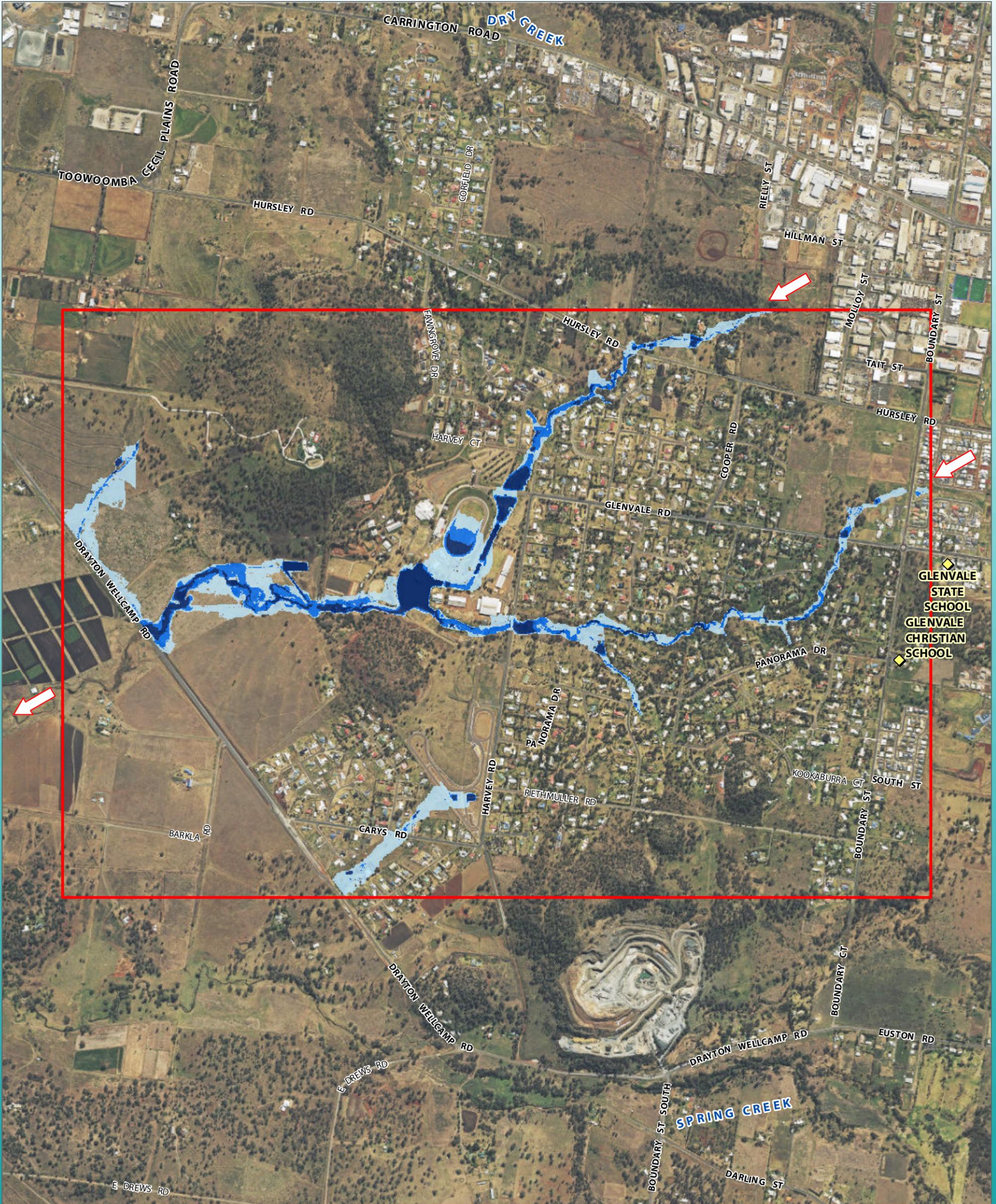
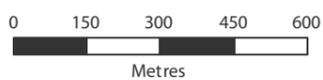


# GLENVALE

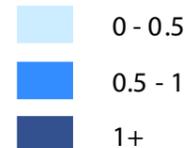


1:14,500 (at A3)



## 1% AEP FLOOD DEPTH RIVERINE

Water Depth (m)



Model Extent



DirectionFlow



Emergency Services



School

# Flood Studies



**TOOWOOMBA  
REGION**

Rich traditions. Bold ambitions.

## 2D Flood Study for Glenvale

September 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**

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.

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## EXECUTIVE SUMMARY

Toowoomba Regional Council is currently in the process of updating the Toowoomba Regional Council Planning Scheme. In February 2012, the State Government approved Council adopting the Toowoomba Regional Planning Scheme with a set of conditions to ensure the planning scheme was compliant with the State Planning Policy 1/03. To meet the conditions, flood mapping of Glenvale catchment downstream to Drayton Wellcamp Road was required.

Glenvale is located approximately seven kilometres to the west of Toowoomba city. The catchment is characterised by steep grades - an average of 6% with some areas greater than 20%. The study area covers about 900 hectares extending from the upper portion of the catchment at Carrington Road to Drayton Wellcamp Road as the downstream extent.

The predominant land uses within the catchment is low density residential with commercial and industrial precincts at the upper extent of the catchment. The catchment also includes the Toowoomba Showgrounds and the Criterium Track. The Toowoomba Regional Council Planning Scheme allows for significant proportions of the Rural and Rural Residential land to be developed in the future.

The primary objective of this study is the development of computer-based models of Glenvale catchment to characterise flooding behaviour relevant to existing and future land use and to identify critical infrastructure and emergency facilities that may be disrupted by flood events. To this end, detailed flood extents, levels and hazard maps prepared within this report are based on the results of the computer-based modelling.

The outcomes of this study are:

- Development of hydrologic and hydraulic models for Glenvale within the study area.
- Flood mapping for design events of Probable Maximum Precipitation Design Flood (PMF-DF) and 20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% AEPs;
- Analysis of the effect of ultimate development within the catchment;
- Analysis of the effect of increased rainfall intensities due to climate change factors;
- Analysis of the sensitivity to flow and roughness variations; and
- Analysis of sensitivity to culvert blockage.

An existing XP-RAFTS hydrologic model (GHD 2005) was upgraded for use in this study and used to simulate a series of synthetic design floods. The outflows from the XP-RAFTS model were applied to a new MIKE FLOOD hydraulic model (DHI, version 2012). Verification of the model was undertaken for the March 2014 flood event for which the simulated results were found to present a good match to the surveyed debris points with eighty-four percent modelled within +/- 0.3 metres.

Following verification, the models were used to simulate design floods. The simulated peak flood levels and discharges show that there is a gradual increase in water levels and discharges at all selected points for the 20% AEP through to PMF-DF. The largest increase in water levels was 2.2m across the comparison points but most changes were in the range 1-2 metres.

Analysis design events showed that only one house is impacted by flooding in Glenvale. This house, to the south of Carys Rd is shown being inundated for all events greater than the 10% AEP, but remains inundated by less than 0.25 metres for all design events up to PMP. This house is in a low hazard area so risk to life is also low. This house should be further investigated by surveying floor levels and the channel adjacent to it to ensure that it has been correctly represented in the hydraulic modelling.

Although there are not many houses inundated, the waterways generally flow through privately owned large block residential areas. The waterways are generally extreme hazard with some high and significant areas. This poses a large risk potential. These waterways need to be considered in future development and it is recommended to explore a legislatively protected way of considering them in future development.

In addition, sensitivity analysis was undertaken for the following parameters:

- Inflows: These were adjusted by +/- 30% to test whether variations in flows were likely to result in significant changes in flooding.
- Roughness: These were also adjusted by +/- 30% to test whether variations in roughness were likely to result in significant changes in flooding.

The results of the sensitivity analysis indicate that the model is generally more sensitive to changes in flows than changes in roughness, however the variations in flood level did not result in significant variations in flooded area. The range of increase in water level was -0.18 metres to 0.16 metres for flows and from -0.9 metres to 0.17 metres for roughness.

Climate change simulations were also undertaken for 2050, 2070 and 2100 design horizons. The model indicates that there is increasing flooding as rainfall intensities increase. However, due to the floodplain topography there is limited increases in flood extent. The largest increase across the comparison points 0.12 metres.

Blockage was also analysed but resulted in small increases in flow. The increase was up to 0.24 metres across the comparison points but is expected to vary more in areas closer to the structures.

Comparisons between the ultimate development conditions were undertaken to assess the likely impacts of the planning scheme being fully developed. The largest increase in of levels for the 1% AEP was 0.16 metres. The impact on the 1% was minimal due to the steep nature of the catchment. It is however expected to have proportionally increased effects on the smaller events because of varying loss model adopted.

The following recommendations are made to improve the accuracy of the modelling for future studies:

- Comprehensive collection of anecdotal evidence following future flood events;
- Installation of pluviographs and water level gauges within the catchment;
- Survey to be undertaken of all culverts, bridges and weirs within the study area;
- More detailed analysis on impacts of future urban developments;
- Comprehensive revision of roughness maps;
- Further exploration of inundated properties by surveying relevant details; and
- Explore a legislatively protected way of ensuring protection of future development from the extreme hazard waterways in private land

# 1. INTRODUCTION

## 1.1 BACKGROUND

Toowoomba Regional Council is currently in the process of updating the Toowoomba Regional Planning Scheme. In February 2012, the State Government approved Council adopting the Toowoomba Regional Planning Scheme with a set of conditions to ensure the scheme was compliant with the nominated State Planning Policies. To meet the conditions flood studies in urban areas are required. Glenvale has been identified due to the absence of comprehensive flood modelling and the potential for flood impacts on the community and critical infrastructure both at the present time and in the future.

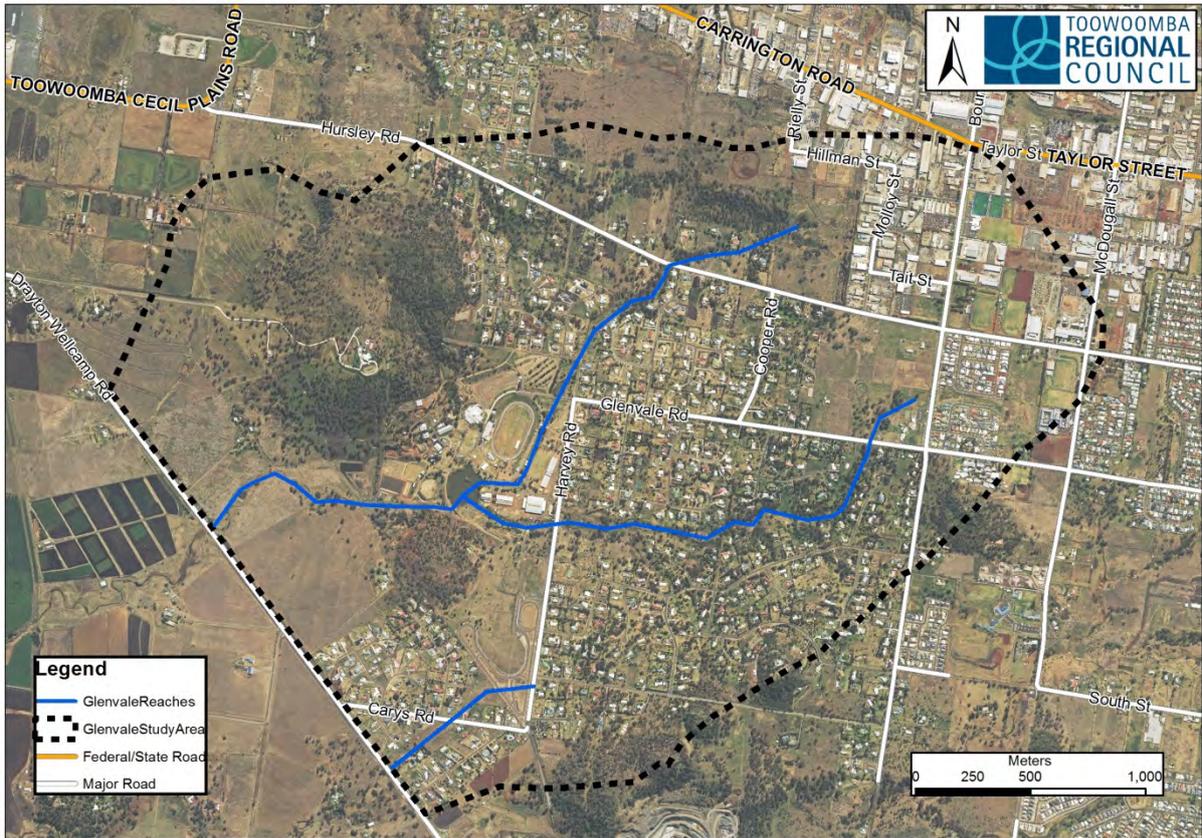
## 1.2 PROJECT OBJECTIVES

The primary objectives of this study are to develop computer-based hydrologic and hydraulic models of the study area to determine and document flood levels, inundation extents, velocities, depths and hazards across the study area for historic events and design events. Other objectives include identification of critical infrastructure and emergency facilities for which safe operation may be disrupted by flood events; identification of flood events that may isolate parts of the community; preparation of detailed maps and GIS layers for inclusion in Council's database and provide emergency planning information to input into Council's emergency planning information databases. The specific deliverables are:

- Development of hydrologic and hydraulic models for Glenvale to represent flow within the floodplain;
- Preparation of maps for flood levels, flood extents, velocities, depths and hazards for design storms at 20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% AEPs and Probable Maximum Precipitation Design Flood PMP-DF; and
- Reporting the process used to develop the model and the outcomes of the study.

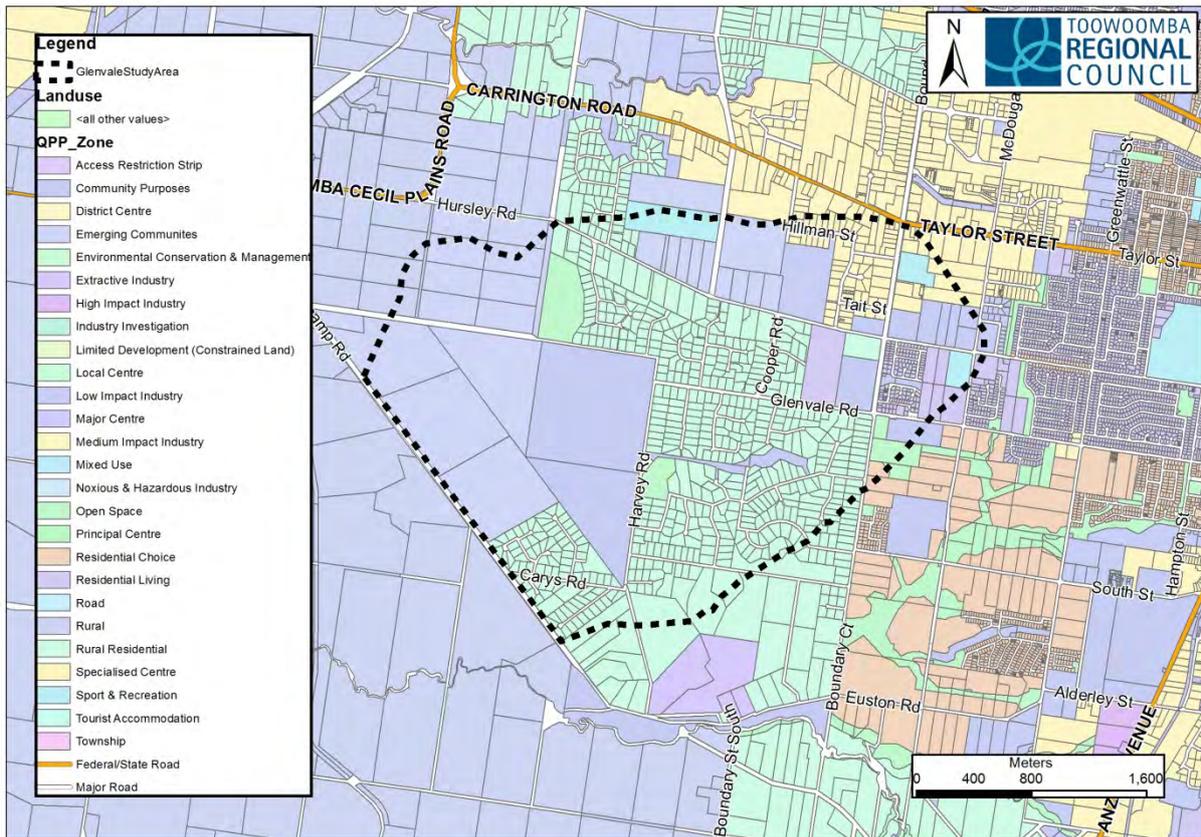
## 1.3 STUDY AREA

The Glenvale study area has a catchment of approximately 900 ha that feeds three significant flow paths. Each flow path travels in a south westerly direction eventually discharging to Spring Creek west of Drayton Wellcamp Road. The headwaters of the two northern flow paths begin in the industrial estate adjacent to Carrington Road and Boundary Street. The most northern of these crosses Hursley Road and Glenvale Road before entering the showgrounds from the north. This flow path then travels adjacent to the Toowoomba Showgrounds arena via a constructed open channel before discharging to the Toowoomba Showgrounds lake. The second northern flow path crosses Boundary Street and Glenvale Road towards Harvey Road. From Harvey Road, the flow path enters Toowoomba Showgrounds from the east and also discharges to the Toowoomba Showgrounds lake. From the Toowoomba Showgrounds lake, flow continues in a south-westerly direction to Drayton Wellcamp Road. The third, southern flow path is considerably shorter and rises at the Criterium Track. This flow path also travels in a south-westerly direction, crossing Carys Road and Drayton Wellcamp road before also discharging to Spring Creek. See Figure 1.1.



**Figure 1.1 Glenvale Study Area**

The Glenvale catchment comprises of urban residential areas, rural and some commercial land use which is predominantly situated in the upper part of the catchment (Figure 1.2). The land use within the study area is shown in Figure 1.2.



**Figure 1.2 Glenvale Land Use**

## 1.4 LIMITATIONS

This report was prepared based on information available at the time of writing. The approach and analysis detailed within this report have been prepared by TRC specifically for use by TRC. For this reason, any third parties are not authorised to use any contents from this report. Their use is specifically prohibited unless written approval from TRC is obtained. TRC believes the report is accurate for the intended purpose and disclaims any responsibility for any loss or damage suffered as a result of placing reliance on the information contained within this report.

Furthermore, the models detailed within this report are based on LiDAR survey. Any development or topographical change occurring within the catchment after the date that this LiDAR was flown is not included within this study.

## 2. AVAILABLE DATA

### 2.1 PREVIOUS STUDIES

A number of previous studies have been undertaken for the study area. These include:

- Glenvale/Torrington/Cotswold Hills DCP Area – Drainage Study (SKM, 1995)
- Glenvale/Torrington/Cotswold Hills Planning Study (SKM, 1995)
- Glenvale/Torrington/Cotswold Hills Development Control plan (SKM,1995)
- Eastern Drain Flood Study (SKM, 2000)
- Toowoomba Showgrounds and Northern Catchment Stormwater Management Plan (GHD, 2001)
- Summary Report on Toowoomba Showgrounds and Northern Catchment Stormwater Management Plan (GHD, 2002)
- Glenvale Stormwater Management Plan (GHD, 2005)

In 2001, GHD completed the Toowoomba Showgrounds and Northern Catchment Stormwater Management Plan for Jondaryan Shire Council. As part of this study an XP-RAFTS hydrological model was developed to determine flows in the region and a number of separate HEC-RAS models were developed to simulate the hydraulics of the two northern flow paths. A further study was completed by GHD for Jondaryan Shire Council in 2005. This study extended the XP-RAFTS hydrological model to include the southern catchments and developed additional HEC-RAS hydraulic models to simulate flows in the southern flow paths. From these studies, several recommendations were made with respect to culvert upgrade requirements and regional detention. Maps of flood inundation were also produced.

### 2.2 HISTORICAL RAINFALL

No pluviographs exist within the Glenvale catchment. Pluviographs exist in neighbouring catchments including at Glenvale Road (sewer pump station less than one kilometre outside the catchment) and Toowoomba Aerodrome. Data for Toowoomba Aerodrome was obtained for both January 2011 and March 30, 2014 flood events. For Glenvale Road, data at low temporal intervals proved difficult to extract for the January 2011 due to data corruption, event however data at about three-minute intervals was extracted for the March 30, 2014 event.

### 2.3 STREAM FLOW GAUGING RECORDS

A search was undertaken for stream gauges downstream of the study area. The nearest stream flow gauge was found to be Oakey Creek at Jondaryan. As the Glenvale catchment only represents a small fraction of the total catchment to Oakey Creek at Jondaryan, this gauge was not considered for calibration.

### 2.4 EVIDENCE OF FLOODING

Evidence of flood inundation was collected post January 2011 and March 30, 2014 events. The post January 2011 data was limited to anecdotal evidence of flood refuse at three locations and evidence gained from photographs of flooding available in the region. Interrogation of the flood refuse data revealed that two of the three locations were likely to be overland flow rather than flood flow i.e. water rising from the main flow paths.

Following the March 30, 2014 flood event, Council's Drainage Planning group undertook a campaign to identify flood levels and flood extents from debris data. These points were marked,

photographed and later surveyed by Council’s qualified surveyors. The surveyed points utilised for model verification are listed in Table2.1.

