Avon River Regional Flood Mapping – Hydraulics Report

February 2016

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1. INTRODUCTION

1.1 Overview

Water Technology was commissioned by the Department of Environment, Land, Water and Planning (DELWP) to undertake regional flood mapping for the Avon River. This project includes detailed hydrological and hydraulic modelling of the Avon River and its tributaries including Freestone Creek, Valencia Creek and Blackall Creek, and will take into account the downstream influences of Lake Wellington. This mapping will be used to satisfy a range of business requirements from planning, emergency response, to community awareness and for insurance purposes.

This report details the hydraulic analysis undertaken for the project, including the following components:

- A general description of the methodology used for the hydraulic assessment,
- A description of the model development and schematisation,
- Details of the model calibration and sensitivity analysis, and
- Design flood event modelling.

1.2 Available Information

All data received and sent regarding the project has been logged by Water Technology in a Project Data Management Record detailing information about the data. The hydraulic models discussed within this report have been developed based on the previously reported information assembled for the Preliminary Report and the Hydrology Report.

1.3 Study Area

The Avon River rises on the slopes of Mount Wellington in the eastern highlands of the Great Dividing Range and flows south to Lake Wellington and the Gippsland Lakes. The mountainous upper catchment is largely forested, while the lower catchment downstream of the confluence with Valencia Creek has lower relief and primarily agriculture land use (EarthTech, 2006). The floodplain in the lower reaches is traversed by watercourses, swamps and lagoons. Overall, the river descends some 664 m over its 122 km length.

The regional flood mapping area includes approximately 40km of the downstream floodplain of the Avon River catchment, as well as large portions of Freestone Creek, Valencia Creek and Blackall Creek. Key towns within this catchment area include Stratford, Boisdale and Briagolong. The study area and significant watercourses or flood related influences are shown in Figure 1-1.

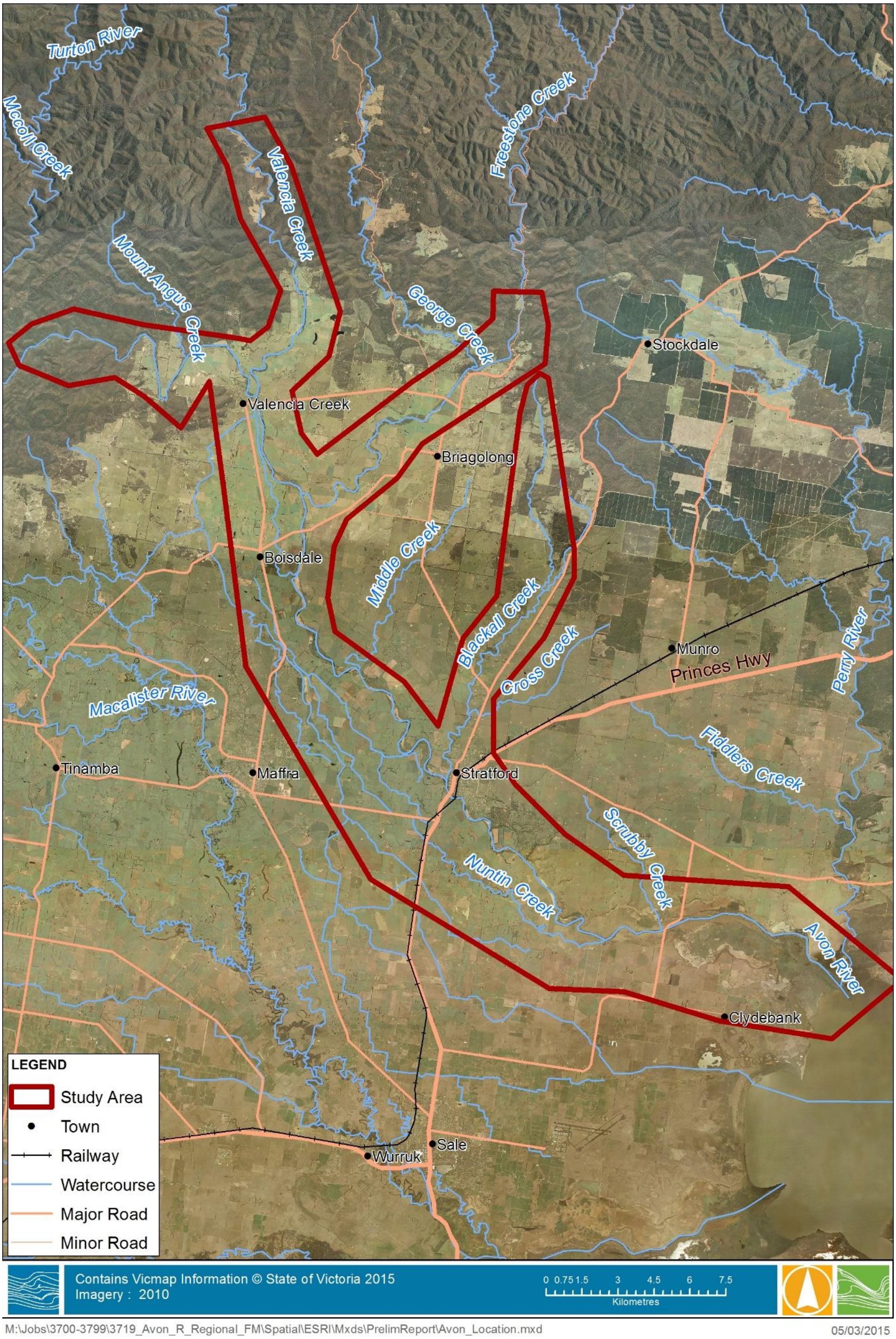

Figure 1-1 Avon River study area

2. PREVIOUS REPORTING

This report should be read in conjunction with the following previous reports:

- Preliminary Report, R01 (Water Technology, 2015a).
- Hydrology Report, R02 (Water technology, 2015b).

2.1 Preliminary Report

The Preliminary Report documented previous flood related information for the study area, including a review of available topographic and structure (bridges and culverts) data. It also outlined the proposed hydrologic and hydraulic modelling scope and methodology.

2.2 Hydrology Report

The final Hydrology Report incorporates the following:

- Flood Frequency Analysis,
- Hydrologic modelling including development and calibration of a RORB rainfall-runoff model,
- Development of design event hydrographs including estimation of the PMF, and
- Comparison with previous studies.

3. HYDRAULIC MODELLING FRAMEWORK

3.1 Overview of the Modelling Approach

A two dimensional (2D) flexible mesh hydraulic model was developed for the study area using MIKE21FM GPU (Mike by DHI). Adopting a flexible mesh modelling approach allowed the hydraulic model to incorporate greater detail in areas of importance, whilst maintaining computational efficiency through a larger element size in less sensitive regions of the modelled area. This allows features within the broader floodplain and the township areas to be resolved in varying detail in the same model whilst maintaining appropriate run times. Model reviews were also undertaken throughout the project, and Appendix B displays the internal hydraulic model review process.

3.2 Hydraulic Model Elements

The hydraulic model framework was required to simulate the flow behaviour across a large portion of the Avon River and its tributaries balancing excessive model simulation times and topographic resolution. The final hydraulic modelling framework comprised of a two dimensional (2D) hydraulic model which is aimed at picking up broad scale floodplain features for large flood events, whilst also providing more refined results in areas of interest.

The hydraulic modelling suite MIKE21 developed by the Danish Hydraulic Institute (DHI) has been applied in this study. The specific module used for this study is MIKE21FM, a state-of-the-art tool for floodplain modelling that applies the dynamic MIKE21FM two-dimensional flexible mesh model systems, while also allowing for the inclusion of one-dimensional elements, and is run with a graphics processing unit (GPU). The GPU allows for greatly accelerated model runs, and represents a recent critical advancement in hydraulic modelling. Further details on the capabilities of the MIKE modelling system can be found at http://www.dhisoftware.com.

3.3 Hydraulic Model Limitations

There are numerous contributing factors to the ultimate output uncertainty in a complex hydraulic modelling exercise such as that undertaken for this study. Some of the uncertainties relate to the data inputs, whilst others are dependent on the numerical modelling processes itself. Sources of output uncertainty related to the input data for the hydraulic modelling include:

- Topographic data
- Definition of hydraulic controls/structures
- Observed and estimated design flows for model input
- Observed flows and water levels for model calibration

Sources of uncertainty related to the hydraulic modelling process include:

- Model numerical and computational schemes
- Floating point accuracy of computing resources
- Model schematisation and set-up
- Model parameters such as computational time-steps, surface-friction and other energy-loss parameters

The hydraulic model development process can only address uncertainties arising from model schematisation and set-up, model parameters and definition of hydraulic controls/structures. The remaining aspects are constrained by the available data sources.

There is a wide variation in the magnitude of the impact associated with each source of uncertainty. In order to identify the most significant sources of uncertainty it is possible to consider items as either first or second order magnitude, where second order items are of a significantly smaller magnitude compared to first order items and can generally be ignored or treated with minor consideration. A list of the main sources of the modelling uncertainty and their approximate magnitudes is provided in Table 3-1.

Due to the complexity of the relationships between the input data and modelling outputs, there is no direct correlation between input and output data accuracy, and the error bounds on the data inputs are generally not cumulative. However, there are inferred relationships between model inputs and output accuracy that are typically developed through hydraulic modelling project experience.

Table 3-1 Comparisons of Sources of Uncertainty

Scenario/Data/Process	Order of Accuracy	Approximate Impact on Results
Topographic data	First	Change in floodplain levels/depths ± 0.1 m. The review of the available LiDAR information for Avon found that there was a systematic offset in one of the key datasets (ISC Rivers LiDAR). The dataset was therefore adjusted to correct for this. Channel representation based on LiDAR can often cause underestimation of channel conveyance. Without more detailed survey, this has to be accepted as a model uncertainty.
Definition of hydraulic controls/structures	First	Change in floodplain levels/depths of 0.1 to 0.2 m. The majority of the hydraulic structures in this model are bridges which can have a significant impact on the local water surface level.

Scenario/Data/Process	Order of Accuracy	Approximate Impact on Results
Observed flows for model calibration	First	Flows are dependent on the reliability of the rating curve. The inflows are generally thought to be gauged to a high quality in the Avon River and are likely to be within ± 10%.
Observed water levels for model calibration	First	Depends on available data, generally ± 0.15 m for observed flood levels. Observed water levels for the 2012 event were pegged from debris lines which may overestimate the actual peak water level. For the 2007 event, the method of identification of water levels is unknown however they are rated as high reliability in the VFD.
Model schematisation and set-up (location of boundaries, mesh resolution)	First	Difficult to quantify, aim for overall accuracy of ± 0.1 m for levels and ± 10 % for flows in calibration.
Model parameters such as computational time-steps, surface-friction and other energy-loss parameters	First	Difficult to quantify, aim for overall accuracy of ± 0.1 m for levels and ± 10 % for flows in calibration.
Model numerical and computational schemes	Second	N/A
Floating point accuracy of computing resources	Second	N/A

4. MODEL DEVELOPMENT AND SCHEMATISATION

4.1 Overview

This section defines the scope of the hydraulic analysis, details the hydraulic model scheme and construction including boundary conditions. Hydraulic model calibration, sensitivity tests and flood behaviour are described in Section 5, while design flood events are detailed in Section 6.

4.2 Hydraulic Model Schematisation

4.2.1 Mesh Extent and Resolution

A detailed representation of the ground surface was required to appropriately capture the topographic detail within the hydraulic model. A flexible mesh approach provides high resolution in areas requiring enhanced detail such as the waterway channels, whilst allowing lower resolution in less sensitive areas such as Lake Wellington and the upstream floodplain areas. Spatially varying the resolution allows the model run times to be optimised whilst maintaining element sizes needed to adequately map the study area.

The mesh comprises of triangular and rectangular elements of varying size. The mesh extent and bathymetry used for this study is illustrated in Figure 4-2. The model extends from state forest areas in the Upper Avon, Freestone and Briagolong catchments to approximately 3.5km downstream from the River's discharge point into Lake Wellington.

The mesh resolution within the townships of Stratford and Boisdale is approximately 15 m^2 with quadrilateral elements aligned in most areas with the roads and properties. Quadrilateral elements of high resolution were also used to delineate channels and levees. The resolution of the mesh reduces towards the floodplain margin and the Lake Wellington boundary, with a median element size throughout the model of $89m^2$ and a maximum element size of 80 $000m^2$. The distribution of mesh element size is shown in Figure 4-1. Triangular elements are used to migrate between quadrilateral sections and areas with different resolutions. An example section of the mesh of the Upper Avon is shown in Figure 4-3, showing the smaller quadrilateral elements in the river, whilst a mixture of larger triangular and quadrilateral elements are used in the broader floodplain.

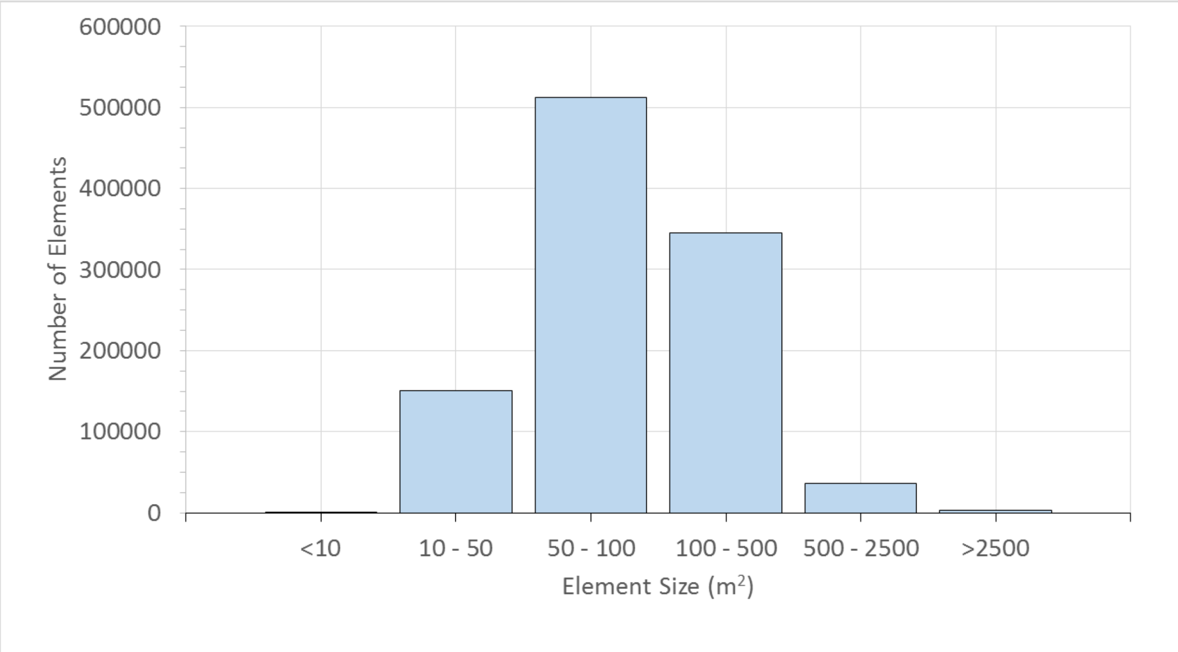

Figure 4-1 Model Mesh Element Size Histogram

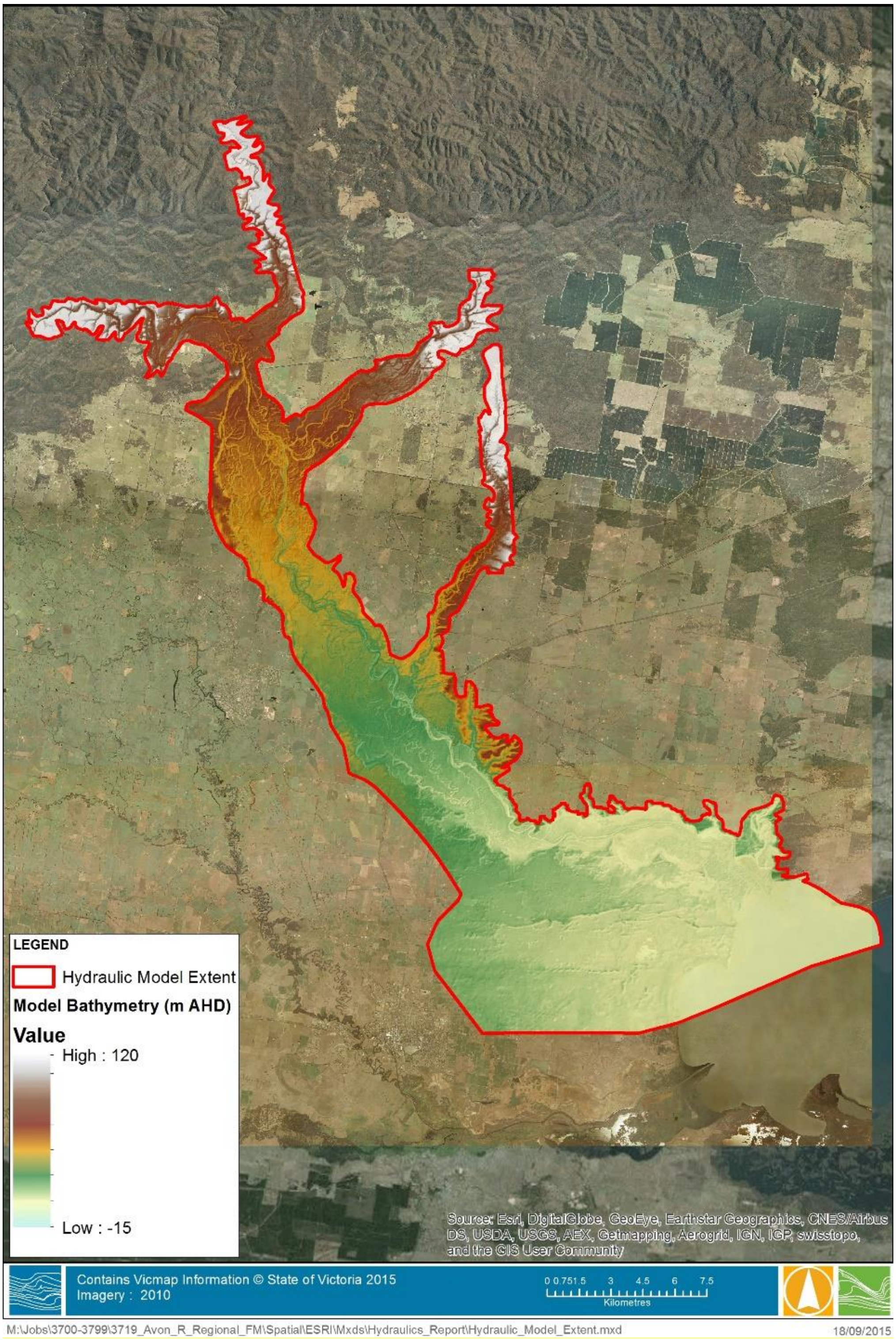

Figure 4-2 Topography generated by the model mesh

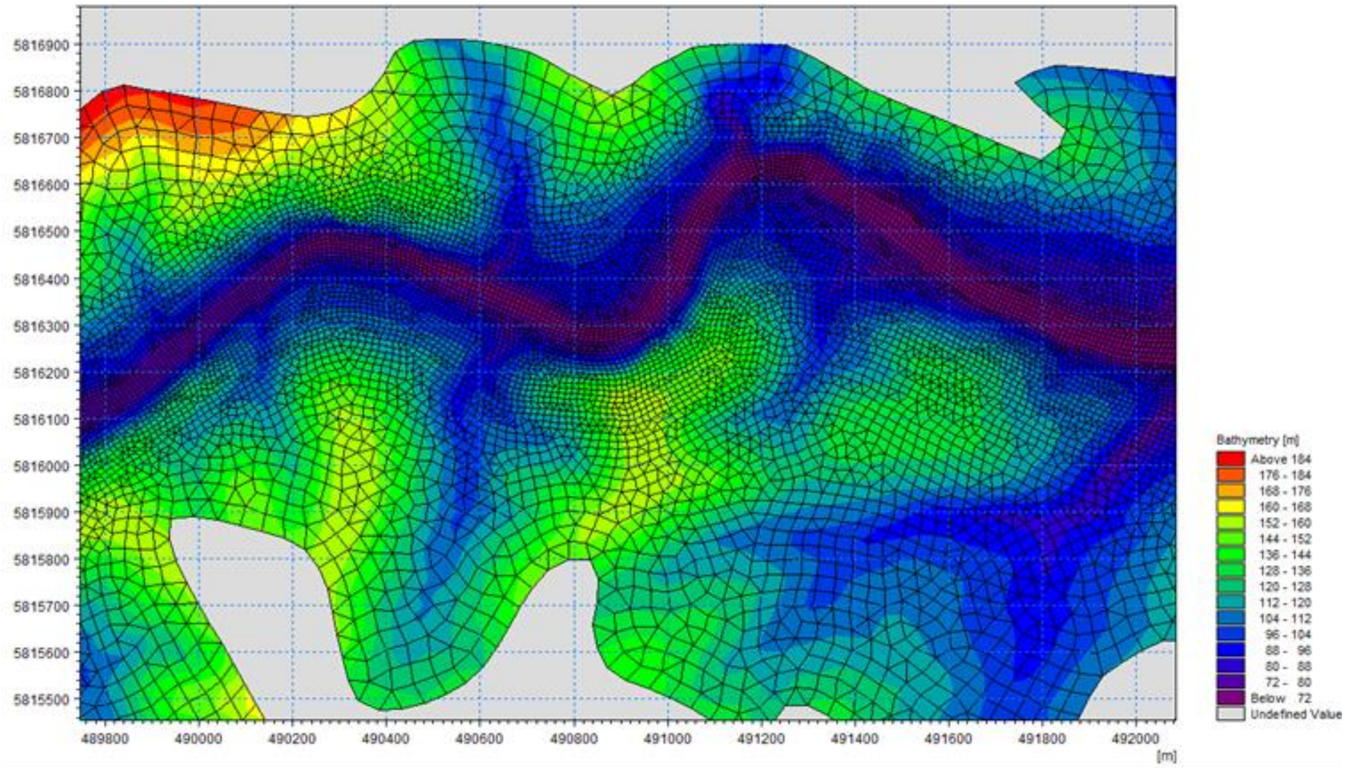

Figure 4-3 Example Mesh of the Upper Avon

4.2.2 Topography

The model topography was based on a mosaic of Index of Stream Condition (ISC) LiDAR, Southern Rural Water (SRW) LiDAR and floodplains LiDAR. This data set was extensively reviewed prior to inclusion in the model (Water Technology, 2015a). This DEM was then sampled at varying resolution using the model mesh, as displayed in Figure 4-3.

4.2.3 Boundary Conditions

There are three key inflow boundaries and one water level boundary controlling the exchange of water into and out of the hydraulic model. These boundaries are identified in Figure 4-4.

Key Inflow Boundaries

Upper Avon River, Valencia Creek and Freestone Creek inflows for the design events and sensitivity testing were provided from the hydrologic model as discussed in the earlier Hydrology Report (Water Technology, 2015b).

Calibration flows for the 2007, 2011 and 2012 historical events were extracted from the Avon River at The Channel gauge (#225224), the Valencia Creek at Gillio Rd gauge (#225223) and the Freestone Creek at Briagolong gauge (#225218), as discussed in the Hydrology Report (Water Technology, 2015b).

The Upper Avon River flows were applied directly to the hydraulic model approximately 2km upstream of the Avon River at The Channel gauge. The Valencia Creek inflows were applied approximately 4km upstream of the Valencia Creek at Gillio Rd gauge and the Freestone Creek inflows were applied approximately 4km upstream of the Freestone Creek at Briagolong gauge.

Baseflow was not considered for inclusion to inflows, as it was found to be insignificant (Water Technology, 2015b).

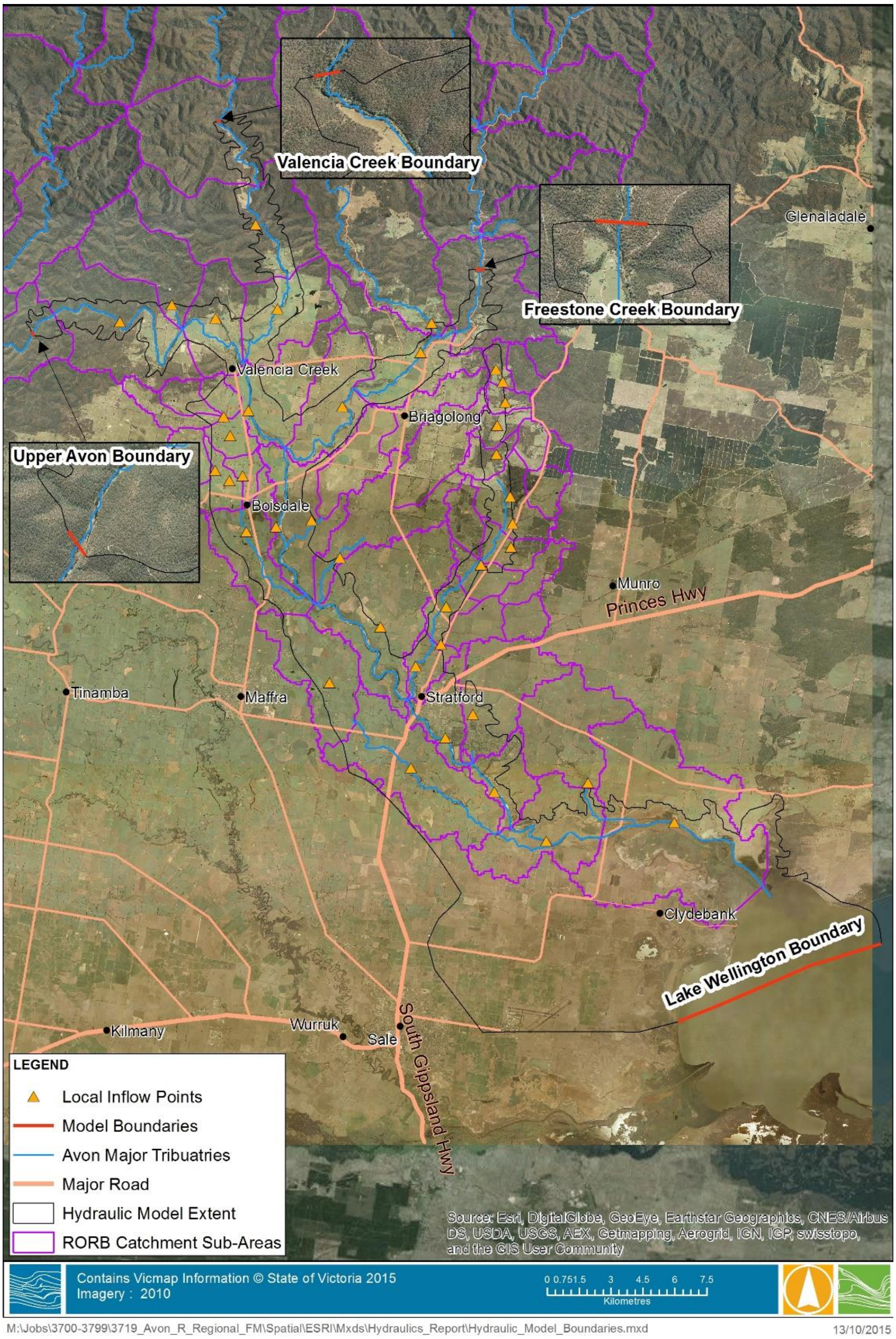

Figure 4-4 Model Boundary Locations

Lake Wellington

For calibration events, water levels for the 2007, 2011 and 2012 historical events were extracted from the Lake Wellington at Bull Bay (#226610) recorded heights, as discussed in the Hydrology Report (Water Technology, 2015b).

