Fraser Coast Regional Council

Bunya Creek

Flood Study Report

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Project Details

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2 Executive Summary

An investigation and assessment utilising a 1D/2D model has been undertaken of the Bunya Creek system and the following outcomes were noted in the flood study:

1. A detailed 1D/2D model was constructed incorporating a 5 metre grid with major hydraulic structures such as bridges and culverts included.

2. A successful calibration has been undertaken with the available information for the August 2014 and March 2020 flood events. The calibration enabled refinement of the hydrological and hydraulic model parameters for use in the design events.

3. Design events have been undertaken utilising 2019 Australian Rainfall and Runoff (ARR) methods. The study has simulated all of the events, durations and ensembles in the hydraulic model to ensure the catchment is fully understood and represented. This has resulted in different flows and water levels across the catchment compared to historical studies, however it is noted that this study provides more advanced and up to date methods and as such is considered technically accurate with the available data.

4. The flood study existing base case results were utilised to undertake development scenario modelling and also an initial flood risk assessment which is documented in a separate report.

Overall, this assessment has been a robust undertaking utilising all of the latest and relevant approaches to flood modelling in accordance with ARR19. The flood model provides valuable information and data to assess flood risk in detail for Council and also provides the ability to update land use planning policies and flood hazard overlays if desired.

3 Background

The Bunya Creek catchment is approximately 71.3 square kilometres in area and the longest travel path is approximately 17.6 kilometres.

The area is zoned primarily rural; however, the top extents of the catchment have a mixture of low and medium density residential use. In addition, there are large areas of rural land that are currently, or will be converted, to urban use in the future.

Previously, a flood study was undertaken by consultants Engeny in 2012 and the following is noted with regards to this study:

- No calibration was undertaken with historical flood events. As such the model has not been fine-tuned with regards to accuracy modifying hydrological and hydraulic models.
- The flood modelling was undertaken with 1987 Australian Rainfall and Runoff (ARR) parameters whereas this study utilises 2019 ARR parameters
- The previous study only provides select storm events, whereas this study provides a full suite of events in accordance with the latest requirements of Fraser Coast Regional Council (FCRC).

This flood study is being conducted to provide a robust fundamental understanding of the existing flood risk in the area, provide the necessary modelling basis for further assessment of development impact.

4 Available Data

A variety of existing data sets were either provided or sourced from a range of agencies for this study. The data sets included a range of digital and hardcopy data provided by Council, Department of Transport and Main Roads (DTMR) and Bureau of Meteorology (BoM). A summary of the various data sets is outlined separately below.

4.1 GIS Datasets

A range of GIS datasets were sourced and provided to Synergy to inform the flood modelling and study. The information below represents a summary of the data made available.

4.2 Lidar

A digital elevation Model (DEM) was sourced through Council and other sources to represent the catchment. A one metre resolution LiDAR data set captured in 2014 was made available that covered all of the catchment (and all the hydraulic area) initially. The 2014 Lidar information was used in the initial phases of the model build and simulation.

Furthermore, the 2022 Lidar was expedited for this project and used in the final existing and design modelling runs. It should be noted that the 2022 Lidar was obtained by the Queensland Department of Resources and an extract was obtained prior to the review of the final data. Furthermore, an internal review identified significant inconsistencies with actual surface levels.

4.3 12D Models

Council supplied 12D models for the Boundary Road extension in both existing (surveyed) and design format.

4.4 Survey

The area of modelling had significant limitations with regards to the invert levels, diameters and missing pipe information altogether. Furthermore, there had been a high volume of new development of which infrastructure information was not captured. An understanding of these information gaps is shown in the figure below

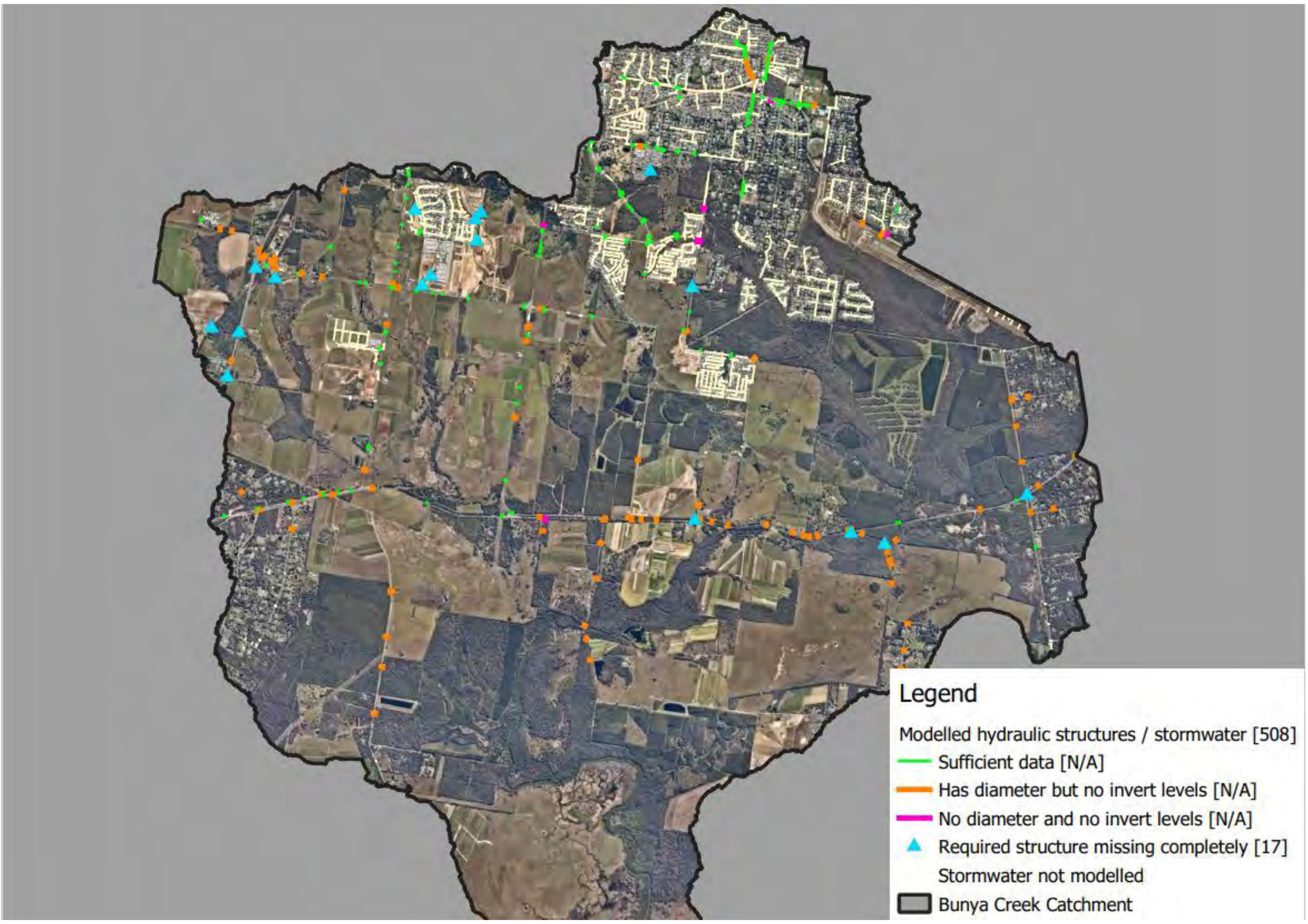


Figure 4-1 Stormwater Missing Information Gaps

It was not possible to survey all missing pipes within the budget allowed and as such surveyors were appointed to capture critical pipes and cross drainage culverts in the area. Surveyors Cullen and Couper were engaged to provide information for missing cross drainage infrastructure that was identified throughout the project. The survey information was used to update the stormwater information within the Tuflow model.

4.5 Site Inspections

Site inspections were undertaken by Synergy Solutions to inform the flood study. The site inspections were undertaken at key points throughout the area and targeted the following aspects:

- Utilising a rapid direct rainfall model to identify initial flows paths and areas of interest.
- Inspection of bridges through the catchment. The inspection assisted with understanding bridge blockages and filling missing data not available from drawings. Measurements were taken of bridge dimensions where possible and safe to do so.
- Inspection of major developments, road corridors and major cross drainage structures.
- Inspection of vegetation particularly on the creek corridor to inform Manning's roughness values.

4.6 External Agency Data

A number of external agencies were utilised to source, collect, and collate data for a variety of needs in the flood study. The information below presents a description and summary of their use.

Department Transport and Main Roads
DTMR was contacted by Synergy and Council to source information on previous modelling and reports. In addition, due to the poor data received by BoM, the TMR data was sourced for the Booral Road Alert.

Furthermore, DTMR also supplied survey and design information in 12D format for the Booral Roadworks.

Bureau of Meteorology
BoM was contacted by Council and Synergy to source a multitude of information required for the flood study. BoM supplied the following information:

- Booral Road Alert rainfall data.
- Booral Road Alert Water Level Data.

More detail on gauging information is presented below.

4.7 Gauge Data

There was only one rain and stream gauge through the catchment and considering the minimal size of the catchment use of this singular rainfall gauge was appropriate for use in calibration. Gauging information was sourced via BoM and DTMR and this information is summarised below in Table 4-1.

Table 4-1 BoM supplied gauge details

Gauge Name	Gauge ID	Type	Ownership
Booral Road	540452	Rain	BoM
Booral Road	540452	Stream	DTMR/BoM

5 Hydrologic Model Development

The following information lists the information, parameters and analysis that was undertaken in order to produce and refine a detailed URBS hydrological model.

5.1 URBS Model Layout

In developing the URBS model, a high level of detail was incorporated in sub catchment breakdown, routing parameters and rainfall data. This was undertaken to ensure a balance between accuracy and not “crowding” model results so as to adequately provide information for land use planning. The sub catchment breakdown was also undertaken to ensure major cross drainage culverts were represented.

As discussed with Council, the main requirements of this study were to ensure the main creek and major tributaries were represented and not the urban environment in detail to ensure results were reasonable to use within a land use planning context.

Sub Catchment Delineation

A direct rainfall model was initially simulated to ensure the flowpaths and catchment areas were well understood. The sub catchment breakdown was undertaken manually to ensure the correct placement of connections to the 2D model and to ensure future development areas could be well represented. The sub catchment breakdown is shown in Figure 5-1.

Figure 5-1 Sub Catchments

Link Routing Process
Zonal statistics were also utilised to accurately assign flowpath lengths, slopes etc into each sub catchment. In this regard, channel routing has been developed based on the lengths and slopes derived from the DEM.

Impervious Fractions and Factors
Impervious areas were developed using a scripted process through QGIS which utilises Manning's roughness grids to accurately account for impervious areas. Zonal statistics were utilised to extract information and assign it to relevant sub catchments. In addition, urbanisation and forest factors were applied to each land use within the model.

This process provides a fundamentally improved estimation of impervious areas rather than estimating percentages through inspection of aerials. The adopted mannings roughness values are shown in Table 6-2.

URBS Parameters

Hydrological and hydraulic calibration was undertaken for the Bunya Creek catchment. The iterations of calibration enabled the fine tuning of mannings roughness values for the hydraulic model and also alpha and beta values for the URBS model.

6 Hydraulic Model Development

As part of the flood study for the Bunya Creek catchment, a detailed 1D/2D TUFLOW model has been developed. The TUFLOW model was based on TUFLOW software version 2020-10-AD-iSP-w64 and also makes use of the Highly Parallelised Compute (HPC) solution scheme. The information below represents the individual build elements of the TUFLOW model and it should be noted that parameters will be revised as part of the calibration and verification assessment and are subject to change.

6.1 Model Extents

The model extents have been selected to align with LiDAR information available and in order to locally focus on the key development areas upstream of Booral Road. The extents were also determined by Council's brief and the need to extend a sufficient distance downstream of the focus area. The tailwater conditions were accounted for in the boundary conditions listed below.

6.2 Boundaries

The upstream and downstream boundaries of the model have been carefully selected to provide the best balance of a highly detailed local assessment, without extending into the Susan River further downstream. This enables capture of the two main tributaries of Bunya Creek and the focus for the study. The boundaries on the creek are as follows:

- The upstream boundary is defined by the extent of the catchment and the sub catchment inputs. The majority of the catchment has been modelled hydraulically. Sub catchments from the URBS model are connected via 2D SA connections to the Tuflow model.
- A downstream boundary a sufficient distance from the interest areas and to ensure capture of the main flowpaths. The downstream boundary has been assigned using a HT boundary to simulate existing, design and climate change runs. Council's required climate change parameters required Mean High Water Springs (MHWS) plus 800mm for climate change (sea level rise).

6.3 Digital Elevation Model

As described above a one metre resolution LiDAR data set captured in 2014 and 2022 was used to develop a DEM for the hydraulic model. Due to the use of Sub grid sampling and a fine resolution hydraulic grid of 5.0 metres, all flowpaths were adequately represented.

6.4 Cell Size Development

The TUFLOW cell size was chosen via a detailed and iterative process of running many flood models to provide the necessary accuracy for a creek system, simulation times, Australian Rainfall and Runoff (ARR) considerations and to adequately and accurately represent any floodplain storage or characteristics that would affect water levels and/or flows. Combinations and iterations of cell size included:

- Utilisation of TUFLOW Quadtree with a variety of nested cell configurations.
- Combinations of standard and quadtree grid sizes of between 2 metres and 10 metres.
- Use of standard and sub grid sampling (SGS) aspects of TUFLOW available in the latest releases.

The findings of this iterative process concluded that:

- The catchment is relatively insensitive to grid sizing adjustment due to the lack of flood storage in the system.
- The use of Quadtree was avoided primarily due to the fact an adequate grid size could be utilised across the whole catchment and to reduce the complexity of future users of the model for development assessment purposes.

With this significant testing, it was deemed appropriate to utilise a TUFLOW model with SGS and a 5m grid size without Quadtree. This provided the most appropriate outcome considering simulation times, ARR19 provisions, accuracy around the future development areas and townships, floodplain representation and simplified models for future use.

6.5 Hydraulic Structures

Hundreds of hydraulic structures are represented in the Bunya Creek catchment and were assessed and if necessary, represented in the hydraulic model. The following information details each of these hydraulic structures in detail.

Culverts and Pipes
Council provided a GIS dataset for culverts in the catchment area. Nearly all of the cross-drainage structures were represented and some trunk drainage system lines. The extent of this representation was defined by the sub catchment breakdown and the desire from Council to have “clean” flood model results in urban areas. In addition, the scope and focus of the study is Bunya Creek itself, not the urban environment.

Bridges
On the Bunya Creek system there is one bridge within the hydraulic extents that required representation in the hydraulic model. The bridge was represented using layered flow constrictions and parameters were sourced from a combination of site inspections, Council GIS information and estimation using terrain data and aerials. The parameters used for the layered shapes in TUFLOW were also developed from the Technical Guideline developed by DTMR titled Hydrologic and Hydraulic Modelling dated October 2019. This guideline provides specific advice on applying TUFLOW parameters for bridges.

The parameters for the layered shape files are shown below in the table below.

Table 6-1 Bridge Details

Name	L1 Obvert (AHD)	L1 Block (%)	L1 FLC	L2 Depth (m)	L2 Block (%)	L2 FLC	L3 Depth (m)	L3 Block (%)	L3 FLC
Doolong Road Pedestrian Bridge	16.0	0	0	0.2	100	1.6	1.5	50	0.15

All the bridges used the terrain surface as the invert of the bridge. The Doolong Road Pedestrian bridge was inspected on site and is shown below in Figure 6-1.