**Table 2-1 March 30, 2014 Surveyed Flood Debris Points**

| ID | Spot Height Location              | Survey Type           | Height (mAHD) |
|----|-----------------------------------|-----------------------|---------------|
| 1  | Hursley Road (northern flow path) | Surveyed flood debris | 558.14        |
| 2  | Hursley Road (northern flow path) | Surveyed flood debris | 558.14        |
| 3  | Harvey Court (northern flow path) | Surveyed flood debris | 543.16        |
| 4  | Harvey Court (northern flow path) | Surveyed flood debris | 543.21        |
| 5  | Harvey Court (northern flow path) | Surveyed flood debris | 543.07        |
| 6  | Harvey Road (central flow path)   | Surveyed flood debris | 539.09        |
| 7  | Harvey Road (central flow path)   | Surveyed flood debris | 539.10        |
| 8  | Harvey Road (central flow path)   | Surveyed flood debris | 539.11        |
| 9  | Harvey Road (central flow path)   | Surveyed flood debris | 539.09        |
| 10 | Harvey Road (central flow path)   | Surveyed flood debris | 539.40        |
| 11 | Drayton Wellcamp Rd               | Surveyed flood debris | 513.23        |
| 12 | Drayton Wellcamp Rd               | Surveyed flood debris | 513.42        |
| 13 | Drayton Wellcamp Rd               | Surveyed flood debris | 513.16        |
| 14 | Drayton Wellcamp Rd               | Surveyed flood debris | 512.48        |
| 15 | Drayton Wellcamp Rd               | Surveyed flood debris | 513.25        |
| 16 | Drayton Wellcamp Rd               | Surveyed flood debris | 513.78        |
| 17 | Drayton Wellcamp Rd               | Surveyed flood debris | 513.53        |
| 18 | Drayton Wellcamp Rd               | Surveyed flood debris | 513.78        |
| 19 | Drayton Wellcamp Rd               | Surveyed flood debris | 514.03        |

The location of these points is shown in Figure 2.1.

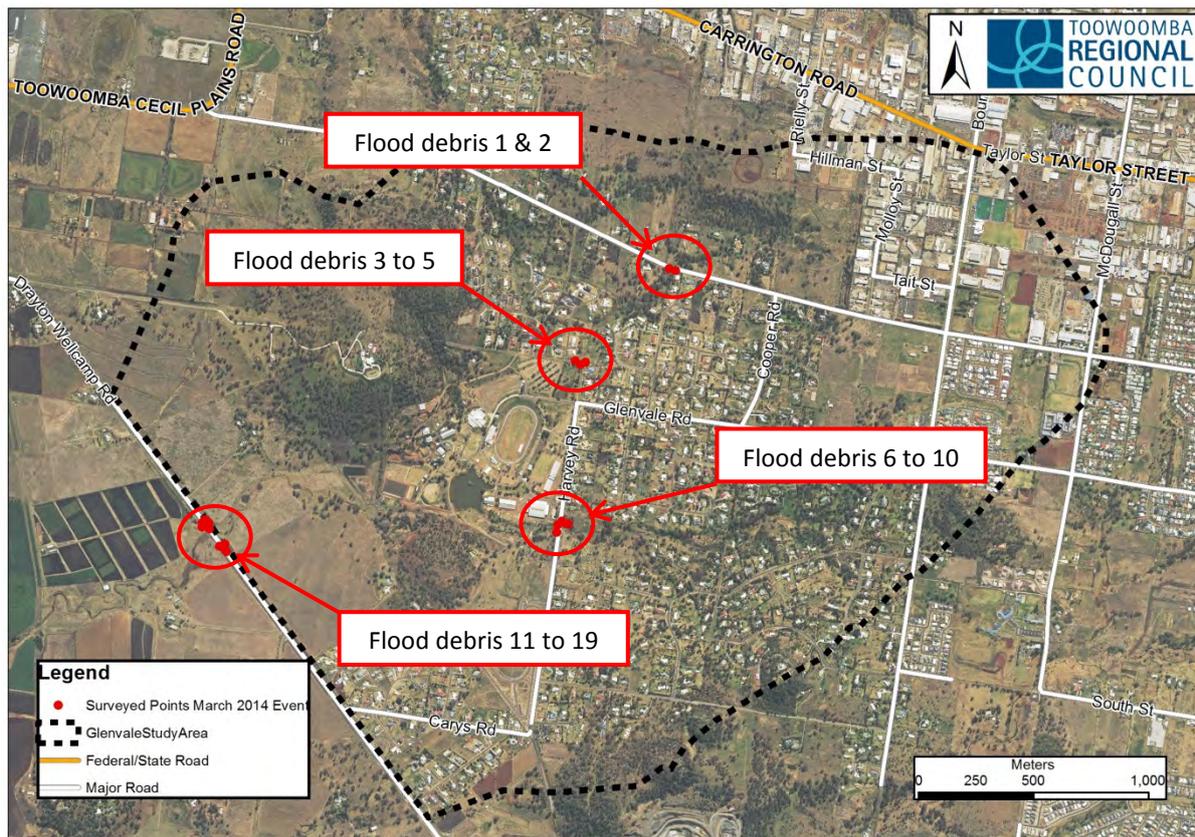


Figure 2.1 Glenvale Flood Debris Points for March 30, 2014 Event.

In addition, photographs and video were collected from residents and businesses within the study area.

## 2.5 TOPOGRAPHIC DATA

The primary topographic data available for the study was a digital elevation model (DEM) with a one-metre grid developed from LiDAR with a quoted accuracy of 94% of points within 0.15m. The DEM was developed from LiDAR flown in 2010 and is available for the whole of the study area. Further to this, the Criterium Track was developed after the LiDAR was flown and represents a significant change to that part of the catchment topography. Subsequently, a one-metre DEM created from survey was obtained for use in this study. The DEM derived from survey of the Criterium Track is shown as Figure 2.2. This survey was detailed survey undertaken by Toowoomba Regional Council surveyors and has an accuracy of +/- 0.01m.

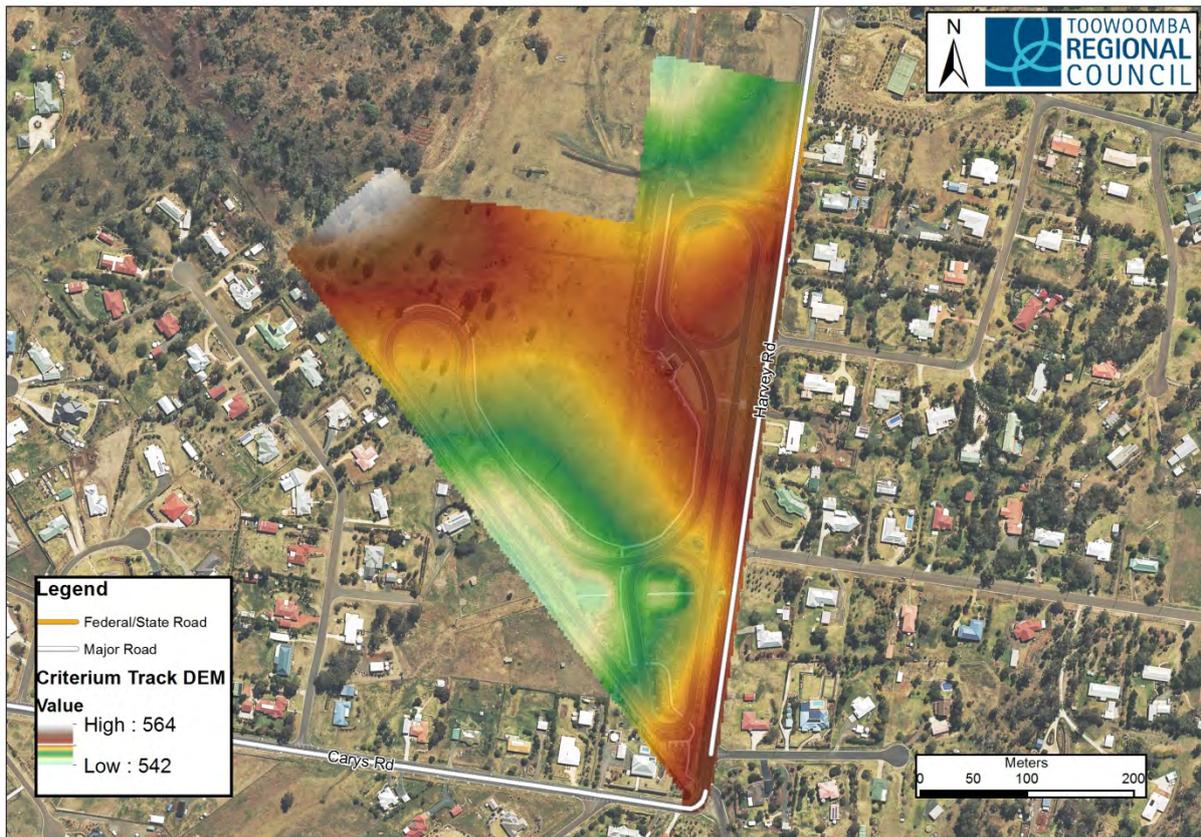


Figure 2.2 DEM Derived from Criterium Track Survey

## 2.6 GIS DATA

The following GIS layers were sourced from Toowoomba Regional Council's GIS:

- Roads: these were used in development of the hydrology model, particularly in determining the percentage of the sub-catchments that were permeable. Additionally, in some cases the roads would cross sub-catchments and change drainage patterns. Therefore the roads were used to assist in the design of the hydrological model sub-catchments;
- Building Footprint Polygons: similarly to the roads layer, the building polygons were used to determine the percentage of the catchment that is permeable;
- Planning Scheme: allowed for the identification of different land use types and delineation of road widths and channels; and
- Aerial imagery: used to assist in spatial orientation and identification of key features such as channels as well as estimate roughness in the floodplain.

## 2.7 STRUCTURE DATA

Limited structure data was available through Council's corporate GIS system. Subsequently a desktop inspection and field trip was undertaken to identify, measure and record the structure type, size and cover. As-constructed drawings were also obtained to implement the structures at the Criterium Track and design drawings were obtained for the culverts under construction at Drayton Wellcamp Road at the time of this study. Structures identified within the catchment are detailed in Table 5.2. Locations of structures are shown in Figure 5.4.

### **3. STUDY APPROACH**

The XP-RAFTS (XP-Software, 2009) model that has been developed utilises IFD curves from the Bureau of Meteorology and parameters from previous models to produce a runoff response for synthetic design floods. Outflows from the XP-RAFTS model are then input into a MIKE FLOOD model, which primarily utilises the DEM of the catchment to represent the floodplain.

There are currently no rainfall pluviographs or stream flow gauges within the catchment. However there is a pluviograph located on Glenvale Road just outside the catchment. In order to verify that the model was representative of the catchment conditions a comparison of the model results against surveyed debris marks from the March 30, 2014 flood.

Additionally, to determine if the model was robust to the parameter selection, sensitivity analysis was undertaken on:

- Inflows: These were varied up and down by 30% to test whether any uncertainty from inflows from the hydrologic model were likely to cause significant changes in the flooding; and
- Roughness: This was varied up and down by 30% to test whether uncertainty in the roughness values used were likely to cause significant changes to the flooding.

Following verification and sensitivity testing, the models have been used to undertake simulation of design storms for both existing and future development scenarios. In addition, analysis of culvert blockage and potential climate change scenarios has also been undertaken. Further details are provided in Model Results below.

## 4. HYDROLOGIC ANALYSIS

### 4.1 HYDROLOGIC MODEL DEVELOPMENT

An existing XP-RAFTS model was obtained from the Glenvale Stormwater Management Plan prepared by GHD for Jondaryan Shire Council in 2005. A review of the model was undertaken and parameters relating to existing development conditions were updated. Historical cadastre was sourced and compared to the present day cadastre in order to isolate catchments with significant changes to impervious areas. For these catchments a new calculation was performed using building foot prints and road reserves to determine new fraction impervious values.

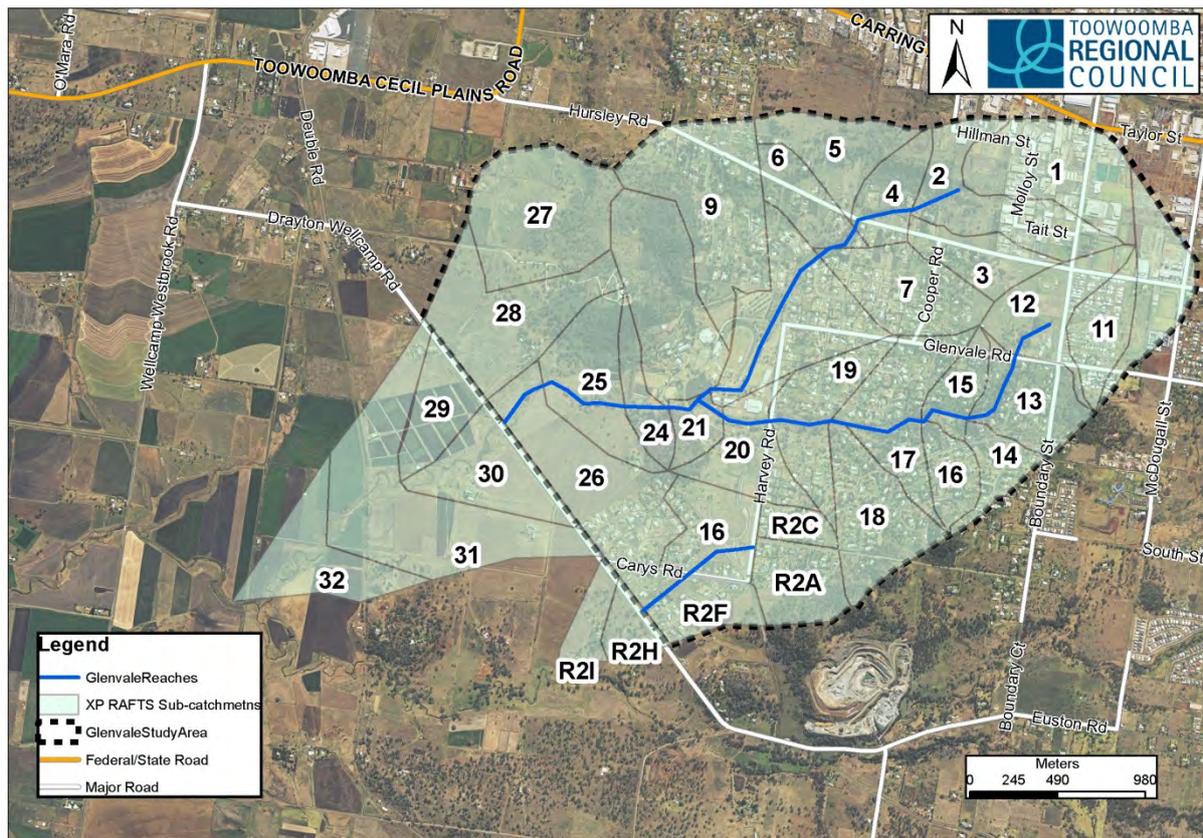


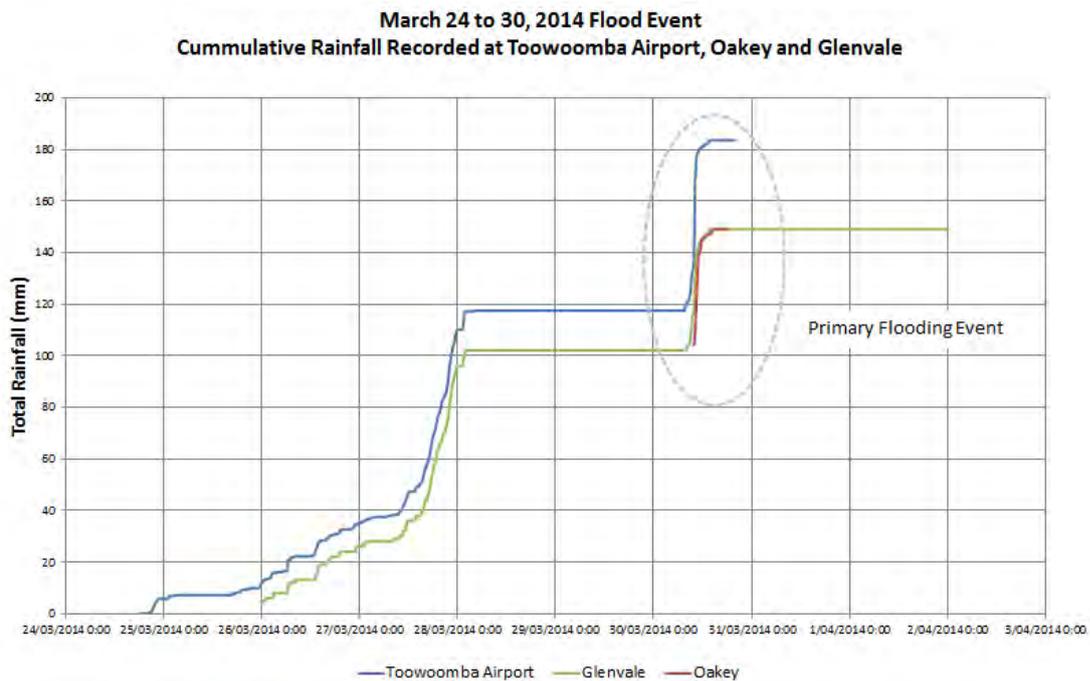
Figure 4.1 Glenvale sub-catchment delineation

Following review and update of fraction impervious values, the XP-RAFTS model was considered suitable for application in the project.

### 4.2 MARCH 2014 EVENT

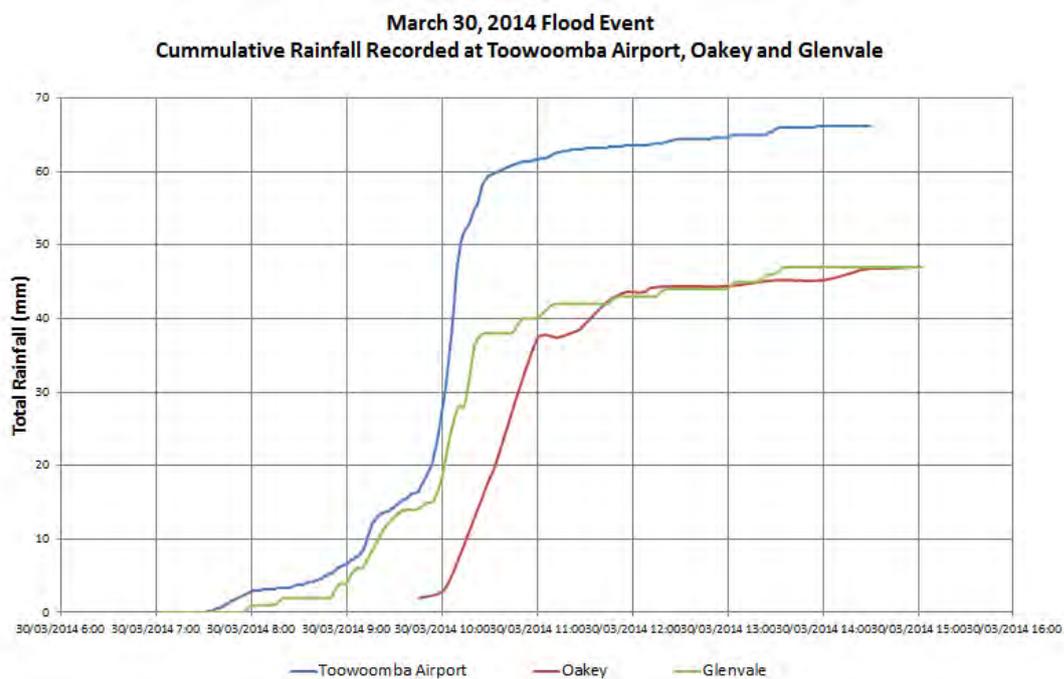
From late on the 26<sup>th</sup> of March, a low-level trough extending from the central interior of Queensland to the Maranoa with heavy rain falls through the southern Central Highlands, Maranoa and Darling Downs during the 27<sup>th</sup>. The trough progressed southeast into the Wide Bay and Burnett and Southeast Coast districts that evening and into the 28<sup>th</sup> with the passage of the trough. Several sites in Queensland exceeded daily rainfall records for March. These included Amberley, Somerset Dam and Tarome as well as Cambooya, Clifton and Greenmount Post Offices within TRC. Localised thunderstorms and rain continued until the end of the month with localised heavy rain in the region surrounding the study area causing flash flooding on the 30<sup>th</sup> of March.

Cumulative rainfall totals for Toowoomba Airport, Oakey and Glenvale sewer pump station are shown in Figure 4.2 for March 24 to 30.



**Figure 4.2 Cumulative Rainfall March 24 to 30, 2014.**

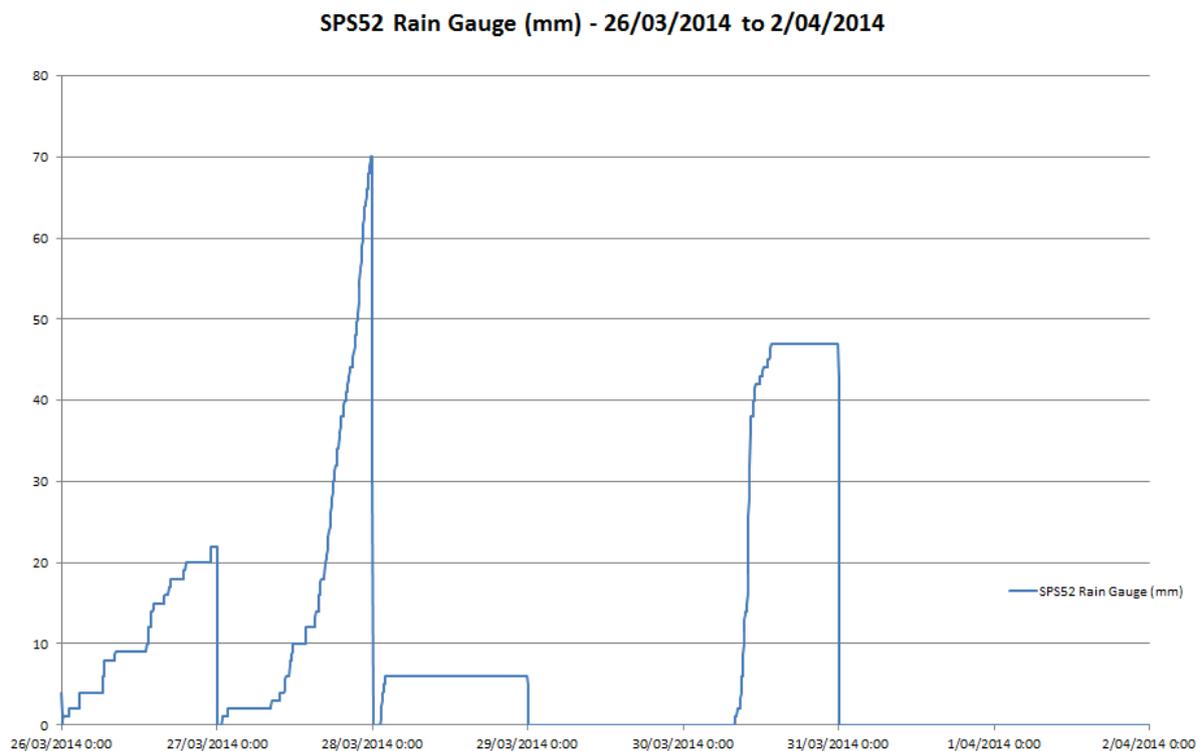
Cumulative rainfall totals for Toowoomba Airport, Oakey and Glenvale sewer pump station are shown in Figure 4.3 for March 30.