For design events and sensitivity testing a steady-state water level boundary was applied to represent tailwater conditions in Lake Wellington.

The dominant forcing mechanism of extreme water levels in Lake Wellington is high river flows. Secondary mechanisms include wind setup and tidal influence. Whilst these secondary mechanisms may be present during a flood, it is unlikely that catchment flooding would occur whilst the water level in Lake Wellington is already high. This would require a flood to occur immediately after another flood. Historic floods on the Avon generally do not have high Lake Wellington levels, which is shown in the calibration events, with the 2007, 2011 and 2012 floods showing approximately 0.40, 0.35 and 0.25m AHD water levels in Lake Wellington at the beginning of each flood, respectively. These calibration levels can be compared to the 10% AEP and 1% AEP Lake Wellington levels of 1.3 and 2.5 m AHD. Sensitivity testing undertaken (see section 5.3.3) show that the water level in Lake Wellington has a minimal impact on the Avon River model, except in the immediate reach upstream of Lake Wellington. It was therefore decided to adopt a 10% AEP flood level in Lake Wellington for the design event simulations as this provides a conservative estimate of Lake Wellington levels during a flood, without the extreme downstream water levels experienced during a 1% AEP flood of Lake Wellington. The Gippsland Lakes are a complex hydraulic system, and it is envisioned that the areas immediately surrounding Lake Wellington would be incorporated into catchment planning via a flood study undertaken on the lake itself, rather than this study which focuses on the Avon River.

These water levels were applied directly to the hydraulic model across approximately 10 km of Lake Wellington.

Local Inflows

Local inflows for the design events, calibration events and sensitivity testing were provided from the hydrologic model as discussed in the earlier Hydrology Report (Water Technology, 2015b).

The local flows were applied directly to the hydraulic model as source points at various locations based on the RORB subareas and are shown in Figure 4-4. As the flows had already been routed in the hydrologic model to the centroid of the hydrologic subcatchments, generally a location near the centroid of the subcatchment was chosen as an inflow location in the hydraulic model, unless the centroid fell outside the model or away from key flow paths. In these cases the source point location was shifted to a more suitable location.

4.2.4 Roughness

Hydraulic roughness within the 2D model was expressed as Manning's n. For the estimation of the floodplain Manning's n, this study assessed land use and vegetation cover. Hydraulic roughness parameters were adopted using industry standard values that represent the channel and floodplain cover, and adjusted as required to calibrate the models. Sensitivity tests were also undertaken on floodplain roughness, as discussed in Section 5.3.1.

Hydraulic roughness values adopted for the 2D hydraulic model are summarised in Table 4-1 and Figure 4-5, which shows the different values adopted for each land use of ground cover. Figure 4-6 is a map of the roughness categories as used in the 2D model. Due to the model sensitivity to roughness values a number of the roughness categories were refined during the calibration process. The final adopted roughness values for each category are shown in the table.

Table 4-1 Roughness Values

Land Use / Topographic Description	Manning's "n"
Valencia Creek stream and bank*	0.015
Road reserve	0.020
Upper Avon River stream and bank*	0.025
General floodplain*	0.040/0.050
Avon River stream and bank*	0.040/0.050
Downstream wetland	0.050
Freestone Creek stream and bank*	0.050
Dense forest	0.10
Built up area	0.20

* modified during the calibration process. Final adopted value shown

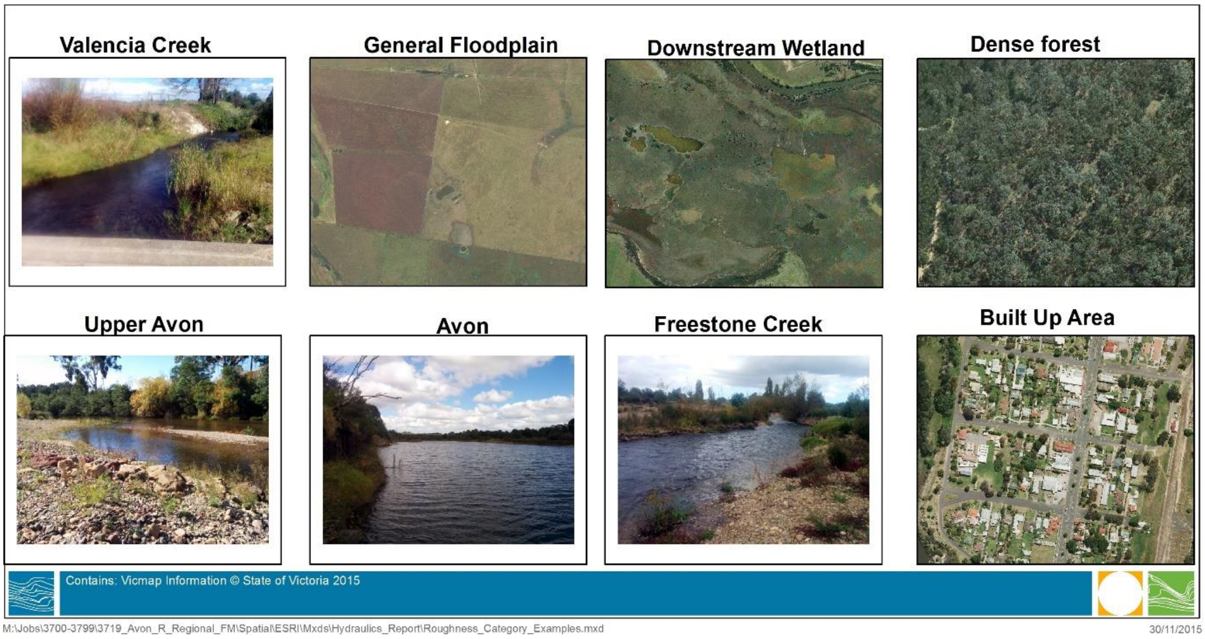

Figure 4-5 Photos showing typical land cover for each roughness category

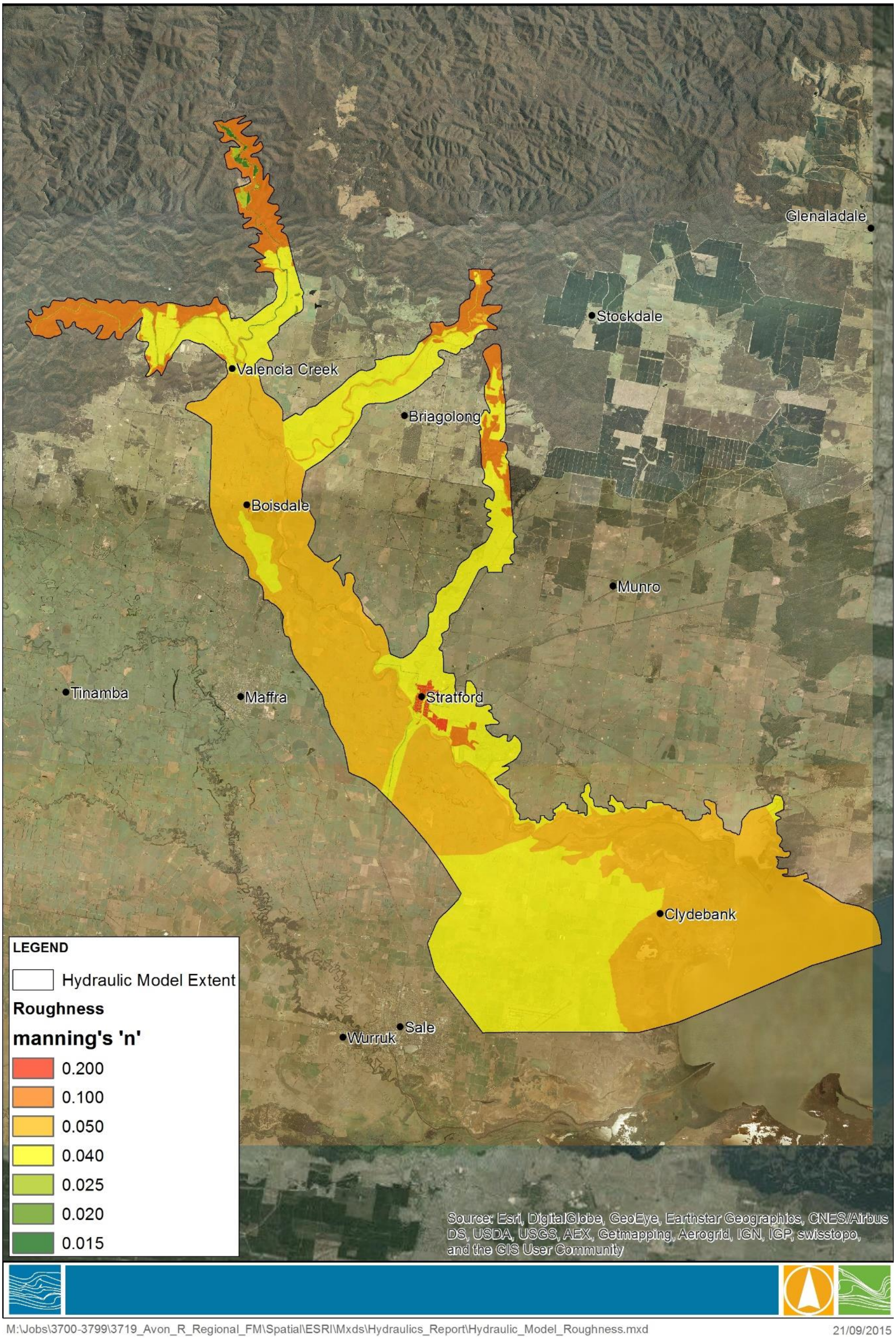

Figure 4-6 Roughness Categories

4.2.5 Hydraulic Structures

Twelve road bridges were explicitly included in the hydraulic model, as shown in Figure 4-7. The road bridges were modelled using a waterway opening cross-section extracted from LiDAR data and a weir crest at the road level, to allow flow both through the waterway opening, and over the bridge deck.

A separate modelling approach was undertaken for the Stratford rail bridge. This bridge has a long span (over 500 m), and is situated in a complex hydraulic location- this area is a key point for riverine breakouts and floodplain flows. The traditional waterway cross-section as adopted for the other bridges would not accurately represent the two-dimensional flow system in this area. Instead, an estimated roughness increase was used as a substitute for the hydraulic energy losses that would occur due to friction losses from the bridge deck and piers.

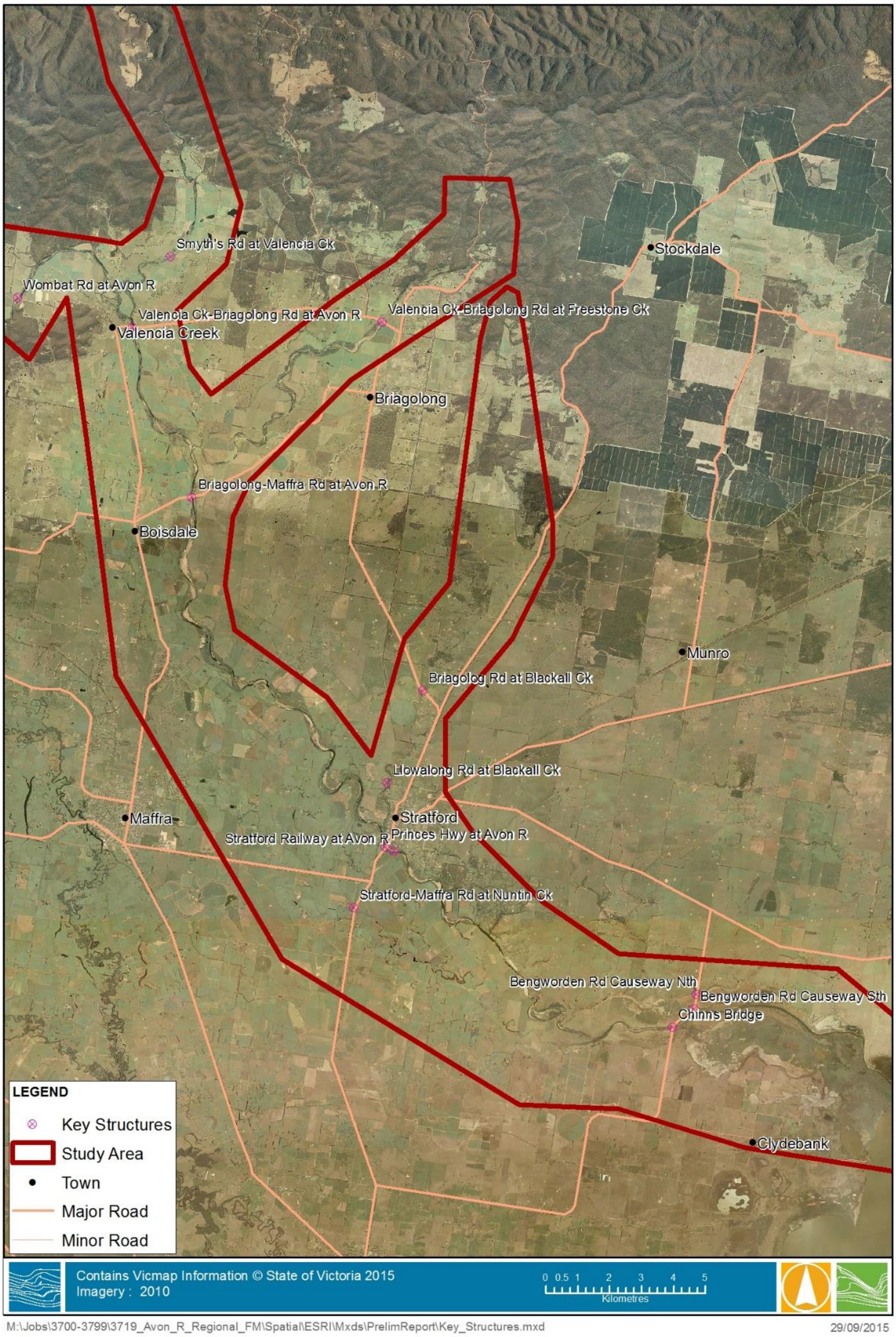

Figure 4-7 Key structures included in the hydraulic model

5. HYDRAULIC MODEL CALIBRATION AND VERIFICATION

5.1 Calibration Approach

This section discusses the refinement of the hydraulic model's parameters through calibration against observed flood levels, water level and stream flow data, and outlines the validation of adopted model parameters.

The calibration process consisted of systematic comparison of observed and modelled flow/flood. This process incorporated comparisons between observed flood levels and flood extents. The models' parameters were adjusted to minimise the differences between the modelled and observed data. The validation process applied the calibrated model parameters to another flood event to assess model performance.

A robust calibration requires the comparison of modelled and observed flood behaviour across a range of flow magnitudes. The following observed data was required for a historical event to be considered in the model calibration:

- Well defined inflows and outflows (boundary conditions).
- Flow and level measurements over time (temporal distribution) at discrete points of interest within and along the river such as effluent points and control structures.
- Flood extent and/or depth measurements (spatial distribution) at multiple times.

The historical flow/flood events used to calibrate/validate the models were chosen on the basis of available observed flood information. The following sections detail the selection of and available data for the calibration/validation events.

The calibration of the model centred on the determination of floodplain and river channel hydraulic roughness values (Manning's n values) to achieve a reasonable agreement between observed and modelled flood levels. Initial Manning's n values were assigned to various land uses based on previous modelling experience, and where necessary to achieve a reasonable agreement, these initial Manning's n values were refined. It was found that slightly different roughness values were required for the stream and wetland areas (particularly the Clydebank area) for calibration of the different events. Inter-annual and seasonal variability of riparian and wetland vegetation is high, therefore it is reasonable that different vegetation conditions would need to be simulated for the events. Typical roughness values were selected for these areas for design flood modelling. The final values are listed in Section 4.2.4.

5.1.1 Available Observed Flood Data and Calibration/Validation Event Selection

The focus of the model calibration and validation was the general flood behaviour during large flood events, in line with the study's interests (20% AEP to 0.5% AEP events). Hence, the selection of calibration and validation events reflected recent large flood events with adequate available observed flood data suitable for this purpose.

The recent flood events in June 2007 and June 2012 were selected for model calibration, given their relatively large flood magnitude and reasonable abundance of observed flood information. Flood level data was available for the 2012 event from WGCMA flood pegging of observed debris lines after the peak had passed. Flood level data for the June 2007 event was available from the VFD and was rated to high accuracy.

The model was also validated using the August 2011 flood event. This event did not have any available observed flood level data and was smaller than the 2007 and 2012 events. However a comparison with water level and flow data at gauges throughout the catchment was undertaken to provide confidence that the model was capable of accurately simulating flood routing and levels over a wide range of events.

Following discussions with the community during the second round of consultation sessions in December 2015, it was decided to incorporate the April 1990 event into model validation. Whilst the Valencia Creek at Gillio Rd gauge was washed out during this event, and water level records were not available for Lake Wellington, assumptions on flows and levels were made to allow simulation of the flood. This flood is the largest in living memory of the Avon River (estimated as an approximate 1% AEP event), and a large number of flood marks are available in the floodplain on the western side of the Avon River between Stratford and Boisdale. The community noted that flood levels in this floodplain area appeared too low in some areas in draft design event mapping, and the 1990 event was the only flood with quantitative flood levels in this area available to assess those comments further.

The existing floodplain condition is assumed to be representative of all calibration and validation events. However, the Nuntin Levee/spillway area is one location where topography has varied since 1990. A levee was built at this location in the 1990s, however the levee was almost completely scoured out in the July 2007 flood event (Alluvium, 2008), and rebuilt as a spillway. This spillway was then modified in 2014 and replaced with a levee again (Alluvium, 2014). LiDAR captured in 2008 (SRW LiDAR) and 2010 (ISC Rivers LiDAR) in this area, documents the post flood scour conditions before reconstruction of the spillway and conditions after re-construction of the spillway. For the calibration events, the decision was made to utilise the 2008 SRW LiDAR (captured prior to spillway construction) in the model as it is likely to represent the floodplain topography during large floods that manage to cause scour in this region. A sensitivity test was undertaken using the 2010 ISC Rivers LiDAR which captured the re-constructed spillway, and the model was found to be relatively insensitive, even for small events (5% AEP). This is further discussed in Section 5.3.4. For the design events the current level of the levee was included in the model topography.

Table 5-1 displays the peak flows and associated approximate AEP for the model calibration /validation events, and general nature of available observed flood information. Approximately AEP is based on the adopted design peak flows for the Stratford gauging station (225201).

Table 5-1 Hydraulic model calibration/validation events – Peak flows, approximate AEP, and available observed flood information

Event	Peak flow (m^3/s) and approximate AEP at Stratford		Available flood information	Use
	Peak Flow (m^3/s)	Approximate AEP (%)		
June 2007	2,156	2.5%	Observed flood marks: 46 Observed flood extent Gauged flows and levels	Calibration
August 2011	889	20%	Gauged flows and levels	Validation
June 2012	1,855	4%	Observed flood levels: 12 Observed flood extent Gauged flows and levels	Calibration
April 1990	2,834	1%	Observed flood marks: 608 Observed flood extent Gauged flows and levels (some missing)	Floodplain Water Level Validation

5.2 Calibration and Validation Results

5.2.1 Gauged Flows and Levels

Modelled water levels and flows at the Stratford gauge and modelled water levels at Clydebank were compared to gauged data for the 2007 and 2012 calibration events and the 2011 validation event. The results are summarised below and in the following figures.

- The modelled results for the June 2007 event had a good match to peak water levels at all gauges (within approximately 0.1 m), and a close match to the peak flow at Stratford (Figure 5-3). The timing of the flood peak was around 1-3 hours early at Stratford and Clydebank. For calibration, peak water level was most accurate when the lower catchment areas around Clydebank had a roughness value of 0.06.
- The June 2012 event also had a very close match of peak water levels (within approximately 0.1 m) at all gauges in the study area, and a close match to the peak flow at Stratford (Figure 5-2). Again, the timing of the rising limb and peak was early at Stratford and Clydebank by 1-3 hours. For calibration, peak water level was most accurate when the lower catchment areas around Clydebank had a roughness value of 0.05, compared to the 2007 event which was calibrated with a roughness of 0.06.
- For the 2011 validation event, the adopted roughness parameters for each of the calibration events were applied to the model and then the 2011 event simulated. The parameter set for the 2012 event with Clydebank roughness of 0.05 was found to produce a slightly better result (Figure 5-3). These roughness parameters were then adopted for calibration events, and they are displayed in Section 4.2.4. Modelled flood levels at Stratford were around 0.3 m higher than measured, probably due to the modelled flow being slightly too high. The modelled rising limb and flood peak were also around 2-3 hours early than measured. Flood levels at Clydebank were around 0.4 m lower than measured values.

  The modelled 2011 event exhibits elevated water levels at upstream gauges compared to the 2007 and 2012 calibration events. The 2011 event is the smallest modelled, and smaller events are more sensitive to channel topography and roughness. It is thought that the higher levels in the 2011 event are primarily due to the regional scale model's representation of topography and roughness within the channel. This is considered a limitation of the model, and events smaller than the 10% AEP may overestimate flood levels. However, considering the model's size and resolution, the focus on calibration was accurate estimation of larger flood events and this is thought to have been achieved via the 2007 and 2012 event calibration.

In addition to the main river gauging stations, comparisons were also made between measured and modelled water levels and the timing of peak flows at a low level crossing gauge in the Avon River upstream of Stratford on Valencia Creek-Briagolong Road. Only information for the 2012 flood event was available. The modelled water level at the gauge site shows a good match for the timing of the measured 2012 flood peak, indicating accurate flood routing through the Upper Avon and Valencia Creek tributaries.

The difference in the timing of the modelled and measured rising limb and flood peak at Stratford and Clydebank in the calibration and validation events indicates that the modelled flood routing through the Avon River floodplain is slightly too efficient. However, the timing difference of the flood peak is small (generally between 1 to 3 hours over a 48-56 hour event), and given that the modelled peak water levels and flows are well represented at all sites, the calibration was deemed to be fit for purpose for regional flood mapping.

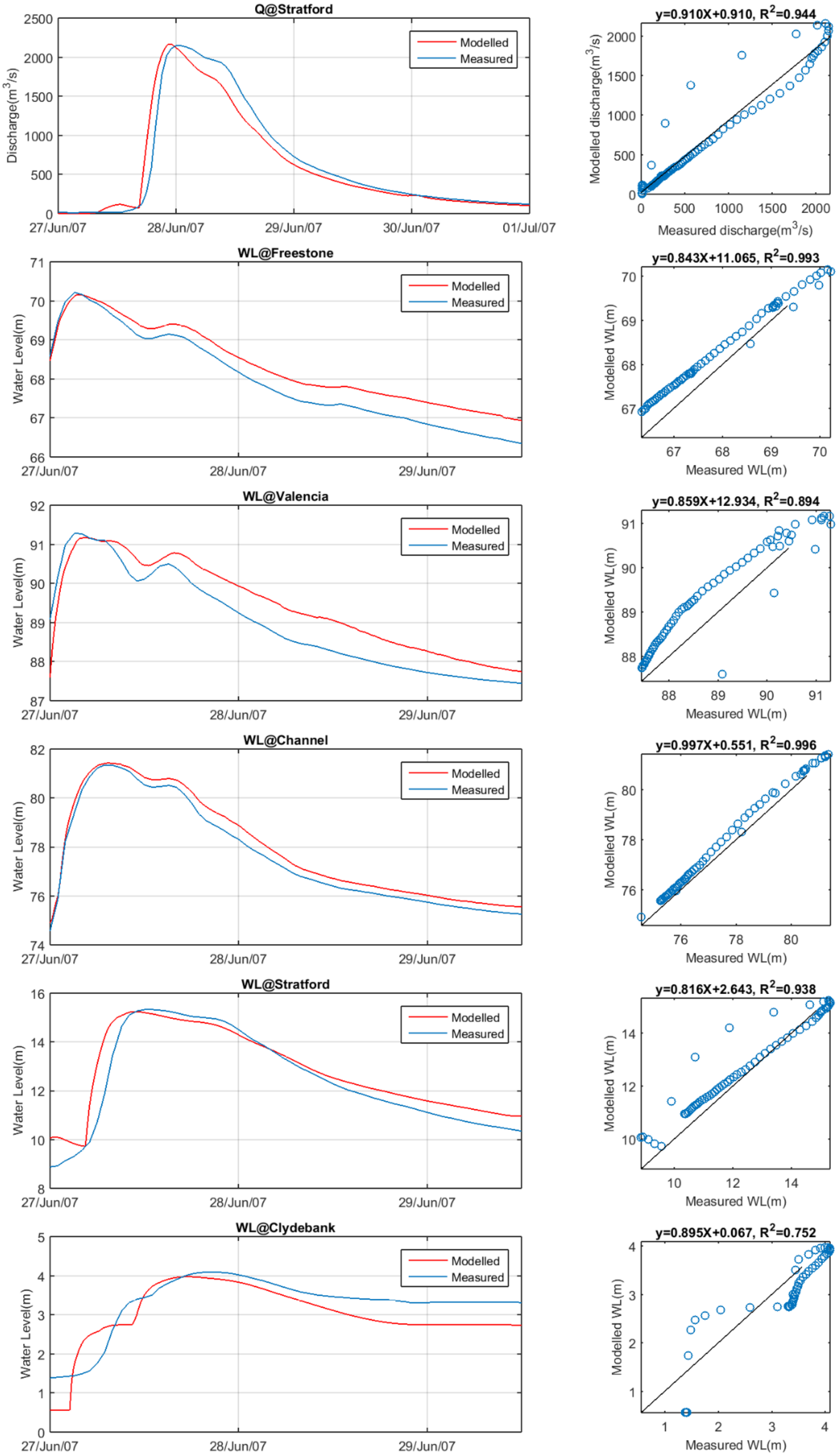

Figure 5-1 Calibration flow and water level results at Stratford and Clydebank gauges, June 2007 event (Clydebank roughness 0.06)