Figure 6-1 Doolong Road Pedestrian Bridge

6.6 Manning's Roughness

Roughness values have been prepared based on the Manning's roughness "n" value in accordance with ARR19 and based on aerial imagery, GIS process, artificial intelligence and field inspections. A photo of typical heavy vegetation along riverbanks is shown in Figure 6-3. The Manning's roughness classifications are shown in the tables and figures below.

The process for defining the Mannings roughness values was as follows:

- The background planning scheme zones were used as a first reference
- GIS process and artificial intelligence (AI) was used to establish a surface mannings roughness. The process uses four types of examples manually implied and AI then applies this to the entire catchment. This becomes the initial basis and provides an exceptional level of detail for vegetation
- Council's road and buildings GIS layers are then utilised to override the raster
- Other major features (such as major grass and concrete channels) are manually specified
- The mannings roughness files are then read in the exact order listed above

Manning's roughness values were refined as necessary as part of the hydrologic and hydraulic calibration for the historical flood events.

Table 6-2 Manning's Roughness Values

Classification	Manning's n
Light Vegetation/floodplain	0.050
Open Ground	0.045
Dense Vegetation	0.085
Bare Earth	0.035
Water	0.030
Medium Vegetation	0.070
Road Pavement	0.016
Buildings	0.2
Concrete Channel	0.016
Overgrown Channel	0.030
Grass Channel	0.035
Watercourse with Vegetation	0.050
Rural Residential Zone	0.070
Low Density Residential	0.12
Medium Density Residential	0.15
High Density Residential	0.20

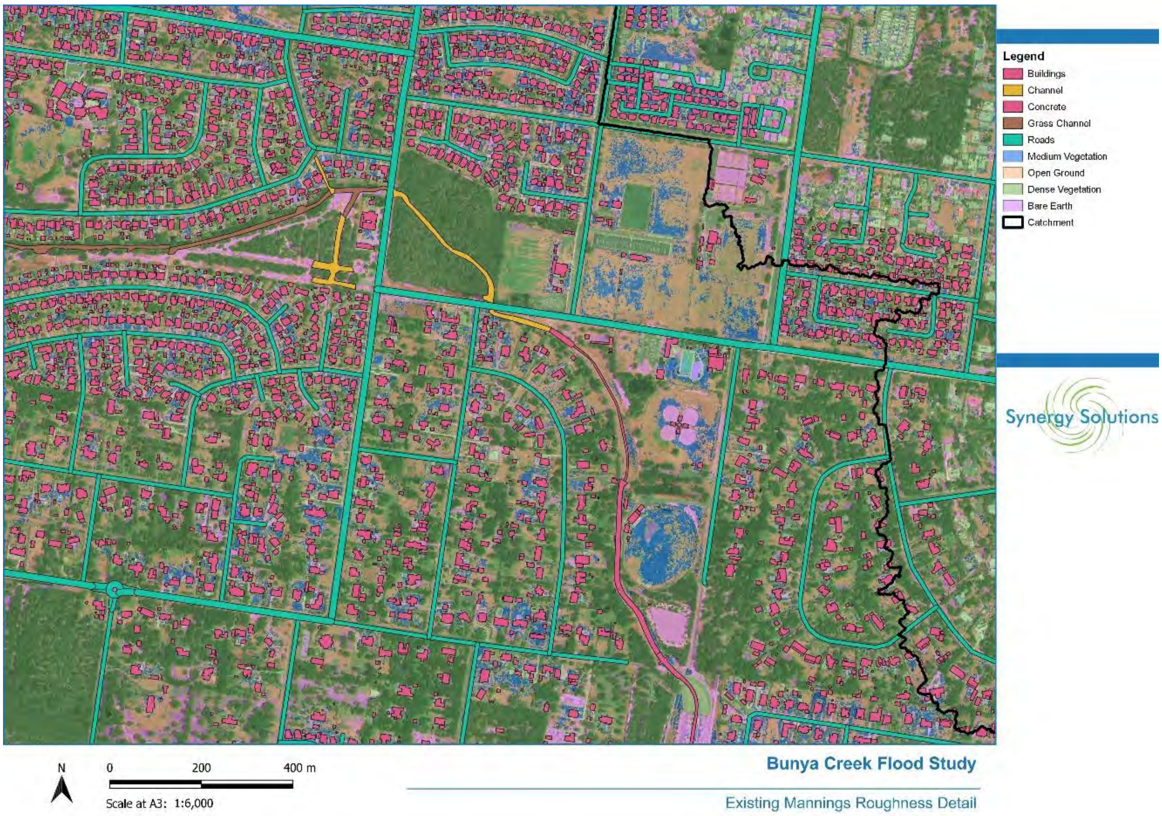


Figure 6-2 Mannings Roughness Example

Figure 6-3 Typical Dense Vegetation Roughness

7 Calibration Overview and Methodology

The information below provides an assessment of the data collected and how it was utilised. In addition, the calibration methodology is explained which is a critical aspect to the flood study.

7.1 Flood Event Selection

The rain and river datasets provided by BoM and DTMR were reviewed and assessed to use the most appropriate flood events for calibration for the records available. Data was only provided up until 2021 and as such the 2022 flood event could not be included. In addition, calibration years were selected to be consistent with the flood modelling undertaken by DTMR.

The flood events chosen, and which gauges are available are shown below in Table 7-1.

Table 7-1 Selected Historical Flood Events

River Height Gauge Location	2014	2020
Booral Road Alert	✓	✓

The flood event spread is an adequate representation of flooding in the area with the events relatively recent and also allowing channel and floodplain flooding throughout the catchment. This allows all the characteristics and complexity of flooding in the area to be represented and ensure all parameters adopted are based on different types and processes of flooding occurring.

7.2 Historical Rainfall Data

As described previously in the model build section of the report, a single rain gauge was used to inform the calibration exercise due to the relatively small size of the catchment and the central location of the Booral Road Alert gauge.

An assessment was also undertaken of the antecedent rainfall conditions to ensure there was some practical initial loss applied to each rain event as shown in Table 4-1. Selecting a consistent initial and continuing loss value provided a good calibration to both events.

Table 7-2 Antecedent Rainfall Conditions

Event	7 Day Antecedent Rainfall (mm)	Calibrated Initial Loss (mm)	Calibrated Continuing Loss (mm)
2014	11	20	2.5
2020	35	20	2.5

8 Calibration Results

The following section provides the results for the calibration undertaken between the hydrological and hydraulic models. The calibration exercise was critical to inform the design events and also to justify a slightly lower continuing loss.

8.1 Approach

Calibration provides a higher level of accuracy to flood models and flood studies. There are however limitations, for this study with the data that is available which can limit this accuracy (lack of survey data, uncertainties of flood gauge characteristics etc). Regardless, an in depth and iterative approach was taken as follows:

By delivering a thorough and accurate joint calibration process, more certainty can be provided that the model is realistically replicating the catchments. This in turn provides the ability to have more confidence in the hydrological model to assess variability in temporal patterns and durations etc during the design event modelling stage.

8.2 2014 Event Analysis

The assessment of the 2014 event is shown below, and commentary provided with regards to the calibration aspects. The graphs below represent the joint calibration undertaken for the URBS and TUFLOW model in comparison to the recorded water levels in the 2014 event.

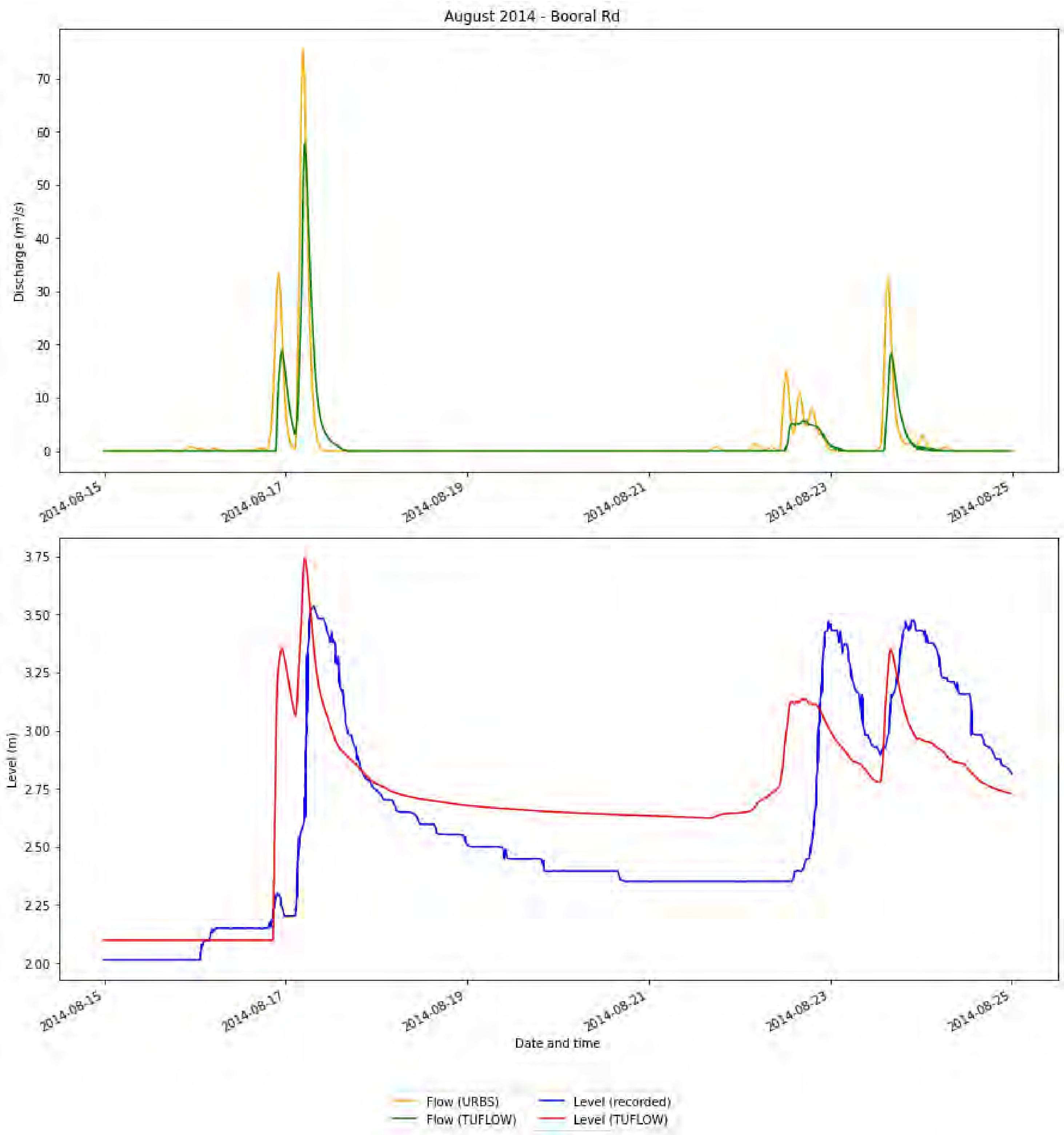


Figure 8-1 2014 Booral Road Alert Calibration Plots

The following is noted with the 2014 event:

- The initial loss of 20mm is a good representation of antecedent catchment conditions whereby there was some rainfall in the 7 day lead up to the event.
- Overall, the TUFLOW model replicates the timing and shape of the flood very well. Secondary peaks and rising limbs are replicated well.
- The modelled peak was 3.777 and the recorded peak level was 3.519. This is considered a satisfactory match and a good balance of replicating peak levels and timing.
- Table 8-1 below shows the recorded verse actual levels at the gauge location. In general, there is good agreement to the historical levels overall.

Table 8-1 2014 Calibration Results

Location	Recorded Peak Level (mAHD)	TUFLOW Calculated Level (mAHD)
Booral Road	3.519	3.777

8.3 2020 Event Analysis

The assessment of the 2020 event is shown below, and commentary provided with regards to the calibration aspects. The graphs below represent the joint calibration undertaken for the URBS and TUFLOW model in comparison to the recorded water levels in the 2014 event.

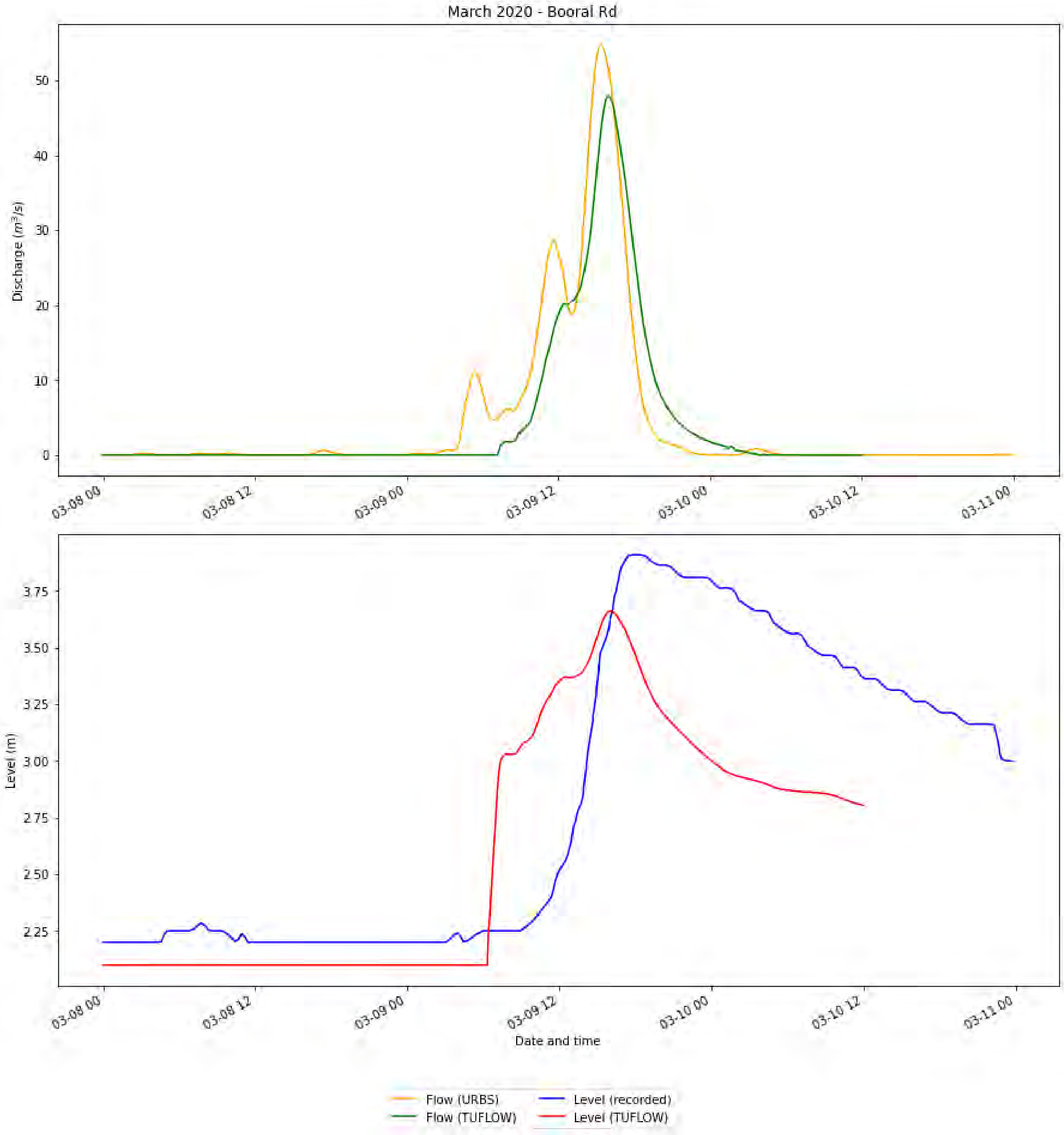


Figure 8-2 2020 Booral Road Alert Calibration Plots

The following is noted with the 2020 event:

- The initial loss of 20mm is a good representation of antecedent catchment conditions whereby there was some rainfall in the 7 day lead up to the event.
- Overall, the TUFLOW model replicates the timing of rainfall well. The model responds slightly faster than the recorded gauge level at first, but correlates well towards the peak
- The modelled peak was 3.707 and the recorded peak level was 3.779. A difference of 72mm is excellent and a good balance of replicating peak levels and timing.
- Table 8-2 below shows the recorded verse actual levels at the gauge location. In general, there is good agreement to the historical levels overall.

