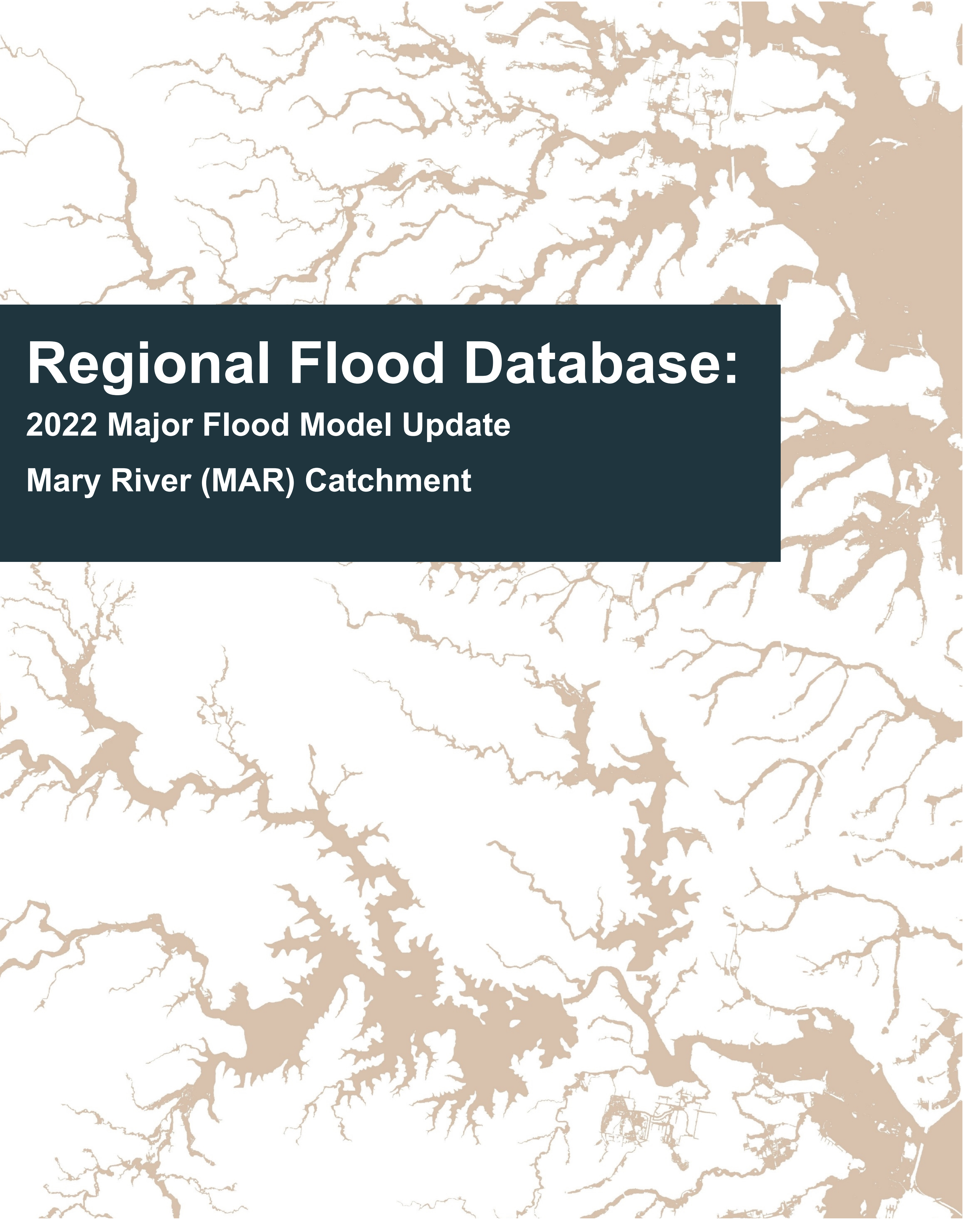

Regional Flood Database:

2022 Major Flood Model Update

Mary River (MAR) Catchment

CITY OF
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Acknowledgment of Traditional Custodians

City of Moreton Bay acknowledges the Jinibara, Kabi Kabi and Turrbal peoples and pays respects to Elders, past, present and emerging. Council recognises that the Moreton Bay region has always been a place of cultural, spiritual, social and economic significance to its Traditional Custodians. Council is committed to reconciliation and working in partnership with Traditional Custodians and Aboriginal and Torres Strait Islander communities to shape a shared future for the benefit of all communities within the City of Moreton Bay and beyond.

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1 Introduction

City of Moreton Bay Council (Council) 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 local government area and for the local community. The RFD model library includes coupled hydrologic and hydraulic models, one for each of the 'minor basins' within the Council area.

A major update to the RFD was initiated in 2019. Stages 1 to 3 involved testing proposed methods, preparing model data, and testing potential modelling approaches.

This report details the project methodology, results and outcomes of Stages 4 and 5 for the Mary River catchment (MAR), referred to as the 2022 RFD. Figure 1.1 presents the location of the Mary River catchment in the context of the wider Local Government Area (LGA) boundaries.

The primary objectives of the Stage 4 study for MAR are:

- Update of the WBNM hydrologic model and TUFLOW hydraulic model according to the outcomes of the Stage 1 project utilising the findings of the Stage 3 project.
- Historic event modelling for the February 2022 event.

A key difference between Stage 4 for MAR and for other catchments in the RFD is that no 'hydraulic-equivalent' hydrology (HEH) model was developed. Additionally, no calibration or validation occurred based on data within the catchment. Calibration parameters were instead adopted to be consistent with other calibrated and validated RFD models.

The primary objectives of the Stage 5 study are:

- Design event modelling for existing (circa 2019 - 2022) and future conditions
- Design event flood surface creation for existing (circa 2019 - 2022) and future conditions

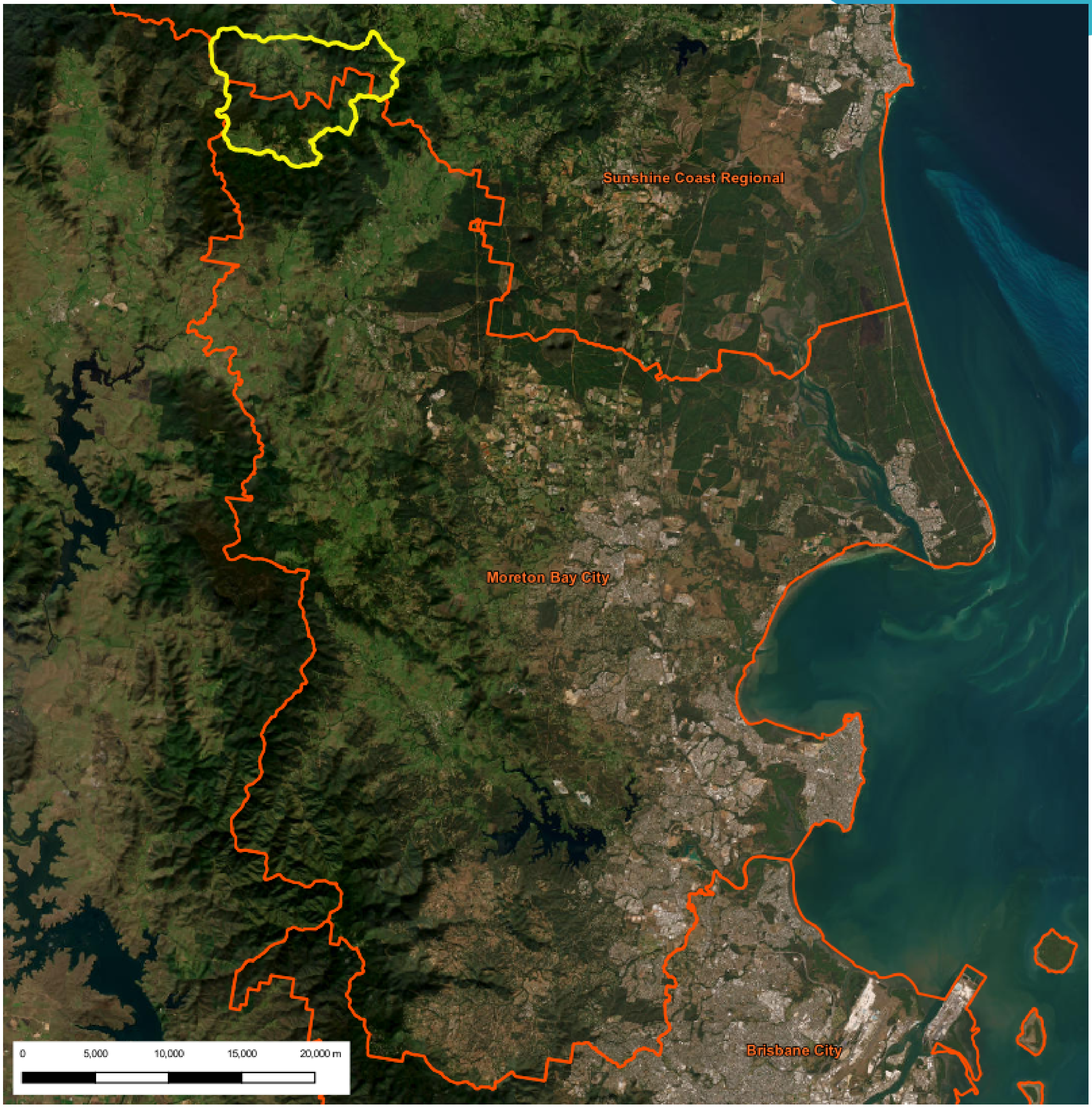

Figure 1.1 Mary River Minor Basin Locality

2 Background

The methodology behind the RFD is primarily based on the national guideline for flood estimation, Australian Rainfall and Runoff 2019 version 4.1(Ball et al. 2019). This guideline underwent a major revision in 2016 (version 4.0) and a minor update in 2019 (version 4.1). The updated guideline, together with recently collected new survey information (i.e. LiDAR flown in 2019) and recent historic flood information across the region, provides Council with an opportunity to undertake a major update to the RFD. This major update was delivered in five stages, with Stages 1, 2 and 3 having been completed previously:

- Stage 1 – Pilot Study – investigated the required/ recommended modelling methodology changes for the RFD, utilising ARR 2019 guidelines (Arup 2021).
- Stage 2 – Hydrography Land use and Hydrology – entailed update of Council's land use roughness layers, catchment delineation and hydrology models (AECOM 2020).
- Stage 3 – Hydraulic model configuration investigation – was an internal investigation conducted by Council staff reviewing recently released software computation methods and capabilities to identify potential application to RFD hydraulic model setup (Moreton Bay Regional Council 2021).

The RFD models for MAR consist of a WBNM hydrologic model and a TUFLOW hydraulic model. These were created at the initiation of the RFD project, commenced 2009 and completed in 2012. The MAR models were last updated in 2015 as part of a RFD Minor Update project which primarily involved updating terrain data from 2009 to 2014 data (MAR model completed in 2015, overall project occurred between 2014-2016). The previous version of the RFD is termed the 2014 RFD models or version 002c RFD. The major update documented by this report is termed the 2022 RFD update or version 003a RFD.

2.1 Catchment Description

The Mary River model extent covers the Mary River catchment within the Moreton Bay LGA, as well as a portion of the catchment within the Sunshine Coast LGA. The Mary River floodplain within the Moreton Bay LGA is characterized by largely undisturbed and heavily vegetated steep meandering streams with minimal dams and storage. The very upper catchment is cleared, with land-use mostly rural and open grazing, with isolated scattered dwellings. The mid-catchment (located at the boundary between the two LGAs) is heavily vegetated, inclusive of Bellthorpe National Park. The lower catchment again features cleared and grazing areas. The majority of dwellings are located in this lower catchment near the suburb of Crystal Waters within the Sunshine Coast Local Government Area.

3 2022 Major Flood Model Update Details

3.1 Key Methodology Changes related to ARR 2019

The 2014 RFD models 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.

Stage 1 of the RFD major update project demonstrated the viability of using a hydrologic model which produces similar results to the hydraulic model (termed a hydraulic equivalent hydrologic model or HEH model) to identify critical storms. A 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. RFD TUFLOW models could be used to inform the hydrologic model storage and routing parameters giving a hydraulic equivalent hydrologic (HEH) model.

As such, the majority of the RFD models use the HEH approach for selection of critical design storms. However, as the MAR model is small in comparison to other RFD models, it was decided to not use the HEH approach. Instead, all storms are simulated in the TUFLOW hydraulic model for the existing conditions scenario, and critical storms determined from processed peak flood surfaces. The future scenario utilises these identified 3 to 4 critical storms.

Should desire exist in the future to use the MAR WBNM model for flood forecasting purposes, it is recommended that a Hydraulically Equivalent Hydrologic (HEH) model is developed.

All ARR 2019 hydrological modelling was undertaken within the Catchment Simulation Solutions Storm Injector software version 1.3.7 along with the WBNM engine included with Storm Injector (version unspecified).

Subsequent to the completion of the majority of the MAR major update, an update to the climate change chapter within Australian Rainfall and Runoff was finalised in late 2024 (referred to as ARR version 4.2). This RFD major update does not incorporate ARR4.2 guidance.

3.2 Rainfall Intensity-Frequency-Duration (IFD) Update

3.2.1 Intensities

Design flood estimates derived for the Mary River Catchment 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) which recommended the high-resolution dataset. The high-resolution dataset is at a more suitable resolution for application to subcatchments throughout the local government area. IFDs were extracted at each subcatchment centroid utilising the Storm Injector custom IFD ingest tool.

3.2.2 ARR 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/). Parameters near the centroid of the catchment are presented in Table 3.1.

Table 3.1 ARR 2019 DataHub Parameters

Parameter	Value
Longitude	152.7265
Latitude	-26.8053
River Region	North East Coast
River Name	Mary River
ARF parameters	East Coast North
Storm Initial Losses (mm)	19.0
Storm Continuing Losses (mm/h)	2.0
Temporal Patterns	East Coast North Point

3.3 WBNM Hydrological Model Update

3.3.1 Subcatchment Updates

The updated WBNM model and associated GIS files were based on the Stage 2 - Hydrography Landuse and Hydrology Study. The MAR WBNM contains 89 individual subcatchments, which were unchanged in geometry from the 2014 RFD model. Figure 3.1 below shows the WBNM subcatchment layout.

