Appendix B

Flood Study Technical Appendix

Throsby, Styx & Cottage Creek Flood Study

Technical Appendix

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1 Introduction

This Technical Appendix has been produced to provide further technical explanation of topics covered in the main body of the report. Expansion of discussion on the following topics include:

- Flood modelling methodologies (**Section 5** of the report main body),
- Flood model calibration and validation (**Section 6** of the report main body), and
- Design event flood behaviour (**Section 7** of the report main body).

The Technical Appendix should be read in conjunction with the main report. It contains details on methodologies and analysis which, while not considered necessary for understanding of the flood study, may be of importance to technical professionals utilising this study for the purposes of assessing changes to flood behaviour in the floodplain. Each section in this appendix correlates to a section in the main body of the flood study report.

2 Modelling Methodology

2.1 Hydrologic Model

2.1.1 Sub-Catchment Delineation

Modification to the subcatchment delineation from the previous *Throsby, Cottage and CBD Flood Study* (BMT WBM, 2008), was undertaken manually using the available terrain data (2021 and 2014 LiDAR datasets), reference to aerial imagery, existing GIS stormwater network, and engineering experience in the setup and configuration of an updated WBNM model. As the model uses the downstream sub-catchments to route the flow, it is important to ensure that the catchment shape that is delineated is appropriately representative to define this routing characteristic.

WBNM undertakes routing (conveyance of flows) by passing flows from the upstream sub-catchment through the next downstream catchment. For the majority of sub catchments, flows are routed within the 2D hydraulic model. In the WBNM hydrologic model, the travel time through the downstream catchment is a function of the downstream sub-catchment area, the 'C' parameter and the streamflow lag. As part of the model schematisation, the routing connections between sub-catchments have been defined. Although the impacts of this on the hydraulic model outputs are more significant in upper areas of the catchment where total upstream inflows from multiple subcatchments are applied to the 2D model domain.

Subcatchment delineation is provided in **Map G150**.

2.1.2 Subcatchment Imperviousness

In this study, the EIA/TIA relationship was defined according to the different land-use zones in the study area. The adopted ratios are shown in **Table 2-1**.

Table 2-1. Adopted EIA/TIA Ratio Based on Land Zoning Classification

Land Zoning Classification	Land Zoning Code	EIA/TIA Ratio
Unzoned Land	UL	0%
Deferred Matter	DM	55%
National Parks and Nature Reserves	E1	55%
Environmental Conservation	E2	55%
Environmental Management	E3	55%
Public Recreation	RE1	55%
Private Recreation	RE2	55%
Transition	RU6	55%
Neighbourhood Centre	B1	65%
Low Density Residential	R2	65%
Medium Density Residential	R3	65%
High Density Residential	R4	65%
Tourist	SP3	65%
Local Centre	B2	80%
Infrastructure	SP2	80%
Commercial Core	B3	90%
Mixed Use	B4	90%

Land Zoning Classification	Land Zoning Code	EIA/TIA Ratio
Business Development	B5	90%
General Industrial	IN1	90%
Light Industrial	IN2	90%
Heavy Industrial	IN3	90%
Special Activities (Newcastle Port)	SP1	100%
Recreational Waterways	W2	100%

The TIA was defined using a GIS based method, which incorporated different spatial data elements. **Table 2-2** summarises the spatial layers considered in the TIA estimation

Table 2-2. GIS Based Methods Used in TIA Definition

Spatial Data Element	Description	Source	TIA estimation
Roads and Footpaths layer	Includes roads, kerbs, footpaths and public carparks	City of Newcastle	The areas covered by this layer were considered to be 100% impervious.
Buildings Layer	Building rooftops extracted from the 2021 LAS data (Point Clouds)	the City of Newcastle	The areas covered by this layer were considered to be 100% impervious.
Zoning Layer	Land use zoning classifications	NSW EPI (DPE, 2021)	The areas covered by this layer (and not covered by the roads and buildings layer) were considered to be partially impervious. The percentage of impervious areas was determined according to the land zoning classification.

Based on the GIS layers summarised in **Table 2-2**, it was possible to divide each sub-catchment into three areas, namely:

- Area 1 – Area covered by the Roads and Footpaths layer
- Area 2 – Area covered by the Buildings Layer
- Area 3 – Remaining area.

Areas 1 and 2 are covered by impervious surfaces and, therefore, were considered to be 100% impervious. Area 3, on the other hand, is composed by both pervious surfaces (gardens, parks, open areas, etc.) and impervious surfaces (driveways, private carparks, sheds, paved backyards, etc.). For this reason, the impervious percentage of Area 3 was estimated based on the land zoning classification.

Table 2-3 summarises the Area 3 TIA percentages for each land-use type. Note that the values in **Table 2-3** refer only to the remaining areas, i.e. the area not covered by the roads and the buildings GIS layers.

Table 2-3. TIA Percentages, Based on Land Zoning Classification*

Land Zoning Classification	Land Zoning Code	Total Impervious Areas
National Parks and Nature Reserves	E1	0%
Environmental Conservation	E2	0%
Environmental Management	E3	0%
Unzoned Land	UL	0%
Deferred Matter	DM	10%
Public Recreation	RE1	10%
Private Recreation	RE2	10%
Low Density Residential	R2	25%
Medium Density Residential	R3	25%
Transition	RU6	50%
Infrastructure	SP2	50%
High Density Residential	R4	60%
Neighbourhood Centre	B1	70%
Tourist	SP3	70%
Local Centre	B2	80%
Commercial Core	B3	90%
Mixed Use	B4	90%
Business Development	B5	90%
General Industrial	IN1	90%
Light Industrial	IN2	90%
Heavy Industrial	IN3	90%
Special Activities (Newcastle Port)	SP1	90%
Recreational Waterways	W2	100%

** Land use classification as at January 2023, prior to changes in B and IN classifications in mid 2023*

2.2 Hydraulic Model

2.2.1 Grid Resolution

Where necessary for faster computation of model results, a coarse-grid model was established utilising a 2D model grid resolution of 8 m. Hydraulic modelling scenarios where this was used include determination of design storm critical durations and representative temporal patterns (**Section 4.1.2.1**) and sensitivity analyses (**Section 3.4** and **Section** Error! Reference source not found.).

A sub-grid sample distance of 1 m was utilised across the 2D model domain. This provides a more accurate stage vs. storage relationship for each grid cell as opposed to a traditional TUFLOW DEM representation which assumes a constant area for each grid cell. Spatially varying raster results are "remapped" to show what depths at each sub-grid cell are. This should not be interpreted as having a 1 m grid cell model resolution. The modelled water elevation and velocity at each sub-grid cell is the same across the 4 m or 8 m grid cell.

2.2.2 Roughness

The point cloud data does not differentiate between paved and un-paved ground surfaces and as such, paved surfaces in public land such as roads and footpaths were delineated using the pavement layer in the City of Newcastle's GIS database.

For urban areas (residential, industrial and commercial), higher roughness values were applied to represent the impact of obstructions such as fences and buildings. These urban areas were delineated using polygons sourced from the cadastral layer in the City of Newcastle's GIS database. Building extents from the 2021 point cloud were included in the hydraulic model with surface areas greater than $500m^2$ and located in non-residential areas.

