharge value is from the storm duration that produces the peak flood level (i.e. critical duration in Cabbage Tree Creek) not the peak flow.*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

350 Muller Road Culvert

BCC Asset ID	N/A	Tributary Name	Taigum Channel
Owner	Private	AMTD (m)	270
Year of Construction	Unknown	Coordinates (GDA94)	E 505412, N 6976176
Year of Significant Modification	N/A	Hydraulic Model ID	S23
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Taigum Channel		

Structure Description		Multiple barrel concrete piped culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	2
Number of Piers in Waterway	N/A	Dimensions (m)	* 1 / 1.725 m RCP + ** 1 / 1.625 m RCP
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	* -0.45 ** -0.51
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	* -0.26 ** -0.67
Structure Length (m) (in direction of flow)		* 9.9 ** 9.56	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 1.9	
Average Handrail Height (m)		Unknown	

Link to Flood Model Results	[G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA](G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA)
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				< 2-yr ARI (50 % AEP)				
AEP (%)	Total Discharge (m^3/s)[8]	Discharge through Structure (m^3/s)[1&8]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	25.4	11.6	4.14	4.15	-0.01	2.6	N/A	6
0.2	21.5	11.6	3.84	3.84	0.00	2.6	N/A	6
1	20.6	13.3	3.18	3.19	-0.01	3.1	N/A	6
2	20.0	12.7	2.99	3.01	-0.02	2.9	N/A	6
5	19.7	14.2	2.73	2.73	0.00	3.3	N/A	6
10	18.3	11.8	2.55	2.55	0.00	2.7	N/A	6
20	16.7	14.1	2.17	2.00	0.17	3.3	N/A	6
50	13.9	13.9	2.03	1.52	0.51	3.3	N/A	3

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

[8]*Structure subject to backwater from Cabbage Tree Creek. The discharge value is from the storm duration that produces the peak flood level (i.e. critical duration in Cabbage Tree Creek) not the peak flow. Total discharge taken as greater of Gateway culvert (S22a) and this culvert (S23).*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

334 Muller Road Culvert

BCC Asset ID	N/A	Tributary Name	Taigum Channel
Owner	Private	AMTD (m)	330
Year of Construction	Unknown	Coordinates (GDA94)	E 505367, N 6976119
Year of Significant Modification	N/A	Hydraulic Model ID	S24
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d culvert / 1d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Taigum Channel		

Structure Description		Multiple barrel concrete piped culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	4
Number of Piers in Waterway	N/A	Dimensions (m)	* 2 / 1.825 m RCP s + ** 1 / 1.825 m RCP + *** 1 / 1.425 m RCP
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	* 0.9 ** -0.32 *** 1.72
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	* 1.0 ** -0.41 *** 1.64
Structure Length (m) (in direction of flow)		~ 4.8	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 3.4	
Average Handrail Height (m)		Unknown	

Image Description	Looking Upstream
Date	Circa 2012
Source	2014 Flood Study

Looking Upstream	Looking Downstream
Date	Circa 2012
Source	2014 Flood Study

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				20-yr ARI (5 % AEP)				
AEP (%)	Total Discharge (m^3/s)[8]	Discharge through Structure (m^3/s)[1&8]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	25.7	25.7	4.15	4.15	0.00	2.8	1.1	6
0.2	25.2	25.2	3.87	3.85	0.02	2.7	1.1	6
1	30.5	30.5	3.66	3.22	0.44	3.3	0.9	1.5
2	28.5	28.5	3.49	3.06	0.43	3.2	0.6	1.5
5	26.8	26.8	3.32	2.95	0.37	3.0	0	1.5
10	24.1	24.1	3.14	2.84	0.30	2.7	0	1.5
20	20.2	20.2	2.92	2.69	0.23	2.4	0	3
50	14.2	14.2	2.54	2.39	0.15	2.1	0	3

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

[8]Structure subject to backwater from Cabbage Tree Creek. The discharge value is from the storm duration that produces the peak flood level (i.e. critical duration in Cabbage Tree Creek) not the peak flow. Total discharge taken as greater of Gateway culvert (S22a) and this culvert (S24).

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

401 Church Road Access Bridge

BCC Asset ID	N/A	Tributary Name	Taigum Channel
Owner	Private	AMTD (m)	915
Year of Construction	Unknown	Coordinates (GDA94)	E 504867, N 6975965
Year of Significant Modification	N/A	Hydraulic Model ID	S25
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d bridge / 1d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Taigum Channel		

Structure Description		Timber access bridge	
Bridges		**Culverts**	
Number of Spans	1	Number of Barrels	N/A
Number of Piers in Waterway	None	Dimensions (m)	N/A
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	1.6	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		3.9	
Span Length (m)		5.0	
Lowest Level of Deck Soffit (m AHD)		~ 3.8	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 4.2	
Average Handrail Height (m)		N/A	

Image Description	Looking Downstream
Date	Circa 2012
Source	2014 Flood Study

Image Description	Looking Upstream
Date	Circa 2012
Source	2014 Flood Study

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				20-yr ARI (5 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	62.6	36.5	4.91	4.58	0.33	3.3	1.4	1
0.2	49.0	35.9	4.76	4.40	0.36	3.2	1.3	1
1	39.4	34.3	4.62	4.26	0.36	3.1	1.1	1.5
2	32.4	32.4	4.42	4.10	0.32	2.9	0.8	1
5	28.5	28.5	4.19	3.97	0.22	2.6	0	1
10	24.5	24.5	4.01	3.88	0.13	2.2	0	1
20	21.8	21.8	3.90	3.81	0.09	2.0	0	3
50	15.1	15.1	3.62	3.60	0.02	1.6	0	3