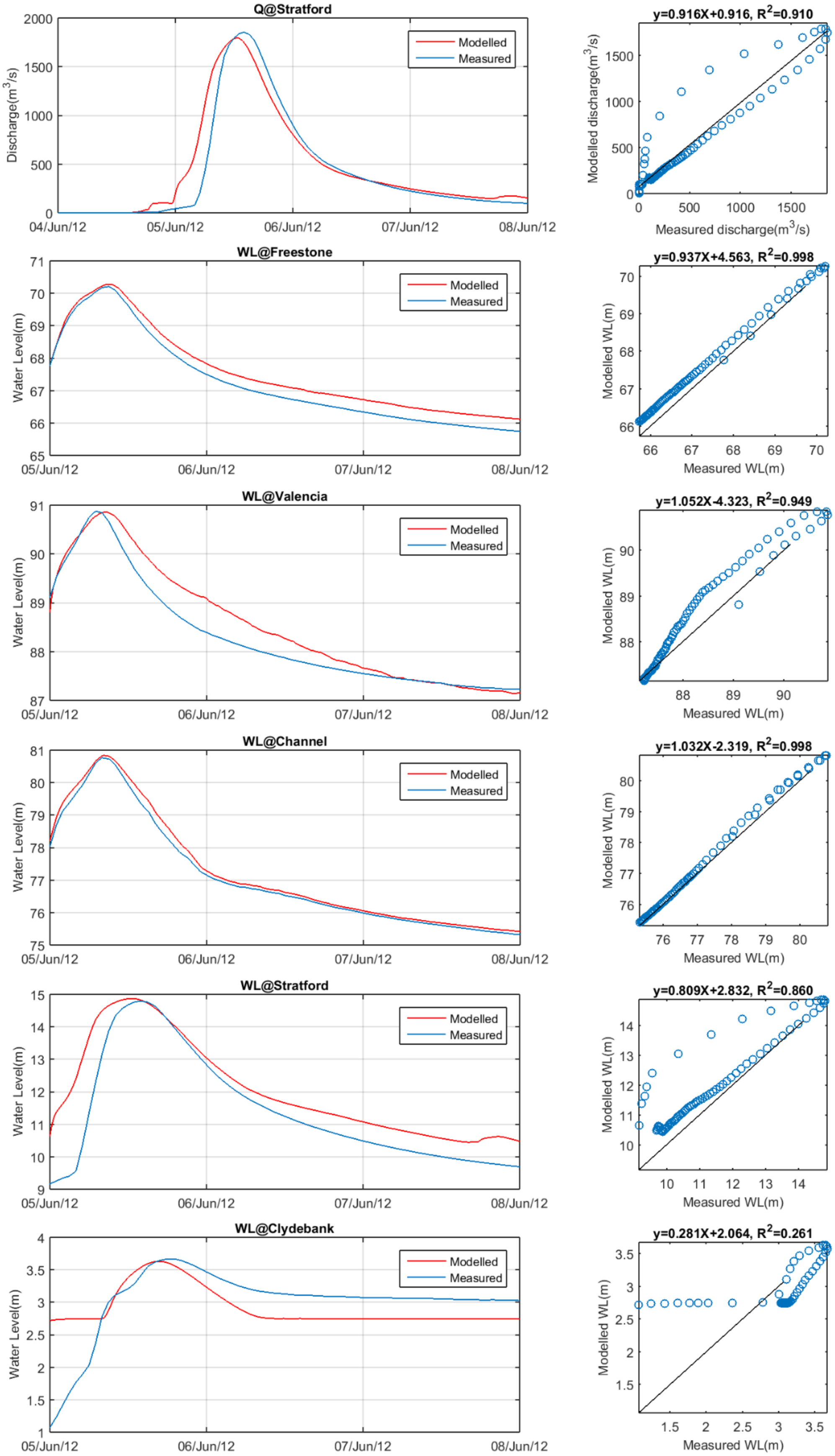

Figure 5-2 Calibration flow and water level results at Stratford and Clydebank gauges, June 2012 event (Clydebank roughness 0.05)

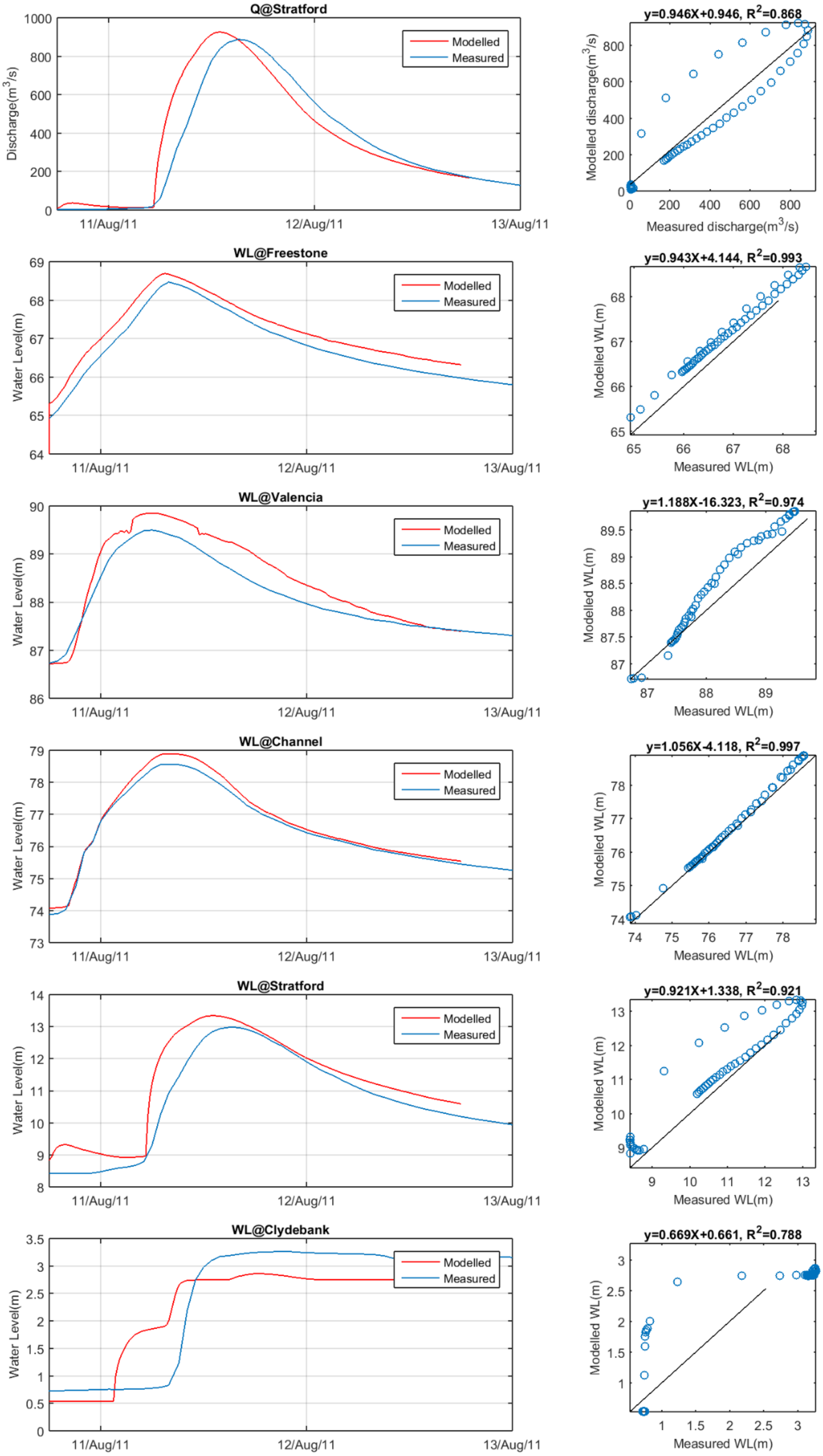

Figure 5-3 Validation flow and water level results at Stratford and Clydebank gauges, August 2011 event (Clydebank roughness 0.05)

5.2.2 Observed Flood Levels and Extents

Apart from river gauges, other observed data was available to verify the calibration and validation events. These include spot levels taken by WGCMA immediately after flooding and digitised flood extents based on aerial imagery. This analysis has been undertaken for the 2007, 2012, and 1990 flood events where sufficient data was available for comparison purposes.

June 2007 Event

Observed flood data for the June 2007 flood event includes 46 surveyed flood marks and a digitised flood extent downstream of Stratford. These flood marks and flood extents were compared to calibrated model results.

Figure 5-5 shows the spatial distribution of these flood marks within the model area. Over 30% of flood marks have less than 200mm difference between measured and modelled results, and over 75% of flood marks are within 600mm. The histogram in Figure 5-4 shows the distribution of difference between the modelled and measured flood marks, with a general trend of modelled water level being lower than measured water level. This discrepancy in the modelled levels and the available post flood survey was not expected given the favourable comparison to the water level gauging stations. This may be associated with the inherent inaccuracies of post event surveyed flood levels, such as estimated peak flood heights and debris lines, and human error; and the inherent model limitations already discussed.

Digitised flood extents are also available for the June 2007 Event. These extents start approximately 1km downstream of Stratford and continue to the Avon River outlet. The digitised and modelled flood extents are very similar, as shown in Figure 5-6.

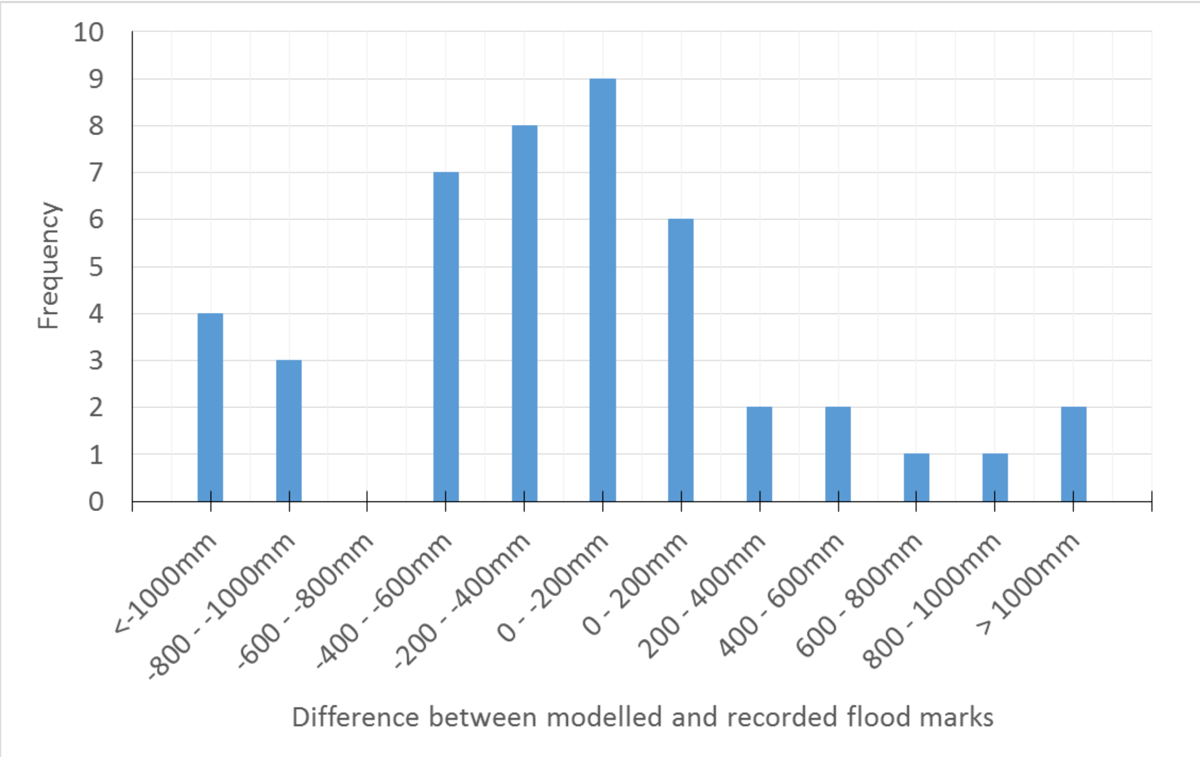

Figure 5-4 Histogram of Modelled and Measured Flood Mark Difference for 2007

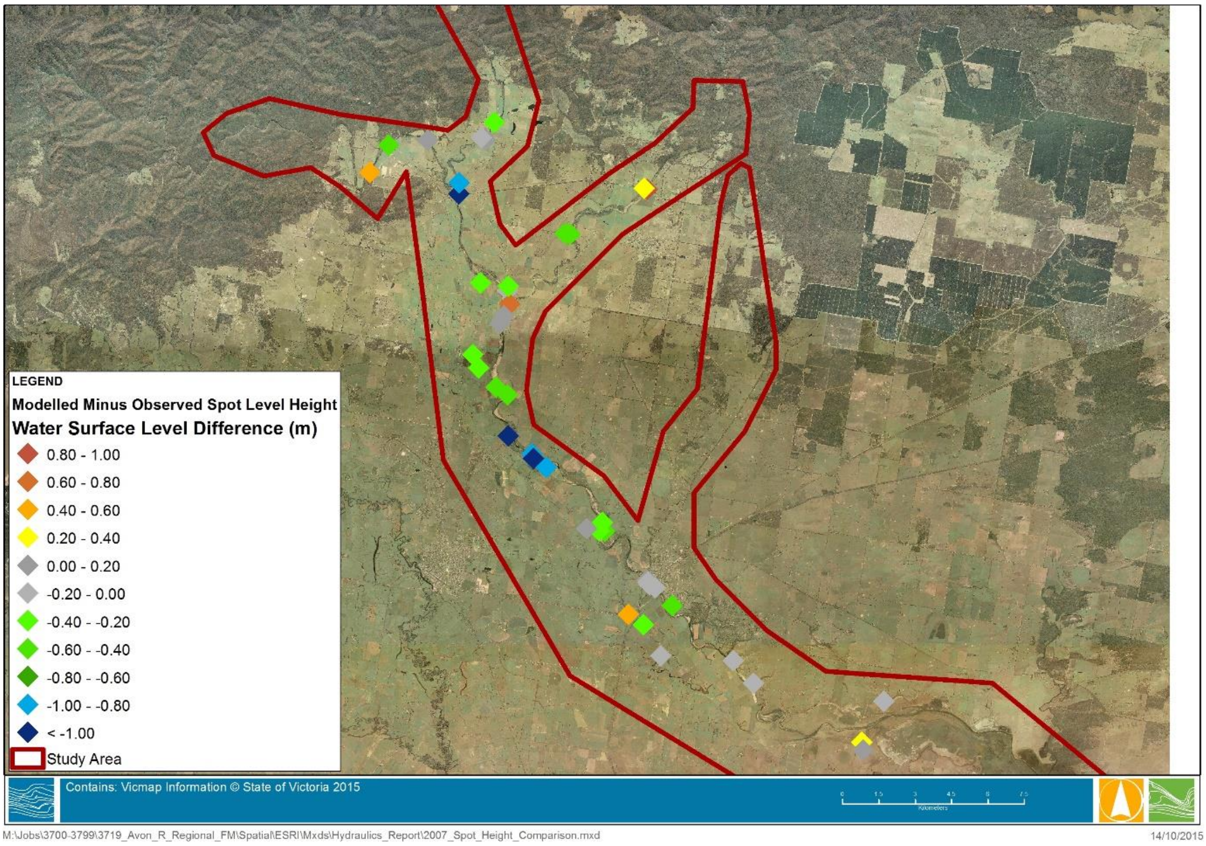

Figure 5-5 June 2007 modelled and observed spot level difference

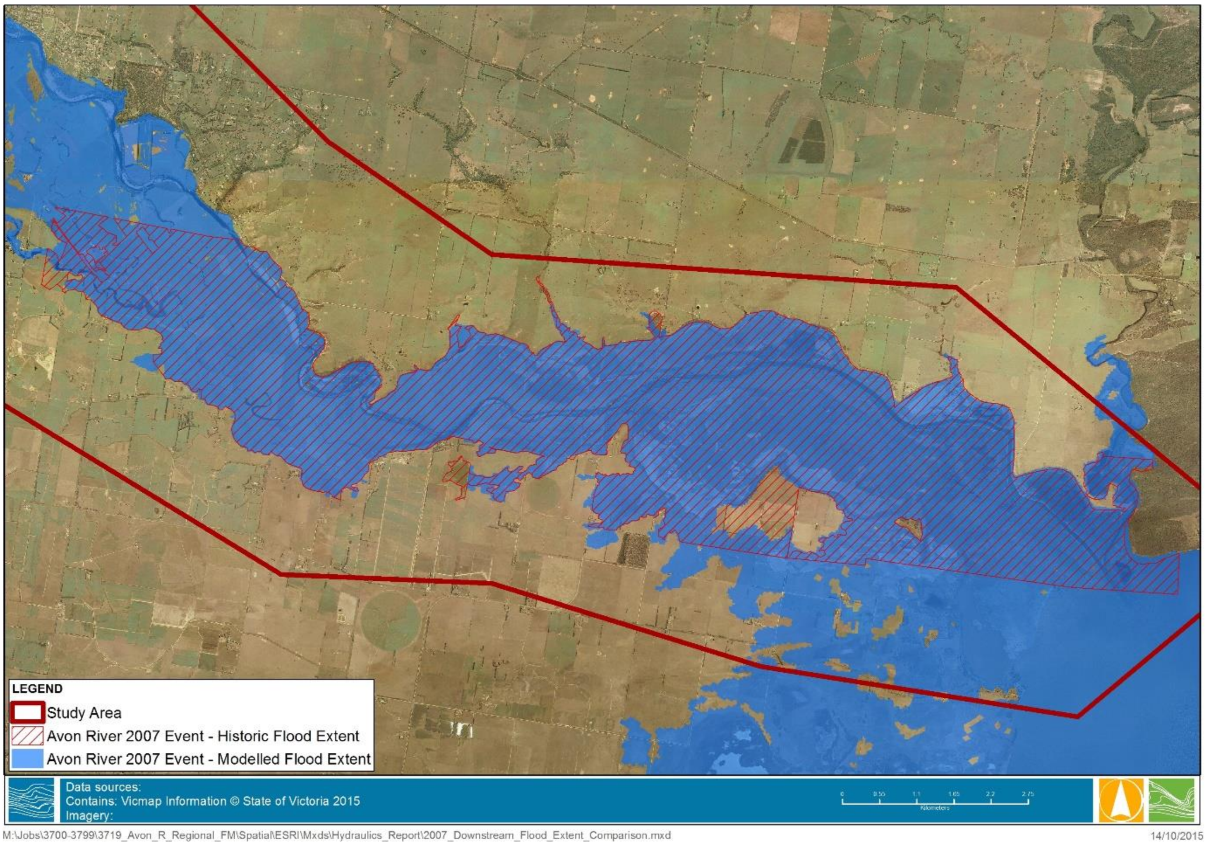

Figure 5-6 June 2007 modelled and observed downstream flood extent

June 2012 Event

Observed flood data for the June 2012 flood event includes 12 surveyed flood marks and a digitised flood extent around Stratford. These flood marks and flood extents were compared to calibrated model results.

Figure 5-8 shows the spatial distribution of these flood marks within the model area. Of the 12 flood marks, nine of them were within 300mm difference between modelled and measured values. The other three flood marks are in relatively small floodplain flow paths that are not picked up within the model topography. The histogram in Figure 5-7 shows the distribution of difference between the modelled and measured flood marks.

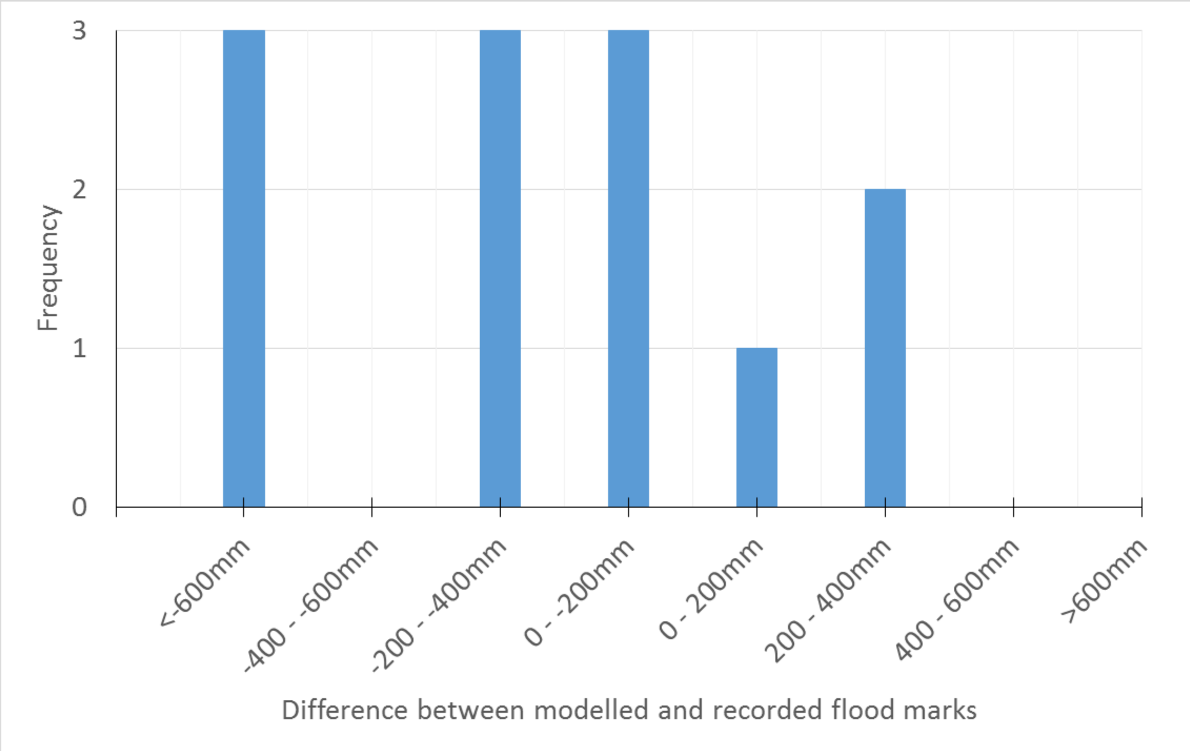

Figure 5-7 Histogram of Modelled and Measured Flood Mark Difference for 2012

Digitised flood extents are also available for the June 2012 Event. These extents start approximately 3 km upstream of Stratford and continue to the Avon River outlet. The digitised and modelled flood extents are very similar in the downstream extent, as shown in Figure 5-9. There are significant differences between the flood extents adjacent to Stratford and the immediate downstream area. The reliability of the digitised flood extents is unknown, as an exact time of capture is not noted in the data. It seems likely that the photos were not captured at the time of peak inundation, as key flow paths are visible, but shallow flow paths only visible around peak flow times are not visible.

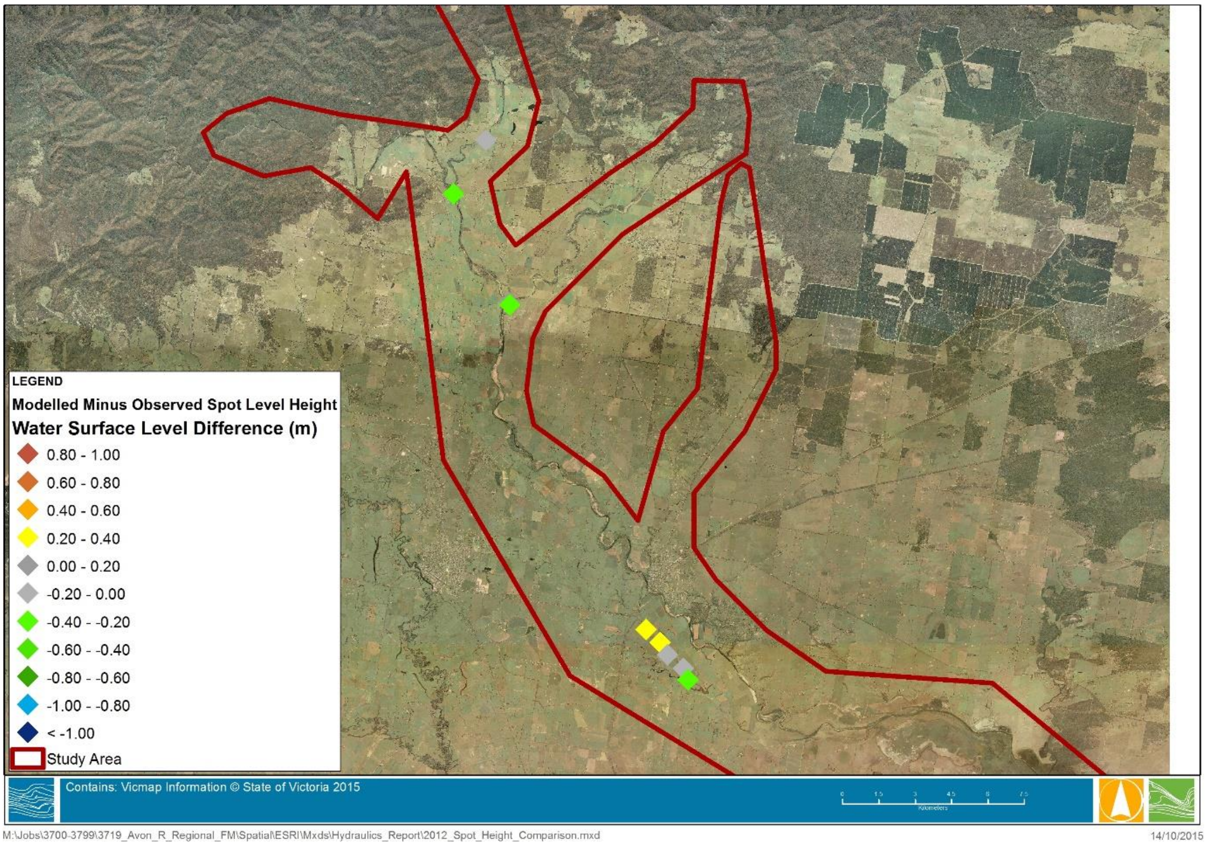

Figure 5-8 June 2012 modelled and observed flood extent and levels

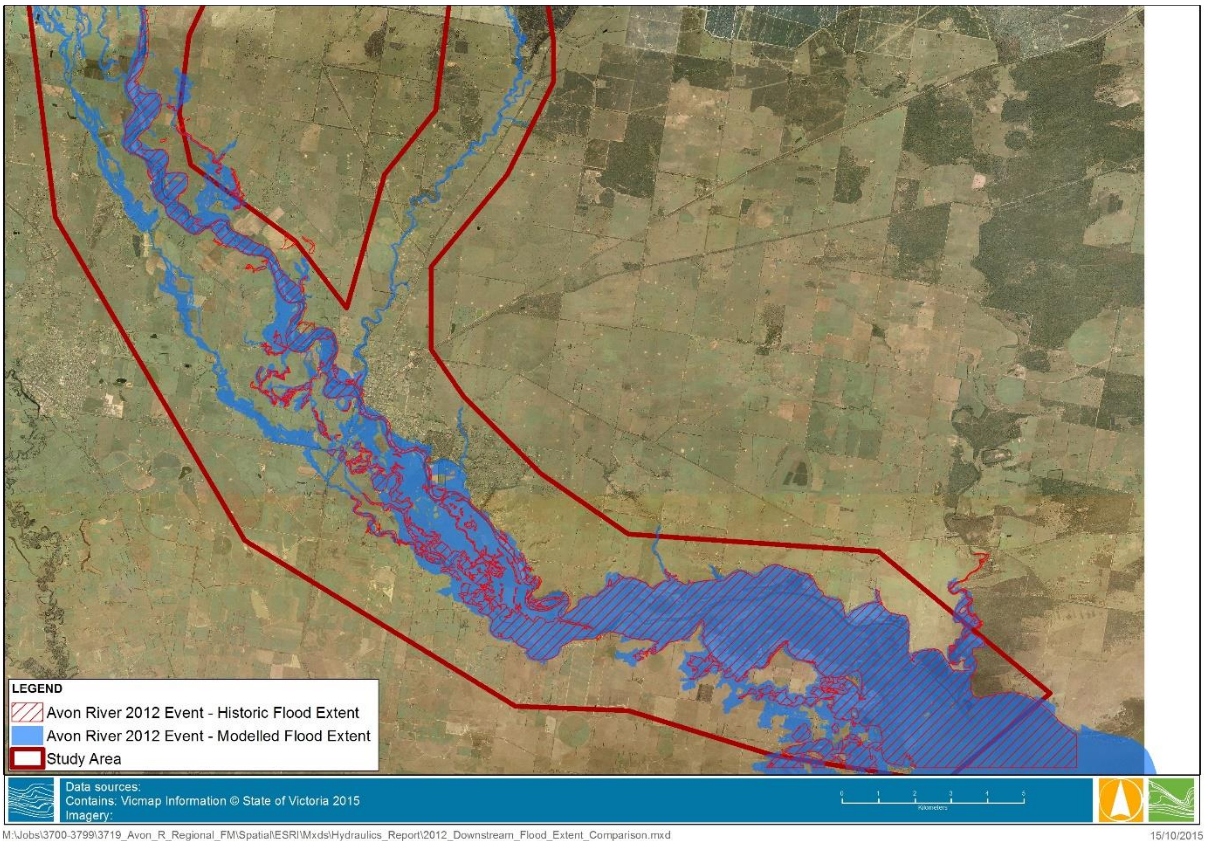

Figure 5-9 June 2012 modelled and observed downstream flood extent

April 1990 Event

Observed flood data for the April 1990 flood event includes 608 surveyed flood marks and a digitised flood extent from Valencia Creek to Stratford. The high number and spatial variation of these flood marks was used to validate water levels in the downstream floodplain, although this comparison is somewhat qualitative as there were no gauged inflows for Valencia Creek for this event and an assumed hydrograph was applied to the model for this boundary.

