Regional Flood Database:

2022 Major Model Update - Burpengary Creek & Caboolture River

Moreton Bay Regional Council

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1 INTRODUCTION

Moreton Bay Regional Council (MBRC) is committed to continuously upgrading and enhancing its region wide hydrologic and hydraulic flood model library since its development in 2009, as part of the establishment of Council's Regional Flood Database (RFD). The RFD flood model library is capable of seamless interaction with a spatial database to efficiently deliver detailed information about flood behaviour across the MBRC area and for the local community. This report details the outcomes of Stages 4 and 5 of the MBRC RFD for the Caboolture River and Burpengary Creek Catchments. Figure 1-1 presents the location of the Caboolture River and Burpengary Creek Catchments (BCR) in the context of the wider Local Government Area (LGA) boundaries.

The primary objectives of the Stage 4 study are:

- Update of the TUFLOW hydraulic models according to the outcomes of the Stage 1 project utilising the findings of the Stage 3 project.
- Model calibration and validation.
- Develop 'hydraulic-equivalent' hydrology (HEH) model.

The primary objectives of the Stage 5 study are:

- Design event modelling.
- Design event flood surface creation.

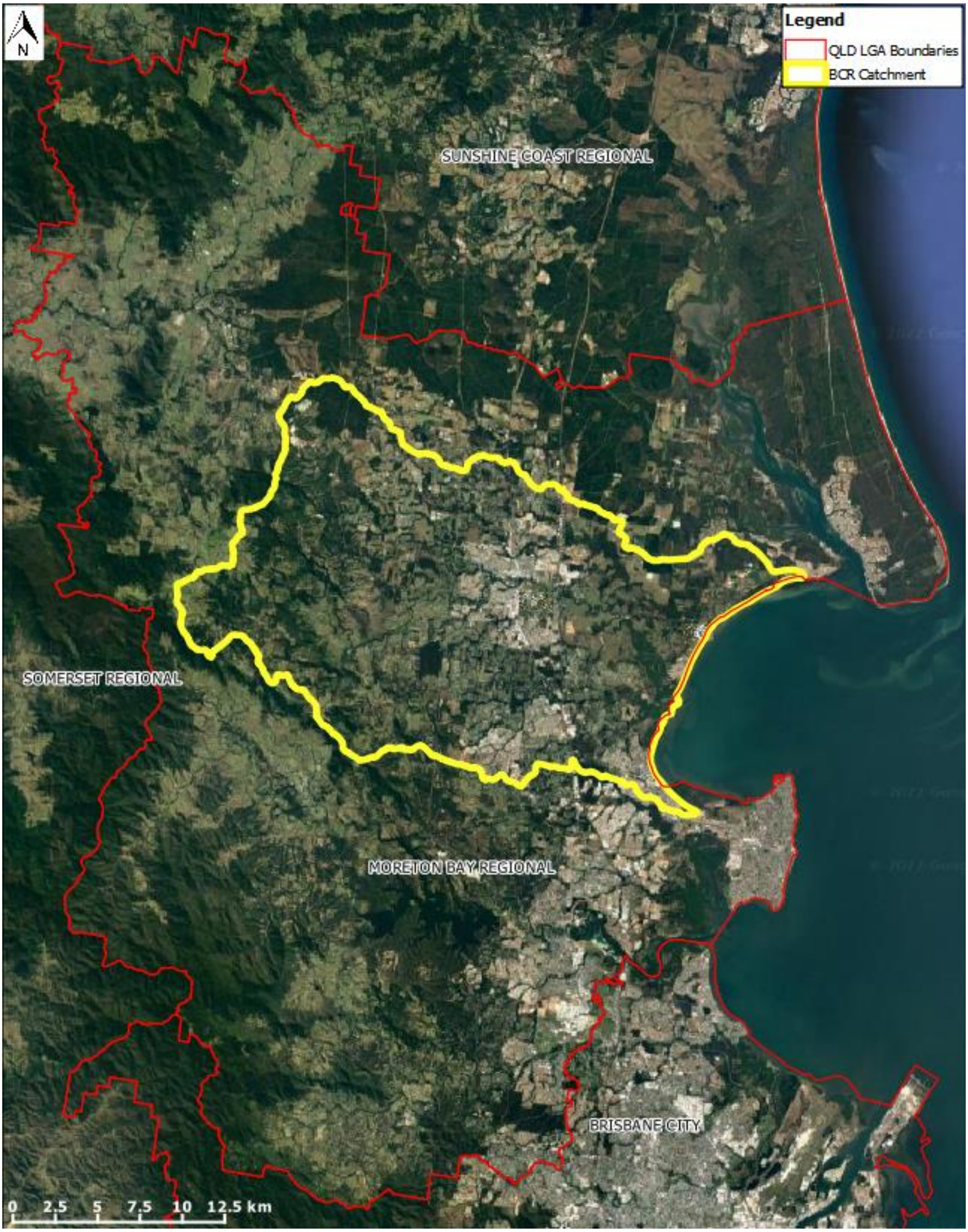


Figure 1-1 Caboolture River and Burpengary Creek Locality

2 BACKGROUND

The methodology behind the RFD is primarily based on the national guideline for flood estimation, Australian Rainfall and Runoff 2019 (ARR 2019). This guideline underwent a major revision in 2016 and then a minor update in 2019. The updated guideline, together with recently collected new survey information (e.g. LiDAR) and recent flood information across the region, provides Council with an opportunity to undertake a major update to the RFD. This major update is being delivered in five stages, with Stages 1, 2 and 3 having been completed already:

- ***Stage 1 - Pilot Study*** - investigated the required/recommended modelling methodology changes for the RFD utilising the ARR 2019 guidelines.
- ***Stage 2 - Hydrography Landuse and Hydrology*** - entailed update of Council's floodplain roughness layers, catchment delineation and hydrology models.
- ***Stage 3 - Hydraulic model configuration investigation*** - was an internal investigation conducted internally by MBRC staff reviewing recently released software computation methods and capabilities to identify the potential application to the RFD hydraulic model setup.

With these three Stages complete, this study represents the subsequent stages 4 and 5 for the Caboolture River and Burpengary Creek Catchments.

2.1 Catchment Description

The Caboolture River and Burpengary Creek catchments comprise approximately 23% of the entire LGA. The catchments were previously represented using separate models (CAB and BUR) and have been combined as part of this update. The downstream floodplain for the Caboolture River and Burpengary Creek is complex and the systems interact depending on the magnitude of flooding.

Western portions of the BCR catchment are primarily rural with isolated areas of rural residential development. The middle reaches of the catchment are dominated by rural residential areas, urbanised neighbourhoods and a substantial amount of area zoned for future development, including the Caboolture West Local Plan area. The mid-lower portions of the catchment are generally urbanised with a high degree of infill development potential. Lower parts of the catchment downstream of the Bruce Highway are a mix of land uses including rural, rural residential, general residential, industry, community facilities, and open space and recreation. Riparian vegetation is generally well-preserved throughout the catchment.

Much of Deception Bay is also included in the model extent and much of it is not directly affected by regional flooding from Burpengary Creek. Similarly, Beachmere and Godwin Beach are contained within the model extent, though Beachmere can be impacted by flooding from the Caboolture River depending on the magnitude of flooding.

3 2022 MAJOR FLOOD MODEL UPDATE DETAILS

3.1 ARR 2019

The previous RFD study had utilised hydrological and hydraulic data based on the guidance from Australian Rainfall and Runoff (ARR) 1987. However, in 2016, along with further updates in 2019, ARR underwent a significant revision, prompting the consideration of a broader range of hydrological variability in design estimates. This included the use of ensembles to run hydrological models, sampling different temporal patterns and other key hydrological parameters.

The ARR 2019 guidelines serve as a comprehensive and widely recognized resource, offering guidelines for estimating design flood characteristics across Australia. By incorporating the updates from ARR 2019 into the flood study, the analysis and assessments align with the most up-to-date understanding of rainfall patterns, hydrological processes, and flood behaviour.

By utilising the guidance provided in ARR 2019, this RFD update ensures it is based on the latest scientific knowledge and best practices in flood estimation. The updated guidelines consider various factors such as climate change projections, improved rainfall analysis techniques, and advancements in hydrological modelling. This incorporation enables a more accurate and robust assessment of flood risk, empowering stakeholders to make informed decisions pertaining to land-use planning, infrastructure design, and emergency management.

A key change introduced in ARR 2019 is the increased use of ensembles of design storms, specifically incorporating 10 temporal patterns per duration, with up to 100 storms per Annual Exceedance Probability (AEP). There is also a heightened sensitivity to Areal Reduction Factors (ARF) to account for spatial variation in rainfall. Given the time-intensive nature of simulating all storms and considering hydrologic variability within the hydraulic model, RFD Stage 1 guidance placed greater reliance on the hydrological models to identify critical storms.

For the selection of final flood surfaces, the hydrological models need to exhibit hydraulic equivalence, ensuring similarity between the hydrologic and hydraulic models. The TUFLOW model has been used to inform the hydrologic model storage and routing parameters giving a hydraulic equivalent hydrologic (HEH) model. The HEH model gives the ability to analyse ARR 2019 hydrologic variability at specific points of interest across the catchment without the need for a significant number of time-consuming hydraulic simulations. The following sections outline the relevant updates made to the hydrologic and hydraulic models to incorporate the ARR 2019 guidelines.

All ARR 2019 hydrological modelling was undertaken within the Catchment Simulation Solutions Storm Injector software version 1.3.7.

3.2 Rainfall Intensity-Frequency-Duration (IFD) Update

3.2.1 Intensities

Design flood estimates derived for the Caboolture River and Burpengary Creek Catchments have been based on the design IFD guidance outlined in ARR 2019 in combination with the updated LIMB 2020 high resolution IFD estimates. A sensitivity assessment was undertaken by Water Technology (2022) recommending the high-resolution dataset as it does appear to reduce flood levels significantly and is at a more suitable resolution for application to subcatchments throughout the MBRC region. IFDs were extracted at each subcatchment centroid through the Storminjector custom IFD ingest tool.

3.2.2 AR&R 2019 Datahub

Design rainfall parameters such as temporal patterns, pre-burst values and areal reduction factors were obtained from the ARR 2019 Data Hub (http://data.arr-software.org/). A parameter set near the centroid of the catchment is presented in Table 3-1.

Table 3-1 ARR 2019 DataHub Parameters

Parameter	Value
Longitude	152.9178
Latitude	-27.1000
River Region	North East Coast
River Name	Pine River
ARF parameters	East Coast North
Storm Initial Losses (mm)	18
Storm Continuing Losses (mm/h)	2.9
Temporal Patterns	East Coast North Point

3.3 WBNM Hydrological Model Update

3.3.1 Subcatchment Updates

Catchment delineation and the hydrologic model was provided by MBRC. The provided WBNM and associated GIS files were based on the Stage 2 - Hydrography Landuse and Hydrology Study and were used as the basis for the BCR WBNM. The BCR WBNM contains 1839 individual subcatchments. Figure 3-1 shows the WBNM subcatchment layout.

3.3.2 Impervious Areas

MBRC provided an Effective Impervious Area (EIA) raster dataset for the entire LGA for the purposes of updating percentage impervious values in the hydrologic models for both existing and future conditions. The EIA raster was created based on guides provided in the Stage 1 Report.

MBRC instructed that EIA calculations were not undertaken within the WBNM hydrologic model package or Storm Injector. An average calculation was undertaken on the provided rasters for each subcatchment to determine the EIA fraction to be applied in the WBNM. Both current and ultimate conditions have been modelled. Where the ultimate EIA raster value was lower than the current EIA the current EIA value was adopted in the ultimate scenario.

3.3.3 Parameters

The Caboolture River and Burpengary Creek Catchments WBNM has adopted the following runoff routing parameters.

- Catchment Lag parameter (C) = 1.6
- Impervious surface reduction lag factor = 0.1
- Catchment non-linearity parameter (m) = 0.77

The parameters were informed by the calibration outcomes of neighbouring catchments and they were further validated by simulation of historical events and comparison to debris marks (see Sections 4 and 5).

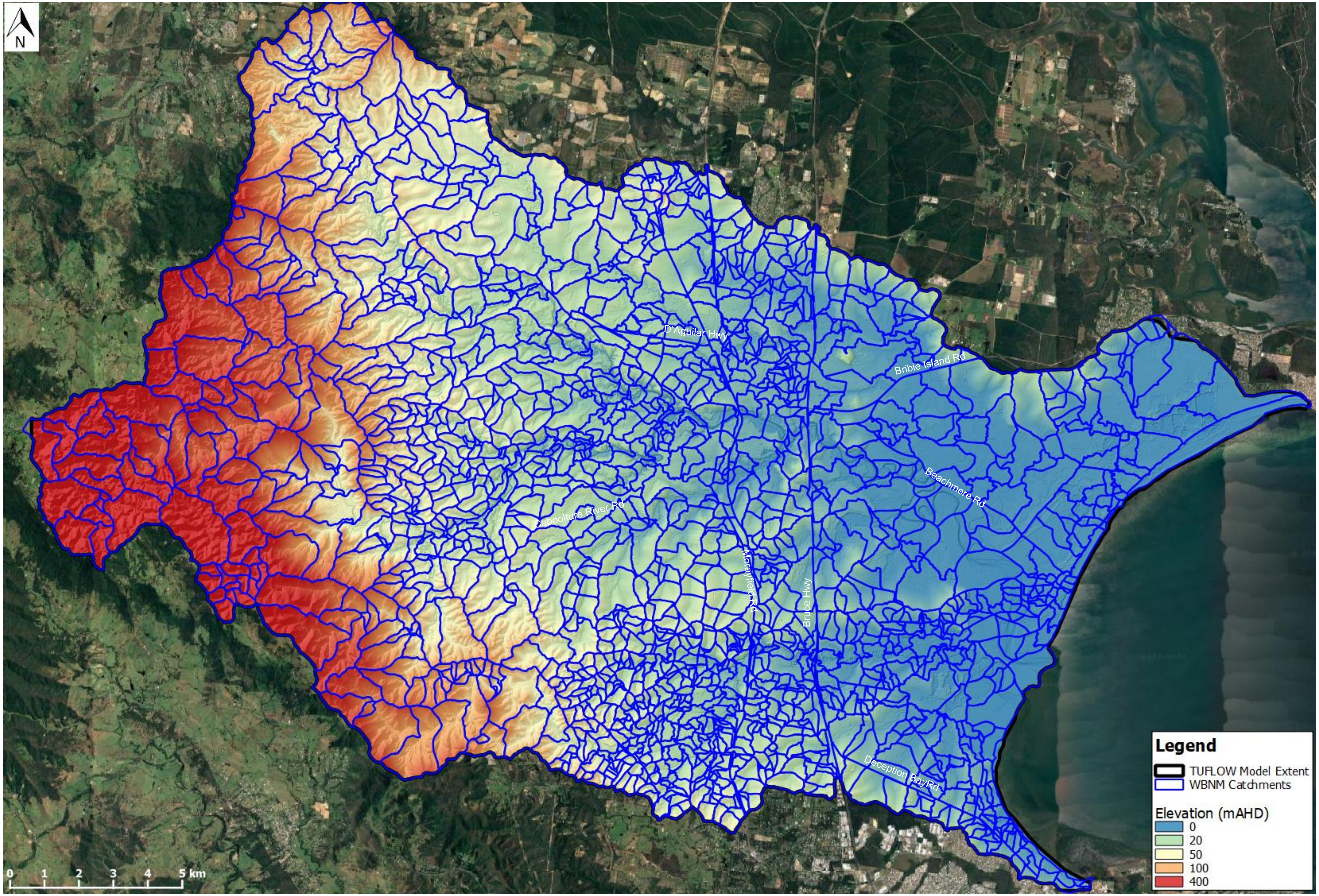


Figure 3-1 BCR WBNM Subcatchments

3.3.4 Areal Reduction Factors

The pilot study recommended that the ARF be calculated at each POI and run the WBNM design event models. It was determined that by grouping POIs into ARF categories it would allow a more practical approach and reduce the number of WBNM simulations. Table 3-2 presents the categories applied to the BCR model. Appendix A provides a table showing each POI and the applicable area and ARF category for the design event modelling.

Table 3-2 ARF Classifications

RFD Naming Convention	# of POIs in class	Area Range (lower to upper bounds)	Applied Area (Storm Injector)	Temporal Pattern Applied
ARFa	6	$0km^2$ to $1.5km^2$	None, ARF = 1	Point
ARFb	30	$1km^2$ to $5km^2$	$2.5km^2$	Point
ARFc	11	$5km^2$ to 15km2	$10km^2$	Point
ARFd	13	$15km^2$ to $35km^2$	$25km^2$	Point
ARFe	12	$35km^2$ to $75km^2$	$50km^2$	Point
ARFf	6	$75km^2$ to $140km^2$	$100km^2$	Areal $100km^2$
ARFg	2	$140km^2$ to $210km^2$	$175km^2$	Areal $200km^2$
ARFh	1	$210km^2$ to $300km^2$	$250km^2$	Areal $200km^2$
ARFi	1	$300km^2$ to $475km^2$	$400km^2$	Areal $500km^2$

3.3.5 Preburst Application

Preburst has been applied by injecting it prior to the storm. Pre-burst rainfall was applied following the methodology in the Stage 1 guidance, with the exception of using the GSDM pattern in lieu of Jordan's pattern. This alteration in temporal pattern was to ensure preburst rainfall was not significantly affecting peak flow. Table 3-3 presents the temporal patterns as applied in Storm Injector software.

Table 3-3 Preburst Temporal Pattern

Temporal Pattern	Duration (min)	Applicable burst durations (min)	Applicable AEPs
GSDM	60	15	20	25	30	45	60	All
GSDM	120	90	120	All
GSDM	240	180	270	360	540	720	1080	1440	1800	2160	All

3.3.6 Future Climate

Simulations of year 2090 future conditions were performed by adopting the RCP8.5 climate change scenario featuring an increase in rainfall intensity of 20%. The future climate modelling also incorporates ultimate landuse data discussed in Section 3.3.2 and consideration of sea level rise as discussed in Section 4.3.3.

3.3.7 Design Event Rainfall Losses

Rainfall losses adopted for the design event modelling are based on the ARR Datahub i.e. 18 mm Initial Loss and 2.9 mm/hr Continuing Loss. This approach is consistent with neighbouring RFD catchments. Refer to the storm injector set up file provided for all other design model settings.

3.4 TUFLOW Hydraulic Model Update

To assess the hydraulic characteristics for the Caboolture River and Burpengary Creek Catchments, a detailed 1D/2D TUFLOW model has been developed by updating the previous hydraulic model (RFD, 2014). The TUFLOW hydraulic model was developed based on the TUFLOW software version 2020-10-AD-iSP-w64 which incorporates the Highly Parallelised Compute (HPC) solution scheme and represented the latest software version release at the time of project commissioning.

WT has undertaken significant updates and improvements to the previous hydraulic model (RFD, 2014) based on the latest available data. The improvements have been guided by Stage 1 and 3 of the RFD process and ongoing discussions with Council. The key improvements to the model are summarised as follows:

- Adoption of TUFLOW build 2020-10-AD for model development and validation.
- Maintained fixed 5m grid with updated 2019 LiDAR.
- Inclusion of new development DEMs after the 2019 LiDAR capture.
- Refinement of roughness layers and adoption of depth-varying roughness to represent flooding more accurately in the catchment.
- Significant updates to the previously adopted 1D network files and inclusion of recently constructed structures.
- Updates of 2D structures.
- Inclusion of more refined inflows and expansion of the hydraulic model extent to capture flooding in more of the catchment.
- HPC has been adopted with simulations using GPU hardware to improve run times.

3.4.1 Model Layout and Extents

The TUFLOW model code boundary covers the entire BCR catchment. The code boundary extent has not been refined from the overall catchment boundary to allow future users to simulate larger events (such as PMF) and cut down the model in other areas of the catchment. The BCR model uses a zero-degree orientation angle which is appropriate given the direction of flow generally occurs from west to east. The model origin changes from the previous model to suit the additional catchment area included in the modelling.

3.4.2 Model Topography

The model base topography is represented using 1.0 m resolution 2019 LiDAR data supplied by MBRC. The LiDAR datasets for the Burpengary Creek and Caboolture River catchments were provided and are read into the model as separate layers. We note that a large number of missing (no data) cells were identified in the Burpengary Creek 2019 LiDAR. To ensure these missing cells did not cause any issues, both 2019 LiDAR datasets were processed to fill in the missing data points with an adjacent value.

The 2019 LiDAR does not represent the coastline; especially the sand banks and mud flats. To ensure that the topography at the downstream boundary is adequately represented, we have clipped out an area of the 2014 LiDAR which does represent the coastline relatively well. These layers are read in subsequent to the base 2019 LiDAR layers to provide an overall good representation of the coastline. Clearly, these coastal features will have naturally shifted and changed since, however, the resulting model DEM ties in well with the more recent data and bathymetric survey.

The following bathymetry datasets are incorporated in the TUFLOW model:

- Caboolture River downstream of Morayfield Road – "DEM_Cab_River_EXG_mAHD_001_trim_clip.flt" (2013).

- Caboolture River upstream of the Caboolture Weir (note that the Wararba Creek Weir is represented in this data, however, z-shapes are used to enforce – "DEM_001_140917_1m_Section_1_2_Hydro_Grid_trim.txt" (2014).
- Caboolture River mouth - "DEM_003_140918_1m_103231 H002 Hydro grid_and_additional_Soundings.txt" (2014).
- Beachmere Lake – "tin_BL_Bathy_2018.dem" (2018).
- Burpengary Creek downstream extent – "203531_Burp_Ck_SB_1m_Grid.asc" (Jan 2022).

The above bathymetry datasets tie in well with the surrounding surfaces. Where bathymetry is not available, gully lines have been used to enforce flow paths. The gully lines from the previous RFD models were combined into a single layer and modified to suit the updated model set up. Where new bathymetry was introduced, gully lines were removed. Many elevation points on gully lines were updated to amend previous errors and tie in with the bathymetry.

Topography modifiers (z-shapes) were used to enforce the Caboolture and Wararba weirs and road crossings which were not included in the LiDAR. Approximately 312 breaklines were digitised to ensure that critical embankments were appropriately represented in the model. These were processed for each 2019 LiDAR dataset using the asc_to_asc utility to automatically generate TUFLOW breakline files.

Several topographic modifiers which were included in the previous RFD models have been removed where they are not necessary or now appropriately represented in the updated LiDAR. Each Z-shape that was retained was reviewed and modified to better represent actual conditions if necessary. For example, the topography modifiers representing the Morayfield Shopping Centre were updated based on site visit observations and measurements.

Approximately 26 DEMs for recent or approved development were provided by MBRC and are included in the model. Where these features exist in the historical events, they have been included using "if" statements in the .tgc file. 26 DEMs for development constructed since the 2019 LiDAR or likely to be completed by the end of 2022 were provided by MBRC. All DEMs were used for the HEH and design event modelling. Elevation models for the King John Creek and Lagoon Creek bridges on the Bruce highway have also been included.

"If" statements have been used to specifically include or exclude model elements (topographic features, stormwater structures and bridges) to, as much as practicable, ensure that catchment conditions are representative for the respective historical event.

The Dale Street levee has been removed for the 2009 and 2011 events by re-introducing a clip of the 2014 LiDAR and removing related culverts.

3.4.3 Floodplain Structures

3.4.3.1 Bridge Structures

A full and detailed review of all bridge structures and associated model parameters and representation has been undertaken. The key alteration from the previous study is that calculation of losses for 2d_lfcsh (layered flow constriction) is set to ***Portion*** compared to the previous ***Cumulate***. On review of the previous adopted values in the 2d_lfcsh layers it was noted the model was overestimating form losses through structures in layer 1 as the applied values had not been divided by the length of the bridge in the flow direction. Furthermore, layer 2 did not have any form loss applied whilst with this update a value of 1.56 has been adopted through the structures deck as advised in the Pilot Study.

In the historical storm simulations, the model includes bridges that existed at the time of the event where this information could be ascertained. We note that substantial construction works were being undertaken on the Bruce Highway during the 2022 event. The calibration simulation includes the Bruce Highway as it appears in the 2019 LiDAR with the old bridges in place (interim works designs were not included in the model).

The final design event simulations include the Bruce Highway upgrade design surfaces and new bridges. Figure 3-2 shows the location of all bridges included in the design event model.

3.4.3.2 Stormwater Pipes and Culverts

MBRC's supplied GIS layer of stormwater and culvert pipes was used for the previous RFD modelling. These stormwater pipes and culverts have been reviewed and updated as part of this study. Numerous erroneous pipe details (adverse grades) and missing pipes have been updated to better reflect current catchment conditions. Where invert data was unavailable, levels were estimated from LiDAR or informed by site visit measurements. DTMR provided data for many culverts in the catchment.

A total of 1422 'Q' type pits are included in the model. All except one are defined using a stage-discharge curve provided by Council (named 'FakeQ' in the inlet_type attribute). To ensure that the pipes downstream of pits convey flow, a flow multiplier of '2' was used. We note that using a higher multiplier can cause very high water levels at surcharging pits and is not recommended.

Figure 3-2 shows the location of all stormwater pipes and culverts included in the updated hydraulic model. Figure 3-3 shows the location of the inflow boundaries in the hydraulic model.

3.4.3.3 Other Structures

Fauna fences within the BCR model were included as layered flow constriction shapes as per the provided GIS files. Guardrails have also been modelled as per the TMR hydrologic and hydraulic guidelines (2019) using layered flow constriction shapes. An assumption of a 340 mm depth to the underside of the W beam and a 360mm depth of cross-member has been assumed without the specific guardrail drawings being available for reference.

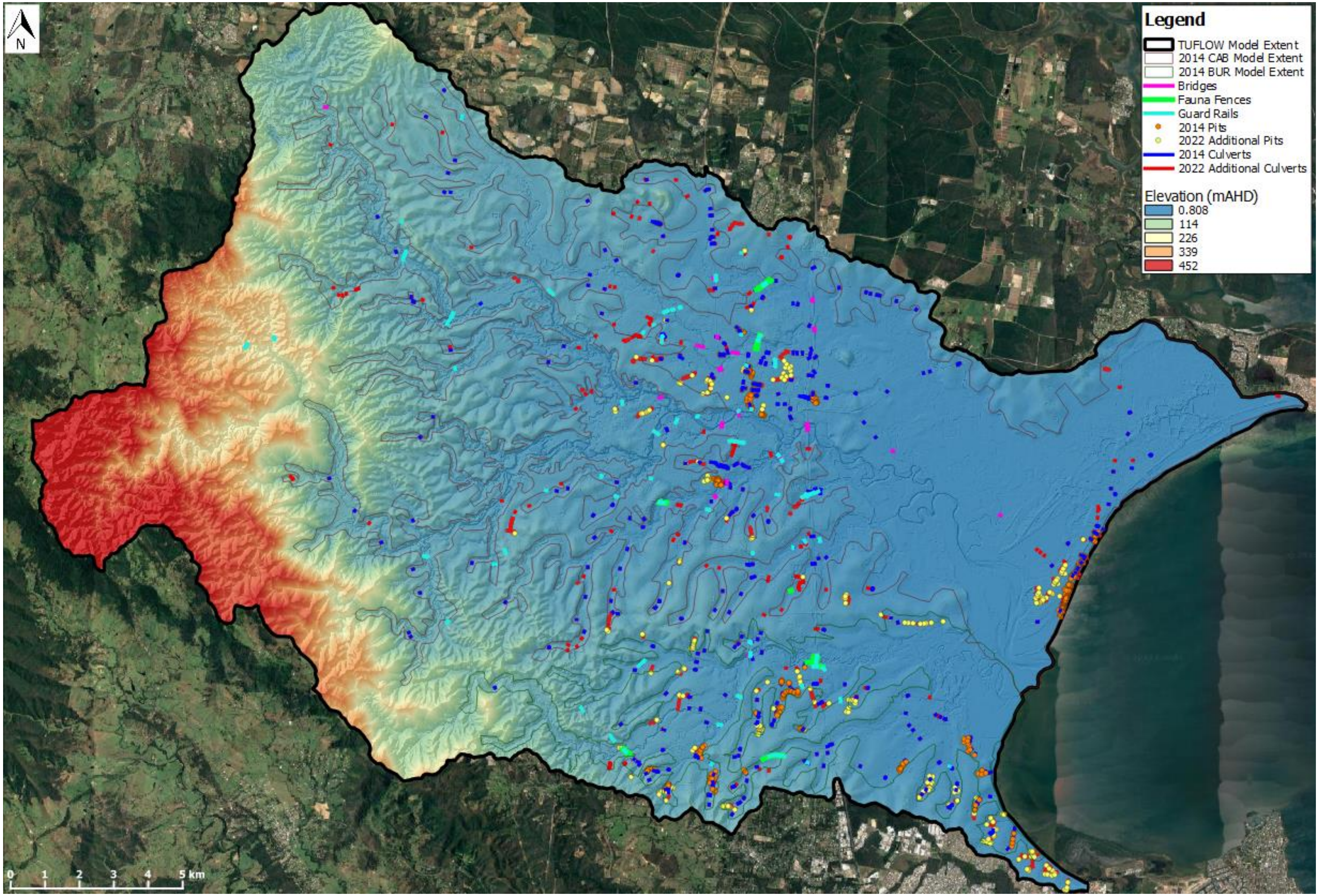


Figure 3-2 Hydraulic Model Extent and Structures

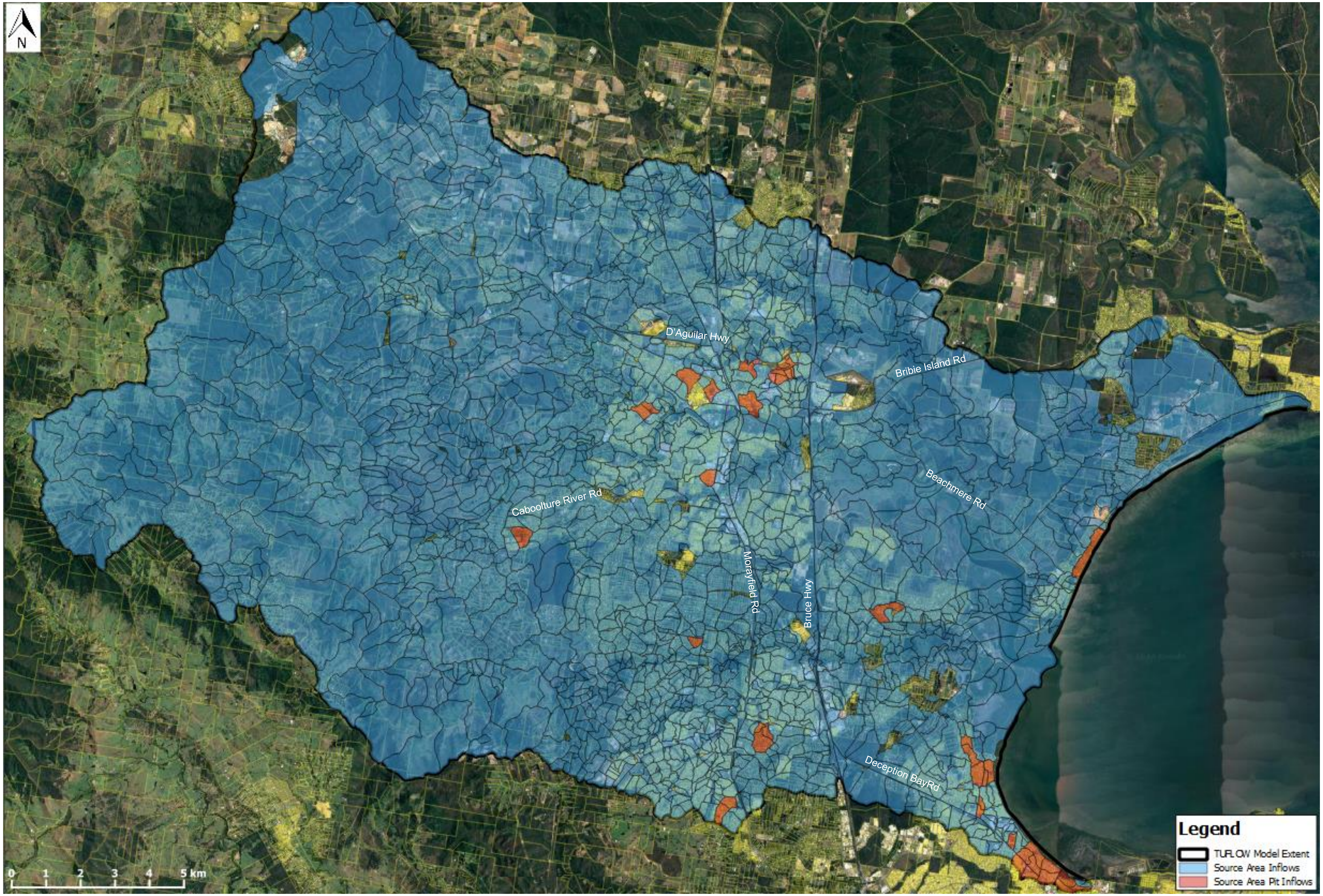


Figure 3-3 Hydraulic Model Inflow Boundaries

3.4.4 Floodplain Roughness

The floodplain roughness spatial delineation rasters and vector GIS files were provided by MBRC (2019) for use in the updated TUFLOW model. The roughness delineation was based on machine learning techniques, as outlined in the Stage 2 Report. The 2019 datasets are raster based and significantly refined compared to the 2014 data (vector datasets). Table 3-1 presents the adopted roughness values for the respective delineated areas and Figure 3-4 shows the adopted depth varying roughness values. These values were determined through the calibration process of several other catchments in the MBRC region and further validated to comparison of debris marks for two historical flood events in this catchment. Figure 3-5 illustrates the spatial variation in roughness applied in the hydraulic model.

Table 3-4 TUFLOW Materials Roughness Values

Material ID	Manning's n	Description
1	Low_Grass_Grazing_004.csv	Open Space (grasses)
2	Low_Dense_Vegetation_004.csv	Low Density Understory - Vegetation
3	Medium_Dense_Vegetation_004.csv	Medium density Understory - Vegetation
4	High_Dense_Class2_Vegetation_001.csv	High density understory - Vegetation
5	0.04	Open Space - Mangroves (Marsh)
6	0.08	Low Density Understory - Mangroves
7	0.10	Medium density Understory - Mangroves
8	0.17	High density understory - Mangroves
9	0.04	Open Space -Crops (Fallow)
10	0.04	Low Density Understory - Crops
11	0.04	Medium density Understory - Crops
12	0.04	High density understory - Crops
13	0.015	Roads
14	0.015	Concrete
15	0.03	Waterbody
16	0.5	Buildings
17	0.5	Horticulture Buildings
18	0.075	Railways
19	0.025	Facilities
20	0.018	CAB River - Wararba Ck to Bruce Hwy

Low Grass Grazing		Low Dense Vegetation	
y (m)	n	y (m)	n
0	0.25	0	0.03
0.025	0.06	1.5	0.03
0.05	0.045	3.5	0.055
0.1	0.035	99	0.055
2	0.025		
99	0.025		

Medium Dense Vegetation		Dense vegetation (class2)	
y (m)	n	y (m)	n
0	0.05	0	0.09
1.5	0.05	1.5	0.09
3.5	0.075	3.5	0.18
99	0.075	99	0.18

Figure 3-4 Depth Varying Manning's Values

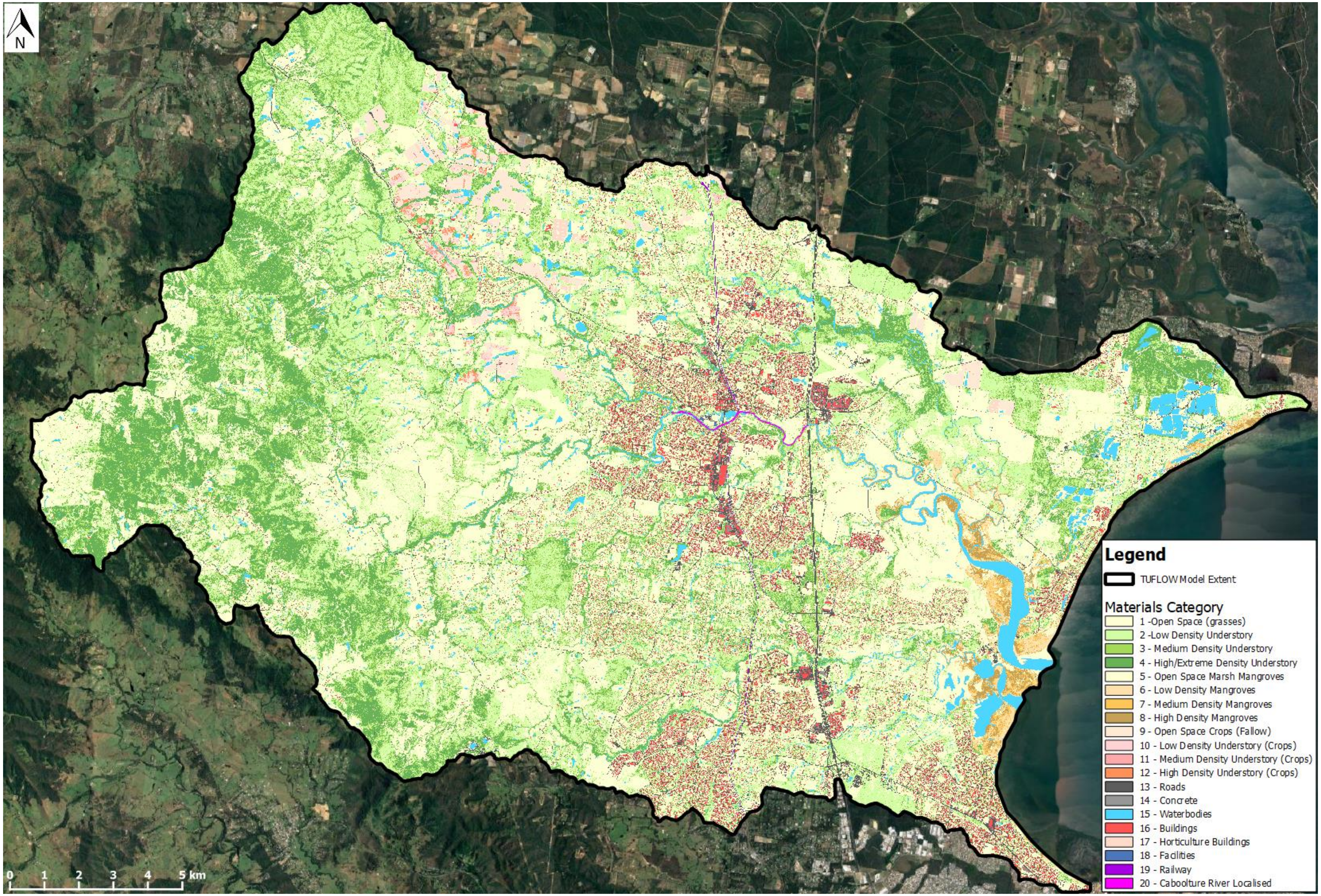


Figure 3-5 Hydraulic Model Roughness Layout

3.4.5 Inflow Boundaries

Model inflows polygons were initially based on the subcatchment breakdown in the provided WBNM from Stage 2. The inflows have been represented in the hydraulic model as a series of local catchment Source Area ("SA") polygon inflow boundaries. The SA polygons are distributed to 1D pit nodes where the trunk drainage is the main flow path through the catchment. For catchments where a clear creek or channel is the main conveyance a standard SA polygon is applied in which flow is initially distributed to the lowest elevation cell and then distributed proportioned by depth thereafter. There are no total inflows applied in the hydraulic model. Therefore, channel routing is undertaken within the hydraulic model.

Initially the subcatchment boundary polygon was applied as the SA boundary although it is acknowledged that there are limitations with this approach in complex urban environments where there can be multiple flowpaths and the trunk drainage can have a different flow direction to the terrain. To address these complexities several subcatchment inflow locations were either split or enforced to localised cells at the outlet. Some SA inflow boundaries were relocated to introduce flow into a channel rather than where it would otherwise represent overland or sheet flow. For the splitting of subcatchments, the flow was proportioned by estimated catchment area weighting. In the scenario where a subcatchment was subject to significant break out flows from an unconnected neighbouring catchment, the outlet cells were enforced as the inflow boundary to ensure the local inflows were not applied at inappropriate locations with the proportional depth distribution method.

4 MODEL METHODOLOGY AND SIMULATIONS

4.1 Calibration and Validation to Historical Events

As part of the historical calibration and validation process undertaken, we have analysed five (5) historical flood events. Stream and rainfall gauge data for the BCR study area was supplied by MBRC. There is generally good coverage of rainfall and stream gauging within the study area, however, the availability of historical data varies substantially between the historical events analysed. The events for which there is considerable data are considered calibration events, and other events for which there is limited data are considered validation events. The historical events analysed include the following:

- 17 – 20 May 2009 (May 2009) – validation.
- 9 – 15 January 2011 (Jan 2011) – validation.
- 21 – 22 February 2015 (Feb 2015) – validation.
- 30 April – 2 May 2015 (May 2015) – calibration.
- 23 – 28 February 2022 (Feb 2022) – calibration.

The following sections provide details of the calibration and validation assessments undertaken for this study.

4.1.1 Rainfall Data Available

MBRC supplied rainfall data at all rain gauge stations surrounding the respective catchments. Figure 4-1 shows the location of the rain gauges for which data was available. Each historical event utilises rainfall data from different gauges depending on data availability and quality. Refer to each individual WBNM calibration model for the gauges used for the respective events.

Rainfall data was extracted for individual events by Council and was provided in CSV format. We note that in the data package provided for the February 2022 event, the Beachmere AL rain gauge was flagged as "*not recording correctly with strong winds. Unreliable readings on 27 February 2022*", therefore, this gauge was disregarded in the calibration modelling.

Rainfall distribution maps for the January 2011, May 2015 and February 2022 events are provided in Appendix B. The maps show the total rainfall for each sub-catchment based on the WBNM output and the location of the gauges used. The May 2015 and January 2011 show a clear and normal rainfall gradient across the catchment. The map for the February 2022 event shows that the rainfall measured by the gauges varies across the catchment with localised areas of higher and lower rainfall compared to the average rainfall over the greater catchment.

We also note that the January 2011 rainfall data provided for the Burpengary (Rowley Rd) AL gauge is not reliable and should be disregarded.

Recorded rainfall data from the rain gauge stations was applied to the WBNM hydrological model. Rainfall is automatically distributed using the standard WBNM approach which assigns rainfall depths to each sub-area based on a weighted average depth calculated using the nearest pluviograph station data. The weights are calculated based on the inverse square of the distance between the pluviography station and the sub-area centroid.

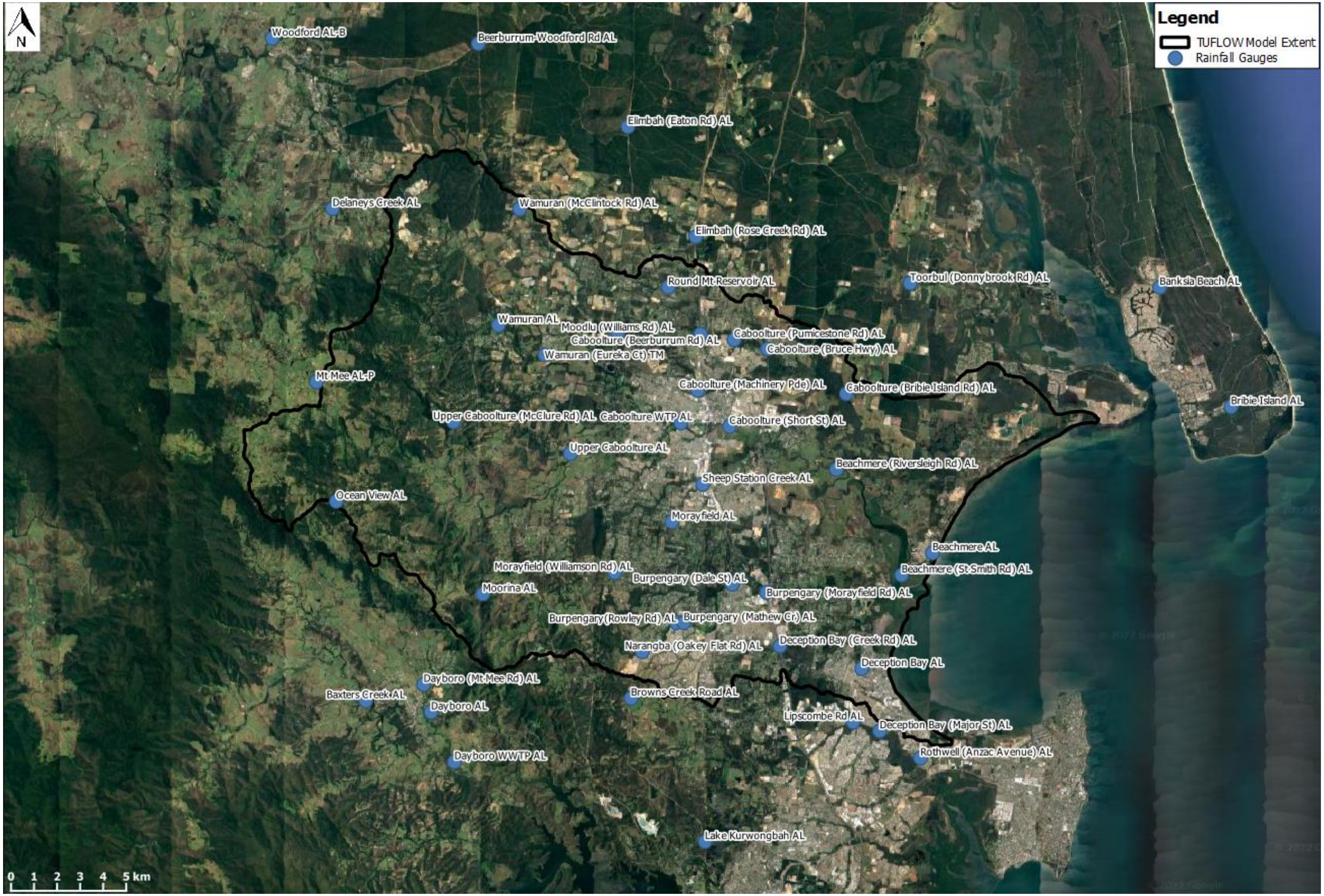


Figure 4-1 Rainfall Gauge Locations

4.1.2 Stream Gauge Data Available

There are 19 stream gauges located within the BCR study area, the details of which are outlined in Table 4-1. The location of the gauges is shown in Figure 4-2. Ticks are included to indicate whether reliable data was available for each historical event. Notes provided with the stream gauge data for February 2022 indicated that the Caboolture (Bribie Island Rd) AL gauge was out of action from 11:15AM 27 Feb 2022. The peak from the Caboolture (Pumicestone Rd) AL gauge was also marked as "suspect".

Table 4-1 Stream Gauges Used for Calibration

Gauge Name	ID	May 2009	Jan 2011	Feb 2015	May 2015	Feb 2022
Beachmere (Riversleigh Rd) AL	540558			✓	✓	✓
Beachmere (St Smith Rd) AL	540740					✓
Beachmere AL	540496			✓	✓	✓
Burpengary (Dale St) AL	540242	✓	✓	✓	✓	✓
Burpengary (Mathew Cr) AL	540619			✓	✓	✓
Burpengary (Rowley Rd) AL	540245	✓	✓	✓	✓	✓
Caboolture (Beerburrum Rd) TM	540773					✓
Caboolture (Bribie Island Rd) AL	540627			✓	✓	✓
Caboolture (Bruce Highway Rd) AL	540624			✓	✓	
Caboolture (MachineryPde) AL	540736					✓
Caboolture (Pumicestone Rd) AL	540561			✓	✓	✓
Caboolture (Short St) AL	540660			✓	✓	✓
Caboolture WTP AL	540243		✓	✓	✓	✓
Deception Bay (Creek Rd) AL	540623					✓
Moodlu (Williams Rd) AL	540557			✓	✓	✓
Narangba (Oakey Flat Rd) AL	540508			✓	✓	✓
Sheep Station Creek AL	540542			✓	✓	✓
Upper Caboolture TM	540208	✓	✓	✓	✓	✓
Wamuran (Eureka Ct) TM	540793					✓
Wamuran AL	540244	✓	✓	✓	✓	✓

Figure 4-2 Steam Gauge Locations

4.1.3 Flood Debris Marks Available

Debris marks left by flood water or other markings, such as painted lines left by residents, are referred to as flood marks and provide an estimate of where peak flood levels extended within the floodplain. Flood marks for four (4) of the historical events based on surveyed levels at each location were provided by Council. These flood marks have been used to validate the peak water levels simulated in the TUFLOW hydraulic model.

It is noted that these levels are subject to uncertainty as debris may get lodged at lower than maximum flood levels, among many other reasons. Hydro-dynamic forces on structures may also result in higher water levels at the structure than in the open floodplain.

Table 4-2 summarises the number of debris marks available for the respective events. It is noted that some debris marks were captured outside of the modelled flood extent and are most likely attributed to model resolution and overland flow rather than the intent of the model which is flooding from creeks and waterways.

Table 4-2 Debris Mark Availability Summary

Event	# of Debris Marks	# of Debris Marks in TUFLOW modelled extent
May 2009	63	45
Jan 2011	160	132
May 2015	129	119
Feb 2022	173	151

4.1.4 Tidal Levels

For the February 2022 event, tidal data for the Scarborough gauge was provided. This time series is shown in Figure 4-3, with the recorded water level at the Beachmere (St Smith Rd) AL stream gauge. The comparison shows that the Scarborough tide gauge data matches well in the lead up to the flood wave occurring and returns to a normal tide level in the aftermath. The tide gauge data was therefore adopted as the downstream boundary for the February 2022 event.