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

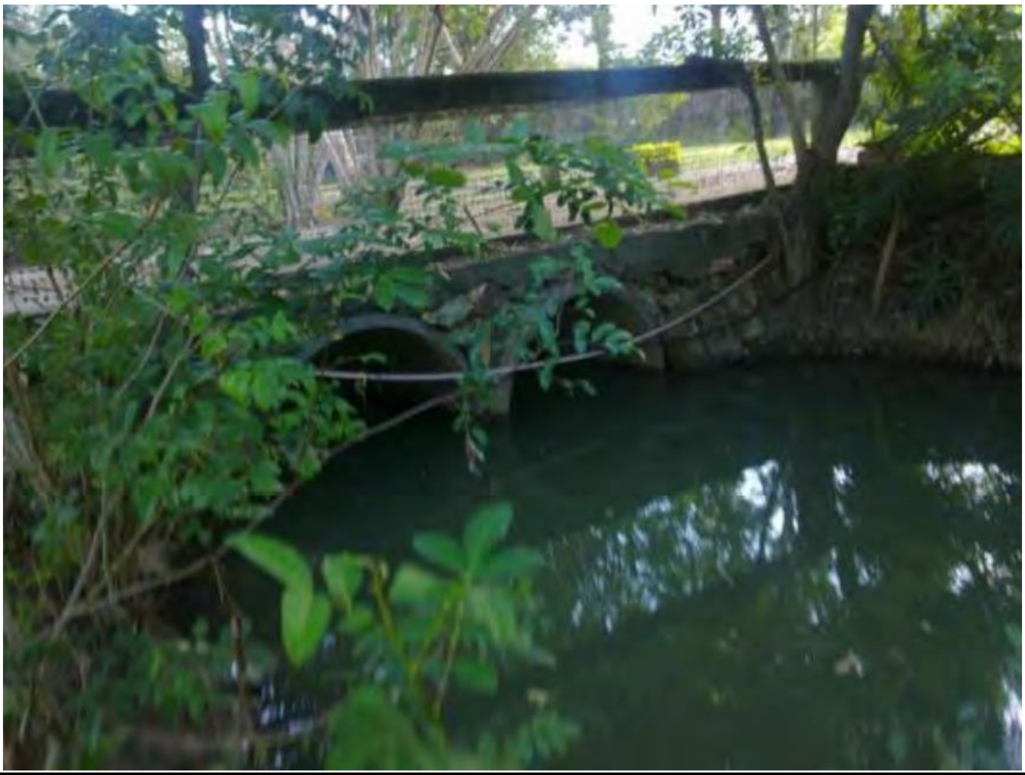
401A Church Road Access Culvert

BCC Asset ID	N/A	Tributary Name	Taigum Channel
Owner	Private	AMTD (m)	970
Year of Construction	Unknown	Coordinates (GDA94)	E 504813, N 6975943
Year of Significant Modification	N/A	Hydraulic Model ID	S26
Source of Structure Information	2012 Taigum Channel Flood Study	Flood Model Representation	1d culvert / 1d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Taigum Channel		

Structure Description		Multiple barrel concrete piped culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	2
Number of Piers in Waterway	N/A	Dimensions (m)	* 1 / 1.725 m RCP + ** 1 / 1.725 m RCP +
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	* 2.19 ** 2.42
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	* 2.16 ** 2.26
Structure Length (m) (in direction of flow)		3.9	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 4.2	
Average Handrail Height (m)		N/A	

Image Description	Looking Downstream
Date	Circa 2012
Source	2014 Flood Study

Image Description	Looking Upstream
Date	Circa 2012
Source	2014 Flood Study



Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				< 2-yr ARI (50 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	62.6	14.3	5.23	5.16	0.07	3.2	1.5	1
0.2	49.0	14.1	5.12	5.04	0.08	3.2	1.5	1
1	39.4	13.9	5.01	4.94	0.07	3.1	1.4	1.5
2	32.1	13.9	4.90	4.81	0.09	3.1	1.4	1
5	26.8	13.9	4.78	4.65	0.13	3.1	1.3	1
10	23.1	13.8	4.68	4.51	0.17	3.1	1.2	1
20	20.3	13.7	4.61	4.41	0.20	3.0	1.1	3
50	14.3	13.5	4.36	4.10	0.26	3.0	0.7	3

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Church Street Culvert

BCC Asset ID	C0433B	Tributary Name	Taigum Channel
Owner	BCC	AMTD (m)	1080
Year of Construction	1998	Coordinates (GDA94)	E 504762, N 6975871
Year of Significant Modification	N/A	Hydraulic Model ID	S27
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d culvert / 1d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Taigum Channel		

Structure Description		Multiple cell concrete rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	4
Number of Piers in Waterway	N/A	Dimensions (m)	3.3 w x 1.5 h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	2.44
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	2.39
Structure Length (m) (in direction of flow)		21.9	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 4.5	
Average Handrail Height (m)		~ 1.2 (steel tubular handrail with top rail and mid rail)	

Image Description	Looking Downstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Image Description	Looking Upstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				< 2-yr ARI (50 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	62.6	14.8	5.51	5.46	0.05	0.8	1.3	1
0.2	49.0	14.1	5.38	5.33	0.05	0.7	1.2	1
1	39.4	14.1	5.26	5.22	0.04	0.7	1.1	1.5
2	32.1	14.6	5.15	5.11	0.04	0.7	1	1
5	26.8	14.5	5.04	5.00	0.04	0.7	1	1
10	23.1	14.6	4.95	4.90	0.05	0.7	0.9	1
20	20.6	14.3	4.87	4.82	0.05	0.7	0.8	3
50	14.3	13.7	4.59	4.54	0.05	0.7	0	3

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Roghan Road Culvert

BCC Asset ID	C0183B	Tributary Name	Taigum Channel
Owner	BCC	AMTD (m)	1275
Year of Construction	1975	Coordinates (GDA94)	E 504664, N 6975693
Year of Significant Modification	N/A	Hydraulic Model ID	S28
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d culvert / 1d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Taigum Channel		

Structure Description		Multiple cell concrete rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	3
Number of Piers in Waterway	N/A	Dimensions (m)	3.6 w x 1.5 h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	3.7
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	3.61
Structure Length (m) (in direction of flow)		17.8	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 5.7	
Average Handrail Height (m)		~ 1.1 (steel tubular handrail with top rail and mid rail)	

Image Description	Looking Downstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Image Description	Looking Upstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				10-yr ARI (10 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	63.8	38.7	6.46	6.31	0.15	2.4	1.5	1
0.2	49.2	35.9	6.27	6.14	0.13	2.2	1.3	1
1	38.9	32.9	6.09	5.98	0.11	2.0	1.1	1.5
2	31.4	29.8	5.91	5.83	0.08	1.8	0.8	1
5	26.2	26.0	5.76	5.70	0.06	1.6	0.5	1
10	22.4	22.4	5.64	5.60	0.04	1.4	0	1
20	19.8	19.8	5.55	5.52	0.03	1.2	0	3
50	13.8	13.8	5.28	5.27	0.01	0.9	0	3

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Quarrion Street Culvert

BCC Asset ID	C2795B	Tributary Name	Taigum Channel
Owner	BCC	AMTD (m)	1690
Year of Construction	2001	Coordinates (GDA94)	E 504550, N 6975290
Year of Significant Modification	N/A	Hydraulic Model ID	S29
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d culvert / 1d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Taigum Channel		

Structure Description		Multiple cell concrete rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	3
Number of Piers in Waterway	N/A	Dimensions (m)	3.6 w x 1.5h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	4.94
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	4.92
Structure Length (m) (in direction of flow)		12	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 6.9	
Average Handrail Height (m)		~ 1.1 (steel tubular handrail with top rail and mid rail)	

Image Description	Looking Downstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Image Description	Looking Upstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	36.8	36.8	6.83	6.80	0.03	1.7	0	1
0.2	28.6	28.6	6.61	6.59	0.02	1.3	0	1
1	22.2	22.2	6.41	6.41	0.01	1.1	0	1.5
2	18.2	18.2	6.24	6.24	0.01	1.0	0	1
5	15.6	15.6	6.11	6.10	0.01	1.0	0	1
10	12.9	12.9	5.99	5.98	0.01	0.9	0	1
20	11.4	11.4	5.90	5.89	0.01	0.9	0	1
50	8.1	8.1	5.69	5.68	0.01	0.8	0	1

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Norris Road Culvert

BCC Asset ID	Unknown	Tributary Name	Carseldine Channel
Owner	BCC	AMTD (m)	1925
Year of Construction	2014	Coordinates (GDA94)	E 502467, N 6976646
Year of Significant Modification	N/A	Hydraulic Model ID	S30
Source of Structure Information	EDQ TUFLOW model developed by WRM Consultants	Flood Model Representation	1d bridge / 2d weir
Link to Data Source	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\model\mi\1d		