The 1990 event was tested using a range of roughness values (both river and floodplain) to assess which floodplain roughness (0.05 or 0.04) gave the most accurate water levels in the ungauged Avon floodplain on the western extent of the study area. This area was typically not inundated during the calibration and validation events and therefore its sensitivity to roughness values could not be assessed from the model results for these events.

The 1990 simulation showed that a roughness value of 0.05 resulted in the best fit for water levels , with 34% of flood marks within 200mm of the surveyed level, whilst a roughness of 0.04 resulted in only 17% of values within this range. There was also over 200 flood marks outside of modelled flood extent in both simulations. This is thought to be due to the fact that post-flood surveying also considered small tributaries, which are too minor to be resolved in the regional scale modelling. The histogram in Figure 5-10 shows the distribution of difference between the modelled and measured flood marks for both model runs, whilst Figure 5-11 shows the spatial distribution of these flood marks.

Based on these results it was agreed with the project steering committee to increase the adopted floodplain roughness for simulation of design events.

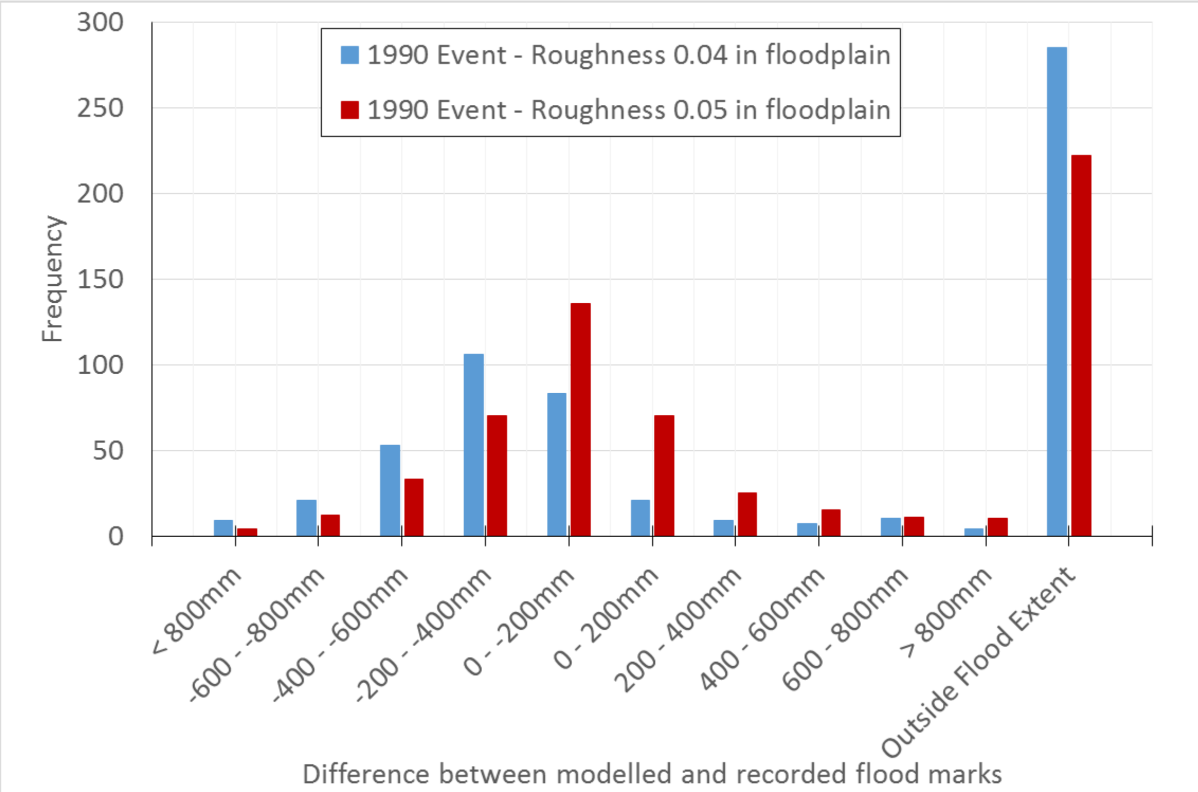

Figure 5-10 Histogram of Modelled and Measured Flood Mark Difference for 1990 Event

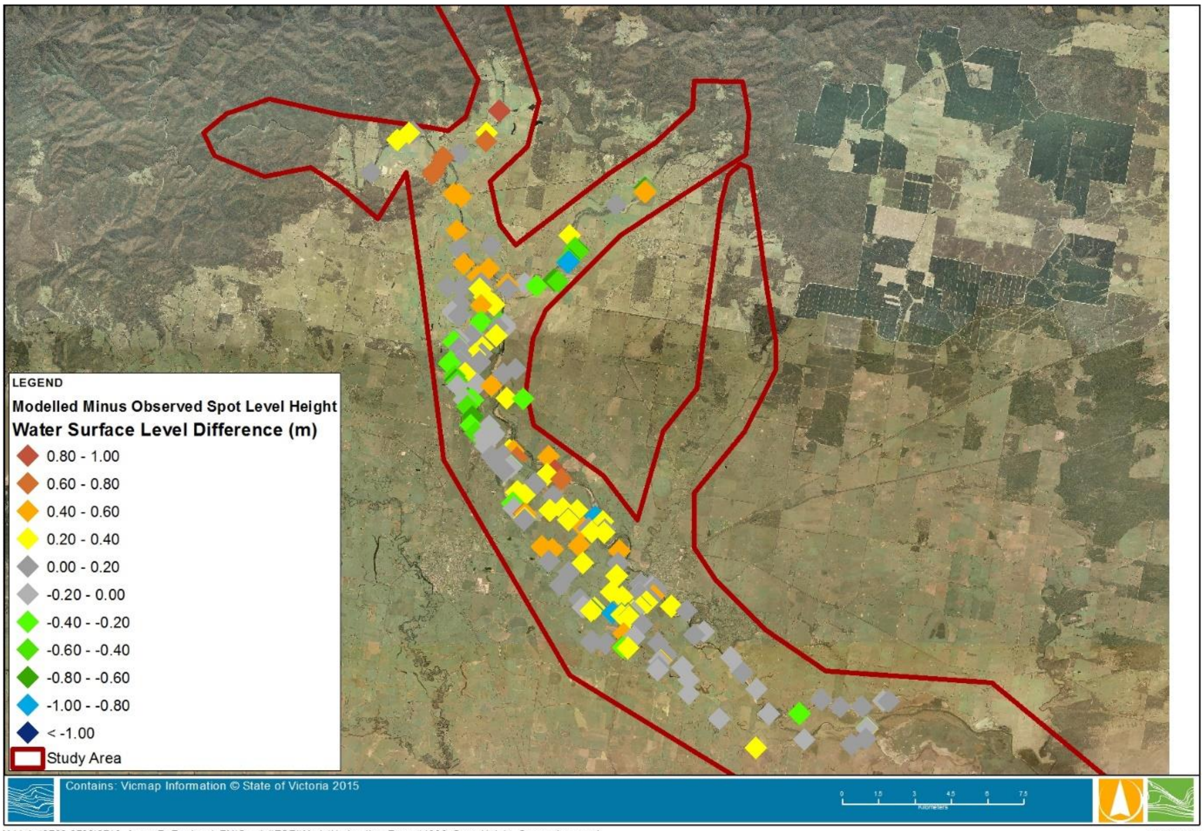

Figure 5-11 April 1990 modelled and observed spot level difference

5.3 Sensitivity Tests

5.3.1 Roughness

Sensitivity to channel and wetland roughness values was tested using the calibration and validation events. Consistent effects were found across the three modelled events, indicating that sensitivity to channel and wetland roughness was independent of event magnitude.

In the Avon River, when roughness was increased from 0.035 to 0.04, flood levels were increased at Stratford and Clydebank by around 0.2-0.3 m, but there was no discernible lag in the timing of the peak. The timing of peak flows in the lower part of the system appears to be largely insensitive to roughness parameters, while peak water levels are quite sensitive.

In Valencia Creek, when roughness was increased from 0.015 to 0.025, flood levels were locally increased by 0.1-0.2 m. This meant a more accurate calibration occurred during the lower roughness case of 0.015. This is considered very low for a natural channel. However, due to the seemingly reliable gauging at Valencia Creek, it was decided to adopt the lower roughness case based on the calibrated water levels.

In Freestone Creek, when roughness was increased from 0.04 to 0.05, flood levels were locally increased by around 0.2 m. There was negligible impact on peak flows, levels and timing at Stratford from altered roughness in Valencia and Freestone Creeks.

In and around Clydebank morass, when roughness was increased from 0.05 to 0.06, flood levels were locally increased by around 0.2 m.

Testing was also undertaken in the Avon River and floodplain between Valencia Creek and Stratford, using the 1990 event validation marks, as discussed in Section 5.2.2. The water level on the floodplain was found to be sensitive to roughness. The water level in this area was most accurately validated with a roughness of 0.05.

The adopted model roughness parameters are displayed in Section 4.2.4, and are a direct outcome from roughness sensitivity testing.

5.3.2 Scour

A consideration during the calibration of this hydraulic model to historic flood events is the scale of channel change that occurs as a result of large floods. The incision of the Avon River channel has created knickpoints in the inflowing tributaries, notably Blackall Creek, Valencia Creek and Freestone Creek which change both the channel slope as well as the hydraulic gradient of these streams. Erosion following European settlement over the last century has resulted in the lower reaches of the Avon comprising of an enlarged sand bed stream which is mobilised during large flood events. A hydraulic modelling study of the lower Snowy River which has a similarly mobile sand bed character upstream of Orbost found that the sand bed could scour during a flood event in the order of metres, which had a significant effect on flood levels and overbank flows.

It is expected that large flood events in the Avon River will generate a channel bed response. Therefore, as well as assessing the impact of channel roughness changes on water levels, a sensitivity test was undertaken for the impact of bed level change on flood levels in the river. To do this, the channel bed elevation was reduced by 0.5m for the entire channel downstream of Valencia Creek / Avon River confluence to replicate a condition where large volumes of sand are mobilised during a flood.

The modelled results showed local reductions in flood level at Stratford of around 0.25 m in the June 2012 event, with impacts of channel bed scour generally confined to the Avon River channel. It was found that changes to floodplain and channel roughness has a more significant impact on flood level than scouring of the channel bed.

Whilst scour is a key mechanism in the movement of sediment in the current geomorphological regime of the Avon River system, it is unlikely to have a major impact to results produced by this study. The impacts of scour fall within the model uncertainties already presented in Section 3.3.

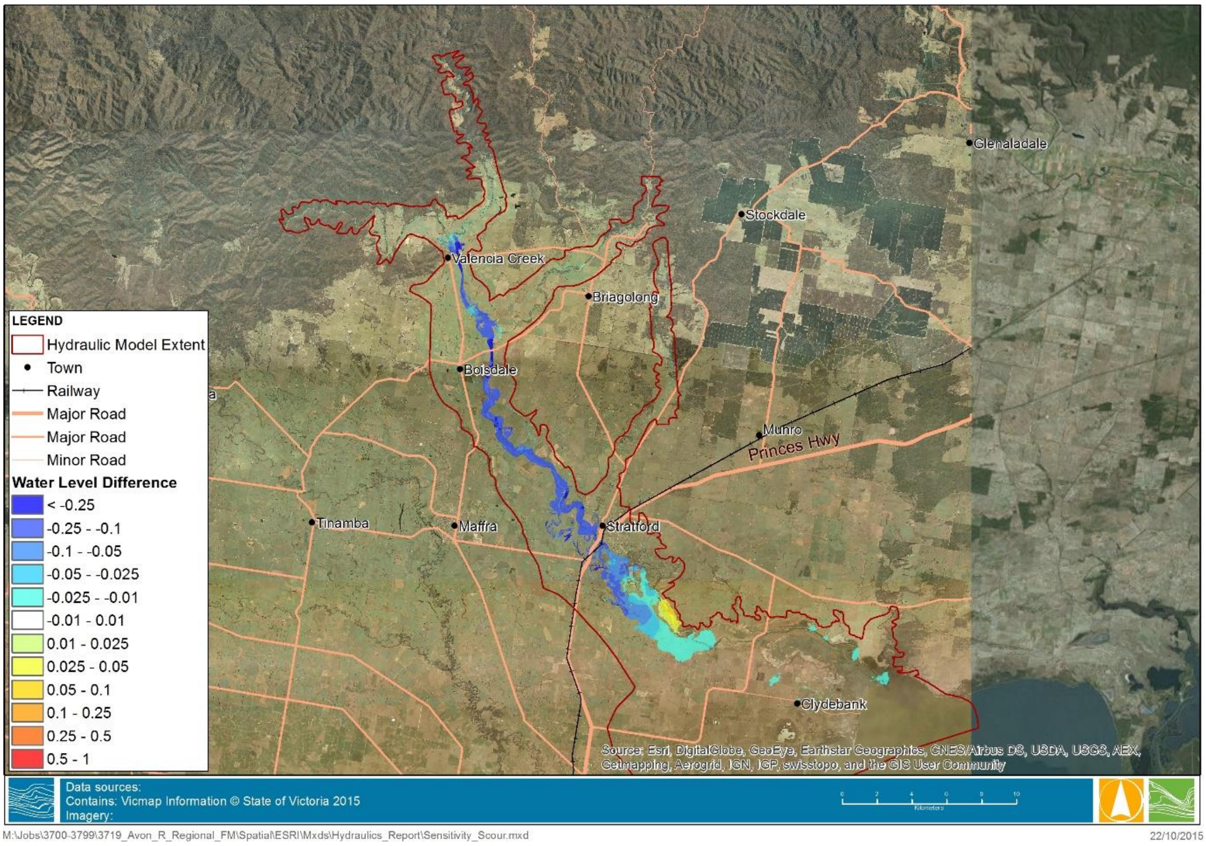

Figure 5-12 Water level difference between scoured and non-scoured Avon River channel for June 2012 event

5.3.3 Lake Wellington

Sensitivity of the modelled flood levels along the Avon River to the water level of Lake Wellington was assessed through the following scenarios:

- 1% AEP catchment generated flood event, with a 1% AEP Lake Wellington flood level (2.5 m AHD).
- 1% AEP catchment generated flood event, with a 10% AEP Lake Wellington flood level (1.3 m AHD).

The 1% AEP Lake Wellington design level was defined by Grayson, et. al. (2004), however the 10% AEP level was extrapolated from the values provided in the report.

The results of the assessment are shown in Figure 5-13 and Figure 5-14. As would be expected, the higher initial water level in Lake Wellington increases flood levels in the Avon River, with the impacts locally significant in Clydebank area, reducing rapidly upstream to around 0.05 m at Bengworden Road, and <0.05m at Stratford. The downstream conditions had no impact on the timing of the flood peak throughout the river. The difference in water levels is shown in Figure 5-15.

This analysis shows that whilst significant in the lower floodplain around Clydebank, Lake Wellington levels have no significant influence in areas upstream of Bengworden Road.

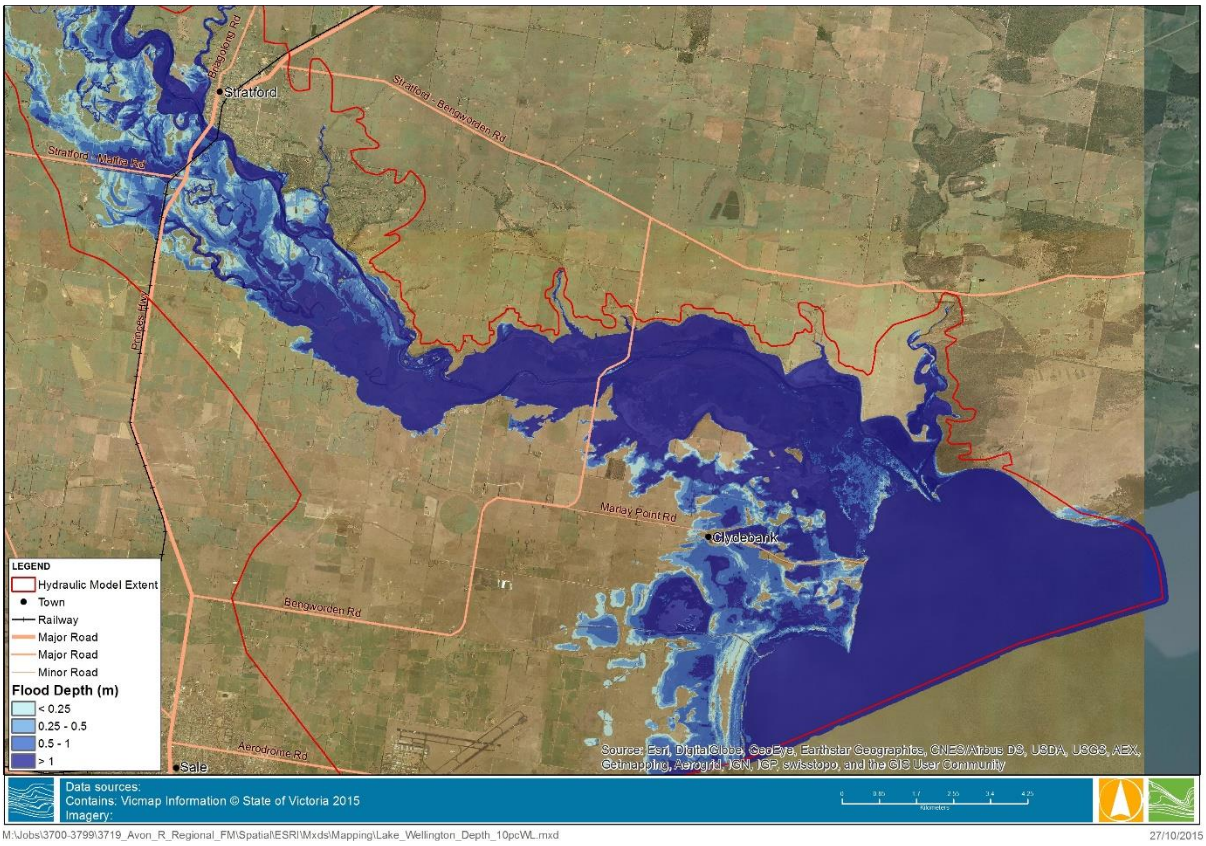

Figure 5-13 1% AEP flood event with 10% AEP Lake Wellington level

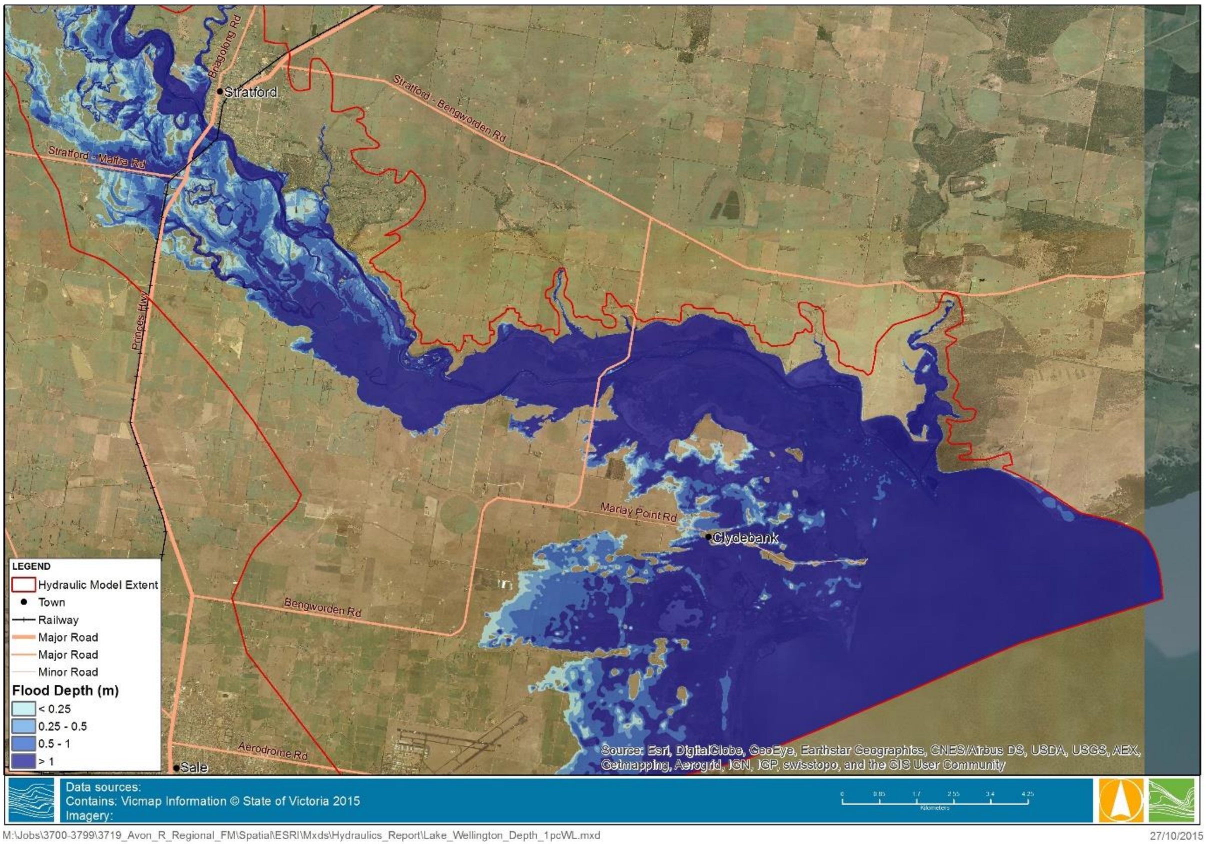

Figure 5-14 1% AEP flood event with 1% AEP Lake Wellington level

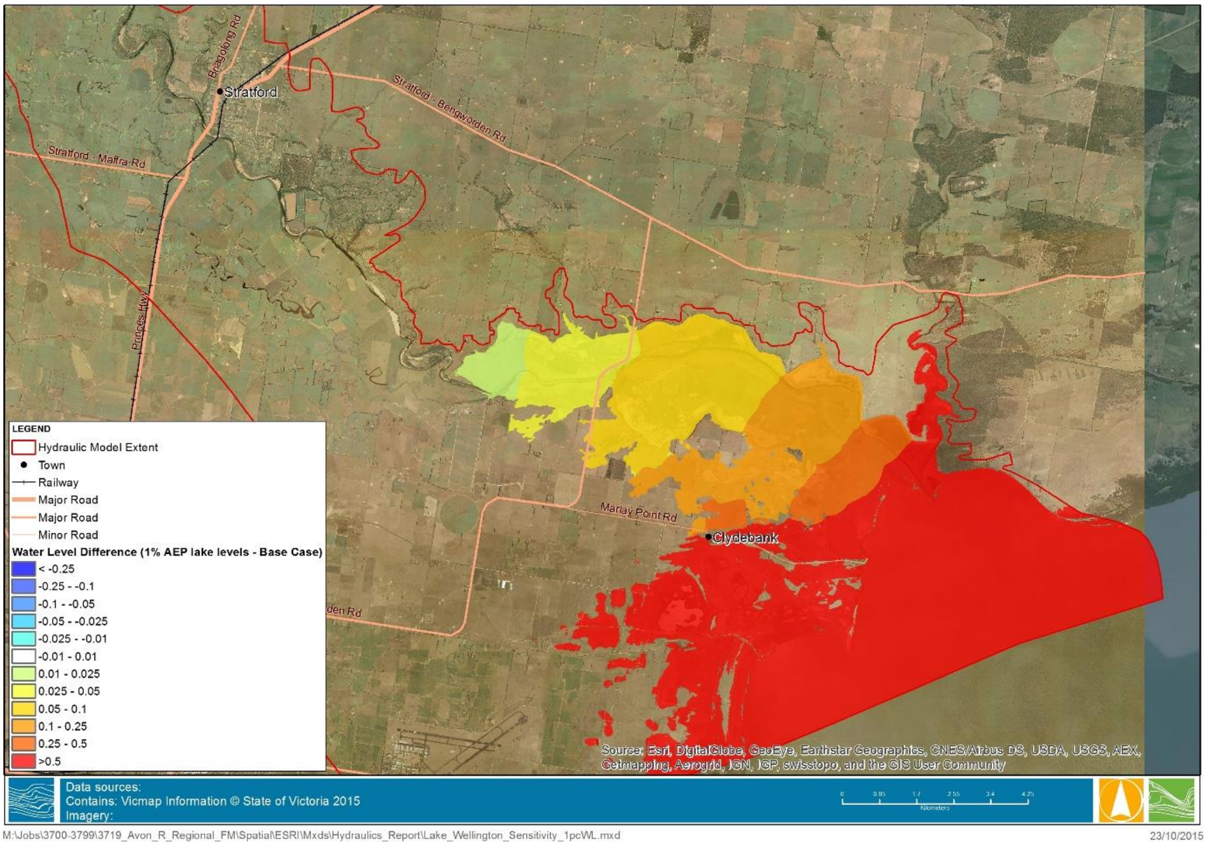

Figure 5-15 **Water level difference between 1% AEP and 10% AEP Lake Wellington level for 1% AEP event**

5.3.4 Nuntin Levee/Spillway

A significant concern in the downstream area of the Avon River is the possibility of an avulsion developing between the Avon River and Nuntin Creek. This area has undergone significant geomorphic change over the past. The creek entrance was protected with a levee (the Nuntin Levee), which was scoured out by flooding in 2007 and replaced with a spillway, which was then later reconstructed into a levee again in 2014. A sensitivity test was undertaken to compare flood level conditions for the situation where the levee is scoured as per post-2007 flood conditions, to the 2013 conditions with the Nuntin spillway in place at 8.4m AHD. The sensitivity tests applied the 20% AEP flood event, as the structure was designed to be overtopped for floods greater than the 20% AEP event.

The results indicated that the flood level just downstream of the spillway was increased by approximately 0.05 m, and out on the broader Nuntin Creek floodplain, levels were increased by approximately 0.01-0.03 m with the spillway in place. In the Avon River main channel and floodplain, levels were locally decreased by around 0.03 m.

A further sensitivity test was undertaken for the case where the Nuntin levee is at its current height of 9.4m AHD, compared to the previous Nuntin spillway level at 8.4m AHD. The results showed similar, but more extensive, impacts to the previous sensitivity case, with localised increases and decreases on rural properties within the vicinity of the levee.

Based on these results it is considered that the Nuntin levee configuration has a significant impact on flood levels locally, especially during large floods. However, flood levels in the wider floodplain and key townships are not sensitive to the levee height. The current height of the structure at 9.4 m AHD was included in the model DEM for the design flood event modelling.

