

# **Data Collection, Review and Flood Study for West Coonamble, Gulargambone and Quambone**

COONAMBLE SHIRE COUNCIL

## **West Coonamble Flood Study Report**

FINAL

October 2016



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**West Coonamble Flood Study Report**

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Cover photo: Castlereagh River at Coonamble

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## Foreword

The primary objective of the New South Wales Government's Flood Prone Land Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods, wherever possible. Under the Policy, the management of flood prone land remains the responsibility of local government.

The policy provides for a floodplain management system comprising the following five sequential stages:

- 1. Data Collection**      Involves compilation of existing data and collection of additional data
- 2. Flood Study**      Determines the nature and extent of the flood problem
- 3. Floodplain Risk Management Study**      Evaluates management options in consideration of social, ecological and economic factors relating to flood risk with respect to both existing and future development
- 4. Floodplain Risk Management Plan**      Involves formal adoption by Council of a plan of management for the floodplain
- 5. Implementation of the Plan**      Implementation of flood, response and property modification measures (including mitigation works, planning controls, flood warnings, flood preparedness, environmental rehabilitation, ongoing data collection and monitoring by Council)

Coonamble Shire Council intends to develop a Floodplain Risk Management Plan for West Coonamble to address the existing, future and continuing flood problems, in accordance with the NSW Floodplain Development Manual (2005). This report represents the first and the second stages of the management process and has been prepared for Council by Jacobs (Sinclair Knight Merz merged with Jacobs in December 2013). It documents the nature and flooding extents within the Study Area for West Coonamble and is an essential resource for the subsequent stages of the floodplain management process.



## **Important note about this report**

The sole purpose of this report and the associated services performed by Jacobs is to prepare a flood study report for West Coonamble in accordance with the scope of services set out in the contract between Jacobs and Coonamble Shire Council (hereafter Council). That scope of services, as described in this report, was developed with the Council.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Council and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Council (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

All topographic data used in this study were sourced from a LiDAR survey and a ground survey which were undertaken by third parties. Undertaking independent checks on the accuracy of the topographic data was outside Jacobs' scope of work for this study.

This report has been prepared on behalf of, and for the exclusive use of, Council, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and Council. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.



## 1. Introduction

The town of Coonamble is located at the confluence of the Castlereagh River (catchment area 8,400 km<sup>2</sup> at the confluence) and Warrena Creek (catchment area 1,240 km<sup>2</sup> creek outlet), approximately 165 km north of Dubbo in north-central NSW. Coonamble is one of the major urban centres in the Castlereagh Valley and had a population of 2998 at the 2011 Census. The Central Business District (CBD) of Coonamble lies between the Castlereagh River and Warrena Creek and is protected from flooding by a ring levee approximately 7 km long. The administrative centre of Coonamble Shire is located at Coonamble and the economic activity in the town is mainly concerned with the provision of services to the surrounding rural areas. Agriculture in the rural areas is based on extensive grazing and dry land farming.

The study area for West Coonamble (refer **Figure 1-1**), is located on the western side of the Castlereagh River. The study area is bounded by Old Dubbo Road to the east, Effie Durham Street and Gadsens Street to the south and Conimba Street to the north. Quambone Road forms the south-western boundary of the study area and Coonamble Levee forms the north-eastern boundary of the study area. Developed areas of Coonamble Township which are located on the western floodplain of the Castlereagh River are included within the study area. Rezoned areas 'Meglo' and 'Riverview' are included in the study area. There are approximately 680 dwellings and 1700 population in West Coonamble. West Coonamble has a history of riverine flooding along the west bank of the Castlereagh River and on either side of Eurimie Creek. Eurimie Creek is a breakout of the Castlereagh River located approximately 1km upstream of the confluence of the Castlereagh River and Warrena Creek. Eurimie Creek initially flows west before turning north and eventually rejoins the Castlereagh River approximately 8-10 km downstream.

Sinclair Knight Merz (operating as Jacobs since December 2013) was engaged by Coonamble Shire Council in May 2013 to undertake a flood study for the study area of West Coonamble.

### 1.1 Objectives

Objectives of this study are to:

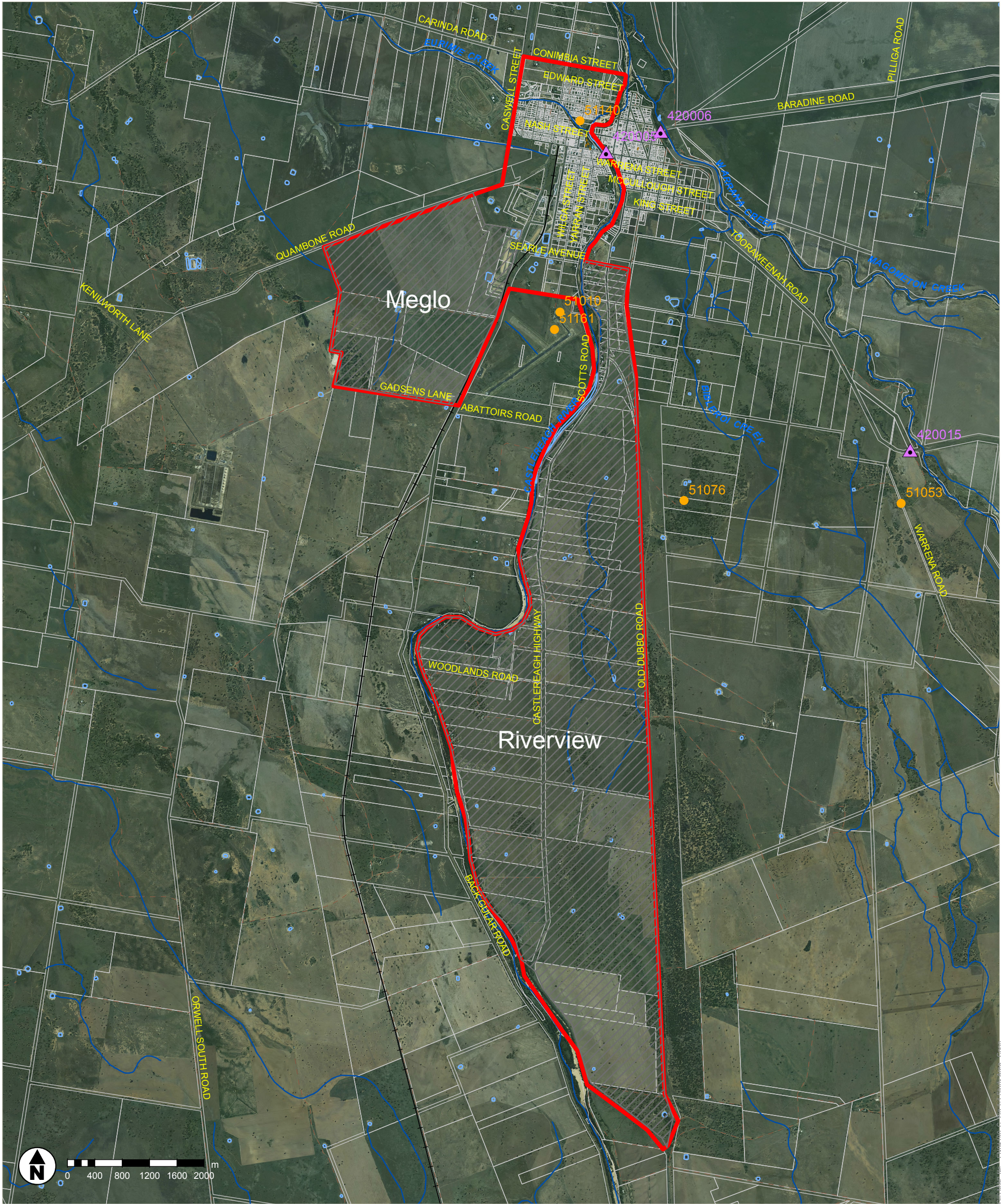
- Define the extent of flooding within West Coonamble and to highlight problem areas for a range of flood events;
- Determine the potential impact of riverine flooding and possibly by the associated overland flooding;
- Identify development controls to minimise any future impact on private and public assets; and
- Prepare a flood planning area map for inclusion into the Coonamble LGA - LEP 2011.

The overall study is being undertaken in two major phases:

#### Stage 1 Initial Investigations

- Undertake a comprehensive site inspection with nominated Council staff, authorised representatives and nominated local residents as arranged by Council.
- Review of all relevant documents, data and available reports.
- Undertake a comprehensive consultation with the local community, Council and relevant agencies.
- Collate and assess all data and information required to satisfy the objectives.
- Identify any gaps in the available data including surveys required to complete the study and update all information as required with the approval of the Council.





Legend

- Study Area
- Cadastre
- Daily Read Rain Gauge
- ▲ Stream Gauge
- Water Course
- Rezoned Area

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Study Area

Flood Study for West Coonamble

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FIGURE 1-1

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Data Sources: LPI, Council.

Data Sources: LPI, Council.

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## Stage 2 Flood Study

- Establish appropriate hydrologic and hydraulic/ hydrodynamic models to include riverine and overland flooding for West Coonamble for use in the estimation of design floods. The events of interest include the 0.5%, 1% and 5% annual exceedance probability (AEP) events, together with the Probable Maximum Flood (PMF) / or relevant extreme flood event.
- Following the above, establish appropriate hydraulic hazard categories including floodways, flood storages, flood fringes, etc. along with the mapping of the Flood Planning Area for residential developments (1% AEP event flood level +0.5 m freeboard – considered to be the flood planning level for residential development) as described in Planning Directions for NSW.
- Propose recommendations for development controls as a management measure in the Floodplain Risk Management process for West Coonamble.

## 1.2 Structure of the Report

This report describes the outcomes from West Coonamble Flood Study. This report has been divided into the following sections:

**Section 1:** introduces the study

**Section 2:** provides details on the initial investigations undertaken for the study including review of the available data and community consultation

**Section 3:** details hydrologic assessment undertaken for this study

**Section 4:** details hydraulic assessment, flood behaviour and flood mapping

**Section 5:** provides conclusions and recommendations on the study

**Section 6:** provides acknowledgements for this study

**Section 7:** provides details on references cited in this report

**Section 8:** provides the glossary of terms

**Appendix A:** contains the Newsletter and Questionnaire sent to residents

**Appendix B:** provides topographic survey details

**Appendix C:** details on hydraulic modelling



## 2. Initial Investigations

### 2.1 Site Inspection

A site inspection was carried out on 4 June 2013 to gain an overall appreciation of the study area, including flood behaviour. Information gained from the site reconnaissance was utilised to define the scope of the topographic survey for this study and to determine modelling parameters such as Manning's roughness coefficients for channels and floodplains located within the study area.

### 2.2 Nature of Flooding

#### 2.2.1 Flood History

The main town of Coonamble has suffered severe inundation on several occasions, notably 1920, 1921, 1950 and 1955. The "flood of record" is generally thought to be the 1950 flood though opinion on this is divided. It is to be noted that the staff gauge (GS 420005) used to observe flood levels in the Castlereagh River at Coonamble is located in the vicinity of Aberford Street Bridge which was a timber bridge up to 1990s. The existing bridge is a concrete bridge. Hence, it is expected that the flood behaviour at the gauge would be different with the old timber bridge and with the existing concrete bridge. In addition, there were some discussions within NSW Office of Environment & Heritage (then Department of Land & Water Conservation) regarding the gauge zero datum of the staff gauge. This appears to be resolved with the accepted gauge zero datum as 175.169 mAHD.

Ranked by stage, the ten largest floods to have occurred in Coonamble, for which reliable records are available, are presented in **Table 2-1** (sourced from SKM 2002 and Lyall & Associates 2013).

■ **Table 2-1 Ten Largest Flood Events Observed in the Castlereagh River @ Coonamble Gauge since 1950**

Rank	Year	Elevation (mAHD)
1	1950	180.82
2	1955	180.76
3	1971	180.70
4	1969	180.65
5	1974	180.61
6	1973	180.48
7	2000	180.47
8	1998	180.46
9	2010	180.39
10	1990	180.27

Major flooding occurred in Warrena Creek in 1974, 2007 and 2009 and Coonamble Levee was about to be overtopped during the flood events of 2007 and 2009. There was minor flooding in the Castlereagh River during the flood events of 2007 and 2009. It is to be noted that the Castlereagh River @ Coonamble gauge (GS 420005) does not represent the magnitude of flooding in Warrena Creek.

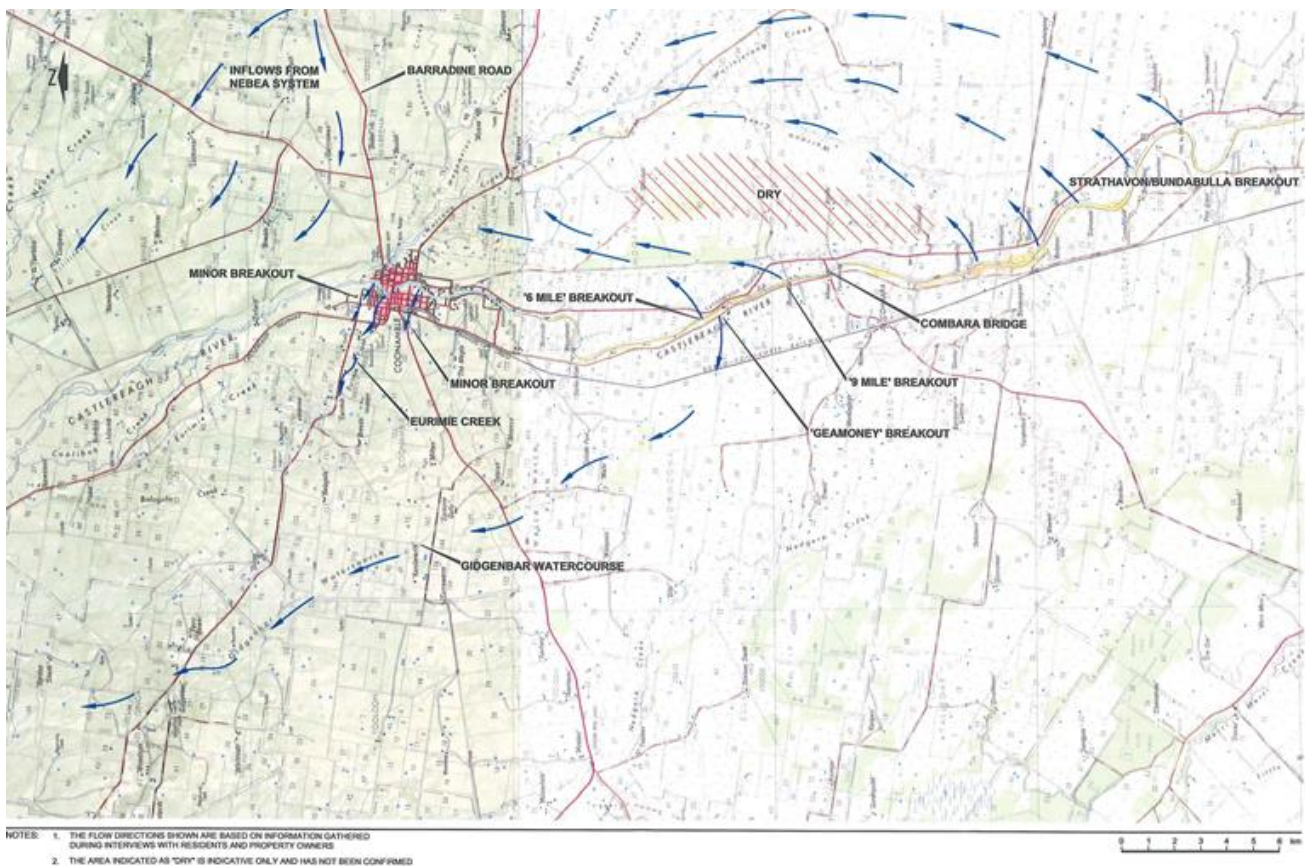


### 2.2.2 Flood Behaviour

The nature of flooding in the vicinity of Coonamble is complex. Both the Castlereagh and Warrena systems have significant catchment areas. The Castlereagh system represents 87% of the catchment at the Castlereagh/Warrena confluence and the Warrena system the remaining 13%.

The flattening of the terrain upstream of Coonamble results in decreased flow velocity and thus a greater flow area is required. This is evidenced through known and identified overbank breakouts from the Castlereagh to both the east and west. The breakouts flood large areas of farmland and often result in the cross connection of water courses. The breakouts to the north generally join the Warrena system and breakouts to the south join the Nedgera system. Both the Warrena and Nedgera systems rejoin the Castlereagh River downstream. The Warrena rejoins at Coonamble and the Nedgera over 10km downstream. The general flood behaviour in the vicinity of Coonamble is shown in **Figure 2-1**.