Table 8-2 2020 Calibration Results

Location	Recorded Peak Level (mAHD)	TUFLOW Calculated Level (mAHD)
Booral Road	3.779	3.707

9 Design Events

The information below provides an overview of the design events methodology and modelling.

9.1 Summary

The design event modelling and outputs have been undertaken in accordance with the parameters and guidance listed in Australian Rainfall and Runoff 2019. The following is a summary of the work undertaken:

- The calibrated URBS and TUFLOW models have been utilised as the basis for providing the design event modelling.
- Parameters and inputs such as pipes, bridges, terrain and Manning's roughness values have remained largely consistent with the calibration models.
- The analysis utilised an assessment of multiple storm durations and all ten temporal patterns in accordance with ARR19.
- A process was applied to select events from the hydrology model to apply to the hydraulic model, such that a maximum envelope of the selected hydraulic model runs would represent an accurate design flood event across the locations of interest.
- Verification has been undertaken using the Regional Flood Frequency Estimation Method (RFFE). At site flood frequency analysis was not undertaken due to the short guage record (~20 years). The RFFE method provided good validation of design flows and was sufficient.
- Climate change outputs for the 1% AEP have been produced by utilising the RCP 8.5 scenario applied to Mean High Water Springs (MHWS) and based on conversations with Council.

Overall, the framework used, and the modelling and outputs produced are robust due to the use of detailed calibration and strict adherence to the ARR19 guidance.

9.2 Design Rainfall IFD

Design flood estimates have been derived on the design IFD guidance outlined in ARR2019 and includes the updated rainfall IFD prepared by the Bureau of Meteorology (BoM) which superseded the previous ARR1987 IFD information. The updated IFDs are considered to be more appropriate and superior to the former ARR1987 IFDs as they include a greater overall number of rainfall stations as well as more stations with a period of record exceeding 30 years.

Investigation of the IFD's was undertaken for the catchment which showed very little variation in rainfall depths and as such only one IFD pattern was applied to the whole catchment.

9.3 Design Event Losses

Design event losses were considered in combination of assessment of the ARR Datahub losses, and the calibration undertaken. As the flood frequency data and assessment was deemed unreliable, unfortunately this was not able to be utilised to further verify and refine losses across different design events.

Table 9-1 below shows the varying losses for each of the datahub and calibration events and the following can be summarised:

- The Datahub initial loss generally represents a good correlation of the various spread of calibration event losses. The adopted value of 28mm compares fairly well to the various datahub estimates and also a balance of calibration event outcomes.

- Continuing losses were quite sensitive to calibration events and due to the relative consistency across all calibration events, this was deemed a more reliable (and conservative) estimate of continuing losses.

Table 9-1 Design Loss Assessment

Data	Initial Loss (mm)	Continuing Loss (mm)
2014	10	1.3
2020	20	0.7
Datahub | Booral Road Gauge	34	3
Design Losses	28	0.7

9.4 Aerial Reduction Factors

Areal Reduction Factors (ARFs) have not been applied as the focus of the study is across the entire catchment. It was necessary to produce flood extents for very small catchments and thus would not have been conservative to adopt ARF's for these catchments.

9.5 Design Combination Selection

Due to the difficulties in applying ARR2019 fully to flood studies due to the many combinations of events, durations and ensembles, a custom method was derived to find a balance between simulation time and accuracy. If all 1000+ hydraulic simulations were produced, this was estimated to take nearly 1000 hours (42 days) of modelling time which is not practical. At the other end of the scale, it is not appropriate to pick one focal point within the catchment due to the results being used over the entire catchment. A process was developed to select a subset of runs for the fine TUFLOW model to create maximum design flood surfaces valid at all locations. The process was undertaken in the following manner:

1. A coarse TUFLOW model was run for all ARIs, durations and ensembles.

2. Peak flood levels were extracted at 80+ locations across the catchment for all runs.

3. For each location and ARI, the target design flood level was calculated using the mean ensemble, maximum duration approach.

4. Each individual run at each location was given a score based on:

   - How close the run was the to the target design flood level.
   - How close the run's storm duration was the to the design critical duration.
   - Whether or not the run exceeded the target design flood level at the given location or any other location by more than 0.15m.

5. For each location and ARI, the run with the best score was selected. This resulted in 156 unique events.

10 Climate Change Assessment

The longest guidance that is provided in ARR2019 applies for climate change projections out to 2090 and at the direction of Council, for this project design rainfall depths were generated assuming Representative Concentration Pathway (RCP) of 8.5.

ARR2019 did not recommend any changes in temporal patterns, spatial patterns or loss rates associated with climate change projections for design floods, recognising that although there was preliminary research demonstrating that some of these flood causing factors may be sensitive to climate change there was insufficient definitive advice on these factors at the time the ARR chapter was drafted (2015). As such, these parameters have been kept consistent with the current day 1% AEP.

The Bunya Creek catchment lies within the East Coast North Natural Resources Management cluster (see Figure 1.6.1 of Bates et al., 2019). Using the guidance in ARR2019, this region is projected to have a 3.7°C increase in temperature to 2090 under RCP 8.5. Applying ARR2019 results in a projected 19.7% increase in design rainfall depths, under this scenario.

A change to the downstream boundary associated with sea level rise was undertaken with the following information:

- The MHWS value of 1.54m AHD was taken from the Bingham (River Heads) in the Mary River.
- The 800mm increase in sea level rise was added to the MHWS to a value of 2.34m AHD.
- The sea level scenario was undertaken under the recommendation by Council and in discussion with the project team.

Overall, it is expected that the sea level aspect will impact the bottom portion of the catchment and rainfall intensity increase will have a more profound impact on the upper portions of the study area.

11 Probable Maximum Flood

The Probable Maximum Flood (PMF) was estimated using the Probable Maximum Precipitation Design Flood (PMPDF) estimation technique of ARR2019. The following methodology was undertaken:

- The Annual Exceedance Probability of the PMP was based on the guidelines outlined in ARR2019, which themselves are based on the estimates outlined in ARR1987 and found to be consistent with more recent reviews.
- Temporal patterns were based on the areal temporal patterns developed for the GTSMR PMP methods for durations greater than 24 hours (BoM, 2003), and a combination of both 24-hour GTSMR and longest duration Generalised Short-Duration Method (GSDM) patterns for durations less than 24 hours.
- For the PMF estimation as it is assumed that the pre-burst rainfalls associated with the PMP design burst will either partly or fully satisfy soil moisture deficits.

The results of the PMF assessment are shown within the Appendices.

12 Model Results and Discussion

The following section of the report provides an overview of the results of the design events simulation and also a description of the characteristics of flooding in the Bunya Creek catchment.

12.1 Critical Durations

Critical durations across the catchment were informed by the design combination selection process described above and the use of a detailed joint calibration model. An example of the different pattern sets for the 1% AEP is shown below.

Table 12-1 1% AEP Duration and Ensemble Sets

Duration (mins)	Ensemble
30	6
60	1, 2, 3, 5, 6
90	1, 2, 3, 5, 8, 9
120	1, 2, 3, 8
180	4, 5, 6, 9
270	7, 9
360	4, 6, 10
720	2

12.2 Post Processing Information

After simulations of all the relevant events, durations and focal points the following post processing was undertaken:

- TUFLOW's asc to asc tool was utilised to collate and provide the maximum surfaces for all durations for all events.
- Each result (level, depth, hazard etc) was maximised based on the collation of the selected temporal pattern and duration and output as a maximum surface combined.

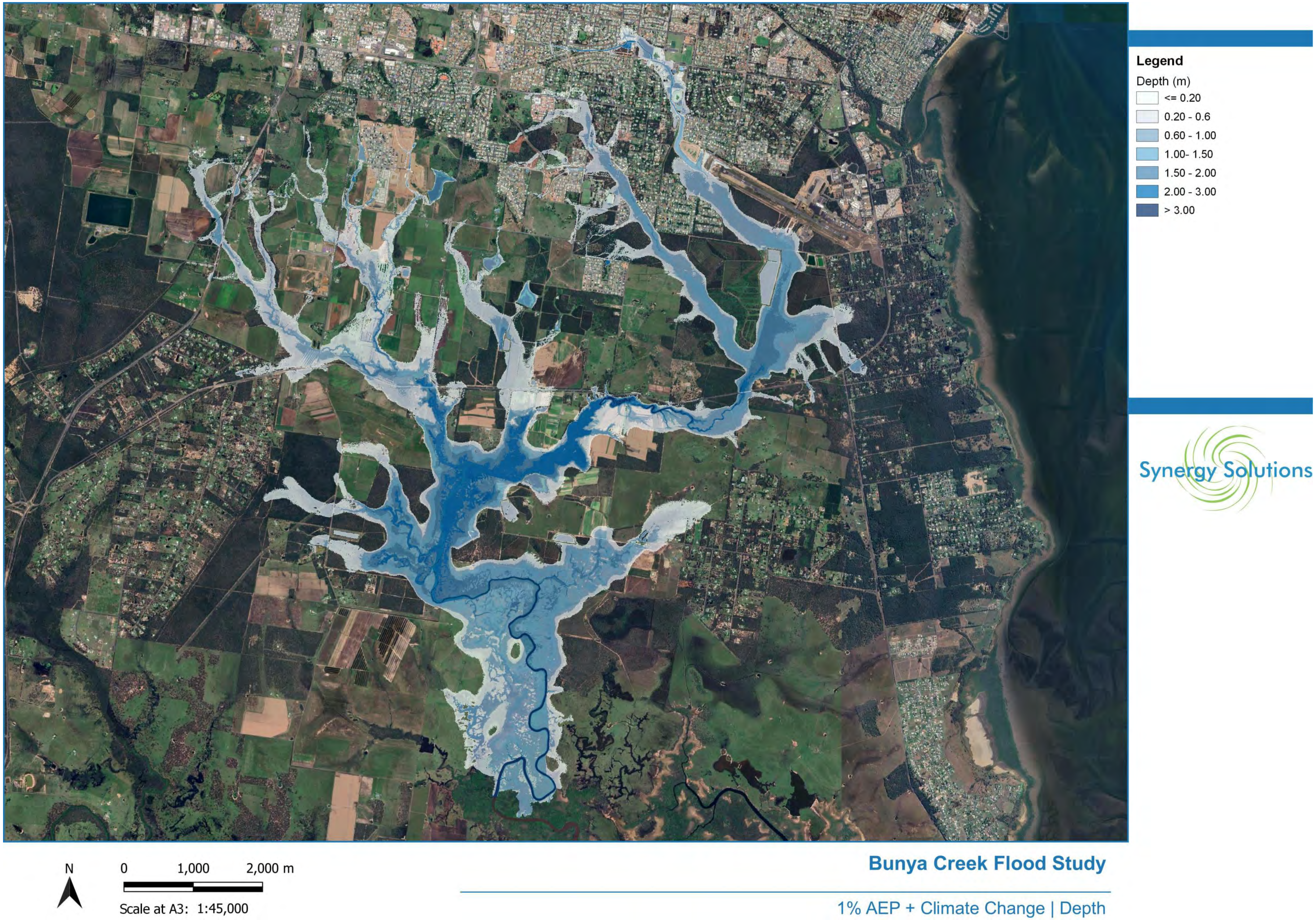


Figure 12-1 **1% AEP with Climate Change Depth**

12.3 Historical Flood Study Comparison

In order to provide a comparison of the new flood study results, the FCRC flood hazard mapping (of which the results were sourced from the Engeny study titled Bunya Creek Flood Mapping and Stormwater Management Study Dated 16th March 2012) and compared in GIS to the new flood study results as shown below.

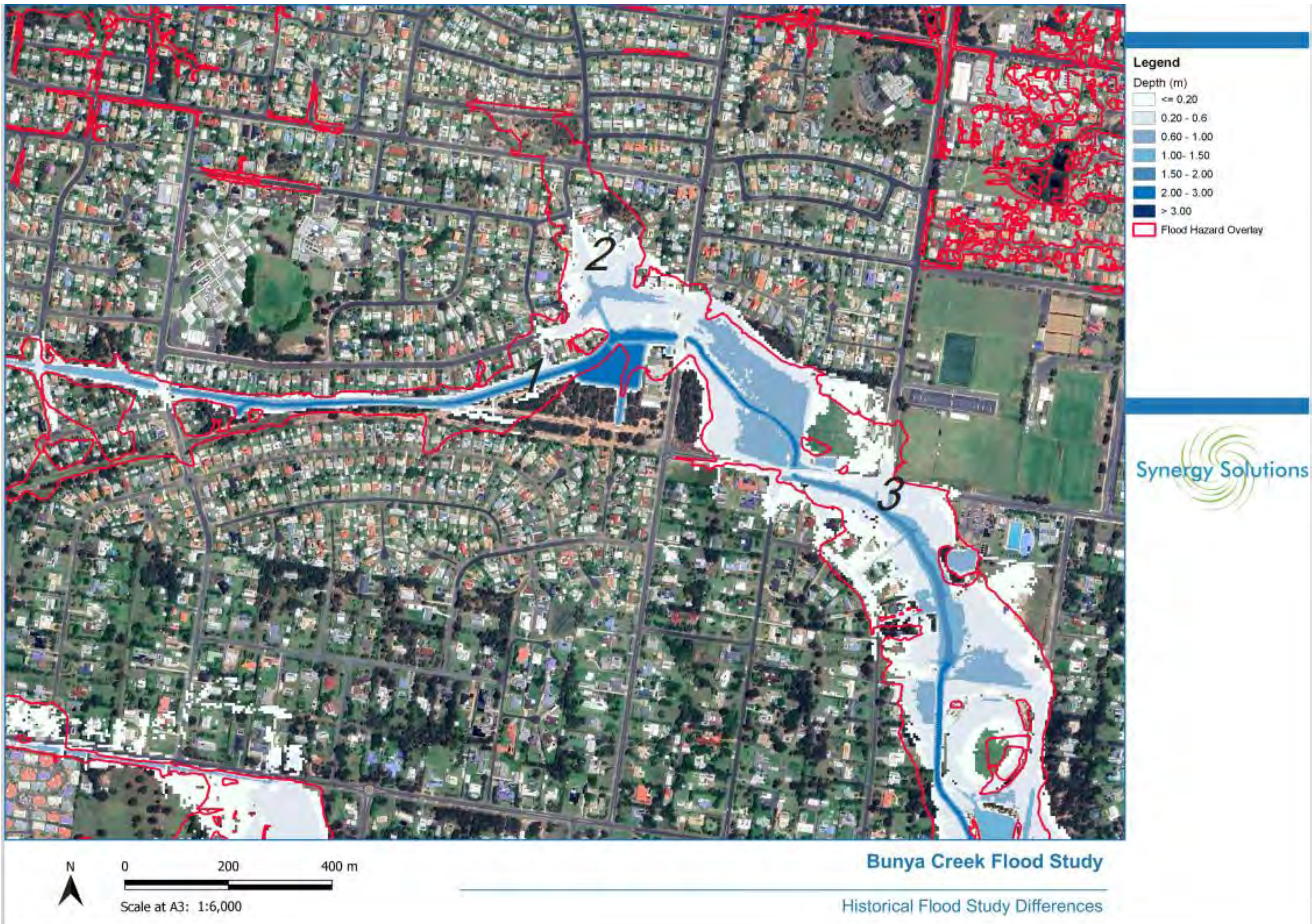


Figure 12-2 Comparison of 1%AEP Climate Change Results Area 1

As it can be seen in Figure 12-2, the following differences are observed:

- There is an extensive reduction in flood levels in the channel south of Honeysuckle Avenue and the Boundary Road area (Area 1). This is primarily due to the extensive roadworks, channel works and constructed detention basin which reduces levels.

