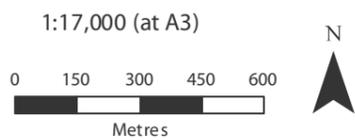
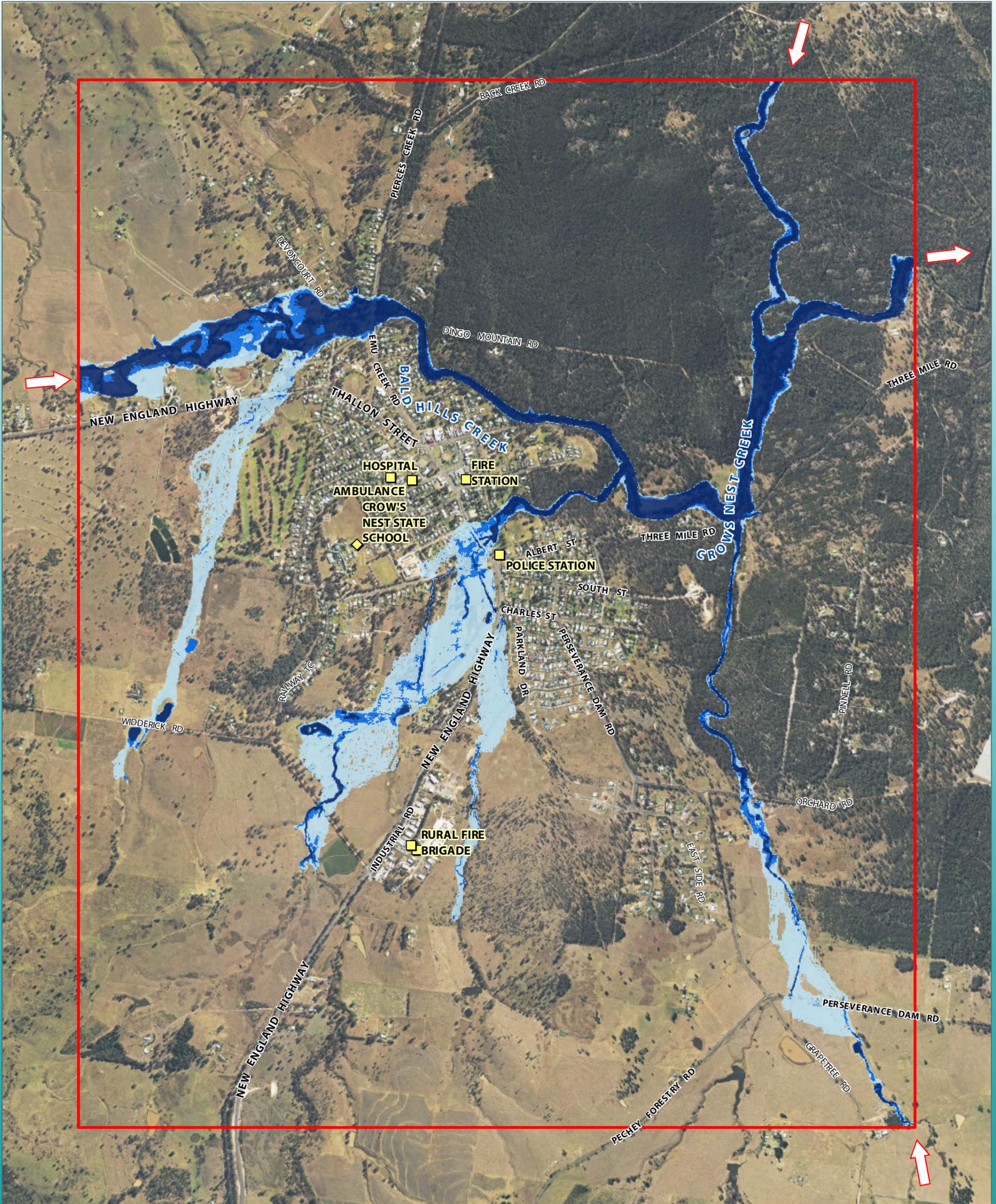


# CROWS NEST



## JANUARY 2011 FLOOD DEPTH RIVERINE

Water Depth (m)		Model Extent
		DirectionFlow
		Emergency Services
		School

While every care is taken by the Toowoomba Regional Council (TRC) to ensure the accuracy of the information contained in this document, Toowoomba Regional Council makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability whether in contract, negligence, tort or otherwise for all expenses, losses, damages (including indirect or consequential damage) and costs which may be incurred in any way and for any reason as a result of reliance on the information.

# A safer, stronger, more resilient region

Financially, socially and  
environmentally sustainable



## Crows Nest Flood Studies Information Sheet

### WHY UNDERTAKE FLOOD STUDIES?

Following extensive flooding across the Toowoomba region, we commissioned a number of flood studies to better understand how flooding can impact our communities. These studies are now complete and available on our website.

The flood studies found that flood behaviour can be complex and vary between locations, depending on landscape, infrastructure and rainfall pattern.

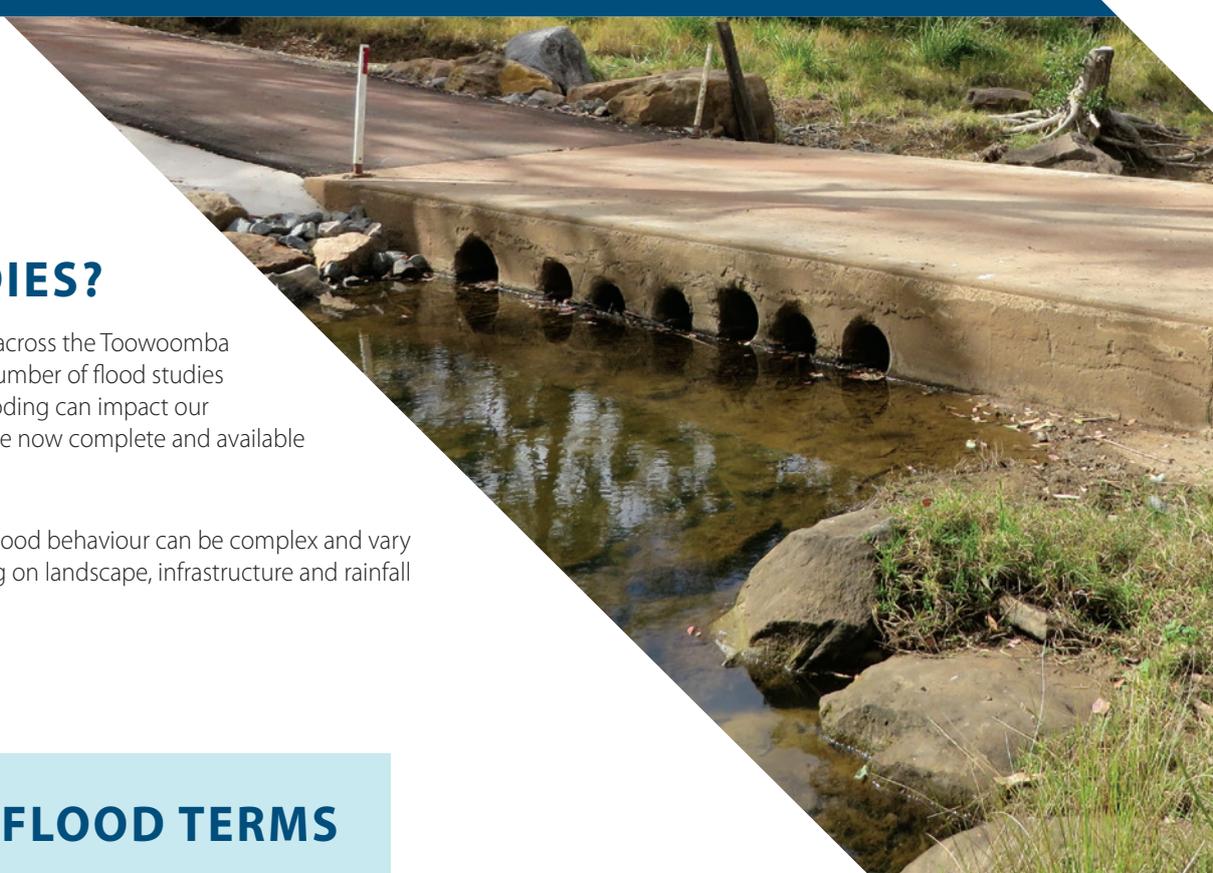
### SOME BASIC FLOOD TERMS

- 1 Overland flow** – short duration flooding of backyards, drainage paths, streets and rural properties caused by stormwater as it makes its way into the creek/river system;
- 2 Creek flooding** – short to medium duration flooding caused by creeks rising and breaking their banks, which can then flood nearby homes, businesses and rural properties;
- 3 River flooding** – longer duration flooding caused by significant rises in a river which can break its banks in the same way as smaller creeks.

Most of the studies undertaken or commissioned by Council relate to the first two types of flooding – overland flow and creek flooding. It's important to note that these types of flooding can occur separately or together.

### KEY MESSAGES

1. Council has a legislative requirement to undertake flood management and the whole community needs to be involved.
2. Flood studies are a foundation and an essential step towards our goal of a safer, stronger, more resilient region.
3. Flood studies have been undertaken by specialist engineers and incorporate the latest data, modelling techniques and community input.
4. Community consultation enables two-way information sharing about the project to increase community awareness, enhance decision making and help achieve our goal of a safer, stronger, more resilient region.



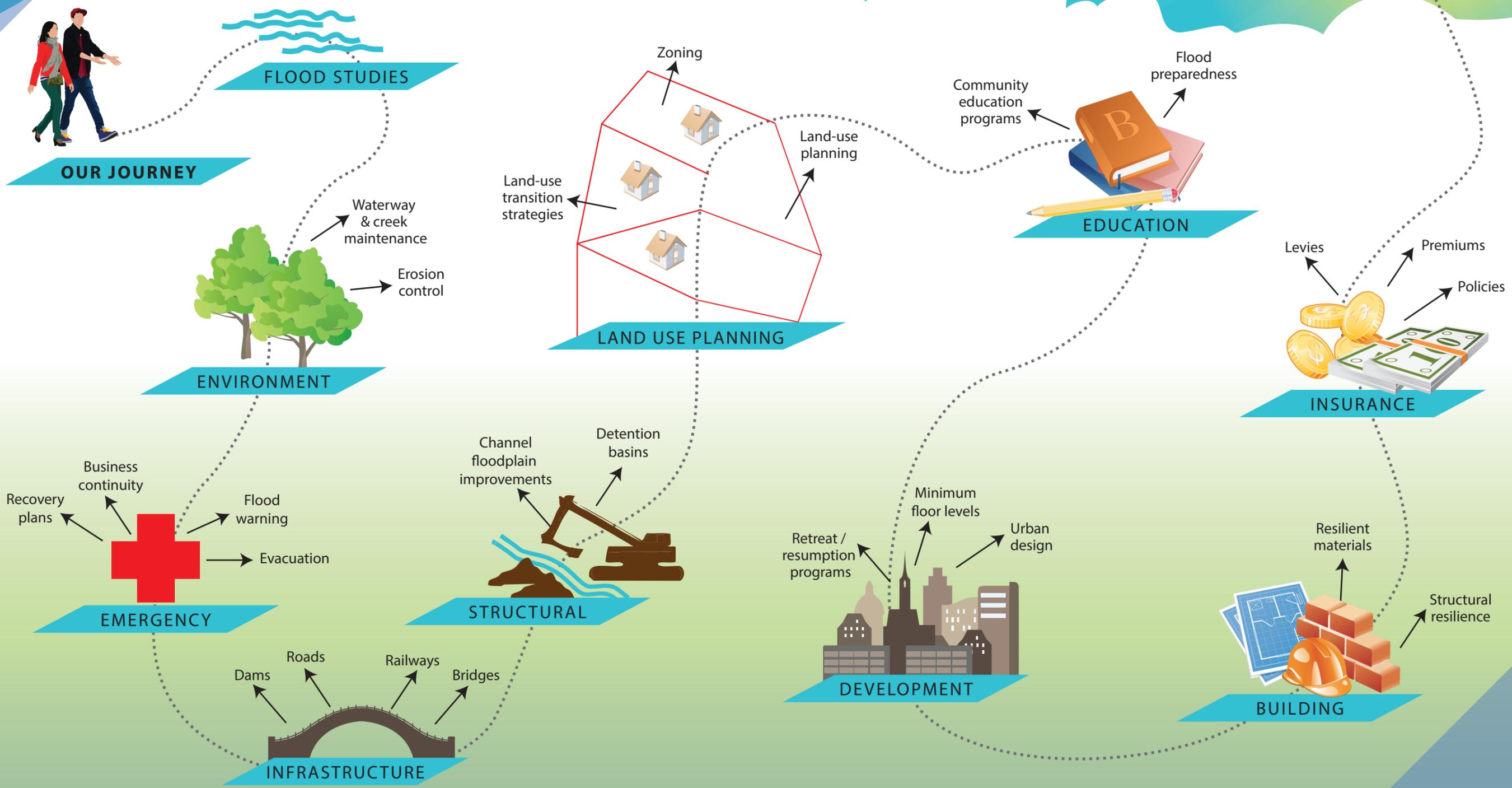
# Flood + us - our journey

Steps on the path to achieving our goal

**A safer,  
stronger,  
more resilient  
region**

*Financially, socially and environmentally sustainable*

**OUR GOAL**





# Crows Nest Flood Studies Information Sheet

## WHAT'S CROWS NEST'S FLOOD STORY?

A flood study and flood maps are now available for Crows Nest residents. The primary source of flood risk to the town is from creek flooding.