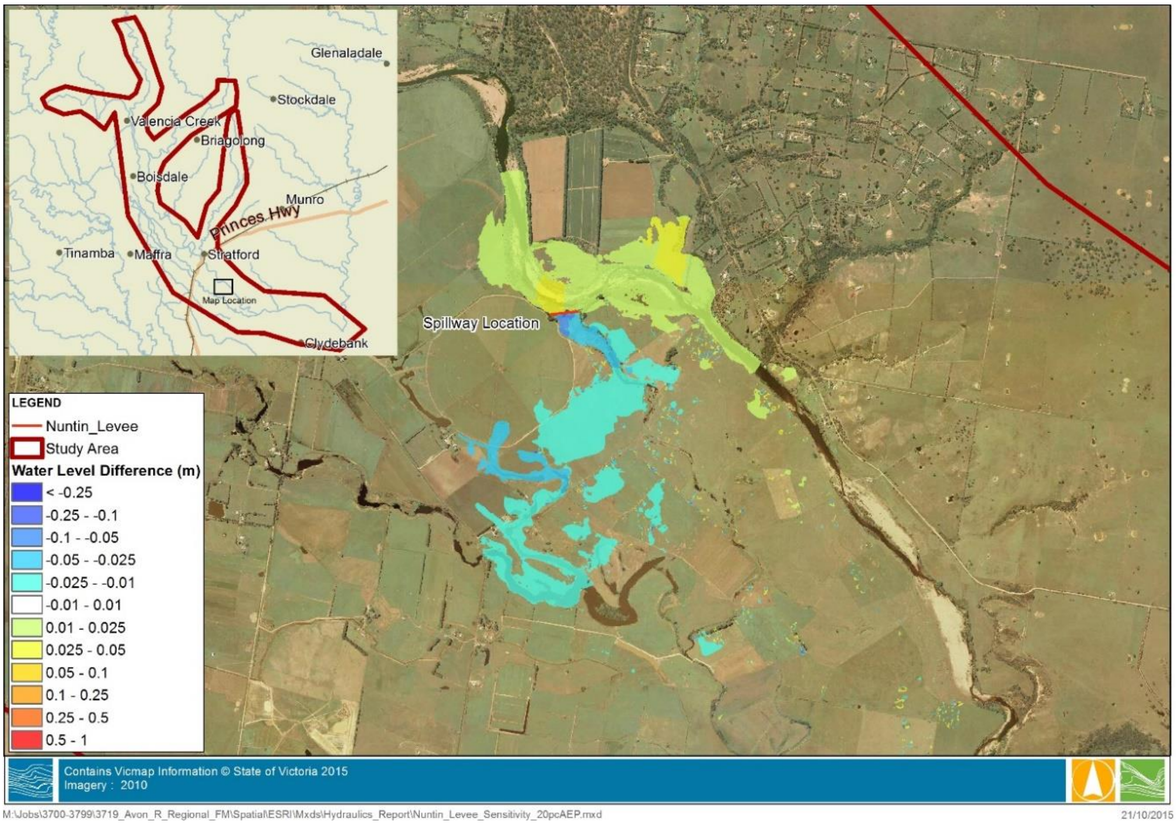

Figure 5-16 **Water level difference at Nuntin Creek for a 20% AEP flood event (with and without the Nuntin spillway)**

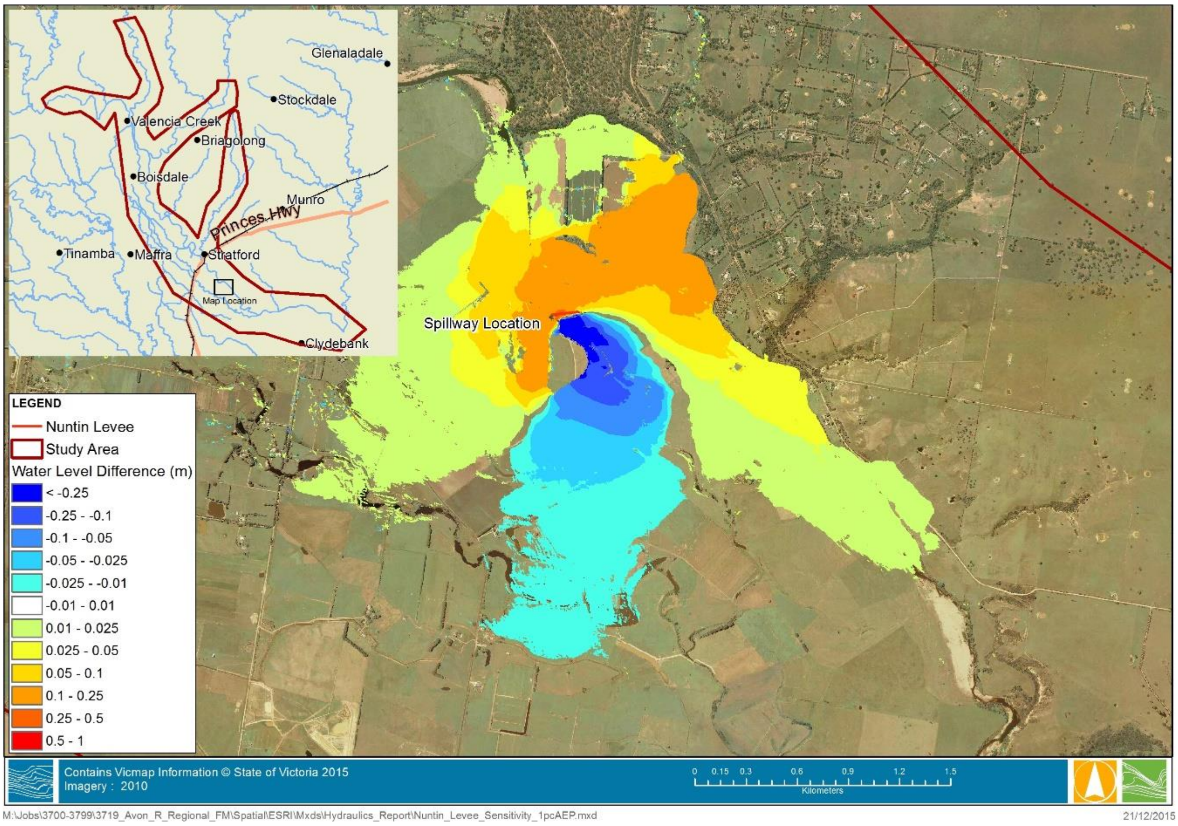

Figure 5-17 **Water level difference at Nuntin Creek for a 1% AEP flood event (with Nuntin levee at 9.4m AHD compared to 8.4m AHD)**

5.3.5 Structure Blockage

A structure blockage scenario was also assessed to determine the effect partially blocked structures would have on the flooding regime. The Upper Avon catchment is steep and heavily forested, presenting conditions that allow for high debris availability and mobility, and it is likely that during a flood there would be debris transported down the Avon River. However, structures on the river are either low flow weirs or large bridges.

For this structure blockage sensitivity test, ARR Draft Project 11: Blockage of Hydraulic Structures (2014) was consulted. Whilst the Avon catchment was found to have a high risk of debris, the large span of bridge structure across the river suggests there would be limited blockage during flood events.

For structure blockage modelling purposes, a 10% blockage was applied to all bridge structures in the model, as recommended by ARR (2014) for structures with much larger spans than likely debris size. Causeways included in the model were not blocked for this assessment, as it is assumed these structures would be significantly overtopped by the time debris has been transported to their location during a flood event.

Results from the structure blockage show less than 50mm upstream increases in water level, and the impacts are generally confined to within 50m upstream of the structure. These impacts are not thought to be significant in a regional model scale.

5.4 Flood Event Behaviour

The flood behaviour in the study area for each of the calibration events is described in this section. The time series of results was analysed to understand the relative timing of flooding at different locations and how local infrastructure performed for each flood event.

5.4.1 June 2007

The June 2007 event was the largest calibration event modelled. In the 2007 event Blackall Creek was the first significant flow into the model, as it had a much shorter response time than the main tributaries. Blackall Creek did not cause any significant flooding within the catchment, and peaked before the other tributaries reached the confluence of Avon River and Blackall Creek.

In the upper catchment area, the major creek confluences were the primary locations of flooding. Water in the Upper Avon, Valencia Creek and Freestone creeks generally remained confined to channel and other recognised flow paths. Water levels at the Valencia Creek-Avon River confluence peaked at approximately 8:30PM on the 27 June 2007, which is 12 hours after the peak rainfall in the upper catchment. In this area there was not any major flooding apart from existing floodplain channels. Downstream of this, at the Avon River–Freestone Creek confluence there is a significant breakout on the western side of the river that heads towards Boisdale. This breakout first occurred at approximately 6:00PM on the 27 June, which is 9.5 hours after peak rainfall in the upper catchment area. In the event floodwaters from this breakout did not reach Boisdale, as the volumes overtopping the Avon channel were absorbed by a secondary channel immediately east of Boisdale, known as Boisdale Drain 1. Instead, this water inundated agricultural land and joined back to the Avon River approximately 3km downstream of the original breakout. This upstream breakout is shown in Figure 5-20. Rainfall in local catchments also caused some nuisance flooding in the eastern side of the Avon River in the upstream areas around Boisdale.

At approximately 6:00PM on the 27 June 2007 (9.5 hours after peak rainfall in the upper catchment), water first broke out significantly from the Avon River in the lower catchment areas. The first breakout was near Stewarts Lane crossing, approximately 3km upstream of Stratford, as shown in Figure 5-18.

Water from this breakout headed west towards a tributary of Nuntin Creek, and caused flooding in predominately agricultural land. Almost immediately after the first breakout flow, numerous other breakouts around Stratford and downstream of Stratford caused an almost unbroken flow path between Nuntin Creek and the Avon River. Water travelling down Nuntin Creek and its tributaries was obstructed by the raised Princes Highway and railway line embankments. This caused increased water levels upstream of these embankments, as shown in Figure 5-18. This floodplain was almost 2km wide and extends for approximately 10km downstream of Stratford, as shown in Figure 5-19. This floodplain appears to be used for agricultural purposes, based on recent aerial imagery. Water levels peaked at Stratford at approximately 11:00pm on the 27 June, 14.5 hours after peak rainfall in the upper catchment. The land remained inundated for approximately 24 hours, before retreating during the night on 28 June. The township of Stratford sat above the floodwaters and does not experience inundation. Downstream of the confluence of the Avon River and Nuntin Creek, Clydebank wetlands were significantly inundated, and remain so until the model ends on the 1 July 2007, almost four days after inundation first started.

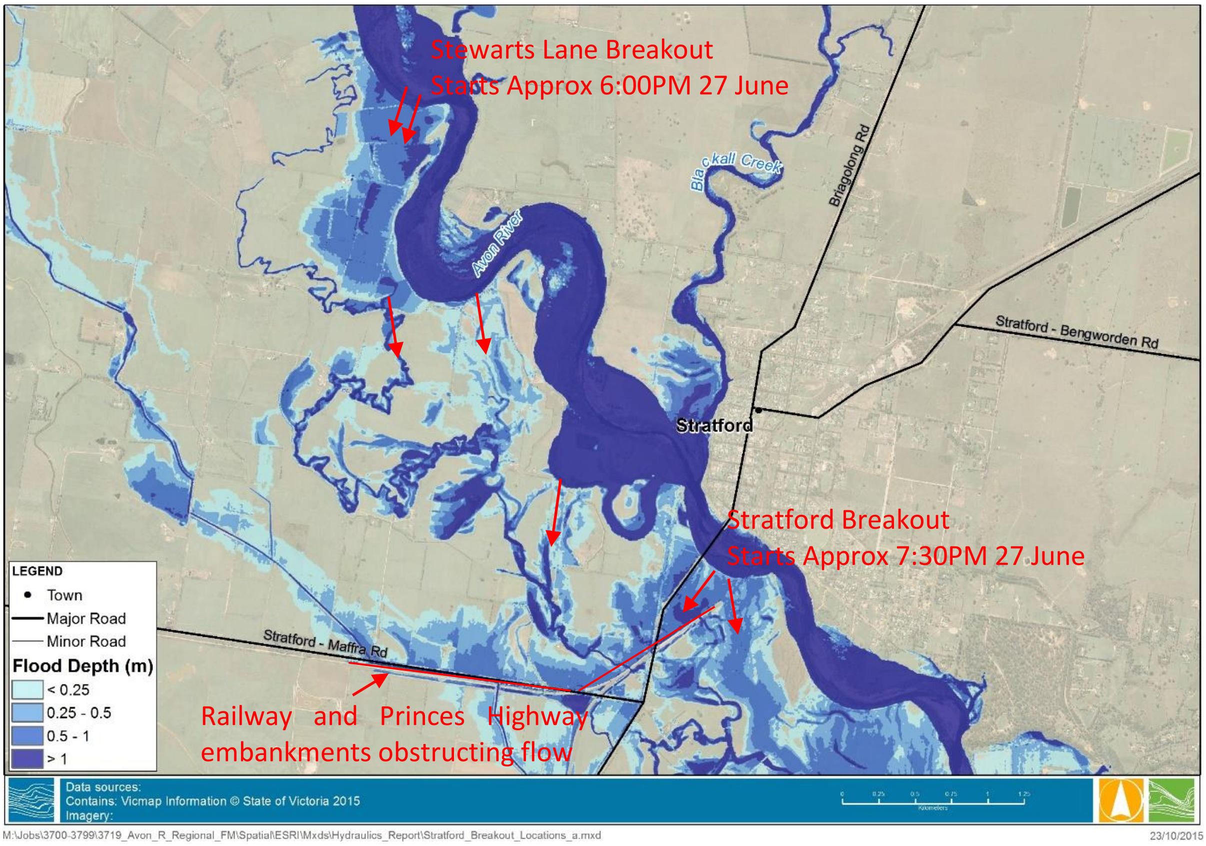

Figure 5-18 Avon River breakout locations during June 2007 flood around Stratford

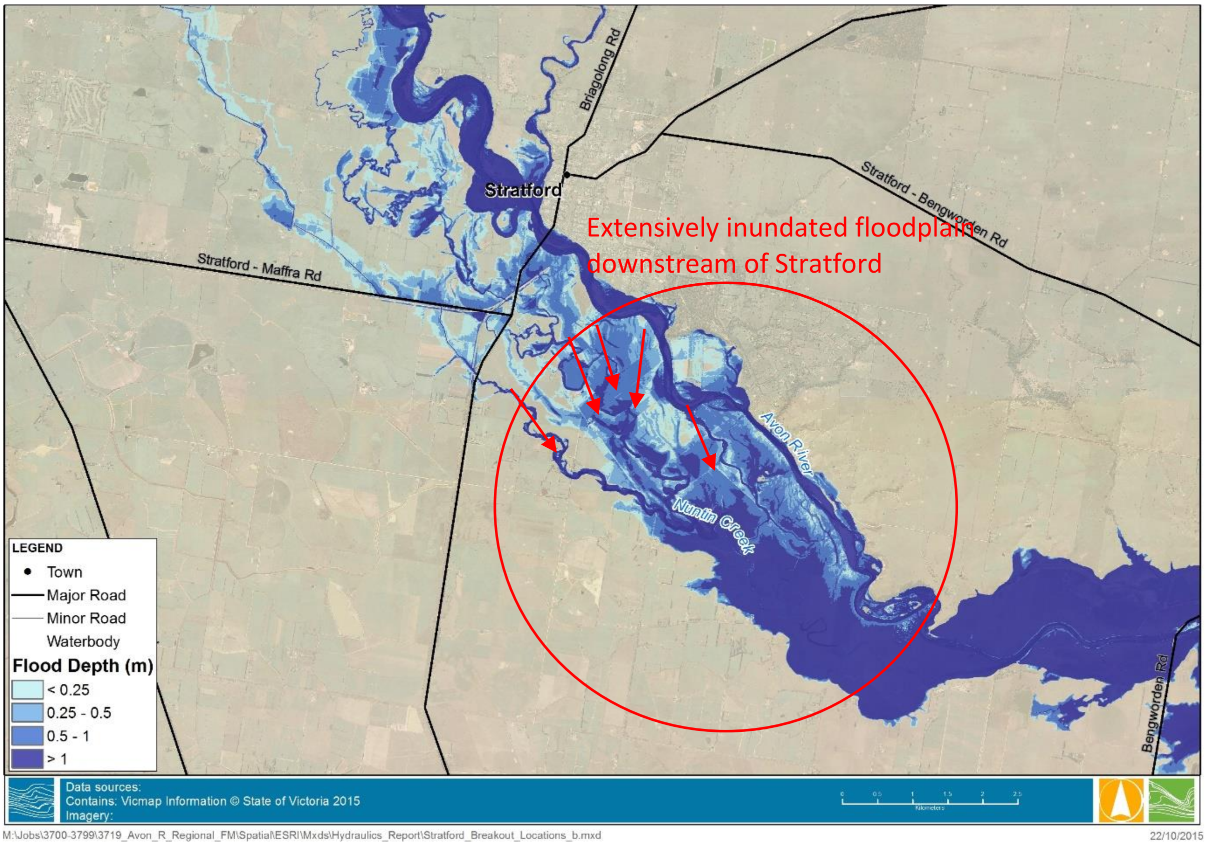

Figure 5-19 Avon River and Nuntin Creek confluence downstream of Stratford in June 2007 flood

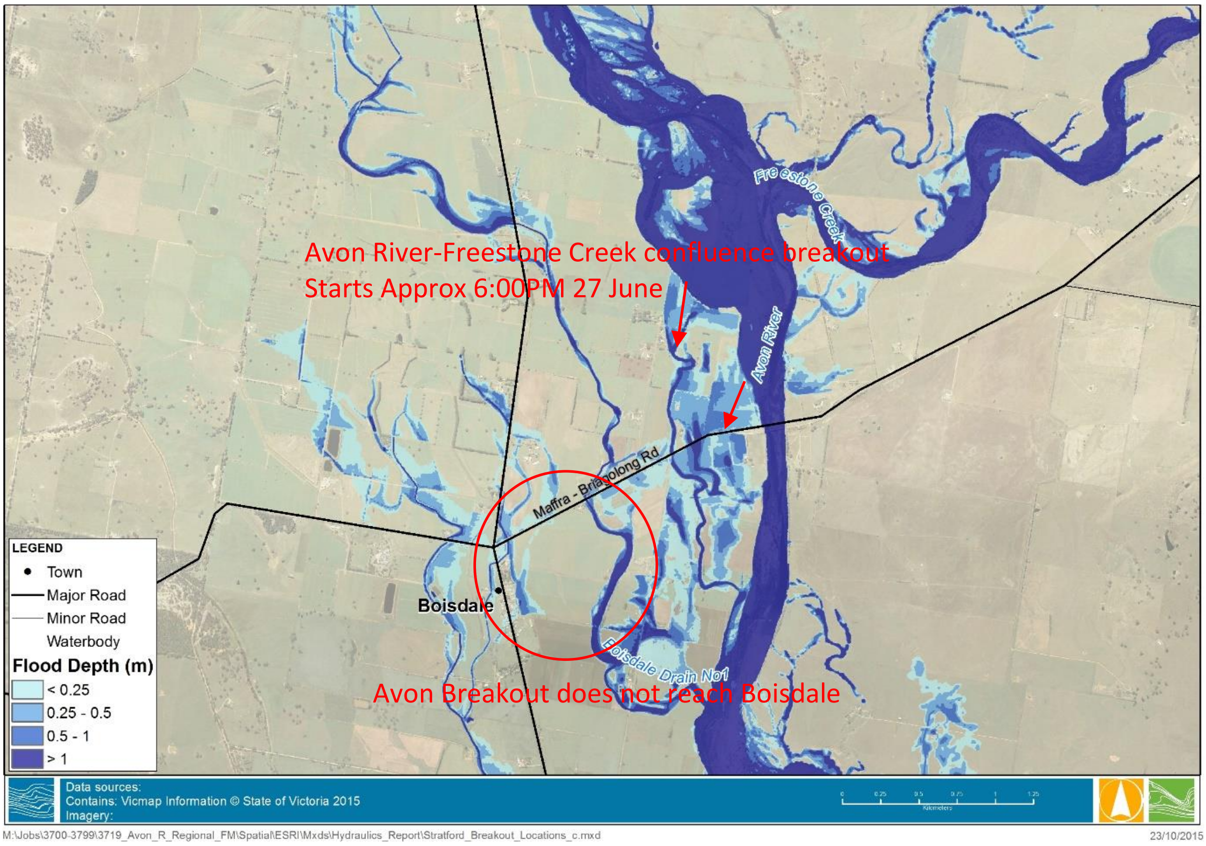

Figure 5-20 Avon River and Freestone Creek confluence near Boisdale in June 2007 flood

5.4.2 August 2011

The August 2011 event was the smallest event modelled. In the 2011 event similar timings were experienced to the 2007 flood, except Avon River flows were kept within channel.

In the upper catchment near Boisdale and around the Stratford area, which are the major locations of breakouts in larger flood events, there was no water that leaves the Avon River channel. At the Avon River-Valencia Creek confluence water levels peaked at approximately 9:30AM on the 11 August, which is approximately 16.5 hours after peak rainfall in the upper catchment. At the Avon River-Freestone Creek confluence water levels peaked at approximately 10:00AM on the 11 August, 17 hours after peak rainfall in the upper catchment. Water levels at Stratford peaked at approximately 1:00PM on the 11 August, 20 hours after peak rainfall in the upper catchment.

Floodplain areas downstream of Stratford near the confluence of Nuntin Creek and the Avon River were heavily inundated as per larger floods, however to a lesser extent than the 2007 and 2012 events.

5.4.3 June 2012

The June 2012 event was smaller than the June 2007 event but larger than the August 2011 event. In the 2007 event Blackall Creek was the first significant flow into the model, this remains the same for the 2012 event. Blackall Creek did not cause any significant flooding within the catchment, and peaked before the other tributaries reached the confluence of Avon River and Blackall Creek.

In the upper catchment area there was no breakouts from the Avon River. The June 2007 event showed a breakout at the Avon River–Freestone Creek confluence, but this was not visible in the June 2012 event. Water levels peaked in the upper catchment area at approximately 10:00AM on 5 June 2012, 17 hours after peak rainfall in the upper catchment.

At approximately 6:30AM on the 5 June 2012, water first broke out significantly from the Avon River, 13.5 hours after peak rainfall in the upper catchment. The first breakout was near Stewarts Lane crossing, approximately 3km upstream of Stratford. Water from this breakout headed west towards a tributary of Nuntin Creek, and caused flooding in predominately agricultural land, as per the 2007 event but of a lesser extent. Almost immediately after the first breakout flow, numerous other breakouts around Stratford and downstream of Stratford caused inundation between Nuntin Creek and the Avon River that extended for approximately 10km downstream of Stratford. The water level peaked at Stratford at approximately 1:00PM on the 5 June 2012, 21 hours after peak rainfall in the upper catchment. This inundation is not as extensive as the June 2007 event, and mainly consisted of swollen existing flow paths rather than the unbroken stretch of water observed in the 2007 model. This land remained inundated for approximately 18 hours, before retreating in the early morning of 6 June.

5.4.4 April 1990

The April 1990 event is the largest event on record, and has the most number of recorded flood marks on the floodplain. However, it is missing key pieces of data, such as the Valencia Creek inflow and Lake Wellington water level. The flood event behaviour will therefore focus on describing the floodplain where levels have been validated from flood marks.

In the upper catchment area the first breakout from the Avon River occurred at approximately 4:00PM on 21 April 1990 upstream of Boisdale. By 7:30PM that day, floodwaters were encroaching Boisdale, and after this the town was extensively inundated.

Downstream of Boisdale there was extensive inundation on the floodplain. Numerous other breakouts between Boisdale and Stratford caused inundation between Nuntin Creek and the Avon River, creating a vast 2km wide floodplain that stretched from upstream of Boisdale to Lake Wellington. This floodplain inundated numerous properties on the western side of the Avon River, and there are very few that remained unaffected from the 1990 flood.

6. DESIGN FLOOD MODELLING

6.1 Overview

This section discusses the application of the hydraulic model to simulate and map flood behaviour (extents, depth, velocities) for a range of flood magnitudes.

Design flood modelling for the 20%, 10%, 5%, 2%, 1% and 0.5% AEP events and PMF event was completed using the hydraulic model parameters determined during the hydraulic model calibration. Whilst not specified in the brief, the 50% AEP was also run to get an approximation for minor flood class events.

The mapping outputs can be used for flood response planning, and land use planning purposes.

6.2 Design Flood Behaviour

Table 6-1 describes the key flood characteristics in the Avon River catchment for each design event. The key aspect to note is that Boisdale is inundated in the 1% AEP and larger flood events. For events larger than a 1% event, the extent of inundation is increased by numerous riverine breakouts upstream of Boisdale. Stratford township remains unaffected by riverine flooding for all design events including the PMF. As inundation of township areas is limited up to the 1% AEP event, in describing the flood behaviour emphasis has been placed on inundation of infrastructure such as roadways.

Table 6-2 to Table 6-6 detail the gauge levels within the catchment during each design event.

Further design flood data, including hydrographs at key locations, result grids, and flood extent data has been provided as part of the project requirements.

Table 6-1 Summary of Flood Behaviour for Various Flood Events

Event	Flood Characteristics	Key roadways inundated
20% AEP	• Flow Remains within channel for most of river • Boisdale unaffected by floodwater from the Avon River • Local catchments start causing some roads to have shallow inundation around Boisdale • Inundation on floodplain downstream of Stratford, initiated by Nuntin Creek spillway	• Bengworden Rd in Clydebank is impassable • Stewarts Lane Avon River crossing is impassable • Valencia Creek-Briagolong Rd Avon River low-level crossing is impassable • Wombat Rd crossing of the Upper Avon is impassable • Smyths Rd crossing of Valencia Creek is impassable • Stratford-Maffra Rd is slightly inundated near Stratford, where the road is low and dips under the railway line • Maffra-Briagolong Rd is impassable in a number of locations downstream of Boisdale • Some shallow inundation on Boisdale-Newry Rd, west of Boisdale • Some shallow inundation on Boisdale-Valencia Creek Rd, north of Boisdale
10% AEP	• Flow Remains within channel for most of river • Boisdale unaffected by floodwater • Inundation on floodplain downstream of Stratford, initiated by Nuntin Creek spillway • Water backs up into the Nuntin system from Nuntin spillway • Small breakout noted just downstream of Stratford, further inundating the Nuntin system	• Stratford-Maffra Rd is impassable near Stratford, where the road is low and dips under the railway line • Local roads around Boisdale are impassable
5% AEP	• Flow Remains within channel for most of upstream section of river • Boisdale unaffected by floodwater, apart from local catchment nuisance flooding • Inundation on floodplain downstream of Stratford, initiated by Nuntin Creek spillway and multiple breakouts just downstream of Stratford • Breakout at Stewarts Lane crossing upstream of Stratford forcing more water into Nuntin system	• Princes Highway is inundated at a low point where it crosses under the railway line west of the Avon River at Stratford

Event	Flood Characteristics	Key roadways inundated
	• Inundation extensive in floodplain around Nuntin Creek-Avon River confluence • Flow blockage from Princes Highway and Railway embankment causing ponding behind embankments	
2% AEP	• Flow Remains within channel for most of upstream section of river • Boisdale unaffected by floodwater, apart from local catchment nuisance flooding. A breakout on the Avon River forces water towards Boisdale, but it does not have the volume to reach Boisdale and is absorbed by the drainage system to the east of Boisdale. • Extensive inundation on floodplain downstream of Stratford, with the entire western side of the Avon River exhibiting an unbroken expanse of floodwater between Nuntin Creek and the Avon River between Stratford and the Nuntin Creek-Avon River confluence. • Breakout at Stewarts Lane crossing and just upstream of Princes Highway crossing upstream of Stratford forcing more water into Nuntin system. This flow is obstructed by Princes Highway and Railway line embankments, and combines with local flows to cause inundation behind these embankments	• Extensive flooding on the Princes Highway west of the Avon River at Stratford
1% AEP	• Numerous breakouts along Avon River • Boisdale affected by floodwater. A breakout on the Avon River forces water towards Boisdale, which is partially absorbed by the drainage system to the east of Boisdale, but also overtops Boisdale Main drain and causes inundation in the township. Water from this breakout also continues into the downstream Nuntin Creek catchment. • Extensive inundation on floodplain downstream of Stratford, with the entire western side of the Avon River exhibiting an unbroken expanse of floodwater between Nuntin Creek and the Avon River between Stratford and the Nuntin Creek-Avon River confluence. • Breakout at Stewarts Lane crossing and just upstream of Princes Highway crossing upstream of Stratford forcing more water into Nuntin system. This flow is obstructed by Princes Highway and Railway line embankments, and combines with local flows to cause inundation behind these embankments	• Some local rural roads on the north side of Stratford become inundated.