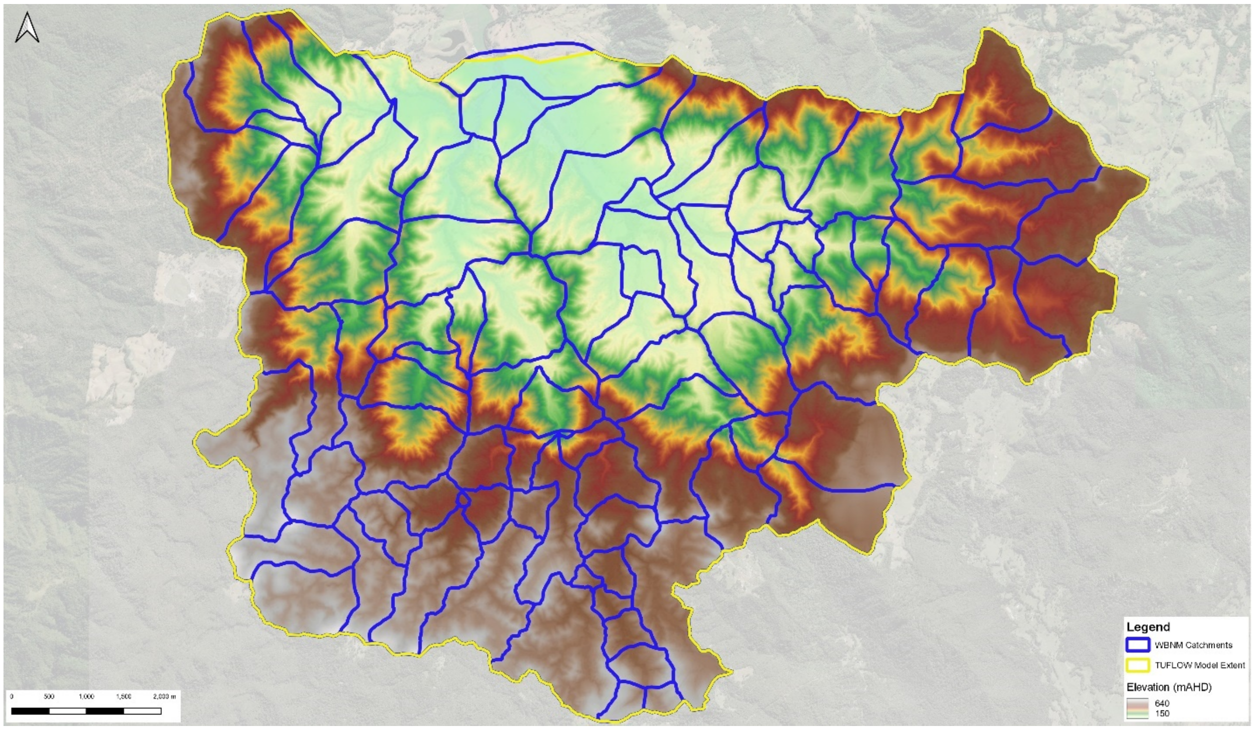

Figure 3.1 MAR WBNM Subcatchments

3.3.2 Impervious Areas

An Effective Impervious Area (EIA) raster dataset for the entire LGA was created for the RFD major update for the purposes of updating percentage impervious values in the hydrologic models, for both existing and future conditions. Impervious fraction calculations were not undertaken within the WBNM hydrologic model package or Storm Injector. Instead, an average calculation was undertaken in ArcMap using pervious/impervious rasters to determine the impervious fraction to be applied in the WBNM model for each subcatchment.

The Stage 1 project identified the manner by which a Total Impervious Area (TIA) raster is to be converted into an EIA raster. The existing conditions EIA raster was created using Stage 2 datasets (i.e. 2019 aerial photography based landuse classification) and based on guidelines provided in the Stage 1 Report. As such, the present-day raster represents catchment conditions in 2019.

The ultimate EIA raster was created by Council Staff using Stage 1 advice and based on the Local Government Infrastructure Planning (LGIP) ultimate development landuse raster. The LGIP ultimate development landuse raster was developed as part of the 2019-2021 LGIP stormwater quantity network planning project (adopted into the planning scheme in 2021). The raster assumes full development according to the land use intent of the planning scheme Strategic Framework Place Types. It is inclusive of growth areas but exclusive of investigation areas.

For context, strategic frameworks are developed to help create a longer vision (perhaps 25 years) for a local government area beyond that of the approximately 15 year timeframe of a Planning Scheme. The LGIP ultimate development landuse raster used by this project cannot have a timestamp allocated to it, as the timeframe for densification of existing landuses is difficult to estimate. However, it could be estimated that the landuse represented by the LGIP ultimate development landuse raster may be reached by approximately 2055. **Error! Reference source not found.** and Figure 3.3 below show the existing and ultimate EIA rasters for the Mary River catchment.

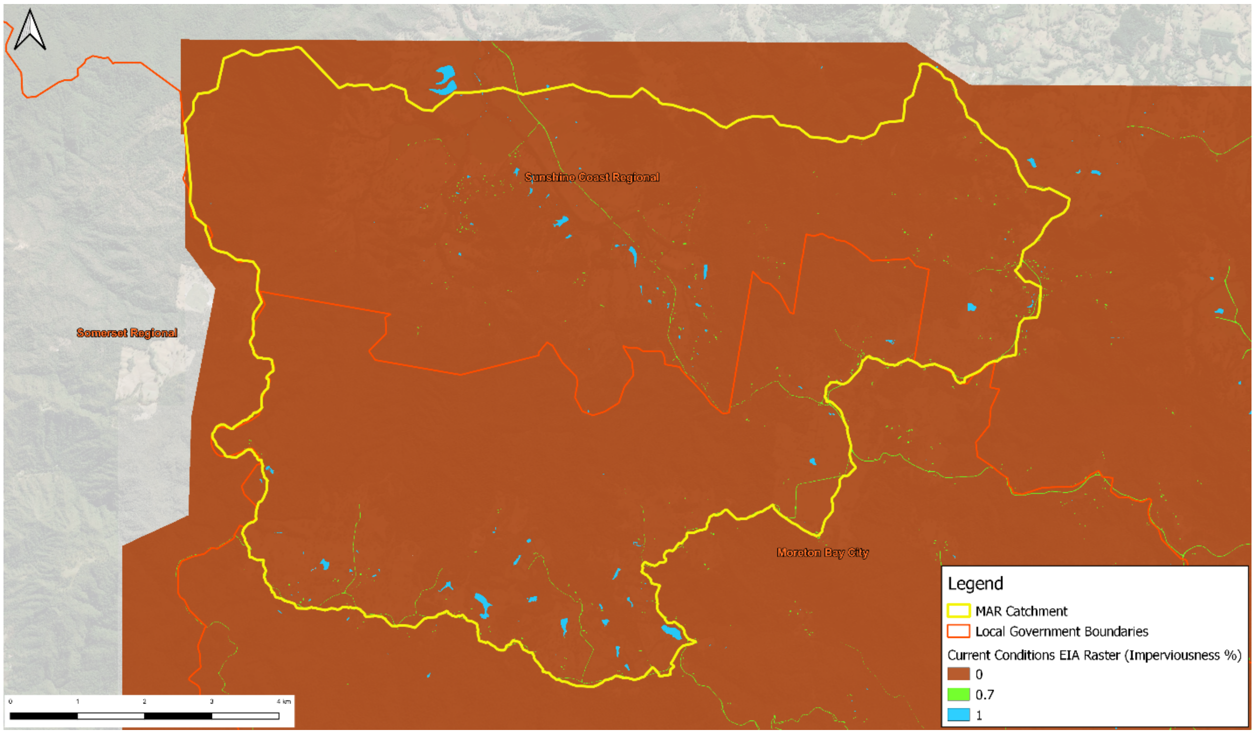

Figure 3.2 Current conditions EIA raster (MAR catchment).

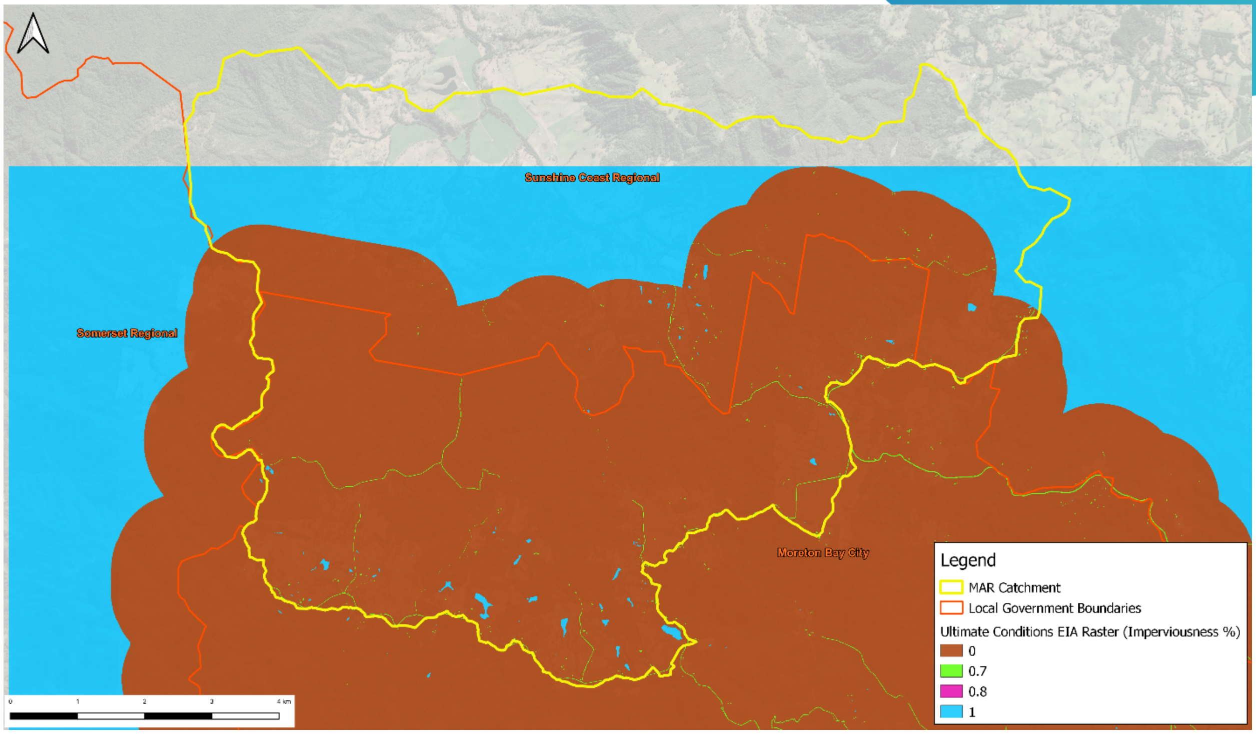

Figure 3.3 Ultimate Conditions EIA Raster (MAR catchment)

For MAR, existing conditions have been modelled with TIA values rather than EIA values. Whilst this is a misalignment with the approach adopted for all other RFD catchments, this was considered a conservative approach, since all TIA subcatchment averages are greater than or equal to EIA values. A future minor update to the MAR catchment should nonetheless seek to rectify this and maintain regional consistency with respect to impervious fraction values.

Future conditions have been predominately modelled with the ultimate EIA values. Owing to the different base datasets used to create the existing and ultimate landuse layers, it is possible for the existing scenario EIA to be greater than the ultimate scenario EIA for a subcatchment. Where the ultimate EIA values for a subcatchment were lower than the existing TIA value, the existing TIA values were adopted in the future scenario. Additionally, 35 subcatchments were entirely or partially outside of the ultimate EIA raster extent (the subcatchments being in the Sunshine Coast LGA), and so the existing TIA value was adopted for these subcatchments.

3.3.3 Parameters

The Mary River Catchment WBNM model 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 since no calibration runs were undertaken for the MAR catchment.

3.3.4 Areal Reduction Factors

The Stage 1 pilot study recommended that areal reduction factors (ARFs) be calculated at each point of interest (POI) to run the WBNM design event models. For MAR, instead of POIs, it was determined that grouping subcatchments into ARF categories would allow a more practical approach. Table 3.2 presents the categories applied to the MAR model. When design event simulation occurred in the TUFLOW model, separate simulations were not completed for each ARF. Instead, for each duration, flow hydrographs for the subcatchments were applied from the applicable ARF category i.e. the 1% 120min TP1 storm TUFLOW run includes hydrographs with ARFc, ARFd and ARFe in the single simulation. Appendix A provides a table of each subcatchment with the applicable ARF category for design event modelling.

A consistent series of ARF groupings was developed for the RFD major update project. For MAR, any subcatchments with areas less than 5km^2 were categorised as ARFc rather than ARFa (for catchments of size 0 to 1.5km^2 with ARF=1) or ARFb (for catchments of size 1 to 5 km^2 with ARF set as calculate for a 2.5km^2 catchment).