**Figure 2-1 : General Flood Behaviour in the vicinity of Coonamble**



The most significant breakouts identified in the SKM 2000 and SKM 2009 study reports are listed below:

- Strathavon-Bundabulla Breakout – right bank breakout with flow initially to the northeast then north. Water exits the Castlereagh approximately 22km south of Coonamble and flows Northeast along a 10km front between the Strathavon and Bundabulla properties and joins the Warrena system;
- Nine Mile Breakout – right bank breakout located approximately 15 kilometres south of Coonamble. Flows north generally parallel to the Castlereagh joining with water from the “6 Mile Break” (see below) and then flowing into Warrena Creek;



- Geamoney Breakout – left bank breakout approximately 11km south of Coonamble. Water exits the Castlereagh to the west before flowing north west generally overland and parallel to the Castlereagh before rejoining the Castlereagh River via Eurimie Creek downstream of Coonamble;
- Six Mile Breakout – right bank breakout located approximately 10 km south of Coonamble. Floodwaters flow north east generally to meet waters from the Nine Mile Breakout and flow into the Warrena Creek; and
- Eurimie Creek breakout – left bank breakout where Eurimie Creek flows due west forming an anabranch of the Castlereagh River. Eurimie Creek initially flows west before turning north and eventually rejoins the Castlereagh 8-10km downstream.

Two additional breakouts were also reported in the Lyall 2013 study. One breakout was located approximately 3 km upstream of Combara Bridge on the eastern bank of the Castlereagh River whilst the second breakout was located on the northern bank of Baronne Creek, a tributary of the Castlereagh River. Breakout from Baronne Creek joined flows in the upper reaches of Warrena Creek.

## 2.3 Data Collection and Review

Council and a number of government agencies including NSW Office of Environment and Heritage (OEH), NSW Department of Primary Industries (DPI) Water, State Emergency Services (SES) and the Bureau of Meteorology, were contacted to collect information on flooding, topographic data and flood evacuation etc. In addition to the recent investigations relating to the upgrade of Coonamble Levee and the Flood Intelligence Report (Lyall 2013) there was very limited additional information available from the agencies.

### 2.3.1 Available Reports

- **Coonamble Shire Flood Emergency Sub Plan (2013)** – The plan covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures from flooding within the Coonamble Shire Council area. The plan covers all levels of flooding within the Council area. The plan does not include any flood intelligence. The plan identifies that the following locations may be suitable for use as flood evacuation centres in Coonamble:
  - Coonamble Public School, Bertram Street;
  - St Bernard's School, Tooloon Street;
  - Coonamble High School, Aberford Street;
  - Coonamble RSL Club, Aberford Street;
  - Coonamble Bowling Club, Aberford Street; and
  - Coonamble Golf Club, Caswell Street.
- **Flood Intelligence Report Castlereagh Valley December 2010 Flood, Draft Report, February 2013 (Lyall & Associates)** The draft report documents flood behaviour for the December 2010 flood event in the Castlereagh Valley on the basis of data collected on the impacts of the December 2010 flood in four urban centres which include Mendooran, Gilgandra, Gulargambone and Coonamble. Key findings from the report on Coonamble are provided below:
  - The December 2010 flood reached a peak of 5.22m on the Coonamble Gauge (GS 420005) and remained near this level for 4-5 days.
  - In addition to "Nine Mile", "Six Mile" and "Geamoney" breakouts, two additional breakouts were also expected to be in operation. One breakout was located approximately 3 km upstream of Combara Bridge on the eastern bank of the Castlereagh River whilst the second breakout was located on the northern bank of Baronne Creek, a tributary of the Castlereagh River. Breakout from Barrone Creek joined flows in the upper reaches of Warrena Creek.
  - The newly constructed Combara Bridge was overtopped.



- High flows were experienced in Warrena Creek which resulted in the peak water level being 0.26m to the crest of Coonamble Levee between the Castlereagh Highway and the Coonamble-Tooraweenah Road.
- Two flood gauges operated by SES located on Warrena Creek at Coonamble were washed out.
- One rural property was impacted by flooding due to floodwaters from the Castlereagh River breaking out through Geamoney Breakout as section of the railway embankment failed.
- Several rural properties located both upstream and downstream of Coonamble were isolated for up to 3 weeks requiring resupply operations by SES.

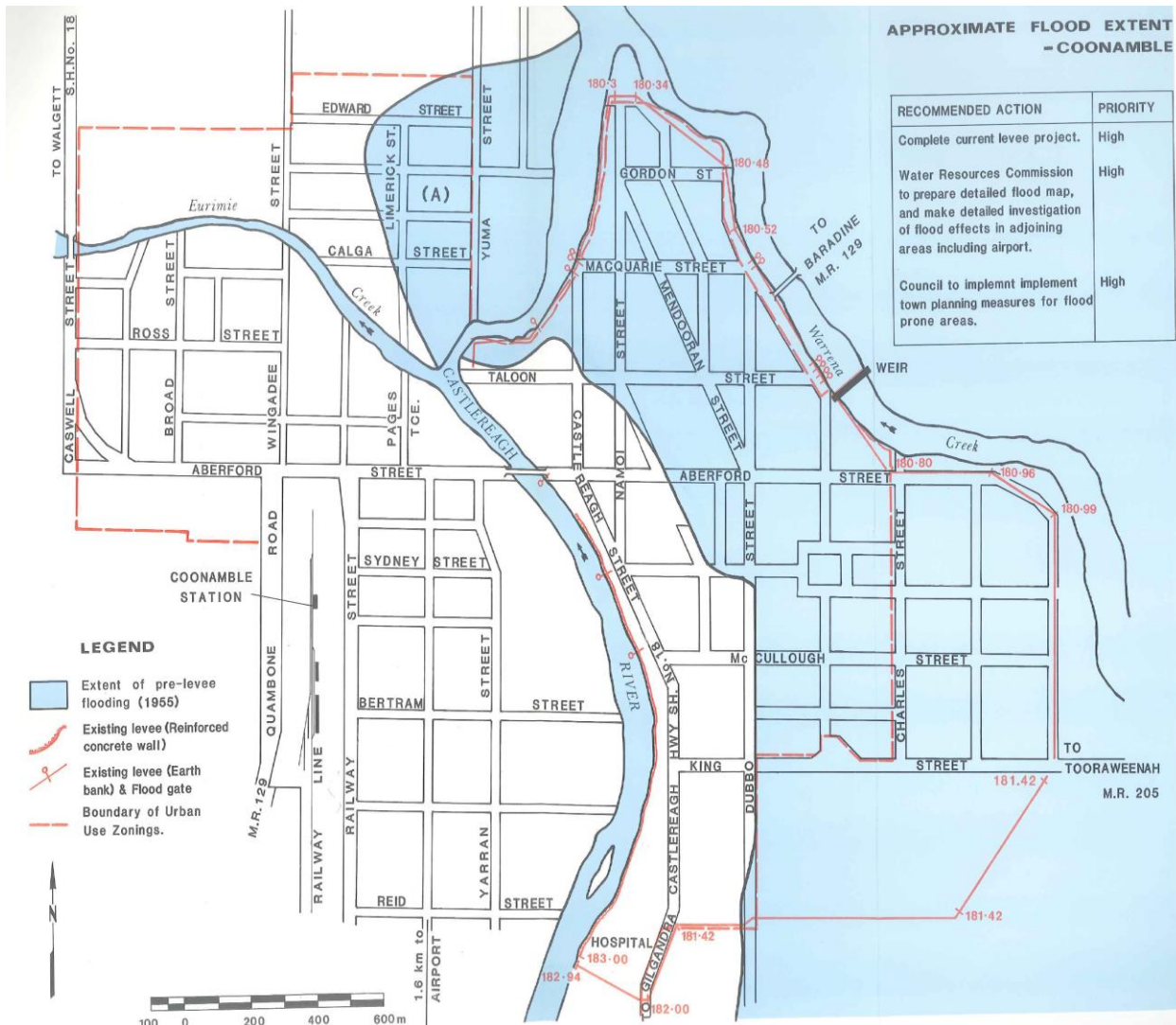
It is to be noted that the flood event of 2000 is not identified by Lyall & Associates as a major event.

- **Review of Environmental Factors, Coonamble Levee Upgrade, November 2012 (Geolyse)** A flood impact assessment for the proposed upgrade of Coonamble Levee was undertaken by SKM using a hydraulic model, which was developed as part of two studies entitled "Coonamble Levee Flood Gradient Sensitivity Modelling Study" (SKM 2009) and "Flood Affection to Properties due to Failure of Coonamble Levee" (SKM 2010). The hydraulic model allowed for overtopping of the existing and the proposed levee due to higher flood levels than crest levels along the levee. Potential impacts due to the proposed levee upgrade on peak water levels, discharges, velocities, duration of flooding and flood affection to properties were assessed for four flood scenarios. A review of modelling results for the existing levee and the proposed levee upgrade indicated up to a maximum 0.11m increment in 100 year ARI flood levels in Warrena Creek on the southern side of the Coonamble - Tooraweenah Road. The increment in flood levels resulted from up to a 19% increase in peak flows in the 100 year ARI event. The increment in peak flows was due to the fact that in the 100 year ARI event, the existing levee was overtopped and the levee with the proposed upgrade was not overtopped. Changes in peak velocities in the 100 year ARI event were less than 0.05m/s.
- **Coonamble Levee Upgrade, Concept Design Report, August 2011 (NSW Public Works)** A concept design for upgrade works of Coonamble Levee (approximately 7 km long) was prepared on the basis of prior investigations which included an audit of the levee undertaken by NSW Public Works, geotechnical investigations undertaken by Douglas Partners and a flood gradient sensitivity study and an internal drainage study undertaken by SKM. The design water level profile along the levee was based on concurrent 100 year ARI flooding in the Castlereagh River and 100 year ARI flooding in Warrena Creek catchment. The design freeboard allowance varied between 0.8m and 1.0m. Other features included in the design were three floodgates for a temporary installation to provide flood protection and a 150m long spillway to cater for possible overtopping.
- **Coonamble Levee Flood Gradient Sensitivity Modelling Study, September 2009 (SKM)** Sensitivity of flood gradients along Coonamble levee for 50 year ARI, 100 year ARI and an extreme flood event were estimated using a hydrologic model (RORB) and a quasi two-dimensional hydraulic computer model (MIKE11). A detailed topographic survey was undertaken as part of the study. The RORB model used to estimate catchment runoff from Warrena Creek catchment. The RORB and MIKE11 models were calibrated/verified against flood events of 1955, 1998, 1999, 2000 and 2007. The modelled flood levels agreed closely with the limited observed flood level data available for Coonamble. The calibrated/verified models were utilised to assess sensitivity of flood gradients along Coonamble Levee for a range of flood scenarios.
- **Coonamble Flood Scoping Study (SKM, 2002):** The study was commissioned by the then Department of Land & Water Conservation (DLWC). The aim of the study was to identify the nature of flooding in and around Coonamble and to advise on and scope issues that need to be addressed in developing a flood model for Coonamble. Investigations involved review of calculation folders available in DECCW, interviews with Statutory Authorities, Emergency Services, Coonamble Shire Council Staff and local residents.
- **New South Wales Inland Rivers Flood Plain Management Studies - Castlereagh Valley (Rankine & Hill 1983) –** The scope of the study included mapping of flood affected land throughout the whole valley; development of floodplain management plan for both urban centres and rural areas; identification of environmental factors and the preparation of a programme of works. The study report provides information



on land use; availability of streamflow records; flood behaviour along the Castlereagh River around urban centres; nature of historic flooding; flood frequency curves; flood hydrographs for major flood events including the flood event of 1955; flood inundation mapping for urban centres including Coonamble shown in Figure 2-2.

■ Figure 2-2 Approximate flood extent and zonings (source: Figure 9.6 Rankin & Hill, 1983)



### 2.3.2 Flood Planning and Development Control Plans

■ **Clause 6.6 of Coonamble Local Environment Plan (LEP, 2011)**

1. The objectives of this clause are as follows:

- to minimise the flood risk to life and property associated with the use of land,
- to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,
- to avoid significant adverse impacts on flood behaviour and the environment.



2. This clause applies to land at or below the flood planning level.
  3. Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:
    - is compatible with the flood hazard of the land, and
    - is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and
    - incorporates appropriate measures to manage risk to life from flood, and
    - is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and
    - is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.
  4. A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0), published in 2005 by the NSW Government, unless it is otherwise defined in this clause.
  5. In this clause, flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.
- **Fencing Policy (1999):** The current fencing policy applies to the study area. The policy does not consider impact of fencing on flood behaviour.
  - **Section 149 Certificate:** Coonamble Shire Council issues Section 149 (2) Planning Certificate and Section 149 (2) & (5) Planning Certificate. Information on flood risk is not included on in these Certificates.

### 2.3.3 Rainfall Data

Rainfall recording stations located within the Castlereagh Valley and its surrounding areas are shown in **Figure 2-3**. The availability of data at these stations is shown in **Table 2-2**. Details on how the available rainfall data were used in the calibration of a hydrology model for Warrena Creek catchment are provided in SKM 2009 report.

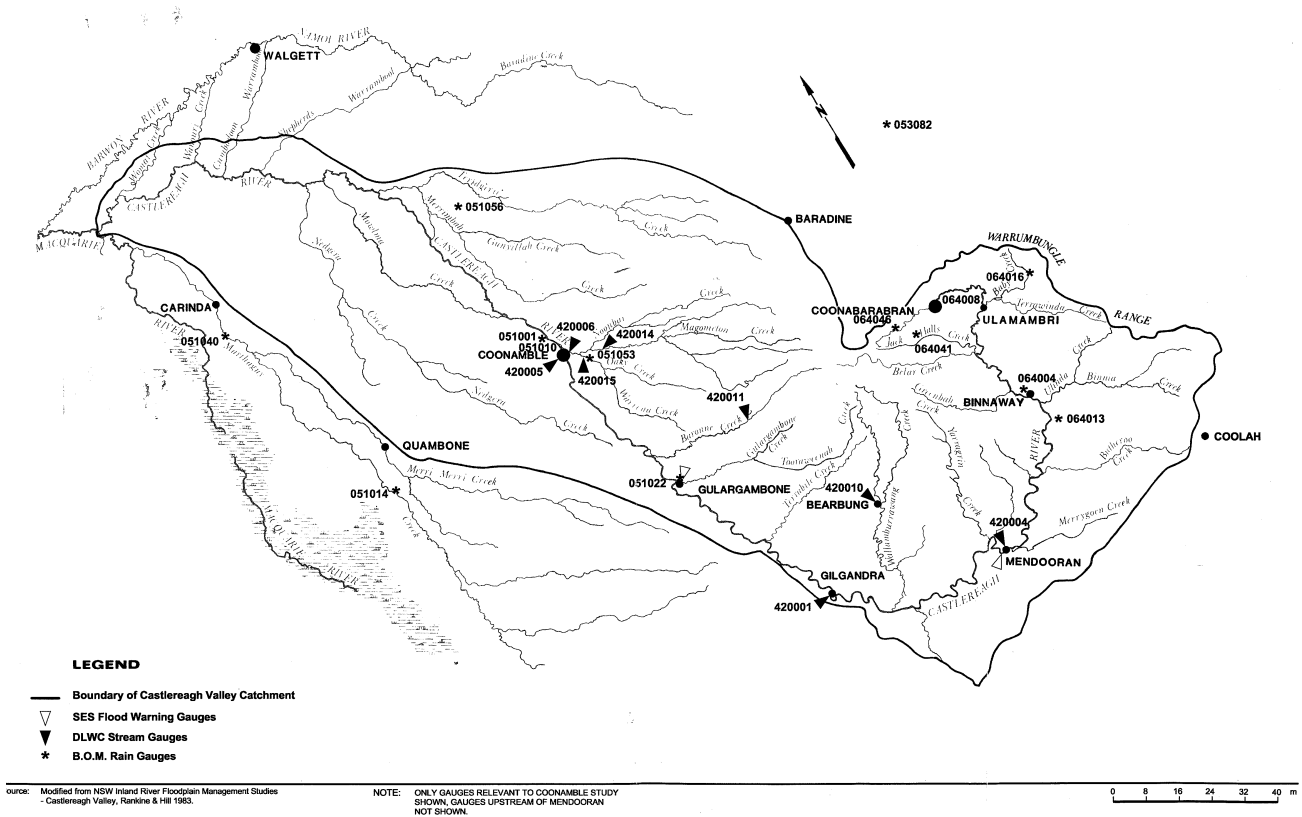
■ **Table 2-2 Rainfall Stations**

Station No.	Description	Period of Record	Comment/Data Type*
051010	Coonamble Comparison	1897 - 2010	WS, continuous record
051001	Coonamble Nardoo	1884 – 2008	Rainfall only, continuous record
051053	Coonamble Warrena	1882 – 1997	Rainfall only, continuous record
051040	Coonamble Pier	1883 – 1966	Rainfall only, continuous record
051056	Coonamble Wingadee	1879 – 1977	Rainfall only, continuous record
064041	Coonabarrabran Barina	1969 - present	Rainfall only, continuous record
064046	Coonabarrabran Echo	1965 – present	Pluviograph, continuous record
064016	Coonabarrabran Mia Mia	1919 – 1977	Rainfall only, continuous record
064008	Coonabarrabran Namoi Street	1897 - present	WS, continuous record
053082	Coonabarrabran Yamborah	1996 – 2005	Rainfall only, continuous record
064013	Binnaway Hawthorne	1886 - present	Rainfall only, continuous record
064004	Binnaway Wattle St.	1901 - present	Rainfall only, continuous record
051014	Gulargambone Emby	1908 - 2008	Rainfall only – ceases in 1993
051022	Gulargambone Yalcogrin St	1886 - 2014	Rainfall only, continuous record

\*WS-Weather Station, Continuous Record – meaning that there is a continuous record of unbroken data entries for the period of record



Figure 2-3 Castlereagh River Catchment Area and Gauge Locations (source: SKM, 2009)



### 2.3.4 Streamflow Data

Streamflow gauging stations of relevance to this study are shown in Figure 2-3 and details on the stations are given in Table 2-3. Details on the station were sourced from PINNEENA version 9.3 (a surface water database released by NSW DPI Water).