Engineers were engaged by Council to complete a historical flood study to quantify flood behaviours from the January 2011 event.

The study confirmed that during the January 2011 flood, parts of Crows Nest were flooded as a result of rising waters within Crows Nest Creek and its tributaries. The New England Highway, which provides access to the town from the south and west, was also cut off as a result of flooding in Crows Nest Creek.

The study has concluded that the January 2011 event was larger than a 1% Annual Exceedance Probability event – meaning that there is a 1% chance in any year to see this size flood event or larger.

Annual Exceedance Probability (AEP) means the chance of a flood of a given size or larger size occurring in any one year, usually expressed as a percentage.

## COMMUNITY INVOLVEMENT

Improving the way we prepare for and respond to flooding as a community is very important to us. Many residents in our region contributed information to build and validate our flood knowledge during the region-wide consultation sessions and other flood studies engagement opportunities.

Community involvement with this project continues to help our region become safer, stronger and more resilient. We encourage you to access the flood study information online and stay up to date with the project by visiting the web address below.

## GET INFORMED

You can access our region's current flood studies and maps by heading to <http://yoursay.toowoombarc.qld.gov.au/flood-resilience>  
For more information, please contact the project team by phone, email or post.

**Phone:** 131 872

**Email:** [info@tr.qld.gov.au](mailto:info@tr.qld.gov.au)

**Post:** Strategic Planning & Economic Development,  
Toowoomba Regional Council, PO Box 3021, Toowoomba Q 4350.



**TOOWOOMBA  
REGION**

# Flood Studies



**TOOWOOMBA  
REGION**  
Rich traditions. Bold ambitions.

## Historical Study for Crows Nest

August 2014 • *Endorsed on 25 February 2015*

## **GENERAL NOTE**

These reports/documents are a base source of information that will be continually refined over time.

## **DISCLAIMER**

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**REPORT TITLE:** Work Package 3 – Historical Study for Crows Nest, Final Report  
**CLIENT:** Toowoomba Regional Council  
**REPORT NUMBER:** 0965-01-F6

Revision Number	Report Date	Description	Report Author	Reviewer
DRAFT 1	9 October 2013	Draft Validation Report	TK/MB	SM/TV
DRAFT 2	10 December 2013	Draft Report	MB	SM/TV
FINAL 1	21 February 2014	Final Report	MB	SM/TV
FINAL 2	24 March 2014	Final Report (rev 1)	MB	SM/TV
FINAL 3	11 April 2014	Final Report (rev 2)	MB	SM/TV
FINAL 4	21 August 2014	Final Report (rev 3)	MB	SM/TV

For and on behalf of  
**WRM Water & Environment Pty Ltd**



**Sharmil Markar**  
Director

**NOTE:** This report has been prepared on the assumption that all information, data and reports provided to us by our client, on behalf of our client, or by third parties (e.g. government agencies) is complete and accurate and on the basis that such other assumptions we have identified (whether or not those assumptions have been identified in this advice) are correct. You must inform us if any of the assumptions are not complete or accurate. This report may only be used by our client for the purpose for which it has been provided by us.

# EXECUTIVE SUMMARY

Toowoomba Regional Council (TRC) appointed WRM Water and Environment Pty Ltd (WRM) in association with DHI Water and Environment Pty Ltd (DHI) to carry out hydraulic investigations of flooding in the town of Crows Nest. The hydraulic modelling was undertaken using a coupled MIKE FLOOD 1D/2D hydrodynamic model.

The majority of the data for the construction of the hydraulic model was derived from a 1m LiDAR Digital Elevation Model (DEM) provided by TRC. A site visit was undertaken on September 3<sup>rd</sup>, 2013. The purpose of the site visit was to allow the project team to identify key drainage features within the catchment, survey structures with potential significant hydraulic impact and gain a general feel for the floodplain.

The validation data consisted of two spot water levels and several locations where flooding was observed during the January 2011 event. The MIKE FLOOD model was validated to this event by scaling steady state flows until areas of known flooding were reproduced by the model and a good match between observed and modelled flood levels was achieved.

Information used is the best information available at this time for the purposes of this study. Marks observed and other anecdotal information obtained after flood events have been obtained from a range of sources and have varying degrees of certainty.

The hydraulic model results show that parts of Crows Nest were flooded from the Crows Nest Creek and its tributaries during the January 2011 event. The New England Highway, which provides access to the town from the south and west, was cut off during the event by Crows Nest Creek within the town and the tributary to the west. Hazard mapping for the January 2011 event classifies parts of Crows Nest as areas of significant to extreme hazard.

A sensitivity analysis was undertaken to assess model sensitivity to adopted flow, roughness and blockage of hydraulic structures. While water levels were sensitive in some areas, a very small variability in the overall flood extent was observed for all sensitivity analysis scenarios.

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# 1 INTRODUCTION

## 1.1 BACKGROUND

Toowoomba Regional Council (TRC) is a large local government area located in the Darling Downs part of Queensland, Australia. TRC comprises an area of nearly 13,000 km<sup>2</sup> with a population of approximately 172,000 people in 33 towns. In 2009 TRC commenced the Toowoomba Regional Planning Project (RPP) to develop one integrated planning scheme policy covering the entire Council area. Later that year TRC commissioned Water Technology Pty Ltd to collate and review the existing flood data in the region and provide advice on the applicability of the data for use in the Planning Scheme. One of the findings from the study was that only a small portion of the Council area is covered by high/medium quality flood mapping.

In 2012 the State Government approved Council adopting the Toowoomba Regional Planning Scheme with a set of conditions to be met to ensure the scheme was compliant with nominated State Planning Policies. To meet the conditions established by the State Government, a scoping study was completed by Council to identify the information required to meet the specified conditions. The study highlighted the need to investigate the flood behaviour and flood risk in several towns in the region.

WRM in association with DHI was commissioned by TRC to undertake the flood study for the town of Crows Nest. The flood study will provide Council with information needed for land development control, infrastructure development and management, emergency planning, and emergency response in the study area.

This report describes the methodology, available data, and development of a hydraulic model used for a historical event simulation for Crows Nest. The report also assesses the sensitivity of the adopted flow, roughness and blockage of hydraulic structures on predicted results. The report ends with concluding remarks and recommendations to further improve the model accuracy.

## 1.2 SCOPE OF PROJECT

The primary objective of this project was to define the nature and extent of flood behaviour in the Crows Nest study area to enable TRC to:

- *“Develop a Flood Risk Management Study and plan to address the flood hazards identified in the flood studies; and*
- *Amend the Toowoomba Regional Planning Scheme to appropriately reflect the flood requirements of State Planning Policy 1/03 and the recommendations of the Queensland Commission of Inquiry” (TRC, 2013).*

The project was divided into a number of phases. The scope of each phase is briefly outlined below.

#### Information Review and Project Start-Up

- Completion of project briefing;
- Development of stakeholder consultation strategy;
- Site visit; and
- Collection and review of available data.

#### MIKE FLOOD Model Development

- Development of a coupled 1D/2D MIKE FLOOD model; and
- Adjusting parameters to ensure model stability.

#### Model Validation

- The model was validated by adjusting steady-state flows to achieve the following targets:
  - All spot levels within  $\pm 0.5\text{m}$
  - A reasonable match between observed and modelled areas of flooding.

#### Sensitivity Analysis

- Assessment of model sensitivity to flow, roughness and blockage of hydraulic structures.

#### Deliverables

- Report detailing methodology, validation and sensitivity analysis results including A3 flood maps; and
- Handover of all model setup and result files.

### **1.3 STUDY AREA**

Crows Nest is a small town located approximately 55 km north of Toowoomba on the Crows Nest Creek floodplain. The town is located on both sides of Crows Nest Creek and its tributaries, with some properties in Crows Nest being within 50 m of the channel banks. Crows Nest is accessible by road from several directions. The primary source of flood risk to the town is from Crows Nest Creek and its tributary originating from the north-west.

Land use within the study area is primarily rural. Within the local area of the Crows Nest township the land use is predominantly residential. The study area is shown in Figure 1.1.

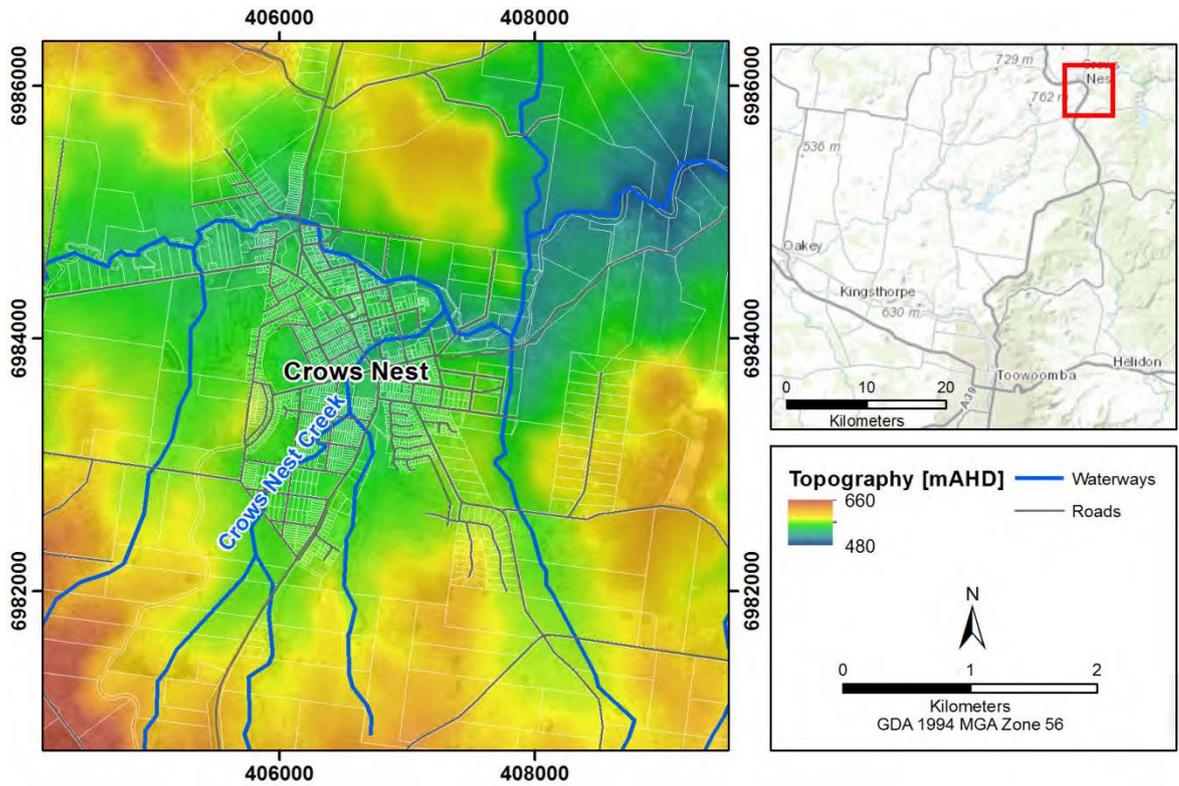


Figure 1.1 Study Area

# 2 AVAILABLE DATA

## 2.1 TOPOGRAPHIC DATA

Tiles of 1m LiDAR-derived gridded topographic data were provided by TRC. The 1m tiles were merged to create a seamless 1m Digital Elevation Model (DEM) of the study area, see Figure 2.1.

## 2.2 GIS LAYERS

The available GIS layers provided by TRC included:

- Aerial photography;
- Cadastral data;
- Road and rail network;
- Structures with a likely hydraulic impact;
- Land use data; and
- Future planning scheme; and
- Location of emergency services.

## 2.3 SITE VISIT

A site visit was undertaken on September 3<sup>rd</sup>, 2013. The purpose of the site visit was to allow the project team to identify key drainage features within the catchment, survey structures with potential significant hydraulic impact and gain a general feel for the floodplain. All information collected during the site visit including photos, structure geometry data and a GIS layer showing the location of the structures was delivered as part of the study.

## 2.4 HISTORICAL FLOOD INFORMATION

Available observed historical flood levels and extents were supplied by TRC. The available historical flood information was limited to the January 2011 flood event. Photographic evidence of inundated areas during the January 2011 flood was obtained from an internet search. However, the photographs could not be used to provide any additional historical flood information to what was already provided by TRC. All available validation data supplied by TRC is summarised in Table 2.1 and shown in Figure 2.1. Note that the points with a 'known flooding' reference in Table 2.1 represent locations where flooding was observed but no depth or level was recorded.

Please note that TRC has collected flood data for this study from a variety of sources including debris marks, flood marks visible and accessible at the time of survey after the January 2011

flood, eyewitness accounts, community consultation, etc. It is possible that some the flood data available to TRC may not be accurate or complete.