Table 3.2 ARF Classifications

RFD Naming Convention	# of subareas in class	Area Range (lower to upper bounds)	Applied Area (Storm Injector)	Temporal Pattern Applied
ARFc	76	5km2 to 15km2	10km2	Point
ARFd	10	15km2 to 35km2	25km2	Point
ARFe	3	35km2 to 75km2	50km2	Point

A sensitivity test was undertaken in WBNM to confirm the adopted ARFc (Area = 10km^2) did not cause a significant reduction in water levels, by comparing to results utilising ARFa (ARF=1). Hydraulic calculations were undertaken using Manning’s equation with simplified trapezoidal channel geometry (shown in

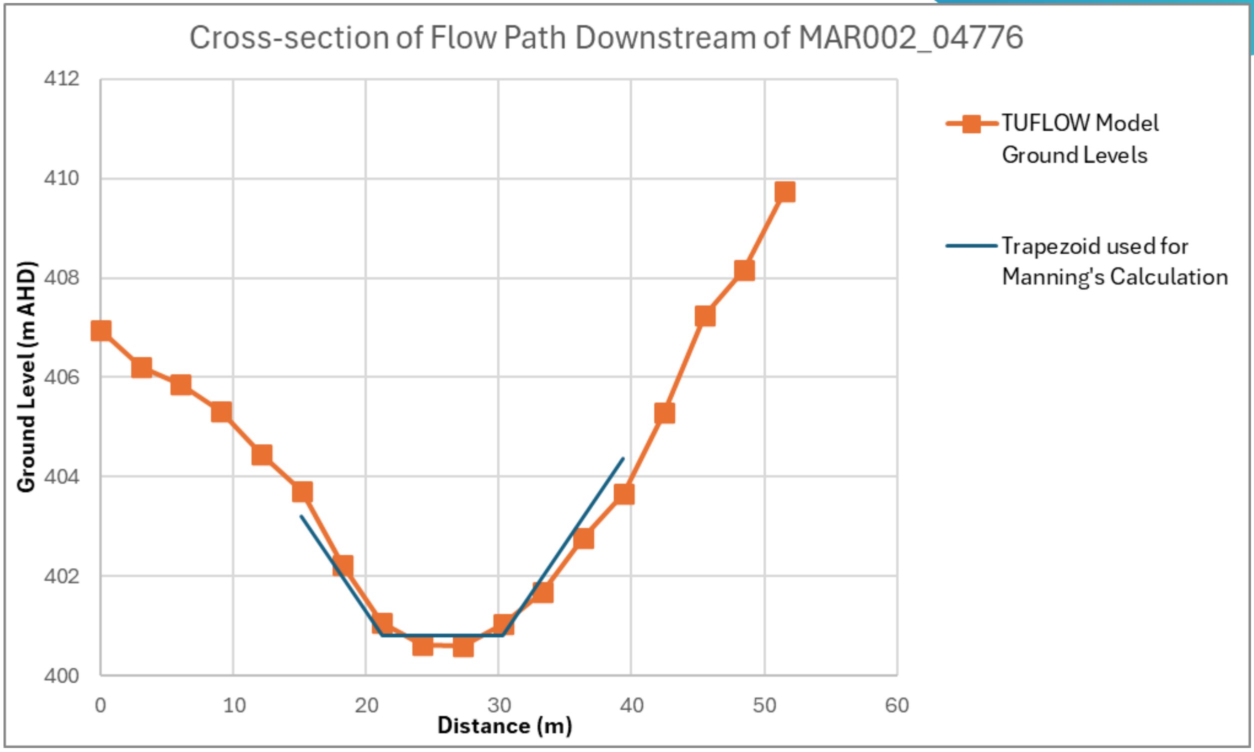

Figure 3.4 below) representative of typical channel geometry (cross section based on channel within subcatchment MAR002_04776with assumed channel roughness of 0.057).

It was found that peak flow difference was less than 10% for the 5% and 1% AEP storms, and was 15% for the 1 in 1000 and 1 in 2000 AEP storms. The largest difference in ARF value was noted as the 1 in 2000 AEP 10 minute storm (ARF value of 0.783; the event is noted to be not a critical duration for the catchment). This resulted in a 35% difference in peak flow (magnitude of 6.5m3/s difference, total flow of 18.7m3/s with ARF=1).

The Manning’s equation results (shown in Table 3.3 below) indicate 30mm or less difference in depth for the 5% and 1% AEP critical storm events (depth approximately 0.9m), and 100mm difference for the 1 in 1000 and 1 in 2000 AEP critical storm events (total depth approximately 1.3m). This was repeated for a channel with a roughness value of 0.03 (results shown in Table 3.4 below). Difference in depth was 20mm or less difference for the 5% and 1% AEP critical storm events (depth approximately 0.6m), and 80mm difference for the 1 in 1000 and 1 in 2000 AEP critical storm events (total depth approximately 0.9m).

Regarding the larger (approximately 100mm) difference for the more rare storms, it is noted that the Stage 1 Pilot study indicated that differences in this order of magnitude could occur if picking a sub-selection of storms for modelling in TUFLOW (as compared to running all storms in TUFLOW). This was considered a tolerable outcome when noting the benefits of running a sub-selection of storms chosen from a HEH model as compared to running all in TUFLOW. Thus, whilst not ideal, the 100mm difference in the MAR model as a result of ARF C (instead of ARF A) for the larger and more rare storms is considered acceptable. It should be considered in the next model update if adopting more conservative ARF values is more appropriate for this catchment.

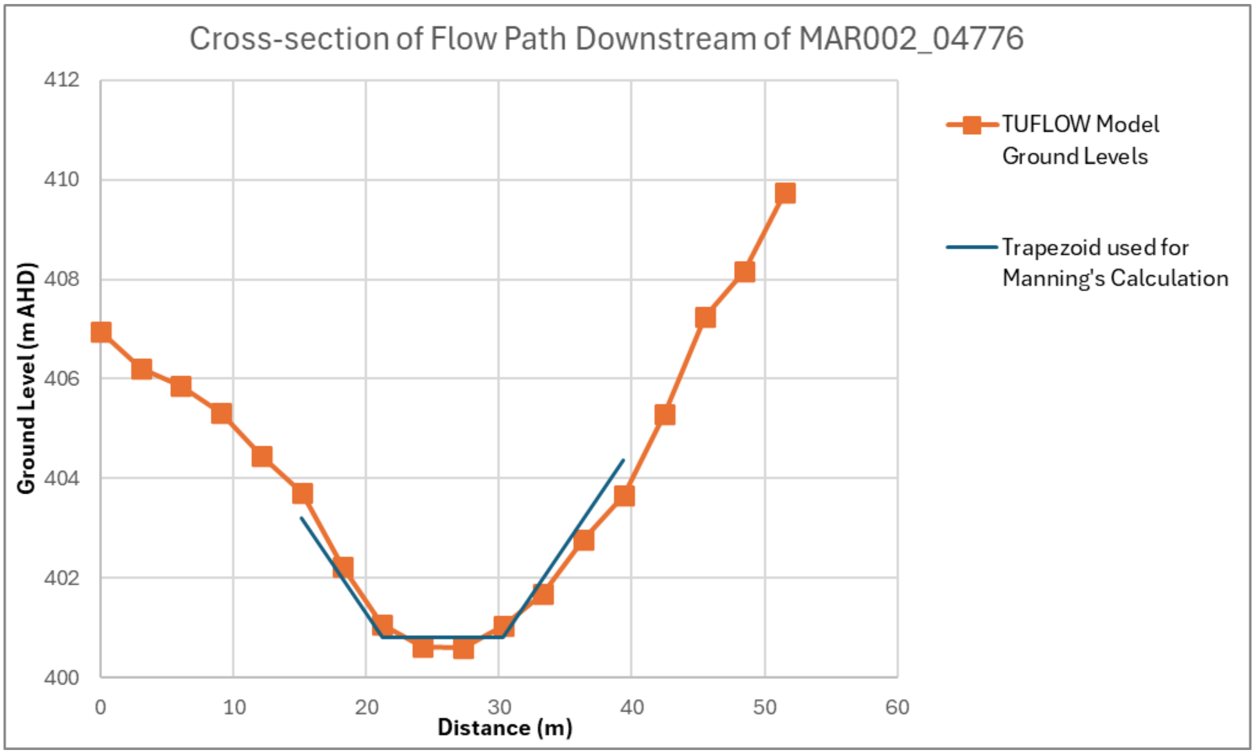

Figure 3.4 Cross-section of representative channel used for comparing peak water level depths with ARFc vs ARFa

Table 3.3 ARFc vs ARFa Manning's equation calculation results, n=0.057

AEP	Critical Event	ARFc value	Peak flow (m3/s)		Calculated Depth (m)		Difference in depth (m)	Difference in flow (%)	Difference in depth (%)
			ARFc	ARFa	ARFc	ARFa			
5%	270m TP9	0.94	18.36	19.58	0.83	0.86	0.03	6%	3%
1%	540m TP1	0.97	23.23	24.12	0.95	0.97	0.02	4%	2%
0.1%	120m TP5	0.88	32.63	38.11	1.15	1.25	0.10	14%	8%
0.05%	120m TP5	0.87	36.00	42.47	1.22	1.33	0.12	15%	9%
0.05%	10min TP7	0.78	12.13	18.73	0.66	0.84	0.19	35%	22%

Table 3.4 ARFc vs ARFa Manning's equation calculation results, n=0.03

AEP	Critical Event	ARFc value	Peak flow (m3/s)		Calculated Depth (m)		Difference in depth (m)	Difference in flow (%)	Difference in depth (%)
			ARFc	ARFa	ARFc	ARFa			
5%	270m TP9	0.94	18.36	19.58	0.58	0.60	0.02	6%	4%

1%	540m TP1	0.97	23.23	24.12	0.66	0.67	0.01	4%	2%
0.1%	120m TP5	0.88	32.63	38.11	0.80	0.88	0.07	14%	8%
0.05%	120m TP5	0.87	36.00	42.47	0.85	0.93	0.08	15%	9%

3.3.5 Preburst Application

Preburst has been applied by injecting it prior to the storm. Pre-burst rainfall was applied generally following the methodology in the Stage 1 guidance, with the main exception of using the GSDM pattern in lieu of Jordan’s pattern (undertaken for all catchments as part of the major RFD update). This alteration to temporal patterns was undertaken to ensure that preburst rainfall was not significantly affecting peak flow. Table 3.5 presents the preburst temporal patterns as applied in Storm Injector.

An additional variance from the Stage 1 guidance was lack of factoring of preburst depth for extreme events and for the future condition scenarios. The 1% AEP preburst depth was utilised for the 1 in 1000 and 1 in 2000 AEP events; it was not scaled as recommended in the Stage 1 guidance. Additionally, whilst burst depth was adjusted by 20% for future conditions scenarios, preburst depth was not. The Stage 1 guidance was produced prior to the adoption of the LIMB 2020 rainfall depth datasets; review of preburst application methodology will likely be considered in future RFD updates.

Table 3.5 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 ARR 2019 interim RCP8.5 climate change scenario featuring an increase in rainfall intensity of 20%. The future climate modelling also incorporates ultimate landuse data as discussed in Section 3.3.2.

3.3.7 Design Event Rainfall Losses

Rainfall losses adopted for the design event modelling are based on the ARR Datahub (i.e. 19 mm Initial Loss and 2.0 mm/hr Continuing Loss). This approach is consistent with neighbouring RFD catchments.

3.4 TUFLOW Hydraulic Model Update

To assess the hydraulic characteristics for the Mary River Catchment, a detailed 1D/2D TUFLOW model has been developed by updating and improving the 2014 RFD hydraulic model. The model is based on TUFLOW software version 2020-10-AF-iSP-w64, which incorporates "Heavily Parallelised Compute" (HPC) with an explicit solution scheme. The model improvements have been guided by Stage 1 and 3 of the RFD major update project, and include:

- Adoption of TUFLOW build 2020-10-AF for model development.
- Adoption of Wu eddy viscosity algorithm (default for 2020-01 onwards)
- Maintained fixed 5m grid with terrain levels updated based on 2019 LiDAR.
- Refinement of roughness layers to represent landuse more precisely within the catchment.
- Inclusion of 4 culverts in 1D network files.
- HPC has been adopted with simulations using GPU hardware to improve run times. For example, the 1% AEP 120 minute TUFLOW simulation reduced from approximately 7 hours to 26 minutes.

3.4.1 Model Layout and Extents

The model code boundary and domain extent has not been updated from the 2014 RFD model. The TUFLOW model code boundary covers the entire MAR catchment. Small areas at the north and east of the catchment are not within the model domain (see Figure 3.5). These areas are upstream of any source-area inflow points and therefore there is no impact on TUFLOW model results. The code boundary extent has not been refined/reduced from the overall catchment boundary, to allow future users to simulate larger events (such as the PMF) and to produce cut-down models without restriction. The MAR model uses a zero-degree orientation angle, which is consistent with the other 2022 RFD models.

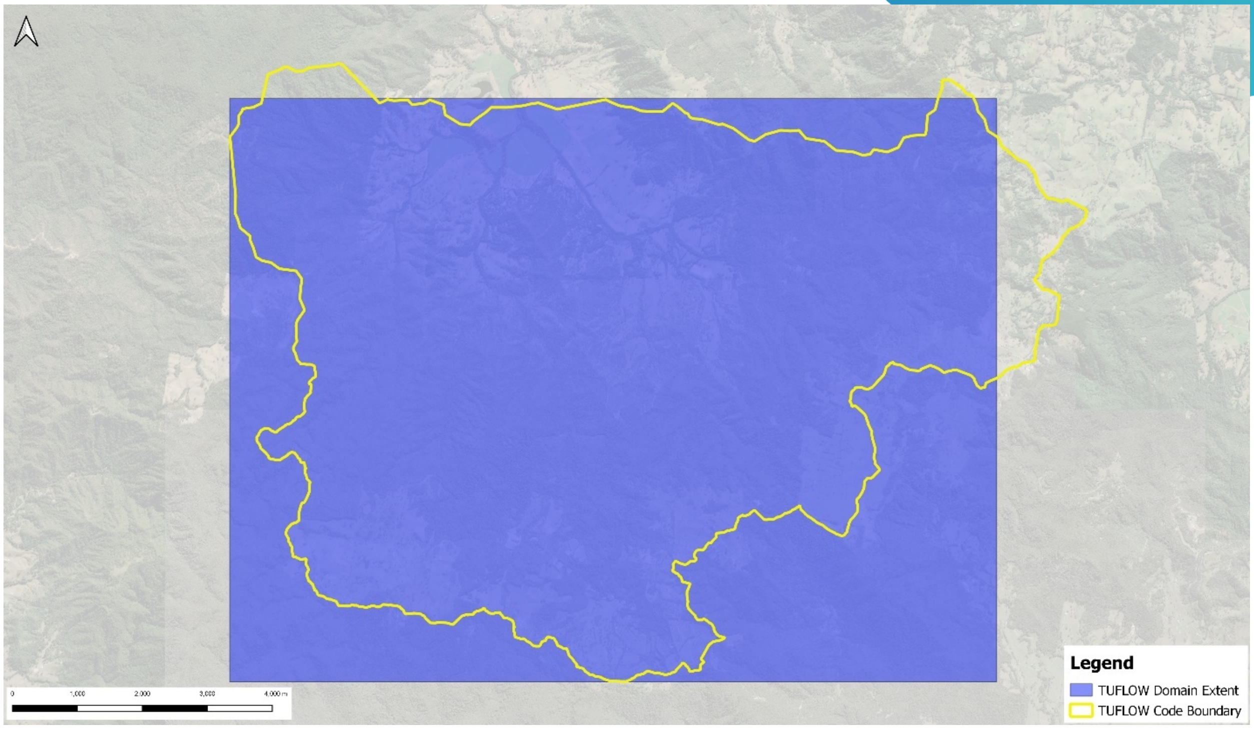

Figure 3.5 003a TUFLOW Model Domain and Code Boundary

3.4.2 Model Topography

The model base topography is represented using:

- 1.0 m resolution 2019 LiDAR data supplied by CMB and
- 1.0 m resolution 2014 LiDAR data supplied by Sunshine Coast Council (where CMB LiDAR is not available)

Subsequent to the development of the MAR model, LiDAR data dated 2023 was gained for multiple locations in Queensland. The 2023 LiDAR covers the relevant Sunshine Coast Council area as well as the Moreton Bay City Council local government area. Therefore, future model updates will benefit from consistent terrain data across the model domain.