Structure Description		Multiple cell concrete rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	15
Number of Piers in Waterway	N/A	Dimensions (m)	1.8 w x 0.9 h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	8.75
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	8.65
Structure Length (m) (in direction of flow)		~ 25.2	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 11	
Average Handrail Height (m)		None	

Image Description	Looking Downstream
Date	August 2018
Source	Site inspection

Image Description	Looking Upstream
Date	August 2018
Source	Site inspection

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	55.9	55.8	10.99	10.48	0.51	2.3	N/A	2
0.2	45.0	45.1	10.69	10.36	0.33	1.9	N/A	2
1	37.7	37.7	10.40	10.20	0.20	1.6	N/A	1.5
2	28.0	28.0	10.26	10.13	0.13	1.2	N/A	4.5
5	27.8	27.8	10.17	10.05	0.12	1.1	N/A	3
10	20.7	20.7	10.03	9.96	0.07	0.9	N/A	6
20	17.5	17.5	9.85	9.81	0.04	0.7	N/A	3
50	11.2	11.2	9.62	9.61	0.01	0.5	N/A	4.5

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

North Coast Railway Culvert

BCC Asset ID	N/A	Tributary Name	Carseldine Channel
Owner	QLD Rail	AMTD (m)	2460
Year of Construction	Unknown	Coordinates (GDA94)	E 502059, N 6976385
Year of Significant Modification	~ 2000 third rail line constructed	Hydraulic Model ID	S31
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Carseldine Channel		

Structure Description		Multiple cell concrete rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	3
Number of Piers in Waterway	N/A	Dimensions (m)	3.45 w x 2.4 h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	9.3
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	9.3
Structure Length (m) (in direction of flow)		~ 27.2	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 12.7	
Average Handrail Height (m)		None	

Link to Flood Model Results	[G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA]()
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	63.7	63.7	12.11	11.40	0.71	2.9	N/A	2
0.2	51.3	51.3	11.80	11.24	0.56	2.5	N/A	2
1	42.6	42.6	11.57	11.14	0.43	2.2	N/A	1.5
2	35.1	35.1	11.38	11.05	0.33	1.9	N/A	2
5	30.9	30.9	11.27	11.00	0.27	1.7	N/A	2
10	26.7	26.7	11.16	10.94	0.22	1.6	N/A	2
20	22.1	22.1	11.04	10.88	0.16	1.3	N/A	3
50	15.0	15.0	10.85	10.76	0.09	1.0	N/A	3

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Lacey Road Culverts

BCC Asset ID	C4080B	Tributary Name	Carseldine Channel
Owner	BCC	AMTD (m)	3080
Year of Construction	2006	Coordinates (GDA94)	E 501554, N 6976204
Year of Significant Modification	N/A	Hydraulic Model ID	S32
Source of Structure Information	Design Drawings	Flood Model Representation	1d culvert / 2d weir
Link to Data Source			

Structure Description		Multiple cell concrete rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	5
Number of Piers in Waterway	N/A	Dimensions (m)	* 4 / 3.3 x 1.5 m RCBCs + ** 1 / 3.3 x 1.8 m RCBC
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	* 10.98 ** 10.68
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	* 10.83 ** 10.53
Structure Length (m) (in direction of flow)		34.8	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 13.3	
Average Handrail Height (m)		Fence only	

Image Description	Looking Downstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Image Description	Looking Upstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				100-yr ARI (1 % AEP) – at structure 2-yr ARI (50 % AEP) – sag location of road				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	63.5	41.8	12.51	12.28	0.23	1.7	N/A	2
0.2	49.0	34.6	12.30	12.07	0.23	1.6	N/A	2
1	37.9	28.3	12.12	11.93	0.19	1.5	N/A	1.5
2	30.7	24.3	12.00	11.83	0.17	1.5	N/A	1.5
5	27.1	22.5	11.95	11.79	0.16	1.5	N/A	1.5
10	23.4	20.6	11.89	11.74	0.15	1.4	N/A	2
20	18.2	17.6	11.80	11.67	0.13	1.4	N/A	3
50	13.5	13.5	11.68	11.59	0.09	1.3	N/A	3

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Gympie Road Culvert

BCC Asset ID	N/A	Tributary Name	Carseldine Channel
Owner	QLD DTMR	AMTD (m)	5630
Year of Construction	Unknown	Coordinates (GDA94)	E 501070, N 6975835
Year of Significant Modification	N/A	Hydraulic Model ID	S33
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Carseldine Channel		

Structure Description		Multiple cell concrete rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	5
Number of Piers in Waterway	N/A	Dimensions (m)	1.5 w x 0.9 h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	15.97
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	15.78
Structure Length (m) (in direction of flow)		30.9	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 17.7 (at median)	
Average Handrail Height (m)		0.7 (Armco)	

Image Description	Looking Downstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Image Description	Looking Upstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				20-yr ARI (5 % AEP) – at structure 10-yr ARI (10 % AEP) – sag location of road				
AEP (%)	Total Discharge (m^3/s)	Discharge through Box Culvert (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Box Culvert Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	45.7	20.8	18.02	17.12	0.90	3.1	N/A	1
0.2	34.8	20.4	17.95	17.07	0.88	3.0	N/A	1
1	27.0	19.8	17.87	17.04	0.83	2.9	N/A	1.5
2	20.5	19.2	17.79	17.02	0.77	2.8	N/A	1
5	18.1	18.0	17.68	17.00	0.68	2.7	N/A	1
10	16.2	16.2	17.50	16.96	0.54	2.4	N/A	1
20	14.3	14.3	17.34	16.93	0.41	2.1	N/A	3
50	10.2	10.2	16.97	16.84	0.13	1.5	N/A	3

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Zillmere Road Culvert

BCC Asset ID	C1005B	Tributary Name	Little Cabbage Tree Creek
Owner	BCC	AMTD (m)	570
Year of Construction	2002	Coordinates (GDA94)	E 502171 N 6974028
Year of Significant Modification	N/A	Hydraulic Model ID	S34
Source of Structure Information	Design drawings (culvert) + 2014 Flood Study (weir)	Flood Model Representation	1d culvert / 1d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Little Cabbage Tree Creek		

Structure Description		Multiple cell concrete rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	5
Number of Piers in Waterway	N/A	Dimensions (m)	3.6 w x 2.4 h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	12.86
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	12.68
Structure Length (m) (in direction of flow)		27.6	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 17.3	
Average Handrail Height (m)		~ 1.2	

Image Description	Looking Upstream
Date	November 2014
Source	BCC Asset Management Records

Image Description	Looking Downstream
Date	September 2015
Source	BCC Asset Management Records

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				500-yr ARI (0.2 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	172.5	137.5	17.45	17.13	0.32	3.2	0	2
0.2	116.0	114.2	17.04	16.84	0.20	2.6	0	1.5
1	94.9	94.9	16.72	16.60	0.12	2.2	0	1.5
2	75.5	75.5	16.36	16.30	0.06	1.8	0	1.5
5	62.2	62.2	16.11	16.08	0.03	1.6	0	3
10	53.9	53.9	15.88	15.86	0.02	1.7	0	1.5
20	46.3	46.3	15.69	15.67	0.02	1.6	0	3
50	30.6	30.6	15.26	15.26	0.00	1.5	0	3