Information used is the best information available at this time for the purposes of this study. Marks observed and other anecdotal information obtained after flood events have been obtained from a range of sources and have varying degrees of certainty.

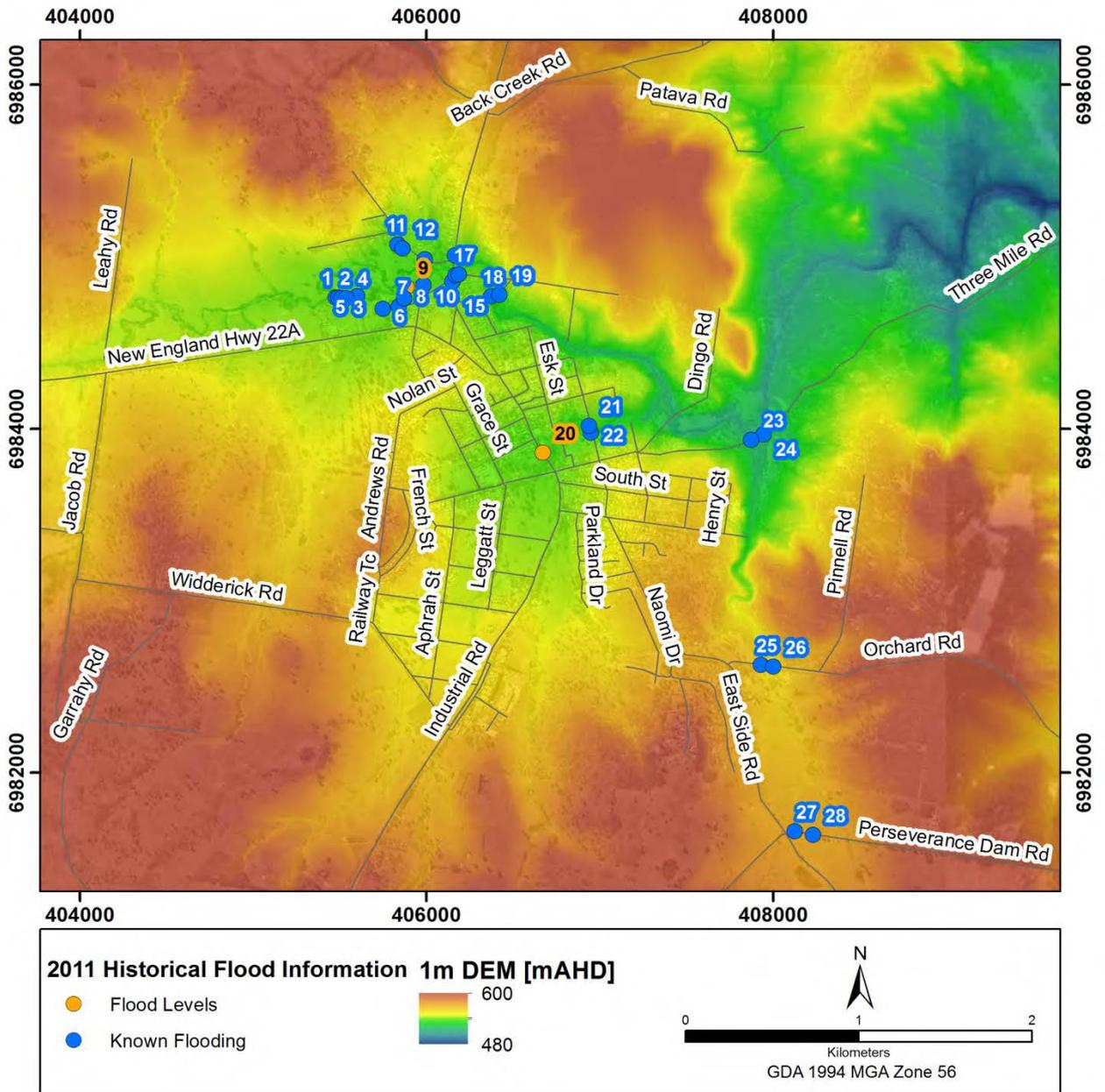


Figure 2.1 LiDAR Derived DEM Extent and Available Historical Flood Information

**Table 2.1 Historical Flood Information, January 2011**

<b>ID</b>	<b>Location</b>	<b>Flood Reference</b>
1	Lot 40 New England Highway (Backyard Point 1)	Known flooding
2	Lot 40 New England Highway (Backyard Point 2)	Known flooding
3	Lot 40 New England Highway (Backyard Point 3)	Known flooding
4	Lot 40 New England Highway (Backyard Point 4)	Known flooding
5	Lot 40 New England Highway (Backyard Point 5)	Known flooding
6	9 Hayden Street	Known flooding
7	7 Hayden Street	Known flooding
8	6 Hayden Street	Known flooding
9	Lot 22 Hayden Street	Flood Level
10	2 Showground Terrace	Known flooding
11	15 Devoncourt Rd	Known flooding
12	11 Devoncourt Rd	Known flooding
13	2 Devoncourt Rd (on road)	Known flooding
14	44 Emu Creek Road (near entrance of driveway)	Known flooding
15	Corner of Showground Terrace and Emu Creek Road	Known flooding
16	Corner of Nielsen Road and Emu Creek Road 1	Known flooding
17	Corner of Nielsen Road and Emu Creek Road 2	Known flooding
18	Dingo Mountain Road West	Known flooding
19	Dingo Mountain Road East	Known flooding
20	New England Highway (Crows Nest Creek crossing)	Flood Level
21	Dale Street (Northern flood point)	Known flooding
22	Dale Street (Southern flood point)	Known flooding
23	Three Mile Road (Western flood point)	Known flooding
24	Three Mile Road (Eastern flood point)	Known flooding
25	Orchard Road (Western flood point)	Known flooding
26	Orchard Road (Eastern flood point)	Known flooding
27	Perseverance Dam Road (Western flood point)	Known flooding
28	Perseverance Dam Road (Eastern flood point)	Known flooding

# 3 HYDRODYNAMIC MODEL DEVELOPMENT

## 3.1 OVERVIEW

The following section documents the development and validation of the hydrodynamic model, selection of key model parameters and assumptions made. The hydrodynamic model was developed in the MIKE FLOOD Release 2012 (Service Pack 2), which was the most recent version available at the time of the project. MIKE FLOOD is a software program that allows coupling of a MIKE 11 (1D) model and a MIKE 21 (2D) model to run together in parallel. The fundamental principle of MIKE FLOOD is that features smaller than the MIKE 21 grid resolution (e.g. small channels and structures) can be represented in MIKE 11, with linkages (couples) that transfer water levels and discharges between MIKE 11 and MIKE 21 at each time step. The MIKE FLOOD model schematisation (DHI, 2013) was agreed with TRC prior to the commencement of model development.

## 3.2 MIKE 21 MODEL

The 2D model domain for Crows Nest extends approximately 3.7km upstream of the New England Highway Crossing along Crows Nest Creek to approximately 3.6km downstream of the crossing as shown in Figure 3.1. The rectangular model domain is approximately 4 km by 5 km.

### 3.2.1 Bathymetry

The MIKE 21 model incorporates a detailed elevation model (bathymetry) of the ground surface. The DEM used in this model was created from the 1m DEM supplied by TRC; the DEM was then resampled to a 4m grid resolution. It was not deemed necessary to update the 'base' bathymetry with crest levels of major roads extracted from the 1m DEM as the road levels were represented appropriately in the 4m grid.

Small flow structures and crossings on secondary flow paths were implemented as they were represented in the source DEM data. These structures were not incorporated as 1D elements, and the 2D bathymetry was not adjusted to reflect any geometry or associated control levels. This implies that most small culverts and structures were assumed to be 100% blocked during a flood, thus producing a conservative estimate of the flood extent.