Table 2-3 Streamflow Gauging Stations

Gauge No.	Description	Catchment Area (km <sup>2</sup> )	Date Commenced and Ceased	Comment
420005	Castlereagh River @ Coonamble	8400	24/10/1958- 30/4/2002	Discontinued. Manually read during flood events.
420001	Castlereagh River @ Gilgandra	6350	01/09/1909-11/04/2000	Discontinued
420901	Castlereagh River @ Lucas Bridge U/S of Gilgandra	NA	01/08/1999 -current	
420004	Castlereagh River @ Mendooran	3600	18/11/1952-current	
420006	Warrena Creek @ Coonamble	1240	21/09/1960-11/12/1980	Discontinued No data available in PINNEENA
420015	Warrena Creek @ Warrana	583	06/12/1969-30/04/2002	Discontinued. Manually read during flood events.
420014	Magometon Creek (Site 3) @ Near Coonamble	540	06/12/1969-30/04/2002	Discontinued
420011	Baronne Creek @ Near Gulargambone	398	07/05/1965-01/06/1973	Discontinued. Manually read during flood events.
420010	Wallumburrawang Creek @ Bearbung	452	08/05/1965-03/05/2002	Discontinued



## 2.4 Satellite Imagery and Aerial Photographs

Details on the availability of satellite imagery and aerial photographs for flood events of 1999, 1998, 2000 and 2007 flood events are provided in SKM 2009. Landsat satellite imagery for Coonamble was captured on 13 and 14 December 2010 (Lyll & Associates 2013).

## 2.5 Flood Levels

Apart from the December 2010 flood event, details on the available observed flood levels for all significant flood events in Coonamble up to and including the 2007 flood event are provided in SKM 2009 report. Observed flood levels for the December 2010 flood event are provided in Lyall & Associates 2013 report.

## 2.6 Community Consultation

### 2.6.1 Flood Questionnaire

A community consultation process was initiated to obtain flood information for past events. This involved sending a newsletter and a questionnaire (refer to **Appendix A**) to residents and landowners within the study area. The newsletter introduced the floodplain management process to the residents of the village, described the purpose of the questionnaire and provided the residents with contacts for their responses. The questionnaire was prepared in consultation with Council to help identify flooding issues for the study area and to provide reliable flood information to assist in the validation of the hydrologic and hydraulic computer models.

The flood information that was requested included:

- General information, such as:
  - Residents from the Study Area
  - Ownership of the residence
  - How long residents lived at the property
- Specific flood information, such as:
  - Experience on flooding in residence and/or at work
  - Location and depth of flood water in the worst flood experienced
  - Duration of flooding
  - Flood damages to residence and business
  - Disruption to vehicular access to residence during flooding
  - Assistance required by residents from SES
  - Flooding to residence made worse by works on other properties or by construction of roads or other structures
  - Identify information (eg. flood photographs, newspaper clippings, flood marks etc) that can be provided to Consultant
  - Residents intention for further development on their land
  - Ranking of development types for protection against flooding
  - Ranking of potential flood mitigation measures
  - Any comments on any other issues associated with this study.



### 2.6.2 Summary of Responses to Flood Questionnaire

In total, thirty five (35) responses were received from the community to the questionnaire. A summary of responses is provided in the following paragraphs.

#### ***Residency status (Question 1)***

Thirty (30) respondents were residents of the study area.

#### ***Length of Residency in West Coonamble and Business Activity (Questions 2-4)***

Respondents lived in the Study Area between 2 to 64 years with an average residency of 27 years. Five (5) respondents managed business located within the study area.

#### ***Experiences of Flooding (Questions 5-12)***

Two properties on Railway Street experienced flooding possibly due to local drainage issues between 1995 and 2005. One property on Pages Terrace experienced yard flooding and one property on Neba Street experienced 1m depth of flooding. One rural property experienced yard flooding several times over the last 20 years.

One respondent identified the duration of flooding being less than 6 hours and six (6) respondents identified the duration of flooding were longer than 3 days.

Access to one property was cut-off by floods and five properties experienced minor disruption in vehicular access to properties.

#### ***Flood Affects to properties due to works (Questions 13 - 14)***

One respondent identified that wild growth of bamboo in the Castlereagh River in the vicinity of the property is likely to impact on the property if no measures are taken by Council to clear bamboos.

#### ***Intention of Respondents for further development (Question 15)***

Four respondents were expecting to undertake minor extensions to the property and seven respondents were unsure about further development.

#### ***Priority for protecting different types of developments from flooding (Question 16)***

Respondents were asked to rank different types of development for protection against flooding. Eleven (11) respondents gave the highest priority for protection of emergency facilities against flooding and nine (9) respondents gave the highest priority for protection of residences against flooding. Three (3) respondents gave the highest priority to critical utilities (eg. power substations, telephone exchanges etc) for protection against flooding.

#### ***Priority for flood mitigation measures (Question 17)***

Sixteen (16) respondents identified that highest priority be given to protecting residents/ business from flooding. Maintaining an emergency flood free access was given the highest priority by four (4) respondents and four (4) respondents gave the highest priority to providing flood warning.

#### ***Willingness to provide additional information (Question 18)***

Four respondents were concerned about increased insurance premiums and three (3) respondents identified upgrading of the Town Levee being critical. Two respondents identified the need for management of vegetation in the Castlereagh River to manage risk of flooding and one respondent identified sand mining as a flood mitigation measure. One respondent expressed their frustration with inaccurate flood warning.

#### ***Contact details for respondents (Question 19)***

Thirty (30) respondents provided their contact details.



## 2.7 Topographic Survey

### 2.7.1 LiDAR Survey

Detailed topographic surveys were undertaken as part of the SKM 2009 study and a LiDAR (Light Detection And Ranging) survey was available for the township of Coonamble. The LiDAR data for the township was captured by LPI on 6 July 2012.

Fugro Spatial Solutions Pty Ltd was engaged by Council to provide topographic survey data based on a LiDAR survey of the study area for West Coonamble and accordingly, the LiDAR survey was undertaken on 21 March 2014. Fugro provided 1m square, 2m square and 10m square grid data and 0.5m contour data for the ground surface. The full LiDAR point cloud was classified to Level 3 according to NSW Land and Property Information (LPI) requirements. The spatial horizontal accuracy of the LiDAR data was 0.19m @ 67% CI and the vertical accuracy of the LiDAR data was 0.09m @ 67% CI.

A Digital Elevation Model (DEM) was created using the 1m square grid data provided by LPI and Fugro and is shown in **Figure 2-4**. LiDAR data from the two sources were utilised to check consistency in DEM along the common boundary. Several short cross sections (typically 5m to 10m long) were cut from the combined DEM to check changes in ground levels at the boundary of the two DEMs. Changes in ground levels were generally within 0.15m which is considered well within the accuracy of the LiDAR survey.

A comparison between surveyed cross sections of the main channel of the Castlereagh River and the corresponding cross sections extracted from the combined DEM showed a reasonable agreement between the two sources of topographic data. The comparison also confirmed that both LiDAR survey were undertaken during dry periods when the main channel was generally dry.

### 2.7.2 Ground Survey

The scope of the ground survey was identified by Jacobs, with Council engaging Geolyse Pty Ltd to undertake the ground survey. Geolyse provided the following results from the ground survey to Jacobs:

- Details (eg. size, shape, invert level, top of road level etc) for 38 culverts;
- Details for one bridge; and
- Four (4) items identified in **Table 2-4** which included floor levels of two buildings within the study area.

Location of surveyed culverts and bridges is shown in **Figure 2-4** and details on the other surveyed features are provided in **Appendix B**. It is to be noted that eight (8) flood marks were identified by residents during the community consultation process. However, during the ground survey residents were unavailable or unable to locate six (6) flood marks and subsequently floor levels of two buildings were surveyed.

■ **Table 2-4 Other features surveyed**

Item No.	Item	Location	RL (m AHD)	Description
1	Floor Level	21 Pages Tce	181.13	Flood mark corresponding to Castlereagh River @ Coonamble Gauge height of 5.2m
2	Floor Level	85-92 Railway St	180.29	
3	Flood Mark	"Riverside Cottage"	186.74	
4	Flood Mark/ground level	"Hamilton"	183.39	
				Ground frequently flooded





Legend

	Study Area	<b>LiDAR Data</b>		180.4 - 182.3	
	Cadastre	<b>Elevation mAHD</b>		182.4 - 184.6	
	Surveyed Culvert		168.9 - 174.3		184.7 - 186.9
	Surveyed Bridge		174.4 - 176.3		187 - 189.2
	LiDAR (LPI)		176.4 - 178.2		189.3 - 191.6
	LiDAR (Fugro)		178.3 - 180.3		191.7 - 196.5

Data Sources: LPI, Council.

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SCALE	A3				
SHEET	1 of 1		GDA 1994 MGA Zone 55		
TITLE	LiDAR Data and Topographic Survey				
PROJECT	Flood Study for Coonamble				
CLIENT	Coonamble Shire Council				
DRAWN	PROJECT #		MAP #	REV	VER
AH	IA013100		FIGURE 2-4	1	1
CHECK	DATE				
AH	15/05/2015				



### 3. Catchment Hydrology

#### 3.1 Sources of Flooding

The study area is located upstream of the confluence of the Castlereagh River (catchment area 8,400 km<sup>2</sup> at the confluence) and Warrena Creek (catchment area 1,260 km<sup>2</sup> at the creek outlet). Hence flooding behaviour within the study area is dominated by flooding in the Castlereagh River and flood flows which escape the river major breakouts including Strathavon-Bundabulla Breakout, Nine Mile Breakout, Geamoney Breakout and Eurimie Creek Breakout. Flooding in the catchment area of Warrena Creek in combination with flooding in the Castlereagh River has the potential to exacerbate flooding in the northern parts of the study area. Hence the Castlereagh River and Warrena Creek are major sources of flooding for the study area.

#### 3.2 Estimation of Design Discharges for the Castlereagh River

Due to a number of breakouts in the Castlereagh River between Gulargambone (catchment area 7,000 km<sup>2</sup>) and Coonamble (catchment area 8,400 km<sup>2</sup>), the flood frequency results for the Castlereagh River @ Gilgandra gauge (catchment area 6,350 km<sup>2</sup>) adopted in the Gilgandra Floodplain Management Study (Lyll & Macoun 1996) were scaled up to estimate design discharges in the Castlereagh River @ Coonamble gauge using the following equation:

$$Q_{\text{Coonamble}} = Q_{\text{Gilgandra}} \times (A_{\text{Coonamble}} / A_{\text{Gilgandra}})^{0.7}$$

where, Q is discharge (m<sup>3</sup>/s) and A is catchment area (km<sup>2</sup>).

In order to estimate design flows for the full range of flood events in a consistent manner, it was considered appropriate to use the above equation. The adopted design discharges in the Castlereagh River at Gilgandra gauge and Coonamble gauge are shown in **Table 3-1**.

**Table 3-1 Adopted design discharges for the Castlereagh River upstream of Coonamble**

AEP	Castlereagh River at Gilgandra gauge (6,350 km <sup>2</sup> )	Castlereagh River at Coonamble (8,400 km <sup>2</sup> )
10%	1,120	1,360
5%	1,870	2,280
2%	3,000	3,650 <b>(3,450)</b>
1%	4,050	4,930 <b>(4,660)</b>
0.5%	5,265	6,400

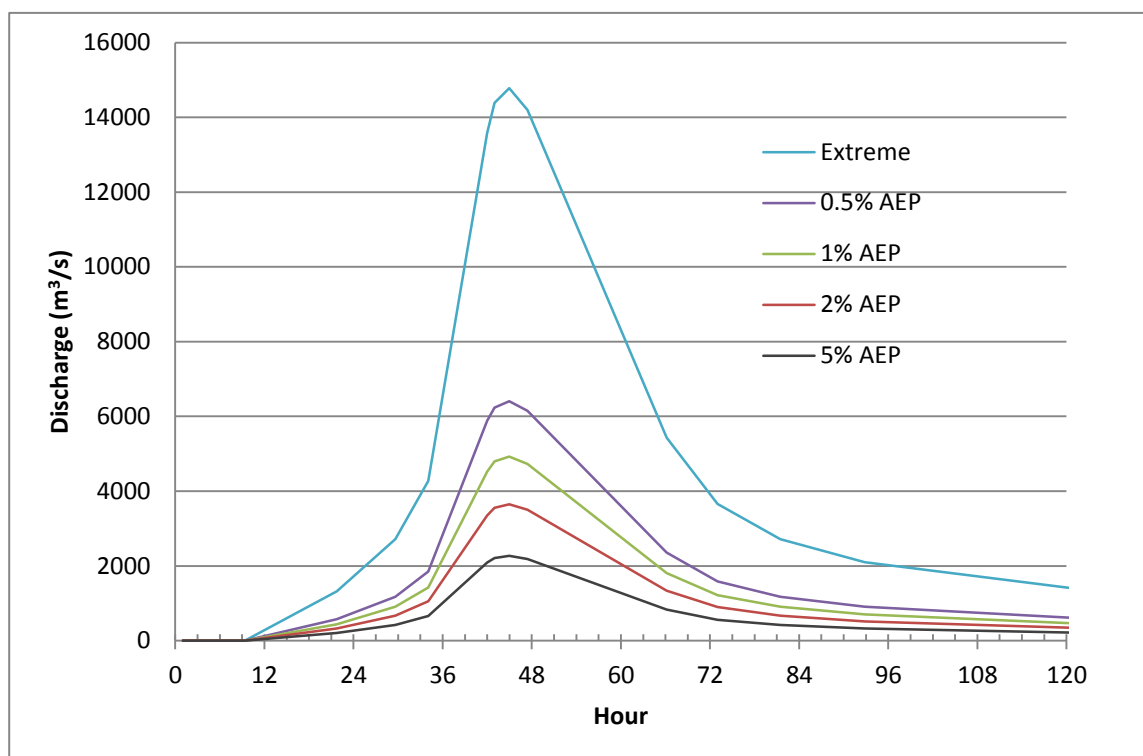
**(3,450)** adopted in SKM 2009 study

It is to be noted that the estimated discharges for the Castlereagh River at Coonamble presented in **Table 3-1** for the 1% and 2% AEP events are similar to those adopted in the SKM 2009 study and the SKM 2009 study focussed on the 2% AEP, 1% AEP and extreme flood events only.

The 1955 inflow hydrograph presented in Rankine & Hill (1993) report for the Castlereagh River @ Gilgandra Gauge was scaled to estimate the corresponding inflow hydrographs at the upstream boundary of the MIKE11 model for the selected design flood events. The resulting hydrographs are shown in **Figure 3-1**. Ordinates of the 1% AEP inflow hydrograph were multiplied by three (3) to estimate the inflow hydrograph for the extreme event as shown in **Figure 3-1**.



Figure 3-1 : Adopted discharge hydrographs for the Castlereagh River



### 3.3 Estimation of Design Discharges for Warrena Creek

A RORB hydrologic model was developed as part of the SKM 2009 study. The RORB model was available for this study and the model was utilised to simulate inflow hydrographs for Warrena Creek and Magometon Creek. The RORB model parameter values adopted in the SKM 2009 study were also adopted in this study to simulate runoff hydrographs. Peak discharges estimated by the RORB model for the selected design events are shown in **Table 3-2**. The 18 hour storm event produced peak discharges for all but the 20% AEP event. The 36 hour storm event produced peak discharge for the 20% AEP event.