**Figure 4.3 Cumulative Rainfall March 30, 2014.**

The Glenvale Road pump station pluviograph was selected for application to the entire study area primarily due to its proximity to the catchment relative to the Toowoomba Airport pluviograph –

although the difference is marginal. The Glenvale Road pump station temporal pattern is shown as Figure 4.4.



**Figure 4.4 Glenvale Road Pump Station Temporal Pattern**

Due to wet conditions preceding the flood event on March 30, the catchment was assumed to be saturated and an Initial Loss value of 0 mm was selected. A Continuing Loss value of 2.5 mm/hr was selected as representative for the catchment. The flows from the XP-RAFTS model for March 30, 2014 were later applied to the MIKE FLOOD model to achieve validation using a joint calibration approach.

### 4.3 DESIGN RAINFALL ESTIMATION

Design storms for 0.2%, 0.5%, 1%, 2%, 5%, 10%, 20% and 50% year AEPs and PMP were applied to the model.

Design storms were determined at the centroid of the catchment and based on rainfall temporal patterns adopted from the Australian Rainfall and Runoff (AR&R, 1998). Rainfall intensities were derived from the Intensity Frequency Duration (IFD) data obtained from the Bureau of Meteorology (BoM) website.

The rainfalls for all AEPs were derived using standard Australian Rainfall and Runoff (AR&R 1987) procedures. These were calculated within XP-RAFTS software as described in the XP-RAFTS user manual (XP Solutions 2009).

Since this is an ungauged catchment, the design rainfall was based on the IFD data supplied by the Bureau of Meteorology, and the Australian Rainfall and Runoff (AR&R) temporal patterns and catchment parameters from the verification event.

The adopted Intensity-Frequency-Duration is shown in Table 4-1.

**Table 4-1 Adopted Intensity-Frequency-Duration (mm/hr)**

| Time<br>(Hrs) | AEP  |      |       |       |       |       |       |       |       |       |
|---------------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|
|               | 99%  | 50%  | 20%   | 10%   | 5%    | 2%    | 1%    | 0.5%  | 0.2%  | PMP   |
| <b>0.25</b>   | 69.8 | 88.5 | 107.4 | 118.8 | 135.2 | 157.3 | 174.6 | 194.0 | 223.5 | 700.7 |
| <b>0.5</b>    | 49.7 | 63.0 | 76.2  | 84.1  | 95.5  | 110.8 | 122.8 | 136.4 | 157.5 | 511.6 |
| <b>1</b>      | 34.1 | 43.1 | 51.9  | 57.2  | 64.8  | 75.1  | 83.1  | 92.3  | 107.2 | 378.0 |
| <b>1.5</b>    | 25.7 | 32.5 | 39.2  | 43.3  | 49.1  | 56.9  | 63.0  | 70.3  | 82.4  | 324.1 |
| <b>2</b>      | 20.9 | 26.5 | 32.0  | 35.3  | 40.1  | 46.6  | 51.6  | 57.6  | 67.9  | 284.2 |
| <b>3</b>      | 15.6 | 19.8 | 24.0  | 26.5  | 30.1  | 35.0  | 38.8  | 43.4  | 51.5  | 229.0 |
| <b>6</b>      | 9.4  | 12.0 | 14.6  | 16.1  | 18.4  | 21.4  | 23.8  | 26.7  | 31.8  | 152.8 |
| <b>12</b>     | 5.7  | 7.3  | 8.9   | 9.9   | 11.2  | 13.1  | 14.6  | 16.3  | 19.2  | 75.9  |
| <b>24</b>     | 3.6  | 4.7  | 5.8   | 6.5   | 7.5   | 8.9   | 9.9   | 11.1  | 12.8  | 36.8  |
| <b>36</b>     | 2.8  | 3.6  | 4.5   | 5.1   | 5.9   | 7.0   | 7.9   | 8.8   | 10.2  | 27.4  |
| <b>48</b>     | 2.3  | 2.9  | 3.7   | 4.2   | 4.9   | 5.9   | 6.6   | 7.4   | 8.6   | 21.7  |

A variable loss model was adopted to apply to the catchments and is summarised in Table 4-2.

**Table 4-2 Design Event Hydrological Losses**

| Event         | Initial Loss (mm) | Continuing Loss (mm/hr) |
|---------------|-------------------|-------------------------|
| 2%-PMP-DF     | 0                 | 2.5                     |
| 5%            | 5                 | 2.5                     |
| 10%           | 10                | 2.5                     |
| Less than 10% | 20                | 2.5                     |

#### 4.4 PMP AND RARE EVENTS

The rarer events and PMP have been estimated in XP-Rafts, using the GSDM method as described in the XP-Rafts user manual and by Bureau of Meteorology (2003). The 0.5% and 0.2% AEPs are then interpolated within the XP-Rafts software ARR87 procedure. The ARR design temporal patterns have been used for the 0.5% and the 0.2% AEPs.

The parameters chosen to estimate PMP are shown below in Table 4-3.

**Table 4-3 PMP Information**

| Factor         | Value                               |
|----------------|-------------------------------------|
| PMP Type       | GSDM (critical under 3hrs)          |
| Mean Elevation | 600 m (AHD)                         |
| MAF            | 0.8                                 |
| Smooth         | 0 (within 20km of range escarpment) |
| Location       | -27.33' 151.53'                     |

The temporal pattern used for the PMP was as recommended by XP-Rafts for the GSDM in the user guide and is shown in Figure 4-5.

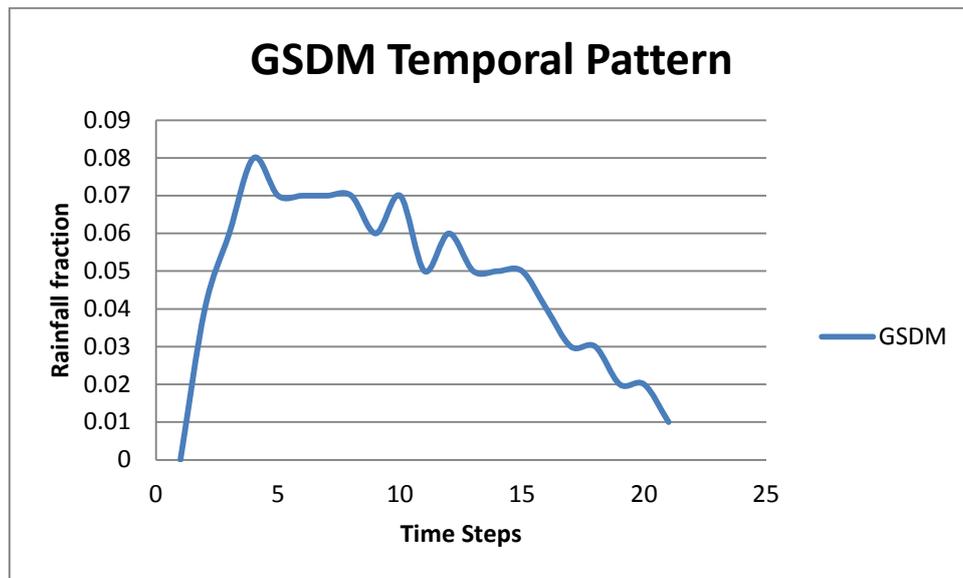


Figure 4-5 GSDM Temporal Pattern

The adopted rainfall depths for the PMP and 0.5% and 0.2% AEP event is shown in Table 4-4.

Table 4-4 Adopted PMP and Rare Event Rainfall Depths

| Time (Hrs)  | AEP     |         |      |
|-------------|---------|---------|------|
|             | 0.5%    | 0.2%    | PMP  |
| <b>0.25</b> | 48.493  | 55.867  | 180  |
| <b>0.5</b>  | 68.223  | 78.762  | 260  |
| <b>1</b>    | 92.321  | 107.203 | 380  |
| <b>1.5</b>  | 105.399 | 123.533 | 490  |
| <b>2</b>    | 115.279 | 135.847 | 570  |
| <b>3</b>    | 130.298 | 154.381 | 690  |
| <b>6</b>    | 160.196 | 191.091 | 920  |
| <b>12</b>   | 196.154 | 230.475 | 910  |
| <b>24</b>   | 266.641 | 307.281 | 880  |
| <b>36</b>   | 317.616 | 366.231 | 990  |
| <b>48</b>   | 357.042 | 412.316 | 1040 |

## 4.5 HYDROLOGICAL MODEL VALIDATION

As the XP-RAFTS model was an update of an existing XP-RAFTS model that had been validated to the Rational Method as part of the GHD study, this was not undertaken again.

## 4.6 CLIMATE CHANGE

The effects of climate change on rainfall intensity were considered on the basis of estimated global warming. Rainfall intensities were calculated for up to four degrees in global temperature increase. A five percent increase in rainfall intensity was adopted for every one degree increase in degrees Celsius. The hydrological model was used to simulate two, three and four degrees Celsius global temperature increase for 2050, 2070 and 2100 design horizons respectively. Adopted rainfall increases are shown in Table 4-5.

**Table 4-5 Adopted rainfall increases as a function of temperature**

| Temperature Increase (degrees Celsius) | Rainfall Intensity Increase (%) |
|--|---------------------------------|
| 2                                      | 10                              |
| 3                                      | 15                              |
| 4                                      | 20                              |

## 5. HYDRAULIC MODELLING

A numerically coupled 1D/2D MIKE FLOOD model was developed to simulate flow across the floodplain. A MIKE FLOOD model consists of a MIKE21 model to simulate the two-dimensional flow and a MIKE11 model to simulate sub-grid scale features. The development of this model is detailed in the following sections.

### 5.1 MIKE 21 MODEL DEVELOPMENT

A MIKE21 model was developed to simulate 2-dimensional flow across the floodplain. Each component of the model development is detailed below.

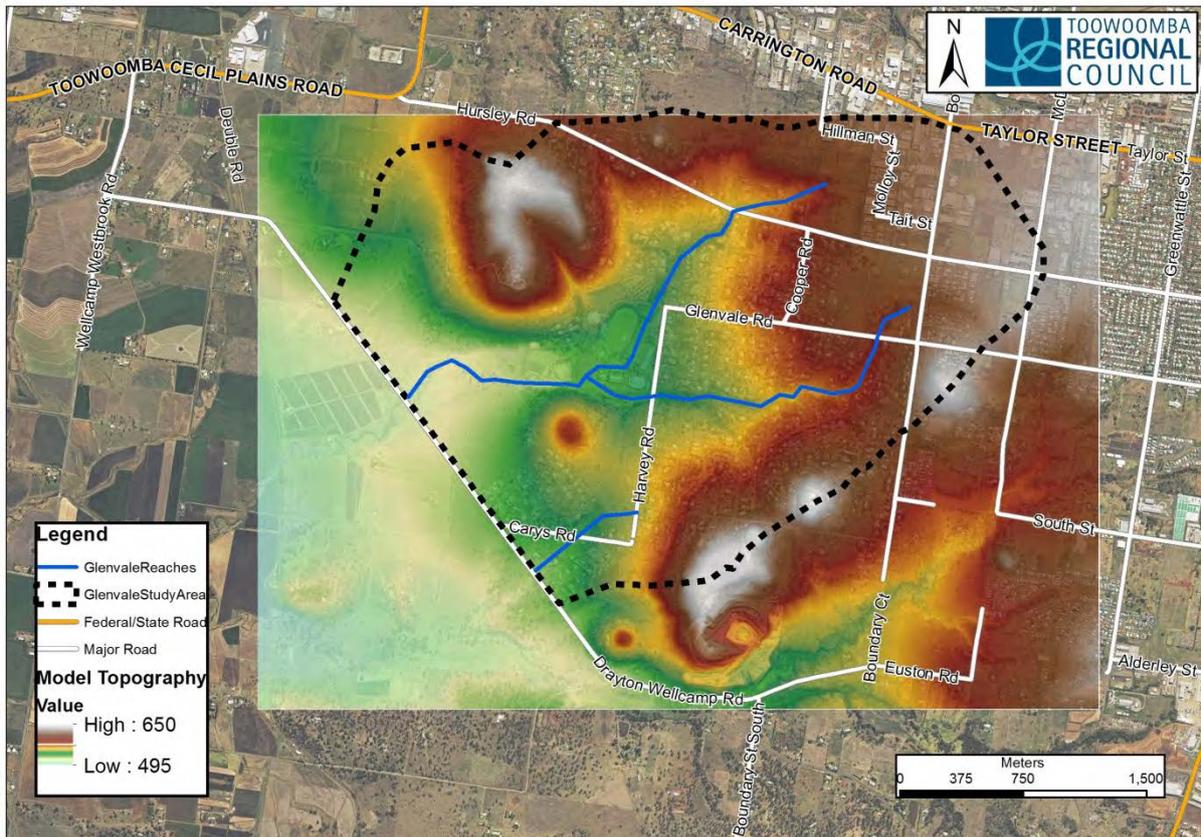
#### 5.1.1 MODEL TOPOGRAPHY

A three-metre model DEM was developed from the one-metre DEM derived from LiDAR. The integrity of low lying roads were then checked against the one-metre DEM to ensure that the elevations were correctly carried over from the original one-metre DEM. The weir level for the Toowoomba Showgrounds lake was also stamped into the model topography where lower values had been applied through the interpolation process.

The one-metre DEM obtained for the Criterium Track was then resampled to a grid spacing of three metres and was 'stamped' into the model topography replacing the data derived from outdated LiDAR.

Additionally, new culverts had also been constructed at the northern crossing of Drayton Wellcamp Road since the LiDAR was flown. For-construction drawings were used to manually update the model topography at this location.

Following these updates, a solid wall of values equal to the land value was introduced around the outer extent of the bathymetry as per the MIKE FLOOD software manual. A single downstream boundary was then developed at the western extent of the model bathymetry. In accordance with standard practice, the boundary was developed by cutting in an artificial pool six grid cells into the model, with a width equal to the maximum anticipated flood width. A single boundary for the two flow paths is considered appropriate due to the considerable distance and fall between the study area and the boundary location. The final model topography is shown as Figure 5.1.



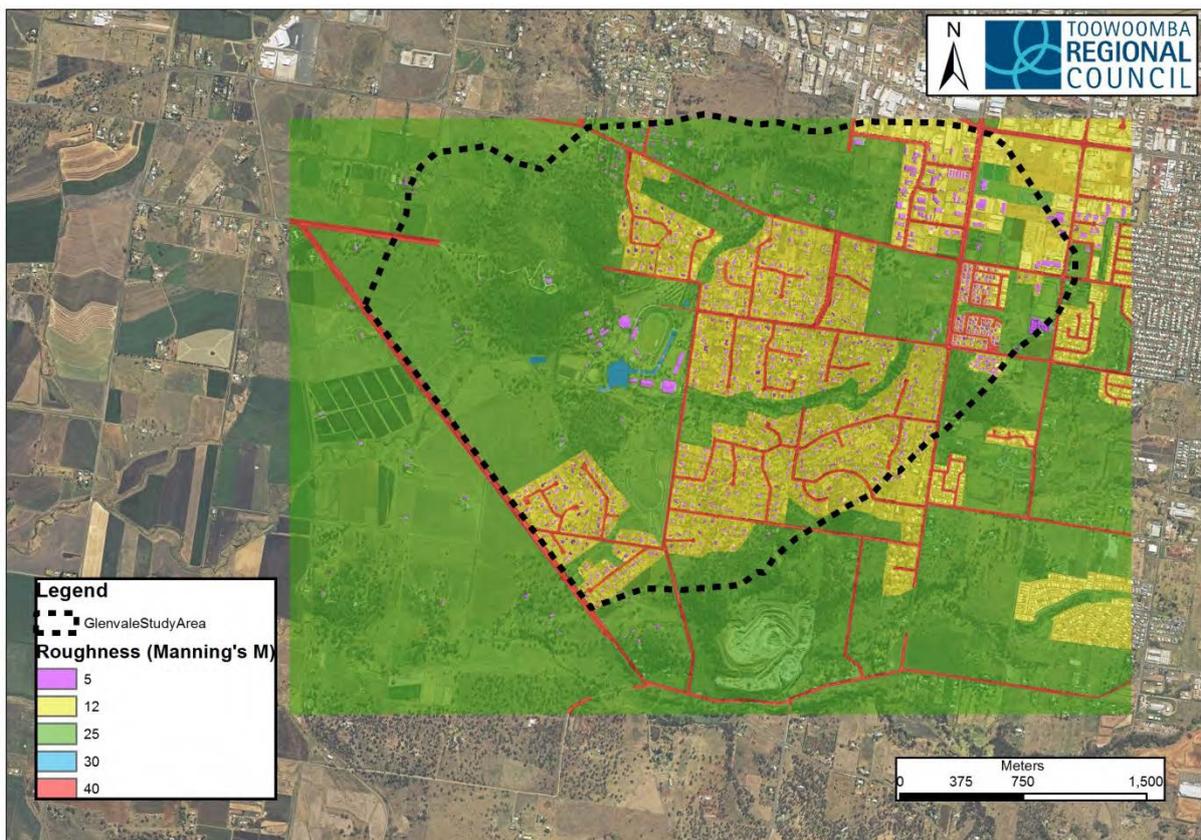
**Figure 5.1 Final Model Topography**

### 5.1.2 HYDRAULIC ROUGHNESS

The model roughness map was developed using the DCDB and Building Footprints GIS layers as the primary inputs. An aerial photograph was also draped over the roughness map to enable manual edits. The Manning’s M (Manning’s n in parenthesis) values were applied as follows:

- Roads – 40 (0.025)
- Waterways – 30 (0.033)
- Developed Areas – 12 (0.083)
- Buildings – 5 (0.2)
- Floodplain – 25 (0.04)

Additionally, during site visits it was noted that the part of the channel through the Toowoomba Showgrounds was smooth and well maintained. Subsequently a smoother roughness of Manning’s M value 30 was applied. The roughness map is shown as Figure 5.2.



**Figure 5.2 Model Roughness**

### 5.1.3 *EDDY VISCOSITY*

Eddy Viscosity values were determined from the Mike 21 Training manual. A value of 0.9 was assigned to the general floodplain whilst a value of 5 was assigned to coupled cells to promote stability.

### 5.1.4 *DOWNSTREAM BOUNDARY CONDITION*

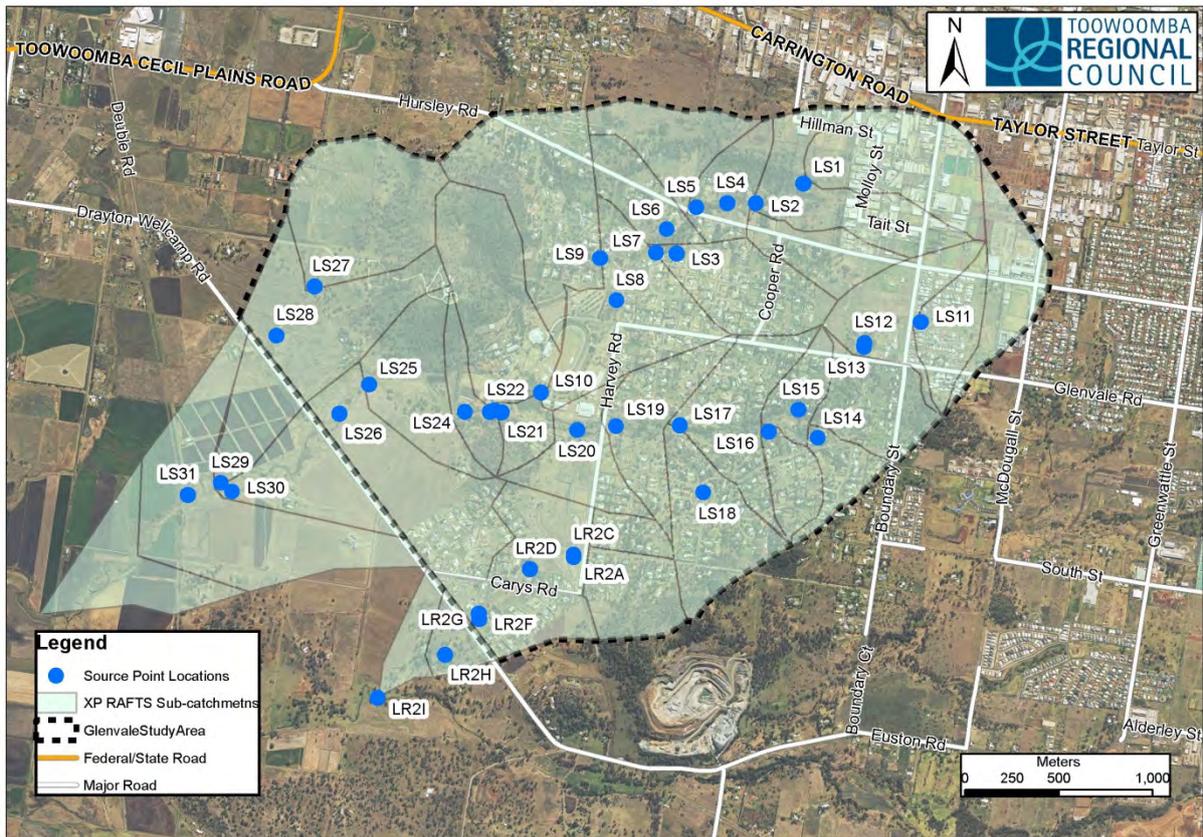
A single, fixed water-level type downstream boundary condition was applied. The boundary condition was located at the downstream extent of the model domain. The water level applied was 496.50 mAHD. This is considered a sufficient distance from the study area at one kilometre with sufficient fall at greater than 10 metres to ensure that the fixed water level boundary does not impact upon the model results. The selected water level ensures that model flows can be adequately drained to minimise the potential for backwater affecting the study area.