The above LiDAR datasets for the Mary River catchment were read into the model as separate layers. Topographic modifiers were included to ensure a smooth transition between the two LiDAR datasets. These modifiers were also used to fix model instabilities in 6 places due to steep terrain.

Bathymetry data was not included in the model; topographic modifiers were instead used to enforce flow paths (“gully lines”). The gully lines from the 2014 RFD model were updated to use 2019 LiDAR values where 2019 LiDAR was available.

Topography modifiers (z-shapes) were used to define road centre-lines which were not clearly defined in the LiDAR. A total of 8 breaklines were digitised to ensure that critical embankments were appropriately represented in the model. For these breaklines, elevation point values were processed from 2019 LiDAR where available; otherwise they were processed from the Sunshine

Coast Council 2014 dataset. Topography modifiers (z-shapes) were also used to adjust terrain at some culvert entry/exits to improve model stability.

Following a review of aerial imagery, it was concluded that the Mary River Catchment has not undergone any significant development since 2014. Inclusion of digital elevation models of new development was therefore not required.

3.4.3 Bridge Structures

The 2014 MAR TUFLOW model included one bridge structure, located in the Sunshine Coast LGA, which was adapted for use in the updated model set up.

A key change is the method for calculation of losses for layered flow constrictions. The updated model uses the “portion” calculation approach, compared to the 2014 RFD model’s “cumulate” approach. Additionally, in the 2014 RFD model, no form loss was applied for the bridge deck (‘Layer 2’). This has been updated to a value of 1.56, as advised in the Stage 1 Pilot Study (Arup 2021). No changes were made to elevation levels for the structure.

It is noted that the bridge is represented as a thin line with no pier losses, which does not match the methodology adopted for the 2022 RFD model as described in a memorandum by BMT (BMT 2022). However, as the bridge is in the Sunshine Coast, the choice of modelling method does not impact model results within Moreton Bay City Council’s local government area.

3.4.4 Stormwater Pipes and Culverts

Stormwater network was not included in the 2014 MAR RFD model. The updated model includes four culverts, with locations and dimensions sourced from the Sunshine Coast Council utilities layer.

The ARR 2019 guidance calls for consideration of structure blockage within design event modelling. Owing to the minimal number of structures within the model, and their location within the Sunshine Coast Council local government area, it was deemed not necessary to undertake a blockage run for the MAR model.

Figure 3.7 provides an overview of the updated TUFLOW model geometry and its features.

3.4.5 Floodplain Roughness

Floodplain roughness files were developed using machine learning techniques, as outlined in the Stage 2 Report (AECOM 2020). The 2019 datasets are largely raster based and significantly refined compared to the 2014 data (vector datasets only). Table 3.6 presents the adopted roughness values for each landuse category and Table 3.7 shows the adopted depth varying roughness values. Roughness values were determined through a calibration process undertaken by other catchments as part of the major RFD update. Figure 3.6 illustrates the spatial variation in roughness applied in the MAR hydraulic model.

Table 3.6 TUFLOW Materials Roughness Values

Material ID	Manning's n	Description
1	Open_Space_001.csv	Open Space (grasses)
2	Low_Dense_Vegetation_002.csv	Low Density Understory - Vegetation
3	Medium_Dense_Vegetation_002.csv	Medium density Understory - Vegetation
4	High_Dense_Class2_Vegetation_002.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	0.025	Facilities
19	0.075	Railways
20	0.15	STABILITY

Table 3.7 Depth Varying Manning’s Values

Open_Space_001.csv		**Low_Dense_Vegetation_002.csv**	
y (m)	n	y (m)	n
0	0.25	0	0.03
0.2	0.06	1.5	0.03
0.4	0.045	3.5	0.055
0.8	0.035	99	0.055
2	0.025		
99	0.025		
Medium_Dense_Vegetation_002.csv		**High_Dense_Class2_Vegetation_002.csv**	
y (m)	n	y (m)	n

Open_Space_001.csv		Low_Dense_Vegetation_002.csv	
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

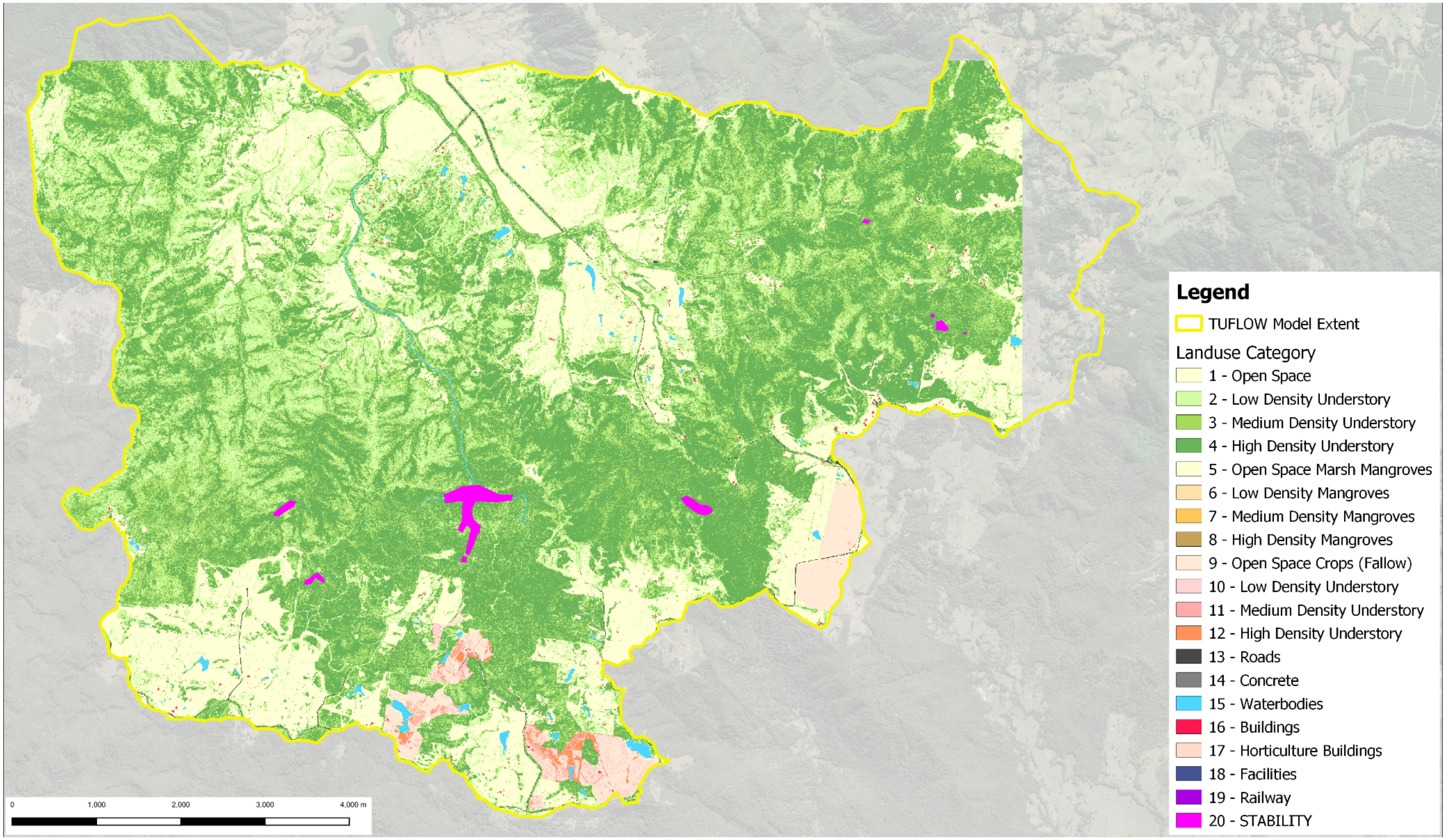

Figure 3.6 Hydraulic Model Roughness Layout

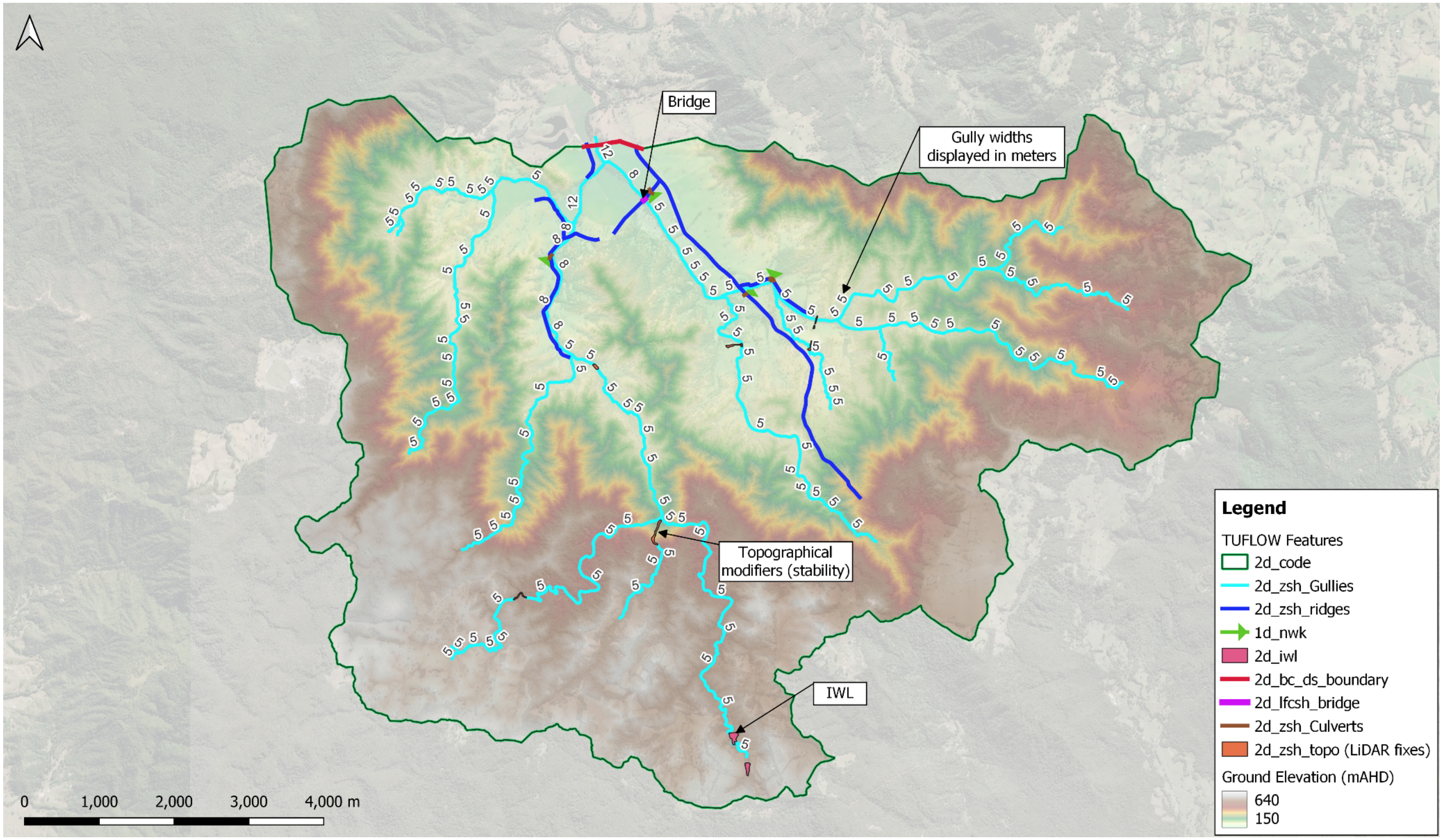

Figure 3.7 TUFLOW Model Features

3.4.6 Inflow Boundaries and Initial Water Levels

Model inflows polygons were based on the subcatchment breakdown from the Stage 2 project. The inflows have been represented in the hydraulic model as a series of local catchment Source Area ("SA") polygon inflow boundaries largely matching subcatchment extent in shape. With this approach, flow is initially distributed to the lowest elevation cell and then applied in proportion to depth within the subcatchment polygon area. There are no total inflows applied in the TUFLOW model; channel routing is undertaken within the hydraulic model.

The inflow polygons remain unchanged from the 2014 RFD model, with the exception of the MAR001_03422 subcatchment. For this subcatchment, the source area polygon was defined to prevent the local inflows being applied incorrectly via the proportional depth distribution method (see Figure 3.8).

