Picton Post Event Analysis

June 2016 Weather and Flood Event

25th November 2016

Level 17, 141 Walker St
North Sydney NSW 2060
Australia

rp301015-03199rg161125_June 2016 Post Event Analysis (Draft for Public Comment).docx

Revision C

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Picton Post Event Analysis – June 2016 Weather and Flood Event

Rev	Description	Author	Review	Advisian Approval	Date
A	Draft Report (*Issued for Internal Review*)	RG	WJH		25/10/2016
B	Draft Report (*Issued for Client Review*)	RG	WJH		31/10/2016
C	Draft Report (*Issued for Public Comment*)	RG	WJH		25/11/2016

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1 INTRODUCTION

During the first week of June 2016 an upper level trough developed over central and eastern Australia along with an accompanying low pressure surface trough. The system intensified on Friday 3rd June and moved across south-east Queensland bringing with it persistent rainfall and high winds.

Early on Sunday 5th June 2016, the system moved off the coast and developed into an East Coast Low causing heavy rain, strong winds and large waves along the NSW coast. The low pressure system brought widespread heavy rainfall to the northern coast and ranges, before the main rainfall focus shifted southwards to impact the south coast and ranges of NSW. Rain persisted through both Saturday and Sunday and many locations reported their wettest June on record in the first week of the month.

In the Sydney Basin, major flooding occurred in a number of catchments, particularly those that drain to the Georges River. Severe coastal erosion was reported in areas including Coogee and Collaroy. In the western areas of the Sydney Basin, major flooding occurred at Picton and Camden, with over 330 mm of rainfall observed during the event.

The major flooding that occurred in Picton resulted in damage to commercial and residential properties. Properties throughout the study area, including many along Argyle Street in the centre of town, experienced significant inundation with depths in excess of 1.5 metres recorded. A large number of trees and other in-bank vegetation were up-rooted during the flood event and conveyed downstream; a reflection of the significant volume and velocity of floodwaters along Stonequarry Creek and its tributaries.

In the aftermath of the event Council has collected High Water Mark (HWM) information for 76 locations throughout the floodplain. These anecdotal or visual records of the peak flood level is particularly useful for the purposes of validating computer models developed for predicting peak flood levels and flood behaviour.

Accordingly, Council has engaged Advisian (*a part of WorleyParsons*) to use the collected HWM information to validate Council's existing two-dimensional RMA-2 flood model. The RMA-2 model was last used to predict flood behaviour for the study area as documented in the '*Picton/Stonequarry Creek Flood Study*' (*WorleyParsons, August 2014*) which is currently in draft (*referred to as the Flood Study herein*).

This report has been prepared first and foremost to document the validation of the RMA-2 model to the June 2016 flood event. Validation of the XP-RAFTS hydrologic model and a review of available event specific data is also included.

Please note that this report is not intended as a standalone document and, as such, does not contain extensive detail regarding the background of the RMA-2 flood model, XP-RAFTS hydrologic model or history of flood modelling for Picton. Additional information is provided within the Flood Study and should therefore be read in conjunction with this report.

2 AVAILABLE DATA FOR THE JUNE 2016 EVENT

2.1 Assessment of Rainfall Data

Rainfall and river level data was obtained from the Bureau of Meteorology (*BOM*) and NSW Office of Water (*NOW*) for a number of gauges in the surrounding area. The nearest pluviometer to the site is located at the Stonequarry Creek river level gauge (*NOW Gauge No. 212053*). No other pluviometers are located within the Stonequarry Creek catchment, although Lake Nerrigorang (*NOW Gauge No. 212063*) and Thurns Road (*NOW Gauge No. 568296*), are close to the western and eastern catchment boundary, respectively.

One daily-read rainfall gauge is available in Picton at the Council Depot (*BOM Gauge No. 68052*). However, no readings were taken on Saturday 4th and Sunday 5th June and the reading for Monday 6th June includes the rain that fell on the two preceding days.

The gauges used in this assessment are:

- Picton Council Depot – *daily read gauge located approximately 500 m to the north-east*
- Stonequarry Creek – *pluviometer gauge located approximately 800 m to the south*
- Thurns Road TBRG – *pluviometer located approximately 4.5 km to the north-east*
- Nerrigorang at Thirlmere – *pluviometer located approximately 9 km to the south-west*
- Camden Airport AWS – *pluviometer located approximately 16 km to the north*
- Campbelltown (Mount Annan) – *pluviometer located approximately 20 km to the north-east*

The rainfall data has been compiled and is presented in **Plate 1**. The pluviograph data shows a consistent pattern of rainfall in the area. Rain began on the morning of Saturday 4th June and continued until about 20:00 on Sunday 5th June.

The total rainfall recorded at the daily-read gauge at Picton Council Depot appears low compared to the rainfall recorded for the corresponding period at surrounding gauges. There is potential that the gauge may have overflowed as it was not emptied in the two days prior. Therefore, it is possible that the total rainfall recorded at this location may be underestimated.

The gauge at Stonequarry Creek recorded the greatest depth of rainfall with 334 mm recorded over the duration of the event. Based on the BOM's Intensity-Frequency-Distribution (*IFD*) data, the rainfall exceeded a 100-year Average Recurrence Interval (*ARI*) event over 9 hours, which is the critical duration determined for the catchment.

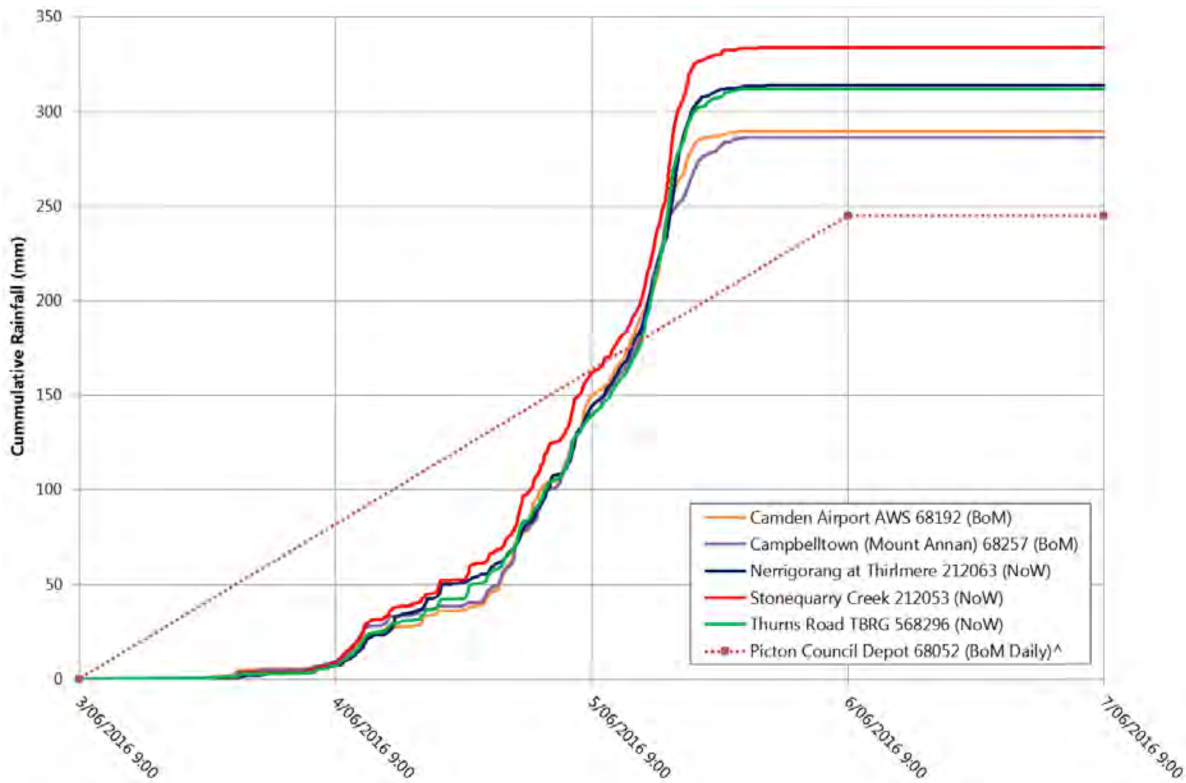


Plate 1: Cumulative Rainfall Data

^ *The gauge at Picton Council Depot is a daily read gauge usually recorded at 09:00 every morning. The gauge was not read on 4th and 5th June and the data for 6th June is accumulated over the 2 days prior. It is possible that the reading at this gauge is an underestimate of the actual total rainfall as it may have filled to capacity and overflowed.*

2.2 Assessment of Streamflow Data

The nearest river level gauge on Stonequarry Creek is located approximately 950 m downstream (*to the south*) of Argyle Street and a short distance upstream of the Railway Crossing. Recorded river level and flow data for this gauge was obtained from the NSW Office of Water. Rainfall data is also recorded at this gauge as discussed above.

River level and rainfall data for the June 2016 event as recorded by the Stonequarry Creek Gauge (*NOW Gauge No. 212053*) is presented in **Plate 2**.

The gauge data shows the creek began to respond at about 10:00 on 4th June with floodwaters rising relatively slowly for the first 15 hours. From the early hours of Sunday 5th June water levels in the creek began to rise more rapidly at about 0.3 m per hour. From around 14:00 on Sunday 5th June, as the rainfall intensified, water levels rose even more rapidly at a rate of 1.3 m/hr to the peak at 18:30. The gauge at Stonequarry Creek recorded a peak water level of 8.8 m. This equates to an elevation of about 156.6 mAHD.

The rainfall began to ease from around 19:00 and water levels dropped rapidly over the next 12 hours.