### 5.1.5 *INITIAL CONDITIONS*

A map of initial condition values was adopted. This enabled both the Toowoomba Showgrounds lake and the lake upstream of Glenvale Road to be filled to their respective spill levels.

### 5.1.6 *SOURCE POINTS*

All flows into the model originate from 'source points'. The source point locations were determined from the location of the hydrological model sub-catchments. Each hydrological sub-catchment is loaded to an individual source point within the MIKE21 component of the model, except for one sub-catchment that is located beyond the extent of the MIKE21 model. The source point locations are shown as Figure 5.3.



**Figure 5.3 Source Points**

The specific model grid location and co-ordinates for each sub-catchment is outlined in Table 5.1.

**Table 5-1 Source Points Locations**

| Rafts ID | J   | K   | Easting  | Northing |
|----------|-----|-----|----------|----------|
| LS31     | 61  | 515 | 387634.5 | 6950115  |
| LS30     | 140 | 521 | 387871.5 | 6950133  |
| LS29     | 120 | 536 | 387811.5 | 6950178  |
| LS28     | 284 | 664 | 388108.5 | 6950970  |
| LS27     | 286 | 888 | 388309.5 | 6951234  |
| LS25     | 383 | 712 | 388600.5 | 6950706  |
| LS26     | 330 | 660 | 388441.5 | 6950550  |
| LS24     | 554 | 664 | 389113.5 | 6950562  |
| LS21     | 619 | 663 | 389308.5 | 6950559  |
| LS20     | 753 | 631 | 389710.5 | 6950463  |
| LS22     | 607 | 666 | 389272.5 | 6950568  |
| LS23     | 598 | 664 | 389245.5 | 6950562  |
| LS10     | 689 | 698 | 389518.5 | 6950664  |
| LS9      | 822 | 935 | 389833.5 | 6951384  |
| LS8      | 823 | 863 | 389920.5 | 6951159  |
| LS6      | 912 | 990 | 390187.5 | 6951540  |

|             |      |      |          |         |
|-------------|------|------|----------|---------|
| <b>LS7</b>  | 893  | 949  | 390130.5 | 6951417 |
| <b>LS5</b>  | 965  | 1029 | 390346.5 | 6951657 |
| <b>LS4</b>  | 1020 | 1037 | 390511.5 | 6951681 |
| <b>LS19</b> | 822  | 638  | 389917.5 | 6950484 |
| <b>LS17</b> | 936  | 639  | 390259.5 | 6950487 |
| <b>LS18</b> | 977  | 519  | 390382.5 | 6950127 |
| <b>LS16</b> | 1093 | 628  | 390730.5 | 6950454 |
| <b>LS15</b> | 1146 | 667  | 390889.5 | 6950571 |
| <b>LS14</b> | 1181 | 617  | 390994.5 | 6950421 |
| <b>LS13</b> | 1263 | 780  | 391240.5 | 6950910 |
| <b>LS12</b> | 1264 | 787  | 391243.5 | 6950931 |
| <b>LS11</b> | 1364 | 824  | 391543.5 | 6951042 |
| <b>LS3</b>  | 930  | 947  | 390241.5 | 6951411 |
| <b>LS2</b>  | 1071 | 1037 | 390664.5 | 6951681 |
| <b>LS1</b>  | 1155 | 1072 | 390916.5 | 6951786 |
| <b>LR2I</b> | 399  | 152  | 388648.5 | 6949026 |
| <b>LR2H</b> | 518  | 229  | 389005.5 | 6949257 |
| <b>LR2G</b> | 578  | 302  | 389185.5 | 6949476 |
| <b>LR2F</b> | 579  | 292  | 389188.5 | 6949446 |
| <b>LR2D</b> | 669  | 382  | 389458.5 | 6949716 |
| <b>LR2A</b> | 747  | 403  | 389692.5 | 6949779 |
| <b>LR2C</b> | 747  | 408  | 389692.5 | 6949794 |

## 5.2 MIKE 11 MODEL DEVELOPMENT

The MIKE11 component of the model was used to simulate cross-drainage structures. The development of the MIKE FLOOD model is detailed below.

### 5.2.1 NETWORK LAYOUT AND STRUCTURES

A series of short branches were implemented into the model at the location of cross-drainage structures. A total of 20 structures were implemented into the MIKE11 model. Where survey data was available through Council's GIS system, this data was used to implement the structures. Where survey data was not available or the data was found to be erroneous, field measurements supplemented by interrogation from Council's one-metre DEM or design drawings were utilised.

Predominantly the structures were implemented as 'explicit' structures where the culvert is modelled in MIKE11 and the weir overflow is modelled in MIKE21. However the structure upstream of Hursley Road was modelled as an 'implicit' structure, primarily due to the short stream length of the structure. The Moat House within Toowoomba Showgrounds has been modelled as a bridge. Furthermore, discussions with staff at Toowoomba Showgrounds revealed that the structure has been modified since the January 2011 flood event to limit the potential for blockage to occur from debris. The roughness map has been modified to a Manning's M of 5 to limit flow through the structure. The structures contained within the MIKE11 model are listed in Table 5.2 and shown geographically in Figure 5.4.

**Table 5-2 Structures Implemented in the MIKE11 Model**

| ID | Location             | Structure Type | Configuration             | Data Source                           | Coupling Technique |
|----|----------------------|----------------|---------------------------|---------------------------------------|--------------------|
| 1  | Hursley Rd           | Culvert        | 6 x 1200 x 900 RCBC       | Measured and Invert Taken From 1m DEM | Implicit           |
| 2  | Hursley Rd           | Culvert        | 3 x 1200 x 900 RCBC       | Measured and Invert Taken From 1m DEM | Explicit           |
| 3  | Harvey Ct            | Culvert        | 12 x 1200 x 600 RCBC      | Measured and Invert Taken From 1m DEM | Explicit           |
| 4  | Glenvale Rd          | Culvert        | 4 x 1200 x 900 RCBC       | Measured and Invert Taken From 1m DEM | Explicit           |
| 5  | Showgrounds          | Culvert        | 1 x 1800 x 900 RCBC       | Measured and Invert Taken From 1m DEM | Explicit           |
| 6  | Moat House           | Bridge         | house structure on piers  | Measured and Invert Taken From 1m DEM | Explicit           |
| 7  | Showgrounds          | Culvert        | 7 x 1200 x 900 RCBC       | Measured and Invert Taken From 1m DEM | Explicit           |
| 8  | Showgrounds          | Culvert        | 2 x 700 RCP & 1 x 900 RCP | Measured and Invert Taken From 1m DEM | Explicit           |
| 9  | Showgrounds          | Culvert        | 2 x 675 RCP & 1 x 750 RCP | Measured and Invert Taken From 1m DEM | Explicit           |
| 10 | Drayton Wellcamp Rd  | Culvert        | 18 x 1200 x 900 RCBC      | Measured and Invert Taken From 1m DEM | Explicit           |
| 11 | Boundary St          | Culvert        | 4 x 1050 RCP              | Survey                                | Explicit           |
| 12 | Glenvale Rd          | Culvert        | 1 x 1800 RCP              | Measured and Invert Taken From 1m DEM | Explicit           |
| 13 | Panorama Dr          | Culvert        | 1 x 1200 RCP              | Measured and Invert Taken From 1m DEM | Explicit           |
| 14 | Harvey Rd            | Culvert        | 1 x 1500 RCP              | Measured and Invert Taken From 1m DEM | Explicit           |
| 15 | Criterion Track      | Culvert        | 1 x 450 RCP               | Survey                                | Explicit           |
| 16 | Criterion Track      | Culvert        | 600 x 375 RCBC            | Survey                                | Explicit           |
| 17 | Cary Rd              | Culvert        | 5 x 600 RCP               | Measured and Invert Taken From 1m DEM | Explicit           |
| 18 | Drayton Wellcamp Rd* | Culvert        | 1 x 450 RCP               | Measured / Design                     | Explicit           |

\*Structure under construction to be implemented for design simulations.

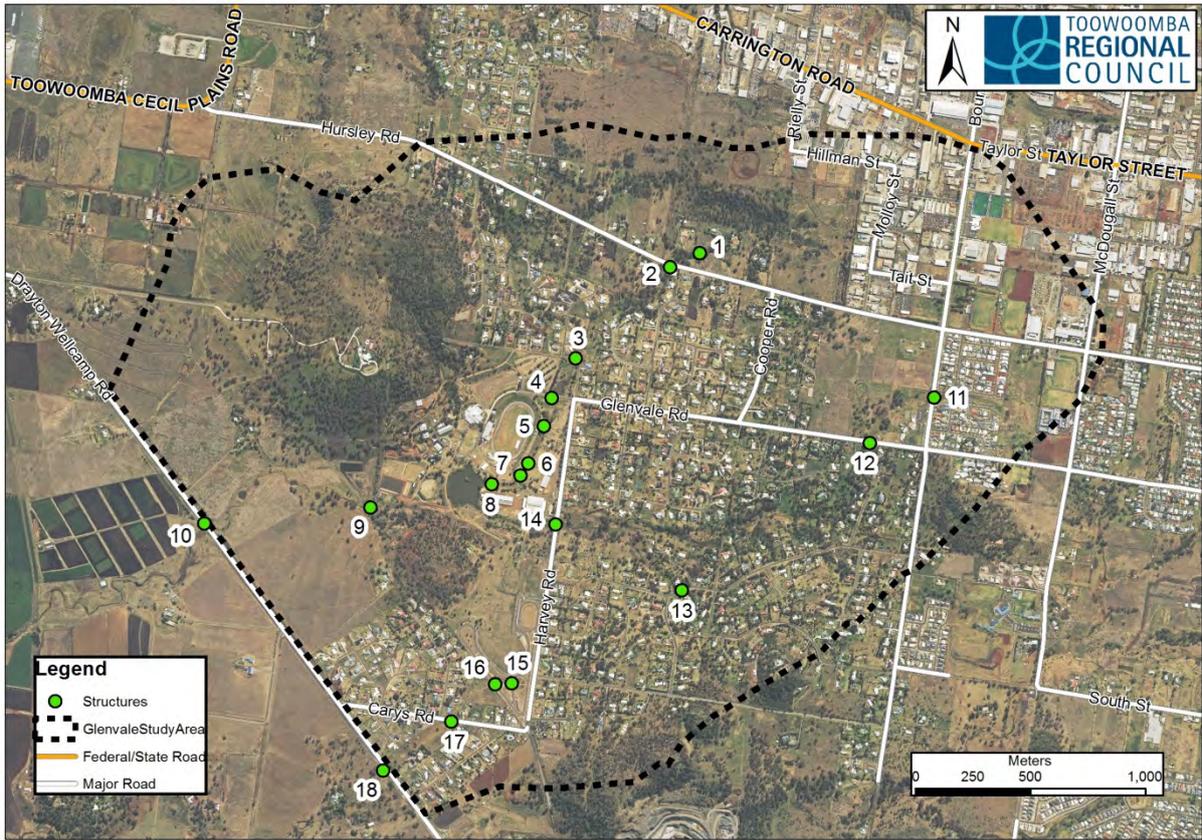


Figure 5.4 Modelled Structures within Glenvale Study Area

These structures are then represented in MIKE11 as shown in Figure 5.5.

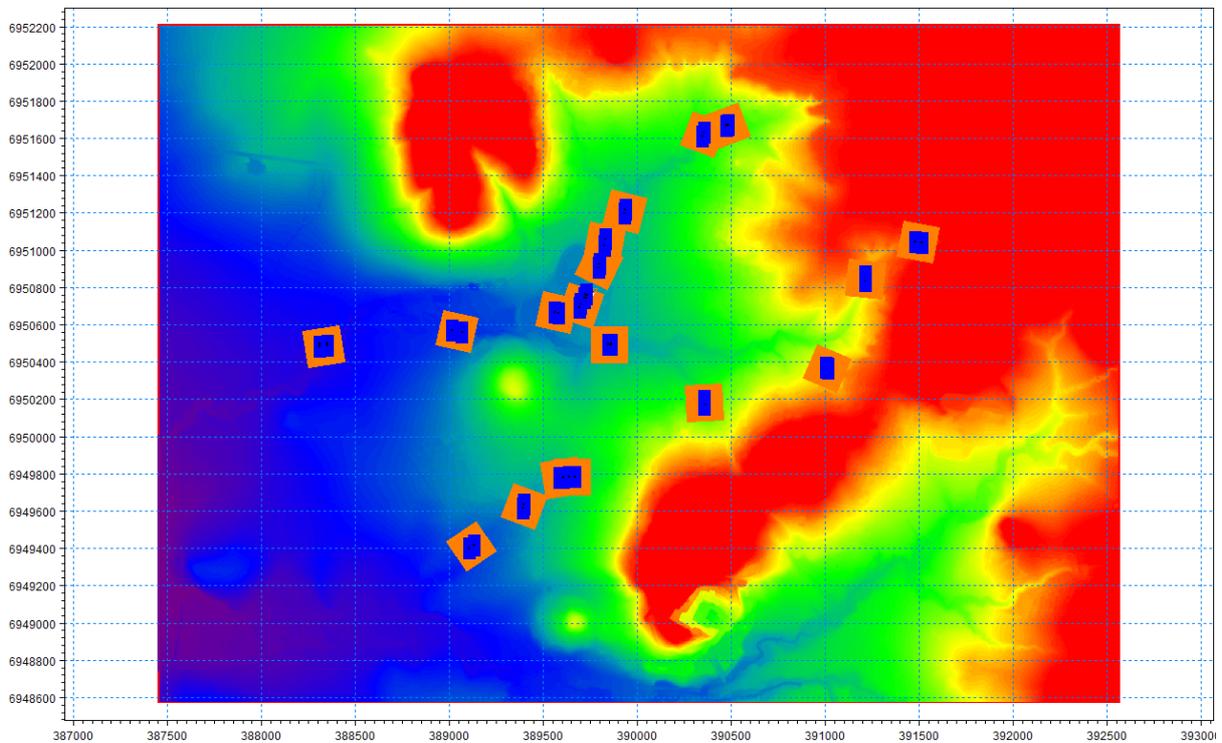


Figure 5.5 Screen view of structures as implemented in MIKE11

### *5.2.2 CROSS-SECTIONS*

To facilitate the implementation of the structures, simple MIKE11 cross-sections were implemented. In accordance with standard model development practice these were of a simple box shape and large enough to incorporate the structure. The inverts of the cross-sections were set below the invert of the structures. Water level boundaries were then applied at each of end of the MIKE11 branch.

## **5.3 MIKE FLOOD MODEL DEVELOPMENT**

The MIKE FLOOD component links the two individual models together. This section describes that process.

### *5.3.1 STRUCTURE COUPLING*

Structures were generally coupled using the explicit technique. The number of coupled cells was determined by the size of the structure. The parameters applied at each structure were as follows:

- Momentum Factor = 1.0
- Extrapolation Factor = 0.0
- Depth Adjust = yes
- Exponential Smoothing Factor = 0.2

### *5.3.2 TIME STEP AND SAVE STEP*

A fixed time step of 0.2 seconds was adopted to ensure a Courant number below one. A save step in the two-dimensional component of once every 750 time steps was selected - equal to every two minutes and thirty seconds. This is considered adequate to capture the behaviour of flooding within the study area whilst maintaining reasonable result file sizes.

## 6. MODEL RESULTS

### 6.1 MODEL VALIDATION

A joint calibration approach was utilised to validate the model to the March 30, 2014 flood event. Flows derived from the XP-RAFTS model were simulated through the MIKE FLOOD model and maximum flood surface elevations from MIKE FLOOD were compared with flood debris marks surveyed after flooding.

Inspection of photos taken at Drayton Wellcamp Road culvert (north of Carys Road) following the March 30, 2014 event revealed significant blockage at this location. Subsequently a blockage of 50 percent was adopted for this culvert. A photograph of the blockage is shown as Figure 6.1.



**Figure 6.1 Flood Points versus Modelled Results at Hursley Road and Harvey Court**

The model was found to present a good match to the surveyed flood debris levels. Eighty-four percent of the verification points were modelled within +/- 0.3 metres of the surveyed level. At two locations a difference of greater than one metre was observed. Both of these locations were on the

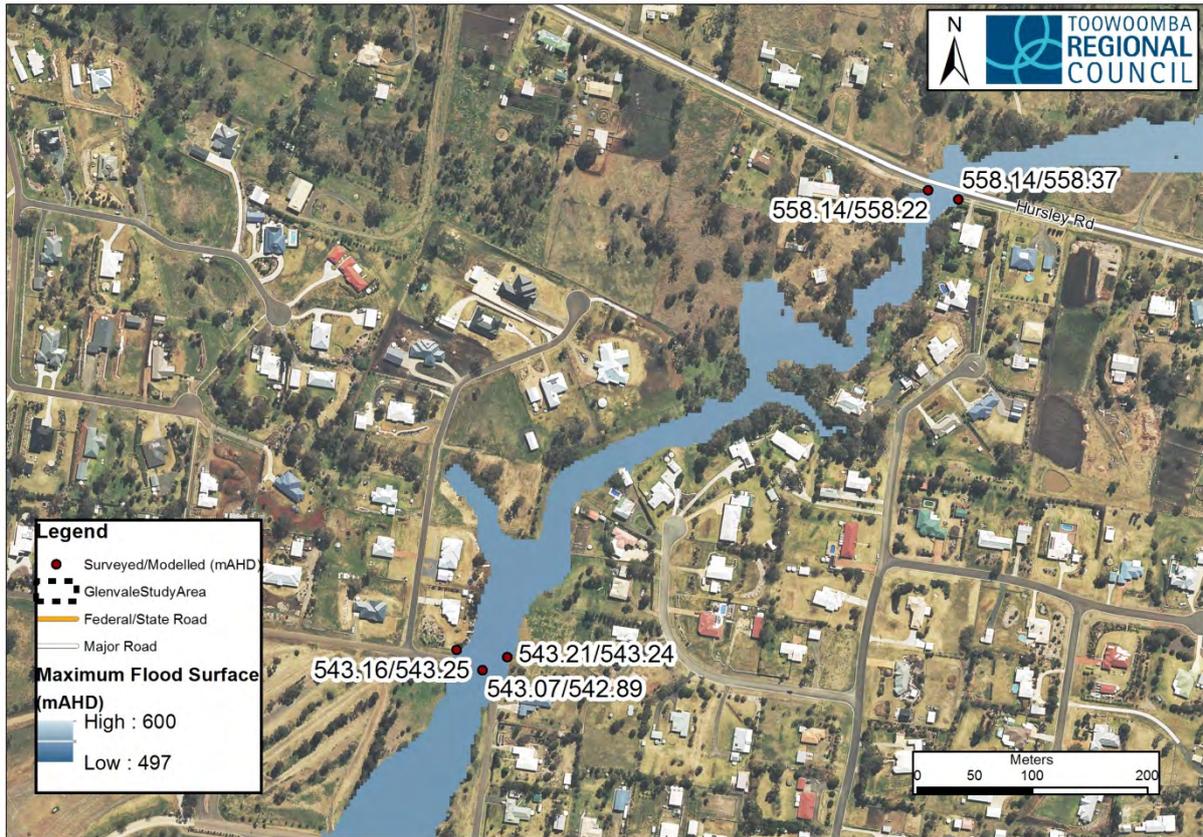
downstream side of the culvert at Harvey Road. As the modelled values are significantly lower than the surveyed values, it is likely that the flood debris at these two locations could be attributed to local drainage flowing to the central flow path. In addition, at Drayton Wellcamp Road three survey points were not shown to be flooded in the model. At these locations, the closest flooded cell was selected for comparison (up to 20 m). Interrogation of the model bathymetry revealed that that the model topography was higher than the surveyed water level (or shadowed by higher model topography values).

**Table 6-1 Level Comparison at Verification Points**

| <b>Spot Height Location</b>       | <b>Survey Type</b>    | <b>Surveyed Elevation (mAHD)</b> | <b>Modelled Elevation (mAHD)</b> | <b>Difference (m)</b> |
|-----------------------------------|-----------------------|----------------------------------|----------------------------------|-----------------------|
| Hursley Road (northern flow path) | Surveyed flood debris | 558.14                           | 558.22                           | 0.08                  |
| Hursley Road (northern flow path) | Surveyed flood debris | 558.14                           | 558.37                           | 0.23                  |
| Harvey Court (northern flow path) | Surveyed flood debris | 543.16                           | 543.25                           | 0.09                  |
| Harvey Court (northern flow path) | Surveyed flood debris | 543.21                           | 543.24                           | 0.03                  |
| Harvey Court (northern flow path) | Surveyed flood debris | 543.07                           | 542.89                           | -0.18                 |
| Harvey Road (central flow path)   | Surveyed flood debris | 539.09                           | 539.07                           | -0.02                 |
| Harvey Road (central flow path)   | Surveyed flood debris | 539.1                            | 539.07                           | -0.03                 |
| Harvey Road (central flow path)   | Surveyed flood debris | 539.11                           | 539.06                           | -0.05                 |
| Harvey Road (central flow path)   | Surveyed flood debris | 539.09                           | 537.78                           | -1.31                 |
| Harvey Road (central flow path)*  | Surveyed flood debris | 539.4                            | 537.45                           | -1.95                 |
| Drayton Wellcamp Rd               | Surveyed flood debris | 513.23                           | 513.47                           | 0.24                  |
| Drayton Wellcamp Rd               | Surveyed flood debris | 513.42                           | 513.28                           | -0.14                 |
| Drayton Wellcamp Rd               | Surveyed flood debris | 513.16                           | 513.00                           | -0.16                 |
| Drayton Wellcamp Rd               | Surveyed flood debris | 512.48                           | 512.32                           | -0.16                 |
| Drayton Wellcamp Rd               | Surveyed flood debris | 513.25                           | 513.34                           | 0.09                  |
| Drayton Wellcamp Rd               | Surveyed flood debris | 513.78                           | 513.51                           | -0.27                 |
| Drayton Wellcamp Rd*              | Surveyed flood debris | 513.53                           | 513.51                           | -0.02                 |
| Drayton Wellcamp Rd*              | Surveyed flood debris | 513.78                           | 513.51                           | -0.27                 |
| Drayton Wellcamp Rd*              | Surveyed flood debris | 514.03                           | 513.51                           | -0.52                 |

\*Cells selected nearby surveyed data.