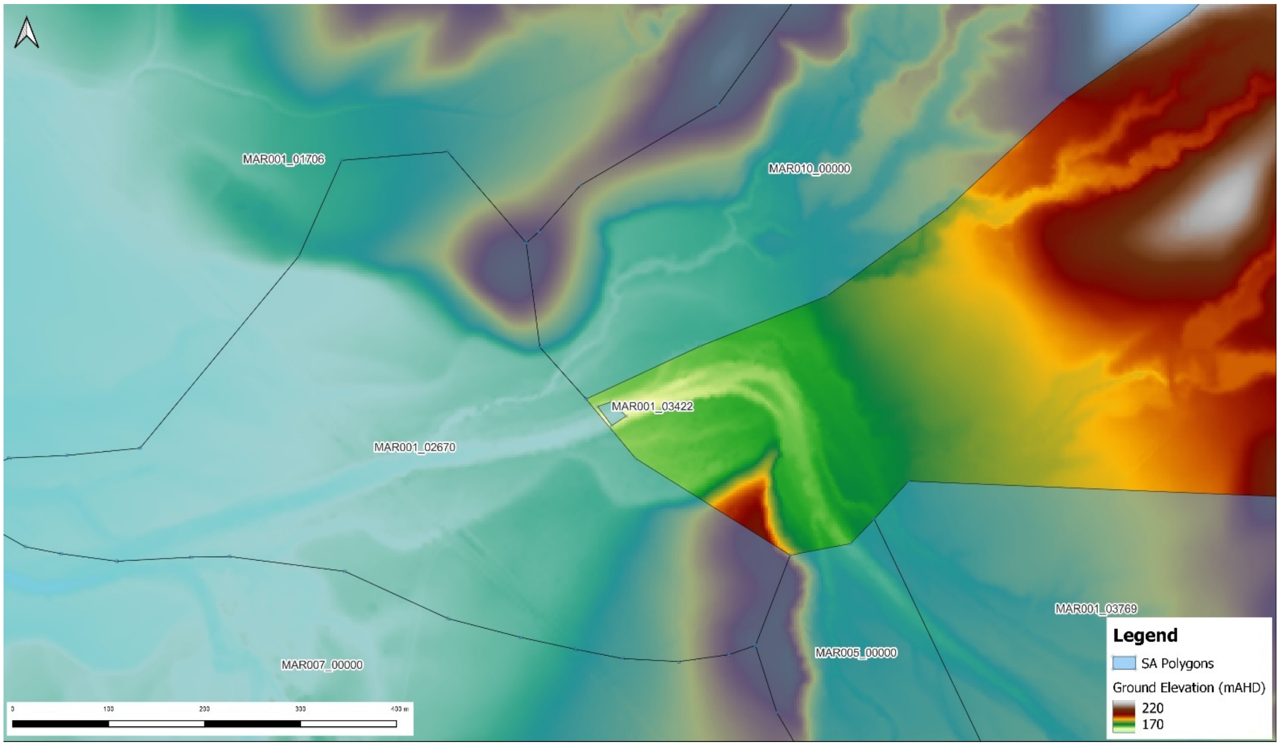

Figure 3.8 MAR001_03422 SA Polygon Geometry

Initial water level polygons, intending to represent full levels within local farm dams, were applied at two locations within the MAR catchment. Initial water levels were conservatively set approximately 200mm above control levels.

4 Model Methodology and Simulations

4.1 Calibration Limitations

Calibration runs for the MAR catchment were not undertaken due to a lack of water level gauge and floodmark data within the area. Instead, the MAR model benefited from the region-wide RFD model update process. For example, the MAR model utilises roughness values developed in the calibration/validation process for neighbouring catchments.

4.2 Design Event Selection

Due to the relatively small size of the MAR catchment, it was feasible to model the full ensemble of events for the existing unblocked scenario (E00) (see Table 4.1).

A set of storms deemed critical by the hydraulic model for the existing unblocked scenario were then identified and selected to simulate the future unblocked scenario (F00), limiting the number of model runs (see Table 4.2). This process assumes the critical storms do not change from the existing to the future scenario; an assumption utilised by all RFD catchments in this major update process.

Table 4.1 Existing Unblocked Scenario (E00) Modelled Events

AEP	Duration (mins)	TP	Bucket (ARF)
0.05%, 0.1%, 1%, 2%, 5%, 10%, 20%	10, 15, 20, 25, 30, 45, 60, 90, 120, 180, 270, 360, 540	1 to 10	C, D and E

Table 4.2 Future Unblocked Scenario (F00) Modelled Events

AEP	Duration (mins)	TP	Bucket (ARF)
0.05%	120	1, 5	C, D and E
0.05%	90	3, 5	C, D and E
0.1%	120	3, 5	C, D and E
0.1%	90	3, 5	C, D and E
1%	120	2, 5, 6	C, D and E
2%	120	3, 5, 6	C, D and E
5%	180	4, 6, 7, 8	C, D and E
10%	180	4, 6, 7	C, D and E
20%	180	1, 2, 5, 9	C, D and E

For each AEP, critical events were selected by identifying the storms which provided results for the largest spatial area within the existing unblocked scenario peak water level result. The peak water levels of the dominant critical durations were compared to the water level results from other durations, and the differences were generally found to be less than 200mm.

As an example, the source raster for the 1% AEP surface is shown in Figure 4.1 below. Here, the 120 minute duration was chosen for use in the future conditions simulations. Figure 4.2 demonstrates that temporal patterns 2, 5 and 6 are critical for the 120 minute event.

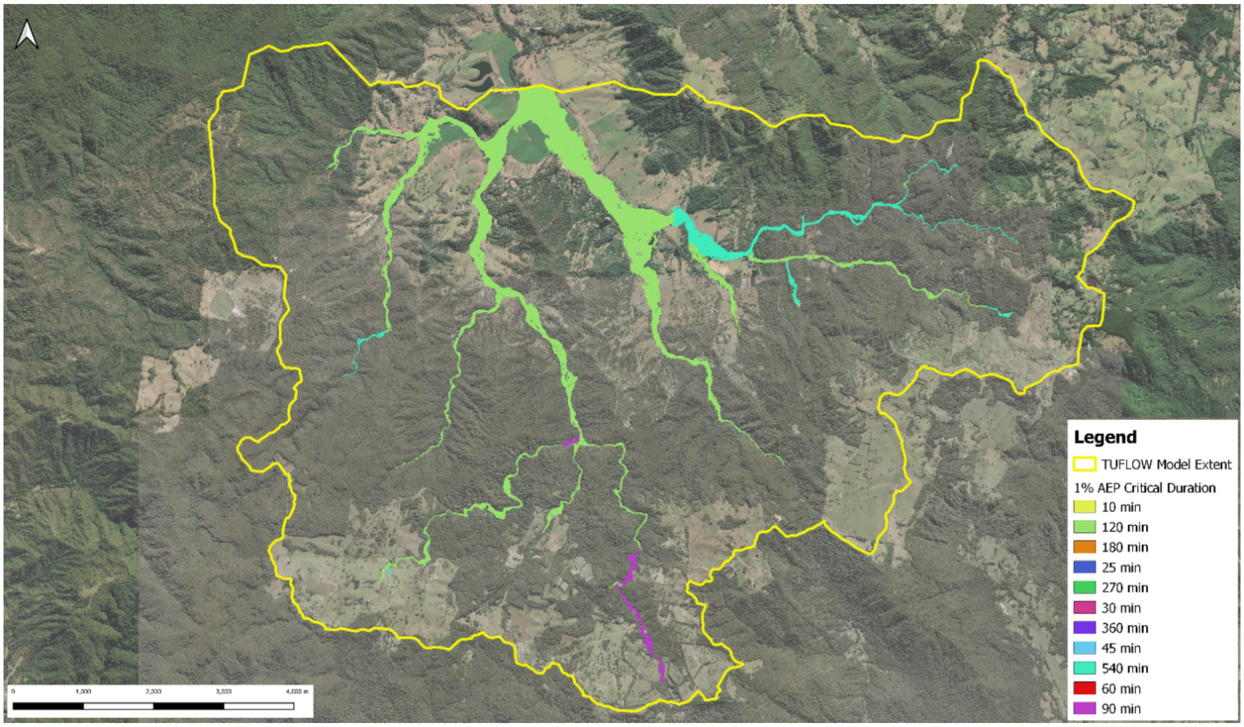

Figure 4.1 Critical durations for the 1% AEP event.

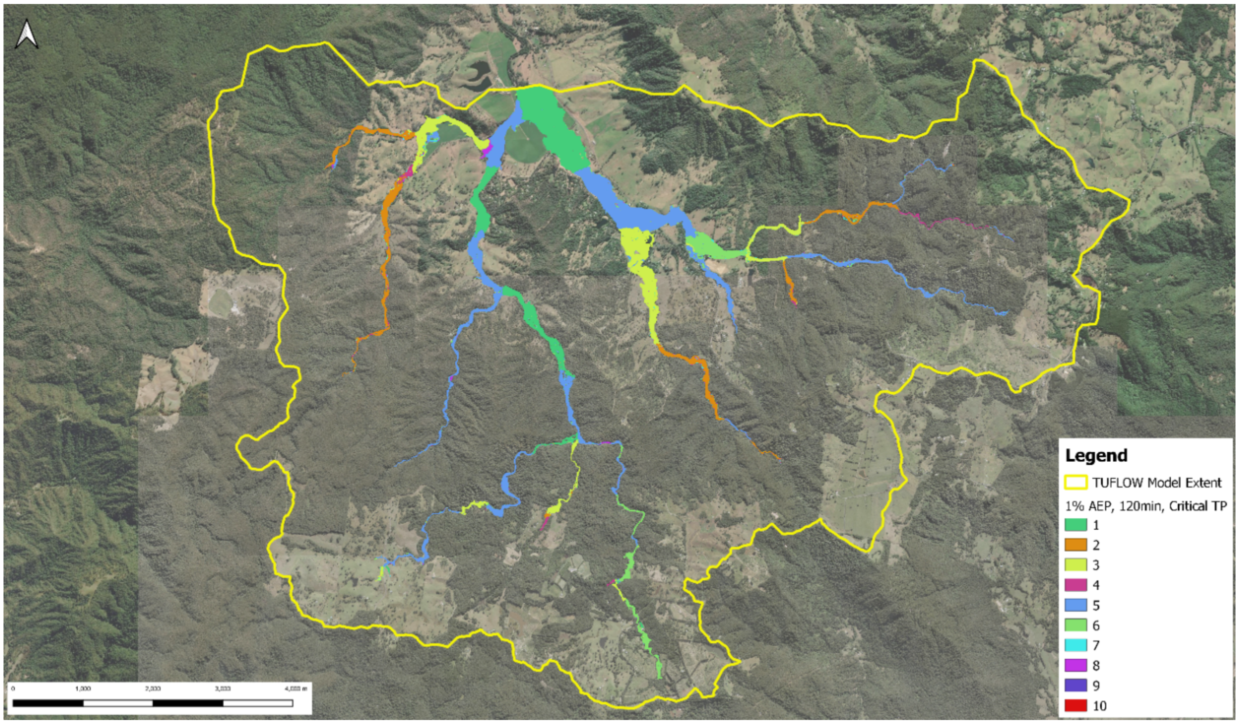

Figure 4.2 Critical temporal patterns for the 1% AEP 120min event.

4.3 TUFLOW Hydraulic Model

4.3.1 Model Setup

The model topography, roughness and other parameters used for design event modelling are consistent with the setup described previously in Section 3.4. The design event model is named "MAR_R_003a_~s1~_~e1~~e2~_~e3~_25.tcf", where:

- s1 – Existing or future scenarios
    - E00 = Existing climate and land use with zero blockage applied to culverts and bridges.
    - F00 = Future climate (20% increase in rainfall) and future land use based on planning layers with zero 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)

It is noted that the "MAR_R_003a_~s1~_~e1~~e2~_~e3~_21.tcf" model was used for the February 2022 historical simulation. No changes were made to the model between _21.tcf and _25.tcf, apart from updates to inflow polygon attributes and the boundary condition database to allow for design event file naming convention.

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 the existing conditions unblocked scenario (E00). A blockage scenario was not simulated.

E00 runs did not include embedded burst filtering/smoothing through omission. However, it was identified that inclusion of embedded burst filtering was not likely to have a significant impact on project results. This was concluded after calculating the number of storms for which filtering was required, and the degree of smoothing required. It was found that;

- No storms required smoothing above 40% (the limit for which removal of the storm from simulation would be warranted)
- Smoothing somewhat tended to be required for ARF E and D, rather than C (the majority of MAR catchments being within the ARF C zone)
- The most number of storms requiring smoothing was for 20% AEP. The 1% AEP had only 4 storms requiring smoothing, of 5% or less. The 0.1% AEP event had one storm with 12% smoothing and one with 7% smoothing, and five storms requiring 5% smoothing or less.
- The critical storms forming the peak water surface level in TUFLOW (from the un-filtered runs) predominately required no smoothing (had no embedded burst), or less than 5% smoothing. The exception was the 20% AEP event, which had one critical storm of 10% smoothing and one of 7% smoothing.

As a sensitivity test, the 20% AEP E00 event was run in WBNM and TUFLOW with embedded burst smoothing (using Storm Injector) and the removal of storms with greater than 40% smoothing required. The resulting water levels were 20-50mm lower than the unfiltered run (see Figure 4.3). This degree of conservatism was considered acceptable, and it was decided to keep the embedded burst filtering omission in the existing case runs. The use of embedded burst filtering was subsequently undertaken for the future scenario runs, as use of embedded burst filtering was recommended by the Stage 1 project.