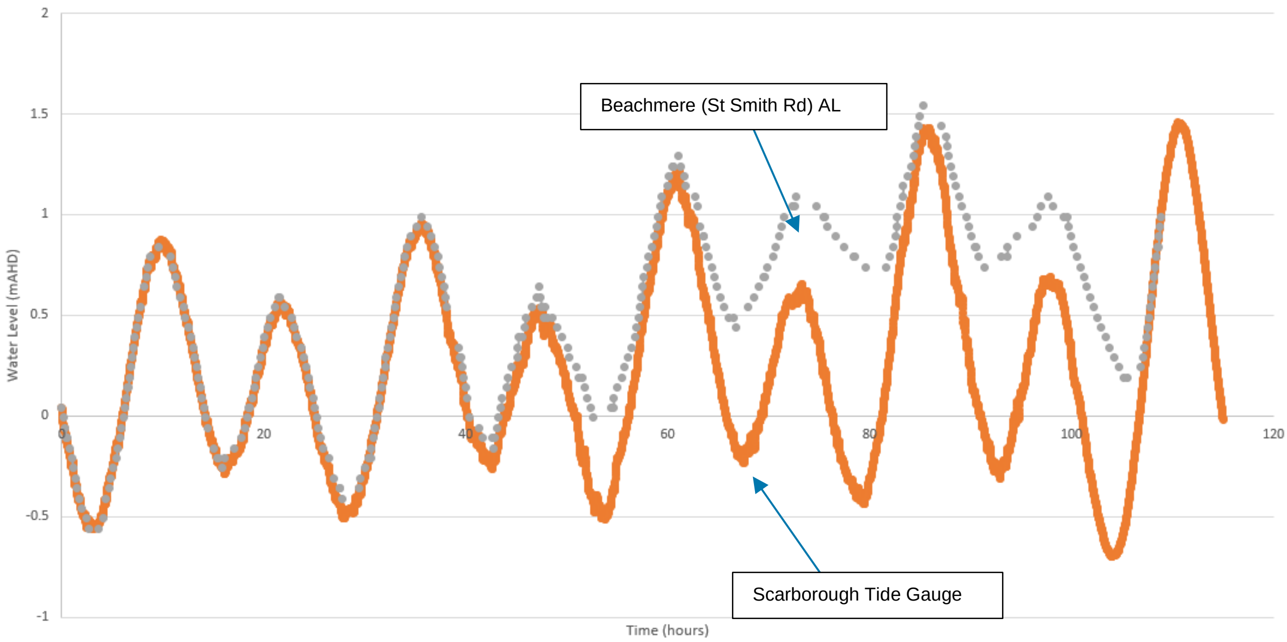


Figure 4-3 Beachmere (St Smith Rd) AL and Approximated Tidal Conditions – Feb 2022

4.1.5 Losses and Catchment Parameters

Table 4-3 presents the adopted Initial and Continuing Loss values for the respective validation events across the study area. A continuing loss value of 2.5 mm/hr was found to produce good hydraulic model calibration results across all historical events and is consistent with other catchments throughout the MBRC region. This value is also consistent with the previous RFD models which provides additional confidence in adopting this value for design event modelling.

Table 4-3 Calibration Events - WBNM Adopted Parameters

Event	Catchment Lag Parameter	Impervious Lag Parameter	Initial Loss (mm)	Continuing Loss (mm/hr)
May 2009	1.6	0.1	5	2.5
Jan 2011	1.6	0.1	0	2.5
Feb 2015	1.6	0.1	10	2.5
May 2015	1.6	0.1	40	2.5
Feb 2022	1.6	0.1	20	2.5

4.1.6 Calibration Start and End Times

Start and end times for each of the calibration events is provided in Table 4-4. These are also noted in the .tef.

Table 4-4 Start and End Times

Event	Start Time (hrs)	End Time (hrs)	Start Real Time	End Real Time
May 2009	0	80	4pm 17.05.2009	12am 21.05.2009
Jan 2011	0	96	12am 9.01.2011	12am 13.01.2011
Feb 2015	0	24	12am 21.02.2015	12am 22.02.2015
May 2015	2	72	12am 30.04.2015	12am 03.05.2015
Feb 2022	0	110	5pm 23.02.2022	7am 28.02.2022

4.1.7 Downstream Boundary

As mentioned previously, the February 2022 event adopts a tidal boundary based on the Scarborough gauge record. This time series is shown in Figure 4-3. To improve the results in downstream areas in other events, an approximate tidal time series for each historical event was derived using a simple sinusoidal function based on stream gauge records (thus removing the flood wave). We note that this simplified approach does not represent the normal behaviour of tides, however, it is appropriate for the validation simulations noting that most of the gauges are not affected by tailwater. Design event modelling utilises static tailwater conditions.

The following gauges were used to generate sinusoidal functions for each event, noting that the February 2022 event utilised the unedited Scarborough Tide Gauge data:

- May 2009 - Deagon AL
- Jan 2011 - Deagon AL
- Nov 2014 - Beachmere (Riversleigh Rd) AL
- Feb 2015 - Beachmere (Riversleigh Rd) AL
- May 2015 - Beachmere (Riversleigh Rd) AL
- Feb 2022 – Scarborough Tide Gauge.

4.2 Hydraulic Equivalent Hydrologic (HEH) Model development

4.2.1 Points of Interest

There are 82 Points of Interest (POIs) across the BCR catchment which have been chosen by Council. The primary reason for selecting these locations is to provide points at which design events will be selected based on the outcomes of the hydrology modelling. The location of the POIs is shown in Figure 4-4. The following outlines the decision-making process applied in selecting these locations:

- POIs have focused on the following locations (in this order of priority):
  - Proximity to key flood evacuation roads.
  - Obtaining a spread of ARFs throughout the catchment – this also involved selecting “typical” Caboolture River and Burpengary Creek Catchments.

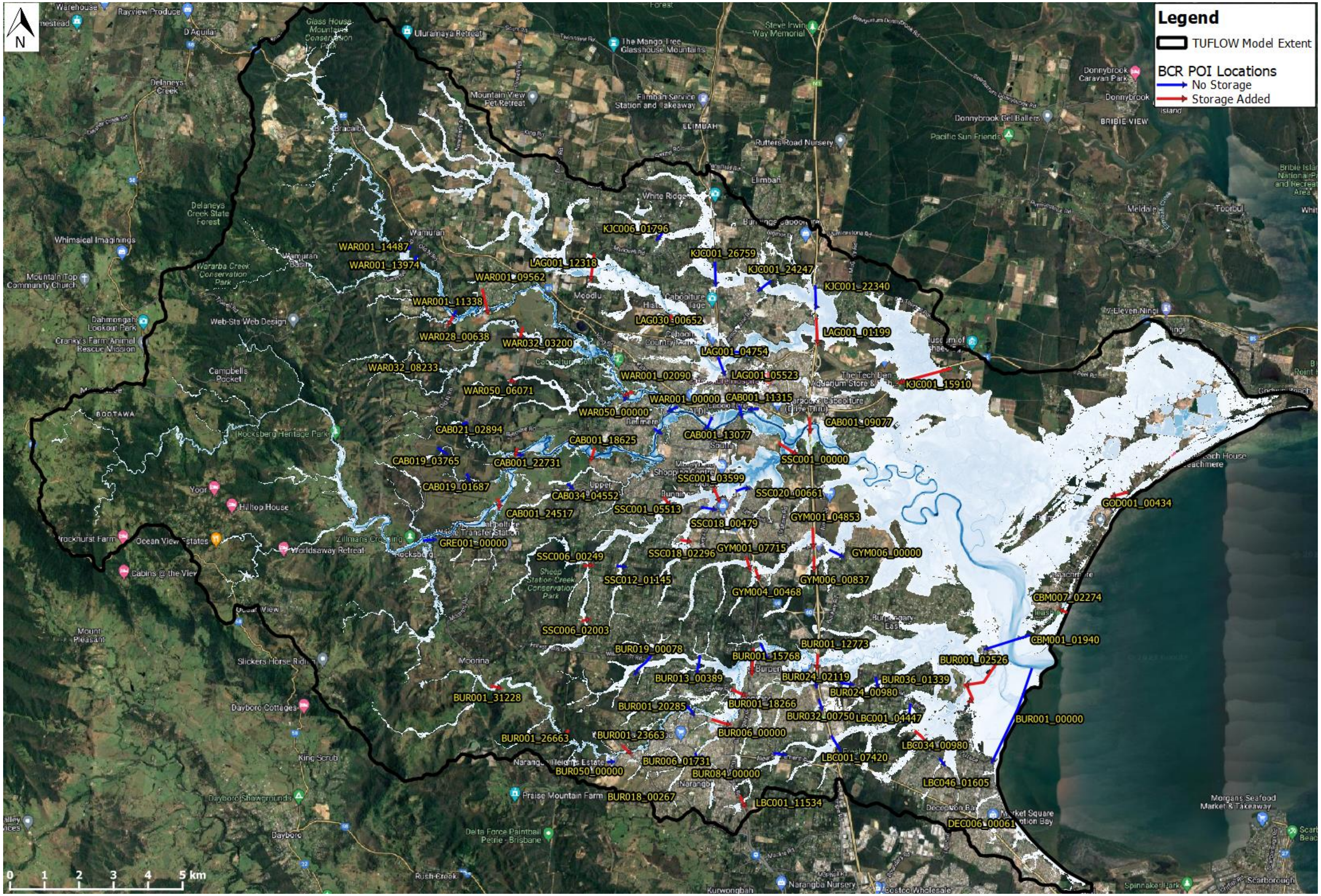


Figure 4-4 BCR Point of Interest Locations

4.2.2 Methodology

The methodology adopted to develop the HEH model for BCR has been based on the technical note provided by BMT titled "Final HEH Modelling Methodology" dated 5 July 2023. A summary of the modelling process undertaken for the BCR catchment is provided below:

- Simulated nine (9) different design flood events – 10%, 1% and 0.05% Annual Exceedance Probability (AEP). For each event, the 120-minute, 360-minute and 720-minute storms were simulated, representing a comprehensive range of design flood events on which to base the HEH analysis. The ARR1987 temporal patterns and IFDs were utilised.
- For each POI a comparison of hydraulic (TUFLOW) and hydrologic (WBNM) models was undertaken. The criteria to determine a successful match of the models was:
  - Peak flows within 10%.
  - Timing of the peak flow within 15 minutes of each other.
  - The Nash Sutcliffe Efficiency (NSE) score was also output for information purposes.
- The initial approach to achieve joint calibration at the POI was to alter the stream routing parameters within the WBNM.
- For locations where stream routing alterations alone were unable to achieve a hydrograph match and the hydraulic model suggested there was significant upstream storage within the catchment, artificial storage was added to the WBNM. Artificial storage was added through Storage – Discharge (SQ) curves generated by comparing WBNM "inflows" and TUFLOW "outflows" for each event as outlined in the technical note. A general shape of the SQ curves was taken from the nine (9) events modelled and applied in the WBNM at the relevant location.
- The HEH WBNM was refined by first investigating routing parameters on all tributaries, starting with the most upstream POI. Once appropriate routing values were derived for each tributary, the analysis moved downstream to the next POI, and if a match could not be achieved to subsequent POIs, a storage curve was then applied. We note that tributary arms were assigned a slightly different routing value so that iterations could be undertaken quickly using find and replace (ie., some tributaries adopt a value of 0.73 instead of a rounder number). This should not be mistaken for additional accuracy, and was only intended for optimising the analysis.
- Good matches between the TUFLOW and WBNM results are harder to attain as the analysis progressed downstream due to the timing of tributaries, natural storages and other complexities in the catchment which cannot be represented in a 1D model.
- Storages were added to 37 (out of 82) POI locations. The location of the POIs where storage was added are shown in Figure 4-4. The number of storages required is representative of the large number of storages in the catchment, including natural in-channel storages, storage upstream of road embankments and storage in regional detention basins or lakes.

4.3 TUFLOW Hydraulic Model

4.3.1 Model Setup

The model topography, roughness and other parameters used for the HEH simulations and design event modelling are consistent with the setup described previously in Section 3.4. The HEH and design event simulations also included approved development DEMs and culverts which were not included in the historical event simulations. A TUFLOW model containing only design event features has been used for the final design simulations analysis. The design event model is "BCR_R_003a_~s1~_~e1~_~e2~_~e3~_~e4~_03.tcf, where:

- s1 – Existing or future scenarios
  - E00 = Existing climate and land use with zero blockage applied to culverts and bridges.
  - E02 = Existing climate and land use with design blockage applied to culverts and bridges.
  - F00 = Future climate (20% increase in rainfall), +0.8m tailwater level, future land use based on planning layers with zero blockage applied to culverts and bridges.
  - F02 = Future climate (20% increase in rainfall), +0.8m tailwater level, future land use based on planning layers with design blockage applied to culverts and bridges.
- e1 – Annual Exceedance Probability of the event expressed in years.
- e2 – Duration of the event expressed in minutes.
- e3 – Temporal Pattern (TP01 to TP10)
- e4 – Areal Reduction Factor bin (ARFa to ARFj).

We note that the BCR_R_003a_~s1~_~e1~_~e2~_~e3~_~e4~_02.tcf model was used for the final calibration and validation simulations.

4.3.2 Existing Climate Simulations

The 20%, 10%, 5%, 2%, 1%, 0.1% and 0.05% AEP design events have been simulated in the TUFLOW model for both unblocked (E00) and blocked (E02) scenarios. An enveloped grid surface (E03) was created for both the blocked/unblocked scenarios.

4.3.3 Future Climate Simulations

5%, 2%, 1%, 0.1% and 0.05% AEP design events were simulated with future climate conditions including increased rainfall intensity (20%), ultimate landuse and increased tailwater levels (+0.8m). This represents the RCP8.5 projection to 2090. The same storms selected for the current climate were modelled for future climate scenarios. An enveloped grid surface (F03) was created for both the blocked/unblocked scenarios.

4.3.4 Design Event Structure Blockage

The Stage 1 project developed a methodology for calculating blockage for bridge culvert structures in alignment with ARR 2019 guidance. Blockages are to be represented for the three different AEP ranges (less than 5% AEP, greater than 0.5% AEP, and in-between these two events) using different 1D network and layered flow constriction files. Within each 1D network file for the ARR 2019 blockage case, each culvert has either a pBlockage (for reduced area method or inlet control culverts) or an increased inlet loss (for modified energy loss method approach). Bridge layered flow constriction files have inlet blockage modelled within L1 pBlock. Table 7-2 presents the representative blockage values where an L10 of 4 metres was adopted for the urbanised Caboolture River and Burpengary Creek Catchments as per Stage 1 guidance. The values considered both inlet blockage and barrel blockage from sedimentation.

Table 4-5 Blockage Configuration

ARI	$W < L_{10}$	$L_{10} \leq W \leq 3^*L_{10}$	$W > 3^*L_{10}$
50% to 10%	25%	0%	0%
5% to 0.5%	50%	15%	0
0.2% to PMF	100%	25%	10%

4.3.5 Adopted Design Tailwater Conditions

A static tailwater of 0.82 mAHD was applied to current climate design event modelling. An increase of 0.8 metres was applied to future climate modelling.

5 MODEL RESULTS AND OUTCOMES

5.1 TUFLOW Hydraulic Model Calibration Results

Stream gauge and TUFLOW hydrograph plots for each historical event are provided in the appendices. Suitable recorded data was available for the specific gauges summarised previously in Table 4-1. A summary of the results of each calibration is provided below.

A detailed analysis has been undertaken comparing surveyed flood marks provided for the May 2009, January 2011, May 2015 and February 2022 events, with the simulated maximum water levels. A summary of the available flood marks has been provided previously in Table 4-2. Maps showing the difference between the simulated maximum water levels and surveyed marks for each event are provided in Appendix C. Histogram plots showing the distribution of the differences are also provided in Appendix C.

5.1.1 May 2009

Recorded stream gauge data was available for four (4) locations. Plots are provided in Appendix D. The simulated water levels at Burpengary (Dale St) AL do not match well with the recorded data, however, the timing of the peak is acceptable. The flood timing is also excellent at the Burpengary (Rowley Rd) AL gauge. Similarly, the modelled hydrographs show excellent timing with the recorded data at the Wamuran AL and Upper Caboolture AL gauges. Adjusting losses may result in slightly improved results, however, the modelled peaks for three (3) of the gauges are lower than the recorded peak, and higher on the Wamuran AL. The discrepancy in simulated flood levels can be attributed to the relative sparsity of rainfall data when compared to more recent events.

In respect to the flood mark analysis, the histogram and mapping provided in Appendix D demonstrate that a large proportion of the simulated water levels are within 200mm of the surveyed marks. The survey mark comparison map does not show any clear pattern.

Overall, the calibration results provide confidence in the hydraulic model parameters, particularly the adopted roughness values. Simulated water levels at the gauge locations are consistent with the previous RFD study (BMT 2012).

5.1.2 January 2011

Recorded stream gauge data was available for four (4) locations. Plots are provided in Appendix E. A reasonable match has been achieved for these gauges and the results are consistent with the RFD 2014 Model Maintenance for Burpengary Creek (Aurecon 2014) and RFD 2014 Model Maintenance for Caboolture River (BMT 2014). The discrepancies are likely due to the rainfall data. We note that removing the Dale Street levee from the model produced significantly improved results at this gauge location.

In respect to the flood mark analysis, the histogram and mapping provided in Appendix E demonstrate that a large proportion of the simulated water levels are within 200mm of the surveyed marks. The mapping shows that simulated levels in the Burpengary Creek catchment are generally within 200mm, with a localised area upstream of the Bruce Highway being between 200mm and 400mm low. There are areas of localised differences exceeding 400mm in the greater BRC catchment. The mapping does not show any other obvious patterns.

5.1.3 February 2015

Recorded stream gauge data was available for 15 locations. Plots are provided in Appendix F. Results of the calibration are mixed, though generally the results do not adequately match gauge records. This is partially due to the absence of a tidal tailwater (for gauges influenced by the tidal boundary). Other discrepancies can be attributed to the quality of the recorded rain and stream gauge data.

5.1.4 May 2015

Recorded stream gauge data was available for 15 locations. Plots are provided in Appendix G. Generally, the model is representing the timing and shape of the hydrographs well, however, water levels are being overpredicted at most locations. For example, the simulated peak water level at the Narangba (Oakey Flat Rd) AL gauge is over 1m higher than the recorded maximum. Initial test simulations adopting the previous RFD roughness values produced better results at this location, however, a good match has been achieved for the February 2022 event using the preferred new roughness parameters. It is possible that vegetation conditions were different between the two events, and we see no reason to make additional changes to the materials layers or parameters for the design events.

The modelled water levels at gauges in the upper catchment such as Wamuran and Upper Caboolture are also up to 1.5m too high. This may be due to localised drier areas of the upper catchment where a higher initial loss would be more appropriate. Decent matches have been achieved at several other gauges including the downstream Beachmere (Riversleigh Rd) gauge. Other gauges for which a match could not be achieved appear to be unreliable (such as Caboolture WTP AL).

In respect to the flood mark analysis, the histogram and mapping provided in Appendix G demonstrate that a large proportion of the simulated water levels are within 200mm of the surveyed marks. A significant number of simulated levels are over 500mm higher than the surveyed mark and the mapping shows that these tend to be located on Lagoon Creek and around the Caboolture and Morayfield area. King John Creek, Burpengary Creek and the lower parts of the Caboolture River show good correlation with the surveyed marks.

5.1.5 February 2022

The February 2022 event provided by far the most abundant and reliable dataset on which to base the calibration. As such, substantially more weight can be given to the results of this calibration event than any others.

Plots are provided in Appendix H for 19 stream gauges. The TUFLOW model is producing good calibration results at all gauges for which reliable data is available. The shape of the hydrographs and timing of the multiple peaks match well, with few exceptions. The following notable issues have been identified and investigated as part of the calibration:

- The simulated water levels at the Caboolture WTP and Caboolture (Short St) gauges are approximately 0.05m and 0.21m higher respectively than the recorded levels. Water levels are also approximately 0.11m higher at the Sheep Station Creek gauge. WT ran several sensitivity simulations to identify if a better match could be achieved. The following parameters were tested:
  - The roughness of the ‘uncategorised’ materials layer (assumed to be dense vegetation) was changed to be low density. This made no appreciable impact.
  - Adopting High Dense Class1 Vegetation versus High Dense Class2 Vegetation made little appreciable difference.
  - Waterway roughness was lowered locally (from the WTP to Bruce Hwy) to n=0.018. This lowered the maximum water level by approximately 40mm. This made the most difference of all the changes tested. The locally lower waterway roughness will be adopted for the design simulations.
  - The bathymetry downstream of the Caboolture Weir and upstream of the Bruce Hwy was lowered by approximately 1m. This made no appreciable difference to maximum water levels.
- The simulated water levels at the Deception Bay (Creek Rd) AL gauge track nicely in terms of timing, however, the peak is much lower than the gauge record (approximately 0.5m). Council suspects that the peak may be erroneous and that road works occurring immediately upstream may have impacted the recording. The discrepancy occurs when the upstream road is overtopped, therefore, conditions downstream and at the gauge would have been very turbulent. The recorded water level may be

associated with localised rough conditions or super-elevations; dynamics which TUFLOW cannot reproduce.

- Simulated water levels at the Caboolture (Beerburrum Rd) gauge (TMR installed) do not match well, however, the recording may be suspect. Simulated water levels may be sensitive to structure representation in the model, however, we see no reason to suspect water levels downstream are too low. Changes to the adopted dense roughness settings made little difference. Matches to upstream flood marks are acceptable.
- In respect to the Wamuran AL and Wamuran (Eureka Ct) AL gauges, simulated water levels track very well with the recordings, however, the peaks are slightly high. The waterway roughness layer was extended upstream past the Wamuran (Eureka Ct) AL gauge, and this improved results. The High Dense Class2 Vegetation category provided the best match.
- In respect to the flood mark analysis, the histogram and mapping provided in Appendix H demonstrate that a large proportion of the simulated water levels are within 200mm of the surveyed marks. Figure 5-1 shows the maximum flood depth and debris mark comparisons for the February 2022 event. A significant number of simulated levels are over 500mm higher than the surveyed mark. According to the comparison map, these tend to be concentrated in the upper Wararba Creek and Caboolture River catchments, and the Caboolture River between Wararba Creek and the Bruce Highway. Burpengary Creek, King John Creek, Sheep Station Creek and Lagoon Creek all contain some points where the surveyed mark is exceeded by 400mm. Areas of Little Burpengary Creek are generally lower than the surveyed level which can be attributed to the rain gauge data. Overall, the analysis shows a decent match to the flood marks.

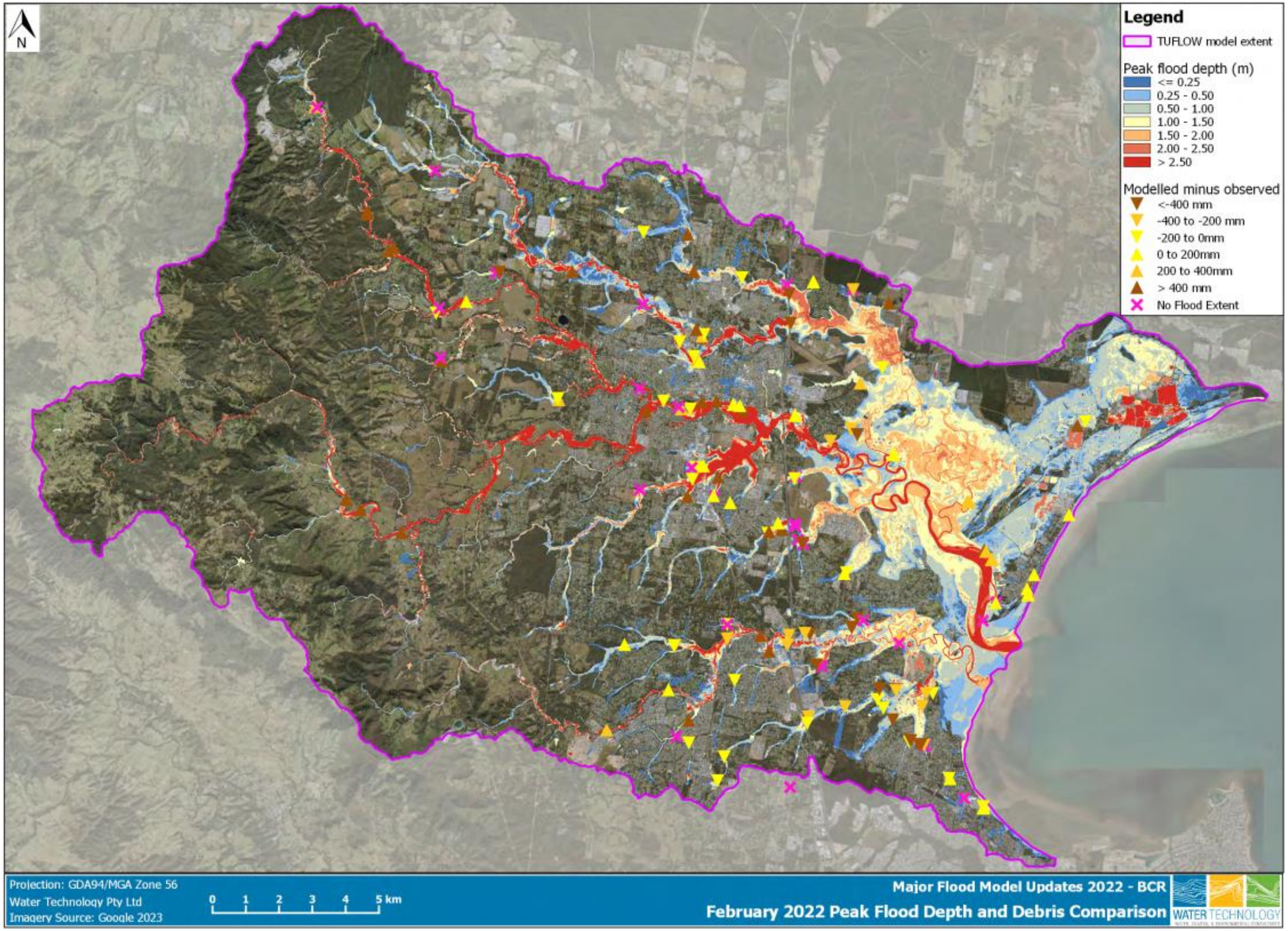


Figure 5-1 February 2022 Peak Flood Depth and Debris Comparison

5.2 WBNM Hydraulic Equivalent Hydrologic Model Performance

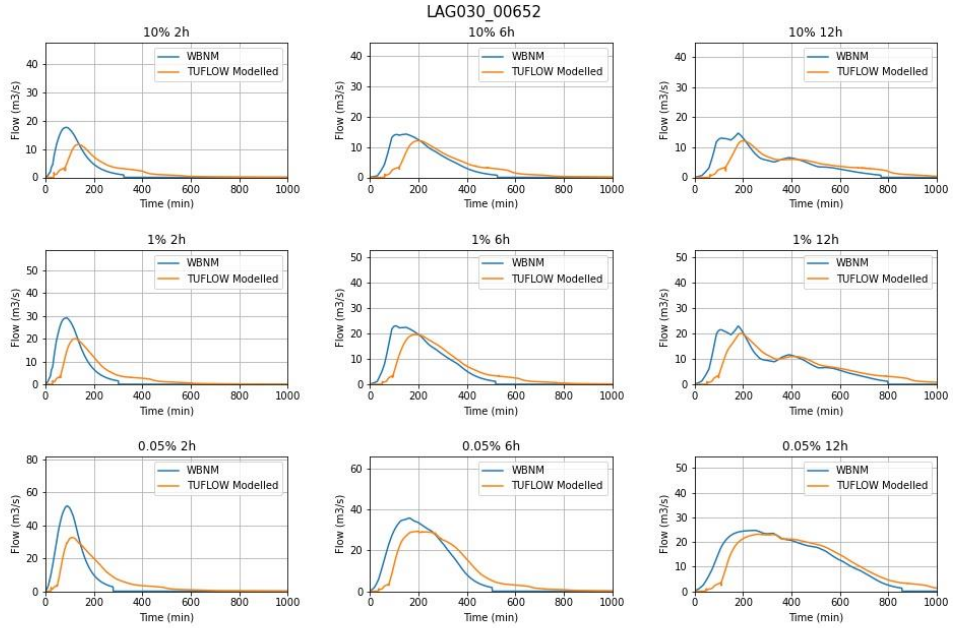
Appendix I provides a tabular description of the results and plots/statistic tables for each simulated event/duration at each POI. The HEH modelling was undertaken to enable selection of design event storms using the hydrology model through alteration of stream routing parameters and the addition of artificial storage curves.

Overall, an excellent match has been achieved to most POIs. Based on the target criteria of being within 10% of the peak flow and 15 minutes of the peak timing, 9 of the 82 POIs achieve this for all 9 simulated events. The criteria is extremely ambitious given the limitations of the hydrology model. 49 of the 82 POIs are within 10% of the hydraulic model peak for 7 to 9 out of 9 events.

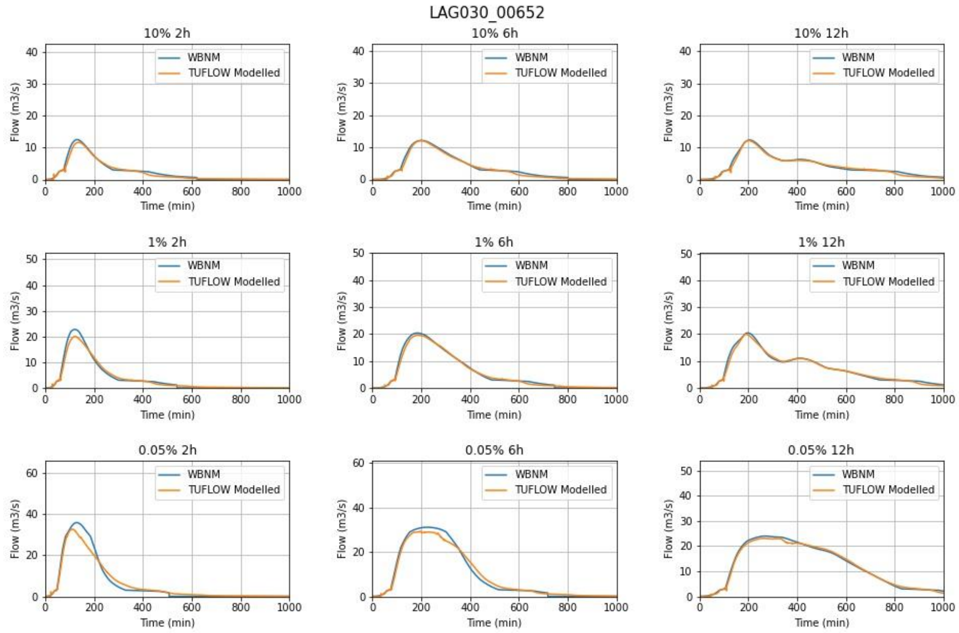
The main exceptions are points at the very downstream end of the Caboolture River (CBM001_01940) and Burpengary Creek (BUR001_00000) due to the effect of the downstream boundary, and Beachmere (GOD001_00434) where the floodplain upstream is complex and not well represented in the WBNM. It is not always possible to achieve good matches across all three AEP events. In these instances, preference was given to achieving a good match to the 1% AEP. Nash-Sutcliffe Efficiency (NSE) values have been calculated at each POI based on the first 1200 timesteps. Most comparison of hydrographs have NSE values over 0.9 with the shape and peaks being replicated well.

An example plot at POI LAG030_00652 is provided in Figure 5-2 which show the results of the HEH modelling at a selected POI with and without artificial storage added. Note that the peaks, timing and NSE value for all improve with storage added.

Several POI locations are affected substantially by backwater flooding (for example “WAR050_00000” and “SSC001_00000”). Others are only affected by backwater in the 0.05% (for example “SSC001_03599” and “CAB001_11315”). Location “SSC001_00000” is situated at the confluence with Sheep Station Creek and the Caboolture River and is heavily influenced by backwater as shown in Figure 5-3. The graphs should be interpreted in context. The rising limb matches very well and departs when backwater affects the location. The WBNM is not capable of representing back flow, though the storage provided by the backwater in Sheep Station Creek is represented at the next downstream POI (“CAB001_09077”). In the absence of the backwater conditions, the WBNM is likely to provide an accurate representation of flooding at this POI. NSE values for POIs affected by backwater are poor but in context have little meaning.

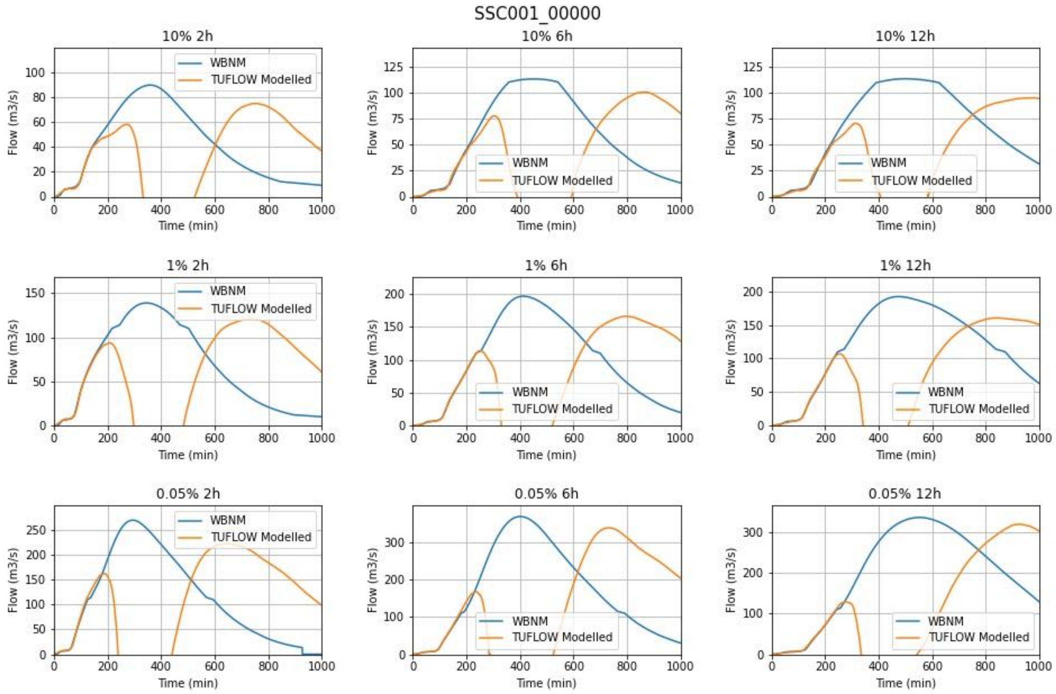


	Peak diff (%)	Peak timing diff (min)	NSE
10% 2h	34.0%	50.0min	-0.21
10% 6h	15.0%	49.0min	0.39
10% 12h	17.0%	21.0min	0.3
1% 2h	31.0%	37.0min	0.18
1% 6h	15.0%	81.0min	0.61
1% 12h	13.0%	9.0min	0.55
0.05% 2h	37.0%	21.0min	0.3
0.05% 6h	18.0%	38.0min	0.75
0.05% 12h	6.0%	9.0min	0.83



	Peak diff (%)	Peak timing diff (min)	NSE
10% 2h	7.0%	5.0min	0.97
10% 6h	1.0%	1.0min	0.99
10% 12h	2.0%	4.0min	0.99
1% 2h	12.0%	1.0min	0.97
1% 6h	4.0%	3.0min	0.99
1% 12h	2.0%	9.0min	0.99
0.05% 2h	9.0%	18.0min	0.95
0.05% 6h	6.0%	23.0min	0.98
0.05% 12h	4.0%	8.0min	0.99

Figure 5-2 HEH Plots for “LAG030_00652” without (top) and with storage (bottom)



	Peak diff (%)	Peak timing diff (min)	NSE
10% 2h	16.0%	394.0min	-1.51
10% 6h	11.0%	412.0min	-1.5
10% 12h	16.0%	475.0min	-1.23
1% 2h	13.0%	387.0min	-1.3
1% 6h	16.0%	382.0min	-1.42
1% 12h	16.0%	372.0min	-0.9
0.05% 2h	18.0%	346.0min	-1.42
0.05% 6h	8.0%	330.0min	-1.61
0.05% 12h	5.0%	374.0min	-0.81

Figure 5-3 TUFLOW and WBNM Hydrographs for "SCC001_0000"

5.2.1 Critical Storm Selection

Table 5-1 presents the selected storm events simulated in the TUFLOW model. Following on from Stage 1 guidance the following process was undertaken for the design event selection. The storms were selected using the HEH model and the process was undertaken for each ARF category (within Storm Injector software) described in Section 3.

1. Design storms generated with relevant ARF applied.
2. Storms with embedded bursts where smoothing was over 40% were removed from the analysis.
3. WBNM HEH model simulated for all design storms.
4. Critical storms and peak flows extracted for corresponding POIs for each ARF category (refer to Appendix A).

From this analysis there was approximately 40 storms critical across the POIs from the WBNM modelling for each AEP. To reduce the number of hydraulic simulations, a process was undertaken to optimise the selected storms for hydraulic simulation. This process involved comparing the WBNM HEH peak flow from a subset of 5 storms (4 storms for the 0.1% and 0.05% AEPs) to the actual critical peak flow (from all storms) across all POIs. All possible combinations of critical storms were tested, and the optimal subset of storms was selected for each AEP based on the mean and minimisation of outlier flow differences. In general, this over or underestimation was aimed to be under +-10%.

Table 5-1 Critical Events Selected

Event	Simulated events
20%	20pcAEP180minTP1_ARFc, 20pcAEP270minTP6_ARFc, 20pcAEP360minTP1_ARFd, 20pcAEP540minTP4_ARFe, 20pcAEP720minTP2_ARFg
10%	10pcAEP90minTP6_ARFa, 10pcAEP180minTP4_ARFb, 10pcAEP360minTP3_ARFe, 10pcAEP540minTP5_ARFe, 10pcAEP720minTP1_ARFg
5%	5pcAEP120minTP6_ARFa, 5pcAEP180minTP5_ARFb, 5pcAEP360minTP7_ARFe, 5pcAEP540minTP10_ARFe, 5pcAEP720minTP7_ARFg
2%	2pcAEP120minTP1_ARFa, 2pcAEP180minTP1_ARFc, 2pcAEP360minTP6_ARFe, 2pcAEP720minTP04_ARFh, 2pcAEP1080minTP10_ARFf
1%	1pcAEP120minTP1_ARFa, 1pcAEP180minTP9_ARFc, 1pcAEP360minTP10_ARFe, 1pcAEP720minTP1_ARFd, 1pcAEP1080minTP4_ARFf
1 in 1000	1in1000120minTP8_ARFb, 1in100090minTP9M_ARFb, 1in1000270minTP7_ARFd, 1in10001080minTP4_ARFf
1 in 2000	1in200060minTP2_ARFa, 1in2000120minTP6_ARFb, 1in2000270minTP7_ARFd, 1in20001080minTP5_ARFi

Table 5-2 presents the difference in peak flow (HEH WBNM modelling) from the maximum of the selected events (Table 5-1) versus the peak flow from simulating all temporal patterns and durations showing that differences are generally less than 10%.

The source grids for the 1% AEP envelope results were inspected and showed that the 120-minute duration dominated all upper reaches and much of the minor tributaries. The 1080-minute duration storm is only critical for isolated areas in Beachmere. The 5% AEP source grids show that the 120-minute storm dominates the upper reaches and tributaries. The 5% AEP 720-minute storm is critical in downstream areas of the model, including Beachmere. The spatial distribution of the critical durations indicates that a good selection of storms are represented in the ensemble. For the 0.1% AEP, no one particular duration dominates, and the selected storms show a good spatial distribution.

Table 5-2 Peak Flow Over/Underestimation at POIs

POI	Peak Flow Difference with Selected Storms (% difference to all storms critical flow)		
BUR001_00000	+ 2 %	+ 6 %	- 8 %
BUR001_02526	+ 0 %	- 2 %	- 9 %
BUR001_12773	+ 0 %	- 9 %	- 3 %
BUR001_15768	+ 0 %	- 13 %	- 4 %
BUR001_16406	+ 0 %	- 13 %	- 5 %
BUR001_18266	- 4 %	- 14 %	- 4 %
BUR001_20285	+ 0 %	- 5 %	+ 0 %
BUR001_23663	+ 5 %	- 1 %	+ 0 %
BUR001_26663	+ 0 %	+ 3 %	+ 7 %
BUR001_31228	- 5 %	+ 6 %	+ 7 %
BUR006_00000	+ 8 %	+ 12 %	+ 14 %
BUR006_01731	+ 0 %	- 4 %	+ 0 %

POI	Peak Flow Difference with Selected Storms (% difference to all storms critical flow)		
BUR011_01509	+ 9 %	+ 12 %	+ 13 %
BUR013_00389	- 1 %	- 2 %	+ 7 %
BUR018_00267	- 6 %	- 7 %	- 6 %
BUR019_00078	+ 1 %	- 2 %	+ 5 %
BUR024_00980	+ 4 %	+ 11 %	+ 12 %
BUR024_02119	- 1 %	+ 7 %	+ 0 %
BUR032_00750	- 1 %	- 2 %	+ 6 %
BUR036_01339	- 5 %	- 9 %	- 2 %
BUR050_00000	- 9 %	- 5 %	- 7 %
BUR084_00000	- 1 %	- 4 %	+ 5 %
CAB001_09077	+ 8 %	+ 8 %	+ 1 %
CAB001_11315	+ 11 %	+ 5 %	+ 8 %
CAB001_11920	+ 12 %	+ 5 %	+ 9 %
CAB001_13077	+ 13 %	+ 5 %	+ 9 %
CAB001_15021	+ 15 %	+ 7 %	+ 10 %
CAB001_18625	+ 16 %	+ 5 %	+ 10 %
CAB001_22731	+ 19 %	+ 10 %	+ 13 %
CAB001_24517	+ 18 %	+ 12 %	+ 14 %
CAB019_01687	+ 1 %	+ 1 %	+ 3 %
CAB019_03765	+ 1 %	+ 5 %	+ 6 %
CAB021_00000	- 2 %	+ 4 %	+ 0 %
CAB021_02894	+ 3 %	- 2 %	+ 1 %
CAB034_04552	- 3 %	+ 3 %	+ 1 %
CBM001_01940	+ 4 %	+ 8 %	+ 3 %
CBM007_02274	- 13 %	+ 2 %	- 3 %
DEC006_00061	- 3 %	- 7 %	+ 6 %
GOD001_00434	- 5 %	+ 0 %	+ 2 %
GRE001_00000	+ 1 %	- 1 %	+ 3 %
GYM001_04853	- 2 %	- 6 %	+ 1 %
GYM001_07715	- 2 %	+ 5 %	+ 0 %
GYM004_00468	+ 0 %	+ 6 %	+ 4 %
GYM006_00000	- 5 %	+ 6 %	+ 0 %
GYM006_00837	- 4 %	+ 7 %	+ 0 %
KJC001_15910	+ 2 %	+ 3 %	- 2 %
KJC001_22340	+ 2 %	- 1 %	- 3 %

POI	Peak Flow Difference with Selected Storms (% difference to all storms critical flow)		
KJC001_24247	- 2 %	+ 0 %	+ 2 %
KJC001_26759	- 2 %	+ 9 %	+ 12 %
KJC006_01796	+ 1 %	+ 3 %	- 2 %
LAG001_01199	- 3 %	- 6 %	- 6 %
LAG001_04754	+ 0 %	- 12 %	- 2 %
LAG001_05523	+ 2 %	- 14 %	+ 0 %
LAG001_12318	- 1 %	- 8 %	- 3 %
LAG030_00652	- 7 %	- 3 %	- 7 %
LBC001_02006	- 6 %	- 9 %	- 5 %
LBC001_04447	+ 1 %	+ 9 %	+ 12 %
LBC001_07420	+ 7 %	+ 12 %	+ 13 %
LBC001_09441	+ 1 %	+ 5 %	+ 2 %
LBC001_11534	+ 0 %	+ 0 %	- 6 %
LBC034_00980	+ 0 %	+ 3 %	+ 0 %
LBC046_01605	- 2 %	+ 1 %	+ 9 %
SSC001_00000	- 3 %	- 11 %	- 7 %
SSC001_03599	- 1 %	- 6 %	+ 1 %
SSC001_05513	+ 2 %	+ 10 %	+ 14 %
SSC006_00249	- 7 %	- 4 %	- 5 %
SSC006_02003	- 11 %	+ 7 %	+ 1 %
SSC012_01145	+ 0 %	+ 5 %	+ 7 %
SSC018_00479	+ 0 %	- 7 %	+ 0 %
SSC018_02296	- 3 %	+ 5 %	+ 0 %
SSC020_00661	+ 1 %	+ 2 %	+ 3 %
WAR001_00000	+ 0 %	- 1 %	- 7 %
WAR001_02090	+ 0 %	- 4 %	- 5 %
WAR001_09562	+ 0 %	- 2 %	+ 1 %
WAR001_11338	+ 0 %	+ 0 %	+ 1 %
WAR001_13974	+ 3 %	+ 1 %	+ 0 %
WAR001_14487	- 1 %	- 2 %	+ 0 %
WAR028_00638	- 5 %	- 2 %	+ 0 %
WAR032_03200	- 2 %	- 1 %	+ 0 %
WAR032_08233	- 4 %	+ 3 %	- 2 %
WAR050_00000	- 1 %	- 3 %	- 2 %
WAR050_06071	+ 1 %	+ 7 %	+ 1 %

5.3 Design Flood Behaviour

5.3.1 Peak Flow Comparison

To confirm the HEH performance a comparison of the WBNM peak flow and TUFLOW peak flow was undertaken at each POI. Table 5-3 presents the comparison for the 1% AEP event (E00). The results show reasonable correlation between the models with similar peak flows and similar critical storms giving further confidence that the HEH WBNM is suitable to be utilised for the selection of critical storms.

Table 5-3 1% AEP WBNM vs TUFLOW Peak Flow Comparison

POI	WBNM Duration (min)	WBNM Adopted TP	WBNM Peak flow	TUFLOW Duration (min)	TUFLOW Adopted TP	TUFLOW Peak flow
BUR001_00000	720	TP1	537.05	0360M	TP10	463.79
BUR001_02526	360	TP4	447.85	0360M	TP10	465.44
BUR001_12773	360	TP4	475.83	0360M	TP10	474.07
BUR001_15768	360	TP10	467.06	0360M	TP10	475.41
BUR001_16406	360	TP10	466.32	0360M	TP10	476.85
BUR001_18266	270	TP3	362.1	0360M	TP10	320.72
BUR001_20285	270	TP1	292.37	0180M	TP09	267.66
BUR001_23663	270	TP7	269.85	0180M	TP09	274.49
BUR001_26663	270	TP7	238.94	0120M	TP01	267.63
BUR001_31228	270	TP2	177.44	0120M	TP01	192.74
BUR006_00000	120	TP1	138.73	0120M	TP01	137.85
BUR006_01731	90	TP9	92.48	0120M	TP01	90.15
BUR011_01509	120	TP8	141.04	0120M	TP01	165.29
BUR013_00389	90	TP5	44.89	0120M	TP01	45.25
BUR018_00267	90	TP2	19.9	0120M	TP01	18.70
BUR019_00078	90	TP9	98.69	0120M	TP01	97.04
BUR024_00980	120	TP8	104.64	0120M	TP01	122.61
BUR024_02119	120	TP8	77.42	0120M	TP01	87.92
BUR032_00750	90	TP6	30.03	0120M	TP01	29.10
BUR036_01339	90	TP2	25.31	0120M	TP01	23.93
BUR050_00000	90	TP2	14.04	0120M	TP01	14.98
BUR084_00000	90	TP6	47.14	0120M	TP01	42.79
CAB001_09077	720	TP4	1454.52	0720M	TP01	1640.74
CAB001_11315	120	TP1	11.40	0120M	TP01	8.84
CAB001_11920	720	TP7	1530.34	0720M	TP01	1540.55
CAB001_13077	720	TP7	1522.14	0720M	TP01	1544.98
CAB001_15021	720	TP4	976.53	0360M	TP10	1015.00

POI	WBNM Duration (min)	WBNM Adopted TP	WBNM Peak flow	TUFLOW Duration (min)	TUFLOW Adopted TP	TUFLOW Peak flow
CAB001_18625	1080	TP4	943.51	0360M	TP10	1021.19
CAB001_22731	1080	TP10	916.96	0360M	TP10	985.71
CAB001_24517	1080	TP10	844.48	0360M	TP10	943.24
CAB019_01687	90	TP6	53.82	0120M	TP01	54.60
CAB019_03765	120	TP6	29.81	0120M	TP01	33.52
CAB021_00000	120	TP5	86.19	0360M	TP10	88.05
CAB021_02894	90	TP9	69.25	0120M	TP01	67.85
CAB034_04552	120	TP1	45.47	0120M	TP01	48.56
CBM001_01940	720	TP8	1844.87	0720M	TP01	1807.10
CBM007_02274	120	TP8	5.94	0120M	TP01	6.05
DEC006_00061	90	TP9	29.99	0120M	TP01	30.14
GOD001_00434	720	TP1	22.82	0720M	TP01	56.02
GRE001_00000	270	TP7	248.4	0120M	TP01	250.20
GYM001_04853	270	TP2	111.51	0180M	TP09	106.08
GYM001_07715	180	TP4	63.48	0120M	TP01	68.14
GYM004_00468	120	TP6	28.79	0120M	TP01	33.71
GYM006_00000	120	TP8	70.35	0120M	TP01	72.09
GYM006_00837	120	TP6	46.01	0120M	TP01	48.31
KJC001_15910	720	TP5	418.58	0720M	TP01	561.29
KJC001_22340	270	TP1	249.91	0180M	TP09	258.35
KJC001_24247	270	TP7	228.43	0120M	TP01	254.53
KJC001_26759	270	TP7	194.23	0120M	TP01	232.43
KJC006_01796	120	TP1	58.57	0120M	TP01	67.59
LAG001_01199	360	TP5	417.69	0360M	TP10	373.20
LAG001_04754	360	TP5	420.36	0360M	TP10	386.79
LAG001_05523	360	TP3	391.78	0360M	TP10	324.79
LAG001_12318	270	TP1	354.46	0180M	TP09	339.54
LAG030_00652	180	TP1	31.15	0120M	TP01	31.83
LBC001_02006	270	TP3	219.59	0180M	TP09	161.20
LBC001_04447	180	TP9	131.7	0120M	TP01	155.57
LBC001_07420	120	TP1	103.38	0120M	TP01	117.55
LBC001_09441	120	TP6	47.23	0120M	TP01	50.06
LBC001_11534	120	TP1	14.1	0120M	TP01	13.25
LBC034_00980	120	TP1	66.93	0120M	TP01	71.15
LBC046_01605	90	TP6	40.31	0120M	TP01	42.83

POI	WBNM Duration (min)	WBNM Adopted TP	WBNM Peak flow	TUFLOW Duration (min)	TUFLOW Adopted TP	TUFLOW Peak flow
SSC001_00000	360	TP4	303.85	0720M	TP01	230.34
SSC001_03599	270	TP1	332.42	0180M	TP09	305.71
SSC001_05513	270	TP7	264.17	0120M	TP01	269.77
SSC006_00249	270	TP7	67.56	0120M	TP01	76.18
SSC006_02003	120	TP6	49.51	0120M	TP01	55.22
SSC012_01145	120	TP6	53.09	0120M	TP01	58.18
SSC018_00479	180	TP8	69.33	0120M	TP01	68.95
SSC018_02296	120	TP8	48.9	0120M	TP01	50.03
SSC020_00661	90	TP6	43.27	0120M	TP01	41.93
WAR001_00000	360	TP5	571.1	0720M	TP01	547.55
WAR001_02090	360	TP3	525.21	0360M	TP10	520.77
WAR001_09562	270	TP1	481.59	0360M	TP10	432.34
WAR001_11338	270	TP1	432.24	0360M	TP10	396.00
WAR001_13974	270	TP1	429.87	0180M	TP09	414.88
WAR001_14487	270	TP1	284.94	0180M	TP09	271.22
WAR028_00638	270	TP2	79.22	0120M	TP01	80.66
WAR032_03200	270	TP7	135.36	0180M	TP09	140.79
WAR032_08233	120	TP1	54.37	0120M	TP01	52.73
WAR050_00000	270	TP2	114.64	0120M	TP01	123.07
WAR050_06071	120	TP6	42.64	0120M	TP01	49.51

5.3.2 Comparison to RFD 2014

Figure 5-4 presents the difference in 1% AEP peak flood level between the RFD 2022 (E00 1% AEP of this study) and the previous RFD 2014 peak flood level across the Caboolture River and Burpengary Creek catchments (unblocked scenarios). It is noted that RFD 2014 did not incorporate blockage into the catchment. In general, the peak flood levels are higher across the catchment, particularly in the mid-lower reaches of the Caboolture River and Burpengary Creek. Some upper tributaries and creek reaches are lower. The area of highest increase of up to +3.2m is on the Caboolture River at Litherland Road crossing.