2.2.3 1D Hydraulic Structures

2.2.3.1 Bridges and Weirs

TUFLOW does not currently support the direct application of blockage factors to 1D bridges. The majority of bridge structures from the *Throsby, Cottage and CBD Flood Study* (BMT WBM, 2008) model were therefore converted to rectangular culverts with an equivalent waterway area in order to enable the application of blockage factors in accordance with ARR2019 procedures. Bridges with significant spans towards the downstream end of the study area as well as elevated, single-span pedestrian bridges were left un-altered from the *Throsby, Cottage and CBD Flood Study* (BMT WBM, 2008) model as blockage analysis is not required on these structures.

2.2.3.2 Pits, Pipes and Culverts

The pit and pipe network from the *Throsby, Cottage and CBD Flood Study* (BMT WBM, 2008) model was retained for the current study, with minor adaptations made, and supplemented with GIS stormwater network data provided by the City of Newcastle.

Where available, survey data provided by the City of Newcastle was used to set the invert levels of the stormwater network. For areas of the network where no invert level data is currently available, invert levels were set based on an assumed 600mm cover over pipe obverts.

Inlet pits have been modelled using the same approach as the *Throsby, Cottage and CBD Flood Study* (BMT WBM, 2008) whereby water is transferred between the 2D model and the 1D pipe network via upright rectangular channels equivalent to twin 2m long by 0.15m high lintels. The nominally high inlet dimensions are based on the assumption that the capacity of the pit and pipe network is limited by pipe conveyance capacity rather than pit inlet capacity and also to account for additional inlets associated with the smaller drainage lines not included in the model. The Engelund pit loss approach was adopted which calculates pit losses at each timestep and accounts for changes in inlet and outlet pipe dimensions and orientations.

Adopted culvert parameters are summarised in **Table 2-4**.

Table 2-4 Culvert Parameters

Structure	Manning's 'n'	Form loss	Height Contraction Coefficient	Width Contraction Coefficient	Entry Loss	Exist Loss
Culvert (converted from bridge)	0.015	Structure specific per BMT WBM (2008) model	0.8	1	0.1	0.3
Culvert	0.015	0	0.6	0.9	0.5	1

2.2.3.3 Blockages

No blockage factors were applied to surface inlet pits. It is assumed that pipe capacity is the limiting factor for the overall stormwater system's capacity.

2.2.4 Boundary Conditions

The selection of inflow method was based on the hydrologic sub-catchment delineation, location within the hydraulic model extent, known flood behaviour from previous modelling and the configuration of open channel and drainage networks. 1D boundary condition polygons were generally used in upstream areas of the catchment with numerous drainage lines; whereas 2D source-area polygons were the preferred method for applying inflows in flatter areas towards the central and downstream portions of the study area where inundation is widespread.

3 Model Calibration and Validation

3.1 June 2007 Calibration Event

3.1.1 Hydrologic Modelling

Spatial distribution of rainfall depths was applied to each subcatchment based on the isohyets created in **Map G200**. Temporal distribution of rainfall was based on the closest gauge to the centroid of each subcatchment.

The default catchment lag factor of 1.6 in the WBNM software was used for all subcatchments. Without any significant regional storages, such as basins, located in the catchment there was no obvious need to adjust this parameter. Furthermore, storages arising from localised depressions in the ground surface and flood waters backing up against road and rail embankments are represented in the hydraulic model.

3.1.2 Hydraulic Modelling

3.1.2.1 Results

Model results show a high degree of correlation with observed flood levels for the June 2007 event, with approximately 80% of modelled levels within 0.2m of observed levels at Grade 1 points located within the estimated flood extents.

Discrepancies between modelled and observed flood levels could be attributed to several factors including:

- Uncertainties in the location of calibration points. Whilst the flood observation points are linked to an address and located within the subject lot, the exact location of the observation point may not always correspond to the location of the flood mark. Any error in the horizontal location of observed points in the upper parts of the catchment where terrain and hydraulic gradients are relatively steep could lead to significant discrepancies between simulated and observed flood levels due to large differences in elevation across these lots.
- Uncertainties in rainfall distribution. The rainfall distribution adopted in the hydrologic analysis has been calculated via the interpolation of rainfall depths from a number of gauges within and surrounding the catchment and thus does not account for fluctuations in rainfall behaviour between gauges. This could lead to local under or overestimation of inflows, particularly for locations within the catchment that are further removed from rainfall gauges.
- Local hydraulic effects due to the presence of obstructions such as walls, fences and buildings. These have been accounted for at a broader scale through the selection of appropriate roughness factors as is the typical approach for catchment wide flood studies; however, this does not capture finer scale hydraulic behaviour such as local run up against obstructions which may result in higher flood marks than surrounding flood levels. This may explain a number of significant variations in recorded flood levels that are in close proximity to each other.
- Representation of pit and pipe networks. This flood study focuses primarily on mainline flooding rather than overland flooding and smaller elements of the drainage network (refer **Section 2.2.3.2**) have not been included in the model. As a consequence, modelled flood behaviour may deviate from observed behaviour in the upper portions of the catchment where the flooding regime is characterised by local overland flow as opposed to floodwaters overtopping channels and major conveyance structures. This may account for modelled flood extents not reaching recorded flood marks in a number of locations.

- Blockage of hydraulic structures. Extensive review of historic photographs and sensitivity testing was undertaken surrounding blockage of critical structures and the impact this has on modelled flood behaviour, particularly around Styx Creek. Despite this, there remains considerable uncertainty regarding the degree of structure blockage that occurred during the 2007 event and the timing of the blockages, noting that TUFLOW does not allow for temporal variance in structure blockage.
- Accuracy in LiDAR levels. The 2021 LiDAR data provided by the City of Newcastle has a vertical accuracy of 0.1 m at the 95% confidence interval which may result in discrepancies in flood levels, particularly in areas of shallow overland flow.

3.2 February 1990 Validation Event

3.2.1 Hydraulic Modelling

3.2.1.1 Model Updates

The TUFLOW hydraulic model was updated in a number of areas to reflect catchment conditions during the 1990 event. Model updates included:

- Updating the model topography at key areas where surface elevations are known to have changed since 1990 (**Map G108**) using z shapes provided with the calibration model files from the *Throsby, Cottage and CBD Flood Study* (BMT WBM, 2008) TUFLOW model. It should be noted that not all model files specific to this event were provided and thus portions of the model topography around Westfield Kotara, the Broadmeadow Soccer Field and Maryville may not be fully representative of 1990 conditions. This may have local impacts on modelled flood behaviour in these areas, but is not considered to have a significant impact on the overall model validation.

3.2.1.2 Results

Considering a lower degree of correlation is typically expected between modelled and observed results for validation events compared to calibration events, the model generally aligns with observed levels from the February 1990 event, with 72% of modelled levels within 0.3m of observed levels at Grade 1 points located within the simulated flood extents. There is considerable uncertainty regarding the accuracy of the stream gauge levels and thus comparison of model levels against the surveyed flood points is considered more suitable for the purpose of model validation.