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Gympie Road Culvert

BCC Asset ID	N/A	Tributary Name	Little Cabbage Tree Creek
Owner	QLD DTMR	AMTD (m)	1270
Year of Construction	1977	Coordinates (GDA94)	E 501681 N 6973595
Year of Significant Modification	1984	Hydraulic Model ID	S35
Source of Structure Information	1996 Flood Study (culvert) + 2014 Flood Study (weir)	Flood Model Representation	1d culvert / 1d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Little Cabbage Tree Creek		

Structure Description		Multiple cell concrete culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	6
Number of Piers in Waterway	N/A	Dimensions (m)	3 / 2.05 x 1.8 RCBCs + 3 / 2 dia RCPs
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	16.00
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	15.50
Structure Length (m) (in direction of flow)		~ 39	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 19.3	
Average Handrail Height (m)		~ 0.7 (Armco)	

Image Description	Looking Downstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Image Description	Looking Upstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Link to Flood Model Results	[G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA]()
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				10-yr ARI (10 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	133.4	66.9	20.18	19.82	0.36	3.3	1.1	1.5
0.2	108.6	66.6	20.03	19.55	0.48	3.2	0.9	1.5
1	92.0	66.1	19.92	19.33	0.59	3.2	0.7	1.5
2	74.1	64.6	19.73	19.10	0.63	3.1	0	1.5
5	61.5	61.1	19.45	18.91	0.54	3.0	0	1.5
10	52.2	52.2	19.13	18.75	0.38	2.5	0	1.5
20	45.2	45.2	18.86	18.62	0.24	2.2	0	3
50	29.8	29.8	18.27	18.19	0.08	1.9	0	3

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Gayford Street Culvert

BCC Asset ID	C0214B	Tributary Name	Little Cabbage Tree Creek
Owner	BCC	AMTD (m)	1300
Year of Construction	1984	Coordinates (GDA94)	E 501651 N 6973587
Year of Significant Modification	N/A	Hydraulic Model ID	S36
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d culvert / 1d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Little Cabbage Tree Creek		

Structure Description		Multiple cell concrete rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	4
Number of Piers in Waterway	N/A	Dimensions (m)	4 w x 2 h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	16.40
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	16.33
Structure Length (m) (in direction of flow)		18	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 19	
Average Handrail Height (m)		~ 0.7 (Armco)	

Image Description	Looking Downstream
Date	December 2017
Source	BCC Asset Management Records

Image Description	Looking Upstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				5-yr ARI (20 % AEP)				
AEP (%)	Total Discharge (m^3/s)[8]	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	133.4	46.7	20.20	20.18	0.02	1.6	1.0	1.5
0.2	108.6	47.6	20.06	20.03	0.03	1.6	0.9	1.5
1	92.0	47.7	19.95	19.92	0.03	1.6	0.9	1.5
2	74.1	49.0	19.76	19.73	0.03	1.6	0.7	1.5
5	61.5	49.8	19.51	19.45	0.06	1.6	0	1.5
10	52.2	46.4	19.17	19.15	0.02	1.6	0	1.5
20	45.2	40.4	18.92	18.87	0.05	1.6	0	3
50	29.8	26.8	18.28	18.27	0.01	1.6	0	3

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

[8]*Total discharge assumed the same as S35*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Albany Creek Road Culvert

BCC Asset ID	C3002B	Tributary Name	Little Cabbage Tree Creek
Owner	BCC	AMTD (m)	1685
Year of Construction	1984	Coordinates (GDA94)	E 501383 N 6973289
Year of Significant Modification	N/A	Hydraulic Model ID	S37
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Little Cabbage Tree Creek		

Structure Description		Multiple cell concrete rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	Varies in direction of flow
Number of Piers in Waterway	N/A	Dimensions (m)	3 / 4.6 x 2.33 m RCBCs to 6 / 2.13 x 2.33 m RCBCs to 3 / 4.6 x 2.33 m RCBCs
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	19.28
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	18.1
Structure Length (m) (in direction of flow)		~ 35	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 22.5 (median)	
Average Handrail Height (m)		~ 0.7 (Armco)	

Image Description	Looking Downstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Image Description	Looking Upstream
Date	3rd May 2019
Source	Photo taken as part of site visit 3rd May 2019

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				100-yr ARI (1 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	136.8	111.0	22.88	21.31	1.57	6.2	N/A	1
0.2	103.8	101.8	22.52	21.23	1.29	5.7	N/A	1.5
1	84.1	84.1	22.03	21.13	0.90	4.2	N/A	1.5
2	68.2	68.2	21.68	21.01	0.67	3.9	N/A	1.5
5	57.3	57.3	21.42	20.91	0.51	3.7	N/A	1.5
10	47.9	47.9	21.17	20.78	0.39	3.4	N/A	1.5
20	40.3	40.3	20.96	20.51	0.45	3.3	N/A	3
50	26.5	26.5	20.54	19.92	0.62	2.8	N/A	3

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Horn Road Bikeway Bridge

BCC Asset ID	B1000	Tributary Name	Little Cabbage Tree Creek
Owner	BCC	AMTD (m)	2795
Year of Construction	1990	Coordinates (GDA94)	E 500525 N 6972746
Year of Significant Modification	N/A	Hydraulic Model ID	S39
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d bridge / 1d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Little Cabbage Tree Creek		

Structure Description		Single span bikeway bridge	
Bridges		**Culverts**	
Number of Spans	1	Number of Barrels	N/A
Number of Piers in Waterway	None	Dimensions (m)	N/A
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	N/A
Bridge Invert Level (m AHD)	25.46	Downstream Invert (m AHD)	N/A
Structure Length (m) (in direction of flow)		~ 2.4	
Span Length (m)		16.8 (centreline of abutments)	
Lowest Level of Deck Soffit (m AHD)		~ 28 (from 2014 Flood Study)	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 28.3 (from 2014 Flood Study)	
Average Handrail Height (m)		~ 1.1 (from 2014 Flood Study)	

Image Description	Looking Downstream
Date	November 2014
Source	BCC Asset Management Records

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				20-yr ARI (5 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	112.5	59.0	29.10	28.72	0.38	3.1	0	1
0.2	87.7	54.1	28.85	28.53	0.32	2.9	0	1
1	69.5	50.3	28.64	28.36	0.28	2.8	0	1.5
2	56.3	46.6	28.43	28.19	0.24	2.8	0	1
5	46.1	43.8	28.29	28.07	0.22	2.7	0	1.5
10	39.0	39.0	28.13	27.96	0.17	2.7	0	1.5
20	35.6	35.6	28.01	27.87	0.14	2.8	0	3
50	25.0	25.0	27.70	27.64	0.06	2.8	0	3

[1]*Flow underneath the road and only for 1D structures*

[2]*Measured at centre-span of bridge or at centre of culvert*

[3]*This is afflux at peak water level*

[4]*(i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening*

[5]*(i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model*

[6]*Velocities provided here are approximate only and the model should be interrogated for design purposes.*

[7]*Based on peak water level*

Hydraulic Structure Reference Sheet

Cabbage Tree Creek Flood Study

Martindale Street Culvert

BCC Asset ID	C5514B	Tributary Name	Little Cabbage Tree Creek
Owner	BCC	AMTD (m)	3510
Year of Construction	1991	Coordinates (GDA94)	E 500507 N 6972066
Year of Significant Modification	N/A	Hydraulic Model ID	S40
Source of Structure Information	2014 Flood Study	Flood Model Representation	1d culvert / 2d weir
Link to Data Source	G:\BI\CD\Proj12\121408_Update_of_Cabbage_Tree_Creek_Flood_Study\Flood Managment\Data\Structure Data\Little Cabbage Tree Creek		