This is partially attributable to increased riparian roughness where previously no riparian roughness was defined (and given increases are observed in much of the creek and river channels upstream of Caboolture) and representation of the road crossing (previously this crossing was modelled as a bridge, whereas, it has been updated to be a road crossing and culvert).

Peak 1% AEP water levels in the Caboolture River upstream of Bellmere are approximately 1-2m higher than the previous RFD 2014 results, however, flooding is still generally contained to the river channel.

Substantially increased water levels are noted in the Caboolture River upstream of the Sheep Station Creek confluence and to Morayfield Road up to approximately 0.9m to 1.0m. This can be attributed to the cumulative effect of (generally) increased IFDs across the catchment, updated temporal patterns and event selection.

Reductions in peak water level are generally confined to the upper reaches of tributaries across the catchment, indicating that this is due to event selection (the shortest duration for the 1% AEP being the 120-minute event).

This study has significantly increased the modelled flood extent due to the more extensive and refine catchment break up and inclusion of subcatchment local inflows. Notable areas which have been included in the catchment modelling that were not previous defined as part of the 2014 study include the upper Caboolture River, upper Wararba Creek, tributaries within the Caboolture West Local Plan area, parts of Deception Bay and some urban areas such as the Caboolture Springs estate.

A similar comparison has been undertaken for the Design Flood Event (DFE) which for this major update is the enveloped future climate 1% AEP scenario (F03). Figure 5-5 presents a comparison of flood levels of the 2022 RFD DFE to the RFD 2014 DFE which was based of the Median Duration Storm (MDS). Similar increases and decreases as discussed above are notable.

A comparison of the blocked (E02) and unblocked (E00) scenarios showed that blockage increased flood levels upstream of key culverts by up to 0.6m in some locations. Generally, blockage of culverts only has localised impacts. Bridge blockage does not substantially impact flood levels.

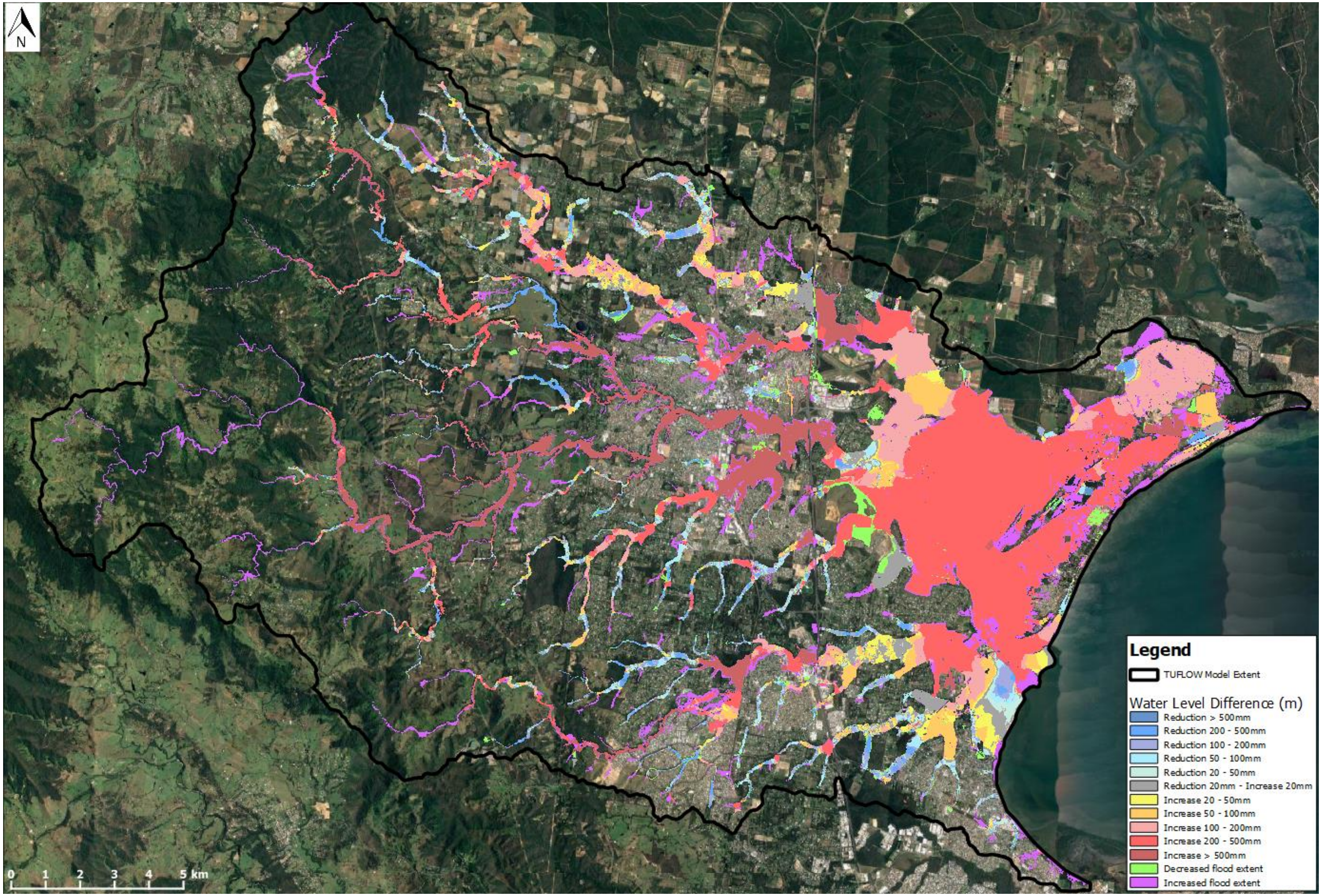


Figure 5-4 RFD 2022 minus RFD 2014 1% AEP peak flood level (unblocked)

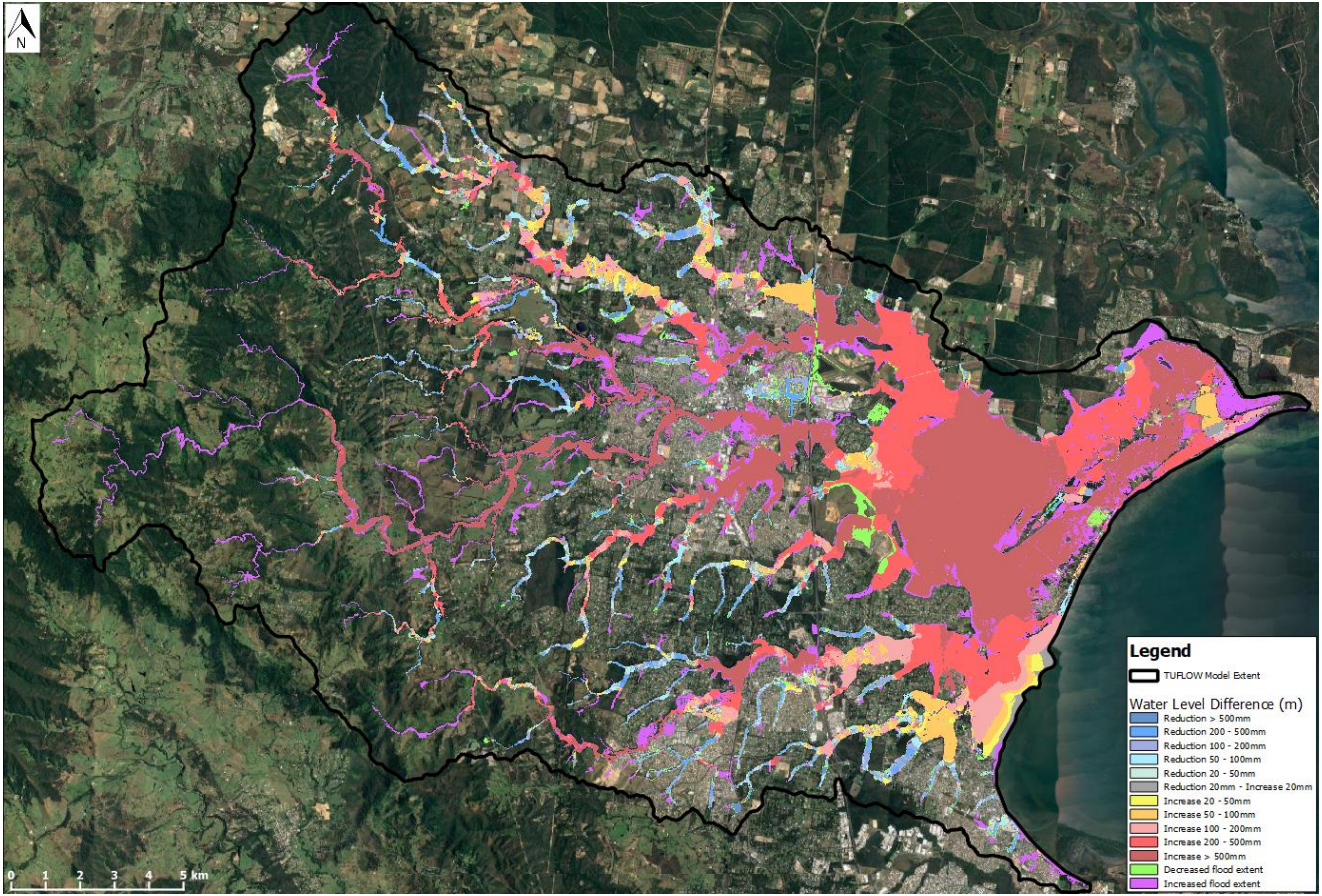


Figure 5-5 RFD 2022 minus RFD 2014 1% AEP DFE peak flood level (future climate)

5.4 Technical Considerations and Model Health

The BCR design model (BCR_R_003a_~s1~_~e1~_~e2~_~e3~_~e4~_03.tcf) requires 16GB RAM to initialise (with xf files). A PC running one simulation is recommended to have a minimum of 32GB RAM. A single simulation of the full model extent requires approximately 26GB RAM. We recommend that a minimum of 24GB GPU RAM is also available (such as with a NVIDIA GeForce RTX 3090 or 4090).

Depending on the AEP, a single simulation can be performed on a NVIDIA GeForce RTX 3090 at a simulation time to real time ratio of approximately 2.3:1 (5% AEP) (i.e, 2.3 hours of model time takes 1 hour to simulate) to 1.4:1 (0.1% AEP). Using a NVIDIA GeForce RTX 4090 is approximately twice as fast as a NVIDIA GeForce RTX 3090.

A plot showing the control numbers and minimum timestep (dt) during the 1% AEP 360-minute event (E00) is shown in Figure 5-6. The minimum dt value dips below 0.1 seconds in most simulations and is associated with deep, fast-moving water as the event peaks. Mapping for the minimum dt shows that cells dictating the timestep are isolated to incised channels and deep downstream channels of the model, which is to be expected. The pattern and response of the control numbers and timestep is normal for a model of this extent, grid size and complexity.

HPC is mass-conserving, so the low Mass Error (ME) is expected, however, the low ME values indicate that the 1D elements and connections are generally stable. Inspections of the culvert flows indicate that pits, pipes and major culverts are stable and performing as intended.

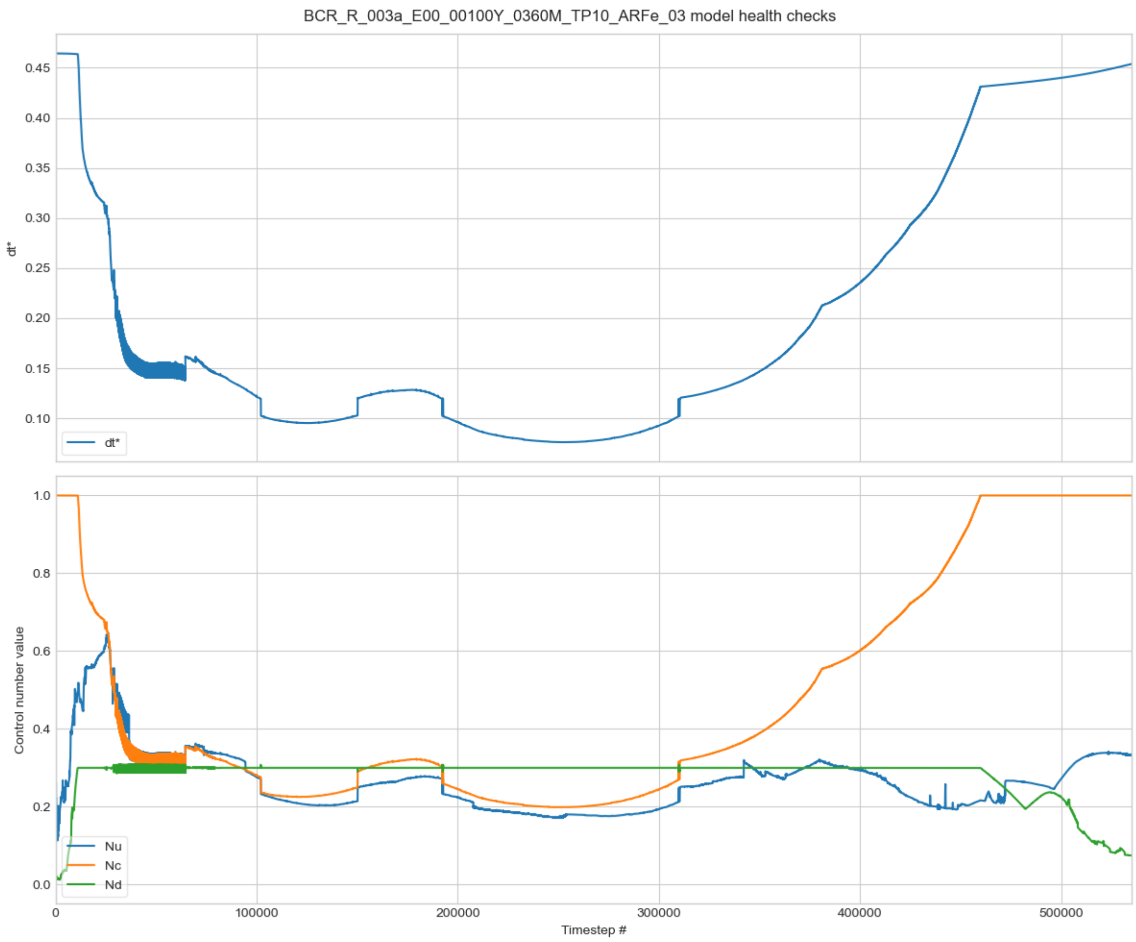


Figure 5-6 TUFLOW Control Numbers and Timestep

5.5 Model Limitations

Watercourses within the Caboolture River and Burpengary Creek catchment were represented using a fixed 2D grid size of 5m. This may not allow adequate representation of minor drainage channels, particularly roadside or urban drains and particularly for smaller, more frequent flood events.

The model terrain is based on available 2019 LiDAR. Substantial effort was made to include recent developments and any other catchment changes in the model (such as new roads and bridges). However, there are likely to be areas of the model that do not represent current conditions. Several of the development designs included are based off approved earthworks designs and have been included for indicative purposes (for example, the North Harbour development). We understand that Council intends to update the models with future LiDAR capture. A detailed review of the topography files will be required to ensure they are still suitable for future updates.

The adopted model roughness was based on previous work undertaken by others and endorsed by Council. Spatially, the materials layers are highly refined and represent a substantial improvement from the previous RFD modelling.

Predicted water levels are dependent on the event selection process as documented herein. Analysis of the WBNM HEH model has shown that for the 1% AEP, the difference between the peak flow of the selected storm and median at each POI is generally less than 10%. Similar results were attained for the 5% and 0.1% AEP events. The ensemble results are therefore adequate for design event representation and to inform future planning.

6 CONCLUSION

As part of the Stage 4 and 5 update of the RFD for Burpengary Creek and Caboolture River (BCR), we have updated a provided WBNM hydrologic model (as part of the Stage 2 study) and an existing TUFLOW hydraulic model according to the latest industry guidance (ARR 2019). The models were specifically set up in accordance with the requirements outlined by the Moreton Bay Regional Council (MBRC) for the Regional Flood Database (RFD) project. The aim was to ensure a consistent approach across the entire Local Government Area (LGA) and facilitate the integration of the model and its outputs into MBRC's database.

The primary objective of the project was to deliver the TUFLOW model and its associated outputs in a digital format. Therefore, this report presents only a selected subset of the results obtained from the model. The focus was on providing the necessary information that can be readily integrated into the database and utilised for further analysis and management of flood risk in the Caboolture River and Burpengary Creek Catchments.

The outcomes of this work will serve as a valuable resource for future stages of the Regional Floodplain Database. The model and its outputs will contribute to a comprehensive understanding of flood behaviour in the Caboolture River and Burpengary Creek Catchments, aiding in the assessment and management of flood risk. The information obtained from the model will support informed decision-making processes related to floodplain management, land-use planning, and infrastructure development in the area. It will also be used in all MBRC public flood mapping products as the Flood Check Reports and Moreton Bay Flood Viewer.

The development and delivery of the models for the Caboolture River and Burpengary Creek Catchments, adhering to the prescribed approach outlined by MBRC, provides a valuable foundation for future stages of the RFD.

7 DISCUSSION

The hydrologic and hydraulic models developed as part of this update reflect the first validated models throughout the Caboolture River and Burpengary Creek Catchments representing a significant improvement on previous iterations. Limitations of the modelling (not exhaustive) have been discussed.

The hydraulic model has been calibrated and validated to historical events using stream gauge records and surveyed flood marks. Results are generally good, however, substantial benefit would be gained from undertaking a detailed gauge survey analysis and comparing the outcomes to the results of the calibration.

8 REFERENCES

1. Australian Rainfall and Runoff (ARR) (2019): A guide to flood estimation, Commonwealth of Australia (Geoscience Australia), 2016.
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3. LIMB 2020 IFD - High Resolution, available at: https://data.arr-software.org/
4. Memorandum - Final HEH Modelling Methodology, BMT, 2022
5. Moreton Bay Regional Council Regional Flood Database ARR 2019 Pilot Study Part 1 Methodology Report & Part 2 Pilot Study Report, ARUP, 2021
6. Regional Flood Database - Hydrologic and Hydraulic Modelling - Redcliffe (RED), BMT WBM, 2012
7. Regional Flood Database - 2014 Model Maintenance Report – Redcliffe, BMT WBM, 2014
8. Regional Flood Database - Stage 2 - Hydrography Landuse and Hydrology, AECOM, 2020
9. Regional Flood Database – Stage 3 Analysis Summary, Moreton Bay Regional Council, 2021

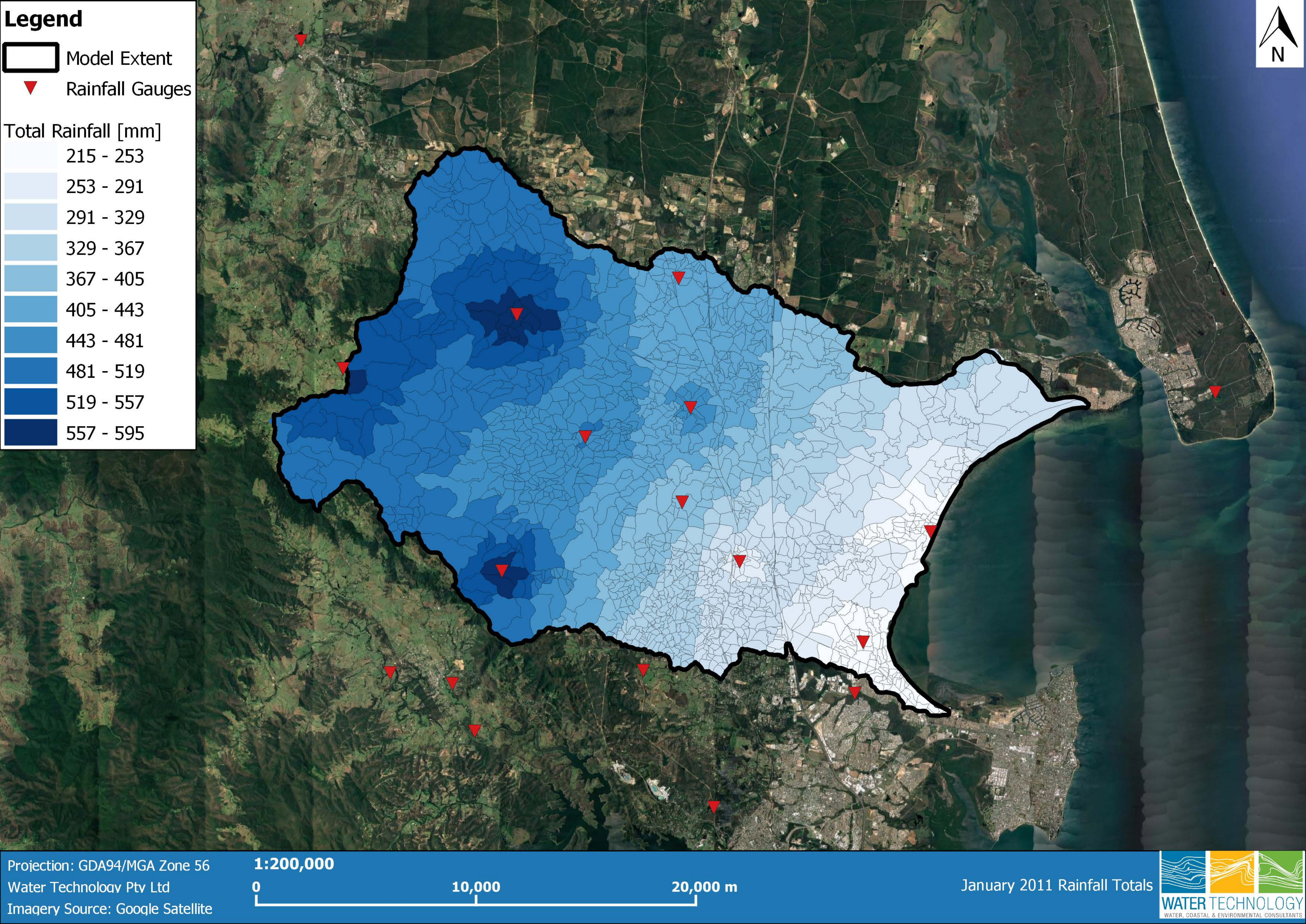
APPENDIX A
POI ARF CLASSIFICATION

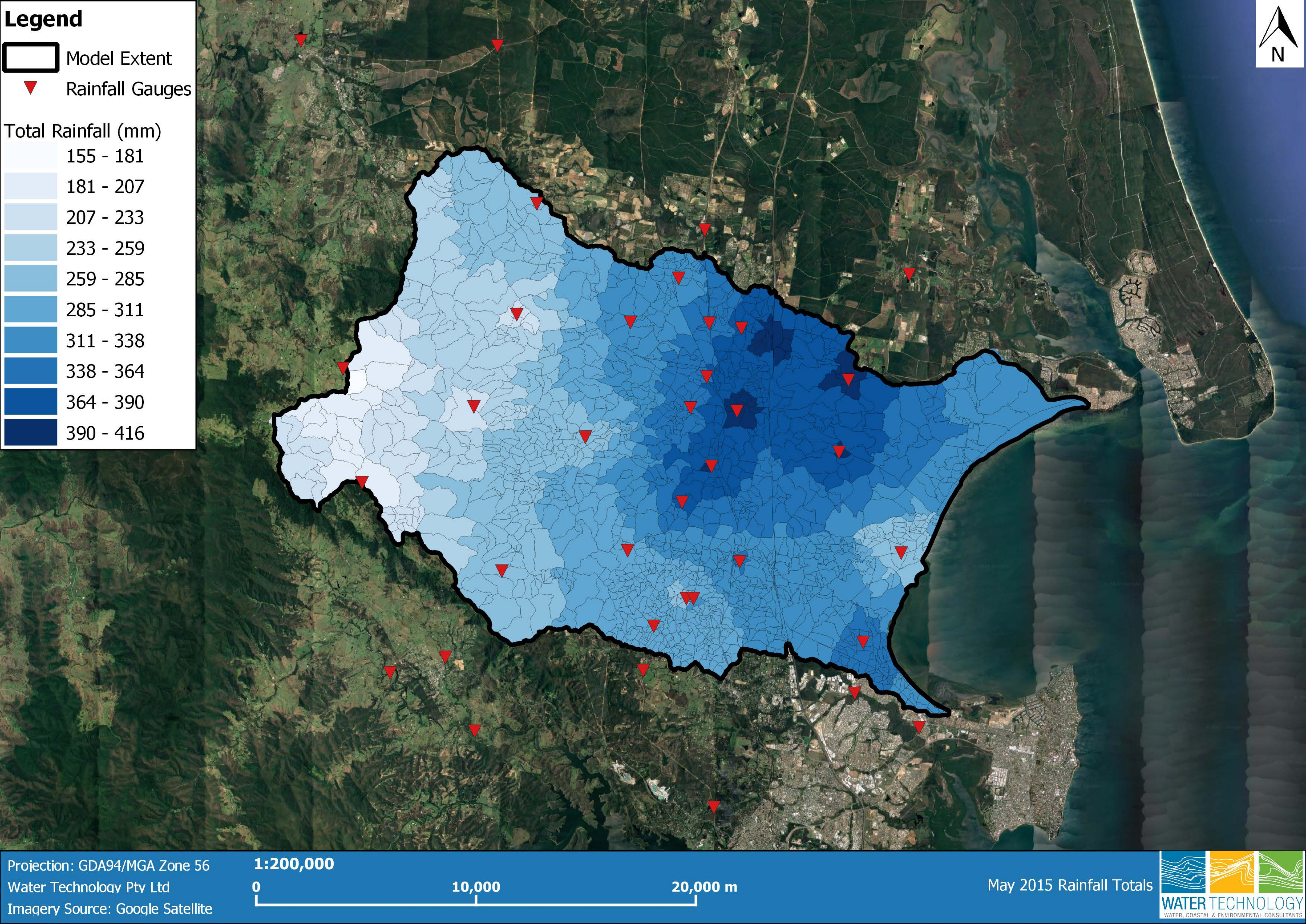
POI ID	Total Upstream Area (km^2)	ARF Class
CAB001_11315	0.31	A
CBM007_02274	0.34	A
BUR050_00000	0.48	A
BUR018_00267	0.65	A
LBC001_11534	0.68	A
BUR036_01339	0.82	A
BUR032_00750	1.06	B
DEC006_00061	1.20	B
GYM004_00468	1.21	B
CAB019_03765	1.24	B
LBC046_01605	1.42	B
SSC020_00661	1.65	B
BUR084_00000	1.69	B
BUR013_00389	1.72	B
LAG030_00652	1.72	B
WAR050_06071	1.90	B
CAB034_04552	1.96	B
GYM006_00837	2.13	B
SSC012_01145	2.17	B
LBC001_09441	2.18	B
CAB019_01687	2.23	B
SSC018_02296	2.25	B
SSC006_02003	2.35	B
KJC006_01796	2.60	B
WAR032_08233	2.69	B
CAB021_02894	2.82	B
LBC034_00980	2.94	B
GYM006_00000	3.29	B
GYM001_07715	3.40	B
BUR024_02119	3.60	B
SSC018_00479	3.63	B
BUR006_01731	3.64	B
SSC006_00249	3.91	B
BUR019_00078	4.16	B
WAR028_00638	4.35	B
CAB021_00000	4.96	B
LBC001_07420	5.43	C

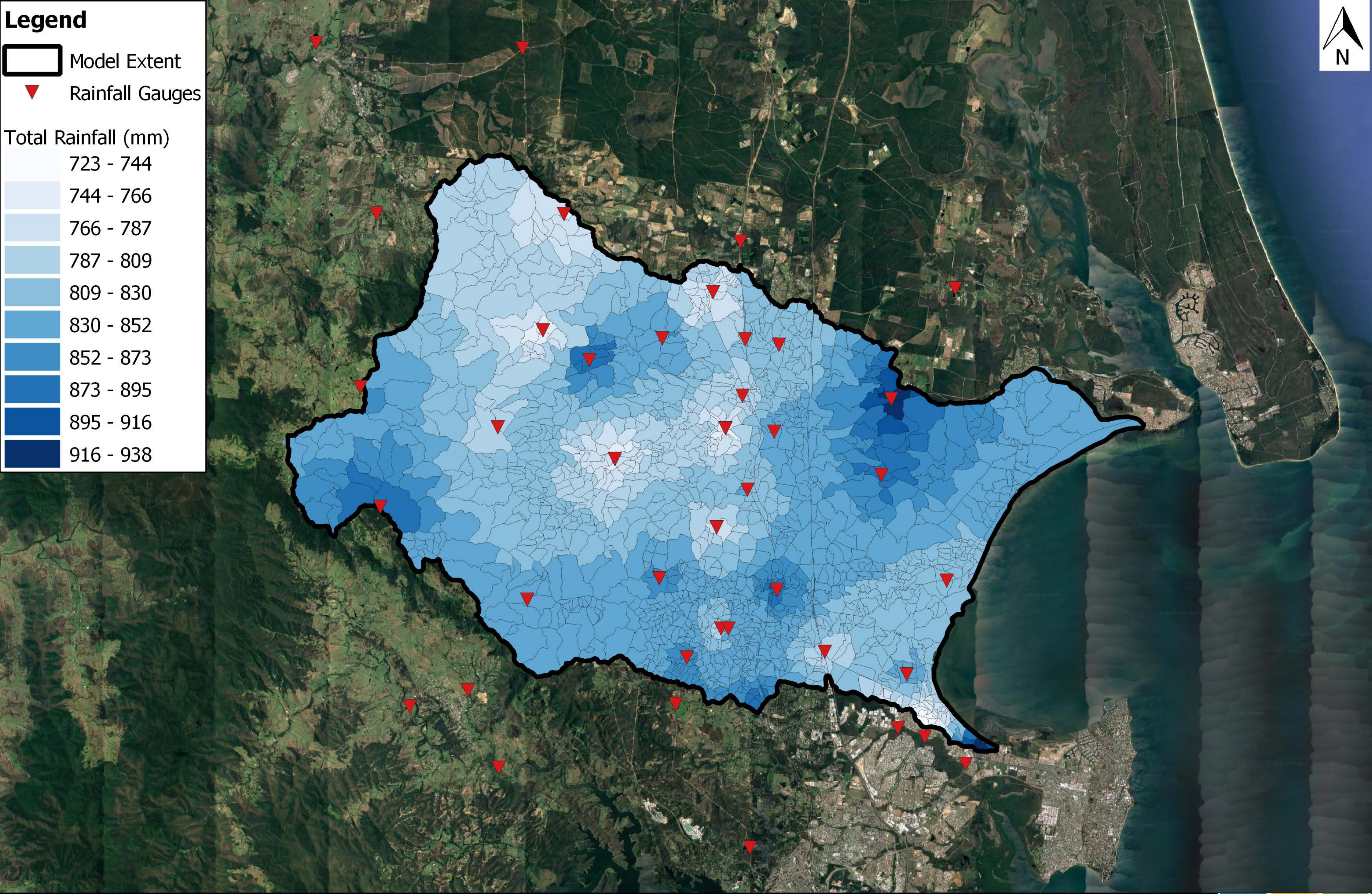
POI ID	Total Upstream Area (km^2)	ARF Class
BUR024_00980	5.80	C
BUR006_00000	6.77	C
BUR011_01509	6.96	C
GYM001_04853	7.04	C
WAR050_00000	7.51	C
LBC001_04447	8.21	C
WAR032_03200	9.07	C
BUR001_31228	10.50	C
KJC001_26759	11.11	C
KJC001_24247	14.19	C
BUR001_26663	15.48	D
LBC001_02006	16.67	D
GRE001_00000	16.70	D
KJC001_22340	17.06	D
SSC001_05513	17.11	D
GOD001_00434	17.91	D
BUR001_23663	18.75	D
BUR001_20285	20.48	D
SSC001_03599	22.60	D
WAR001_14487	23.86	D
LAG001_12318	27.52	D
BUR001_18266	29.16	D
SSC001_00000	30.96	D
LAG001_05523	36.46	E
WAR001_13974	36.55	E
WAR001_11338	38.07	E
BUR001_16406	40.32	E
BUR001_15768	40.65	E
LAG001_04754	40.86	E
WAR001_09562	43.45	E
BUR001_12773	44.33	E
LAG001_01199	44.75	E
WAR001_02090	61.91	E
BUR001_02526	62.07	E
WAR001_00000	71.80	E
KJC001_15910	75.38	F
BUR001_00000	81.06	F

POI ID	Total Upstream Area (km^2)	ARF Class
CAB001_24517	83.83	F
CAB001_22731	92.74	F
CAB001_18625	100.35	F
CAB001_15021	108.10	F
CAB001_13077	181.11	G
CAB001_11920	182.70	G
CAB001_09077	217.95	H
CBM001_01940	354.15	I

APPENDIX B
RAINFALL DISTRIBUTION MAPS


Legend
Model Extent
Rainfall Gauges
Total Rainfall [mm]
215 - 253
253 - 291
291 - 329
329 - 367
367 - 405
405 - 443
443 - 481
481 - 519
519 - 557
557 - 595
N
Projection: GDA94/MGA Zone 56
Water Technology Pty Ltd
Imagery Source: Google Satellite
1:200,000
0
10,000
20,000 m
January 2011 Rainfall Totals
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS


Legend
Model Extent
Rainfall Gauges
Total Rainfall (mm)
155 - 181
181 - 207
207 - 233
233 - 259
259 - 285
285 - 311
311 - 338
338 - 364
364 - 390
390 - 416
N
Projection: GDA94/MGA Zone 56
Water Technology Pty Ltd
Imagery Source: Google Satellite
1:200,000
0
10,000
20,000 m
May 2015 Rainfall Totals
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



Projection: GDA94/MGA Zone 56
Water Technology Pty Ltd
Imagery Source: Google Satellite

1:200,000

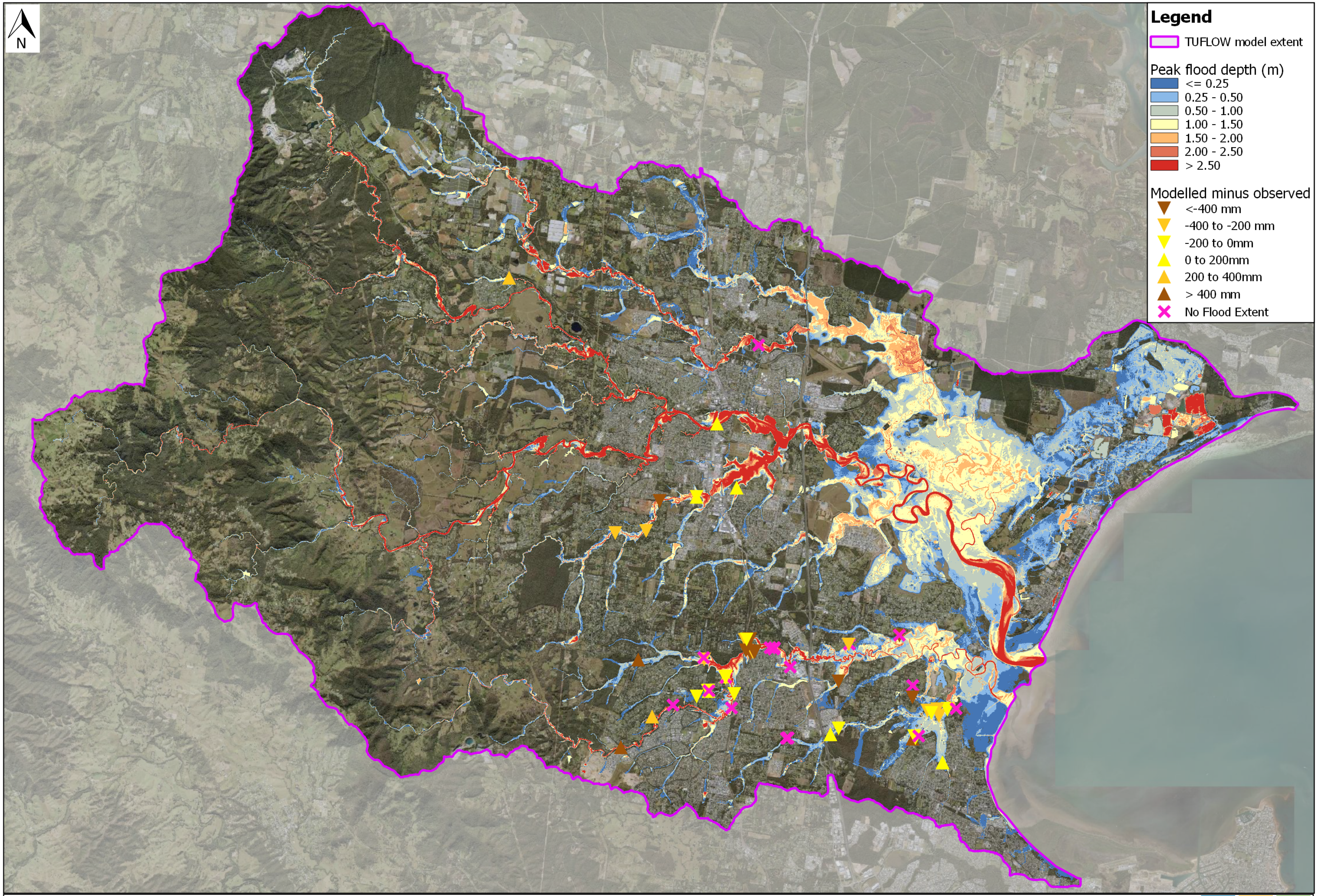
0 10,000 20,000 m

February 2022 Rainfall Totals

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX C
FLOOD MARK MAPPING AND ANALYSIS



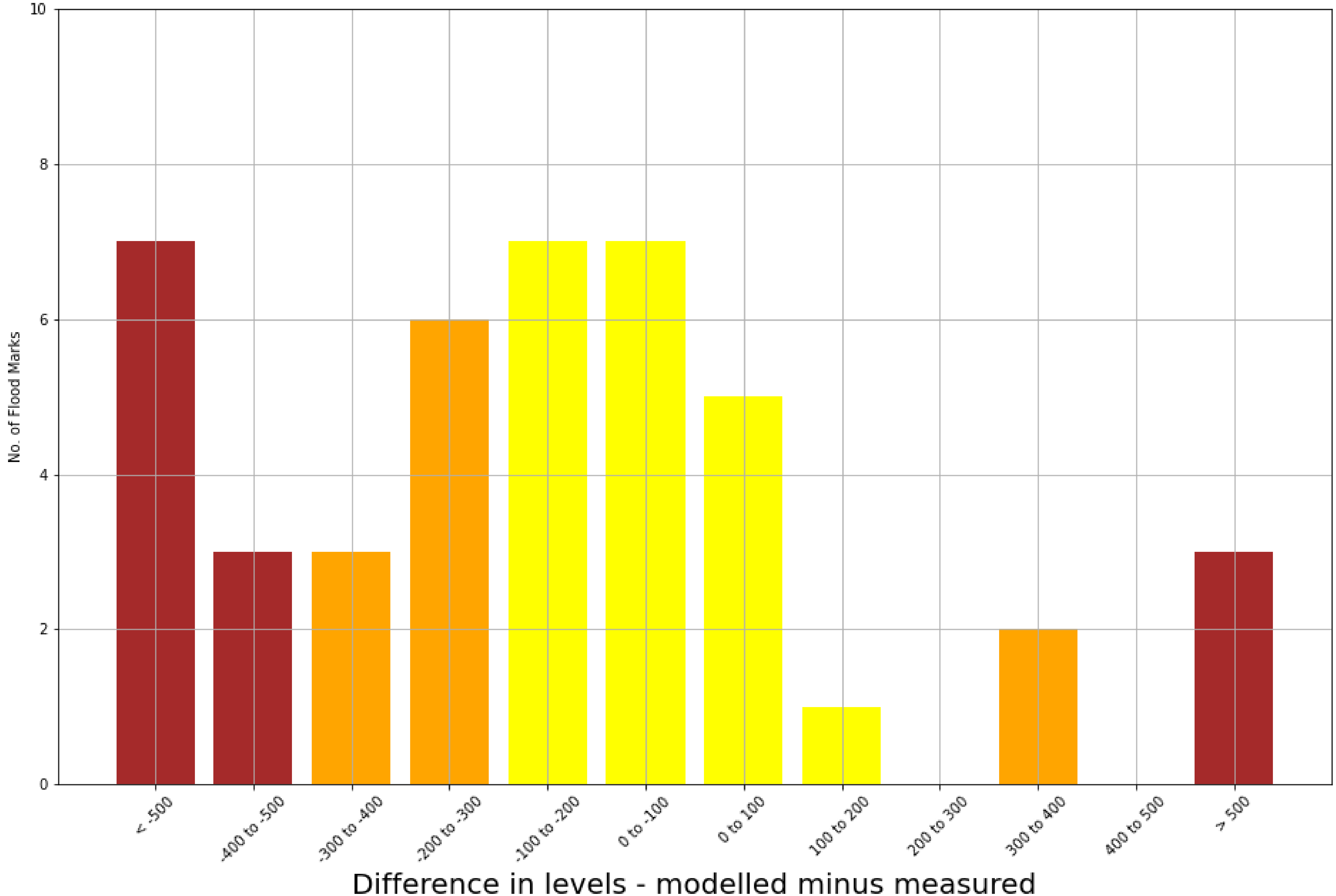
Projection: GDA94/MGA Zone 56
Water Technology Pty Ltd
Imagery Source: Google 2023

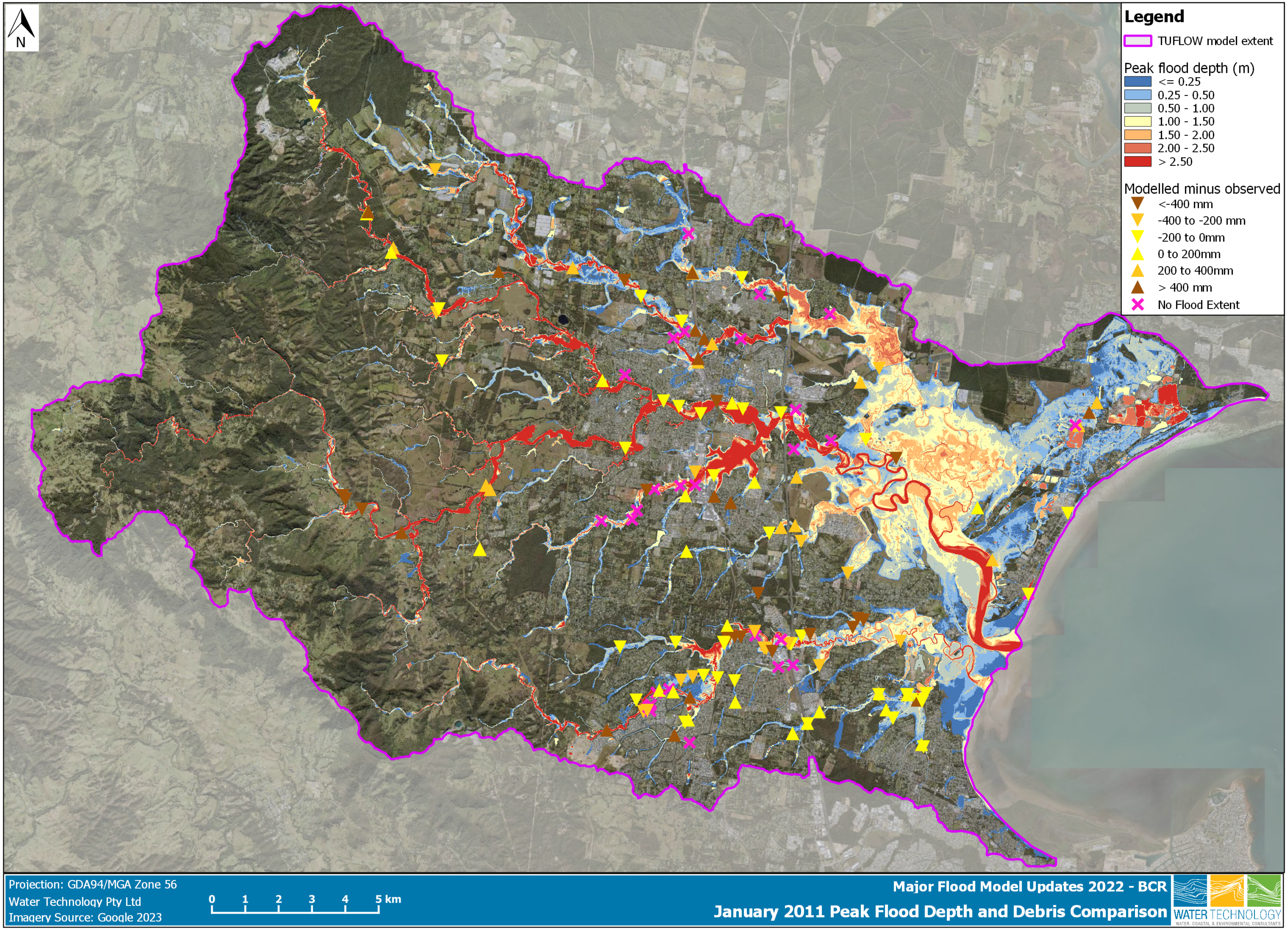
Major Flood Model Updates 2022 - BCR

May 2009 Peak Flood Depth and Debris Comparison

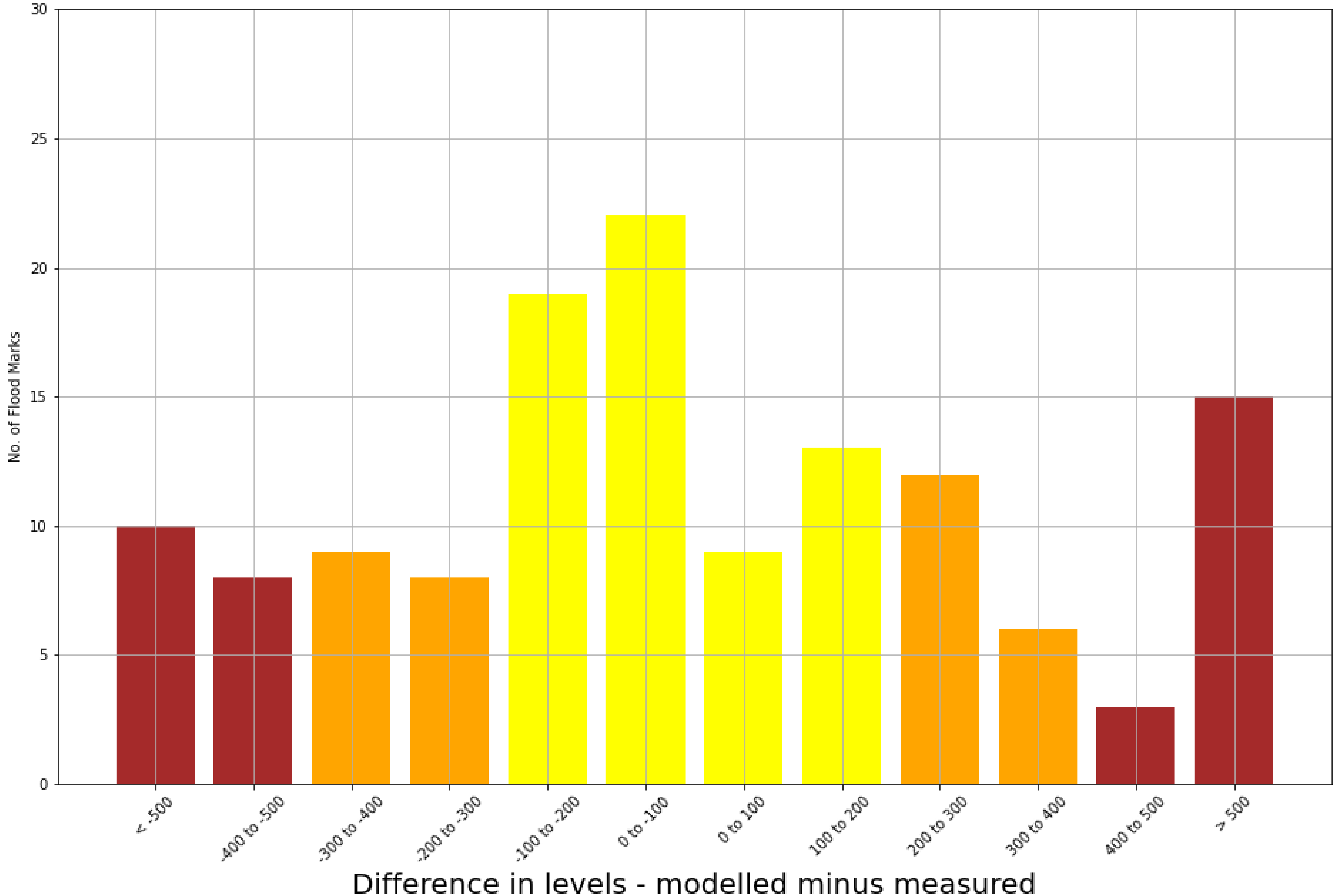
WATER TECHNOLOGY

)7-18T16:01:26.432

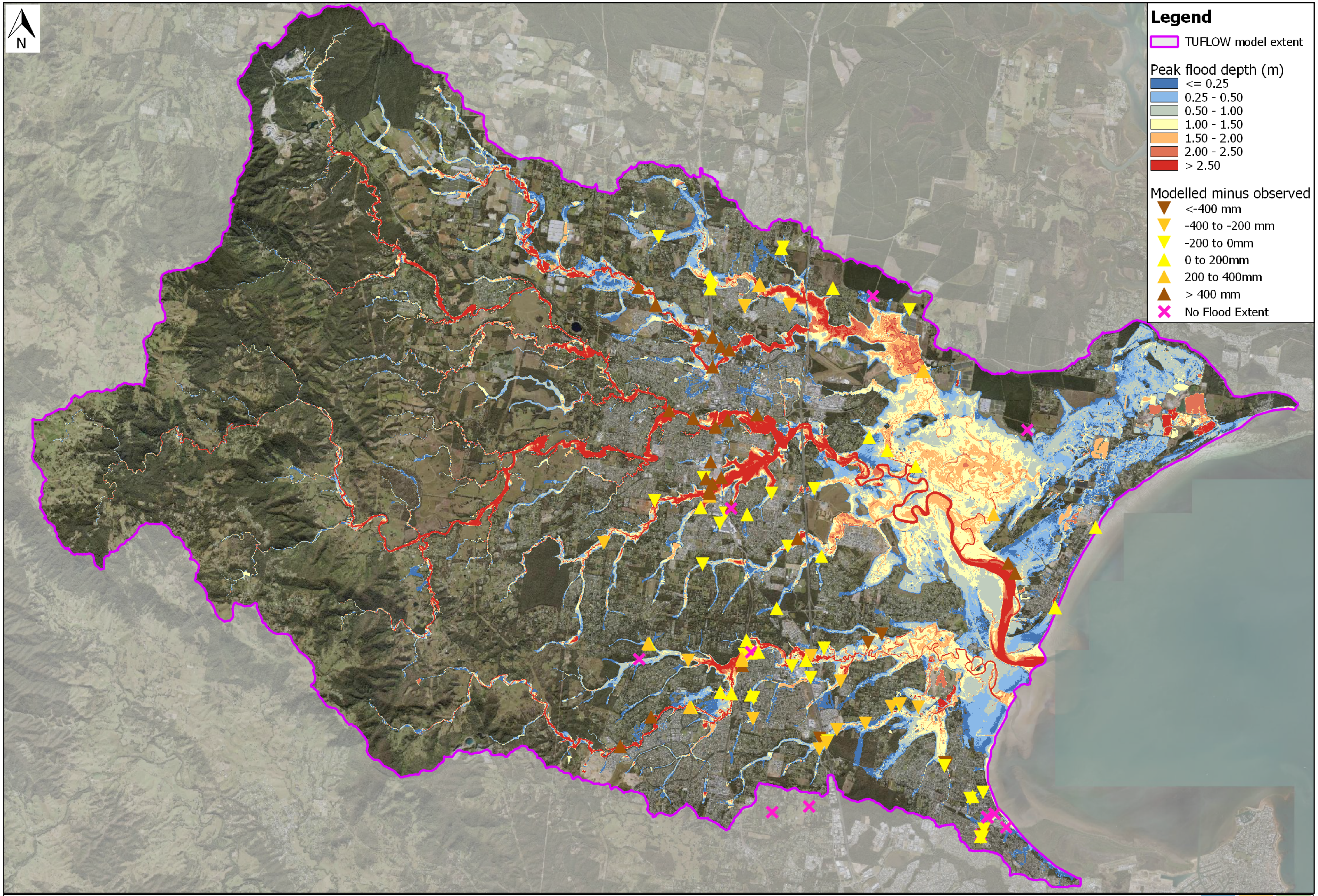

10
8
6
4
2
0
No. of Flood Marks
< -500
-400 to -500
-300 to -400
-200 to -300
-100 to -200
0 to -100
0 to 100
100 to 200
200 to 300
300 to 400
400 to 500
> 500
Difference in levels - modelled minus measured