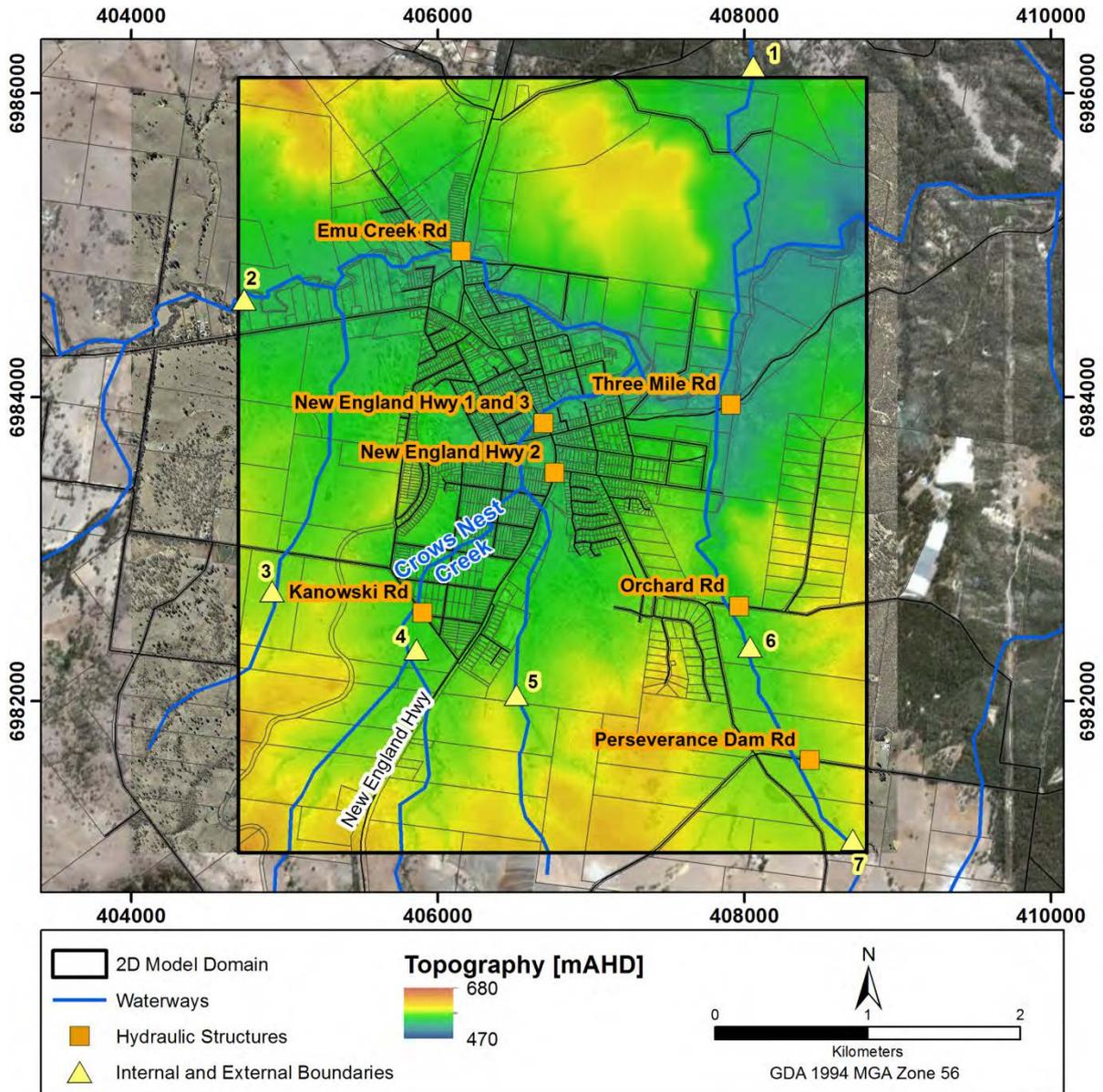


Figure 3.1 MIKE FLOOD Model Setup

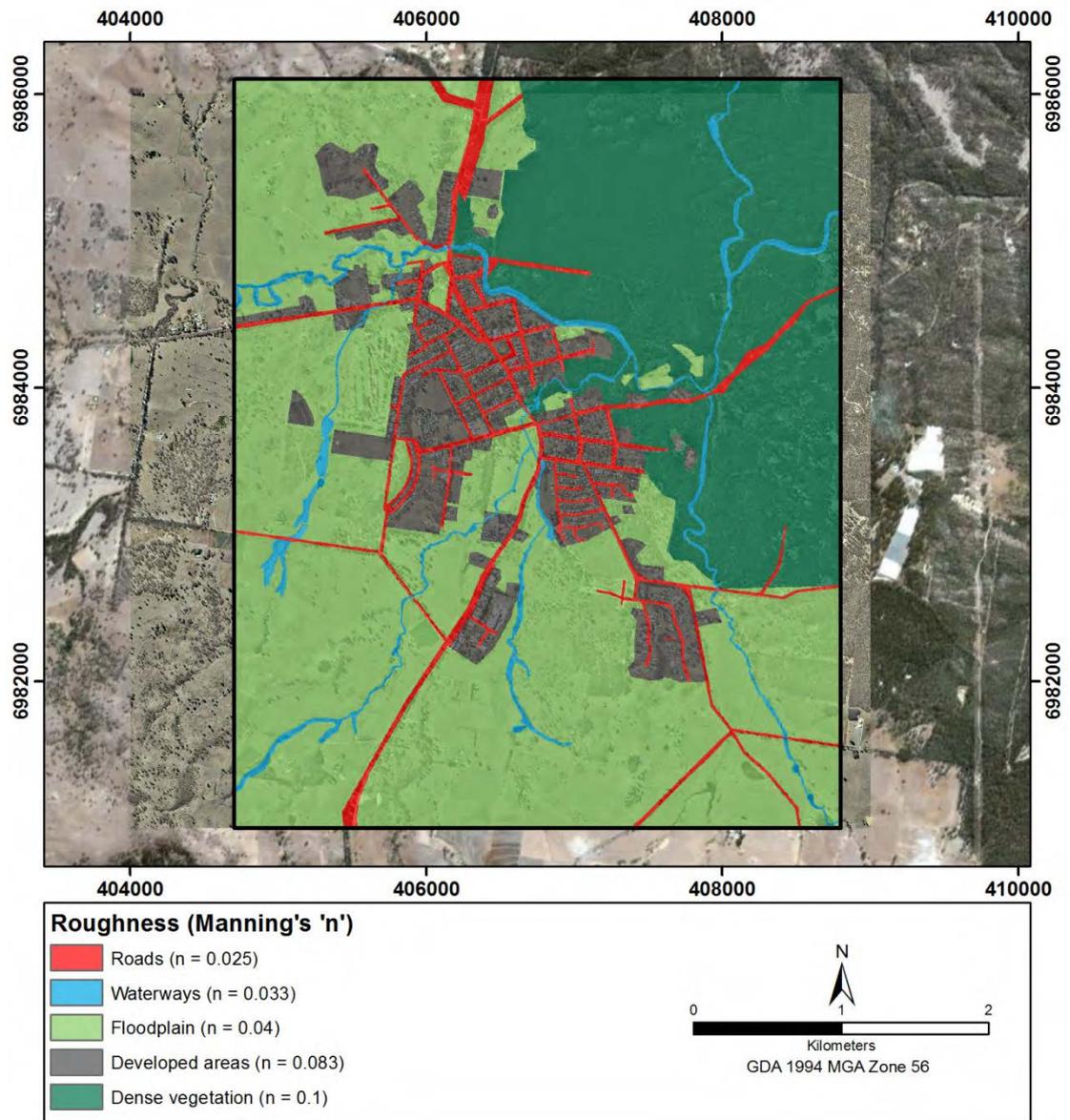
### 3.2.2 Hydraulic Roughness

MIKE21 models require the specification of hydraulic roughness to be applied in each cell, either as a constant value or in the form of a map (grid) of roughness values. A spatially distributed roughness map for the model domain was created based on the land uses classes provided by TRC as well as vegetation coverage identified from the aerial photography, also supplied by TRC. Five distinct land use classes were identified within the study area. The adopted hydraulic roughness values (Manning's 'n' and its reciprocal Manning's 'M') for each class are shown in Table 3.1. These values were based on DHI's previous experience in Queensland, whilst also taking into account Australian Rainfall and Runoff (ARR) Revision Project's valid Manning's 'n' ranges for different land use types (Smith and Wasko, 2012). It should be noted that the adopted Manning's 'n' value for 'Developed Areas' is slightly lower than the ARR recommended range of roughness values for this land use type. This is due to the coarse delineation of 'Developed Areas' based on land use classes, resulting in a Manning's 'n' value of 0.083 being applied to buildings as well as some open pervious areas. The spatial distribution of roughness is presented in Figure 3.2.

**Table 3.1 Adopted Hydraulic Roughness Values in MIKE FLOOD**

Land Use	Manning's 'M'	Manning's 'n'	Range of Manning's 'n' Values <sup>a</sup>
Floodplain	25	0.04	0.03 – 0.05
Roads	40	0.025	0.02 – 0.03
Developed Areas	12	0.083	0.10 – 0.20
Waterways	30	0.033	0.02 – 0.04
Dense Vegetation	10	0.1	0.07 – 0.12

Notes: <sup>a</sup> (Smith and Wasko, 2012)



**Figure 3.2 Spatial Distribution of Roughness**

### 3.2.3 Flooding and Drying Depths

In the MIKE FLOOD Release 2012, there is a new 'Inland Flooding' option available which results in much improved mass balances in urban flooding and floodplain applications. Continuity is fully preserved during the flooding and drying process, as the water depths at the points which are dried out are saved and then reused when the point becomes flooded again. A flooding depth of 0.05 m and a drying depth of 0.02 m were adopted in this study.

### 3.2.4 Eddy Viscosity

Eddy viscosity is used to represent sub-grid scale turbulence to provide the modeller with the opportunity to enhance or retard the natural generation of flow eddies in the solution scheme for the purpose of matching observed flow phenomena. A velocity based eddy viscosity formulation was applied and is recommended in floodplain applications.

Values for eddy viscosity can be calculated using a number of empirical formulas related to grid size and time step. Selecting an eddy viscosity value that is too high will result in the modelled flow having a more uniform velocity distribution tending to distribute more of the total flow to the floodplain. Selecting an eddy viscosity value that is too low can result in significant variability in the velocity field, formation of large modelled eddies in areas of no physical manifestation of this hydraulic phenomenon and contribute to model instability.

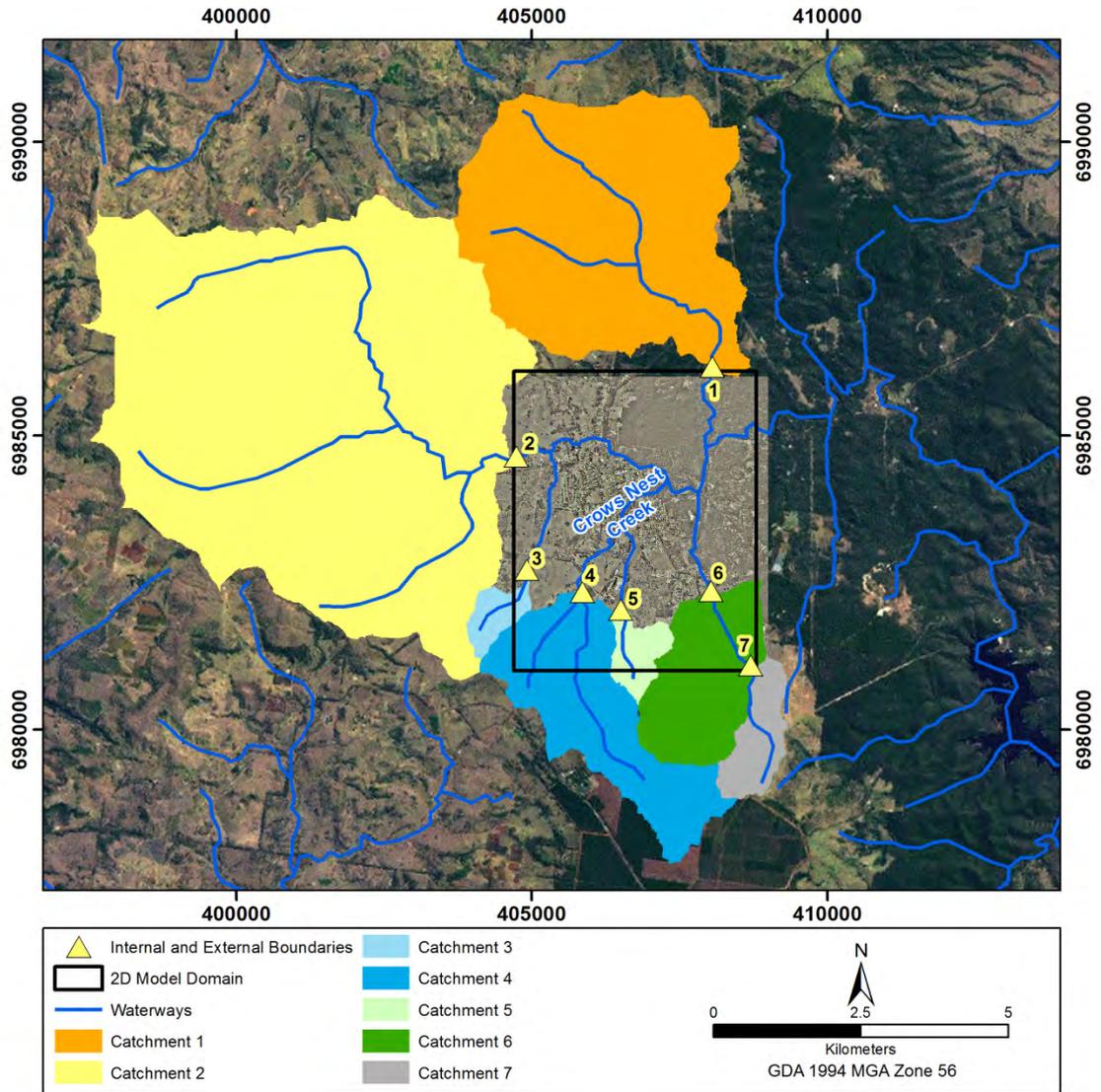
In this study, the eddy viscosity was set to 0.5 m<sup>2</sup>/s, which is consistent with the model resolution and based on DHI's previous experience with selection of secondary model parameters. At a small number of locations associated with 1D/2D couples an eddy viscosity of 5 m<sup>2</sup>/s was used to improve model stability.

### 3.2.5 Model Boundaries

Steady state flows were applied to the model at three external and four internal boundaries (source points), see Figure 3.3 and Table 3.2. A total flow of 850m<sup>3</sup>/s was applied. The flows were scaled by the total catchment area upstream of each point, see Figure 3.3. Source points with large peak discharges were split equally and applied over a number of grid cells to enhance model stability.

**Table 3.2      Steady-State Flows Applied**

<b>Internal/External Boundary</b>	<b>Catchment Area [km<sup>2</sup>]</b>	<b>Steady-State Flow [m<sup>3</sup>/s]</b>
1	18.3	204
2	42.3	472
3	0.79	9
4	7.11	80
5	0.99	11
6	4.93	55
7	1.69	19



**Figure 3.3 Sub-Catchments Upstream of MIKE 21 Inflow Locations**

One downstream open model boundary was specified using a constant water level of 489mAHD. The level was chosen based on the topographic features in the downstream part of the model domain. The model boundary was positioned as far downstream of the area of interest as possible to minimise backwater effects from assumptions made at the boundary location.

### 3.2.6 Time Step and Save Step

A 0.4 second time step was used based on Courant number considerations. The save step in MIKE 21 was set to 10 minutes.

## 3.3 MIKE 11 MODEL

### 3.3.1 Network and Structures

The MIKE 11 network consists of eight short branches used to model structures with potential significant hydraulic impact. Structure dimensions were implemented based on the measurements taken during the site visit. Invert levels of structures and their waterway length

were estimated from the 1m DEM and aerial photography, respectively. Bridge railing has not been considered in the structure definition, i.e. it was assumed no blockage of rails occurred during the validation flood event.

### 3.3.2 Cross-Sections

The cross-sections defined at the upstream and downstream ends of each MIKE 11 branch were extracted from the 1m DEM. Cross-sections upstream and downstream of structures were enlarged if they were smaller than the structure dimensions. This is necessary to ensure a realistic head loss across the structure.

### 3.3.3 Time Step and Save Step

When MIKE 11 and MIKE 21 models are coupled, MIKE 11 is forced to use the same time step as MIKE 21. The MIKE 11 results were saved every 10 minutes.

## 3.4 MIKE FLOOD MODEL

A total of eight coupling points were implemented in the MIKE FLOOD model. The structures and couple types are listed in Table 3.3. Photographs of the structures taken during the site visit are shown in Appendix A. Structures with a waterway length greater than two MIKE 21 grid cells (8m) were modelled using the ‘Standard’ link type, where structure submergence and overtopping is modelled in MIKE 11 and MIKE 21, respectively. In a ‘Structure’ link the upstream and downstream linked MIKE 21 cells must be adjacent. This link type was therefore applied to structures with a waterway length of 8m or less. Structure submergence and overtopping are both modelled in MIKE 11 for this link type.