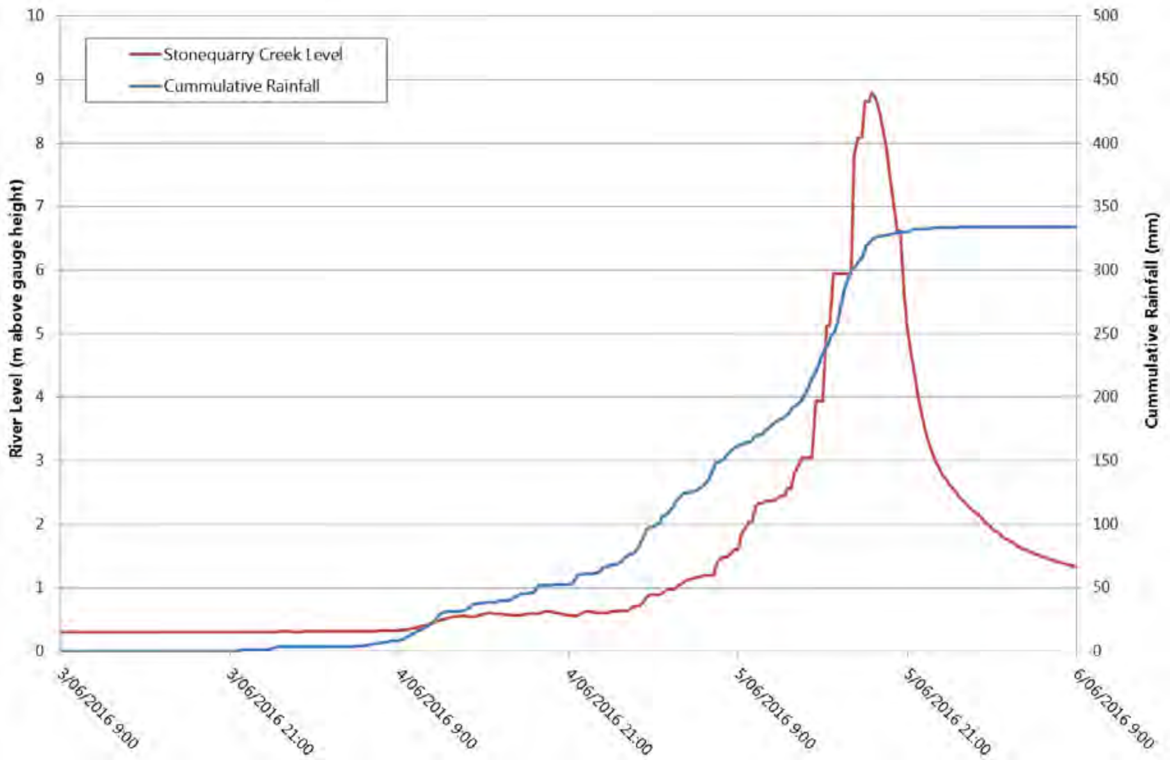


Plate 2: Recorded river levels and rainfall data at Stonequarry Creek gauge

A rating curve has been developed for the river level gauge by NOW to convert recorded levels into a discharge hydrograph. The discharge hydrograph for the June 2016 event was exported directly from the NOW website at 15 minute intervals. The rating curve indicates that flows along Stonequarry Creek had peaked at approximately 575 m^3/sec during the June 2016 event. A plot of recorded levels and corresponding flows is shown in **Plate 3** below.

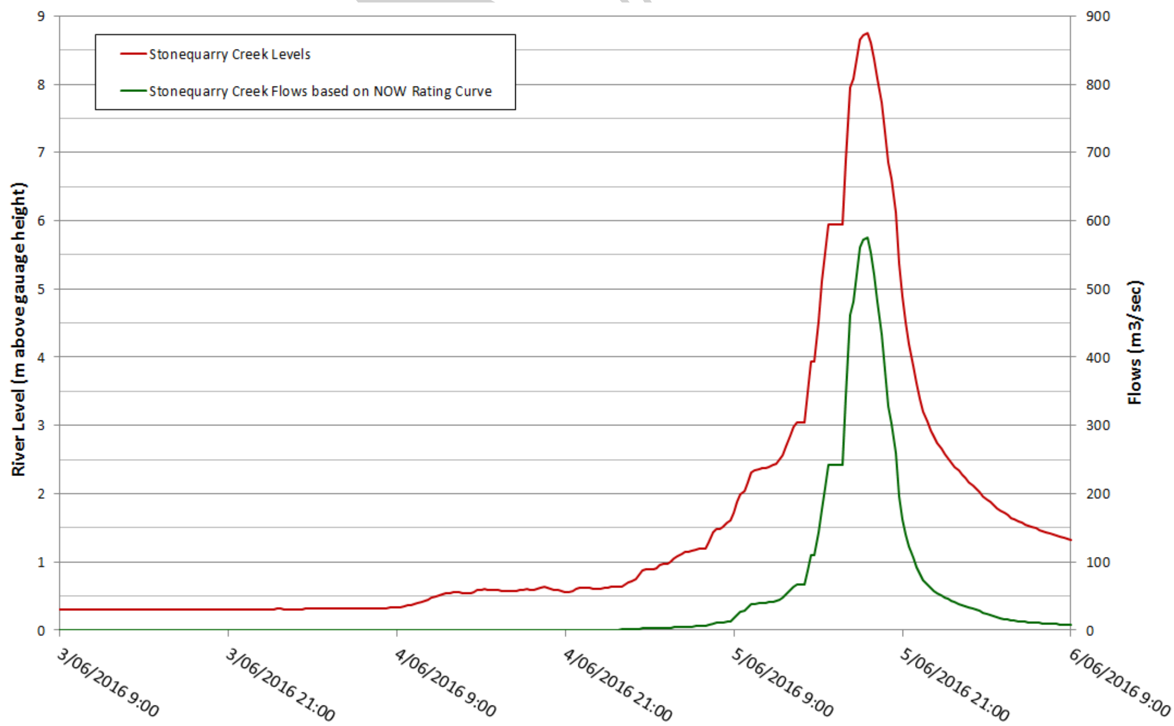


Plate 3: Recorded river levels and corresponding flows at Stonequarry Creek gauge

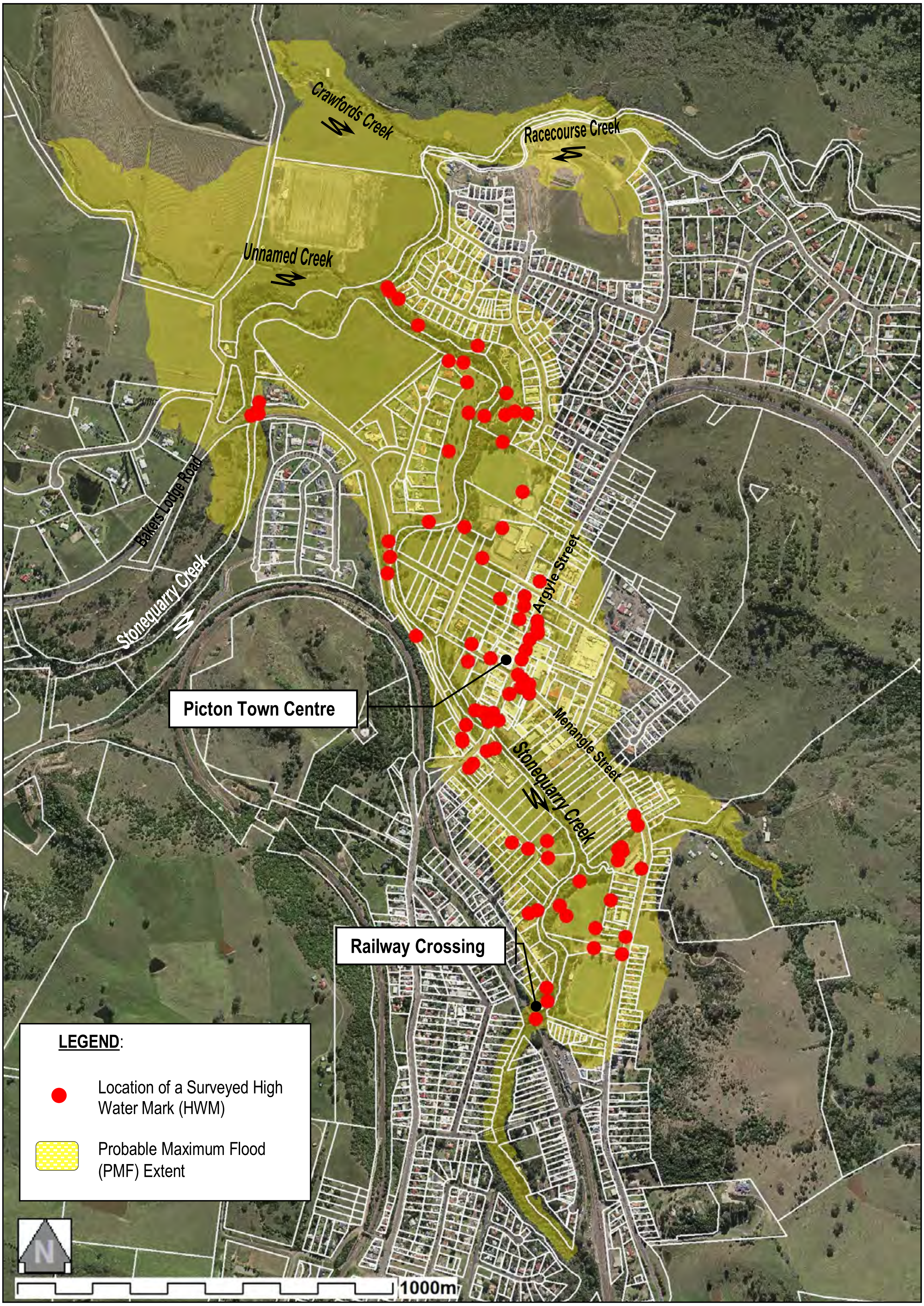
2.3 High Water Mark (*HWM*) Data

Following the June 2016 flood event Council officers were successful in collecting 76 HWMs throughout the study area. The majority of the collected HWMs were identified based on debris lines observed on fences, trees and buildings both externally and internally. Where possible the HWMs were surveyed to determine a peak flood elevation reduced to Australian Height Datum (*AHD*). This approach was adopted for approximately 30% of the HWMs.