)7-18T16:03:29.804



30
25
20
15
10
5
0
No. of Flood Marks
< -500
-400 to -500
-300 to -400
-200 to -300
-100 to -200
0 to -100
0 to 100
100 to 200
200 to 300
300 to 400
400 to 500
> 500
Difference in levels - modelled minus measured

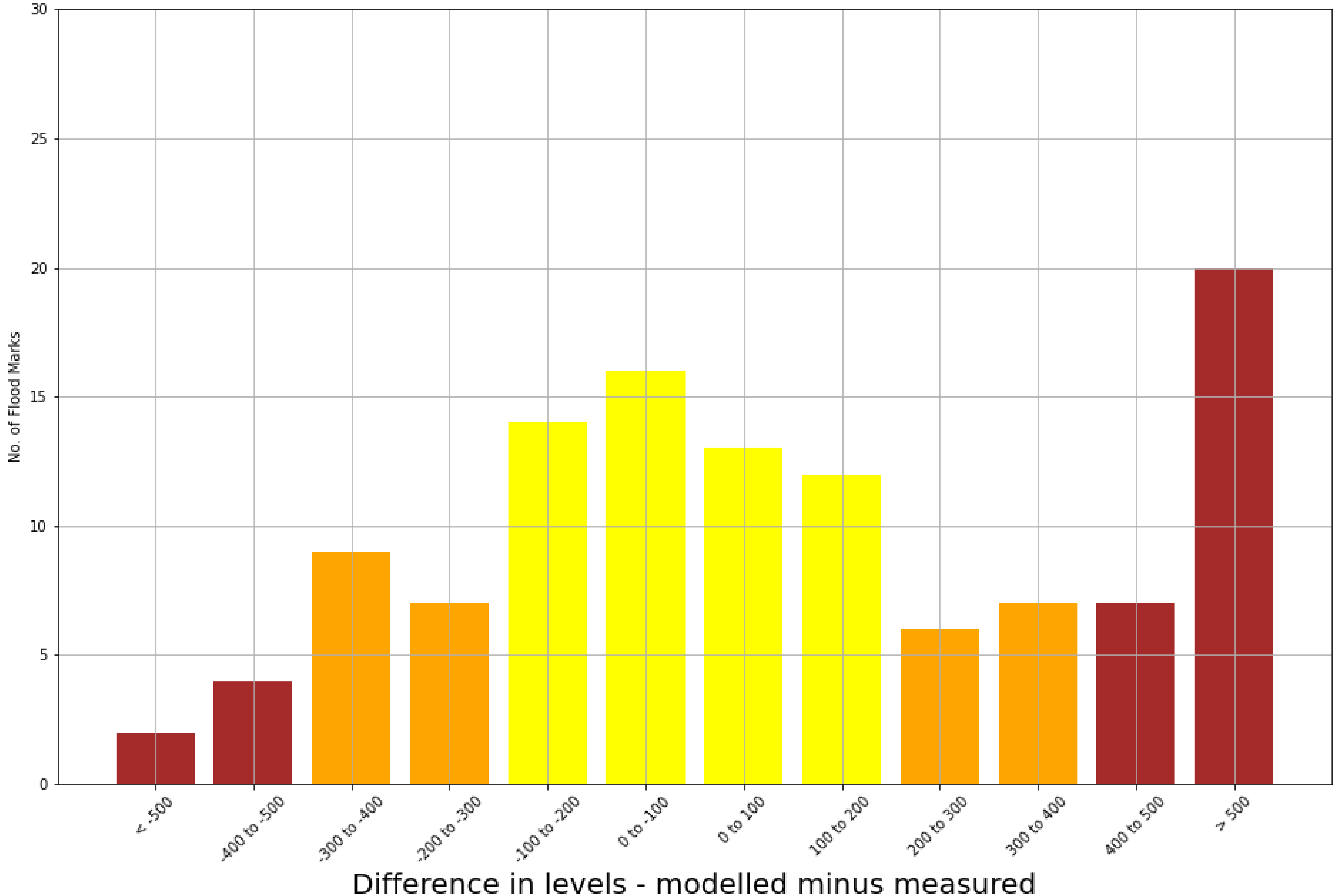


Projection: GDA94/MGA Zone 56
Water Technology Pty Ltd
Imagery Source: Google 2023

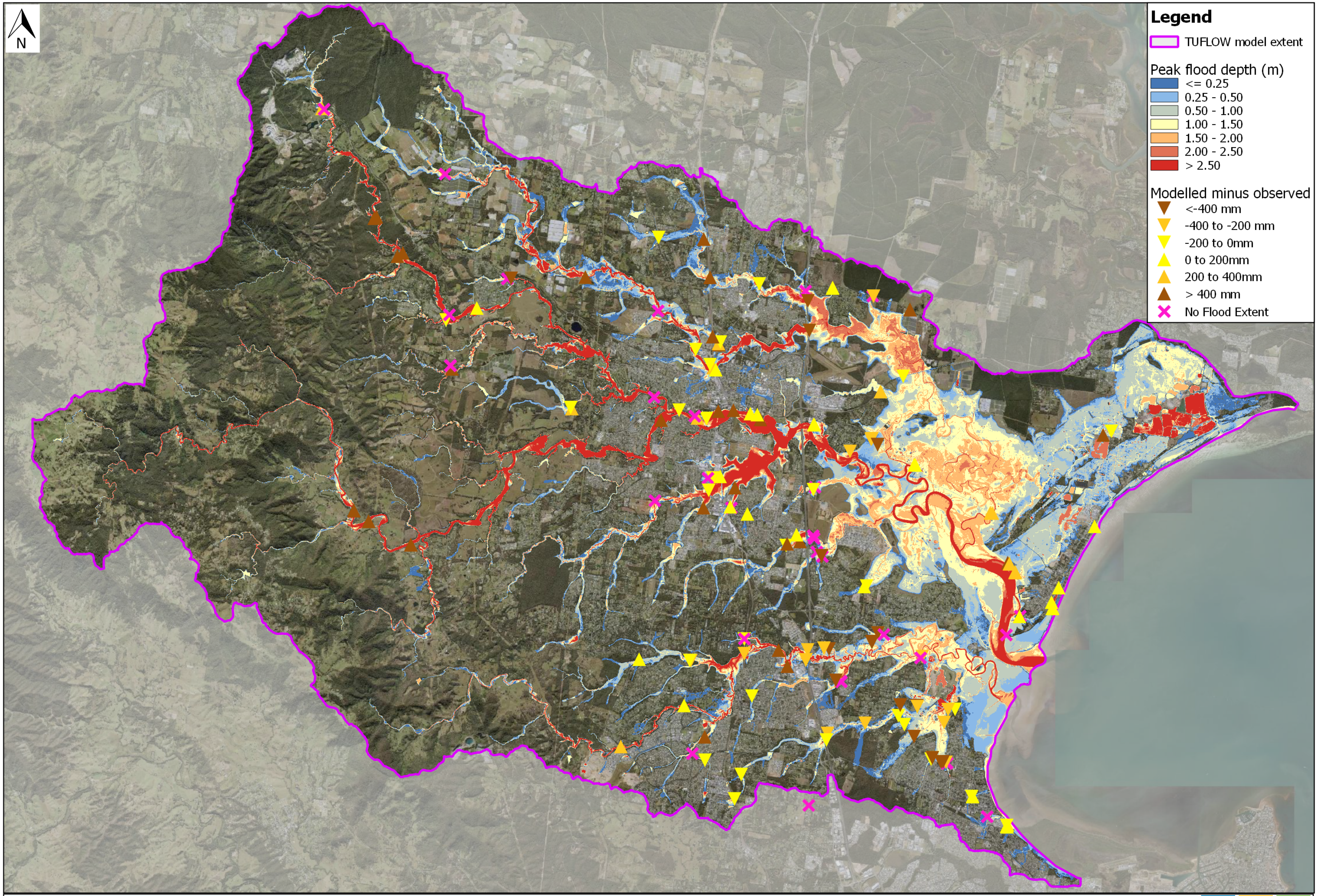
Major Flood Model Updates 2022 - BCR

May 2015 Peak Flood Depth and Debris Comparison

)7-18T16:05:34.730



30
25
20
15
10
5
0
No. of Flood Marks
< -500
-400 to -500
-300 to -400
-200 to -300
-100 to -200
0 to -100
0 to 100
100 to 200
200 to 300
300 to 400
400 to 500
> 500
Difference in levels - modelled minus measured



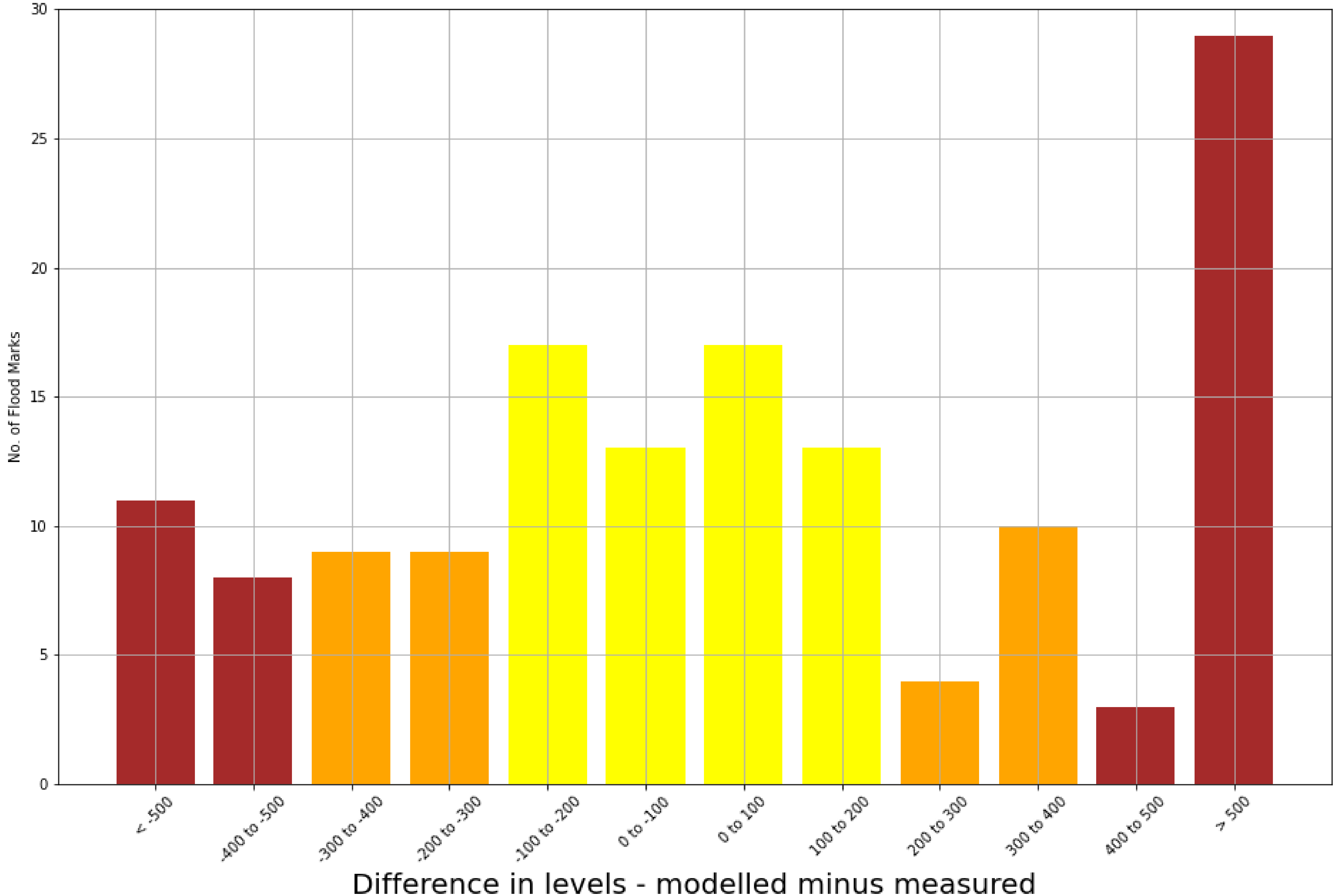
Projection: GDA94/MGA Zone 56
Water Technology Pty Ltd
Imagery Source: Google 2023

Major Flood Model Updates 2022 - BCR

February 2022 Peak Flood Depth and Debris Comparison

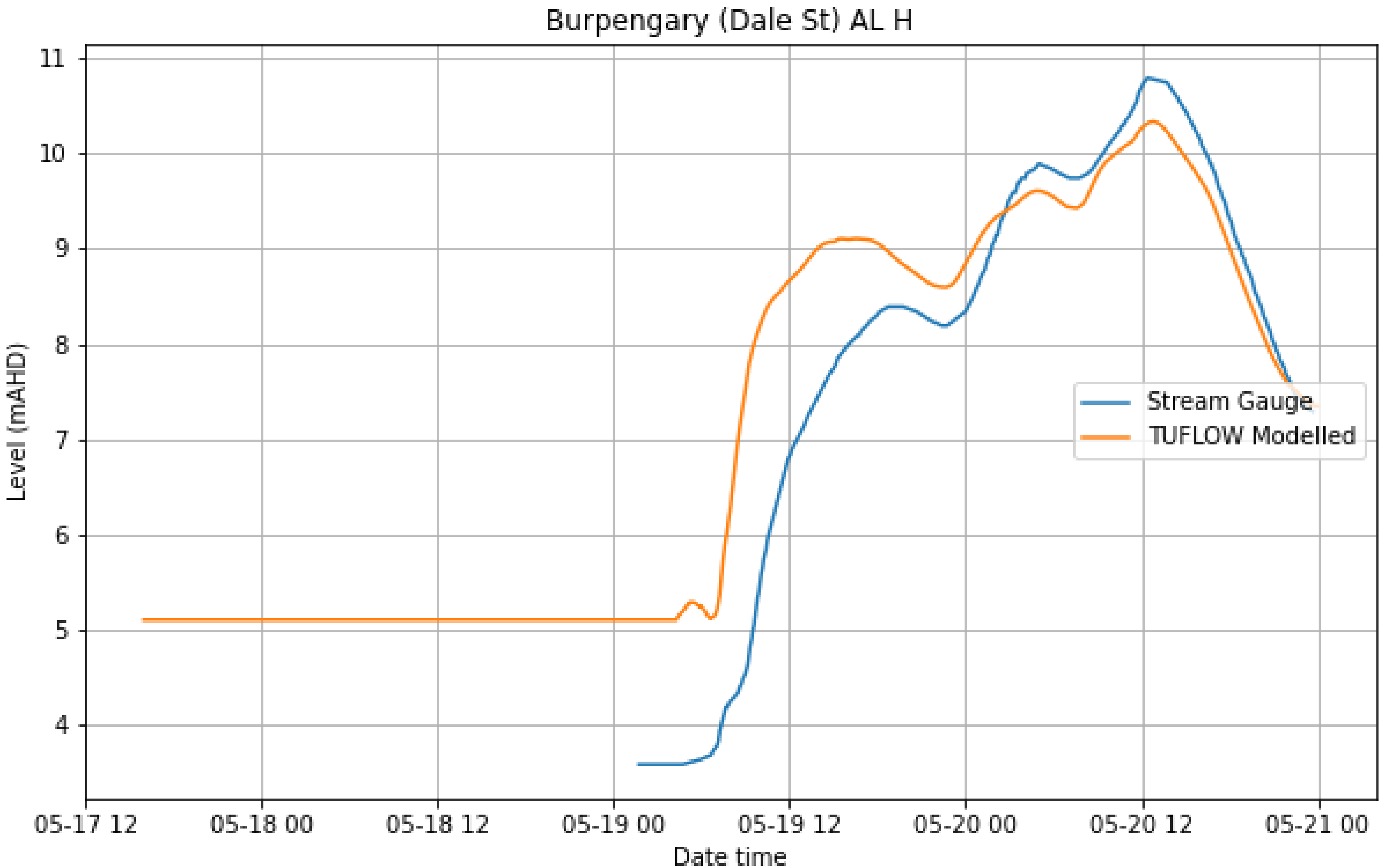
WATER TECHNOLOGY

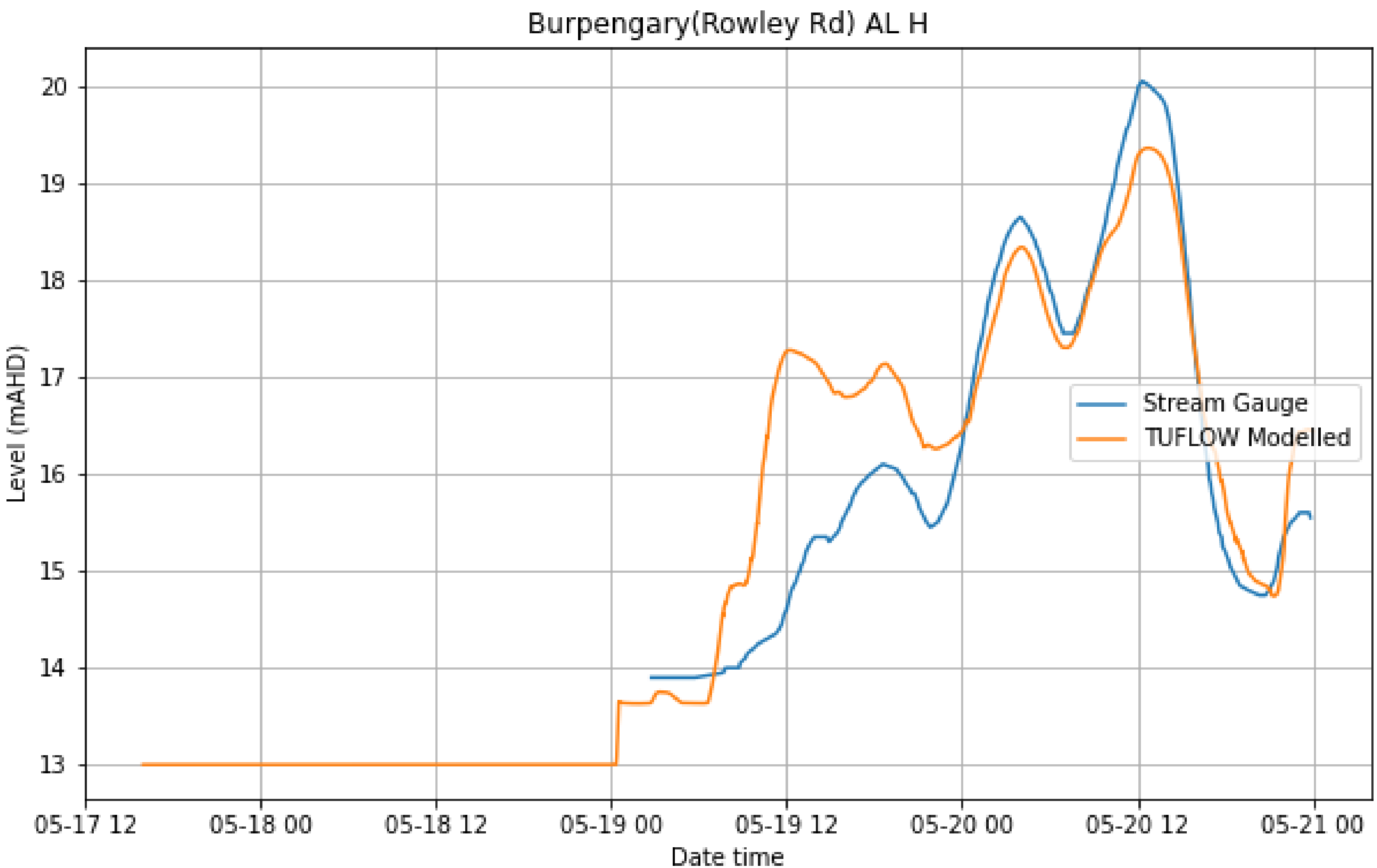
)7-18T16:06:39.964

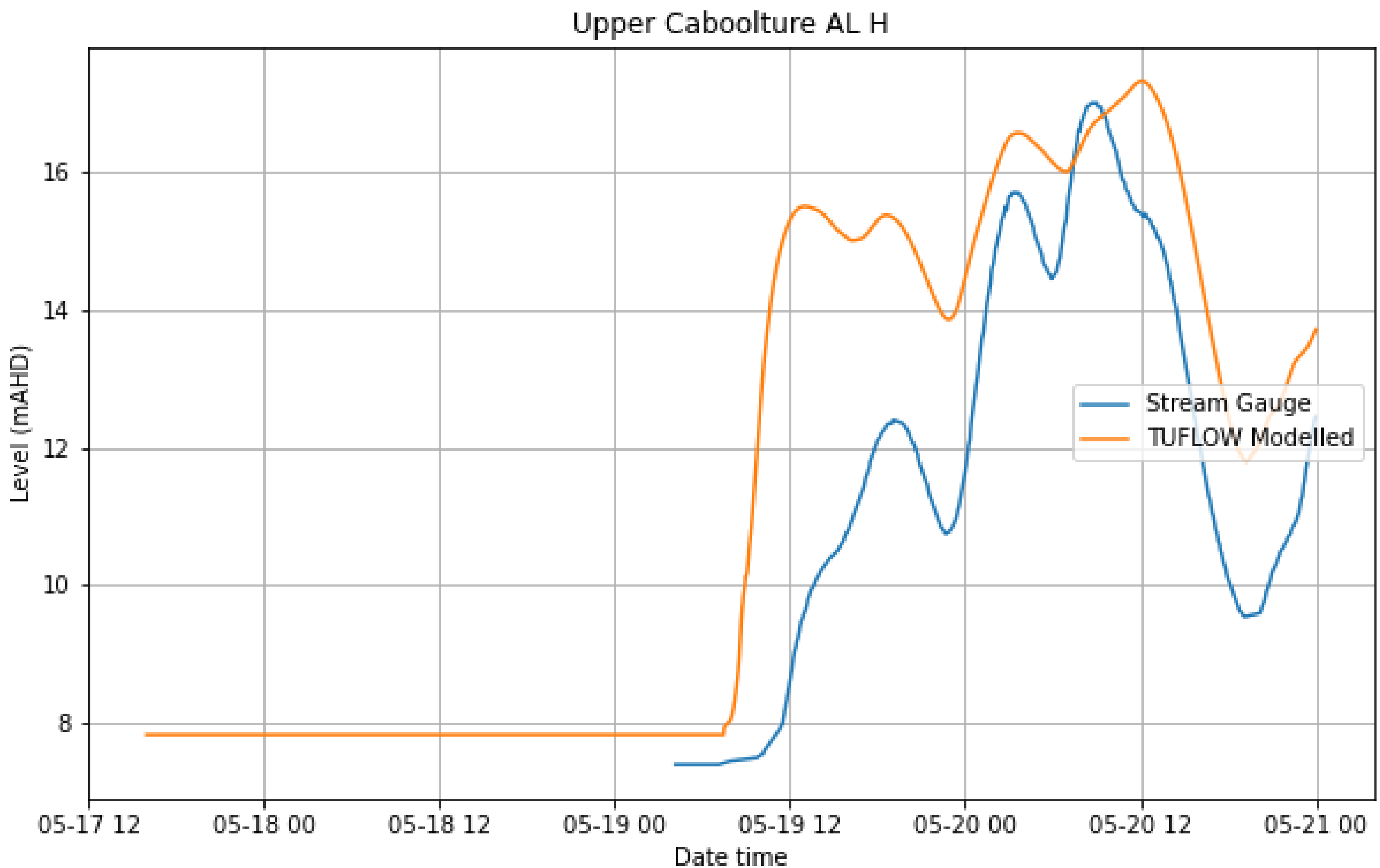


30
25
20
15
10
5
0
No. of Flood Marks
< -500
-400 to -500
-300 to -400
-200 to -300
-100 to -200
0 to -100
0 to 100
100 to 200
200 to 300
300 to 400
400 to 500
> 500
Difference in levels - modelled minus measured

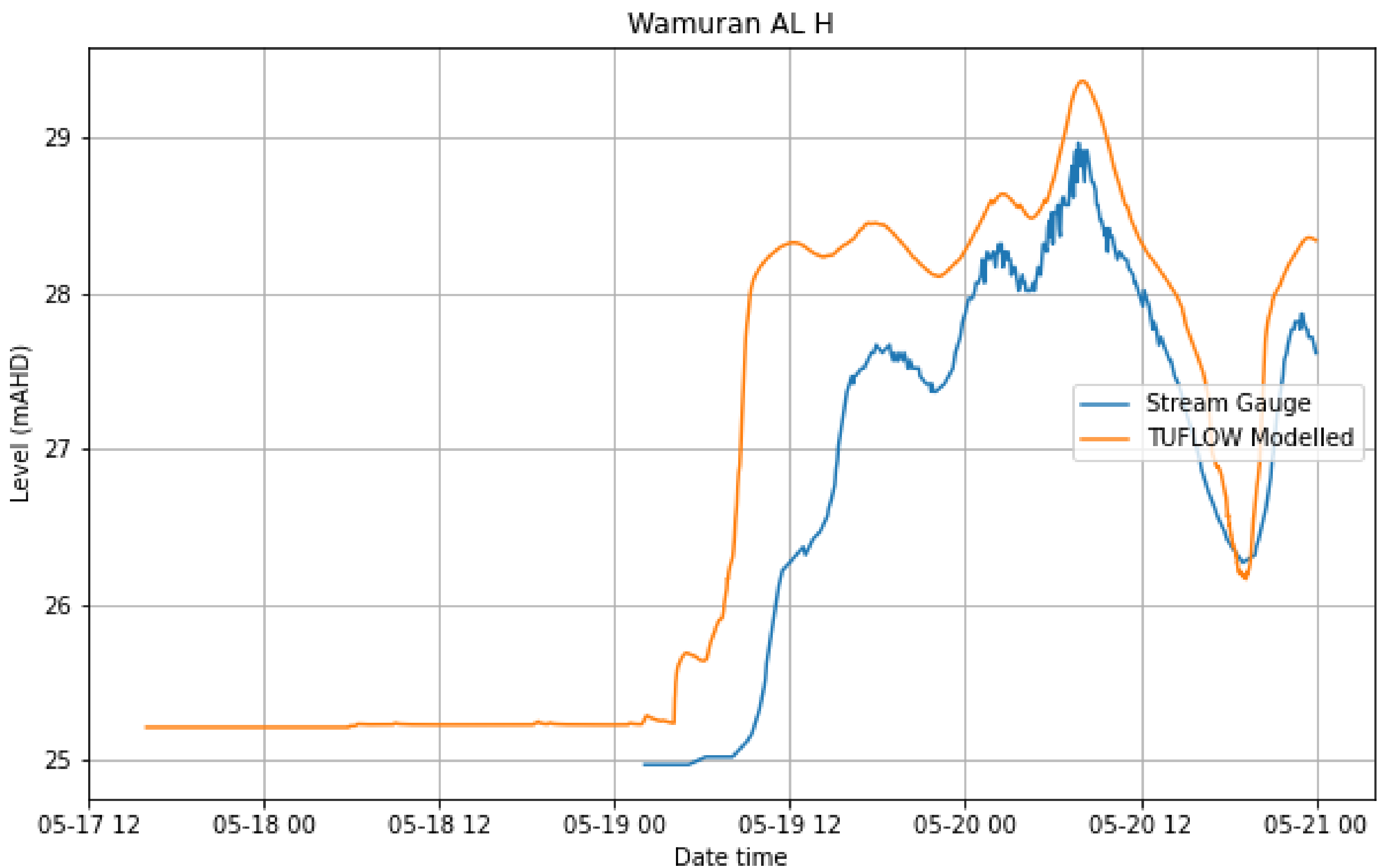
APPENDIX D
MAY 2009 – CALIBRATION PLOTS


Burpengary (Dale St) AL H
Level (mAHD)
11
10
9
8
7
6
5
4
05-17 12
05-18 00
05-18 12
05-19 00
05-19 12
05-20 00
05-20 12
05-21 00
Date time
Stream Gauge
TUFLOW Modelled


Burpengary(Rowley Rd) AL H
Level (mAHD)
20
19
18
17
16
15
14
13
05-17 12
05-18 00
05-18 12
05-19 00
05-19 12
05-20 00
05-20 12
05-21 00
Date time
Stream Gauge
TUFLOW Modelled

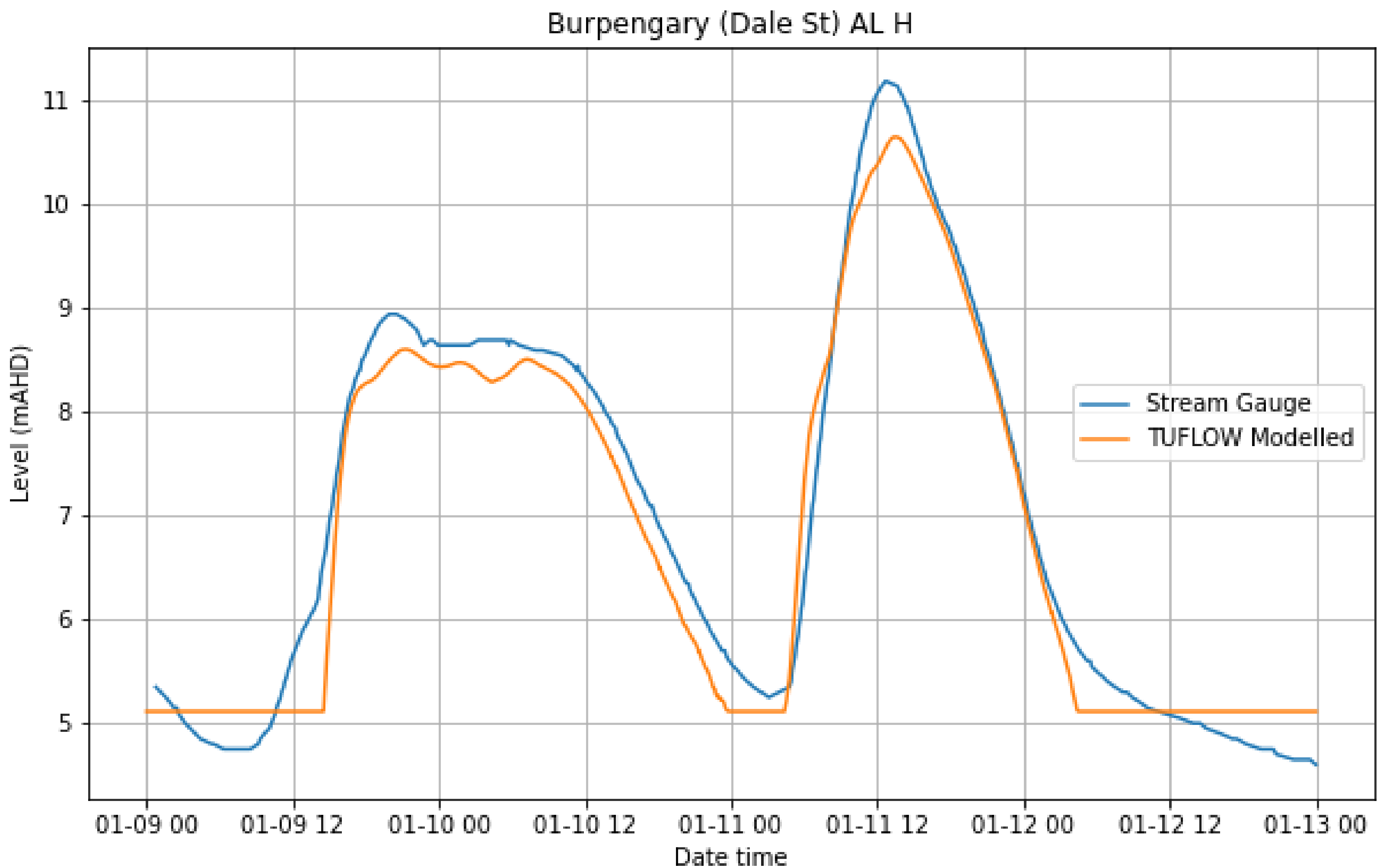


Upper Caboolture AL H
Level (mAHD)
16
14
12
10
8
05-17 12
05-18 00
05-18 12
05-19 00
05-19 12
05-20 00
05-20 12
05-21 00
Date time
Stream Gauge
TUFLOW Modelled

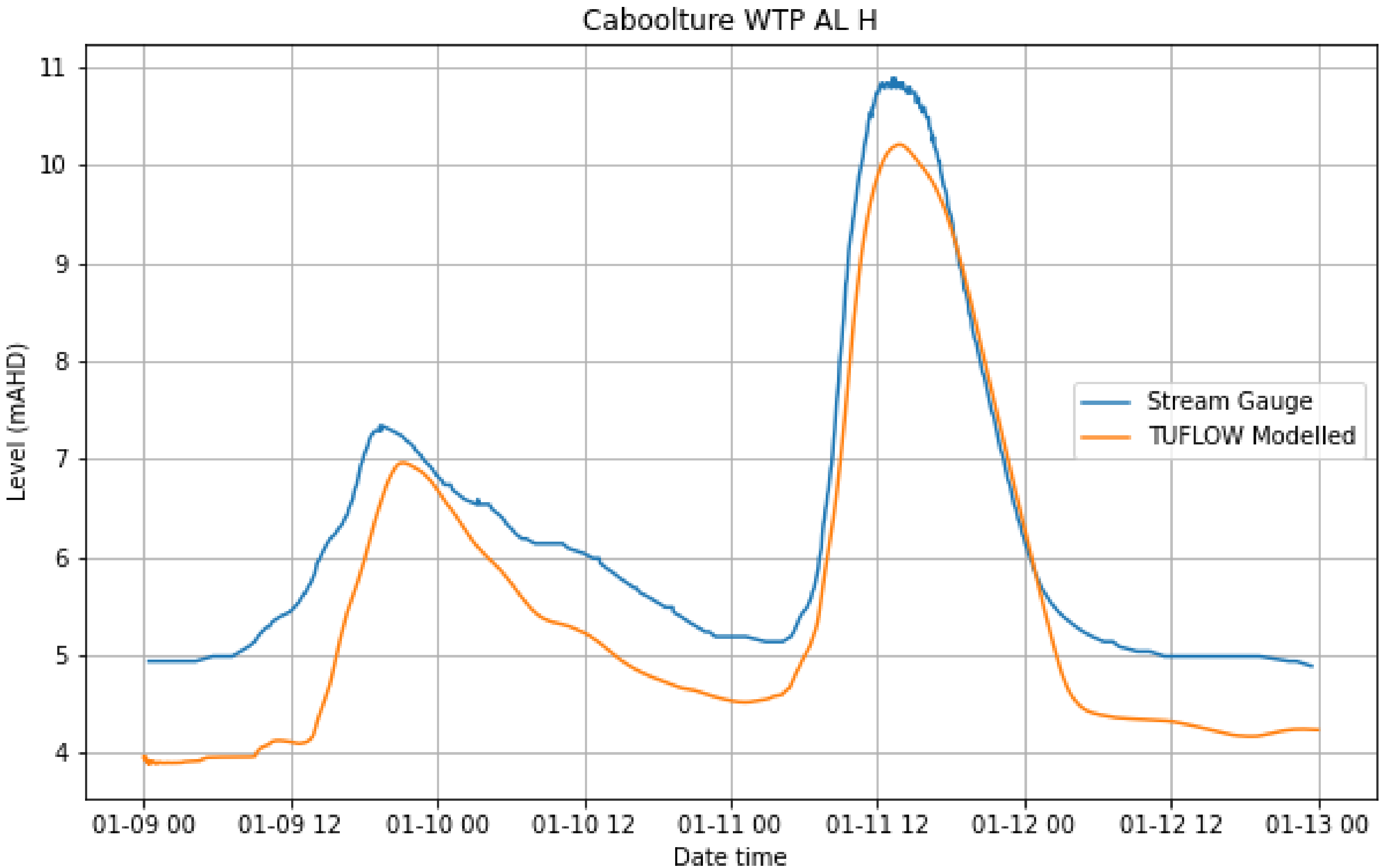


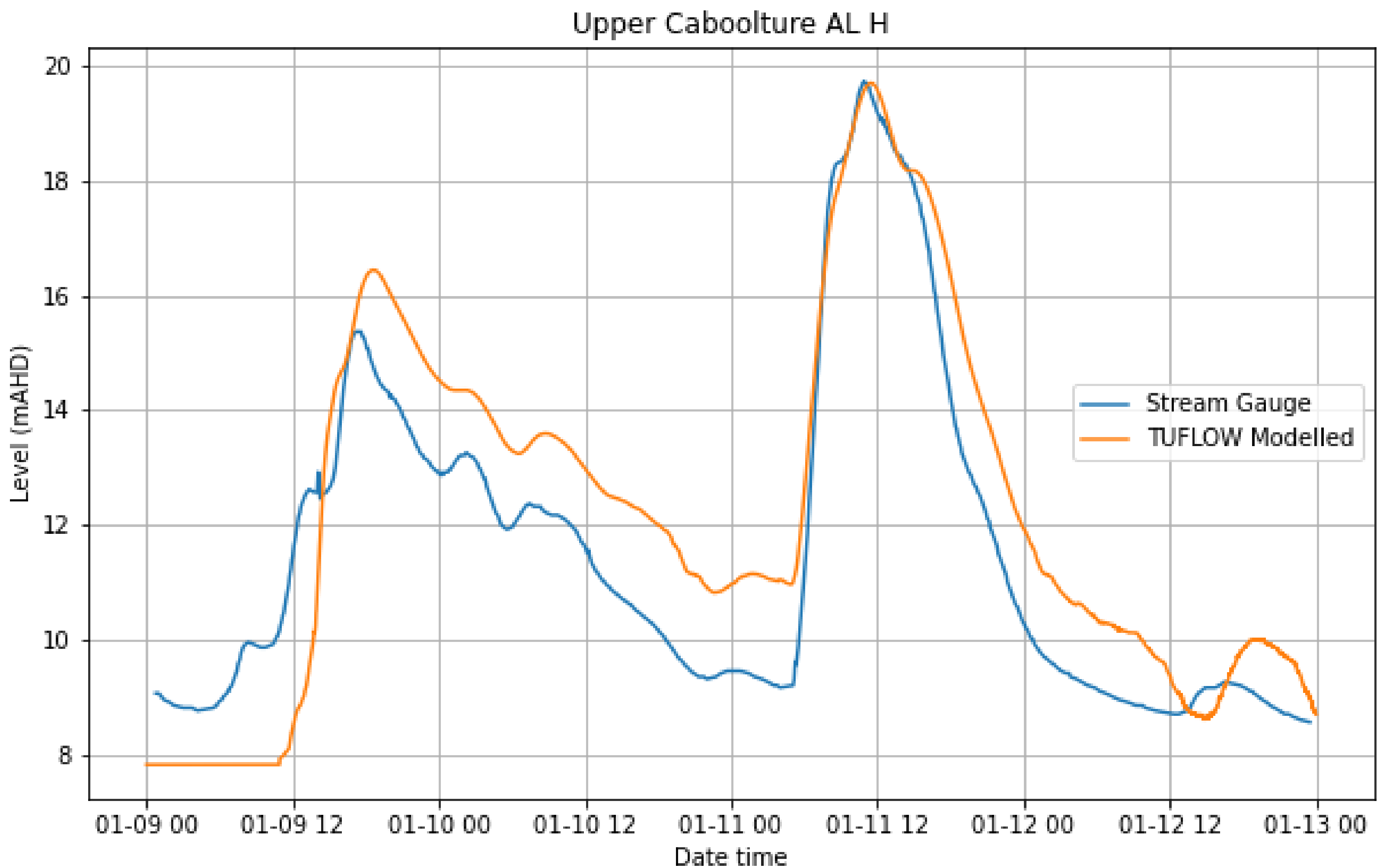
Wamuran AL H
Level (mAHD)
29
28
27
26
25
05-17 12
05-18 00
05-18 12
05-19 00
05-19 12
05-20 00
05-20 12
05-21 00
Date time
Stream Gauge
TUFLOW Modelled

APPENDIX E
JAN 2011 – CALIBRATION PLOTS

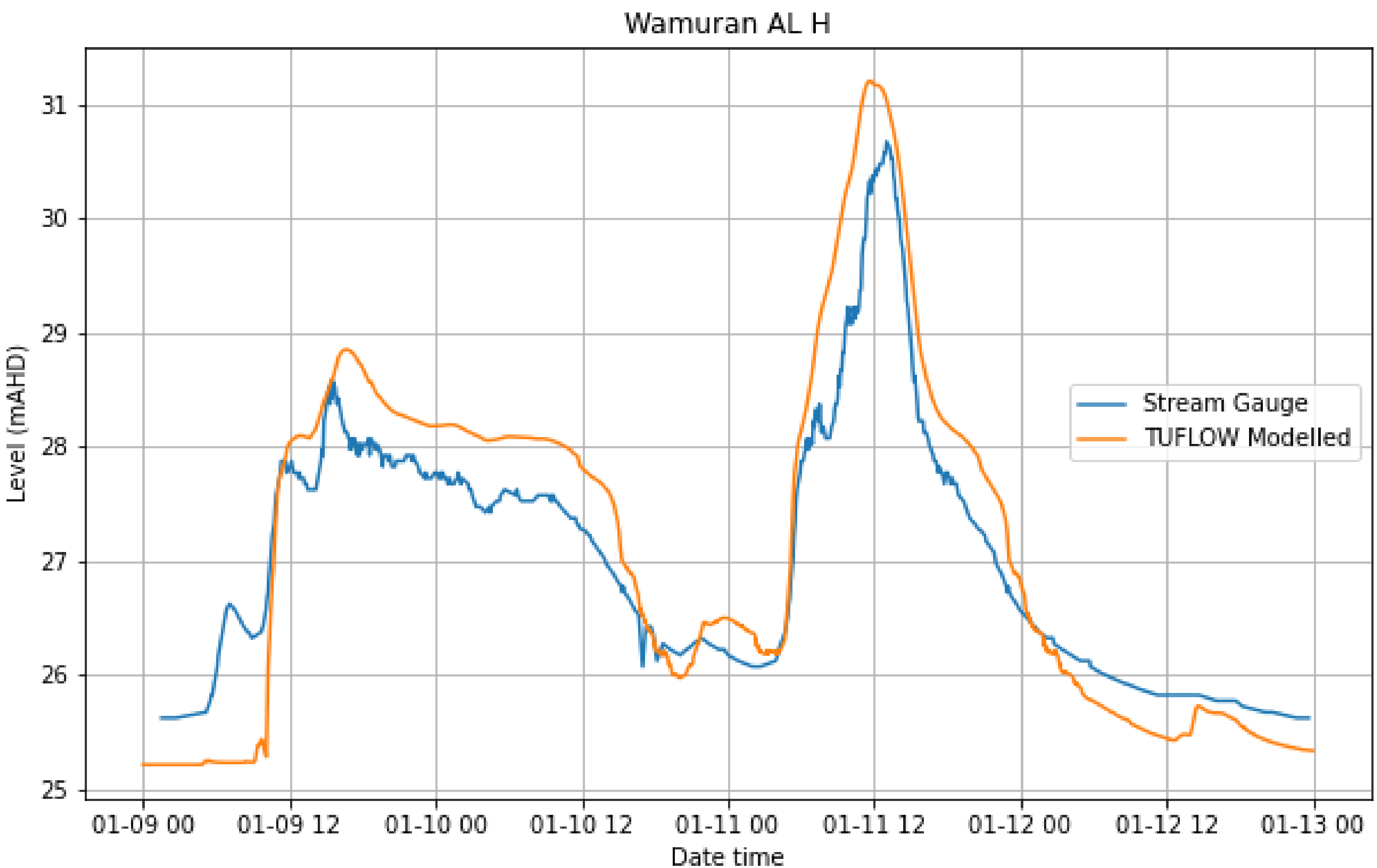


Burpengary (Dale St) AL H
Level (mAHD)
11
10
9
8
7
6
5
01-09 00
01-09 12
01-10 00
01-10 12
01-11 00
01-11 12
01-12 00
01-12 12
01-13 00
Date time
Stream Gauge
TUFLOW Modelled


Caboolture WTP AL H
Level (mAHD)
11
10
9
8
7
6
5
4
01-09 00
01-09 12
01-10 00
01-10 12
01-11 00
01-11 12
01-12 00
01-12 12
01-13 00
Date time
Stream Gauge
TUFLOW Modelled