Event	Flood Characteristics	Key roadways inundated
0.5% AEP	• Numerous breakouts along Avon River • Boisdale extensively inundated by floodwater. A breakout on the Avon River forces water towards Boisdale, overtops Boisdale Main drain and causes inundation in the township. A breakout from the Avon River near the Valencia Creek confluence also adds additional water to the Boisdale area. • Freestone and Valencia Creeks are also overtopping their banks, with various breakout flows inundating local areas. • Extensive inundation on floodplain on the entire western side of the Avon River with large expanses of floodwater in large sections from the Avon-Valencia Creek confluence to the outlet at Lake Wellington. • Railway line yet to be overtopped and causing extensive obstruction to flow	• Valencia Creek - Briagolong bridge over Freestone Creek is impassable
0.2% AEP	• Numerous breakouts along Avon River • Boisdale extensively inundated by floodwater. A breakout on the Avon River forces water towards Boisdale, overtops Boisdale Main drain and causes inundation in the township. • Water is also breaking out on the eastern side of the river in multiple locations, near the Valencia Creek confluence and upstream of Stratford. Stratford remains unaffected. • Freestone and Valencia Creeks are also overtopping their banks, with various breakout flows inundating local areas. • Extensive inundation on floodplain on the entire western side of the Avon River with expanses of floodwater in large sections from the Avon-Valencia Creek confluence to the outlet at Lake Wellington. • Railway line yet to be overtopped and causing extensive obstruction to flow.	
PMF	• Numerous breakouts along Avon River • Boisdale extensively inundated by floodwater. • Freestone and Valencia Creeks are also overtopping their banks, with various breakout flows inundating local areas. • Extensive inundation on floodplain on the entire western side of the Avon River and eastern side of the river upstream of Stratford, with expanses of floodwater	• Bushy Park Rd bridge over Freestone Creek is impassable

Event	Flood Characteristics	Key roadways inundated
	in large sections from the Avon-Valencia Creek confluence to the outlet at Lake Wellington. • Stratford unaffected by floodwater. • Railway line partially overtopped and causing extensive obstruction to flow.	

Table 6-2 Avon River at Stratford Gauge Heights for Design Flood Events

Gauge Height[1] (m)	Flood level at Gauge (m AHD)	Design Flood Event AEP (%)	Design Flood Event ARI (years)
6.9	13.4	20	5
7.7	14.2	10	10
8.4	14.9	5	20
8.7	15.2	2	50
9.0	15.5	1	100
9.1	15.6	0.5	200
9.4	15.8	0.2	500

Table 6-3 Avon River at The Channel Gauge Heights for Design Flood Events

Gauge Height[2] (m)	Flood level at Gauge (m AHD)	Design Flood Event AEP (%)	Design Flood Event ARI (years)
6.2	78.2	20	5
7.4	79.4	10	10
8.6	80.6	5	20
9.7	81.7	2	50
10.9	82.9	1	100
11.8	83.8	0.5	200
13.0	85.0	0.2	500

Table 6-4 Avon River at Clydebank Gauge Heights for Design Flood Events

Gauge Height[3] (m)	Flood level at Gauge (m AHD)	Design Flood Event AEP (%)	Design Flood Event ARI (years)
3.1	2.9	20	5
3.4	3.2	10	10
3.8	3.6	5	20
4.1	3.9	2	50
4.4	4.2	1	100
4.7	4.5	0.5	200
5.0	4.8	0.2	500

[1] The Stratford gauge is located adjacent to Stratford on the Avon River. Gauge zero is 6.479m AHD
[2] The Channel gauge is located upstream of the Avon-Valencia Creek confluence. Gauge zero is 72m AHD
[3] The Clydebank gauge is located in the downstream Avon wetlands near Clydebank. Gauge zero is -0.21m AHD

Table 6-5 Freestone Creek at Briagolong Gauge Heights for Design Flood Events

Gauge Height[4] (m)	Flood level at Gauge (m AHD)	Design Flood Event AEP (%)	Design Flood Event ARI (years)
5.4	68.6	20	5
6.0	69.2	10	10
6.8	70.0	5	20
7.4	70.6	2	50
8.1	71.3	1	100
8.7	71.9	0.5	200
9.3	72.5	0.2	500

Table 6-6 Valencia Creek at Gillio Rd Gauge Heights for Design Flood Events

Gauge Height[5] (m)	Flood level at Gauge (m AHD)	Design Flood Event AEP (%)	Design Flood Event ARI (years)
3.6	89.1	20	5
4.2	89.7	10	10
5.0	90.5	5	20
5.5	91.0	2	50
6.1	91.6	1	100
6.5	92.0	0.5	200
7.1	92.6	0.2	500

6.3 Flood Class Event Behaviour

For this study, minor, moderate and major flood class events have been analysed hydraulically. Hydrologic analysis (Water Technology, 2015b) allowed for magnitude estimations of different flood classes. A more detailed estimate of flood class exceedance probability magnitude can be made with flood levels in the hydraulic model, as shown in Table 6-7.

Table 6-7 Estimated AEP of the Flood Class Events

Gauge Station	Minor		Moderate		Major	
	Water Level (Gauge - m)	Approximate AEP (%)(AEP gauge level)	Water Level (Gauge - m)	Approximate AEP % (AEP gauge level)	Water Level (Gauge - m)	Approximate AEP (%) (AEP gauge level)
Avon River at the Channel	5.0	50% (4.89)	6.9	10 - 20% (7.36 – 6.20)	7.5	10% (7.36)
Avon River at Stratford	4.5	<50% (5.80)	6.0	20% - 50% (6.88 – 5.80)	6.5	20% (6.88)

[4] The Briagolong gauge is located adjacent to Briagolong on Freestone Creek. Gauge zero is 63.238m AHD
[5] The Gillio Rd gauge is located upstream of the Valencia Creek area. Gauge zero is 85.481m AHD

6.4 Supplied Model Outputs

The study deliverables provide a comprehensive set of data that support the study outcomes. From the hydraulic model, outputs included:

Grids

Gridded datasets of model results were provided for the following:

- Design events (20%, 10%, 5%, 2%, 1%, 0.5%, 0.2% AEP and PMF events) – maximum depth, hazard, velocity and water surface elevation.
- Calibration events (2007, 2011, and 2012 events) – maximum depth, hazard, velocity and water surface elevation.

Vector Data

ERSI shapefiles in VFD format were provided for the following:

- Peak flood extents
- Peak flood depth contours
- Peak flood elevation contours
- Peak flood velocity contours
- Peak flood velocity arrows
- Peak flood hazard contours
- Mapping limits

Data Tables

Data tables in excel CSV format were provided for the following:

- Stage height hydrographs at 12 key locations across the study area for 6 design events (20%, 10%, 5%, 2%, 1% and 0.5% AEP events). The key locations are displayed in Figure 6-1.
- Water surface level profile along the Avon River for 6 design events (20%, 10%, 5%, 2%, 1% and 0.5% AEP events). The long section profile location is shown in Figure 6-1.

Maps

The flood maps have been produced for the following design flood events:

- 10% and 1% AEP events – maximum depth, hazard, velocity and water surface elevation.

Each map includes:

- Flood extent,
- Flood level contour at 1m intervals,
- Depth of inundation,
- Identification of essential services,
- Major Road/street names
- Cadastral base
- Gauge height indication for the Avon River catchment at the five currently active gauges – Avon River at The Channel, Avon River at Stratford, Avon River at Clydebank, Freestone Creek at Briagolong and Valencia Creek at Gillio Road.

Copies of the maps were provided as PDFs. The maps are included in Appendix C of this report.

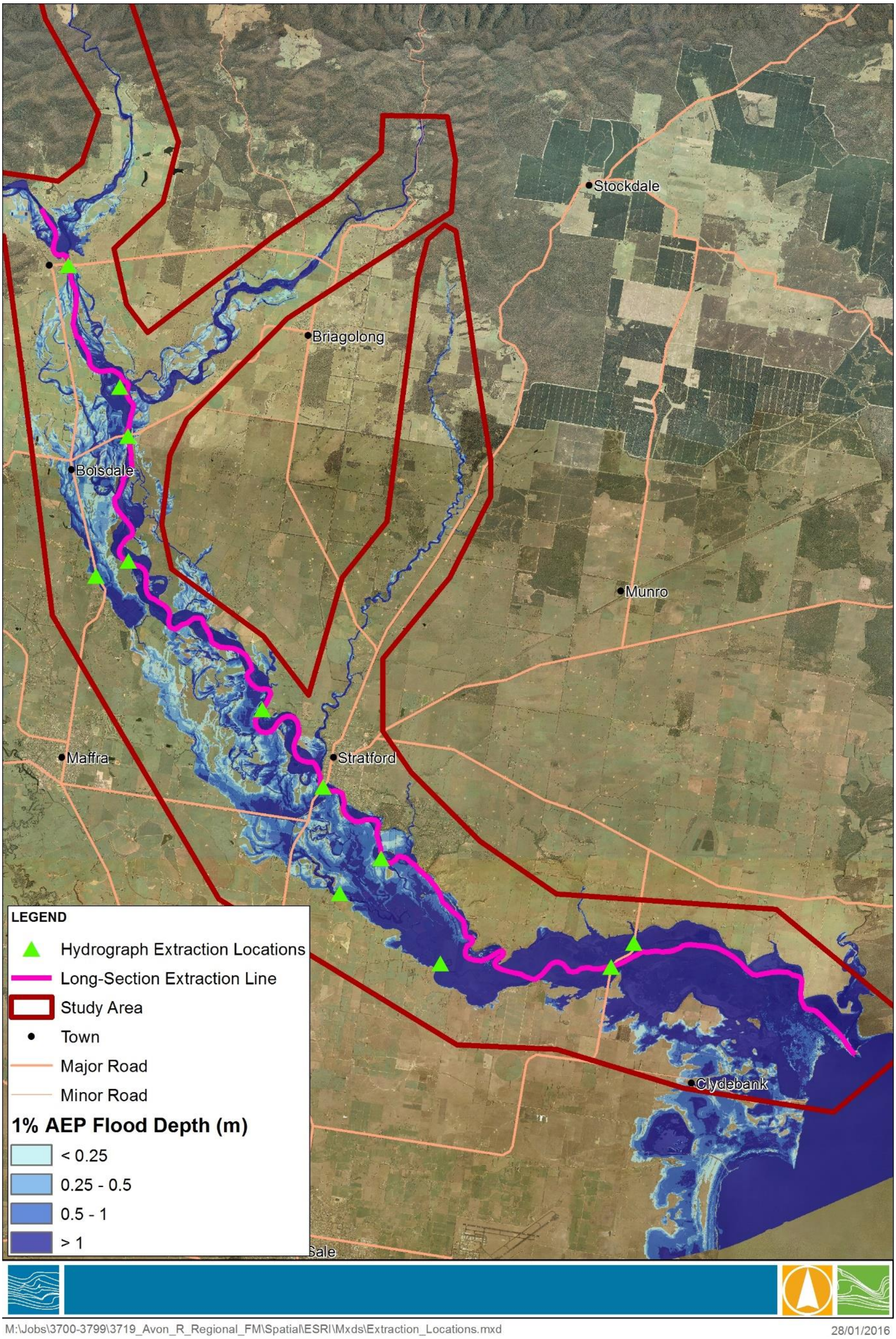

Figure 6-1 Supplied Data Location

7. REFERENCES

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APPENDIX A – CALIBRATION EVENT FLOOD MARK DATA

June 2007 Calibration Event

Location ID	X Co-Ordinate	Y Co-Ordinate	Measured (m AHD)	Modelled (m AHD)	Difference (m)	Comment
1	5808257.08	5808257.08	36.82	36.88	0.06	
2	5809604.75	5809604.75	38.56	38.47	-0.09	
3	5809049.33	5809049.33	37.35	38.14	0.79	Survey seems low compared to LiDAR
4	5808567.94	5808567.94	37.08	37.15	0.07	
5	5811940.63	5811940.63	49.73	49.22	-0.51	
6	5813778.96	5813778.96	62.41	63.29	0.88	Adjacent to flow constriction – model appears high in this area
7	5813819.23	5813819.23	62.02	62.42	0.40	Adjacent to flow constriction – model appears high in this area
8	5811966.57	5811966.57	50.10	49.57	-0.53	Likely picking up local catchment flows not included in model
9	5809792.03	5809792.03	38.42	38.19	-0.23	
10	5813593.47	5813593.47	47.39	46.22	-1.17	Likely picking up local catchment flows not included in model
11	5814051.36	5814051.36	48.50	47.67	-0.83	Decreased model confidence in this location – LiDAR supplemented with 50m DEM
12	5815814.84	5815814.84	54.64	54.72	0.08	
13	5816557.96	5816557.96	57.42	57.12	-0.30	
14	5814473.66	5814473.66	57.47	57.92	0.45	
15	5815611.08	5815611.08	55.57	54.99	-0.58	
16	5814033.05	5814033.05	45.18	47.79	2.61	Steep, highly vegetated area – possibly LiDAR/ survey issues.
17	5797672.10	5797672.10	15.22	15.40	0.18	

Location ID	X Co-Ordinate	Y Co-Ordinate	Measured (m AHD)	Modelled (m AHD)	Difference (m)	Comment
18	5797587.42	5797587.42	14.95	14.79	-0.16	
19	5797472.53	5797472.53	14.83	14.78	-0.05	
20	5797347.29	5797347.29	14.40	14.36	-0.04	
21	5796617.59	5796617.59	12.98	12.48	-0.50	
22	5799678.91	5799678.91	19.25	18.66	-0.59	Modelled low, however adjacent flood marks are closer
23	5802862.14	5802862.14	26.50	25.66	-0.84	Model appears low in this area according to flood mark 23, 24, 33 and 34
24	5802679.94	5802679.94	26.44	25.18	-1.26	Model appears low in this area according to flood mark 23, 24, 33 and 34
25	5805308.22	5805308.22	31.29	30.84	-0.45	
26	5815913.47	5815913.47	54.80	54.64	-0.16	
27	5815811.96	5815811.96	51.41	51.50	0.09	
28	5810753.94	5810753.94	40.27	N/A	N/A	No flowpath picked up here – appears to be a local flowpath.
29	5809928.78	5809928.78	38.62	38.32	-0.30	
30	5806966.85	5806966.85	34.14	33.88	-0.26	
31	5806414.78	5806414.78	33.52	33.32	-0.20	
32	5805619.48	5805619.48	31.47	30.96	-0.51	
33	5803613.56	5803613.56	27.86	26.68	-1.18	Model appears low in this area according to flood mark 23, 24, 33 and 34
34	5802312.88	5802312.88	24.88	24.03	-0.85	Model appears low in this area according to flood mark 23, 24, 33 and 34
35	5799703.57	5799703.57	20.10	19.89	-0.21	

Location ID	X Co-Ordinate	Y Co-Ordinate	Measured (m AHD)	Modelled (m AHD)	Difference (m)	Comment
36	5800053.53	5800053.53	20.12	19.77	-0.35	
37	5799784.06	5799784.06	19.56	19.58	0.02	
38	5796255.19	5796255.19	13.03	13.48	0.45	
39	5794355.50	5794355.50	8.08	7.92	-0.16	
40	5793424.19	5793424.19	6.46	6.46	0.00	
41	5792674.06	5792674.06	3.63	3.58	-0.05	
42	5790988.89	5790988.89	3.69	3.95	0.26	
43	5790658.47	5790658.47	3.34	3.35	0.01	
44	5791005.39	5791005.39	3.55	5.22	1.67	Steep terrain, modelled flood extent close
45	5794554.65	5794554.65	9.86	9.68	-0.18	
46	5795826.76	5795826.76	11.98	11.74	-0.24	

June 2012 Calibration Event

Location ID	X Co-Ordinate	Y Co-Ordinate	Measured (m AHD)	Modelled (m AHD)	Difference (m)	Comment
AvoF002	500268.95	5808184.98	35.77	N/A	N/A	Flowpath not in model
AvoF003	500155.91	5808129.62	35.74	N/A	N/A	Flowpath not in model
AvoF001	505757.60	5796281.55	13.10	N/A	N/A	Flowpath not in model
AvoF007	501042.48	5809018.05	38.30	38.03	-0.268	
AvoF005	498733.96	5813596.29	45.83	45.58	-0.244	
AvoF012	508412.39	5793564.25	7.15	6.93	-0.216	
AvoF004	500063.47	5815806.46	54.65	54.58	-0.078	
AvoF011	508202.64	5794036.60	7.90	7.83	-0.068	
AvoF010	507545.83	5794592.32	9.09	9.06	-0.037	
AvoF006	501007.95	5809132.46	38.01	38.02	0.016	
AvoF008	506661.74	5795630.46	11.12	11.34	0.220	
AvoF009	507240.92	5795101.84	10.28	10.55	0.269	

April 1990 Calibration Event

Location ID	X Co-Ordinate	Y Co-Ordinate	Measured (m AHD)	Modelled (m AHD)	Difference (m)
7272	500885.7	5817690	63.05	N/A	N/A
7275	500845.4	5817667	63.05	N/A	N/A
7292	500627	5817030	60.22	59.35	0.875
7293	500614.4	5817027	60.22	59.32	0.896
7298	500910	5816901	59.99	N/A	N/A
7299	500899.4	5816900	59.99	N/A	N/A
7332	497046.2	5816156	53.6	53.51	0.085
7333	497019.4	5816152	53.6	53.51	0.094
7335	500092.4	5816120	55.67	55.35	0.321
7336	500081.5	5816119	55.67	55.28	0.387
7338	496896.8	5816111	53.77	53.57	0.202
7339	496858.4	5816098	53.77	N/A	N/A
7340	500796.8	5816087	57.03	N/A	N/A
7341	500803.4	5816086	57.03	N/A	N/A
7357	496391.5	5815828	55.05	54.66	0.394
7358	496368.4	5815802	55.05	N/A	N/A
7359	497757.5	5815792	51.6	N/A	N/A
7360	500057.2	5815788	55.44	54.79	0.649
7361	500071.4	5815781	55.44	N/A	N/A
7362	497730.4	5815780	51.6	N/A	N/A
7366	499257.4	5815700	52.48	N/A	N/A
7369	499253	5815678	52.48	N/A	N/A
7385	496112.7	5815298	58.17	N/A	N/A
7388	498973.3	5815275	50.52	N/A	N/A
7390	498978.1	5815266	50.52	50.52	0.002
7392	496071.4	5815260	58.17	N/A	N/A
7394	496682.5	5815253	52.49	N/A	N/A
7395	496651.4	5815235	52.49	N/A	N/A
7397	498289.4	5815124	50.25	49.63	0.624
7399	498299.1	5815104	50.25	49.63	0.617
7400	497058.4	5815083	51.32	N/A	N/A
7401	500211.3	5815082	52.51	N/A	N/A
7403	500210.8	5815079	52.51	N/A	N/A
7404	497030.4	5815072	51.32	N/A	N/A
7409	496735	5814881	51.8	N/A	N/A
7410	496707.4	5814857	51.8	N/A	N/A
7428	497931.4	5814587	49.93	49.32	0.615
7433	497931.4	5814565	49.93	49.31	0.623
7441	495340.8	5814517	59.11	N/A	N/A
7442	495315.4	5814507	59.11	58.94	0.167
7447	499620.7	5814460	49.47	N/A	N/A
7448	499674.3	5814446	49.47	N/A	N/A
7450	497870.8	5814432	50.02	49.29	0.727
7453	497735.4	5814401	50.02	N/A	N/A
7466	499503.5	5814157	49.72	N/A	N/A
7468	499540.3	5814137	49.72	N/A	N/A
7483	506596.3	5813861	62.96	N/A	N/A
7485	506639.3	5813856	62.96	63.74	-0.778
7488	506495.3	5813776	62.42	N/A	N/A
7489	506520.3	5813772	62.42	N/A	N/A

7491	506708.3	5813755	62.97	63.51	-0.543
7492	506701.4	5813752	62.97	62.96	0.01
7499	506612.5	5813691	62.63	62.16	0.467
7500	506650.3	5813682	62.63	62.17	0.464
7512	498721.3	5813602	47.59	47.19	0.401
7513	498961.3	5813590	47.75	N/A	N/A
7515	498945.8	5813586	47.75	47.24	0.512
7517	498707.3	5813582	47.59	N/A	N/A
7531	499044.3	5813483	47.16	N/A	N/A
7532	499018.5	5813481	47.16	46.69	0.466
7549	505465.3	5813162	57.14	N/A	N/A
7550	505424.3	5813149	57.14	57.08	0.065
7565	505374.3	5812920	57.54	N/A	N/A
7566	505347.5	5812894	57.54	N/A	N/A
7567	504750.3	5812888	55.45	N/A	N/A
7569	504717	5812878	55.45	54.22	1.233
7574	498459.3	5812694	45.38	N/A	N/A
7576	498460.8	5812680	45.38	N/A	N/A
7581	504710.3	5812649	54.84	N/A	N/A
7582	504668.6	5812639	54.84	N/A	N/A
7587	499834.3	5812441	43.78	N/A	N/A
7588	499810.6	5812412	43.78	N/A	N/A
7599	498872.3	5812088	44.97	44.49	0.485
7600	498881.1	5812077	44.97	N/A	N/A
7602	503334.3	5812033	50.28	N/A	N/A
7603	503314.6	5812012	50.28	N/A	N/A
7604	503532.3	5811950	49.85	N/A	N/A
7605	503512.6	5811890	49.85	49.55	0.304
7606	503338.3	5811886	50.07	N/A	N/A
7608	503326.8	5811866	50.07	N/A	N/A
7616	500251.3	5811498	41.81	N/A	N/A
7618	500255.2	5811466	41.81	41.79	0.015
7620	503737.3	5811365	47.95	48.51	-0.556
7622	498801.3	5811350	42.79	N/A	N/A
7624	498986.3	5811336	43.06	42.98	0.082
7626	498816.4	5811332	42.79	N/A	N/A
7627	499002.3	5811324	43.06	42.96	0.103
7628	503714.7	5811308	47.95	48.51	-0.558
7629	503899.3	5811279	47.85	48.47	-0.615
7630	503872.3	5811223	47.85	48.44	-0.593
7634	498774.3	5810994	41.75	N/A	N/A
7636	498792.2	5810964	41.75	N/A	N/A
7637	497761.3	5810959	41.14	N/A	N/A
7638	497765.6	5810931	41.14	N/A	N/A
7639	503501.3	5810925	46.52	47.17	-0.651
7640	503464.2	5810899	46.52	47.10	-0.577
7641	503479.3	5810811	46.24	47.06	-0.821
7642	503444	5810790	46.24	47.06	-0.825
7643	499136.3	5810717	41.66	N/A	N/A
7644	499151.8	5810713	41.66	41.11	0.55
7652	500169.3	5810525	39.89	N/A	N/A
7653	500166.2	5810510	39.89	39.36	0.528
7659	499540.3	5810283	40.7	N/A	N/A
7660	499572.2	5810256	40.7	N/A	N/A

7662	499682.3	5810231	40.44	N/A	N/A
7663	499705.5	5810215	40.44	39.92	0.519
7664	500998.8	5810166	39.46	N/A	N/A
7665	501012.3	5810165	39.46	N/A	N/A
7667	501061.3	5810132	39.39	N/A	N/A
7668	501039.2	5810122	39.39	N/A	N/A
7670	502893.3	5810069	43.47	44.12	-0.649
7671	502857.9	5810065	43.47	44.08	-0.613
7674	503043.8	5809984	43.95	44.35	-0.402
7675	503065.3	5809974	43.95	N/A	N/A
7677	501649.5	5809936	40.81	40.82	-0.014
7678	499871.2	5809936	39.11	38.91	0.197
7679	501676.3	5809931	40.81	N/A	N/A
7680	499848.3	5809928	39.11	38.95	0.158
7683	500934.2	5809851	39.21	38.80	0.414
7684	500939.3	5809836	39.21	38.80	0.412
7685	501803	5809835	41.3	N/A	N/A
7687	501822.3	5809822	41.3	N/A	N/A
7688	502142.6	5809818	40.99	41.25	-0.262
7689	502163.3	5809812	40.99	N/A	N/A
7690	501047.3	5809802	39.51	N/A	N/A
7691	498468.8	5809786	38.5	38.34	0.165
7692	501061.3	5809782	39.51	N/A	N/A
7693	498406.3	5809758	38.5	N/A	N/A
7694	499103.4	5809754	38.1	N/A	N/A
7695	499067.3	5809739	38.1	37.94	0.156
7698	500966.5	5809705	38.89	38.73	0.165
7699	500968.3	5809699	38.89	38.76	0.127
7700	499815.3	5809697	39.03	38.68	0.346
7701	499838.9	5809677	39.03	38.69	0.345
7708	500032.9	5809353	38.81	38.53	0.284
7709	500005.3	5809348	38.81	38.52	0.29
7712	498960.3	5809099	37.2	37.18	0.017
7713	498994.2	5809094	37.2	N/A	N/A
7715	500396.7	5809041	38.83	38.47	0.358
7716	500382.3	5809035	38.83	38.48	0.35
7722	499853.3	5808998	38.18	37.58	0.6
7723	501019	5808993	38.54	N/A	N/A
7724	499887.4	5808993	38.18	N/A	N/A
7725	501034.3	5808984	38.54	N/A	N/A
7729	498643.3	5808760	35.74	N/A	N/A
7730	498670.9	5808754	35.74	35.84	-0.103
7732	498974.1	5808596	36	35.93	0.067
7733	498942.3	5808592	36	35.89	0.112
7741	499851	5808309	36.39	36.68	-0.29
7742	499834.3	5808307	36.39	36.65	-0.259
7745	500651.3	5808285	37.05	37.54	-0.487
7746	500636.3	5808265	37.05	37.55	-0.499
7748	500829.1	5808244	37.02	36.89	0.13
7750	500825.3	5808234	37.02	36.89	0.133
7753	500837.2	5808200	36.8	36.90	-0.099
7755	500835.3	5808175	36.8	36.89	-0.094
7758	500562.3	5808094	37.21	37.02	0.191
7760	500849.3	5808086	36.77	36.78	-0.01

7763	500829.3	5808080	36.77	N/A	N/A
7764	500534.3	5808078	37.21	37.02	0.186
7776	500837.1	5807815	35.59	N/A	N/A
7777	500813.3	5807787	35.59	N/A	N/A
7778	500497.7	5807783	36.8	36.50	0.298
7782	499475.2	5807767	35.41	35.47	-0.057
7783	500482.3	5807756	36.8	36.50	0.301
7784	499457.3	5807747	35.41	35.40	0.009
7791	498840.6	5807617	34.24	34.31	-0.072
7792	498816.3	5807595	34.24	N/A	N/A
7796	498933.6	5807584	34.32	34.42	-0.104
7800	498905.3	5807566	34.32	34.36	-0.037
7801	498784.1	5807552	34.28	34.19	0.092
7806	498762.3	5807532	34.28	34.16	0.122
7810	498731.5	5807512	33.92	34.13	-0.213
7811	498549.6	5807512	33.2	N/A	N/A
7814	498712.3	5807503	33.92	34.12	-0.203
7815	498523.3	5807488	33.2	N/A	N/A
7824	498448.6	5807398	33.11	N/A	N/A
7830	498431.3	5807378	33.11	N/A	N/A
7841	499948	5807281	35.25	35.22	0.028
7843	499913.3	5807267	35.25	34.94	0.307
7845	498961.9	5807257	34.01	34.05	-0.036
7847	498944.3	5807242	34.01	34.00	0.014
7862	498990.2	5807131	33.96	33.91	0.046
7871	498961.3	5807107	33.96	33.83	0.134
7875	499899.5	5807018	34.58	34.48	0.103
7877	499882.3	5806996	34.58	34.43	0.151
7880	499612.6	5806985	34.89	34.49	0.397
7884	499058.9	5806965	33.88	33.84	0.044
7885	499595.3	5806959	34.89	34.50	0.392
7888	499044.3	5806951	33.88	33.77	0.106
7891	499018.4	5806872	33.63	33.56	0.065
7895	499000.3	5806853	33.63	33.49	0.144
7905	499095.3	5806767	33.39	33.28	0.107
7907	499075.3	5806745	33.39	33.28	0.115
7911	498594.1	5806702	32.74	33.07	-0.331
7912	499810.6	5806694	34.45	34.36	0.09
7913	498982	5806690	33.13	33.15	-0.024
7915	498568.3	5806682	32.74	N/A	N/A
7916	498963.3	5806669	33.13	33.10	0.029
7917	499794.3	5806666	34.45	34.34	0.105
7918	498941.7	5806646	33.1	33.05	0.049
7919	499790.4	5806645	34.4	34.30	0.104
7921	498573.9	5806629	32.66	32.98	-0.319
7923	498914.3	5806622	33.1	N/A	N/A
7924	499766.3	5806611	34.4	34.24	0.159
7925	498545.3	5806609	32.66	32.96	-0.305
7932	499843	5806552	34.12	N/A	N/A
7934	499822.3	5806534	34.12	N/A	N/A
7948	501249.4	5806371	32.27	N/A	N/A
7949	501278.3	5806370	32.27	32.24	0.029
7964	499199.3	5806232	32.45	32.32	0.126
7966	499172	5806222	32.45	32.28	0.168