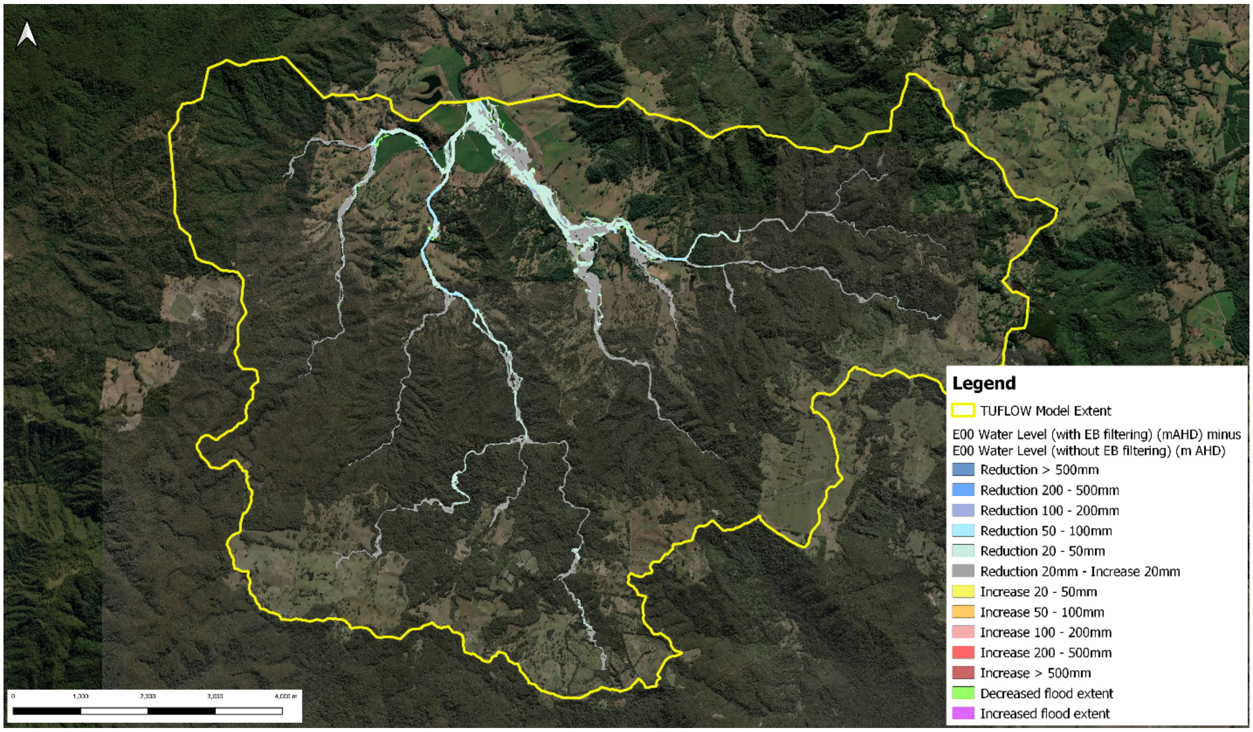

Figure 4.3 Sensitivity test results: Existing Unblocked (E00) 20% AEP water level with EB filtering compared to the “no EB filtering” run.

4.3.3 Future Climate Simulations

The 20%, 10%, 5%, 2%, 1%, 0.1% and 0.05% AEP design events were simulated for the future climate conditions unblocked scenario (F00), which included increased rainfall intensity (20%) and ultimate landuse EIA values. A subset of storms identified as critical from the existing conditions scenario (see Section 4.2) were modelled for the future climate scenario. Embedded burst smoothing and filtering was utilised. A blockage scenario was not simulated.

4.3.4 Adopted Design Tailwater Conditions

Tailwater conditions were defined via two HQ boundaries with water surface slopes of 0.01m/m and 0.1m/m (see Figure 4.4). The model boundary could be improved and should be addressed in future model updates.

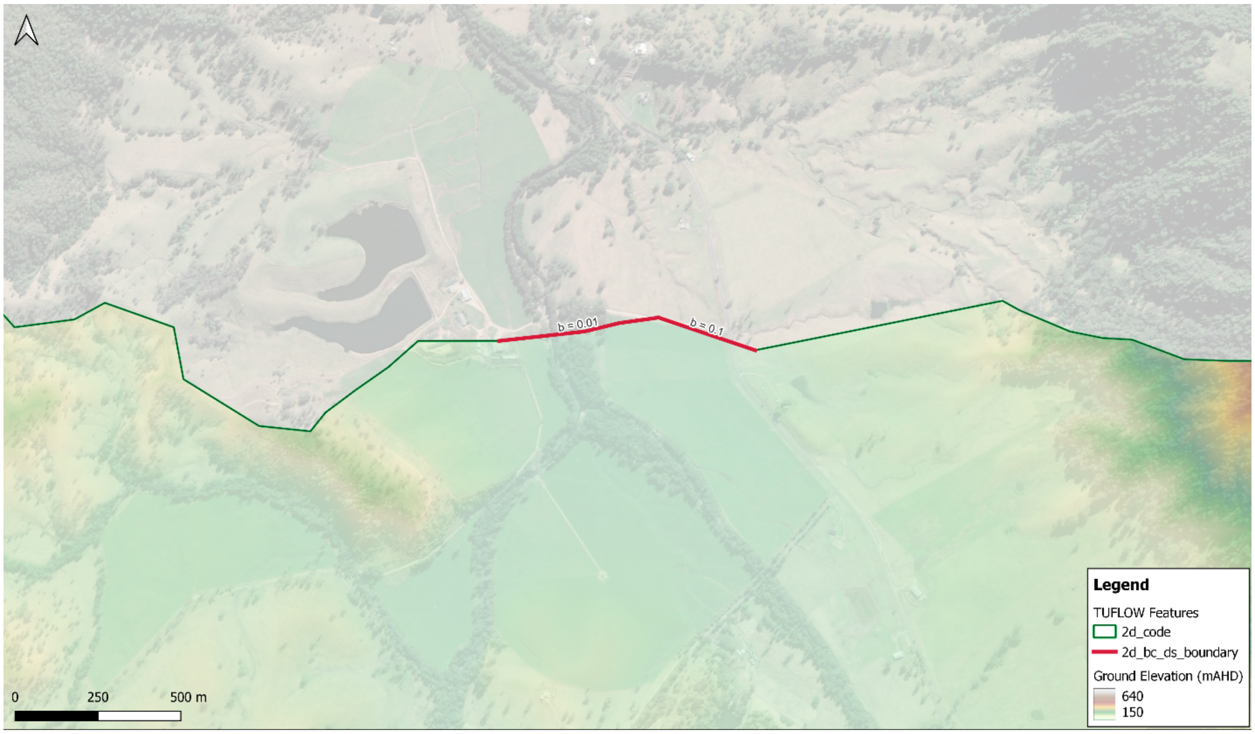

Figure 4.4 Tailwater (HQ) conditions with slopes labelled.

5 Model Results and Outcomes

5.1 February 2022 Historical Event

As no gauge level or flood mark data exists in the MAR catchment, calibration was not undertaken for the MAR model. The February 2022 historic flood event was nonetheless run for informational purposes. Rainfall data from 22 nearby gauges was used, from the period 23/03/2022 6:05 to 28/02/2022 6:05 (120 hours). A smaller burst before the event (peaking around 23/03/2022 3:00) was excluded from the analysis (see Figure 5.1).

Loss rates were set based on the values adopted for the calibration of the neighbouring Stanley River Neurum Creek catchment model; initial loss of 0mm and continuing loss of 2.5mm/hr.

The remainder of the WBNM and TUFLOW model setup remained as for the existing unblocked (E00) event.

Peak water depths for the February 2022 event are shown in Figure 5.2.

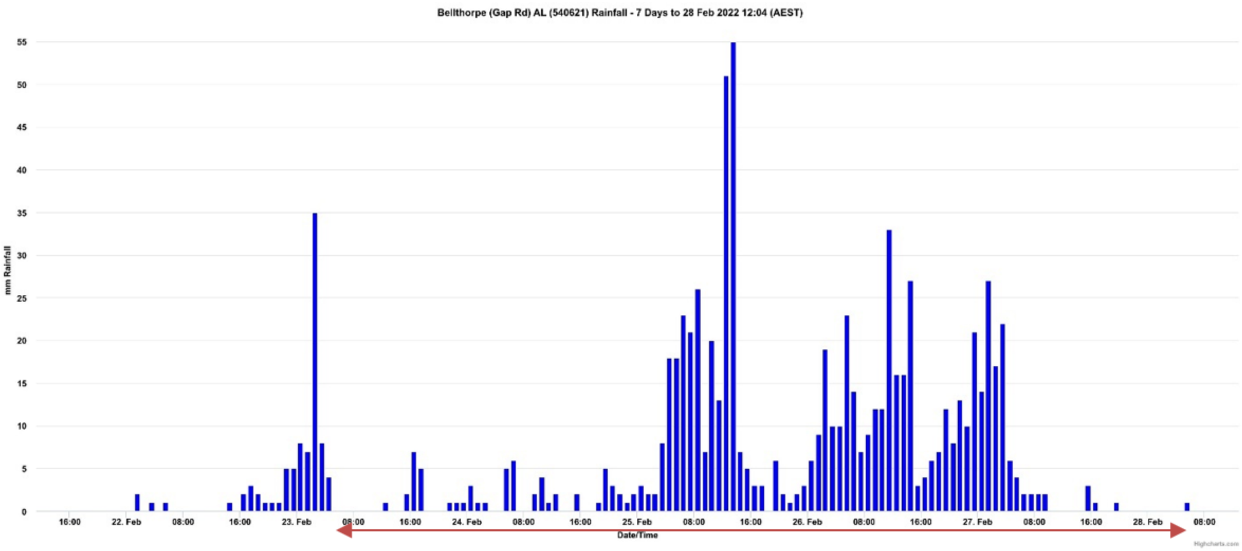

Figure 5.1 Bellthorpe (Gap Rd) AL Rainfall Hyetograph. Red arrow represents the simulated time period. A rainfall burst peaking at 23/03/2022 3:00 is excluded from the analysis.

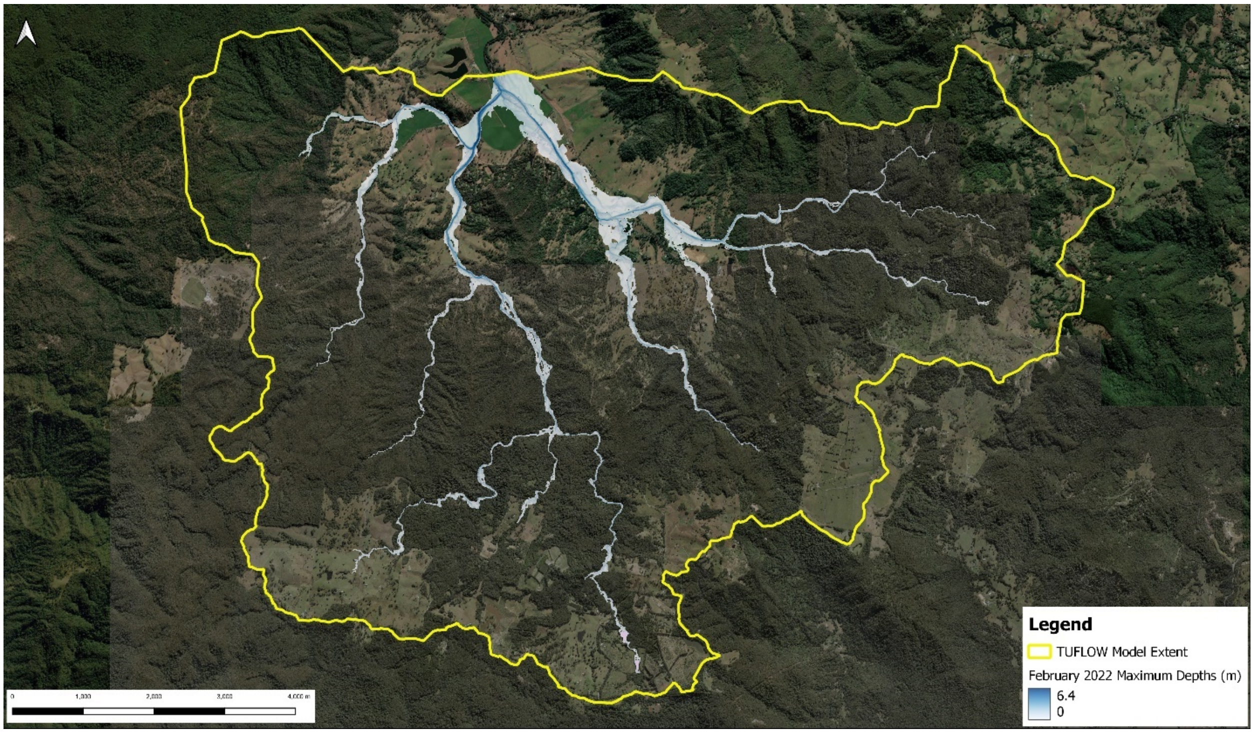

Figure 5.2 February 2022 Maximum Depth Results (m)

5.2 Design Flood Behaviour and Processing

Appendix B presents the processed maximum water depth grids for the existing unblocked (E00) and future unblocked (F00) scenarios for the 1% AEP event.

The existing scenario (E00) results were processed (using TUFLOW Asc_to_Asc utility) as follows:

- Median (rank 6) result surfaces were developed for each duration based on the modelled temporal patterns (up to 10 per duration)
- For each AEP, the maximum water level surface was developed based on the median surfaces (up to 13 durations per AEP)

The future scenario (F00) results were processed (using TUFLOW Asc_to_Asc utility) as follows:

- The maximum water level was extracted from the (chosen event) results for each AEP

The processed results were checked for AEP neutrality by comparing the peak water level surface for each AEP event and confirming that the more rare event had greater levels than the more frequent event.

The future scenario results were reviewed to confirm the peak water surface level was not dominated by a single storm duration. The 10% and 5% AEP runs were found to draw extensively upon the 180minute TP7 results, but all other events demonstrated a balance of source surfaces.

5.3 Comparison to RFD 2014

Figure 5.3 presents the difference in 1% AEP peak flood level developed by this major update project (E00 of this study, referred to as the 2022 RFD) as compared to that of the previous model version, the 2014 RFD. In general, the peak water levels have decreased across the catchment, typically by approximately 300mm.

The decrease in water levels is partially attributable to decreased riparian roughness values (Manning’s n values), with more of the waterways in the updated model set to ‘Waterbody’ or ‘Low Dense Vegetation’, in place of ‘Dense Vegetation’. This is based on the vegetation density rasters generated by the Stage 2 project, which considered understory vegetation as opposed to being limited to an aerial view of vegetation canopy to estimate roughness values.

A comparison of TUFLOW model inflows in the 2014 and 2022 RFD MAR models was completed, focused on the 1% AEP 120-minute event, which was chosen as this event is critical at one location near the downstream part of the catchment. The “Total Volume In” for the 2022 RFD TUFLOW MAR model was approximately 5.5% less than for the previous 2014 RFD model. The average (over all subcatchments) peak inflow for this event was also approximately

9% lower for the 2022 RFD model, which is likely the main contributor to the decrease in peak water levels.

A comparison of 2020 LIMB IFD and 1987 IFD rainfall depths was undertaken at three locations within the Mary River catchment. The 2020 IFD depths are generally 5 to 10% greater than the 1987 depth for durations of interest. As such, it is possible that use of embedded burst smoothing and the multiple temporal pattern approach plays greater role in decreased peak flows than the rainfall depths.