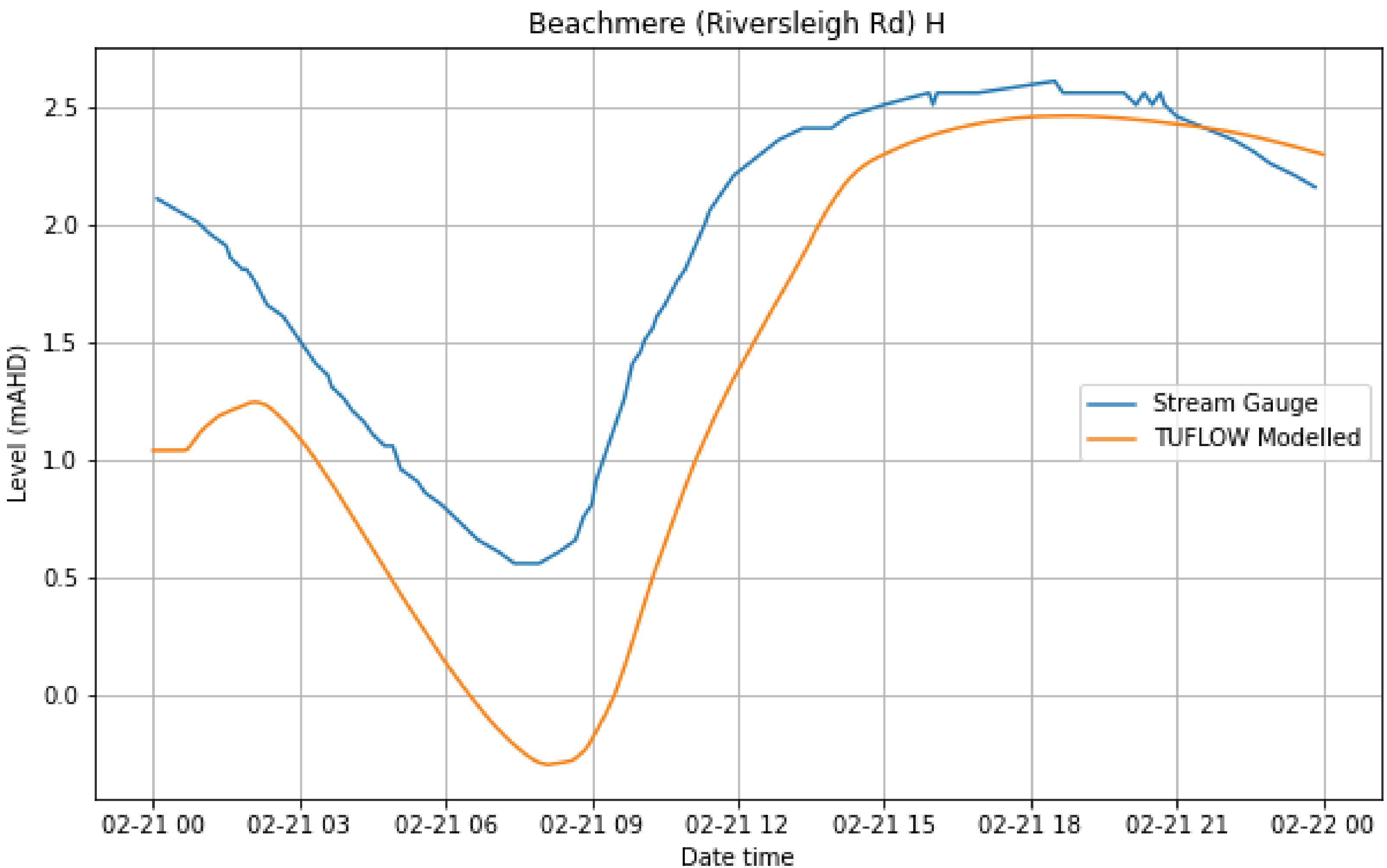


Upper Caboolture AL H
Level (mAHD)
20
18
16
14
12
10
8
01-09 00
01-09 12
01-10 00
01-10 12
01-11 00
01-11 12
01-12 00
01-12 12
01-13 00
Date time
Stream Gauge
TUFLOW Modelled

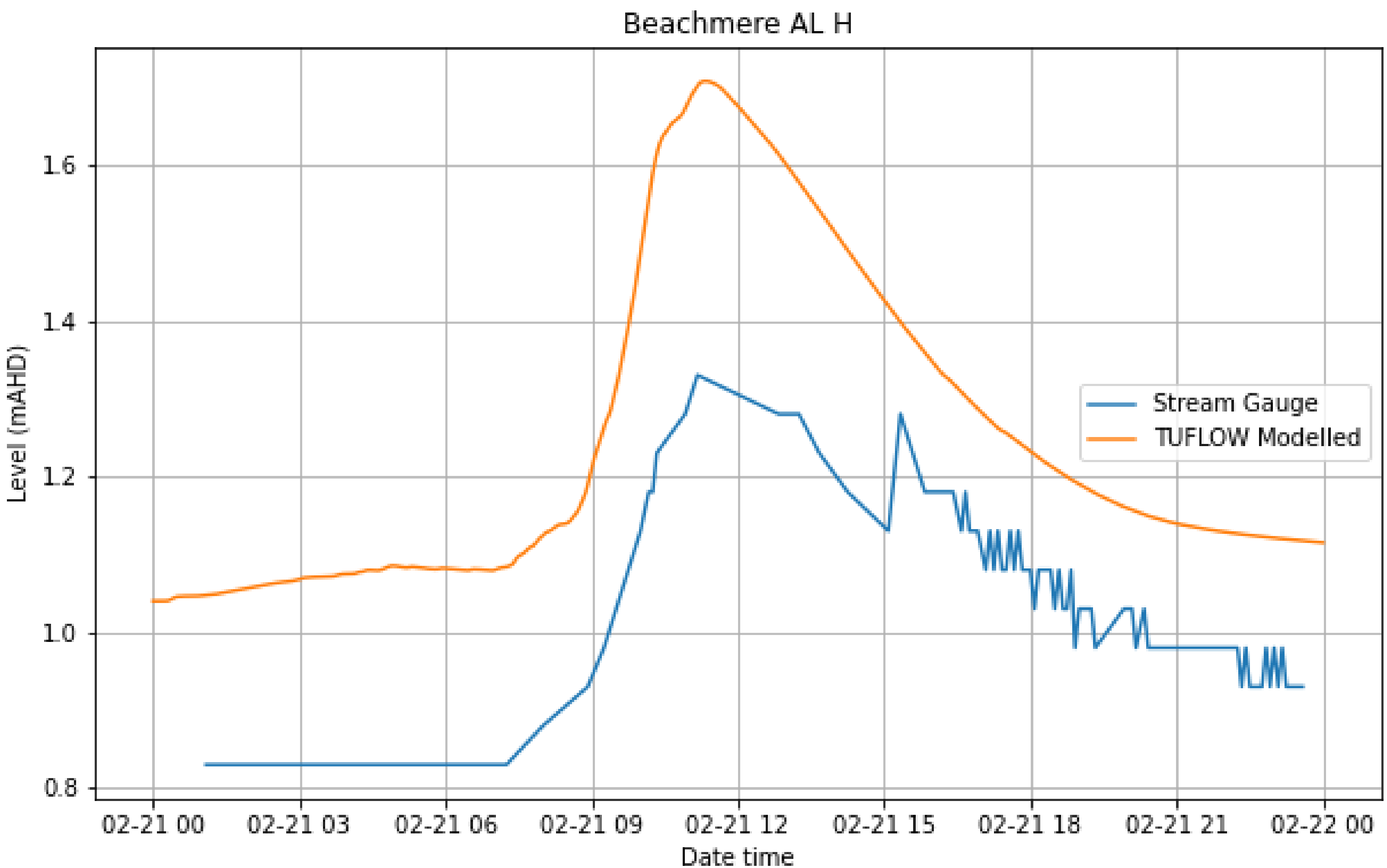


Wamuran AL H
Level (mAHD)
25
26
27
28
29
30
31
Date time
01-09 00
01-09 12
01-10 00
01-10 12
01-11 00
01-11 12
01-12 00
01-12 12
01-13 00
Stream Gauge
TUFLOW Modelled

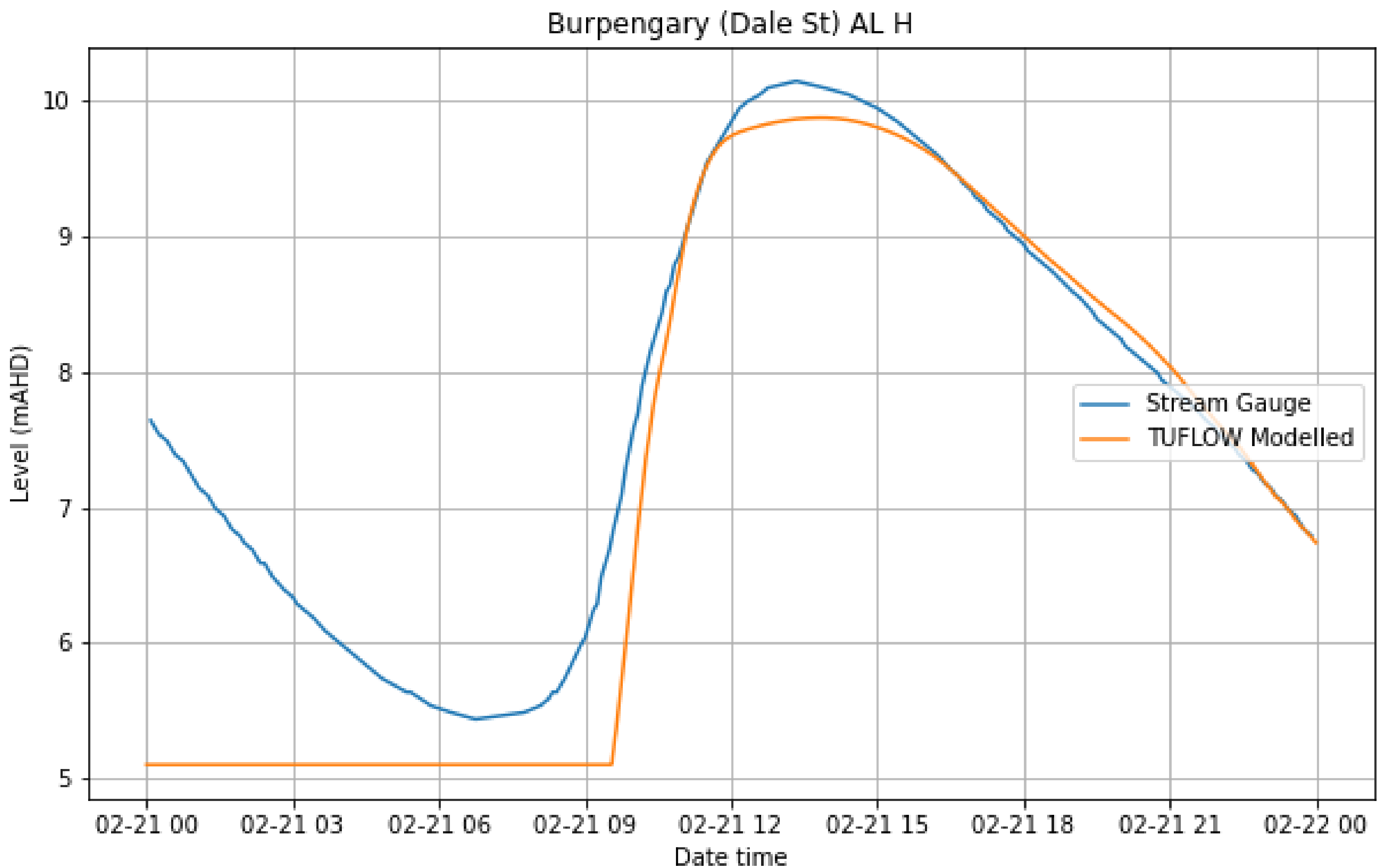
APPENDIX F
FEB 2015 – CALIBRATION PLOTS



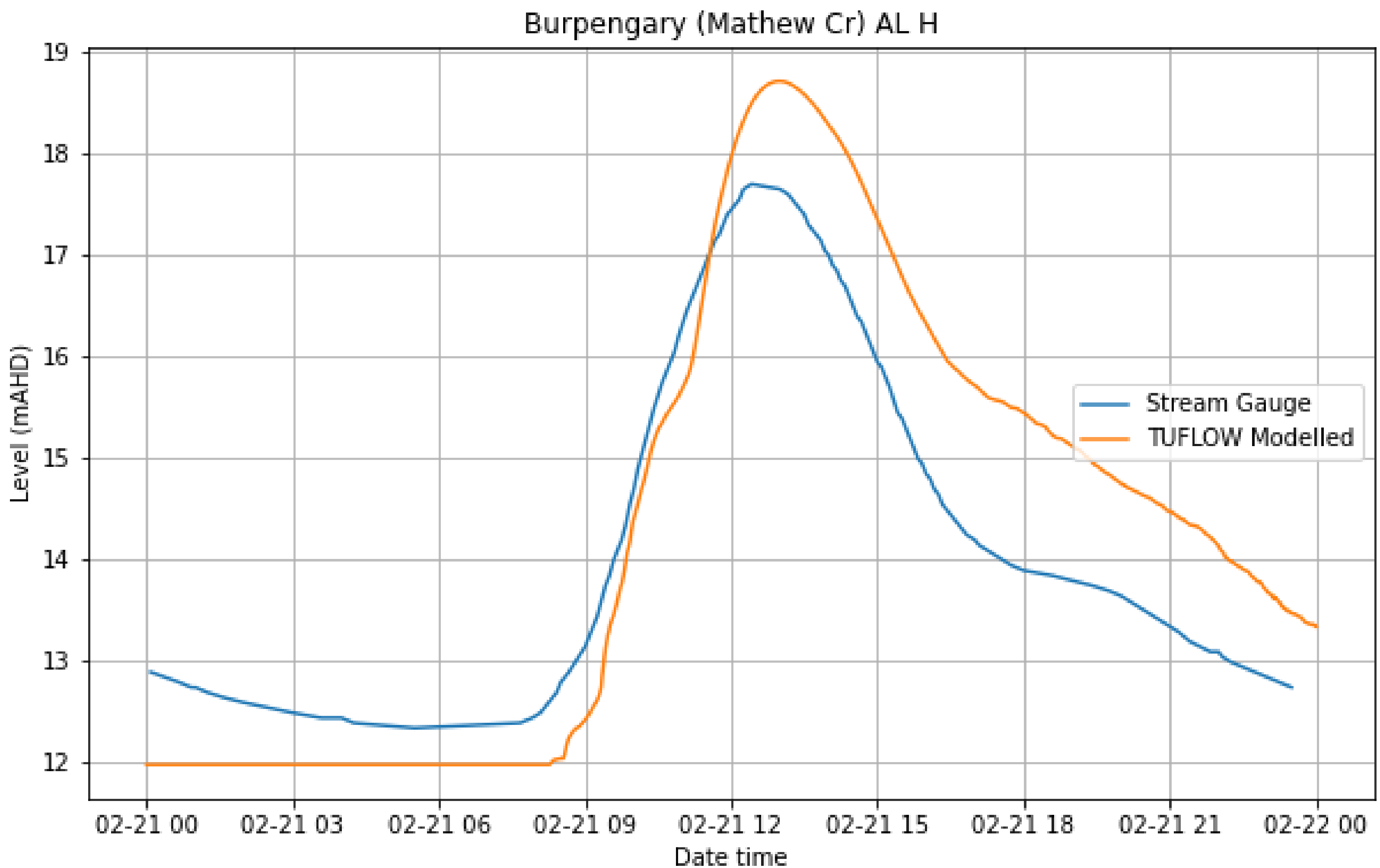
Beachmere (Riversleigh Rd) H
Level (mAHD)
2.5
2.0
1.5
1.0
0.5
0.0
Stream Gauge
TUFLOW Modelled
02-21 00
02-21 03
02-21 06
02-21 09
02-21 12
02-21 15
02-21 18
02-21 21
02-22 00
Date time



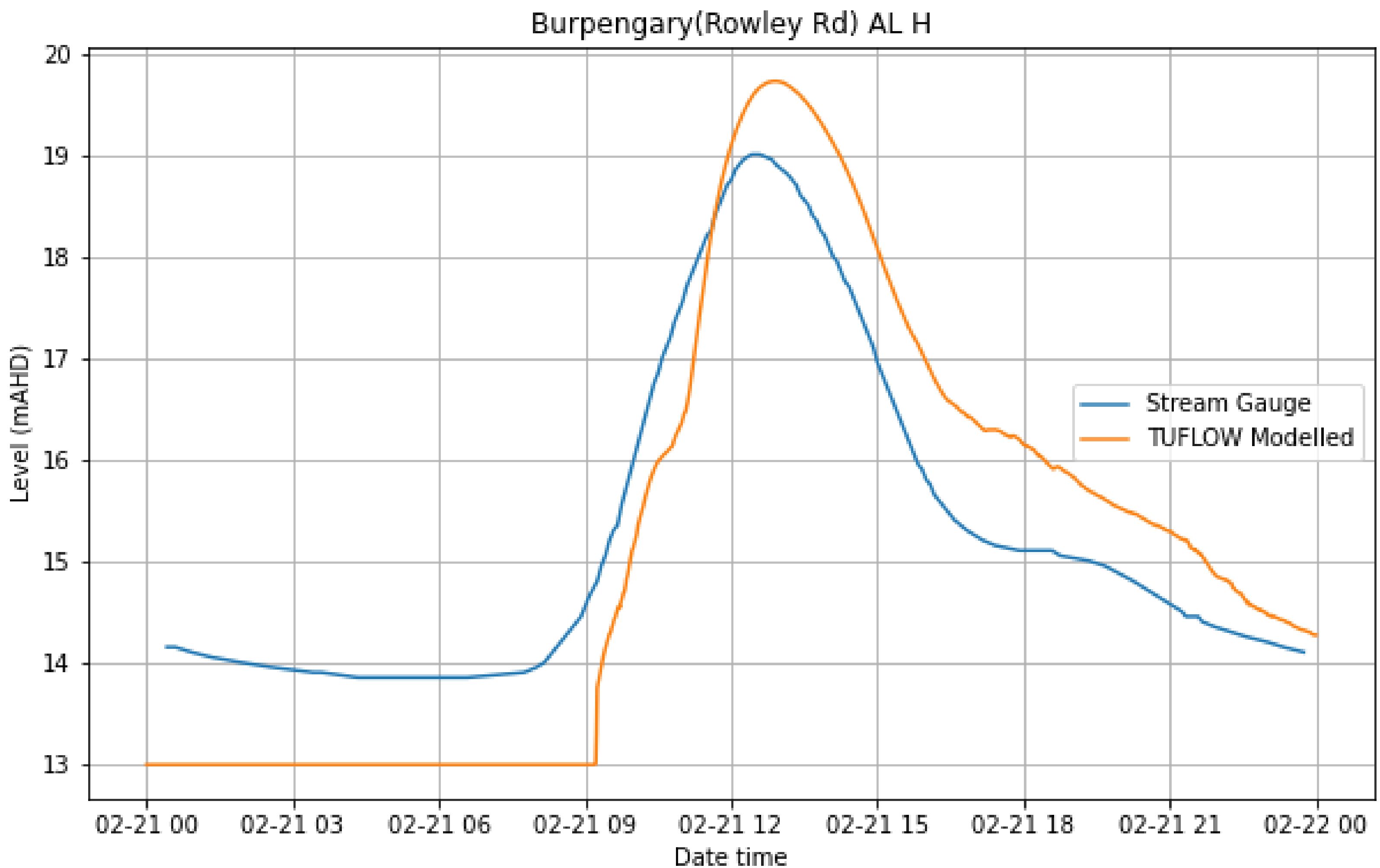
Beachmere AL H
Level (mAHD)
1.6
1.4
1.2
1.0
0.8
02-21 00
02-21 03
02-21 06
02-21 09
02-21 12
02-21 15
02-21 18
02-21 21
02-22 00
Date time
Stream Gauge
TUFLOW Modelled



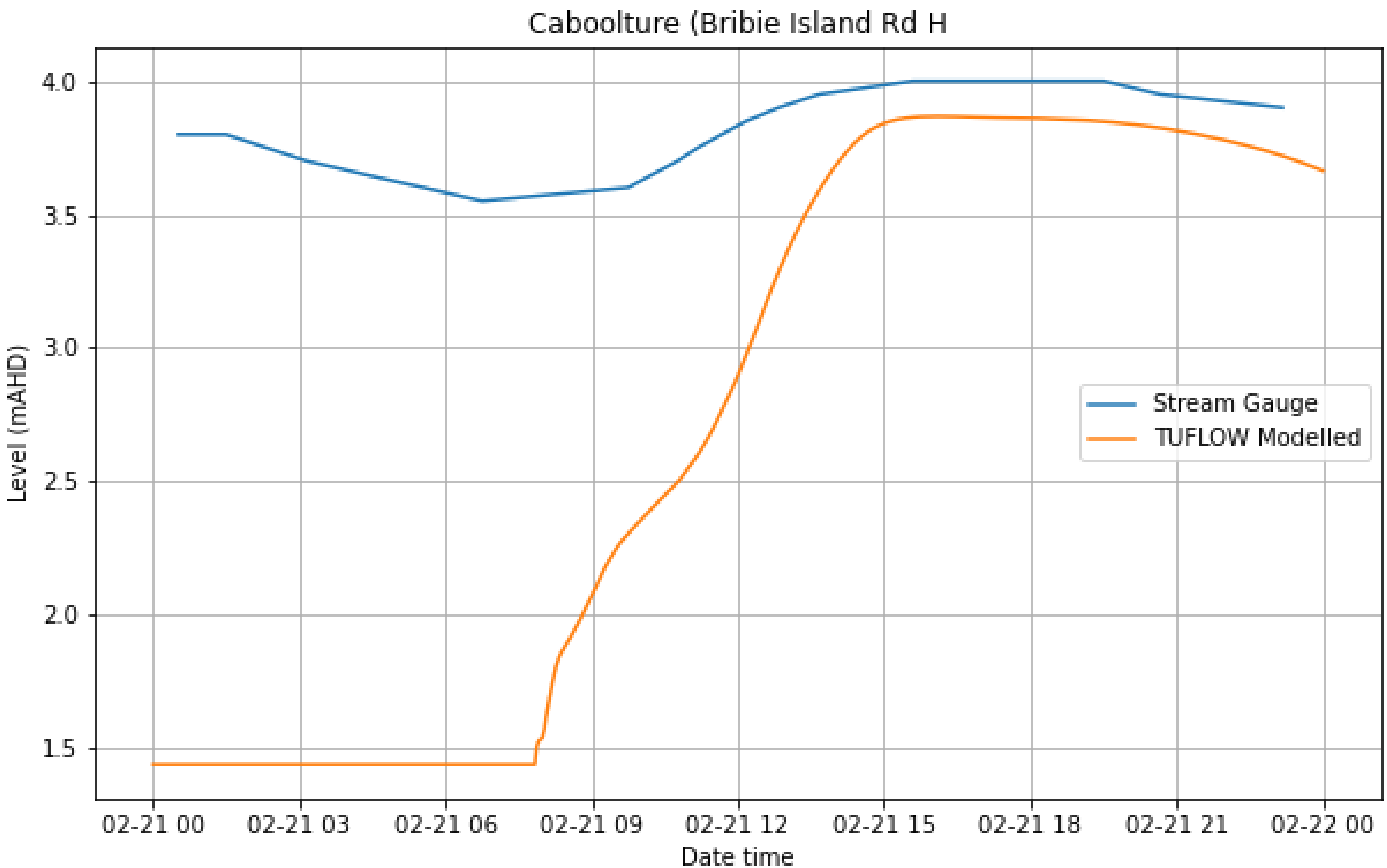
Burpengary (Dale St) AL H
Level (mAHD)
10
9
8
7
6
5
02-21 00
02-21 03
02-21 06
02-21 09
02-21 12
02-21 15
02-21 18
02-21 21
02-22 00
Date time
Stream Gauge
TUFLOW Modelled



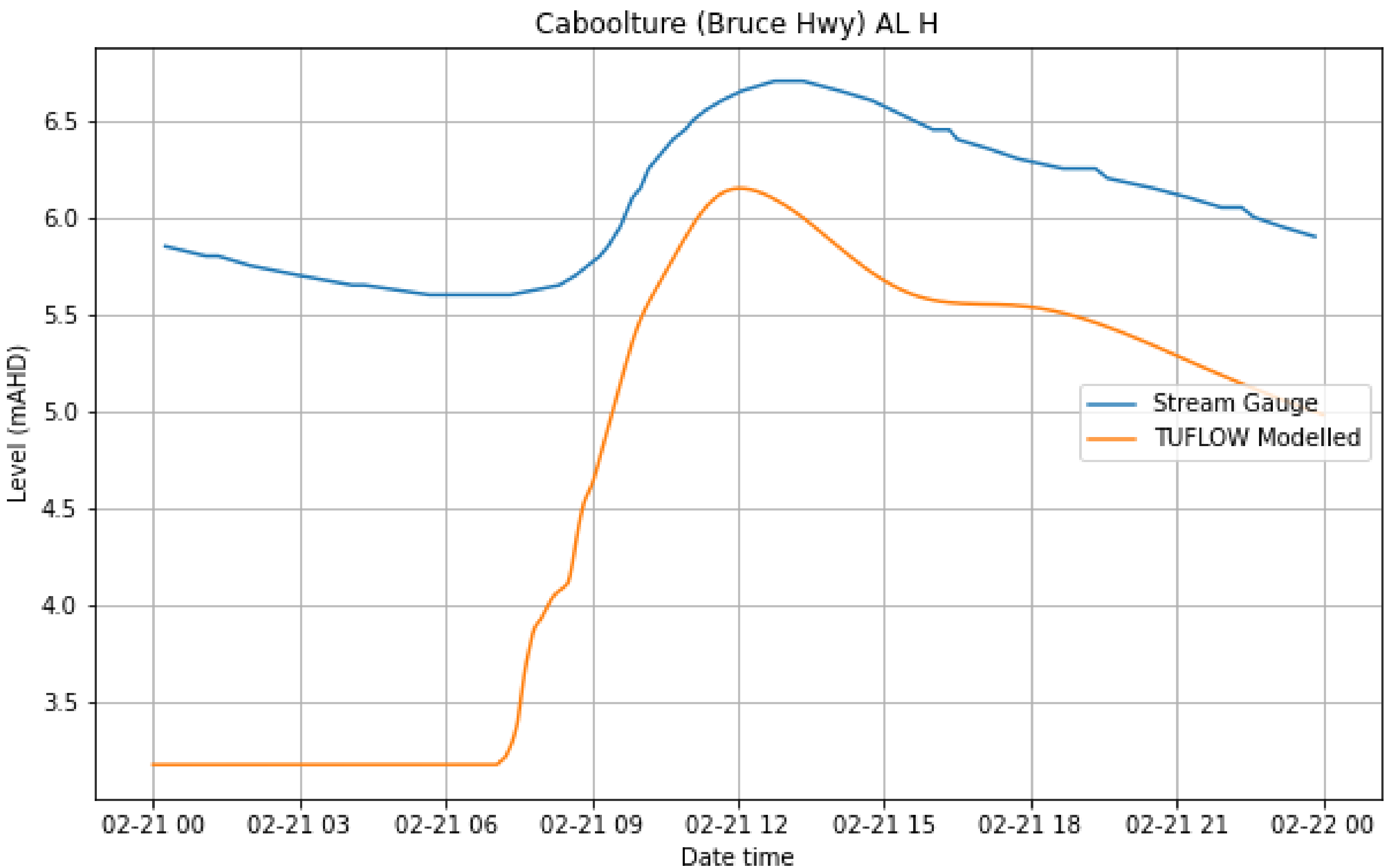
Burpengary (Mathew Cr) AL H
Level (mAHD)
19
18
17
16
15
14
13
12
02-21 00
02-21 03
02-21 06
02-21 09
02-21 12
02-21 15
02-21 18
02-21 21
02-22 00
Date time
Stream Gauge
TUFLOW Modelled



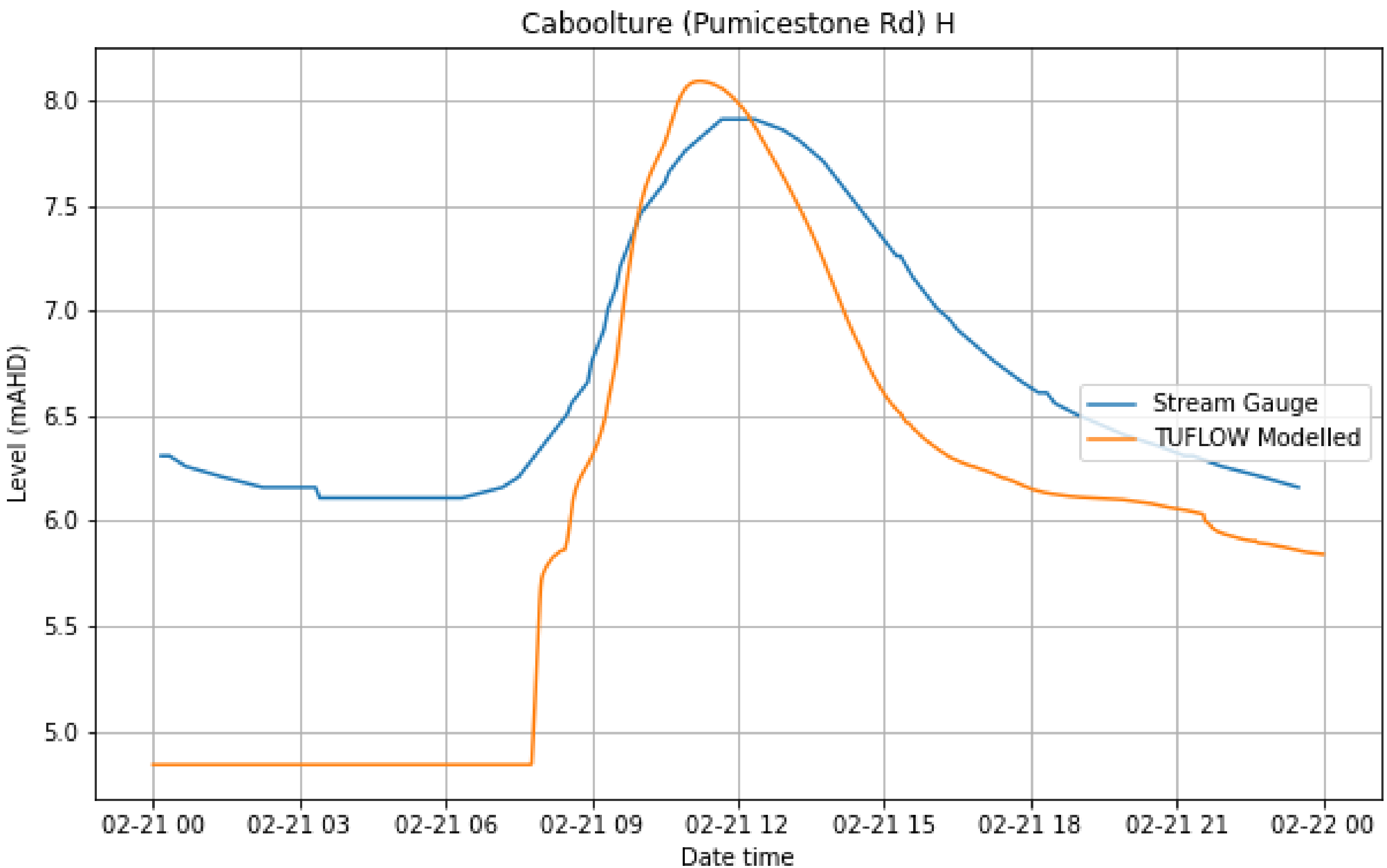
Burpengary(Rowley Rd) AL H
Level (mAHD)
20
19
18
17
16
15
14
13
02-21 00
02-21 03
02-21 06
02-21 09
02-21 12
02-21 15
02-21 18
02-21 21
02-22 00
Date time
Stream Gauge
TUFLOW Modelled

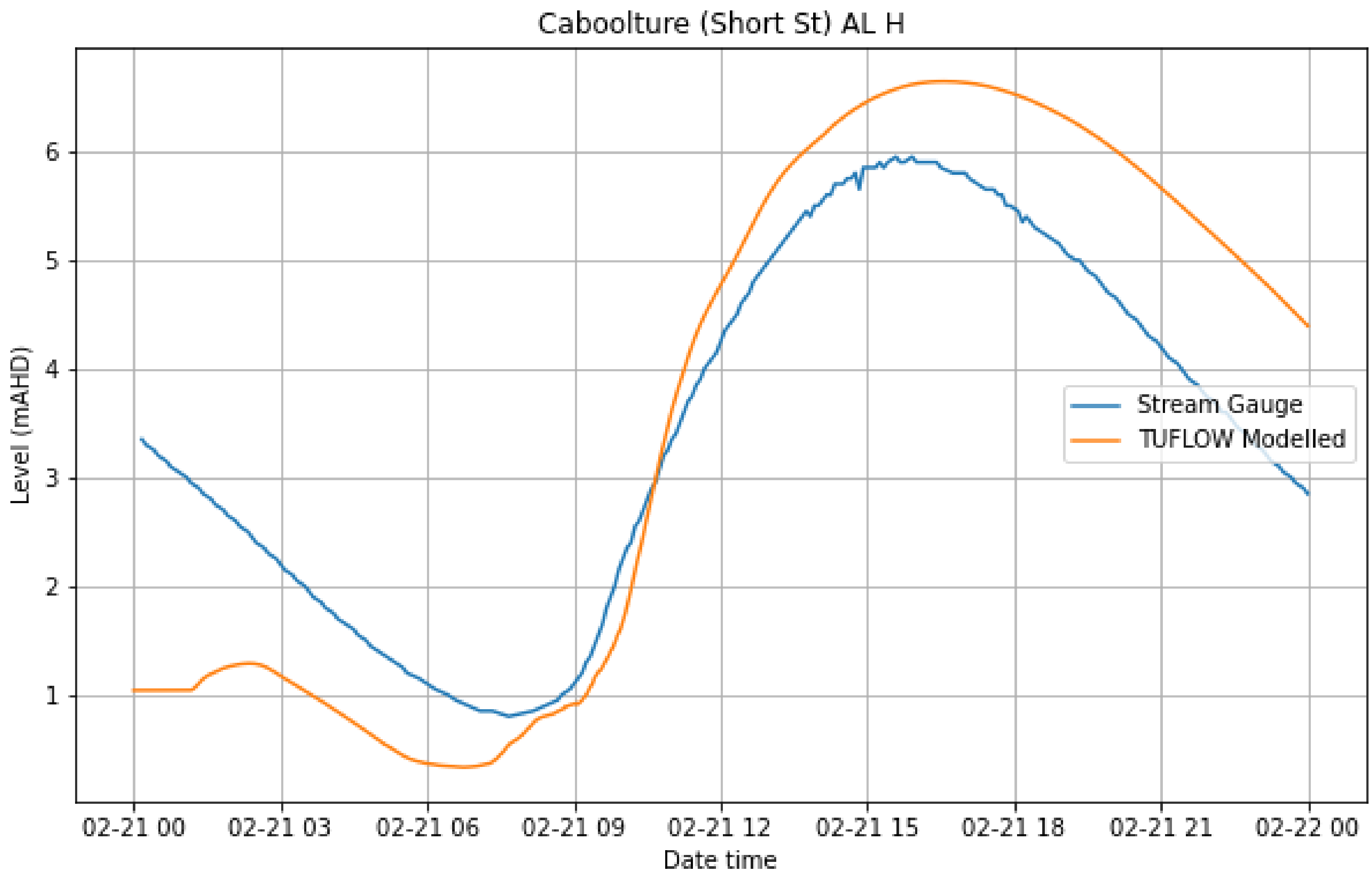


Caboolture (Bribie Island Rd H
Level (mAHD)
4.0
3.5
3.0
2.5
2.0
1.5
02-21 00
02-21 03
02-21 06
02-21 09
02-21 12
02-21 15
02-21 18
02-21 21
02-22 00
Date time
Stream Gauge
TUFLOW Modelled

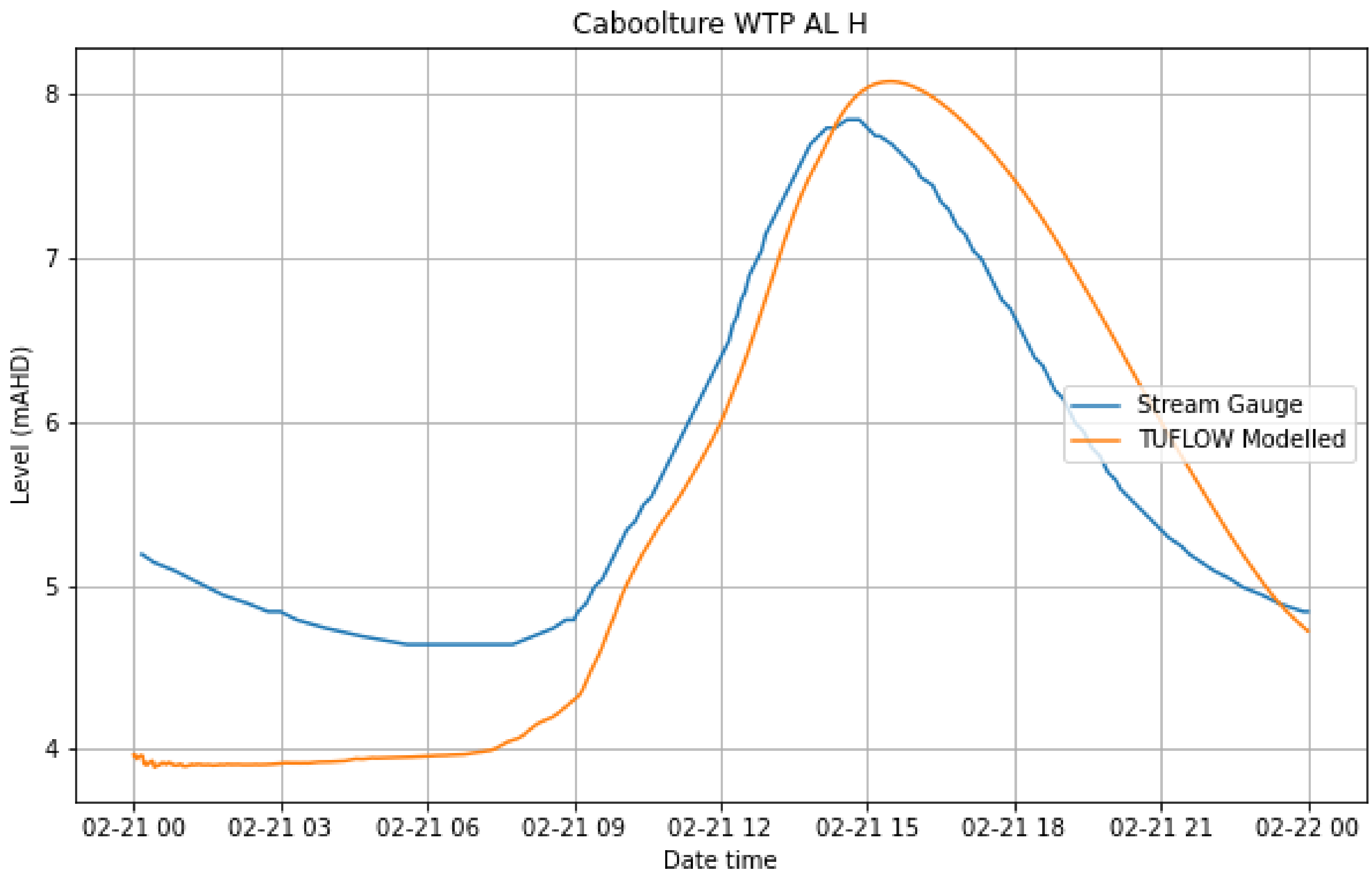


Caboolture (Bruce Hwy) AL H
Level (mAHD)
6.5
6.0
5.5
5.0
4.5
4.0
3.5
02-21 00
02-21 03
02-21 06
02-21 09
02-21 12
02-21 15
02-21 18
02-21 21
02-22 00
Date time
Stream Gauge
TUFLOW Modelled

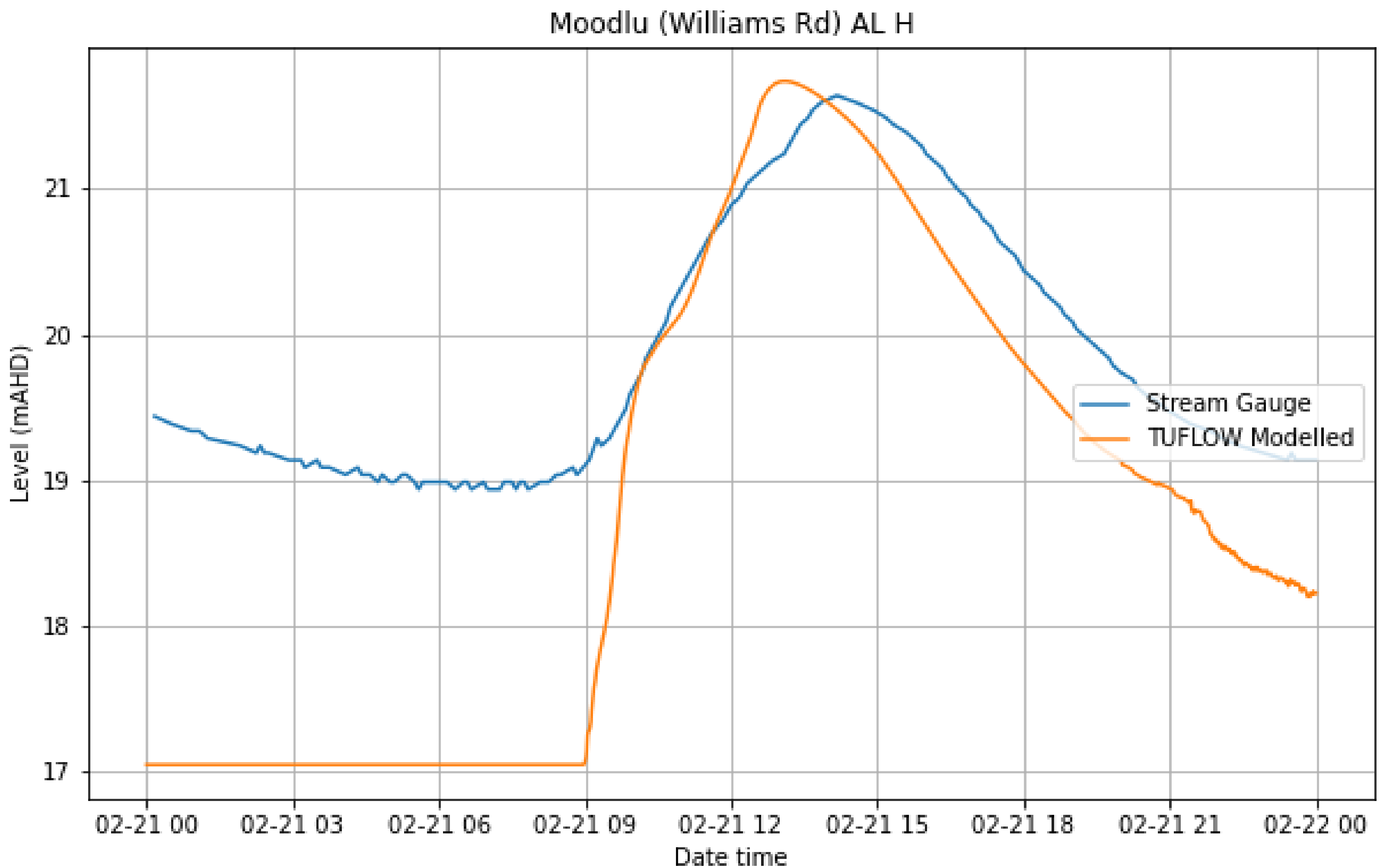

Caboolture (Pumicestone Rd) H
8.0
7.5
7.0
6.5
6.0
5.5
5.0
Level (mAHD)
02-21 00
02-21 03
02-21 06
02-21 09
02-21 12
02-21 15
02-21 18
02-21 21
02-22 00
Date time
Stream Gauge
TUFLOW Modelled



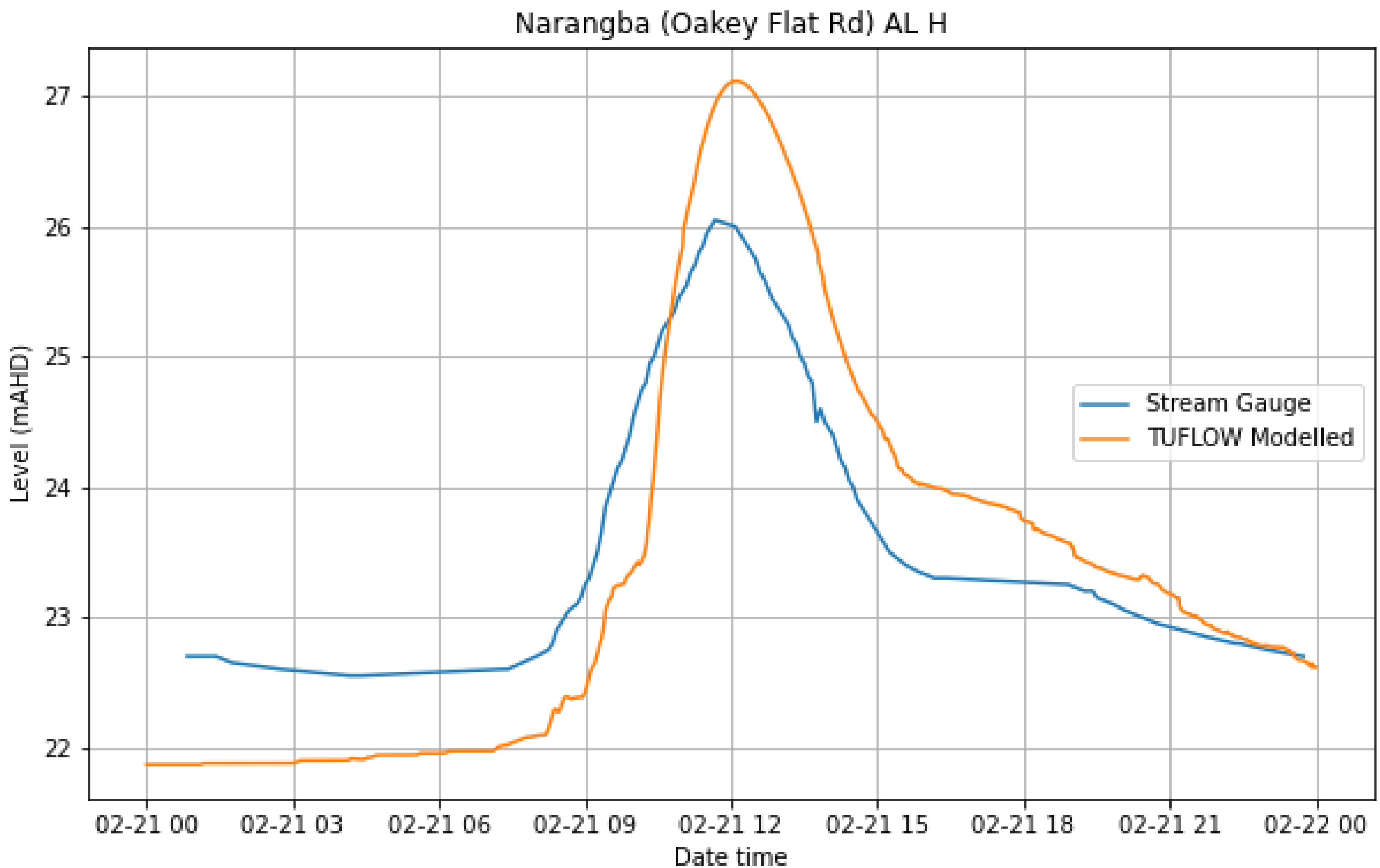
Caboolture (Short St) AL H
Level (mAHD)
1
2
3
4
5
6
02-21 00
02-21 03
02-21 06
02-21 09
02-21 12
02-21 15
02-21 18
02-21 21
02-22 00
Date time
Stream Gauge
TUFLOW Modelled



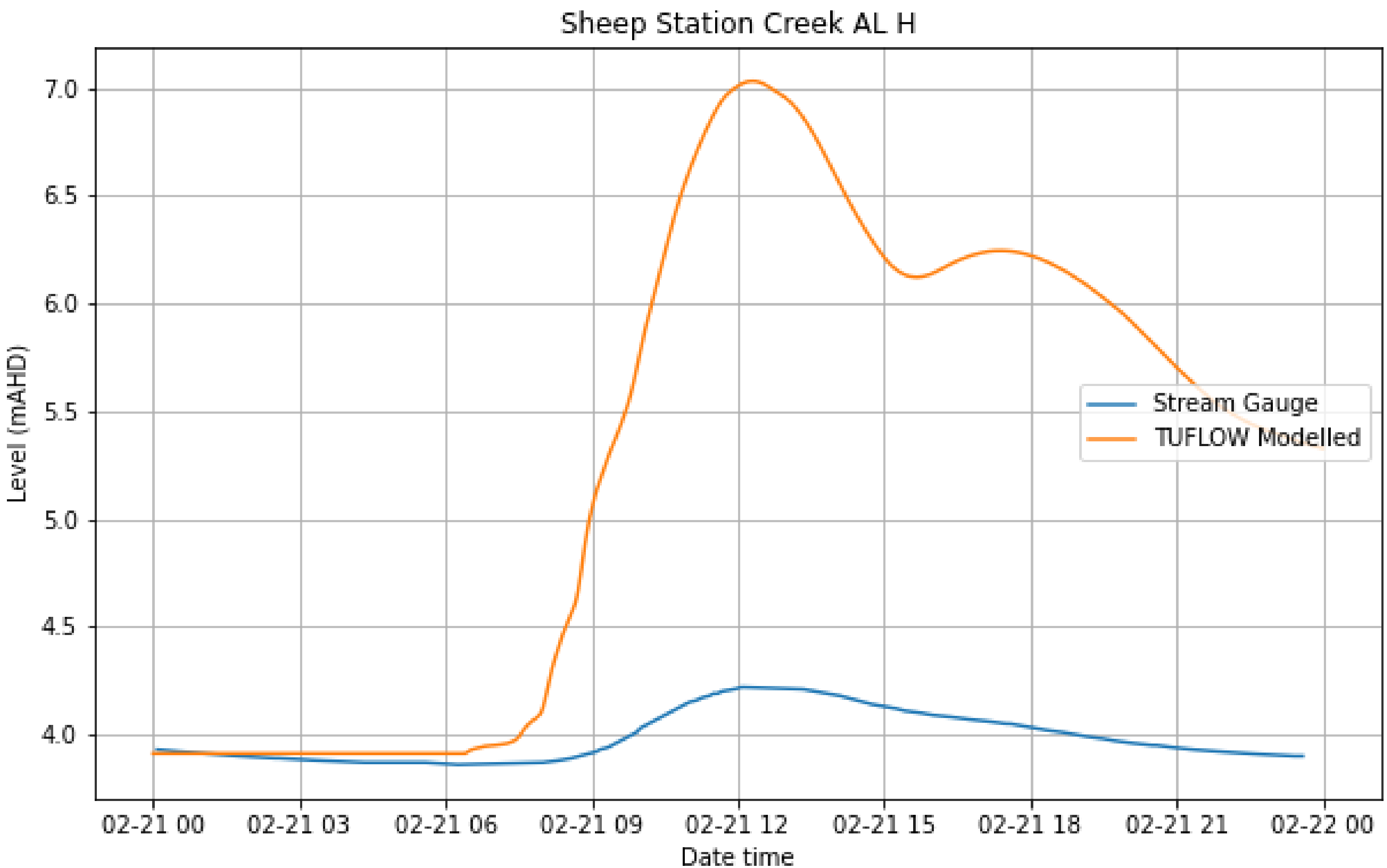
Caboolture WTP AL H
Level (mAHD)
8
7
6
5
4
02-21 00
02-21 03
02-21 06
02-21 09
02-21 12
02-21 15
02-21 18
02-21 21
02-22 00
Date time
Stream Gauge
TUFLOW Modelled