**Table 3.3 Structures Implemented in MIKE FLOOD**

Structure	Link Type	Modelled Structure	Height/Width or Diameter	Comments
Perseverance Dam Road	Standard	Culvert	0.6	3 circular culverts
Orchard Road	Standard	Culvert	1.2	2 circular culverts
Kanowski Road	Structure	Culvert/weir	0.45	1 circular culvert
Three-Mile Road	Standard	Culvert	0.6	1 circular culvert
New England Highway 1	Standard	Culvert	2.14m/2.1m and 2.1m/1.7m - 2.1m	4 rectangular culverts
New England Highway 2	Standard	Culvert	1.53m/2.32m and 1.53m/2.1m - 2.32m	3 rectangular culverts
New England Highway 3	Standard	Culvert	1.27m/2.1m and 1.27m/1.9m - 2.1m	3 rectangular culverts
Emu-Creek Road	Standard	Bridge	-	Geometry based on 1m DEM and site visit photos (see Appendix A)

### 3.4.1 Standard/Structure Link Options

The standard/structure link parameters adopted in the MIKE FLOOD model are summarised in Table 3.4. The momentum factor was set to 1 at all explicit links. In general, an exponential

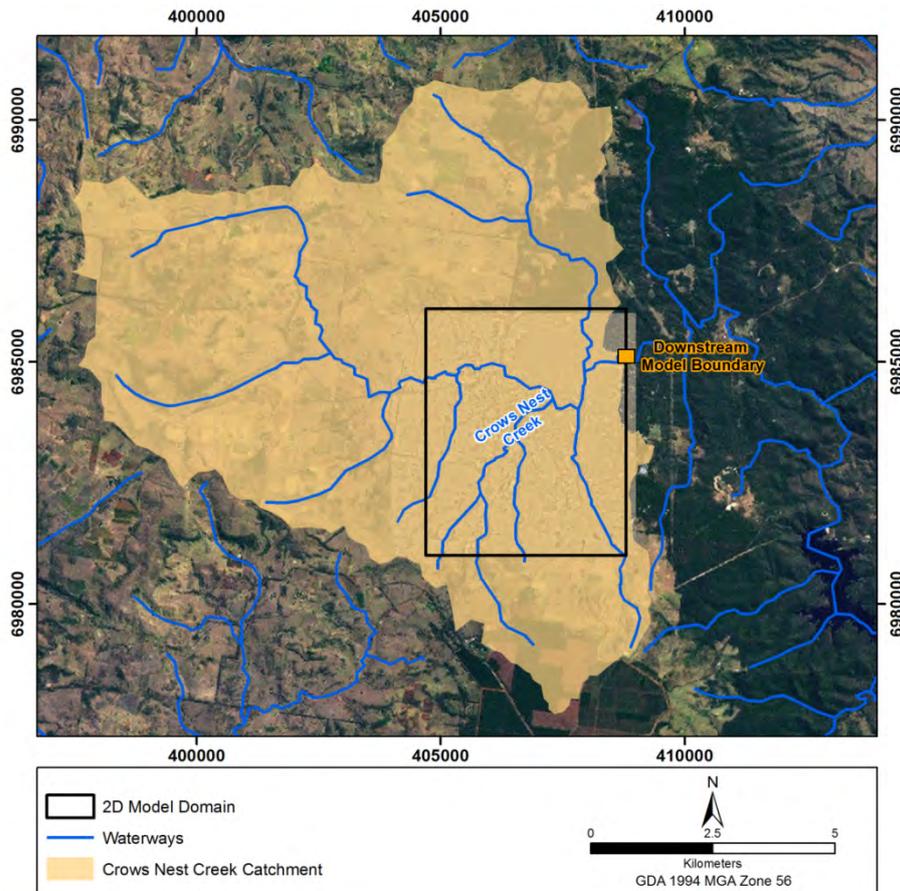
smoothing factor of 0.2 was adopted; however, 0.1 was adopted at the New England Highway 1 structure to promote stability.

**Table 3.4 Adopted Standard/Structure Link Parameters**

Parameter	Value/Option
Momentum factor	1
Extrapolation factor	0
Add/Replace Flow	Replace
Depth Adjustment	Yes
Exponential Smoothing Factor	0.1/0.2

### 3.5 MAGNITUDE OF THE JANUARY 2011 FLOOD EVENT

The 100 year ARI peak discharge in the Crows Nest Creek at the downstream boundary of the hydraulic model (see Figure 3.4) was calculated using the Rational Method. The time of concentration was estimated using the Bransby Williams formula to be 419 minutes or approximately 7 hours. The parameters adopted for the Rational Method calculation are listed in Table 3.5.



**Figure 3.4 Crows Nest Creek Catchment Outline**

**Table 3.5      Adopted Rational Method Parameters**

<b>Parameter</b>	<b>Value</b>
Catchment Area (km <sup>2</sup> )	93.8
Mainstream Length (km)	17.1
Average Slope (m/km)	7.7
Rainfall Intensity, $I_{tc,100}$ (mm/hr)	18.67
Runoff Coefficient ( $C_{100}$ )	0.70

The 100 year ARI peak discharge was estimated to be 341m<sup>3</sup>/s. The January 2011 event therefore appears to be significantly larger than the 100 year ARI event (850m<sup>3</sup>/s compared to 341m<sup>3</sup>/s).

# 4 ASSESSMENT OF MODEL PERFORMANCE

The MIKE FLOOD model was validated for the January 2011 flood event by scaling inflows until a satisfactory match with observed levels and areas of known flooding was achieved. Information used is the best information available at this time for the purposes of this study. Marks observed and other anecdotal information obtained after flood events have been obtained from a range of sources and have varying degrees of certainty.

The fit between modelled and observed flood levels as well as modelled and observed flooding is summarised in Table 4.1. The differences between modelled and observed water levels are well within the targeted  $\pm 0.5$  m. Twenty three out of twenty six locations known to have been inundated during the January 2011 flood have been reproduced by the model. At the remaining three locations, the modelled flood extent is within a 12 m distance of the observed flood extent.

Peak flood surface elevation, peak water depth, flood hazard and hydraulic category maps are included in Appendix C of this report. The predicted head losses at the hydraulic structures are listed in Appendix B, Table B.1. Note that the head losses have been calculated as the difference between upstream and downstream peak water levels extracted from either MIKE 11 or MIKE 21 results. At structures coupled to one grid cell as well as structures modelled using the 'Standard' link type, where structure overtopping is modelled in MIKE 21, the 2D results are often more representative of the actual head loss across the structure than the 1D results.

**Table 4.1 Measured and Modelled Flood Levels**

ID	Location	Observed Flood Level (m AHD)	Modelled Flood Level (m AHD)	Difference (m)
1	Lot 40 New England Highway (Backyard Point 1)	Flooded	Flooded	-
2	Lot 40 New England Highway (Backyard Point 2)	Flooded	Flooded	-
3	Lot 40 New England Highway (Backyard Point 3)	Flooded	Flooded	-
4	Lot 40 New England Highway (Backyard Point 4)	Flooded	Flooded	-
5	Lot 40 New England Highway (Backyard Point 5)	Flooded	Flooded	-
6	9 Hayden Street	Flooded	Flooded	-
7	7 Hayden Street	Flooded	Not flooded	-
8	6 Hayden Street	Flooded	Flooded	-
9	Lot 22 Hayden Street	535.42	535.68	0.26
10	2 Showground Terrace	Flooded	Flooded	-
11	15 Devoncourt Rd	Flooded	Flooded	-
12	11 Devoncourt Rd	Flooded	Flooded	-
13	2 Devoncourt Rd (on road)	Flooded	Flooded	-
14	44 Emu Creek Road (near entrance of driveway)	Flooded	Flooded	-
15	Corner of Showground Terrace and Emu Creek Road	Flooded	Flooded	-
16	Corner of Nielsen Road and Emu Creek Road 1	Flooded	Flooded	-
17	Corner of Nielsen Road and Emu Creek Road 2	Flooded	Flooded	-
18	Dingo Mountain Road West	Flooded	Flooded	-
19	Dingo Mountain Road East	Flooded	Flooded	-
20	New England Highway (Crows Nest Creek crossing)	534.85	534.84	-0.01
21	Dale Street (Northern flood point)	Flooded	Flooded	-
22	Dale Street (Southern flood point)	Flooded	Flooded	-
23	Three Mile Road (Western flood point)	Flooded	Flooded	-
24	Three Mile Road (Eastern flood point)	Flooded	Flooded	-
25	Orchard Road (Western flood point)	Flooded	Not flooded	-
26	Orchard Road (Eastern flood point)	Flooded	Flooded	-
27	Perseverance Dam Road (Western flood point)	Flooded	Not flooded	-
28	Perseverance Dam Road (Eastern flood point)	Flooded	Flooded	-

# 5 SENSITIVITY ANALYSIS

## 5.1 OVERVIEW

The model was tested for sensitivity to adopted flow, roughness and blockage of hydraulic structures. The January 2011 event was used as the baseline scenario. The following four sensitivity runs were undertaken:

- $\pm 30\%$  variation in flow;
- Increase in roughness (30% reduction in Manning's 'M'); and
- 50% blockage of hydraulic structures.

The sensitivity to blockage of structures was assessed as follows:

- The width of rectangular culverts was halved while maintaining the existing invert and obvert levels;
- The cross-sectional area of circular culverts was halved by reducing the diameter;
- The pier blockage factor was set to 0.5 for bridge openings; and
- Handrails were treated as fully blocked. The blockage of handrails was modelled by raising the road level in the MIKE 21 bathymetry file.

## 5.2 RESULTS

Structure head losses, discharges and velocities for the four sensitivity runs are listed in Appendix B. Maps of the model sensitivity to flow, roughness and blockage of structures are included in Appendix D. A very small variability in the overall flood extent was observed for all sensitivity analysis scenarios.

A comparison of the modelled surface elevation for the validation event and all sensitivity analysis scenarios is listed in Table 5.1 at selected validation points. The peak water levels are quite sensitive to changes in flow especially at ID23 Three Mile Road (see Figure 2.1 for location) and, to a lesser extent, changes in roughness and blockage of structures.

**Table 5.1 Modelled Surface Elevation at Selected Validation Points for All Sensitivity Analysis Scenarios**

<b>Scenario</b>	<b>ID3</b>	<b>ID9</b>	<b>ID11</b>	<b>ID19</b>	<b>ID20</b>	<b>ID23</b>	<b>ID25</b>	<b>ID27</b>
Baseline [mAHD]	538.79	535.68	535.76	530.09	534.84	517.25	558.31	573.49
Flow +30% [mAHD]	538.96	536.14	536.20	530.39	534.96	518.02	558.47	573.51
<b>Difference [m]</b>	<b>0.17</b>	<b>0.46</b>	<b>0.44</b>	<b>0.30</b>	<b>0.12</b>	<b>0.77</b>	<b>0.16</b>	<b>0.02</b>
Flow -30% [mAHD]	538.56	535.31	535.36	529.82	534.68	516.40	-	573.46
<b>Difference [m]</b>	<b>-0.23</b>	<b>-0.37</b>	<b>-0.40</b>	<b>-0.27</b>	<b>-0.16</b>	<b>-0.85</b>	<b>-</b>	<b>-0.03</b>
Manning's 'M' -30% [mAHD]	538.86	536.00	536.06	530.57	534.92	517.82	558.39	573.52
<b>Difference [m]</b>	<b>0.07</b>	<b>0.32</b>	<b>0.30</b>	<b>0.48</b>	<b>0.08</b>	<b>0.57</b>	<b>0.08</b>	<b>0.03</b>
50% Blockage [mAHD]	538.79	535.70	535.79	530.09	534.67	517.25	558.32	573.49
<b>Difference [m]</b>	<b>0.00</b>	<b>0.02</b>	<b>0.03</b>	<b>0.00</b>	<b>-0.17</b>	<b>0.00</b>	<b>0.01</b>	<b>0.00</b>

# 6 SUMMARY AND CONCLUSIONS

The primary objective of this historical study was to define the nature and extent of flood behaviour in the Crows Nest study area to enable Toowoomba Regional Council to develop a Flood Risk Management Study and amend the regional planning scheme to reflect flood requirements of the State Planning Policy and the recommendations of the Queensland Commission of Inquiry.

A coupled 1D/2D (MIKE FLOOD) hydraulic model has been successfully developed and validated for the Crows Nest study area. The model was validated for the January 2011 flood event and the validation results were demonstrated graphically. The predicted levels were within the required accuracy of  $\pm 0.5\text{m}$  and areas of known flooding were able to be reproduced by the model.

The hydraulic model results show that parts of Crows Nest were flooded from the Crows Nest Creek and its tributaries during the January 2011 event. The New England Highway, which provides access to the town from the south and west, was cut off during the event by Crows Nest Creek within the town and the tributary to the west.

A comparison with peak discharges estimated using the Rational Method appears to indicate that the January 2011 flood event at Crows Nest was larger than a 100 year ARI event.

A sensitivity analysis was undertaken to assess model sensitivity to adopted flow, roughness and blockage of hydraulic structures. While water levels were sensitive in some areas, a very small variability in the overall flood extent was observed for all sensitivity analysis scenarios.

Peak flood surface elevation, peak water depth, flood hazard and hydraulic category maps are included in Appendix C of this report. Hazard mapping for the January 2011 event classifies parts of Crows Nest as areas of significant to extreme hazard. Maps of the model sensitivity to flow, roughness and blockage of hydraulic structures are included in Appendix D. Digital mapping and model data files were also delivered as part of the study.

# 7 RECOMMENDATIONS

The following recommendations should be considered to improve the accuracy of the model performance.

1. Detailed calibration for at least two historical flood events should be performed to improve the model accuracy if more data becomes available. As the model has only been validated against two observed flood levels and several locations of known flooding, the model results should be used with caution.
2. Should a flood event occur it is recommended that as a minimum peak flood levels and extents are collected to further aid the validity of the model.
3. Model sensitivity to assumed downstream boundary levels was not part of the scope of the study, but could be considered.

# 8 REFERENCES

- DHI, 2013                      Hydraulic Model Development. Proposed Model Schematisation. September, 2013.
- Smith, G. and Wasko, C., 2012                      Australian Rainfall and Runoff, Revision Project 15: *Two Dimensional Simulations in Urban Areas - Representation of Buildings in 2D Numerical Flood Models*. Engineers Australia, Barton, ACT, February 2012.
- Toowoomba Regional Council, 2013                      SP 051 Flood Studies. Local Buy Contract BUS 226-0212. Engineering Consultancy Services. Work Package 3 – Historical Studies for: Brookstead, Clifton, Crows Nest, Jondaryan and Millmerran. Project Brief.