A series of maps displaying comparison of surveyed flood debris levels versus modelled flood levels is shown as Figures 6.2 to 6.4.



**Figure 6.2 Surveyed Flood Points versus Modelled Results at Hursley Road and Harvey Court (Surveyed/Modelled)**

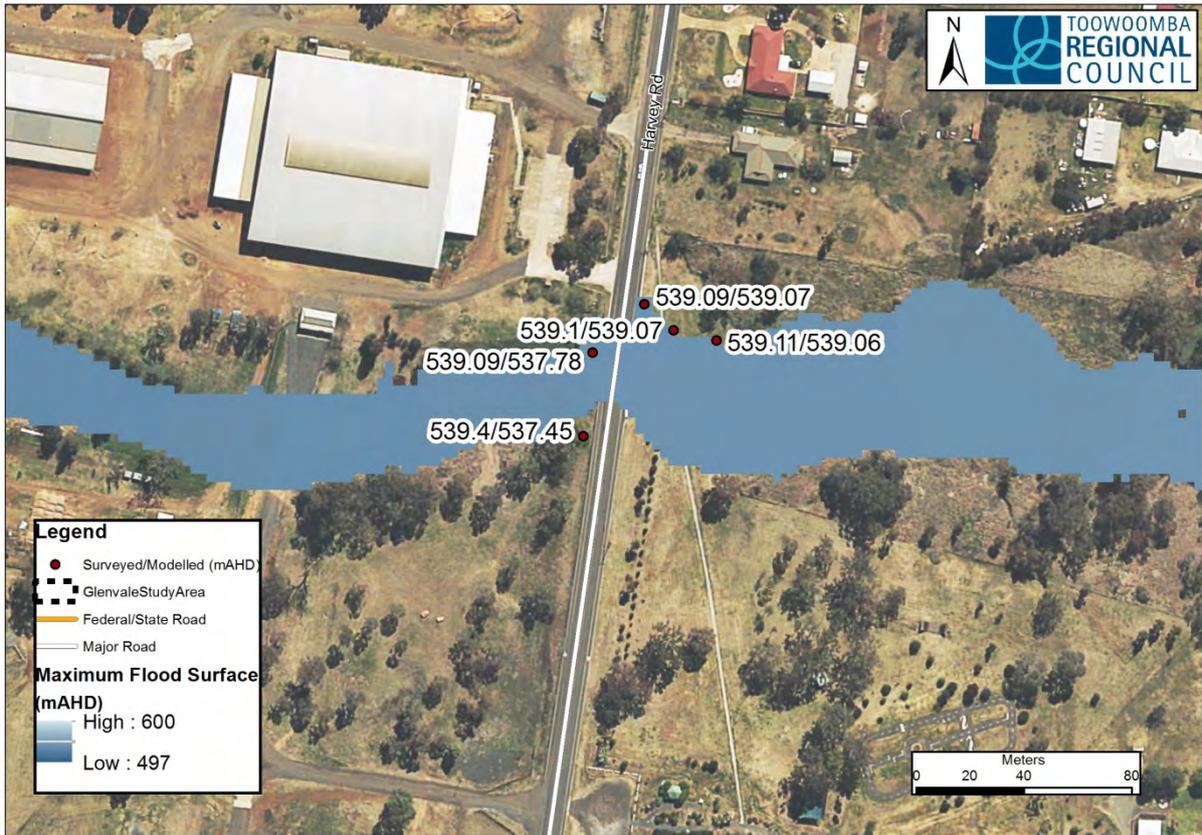


Figure 6.3 Flood Points versus Modelled Results at Harvey Road (Surveyed/Modelled)

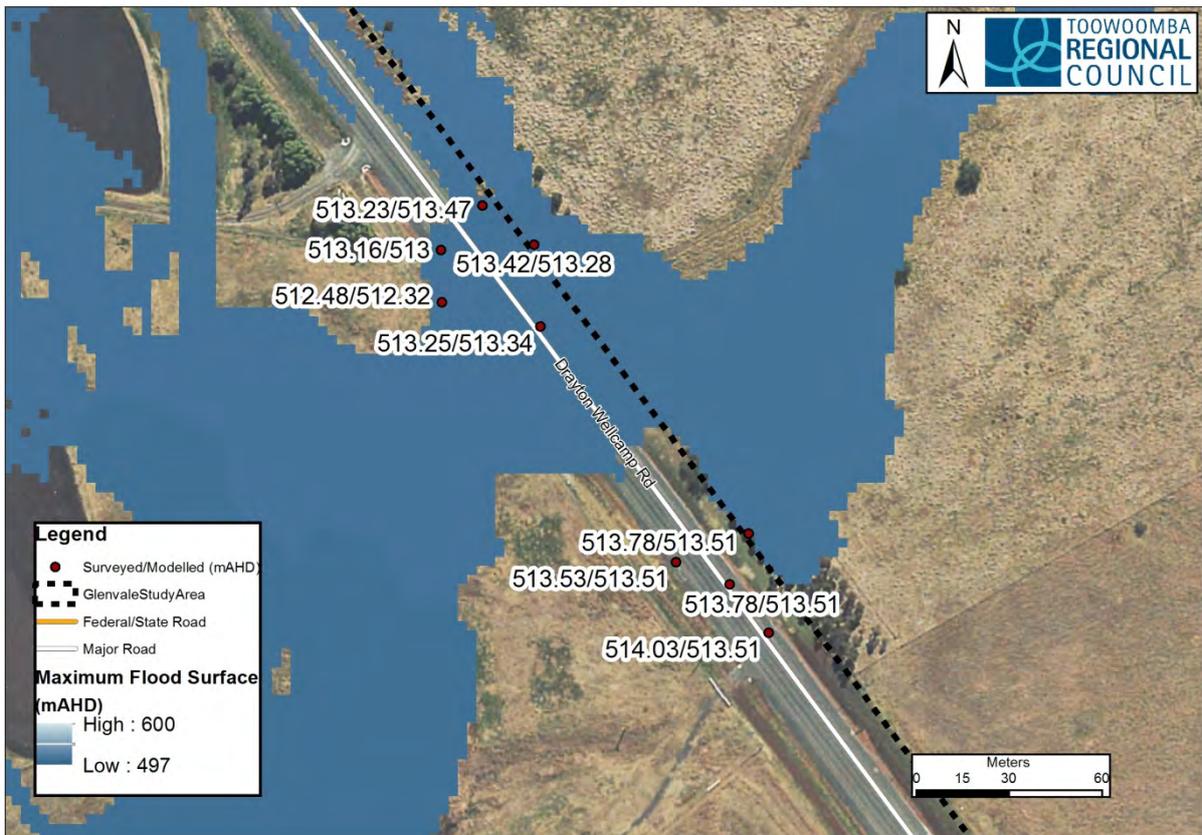


Figure 6.4 Flood Points versus Modelled Results at Drayton Wellcamp Road. (Surveyed/Modelled)

### 6.1.1 ANECDOTAL BEHAVIOUR

In addition to the flood debris points, the model results were considered against the anecdotal behaviour. A number of photographs were made available to this study through residents and business within the study area as well as advice of flood behaviour for March 30, 2014. Selected photos of flooding at Toowoomba Showgrounds are shown as Figure 6.4 and photos taken at Windorah Close, upstream of the Showgrounds on the northern flow path are shown as Figure 6.5.

Discussions with staff at Toowoomba Showgrounds indicated that:

- Glenvale Road was overtopped upstream of the showgrounds;
- The flood level was slightly above the floor level at the Moat House;
- Water in the main arena was predominantly from rainfall;
- Harvey Road was overtopped for the second time in about 30 years; and
- Floodwater exited the Showgrounds Lake via the spillway and did not overtop at any other location.

Each of these reported behaviours is matched by model results. However, it is possible that the model is overestimating the flow entering the main arena due to impediment imposed by the Moat House structure. Photos of flooding at Toowoomba Showgrounds are shown as Figure 6.5.

Discussions with residents at Windorah Close revealed that flooding was mostly confined to the formed flow paths with a depth of approximately 600 mm. Again the model reflects this along the northern flow path. Photos of flooding at Windorah Court are shown as Figure 6.6.

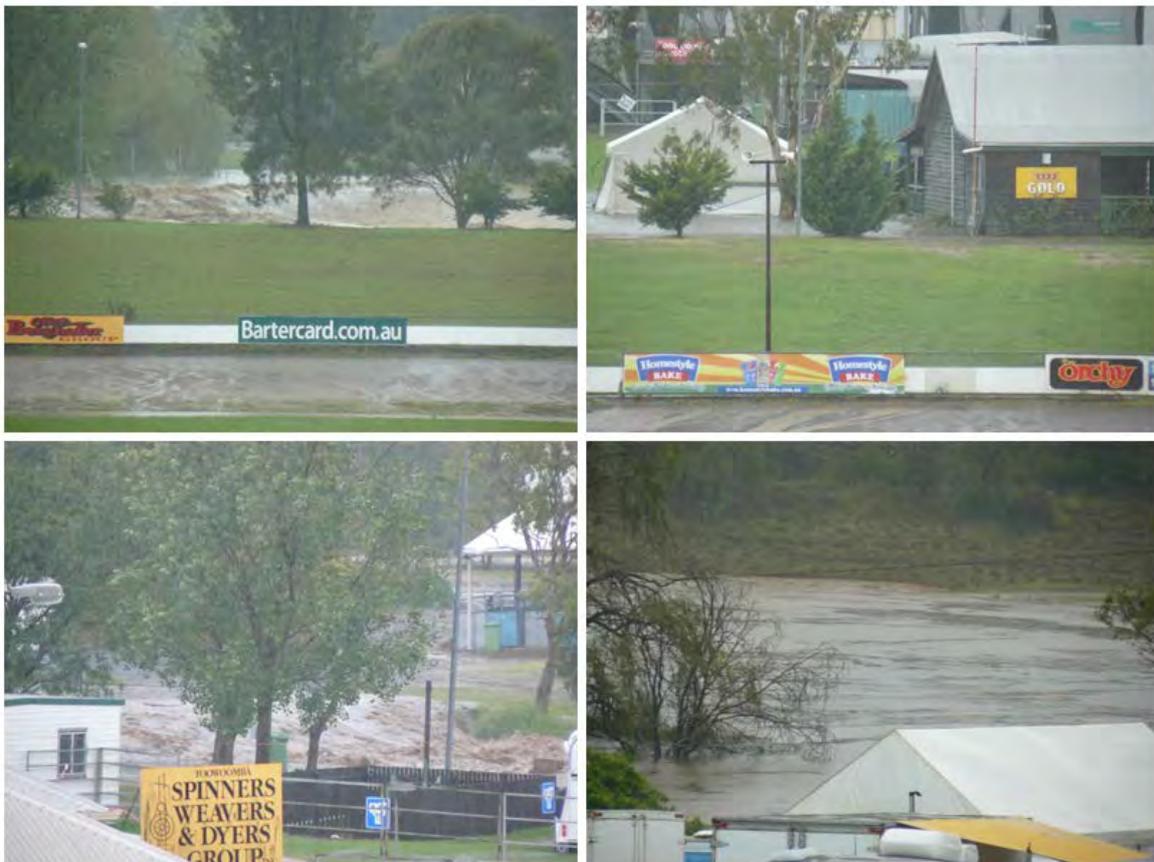


Figure 6.5 Selected photos of flooding at Toowoomba Showgrounds (March 30, 2014)



Figure 6.6 Selected photos of flooding at Windorah Court (March 30, 2014)

## 6.2 ASSESSMENT OF CRITICAL DURATION

Following development of the design flows, an assessment of the critical duration was undertaken. The assessment was conducted based on the 1% AEP with storm durations ranging from 30 minutes to 3 hours. These events were simulated in the MIKE FLOOD model and seven locations throughout the model were selected for comparison. The comparison locations are shown as Figure 6.7.

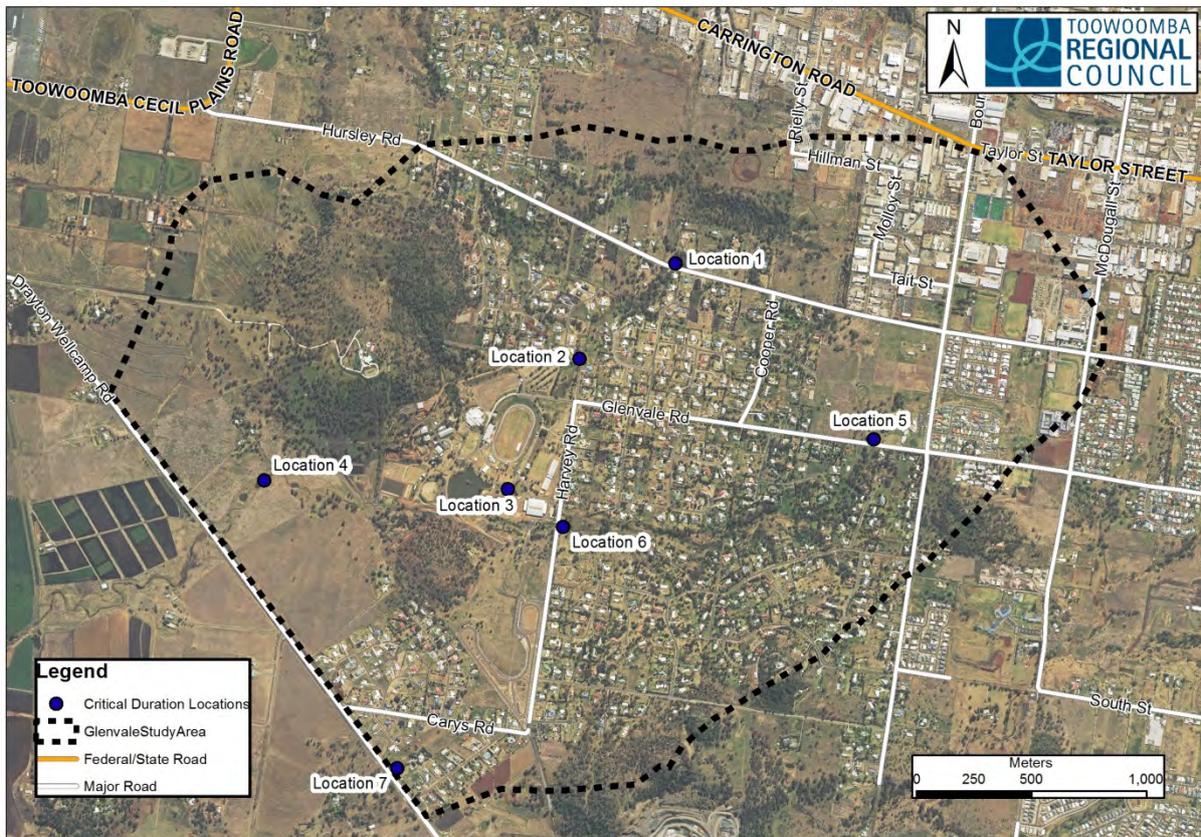


Figure 6.7 Critical duration comparison locations.

The results of the comparison of maximum water level at each location are shown as Table 6-2.

**Table 6-2 Maximum water level by storm duration for 1% AEP event.**

| ID | Location                | Maximum Water Level (mAHD) by Storm Duration |        |        |        |         |         |
|----|-------------------------|--|--------|--------|--------|---------|---------|
|    |                         | 30 min                                       | 45 min | 60 min | 90 min | 120 min | 180 min |
| 1  | Hursley Road            | 558.47                                       | 558.49 | 558.51 | 558.46 | 558.47  | 558.48  |
| 2  | Harvey Court            | 543.51                                       | 543.53 | 543.55 | 543.49 | 543.50  | 543.51  |
| 3  | Showgrounds             | 532.98                                       | 532.98 | 533.01 | 532.95 | 532.96  | 532.97  |
| 4  | Drayton Wellcamp Road 1 | 517.03                                       | 517.09 | 517.12 | 517.06 | 517.06  | 517.08  |
| 5  | Glenvale Road           | 587.47                                       | 587.48 | 587.50 | 587.45 | 587.47  | 587.48  |
| 6  | Harvey Road             | 539.51                                       | 539.53 | 539.56 | 539.49 | 539.50  | 539.50  |
| 7  | Drayton Wellcamp Road 2 | 526.26                                       | 526.26 | 526.27 | 526.24 | 526.25  | 526.25  |

The results show that for all seven locations, the 60 minute storm duration is critical. Although minor changes were later made to the MIKE FLOOD model, based on this assessment, design simulations were undertaken using the 60 minute storm duration.

### 6.3 DESIGN SIMULATIONS

The MIKE FLOOD hydrodynamic model was used to simulate the design flows derived from the XP-RAFTS model. The simulations were undertaken for the 20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% AEP and PMF-DF design flood events. The results for maximum water level and maximum discharge for the 1% AEP design event are shown as Table 6-3 for the seven comparison locations (refer Figure 6.7). The surface levels for all AEP are shown Table 6.4. Mapping of design events for maximum flood levels, hazard and hydraulic category are presented in Appendix A as Figure A-1 to A-18.

**Table 6-3 Simulated maximum design flood levels and discharges (1% AEP)**

| ID | Location                | Maximum Flood Level (mAHD) | Maximum Discharge (m <sup>3</sup> /s) |
|----|-------------------------|----------------------------|---------------------------------------|
| 1  | Hursley Road            | 558.50                     | 19                                    |
| 2  | Harvey Court            | 543.23                     | 54                                    |
| 3  | Showgrounds             | 533.03                     | 59                                    |
| 4  | Drayton Wellcamp Road 1 | 517.10                     | 104                                   |
| 5  | Glenvale Road           | 587.51                     | 14                                    |
| 6  | Harvey Road             | 539.56                     | 45                                    |
| 7  | Drayton Wellcamp Road 2 | 526.31                     | 21                                    |

**Table 6-4 Surface Levels for all AEPs**

| ID | 20%   | 10%   | 5%    | 2%    | 1%    | 0.5%  | 0.2%  | PMP   |
|----|-------|-------|-------|-------|-------|-------|-------|-------|
| 1  | 557.9 | 558.2 | 558.3 | 558.4 | 558.5 | 558.5 | 558.6 | 559.5 |
| 2  | 542.7 | 543.0 | 543.1 | 543.2 | 543.2 | 543.3 | 543.4 | 544.6 |
| 3  | 532.7 | 532.8 | 532.9 | 533.0 | 533.0 | 533.1 | 533.1 | 533.9 |
| 4  | 516.6 | 516.8 | 516.9 | 517.0 | 517.1 | 517.2 | 517.3 | 518.3 |
| 5  | 587.0 | 587.3 | 587.4 | 587.5 | 587.5 | 587.5 | 587.6 | 588.2 |
| 6  | 538.6 | 539.2 | 539.4 | 539.5 | 539.6 | 539.6 | 539.7 | 540.8 |
| 7  | 526.2 | 526.2 | 526.3 | 526.3 | 526.3 | 526.3 | 526.3 | 526.7 |

The MIKE FLOOD hydrodynamic model was also used to simulate the ultimate development scenario for the design flood events. A comparison of the results for the 1% AEP is shown as Table 6-5. The results indicate a significant increase in maximum flood level at some locations (including Hursley Road) indicating that consideration to further mitigation works within the catchment may be necessary in the future.

**Table 6-5 Comparison of simulated existing and future maximum flood levels for 1% AEP.**

| ID | Location                | Existing Case<br>Max Level<br>(mAHD) | Future Case<br>Max Level<br>(mAHD) | Difference<br>(m) |
|----|-------------------------|--------------------------------------|------------------------------------|-------------------|
| 1  | Hursley Road            | 558.50                               | 558.66                             | 0.16              |
| 2  | Harvey Court            | 543.23                               | 543.31                             | 0.08              |
| 3  | Showgrounds             | 533.03                               | 533.08                             | 0.05              |
| 4  | Drayton Wellcamp Road 1 | 517.10                               | 517.11                             | 0.01              |
| 5  | Glenvale Road           | 587.51                               | 587.56                             | 0.07              |
| 6  | Harvey Road             | 539.56                               | 539.58                             | 0.02              |
| 7  | Drayton Wellcamp Road 2 | 526.31                               | 526.31                             | 0.00              |

## 6.4 SENSITIVITY ANALYSIS

The aim of sensitivity checks is to observe the sensitivity of the catchment to large variations in flow and roughness. To examine this sensitivity, the following variations were imposed:

- +/- 30% variation in flows (See Figure A-19)
- +/- 30% variation in roughness(See Figure A-19)

Table 6-6 summarises the results obtained at the seven comparison locations (refer Figure 6.7) for the 1% AEP event for roughness whilst Table 6-77 summarises the results obtained for variation in flows. The results indicate that the catchment is more sensitive to variation in flows than to variation in roughness. Whilst the variation in water level is significant at some locations, the variation in flood extent is limited. This is expected due to the steep nature of the catchment.