Table 3-2 Adopted design discharges for Warrena Creek Catchment

AEP	Warrena Creek @ Warrana gauge (583 km²)	Magometon Creek (Site 3) @ Near Coonamble gauge (540 km²)
20%	88	308
5%	163	530
2%	229	719
1%	298	906

Adopted design discharge hydrographs for Warrena Creek @ Warrana gauge and Magometon Creek @ Near Coonamble gauge are shown in **Figure 3-2** and **Figure 3-3** respectively. Design inflow hydrographs for Warrena Creek and Magometon Creek were timed to coincide with breakouts from the Castlereagh River into Warrena Creek which is consistent with the approach adopted in the SKM 2009 study.



Figure 3-2 : Adopted discharge hydrographs for Warrena Creek @ Warrana gauge

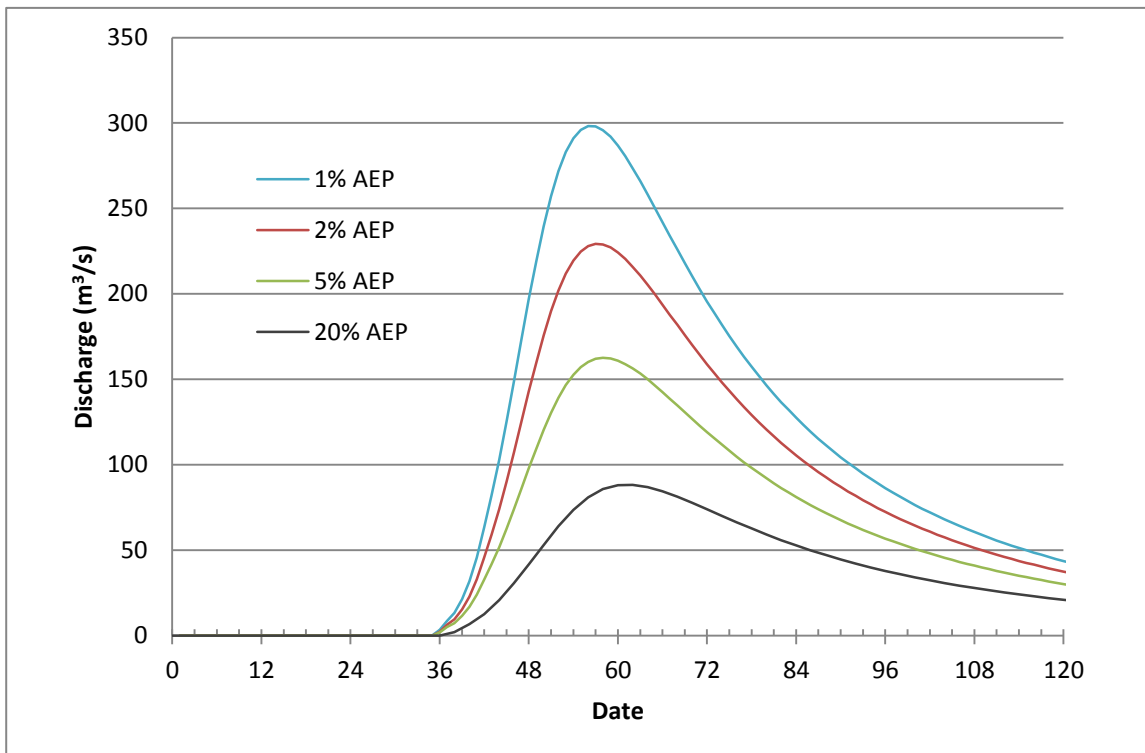
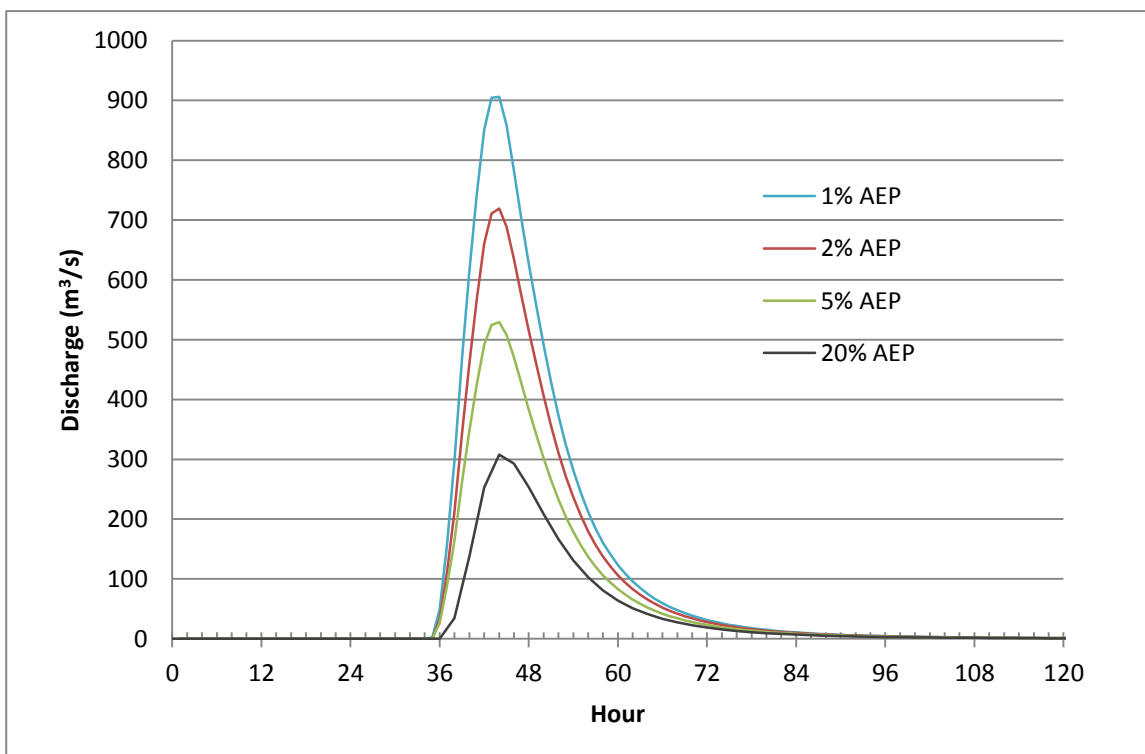


Figure 3-3 : Adopted discharge hydrographs for Magometon Creek (Site 2) @ Near Coonamble gauge





## 4. Hydraulic Modelling

### 4.1 Approach

A MIKE11 model was developed as part of the SKM 2009 Study on “Coonamble Levee Flood Gradient Sensitivity Modelling Study”. Main flow paths represented in the model included the following:

- Castlereagh River;
- Warrena Creek;
- Overland flowpath representing the Strathavon-Bundabulla Breakout;
- Overland flowpaths representing the Nine Mile Breakout and the Six Mile Breakout;
- Overland flowpaths representing Geamoney Breakout; and
- Eurimie Creek.

The MIKE11 model schematic is presented in **Appendix C**.

The MIKE11 model was calibrated against the flood event of 1998 and the model was verified against flood events of 1955 (the second largest flood on record in Coonamble), 1999, 2000 and 2007 (the largest flood on record in Warrena Creek catchment). The calibrated and verified MIKE11 model for Coonamble developed in the SKM 2009 study was available to this study and considering the focus of the current study and the availability of LiDAR data for the study area, it was considered a pragmatic approach to update the 2009 MIKE11 model for use in this study.

### 4.2 Updated MIKE11 Model

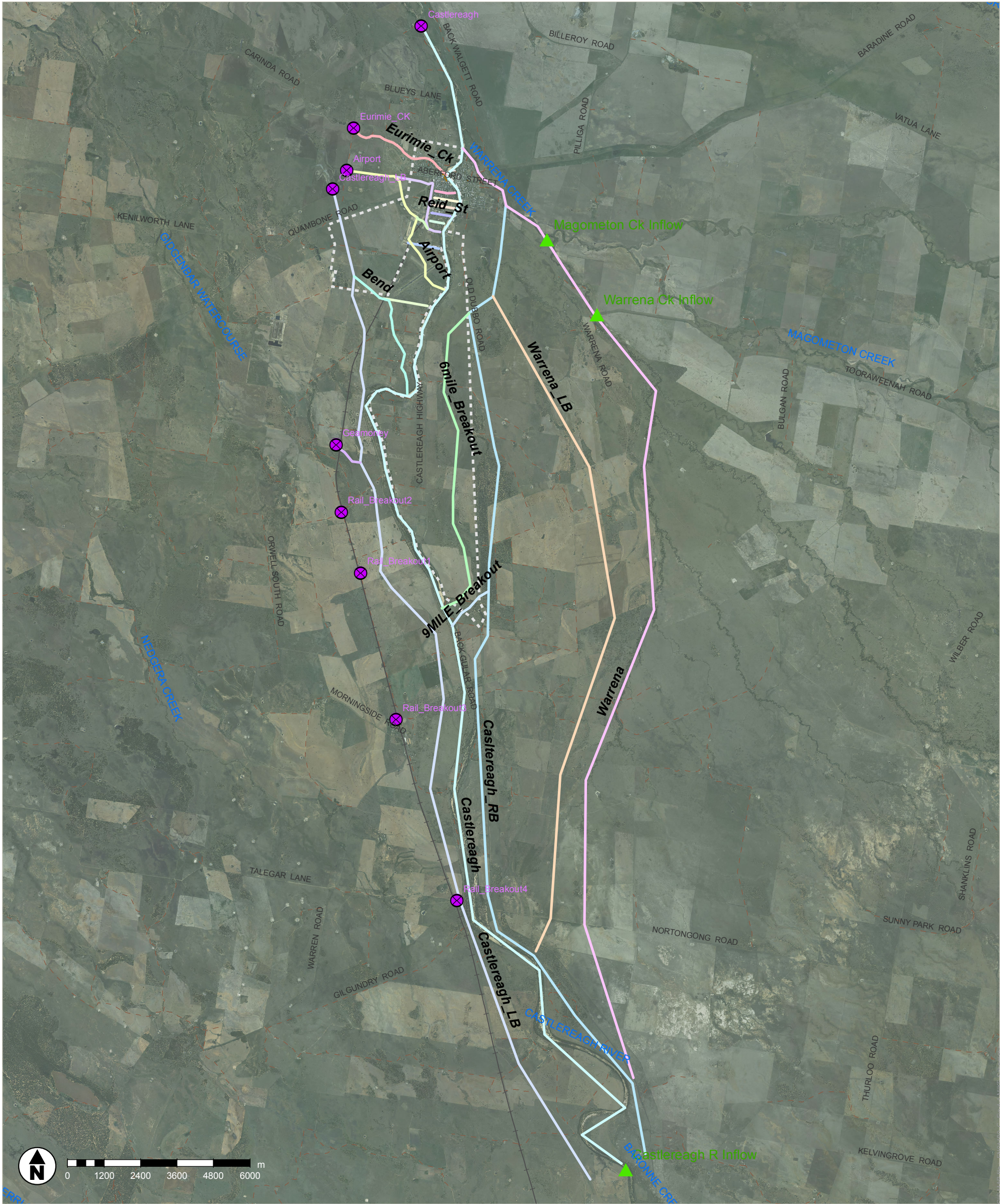
Updates made to the MIKE11 model are discussed in the following sections and the schematic of the updated model is shown in **Figure 4-1** and further details on the model schematic are provided in **Appendix C**.

#### 4.2.1 Flow paths

The following flow paths were updated:

- 6MILE\_BREAKOUT: twenty four (24) cross sections were extracted from the LiDAR data to update cross sections for this flow path.
- 9MILE\_BREAKOUT: Seven (7) cross sections were extracted from the LiDAR data to update representation of this flow path in the MIKE11 model.
- AIRPORT: a new 6320m long flow path was represented in the MIKE11 model by twenty six (26) cross sections extracted from the LiDAR data. Four waterway crossings located across the flow path were also represented in the MIKE11 model.
- BEND: a new 3940m long flow path was represented in the MIKE11 model by eleven (11) cross sections extracted from the LiDAR data.
- BYPASS\_RAIL\_ST: five cross sections were extracted from the LiDAR data to represent this new flow path in the MIKE11 model.
- CASTLEREAGH\_LB: twenty six (26) additional cross sections were extracted from the LiDAR data to extend and update this flow path.
- CASTLERAGH\_RB: fourteen (14) additional cross sections were added in the MIKE11 model for updating this flow path.
- CASTLEREAGH: twenty three (23) additional cross sections were extracted from the LiDAR data to update the geometry of the main channel of the Castlereagh River in the MIKE11 model.





Legend

MIKE11 Flowpath

- Bypass\_Railway\_St
- Castlereagh\_RB
- 6mile\_Breakout
- Castlereagh
- 9MILE\_Breakout
- Castlereagh\_LB
- Airport
- Durham\_St
- Barton\_St
- Eurimie\_Ck
- Bend
- Geamoney\_Breakout
- Bertram\_St
- McMahon\_St
- Quanmoona\_St
- Railway\_St
- Reid\_St
- Warrena
- Warrena\_LB
- Wilga\_Glen\_Rd
- D/S Boundary

Data Sources: LPI, Council.

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SCALE		A3	
SHEET	1 of 1		GDA 1994 MGA Zone 55
TITLE Updated MIKE11 Model Schematic			
PROJECT Flood Study for West Coonamble			
CLIENT Coonamble Shire Council			
DRAWN	PROJECT #	MAP #	REV VER
AH	IA0131100	FIGURE 4-1	1 1
CHECK	DATE		
AH	27/03/2016		



- EURIMIE\_CK: six (6) additional cross sections were extracted to extend the flow path over 2000m.
- RAILWAY\_ST: nine (9) cross sections were extracted from the LiDAR data to extend this flow path.

For overflow branches, link channels were generally used to connect the branches.

The approach used in the SKM 2009 study to define bed resistance for MIKE11 cross sections was followed in defining bed resistance for new MIKE11 cross sections. Bed resistance in the MIKE11 model was defined in terms of Manning's n. Typical Manning's n values adopted for the various surfaces are given in **Table 4-1**.

■ **Table 4-1 Adopted Manning's n Values**

Surface	Manning's n
Main Channel	0.05
Road Surface	0.015 – 0.02
Floodplain (light brush)	0.05
Floodplain (medium brush)	0.07
Floodplain (dense brush)	0.10

#### 4.2.2 Culverts and Bridges

An additional Road Bridge across Eurimie Creek and eighteen (18) additional culvert crossings were represented in the updated model based on the topographic survey undertaken for this study.

#### 4.2.3 Boundary Conditions

The inflow boundaries were not updated and the following downstream boundary conditions represented as stage-discharge relationships were removed from the updated MIKE11 due to extension of the model domain:

- Western end of Wilga Glen Road;
- Western end of Durham Street;
- Northern end of Railway Street; and
- Eurimie Creek downstream of Caswell Street.

The following additional downstream boundary conditions were defined as stage-discharge relationships in the updated MIKE11 model:

- Flowpath EURIMIE\_CK at chainage 3490m (approximately 2300m downstream of Caswell Street);
- Flowpath AIRPORT at chainage 6320m; and
- Flowpath CASTLEREAGH\_LB at chainage 44160m.

The adopted stage discharge relationship was calculated for each location within MIKE11 assuming a constant friction slope of 0.001 and a Manning's n value of 0.05. The resulting stage-discharge relationships for the downstream boundaries are presented in **Appendix C**.

### 4.3 Model Calibration and Verification

The original MIKE11 model was calibrated against the flood event of 1998 which was larger than the 2010 flood event (refer to **Table 2-1**) and the original model was verified against flood events of 1955 (the second largest flood on record in Coonamble), 1999 (a smaller flood event representing close to bankfull condition), 2000 (larger than 2010 flood as shown in **Table 2-1**) and 2007 (the largest flood on record in Warrena Creek



catchment). The extensive calibration and verification undertaken for the original model did not warrant additional calibration and verification for the updated model. In addition, undertaking calibration and verification for the updated model was beyond the scope of this study. Design flood behaviour simulated by the updated model is compared (refer to **Section 4.8**) against the corresponding flood behaviour simulated by the original MIKE11 model for the same design event to provide confidence in model results.

#### 4.4 Coincidental Flooding

Flooding in east Coonamble can result from a range of combination of flooding in Warrena Creek and the Castlereagh River. However, flooding within the study area is dominated by flooding in the Castlereagh River. Flooding in the Castlereagh River downstream of Aberford Street may be influenced by flooding in Warrena Creek to some extent. In recognition of these factors significant flooding in Warrena Creek coincident with the flooding in the Castlereagh River was considered. Coincident flooding adopted in this study for the selected flood events in the Castlereagh River and the corresponding events in Warrena Creek are shown in **Table 4-2**. Details on the adopted inflows for the selected flood events are provided in **Section 3**.