# 9 DISCLAIMER

*Information used is the best information available at this time for the purposes of this study. Marks observed and other anecdotal information obtained after flood events have been obtained from a range of sources and have varying degrees of certainty.*

*While every care is taken by the Toowoomba Regional Council (TRC) to ensure the accuracy of the data used in the study and published in the report, Toowoomba Regional Council makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaim all responsibility and all liability whether in contract, negligence or otherwise for all expenses, losses, damages (including indirect or consequential damage) and costs which may be incurred in any way and for any reason as a result of data being inaccurate or incomplete.*

# **APPENDIX A**

## **STRUCTURE ATTRIBUTES**



Perseverance Dam Road

Location:  
-27.28542  
152.074715



Crows Nest  
Orchard Rd  
2 culverts, d=1.2m

Orchard Road

Location:  
-27.276238  
152.07009



Kanowski Road

Location:  
-27.276516  
152.049282



Three-Mile Road

Location:  
-27.26426  
152.06964



New England Highway 1

Location:  
-27.265287  
152.057302



New England Highway 2

Location:  
-27.268218  
152.058047



New England Highway 3

Location:  
-27.265042  
152.05713



Emu-Creek Road

Location:  
-27.255075  
152.052015

# **APPENDIX B**

## **STRUCTURE HEAD LOSSES, DISCHARGES AND VELOCITIES**

**Table B.1 Head Losses, Discharges and Velocities at Structures - January 2011 Validation Event**

Structure	Upstream Water Level (mAHD)	Road Level (mAHD)	Downstream Water Level (mAHD)	Structure Invert (mAHD)	Structure Obvert (mAHD)	Head Loss* (m)	Peak Discharge** (m <sup>3</sup> /s)	Peak Velocity*** (m/s)	Road Overtopped
Perseverance Dam Road	577.31	577.10	577.09	576.10	576.70	0.22	2	2.5	✓
Orchard Road	558.52	557.65	558.14	555.45	556.65	0.38	5	2.2	✓
Kanowski Road	556.32	555.06	555.98	554.00	554.45	0.34	5	3.1	✓
Three-Mile Road	517.20	512.85	517.16	511.70	512.30	0.04	0.1	0.5	✓
New England Highway 1	534.89	534.74	534.86	532.30	534.44	0.03	21	1.3	✓
New England Highway 2	539.43	540.20	539.40	538.10	539.63	0.03	8	0.9	
New England Highway 3	534.99	534.67	534.83	532.88	534.15	0.16	15	1.9	✓
Emu Creek Road	535.12	532.50	534.90	529.85	531.60	0.22	15	0.7	✓

**Table B.2 Head Losses, Discharges and Velocities at Structures - Sensitivity Analysis (+30% Flow)**

Structure	Upstream Water Level (mAHD)	Road Level (mAHD)	Downstream Water Level (mAHD)	Structure Invert (mAHD)	Structure Obvert (mAHD)	Head Loss* (m)	Peak Discharge** (m <sup>3</sup> /s)	Peak Velocity*** (m/s)	Road Overtopped
Perseverance Dam Road	577.33	577.10	577.10	576.10	576.70	0.23	2	2.5	✓
Orchard Road	558.69	557.65	558.29	555.45	556.65	0.40	5	2.3	✓
Kanowski Road	556.44	555.06	556.07	554.00	554.45	0.37	6	3.3	✓
Three-Mile Road	517.94	512.85	517.90	511.70	512.30	0.04	0.1	0.5	✓
New England Highway 1	535.01	534.74	534.98	532.30	534.44	0.03	22	1.3	✓
New England Highway 2	539.57	540.20	539.54	538.10	539.63	0.03	10	1.0	
New England Highway 3	535.13	534.67	534.96	532.88	534.15	0.17	15	1.9	✓
Emu Creek Road	535.76	532.50	535.56	529.85	531.60	0.20	12	0.5	✓

\* The head loss is calculated as the difference between the upstream and downstream peak water levels in MIKE 11 or MIKE 21, see Section 4 for explanation

\*\* Peak discharge is reported through the culvert or bridge

\*\*\* Peak velocity is reported through the culvert or bridge

**Table B.3 Head Losses, Discharges and Velocities at Structures - Sensitivity Analysis (-30% Flow)**

Structure	Upstream Water Level (mAHD)	Road Level (mAHD)	Downstream Water Level (mAHD)	Structure Invert (mAHD)	Structure Obvert (mAHD)	Head Loss* (m)	Peak Discharge** (m <sup>3</sup> /s)	Peak Velocity*** (m/s)	Road Overtopped
Perseverance Dam Road	577.18	577.10	577.08	576.10	576.70	0.10	2	2.4	✓
Orchard Road	558.34	557.65	557.93	555.45	556.65	0.41	5	2.3	✓
Kanowski Road	556.20	555.06	555.85	554.00	554.45	0.35	4	3.0	✓
Three-Mile Road	516.35	512.85	516.32	511.70	512.30	0.03	0.1	0.5	✓
New England Highway 1	534.74	534.74	534.72	532.30	534.44	0.02	20	1.2	✓
New England Highway 2	539.23	540.20	539.21	538.10	539.63	0.02	6	0.8	
New England Highway 3	534.80	534.67	534.66	532.88	534.15	0.14	14	1.8	✓
Emu Creek Road	534.49	532.50	534.18	529.85	531.60	0.31	20	0.9	✓

**Table B.4 Head Losses, Discharges and Velocities at Structures - Sensitivity Analysis (-30% Manning's 'M')**

Structure	Upstream Water Level (mAHD)	Road Level (mAHD)	Downstream Water Level (mAHD)	Structure Invert (mAHD)	Structure Obvert (mAHD)	Head Loss* (m)	Peak Discharge** (m <sup>3</sup> /s)	Peak Velocity*** (m/s)	Road Overtopped
Perseverance Dam Road	577.31	577.10	577.09	576.10	576.70	0.22	2	2.4	✓
Orchard Road	558.61	557.65	558.25	555.45	556.65	0.36	5	2.3	✓
Kanowski Road	556.34	555.06	556.08	554.00	554.45	0.26	5	3.0	✓
Three-Mile Road	517.75	512.85	517.72	511.70	512.30	0.03	0.1	0.5	✓
New England Highway 1	534.98	534.74	534.95	532.30	534.44	0.03	20	1.2	✓
New England Highway 2	539.47	540.20	539.45	538.10	539.63	0.02	8	0.8	
New England Highway 3	535.05	534.67	534.92	532.88	534.15	0.13	13	1.7	✓
Emu Creek Road	535.44	532.50	535.28	529.85	531.60	0.16	11	0.5	✓

\* The head loss is calculated as the difference between the upstream and downstream peak water levels in MIKE 11 or MIKE 21, see Section 4 for explanation

\*\* Peak discharge is reported through the culvert or bridge

\*\*\* Peak velocity is reported through the culvert or bridge

Table B.5 Head Losses, Discharges and Velocities at Structures - Sensitivity Analysis (50% Blockage)

Structure	Upstream Water Level (mAHD)	Road Level (mAHD)	Downstream Water Level (mAHD)	Structure Invert (mAHD)	Structure Obvert (mAHD)	Head Loss* (m)	Peak Discharge** (m <sup>3</sup> /s)	Peak Velocity*** (m/s)	Road Overtopped
Perseverance Dam Road	577.31	577.10	577.10	576.10	576.70	0.21	1	2.4	✓
Orchard Road	558.59	557.65	558.06	555.45	556.65	0.53	3	2.3	✓
Kanowski Road	556.33	555.06	555.98	554.00	554.45	0.35	5	2.8	✓
Three-Mile Road	517.20	512.85	517.16	511.70	512.30	0.04	0.07	0.5	✓
New England Highway 1	535.02	534.74	534.72	532.30	534.44	0.30	21	2.5	✓
New England Highway 2	539.64	540.20	539.41	538.10	539.63	0.23	8	1.9	
New England Highway 3	535.15	534.67	534.65	532.88	534.15	0.50	10	2.7	✓
Emu Creek Road	535.28	532.50	534.86	529.85	531.60	0.42	13	1.2	✓

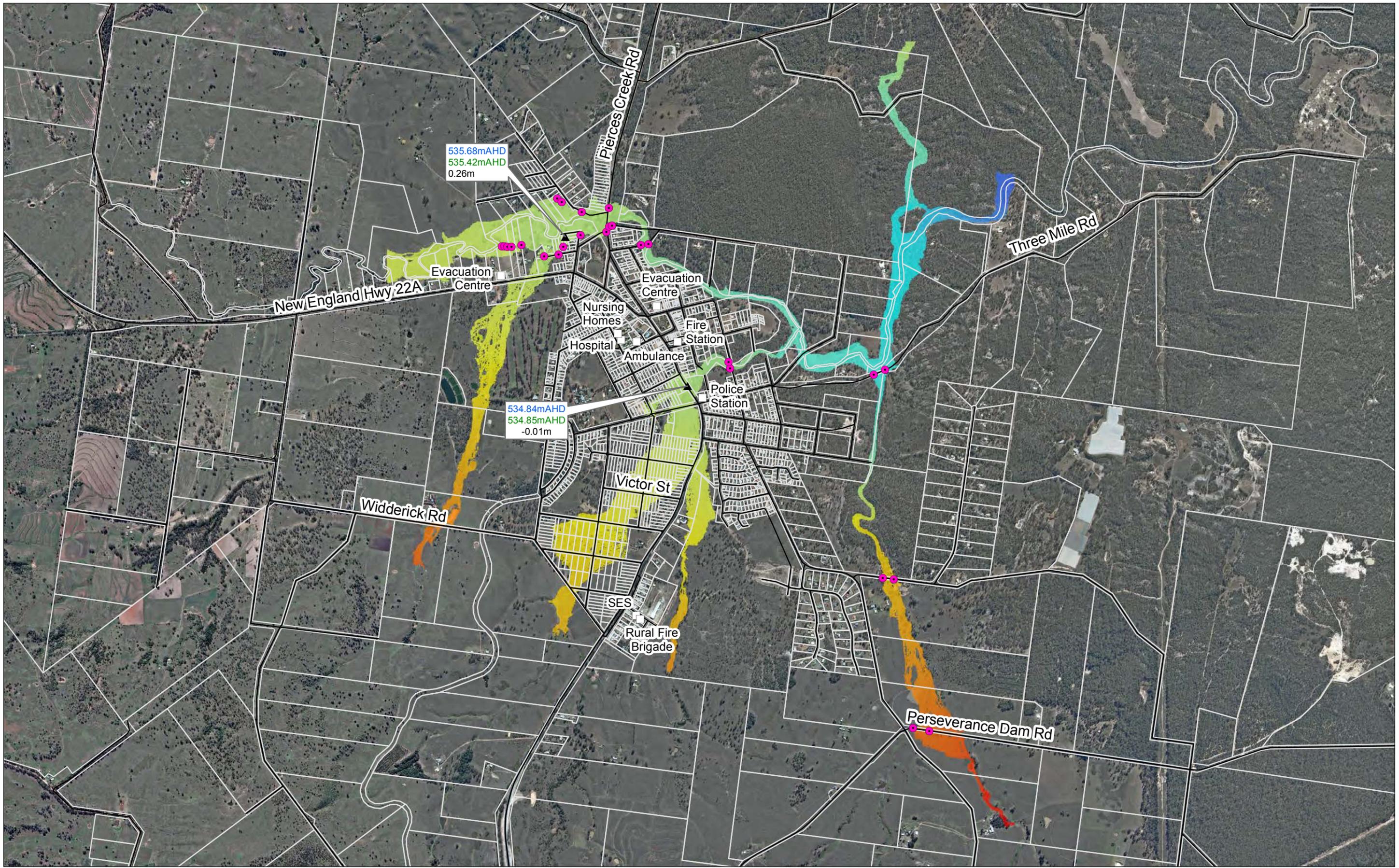
\* The head loss is calculated as the difference between the upstream and downstream peak water levels in MIKE 11 or MIKE 21, see Section 4 for explanation

\*\* Peak discharge is reported through the culvert or bridge

\*\*\* Peak velocity is reported through the culvert or bridge

# **APPENDIX C**

## VALIDATION MAPPING



1:22,000 (at A3)