A height above ground measurement was taken for the remaining HWMs. This height information was translated to an elevation in mAHD by adding it to a ground elevation determined by Advisian according to the available LiDAR data. This approach is less reliable than surveying (refer above) and is expected to provide a vertical accuracy of +/- 0.2 metres. Where HWM heights were measured within buildings, Council provided Advisian with a surveyed floor height on which to determine the appropriate HWM elevation.

The location of all HWMs are shown in **Figure 1**.

FIGURE 1



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301015-03199-Stonequarry Ck Flood Modelling
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LOCATION OF COLLECTED HIGH WATER MARKS (HWM) FOR THE JUNE 2016 EVENT

3 JUNE 2016 EVENT HYDROLOGIC AND HYDRAULIC MODELLING

The available rainfall, streamflow and HWM data described in **Section 2** provides an opportunity to validate the RMA-2 flood model to the June 2016 flood event. The opportunity to validate/calibrate the model was not available at the time the model was developed due to the absence of any sizeable floods in the study area since gauging commenced.

The following sections discuss the process and findings of the RMA-2 model validation. This includes discussion on the adopted inflow hydrographs, simulation parameters and differences between recorded and simulated flood levels.

3.1 XP-RAFTS Hydrologic Modelling

In order to validate the RMA-2 model a reliable estimate is required of the June 2016 inflow hydrographs. The Stonequarry Creek RMA-2 model requires inflow hydrographs to be specified for all of the upstream model boundaries located at Stonequarry Creek, Halfway Creek, Crawfords Creek and an unnamed creek.

Discharge hydrographs for the June 2016 event can be estimated for input to the RMA-2 model using the existing XP-RAFTS hydrologic model (*refer Flood Study for further discussion*) and the rainfall data discussed in **Section 2.1**. As there are multiple rainfall gauges within the catchment rainfall was applied to catchments based on their proximity to the guage. A figure showing the distribution of catchments relative to the applied rainfall data is shown in **Figure 2**.

As shown, only three of the rainfall gauges were adopted to represent the June 2016 rainfall event across the study area. This is based on the proximity of the gauges relative to the catchment and their spread across the centre and perimeters of the catchment. Analysis of the recorded rainfall for each of the adopted gauges also indicates that the recorded rainfall intensities (*mm/hr*) and total cumulative rainfall (*mm*) was similar for each. It is therefore unlikely that the modelling would be sensitive to any variation in the application of gauge data to the catchments (*refer* **Figure 2**).

Initial XP-RAFTS simulations of the June 2016 rainfall event were based without change on the XP-RAFTS model adopted for the Updated Flood Study. That is, all catchment and routing parameters such as roughness, slope and storage coefficients and the initial and continuing losses were left unchanged.

The flow hydrograph predicted by the base XP-RAFTS Flood Study model at the downstream limit of the model, which coincides with the Railway Crossing and the river level gauge (*NOW Gauge No. 212053*), is shown in **Plate 4**. The flow hydrograph determined by NOW is superimposed for comparison.

The base XP-RAFTS Flood Study model is shown to predict flows that are within 20 m^3/sec of the NOW gauge at the peak of the flood event. The timing of the peak flow is also close and within 60 minutes. The base XP-RAFTS Flood Study model does not align with the gauged hydrograph during the early stages of the event; i.e., during the rising limb of the flood. As shown in **Plate 4**,

FIGURE 2

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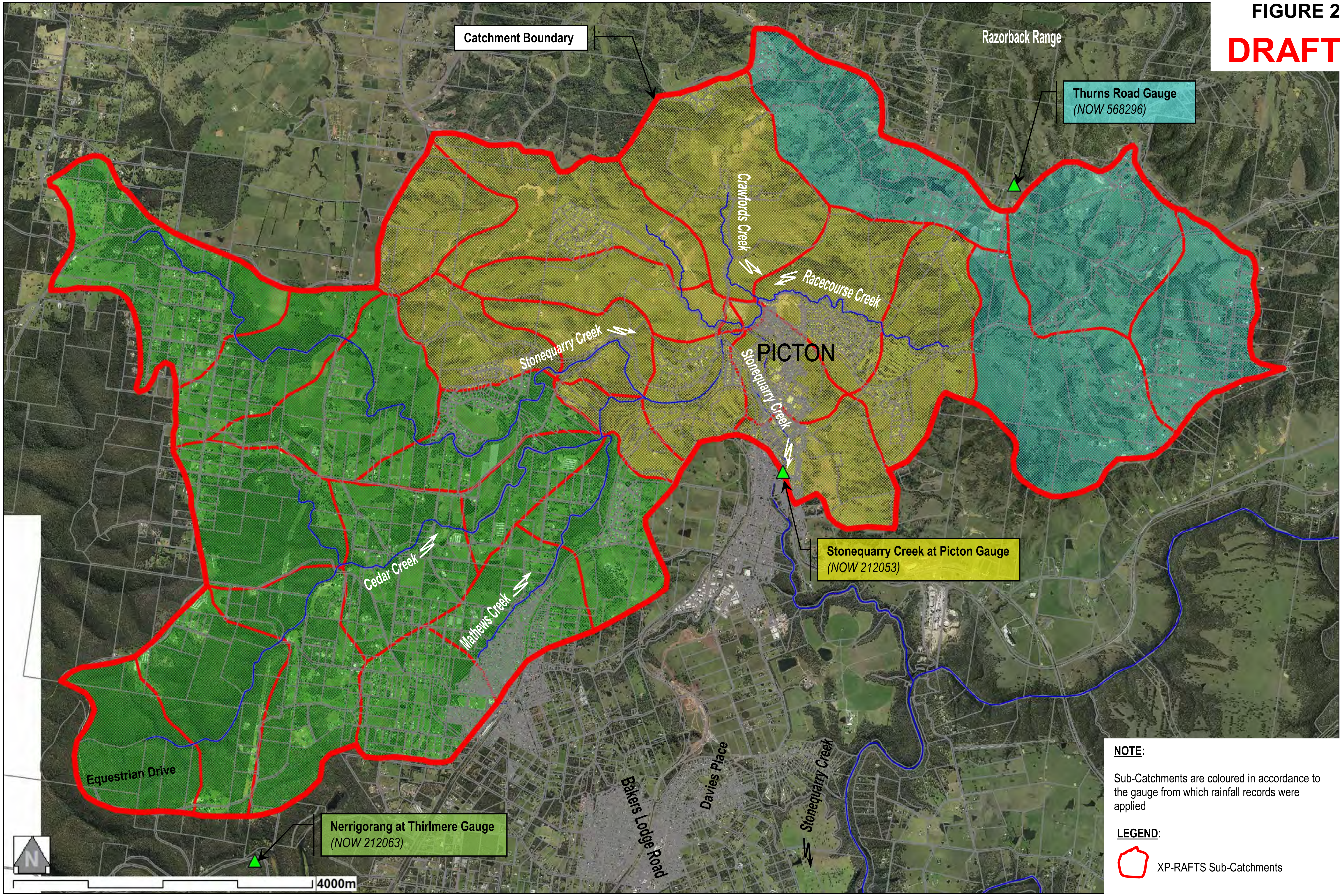

NOTE:

Sub-Catchments are coloured in accordance to the gauge from which rainfall records were applied

LEGEND:

XP-RAFTS Sub-Catchments

GAUGE RAINFALL RECORDS ADOPTED FOR EACH SUB-CATCHMENT

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301015-03199-Stonequarry Ck Flood Modelling
fg301015-03199rg161013_Fig2_Adopted Gauge to Catchment Breaup.doc

the base XP-RAFTS model predicts that flows would have risen along Stonequarry Creek much sooner and quicker indicating a faster response time for the catchment.

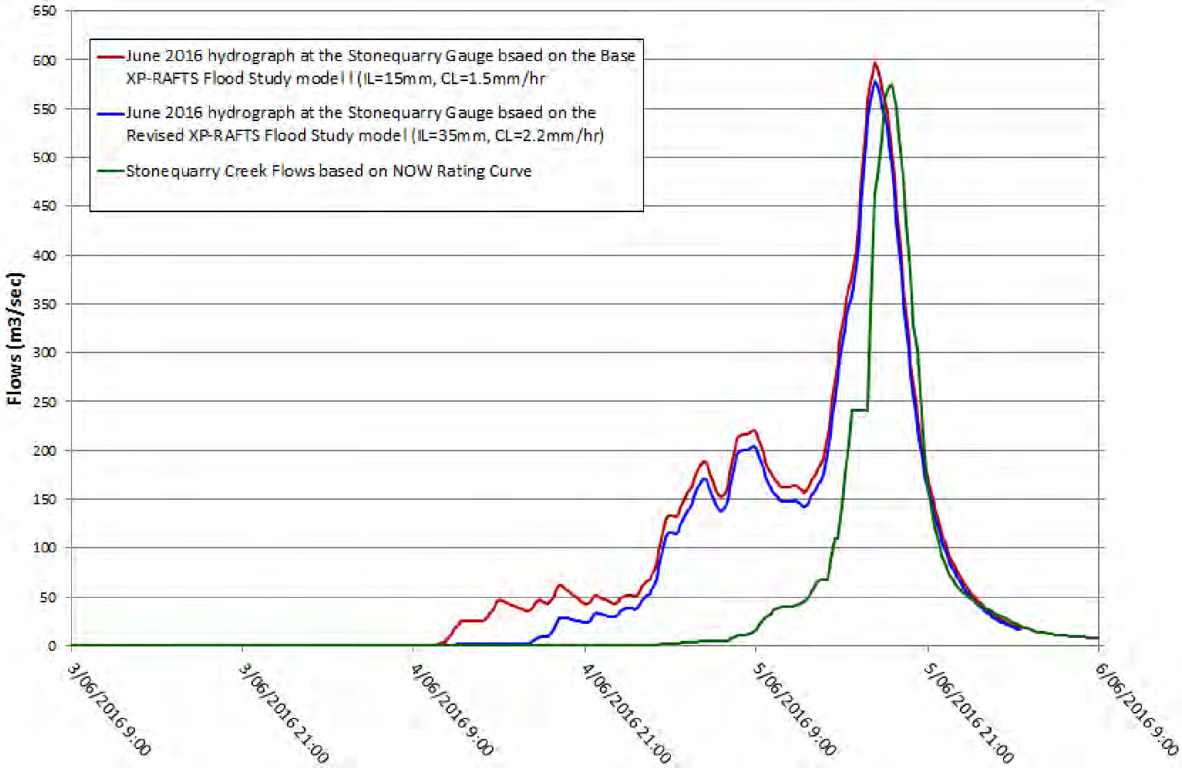

Plate 4: Comparison of XP-RAFTS hydrographs to the recorded/calculated flows at the Stonequarry Gauge

To try achieve a better '*fit*' between the simulated and recorded flows the model was tested with varying values of initial and continuing rainfall losses for pervious catchments. These parameters are most commonly adjusted between historic events to better reflect antecedent rainfall conditions; for example, the weeks or months may have been particularly dry or wet in the lead up to an event, which can be taken into consideration to achieve a better calibration.