  In addition, the flooding has been removed from the northern urban area of Honeysuckle Avenue (Area 2) as this area has not been modelled due to the complex urban drainage network (which cannot be adequately represented in a regional model).

- Area 3 along Kathleen Crescent (and south of Boundary Road) has less flood extents as a significant flood mitigation channel has been installed (and represented in the latest Lidar). This channel also likely reduces flood levels upstream into the Honeysuckle Avenue area.

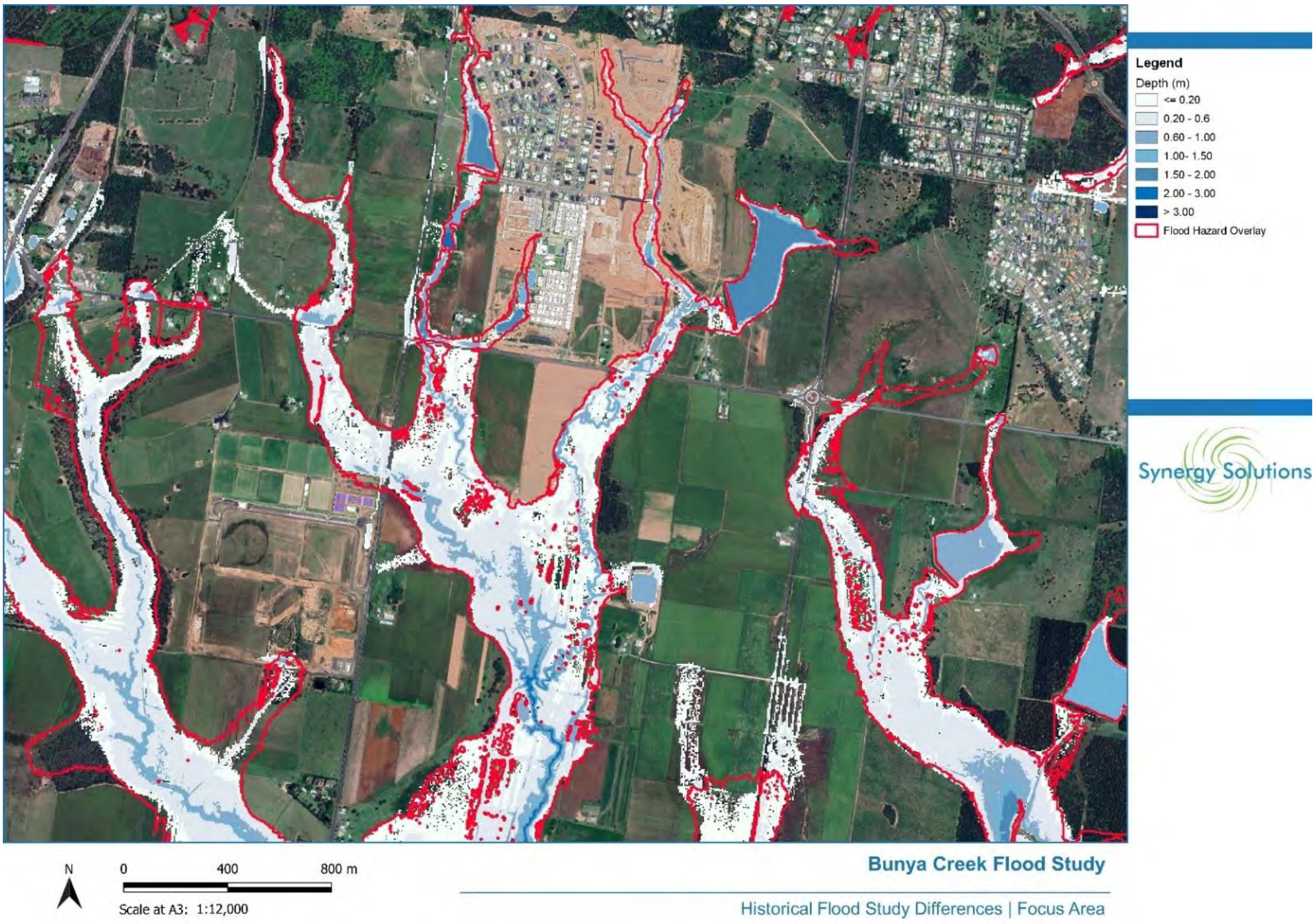


Figure 12-3 Comparison of 1%AEP Climate Change Results Focus Area

The following comments are noted in the focus area:

- In general, flood extents are similar, although overall the levels and extents are slightly less
- There are significant reductions in flood extents in the existing emerging community area due to the extensive development that has occurred (redirection of flow paths, filling etc)

Other factors that result in differences between the studies include:

- This current flood study utilises a more recent and higher resolution Lidar dataset. In general, the Lidar represents the channels and gullies more efficiently resulting in lower elevation and thus lower flood levels
- The current flood study is more refined in several components. The study utilises a finder grid size, more superior computation method and most importantly uses sub grid sampling (SGS) at a one metre resolution. SGS allows for a finer resolution and representation of terrain and more defined and deeper main flowpaths (thus generally reducing levels)
- This flood study has been calibrated to two historical flood events and validated. This provides more certainty in the parameters adopted.
- This flood study utilises the latest application of Australian Rainfall and Runoff 2019.

13 Validation

Validation of flood modelling is an important component of accurate assessment of design flows and thus flood levels.

13.1 Regional Flood Frequency Assessment

An assessment below shows the design events verse the Regional Flood Frequency Estimation (RFFE) method at various locations in the catchment.

Table 13-1 RFFE verse Design Events Comparison 1% AEP

Location	1% Design Event Flow (m3/s)	RFFE Estimate (m3/s)	RFFE Lower Estimate (m3/s)	RFFE Upper Estimate (m3/s)
Mid Catchment (PO Qmid01)	144.723	283	75.6	995
Bottom Catchment	266.495	576	158	2080

Table 13-2 RFFE verse Design Events Comparison 20% AEP

Location	20% Design Event Flow (m3/s)	RFFE Estimate (m3/s)	RFFE Lower Estimate (m3/s)	RFFE Upper Estimate (m3/s)
Mid Catchment	68.223	60.9	25.3	148
Bottom Catchment	90.076	125	52.0	305

Each estimate of design flow fits within the lower and upper bounds of the RFFE estimate, however for the 1% AEP it is noted the flows are on the low side. Lower design flows are likely associated with reduced rainfall depths with ARR2019 which has been note across Queensland as an issue to address in the future. Due to the catchment configuration and ultimately how the catchment responds however, the 1% with climate change at the bottom catchment is much higher in flow (336 m3/s). As this event is the main combination used as the design flood event and the risk based outputs, this provides a higher level of conservatism.

The 20% AEP event however provides a good correlation to the RFFE estimate.

It should also be noted that the RFFE is an estimation method only and can be prone to significant error (and this is a reason for its current revision underway). Furthermore, without a gauge with a long history and a flood frequency assessment, there is no reasonable way to adjust/increase flows to match FFA.

It is considered that the RFFE provides a reasonable validation. The full RFFE extracts are available in the appendices.

13.2 Rational Method Validation

Further validation was undertaken with an alternative method at locations that had smaller catchment areas.

Table 13-3 Rational method verse Design Events Comparison 1% AEP

Location	1% Design Event Flow (m3/s)	Rational Method Estimate (m3/s)	Difference (m3/s)	% Difference (%)
PO Upper 10	11.052	14.390	3.338	23.1
PO Upper 7	47.913	52.760	4.847	9.2

The Rational method validation has been utilised at Council's request; however, the following should be noted with regards to the difference in flows and the use of the Rational method overall:

- ARR2019 recommends discontinuing the use of the Rational Method for a variety of reasons. ARR guidance can be consulted regarding this.
- Section 4.2.2 of the Queensland Urban Drainage Manual QUDM provides situations where the Rational method should not be used in complex environments. Nearly all situations in this model and the calculations undertaken at available locations accord to many of these exclusions. As such any comparisons should be treated with caution

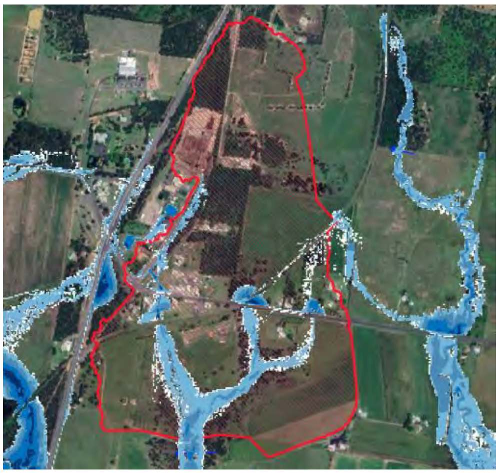


Figure 13-1 Rational method Validation Location 1

Figure 13-2 Rational method Validation Location 2

14 Conclusion

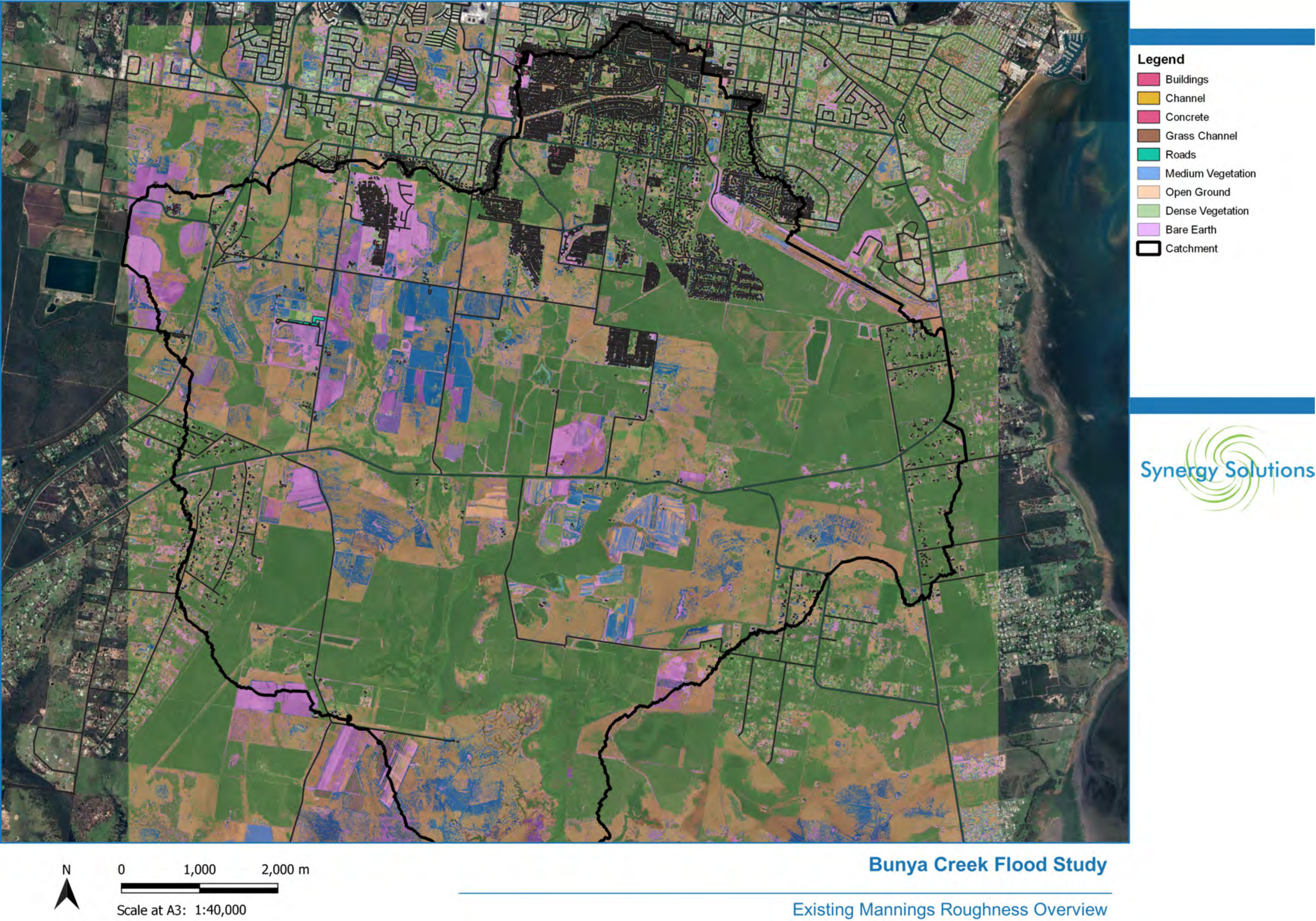
The Bunya Creek Flood Study has been undertaken to fulfill the requirement of the scope and to provide Fraser Coast Regional Council a robust flood model for planning purposes. The model will also be utilised in further assessment of development scenarios and impact, culvert upgrades and an initial flood risk-based assessment.

15 Limitations and Assumptions

The work undertaken in this report and project, is subject to the following limitations:

- Data provided by external sources and Council is assumed true and correct.
- Aspects of this project have been discussed and agreed with Fraser Coast Regional Council. Limitations are present within these joint project decisions and have been identified.
- Calibration has been undertaken to be consistent with DTMR works in the catchment. Larger flood events may have been present in the dataset.
- Future use of this flood model requires an understanding of the events, durations and temporal patterns utilised. Synergy Solutions have documented and handed over all necessary data to Council for this to occur.