■ **Table 4-2 Adopted coincident inflows**

Flood Event	Castlereagh River	Warrena Creek
5% AEP	5% AEP	20% AEP
1% AEP	1% AEP	5% AEP
0.5% AEP	0.5% AEP	2% AEP
Extreme	Extreme	1% AEP

#### 4.5 Flood Behaviour

The MIKE11 model was run for the 0.5%, 1%, 5% AEP events and an extreme flood event for the coincident flood events shown in **Table 4-2**. Modelled peak water levels, discharge and velocities are presented in **Appendix C**.

##### 4.5.1 Flow Distribution

Modelled peak discharges in the Castlereagh River at selected locations, breakouts along the western floodplain of the Castlereagh River and Warrena Creek as a percentage of the adopted corresponding peak design inflow in the Castlereagh River upstream of Strathavon-Bundabulla Breakout are shown in **Table 4-3**. Following observations are made from **Table 4-3**:

- The discharge conveyed by the main channel of the Castlereagh River is diminished progressively with increasing distance downstream of the MIKE11 model boundary located upstream of Strathavon-Bundabulla Breakout. The fraction of the inflow conveyed by the river at Combara Bridge is reduced further at Aberford Street Bridge. Castlereagh River conveys approximately 54% to 58% of the upstream inflow downstream of its confluence with Warrena Creek which include rainfall runoff generated from the catchment area of Warrena Creek and discharges that breakout from the river along its eastern bank (ie. Strathavon-Bundabulla Breakout, Six Mile Breakout and Nine Mile Breakout).
- Approximately 41% to 44% of the peak upstream inflow escapes the Castlereagh River through the western breakouts. Flows that escape the river through five major breakouts do not traverse through the study area. The dominating breakout that traverses through the study area is CASTLEREAGH\_LB which crosses Quambone Road conveys up to a maximum of 5% of the peak upstream inflow. Flows conveyed by the other two breakouts (ie. AIRPORT and EURIMIE\_CK) which are located within the study area are generally small due to the effluent nature of the breakouts.
- Approximately 26% to 53% of the peak upstream inflows in the Castlereagh River are conveyed by Warrena Creek for the modelled flood events. Flows in Warrena Creek include rainfall runoff generated



from the catchment area of Warrena Creek and discharges that breakout from the Castlereagh River along its eastern bank including Strathavon-Bundabulla Breakout, Six Mile Breakout and Nine Mile Breakout.

The discharge conveyed by Warrena Creek increases with increasing magnitude of the flood.

The flow distribution shown in **Table 4-3** is generally consistent with the SKM 2009 study as detailed in **Section 4.8**. The minor discrepancy in the distribution of peak flow for the 1% and 5% AEP events result from timing of peak flows in different branches in different times.

It is to be noted that a number of flowpaths represented in the MIKE11 model conveyed insignificant flows. This is due to the fact that flowpaths were defined in the MIKE11 model on the basis of the available flood imagery and the topographic data. Due to the effluent nature of the flowpaths, insignificant flows were conveyed by a number of flowpaths.

■ **Table 4-3 Flow distribution as % of the adopted upstream peak inflow in the Castlereagh River**

Waterway	MIKE11 Flow Path	Chainage (m)	5% AEP	1% AEP	0.5% AEP	Extreme	Remark
Castlereagh River	CASTLEREAGH	9750	100	100	100	100	Upstream inflow
	CASTLEREAGH	29310	52	27	22	12	Combara Bridge
	CASTLEREAGH	48120	34	16	12	5	Aberford Street Bridge
	CASTLEREAGH	49850	58	54	56	58	D/S of confluence with Warrena Creek
Western Breakouts of Castlereagh River	RAIL_BREAKOUT1	110	1	5	6	8	Railway
	RAIL_BREAKOUT2	110	18	13	12	9	Railway
	RAIL_BREAKOUT3	160	8	9	9	8	Railway
	RAIL_BREAKOUT4	110	0	8	10	13	Railway
	GEAMONEY_BREAKOUT	410	7	4	3	2	Railway
	CASTLEREAGH_LB	43140	5	4	3	2	Quambone Road
	AIRPORT	4320	0	0	0	0	Outlet
	EURIMIE_CK	1175	1	1	1	1	Aberford Street Bridge
	<b>Sub-total</b>		<b>41</b>	<b>44</b>	<b>44</b>	<b>42</b>	
Warrena Creek	WARRENA	32455	26	38	44	53	Warrana Weir

#### 4.5.2 Peak Water Levels

Modelled peak water levels were used to plot peak water level profiles along three major flow paths within the study area which include the Castlereagh River (refer **Figure 4-2**), "CASTLEREAGH\_LB" (refer **Figure 4-3**) and "6MILE\_BREAKOUT" (refer **Figure 4-4**).

Following observations are made from **Figure 4-2**:

- Peak water level profiles along the Castlereagh River are generally consistent for all design flood events;
- Differences between water level profiles for the four design events are pronounced upstream of Combara Bridge. However, differences in peak water level profiles for the four design flood events between XS 97 (MIKE11 chainage 34320m) and Reid Street are almost negligible. This is due to the fact that the peak water levels in this reach of the Castlereagh River are controlled by the capacity of the main channel. Discharges in-excess of the channel capacity escapes the river through the western and eastern breakouts



located upstream of this reach. Flows that escape the river through the eastern breakouts ultimately find their way into Warrena Creek and join the river downstream.

- Combara Bridge is subject to approximately 1m and 2m depth of inundation in the 5% AEP event and the extreme event respectively. It is to be noted that the bridge was overtopped during flood events of 1998, 2000 and 2010. Aberford Street Bridge is not overtopped by the flood events assessed in this study.

**Figure 4-3** shows that peak water level profiles along the flowpath "CASTLEREAGH\_LB" are generally consistent for all design flood events. Differences between water level profiles for the four design events are pronounced upstream of flowpath "RAIL\_BREAKOUT2". However, downstream of flowpath "RAIL\_BREAKOUT2" differences in peak water level profiles for the four design flood events are almost negligible. This is due to the fact that the majority of the flows conveyed by "CASTLEREAGH\_LB" escape the flowpath and cross the railway line.

**Figure 4-4** shows that peak water level profiles along the flowpath "6MILE\_BREAKOUT" are generally consistent for all modelled flood events. Differences in peak water levels for the four modelled flood events are less pronounced in the vicinity of the Castlereagh River than away from the river.

#### 4.5.3 Peak Velocities

Modelled peak velocities are shown in **Appendix C**. Peak velocities in the Castlereagh River vary between 1m/s and 3m/s and peak velocities are generally higher at waterway crossings. Combara Bridge is overtopped in all design events and due to overtopping flow velocities are high in the vicinity of the bridge.

## 4.6 Sensitivity Analysis

A sensitivity analysis was undertaken to assess changes in peak water levels for the 1% AEP event due to changes in the adopted design discharges, Manning's n values and downstream boundary conditions.

The sensitivity of peak water levels to adopted Manning's n values was assessed by changing Manning's n values by 20%. The sensitivity of the 1% AEP peak water level profile on the adopted downstream boundary conditions was assessed by lowering and raising all downstream boundary conditions by 0.5m.

Outcomes from the sensitivity analysis on the 1% AEP peak water levels within the study area are summarised in **Table 4-4**.

**Table 4-4 Changes in 1% AEP peak water levels within the study area**

MIKE11 Flowpath	Manning's n		Downstream Boundary	
	20% less	20% more	0.5m lower	0.5m higher
6MILE_BREAKOUT	-0.15	0.10	0.00	0.00
AIRPORT	0.06	-0.04	0.00	0.00
CASTLEREAGH	-0.11	0.12	0.00	0.00
CASTLEREAGH_LB	0.06	-0.04	0.00	0.00
CASTLEREAGH_RB	-0.17	0.15	0.00	0.00
EURIMIE_CK	-0.04	0.05	0.00	0.01

**Table 4-4** shows that a 20% change in the adopted Manning's n values results in up to a maximum 0.17m change in 1% AEP peak water levels within the study area and a 0.5m change in the adopted downstream boundary condition has negligible impacts on 1% AEP flood levels within the study area.



Figure 4-2 : Modelled Peak Water Level Profiles along the Castlereagh River

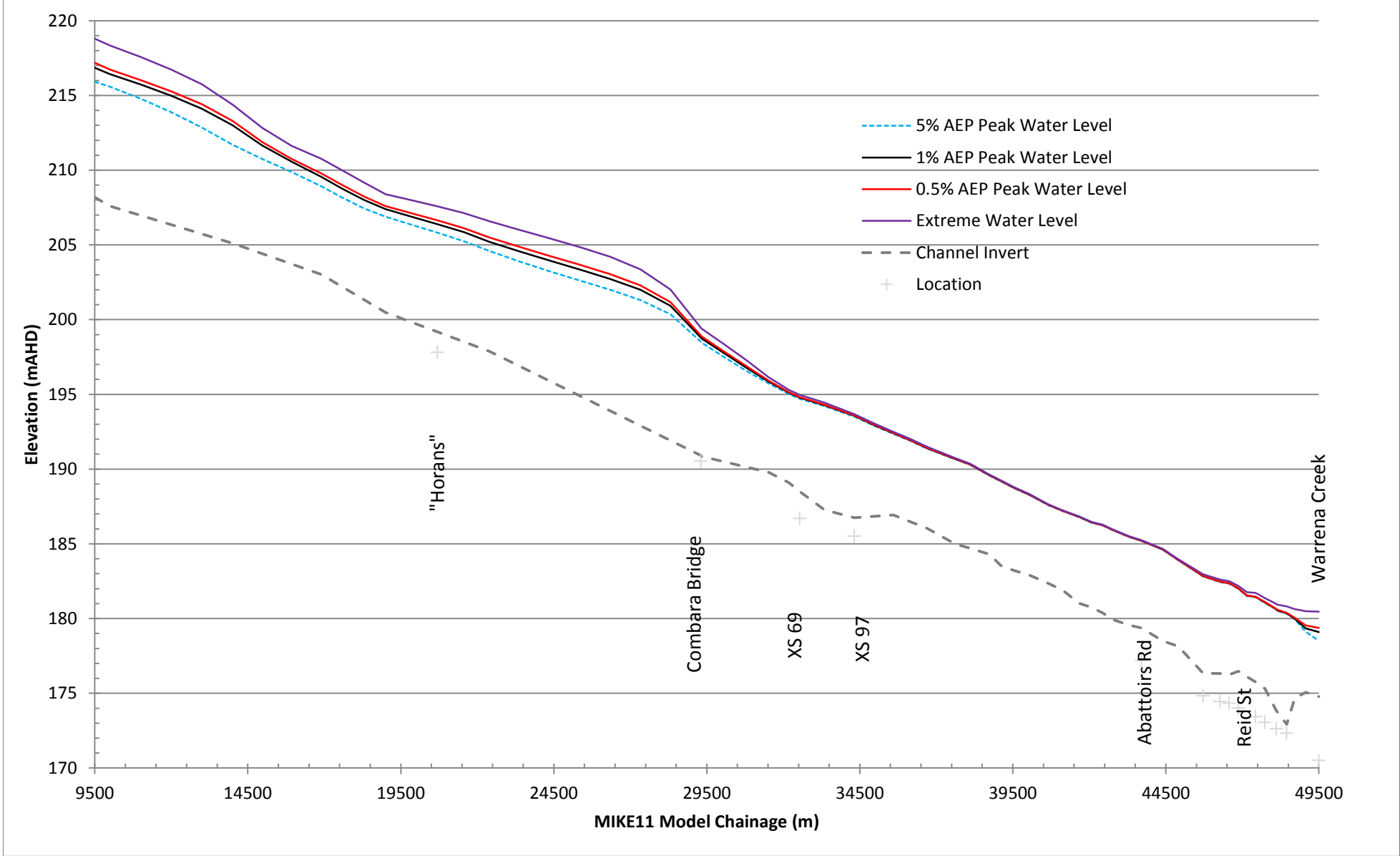




Figure 4-3 : Modelled Peak Water Level Profiles along MIKE11 flowpath "CASTLREAGH\_LB"

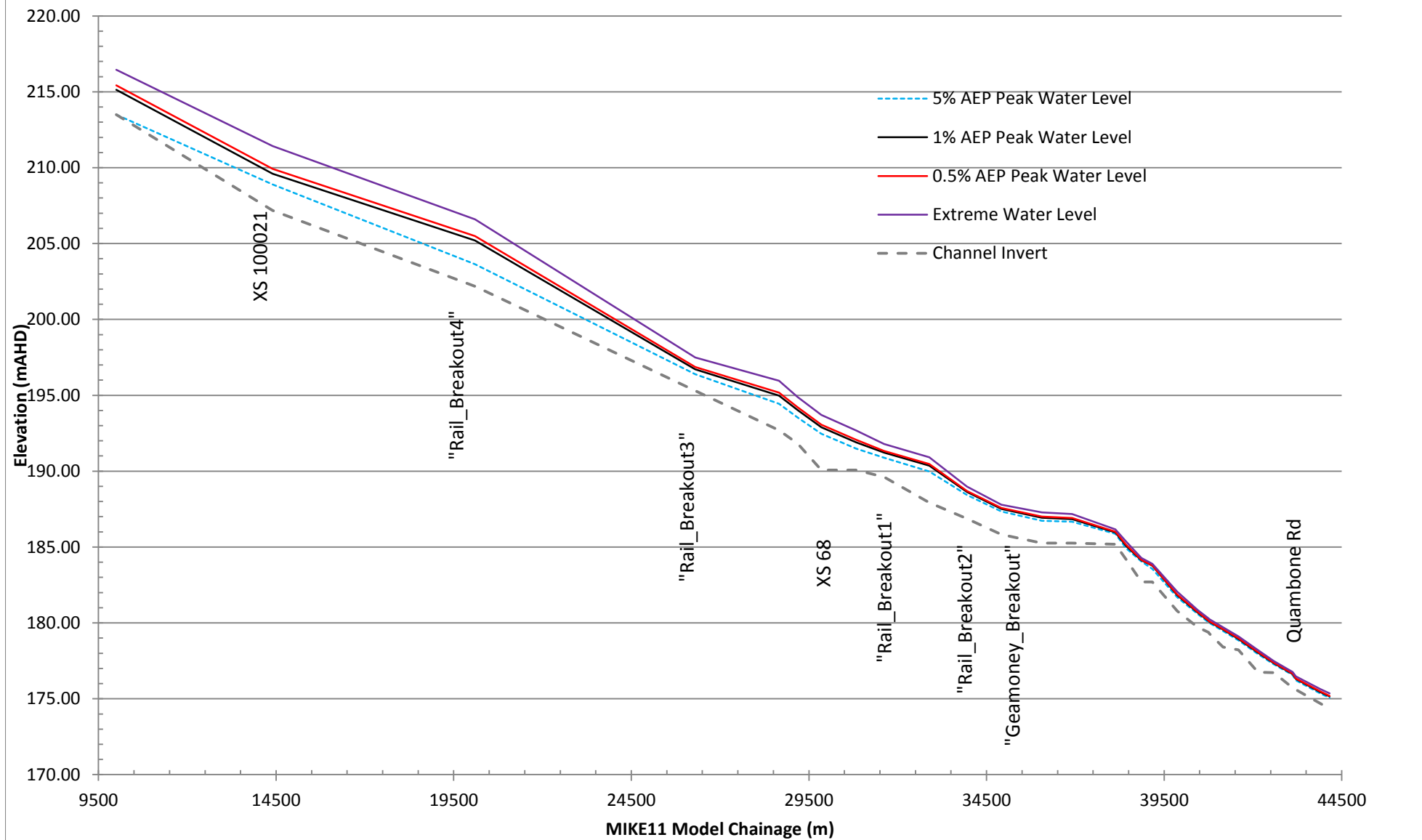
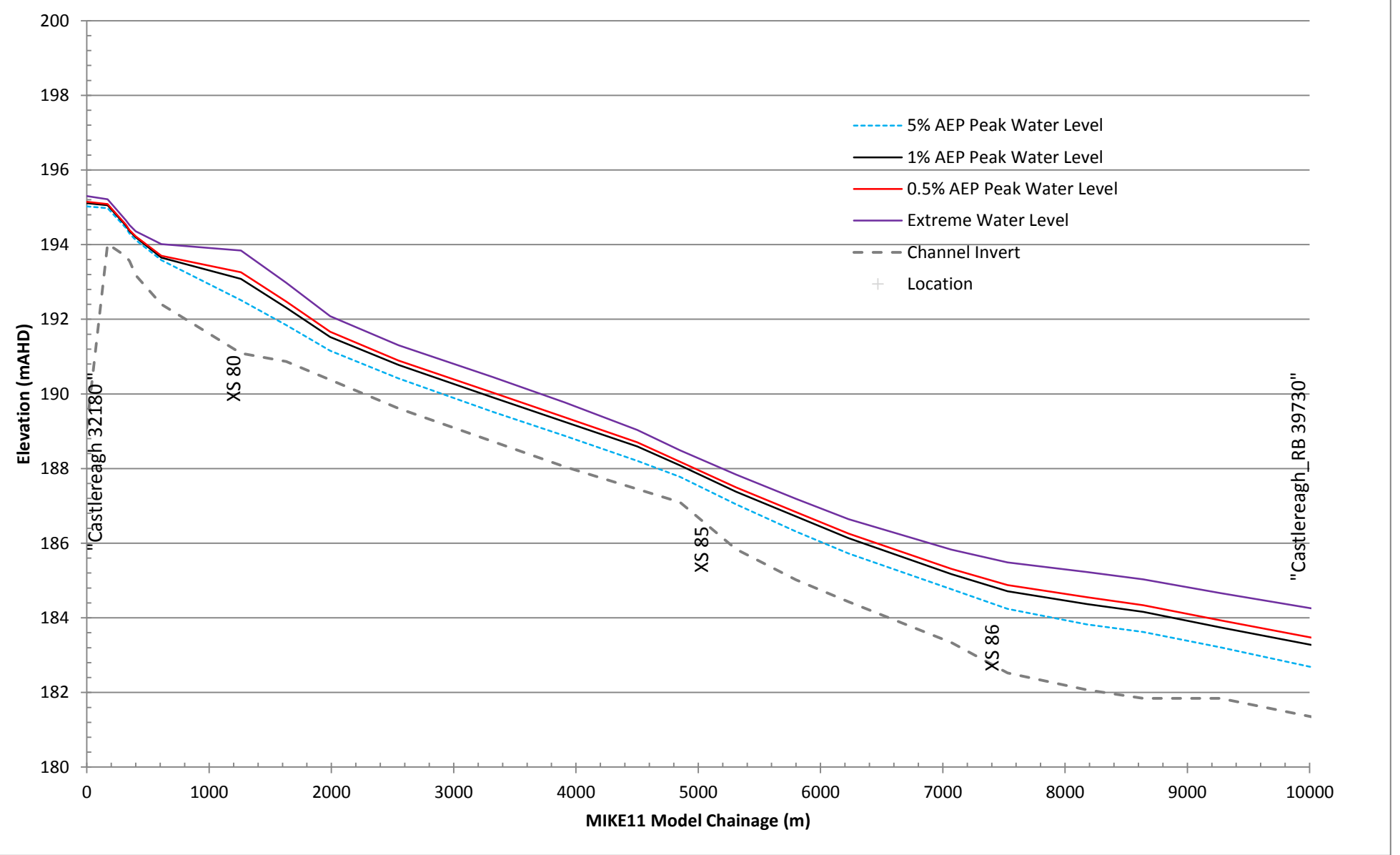