Review of **Plate 4** suggests that the initial and continuing losses adopted in the base XP-RAFTS Flood Study model are likely to be low and not representative of the June 2016 event. Increasing the initial (*mm*) and continuing loss rates (*mm/hr*) would act to to slow the response time of the catchment whilst also reduce the peak flow rates.

The initial and continuing losses adopted for the base XP-RAFTS Flood Study model are 15 mm and 1.5 mm/hr, respectively. These values are considered on the lower-to-mid range of values for pervious catchments with loss parameters recommended to range between 0 to 35 mm and 1 to 4 mm/hr for initial and continuing losses, respectively. This range of loss values are recommended as '*typical*' values in Australian Rainfall & Runoff (*1987*).

Following a sensitivity assessment to test the impact of modified initial and continuing losses on the flow hydrograph at the Railway Viaduct the final values adopted were 35 mm and 2.2 mm/hr, respectively. These revised loss values provided a much closer match to the peak flow rate recorded at the Railway Viaduct. In that regard, the revised losses led to a predicted peak of 578 m^3/s compared to a recorded peak flow of 575 m^3/s.

The flow hydrograph determined using these revised parameters is superimposed on **Plate 4**.

The increased initial losses have acted to delay the rise in flows by approximately 8 hours. Although this has led to a closer match to the gauge, the rising limb of the two hydrographs are still not aligned, with the revised XP-RAFTS hydrograph still rising considerably sooner.

Although the simulated hydrograph could further be delayed by increasing the initial loss rates, sensitivity modelling showed initial losses would need to be increased to between 80 mm and 100 mm to achieve a reasonable match. This is considered to represent a very high estimate of initial losses which would be difficult to justify without detailed investigation. This suggests there may have been event-specific phenomenon unaccounted for, or potentially an error with the NOW Rating Curve for low gauge levels.

For the purposes of this assessment, the discrepancies between the simulated and calculated flows (NOW Rating Curve) during the initial stages of the flood were not further investigated. This discrepancy does not impact the predicted flows at the peak of the event and hence would not impact the RMA-2 model validation to peak flood level data, which is the main purpose of this investigation.

3.1.1 Discussion

An increase in the adopted initial and continuing losses (*beyond the base values adopted in the Flood Study*) is considered appropriate based on a review of rainfall records in the months leading up to the event. As shown in **Appendix A**, monthly rainfall records for the three gauges nearest to the catchment all recorded below average rainfall over a period of at least 6 months prior to the event. This lower than average rainfall would have resulted in particularly dry conditions, which would support adopting a higher than average initial and continuing loss rate.

Overall the XP-RAFTS model has been shown to predict a hydrograph shape (*with the exception of the initial stages of the flood*) and peak flow rate that is reflective of the recorded data at the Stonequarry Creek Gauge. This has been achieved by only modifying the initial and continuing loss values for pervious catchments, which is typical for event-specific modelling.

3.2 RMA-2 Hydrodynamic Modelling

3.2.1 Model Set-Up

Upstream Boundary Conditions

The upstream boundary conditions for the RMA-2 model are based on inflow hydrographs extracted from the XP-RAFTS hydrologic model (*discussed in* **Section 3.1**). In that regard, flow hydrographs were extracted from the revised XP-RAFTS model simulation of the June 2016 event at the following locations:

- Stonequarry Creek – 300 metres upstream of Bakers Lodge Road,
- Racecourse Creek – 850 metres upstream of Confluence with Crawfords Creek,
- Crawfords Creek – 550 metres upstream of Confluence with Racecourse Creek, and
- Unnamed Creek – 850 metres upstream of Evelyn Bridge Crossing.

The inflow hydrograph for the June 2016 event at each model boundary location are shown in **Plate 5**.

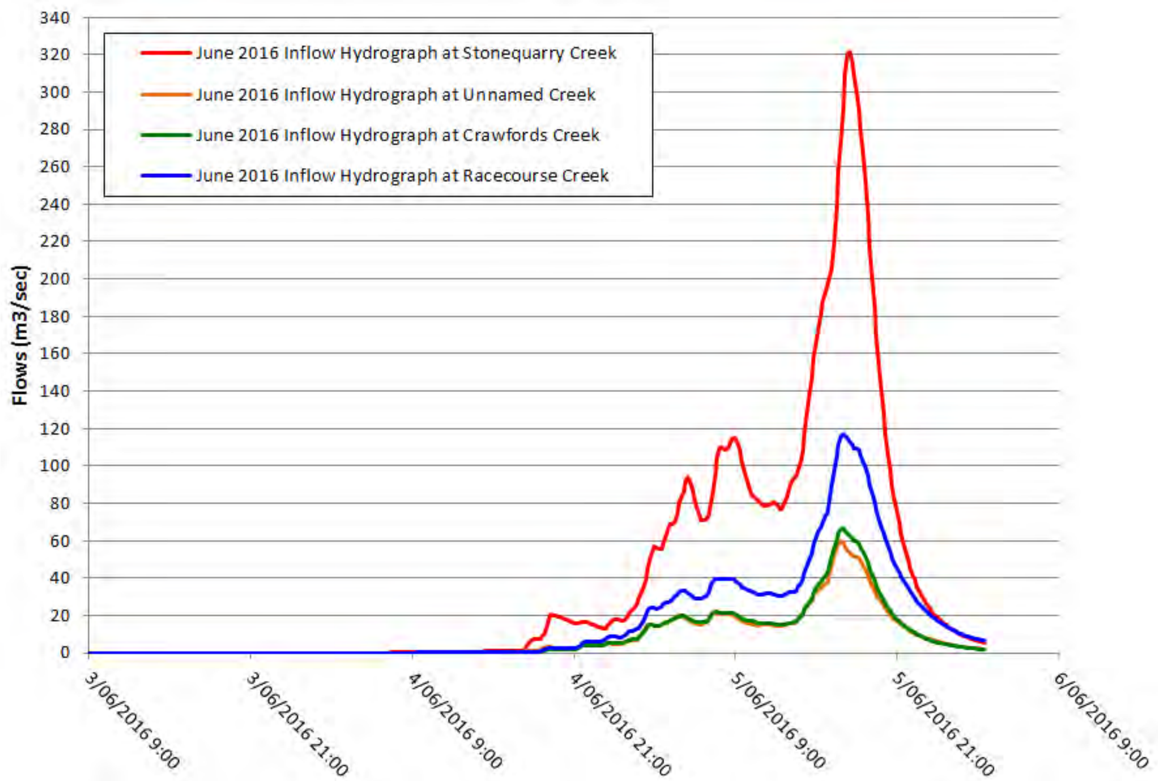

Plate 5: Adopted RMA-2 Inflow Hydrographs for the June 2016 Event

Downstream Boundary Condition

The downstream boundary condition for the RMA-2 model is based on a stage-discharge relationship determined using a 'normal depth' analysis (*refer to the Flood Study for further information*). The stage-discharge boundary allows water levels at the boundary to be updated within the model as the simulation progresses and flows are increased or decreased.

This boundary condition is appropriate for use in simulating the June 2016 event and therefore was not changed.

Model Network and Material Roughness

No changes were made to the RMA-2 model network or material roughness values and distribution as part of the June 2016 event validation. In that regard, similarly to simulations for all design events documented in the *Flood Study*, all buildings (*residential and commercial*) were completely 'blocked-out' of the model to simulate the significant obstructions they impose to floodwaters.

By not changing the material roughness values and distribution this exercise is more reflective of a model validation, rather than a recalibration.

3.2.2 Comparison of Simulated and Recorded HWMs

The Flood Study RMA-2 model was simulated with the boundary conditions discussed in **Section 3.2.1** and the inflow hydrographs shown in **Plate 5**. In order to validate the model the predicted flood level at the location of each HWM was extracted and recorded. This flood level was subsequently compared to the flood level recorded at the HWM and the difference noted.

The findings of this comparison are shown in **Figure 3**, **Figure 4** and **Figure 5**. The figures show the locations of each HWM and the calculated difference between modelled and recorded June 2016 flood levels.

Differences are shown to generally range between -0.05 to -0.20 metres, with the exception of scattered outliers. Closer investigation of the outliers shows that in most cases there is an inconsistency in the recorded HWMs with those upstream or downstream. Other differences appear to be influenced by localised hydraulic effects, such as a loss of hydraulic efficiency due to debris build-up along fences or along the upstream side of bridges. These local and event specific occurrences are difficult to capture in hydraulic modelling unless event specific models and modelling parameters are adopted.

A statistical analysis of the flood level differences indicates that the RMA-2 model predicts flood levels to within an average of 0.18 metres and median of 0.145 metres when compared to all of the 76 recorded HWMs. This statistical analysis is broken-down further in **Table 1**, providing the mean and median difference based on the HWMs included in each figure. This break-down analysis is beneficial as it loosely represents the model accuracy for the upper (upstream of the town), middle (*Picton Town Centre*) and lower (*downstream of the town*) model reaches.