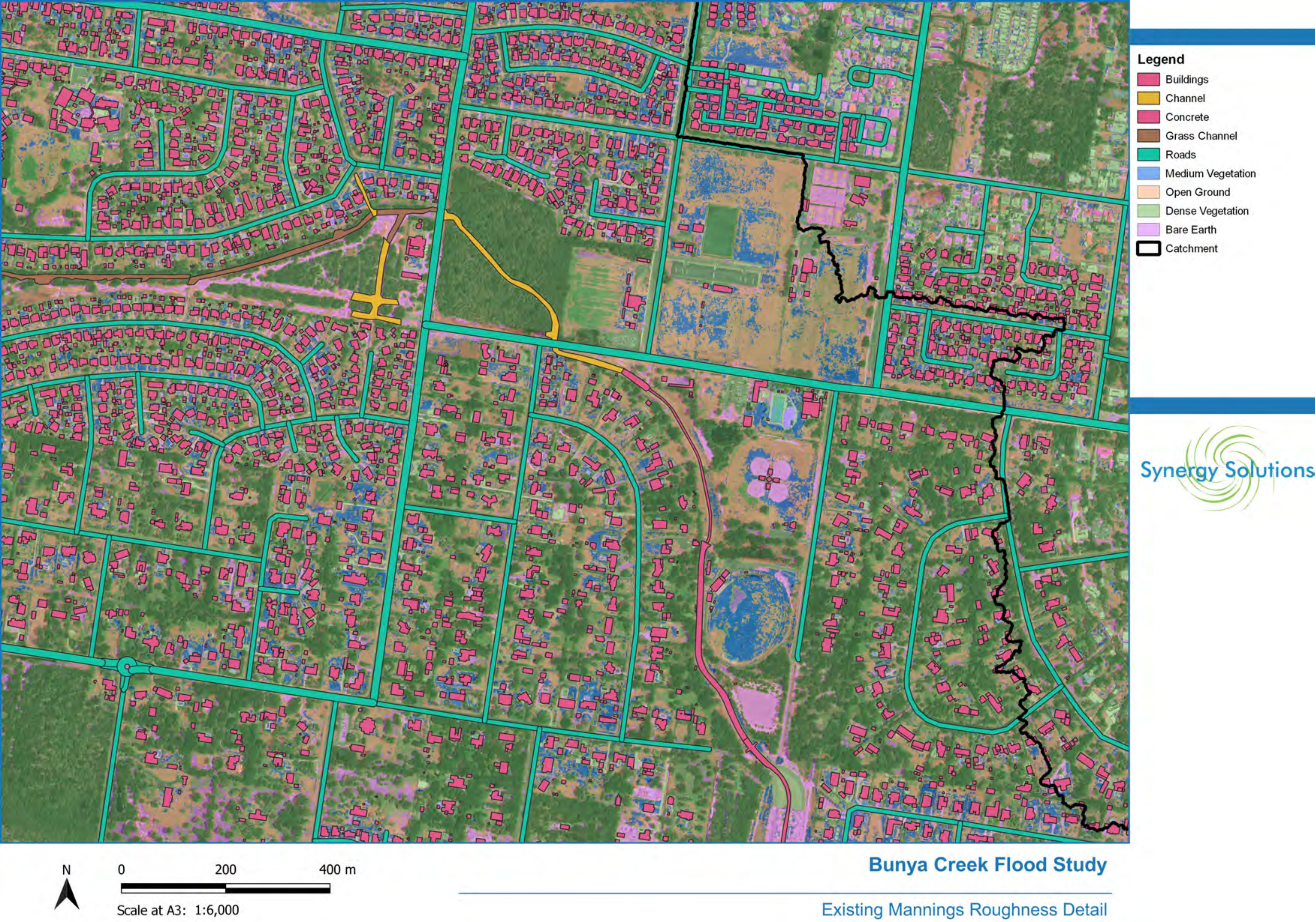
16 Appendix A | Model Build



Synergy Solutions

Bunya Creek Flood Study

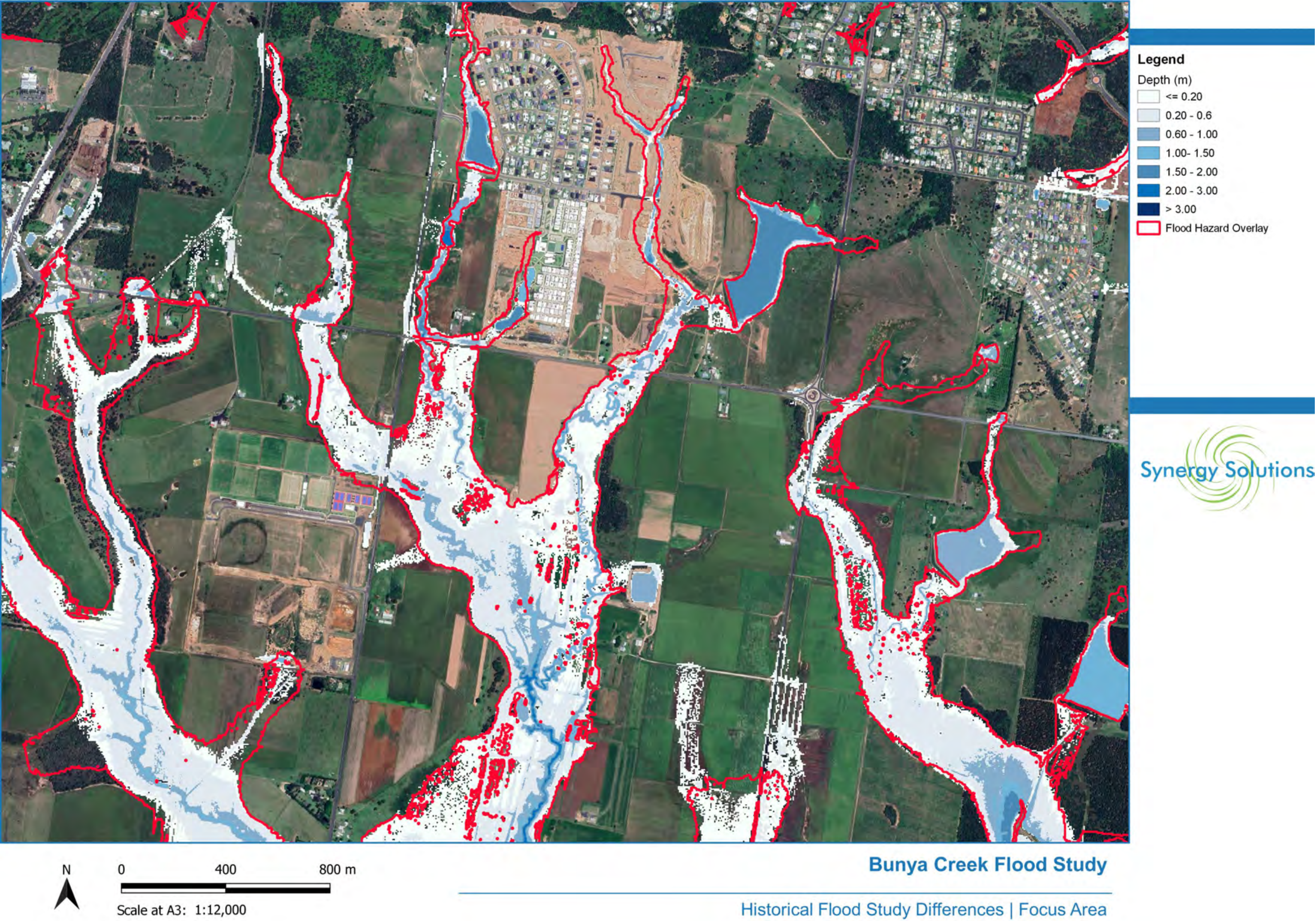
Existing Mannings Roughness Overview



Synergy Solutions

Bunya Creek Flood Study

Existing Mannings Roughness Detail



Bunya Creek Flood Study

Historical Flood Study Differences | Focus Area

Legend

Depth (m)

- <= 0.20
- 0.20 - 0.6
- 0.60 - 1.00
- 1.00- 1.50
- 1.50 - 2.00
- 2.00 - 3.00
- > 3.00
- Flood Hazard Overlay