**Table 6-6 Sensitivity analysis for variation in roughness (1% AEP).**

| ID | Location                | Base Case<br>Flood<br>Level<br>(mAHD) | Increased<br>Roughness<br>Flood<br>Level<br>(mAHD) | Difference<br>(m) | Decreased<br>Roughness<br>Flood<br>Level<br>(mAHD) | Difference<br>(m) |
|----|-------------------------|---------------------------------------|--|-------------------|--|-------------------|
| 1  | Hursley Road            | 558.50                                | 558.54   | 0.04              | 558.47   | -0.03             |
| 2  | Harvey Court            | 543.23                                | 543.32   | 0.09              | 543.16   | -0.07             |
| 3  | Showgrounds             | 533.03                                | 533.15   | 0.12              | 532.94   | -0.09             |
| 4  | Drayton Wellcamp Road 1 | 517.10                                | 517.17   | 0.17              | 517.07   | -0.03             |
| 5  | Glenvale Road           | 587.51                                | 587.52   | 0.01              | 587.50   | -0.01             |
| 6  | Harvey Road             | 539.56                                | 539.57   | 0.01              | 539.55   | -0.05             |
| 7  | Drayton Wellcamp Road 2 | 526.31                                | 526.36   | 0.05              | 526.27   | -0.04             |

**Table 6-7 Sensitivity analysis for variation in flows (1% AEP).**

| ID | Location                | Base Case<br>Flood<br>Level<br>(mAHD) | Increased<br>Flow<br>Flood<br>Level<br>(mAHD) | Difference<br>(m) | Decreased<br>Flow<br>Flood<br>Level<br>(mAHD) | Difference<br>(m) |
|----|-------------------------|---------------------------------------|---|-------------------|---|-------------------|
| 1  | Hursley Road            | 558.50                                | 558.61  | 0.11              | 558.36  | -0.14             |
| 2  | Harvey Court            | 543.23                                | 543.34  | 0.11              | 543.09  | -0.14             |
| 3  | Showgrounds             | 533.03                                | 533.13  | 0.10              | 532.93  | -0.10             |
| 4  | Drayton Wellcamp Road 1 | 517.10                                | 517.26  | 0.16              | 516.92  | -0.18             |
| 5  | Glenvale Road           | 587.51                                | 587.58  | 0.07              | 587.41  | -0.10             |
| 6  | Harvey Road             | 539.56                                | 539.70  | 0.04              | 539.38  | -0.18             |
| 7  | Drayton Wellcamp Road 2 | 526.31                                | 526.35  | 0.04              | 526.26  | -0.05             |

## 6.5 CLIMATE CHANGE ANALYSIS

Hydrodynamic model simulations were conducted for 2050, 2070 and 2100 climate change scenarios in accordance with Section 4.5. Also See Figures A21-29 of Appendix A. A comparison of the maximum flood levels for the six comparison locations is presented in Table 6-8. As expected, the results generally show increasing maximum flood levels with increasing rainfall intensity due to climate change. For the 1% AEP, the 2100 case shows significant increases in maximum flood levels at some locations including Drayton Wellcamp Road (point 4) however, changes to flood behaviour and flood extent are limited. For mapping of climate change scenarios refer to Appendix A.

**Table 6-8 Results of Climate Change analysis for 1% AEP 60 minute maximum flood levels.**

| Point ID | Location     | Base<br>Case<br>(mAHD) | 2050<br>Case<br>(mAHD) | Difference<br>(m) | 2070<br>Case<br>(mAHD) | Difference<br>(m) | 2100<br>Case<br>(mAHD) | Difference<br>(m) |
|----------|--------------|------------------------|------------------------|-------------------|------------------------|-------------------|------------------------|-------------------|
| 1        | Hursley Road | 558.50                 | 558.55                 | 0.05              | 558.57                 | 0.07              | 558.59                 | 0.09              |
| 2        | Harvey Court | 543.23                 | 543.28                 | 0.05              | 543.3                  | 0.07              | 543.33                 | 0.1               |
| 3        | Showgrounds  | 533.03                 | 533.07                 | 0.04              | 533.09                 | 0.06              | 533.11                 | 0.08              |

|   |                            |        |        |      |        |      |        |      |
|---|----------------------------|--------|--------|------|--------|------|--------|------|
| 4 | Drayton<br>Wellcamp Road 1 | 517.1  | 517.17 | 0.07 | 517.19 | 0.09 | 517.22 | 0.12 |
| 5 | Glenvale Road              | 587.51 | 587.54 | 0.03 | 587.56 | 0.05 | 587.57 | 0.06 |
| 6 | Harvey Road                | 539.56 | 539.61 | 0.05 | 539.64 | 0.08 | 539.67 | 0.11 |
| 7 | Drayton<br>Wellcamp Road 2 | 526.31 | 526.32 | 0.01 | 526.33 | 0.02 | 526.34 | 0.03 |

## 6.6 ASSESSMENT OF CULVERT BLOCKAGE

To analyse the impact of potential structure blockage, a simulation was undertaken where each structure was assumed to have 50 percent blockage See Figure A20. The blockage was implemented by reducing the structure area by 50 percent whilst maintaining the invert level. The 1% AEP was selected as the event for blockage analysis. Changes in maximum flood level are presented for the comparison locations in Table 6-9.

**Table 6-9 Maximum flood level comparison for blockage scenario.**

| ID | Location                | Base Case<br>(mAHD) | Blockage Case<br>(mAHD) | Difference (m) |
|----|-------------------------|---------------------|-------------------------|----------------|
| 1  | Hursley Road            | 558.50              | 558.60                  | 0.10           |
| 2  | Harvey Court            | 543.23              | 543.37                  | 0.24           |
| 3  | Showgrounds             | 533.03              | 532.98                  | -0.05          |
| 4  | Drayton Wellcamp Road 1 | 517.10              | 517.09                  | -0.01          |
| 5  | Glenvale Road           | 587.51              | 587.55                  | 0.04           |
| 6  | Harvey Road             | 539.56              | 539.66                  | 0.10           |
| 7* | Drayton Wellcamp Road 2 | 526.31              | 526.31                  | 0.00           |

*\*Culverts currently under construction in this location have not been included in this analysis.*

The results show that the impact of culvert blockage is significant at some of the comparison locations, particularly where these are adjacent to structures. The impact dissipates at reasonably short distances from the structures. This is expected as the floodplain is relatively steep. For mapping of culvert blockage scenario refer to Appendix A.

## 7. SUMMARY

The objective of this study was to a computer-based model to identify and map potential flooding within the Glenvale catchment from the top of the catchment to Drayton Wellcamp Road. It was not the objective of this study to develop a stormwater management plan or to recommend specific upgrades to the drainage network. In order to achieve the objectives of the study, XP-RAFTS was used to generate catchment flows that were then applied to MIKE FLOOD to simulate flooding.

A validation of the models to the March 2014 flood event was undertaken. The models were found to reasonably match the surveyed flood levels and the described flood behaviour.

The study produced a series of maps showing the extent of simulated flooding within the study area. Maps were produced indicating the associated hazard with selected flood events along with depth, surface elevation and hydraulic category.

Analysis of design events shows that flooding is mostly confined to well defined channels within the floodplain. Maximum flood levels and flood extents were found to steadily increase with increasing design storm size, however the flood behaviour was found to remain similar i.e. mostly confined to well defined channels. Simulation of future development conditions indicates increases in maximum flood levels at some locations. This may require additional investigation in the future. The largest increase in water levels was 2.2m across the comparison points but most changes were in the range 1-2 metres.

Sensitivity analysis showed that the floodplain is more susceptible to changes in flow, -0.18 metres to 0.16 metres across the comparison points, than changes in floodplain resistance, -0.9 metres to 0.17 metres. The sensitivity analysis did not show significant changes in flood behaviour which is expected due to the nature of the floodplain.

Climate change simulations were also undertaken for 2050, 2070 and 2100 design horizons. The model indicates that there is increasing flooding as rainfall intensities increase. However, due to the floodplain topography there is limited increases in flood extent. The largest increase across the comparison points 0.12 metres.

Blockage was also analysed but resulted in small increases in flow. The increase was up to 0.24 metres across the comparison points but is expected to vary more in areas closer to the structures.

Comparisons between the ultimate development conditions were undertaken to assess the likely impacts of the planning scheme being fully developed. The largest increase in of levels for the 1% AEP was 0.16 metres. The impact on the 1% was minimal due to the steep nature of the catchment. It is however expected to have proportionally increased effects on the smaller events because of varying loss model adopted.

Analysis design events showed that only one house is impacted by flooding in Glenvale. This house, to the south of Carys Rd is shown being inundated for all events greater than the 10% AEP, but remains inundated by less than 0.25 metres for all design events up to PMP. This house is in a low hazard area so risk to life is also low. This house should be further investigated by surveying floor levels and the channel adjacent to it to ensure that it has been correctly represented in the hydraulic modelling.

Although there are not many houses inundated, the waterways generally flow through privately owned large block residential areas. The waterways are generally extreme hazard with some high and significant areas. This poses a large risk potential. These waterways need to be considered in

future development and it is recommended to explore a legislatively protected way of considering them in future development.

## **8. RECOMMENDATIONS**

The following recommendations are made to improve the accuracy of flood modelling within the study area:

- Comprehensive collection of anecdotal evidence following future flood events;
- Survey be undertaken of all culverts, bridges and other structures within the floodplain; and
- Consideration be given to installation of pluviographs and water level gauges within the catchment.
- More detailed analysis on impacts of future urban developments;
- Comprehensive revision of roughness maps;
- Further exploration of inundated properties by surveying relevant details; and
- Explore a legislatively protected way of ensuring protection of future development from the extreme hazard waterways in private land.

## 9. REFERENCES

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- Eastern Drain Flood Study (SKM, 2000)
- Toowoomba Showgrounds and Northern Catchment Stormwater Management Plan (GHD, 2001)
- Summary Report on Toowoomba Showgrounds and Northern Catchment Stormwater Management Plan (GHD, 2002)
- Glenvale Stormwater Management Plan (GHD, 2005)

## APPENDIX A MAPPING



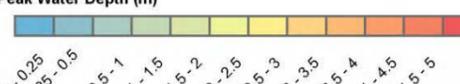
|   |  |        |          |       |       |       |       |       |       |       |       |       |    |  |   |
|---|--|--------|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----|--|---|
|  <p>1:11,000 (at A3)</p> <p>0 100 200 300 400 Metres</p> <p>GDA 1994 MGA Zone 56</p> | <p><b>Legend</b></p> <p><b>Peak Water Depth (m)</b></p> <table border="1"> <tr> <td>0-0.25</td> <td>0.25-0.5</td> <td>0.5-1</td> <td>1-1.5</td> <td>1.5-2</td> <td>2-2.5</td> <td>2.5-3</td> <td>3-3.5</td> <td>3.5-4</td> <td>4-4.5</td> <td>4.5-5</td> <td>&gt;5</td> </tr> </table> | 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 | <p><input type="checkbox"/> Emergency Services</p> <p><input type="checkbox"/> Rail</p> <p><input type="checkbox"/> Cadastre</p> | <p><b>GLENVALE</b></p> <p><b>50% AEP Peak Flood Depth</b></p> |
| 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    |       |    |  |   |

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Figure A-1 50% AEP Peak Depth



|   |  |   |   |
|---|--|---|---|
|  <p>1:11,000 (at A3)</p> <p>0 100 200 300 400 Metres</p> <p>ODA 1994 MOA Zone 56</p> | <p><b>Legend</b></p> <p><b>Peak Water Depth (m)</b></p>  | <p>□ Emergency Services</p> <p>— Rail</p> <p>□ Cadastre</p> | <p><b>GLENVALE</b></p> <p><b>20% AEP Peak Flood Depth</b></p> |
|---|--|---|---|

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**Figure A-2 20% AEP Peak Depth**



|   |   |        |          |       |       |       |       |       |       |       |       |       |    |  |   |
|---|---|--------|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----|--|---|
|  <p>1:11,000 (at A3)</p> <p>0 100 200 300 400 Metres</p> <p>IDA 1994 MOA Zone 56</p> | <p><b>Legend</b></p> <p>Peak Water Depth (m)</p> <table border="1"> <tr> <td>0-0.25</td> <td>0.25-0.5</td> <td>0.5-1</td> <td>1-1.5</td> <td>1.5-2</td> <td>2-2.5</td> <td>2.5-3</td> <td>3-3.5</td> <td>3.5-4</td> <td>4-4.5</td> <td>4.5-5</td> <td>&gt;5</td> </tr> </table> | 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 | <ul style="list-style-type: none"> <li> Emergency Services</li> <li> Rail</li> <li> Cadastre</li> </ul> | <p><b>GLENVALE</b></p> <p><b>10% AEP Peak Flood Depth</b></p> |
| 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    |       |    |  |   |

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**Figure A-3 10% AEP Peak Depth**



|   |  |          |            |         |         |         |         |         |         |         |         |         |     |  |
|---|--|----------|------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-----|--|
|  <p>1:11,000 (at A3)</p> <p>0 100 200 300 400 Metres</p> <p>IDA 1994 MOA Zone 56</p> | <p><b>Legend</b></p> <p><b>Peak Water Depth (m)</b></p> <table border="1"> <tr> <td>0 - 0.25</td> <td>0.25 - 0.5</td> <td>0.5 - 1</td> <td>1 - 1.5</td> <td>1.5 - 2</td> <td>2 - 2.5</td> <td>2.5 - 3</td> <td>3 - 3.5</td> <td>3.5 - 4</td> <td>4 - 4.5</td> <td>4.5 - 5</td> <td>&gt; 5</td> </tr> </table> <p> <input type="checkbox"/> Emergency Services<br/> <input type="checkbox"/> Rail<br/> <input type="checkbox"/> Cadastre         </p> | 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 | <p align="center"><b>GLENVALE</b><br/><b>5% AEP Peak Flood Depth</b></p> |
| 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     |         |     |  |

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**Figure A-4 5% AEP Peak Depth**



**TOOWOOMBA REGIONAL COUNCIL**  
 1:11,000 (at A3)  
 0 100 200 300 400 Metres  
 GDA 1994 MGA Zone 56

**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

Emergency Services  
 Rail  
 Cadastre

**GLENVALE  
 2% AEP Peak Flood Depth**

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Figure A-5 2% AEP Peak Depth



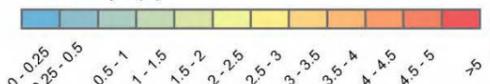
|   |   |          |            |         |         |         |         |         |         |         |         |         |    |  |
|---|---|----------|------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----|--|
|  <p>1:11,000 (at A3)</p> <p>0 100 200 300 400 Metres</p> <p>GDA 1984 MGA Zone 56</p> | <p><b>Legend</b></p> <p><b>Peak Water Depth (m)</b></p> <table border="1"> <tr> <td>0 - 0.25</td> <td>0.25 - 0.5</td> <td>0.5 - 1</td> <td>1 - 1.5</td> <td>1.5 - 2</td> <td>2 - 2.5</td> <td>2.5 - 3</td> <td>3 - 3.5</td> <td>3.5 - 4</td> <td>4 - 4.5</td> <td>4.5 - 5</td> <td>&gt;5</td> </tr> </table> <p> <input type="checkbox"/> Emergency Services<br/> <input type="checkbox"/> Rail<br/> <input type="checkbox"/> Cadastre         </p> | 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 | <p align="center"><b>GLENVALE</b><br/><b>1% AEP Peak Flood Depth</b></p> |
| 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      |         |    |  |

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Figure A-6 1% AEP Peak Depth



|   |   |  |
|---|---|--|
|  <p>1:11,000 (at A3)</p> <p>0 100 200 300 400 Metres</p> <p>GDA 1994 MGA Zone 56</p> | <p><b>Legend</b></p> <p><b>Peak Water Depth (m)</b></p>  <p>0-0.25<br/>0.25-0.5<br/>0.5-1<br/>1-1.5<br/>1.5-2<br/>2-2.5<br/>2.5-3<br/>3-3.5<br/>3.5-4<br/>4-4.5<br/>4.5-5<br/>&gt;5</p> <p>Emergency Services<br/>Rail<br/>Cadastre</p> | <p align="center"><b>GLENVALE</b><br/><b>0.5% AEP Peak Flood Depth</b></p> |
|---|---|--|

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Figure A-7 0.5% AEP Peak Depth

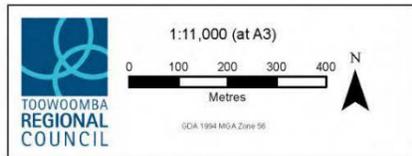


|   |   |        |          |       |       |       |       |       |       |       |       |       |    |  |
|---|---|--------|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----|--|
|  <p>1:11,000 (at A3)</p> <p>0 100 200 300 400 Metres</p> <p>GDA 1994 MGA Zone 56</p> | <p><b>Legend</b></p> <p><b>Peak Water Depth (m)</b></p> <table border="1"> <tr> <td>0-0.25</td> <td>0.25-0.5</td> <td>0.5-1</td> <td>1-1.5</td> <td>1.5-2</td> <td>2-2.5</td> <td>2.5-3</td> <td>3-3.5</td> <td>3.5-4</td> <td>4-4.5</td> <td>4.5-5</td> <td>&gt;5</td> </tr> </table> <p> <input type="checkbox"/> Emergency Services<br/> <input type="checkbox"/> Rail<br/> <input type="checkbox"/> Cadastre         </p> | 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 | <p align="center"><b>GLENVALE</b><br/><b>0.2% AEP Peak Flood Depth</b></p> |
| 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    |       |    |  |

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Figure A-8 0.2% AEP Peak Depth



| Legend |                     |  |                   |  |                    |
|--------|---------------------|--|-------------------|--|--------------------|
|        | 5m Contours (m AHD) |  | Inundation Extent |  | Emergency Services |
|        | Inundation Extent   |  | Rail              |  | Cadastre           |

**GLENVALE**  
**50% AEP Peak Water Surface Level**

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**Figure A-9 50% AEP Water Surface Level**



1:11,000 (at A3)

0 100 200 300 400 Metres

GDA 1984 MGA Zone 56

**Legend**

- 5m Contours (m AHD)
- Inundation Extent
- Emergency Services
- Cadastre
- Rail

**GLENVALE**  
**20% AEP Peak Water Surface Level**

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**Figure A-10 20% AEP Water Surface Level**






 1:11,000 (at A3)  
 0 100 200 300 400  
 Metres  
GDA 1984 MGA Zone 56

**Legend**

|   |  |
|---|--|
|  5m Contours (m AHD) |  Emergency Services |
|  Inundation Extent   |  Rail               |
|  Cadastral           |  |

**GLENVALE**  
**5% AEP Peak Water Surface Level**

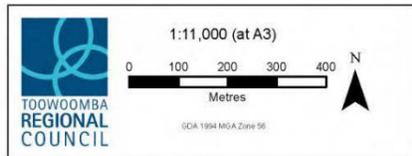
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**Figure A-12 5% AEP Water Surface Level**







| Legend              |                   |
|---------------------|-------------------|
| 5m Contours (m AHD) | Inundation Extent |
| Emergency Services  | Rail              |
| Cadastre            |                   |

**GLENVALE**  
**0.5% AEP Peak Water Surface Level**

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**Figure A-15 0.5% AEP Water Surface Level**



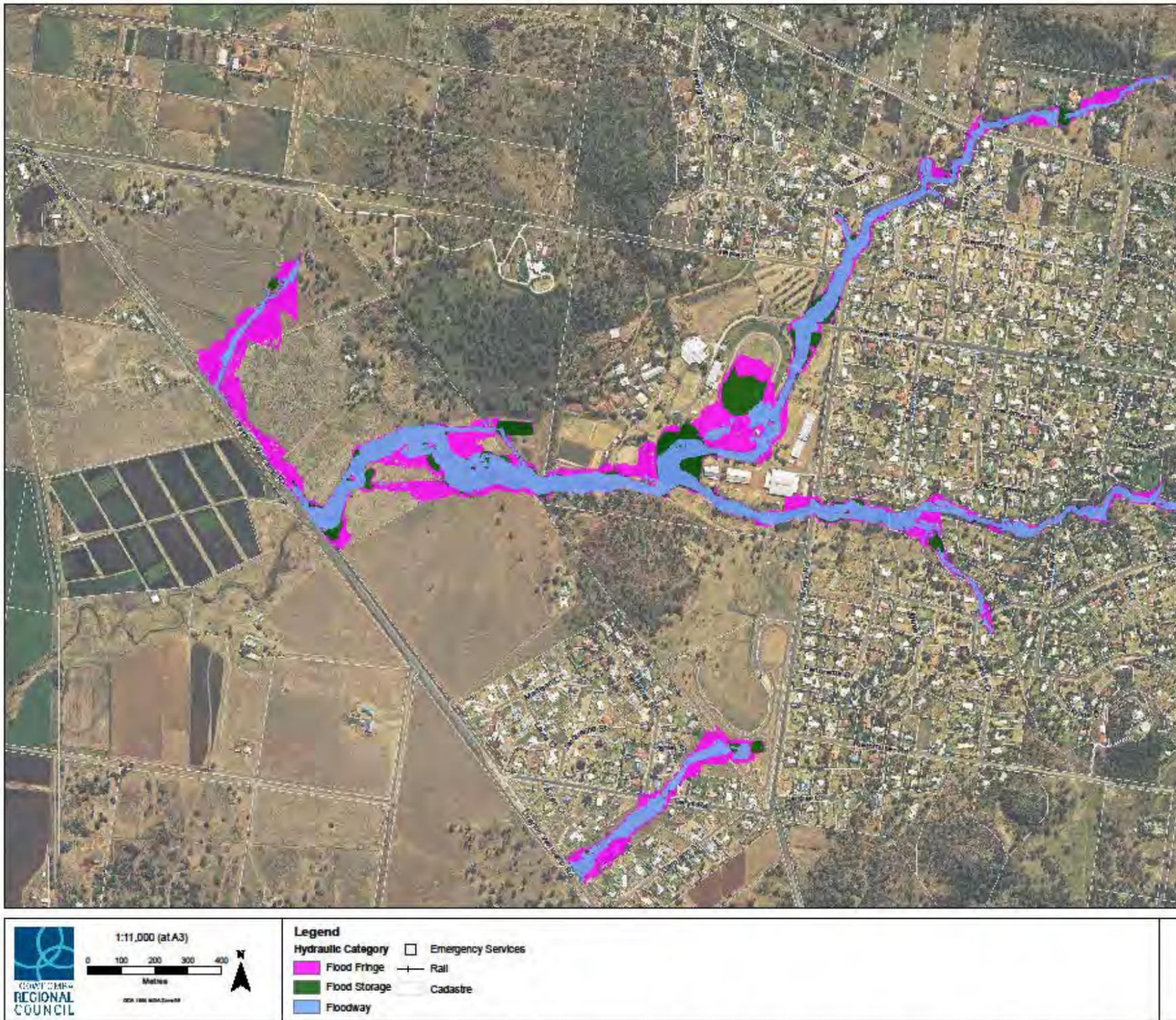
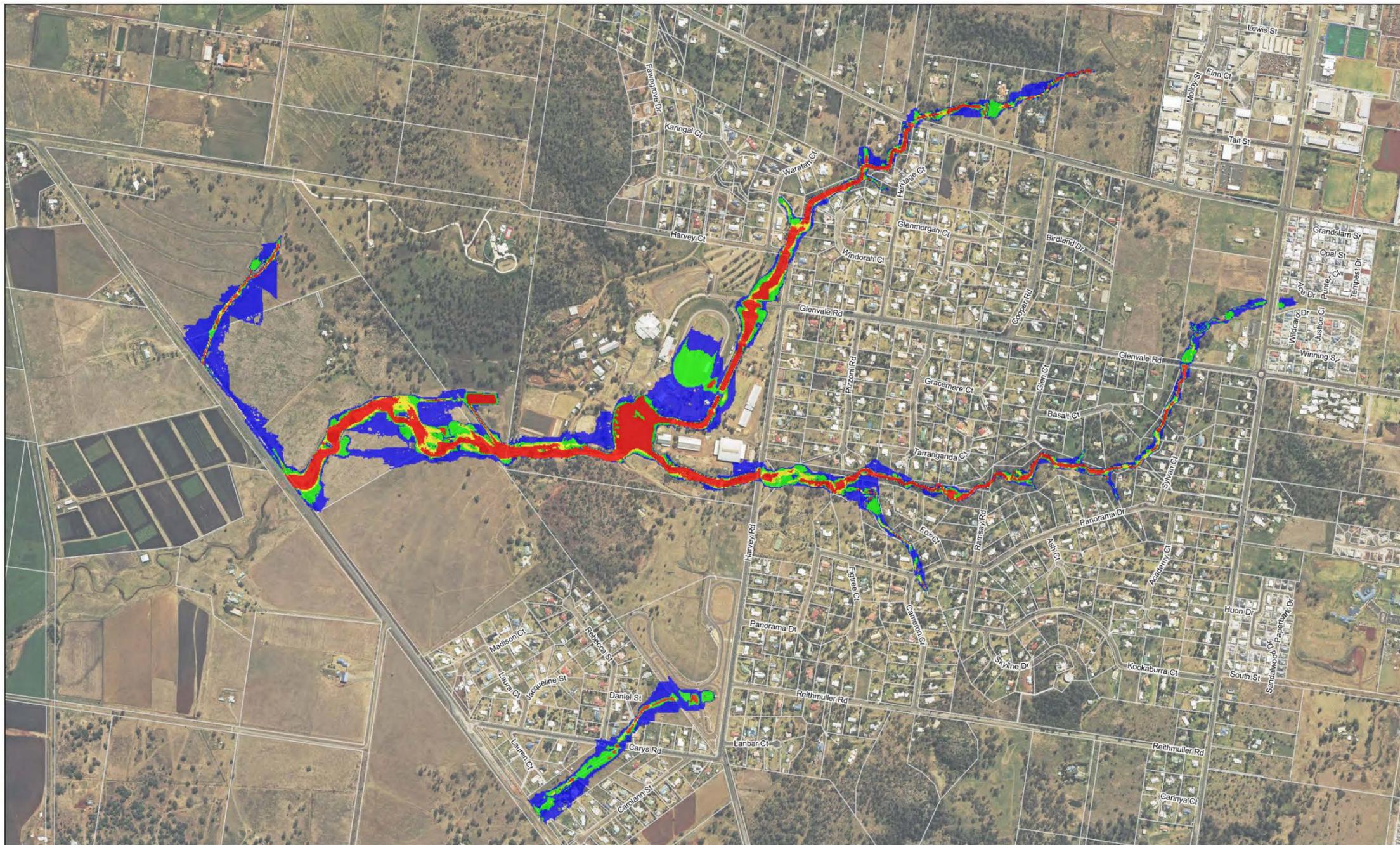