7970	500802.3	5806198	32.44	N/A	N/A
7971	499201.3	5806194	32.46	32.23	0.228
7973	500780.5	5806190	32.44	32.30	0.138
7974	499176.1	5806190	32.46	32.22	0.238
7987	498767.3	5806081	31.72	32.20	-0.482
7988	498751.7	5806078	31.72	N/A	N/A
8001	498837.3	5805921	31.44	32.09	-0.653
8003	498812.4	5805920	31.49	32.10	-0.606
8012	498888.3	5805834	31.45	31.86	-0.411
8014	498855.5	5805827	31.45	31.87	-0.423
8028	499716.3	5805737	31.56	31.74	-0.179
8029	499691.5	5805736	31.56	31.71	-0.147
8033	500264.6	5805710	32.59	N/A	N/A
8036	500291.3	5805705	32.59	32.12	0.471
8038	498893.3	5805698	31.55	31.73	-0.177
8040	498864.8	5805692	31.55	N/A	N/A
8043	500414.9	5805638	32	N/A	N/A
8044	500428.3	5805626	32	N/A	N/A
8051	500405.5	5805579	31.44	N/A	N/A
8052	500427.3	5805578	31.44	N/A	N/A
8085	500966.3	5805229	31.85	N/A	N/A
8086	500941	5805224	31.85	N/A	N/A
8088	499015.1	5805214	31.38	N/A	N/A
8089	499031.3	5805212	31.38	N/A	N/A
8091	500942.3	5805184	31.69	N/A	N/A
8094	500908.1	5805177	31.69	31.44	0.254
8095	501629.3	5805162	30.41	N/A	N/A
8097	501596.3	5805156	30.41	30.69	-0.282
8100	499163.1	5805139	31.27	31.31	-0.039
8101	499188.3	5805136	31.27	31.25	0.018
8102	499188.3	5805136	30.92	31.25	-0.332
8103	499174.9	5805121	30.92	31.28	-0.359
8104	499503.7	5805111	30.92	31.10	-0.181
8105	499423.8	5805111	30.87	31.12	-0.245
8106	499447.3	5805107	30.87	31.10	-0.23
8109	499526.3	5805095	30.85	31.06	-0.206
8110	499526.3	5805095	30.92	31.06	-0.136
8111	499508.3	5805095	30.85	31.06	-0.215
8112	499188.3	5805083	31.13	31.24	-0.106
8113	499165.5	5805081	31.13	31.31	-0.181
8116	499198.4	5805043	30.85	N/A	N/A
8118	499215.3	5805031	30.85	N/A	N/A
8130	499306.3	5804850	30.48	30.87	-0.392
8131	499280.5	5804844	30.48	30.88	-0.4
8143	501285.3	5804486	29.54	N/A	N/A
8144	501260.5	5804484	29.54	N/A	N/A
8147	501322.3	5804450	29.53	N/A	N/A
8148	501307.4	5804447	29.53	N/A	N/A
8149	499482.6	5804440	29.54	30.03	-0.495
8150	499488.3	5804437	29.54	30.03	-0.491
8153	499505.3	5804396	29.34	30.00	-0.661
8154	499494.3	5804390	29.34	29.99	-0.655
8165	499434.3	5804061	29.38	29.71	-0.33
8166	499426.2	5804054	29.38	29.71	-0.328

8168	500211.3	5804029	29.17	29.35	-0.181
8169	500213	5804023	29.17	29.35	-0.177
8175	500105.3	5803849	29.1	29.28	-0.178
8176	500112	5803829	29.1	29.25	-0.155
8177	499618.3	5803755	28.92	N/A	N/A
8178	499625.8	5803742	28.92	29.38	-0.46
8179	500376.3	5803714	29.11	29.12	-0.014
8180	500389.1	5803705	29.11	29.12	-0.009
8181	499996.3	5803655	29.07	29.16	-0.091
8182	500358.3	5803647	28.83	29.07	-0.237
8183	500001.6	5803642	29.07	29.14	-0.071
8184	500365.6	5803630	28.83	29.00	-0.173
8190	500003.9	5803457	28.98	29.01	-0.026
8193	500959.8	5803312	28.59	N/A	N/A
8194	500960.3	5803307	28.59	N/A	N/A
8195	500045.3	5803211	28.85	28.91	-0.057
8196	500041.5	5803209	28.85	28.91	-0.058
8198	502824.6	5803174	25.96	N/A	N/A
8199	502836.3	5803172	25.96	N/A	N/A
8210	501824.1	5803026	27.14	N/A	N/A
8211	501830.3	5803026	27.14	N/A	N/A
8212	501830.3	5803026	27.17	N/A	N/A
8213	501034.3	5803024	28.68	28.36	0.322
8214	501037.3	5803021	28.68	28.35	0.329
8215	501831.2	5803019	27.17	N/A	N/A
8216	501201.3	5803008	28.22	27.65	0.566
8217	501197	5803005	28.22	27.79	0.427
8221	500786	5802820	28.71	28.67	0.038
8222	500773.3	5802820	28.71	28.67	0.037
8227	500299.9	5802769	28.74	28.72	0.02
8228	502660.3	5802761	25.61	25.16	0.453
8229	500279.3	5802761	28.74	28.72	0.017
8231	502641.4	5802757	25.61	25.16	0.446
8233	501360.3	5802732	27.3	26.56	0.744
8234	501337.9	5802729	27.3	N/A	N/A
8238	501400.3	5802618	27.37	N/A	N/A
8240	501406	5802612	27.37	N/A	N/A
8241	501453.3	5802603	27.2	N/A	N/A
8242	501457.7	5802593	27.2	N/A	N/A
8244	501586.3	5802507	27.13	N/A	N/A
8246	501598.6	5802502	27.13	N/A	N/A
8248	500534.7	5802493	28.74	28.69	0.052
8250	500521.3	5802483	28.74	28.69	0.047
8251	501067.3	5802463	28.71	28.68	0.03
8252	501052.3	5802447	28.72	28.68	0.039
8253	501079.6	5802443	28.71	28.68	0.027
8254	501100.3	5802429	27.29	N/A	N/A
8255	501053.7	5802420	28.72	28.68	0.037
8256	501119.5	5802418	27.29	N/A	N/A
8257	501088.3	5802415	28.4	N/A	N/A
8258	501132.3	5802399	27.14	28.14	-0.998
8259	501122.3	5802386	28.38	28.11	0.272
8260	501143	5802385	27.14	N/A	N/A
8261	501086.6	5802376	28.4	N/A	N/A

8262	501114.8	5802345	28.38	28.51	-0.132
8265	500958.3	5802265	28.44	28.59	-0.149
8266	500959.8	5802254	28.44	N/A	N/A
8267	500960.3	5802219	28.3	N/A	N/A
8268	500912.3	5802219	28.45	N/A	N/A
8269	500966.9	5802214	28.3	N/A	N/A
8270	500777.3	5802205	28.72	28.65	0.069
8271	500929.3	5802205	28.45	28.53	-0.077
8273	500838.3	5802194	28.48	28.55	-0.068
8274	500797.7	5802193	28.72	28.59	0.129
8275	500856.5	5802191	28.48	N/A	N/A
8277	502923.2	5802179	25.19	24.28	0.906
8278	503471.3	5802170	24.32	N/A	N/A
8279	503458.8	5802170	24.32	N/A	N/A
8280	502902.3	5802161	25.19	24.28	0.907
8281	502601.5	5802041	25.24	24.86	0.384
8282	502573.3	5802021	25.24	24.87	0.367
8284	501741.8	5801896	26.12	N/A	N/A
8285	501715.3	5801882	25.56	N/A	N/A
8286	503188.7	5801840	24.62	23.90	0.721
8287	503165.3	5801821	24.62	23.93	0.695
8290	501218.3	5801781	26.86	N/A	N/A
8291	501237	5801779	26.86	N/A	N/A
8293	501824.1	5801753	25.56	N/A	N/A
8295	501633.8	5801730	24.91	N/A	N/A
8296	501126.6	5801718	27.05	N/A	N/A
8297	501596.3	5801717	24.91	N/A	N/A
8298	501113.3	5801717	27.05	N/A	N/A
8301	502115.4	5801641	25.05	24.94	0.106
8302	502071.3	5801638	25.05	25.03	0.024
8306	501777.1	5801482	24.44	N/A	N/A
8307	501744.3	5801478	24.44	N/A	N/A
8311	502906.8	5801432	23.93	N/A	N/A
8312	502867.3	5801422	23.93	N/A	N/A
8314	504478	5801332	22.82	N/A	N/A
8315	504495.3	5801331	22.8	N/A	N/A
8316	504495.3	5801331	22.82	N/A	N/A
8317	504492.1	5801322	22.8	N/A	N/A
8318	501368.5	5801304	24.63	24.34	0.287
8319	501329.3	5801295	24.63	24.37	0.263
8322	501664.4	5801161	24.18	23.88	0.295
8326	501615.3	5801146	24.18	23.92	0.256
8327	502845.7	5801121	22.55	22.52	0.029
8328	502822.3	5801103	22.55	22.46	0.092
8354	501180.6	5800854	22.73	23.02	-0.289
8356	501150.3	5800844	22.73	23.02	-0.287
8362	501227.5	5800644	22.87	22.91	-0.035
8363	503228.5	5800639	22.03	21.67	0.356
8364	501205.3	5800632	22.87	22.91	-0.04
8366	503200.3	5800615	22.03	21.68	0.346
8369	503832.2	5800571	21.84	N/A	N/A
8371	502725.9	5800559	22.22	21.87	0.349
8372	503819.3	5800547	21.84	21.51	0.329
8373	502694.3	5800536	22.22	21.87	0.35

8380	501629.2	5800400	22.7	21.92	0.779
8382	501676.1	5800398	22.3	21.90	0.403
8383	501582.3	5800366	22.7	N/A	N/A
8384	501635.3	5800363	22.3	N/A	N/A
8387	504586	5800281	20.34	21.28	-0.937
8389	504572.3	5800264	20.34	21.21	-0.875
8391	501669.1	5800227	21.83	21.52	0.309
8393	501627.3	5800203	21.83	N/A	N/A
8394	503461.1	5800190	21.25	21.21	0.039
8395	501669.1	5800185	21.47	21.49	-0.017
8397	503433.3	5800174	21.25	21.20	0.051
8399	501631.3	5800155	21.47	21.45	0.024
8401	503479.9	5800150	21.23	21.11	0.116
8403	503458.3	5800135	21.23	20.99	0.244
8406	504889	5800075	20.88	20.51	0.374
8407	504875.3	5800065	20.88	20.53	0.355
8416	504099.9	5799827	20.46	20.04	0.422
8417	504082.3	5799820	20.46	20.01	0.454
8418	504306.6	5799808	20.2	20.06	0.14
8419	504301.3	5799805	20.2	20.06	0.142
8423	504980.3	5799757	19.72	19.55	0.172
8425	504978.3	5799745	19.72	19.63	0.085
8426	504988.3	5799722	19.79	N/A	N/A
8428	504987.7	5799698	19.79	N/A	N/A
8429	504991.3	5799691	19.53	N/A	N/A
8431	504431.1	5799670	20.05	19.85	0.195
8433	504987.6	5799663	19.53	N/A	N/A
8434	504422.3	5799655	20.05	19.83	0.217
8436	504955.3	5799635	19.44	19.22	0.224
8437	504957.1	5799630	19.44	19.21	0.23
8440	505964.7	5799532	18.07	N/A	N/A
8442	505956.3	5799512	18.07	N/A	N/A
8450	506814.9	5799310	17.15	18.51	-1.362
8451	506821.3	5799296	17.15	18.50	-1.35
8455	503343.7	5799179	18.98	N/A	N/A
8456	503331.3	5799157	18.98	N/A	N/A
8457	503914.3	5799106	20.16	19.72	0.441
8458	503891.3	5799088	20.16	19.72	0.441
8459	502383	5799071	19.87	19.37	0.503
8460	502364.3	5799032	19.87	19.33	0.539
8463	502801.1	5798938	19.05	18.62	0.427
8464	502794.3	5798913	19.05	18.60	0.449
8465	505570.1	5798877	17.22	16.80	0.424
8466	505570.3	5798861	17.22	16.78	0.441
8470	502657.9	5798449	18.01	17.88	0.132
8471	502648.3	5798420	18.01	17.87	0.138
8472	504092.8	5798409	17.95	N/A	N/A
8475	504071.3	5798379	17.95	17.71	0.241
8476	505506.7	5798374	17.31	17.18	0.134
8478	502693.1	5798360	17.88	N/A	N/A
8479	505510.3	5798352	17.31	17.13	0.177
8481	502686.3	5798345	17.88	N/A	N/A
8486	503489.3	5797999	16.94	16.86	0.076
8487	503320.2	5797976	17.11	N/A	N/A

8488	503481.3	5797971	16.94	16.78	0.159
8490	503312.3	5797951	17.11	N/A	N/A
8493	505455.1	5797845	16.8	16.59	0.208
8494	505455.3	5797826	16.8	16.59	0.213
8498	506746.8	5797651	15.55	N/A	N/A
8499	506756.3	5797637	15.55	N/A	N/A
8500	506789.1	5797573	15.38	N/A	N/A
8501	506790.3	5797548	15.38	N/A	N/A
8502	506469.7	5797517	16.05	16.08	-0.026
8504	506468.3	5797499	16.05	16.03	0.025
8507	504463.9	5797477	17.04	N/A	N/A
8508	506866.5	5797470	15.06	N/A	N/A
8509	504720	5797468	16.92	N/A	N/A
8510	504446.3	5797454	17.04	N/A	N/A
8511	503106.4	5797452	16.78	16.70	0.076
8512	504711.3	5797447	16.92	N/A	N/A
8513	506869.3	5797436	15.06	15.00	0.06
8514	503102.3	5797411	16.78	N/A	N/A
8515	506948.8	5797407	14.85	14.82	0.034
8516	506945.3	5797377	14.85	14.86	-0.014
8517	507047.5	5797328	14.74	14.62	0.123
8519	504297.1	5797321	15.3	N/A	N/A
8521	507131.9	5797314	14.62	N/A	N/A
8522	507082.7	5797314	14.74	14.60	0.144
8523	507049.3	5797311	14.74	14.61	0.133
8524	504569.7	5797304	15.44	N/A	N/A
8525	504286.3	5797295	15.3	N/A	N/A
8527	507124.3	5797288	14.62	14.58	0.044
8528	507088.3	5797288	14.74	14.59	0.148
8529	504567.3	5797286	15.44	N/A	N/A
8534	505241.3	5797168	16.01	15.75	0.263
8535	506411	5797147	15.13	15.14	-0.014
8536	505244.3	5797145	16.01	N/A	N/A
8537	506403.3	5797120	15.13	15.07	0.062
8543	506988.7	5797033	15.15	14.71	0.439
8544	506980.3	5797002	15.15	14.63	0.52
8545	505704	5796974	15.62	15.28	0.337
8546	505702.3	5796943	15.62	15.25	0.372
8548	506833.7	5796899	14.85	14.66	0.188
8549	503951.9	5796876	15.34	15.23	0.107
8550	506821.3	5796871	14.85	14.67	0.18
8551	506854.8	5796862	14.01	N/A	N/A
8552	503932.3	5796847	15.34	15.22	0.118
8553	506845.3	5796837	14.01	N/A	N/A
8554	506723.3	5796822	14.82	14.70	0.122
8555	506703.3	5796782	14.82	14.58	0.242
8556	506735	5796775	14	N/A	N/A
8557	506726.3	5796749	14	13.79	0.213
8560	507730.9	5796614	13.08	12.75	0.328
8561	506420.3	5796597	14.89	14.78	0.111
8562	507713.3	5796586	13.08	12.73	0.346
8563	506403.3	5796574	14.89	14.79	0.098
8564	506443.8	5796560	13.68	N/A	N/A
8565	504076.4	5796560	14.94	15.06	-0.124

8566	504072.3	5796546	14.94	15.06	-0.124
8569	506431.3	5796537	13.68	13.34	0.339
8572	504557.9	5796513	15.34	14.98	0.357
8573	504547.3	5796485	15.34	14.98	0.357
8575	504442.8	5796476	14.94	15.00	-0.064
8577	504420.3	5796452	14.94	15.00	-0.061
8578	504445.1	5796436	14.26	15.01	-0.751
8579	508449.5	5796417	12.33	N/A	N/A
8580	508357.9	5796417	12.43	N/A	N/A
8581	506155	5796410	15.12	14.82	0.295
8583	504417.3	5796406	14.26	14.00	0.262
8584	508351.3	5796401	12.43	12.28	0.147
8585	506141.3	5796382	15.12	14.83	0.294
8587	506185.5	5796380	13.66	N/A	N/A
8588	508433.3	5796377	12.33	N/A	N/A
8589	505283.6	5796356	15.01	14.92	0.089
8590	506165.3	5796348	13.66	13.68	-0.021
8593	505277.3	5796334	15.01	14.91	0.1
8594	505281.3	5796326	14.07	14.90	-0.831
8595	505943.6	5796312	15.19	14.81	0.377
8596	505267.3	5796296	14.07	N/A	N/A
8597	505671.2	5796296	15.02	14.88	0.143
8598	505926.3	5796289	15.19	14.77	0.419
8599	505950.6	5796277	14.05	14.76	-0.709
8600	505661.3	5796271	15.02	14.88	0.14
8601	505673.5	5796258	14.06	14.88	-0.815
8602	505937.3	5796255	14.05	13.93	0.124
8603	505657.3	5796227	14.06	13.82	0.235
8604	505957.7	5796214	14.18	13.85	0.325
8605	505945.3	5796188	14.18	13.94	0.237
8606	506002.3	5796188	13.41	13.22	0.193
8608	505988.3	5796150	13.41	13.08	0.332
8610	504327.7	5796087	13.51	N/A	N/A
8611	504305.3	5796054	13.51	N/A	N/A
8623	506532.3	5795834	12.38	12.19	0.194
8624	506528.3	5795832	12.38	12.20	0.179
8651	509067.4	5795540	9.82	9.91	-0.093
8652	509062.5	5795531	9.82	9.91	-0.09
8654	505766.3	5795479	13.32	12.93	0.385
8655	505814.3	5795472	12.6	12.27	0.33
8657	505809.7	5795451	12.6	12.32	0.279
8658	505758	5795451	13.32	12.87	0.447
8660	508659.3	5795411	10.63	10.54	0.088
8661	508653.9	5795411	10.63	10.55	0.075
8671	506177.3	5795329	11.54	11.68	-0.145
8674	506178.5	5795300	11.54	11.68	-0.145
8680	509588.4	5795187	9.16	N/A	N/A
8681	509612.2	5795185	9.16	N/A	N/A
8685	504438.1	5795153	13.32	13.23	0.09
8689	504414.3	5795098	13.32	13.23	0.093
8693	507173.3	5795055	10.71	10.64	0.075
8694	505039.3	5795055	13.31	13.17	0.136
8695	507188.4	5795043	10.71	10.57	0.135
8697	505006.3	5795015	13.31	13.18	0.131

8703	505716.3	5794894	11.41	12.28	-0.867
8704	505660.3	5794893	13.31	12.52	0.788
8705	505657	5794879	13.31	12.51	0.796
8706	505925.3	5794877	12.07	11.84	0.231
8708	505708.7	5794874	11.91	12.29	-0.382
8709	505922.4	5794862	12.07	11.83	0.242
8727	507489	5794615	10.05	9.98	0.072
8732	507473.3	5794588	10.05	9.98	0.07
8735	507533.6	5794549	9.89	9.85	0.036
8736	507513.3	5794535	9.89	9.87	0.021
8737	510169.3	5794498	8.06	8.12	-0.058
8738	510171.1	5794490	8.06	8.12	-0.058
8746	507284.3	5794329	9.75	9.35	0.399
8749	507294	5794318	9.75	9.32	0.429
8752	507230.3	5794307	9.61	9.65	-0.042
8754	507242.3	5794292	9.61	9.63	-0.017
8767	507100.3	5794211	9.5	N/A	N/A
8770	507106.2	5794191	9.5	N/A	N/A
8778	508166.3	5794075	8.4	8.54	-0.142
8779	507196.3	5794073	9.5	9.49	0.012
8781	508172.4	5794064	8.4	8.52	-0.125
8782	507207.1	5794062	9.5	9.49	0.013
8788	510554.3	5793984	7.31	N/A	N/A
8789	510546.9	5793972	7.31	7.37	-0.062
8790	507146.3	5793960	9.05	9.23	-0.184
8792	507155.5	5793944	9.05	9.22	-0.175
8796	510816.9	5793902	7.03	N/A	N/A
8798	510822.3	5793896	7.03	N/A	N/A
8803	510663.4	5793841	7.28	7.21	0.07
8805	510654.9	5793831	7.28	7.21	0.071
8818	508423.3	5793550	7.83	7.86	-0.029
8819	508426	5793539	7.83	7.85	-0.023
8848	511273.3	5793171	6.71	N/A	N/A
8850	511249.1	5793165	6.71	6.75	-0.041
8860	508442.5	5792972	7.6	7.63	-0.032
8861	508430.3	5792971	7.6	7.63	-0.034
8866	513919.5	5792736	4.59	4.56	0.033
8869	513925.4	5792714	4.59	4.56	0.033
8871	516479.5	5792698	3.74	N/A	N/A
8873	516700.3	5792684	3.93	3.75	0.184
8876	516477.4	5792673	3.74	3.82	-0.084
8878	516697.4	5792658	3.93	3.74	0.187
8900	515594	5792463	4.29	4.19	0.099
8901	514682.8	5792461	4.39	N/A	N/A
8903	515609.4	5792438	4.29	4.18	0.11
8904	514684.4	5792438	4.39	4.36	0.026
8913	512996.5	5792157	4.52	4.87	-0.351
8914	513001.4	5792146	4.52	4.87	-0.355
8916	511739.3	5792130	5.93	5.96	-0.033
8917	511730.5	5792129	5.93	5.97	-0.036
8927	509716.3	5791937	6.66	6.65	0.006
8928	509696.7	5791933	6.66	6.66	-0.004
8934	512388.2	5791780	5.95	N/A	N/A
8935	512382.4	5791774	5.95	N/A	N/A

8942	515831.3	5791651	4.2	4.13	0.075
8944	515821.4	5791637	4.2	4.12	0.077
8947	515767.8	5791578	3.97	4.17	-0.2
8948	515786.7	5791566	4.2	N/A	N/A
8949	515807.8	5791552	4.39	4.14	0.245
8950	515783.4	5791545	4.2	4.15	0.055
8951	515783.4	5791545	4.39	4.15	0.245
8952	515783.4	5791545	3.97	4.15	-0.175
8965	515766.6	5791112	4.34	4.26	0.084
8966	515755.4	5791099	4.34	4.26	0.082
8967	513231.3	5791090	5.27	N/A	N/A
8968	513215.4	5791085	5.27	5.34	-0.069
8970	512604.3	5790987	5.66	N/A	N/A
8972	512584.4	5790977	5.66	N/A	N/A
8977	515178.3	5790895	4.35	4.31	0.039
8978	515161.4	5790887	4.35	4.31	0.038
8981	511220.3	5790752	6.2	6.00	0.204
8982	511206.8	5790742	6.2	N/A	N/A