Synergy Solutions

N

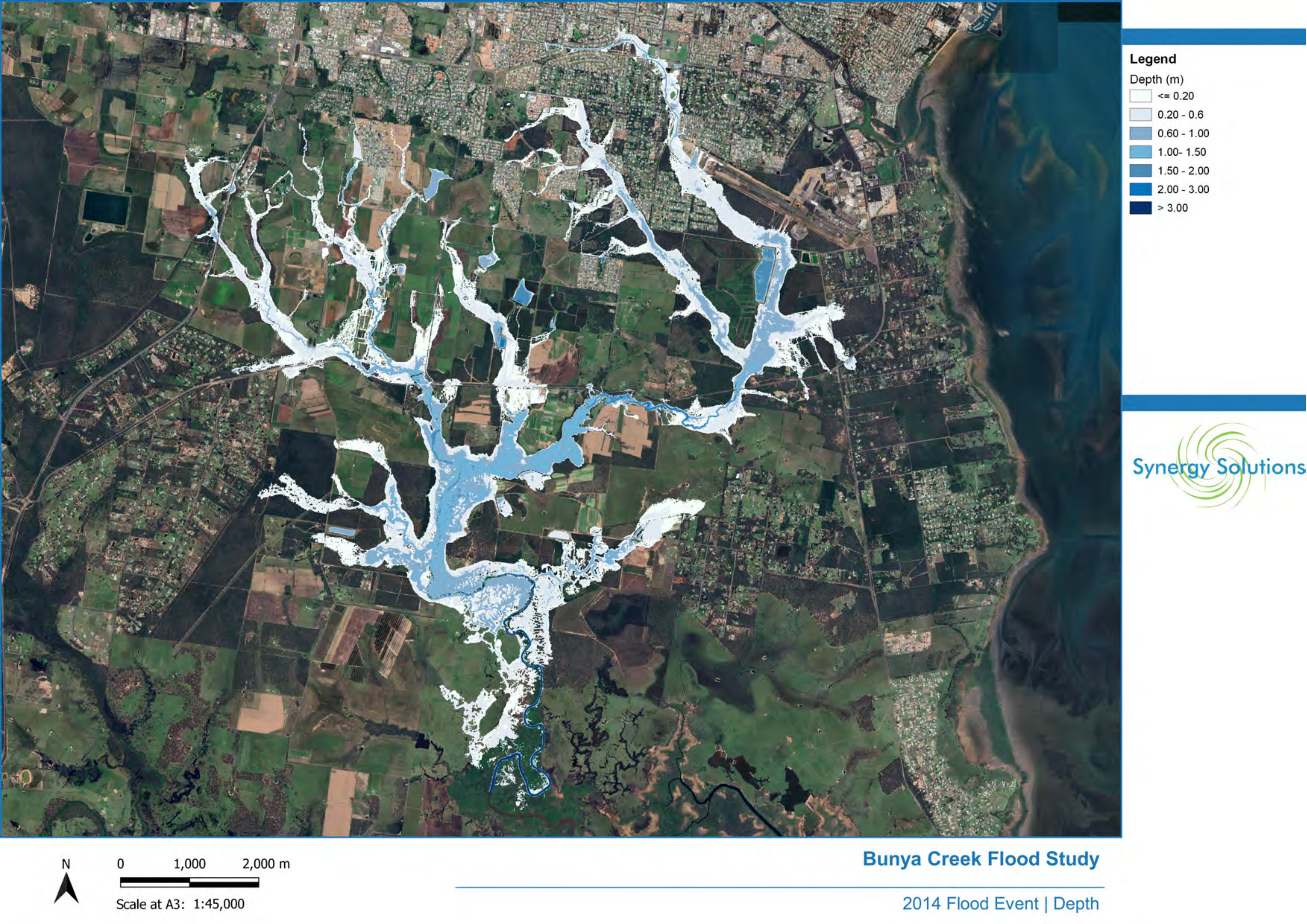
0 200 400 m

Scale at A3: 1:6,000

Bunya Creek Flood Study

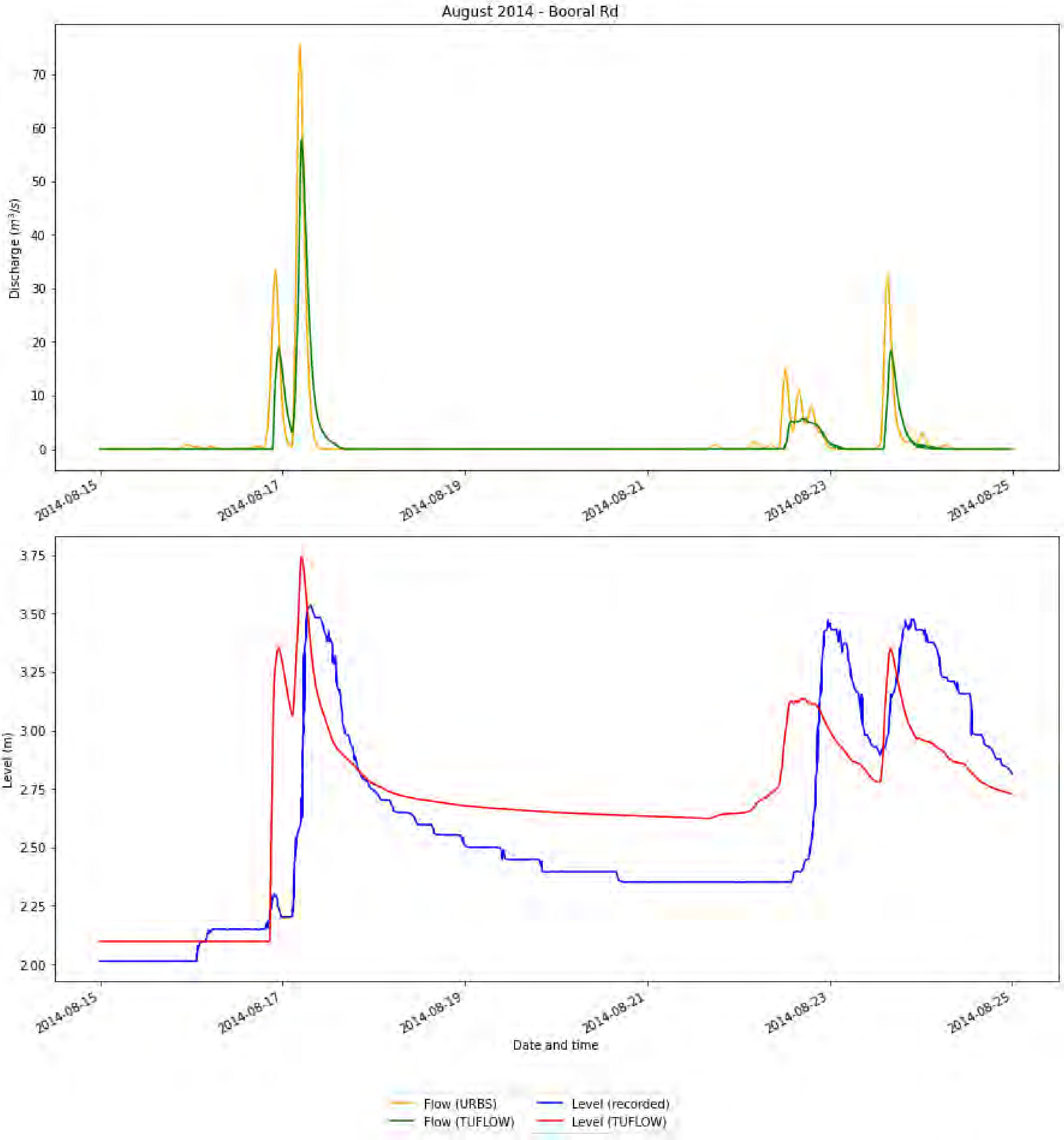
Historical Flood Study Differences

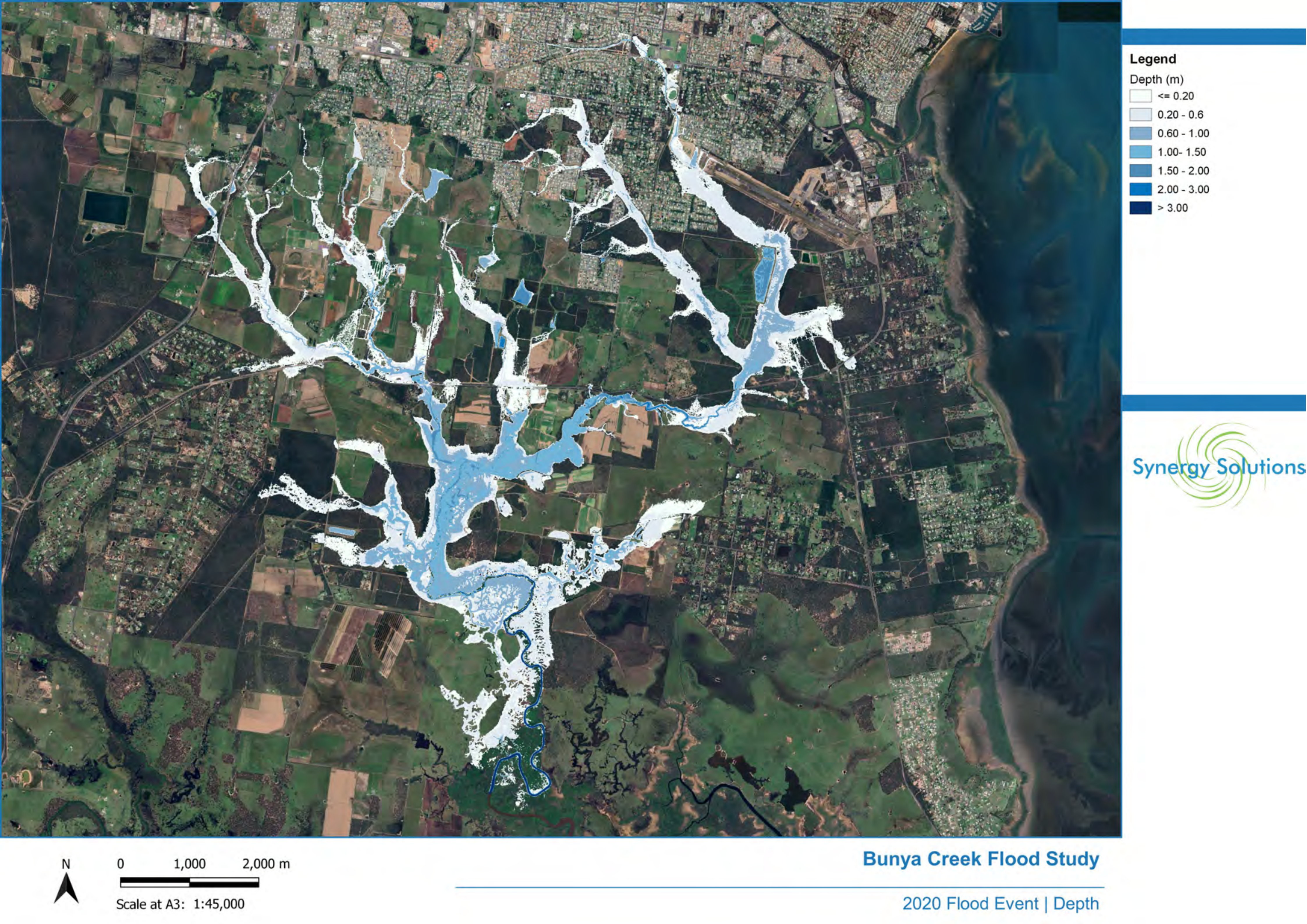
17 Appendix B | Calibration Event Maps



Bunya Creek Flood Study

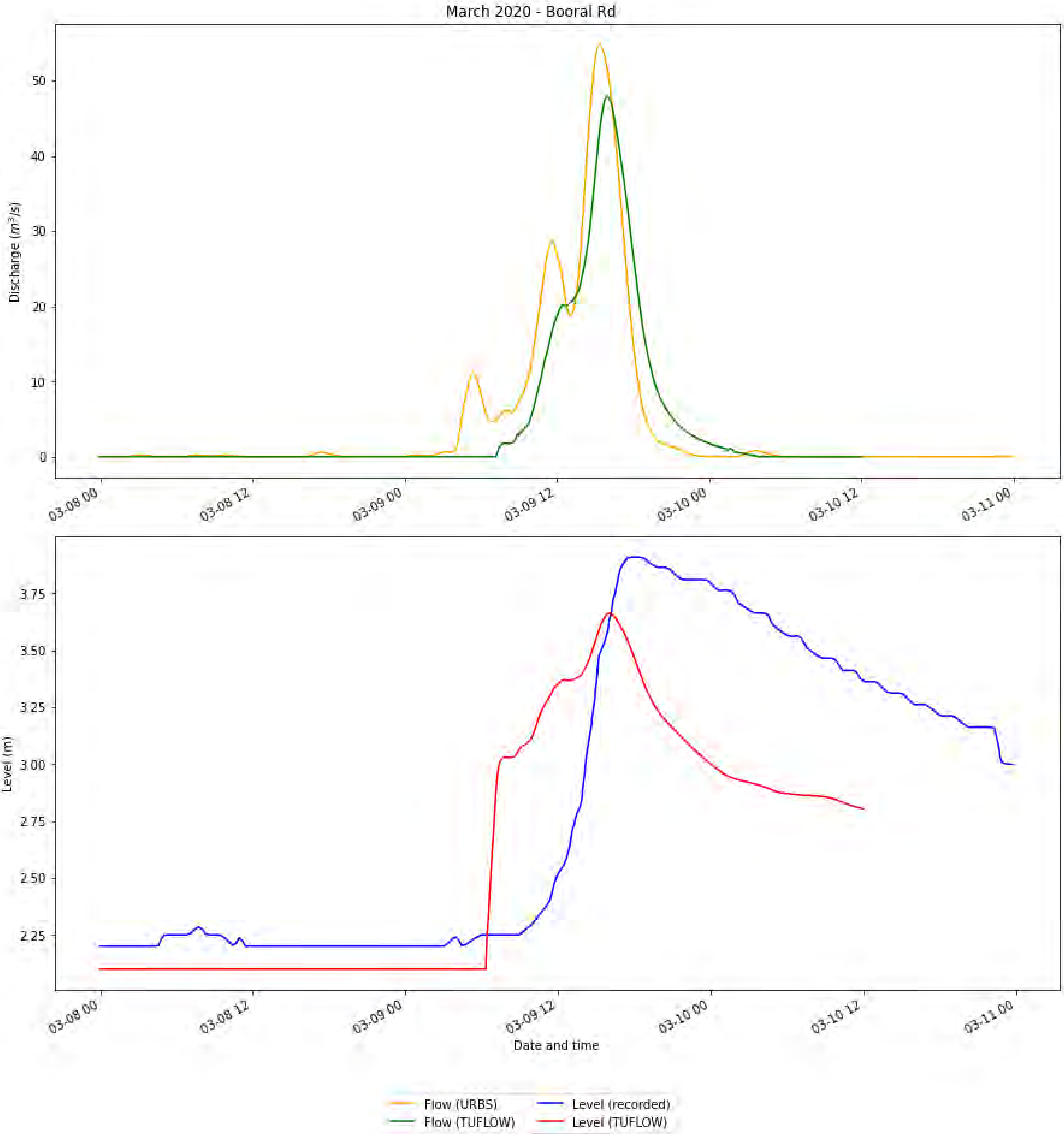
2014 Flood Event | Depth


August 2014 - Booral Rd
Discharge (m^3/s)
Level (m)
Date and time
2014-08-15
2014-08-17
2014-08-19
2014-08-21
2014-08-23
2014-08-25
Flow (URBS)
Flow (TUFLOW)
Level (recorded)
Level (TUFLOW)



Bunya Creek Flood Study

2020 Flood Event | Depth


March 2020 - Booral Rd
Discharge (m^3/s)
0
10
20
30
40
50
Level (m)
2.25
2.50
2.75
3.00
3.25
3.50
3.75
03-08 00
03-08 12
03-09 00
03-09 12
03-10 00
03-10 12
03-11 00
Date and time
Flow (URBS)
Flow (TUFLOW)
Level (recorded)
Level (TUFLOW)

18 Appendix C | Existing Flood Depth Maps

Legend

Depth (m)

- <= 0.20
- 0.20 - 0.6
- 0.60 - 1.00
- 1.00- 1.50
- 1.50 - 2.00
- 2.00 - 3.00
- > 3.00

N

0 1,000 2,000 m

Scale at A3: 1:45,000

Bunya Creek Flood Study

63.2% AEP | Depth

Legend

Depth (m)

- <= 0.20
- 0.20 - 0.6
- 0.60 - 1.00
- 1.00- 1.50
- 1.50 - 2.00
- 2.00 - 3.00
- > 3.00

Synergy Solutions

N

0 1,000 2,000 m

Scale at A3: 1:45,000

Bunya Creek Flood Study

39.35% AEP | Depth

Bunya Creek Flood Study

18.13% AEP | Depth

Bunya Creek Flood Study

10% AEP | Depth

Legend

Depth (m)

- <= 0.20
- 0.20 - 0.6
- 0.60 - 1.00
- 1.00- 1.50
- 1.50 - 2.00
- 2.00 - 3.00
- > 3.00

Synergy Solutions

N

0 1,000 2,000 m

Scale at A3: 1:45,000

Bunya Creek Flood Study

5% AEP | Depth

Bunya Creek Flood Study

2% AEP | Depth

Legend

Depth (m)

- <= 0.20
- 0.20 - 0.6
- 0.60 - 1.00
- 1.00- 1.50
- 1.50 - 2.00
- 2.00 - 3.00
- > 3.00