Overestimations of modelled flood levels compared to observed levels at a number of locations can likely be attributed to conservative blockage assumptions using the matrix blockage method. Model sensitivity testing with reduced blockages (refer **Section 3.4**) showed improved correlation with observed levels around Styx Creek during the February 1990 event.

3.3 April 1988 Validation Event

3.3.1 Hydraulic Modelling

3.3.1.1 Results

Results of the statistical analysis show approximately 61% of modelled levels falling within 0.3m of observed levels for Grade 1 points located within the simulated flood extents, which is considered reasonable for a validation event with significant uncertainty surrounding model inputs. Discrepancies between modelled and observed flood levels in this event could largely be attributed to the considerable variation and uncertainty with rainfall data across the catchment.

3.4 Model Sensitivity

To reduce prohibitive model runs times (over 24 hours for each run) during the sensitivity analysis a coarse grid model was established using an 8 m grid cell size but maintaining the 1 m sub-grid sample size. The results for the July 2007 calibration event using an 8 m grid are compared against the original 4 m grid in **Map G230**. The differences in peak flood elevations using this coarse grid model were seen across the catchment but were generally only +/- 50 mm. This coarse grid model was considered adequate for the sensitivity analysis.

3.4.1 Blockage

The sensitivity blockage rate is applied to the bridges which were converted to culverts (refer **Section 2.2.3.3**), circular or box culverts, and pipes within the stormwater network with headwall immediately upstream. Blockage was not applied to pit inlet capacities.

4 Understanding Flood Behaviour

4.1 Design Flood Behaviour

Published maps are an envelope of a number of durations. The methodology for preparing mapped results involved:

- The determination of the median temporal pattern event for each duration and recurrence interval, and
- The determination of the maximum of the median temporal pattern values for each recurrence interval.

4.1.1 Hydrologic Modelling

The metadata for input downloaded from the ARR Data Hub is shown in **Table 4-1**.

Table 4-1. ARR Data Hub Metadata

Parameter	Value
Latitude	-32.934
Longitude	151.740
Storm Initial Losses (mm)	21.0
Storm Continuing Losses (mm/h)	2.2[1]
River Region - Division	South East Coast (NSW)
River Region - Number	10
River Region	Hunter River
Point Temporal Pattern Code	ECsouth
Point Temporal Pattern Label	East Coast South
Areal Temporal Pattern Code	ECsouth
Areal Temporal Pattern Label	East Coast South
Version	2016_v1

While the initial and continuing loss values of 10 mm and 2 mm/hr, respectively, were adopted for the 2007 calibration event, sensitivity testing indicated that the mostly urban catchment is not particularly sensitive to the adopted losses for pervious areas. The probability neutral losses are generally consistent with the 10mm calibrated initial loss, so the probability neutral losses were adopted for design storm flood estimation. The 2 mm/hr calibration continuing loss value was adopted as it was generally consistent with the continuing losses recommended in the NSW specific guidance for ARR2019.

The hydrologic model was used to identify a range of design event durations and temporal patterns producing the highest discharge within Throsby, Styx and Cottage Creeks. However, this model does not adequately reflect the smaller scale storages within the catchment such as localised depressions and ponding behind road and rail embankments. The hydraulic model provides representation of flood behaviour considering the impacts of catchment storage, and the hydrologic model was used to identify

[1] NSW specific guidance for ARR2019 recommends that losses be adopted from flood studies established in the catchment, or this value should be multiplied by 0.4.

the preliminary storm durations considered for further design storm assessment. The design storms brought forward for selection of critical durations and representative temporal patterns in the hydraulic model ranged from 30 minutes to 24 hours.

4.1.2 Hydraulic Modelling

4.1.2.1 Selection of Durations and Temporal Patterns

Mapped flood behaviour is a combination of different design storm durations and consideration of multiple temporal patterns for each of those durations. ARR2019 includes a combination of storm durations and temporal patterns to be considered in flood analysis. There are a total of 10 temporal patterns for each duration, leading to a large number of potential simulations. A process was undertaken using the coarse grid model to identify the critical durations and temporal patterns, to then be analysed in the detailed fine grid model. This is outlined below:

1. In the hydrologic model, all temporal patterns and storm durations for the PMF, 0.2%, 0.5%, 1%, 2%, 5%, and 10% AEPs were assessed. This indicated that peak flows generally fell within the 30 minute to 9 hour range across all storm frequencies.
2. The coarse-grid hydraulic model (refer **Section 2.2.1**) was run for all temporal patterns and storm durations up to the 24 hour event (for the 1% AEP and 5% AEP) to ensure that the effects of flood storages across the study area (e.g. ponding behind embankments, cross-subcatchment flows, etc.) are more appropriately considered. The selection of durations and temporal patterns to be run in the fine-grid hydraulic model have been defined by peak flood elevations in the coarse-grid hydraulic model and not peak discharge in the hydrologic model.
3. The coarse grid assessment of the 1% AEP design storm durations was used to inform the critical durations for very rare events (0.2% and 0.5% AEPs) and while the5% AEP design storm durations were used to inform the selection of critical durations for rare events (10% and 2% AEPs). This approach reduces total model run times for selection of critical durations for all modelled AEP events. The following durations were found to be critical across the study area:
    - Extreme event (PMF): 1hr, 1.5hr, 3hr and 5hr;
    - Very rare events (0.2%, 0.5% and 1% AEPs): 12hr, 3hr, 2hr and 1hr; and
    - Rare events (2%, 5% and 10% AEPs): 12hr, 6hr, 3hr and 1hr.
4. The above durations were then run through the coarse grid model for all AEP events, except the PMF. For each model duration, a representative temporal pattern was adopted that was closest to the median peak water levels across the study area. This temporal pattern was adopted through a quantitative and qualitative GIS analysis of the results, to ensure that the adopted temporal pattern provided the least variation to the median.

The resulting storms (critical durations and temporal patterns) selected for running in the final, fine-grid hydraulic model are listed in **Table 4-2**. Note that only one temporal pattern exists for the Generalised Short-Duration Method (GSDM) PMF event.

Table 4-2. Selected Critical Durations and Representative Temporal Pattern ID Number

Storm Duration (hr)	PMF	0.2% AEP	0.5% AEP	1% AEP	2% AEP	5% AEP	10% AEP
1	GSDM	4559	4559	4559	4559	4573	4573
1.5	GSDM						
2		4618	4618	4618			
3	GSDM	4599	4599	4599	4653	4678	4659
5	GSDM						
6					4743	4697	4766
12		4787	4785	4785	4787	4793	4703

4.1.3 Hydrologic Model Inflows

A sensitivity analysis was undertaken on the hydrologic model by adjusting the catchment lag parameter (C=1.4 and C=1.8) and pervious surface initial and continuing losses (+/- 20%). Model runs for each permutation of these parameters was run and the resulting maximum and minimum discharge scenarios were exported for assessment in the hydraulic model.

As anticipated, discharge is maximised when both catchment lag and losses are minimised. Conversely, discharge is minimised when catchment lag and losses are maximised. **Figure 4-2** through **Figure 4-4** show the results of this sensitivity assessment within the hydrologic model at select locations (refer **Figure 4-1**) to provide an indication of the overall variation to catchment discharge.