0 200 400 800  
Meters  
GDA 1994 MGA Zone 56

N

**Legend**

**Surface Elevation [mAHD]**

585  
480

— Roads  
□ Cadastre  
□ Emergency Services

**2011 Validation Data**

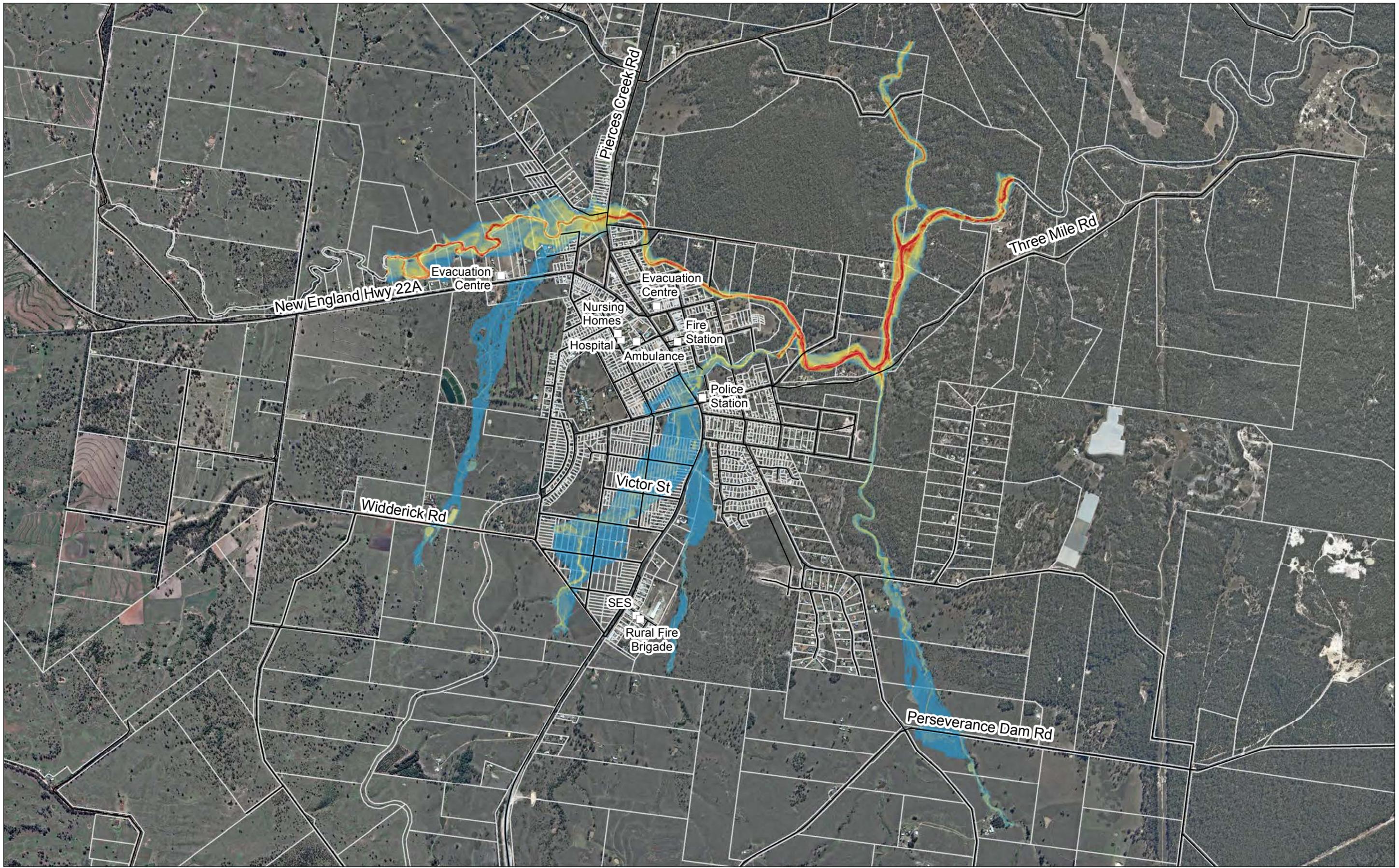
▲ Flood Levels  
● Known Flooding

Modelled  
Observed  
Modelled-Observed

Disclaimer: The flood information contained in the maps is based on debris lines and marks that were visible and accessible at the time of recording after the January 2011 flood event and may not be accurate or complete and reliance should not be placed on it. Toowoomba Regional Council makes no representations or warranties about the accuracy, reliability, completeness or suitability for any particular purpose and disclaim all responsibility and all liability whether in contract, negligence or otherwise for all expenses, losses, damages (including indirect or consequential damage) and costs which may be incurred in any way and for any reason as a result of the flood information contained in the maps being inaccurate or incomplete.

**SP051 Flood Studies  
Work Package 3 Crows Nest  
January 2011  
Water Surface Elevation**

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1:22,000 (at A3)

0 200 400 800  
Meters  
GDA 1994 MGA Zone 56

N

**Legend**  
Peak Water Depth [m]

0 - 0.25	0.25 - 0.5	0.5 - 1	1 - 1.5	1.5 - 2	2 - 2.5	2.5 - 3	3 - 3.5	3.5 - 4	4 - 4.5	4.5 - 5	>5
----------	------------	---------	---------	---------	---------	---------	---------	---------	---------	---------	----

— Roads  
□ Cadastre  
□ Emergency Services

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**SP051 Flood Studies  
Work Package 3 Crows Nest  
January 2011  
Peak Water Depth**

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### Hazard Category Mapping

Flood hazard categories are as defined in Schedule 4 of the Queensland Reconstruction Authority's (QRA) *Planning for stronger, more resilient floodplains* (2012), see Figure C.1.

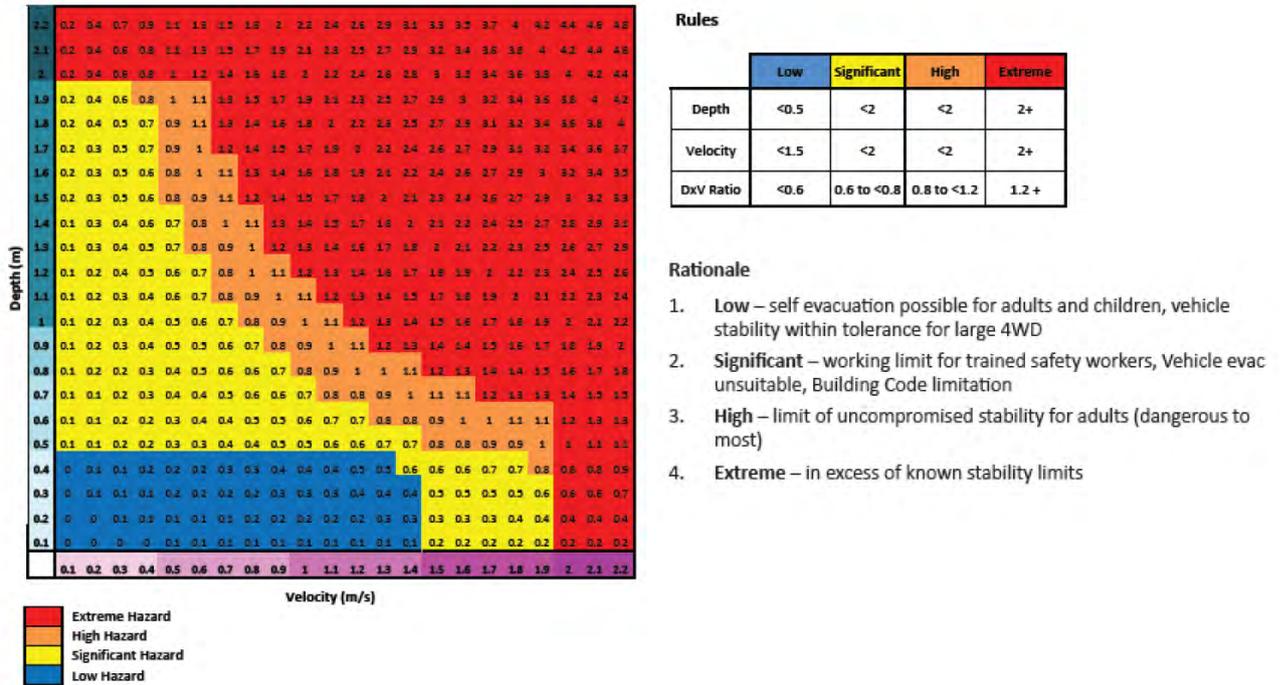
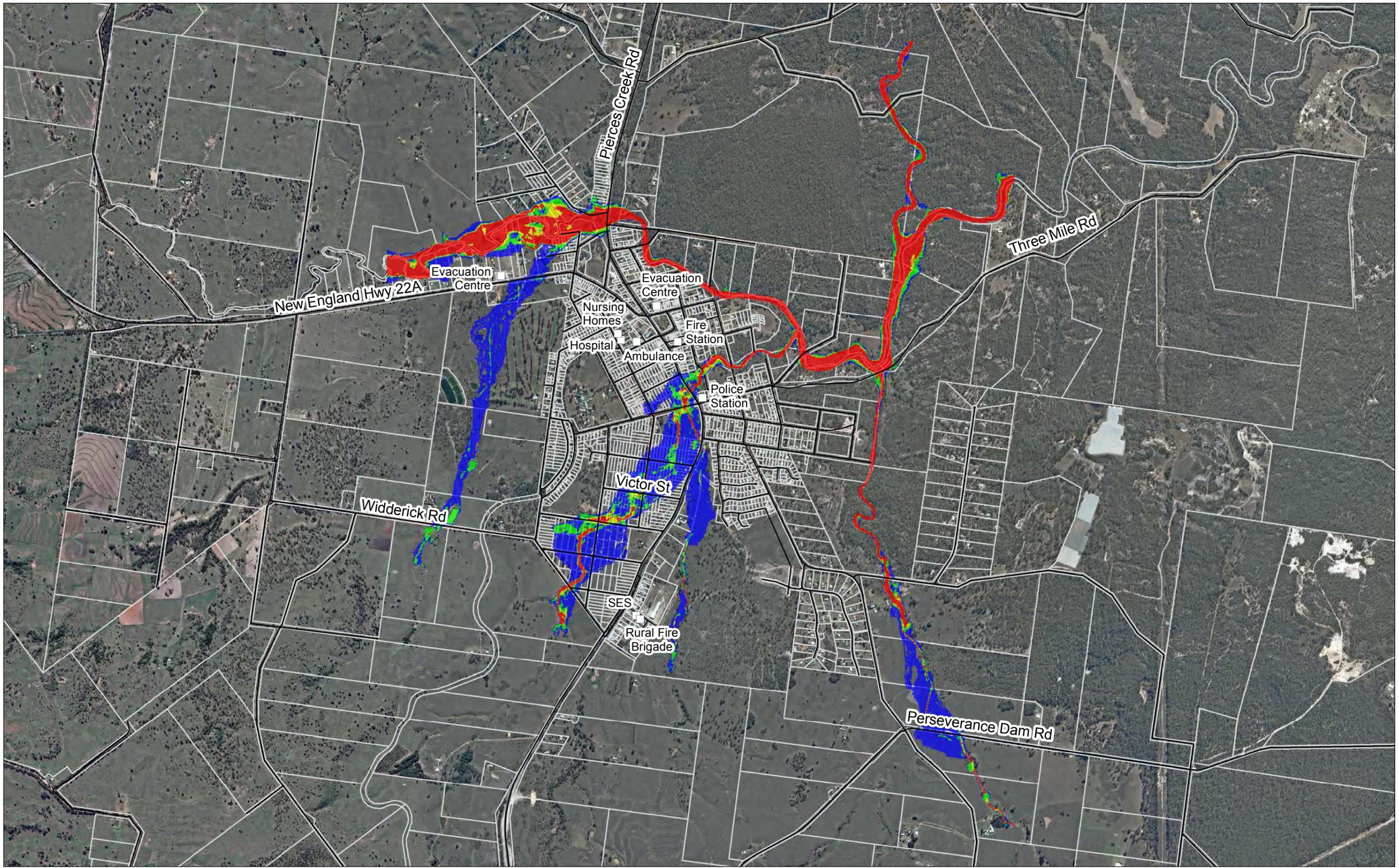


Figure C.1 Adopted Flood Hazard Classification

### Hydraulic Category Mapping

The following hydraulic categories were adopted.