Table 1 Findings of RMA-2 Model Validation

	Figure 3 *Upstream Town*	**Figure 4** *Town Centre*	**Figure 5** *Downstream Town*	**All HWMs**
Number of HWMs	17	38	21	76
Mean Difference (m)	- 0.21	- 0.17	- 0.18	- 0.18
Median Difference (m)	- 0.19	- 0.15	- 0.13	- 0.145

Table 1 indicates that the simulated and recorded flood level differences are largely uniform throughout the study area with the calculated mean and median differences only changing marginally between figures. A mean difference of less than 0.2 metres for all figures is considered to represent a favourable validation. This indicates that the RMA-2 model is in good agreement with the HWM data and shows that the RMA-2 model can be a reliable tool for the estimation of flood behaviour across the study area.

The mean and median differences shown in **Table 1** indicate a consistent trend that suggests the RMA-2 model may be under-predicting flood levels by between 0.13 to 0.21 metres. This result was unexpected given there has been concern that the RMA-2 model is over-predicting flood levels across the study area. This concern is based on a comparison documented in the

FIGURE 3

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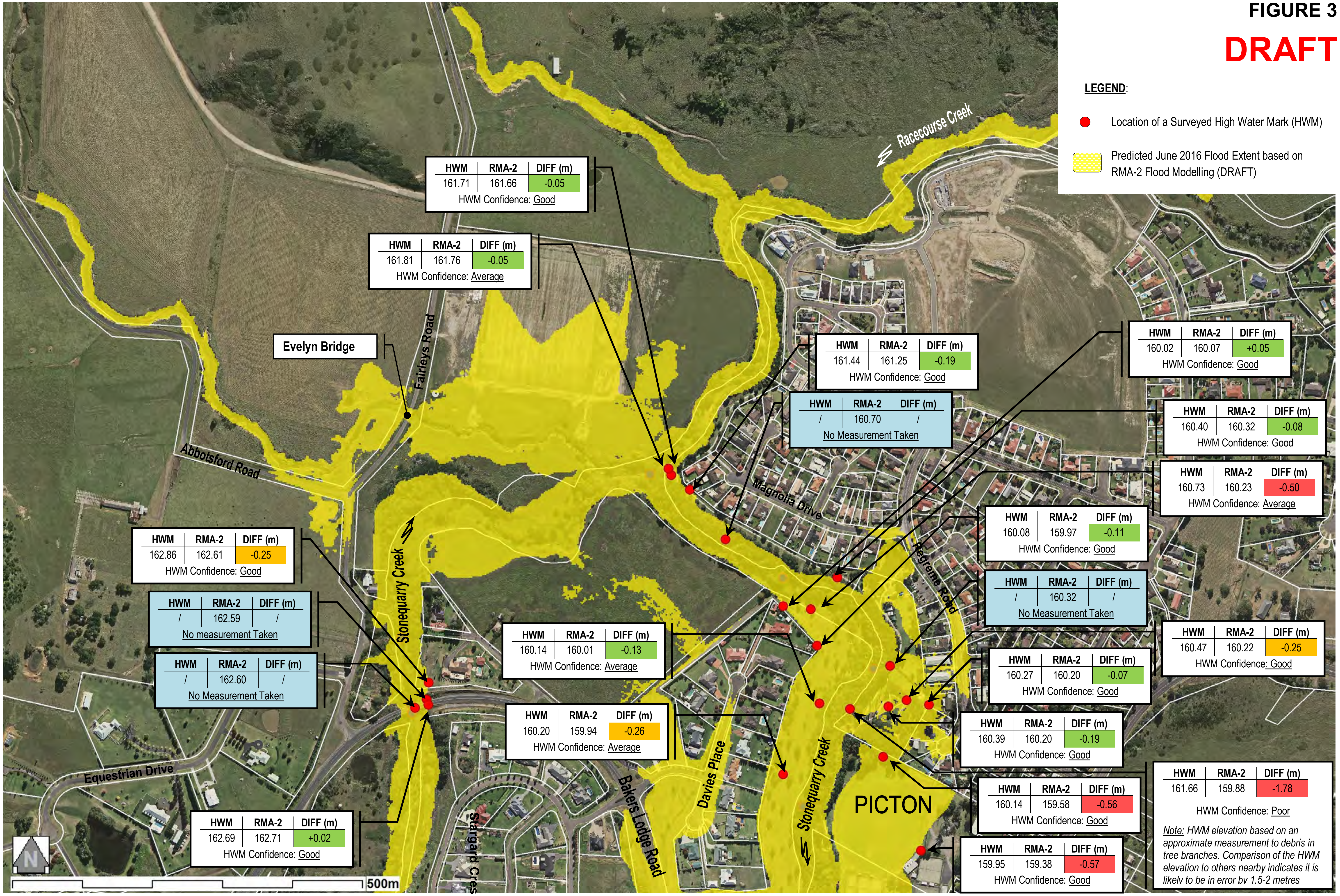

Note: Shading representative of magnitude of WL difference between observed and modelled flood levels.
Green = 0 – 200 mm difference, Orange = 200 – 400 mm difference, Red = 400+ mm

COMPARISON OF RMA-2 MODELLED LEVELS FOR THE ‘JUNE 2016’ FLOOD EVENT FLOOD TO SURVEYED HWMs

[EXTENT 1 OF 3]

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301015-03199-Stonequarry Ck Flood Modelling
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FIGURE 4

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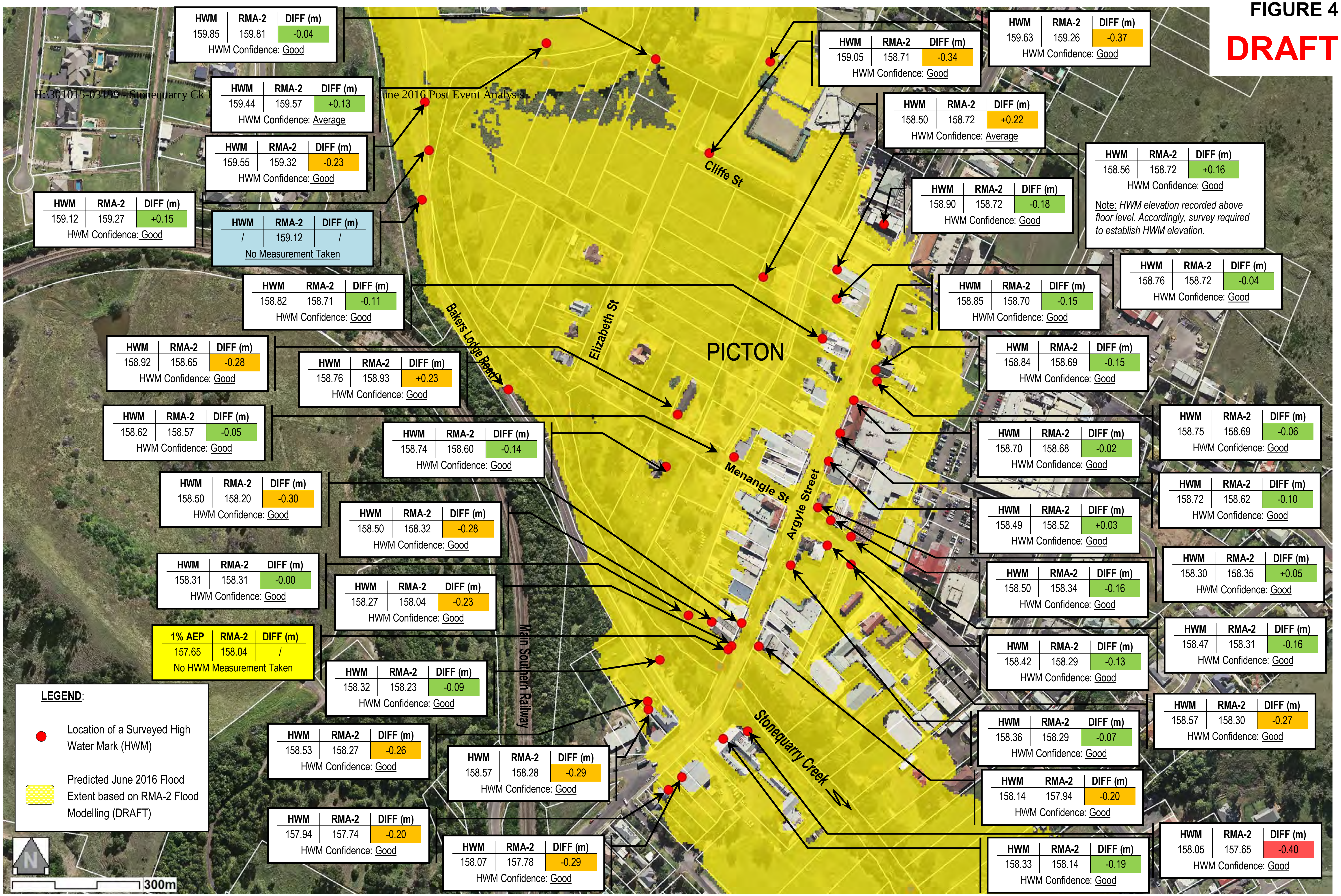

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Note: Shading representative of magnitude of WL difference between observed and modelled flood levels.
Green = 0 – 200 mm difference, Orange = 200 – 400 mm difference, Red = 400+ mm

COMPARISON OF RMA-2 MODELLED LEVELS FOR THE 'JUNE 2016' FLOOD EVENT FLOOD TO SURVEYED HWMs
[EXTENT 2 OF 3]