Structure Description		Multiple cell concrete rectangular culvert	
Bridges		**Culverts**	
Number of Spans	N/A	Number of Barrels	5
Number of Piers in Waterway	N/A	Dimensions (m)	3.6 w x 3 h
Pier shape and Width (m)	N/A	Upstream Invert (m AHD)	28.65
Bridge Invert Level (m AHD)	N/A	Downstream Invert (m AHD)	28.56
Structure Length (m) (in direction of flow)		15	
Span Length (m)		N/A	
Lowest Level of Deck Soffit (m AHD)		N/A	
Overtopping Level of Weir/Road (m AHD) (not including handrail)		~ 32.6	
Average Handrail Height (m)		1.5	

Image Description	Looking Upstream
Date	November 2014
Source	BCC Asset Management Records

Image Description	Looking Downstream
Date	May 2013
Source	BCC Asset Management Records

Link to Flood Model Results	G:\BI\CD\Proj19\190477_Cabbage_Tree_Crk_Fld_Study\Flood Management\Tuflow\results\S1_DES\CLA
Model Version Number	CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
Model Scenario	Scenario 1 Design (S1_DES) / Scenario 1 Extreme (S1_EXT)

Structure Flood Immunity (immunity of lowest point of weir above structure)				> 2000-yr ARI (0.05 % AEP)				
AEP (%)	Total Discharge (m^3/s)	Discharge through Structure (m^3/s)[1]	U/S Peak Water Level (m AHD)[2]	D/S Peak Water Level (m AHD)[2]	Afflux (m)[3]	Structure Velocity (m/s)[4&6]	Weir Velocity (m/s)[5&6]	Critical Storm Duration (hrs)[7]
0.05	96.1	95.8	32.57	32.29	0.28	1.8	N/A	1
0.2	75.2	75.2	32.28	32.11	0.17	1.4	N/A	1
1	59.0	59.0	32.06	31.96	0.11	1.1	N/A	1.5
2	48.3	48.3	31.91	31.83	0.07	0.9	N/A	1
5	40.1	40.1	31.77	31.73	0.05	0.7	N/A	1
10	34.2	34.2	31.67	31.63	0.03	0.6	N/A	1
20	30.3	30.3	31.59	31.57	0.03	0.6	N/A	3
50	20.5	20.5	31.36	31.34	0.02	0.4	N/A	3

[1]Flow underneath the road and only for 1D structures

[2]Measured at centre-span of bridge or at centre of culvert

[3]This is afflux at peak water level

[4](i) Only for 1D structures. (ii) This is the peak of the depth/width averaged velocity within the structure opening

[5](i) Only for 1D structures (ii) This is the peak of the depth/width averaged velocity across the 1D weir section of the model

[6]Velocities provided here are approximate only and the model should be interrogated for design purposes.

[7]Based on peak water level

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Appendix N: External Peer Review Documentation

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Our Ref: L.B20679.012.CTC.docx

30 July 2019

Brisbane City Council
City Projects Office
Green Square, Level 1
505 St Pauls Terrace
Fortitude Valley
Qld 4006

Attention: Scott Glover

Dear Scott

RE: CABBAGE TREE CREEK FLOOD MODELLING PEER REVIEW

Background

BMT was commissioned by Council to undertake a peer review of the Cabbage Tree Creek flood modelling prepared as part of the Cabbage Tree Creek Flood Study. This letter documents the outcomes of BMT's review.

The review was undertaken in three stages: firstly, the initial model design, then model calibration and finally the design event modelling was reviewed. At the commencement of these review stages, Council submitted the following data to BMT:

- Hydrologic models (URBS);
- Hydraulic models including model output files (TUFLOW);
- GIS data; and
- Preliminary flood study reporting.

Review responses were provided to Council via email, and Council provided suitable responses to all queries.

Overview of the Modelling Approach

Hydrological models were developed using URBS. The structure of the URBS models and the sub-catchment parameters has been reviewed. The URBS model parameters have been appropriately applied and are within the standard values for URBS models. The design event rainfall IFD used in the URBS model is appropriate for the catchment. It is noted that ARR2019 was used to compute the design storm events. An ARF of one was applied as a simplification on the ARR2019 guidance. This will result in overestimated design rainfall depths. Given the challenges in applying ARR2019 for a catchment study such as this, this is considered an adequate compromise. However, future users of the model should note that the flows and flood levels may be overestimated, especially in lower reaches, and the hydrology could be revisited for design of infrastructure within the catchment. Zero rainfall losses have been applied in pervious portions of the catchment. While this is appropriate for the purpose of the current study, it may be more conservative to apply rainfall losses in permeable areas when using the model to undertake development assessments in future. It is noted that Council increased design rainfall depths by 9.8% to account for estimated climate change impacts, as per ARR2019 guidance. While climate change is also expected to cause rising sea levels, sea level rise has not been included in the design flood events. Therefore, climate change is only partly accounted for in the design flood events and sea level rise was included in separate climate change simulations.

Hydraulic models of the creeks in the study area were developed using TUFLOW. A 4m computational grid cell size was used. The creeks were modelled in 1D and linked to the 2D model domain of the floodplain.

While all ensemble temporal patterns were simulated in the hydrology model, only a small selection of events were modelled in the hydraulic model. This was done to reduce the number of hydraulic model runs to a more pragmatic number of simulations. Up to two representative ensemble temporal patterns were adopted for each storm duration for frequent, intermediate and rare events based on the peak flows estimated by the hydrology model. In localities where the adopted ensemble event did not produce the true median peak flow, the adopted design event peak flow tends to differ by less than 1% on average and 2.6% at most compared to the true median peak flow. The method was verified against the full set of ensemble temporal patterns simulated in the TUFLOW model for the 10% and 1% AEP events. Thus, the adopted approach is considered suitable.

Model Performance

The model performance has been checked in relation to: mass balance error (-0.9%), negative depth warnings, and instability. While minor instability occurs in a few of the 1D elements the model performance is considered suitable. It is noted that Council has also assessed the model performance in relation to replication of historical events (calibration and verification) and bridge structures have been compared to equivalent HEC-RAS models. Generally, Council’s acceptable tolerance for calibration is 0.15m variance for peak flood levels at stream gauges and 0.3m variance for peak flood levels at maximum height gauges. Council has achieved these tolerances in most instances.

Limitations of the Review

This review focussed on scrutinising the design and performance of the models developed by Council. The scope of the review does not extend to the underlying data used to develop the model or the broader flood study methodology and procedure. For example, the accuracy of the topographic data, land use mapping (based on Brisbane City Council’s City Plan and refined using aerial imagery), structure details and historic flood data has not been explicitly checked. If supplied information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions may change. As a consequence, BMT provides no liability to the accuracy or the precision of the supplied data. All liability to do with the assumptions that rely on the accuracy or the precision of the supplied data rest with Brisbane City Council.

Conclusion

The flood modelling undertaken as part of the Cabbage Tree Creek Flood Study complies with current industry practice and is considered suitable for the purposes of the study.