APPENDIX B – MODEL QA SHEET

Modeller: **Reviewer:**

Job Title/Number: 3719-01 Avon River Regional **Date: 10/12/2015**

Model Name: Avon River

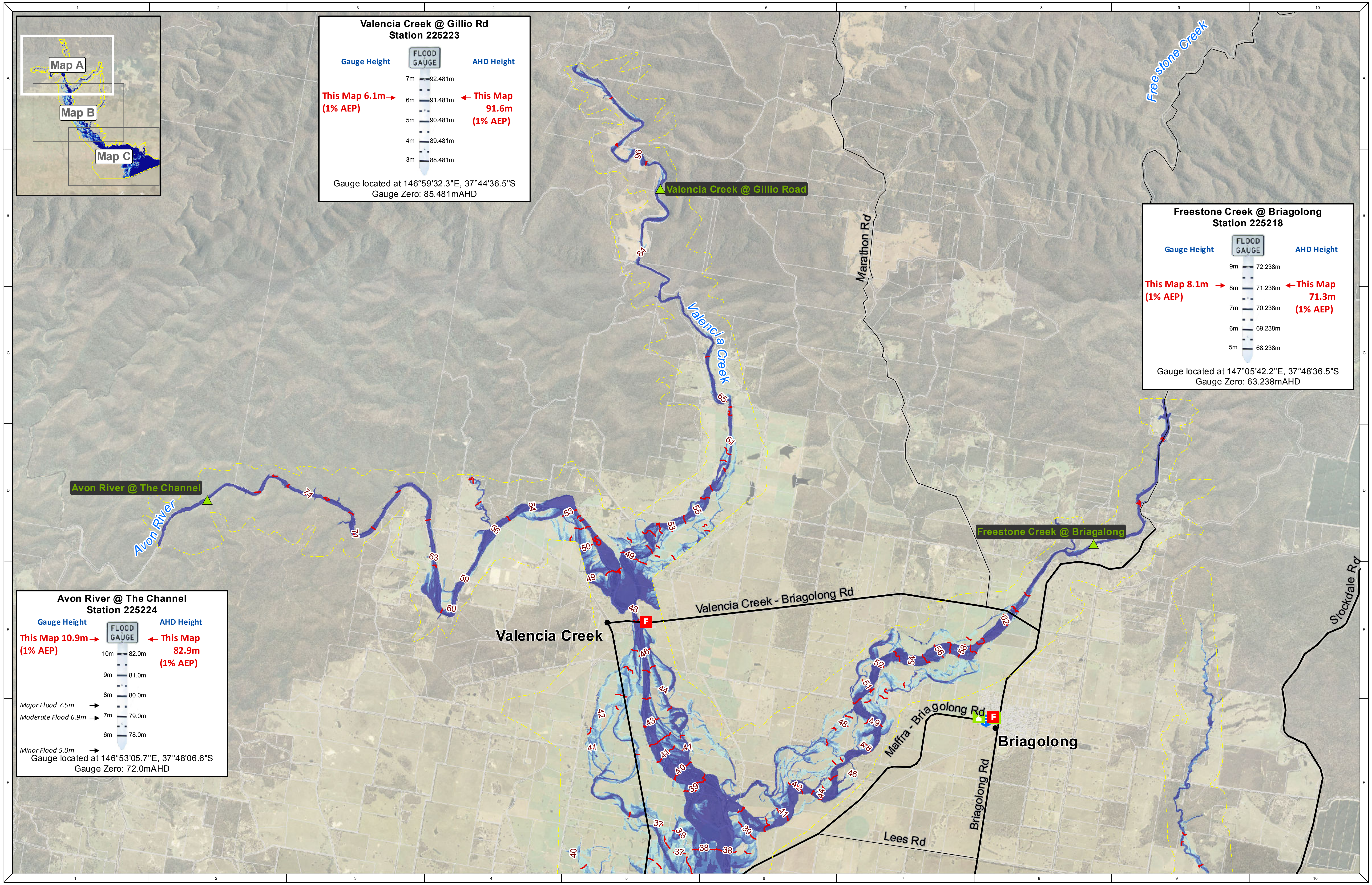
MIKE by DHI Quality Assurance Checklist

Item	Description	Calibration	Reviewed
MODEL INPUTS			
Client specification / Description of deliverables: Regional Flood Mapping, Other flood intelligence			**CLA**
Reference data and/or drawings: Nuntin Levee as constructed survey			**CLA**
Calibration data: AR @ Stratford, AR @ The Channel, AR @ Clydebank, VC @ Gillio Rd, FC @ Briagolong			**CLA**
Topographic data: LiDAR			**CJC**
Inflow Data: See hydrology report			**KLR**
Other inputs: Structures from VicRoads and VicRail			
Model Input Identification Approved - PM Sign:		**Date: 1/3/2015**	
Model Setup			
MIKE Model Build	Latest model build?	MIKE 2014 FM GPU	CLA
Module Selection	Modules used, Flexible Mesh	FM with GPU	CLA
GPU	Recommended for large FM floodplain models	Yes	CLA
Naming Convention		Avon_Cal_2007_001	CLA
Scenarios and Events		2007, 2012, 2011	CLA
Modelling Log	Using a manual runsheet is recommended for MIKE	Yes	CLA
Domain		As specified in brief	CLA
Element Size	4-5 cells across 2d waterways	~5m in waterways	CLA
Mesh Build Type	SMS with GIS softweare? Native MIKE mesh?	SMS	CLA
Mesh Reviewed by software	Report mesh analysis	Yes - ok	CLA
Mesh Reviewed manually	Mesh configuration checked internally?	Yes - YZ (13/07/2015)	CLA
2d Timestep	One half to one fifth the 2d cell size	0.01 - 30s (variable)	CLA
1d Timestep	One half to one quarter the 2d cell size	NA	
Structure Checks			
Pipes Flow Direction	Plot Long Section – flow should be downhill	Yes	CLA
Pipes Flow Magnitude	Check flow rates	Yes	CLA
1d Hydrographs	Graph Time series – Hydrographs should be stable	Yes	CLA
Pipe Cover	Minimum cover check	NA	
1d Output Interval	Usually can be greater than 1 minute	NA	
2d Checks			
Topography	Topography dfs2/dfsu Check, comparison to survey.	Yes - checked to cross section and between LiDAR sets	
Land Use	Roughness dfs2/dfsu Check, modelling of buildings.	Roughness calibrated in channel	CLA
Roughness	Roughness values – Check against recommended values (Chow, 1959; AR&R, 1987)	Yes	CLA
1d-2d Boundaries	MFLOOD schematisation - approriate number of linked cells?, MFM mesh alignment	Mesh aligned to structures	CLA
Initial Conditions	Initial conditions to encourage stability at start of model	Wet lower catchment	CLA
Downstream Boundary	Visual check for ponding behind boundary	ok	CLA
External Inflow Schematisation	Are inflows working?	Yes	CLA
Internal Inflow Schematisation	Routed or Unrouted flows working, in appropriate locations	Yes	CLA
1d Water Level Lines	Schematisation (bridges/culverts)	ok	CLA
PO Hydrographs Stability	Graph Time Series	Yes	CLA
Water Level Increasing with AEP	Visual inspection	Yes	CLA
2d Output Type	Appropriate outputs being used?	dfsU over domain, dfs1 hydrographs	CLA
2d Output Interval	Consider file size when specifying	30 min	CLA

2d Output Spatial Variation	Consider using output zones	No	CLA
QA Checks			
Instabilities	Check MIKE log files	No	CLA
Final Mass Error	MIKE log files and mass error outputs	-0.49% (2007), -0.98% (2012), -0.02% (2011)'	CLA
Warnings Prior to Simulation	Check MIKE log files	ok	CLA
Warnings During Simulation	Check MIKE log files	ok	CLA
Comments			

MODEL OUTPUT VERIFICATION AND VALIDATION
Outputs may be released if Reviewer is satisfied of the following:
Output meets/addresses activity objectives. Yes
Output provides appropriate information for intended purpose Yes Reviewer: Date: 29/10/2015
Output complies with appropriate acceptance criteria. Yes
Customer satisfied with output (from preliminary results & discussions) - Validation) yes, refer Peer review report
Outputs verified & authorised for issue: Yes PM Sign: Date: 14/12/2015
If required, independent review conducted by : Steering committee

APPENDIX C – FLOOD MAPS



- Stream Gauge
- Fire Station
- Police Station
- School/Child Care
- Major Road
- Minor Road
- Cadastre
- AHD Contour (1m)
- Limit of Flood Mapping

Flood Depth (m)
- < 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

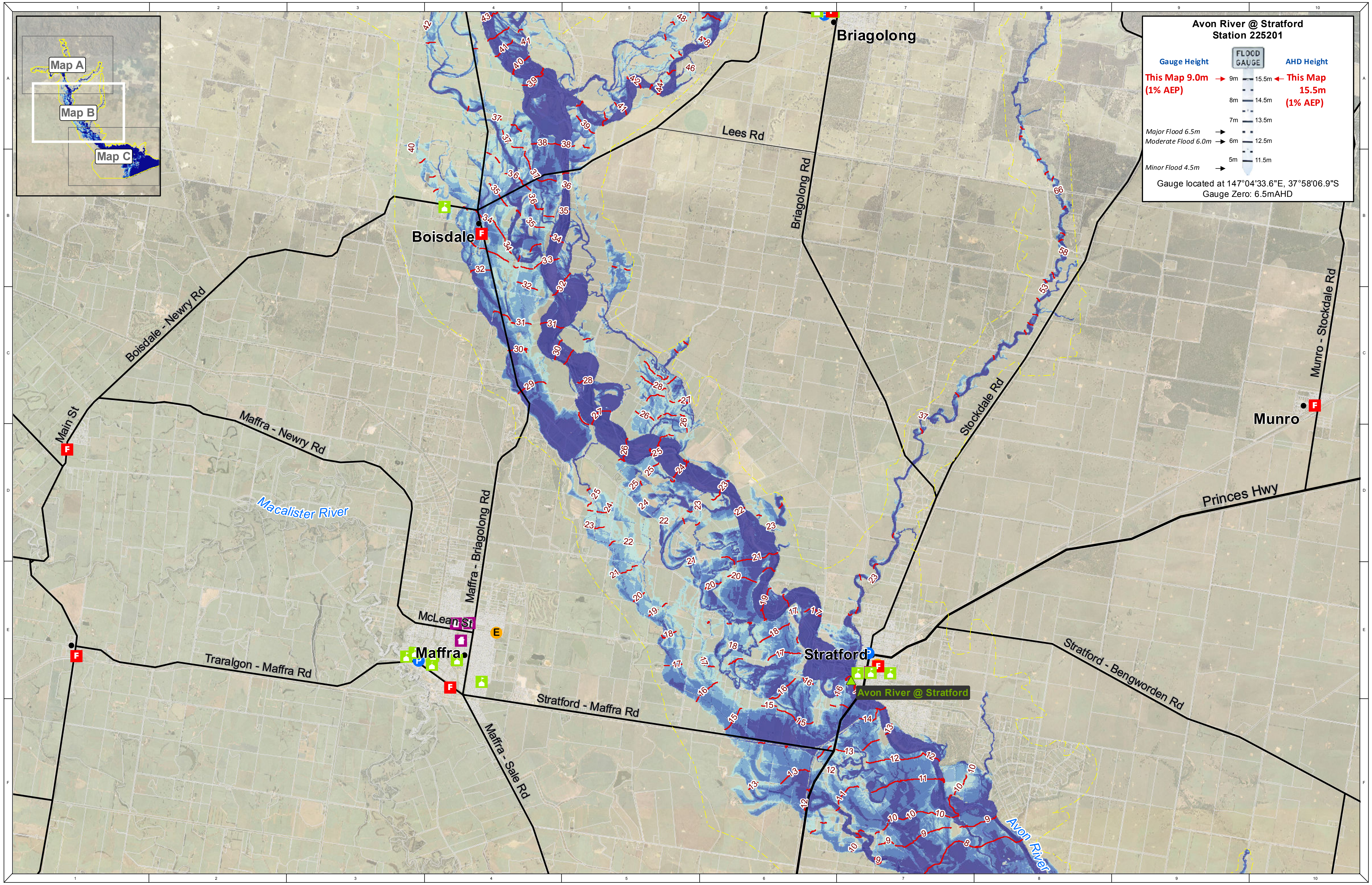
0 0.75 1.5 3 Kilometers 1:75,000 at A3

WATER TECHNOLOGY
State Government Victoria
Department of Environment, Land, Water & Planning

Avon River Regional Flood Mapping

1% AEP Flood Event - Depth Map

SHEET: 1 of 3
DRAWING NUMBER: A



Imagery: 2010

Stream Gauge
Emergency Services
Fire Station
Hospital
Nursing Home
Police Station
School/Child Care
Highway
Major Road
Minor Road
Cadastre
AHD Contour (1m)
Limit of Flood Mapping

Flood Depth (m)
< 0.25
0.25 - 0.5
0.5 - 1
> 1

0 0.75 1.5 3 Kilometers 1:75,000 at A3

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WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

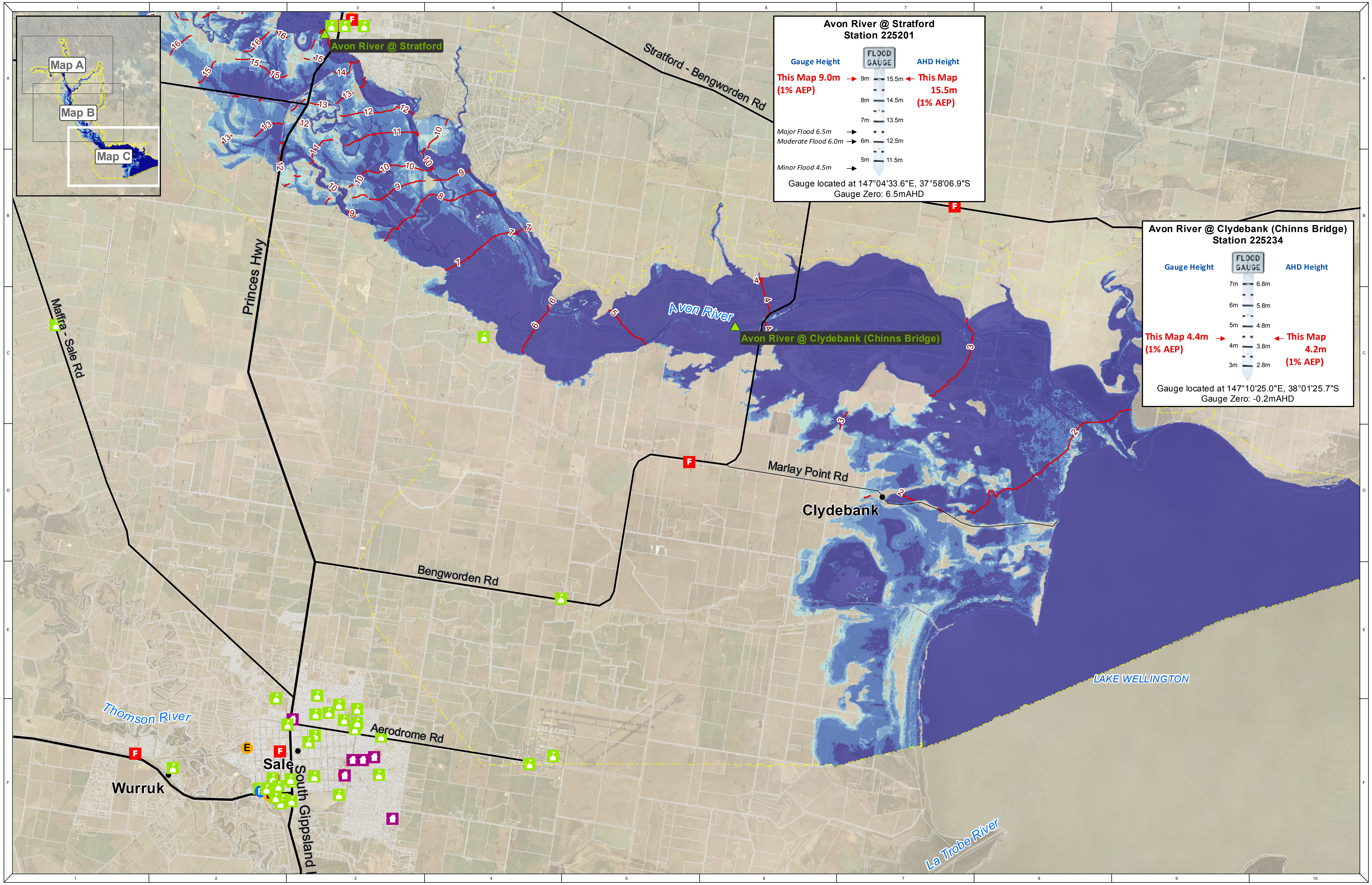
State Government Victoria
Department of Environment, Land, Water & Planning

Avon River Regional Flood Mapping

1% AEP Flood Event - Depth Map

REFERENCE: M:\JOBS\3700-3799\3719_AVON_R_REGIONAL_FM\SPATIAL\ESRI\MXDS\MAPPING\3719-01_100Y_DEPTHMAP_A3L-B.MXD

DATE: 08/03/2016 | SHEET: 2 of 3 | DRAWING NUMBER: B



Stream Gauge
E Emergency Services
F Fire Station
Hospital
Nursing Home
P Police Station
School/Child Care
Highway
Major Road
Minor Road
Cadastre
AHD Contour (1m)
Limit of Flood Mapping
Flood Depth (m)
< 0.25
0.25 - 0.5
0.5 - 1
> 1

0 0.75 1.5 3 Kilometers
1:75,000 at A3

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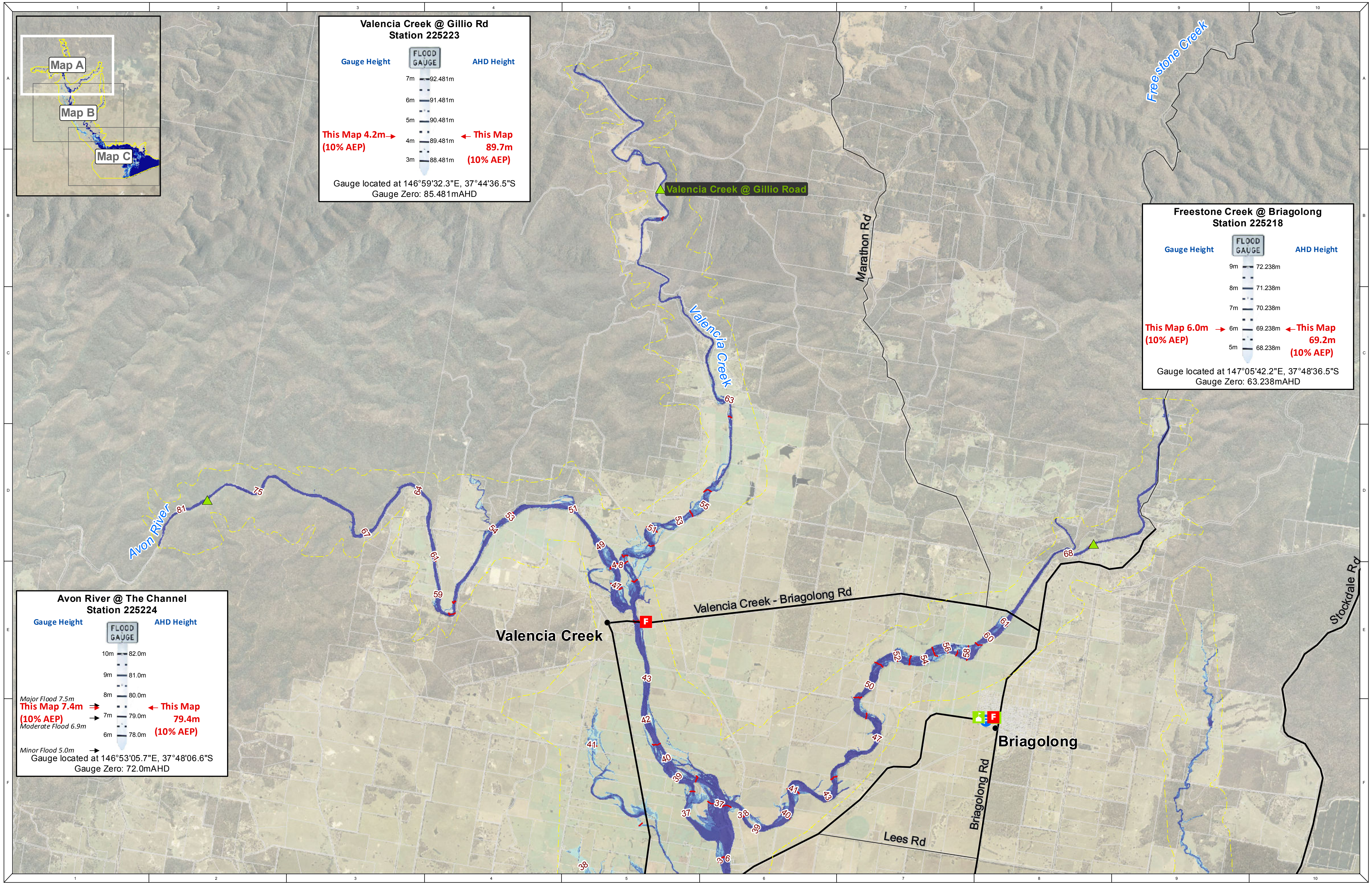
Avon River Regional Flood Mapping

1% AEP Flood Event - Depth Map

SHEET: 3 of 3
DRAWING NUMBER: C



Imagery: 2010

Stream Gauge
Fire Station
Police Station
School/Child Care

Major Road
Minor Road
Cadastre
AHD Contour (1m)
Limit of Flood Mapping

Flood Depth (m)
< 0.25
0.25 - 0.5
0.5 - 1
> 1

0 0.75 1.5 3 Kilometers
1:75,000 at A3

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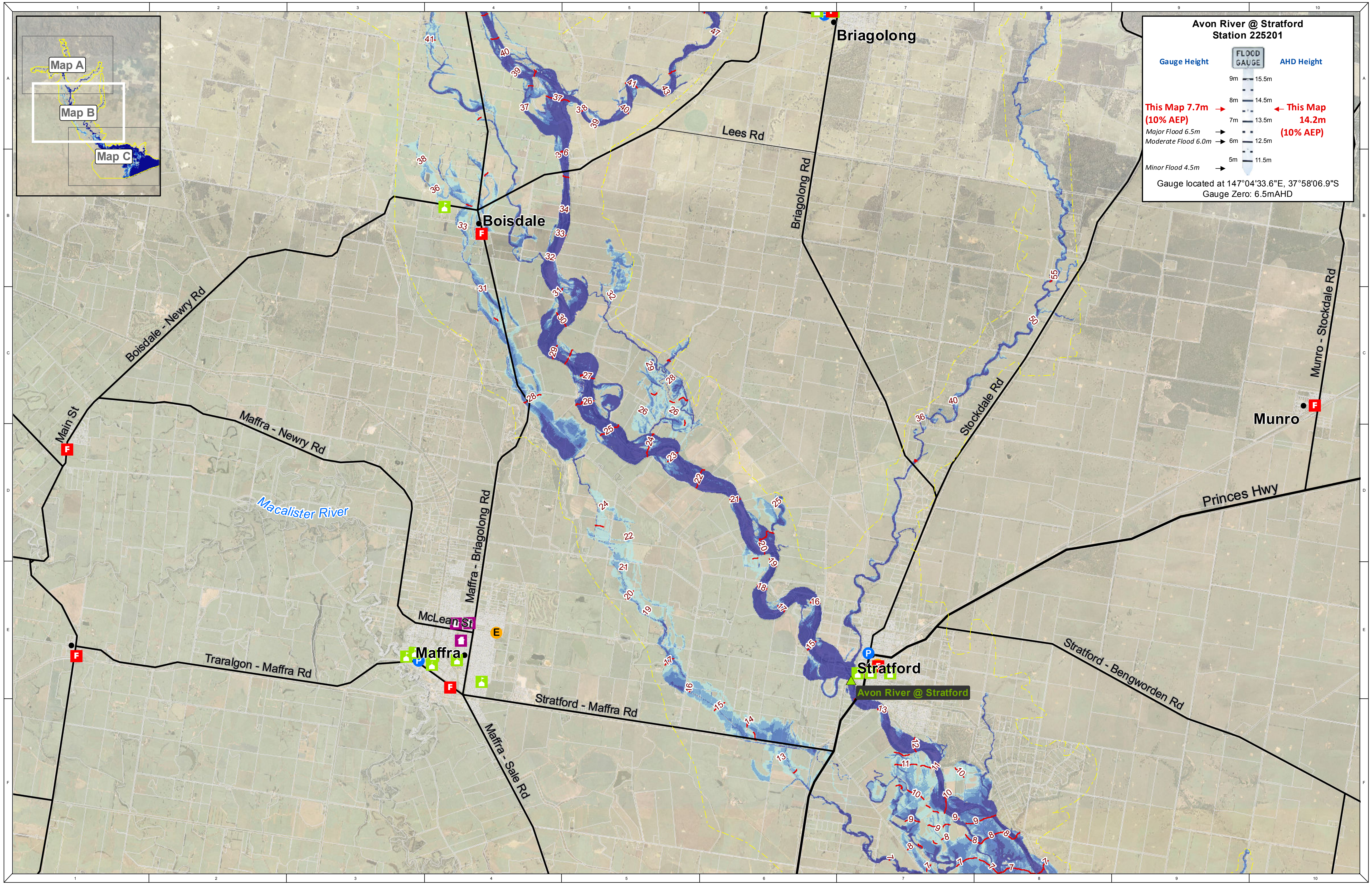
Avon River Regional Flood Mapping

10% AEP Flood Event - Depth Map

REFERENCE: M:\JOBS\3700-3799\3719_AVON_R_REGIONAL_FM\SPATIAL\ESRI\MXDS\MAPPING\3719-01_10Y_DEPTHMAP_A3L-A.MXD

DATE: 08/03/2016 | SHEET: 1 of 3 | DRAWING NUMBER: A



Imagery: 2010

N W E S

- Stream Gauge
- Emergency Services
- Fire Station
- Hospital
- Nursing Home
- Police Station
- School/Child Care
- Highway
- Major Road
- Minor Road
- Cadastre
- AHD Contour (1m)
- Limit of Flood Mapping

Flood Depth (m)
- < 0.25
- 0.25 - 0.5
- 0.5 - 1
- > 1

0 0.75 1.5 3 Kilometers 1:75,000 at A3

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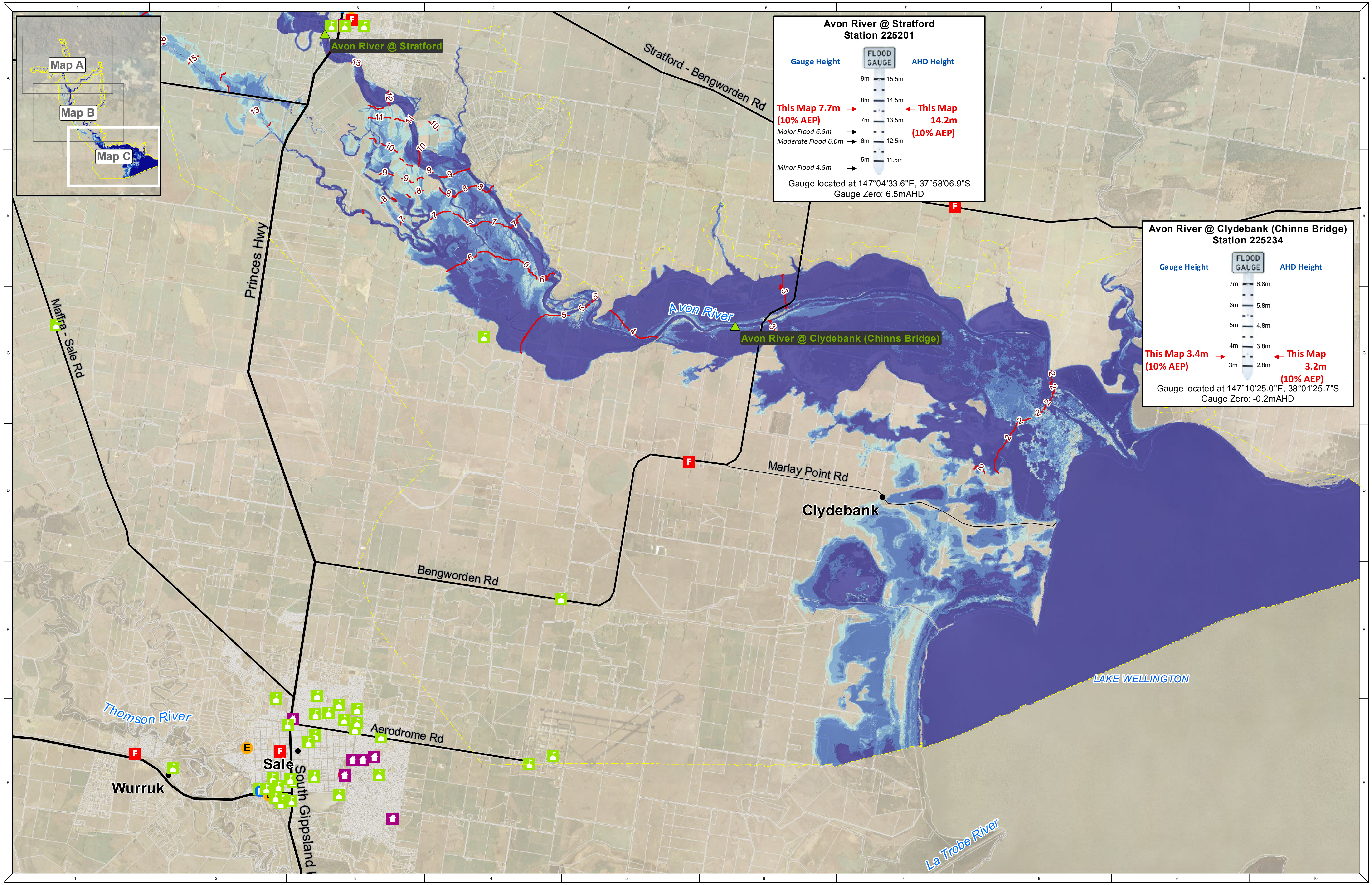
10% AEP Flood Event - Depth Map

REFERENCE: M:\JOBS\3700-3799\3719_AVON_R_REGIONAL_FM\SPATIAL\ESRI\MXDS\MAPPING\3719-01_10Y_DEPTHMAP_A3L-B.MXD

DATE: 08/03/2016 | SHEET: 2 of 3 | DRAWING NUMBER: B



Imagery: 2010

Stream Gauge
Emergency Services
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10% AEP Flood Event - Depth Map

REFERENCE: M:\JOBS\3700-3799\3719_AVON_R_REGIONAL_FM\SPATIAL\ESRI\MXDS\MAPPING\3719-01_10Y_DEPTHMAP_A3L-C.MXD

DATE: 08/03/2016 | SHEET: 3 of 3 | DRAWING NUMBER: C