A comparison of the future scenario 2022 RFD 1% AEP and the 2014 RFD Design Flood Event (DFE) was also completed (see Figure 5.4). The DFE is the maximum of a suite of scenarios primarily based on the Moreton Bay Design Storm; a 15 minute in 270 minute embedded design storm. A similar water level differences was noted to that discussed above.

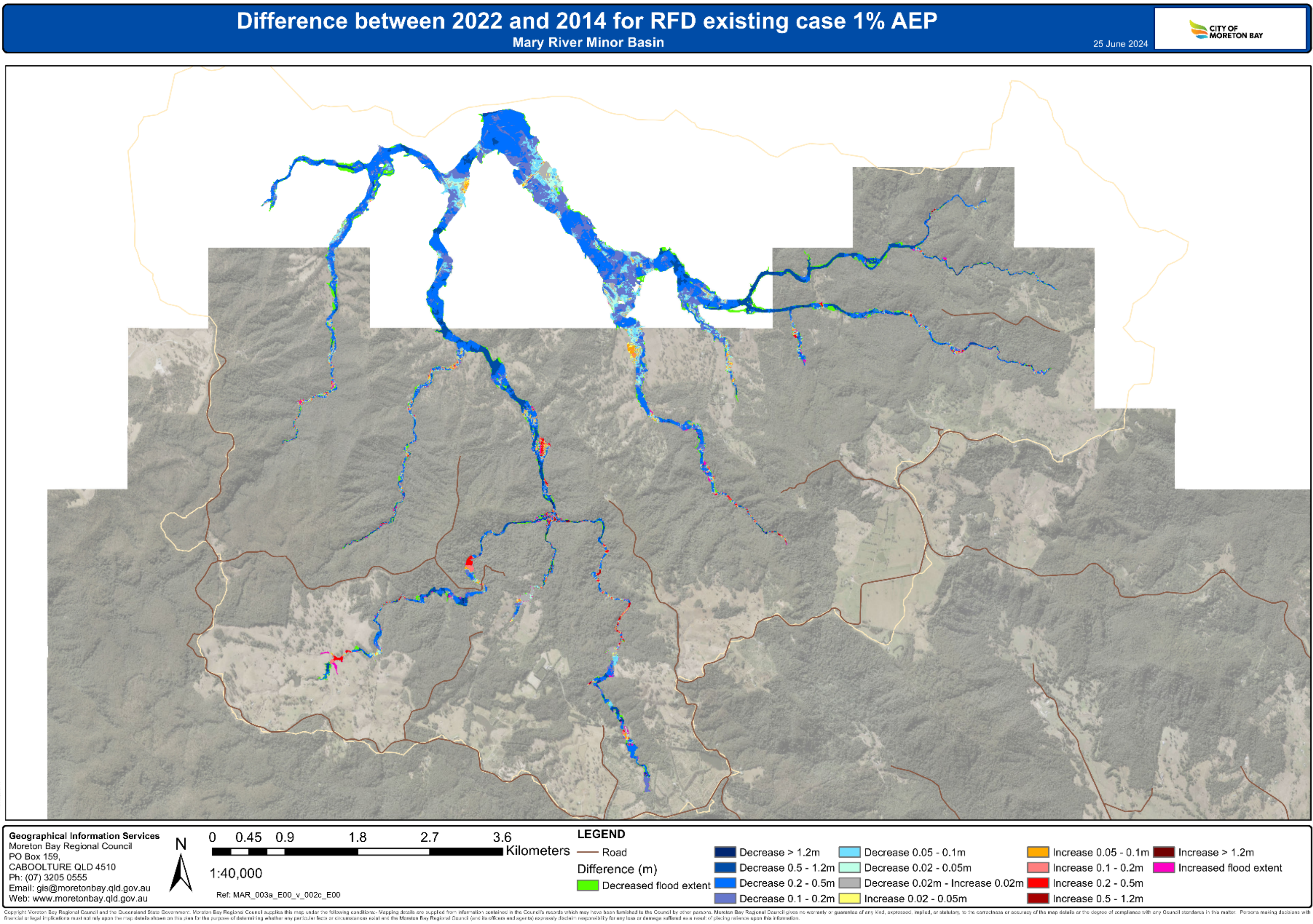

Figure 5.3 Difference between 2022 and 2014 RFD Existing Scenario 1% AEP

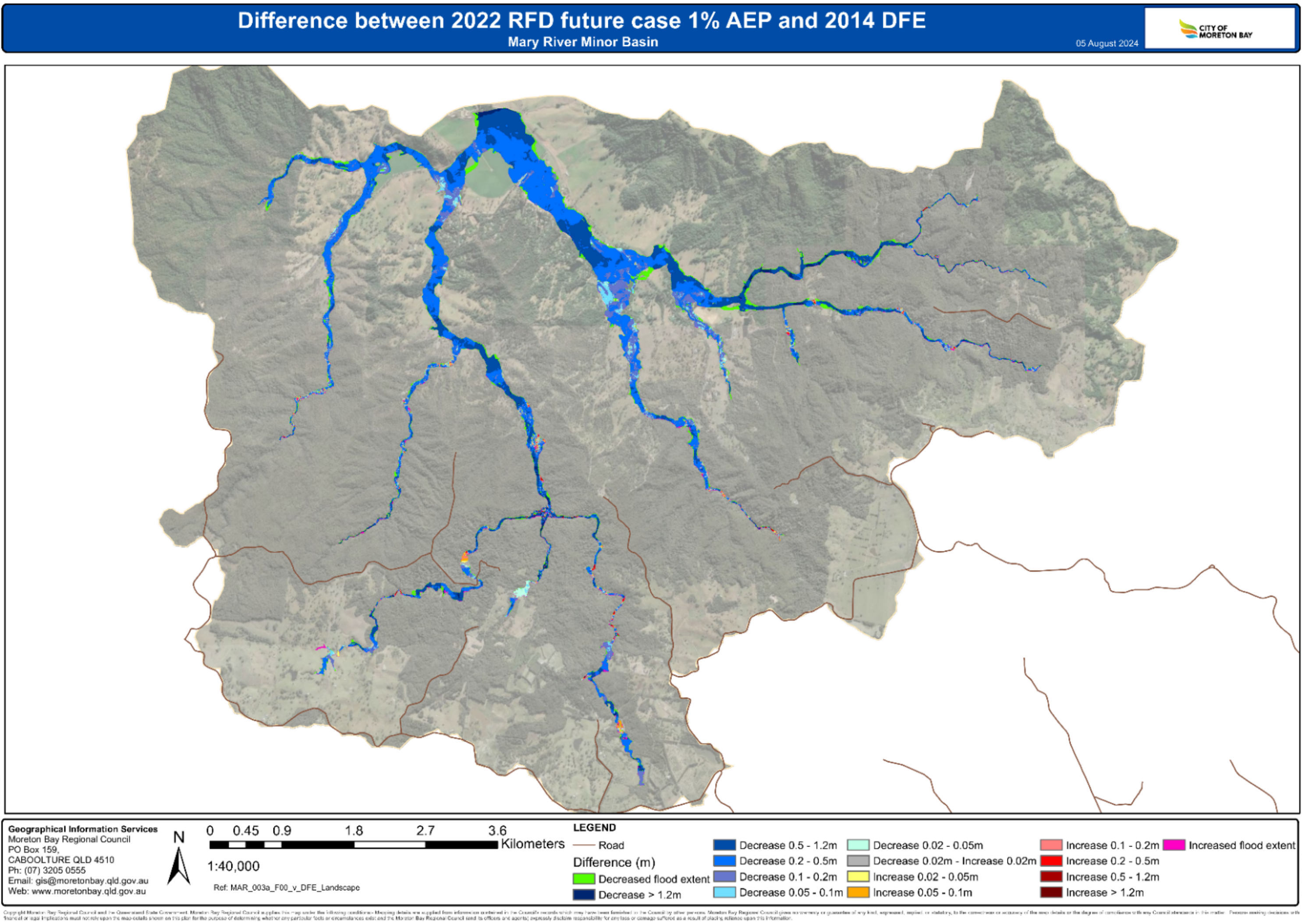

Figure 5.4 Difference between 2022 Future Scenario 1% AEP and 2014 RFD DFE

5.4 Technical Considerations and Model Health

The MAR design model (MAR_R_003a_~s1~_~e1~~e2~_~e3~_25.tcf) requires 2.4GB RAM to initialise (with xf files). A PC running one simulation is recommended to have a minimum of 4.8GB RAM. GPUs such as the NVIDIA Quadro RTX 4000, NVIDIA GeForce RTX 3090 or 4090 would be good choices for running this model.

A single simulation can be performed on a NVIDIA GeForce RTX 3090 at a simulation time to real time ratio of approximately 17:1 (i.e. 17 hours of model time takes 1 hour to simulate), which appeared to be similar across AEPs. Based on TUFLOW benchmarking runs, using a NVIDIA GeForce RTX 4090 would be approximately 50% faster than an NVIDIA GeForce RTX 3090.

Simulation timesteps (dt) were plotted for all runs and the minimum dt values for each AEP are shown in Table 5.1 and Table 5.2 below.

Table 5.1 Minimum simulation timesteps for each AEP (existing scenarios)

AEP	Minimum dt (s)
20%	0.13
10%	0.15
5%	0.10
2%	0.08
1%	0.09
0.1%	0.06
0.05%	0.04

Table 5.2 Minimum simulation timesteps for each AEP (future scenarios)

AEP	Minimum dt (s)
20%	0.17
10%	0.15
5%	0.10
2%	0.10
1%	0.1
0.1%	0.06
0.05%	0.06

The storm with the lowest dt plot (0.05% AEP, 540 minutes, TP5) and corresponding control numbers are shown in Figure 5.5 and Figure 5.6 on the following page.

Generally speaking, the minimum dt values were identified to be lower than ideal for a 5m grid model. However, run-times were reasonable for practical purposes, and therefore improvement of minimum dt for the purposed of increasing run efficiency was deemed unnecessary. As such, the location of minimum dt values was reviewed.

The low dt zones correspond with the steep slopes and high velocities/depths. It was found that there were no instabilities in the peak water surface surface at the minimum dt locations. There is potential for the model to be improved with decreases in Manning's n values or the smoothing of terrain in problem areas.

The storm with the lowest dt plot additionally demonstrated a low Mass Error, which is expected as HPC is mass-conserving. The low Mass Error values indicate that the 1D elements and connections are generally stable. Inspections of the culvert flow results for this storm event simulation indicate that culverts are stable and performing as intended.

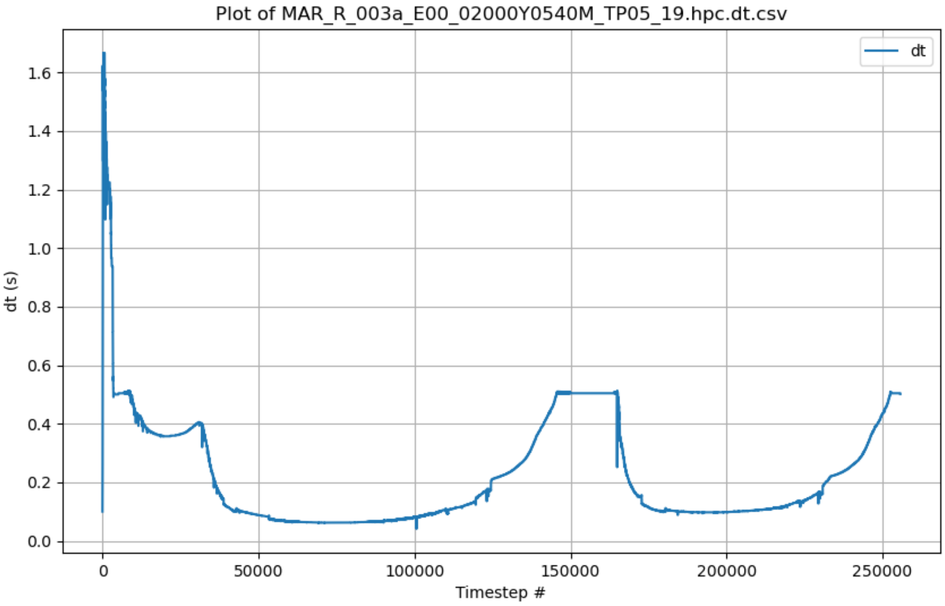

Figure 5.5 Plot of simulation timestep

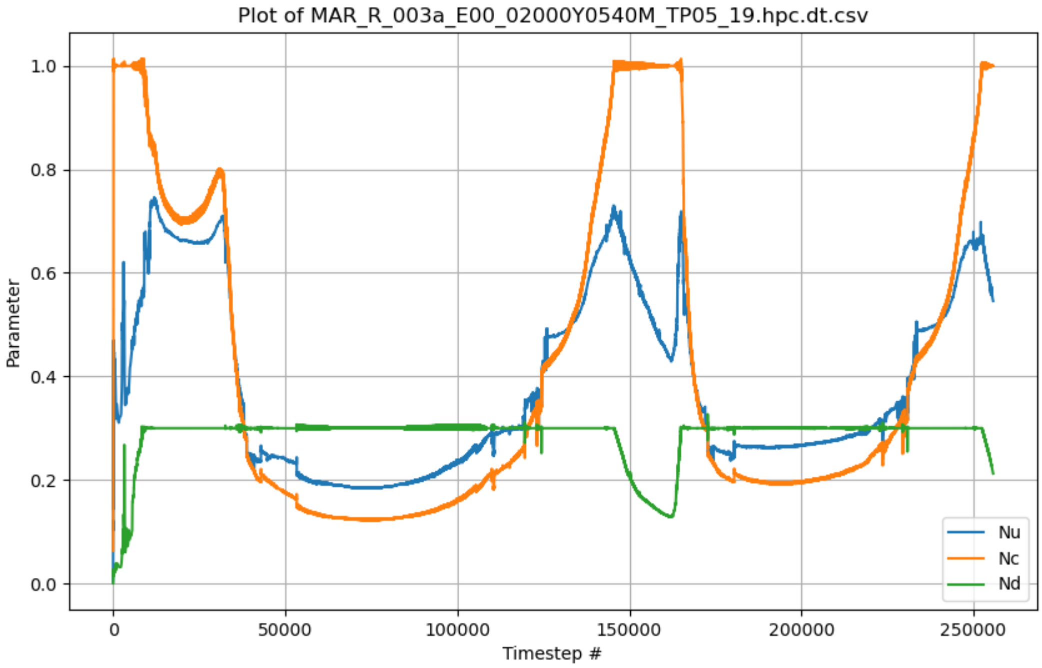

Figure 5.6 Plot of simulation control numbers

5.5 Model Limitations

Watercourses within the Mary River catchment were represented using a fixed 2D grid size of 5m, with streamlines at the locations of main flow paths. This may not allow adequate representation of waterways narrower than 5m in width.