FIGURE 5

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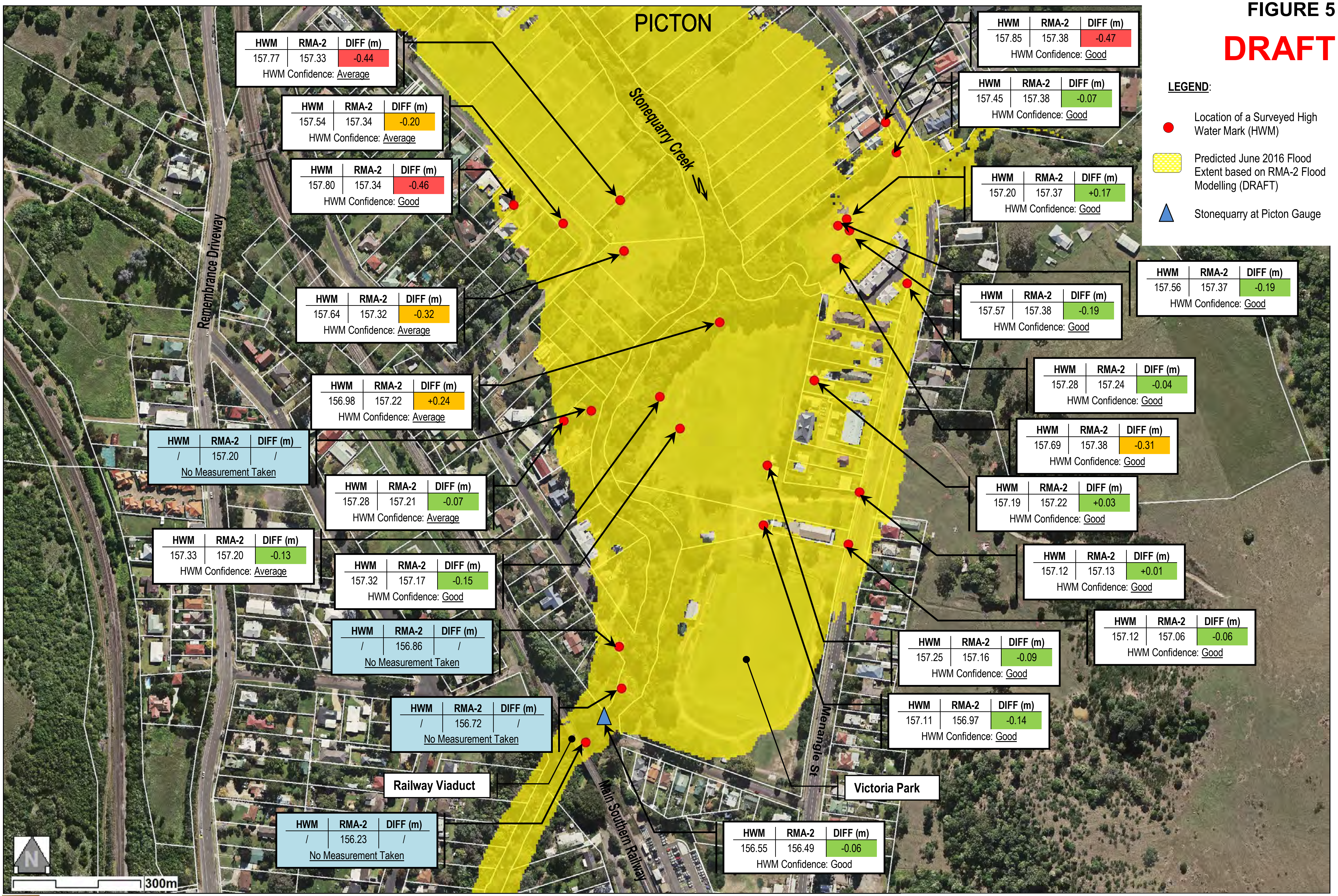

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Note: Shading representative of magnitude of WL difference between observed and modelled flood levels.
Green = 0 – 200 mm difference, Orange = 200 – 400 mm difference, Red = 400+ mm

COMPARISON OF RMA-2 MODELLED LEVELS FOR THE 'JUNE 2016' FLOOD EVENT FLOOD TO SURVEYED HWMs

[EXTENT 3 OF 3]

301015-03199-Stonequarry Ck Flood Modelling
fg301015-03199rg130417_Fig2_Predicted Flood levels (100yr_North).doc

Flood Study which shows that RMA-2 levels for the 1% Annual Exceedance Probability (*AEP*) flood were consistently higher than the HEC-RAS modelling that it is proposed to supersede.

3.2.3 Comparison to the 1% AEP Flood

Peak flood levels modelled for the June 2016 event were compared to the peak 1% AEP flood levels documented in the Flood Study (*2014*). This comparison involved preparation of flood level difference mapping to allow a graphical comparison of peak flood levels at each location within the study area.

Figure 6 to **Figure 8** shows the flood level difference mapping. The varying shades of red mapping indicates locations where the June 2016 flood event is predicted to be higher than the 1% AEP flood. The darker shades of red represent locations where differences are higher in magnitude.

As shown in **Figure 6** to **Figure 8**, flood levels for the June 2016 flood event are predicted to be between 0.02 to 0.22 metres higher across the study area than those predicted for the 1% AEP event (*as documented in the Flood Study*). The difference between June 2016 and 1% AEP flood levels can further be broken-down into the following:

- 0.02 to 0.07 metres higher for areas upstream of the Town (*refer* **Figure 6**),
- 0.07 to 0.16 metres higher for areas around the Town Centre (*refer* **Figure 7**), and
- 0.160 to 0.22 metres higher for areas downstream of the Town (*refer* **Figure 8**).

The difference in flood levels is generally highest downstream of the Town where floodwaters are constricted by the Railway Crossing and gorge (*refer* **Figure 6** *to* **Figure 8**).

FIGURE 6

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LEGEND:

Areas predicted to flood during the June 2016 event and not predicted to flood during the 1% AEP event

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301015-03199-Stonequarry Ck Flood Modelling
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COMPARISON OF RMA-2 MODELLED LEVELS FOR THE 'JUNE 2016' FLOOD EVENT AND THE 1% AEP FLOOD
[June 2016 less 1% AEP - Extent 1 of 3]

FIGURE 7

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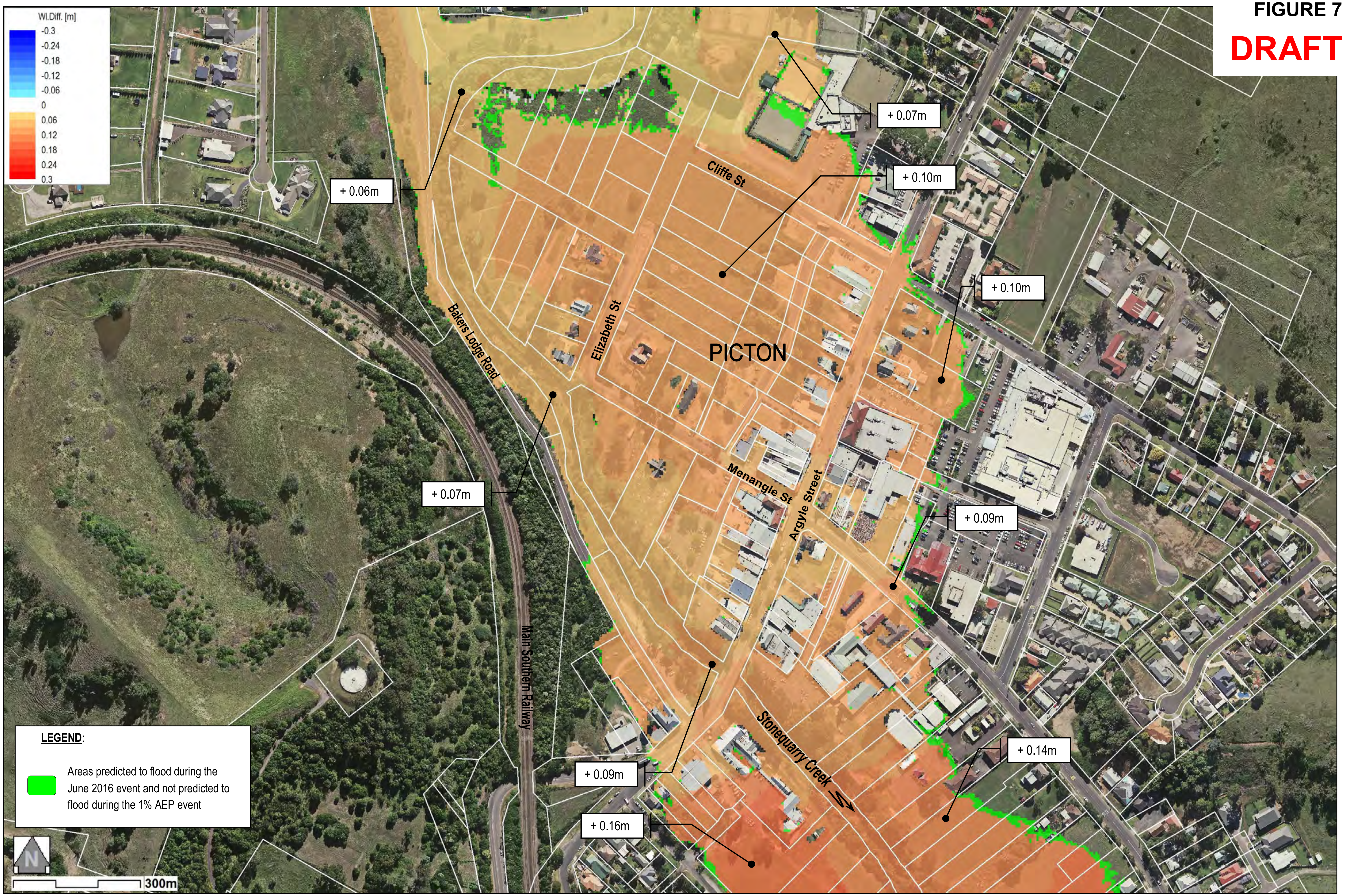

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COMPARISON OF RMA-2 MODELLED LEVELS FOR THE 'JUNE 2016' FLOOD EVENT AND THE 1% AEP FLOOD
[June 2016 less 1% AEP - Extent 2 of 3]