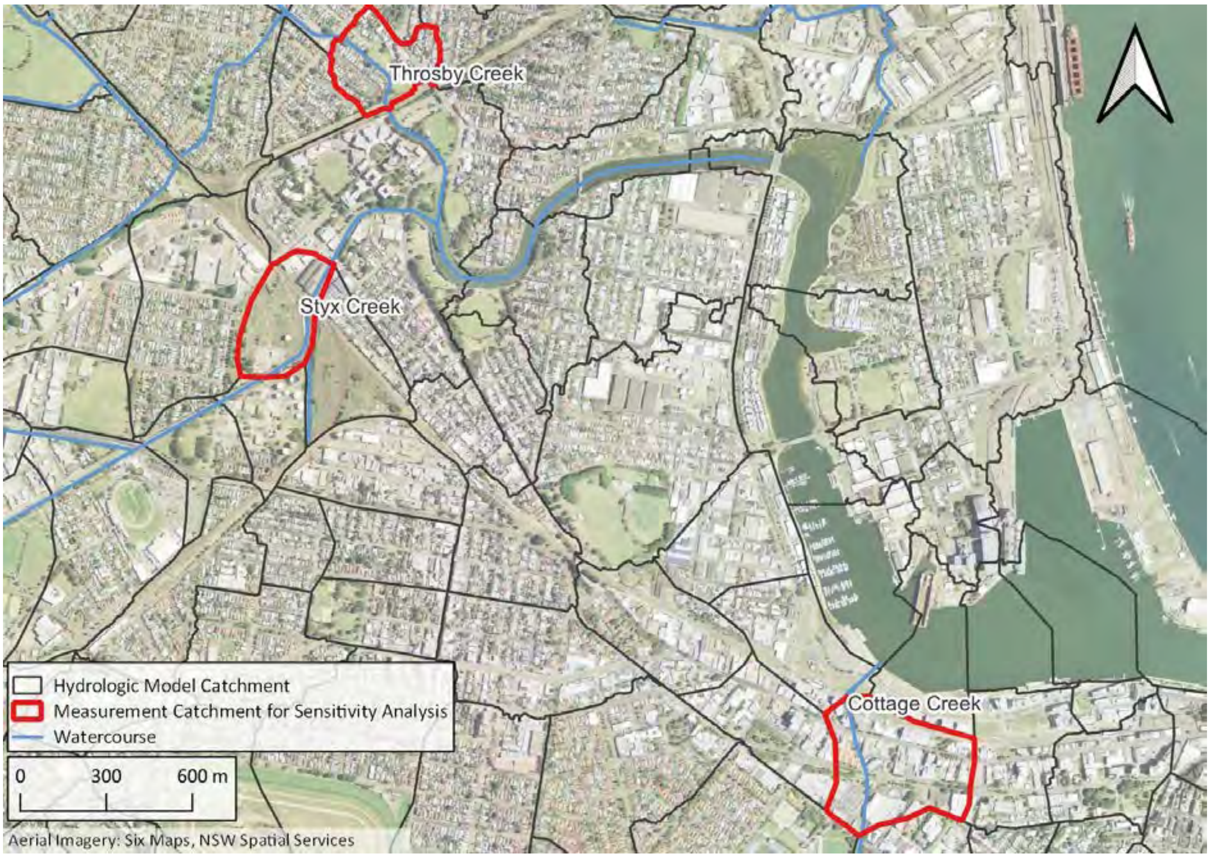

Figure 4-1. Hydrologic Model Sensitivity Results – Measurement Subcatchments

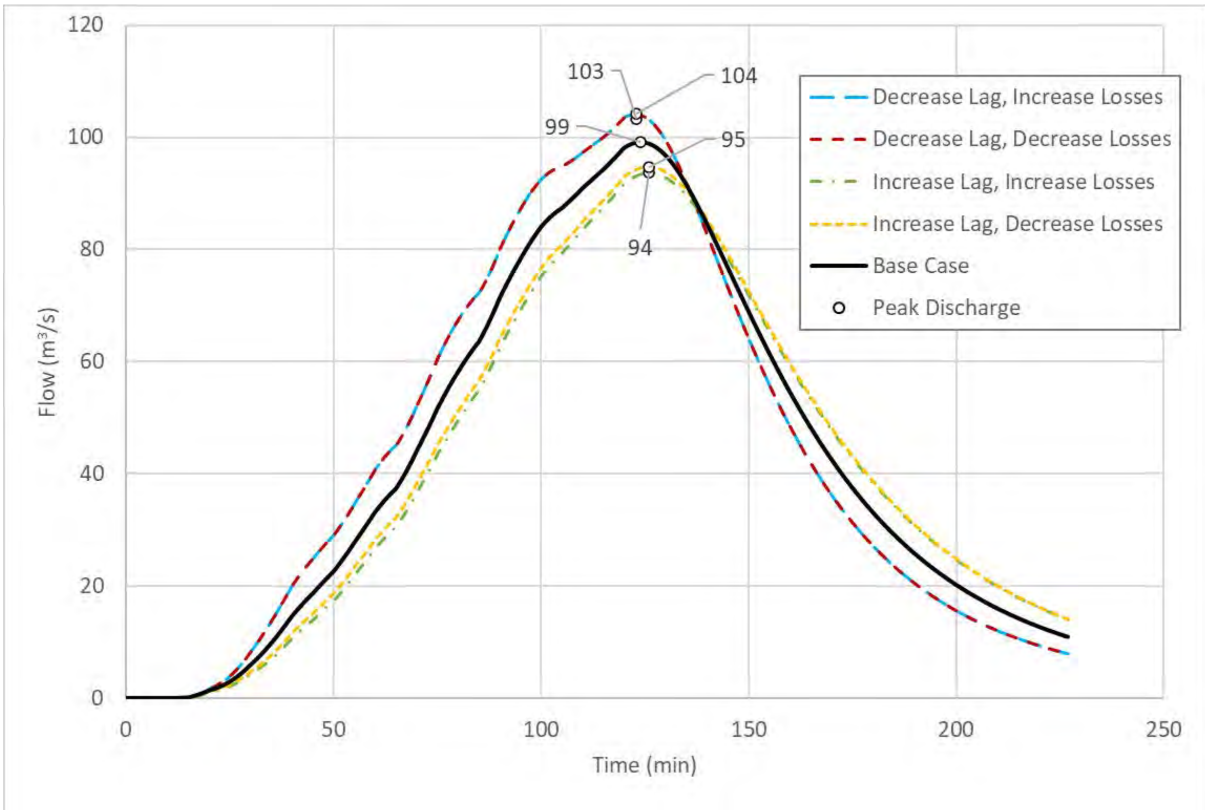

Figure 4-2. Hydrologic Model Sensitivity Results - Throsby Creek

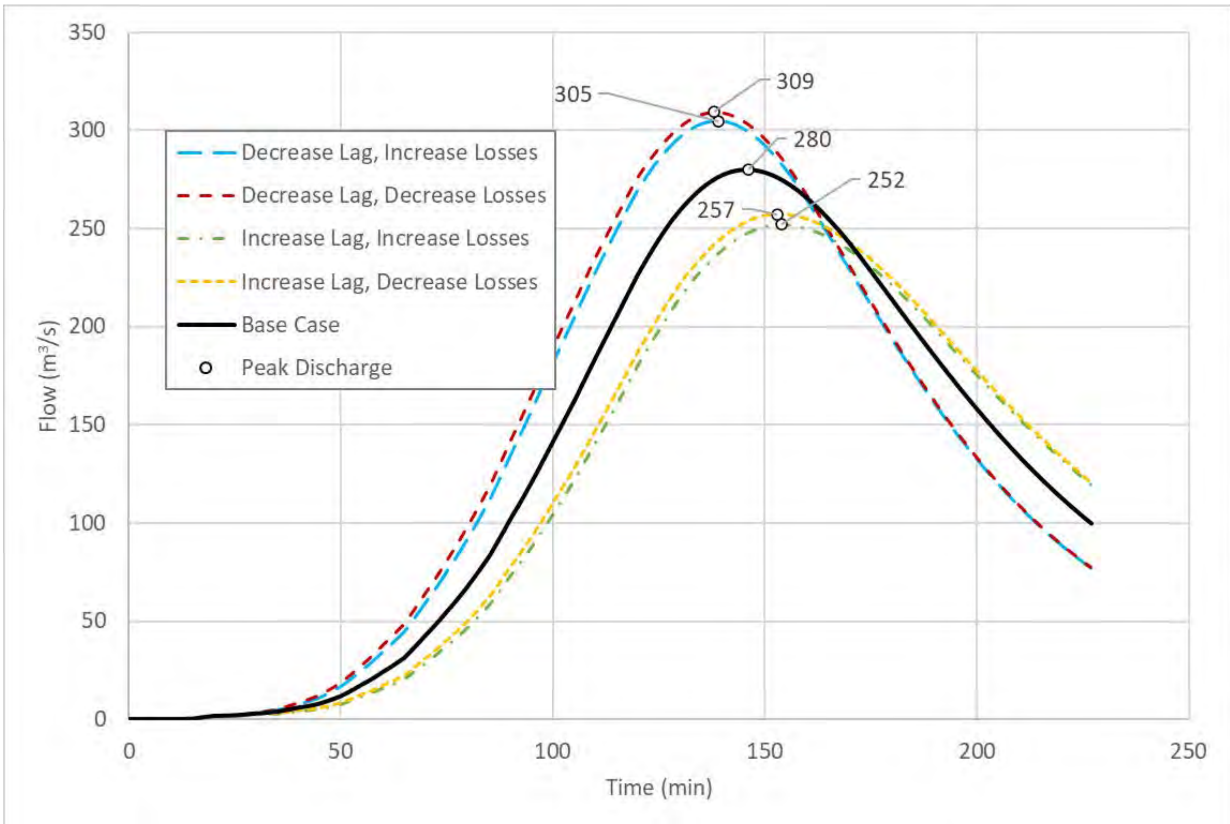

Figure 4-3. Hydrologic Model Sensitivity Results - Styx Creek

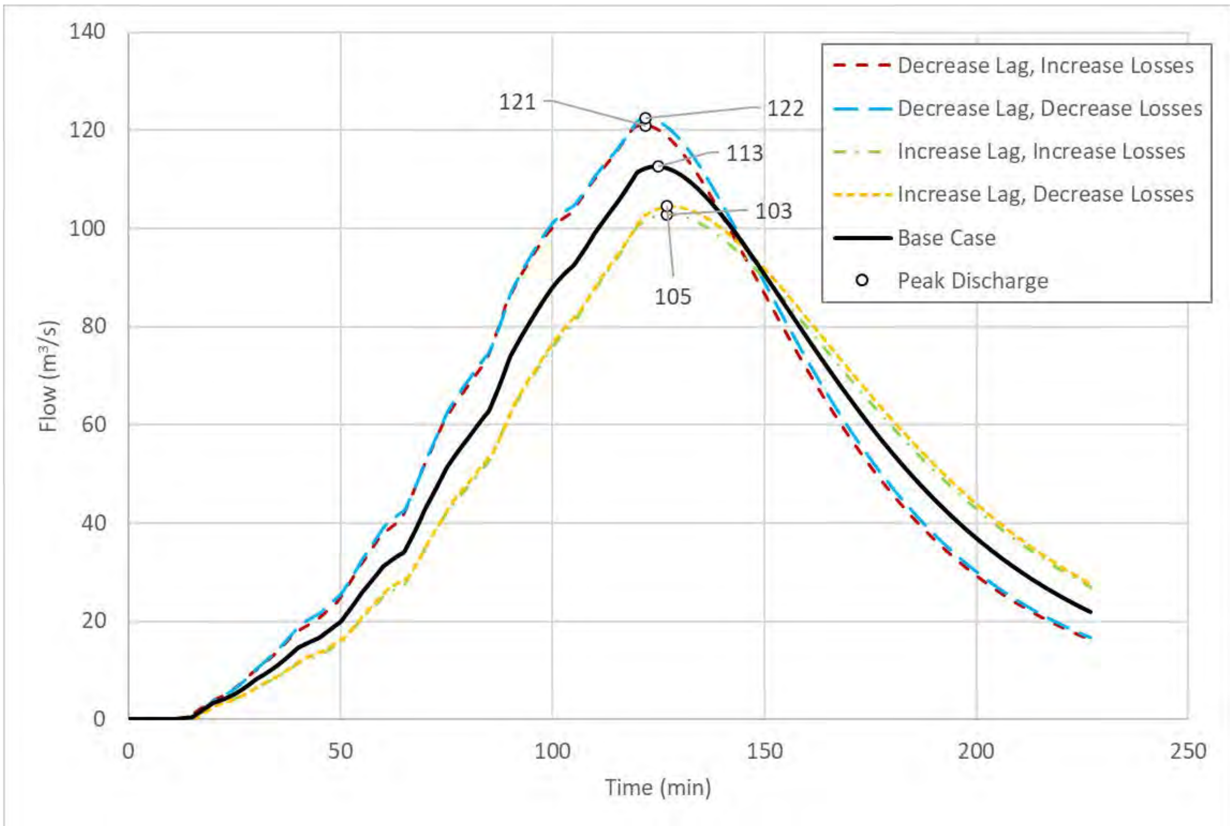

Figure 4-4. Hydrologic Model Sensitivity Results - Cottage Creek

Generally, the hydrologic inflows increase and decrease by approximately 5% to 10%, and timing of hydrograph peaks changes by up to approximately 10 minutes for the 2 hour event. The change in peak discharge is predominantly caused by the catchment lag changes, as the study area's relatively high proportion of impervious surfaces results in less impact on runoff when the pervious surface loss values are altered. **Sections** Error! Reference source not found. and Error! Reference source not found. of this report discuss the relative impacts of impervious areas and losses on modelled flood levels for this study area.

4.1.4 Rate of Rise Assessment

Figure 4-5 through **Figure 4-10** provide a water level vs. time curve for each storm duration considered (refer **Table 4-2** for critical duration selection) and each design event frequency. Temporal patterns shown in these figures are the "front-loaded" patterns selected from the hydrologic model. Note that the figures only show the first three to five hours of each storm event for clarity of the rising arm. **Figure 4-8** to **Figure 4-10** show flood levels affected by sea level rise (i.e. in the 1% AEP event for 2050).