Yours Faithfully
BMT

Richard Sharpe RPEQ (18843)
Senior Flood Engineer

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Appendix P: Modelling User Guide

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Cabbage Tree Creek Flood Study

Model User Guide

Prepared by Brisbane City Council's, City Projects Office

August 2019

BRISBANE CITY

Dedicated to a better Brisbane

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Table of Contents

List of Tables

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1.0 Introduction

1.1 Cabbage Tree Creek Flood Study (2019)

This document is to be read in conjunction with the Cabbage Tree Creek Flood Study - Volume 1 (2019).

The Cabbage Tree Creek Flood Study (2019) incorporates the calibration and verification of the hydrologic and hydraulic models; design event modelling; extreme event modelling and sensitivity modelling. Hydrologic and hydraulic models have been developed using the URBS and TUFLOW modelling software respectively.

Calibration of the URBS and TUFLOW models was undertaken utilising two historical storms; namely 1st May 2015 and 4th June 2016. Verification of the URBS and TUFLOW models utilised the 19th June 2016 historical storm event.

Design and extreme flood magnitudes were estimated for the full range of events from 2-yr ARI (50 % AEP) to PMF. These analyses assumed hydrologic ultimate catchment development conditions in accordance with the current version of BCC City Plan.

Three waterway scenarios were considered, as follows:

- Scenario 1 – Existing Waterway Conditions: Based on the current waterway conditions. Some minor modifications were made to the TUFLOW model developed as part of the calibration / verification phase.
- Scenario 2 – Minimum Riparian Corridor (MRC): Includes an allowance for a riparian corridor along the edge of the channel.
- Scenario 3 – Ultimate Conditions: Includes an allowance for the minimum riparian corridor (as per Scenario 2) and also assumes development infill to the boundary of the "Modelled Flood Corridor" in order to simulate potential development.

A sensitivity analysis was undertaken to understand the impacts of projected sea level rise due to climate change for Climate Future Year 2100.

1.2 Scope of this Document

This document provides a guide to users of the URBS hydrologic and TUFLOW hydraulic models that were developed as part of the flood study.

2.0 Hydrologic and Hydraulic Models

2.1 Hydrologic Models

2.1.1 General

The URBS modelling has been undertaken using Version 6.34 (beta), with simulations performed using the URBS Control Centre Version 4.3.4 in lieu of a batch file.

The name and location of the URBS Control Centre project is as follows:

..\URBS\Cabbage\2018\Cabbage.prj

The URBS modelling has been separated into:

- Calibration / Verification, and
- Design / Rare and Extreme

The following sections discuss each respectively.

2.1.2 Calibration and Verification Models

For the calibration / verification runs, a separate model for each of the historical events has been developed. These are discussed individually in the following sections:

Event 1 – 1st May 2015

The name and location of the 1st May 2015 event folder is as indicated below, with the URBS Control Centre settings indicated in Figure 2.1

..\URBS\Cabbage\2018\Calibration\1_May_2015

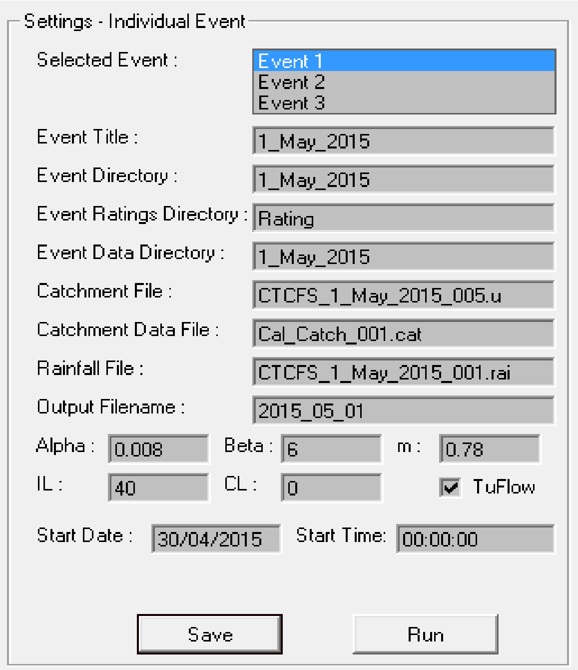

Figure 2.1: Event 1 (1st May 2015)

Event 2 – 4th June 2016

The name and location of the 4th June 2016 event folder is as indicated below, with the URBS Control Centre settings indicated in Figure 2.2.

..\URBS\Cabbage\2018\Calibration\4_June_2016

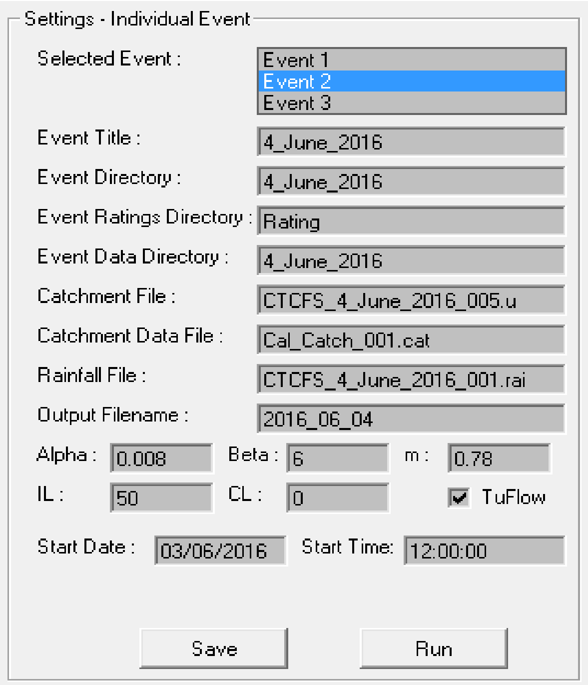

Figure 2.2: Event 2 (4th June 2016)

Event 3 – 19th June 2016

The name and location of the 19th June 2016 event folder is as indicated below, with the URBS Control Centre settings indicated in Figure 2.3.

..\URBS\Cabbage\2018\Calibration\19_June_2016

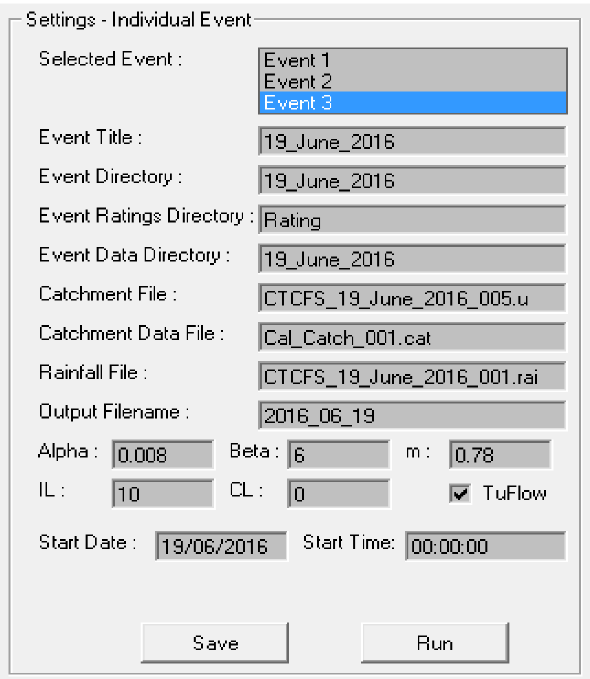

Figure 2.3: Event 3 (19th June 2016)

2.1.3 Design Model

For the design and rare / extreme events, one model has been developed. The name and location of the Design model folder(s) is as indicated below, with the URBS Control Centre settings indicated in Figure 2.4 and Figure 2.5.