Synergy Solutions

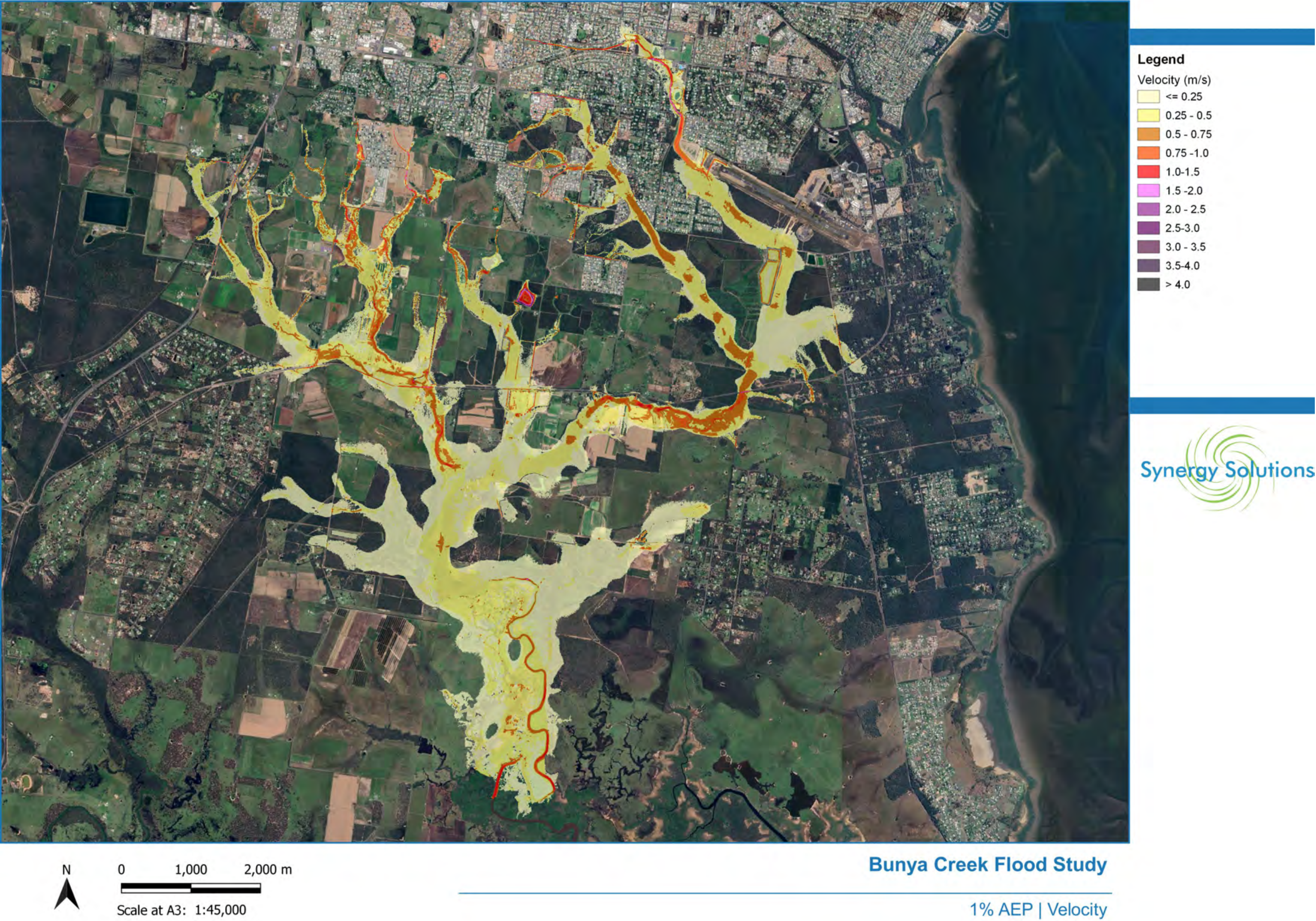
N

0 1,000 2,000 m

Scale at A3: 1:45,000

Bunya Creek Flood Study

1% AEP | Depth

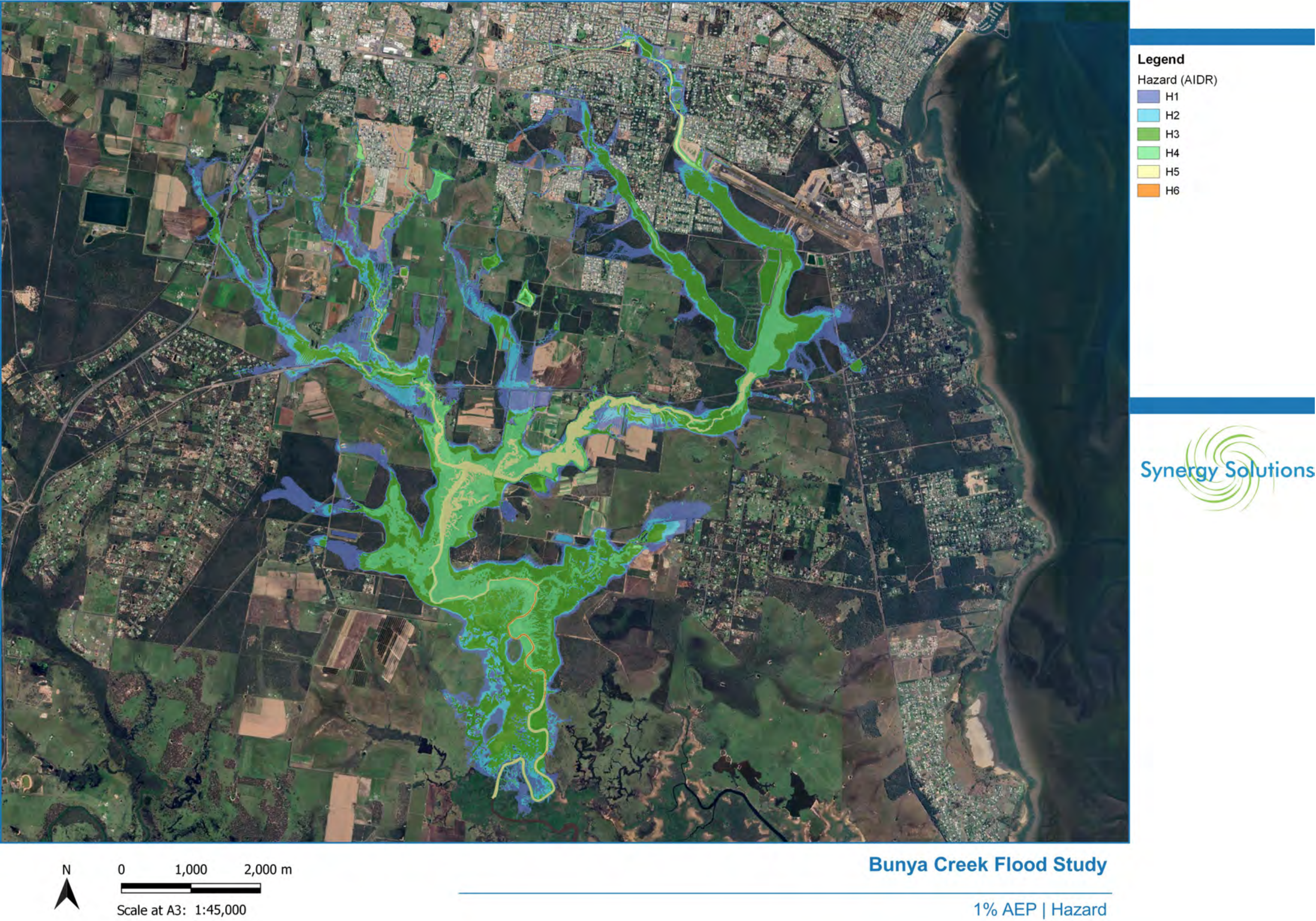


Bunya Creek Flood Study

1% AEP | Velocity

Bunya Creek Flood Study

1% AEP | Velocity Depth Product

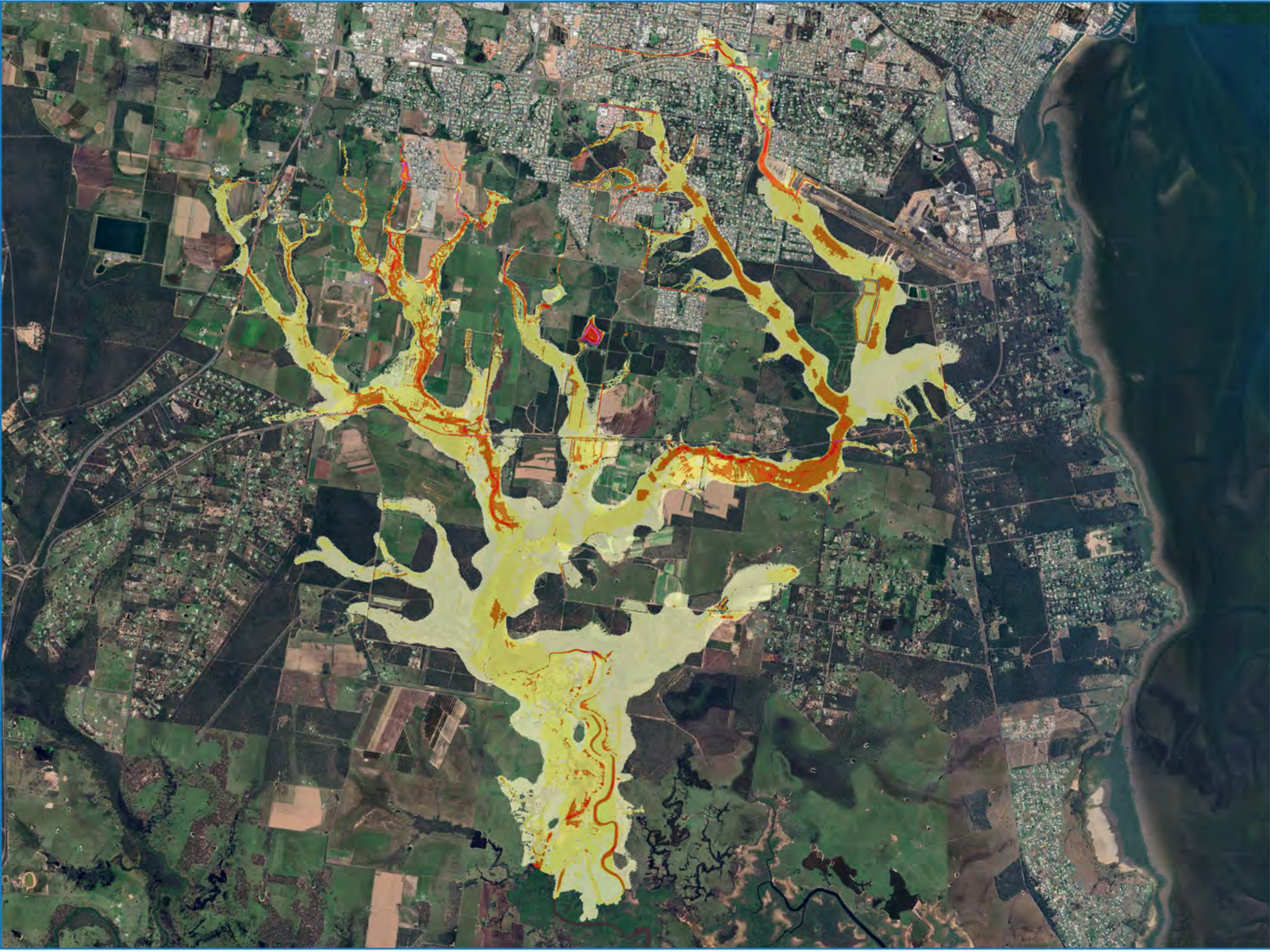


Bunya Creek Flood Study

1% AEP | Hazard

Bunya Creek Flood Study

1% AEP + Climate Change | Depth



Legend

Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 -1.0
- 1.0-1.5
- 1.5 -2.0
- 2.0 - 2.5
- 2.5-3.0
- 3.0 - 3.5
- 3.5-4.0
- > 4.0

Synergy Solutions

N

0 1,000 2,000 m

Scale at A3: 1:45,000

Bunya Creek Flood Study

1% AEP + Climate Change | Velocity

Legend

Velocity Depth Product (m2/s)

	<= 0.2
	0.2 - 0.4
	0.4 - 0.6
	0.6 - 0.8
	0.8 - 2.0
	> 2.0

Synergy Solutions

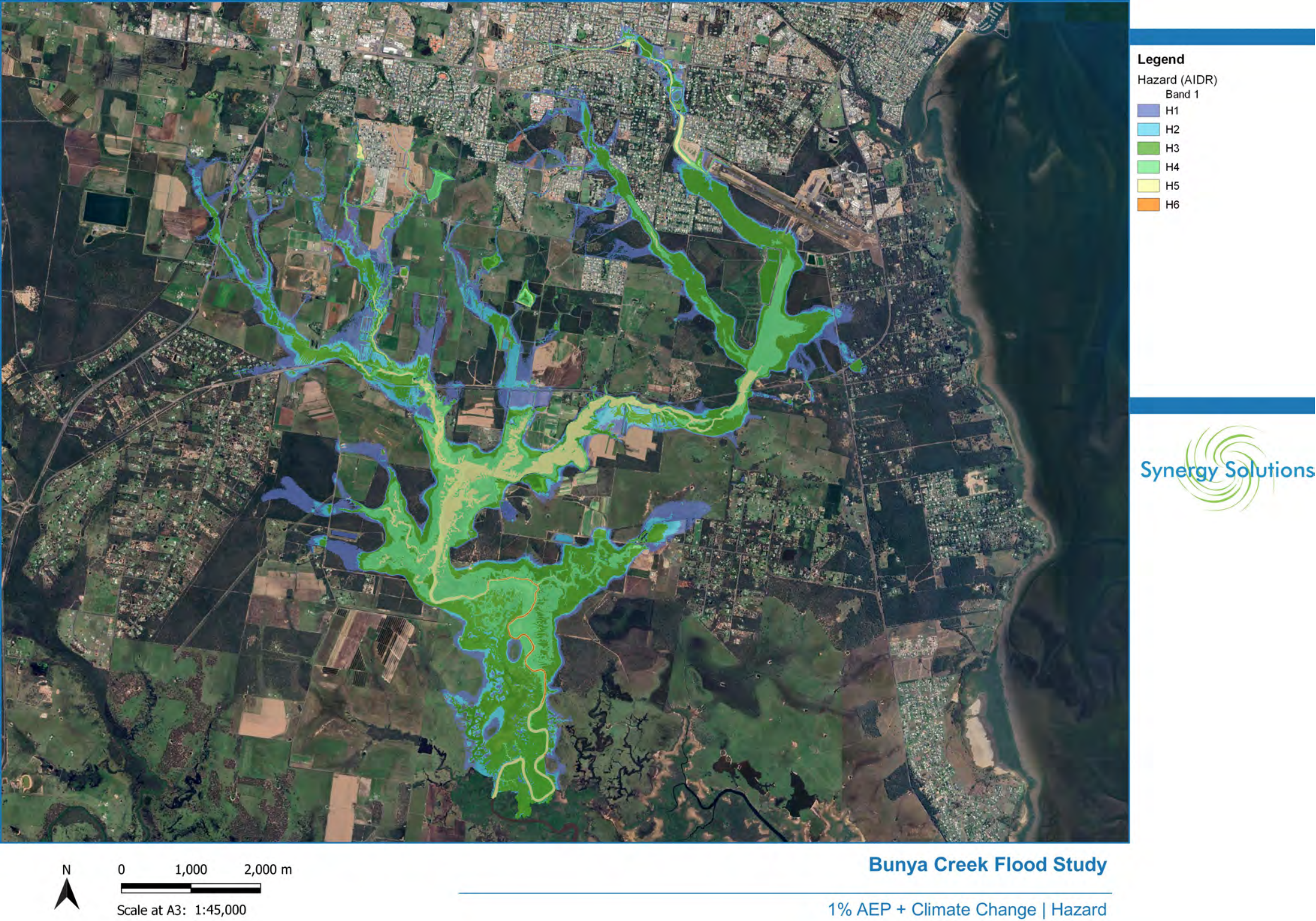
N

0 1,000 2,000 m

Scale at A3: 1:45,000

Bunya Creek Flood Study

1% AEP + Climate Change | Velocity Depth Product



Bunya Creek Flood Study

1% AEP + Climate Change | Hazard

Legend

Depth (m)

- <= 0.20
- 0.20 - 0.6
- 0.60 - 1.00
- 1.00- 1.50
- 1.50 - 2.00
- 2.00 - 3.00
- > 3.00

Synergy Solutions

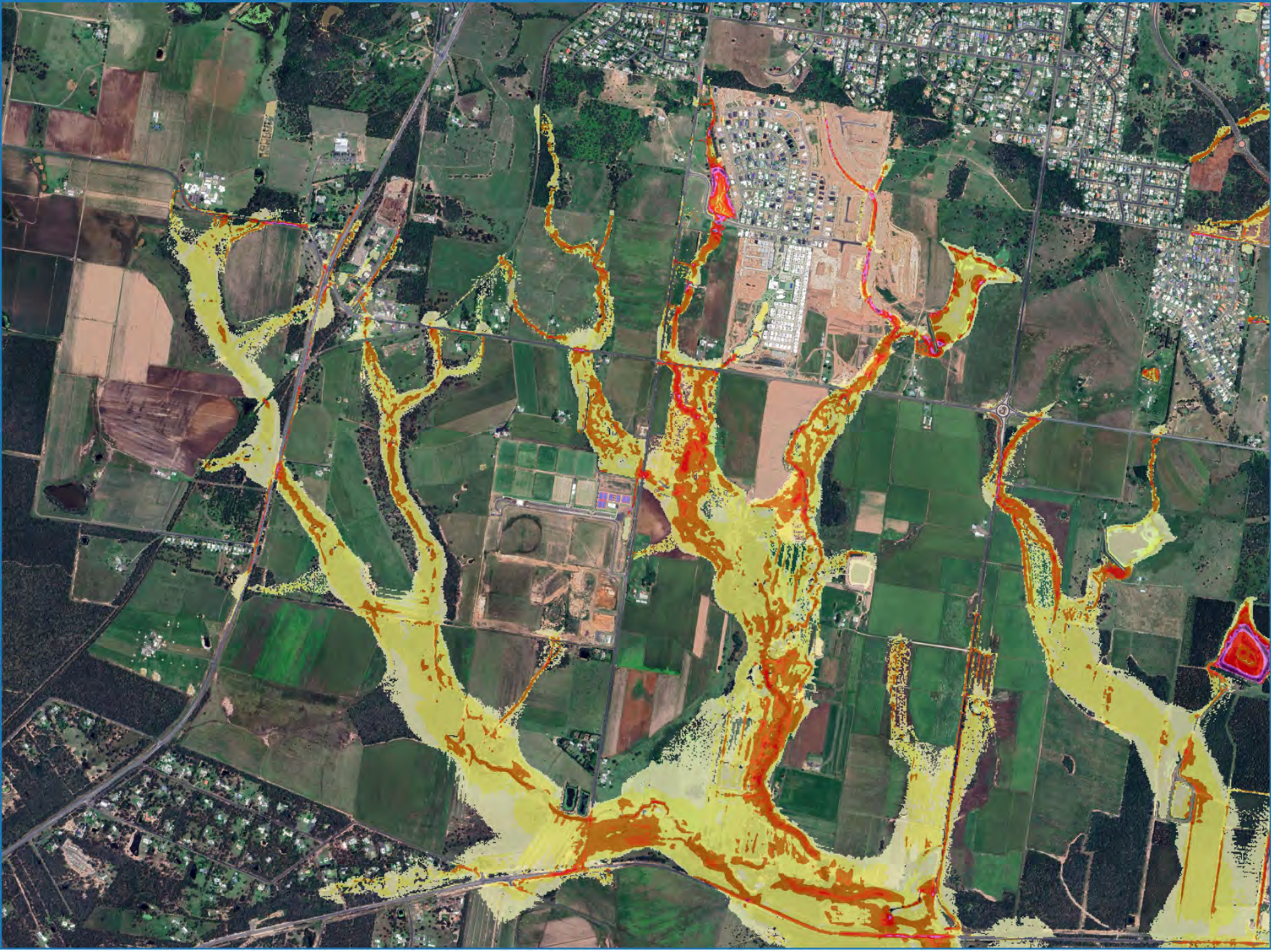
N

0 500 1,000 m

Scale at A3: 1:16,000

Bunya Creek Flood Study

1% AEP + Climate Change Inset | Depth



Legend

Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 -1.0
- 1.0-1.5
- 1.5 -2.0
- 2.0 - 2.5
- 2.5-3.0
- 3.0 - 3.5
- 3.5-4.0
- > 4.0