Figure 4-4 : Modelled Peak Water Level Profiles along MIKE11 flowpath "6MILE\_BREAKOUT"





## 4.7 Flood Extent Mapping

Modelled peak water levels for the 5%, 1% AEP, 1% AEP event plus 0.5m freeboard at MIKE11 model cross sections and the extreme event were used to create a flood surface for each event which was then intersected with the DTM representing the ground surface to delineate the flood extent for that event. The flood mapping was undertaken using the available routines in ArcMap and modelled flood extents for the 1% AEP event, 1% AEP event plus 0.5m freeboard and the extreme event are shown in **Figure 4-5**. Approximately 80% of the study area is subject to flood inundation in the 1% AEP event and the entire study area is located below 1% AEP event plus 0.5m freeboard as shown in **Figure 4-5**. However, some areas which are not flooded in the extreme event are flooded in the 1% AEP event plus 0.5m freeboard. This issue is to be considered in defining flood planning area as part of the Floodplain Risk Management Study for the study area. Approximately 70% of the area of 'Meglo' and 85% of the area of 'Riverview' are impacted by 1% AEP flood event. Both 'Riverview' and 'Meglo' are isolated from neighbouring towns in the 1% AEP event.

## 4.8 Comparison of Modelled Flood Behaviour

A comparison between modelled peak discharges between this study and the SKM 2009 study is shown in **Table 4-5** which shows consistency between this study and the SKM 2009 study. Minor differences in discharges results from the fact that design discharges adopted in this study for the Castlereagh River are slightly higher than that adopted in the SKM 2009 study and difference in coincident flooding in Warrena Creek between the two studies. A coincident 5% AEP flooding is adopted in this study a coincident 2% AEP flooding in Warrena Creek was assumed in the SKM 2009 study corresponding to the 1% AEP event in the Castlereagh River.

**Table 4-5 Comparison of 1% AEP peak discharges**

Waterway	MIKE11 Flow Path	Chainage (m)	1% AEP Peak Discharge (m <sup>3</sup> /s)		Remark
			This study	SKM 2009	
Castlereagh River	CASTLEREAGH	9750	4,922	4,654	Upstream inflow
	CASTLEREAGH	29310	1,333	1,194	Combara Bridge
	CASTLEREAGH	48120	776	741	Aberford Street Bridge
	CASTLEREAGH	49850	2,640	2,649	D/S Warrena Creek
Warrena Creek	WARRENA	32455	1,893	1,929	Weir

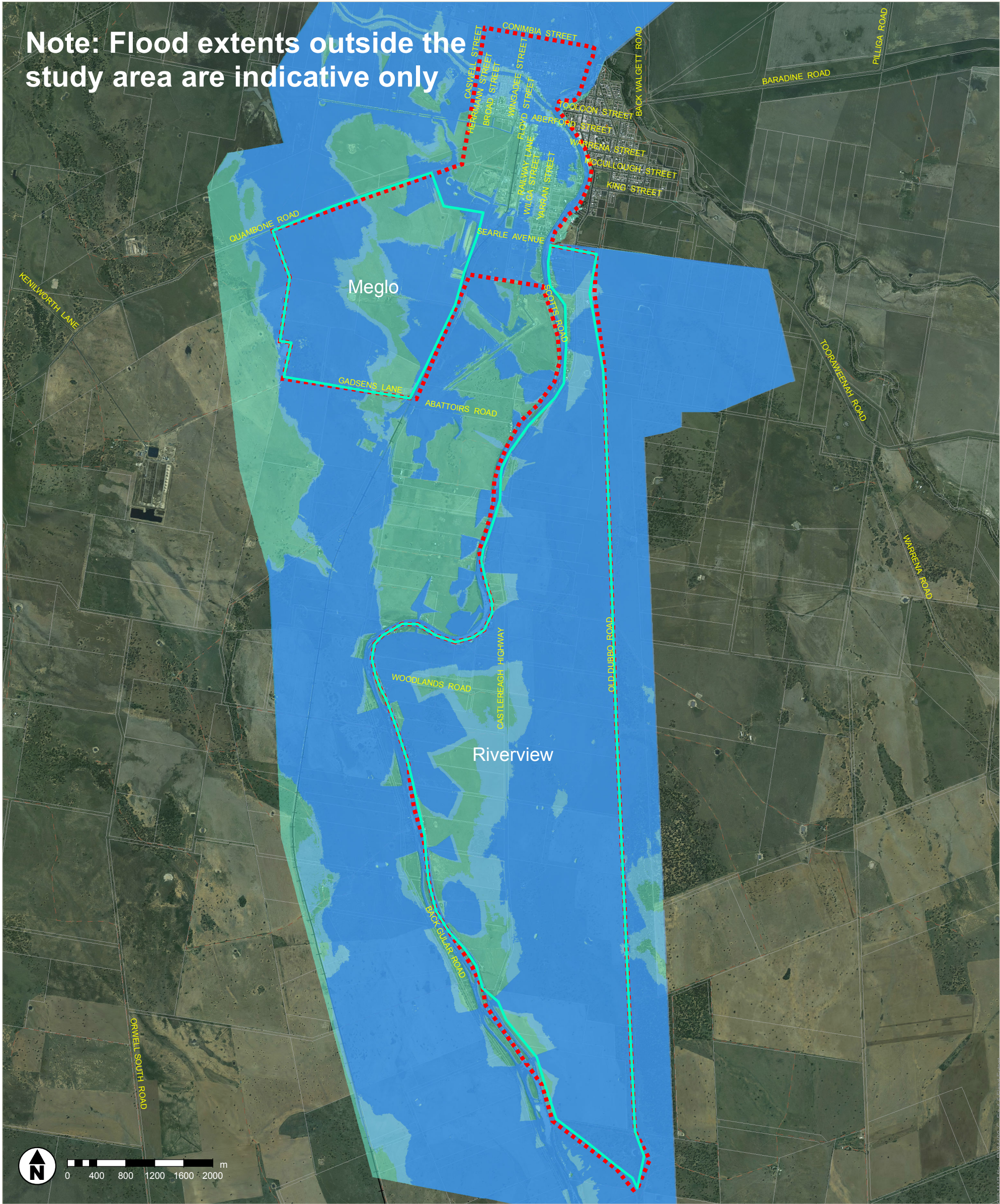
A comparison between 1% AEP peak water level profiles in the Castlereagh River between this study and the SKM 2009 study is shown in **Figure 4-6** which shows the general consistency in modelled peak water levels between the two studies.

The following observations are made from **Figure 4-6**:

- Modelled peak water levels at Combara Bridge, Aberford Street Bridge and at Warrena Creek confluence agree closely with the SKM 2009 study;
- Simulated peak water levels in the SKM 2009 study for an approximately 2 km reach of the Castlereagh River located downstream of Combara Bridge are slightly higher than that adopted in this study;

Simulated peak water levels in this study are generally higher than the corresponding peak water levels in the SKM 2009 study between "XS 69" and "Reid St".





Legend

- Study Area
- Cadastre
- Rezoned Areas
- 1% AEP Flood Extent
- Extreme Flood Extent
- 1% AEP + 0.5m Flood Extent

Data Sources: LPI, Council.

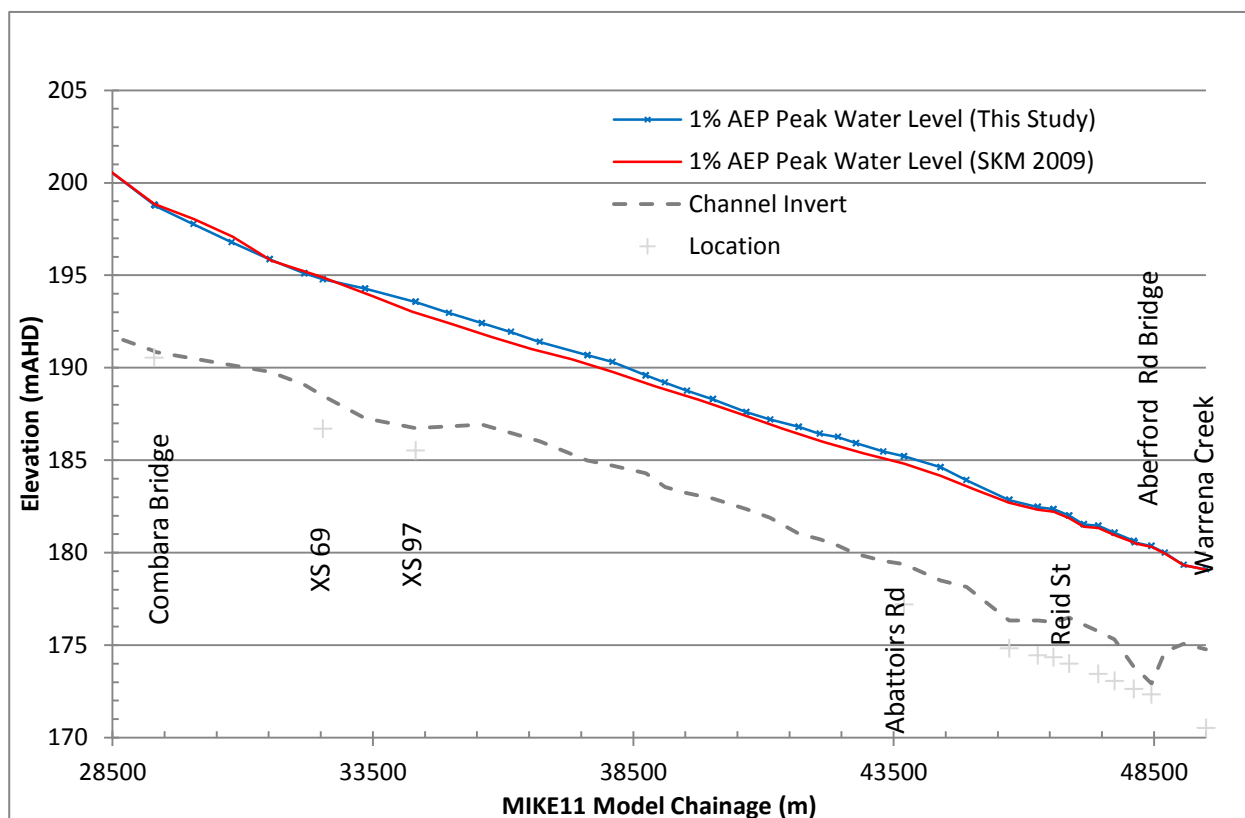
LIMITATIONS: This mapping is based on data and assumptions identified in the West Coonamble Flood Study Report (2016) prepared by Jacobs. Jacobs does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

SCALE	A3			
SHEET	1 of 1	GDA 1994 MGA Zone 55		
TITLE	Modelled Flood Extents			
PROJECT	Flood Study for West Coonamble			
CLIENT	Coonamble Shire Council			
DRAWN	PROJECT #	MAP #	REV	VER
AH	IA013100	FIGURE 4-5	1	1
CHECK	DATE			
AH	26/03/2016			



It is to be noted that additional cross sections were included in the updated MIKE11 model to refine the flood behaviour within the study area including the Castlereagh River. In addition, the updated MIKE11 model was extended to represent flooding along Quambone Road which involved removal of four downstream boundary conditions from the MIKE11 model used in the SKM 2009 study. Considering updates made to the MIKE11 model adopted in this study, further model refinement were not warranted to match the peak water levels between the two studies. However, it is recommended that adequate monitoring be undertaken during major flood events so that the adopted MIKE11 model could be validated against large observed flood events.

Figure 4-6 : Comparison of 1% AEP peak water level profiles



#### 4.9 Mapping of Hazard and Hydraulic Categories

MIKE11 modelling results for the 1% AEP event were used in ArcMap to delineate the flood hazard areas for the study area based on the hydraulic hazard category diagram presented in the *Floodplain Development Manual* (DECC, 2005), shown in Figure 4-7. The resulting high and low flood hazard areas for the 1% AEP event are shown in Figure 4-8. It is to be noted that high hazard areas results from either the depth of flooding is 1m or greater or the product of flood depth and velocity equal to or greater than  $1\text{m}^2/\text{s}$  or the velocity is greater than  $2\text{m/s}$ . The flood extent for the 5% AEP event is also shown in Figure 4-8 which indicates that the flood extent for the 5% AEP event is more extensive than the identified high flood hazard areas for the 1% AEP event.

The delineation of hydraulic categories is important with the adoption of merit based flood policy. This is because the NSW Government's *Floodplain Development Manual* (2005) recognises three hydraulic categories of flood prone land (floodway, flood fringe and flood storage). Definition of floodways, flood storage and flood fringe, as given in the Manual, are presented below:

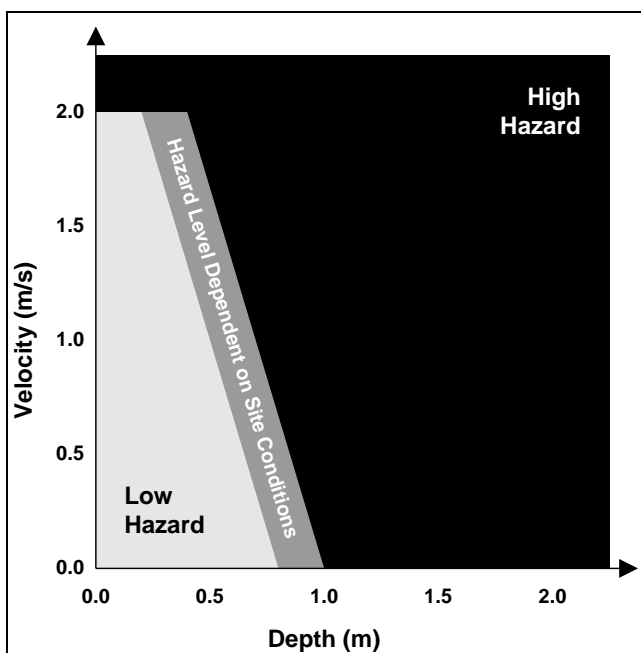
- Floodways are those areas where a significant volume of water flows during floods and are often aligned with obvious natural channels. They are areas that, even if only partially blocked, would cause a significant



increase in flood levels and/or a significant redistribution of flood flow, which may in turn adversely affect other areas. They are often, but not necessarily, areas with deeper flows or areas where higher velocities occur.

- Flood Storage areas are those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
- Flood fringe is the remaining area of land affected by flooding, after floodway and flood storage areas have been defined. Development in flood fringe areas would not have any significant effect on the pattern of flood flows and/or flood levels.