The model terrain is based on available 2019 LiDAR, and 2014 LiDAR in the Sunshine Coast Council local government area. No new developments were identified or included to update the data. It may be possible that there are small areas of the model that do not represent current terrain conditions.

The adopted model roughness was based on previous work undertaken by external consultants and approved by Council staff. Spatially, the materials layers are highly refined and represent a substantial improvement from the previous 2014 RFD modelling.

As documented in Section 3.3.4, a simplified approach to ARFs was adopted.

As documented in Section 3.3.2, TIA was adopted instead of EIA for the existing conditions runs.

Predicted water levels in the future scenario (F00) are dependent on the event selection process as documented in Section 4.2. This approach assumes that future critical events generally align with existing critical events.

6 Conclusion

As part of the Stage 4 and 5 major update of the RFD for Mary River, an updated WBNM hydrologic model (created as part of the Stage 2 study) and a TUFLOW hydraulic model have been developed according to the latest industry guidance (ARR 2019). The models were specifically set up in accordance with the requirements outlined by City of Moreton Bay for the 2022 Regional Flood Database major update project. An aim of the project was to promote a consistent approach to model upgrade across the entire Local Government Area and facilitate the integration of the model and its outputs into Council's flood database.

The primary objective of the project was to deliver the WBNM and 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. This information can be integrated into Council's flood database and utilised for further analysis and management of flood risk in the Mary River catchment.

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.

Future model updates may consider the below items, to potentially improve model results and performance:

- Incorporation of minor updates identified as part of the internal and independent technical reviews
- Inclusion of new stormwater network and development information (standard maintenance activity)
- Inclusion of latest LiDAR/topography information (at the time of writing, 2023 LiDAR flown by the Queensland State Government is available for the catchment)
- Review of bridge modelling methodology to incorporate latest industry guidance (e.g. TUFLOW Method D, 2d_bg shp, etc.)
- Incorporation of latest ARR guidelines, particularly regarding climate change modelling
- Review of Fraction Impervious layers
- Review of appropriate pre-burst value for use with LIMB 2020 IFDs
- Inclusion of pre-burst scaling for both extreme events and future climate scenarios

7 References

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Hydrology and Water Management Consulting, 2015, “Regional Flood Database - 2014 Model Maintenance Report for Upper Mary River (MAR)”

Appendix A Subcatchment ARF Classification

Subcatchment ID	ARF Class
MAR007_00000	ARFc
MAR037_00000	ARFc
MAR004_01285	ARFc
MAR010_00000	ARFc
MAR033_03278	ARFc
MAR039_00000	ARFc
MAR005_01678	ARFc
MAR002_00000	ARFc
MAR002_01066	ARFc
MAR002_02700	ARFc
MAR001_09409	ARFc
MAR003_00000	ARFc
MAR001_05924	ARFc
MAR001_06944	ARFc
MAR031_00656	ARFc
MAR001_08939	ARFc
MAR003_00821	ARFc
MAR007_02376	ARFc
MAR031_02033	ARFc
MAR039_03499	ARFc
MAR025_00801	ARFc
MAR017_06964	ARFc
MAR007_03410	ARFc
MAR031_02700	ARFc
MAR025_02997	ARFc
MAR039_04525	ARFc
MAR025_01829	ARFc
MAR011_00000	ARFc
MAR007_05262	ARFc
MAR017_07989	ARFc
MAR025_04025	ARFc
MAR023_00000	ARFc
MAR027_00000	ARFc
MAR029_00000	ARFc
MAR023_01820	ARFc
MAR021_00000	ARFc
MAR017_09893	ARFc

Subcatchment ID	ARF Class
MAR019_01269	ARFc
MAR039_03023	ARFc
MAR031_01679	ARFc
MAR025_00000	ARFc
MAR023_00797	ARFc
MAR001_07964	ARFc
MAR001_06458	ARFc
MAR017_06184	ARFc
MAR017_06128	ARFc
MAR031_00000	ARFc
MAR004_00000	ARFc
MAR017_09692	ARFc
MAR017_09007	ARFc
MAR025_02848	ARFc
MAR009_00000	ARFc
MAR007_04429	ARFc
MAR001_04696	ARFc
MAR001_03422	ARFc
MAR008_00000	ARFc
MAR001_05320	ARFc
MAR006_00000	ARFc
MAR033_01364	ARFc
MAR033_02918	ARFc
MAR025_05815	ARFc
MAR025_05056	ARFc
MAR031_04117	ARFc
MAR005_00000	ARFc
MAR013_00000	ARFc
MAR007_01582	ARFc
MAR035_00000	ARFc
MAR033_02265	ARFc
MAR039_01813	ARFc
MAR002_04776	ARFc
MAR041_00000	ARFc
MAR007_00782	ARFc
MAR019_00713	ARFc
MAR019_01925	ARFc
MAR015_00000	ARFc
MAR019_00000	ARFc
MAR001_01117	ARFd
MAR017_03102	ARFd
MAR017_02268	ARFd

Subcatchment ID	ARF Class
MAR017_05096	ARFd
MAR017_04940	ARFd
MAR001_03769	ARFd
MAR033_00000	ARFd
MAR017_00973	ARFd
MAR001_01706	ARFd
MAR001_02670	ARFd
MAR017_00000	ARFe
MAR001_00367	ARFe
MAR001_00000	ARFe

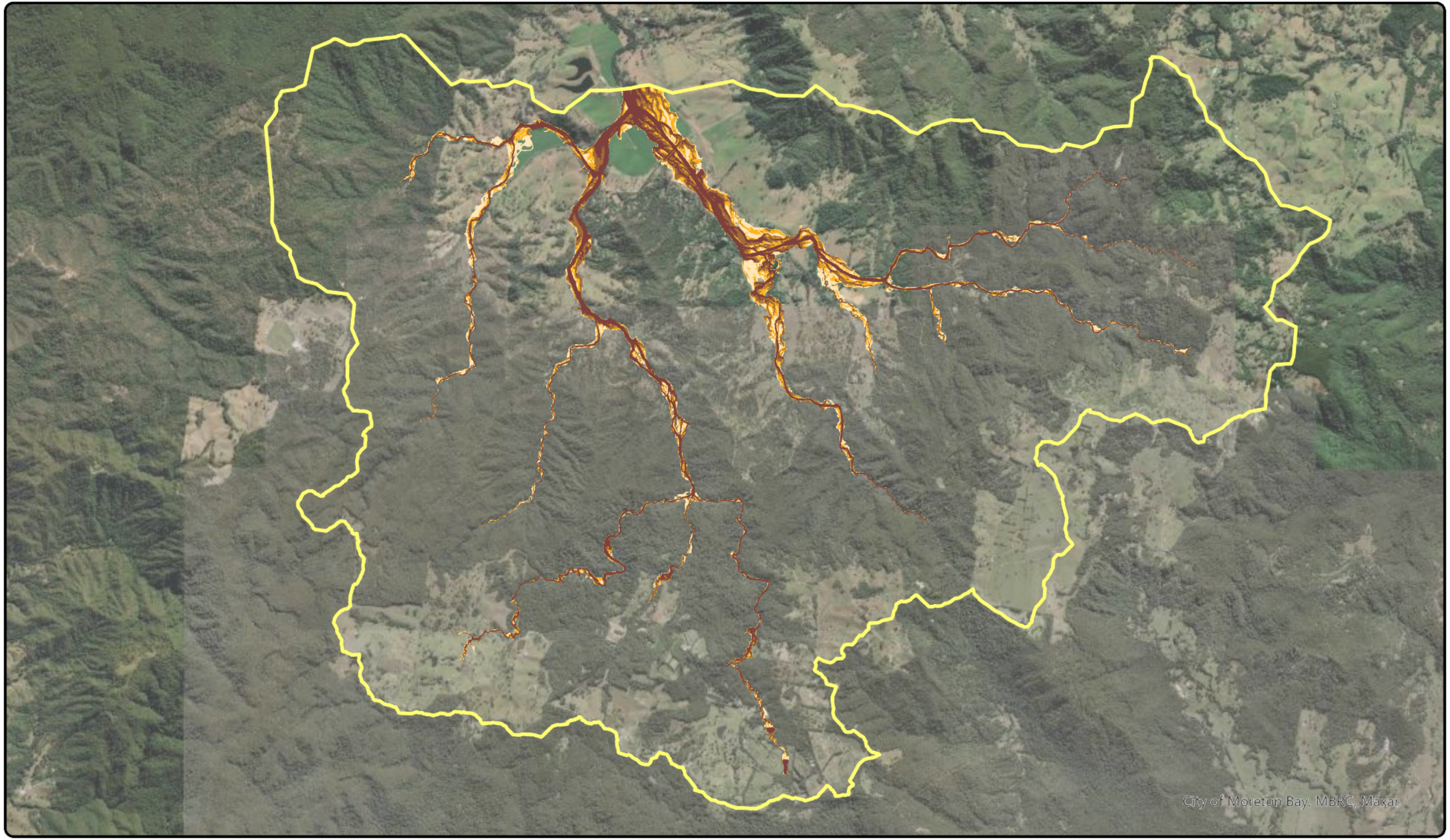
Appendix B 1% AEP Processed Results

Existing Unblocked (E00) 1% AEP Depths (m)

Mary River Minor Basin

28 January 2025

CITY OF MORETON BAY



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SCALE (A4) 1:70,000

Legend

TUFLOW Model Extent

Existing Unblocked (E00) 1% AEP Depths (m)

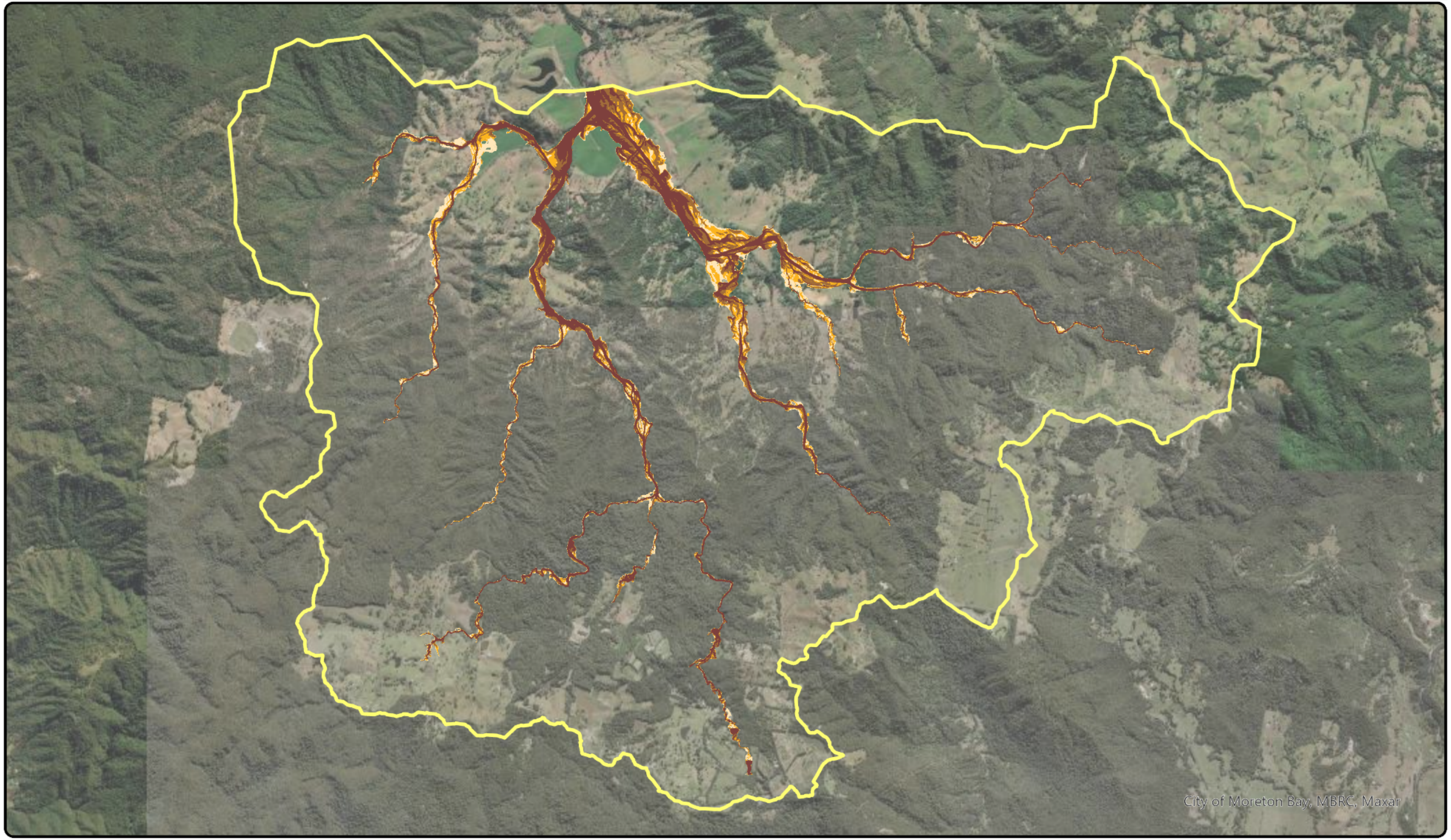
0 - 0.25m	0.5 - 1m
0.25 - 0.5m	>1m

Future Unblocked (F00) 1% AEP Depths (m)

Mary River Minor Basin

28 January 2025

CITY OF MORETON BAY



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SCALE (A4) 1:70,000

Legend

▭ TUFLOW Model Extent

Future Unblocked (E00) 1% AEP Depths (m)

- ▨ 0 - 0.25m
- ▨ 0.25 - 0.5m
- ▨ 0.5 - 1m
- ▨ >1m

CITY OF
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