Synergy Solutions

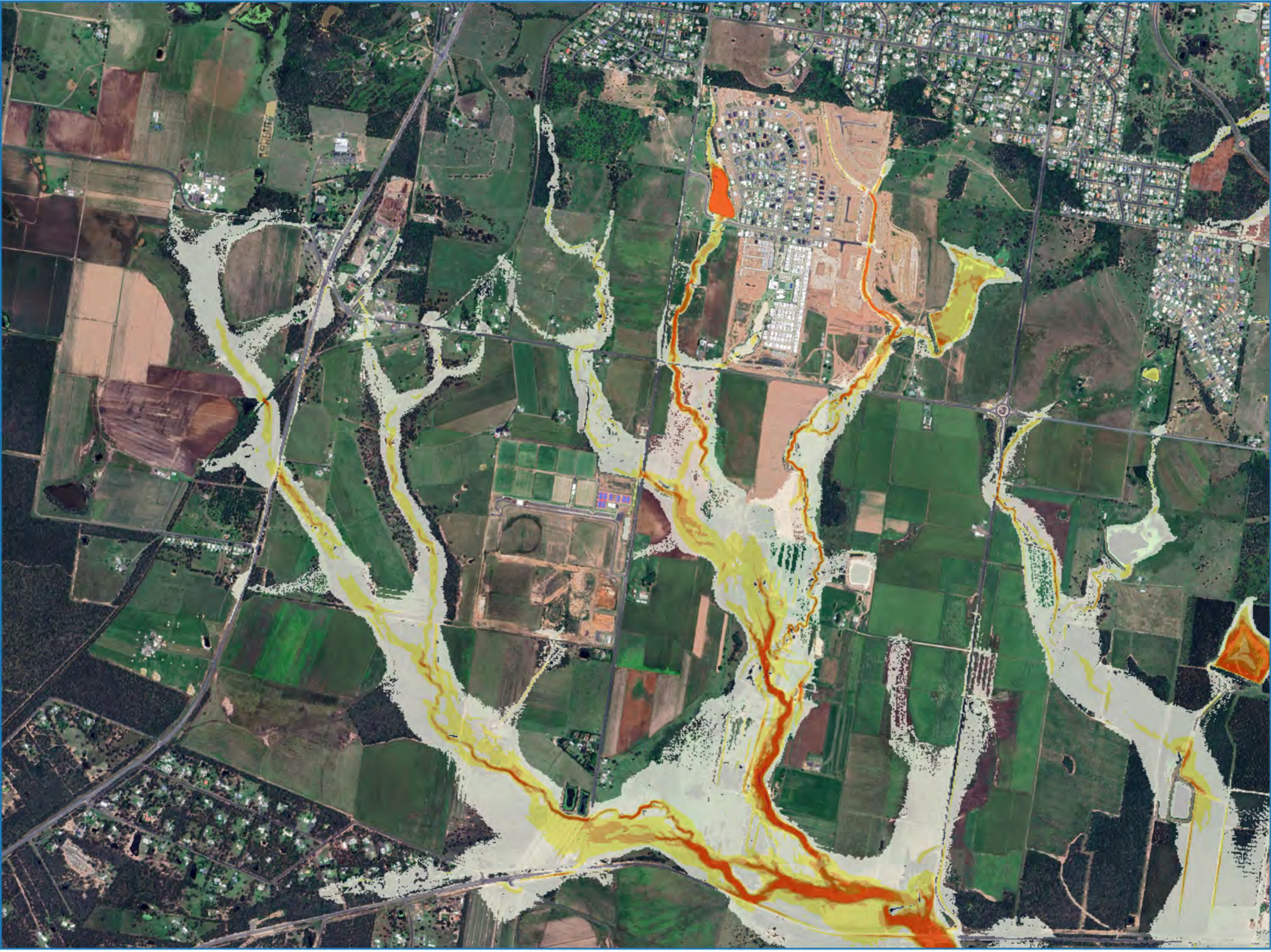
N

0 500 1,000 m

Scale at A3: 1:16,000

Bunya Creek Flood Study

1% AEP + Climate Change Inset | Velocity



Legend

Velocity Depth Product (m2/s)

- <= 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 2.0
- > 2.0

Synergy Solutions

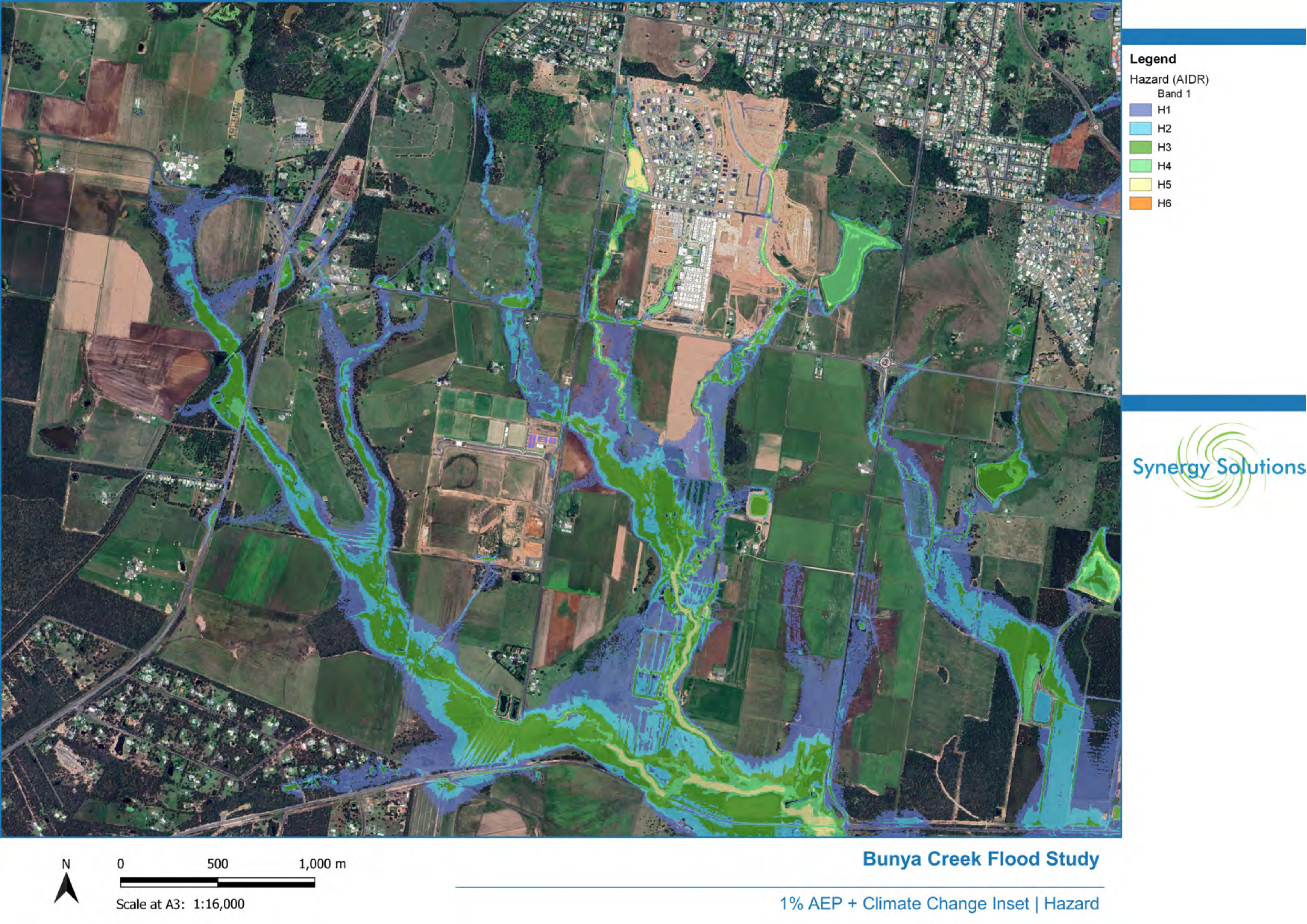
N

0 500 1,000 m

Scale at A3: 1:16,000

Bunya Creek Flood Study

1% AEP + Climate Change | Velocity Depth Product



Bunya Creek Flood Study

1% AEP + Climate Change Inset | Hazard

Bunya Creek Flood Study

0.2% AEP | Depth

Bunya Creek Flood Study

0.05% AEP | Depth

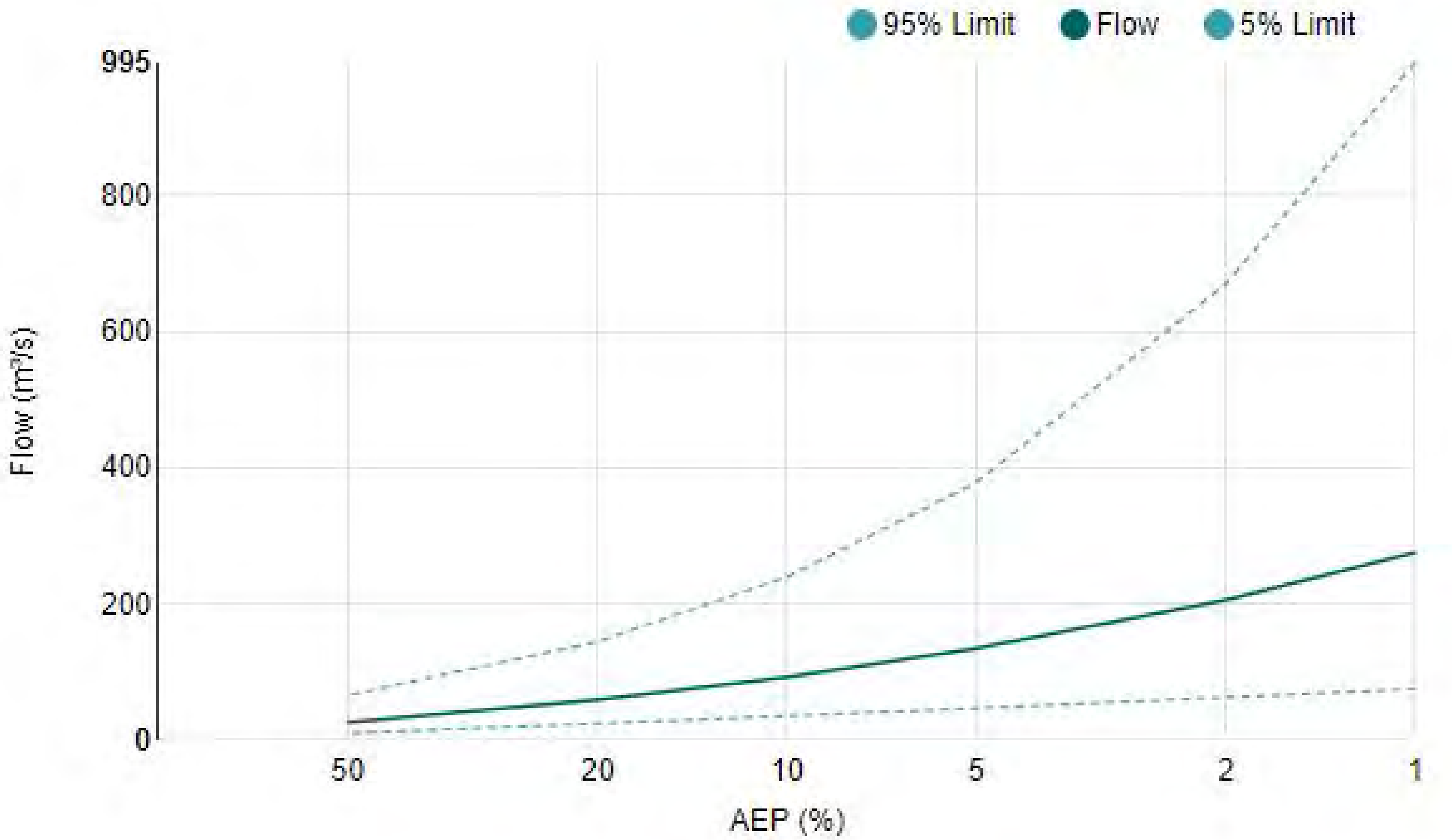
Synergy Solutions

Bunya Creek Flood Study

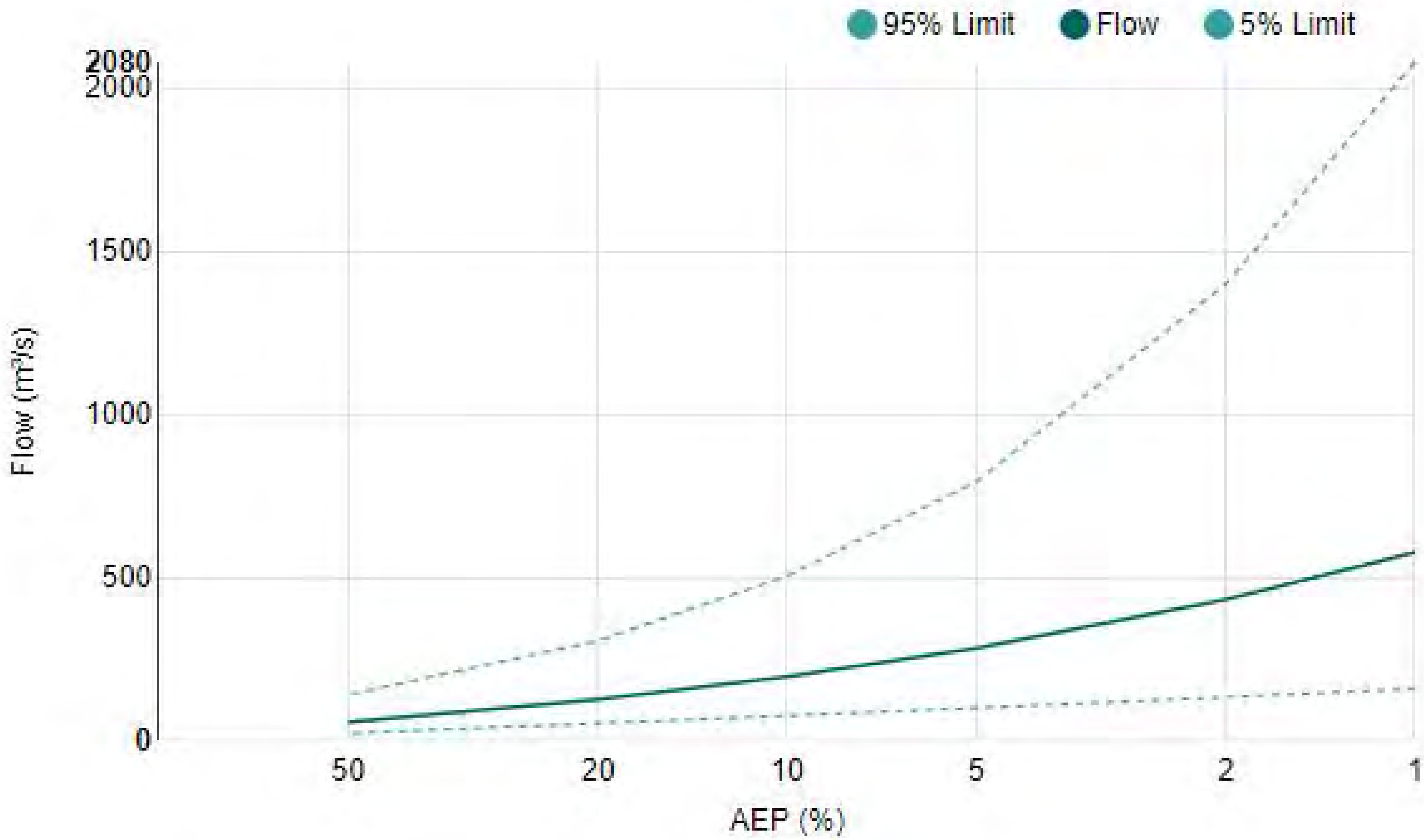
Probable Maximum Flood | Depth

19 Appendix D | RFFE Results

AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	26.4	10.5	66.1
20	59.6	24.7	145
10	92.7	36.0	240
5	135	47.3	378
2	206	63.2	670
1	276	75.6	995


95% Limit
Flow
5% Limit
995
800
600
400
200
0
Flow (m³/s)
50
20
10
5
2
1
AEP (%)

AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	55.6	22.1	140
20	125	52.0	305
10	195	75.5	504
5	282	99.1	793
2	432	132	1400
1	576	158	2080


95% Limit
Flow
5% Limit
2080
2000
1500
1000
500
0
Flow (m³/s)
50
20
10
5
2
1
AEP (%)