Figure 4-7 : Hydraulic Hazard Category Diagram (reproduced from Figure L2 in *NSW Floodplain Development Manual*)



Provisional floodways located within the study area have been delineated (refer to **Figure 4-8**) after reviewing the nature of riverine flooding in the study area, considering the definition of floodways in the Floodplain Development Manual and in recognition of the topography. It is recommended that the remaining floodplain located within the study area be classified as flood fringe (refer to **Figure 4-8**). It is further recommended that the provisional hazard categories be based on hazard categories shown in **Figure 4-8** for the 1% AEP event.





Legend

- Study Area
- Cadastre
- Rezoned Areas
- 1% AEP High Hazard
- 5% AEP Flood Extent
- 1% AEP Low Hazard
- Provisional Flood Fringe
- Provisional Floodway within Study Area

Data Sources: LPI, Council.		SCALE		A3	
		SHEET		1 of 1	
				GDA 1994 MGA Zone 55	
		TITLE		Provisional Hydraulic & Hazard Categories	
		PROJECT		Flood Study for West Coonamble	
		CLIENT		Coonamble Shire Council	
		DRAWN		PROJECT #	
		AH		IA013100	
		CHECK		DATE	
		AH		24/05/2016	
		MAP #		REV	
		FIGURE 4-8		1	
				VER	
				1	



## 5. Conclusions and Recommendations

In accordance with NSW Government Policy, Coonamble Shire Council is responsible for managing flood risk within its local government area, which includes the study area for West Coonamble. This report documents the first two stages of the process of preparing the Floodplain Risk Management Plan – that is, the preparation of a Flood Study. In addition, this Study recommends development controls which Council could adopt to manage flood risk until the Plan is prepared.

### 5.1 Conclusions

A community consultation process was undertaken to collect information on flooding from the community. In total, thirty five (35) responses were received from the community to the questionnaire and thirty (30) respondents were residents of the study area. Sixteen (16) respondents identified that highest priority be given to protecting residents/ business from flooding. Maintaining an emergency flood free access was given the highest priority by four (4) respondents and four (4) respondents gave the highest priority to providing flood warning.

LiDAR and ground surveys were undertaken to capture the required topographic data for this flood study. The topographic data was used to update an available MIKE11 hydraulic computer model for Coonamble which were used to analyse sensitivity of design peak water level profiles along Coonamble Levee.

The available flood frequency analysis for the Castlereagh River @ Gilgandra gauge and the 1955 inflow hydrograph for the gauge were used in this study to estimate design inflow hydrographs for the Castlereagh River for all modelled events. An existing RORB hydrologic model was utilised in the estimation of design inflows hydrographs for Warrena Creek catchment. Coincident flooding in the Castlereagh River and Warrena Creek catchment was considered. Flood behaviour in the study area for the 0.5%, 1% and 5% AEP events and an extreme flood event (i.e. 3 times 1% AEP event) were assessed in this study.

Modelled peak water levels for the 1% and 5% AEP events and an extreme event were utilised to create flood extent maps. The flood map for the 5% AEP map shows that the study area is cut-off from neighbouring towns and lands within the entire study area is located below 1% AEP flood level with 0.5m freeboard. However, some areas which are not flooded in the extreme event are flooded in the 1% AEP event plus 0.5m freeboard. This issue is to be considered in defining flood planning area as part of the Floodplain Risk Management Study for the study area. Provisional hydraulic and hazard category mapping was undertaken for the study area. These mapping need to be updated during the Floodplain Risk Management Study for the study area.

### 5.2 Recommendations

The scope of the study did not include undertaking an encroachment assessment to define the floodway and to provide detailed information to satisfy the requirements of the SES. It is recommended that Council undertakes these tasks at the Floodplain Risk Management Study stage.

The following recommendations are made for consideration by Council to manage flood risk for the study area until a Floodplain Risk Management Plan is adopted by Council:

- Council adopts this Flood Study;
- Council to erect flood signage along sections of roads which are located within the provisional high hazard areas in the 1% AEP event;
- No developments be permitted within the provisional floodway;
- Council to implement a porous fencing policy for all boundary fencing located within the provisional floodway;
- Council to consider voluntary purchase of all habitable buildings located within the provisional floodway;



- Council to consider voluntary house raising or flood proofing for all existing habitable buildings which are located within the provisional flood fringe;
- New developments/ redevelopments to use flood compatible building materials which can withstand the flood depth and velocity of flood waters and floor levels of buildings are be located, at least, at the FPL;
- SES and Council to update the flood intelligence and evacuation plan on the basis of this report and any potential development within 'Meglo' and 'Riverview' and communicate the update to the community; and
- SES and Council to monitor flood behaviour within the study area during major floods and capture photographs with a date stamp.



## 6. Acknowledgements

This study was undertaken by Jacobs on behalf of Coonamble Shire Council. Coonamble Shire Council has prepared this document with financial assistance from the NSW Government through its Floodplain Management Program. This document does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage.

A number of organisations and individuals have contributed both time and valuable information to this study. The assistance of the following in providing data and/or guidance to the study is gratefully acknowledged:

- Residents of the study area;
- Coonamble Shire Council; and
- Office of Environment and Heritage.



## 7. References

Coonamble Shire Council & NSW State Emergency Service (2013) Coonamble Shire Flood Emergency Sub Plan

Coonamble Shire Council 2011 LEP <http://www.coonambleshire.nsw.gov.au/PlanningDevelopment/LEP>

Department of Water Resources (1994) Flood Study Report, Gilgandra

Geolyse (2012) Review of Environmental Factors, Coonamble Levee Upgrade, November 2012

Laurenson EM; Mein, RG; Nathan, RJ (2010). 'RORB Version 6 Runoff Routing Program User Manual', Monash University Department of Civil Engineering and Sinclair Knight Merz, January 2010.

Lyll & Associates (2013) Flood Intelligence Report Castlereagh Valley December 2010 Flood, Volume 1 – Report, Draft Report, report prepared for NSW State Emergency Service

Lyll & Macoun (1996) Gilgandra Floodplain Management Study

Public Works (2011) Coonamble Levee Upgrade, Concept Design Report, August 2011

SKM (2002) Coonamble Flood Scoping Study, Final Report

SKM (2009) Coonamble Levee – Flood Gradient Sensitivity Modelling Study, Final Report, September 2009

Rankine & Hill (1983) New South Wales Inland Rivers Flood Plain Management Studies - Castlereagh Valley (1983)



## 8. Glossary

Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrences of a flood as big as or larger than the selected event. For example, floods with a discharge as great as or greater than the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
Development	<p>Is defined in Part 4 of the EP&amp;A Act</p> <p><u>In fill development</u>: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development.</p> <p>New development: refers to development of a completely different nature to that associated with the former land use. Eg. The urban subdivision of an area previously used for rural purposes. New developments involve re-zoning and typically require major extensions of exiting urban services, such as roads, water supply, sewerage and electric power.</p> <p>Redevelopment: refers to rebuilding in an area. Eg. As urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either re-zoning or major extensions to urban services.</p>
Effective Warning Time	The time available after receiving advise of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.



Flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
Flood liable land	Is synonymous with flood prone land (i.e.) land susceptibility to flooding by the PMF event. Note that the term flooding liable land covers the whole floodplain, not just that part below the FPL (see flood planning area)
Floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is flood prone land.
Floodplain risk management options	The measures that might be feasible for the management of particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
Floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually include both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defines objectives.
Flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at state, division and local levels. Local flood plans are prepared under the leadership of the SES.
Flood planning levels (FPLs)	Are the combination of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the "designated flood" or the "flood standard" used in earlier studies.
Flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings and structures subject to flooding, to reduce or eliminate flood damages.
Flood readiness	Readiness is an ability to react within the effective warning time.
Flood risk	<p>Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below.</p> <p><u>Existing flood risk:</u> the risk a community is exposed to as a result of its location on the floodplain.</p> <p><u>Future flood risk:</u> the risk a community may be exposed to as a result of new development on the floodplain.</p> <p><u>Continuing flood risk:</u> the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For</p>



an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.

Flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
Hazard	A source of potential harm or situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community.
Local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
m AHD	Metres Australian Height Datum (AHD)
m/s	Metres per second. Unit used to describe the velocity of floodwaters.
m <sup>3</sup> /s	Cubic metres per second or "cusecs". A unit of measurement of creek or river flows or discharges. It is the rate of flow of water measured in terms of volume per unit time.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
MIKE11	A computer program used for analysing behaviour of unsteady flow in open channels and floodplains.
Modification measures	Measures that modify either the flood, the property or the response to flooding.
Overland flowpath	The path that floodwaters can follow as they are conveyed towards the main flow channel or if they leave the confines of the main flow channel. Overland flowpaths can occur through private property or along roads.
Probable Maximum Flood (PMF)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically



possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain.

Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
RORB	RORB is a general runoff and streamflow routing computer program used to calculate flood hydrographs from rainfall and other channel inputs.
Runoff	The amount of rainfall which actually ends up as a streamflow, also known as rainfall excess.
Stage	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.



## **Appendix A. Questionnaire**





## Flood Study for West Coonamble - Questionnaire

Coonamble Shire Council has contracted the Consultant, Sinclair Knight Merz (SKM), to undertake a flood study for West Coonamble. The flood study area for West Coonamble is shown in the attached Map 1.

The objective of this study is to define the riverine as well as overland flooding behaviour within the study area. The study will produce information on flood levels, velocities and flows for a range of flood events under existing catchment conditions. Outcomes from the study would assist Council to apply appropriate development controls as a management measure in the floodplain risk management process, as it is believed to be most feasible management option for Council's consideration at this stage.

**The Consultant would like to receive feedback from the community on a number of issues and topics already highlighted by the Council with regard to flooding in the study area.**

If you cannot answer any question in the questionnaire, or do not wish to answer a question, then leave it unanswered and proceed to the next question. **Your input to this important study will be greatly appreciated.** If you need additional space, please add sheets.

Please send your response to this questionnaire directly to the Consultant **before 28 June 2013** at the address provided below.

Akhter Hossain  
P O Box 164  
St Leonards, NSW 1590  
or  
email: [ahossain@globalskm.com](mailto:ahossain@globalskm.com)

**Place a tick or write a number in the relevant box as per instruction or write answers.**

Question No.	Question and Answer
1.	<p><b>Do you live (reside) or have lived in the study area shown on Map 1?</b></p> <p>A <input type="checkbox"/> Yes (Please provide your address and put an 'X' on the relevant map)</p> <p>.....</p> <p>.....</p> <p>B <input type="checkbox"/> No (Go to Question 3)</p>
2.	<p><b>Do you own or rent your residence in the study area shown on Map 1?</b></p> <p>A <input type="checkbox"/> Own</p> <p>B <input type="checkbox"/> Rent</p> <p>C How long have you lived in the study area? (Please write number of years).....</p> <p><u>***If you are not sure whether you are in the map or not, please provide address</u></p>
3.	<p><b>Do you own or manage a business in the study area?</b></p> <p>A <input type="checkbox"/> Yes, For how many years? .....</p> <p>B <input type="checkbox"/> No (go to Question 5)</p>



Question No.	Question and Answer
4.	<p><b>What kind of business is yours?</b></p> <p>A <input type="checkbox"/> Home based business  B <input type="checkbox"/> Shop/commercial premises  C <input type="checkbox"/> Light industrial  D <input type="checkbox"/> Heavy industry  E <input type="checkbox"/> Others, please write type of business .....</p>
5.	<p><b>Have you had any experience of flooding (due to both the Castlereagh River and storm events as well) in and around where you live or work?</b></p> <p>A <input type="checkbox"/> Yes  B <input type="checkbox"/> No (Go to Question 15)</p>
6.	<p><b>How deep was the floodwater (from both the Castlereagh River and storm water as well) in the worst flood/ storm event that you experienced?</b>  Please estimate the depth .....  What was the year of this flood?.....  Where was this flood?  A <input type="checkbox"/> At your house?  B <input type="checkbox"/> At work?  C <input type="checkbox"/> Elsewhere?  Please provide the street address for this flood? .....</p>
7.	<p><b>How long did the floodwaters stay up?</b></p> <p>A <input type="checkbox"/> Less than 6 hours  B <input type="checkbox"/> Approximately 1 day  C <input type="checkbox"/> More than 3 days</p>
8.	<p><b>What damage resulted from this flood in your residence?</b>  (Please indicate either "none", "minor", "moderate" or "major".</p> <p>A <input type="checkbox"/> Damage to garden, lawns or backyard  B <input type="checkbox"/> Damage to external house walls  C <input type="checkbox"/> Damage to internal parts of house (floor, doors, walls etc)  D <input type="checkbox"/> Damage to possessions (fridge, television etc)  E <input type="checkbox"/> Damage to car  F <input type="checkbox"/> Damage to garage  G <input type="checkbox"/> Other damage, please list.....  H <input type="checkbox"/> What was the cost of the repairs, if any?.....</p>
9.	<p><b>What damage resulted from this flood in your business?</b>  (Please indicate either "none", "minor", "moderate" or "major".)</p> <p>A <input type="checkbox"/> Damage to surroundings  B <input type="checkbox"/> Damage to building  C <input type="checkbox"/> Damage to stock  D <input type="checkbox"/> Other damages, please list.....  E <input type="checkbox"/> What was the cost of the repairs, if any?.....</p>
10.	<p><b>Was vehicle access to/from your property disrupted due to floodwaters during the worst flooding/ storm event?</b></p> <p>A <input type="checkbox"/> Not affected</p>



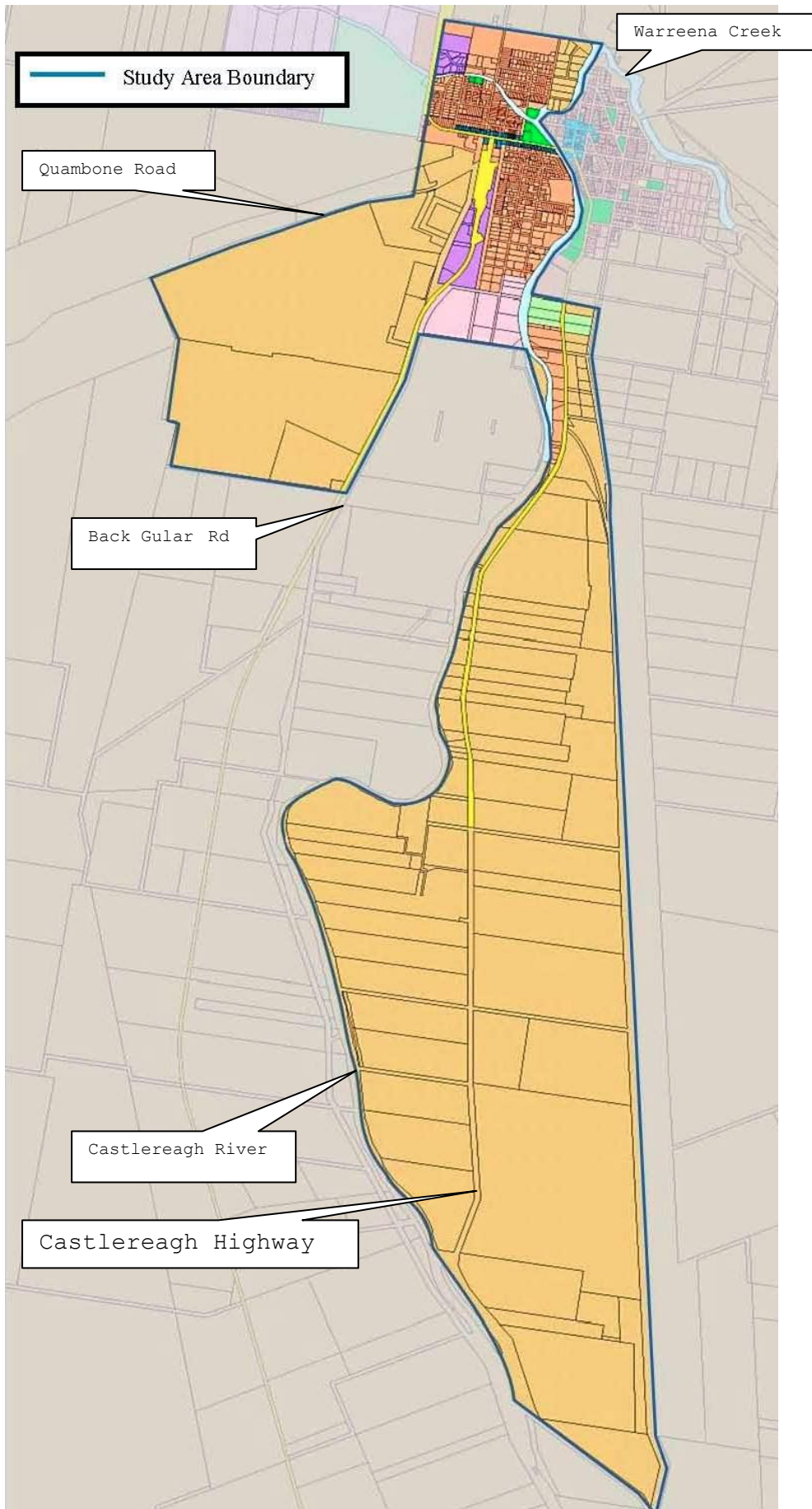
Question No.	Question and Answer
	<p>B Minor disruption (roads flooded but still driveable)</p> <p>C <input type="checkbox"/> Access cut off</p>
11.	<p><b>Were you or members of your family required assistance from SES during flood events?</b></p> <p>A <input type="checkbox"/> No</p> <p>B Yes, Please specify how many times (in total) members of your family required assistance? .....</p>
12.	<p><b>What information can you provide on past floods/ storm events that created flooding?</b> (You can tick more than one item). Please write any descriptions at the end of the questionnaire</p> <p>A <input type="checkbox"/> No information</p> <p>B <input type="checkbox"/> Information on extent or depth of floodwater at particular locations, newspaper clippings or other images on the past floods</p> <p>C <input type="checkbox"/> Any permanent marks indicating maximum flood level for particular floods</p> <p>D <input type="checkbox"/> Memory of flow directions, depth or velocities</p>
13.	<p><b>Do you consider that flooding of your property has been made worse by works on other properties, or by the construction of roads or other structures?</b></p> <p>A <input type="checkbox"/> Yes (please provide further details and attach extra pages if necessary. Please provide a sketch if possible).</p> <p>B <input type="checkbox"/> Unsure</p> <p>C <input type="checkbox"/> No</p>
14.	<p><b>Do you have any photographs of past floods that would be useful for the consultant to help him understand the area flooded or other flood effects and are you willing to provide copies?</b> If possible please attach the photographs (with dates and location) which will be copied and returned.</p> <p>A <input type="checkbox"/> Yes (either attach or the consultant will contact you to arrange for a copy to be made and returned)</p> <p>B <input type="checkbox"/> No</p>
15.	<p><b>Do you expect to undertake any further development on your land in the future?</b></p> <p>A <input type="checkbox"/> No</p> <p>B <input type="checkbox"/> Minor extensions</p> <p>C <input type="checkbox"/> New building</p> <p>D <input type="checkbox"/> Unsure</p> <p>E <input type="checkbox"/> Other (please specify) _____</p>
16.	<p><b>Please rank the following development types according to what you consider should be assigned greatest priority in protecting from flooding</b> (1 = greatest priority to 7 = least priority). <b>Please identify specific items if necessary.</b></p> <p>A <input type="checkbox"/> Commercial</p> <p>B <input type="checkbox"/> Heritage items, please specify _____</p> <p>C <input type="checkbox"/> Residential</p> <p>D <input type="checkbox"/> Community facilities (schools, halls, etc.) _____</p> <p>E <input type="checkbox"/> Critical utilities (power substations, telephone exchanges, etc.) _____</p> <p>F <input type="checkbox"/> Emergency facilities (Hospital, Police Station, etc.) _____</p> <p>G <input type="checkbox"/> Recreation areas and facilities _____</p>