Figure A-17 1% AEP Hydraulic Category



|   |   |   |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|--|--|--|--|--|--|--|--|--|--|--|--|
|  <p>1:11,000 (at A3)</p> <p>0 100 200 300 400 Metres</p> <p>GDA 1984 MGA Zone 56</p>   | <p><b>Legend</b></p> <table border="0"> <tr> <td><span style="color: blue;">■</span> Low</td> <td> Rail</td> <td> Emergency Services</td> </tr> <tr> <td><span style="color: green;">■</span> Significant</td> <td> Cadastre</td> <td></td> </tr> <tr> <td><span style="color: yellow;">■</span> High</td> <td></td> <td></td> </tr> <tr> <td><span style="color: red;">■</span> Extreme</td> <td></td> <td></td> </tr> </table> | <span style="color: blue;">■</span> Low |  Rail |  Emergency Services | <span style="color: green;">■</span> Significant |  Cadastre |  | <span style="color: yellow;">■</span> High |  |  | <span style="color: red;">■</span> Extreme |  |  | <p><b>GLENVALE</b><br/><b>1% AEP Hazard Category</b></p> |
|   |   | <span style="color: blue;">■</span> Low |  Rail |  Emergency Services |  |  |  |  |  |  |  |  |  |  |
| <span style="color: green;">■</span> Significant  |  Cadastre  |   |  |  |  |  |  |  |  |  |  |  |  |  |
| <span style="color: yellow;">■</span> High  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |
| <span style="color: red;">■</span> Extreme  |   |   |  |  |  |  |  |  |  |  |  |  |  |  |
| <p><small>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 disclaims all responsibility and all liability whether in contract, negligence or otherwise for all expenses, losses, damages (including indirect or consequential damages) 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.</small></p> <p><small>Disclaimer: Whilst all due care has been taken in the preparation of the plan and all information (the Plan and all information is referred to as "Plan Information"), the accuracy of the Plan Information cannot be guaranteed. The Plan Information is provided as a guide and should not be relied upon in any way whatsoever. Toowoomba Regional Council takes no responsibility for inaccuracies in the Plan Information and is not liable under any circumstances for any loss or damage whatsoever or howsoever caused arising directly or indirectly in connection with its use. The recipient must verify the Plan Information on site. Please refer any discrepancies to Toowoomba Regional Council - Information, Communications &amp; Technology. No part of the Plan Information should be reproduced without the permission of the Coordinator GIS - ICT Branch, or other delegated representative of Council (131872). U:\Projects\GIS\Projects\TTC Flood Study 2014\TTC_Flood_Study_2014\Glenvale_GLN\Hazard\GLN_Hazard_1%AEPMxd Author: laurek 17/07/2014</small></p> |   |   |  |  |  |  |  |  |  |  |  |  |  |  |

Figure A-18 1% AEP Hazard Category

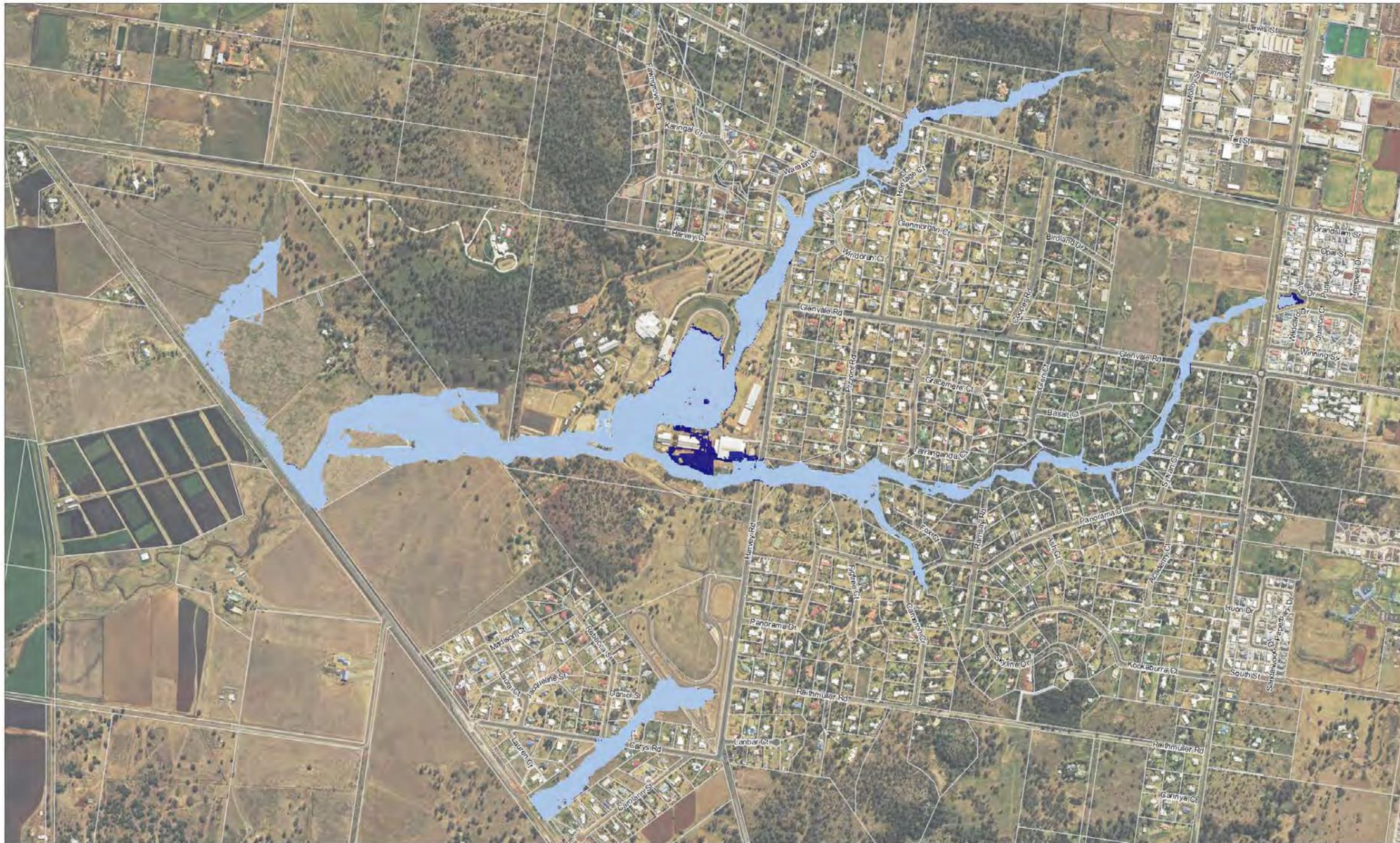


|   |  |   |   |
|---|--|---|---|
|  <p>1:11,000 (at A3)</p> <p>0 100 200 300 400 Metres</p> <p>GDA 1994 MGA Zone 56</p> | <p><b>Legend</b></p>   |   | <p><b>GLENVALE</b><br/><b>1% AEP Sensitivity Analysis</b></p> |
|   | <p><b>Inundation Extent</b></p> <ul style="list-style-type: none"> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #e0f0ff; border: 1px solid black; margin-right: 5px;"></span> 30% Reduction in Flow</li> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #add8e6; border: 1px solid black; margin-right: 5px;"></span> 30% Reduction in Roughness</li> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #d8bfd8; border: 1px solid black; margin-right: 5px;"></span> Baseline</li> </ul> | <ul style="list-style-type: none"> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #ffcc99; border: 1px solid black; margin-right: 5px;"></span> 30% Increase in Roughness</li> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #000080; border: 1px solid black; margin-right: 5px;"></span> 30% Increase in Flow</li> </ul> |   |

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Figure A-19 1% AEP Sensitivity Analysis

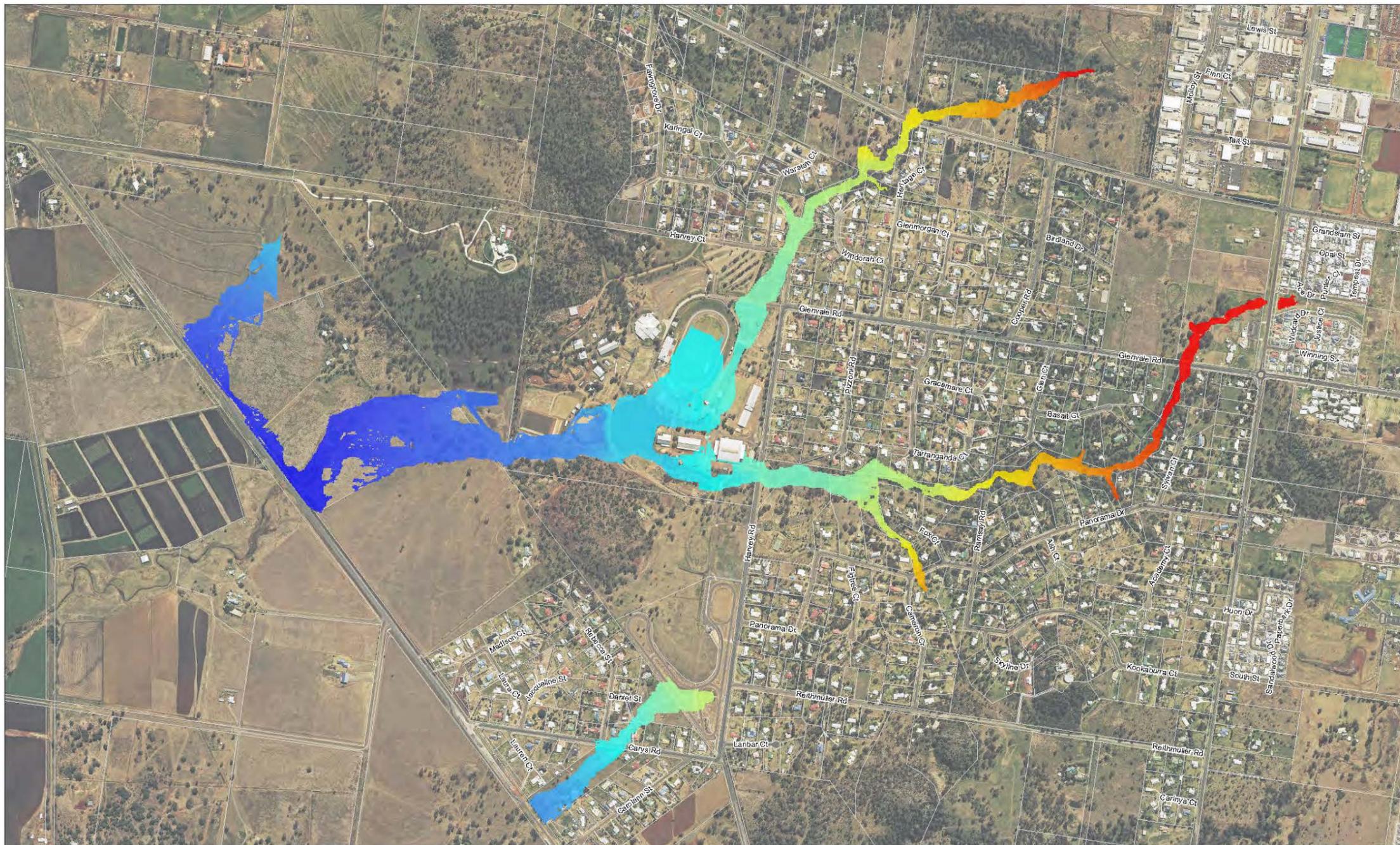


|   |   |  |  |  |  |  |  |   |
|---|---|--|--|--|--|--|--|---|
|  <p>1:11,000 (at A3)</p> <p>0 100 200 300 400 Metres</p> <p>GDA1984 UTM 55</p> | <p><b>Legend</b></p> <table border="0"> <tr> <td> Baseline</td> <td> Emergency Services</td> </tr> <tr> <td> 50% Blockage of Structures</td> <td> Rail</td> </tr> <tr> <td> Cadastre</td> <td></td> </tr> </table> |  Baseline |  Emergency Services |  50% Blockage of Structures |  Rail |  Cadastre |  | <p align="center"><b>GLENVALE<br/>1% AEP Blockage</b></p> |
|  Baseline  |  Emergency Services  |  |  |  |  |  |  |   |
|  50% Blockage of Structures  |  Rail  |  |  |  |  |  |  |   |
|  Cadastre  |   |  |  |  |  |  |  |   |

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 lastmodified:FloodData\TRC\_2014\_Flood\_Studies\GLENVALE\GIS\XDGLN\_Blockage\_1%AEF.mxd Author:Kate Isaac 26/06/2014

**Figure A-20 1% AEP Blockage**

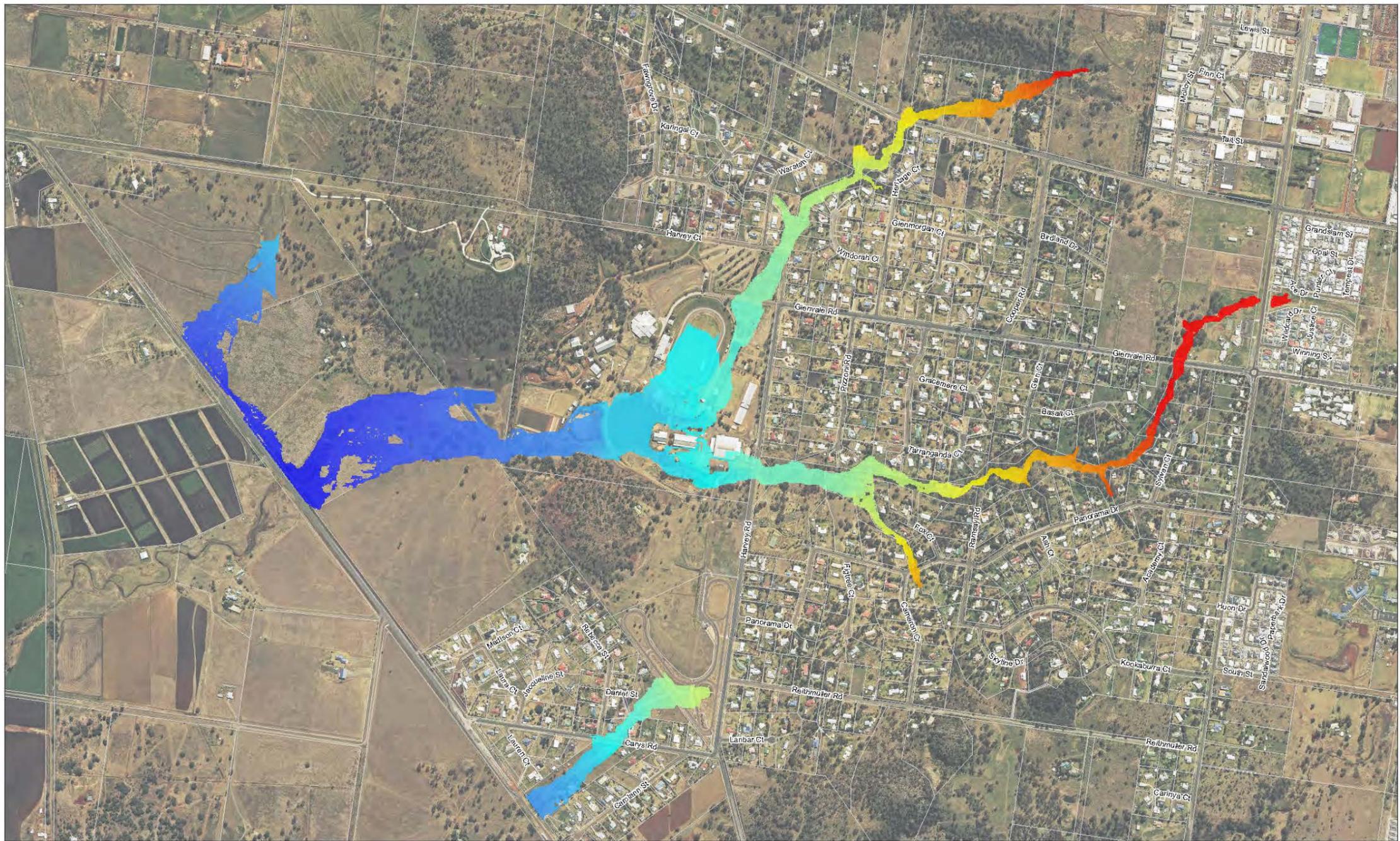


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|---|--|---|
|  <p>1:11,000 (at A3)</p> <p>0 100 200 300 400 Metres</p> <p>GDA 1994 MGA20M 56</p> | <p><b>Legend</b></p> <p>Surface Elevation (m AHD)</p> <p>High : 601.11</p> <p>Low : 496.49</p> <p>Emergency Services</p> <p>Rail</p> <p>Cadastre</p> | <p align="center"><b>GLENVALE</b></p> <p align="center"><b>1% AEP Climate Change Scenario 2050</b></p> <p align="center"><b>Water Surface Elevation</b></p> |
|---|--|---|

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**Figure A-21 1% AEP Climate Change Scenario 2050**