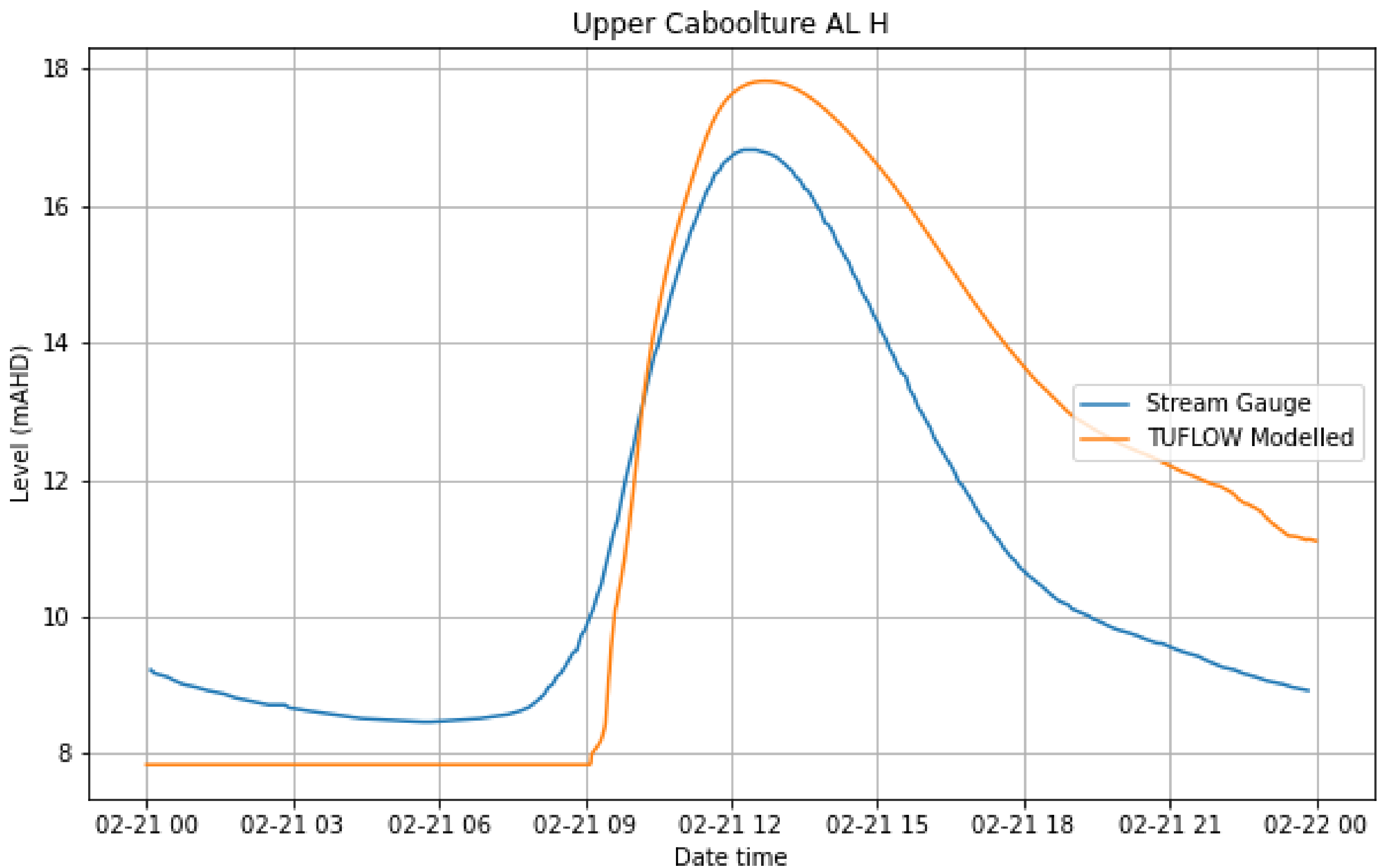


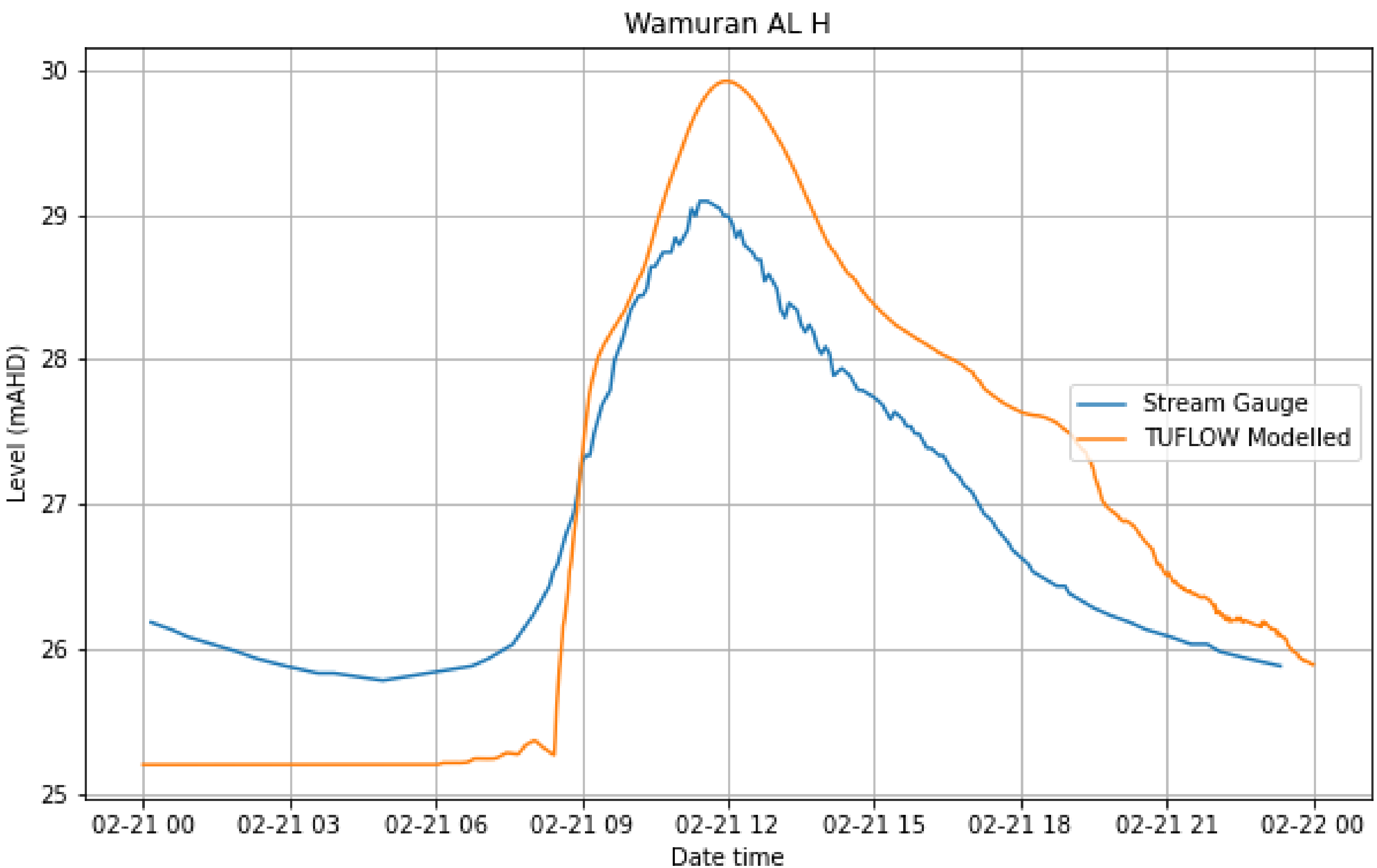
Moodlu (Williams Rd) AL H
Level (mAHD)
17
18
19
20
21
02-21 00
02-21 03
02-21 06
02-21 09
02-21 12
02-21 15
02-21 18
02-21 21
02-22 00
Date time
Stream Gauge
TUFLOW Modelled



Narangba (Oakey Flat Rd) AL H
Level (mAHD)
27
26
25
24
23
22
02-21 00
02-21 03
02-21 06
02-21 09
02-21 12
02-21 15
02-21 18
02-21 21
02-22 00
Date time
Stream Gauge
TUFLOW Modelled

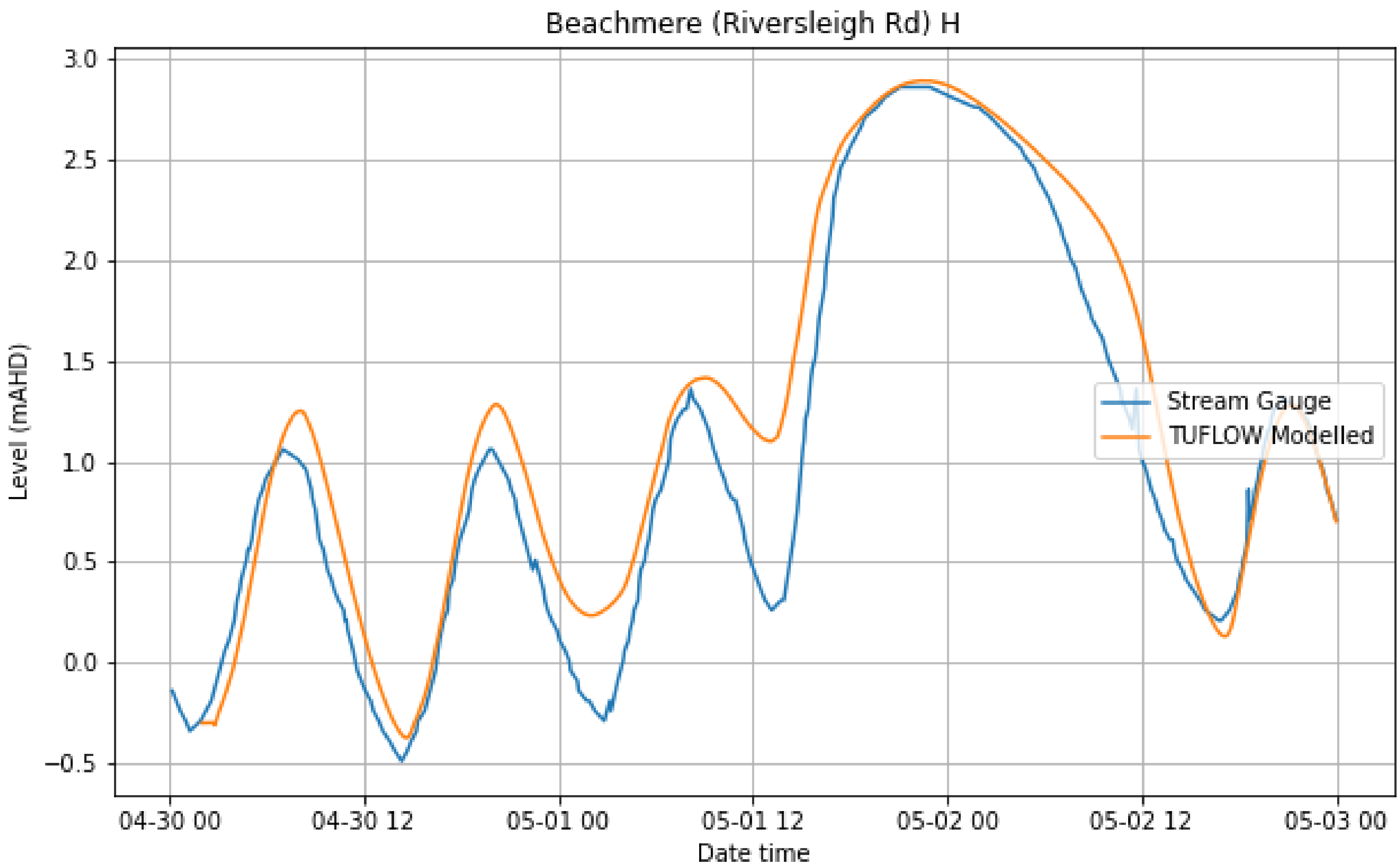

Sheep Station Creek AL H
7.0
6.5
6.0
5.5
5.0
4.5
4.0
Level (mAHD)
02-21 00
02-21 03
02-21 06
02-21 09
02-21 12
02-21 15
02-21 18
02-21 21
02-22 00
Date time
Stream Gauge
TUFLOW Modelled


Upper Caboolture AL H
Level (mAHD)
Date time
18
16
14
12
10
8
02-21 00
02-21 03
02-21 06
02-21 09
02-21 12
02-21 15
02-21 18
02-21 21
02-22 00
Stream Gauge
TUFLOW Modelled

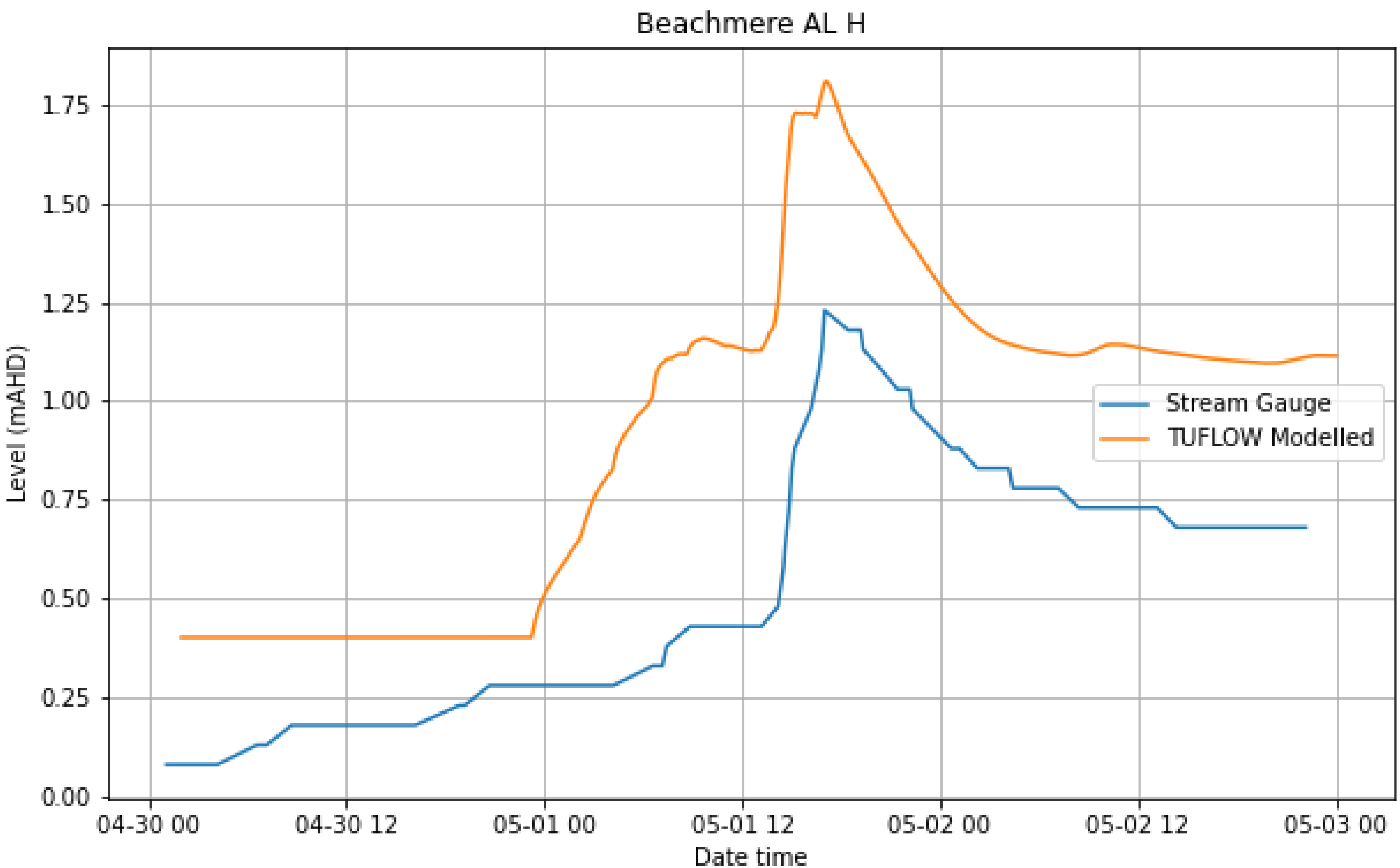


Wamuran AL H
Level (mAHD)
30
29
28
27
26
25
02-21 00
02-21 03
02-21 06
02-21 09
02-21 12
02-21 15
02-21 18
02-21 21
02-22 00
Date time
Stream Gauge
TUFLOW Modelled

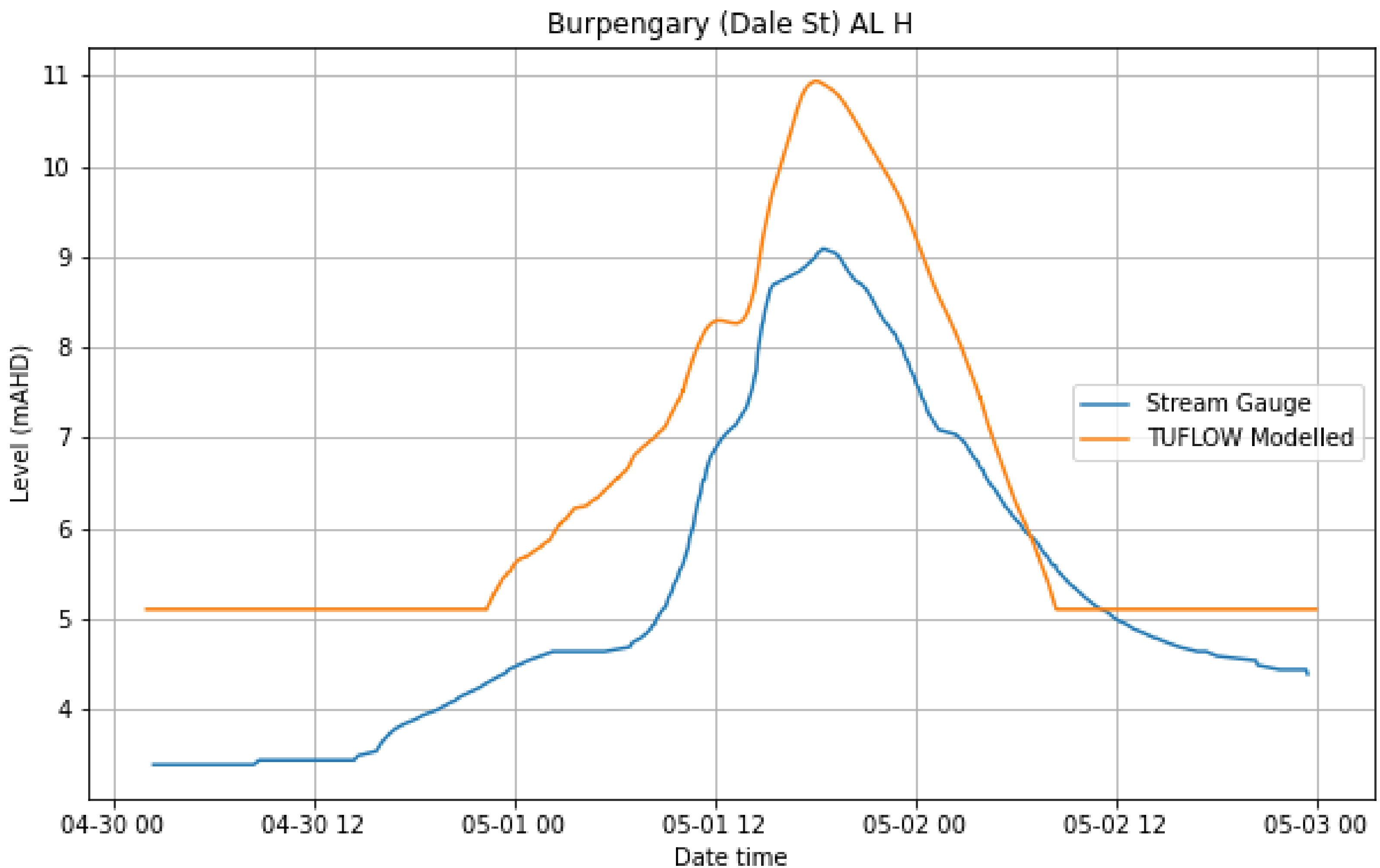
APPENDIX G
MAY 2015 – CALIBRATION PLOTS



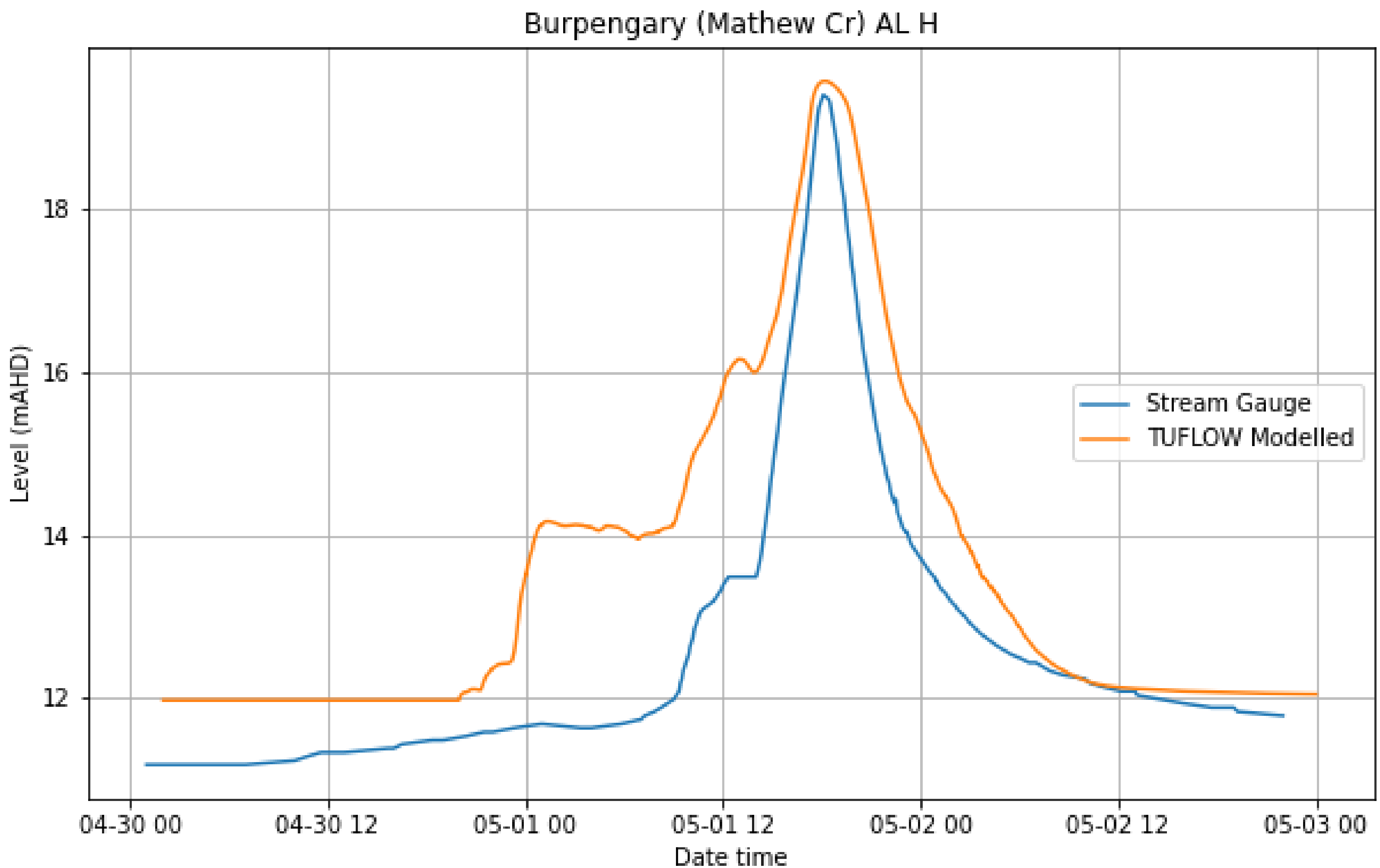
Beachmere (Riversleigh Rd) H
Level (mAHD)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
04-30 00
04-30 12
05-01 00
05-01 12
05-02 00
05-02 12
05-03 00
Date time
Stream Gauge
TUFLOW Modelled

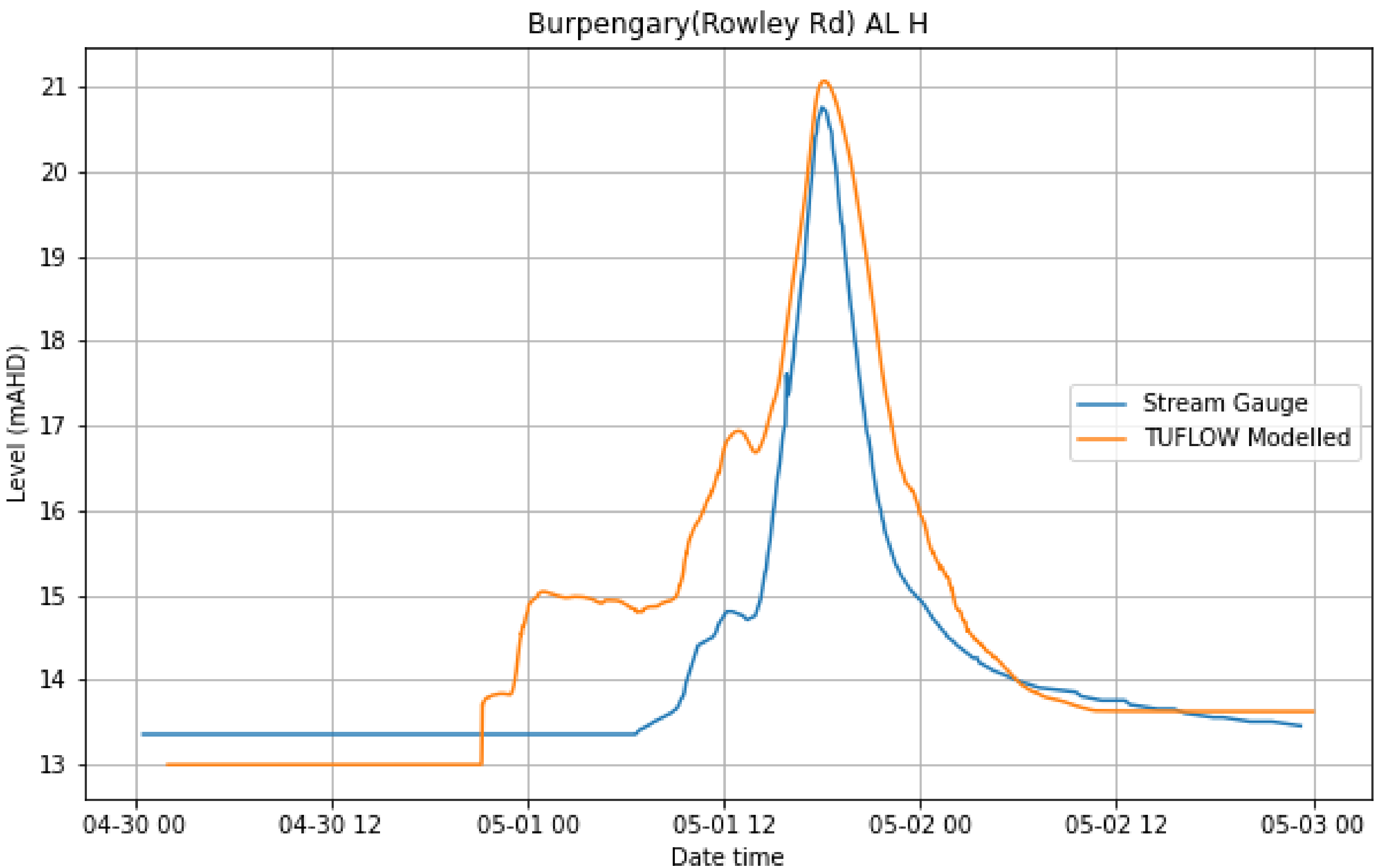


Beachmere AL H
Level (mAHD)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
04-30 00
04-30 12
05-01 00
05-01 12
05-02 00
05-02 12
05-03 00
Date time
Stream Gauge
TUFLOW Modelled

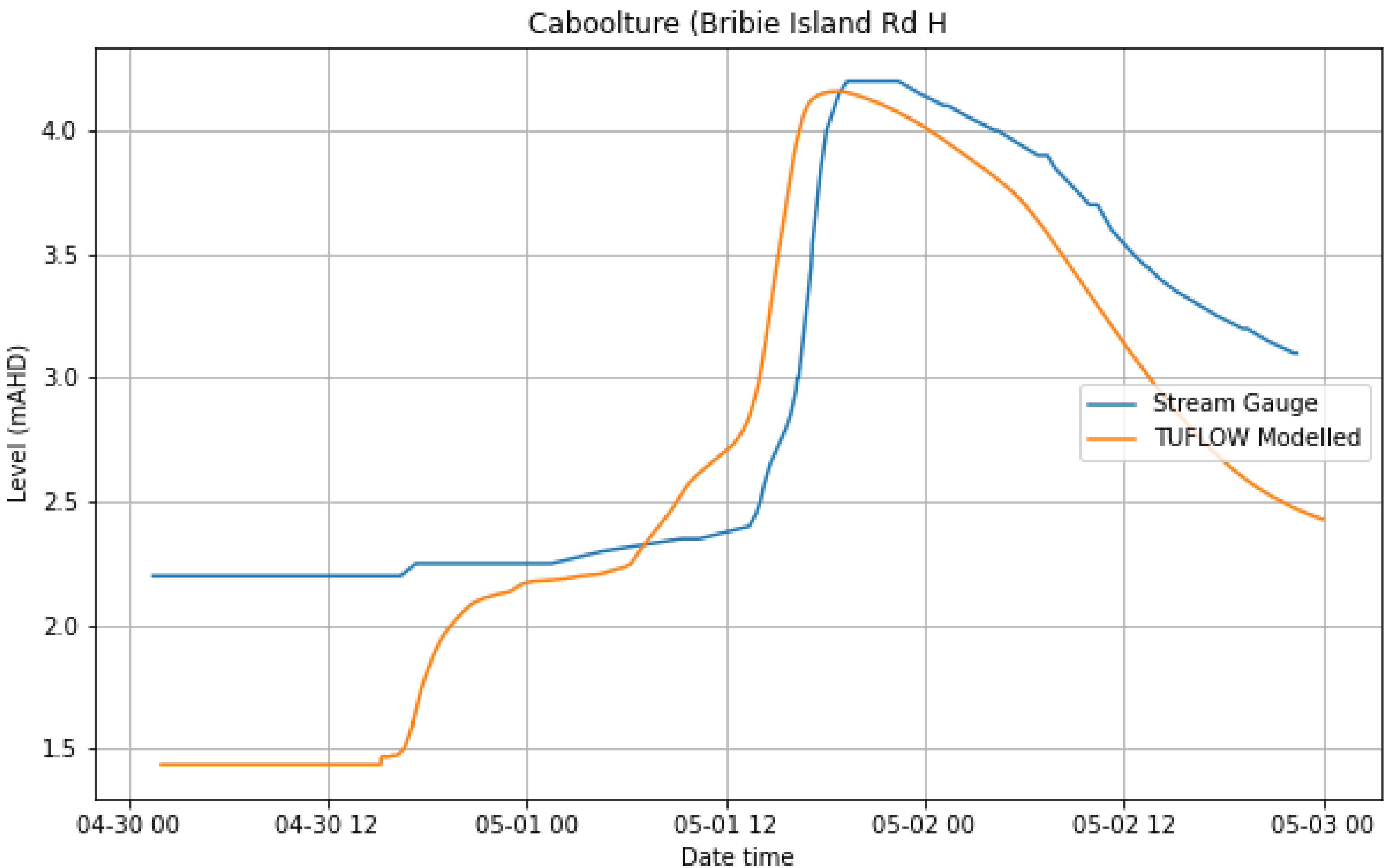


Burpengary (Dale St) AL H
Level (mAHD)
11
10
9
8
7
6
5
4
04-30 00
04-30 12
05-01 00
05-01 12
05-02 00
05-02 12
05-03 00
Date time
Stream Gauge
TUFLOW Modelled

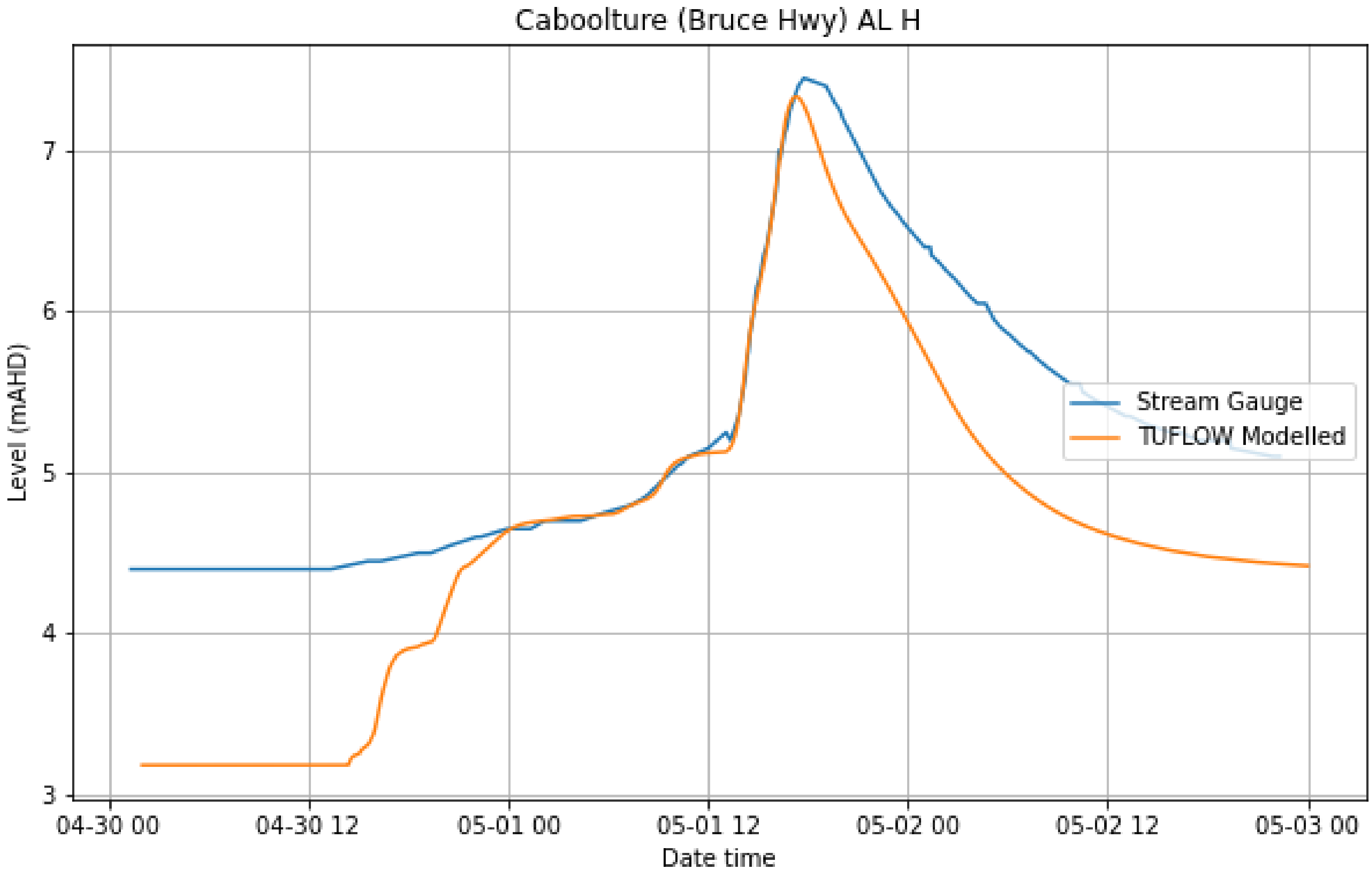

Burpengary (Mathew Cr) AL H
Level (mAHD)
18
16
14
12
04-30 00
04-30 12
05-01 00
05-01 12
05-02 00
05-02 12
05-03 00
Date time
Stream Gauge
TUFLOW Modelled



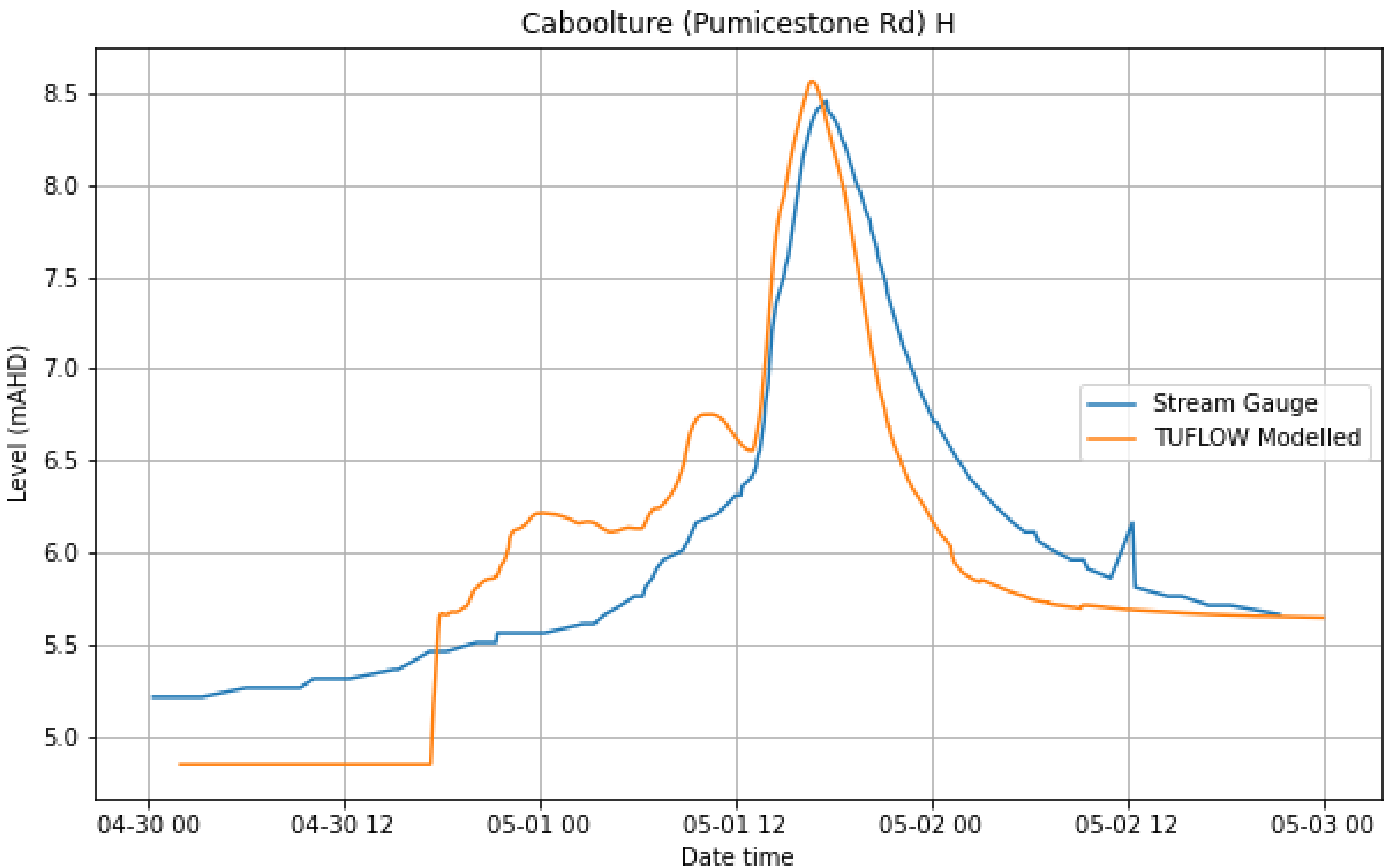
Burpengary(Rowley Rd) AL H
Level (mAHD)
21
20
19
18
17
16
15
14
13
04-30 00
04-30 12
05-01 00
05-01 12
05-02 00
05-02 12
05-03 00
Date time
Stream Gauge
TUFLOW Modelled



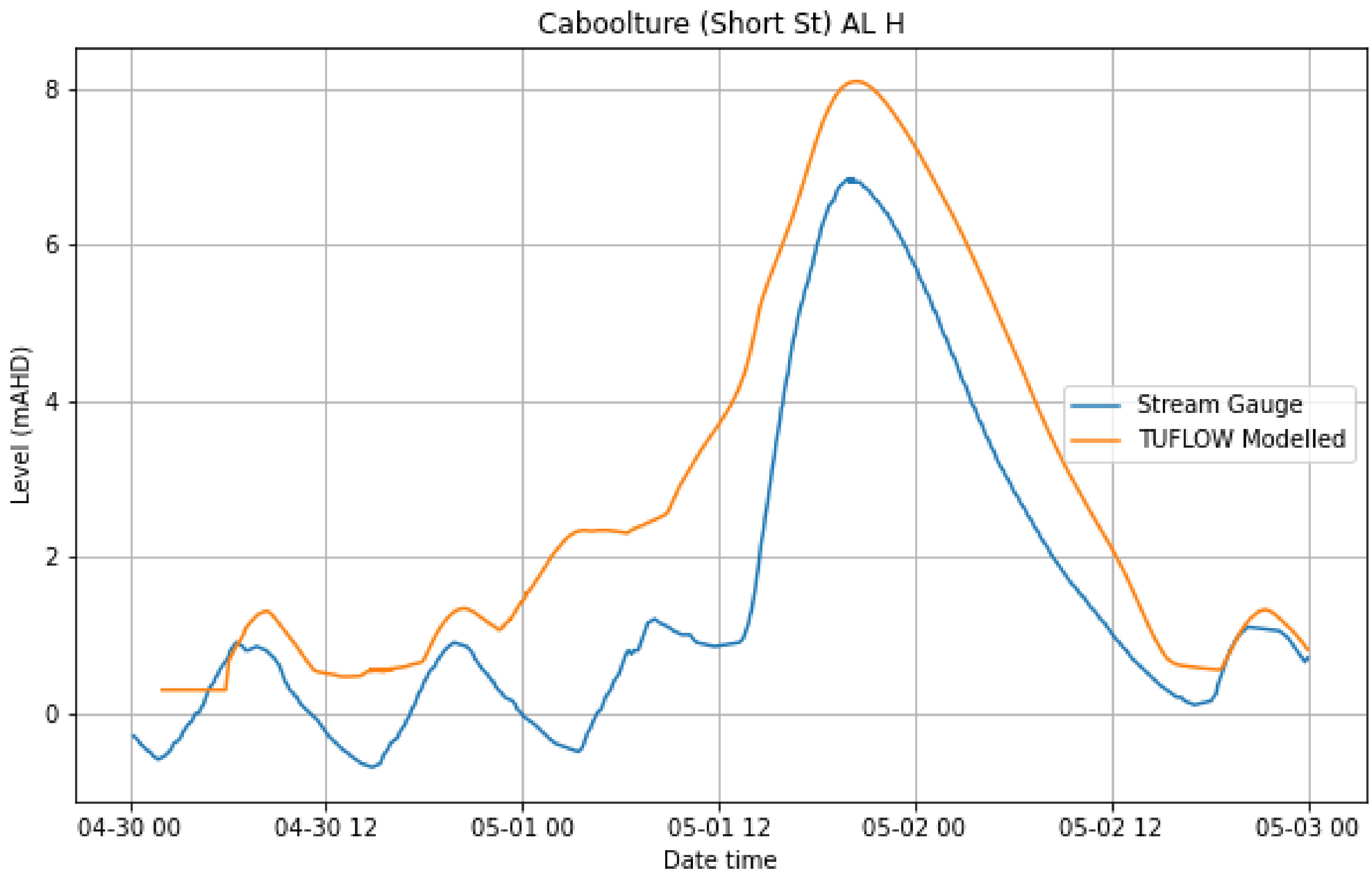
Caboolture (Bribie Island Rd H
Level (mAHD)
4.0
3.5
3.0
2.5
2.0
1.5
04-30 00
04-30 12
05-01 00
05-01 12
05-02 00
05-02 12
05-03 00
Date time
Stream Gauge
TUFLOW Modelled



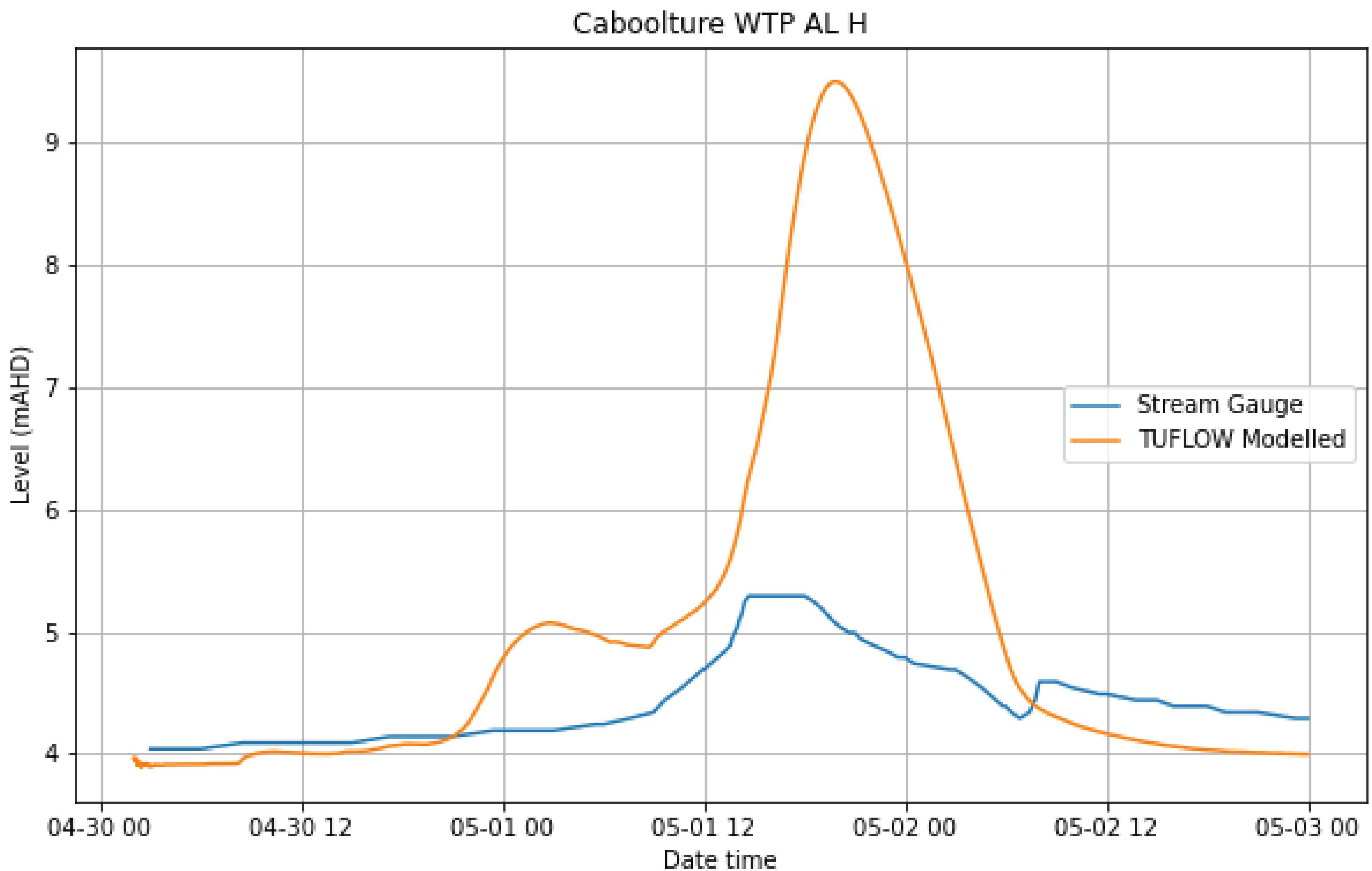
Caboolture (Bruce Hwy) AL H
Level (mAHD)
7
6
5
4
3
04-30 00
04-30 12
05-01 00
05-01 12
05-02 00
05-02 12
05-03 00
Date time
Stream Gauge
TUFLOW Modelled