FIGURE 8

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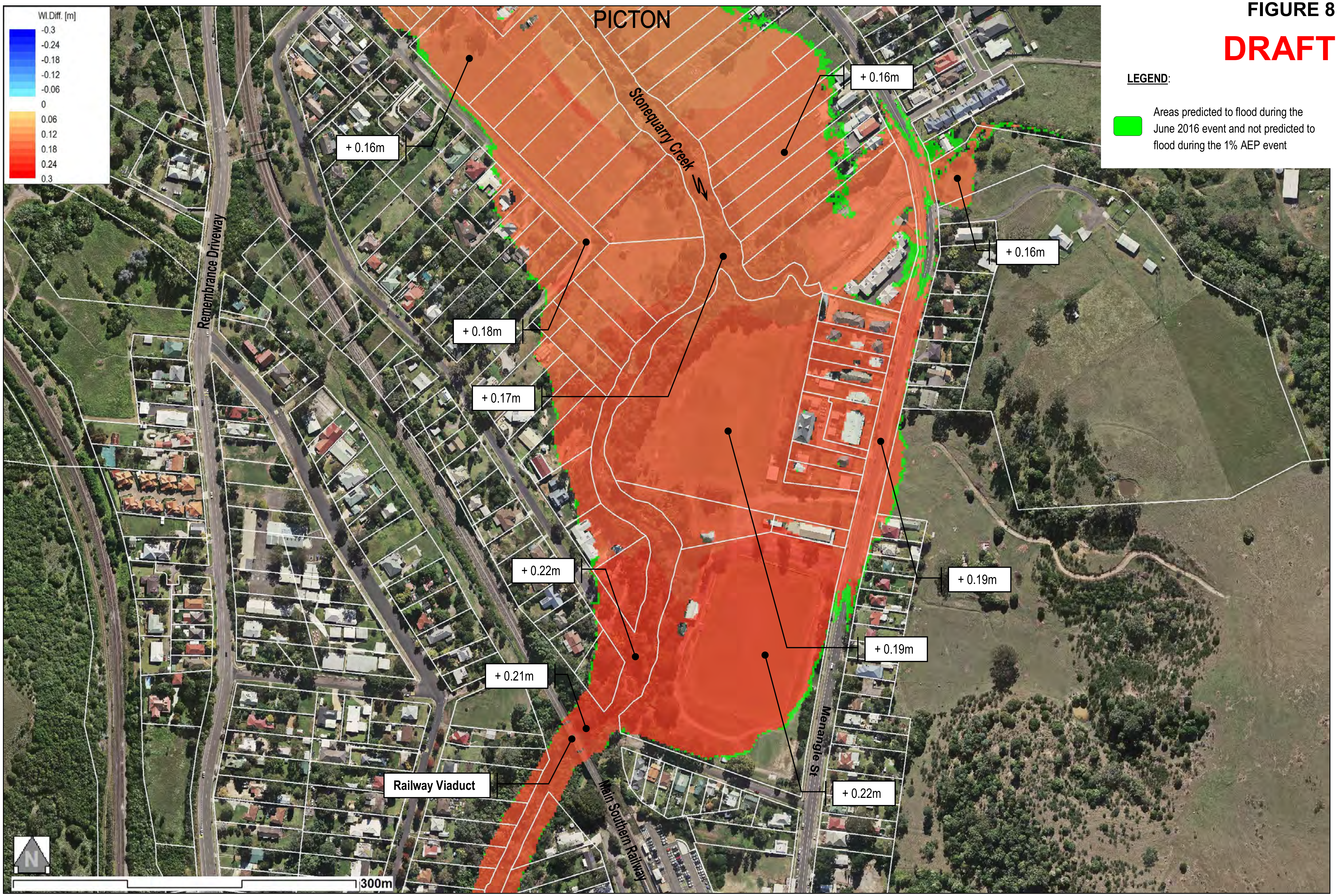
LEGEND:

Areas predicted to flood during the June 2016 event and not predicted to flood during the 1% AEP event



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301015-03199-Stonequarry Ck Flood Modelling
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COMPARISON OF RMA-2 MODELLED LEVELS FOR THE 'JUNE 2016' FLOOD EVENT AND THE 1% AEP FLOOD
[June 2016 less 1% AEP - Extent 3 of 3]

4 CONCLUSIONS

The post event analysis for the June 2016 weather event at Picton has determined that the recorded rainfall exceeded the amount predicted for a 1% Annual Exceedance Probability (*AEP*) event. In that regard, rainfall records at the three nearest rainfall gauges all exceeded the rainfall depths required for a 1% AEP event over the critical catchment duration of 9 hours.

Hydrologic modelling and hydrodynamic modelling using the existing XP-RAFTS and RMA-2 models, respectively, has also supported the above findings. In that regard, the RMA-2 model predicts flood levels for the June 2016 event that are between 0.02 to 0.22 metres higher than those predicted for the 1% AEP event (*as documented in the Flood Study*).

The validation completed for the XP-RAFTS hydrologic model and RMA-2 hydrodynamic model has drawn the following conclusions:

- The existing XP-RAFTS model was used to simulated the June 2016 event and match the peak flow recorded at the Stonequarry Gauge with only minor modifications required to initial and continuing losses.
- The hydrograph shape predicted by XP-RAFTS during the rising limb of the flood does not align with recorded data. Sensitivity analysis indicates initial rainfall losses would need to be increased to between 80 to 100 mm to achieve a good fit. This range of values is considered high but not unreasonable given the dry catchment conditions that preceded the event in June (*refer* **Appendix A**).
- The RMA-2 model predicted flood levels for the June 2016 event that were on average 0.18 metres lower than the peak flood level recorded at all 76 High Water Marks (HWM); refer **Figure 3** to **Figure 5**.
- The June 2016 validation exercise is considered to provide an acceptable agreement between flood levels simulated using RMA-2 to the recorded HWM levels.

5 REFERENCES

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- Wollondilly Shire Council (*2014*), '*Picton/Stonequarry Creek Flood Study*' (*Issue 1 - Draft*); prepared by WorleyParsons.

Appendix A:
Rainfall Records for Preceding Months

Daily Rainfall (millimetres)

PICTON COUNCIL DEPOT

Station Number: 068052 · State: NSW · Opened: 1880 · Status: Open · Latitude: 34.17°S · Longitude: 150.61°E · Elevation: 165 m

2016	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st	*0*	*0*	*0*	*0*	*0*	*1.2*	*0*	*0*	*0*			
2nd	*0*	*1.2*	*0*	↓	*0*	*1.2*	*0*	*0*	*3.4*			
3rd	*0*	*0*	*0*	↓	*2.0*	*0*	*0*	*17.0*	↓			
4th	*0.6*	*3.0*	*0*	*0.2*	*0*	↓	*0*	*0.2*	↓			
5th	*47.6*	*0*	*0*	*0*	*0*	↓	*1.2*	*1.6*	*25.2*			
6th	*16.8*	↓	*0*	*0*	↓	*245.0*	*3.2*	↓	*0*			
7th	*5.6*	↓	*0*	*0*	↓	*0*	*0.4*	↓	*0*			
8th	*0.2*	*0.4*	*0*	*0*	↓	*0*	*2.0*	*1.0*	*0*			
9th	*0*	*0*	*0.2*	*0*	↓	*0.4*	↓	*0.2*	*0*			
10th	*0*	*0*	*0*	*0*	*13.6*	*0*	↓	*0*	↓			
11th	*0*	*0*	*0*	*0*	*0*	*0*	*6.4*	*0*	↓			
12th	*0*	*0*	*0*	*1.8*	*0*	*0*	*0*	*0*	*2.6*			
13th	*0*	*0*	*0*	*0*	*0*	*0*	*0.6*	*0*	*0*			
14th	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*				
15th	*32.0*	*0*	*7.0*	*0*	*0*	*0*	*0*	*0*				
16th	*0*	*0*	*0*	↓	*0*	*0*	↓	*0*				
17th	*0*	*0*	*2.0*	↓	*0*	*0*	↓	*0*				
18th	*0*	*0*	*0*	*2.0*	*0*	↓	*2.0*	*0*				
19th	*0*	*0*	↓	*2.5*	*0*	↓	*0*	*0*				
20th	*0*	↓	↓	*0*	*0*	*30.0*	*7.0*	↓				
21st	*0*	↓	*2.6*	*0*	*0*	*0.2*	*15.2*	↓				
22nd	↓	*6.4*	*0*	*0*	*0*	*0*	*1.0*	*1.2*				
23rd	↓	*0*	*0*	*0*	*0*	*0*	↓	*2.8*				
24th	*37.0*	*0*	*0*	↓	*0*	*0*	↓	*0.2*				
25th	*0*	*0*	*0*	↓	*0*	↓	*11.6*	*24.2*				
26th	↓	*0*	*0*	*2.0*	*0.2*	↓	*0*	*0.2*				
27th	*11.6*	*0*	*0*	*0.2*	*0*	*0.6*	*0*	*0*				
28th	*7.2*	*0*	*0*	*0*	↓	*0.8*	*0*	*0*				
29th	↓	*0*	*5.8*	*0*	↓	*0*	*0*	*0*				
30th	↓		*14.0*	*0*	*4.2*	*0*	*0*	*0*				
31st	*15.6*		*0*		*0*		*0*	*0*				
Highest daily	*47.6*	*3.0*	*14.0*	*2.5*	*2.0*	*1.2*	*15.2*	*24.2*	*3.4*			
Monthly Total	*174.2*	*11.0*	*31.6*	*8.7*	*20.0*	*279.4*	*50.6*	*48.6*				

↓ This day is part of an accumulated total
Quality control: 12.3 Done & acceptable, *12.3* Not completed or unknown

Product code: IDCJAC0009 reference: 26099849

Daily Rainfall (millimetres)

PICTON COUNCIL DEPOT

Station Number: 068052 · State: NSW · Opened: 1880 · Status: Open · Latitude: 34.17°S · Longitude: 150.61°E · Elevation: 165 m

Statistics for this station calculated over all years of data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	87.4	90.0	87.8	69.9	56.1	67.7	49.7	44.9	44.0	63.7	72.2	70.3
Median	67.1	66.4	67.2	49.3	31.2	43.3	26.1	25.2	37.5	49.5	55.5	54.4
Highest daily	211.6	216.7	132.6	156.0	132.1	201.9	124.5	118.4	77.5	141.5	245.9	104.1
Date of highest daily	23rd 1933	10th 1956	25th 1890	16th 1969	21st 1949	12th 1964	10th 1904	30th 1963	11th 1929	5th 1916	9th 1966	13th 1910

1) Calculation of statistics

Summary statistics, other than the Highest and Lowest values, are only calculated if there are at least 20 years of data available.