For locations affected by tidal conditions in Newcastle Harbour (TC_01, Wck_01, and CC_01), the rate of rise curves begin at1.25 m AHD (the HHWSS) for the 5% and 10% AEP events and 1.85 m AHD (the 5% AEP ocean storm level, plus 0.4 m sea level rise). Refer to Error! Reference source not found. for the selected coinciding ocean boundary level for each design rainfall event.

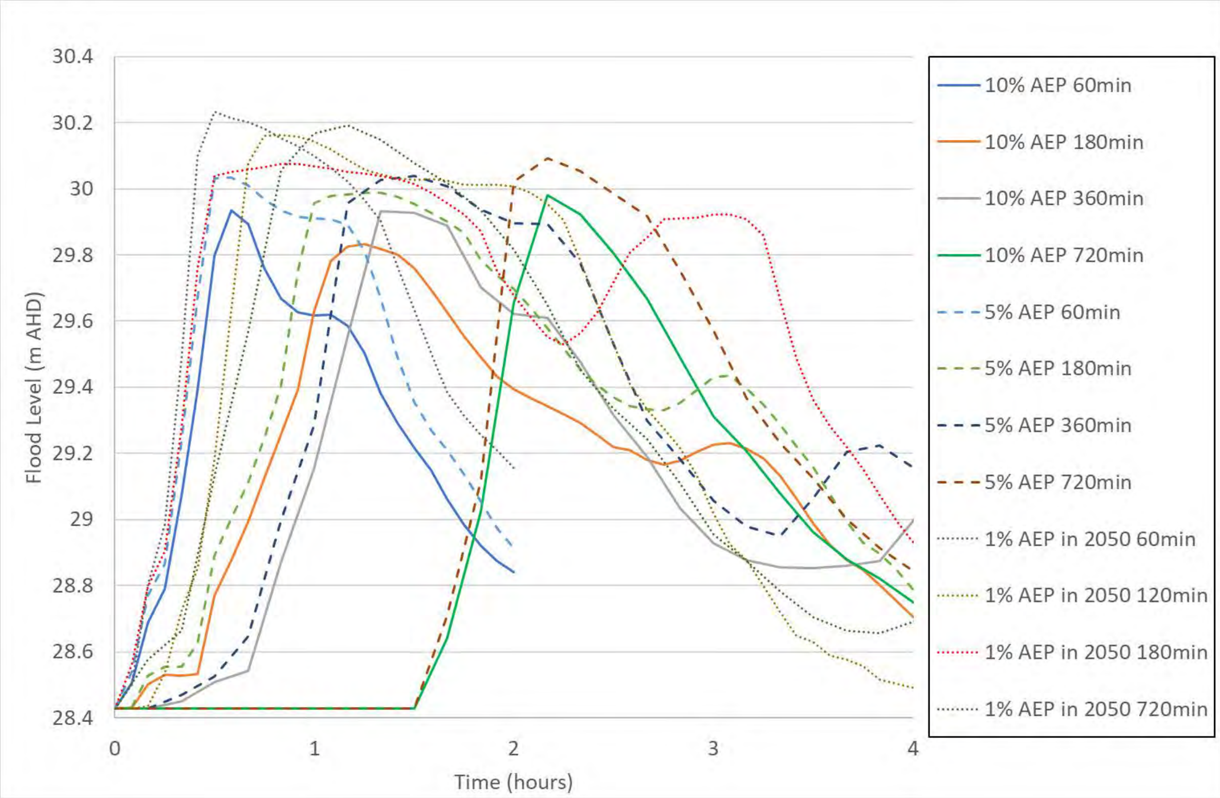

Figure 4-5. Rate of Rise at Location WDC_01

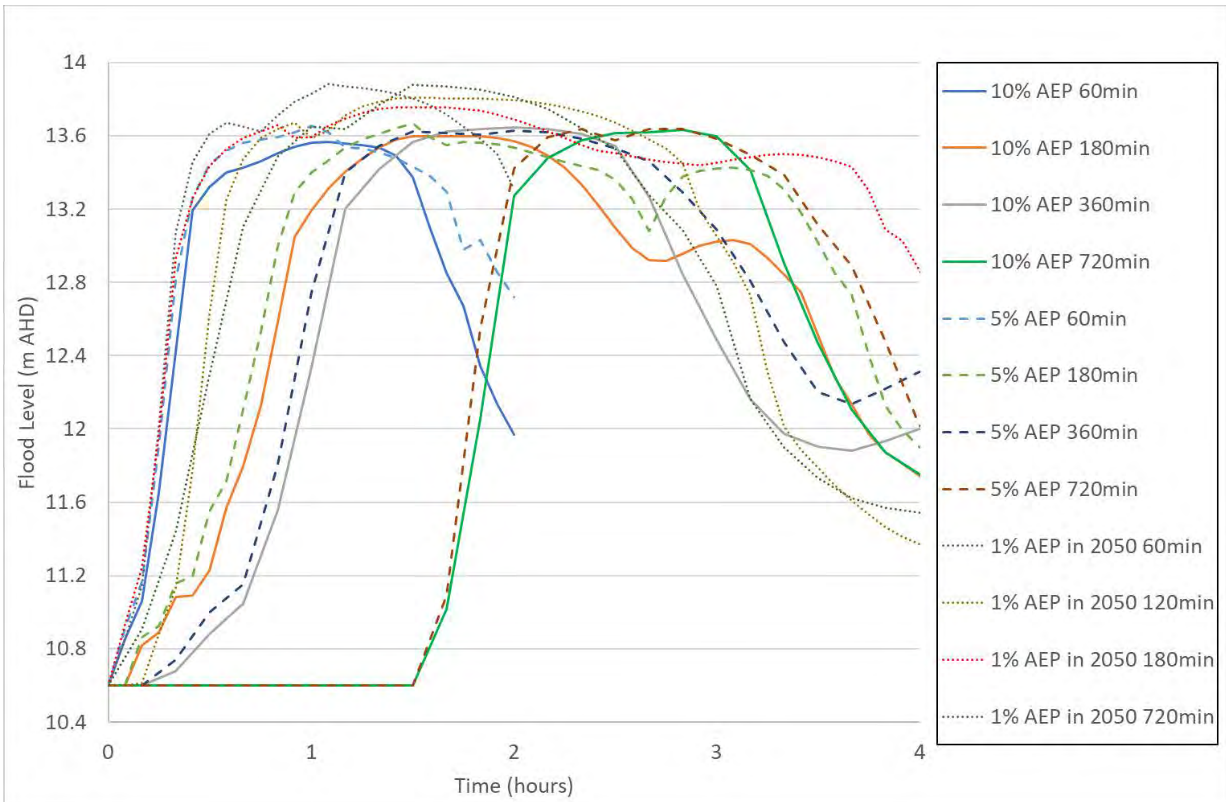

Figure 4-6. Rate of Rise at Location SC_01

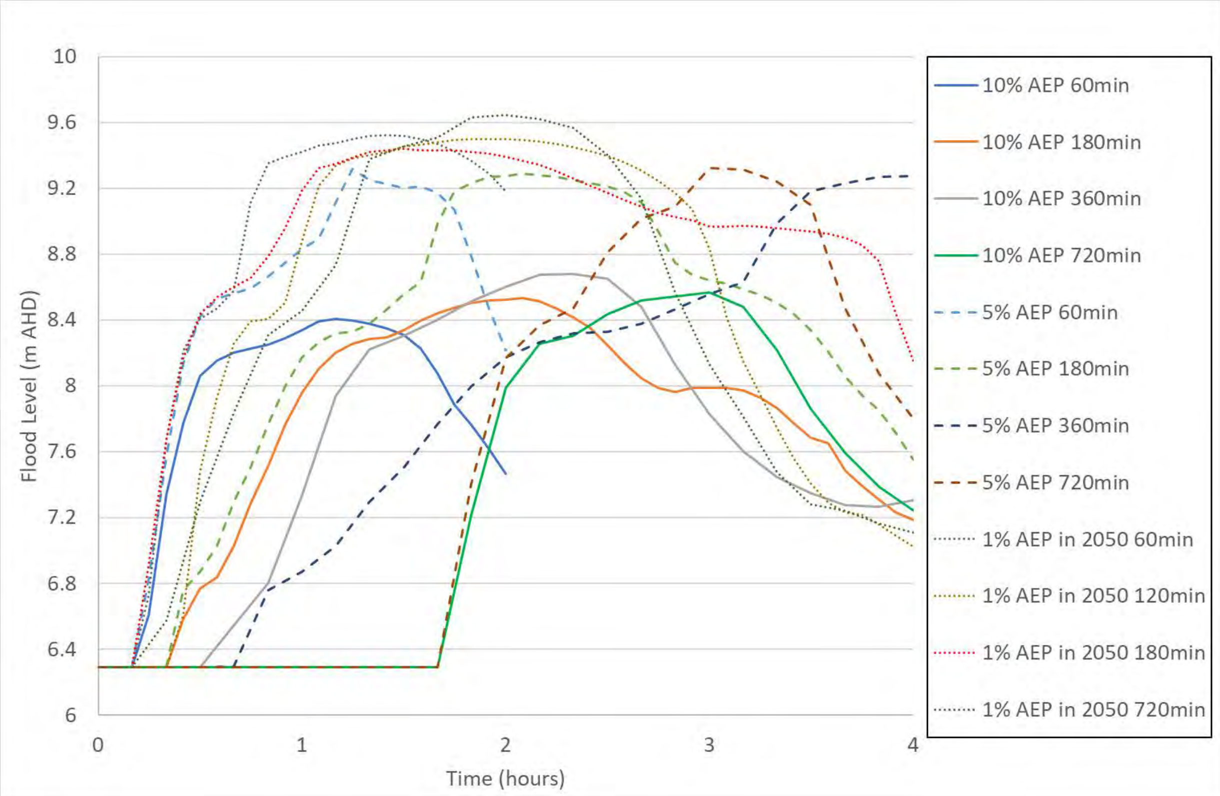

Figure 4-7. Rate of Rise at Location SC_02

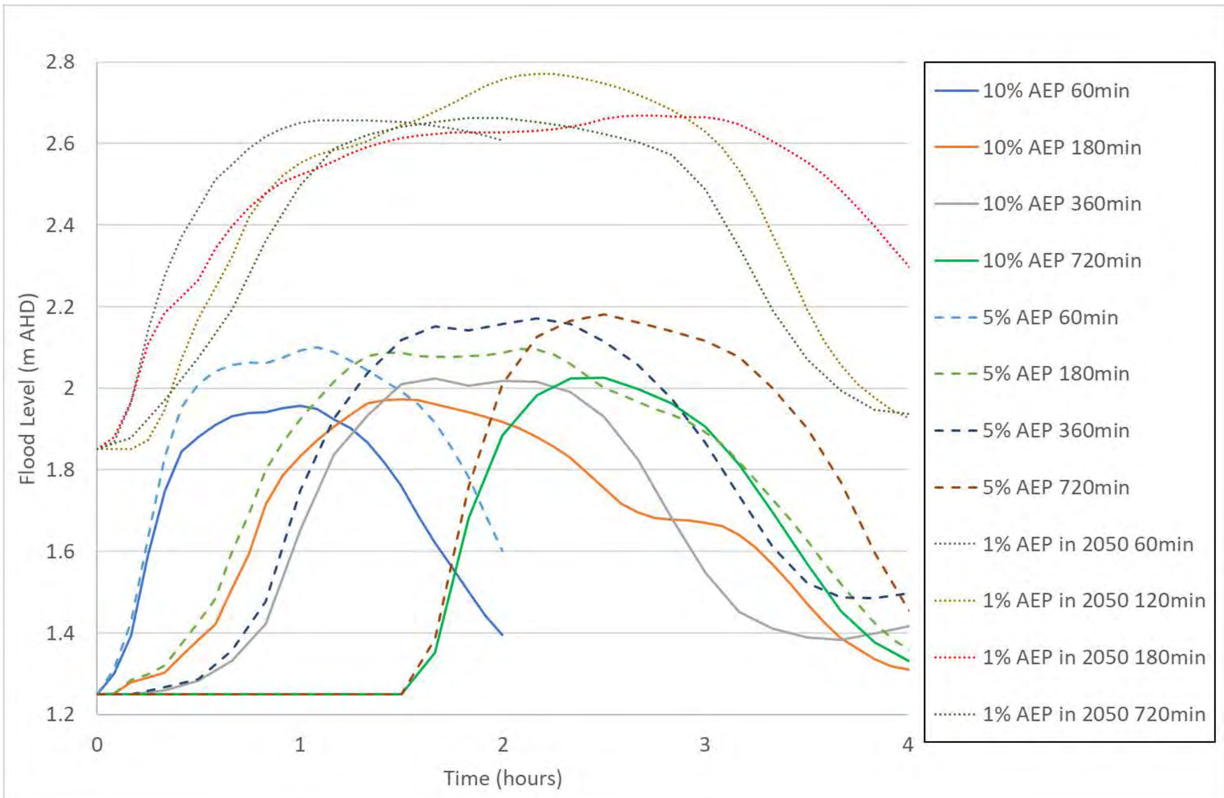

Figure 4-8. Rate of Rise at Location TC_01

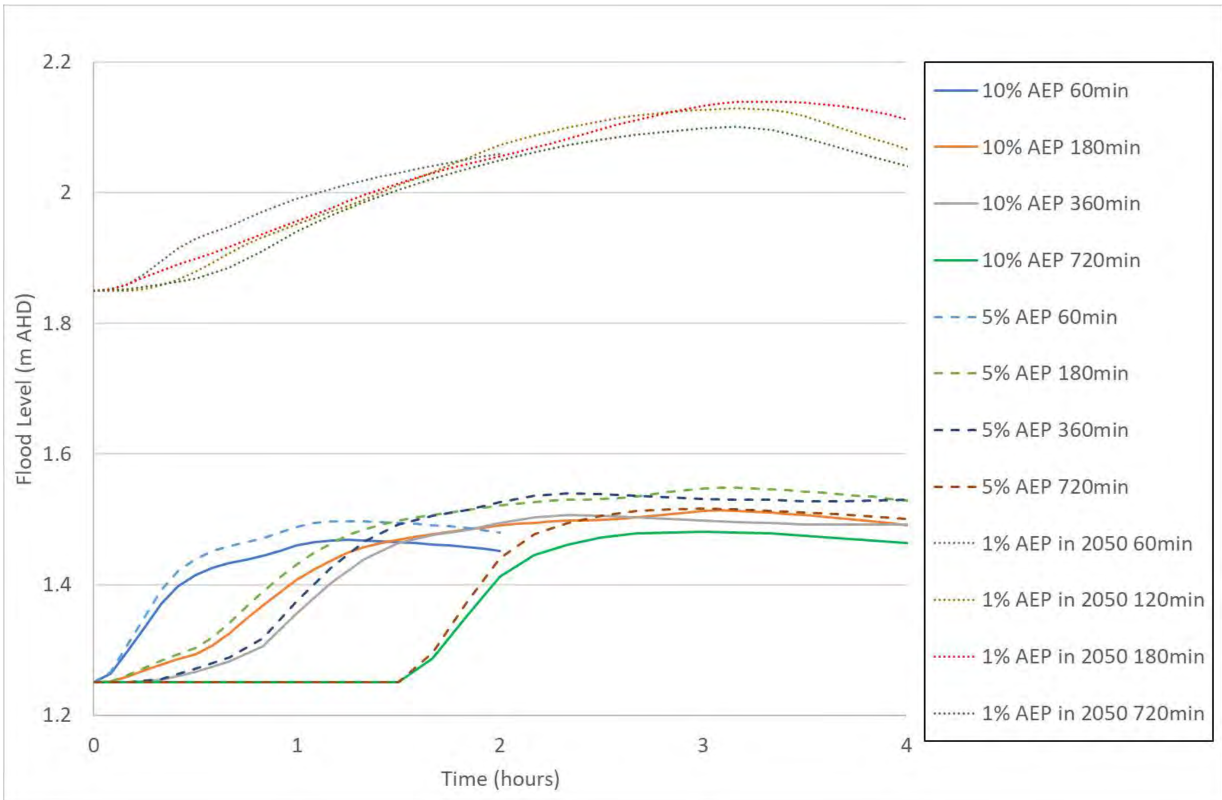

Figure 4-9. Rate of Rise at Location Wck_01

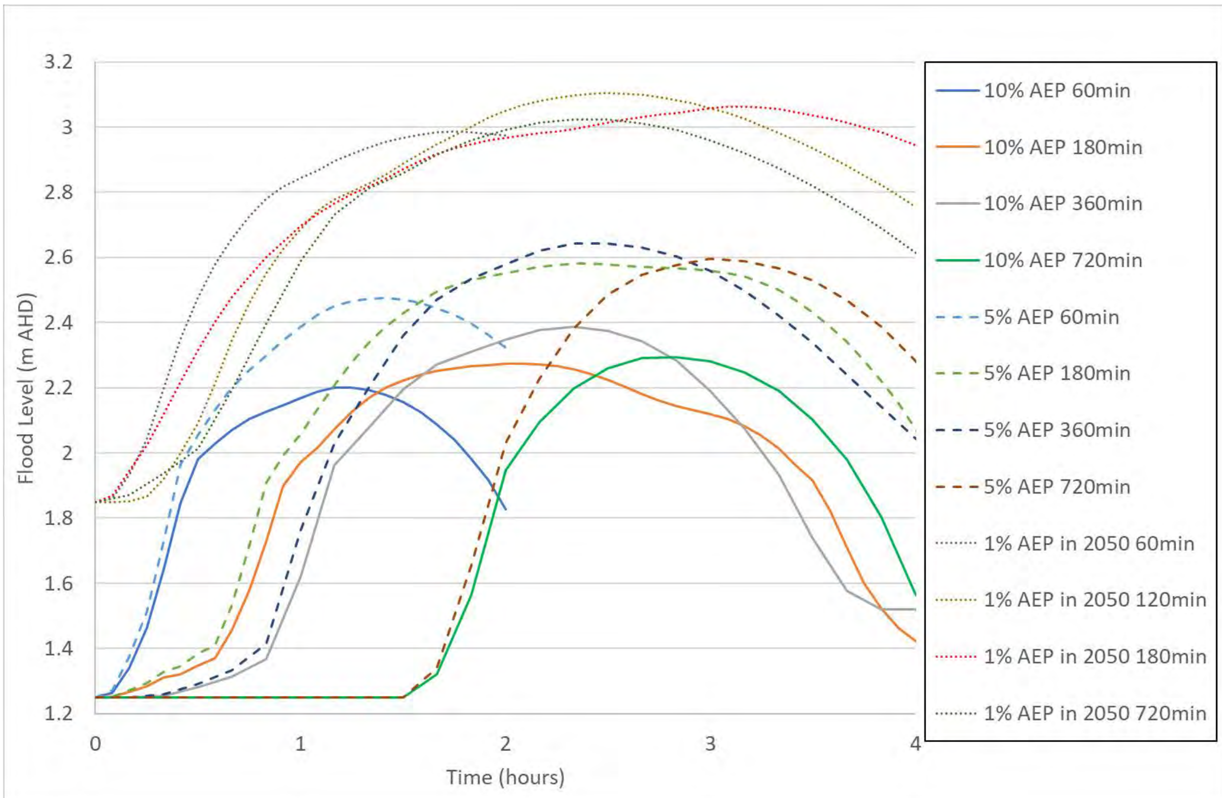