- Floodway
  - Velocity-depth product  $\geq 0.5 \text{ m}^2/\text{s}$  or
  - Velocity  $\geq 1 \text{ m/s}$
- Flood storage
  - Velocity-depth product  $< 0.5 \text{ m}^2/\text{s}$  and
  - Depth  $\geq 0.5 \text{ m}$
- Flood fringe
  - Velocity-depth product  $< 0.5 \text{ m}^2/\text{s}$  and
  - Depth  $< 0.5 \text{ m}$



1:22,000 (at A3)

0 200 400 800  
Meters

GDA 1994 MGA Zone 56

N

**Legend**

Hazard Category

- Low
- Significant
- High
- Extreme

— Roads

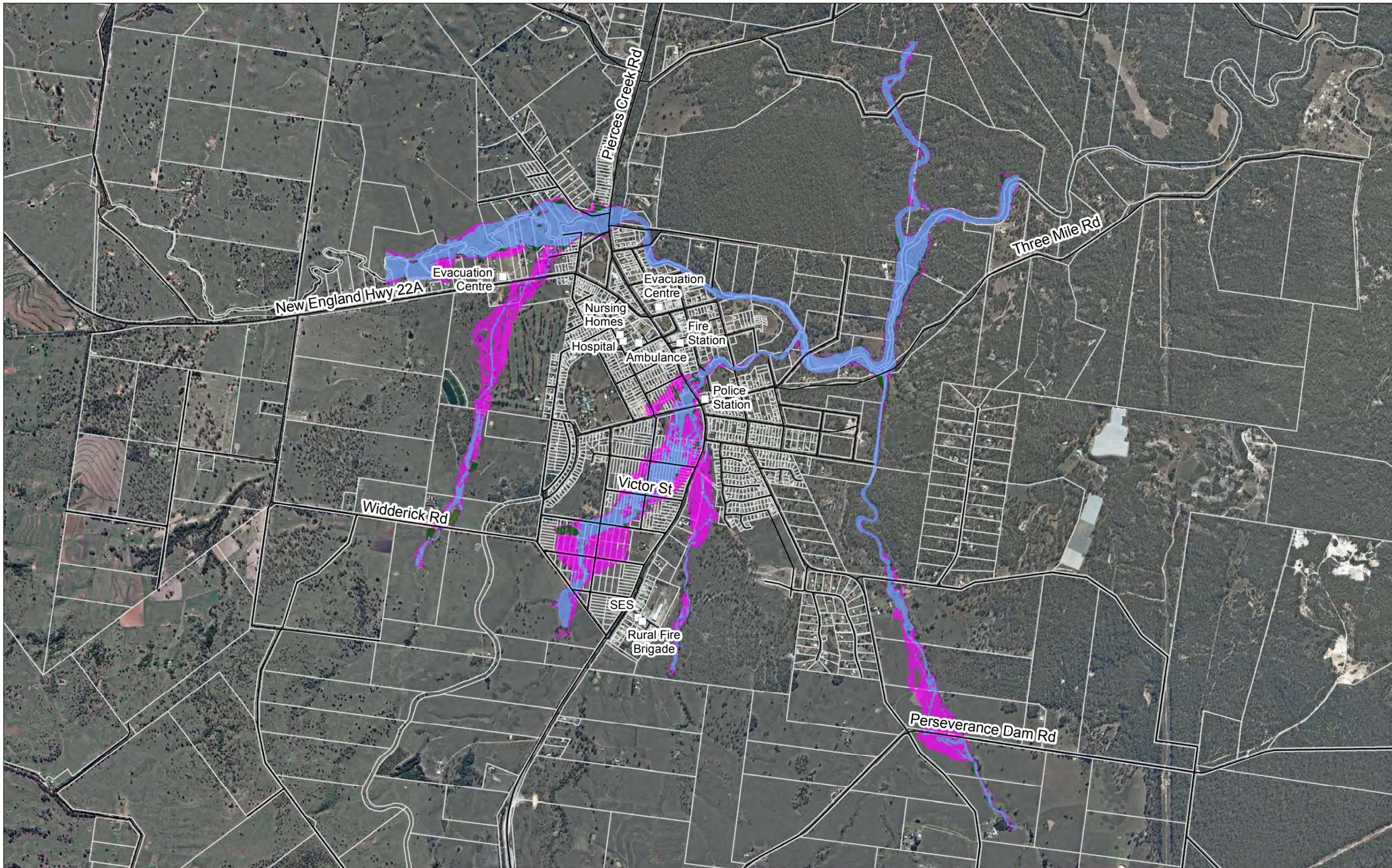
□ Cadastre

□ Emergency Services

Disclaimer: The flood information contained in the maps is based on debris lines and marks that were visible and accessible at the time of recording after the January 2011 flood event and may not be accurate or complete and reliance should not be placed on it. Toowoomba Regional Council makes no representations or warranties about the accuracy, reliability, completeness or suitability for any particular purpose and disclaim all responsibility and all liability whether in contract, negligence or otherwise for all expenses, losses, damages (including indirect or consequential damage) and costs which may be incurred in any way and for any reason as a result of the flood information contained in the maps being inaccurate or incomplete.

**SP051 Flood Studies  
Work Package 3 Crows Nest  
January 2011  
Hazard Category**

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1:22,000 (at A3)

0 200 400 800  
Meters  
GDA 1994 MGA Zone 56

N

**TOOWOOMBA REGIONAL COUNCIL**

**Legend**

Hydraulic Category	— Roads
<span style="color: magenta;">█</span> Flood Fringe	▭ Cadastre
<span style="color: green;">█</span> Flood Storage	▭ Emergency Services
<span style="color: blue;">█</span> Floodway	

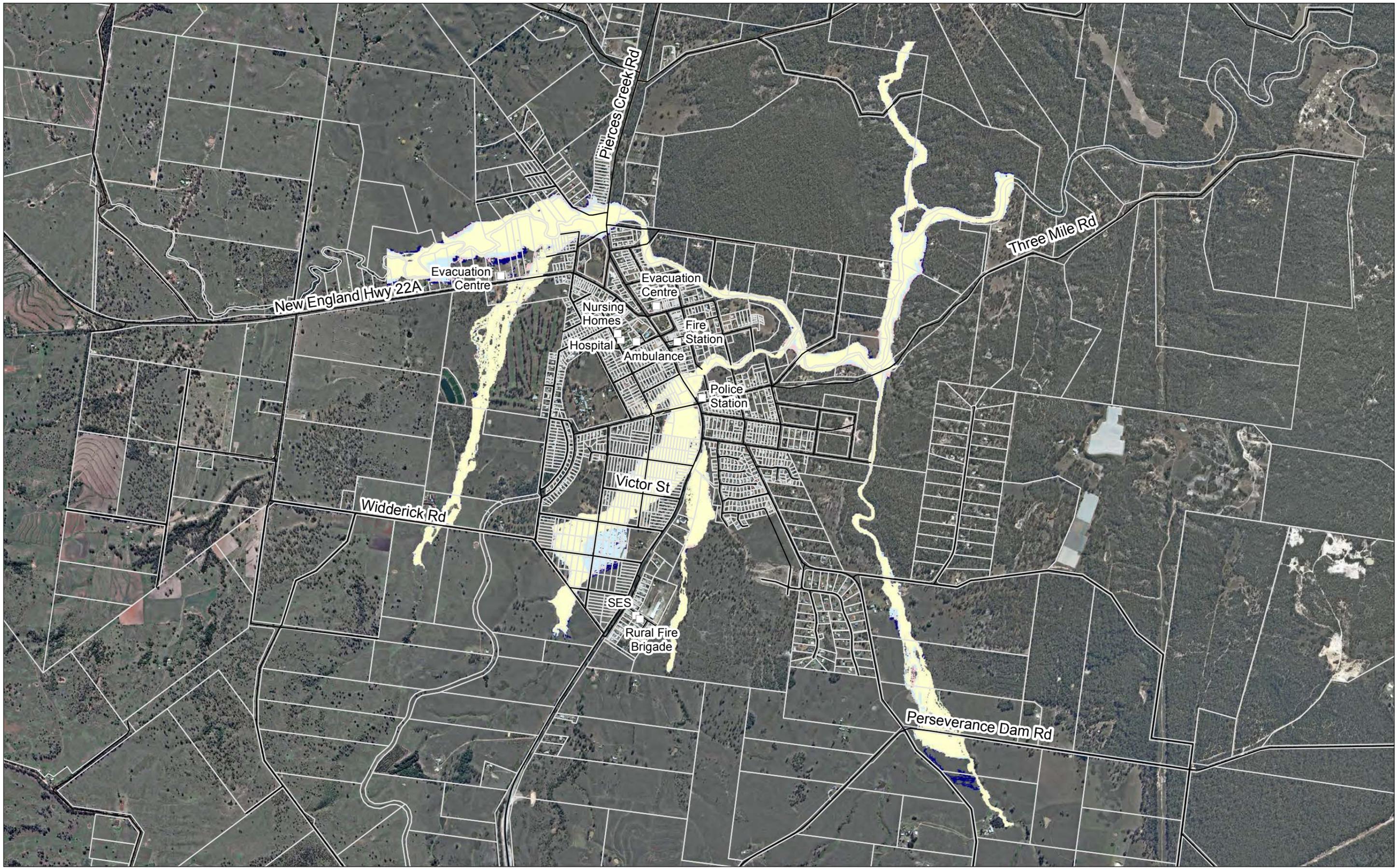
Disclaimer: The flood information contained in the maps is based on debris lines and marks that were visible and accessible at the time of recording after the January 2011 flood event and may not be accurate or complete and reliance should not be placed on it. Toowoomba Regional Council makes no representations or warranties about the accuracy, reliability, completeness or suitability for any particular purpose and disclaim all responsibility and all liability whether in contract, negligence or otherwise for all expenses, losses, damages (including indirect or consequential damage) and costs which may be incurred in any way and for any reason as a result of the flood information contained in the maps being inaccurate or incomplete.

**SP051 Flood Studies  
Work Package 3 Crows Nest  
January 2011  
Hydraulic Category**

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# **APPENDIX D**

## **SENSITIVITY ANALYSIS MAPPING**



1:22,000 (at A3)

0 200 400 800  
Meters  
GDA 1994 MGA Zone 56

N

**Legend**

**Inundation Extent**

- 30% Reduction in Flow
- Baseline
- 30% Increase in Roughness
- 30% Increase in Flow

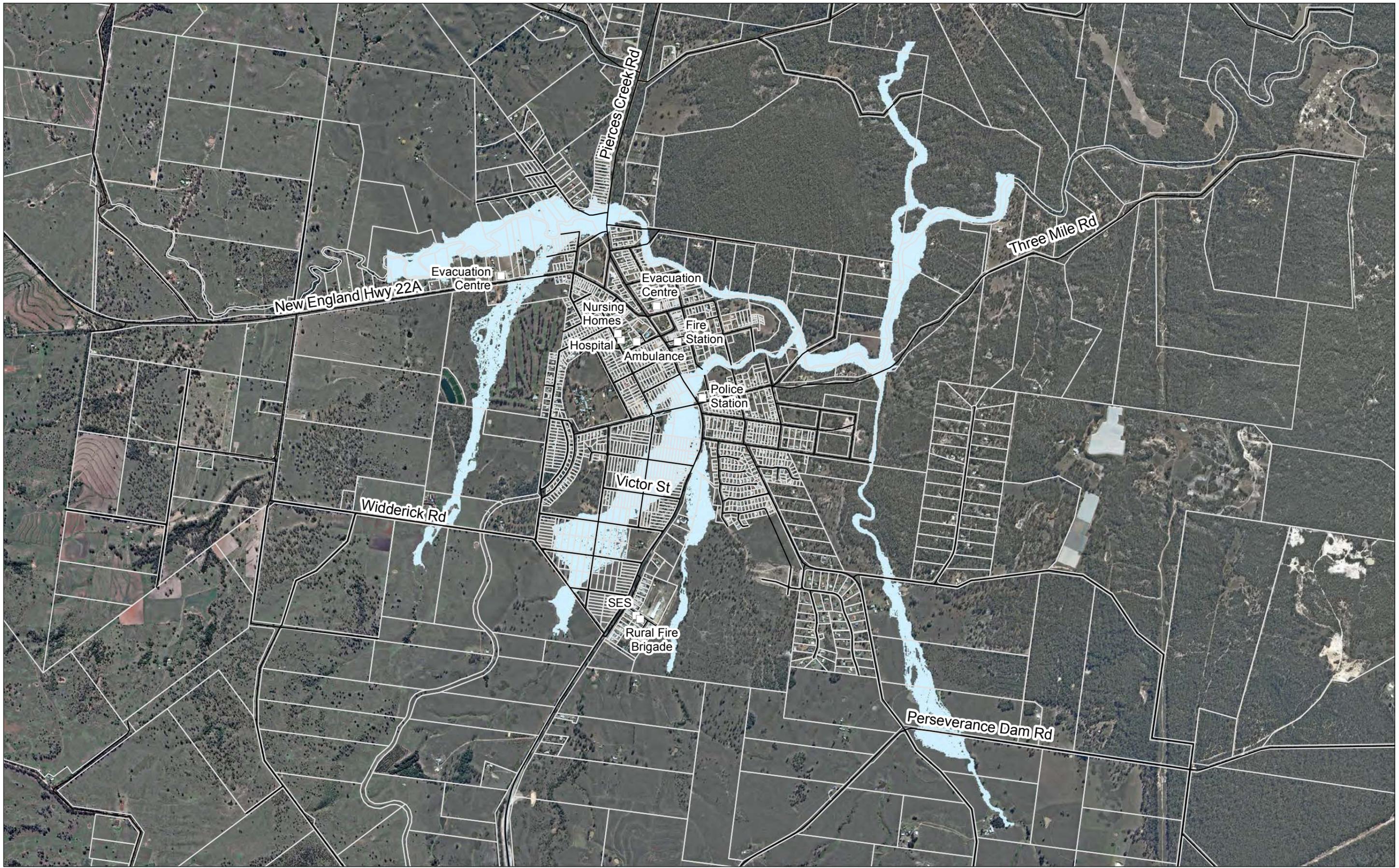
**Other Symbols**

- Roads
- Emergency Services
- Cadastre

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**SP051 Flood Studies  
Work Package 3 Crows Nest  
Sensitivity to Flow and Roughness**

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1:22,000 (at A3)

0 200 400 800  
Meters  
GDA 1994 MGA Zone 56

N

**Legend**

**Inundation Extent**

- Baseline
- 50% Blockage of Structures

**Other Features**

- Roads
- Emergency Services
- Cadastre

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**SP051 Flood Studies  
Work Package 3 Crows Nest  
Sensitivity to Blockage of Structures**

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[yoursay.toowoombaRC.qld.gov.au/flood-resilience](https://yoursay.toowoombaRC.qld.gov.au/flood-resilience)