- AR&R 2016: ..\URBS\Cabbage\2018\Des16
- AR&R 1987: ..\URBS\Cabbage\2018\Des87

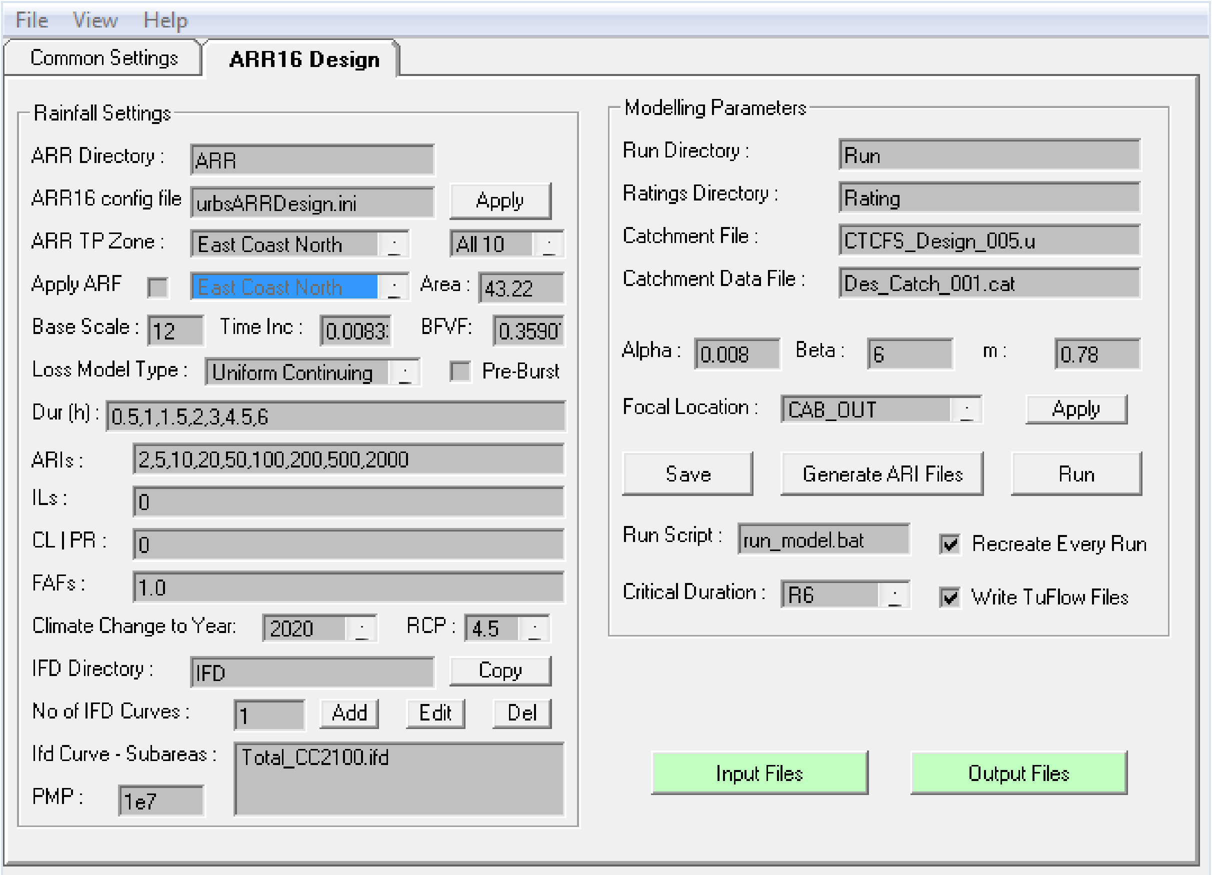

Figure 2.4: Design Run Settings – 2-yr to 2000-yr ARI

In order to run the PMF event, the URBS Control Centre settings are as per Figure 2.5.

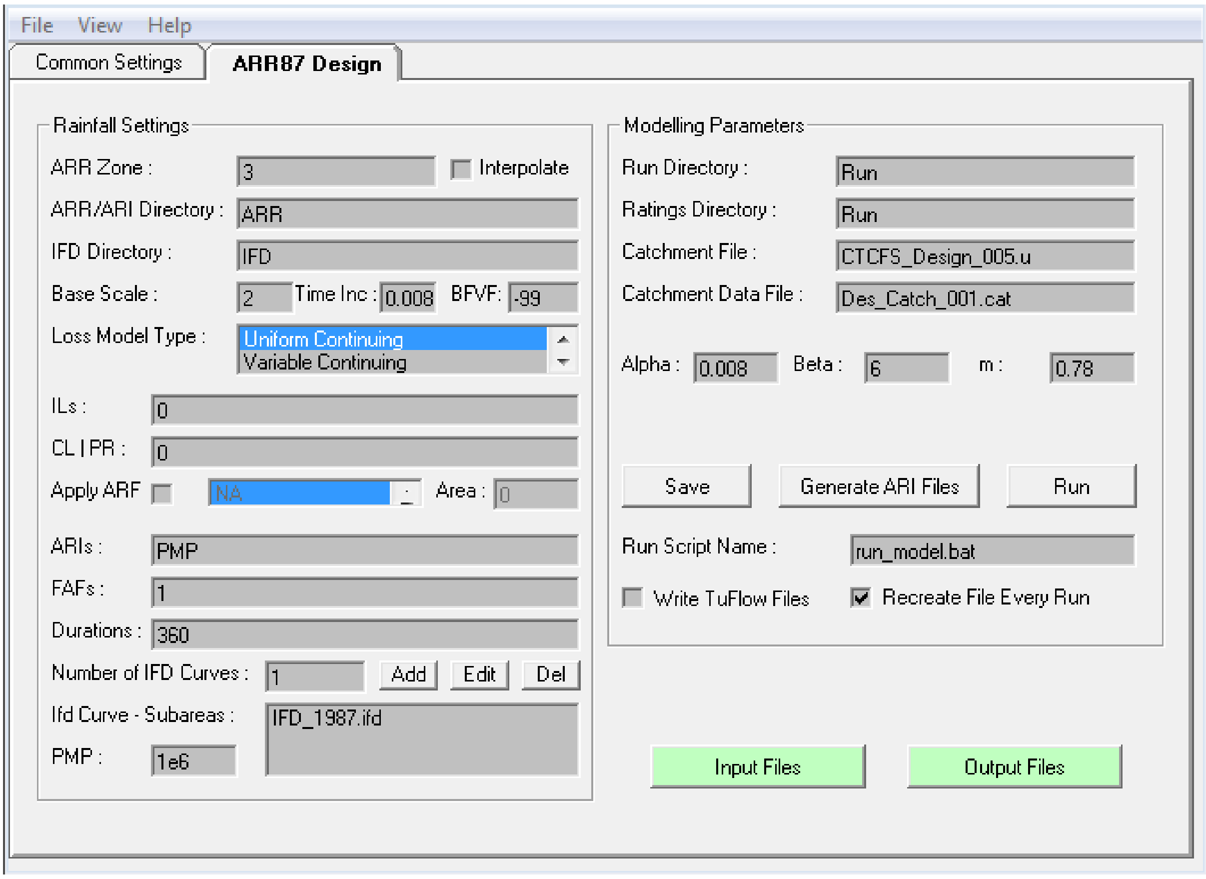

Figure 2.5: Design Run Settings – PMF

2.2 Hydraulic Models

2.2.1 General

TUFLOW modelling was undertaken using build: 2018-03-AB-iSP-w64.