Figure 4-10. Rate of Rise at Location CC_01

4.2 Flood Function

As part of this flood study, multiple criteria were considered for the preliminary definition of flood function across the floodplain. These criteria were scrutinised based on previous experience with urban flooding and understanding of the implications of flood function definition on future development. Options for flood function definition criteria (for only the 1% AEP in 2050, or the DFE) were encroachment tested by removing the flood fringe areas from the model and analysing this impact to floodplain water levels.

The preliminary flood function definition criteria are as follows:

- The 1% AEP in 2050, or DFE:
    - Floodway – Velocity x Depth Product is greater than 0.25 m^2/s;
    - Flood Storage – Velocity x Depth product is less than 0.25 m^2/s and depth is greater than 0.2 m; and
    - Flood Fringe – areas in the flood extent outside of the above criteria.
- The PMF:
    - Floodway – Velocity x Depth Product is greater than 1.0 m^2/s;
    - Flood Storage – Velocity x Depth product is less than 1.0 m^2/s and depth is greater than 1.0 m; and
    - Flood Fringe – areas in the flood extent outside of the above criteria.

5 References

ARR2019 [Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors)], 2019, *Australian Rainfall and Runoff: A Guide to Flood Estimation*, Commonwealth of Australia.

BMT WBM (2008). *Throsby, Cottage and CBD Flood Study*. Prepared for the City of Newcastle, August 2008, Revision 0.

NSW Department of Planning and Environment (2023). *Flood Risk Management Manual, the policy and manual for the management of flood liable land,* ISBN 978-1-923076-17-4, June 2023.