2) Gaps and missing data

Gaps may be caused by a damaged instrument, a temporary change to the site operation, or due to the absence or illness of an observer.

3) Further information

http://www.bom.gov.au/climate/cdo/about/about-rain-data.shtml.

Product code: IDCJAC0009 reference: 26099849 Created on Tue 13 Sep 2016 14:18:48 PM EST

Daily Rainfall (millimetres)

OAKDALE (COOYONG PARK)

Station Number: 068125 · State: NSW · Opened: 1963 · Status: Open · Latitude: 34.09°S · Longitude: 150.51°E · Elevation: 440 m

2016	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st	*0*	*0*	*0*	*0*	*0*	*9.4*	*0*	*0*				
2nd	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*				
3rd	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*20.2*				
4th	*6.6*	*0*	*0*	*1.0*	*0*	*12.0*	*0*	*0*				
5th	*39.4*	*0*	*0*	*0*	*0*	*100.0*	*4.4*	*2.0*				
6th	*26.0*	*0*	*0*	*0*	*0*	*149.0*	*1.4*	*0*				
7th	*0*	*0*	*0*	*0*	*0*	*0*	*0.8*	*1.8*				
8th	*0*	*8.0*	*0*	*0*	*0*	*0*	*0.8*	*0*				
9th	*0*	*0*	*0*	*0*	*9.2*	*0*	*0*	*0*				
10th	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*				
11th	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*				
12th	*0*	*0*	*0.4*	*0*	*0*	*0*	*2.4*	*0*				
13th	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*				
14th	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*				
15th	*33.0*	*0*	*2.0*	*0*	*0*	*0*	*0*	*0*				
16th	*1.4*	*0*	*4.0*	*0*	*0*	*0*	*0*	*0*				
17th	*0*	*0*	*3.2*	*6.6*	*0*	*0*	*0*	*0*				
18th	*0*	*0*	*0*	*0.6*	*0*	*6.4*	*1.4*	*0*				
19th	*0*	*0*	*0*	*6.0*	*0*	*0*	*0*	*0*				
20th	*0*	*0*	*0*	*0*	*0*	*32.4*	*12.4*	*0*				
21st	*0*	*26.2*	*0*	*0*	*0*	*0*	*10.0*	*0*				
22nd	*21.0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*				
23rd		*0*	*0*	*1.6*	*0*	*0*	*12.0*	*5.0*				
24th	*4.4*	*0*	*0*	*0.8*	*0*	*0*	*0*	*0*				
25th	*1.8*	*0*	*0*	*0*	*0*	*0*	*0*	*30.8*				
26th	*3.4*	*0*	*0*	*0*	*0*	*1.4*	*0*	*0*				
27th	*2.0*	*0.4*	*0*	*0*	*0*	*0*	*0*	*0*				
28th	*7.0*	*0*	*7.4*	*0*	*0*	*0*	*0*	*0*				
29th		*0*	*0*	*0*	*1.6*	*0*	*0*	*0*				
30th	*15.0*		*11.4*	*1.4*	*0*	*0*	*0*	*0*				
31st	*4.0*		*0*		*0*		*0*	*0*				
Highest daily	*39.4*	*26.2*	*11.4*	*6.6*	*9.2*	*149.0*	*12.4*	*30.8*				
Monthly Total		*34.6*	*28.4*	*18.0*	*10.8*	*310.6*	*45.6*	*59.8*				

↓ This day is part of an accumulated total
Quality control: 12.3 Done & acceptable, *12.3* Not completed or unknown

Product code: IDCJAC0009 reference: 26100117

Daily Rainfall (millimetres)

OAKDALE (COOYONG PARK)

Station Number: 068125 · State: NSW · Opened: 1963 · Status: Open · Latitude: 34.09°S · Longitude: 150.51°E · Elevation: 440 m

Statistics for this station calculated over all years of data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	102.7	130.7	113.4	78.4	50.5	85.9	33.7	44.7	44.4	77.0	99.8	78.6
Median	76.3	109.8	85.3	68.6	37.1	49.5	19.4	25.7	42.5	56.6	74.2	78.2
Highest daily	131.0	173.6	125.0	162.1	76.2	208.0	52.0	203.2	80.6	106.6	195.8	84.6
Date of highest daily	29th 2013	11th 2007	22nd 1983	16th 1969	8th 1963	12th 1964	28th 1984	7th 1967	21st 1982	24th 1975	7th 1966	8th 1970

1) Calculation of statistics

Summary statistics, other than the Highest and Lowest values, are only calculated if there are at least 20 years of data available.

2) Gaps and missing data

Gaps may be caused by a damaged instrument, a temporary change to the site operation, or due to the absence or illness of an observer.

3) Further information

http://www.bom.gov.au/climate/cdo/about/about-rain-data.shtml.

Product code: IDCJAC0009 reference: 26100117 Created on Tue 13 Sep 2016 14:27:56 PM EST

Daily Rainfall (millimetres)

MENANGLE BRIDGE (NEPEAN RIVER)

Station Number: 068216 · State: NSW · Opened: 1963 · Status: Open · Latitude: 34.12°S · Longitude: 150.74°E · Elevation: Unknown m

2016	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st	*0*	*0*	*0*	*0*	*0*	*2.0*	*0*	*0*	*0*			
2nd	*0*	*2.0*	*0*	*0*	*0*	*1.0*	*0*	*0*	*7.0*			
3rd	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*15.0*	*21.0*			
4th	*8.0*	*5.0*	*0*	*2.0*	*0*	*11.0*	*0*	*1.0*	*0*			
5th	*44.0*	*0*	*0*	*0*	*0*	*137.0*	*5.0*	*3.0*	*0*			
6th	*15.0*	*0*	*0*	*0*	*0*	*122.0*	*0*	*0*	*0*			
7th	*4.0*	*0*	*0*	*0*	*0*	*0*	*2.0*	*0*	*0*			
8th	*0*	*0*	*0*	*0*	*0*	*0*	*6.0*	*0*	*0*			
9th	*0*	*0*	*0*	*0*	*10.0*	*0*	*1.0*	*1.0*	*0*			
10th	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*2.0*			
11th	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*			
12th	*0*	*0*	*0*	*3.0*	*0*	*0*	*0*	*0*	*0*			
13th	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*			
14th	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*				
15th	*31.0*	*0*	*4.0*	*0*	*0*	*0*	*0*	*0*				
16th	*1.0*	*0*	*1.0*	*0*	*0*	*0*	*0*	*0*				
17th	*0*	*0*	*4.0*	*2.0*	*0*	*0*	*0*	*0*				
18th	*0*	*0*	*1.0*	*0*	*0*	*6.0*	*1.0*	*0*				
19th	*0*	*0*	*1.0*	*4.0*	*0*	*0*	*0*	*0*				
20th	*0*	*0*	*0*	*0*	*0*	*23.0*	*14.0*	*1.0*				
21st	*0*	*1.0*	*0*	*0*	*0*	*0*	*8.0*	*0*				
22nd	*10.0*	*0*	*0*	*0*	*0*	*0*	*1.0*	*0*				
23rd	*12.0*	*0*	*0*	*1.0*	*0*	*0*	*8.0*	*1.0*				
24th	*3.0*	*0*	*0*	*2.0*	*0*	*0*	*0*	*1.0*				
25th	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*24.0*				
26th	*1.0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*				
27th	*0*	*0*	*0*	*0*	*0*	*1.0*	*0*	*0*				
28th	*1.0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*				
29th	*0*	*0*	*0*	*0*	*3.0*	*0*	*0*	*0*				
30th	*50.0*		*19.0*	*1.0*	*0*	*0*	*0*	*0*				
31st	*8.0*		*0*		*0*		*0*	*0*				
Highest daily	*50.0*	*5.0*	*19.0*	*4.0*	*10.0*	*137.0*	*14.0*	*24.0*	*21.0*			
Monthly Total	*188.0*	*8.0*	*30.0*	*15.0*	*13.0*	*303.0*	*46.0*	*47.0*				

↓ This day is part of an accumulated total
Quality control: 12.3 Done & acceptable, *12.3* Not completed or unknown

Product code: IDCJAC0009 reference: 26100134

Australian Government
Bureau of Meteorology

Daily Rainfall (millimetres)

MENANGLE BRIDGE (NEPEAN RIVER)

Station Number: 068216 · State: NSW · Opened: 1963 · Status: Open · Latitude: 34.12°S · Longitude: 150.74°E · Elevation: Unknown m

Statistics for this station calculated over all years of data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Highest daily	*100.0*	*79.0*	*84.0*	*68.0*	*38.0*	*137.0*	*56.0*	*61.0*	*32.0*	*90.0*	*35.0*	*53.0*
Date of highest daily	29th 2013	11th 2007	1st 2007	19th 2012	27th 2010	5th 2016	1st 2005	25th 2015	7th 2006	10th 2010	23rd 2013	11th 2004

1) Calculation of statistics

Summary statistics, other than the Highest and Lowest values, are only calculated if there are at least 20 years of data available.

2) Gaps and missing data

Gaps may be caused by a damaged instrument, a temporary change to the site operation, or due to the absence or illness of an observer.

3) Further information

http://www.bom.gov.au/climate/cdo/about/about-rain-data.shtml.

Product code: IDCJAC0009 reference: 26100134 Created on Tue 13 Sep 2016 14:29:25 PM EST