The TUFLOW modelling was undertaken using a single TUFLOW Control File (TCF), which was named: CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf. The ESTRY Control File (ECF) is embedded into the TCF.

This TCF can be used to simulate all of the model runs undertaken as part of the flood study. The model is run using the appropriate TUFLOW batch command based on the required scenario and events.

2.2.2 TUFLOW Calibration and Verification Models

TUFLOW simulations were undertaken for all three historical events. The model is essentially the same for each, apart from the boundary conditions. Table 2.1 indicates the scenario and event codes to be used inside the TUFLOW batch file.

Table 2.1 – TUFLOW Calibration and Verification Batch Codes

Model Simulation	Scenario 1 (~s1~)	Scenario 2 (~s2~)	Event 1 (~e1~)	Event 2 (~e2~)	Event 3 (~e3~)
Calibration – 1st May 2015	CAL	CLA	2015	05	01
Calibration – 4th June 2016	CAL	CLA	2016	06	04
Verification – 19th June 2016	CAL	CLA	2016	06	19

As an example, the batch file command for 1st May 2015 simulation would be as follows:

tuflow_iSP_w64.exe -b -s1 CAL -s2 CLA -e1 2015 -e2 05 –e3 01 CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf

2.2.3 TUFLOW Design Event Models

TUFLOW simulations were undertaken for all Scenario 1, Scenario 2 and Scenario 3 design events up to and including the 100-yr ARI (1 % AEP) event. Table 2.2 and Table 2.3 indicate the scenario and event codes to be used inside the TUFLOW batch file.

Table 2.2 – TUFLOW Scenario 1 and Scenario 3 Design Event Batch Codes

Model Simulation	Scenario 1 (~s1~)	Scenario 2 (~s2~)	Event 1 (~e1~)	Event 2 (~e2~)	Event 3 (~e3~)
Design Events (Scenario 1 and 3)	S1_DES or S3_DES	CLA	002y or 002yCC	E4	060m
				E2	090m
				E8	120m
				E1	180m
				E8	180m
				E4	270m
				E3	360m
			005y or 005yCC	E4	060m
				E2	090m
				E8	120m
				E1	180m
				E8	180m
				E4	270m
				E3	360m
			010y or 010yCC	E3	030m
				E8	060m
				E6	090m
				E10	120m

Model Simulation	Scenario 1 (~s1~)	Scenario 2 (~s2~)	Event 1 (~e1~)	Event 2 (~e2~)	Event 3 (~e3~)
Design Events (Scenario 1 and 3)	S1_DES or S3_DES	CLA		E8	180m
				E5	270m
				E3	360m
				E10	360m
			020y or 020yCC	E3	030m
				E8	060m
				E6	090m
				E10	120m
				E8	180m
				E5	270m
				E3	360m
				E10	360m
			050y or 050yCC	E7	030m
				E4	060m
				E5	090m
				E1	120m
				E4	180m
				E3	270m
				E6	360m
			100y or 100yCC	E7	030m
				E4	060m
				E5	090m
				E1	120m
				E4	180m
				E3	270m
				E6	360m

As an example, the batch file command for Scenario 1 100-yr ARI Ensemble #4 60-minute simulation would be as follows:

```
tuflow_iSP_w64.exe -b -s1 S1_DES -s2 CLA -e1 100y -e2 E4 –e3 060m CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
```

Table 2.3 – TUFLOW Scenario 2 Design Event Batch Codes

Model Simulation	Scenario 1 (~s1~)	Scenario 2 (~s2~)	Event 1 (~e1~)	Event 2 (~e2~)	Event 3 (~e3~)
Design Events (Scenario 2)	S2_DES	CLA	100yCC	E7	030m
				E4	060m
				E5	090m
				E1	120m
				E4	180m
				E3	270m
				E6	360m

As an example, the batch file command for Scenario 2 100-yr ARI Ensemble #4 60-minute simulation would be as follows:

```
tuflow_iSP_w64.exe -b -s1 S2_DES -s2 CLA -e1 100yCC -e2 E4 –e3 060m CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
```

2.2.4 TUFLOW Rare and Extreme Event Models

TUFLOW simulations were undertaken for the Scenario 1 and Scenario 3 extreme events up to and including the PMF event. Table 2.4 indicates the scenario and event codes to be used inside the TUFLOW batch file.

As an example, the batch file command for Scenario 1 200-yr ARI Ensemble #4 60-minute simulation would be as follows:

```
tuflow_iSP_w64.exe -b -s1 S1_EXT -s2 CLA -e1 200y -e2 E4 –e3 060m CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
```

Similarly, the batch file command for Scenario 1 PMF simulation would be as follows:

```
tuflow_iSP_w64.exe -b -s1 S1_EXT -s2 CLA -e1 PMF -e2 E0 –e3 360m CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
```

2.2.5 TUFLOW Sensitivity Analysis Models

TUFLOW climate sensitivity simulations were undertaken for the projected sea level rise at Climate Future Year 2100. Table 2.5 indicates the scenario and event codes to be used inside the TUFLOW batch file.

As an example, the batch file command for the Scenario 1 Ensemble #5 100-yr 30-minute simulation would be as follows:

```
tuflow_iSP_w64.exe -b -s1 S1_SLR -s2 CLA -e1 100yCC -e2 E5 –e3 030m CTCFS_~s1~_~s2~_~e1~_~e2~_~e3~_038.tcf
```

Table 2.4 – TUFLOW Scenario 1 Rare and Extreme Event Batch Codes

Model Simulation	Scenario 1 (~s1~)	Scenario 2 (~s2~)	Event 1 (~e1~)	Event 2 (~e2~)	Event 3 (~e3~)
Rare and Extreme Events (Scenario 1 and 3)	S1_EXT or S3_EXT	CLA	200y or 200yCC	E7	030m
				E4	060m
				E5	090m
				E1	120m
				E4	180m
				E3	270m
				E6	360m
			500y or 500yCC	E7	030m
				E4	060m
				E5	090m
				E1	120m
				E4	180m
				E3	270m
				E6	360m
	S1_EXT		2000y or 2000yCC	E7	030m
				E4	060m
				E5	090m
				E1	120m
				E4	180m
				E3	270m
				E6	360m
			PMF	E0	360m

Table 2.5 – TUFLOW Sensitivity Analysis Batch Codes

Model Simulation	Scenario 1 (~s1~)	Scenario 2 (~s2~)	Event 1 (~e1~)	Event 2 (~e2~)	Event 3 (~e3~)
Sea Level Rise Climate Future Year 2100 (Scenario 1 and 3)	S1_SLR or S3_SLR	CLA	100yCC	E7	030m
				E4	060m
				E5	090m
				E1	120m
				E4	180m
				E3	270m
				E6	360m

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