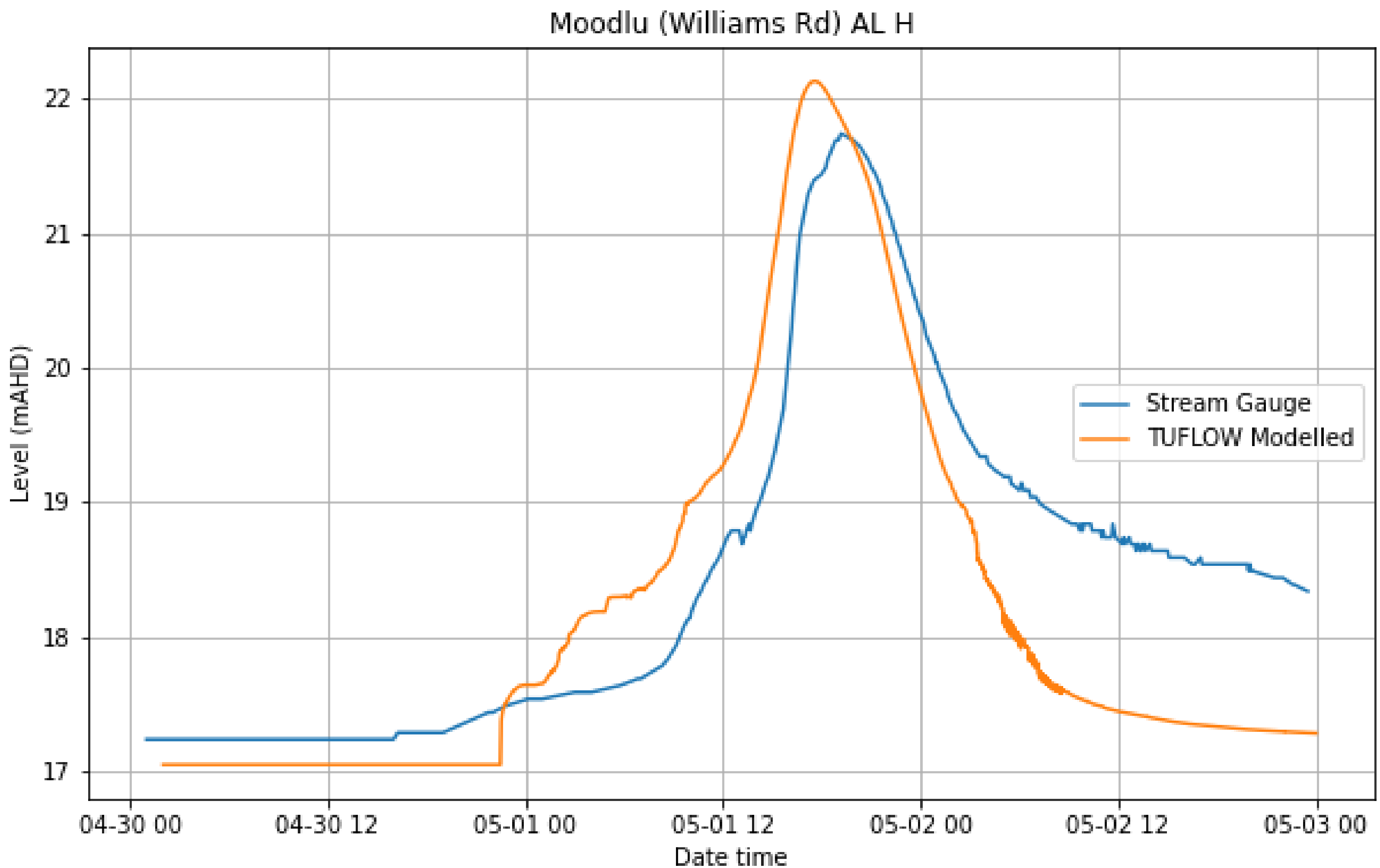


Caboolture (Pumicestone Rd) H
Level (mAHD)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
04-30 00
04-30 12
05-01 00
05-01 12
05-02 00
05-02 12
05-03 00
Date time
Stream Gauge
TUFLOW Modelled

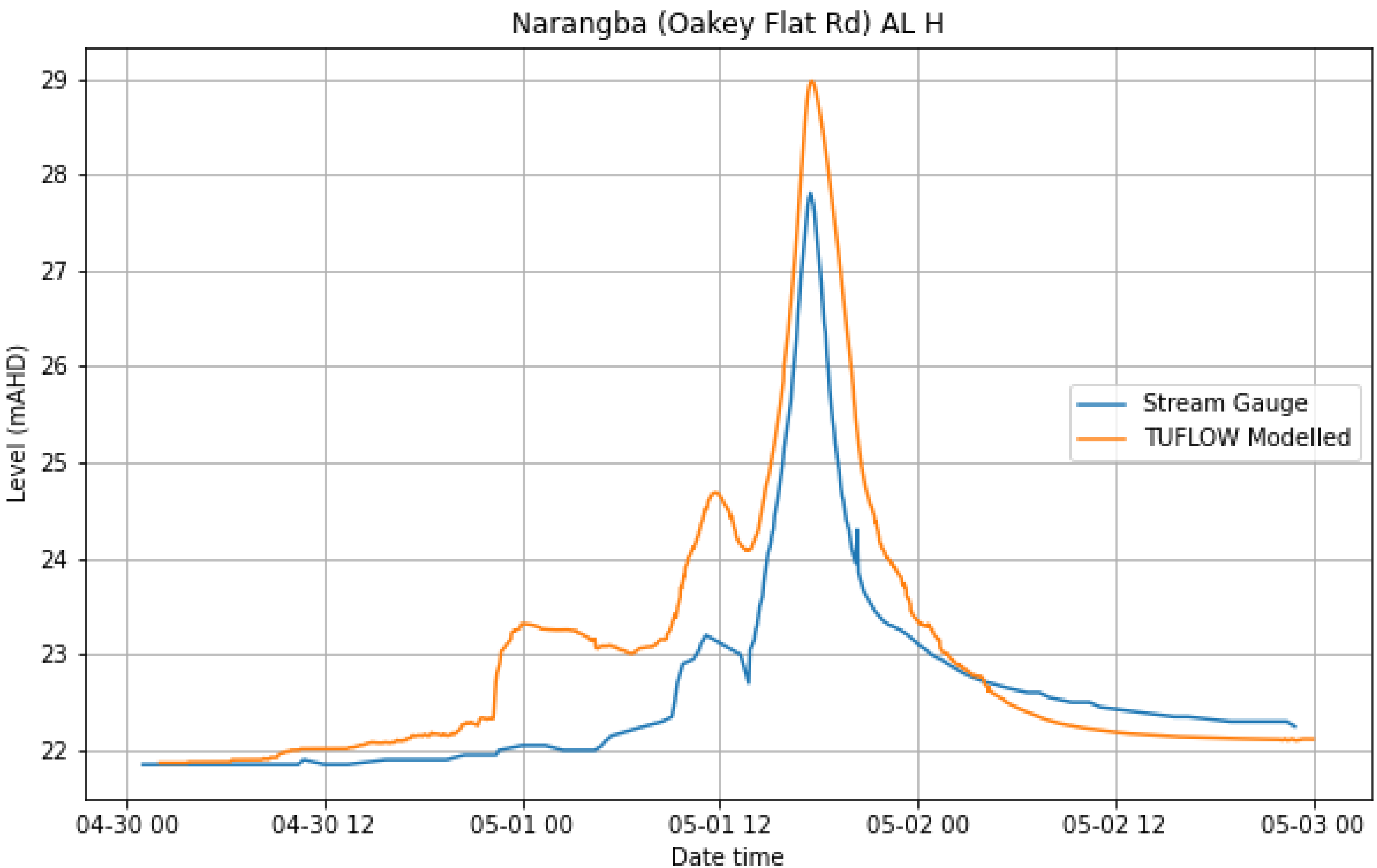


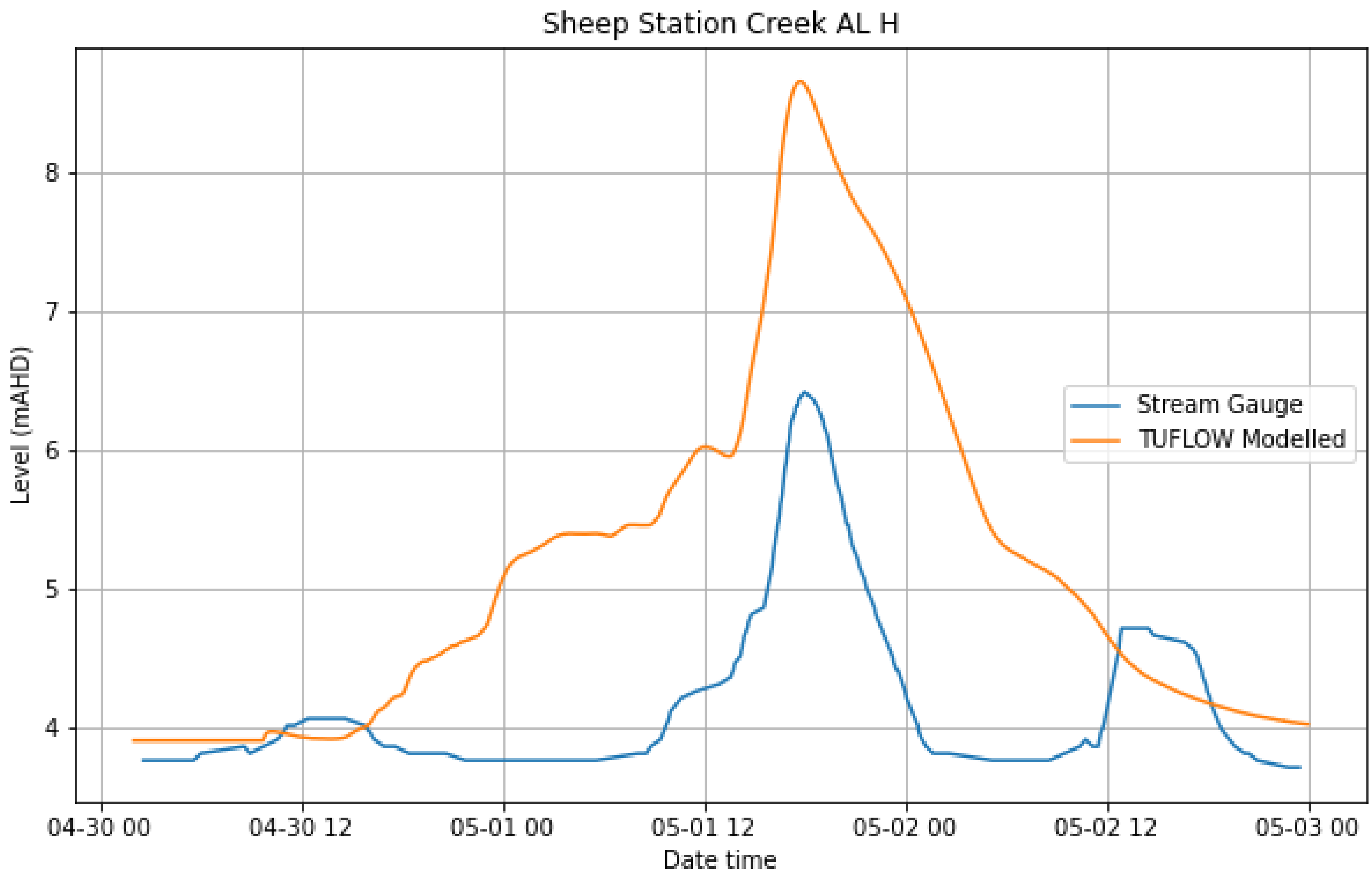
Caboolture (Short St) AL H
8
6
4
2
0
Level (mAHD)
04-30 00
04-30 12
05-01 00
05-01 12
05-02 00
05-02 12
05-03 00
Date time
Stream Gauge
TUFLOW Modelled


Caboolture WTP AL H
Level (mAHD)
9
8
7
6
5
4
04-30 00
04-30 12
05-01 00
05-01 12
05-02 00
05-02 12
05-03 00
Date time
Stream Gauge
TUFLOW Modelled

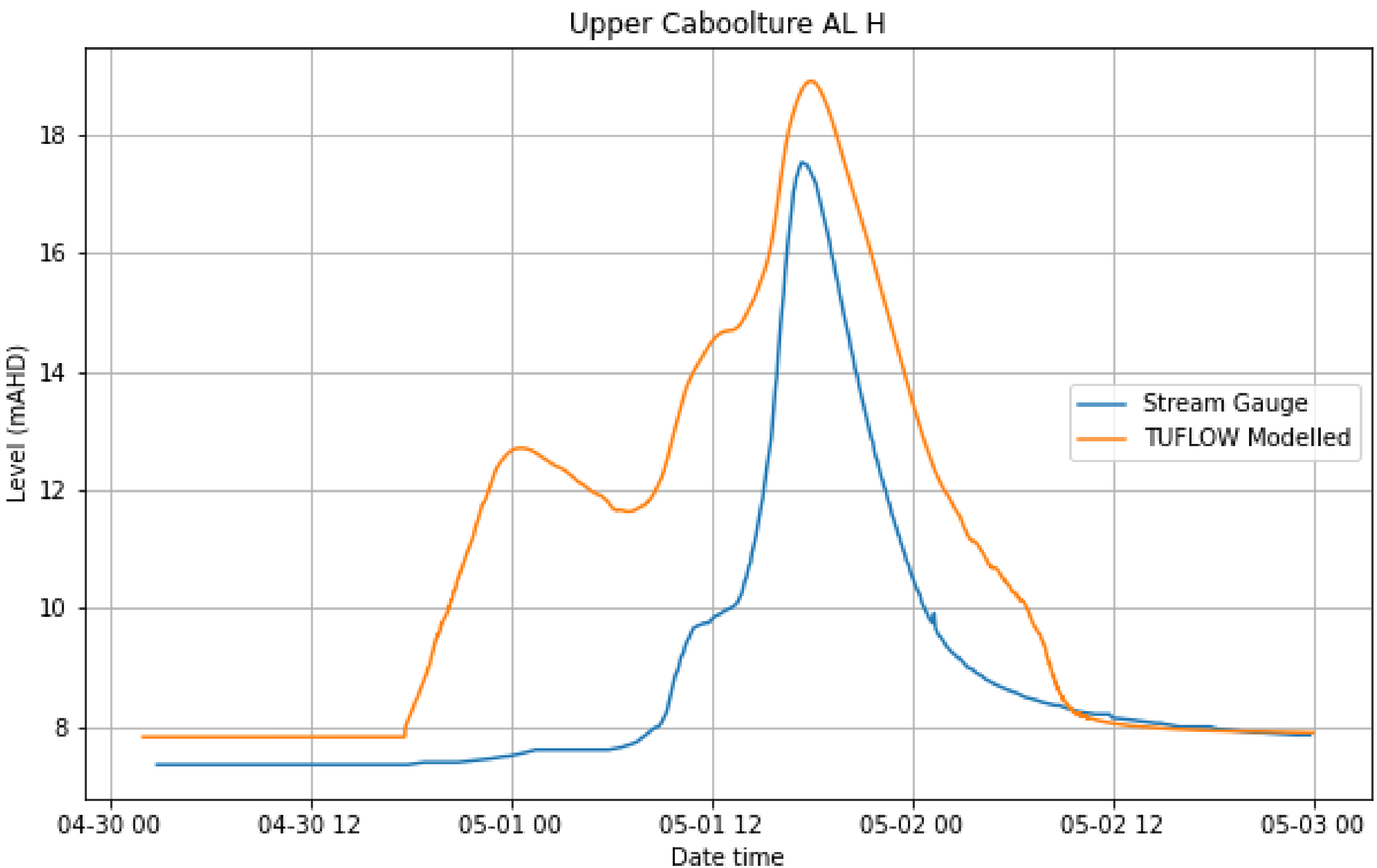


Moodlu (Williams Rd) AL H
Level (mAHD)
22
21
20
19
18
17
04-30 00
04-30 12
05-01 00
05-01 12
05-02 00
05-02 12
05-03 00
Date time
Stream Gauge
TUFLOW Modelled

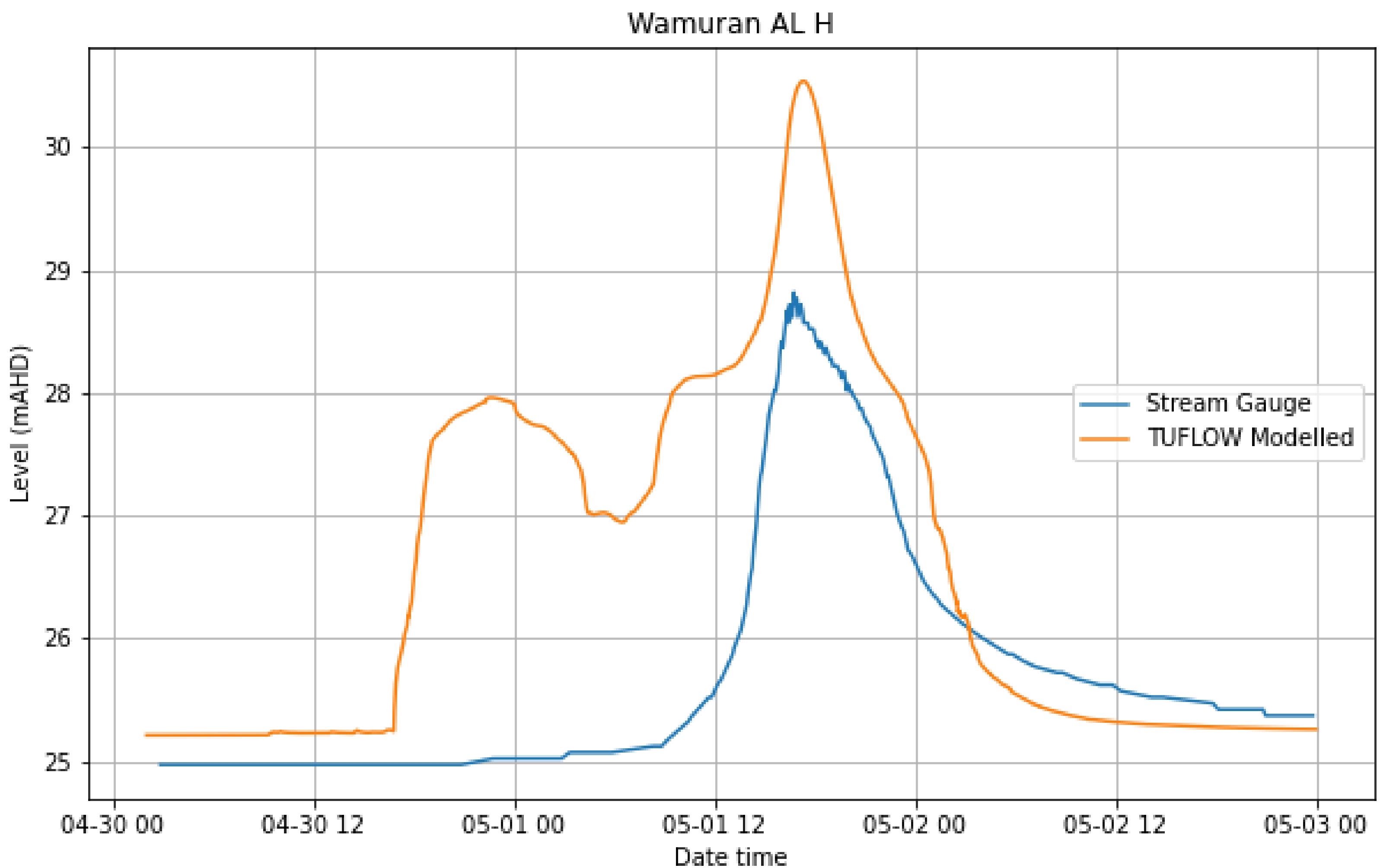

Narangba (Oakey Flat Rd) AL H
Level (mAHD)
29
28
27
26
25
24
23
22
04-30 00
04-30 12
05-01 00
05-01 12
05-02 00
05-02 12
05-03 00
Date time
Stream Gauge
TUFLOW Modelled



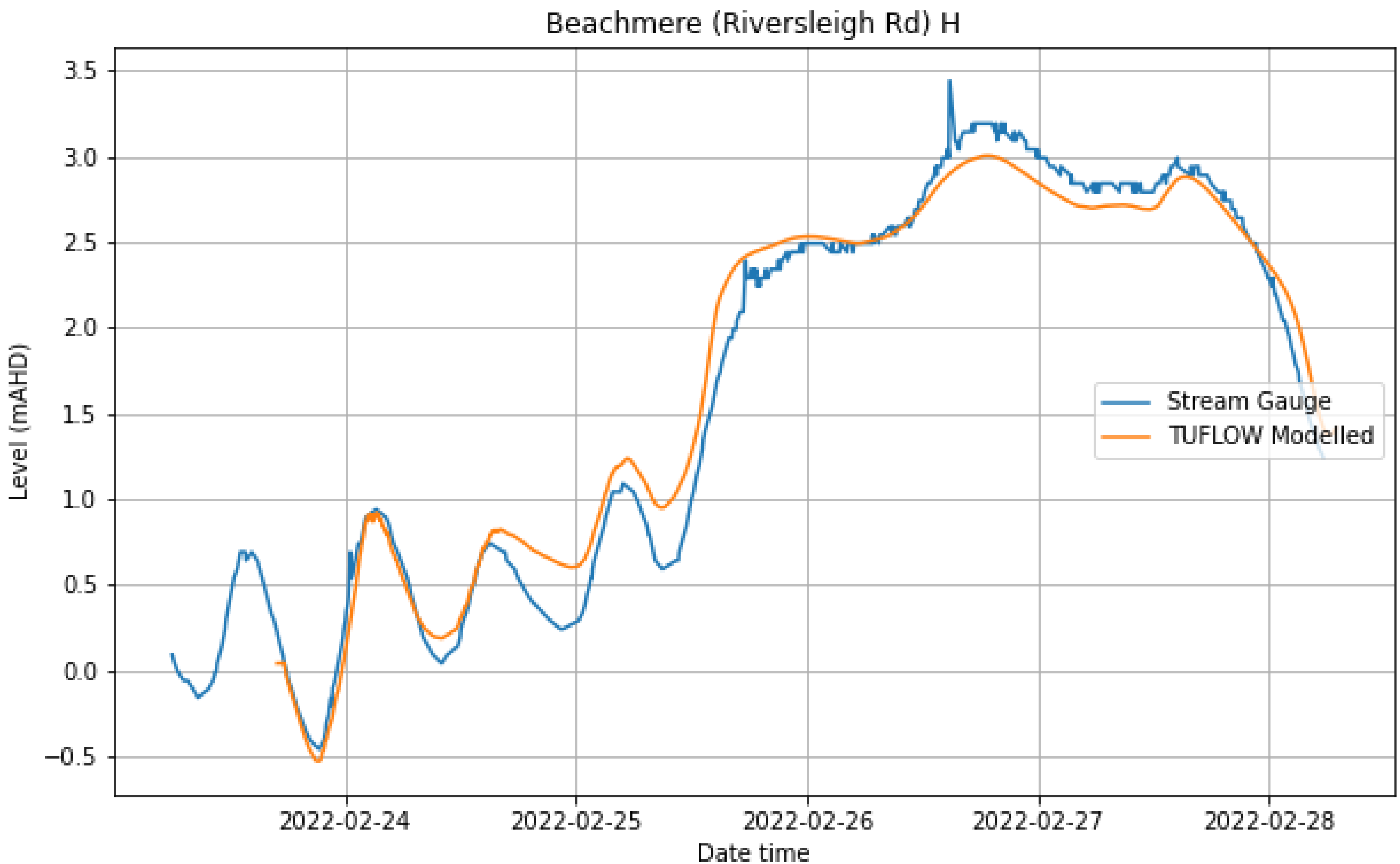
Sheep Station Creek AL H
Level (mAHD)
8
7
6
5
4
04-30 00
04-30 12
05-01 00
05-01 12
05-02 00
05-02 12
05-03 00
Date time
Stream Gauge
TUFLOW Modelled

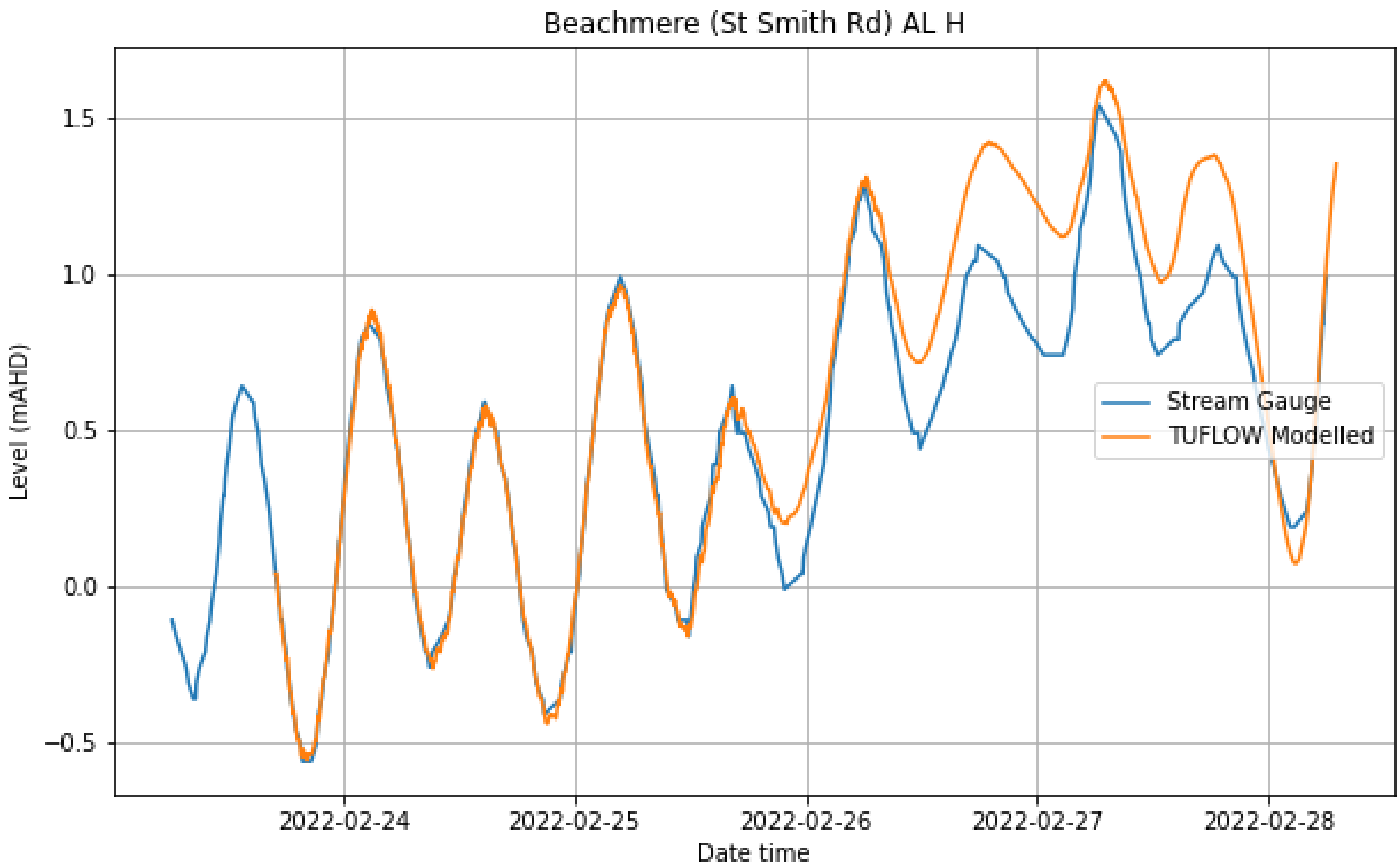


Upper Caboolture AL H
Level (mAHD)
18
16
14
12
10
8
04-30 00
04-30 12
05-01 00
05-01 12
05-02 00
05-02 12
05-03 00
Date time
Stream Gauge
TUFLOW Modelled

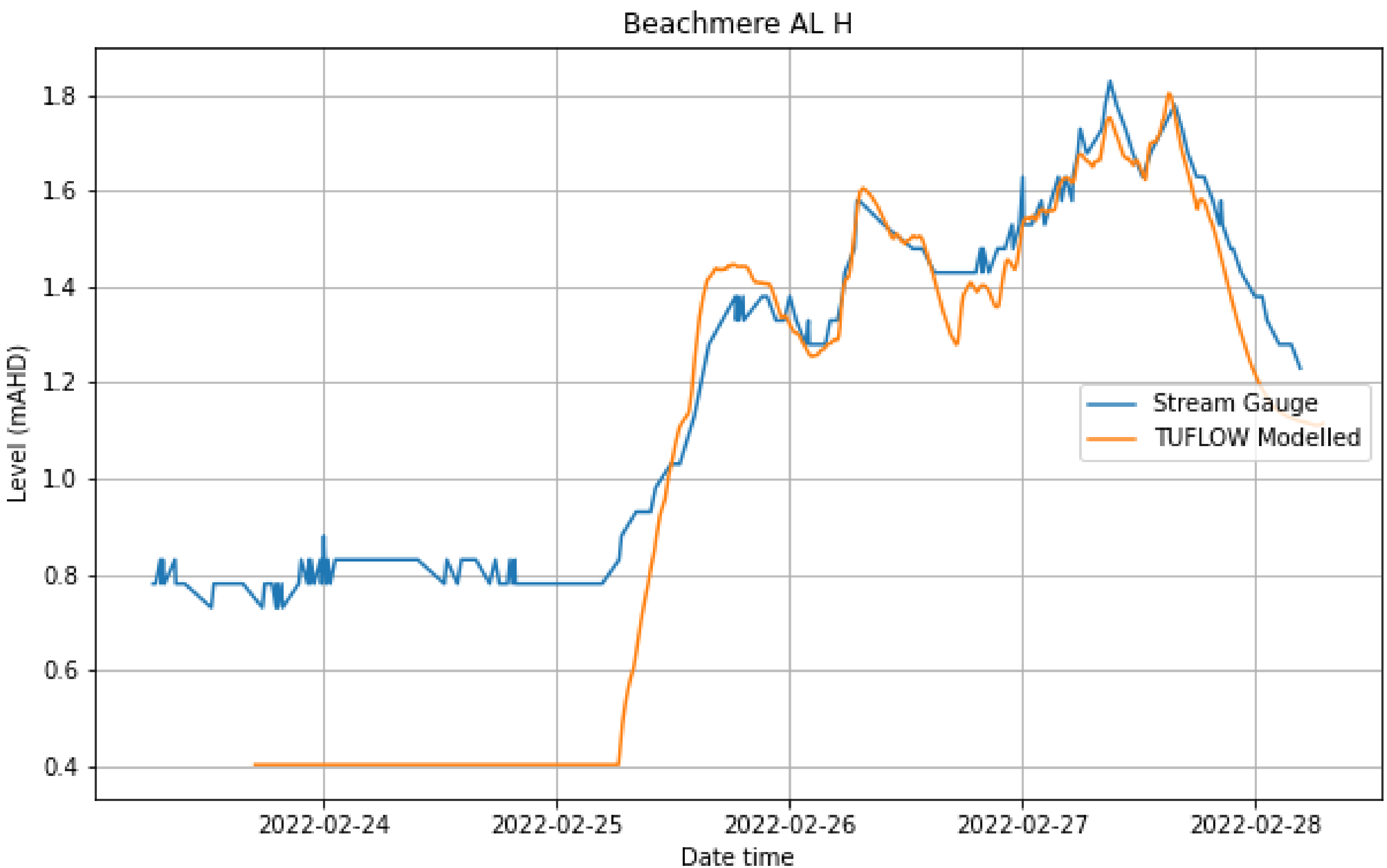

Wamuran AL H
Level (mAHD)
30
29
28
27
26
25
04-30 00
04-30 12
05-01 00
05-01 12
05-02 00
05-02 12
05-03 00
Date time
Stream Gauge
TUFLOW Modelled

APPENDIX H
FEB 2022 – CALIBRATION PLOTS

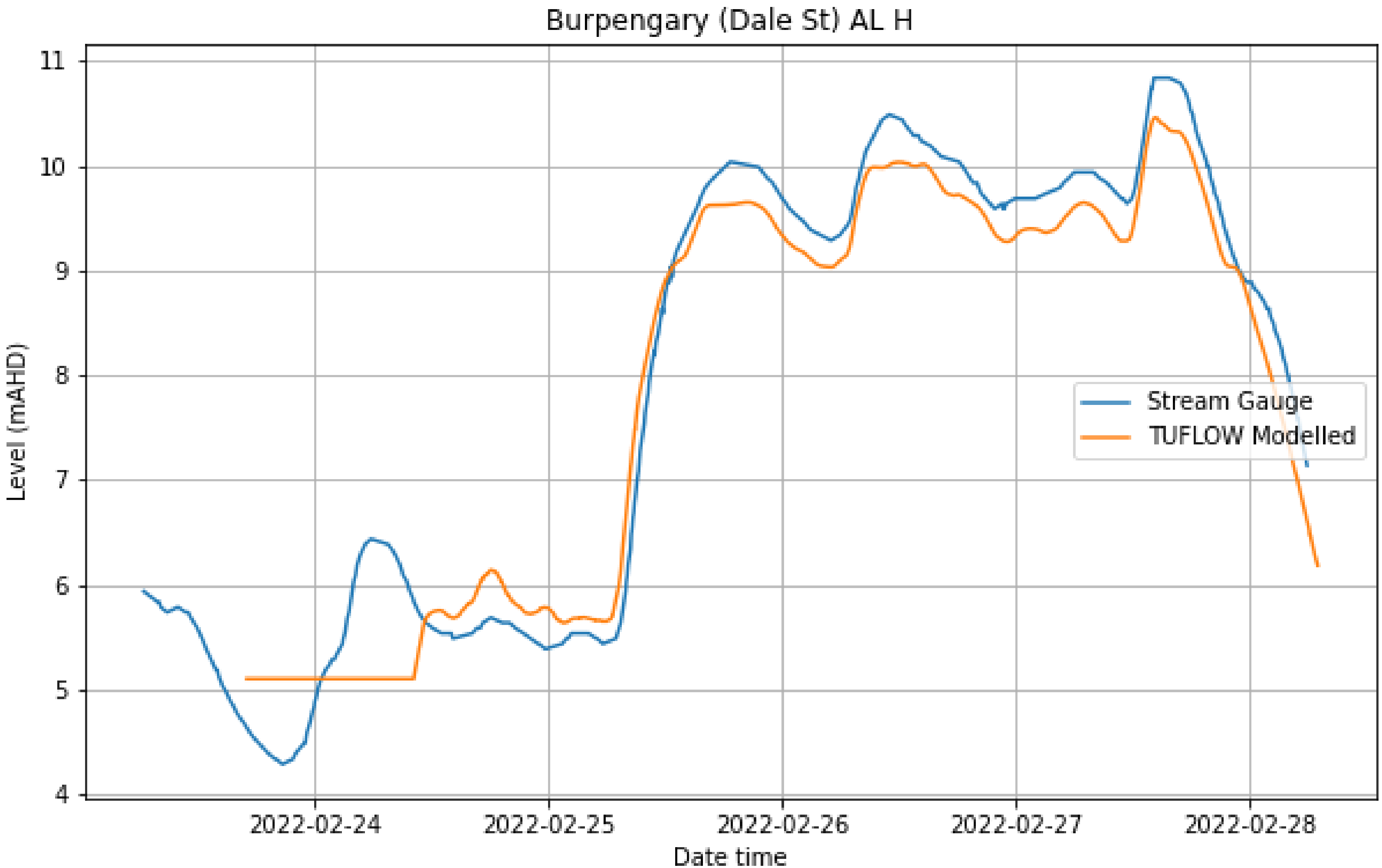

Beachmere (Riversleigh Rd) H
Level (mAHD)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Date time
Stream Gauge
TUFLOW Modelled



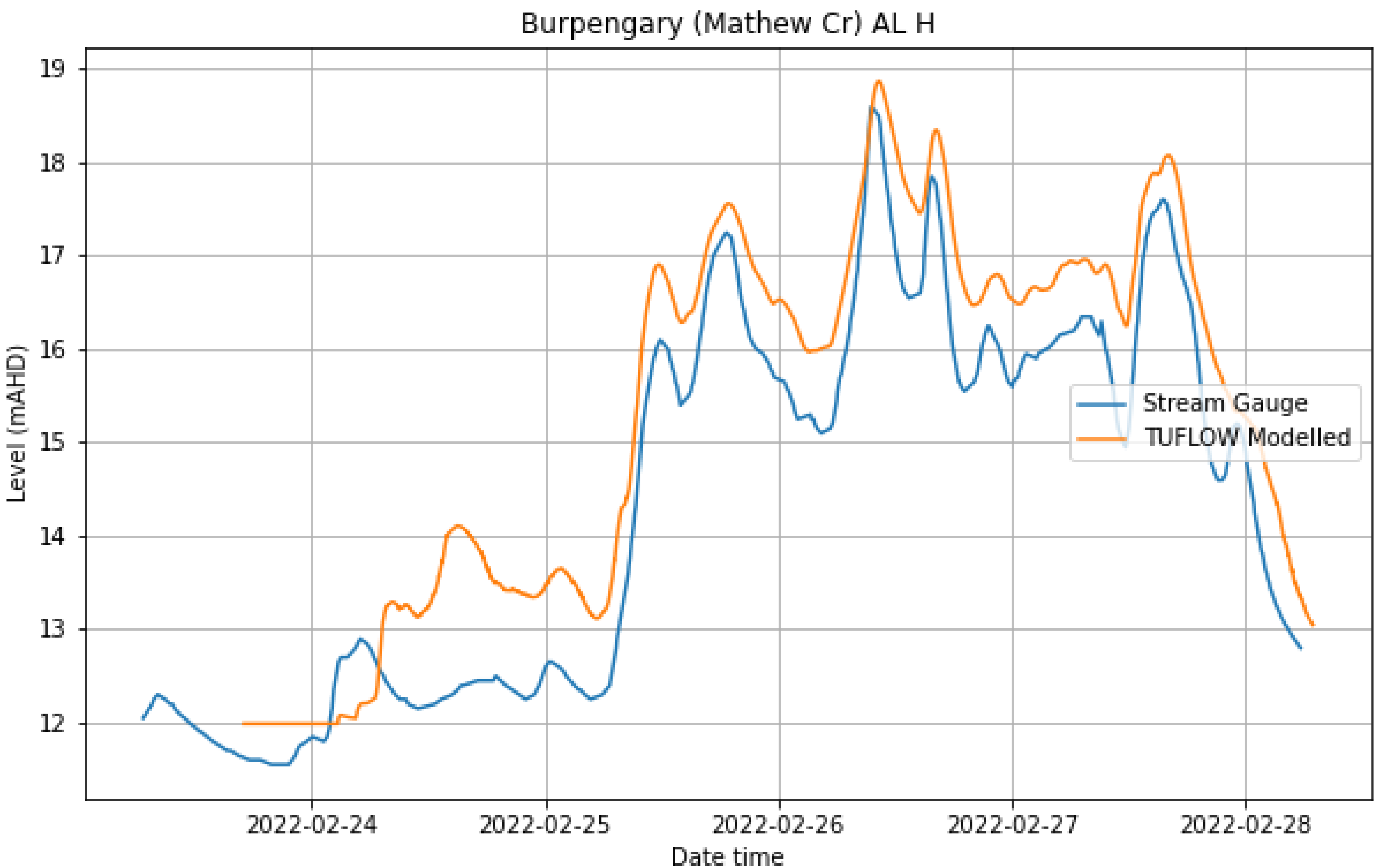
Beachmere (St Smith Rd) AL H
Level (mAHD)
1.5
1.0
0.5
0.0
−0.5
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Date time
Stream Gauge
TUFLOW Modelled

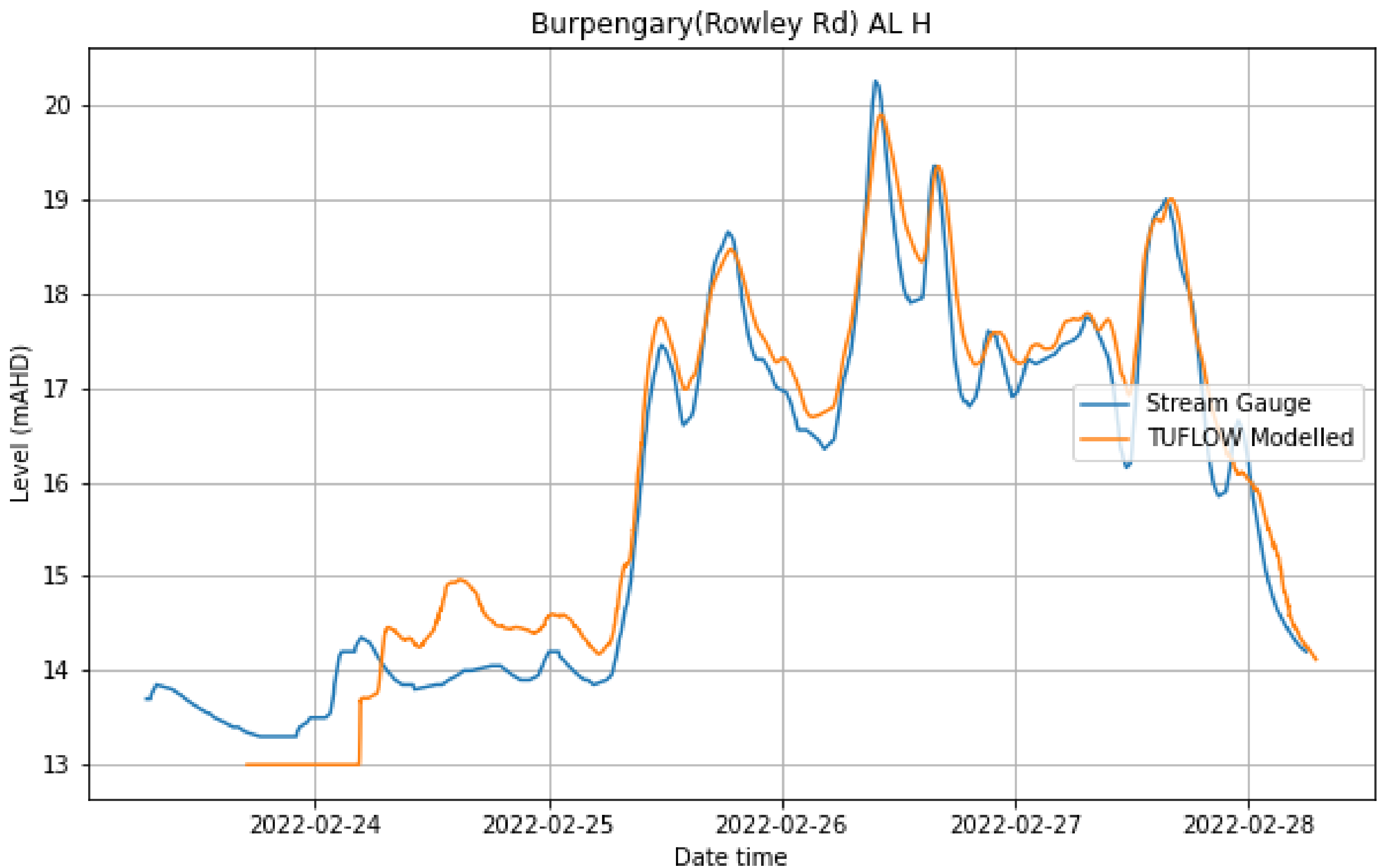


Beachmere AL H
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
Level (mAHD)
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Date time
Stream Gauge
TUFLOW Modelled

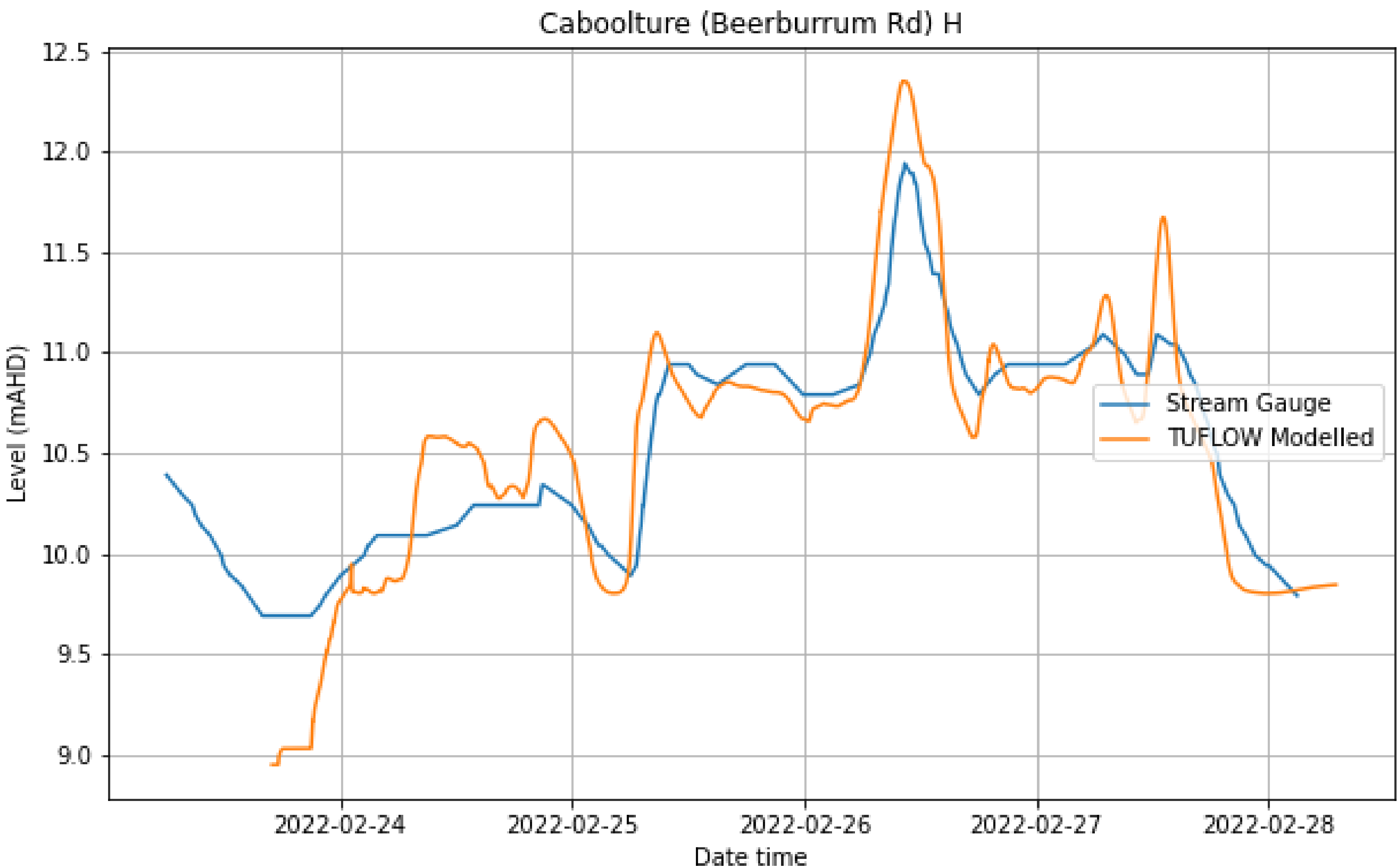


Burpengary (Dale St) AL H
Level (mAHD)
11
10
9
8
7
6
5
4
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Date time
Stream Gauge
TUFLOW Modelled

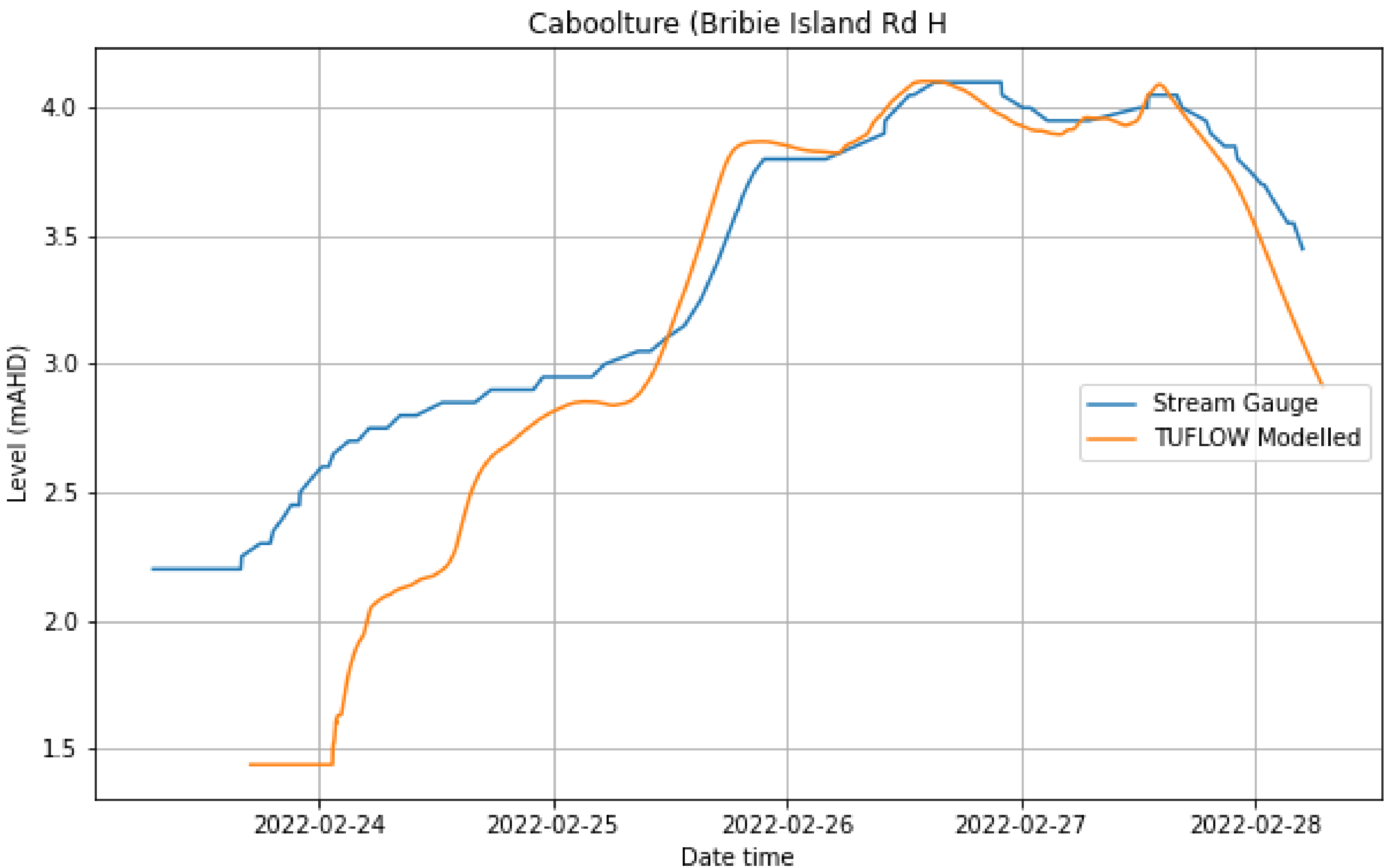

Burpengary (Mathew Cr) AL H
Level (mAHD)
19
18
17
16
15
14
13
12
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Date time
Stream Gauge
TUFLOW Modelled