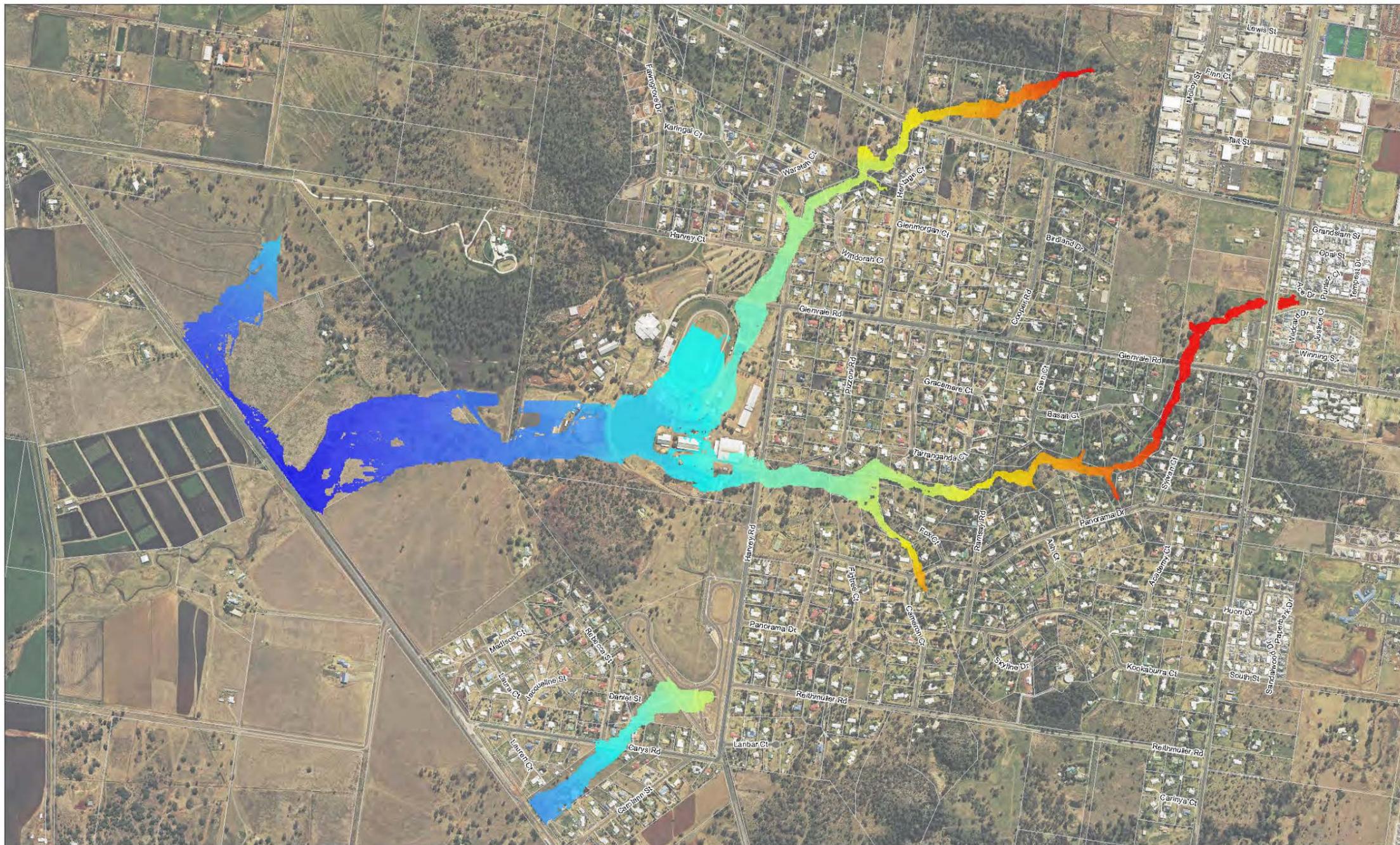


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|---|--|---|
|  <p>1:11,000 (at A3)</p> <p>0 100 200 300 400 Metres</p> <p>GDA 1994 MGA20M 56</p> | <p><b>Legend</b></p> <p>Surface Elevation (m AHD)</p> <p>High : 601.14</p> <p>Low : 496.49</p> <p>Emergency Services</p> <p>Rail</p> <p>Cadastre</p> | <p align="center"><b>GLENVALE</b></p> <p align="center"><b>1% AEP Climate Change Scenario 2070</b></p> <p align="center"><b>Water Surface Elevation</b></p> |
|---|--|---|

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**Figure A-22 1% AEP Climate Change Scenario 2070**



1:11,000 (at A3)

0 100 200 300 400 Metres

GDA 1994 MGA20M 56

**Legend**

Surface Elevation (m AHD)

High : 601.17

Low : 496.49

Emergency Services

Rail

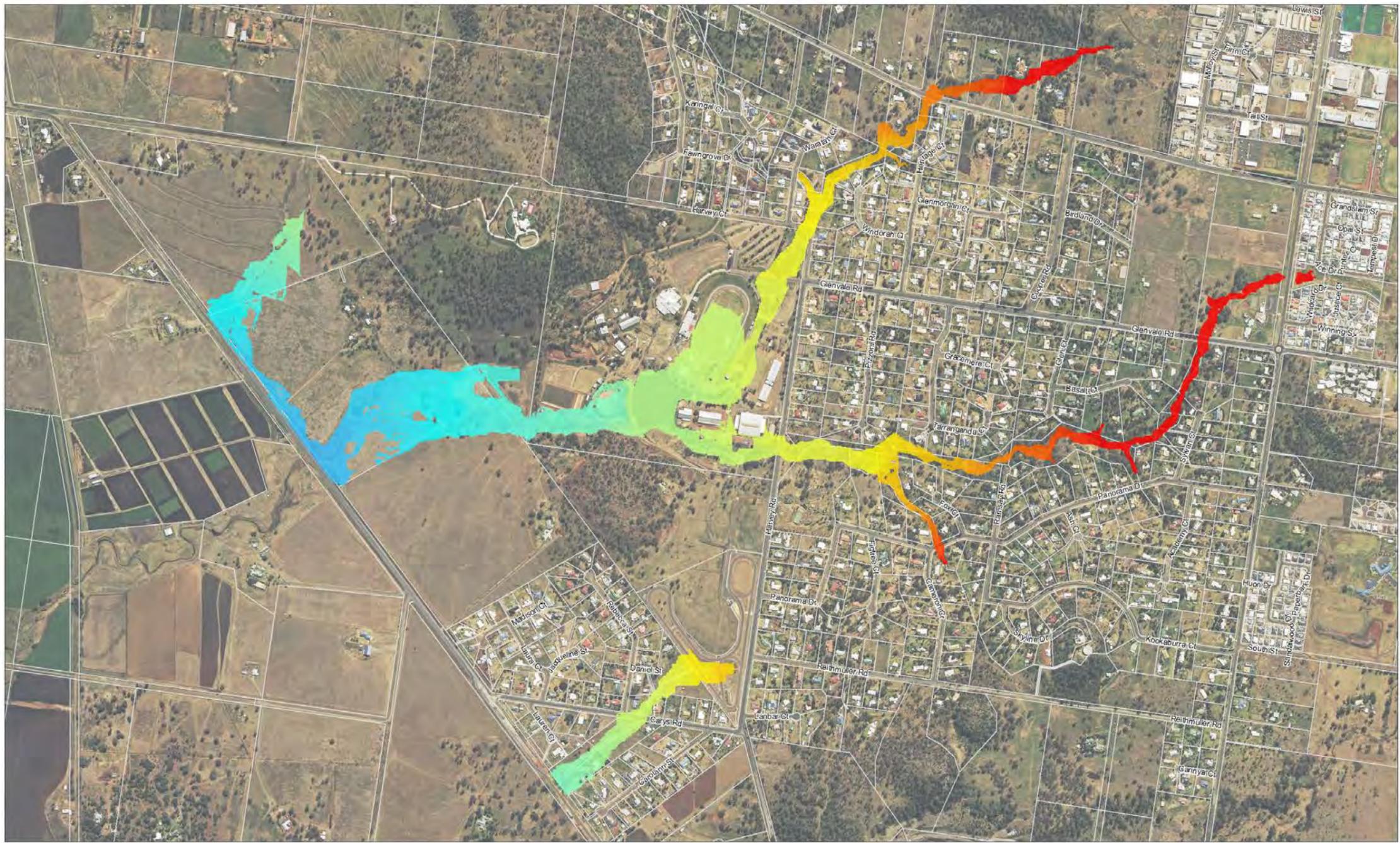
Cadastre

**GLENVALE**  
**1% AEP Climate Change Scenario 2100**  
**Water Surface Elevation**

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Figure A-23 1% AEP Climate Change Scenario 2100



**GLENVALE  
0.5% AEP Climate Change Scenario 2050  
Water Surface Elevation**

1:11,000 (at A3)

0 100 200 300 400 N  
Metres

QDA1984 UGA.2m 55

**Legend**

Surface Elevation (m AHD)

High : 643.314

Low : 510.51

Emergency Services

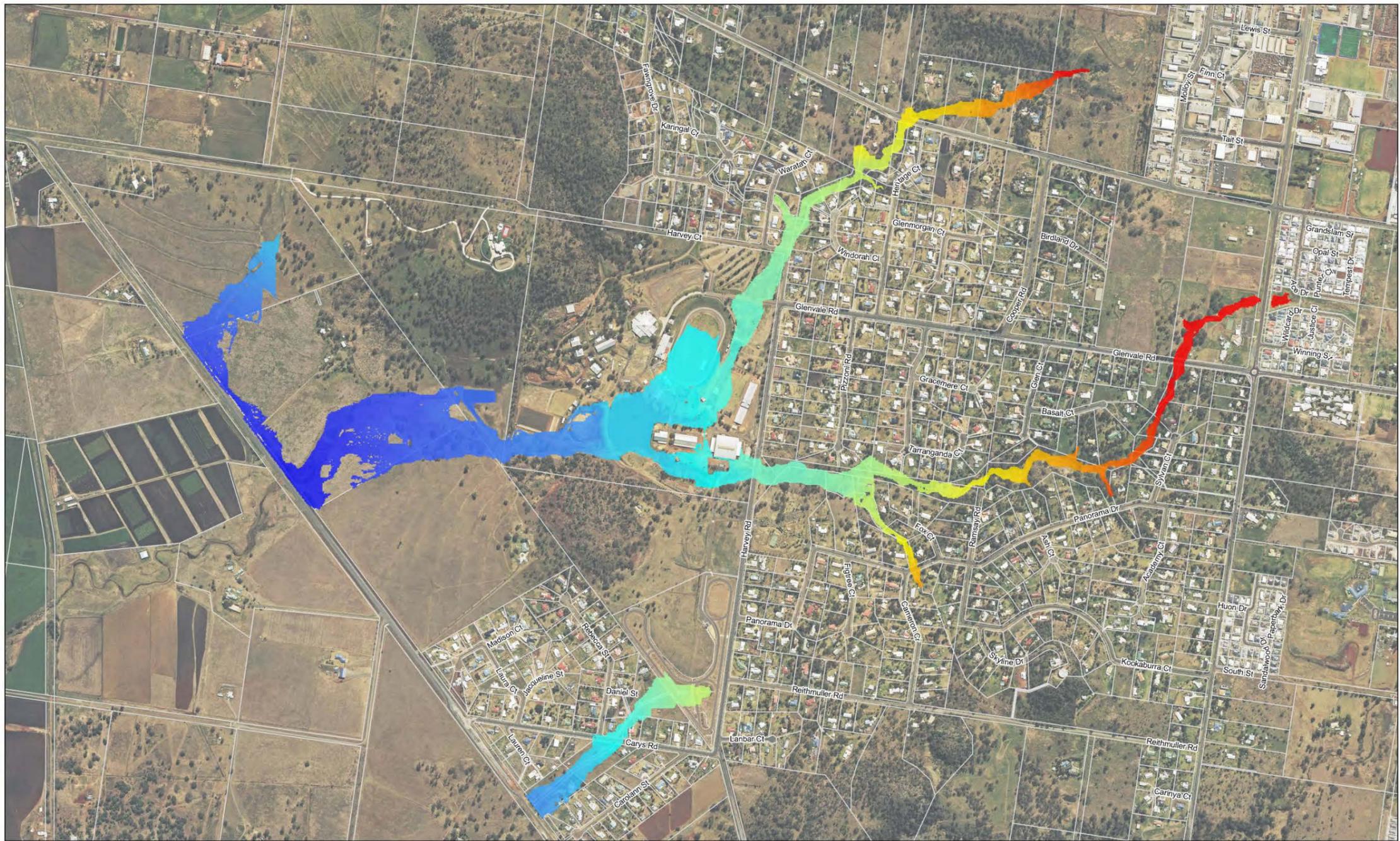
Rail

Cadastre

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lastmodified: FloodData\TRC\_2014\_Flood\_Studies\GLENVALE\GISM\XDGL\ClimateChange\_0.5NAEP\_2050.mxd Author: laureka 26/08/2014

Figure A-24 0.5% AEP Climate Change Scenario 2050



**GLENVALE**  
**0.5% AEP Climate Change Scenario 2070**  
**Water Surface Elevation**

1:11,000 (at A3)

0 100 200 300 400 Metres

GDA 1994 MGA Zone 56

**Legend**

Surface Elevation (m AHD)  
 High : 643.314  
 Low : 510.51

Emergency Services  
 Rail  
 Cadastre

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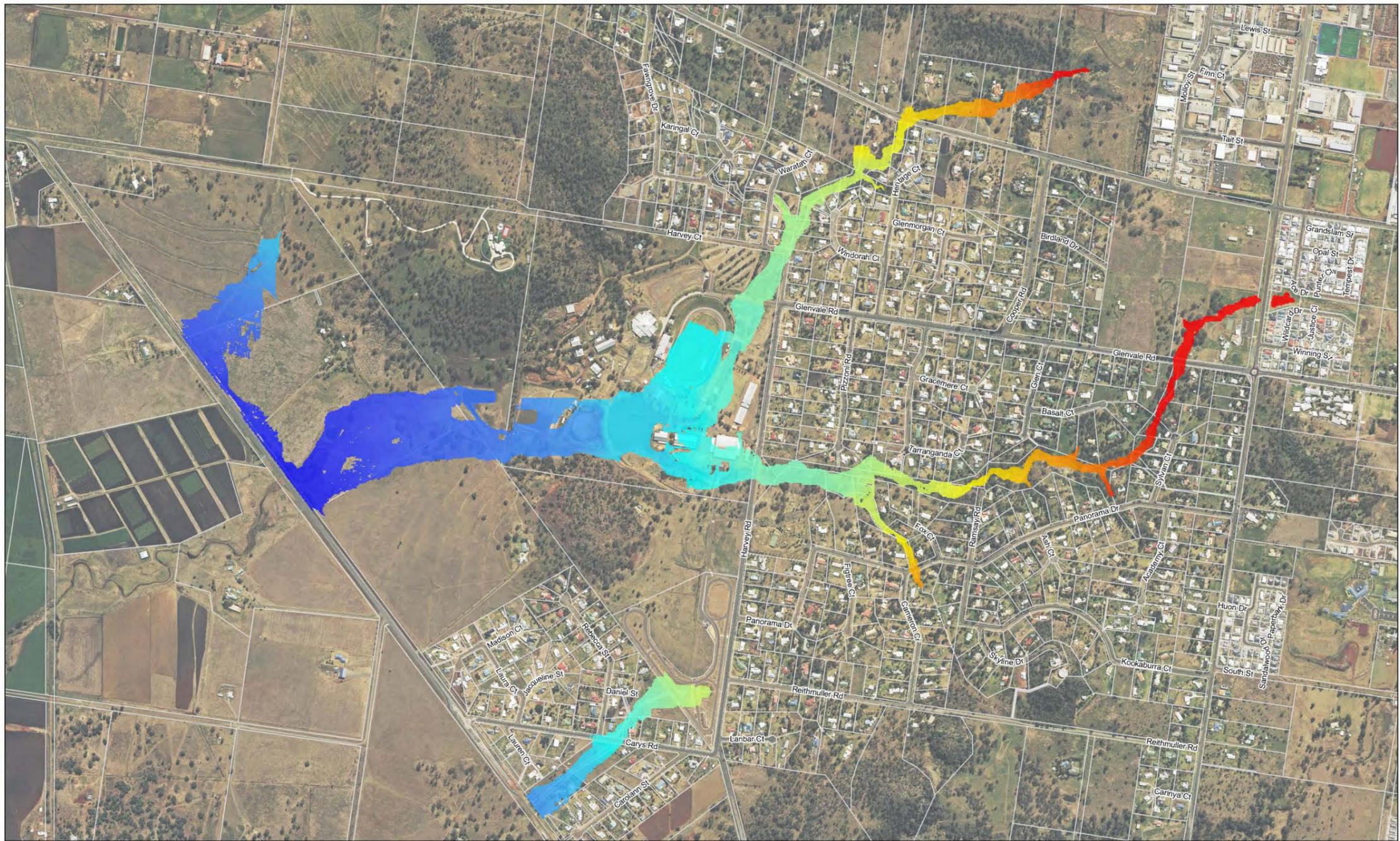
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**Figure A-25 0.5% AEP Climate Change Scenario 2070**









|   |   |  |
|---|---|--|
|  <p>1:11,000 (at A3)</p> <p>0 100 200 300 400 Metres</p> <p>GDA 1994 MGA Zone 56</p> | <p><b>Legend</b></p> <p>Surface Elevation (m AHD)</p> <p>High : 643.314</p> <p>Low : 510.51</p> <p>Emergency Services</p> <p>Rail</p> <p>Cadastre</p> | <p><b>GLENVALE</b></p> <p><b>0.2% AEP Climate Change Scenario 2100</b></p> <p><b>Water Surface Elevation</b></p> |
|---|---|--|

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Figure A-29 0.2% AEP Climate Change Scenario 2100



131 872 | [info@tr.qld.gov.au](mailto:info@tr.qld.gov.au) | [www.tr.qld.gov.au](http://www.tr.qld.gov.au)  
PO Box 3021 Toowoomba QLD 4350 | Toowoomba Regional Council



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

# A safer, stronger, more resilient region

Financially, socially and  
environmentally sustainable



## Glenvale 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.

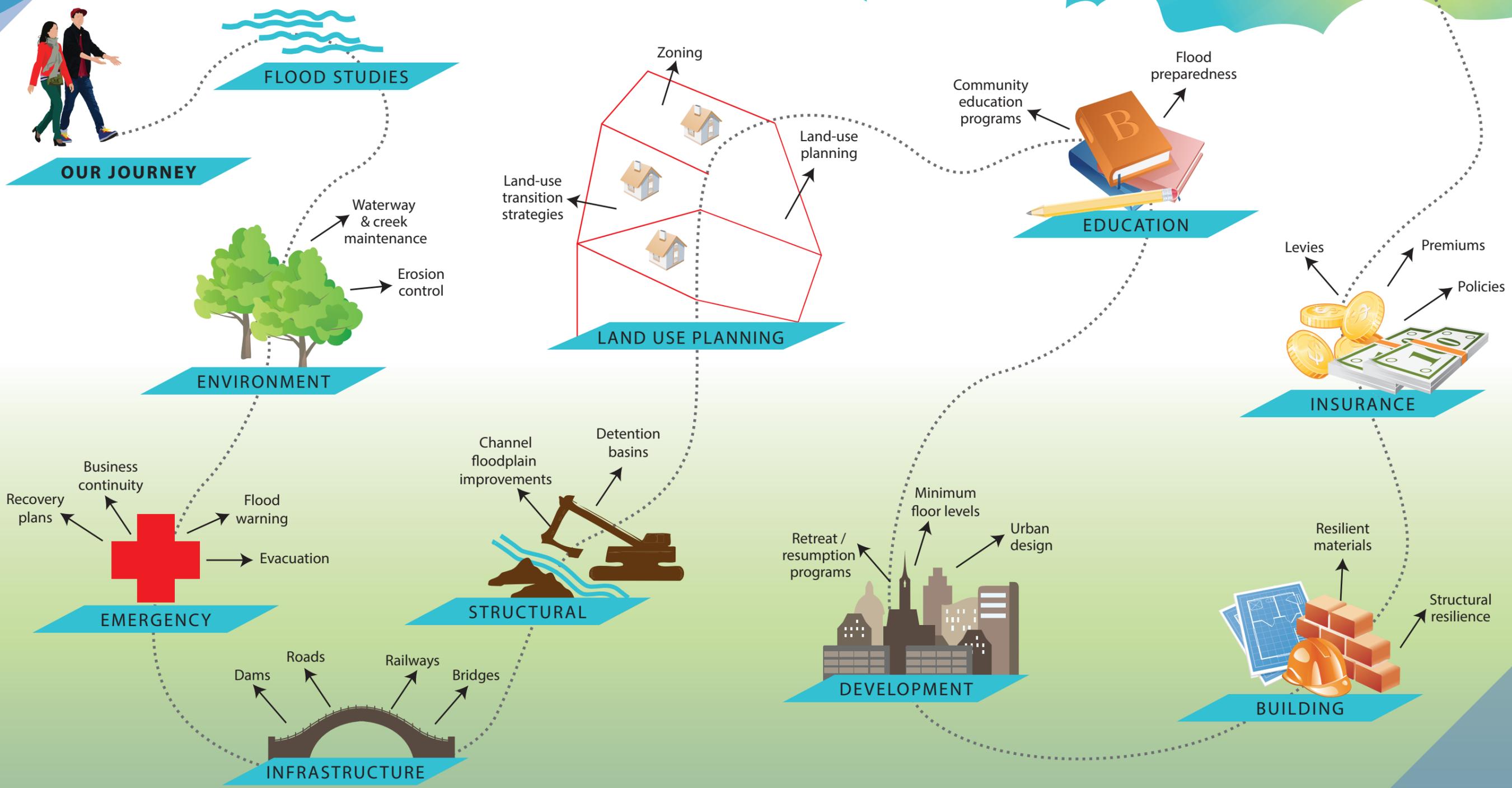
# Flood + us - our journey

Steps on the path to achieving our goal

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

*Financially, socially and environmentally sustainable*

**OUR GOAL**





# Glenvale Flood Studies Information Sheet

## WHAT'S GLENVALE'S FLOOD STORY?

A flood study and flood maps are now available for Glenvale residents. The main source of flooding for the town of Glenvale is from overland flow and creek flooding.

The Glenvale study area has a steeply graded catchment of approximately 9 km<sup>2</sup>, feeding three significant flow paths that each travel in a south-westerly direction and eventually discharging to Spring Creek. The headwaters of the two northern flow paths begin in the industrial estate adjacent to Carrington Road and Boundary Street and both enter the Toowoomba Showgrounds (one from the north and one from the east). From there, both flow paths discharge into the Toowoomba Showgrounds Lake from which the flow continues past Drayton Wellcamp Road and on to Spring Creek. The third southern flow path is considerably shorter and rises at the Criterium Track. This flow path also travels in a south-westerly direction, crossing Carys Road and Drayton-Wellcamp Road before also discharging to Spring Creek.

Glenvale recently experienced flooding in January 2011 and March 2014. Analysis of flood scenarios showed that flooding is mostly confined to channels in the floodplain and while flood levels increase with an intensified storm event, the flood behaviour remains similar – that is, mostly confined to channels. The waterways are generally flowing through large block residential areas and most often are of extreme hazard with some high and significant hazard

areas. The study provides flood maps for a range of flood scenarios for the catchment.

An assessment was made of the size of the March 2014 flood, by comparing modelled levels at a number of locations. At most locations in the catchment, the 2014 event is approximated by a 1% Annual Exceedance Probability event – meaning there is a 1% chance in any year of an event of this size or larger occurring.

**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**