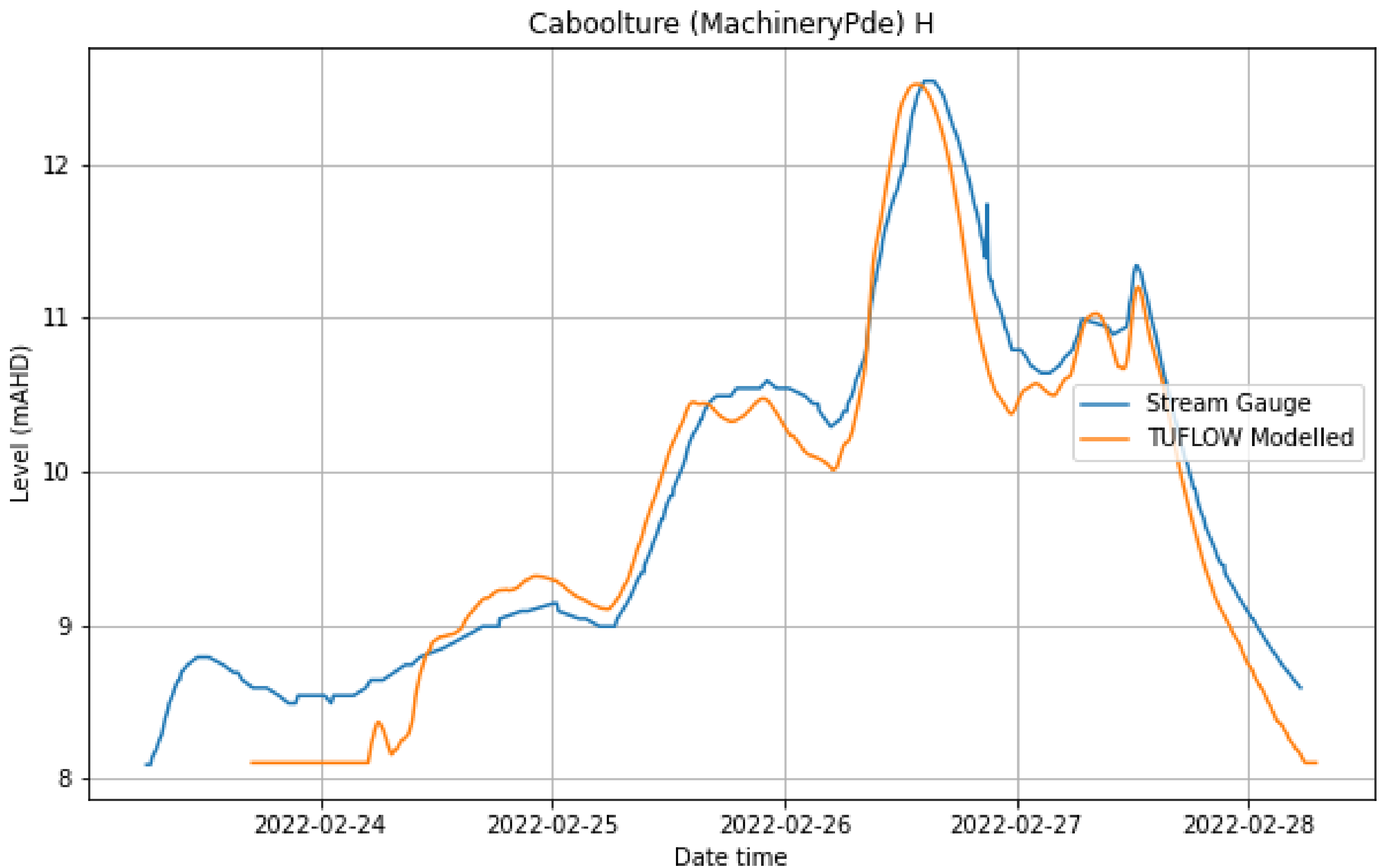
Burpengary(Rowley Rd) AL H
Level (mAHD)
20
19
18
17
16
15
14
13
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Date time
Stream Gauge
TUFLOW Modelled

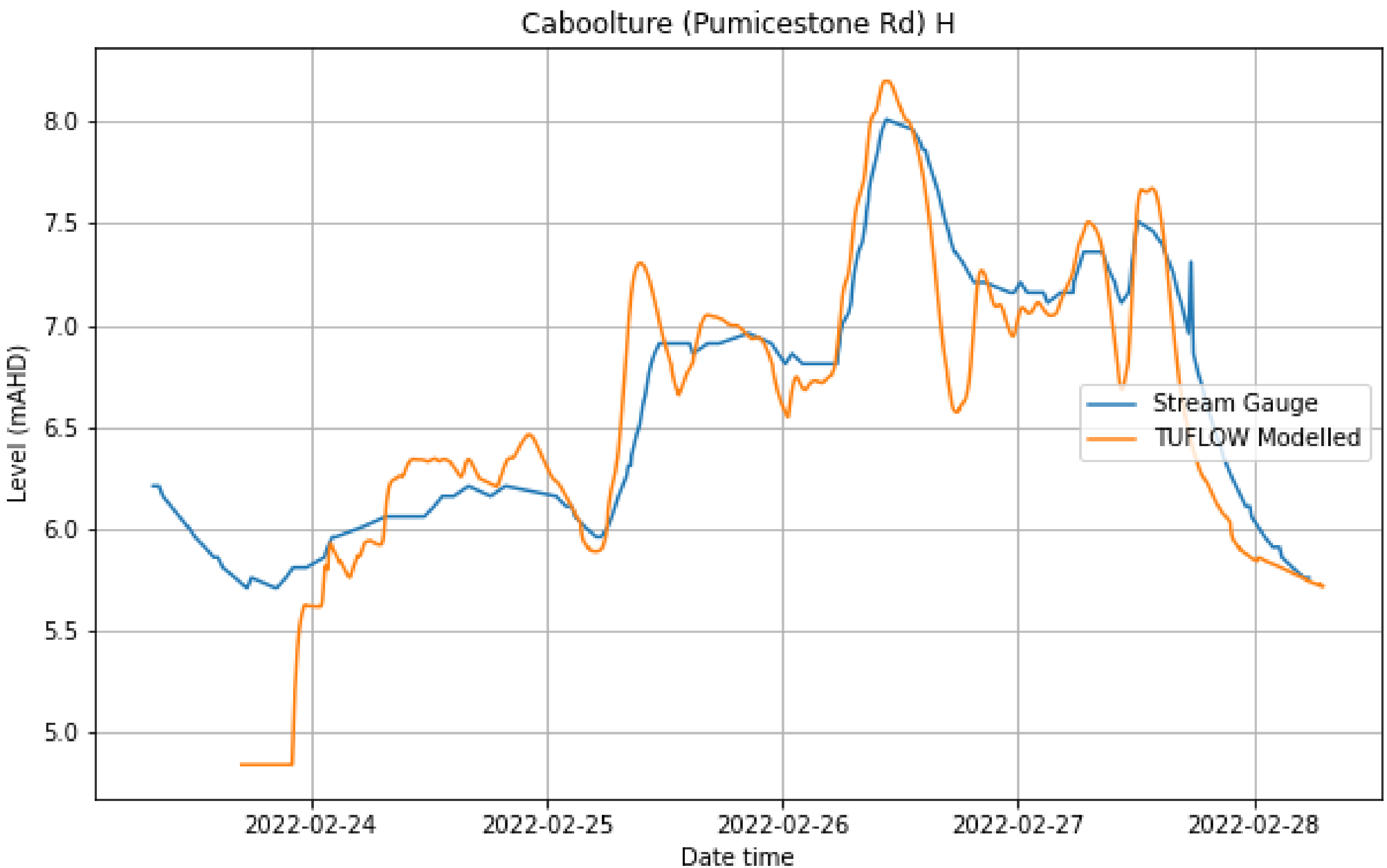


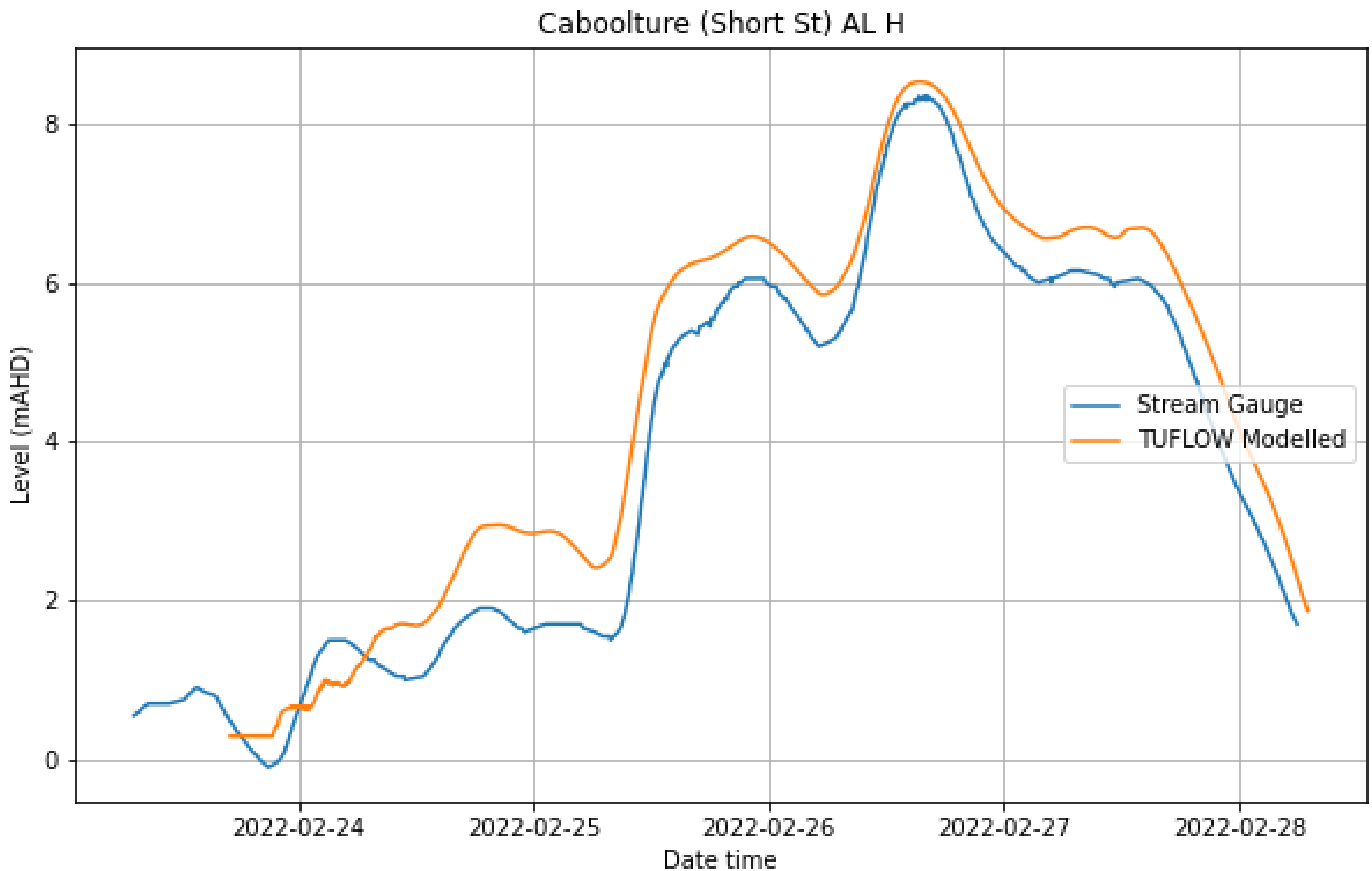
Caboolture (Beerburrum Rd) H
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
Level (mAHD)
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Date time
Stream Gauge
TUFLOW Modelled



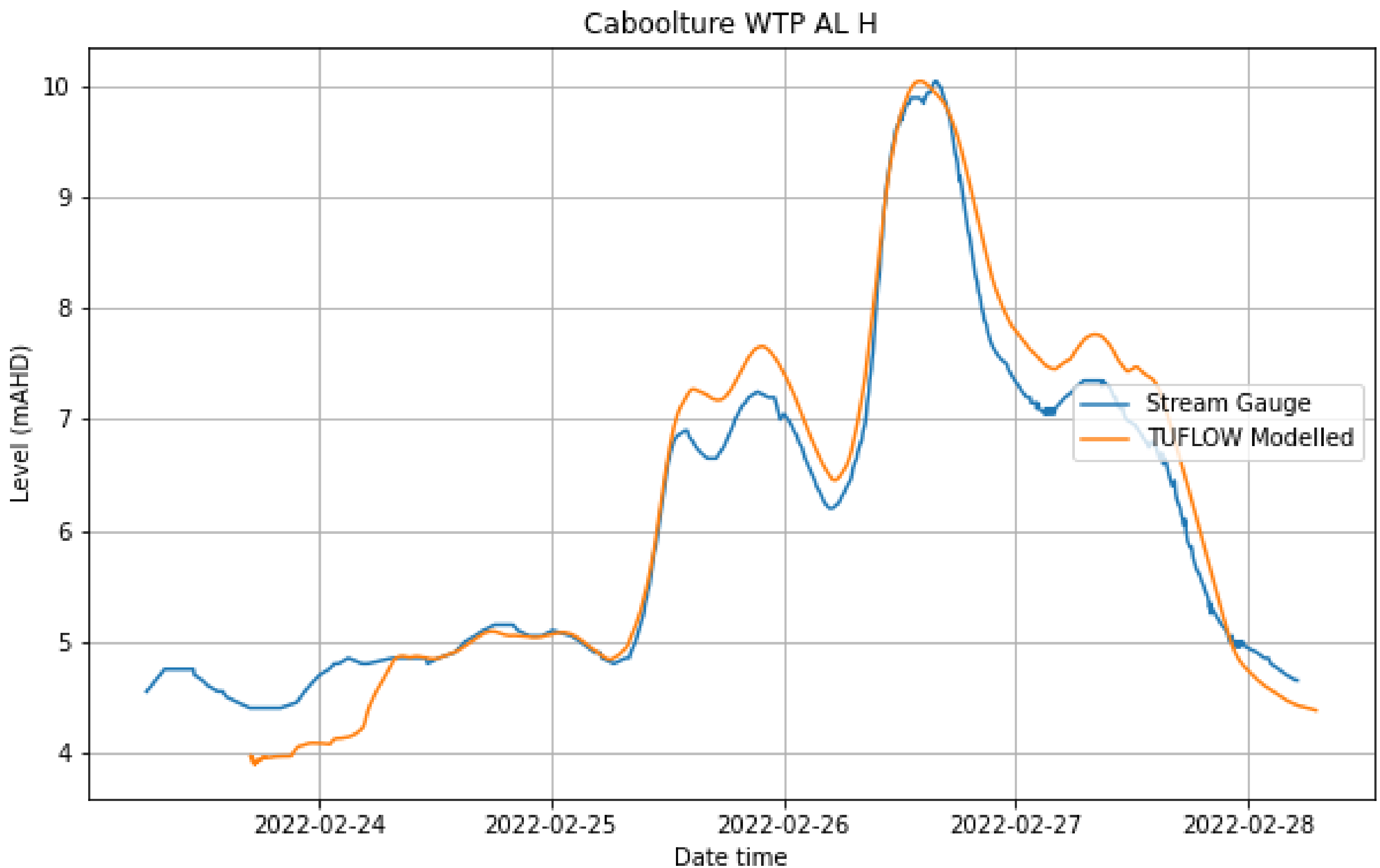
Caboolture (Bribie Island Rd H
Level (mAHD)
4.0
3.5
3.0
2.5
2.0
1.5
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Date time
Stream Gauge
TUFLOW Modelled

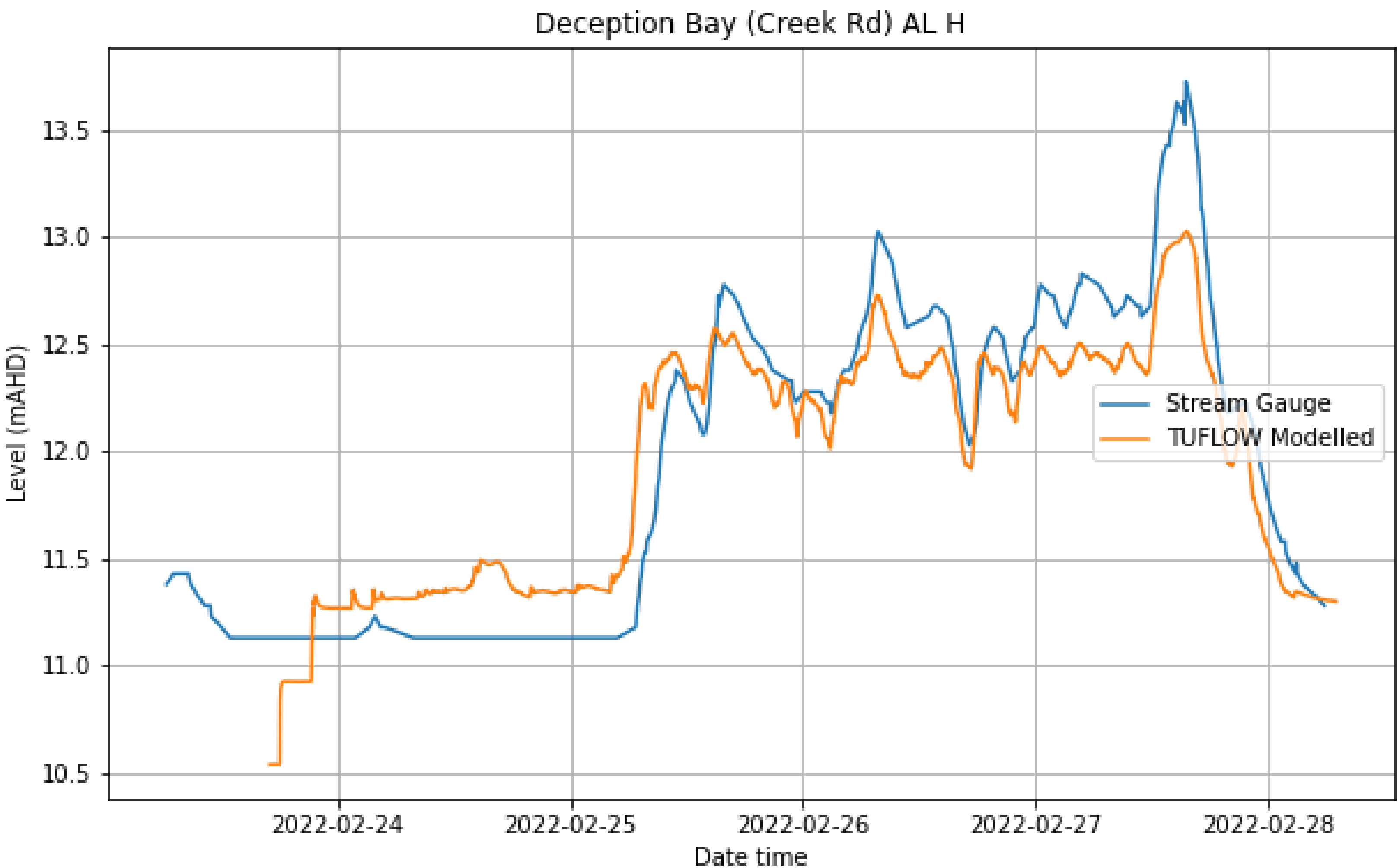

Caboolture (MachineryPde) H
Level (mAHD)
8
9
10
11
12
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Date time
Stream Gauge
TUFLOW Modelled


Caboolture (Pumicestone Rd) H
Level (mAHD)
8.0
7.5
7.0
6.5
6.0
5.5
5.0
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Date time
Stream Gauge
TUFLOW Modelled

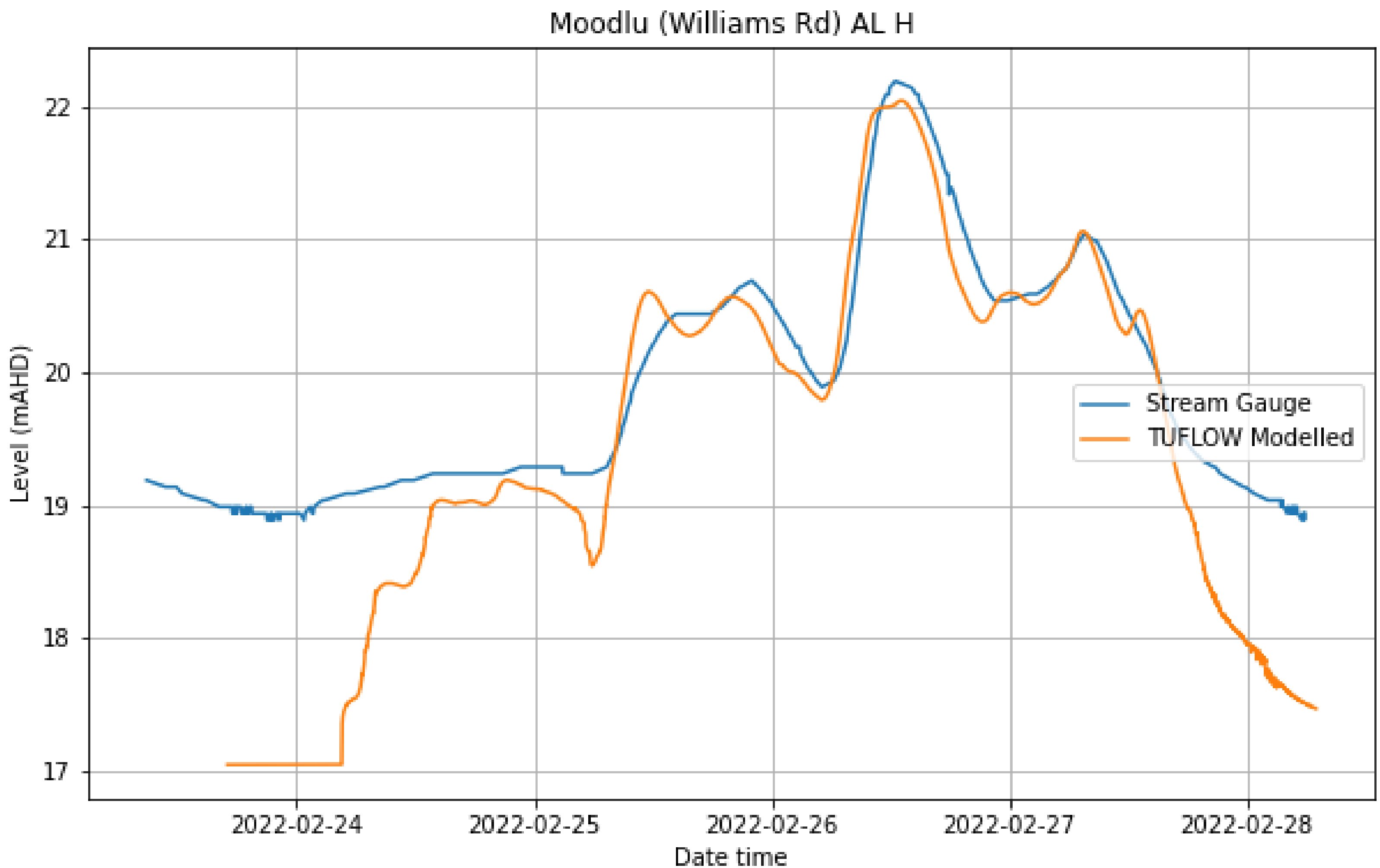


Caboolture (Short St) AL H
Level (mAHD)
0
2
4
6
8
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Date time
Stream Gauge
TUFLOW Modelled

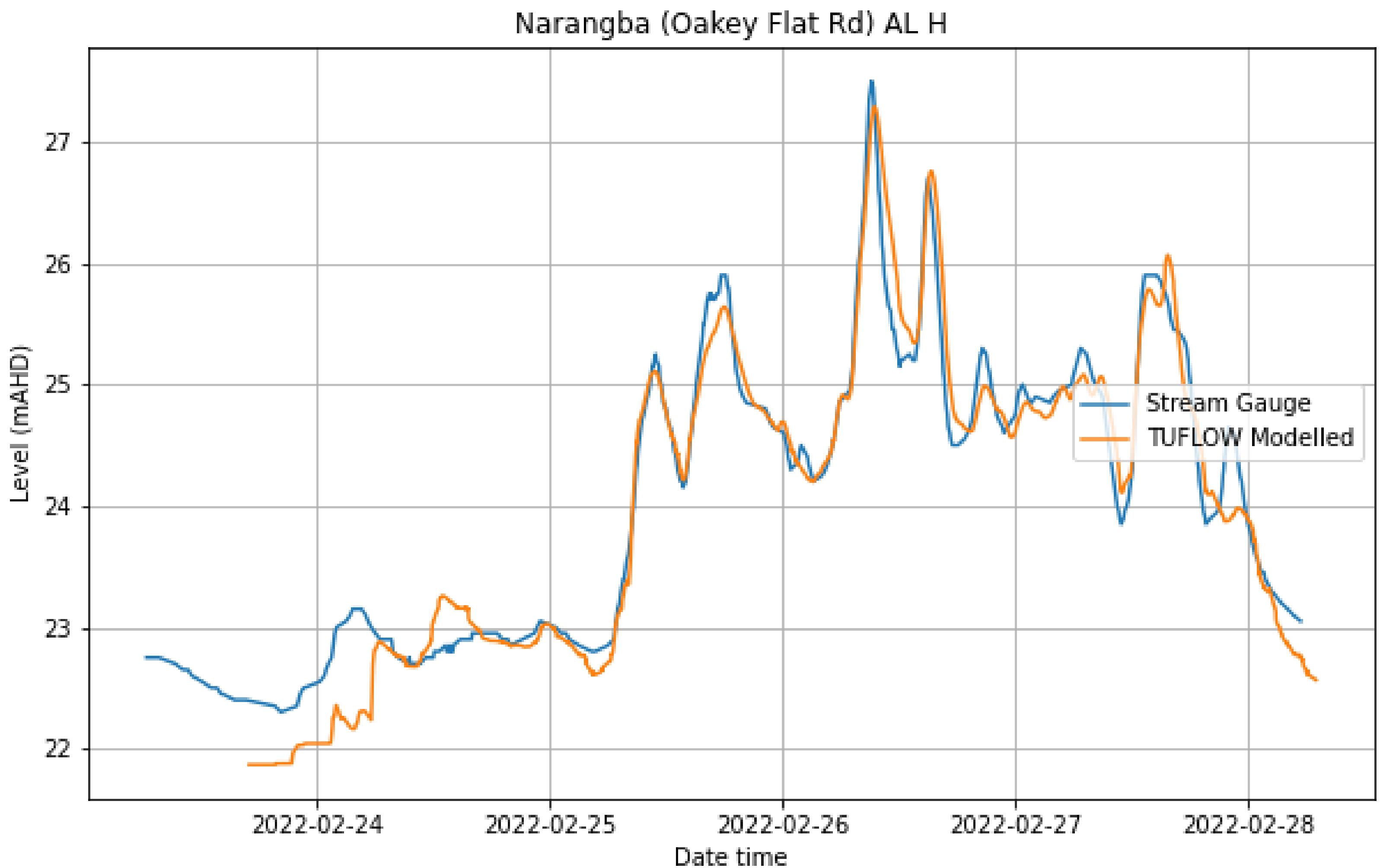

Caboolture WTP AL H
Level (mAHD)
Date time
10
9
8
7
6
5
4
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Stream Gauge
TUFLOW Modelled

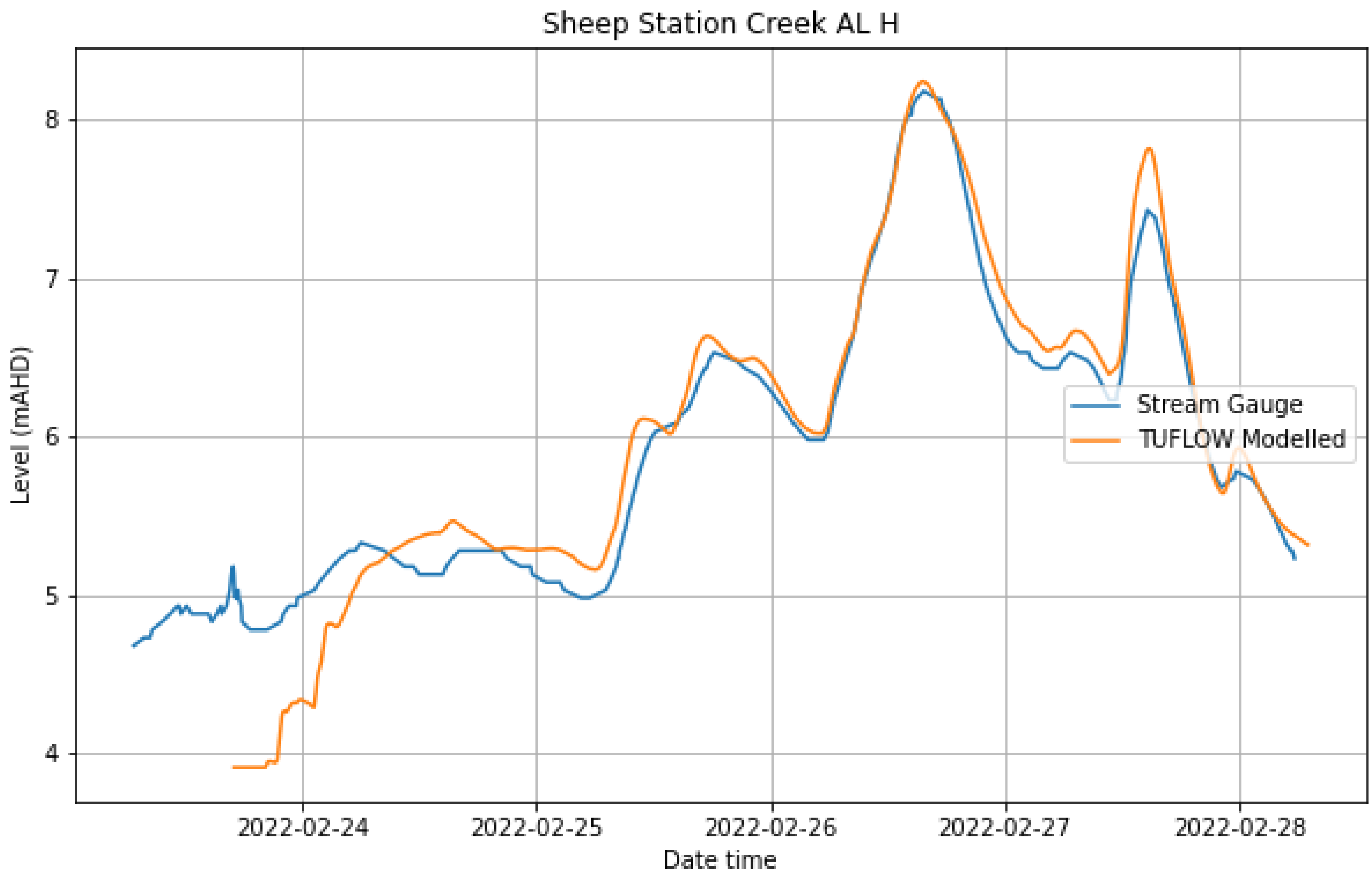


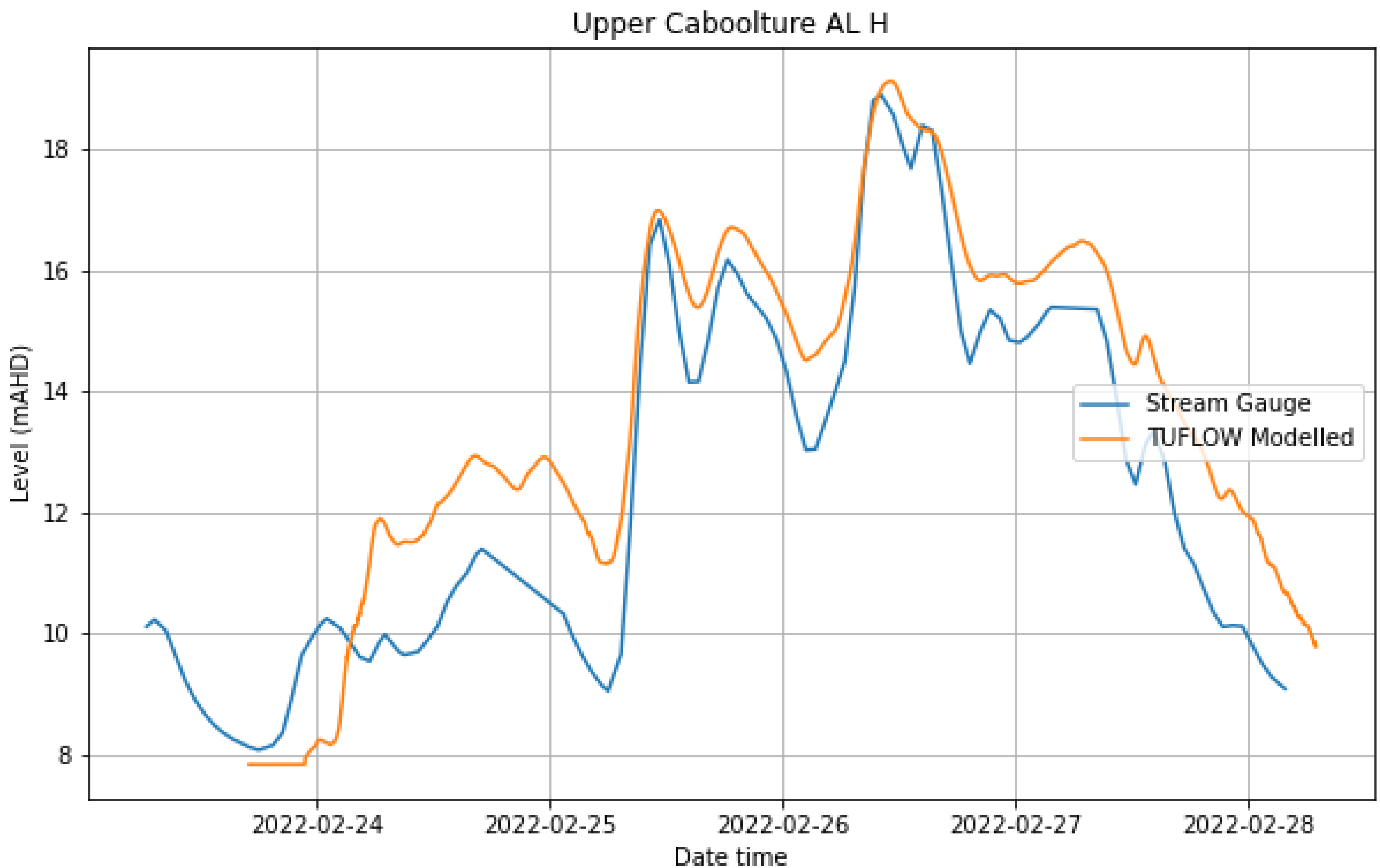
Deception Bay (Creek Rd) AL H
Level (mAHD)
13.5
13.0
12.5
12.0
11.5
11.0
10.5
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Date time
Stream Gauge
TUFLOW Modelled

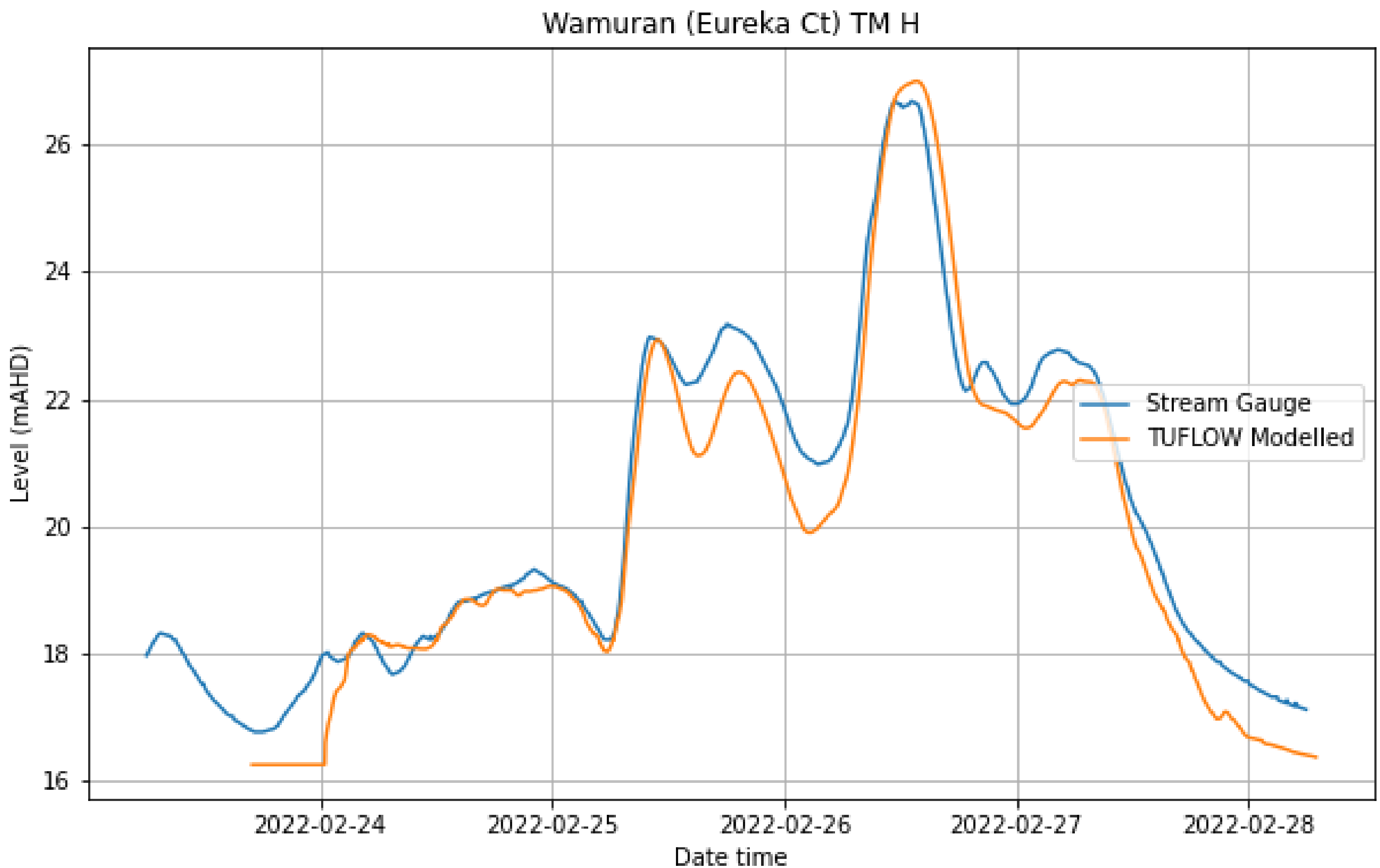


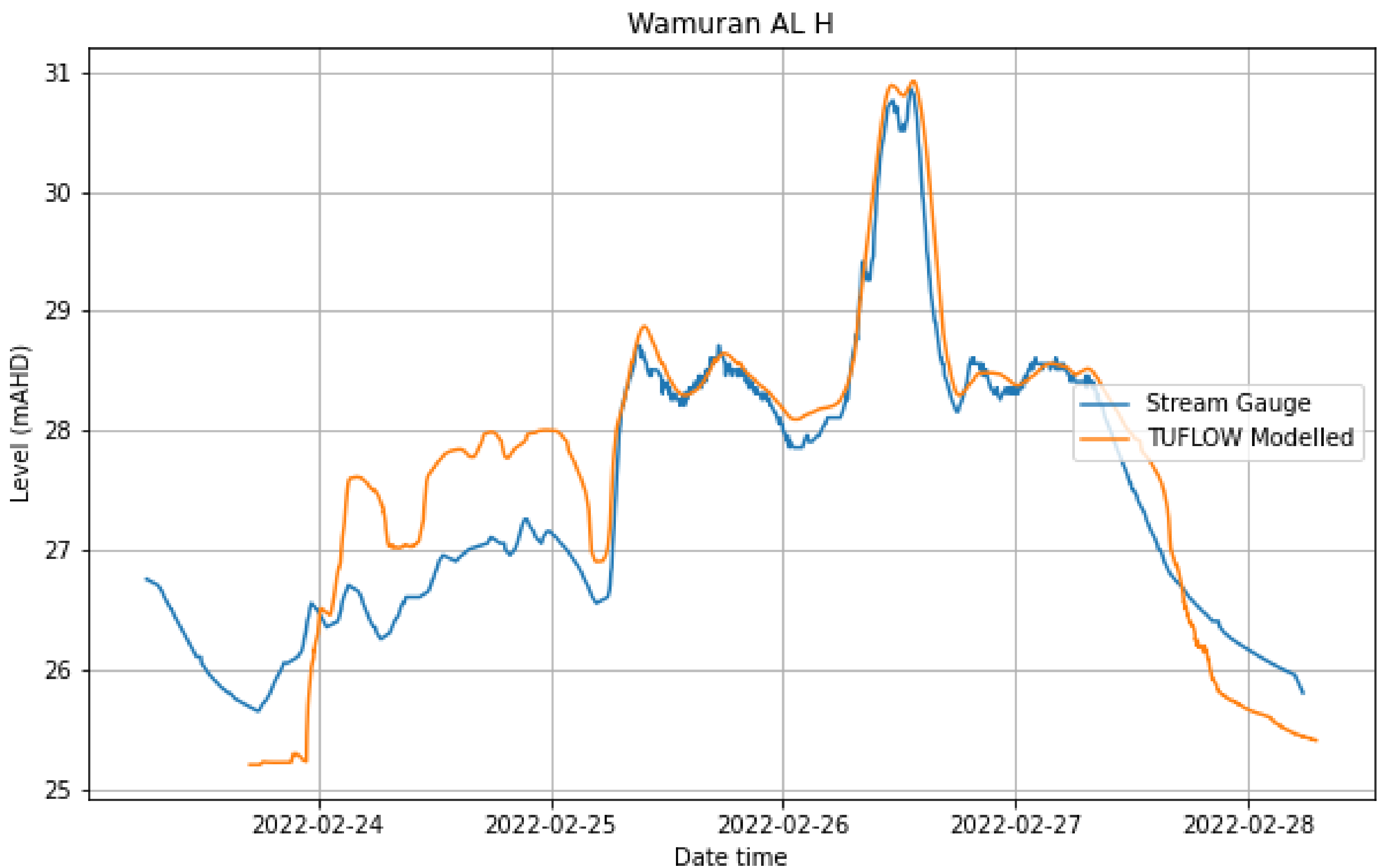
Moodlu (Williams Rd) AL H
Level (mAHD)
22
21
20
19
18
17
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Date time
Stream Gauge
TUFLOW Modelled


Narangba (Oakey Flat Rd) AL H
Level (mAHD)
27
26
25
24
23
22
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Date time
Stream Gauge
TUFLOW Modelled


Sheep Station Creek AL H
Level (mAHD)
8
7
6
5
4
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Date time
Stream Gauge
TUFLOW Modelled


Upper Caboolture AL H
Level (mAHD)
8
10
12
14
16
18
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Date time
Stream Gauge
TUFLOW Modelled


Wamuran (Eureka Ct) TM H
Level (mAHD)
16
18
20
22
24
26
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Date time
Stream Gauge
TUFLOW Modelled



Wamuran AL H
Level (mAHD)
31
30
29
28
27
26
25
2022-02-24
2022-02-25
2022-02-26
2022-02-27
2022-02-28
Date time
Stream Gauge
TUFLOW Modelled

APPENDIX I
HEH PLOTS AND SUMMARY TABLE

POI HEH performance summary

POI	Artificial Storage	Storage description	No. of model runs with peaks within 10%	No. of model runs with timing within 15min
BUR001_00000			0	1
BUR001_02526	✓	Large floodplain storage in tidally influenced downstream area of Burpengary Creek	5	1
BUR001_12773	✓	In-stream and floodplain storage upstream of Bruce Highway crossing	5	4
BUR001_15768			6	5
BUR001_16406	✓	In-stream and floodplain storage upstream of rail corridor crossing	7	4
BUR001_18266	✓	In-stream and floodplain storage upstream of Rowley Road bridge crossing	7	3
BUR001_20285			7	4
BUR001_23663	✓	In-stream natural channel storage	5	6
BUR001_26663	✓	In-stream natural channel storage	5	6
BUR001_31228	✓	In-stream natural channel storage	5	5
BUR006_00000	✓	Downstream of large regional detention basin	1	7
BUR006_01731			7	7
BUR011_01509			9	6
BUR013_00389			9	6
BUR018_00267			9	9
BUR019_00078			9	9
BUR024_00980			9	6

POI	Artificial Storage	Storage description	No. of model runs with peaks within 10%	No. of model runs with timing within 15min
BUR024_02119			8	7
BUR032_00750			9	9
BUR036_01339			8	9
BUR050_00000			8	8
BUR084_00000			8	7
CAB001_09077	✓	Large in-stream and floodplain storage upstream of Bruce Highway crossing (and including backwater in Sheep Station Creek)	5	2
CAB001_11315			3	7
CAB001_11920			8	0
CAB001_13077			9	2
CAB001_15021			9	1
CAB001_18625	✓	In-stream natural channel and floodplain storage	7	6
CAB001_22731			4	5
CAB001_24517	✓	In-stream natural channel storage	5	4
CAB019_01687			9	5
CAB019_03765			4	9
CAB021_00000	✓	In-stream natural channel storage	6	4
CAB021_02894			8	9
CAB034_04552			8	2
CBM001_01940			0	1

POI	Artificial Storage	Storage description	No. of model runs with peaks within 10%	No. of model runs with timing within 15min
CBM007_02274	✓	Beachmere lake	3	6
DEC006_00061			5	8
GOD001_00434	✓	Complex floodplain storage – curve does not perform well	0	0
GRE001_00000			6	5
GYM001_04853	✓	Storage upstream of Bruce Highway crossing	8	2
GYM001_07715	✓	Storage upstream of Morayfield Road and Rail corridor crossings	5	5
GYM004_00468	✓	Storage upstream of Morayfield Road and Rail corridor crossings	6	7
GYM006_00000			7	4
GYM006_00837	✓	Storage upstream of Bruce Highway crossing	7	7
KJC001_15910	✓	Large floodplain storage upstream of Bribie Island Road	0	3
KJC001_22340			9	4
KJC001_24247			8	4
KJC001_26759			7	5
KJC006_01796			8	9
LAG001_01199	✓	Storage upstream of Bruce Highway crossing	5	4
LAG001_04754			8	6
LAG001_05523			2	3
LAG001_12318	✓	In-stream natural channel storage	7	6
LAG030_00652	✓	Central Springs lake upstream of Smiths Road	8	7

POI	Artificial Storage	Storage description	No. of model runs with peaks within 10%	No. of model runs with timing within 15min
LBC001_02006	✓	In-stream natural channel and floodplain storage	2	1
LBC001_04447			9	6
LBC001_07420			5	5
LBC001_09441			9	4
LBC001_11534	✓	Gekko Gully Park detention basin and storage upstream of Omara Road	8	6
LBC034_00980	✓	In-stream natural channel and floodplain storage	9	6
LBC046_01605			9	9
SSC001_00000	✓	In-stream natural channel and floodplain storage including Riverbank decanting basins	n/a	n/a
SSC001_03599	✓	Storage upstream of Morayfield Road	9	9
SSC001_05513	✓	Storage upstream of Walkers Road	6	1
SSC006_00249	✓	Storage upstream of McLoughlin Road	8	5
SSC006_02003	✓	Storage between Williamson Road and Forest Hills Drive	8	5
SSC012_01145			5	4
SSC018_00479			8	4
SSC018_02296	✓	Verschave Lake, Hatte Lake and additional small storages upstream, including on-line detention at Burbury Road	9	9
SSC020_00661			9	5
WAR001_00000			7	3
WAR001_02090	✓	In-stream natural channel storage	8	3
WAR001_09562	✓	In-stream natural channel storage	6	5

POI	Artificial Storage	Storage description	No. of model runs with peaks within 10%	No. of model runs with timing within 15min
WAR001_11338			8	5
WAR001_13974			9	6
WAR001_14487			9	5
WAR028_00638	✓	Storage upstream of Old N Road culverts	7	4
WAR032_03200	✓	In-stream natural channel storage	6	5
WAR032_08233	✓	In-stream natural channel storage	5	5
WAR050_00000			6	4
WAR050_06071	✓	In-stream natural channel storage and several large on-stream farm dams	8	8