Question No.	Question and Answer
17.	<p><b>Please rank the following by placing numbers from 1 to 6 ( 1 = greatest priority to 6 = least priority) next to A, B, C, D, E and F.</b></p> <p>A <input type="checkbox"/> Protecting residents/business from flooding  B <input type="checkbox"/> Protecting land of residents/businesses from flooding  C <input type="checkbox"/> Maintaining an emergency flood free access  D <input type="checkbox"/> Providing flood signage for public safety  E <input type="checkbox"/> Support from SES  F <input type="checkbox"/> Providing flood warning</p>
18.	<p><b>Do you wish to comment on any other issues associated with this study? Please add comments at the end of the questionnaire or please indicate your willingness to answer questions over the phone?</b></p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p>
19.	<p><b>Do you wish to remain on the mailing list for further details, Newsletters etc?</b></p> <p>A <input type="checkbox"/> Yes (please provide contact details, see next question)  B <input type="checkbox"/> No</p>
20.	<p>If you would like, please provide details of where you live and how we can contact you if we need to follow up on some details or seek additional comment.</p> <p><b>Name:</b> _____</p> <p><b>Address:</b> _____</p> <p>_____</p> <p><b>Telephone:</b> .....</p> <p><b>Fax:</b> .....</p> <p><b>Email:</b>.....</p>
	<p><b>Space for additional comments</b></p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p>



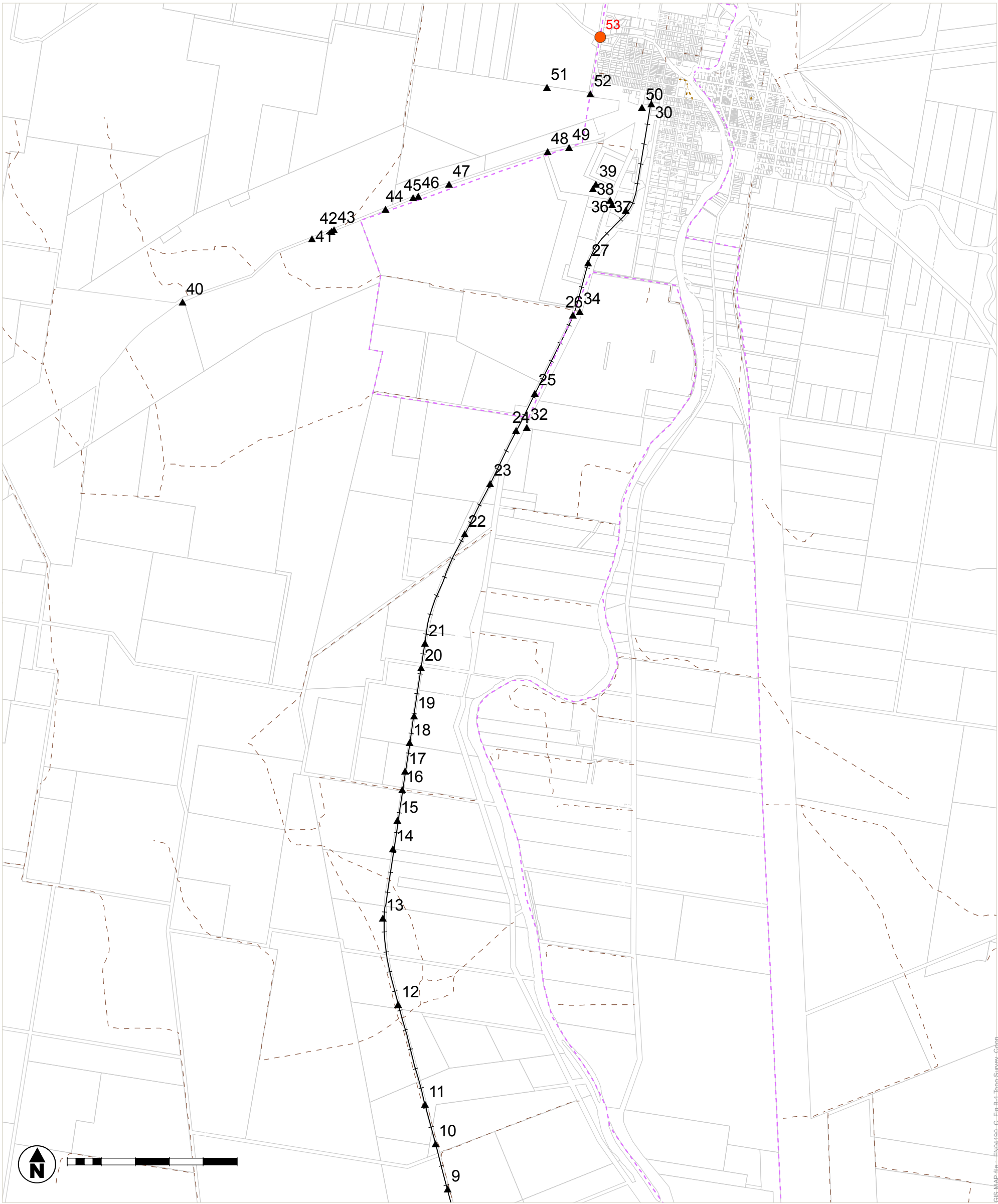
## Map 1 – Study Area for West Coonamble





## **Appendix B. Topographic Survey**





GIS MAP file: EN04190\_C\_Fig B.1 Topo Survey\_Coon

Legend

- Study Area
- Cadastre
- Surveyed Culvert
- Surveyed Bridge
- Railway

Data Sources: LPI, Council.		SCALE		A3	
		SHEET		1 of 1	
				GDA 1994 MGA Zone 55	
		TITLE		Topographic Survey	
		PROJECT		Flood Study for West Coonamble	
		CLIENT		Coonamble Shire Council	
DRAWN	PROJECT #	MAP #	REV	VER	
AH	IA013100	FIGURE B.1	1	1	
CHECK	DATE				
AH	18/05/2015				

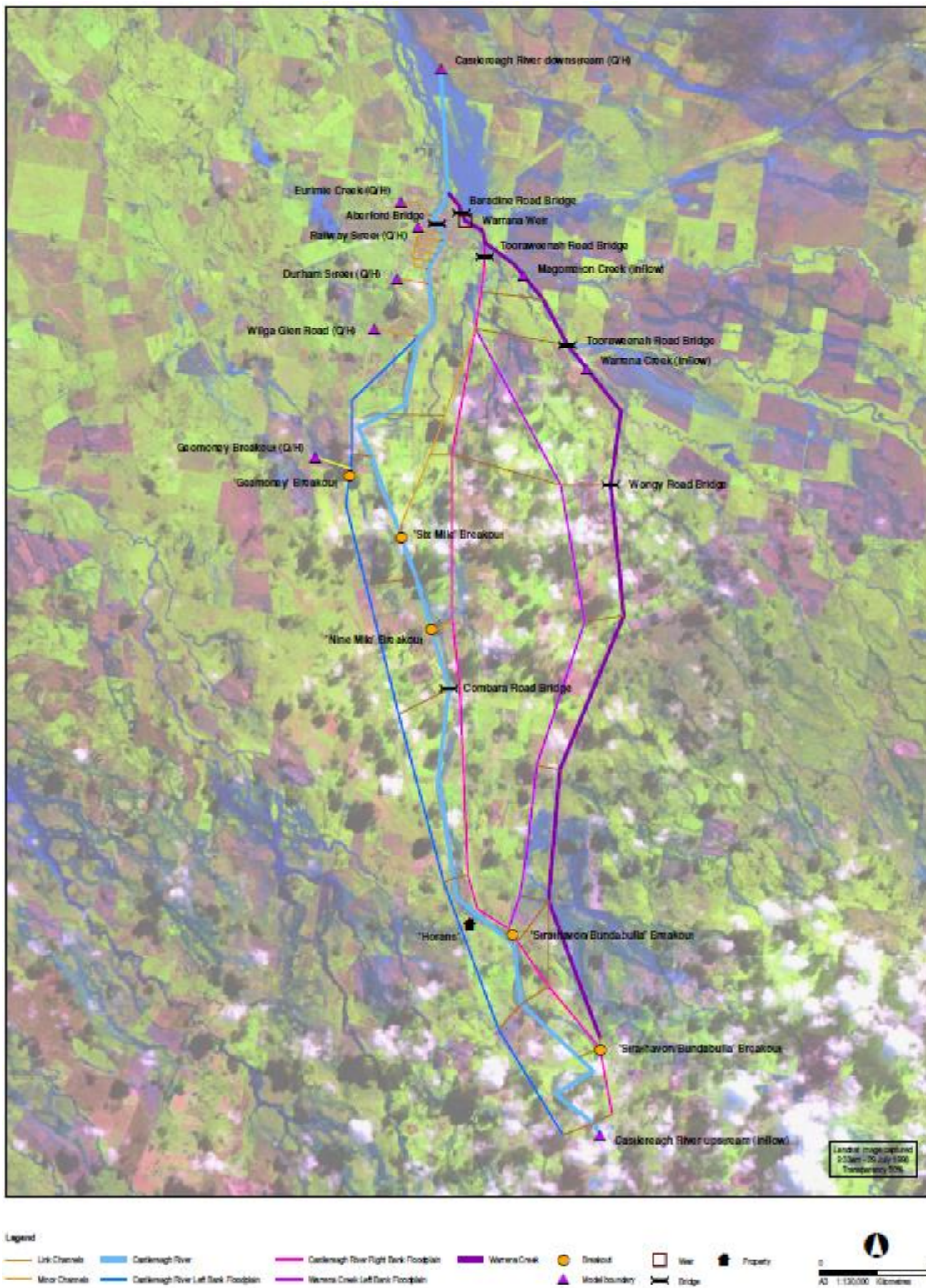
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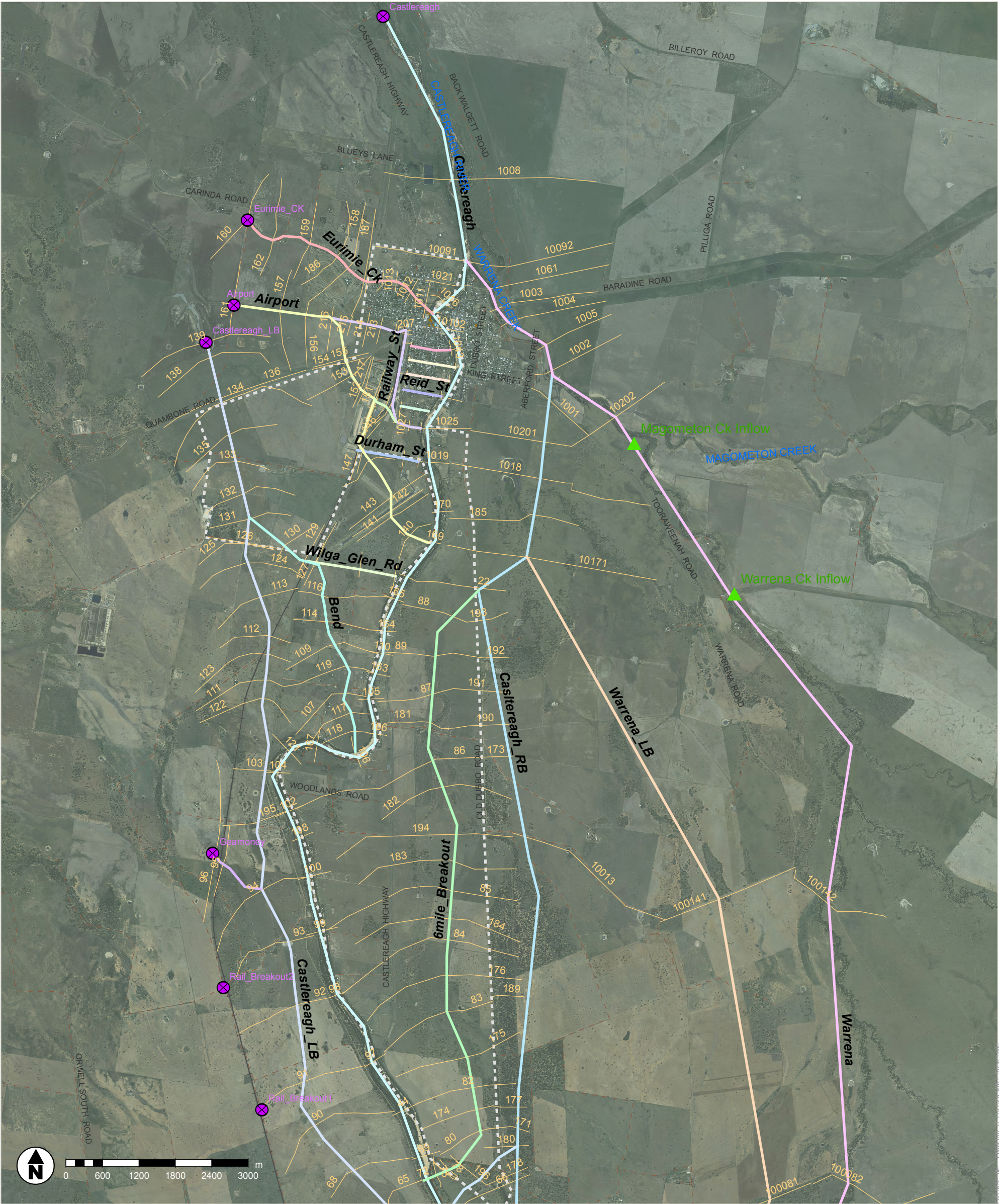
## **Appendix C. Hydraulic Modelling**



Figure C-1 : MIKE11 Model Schematic (source: SKM 2009)







Legend

MIKE11 Flowpath

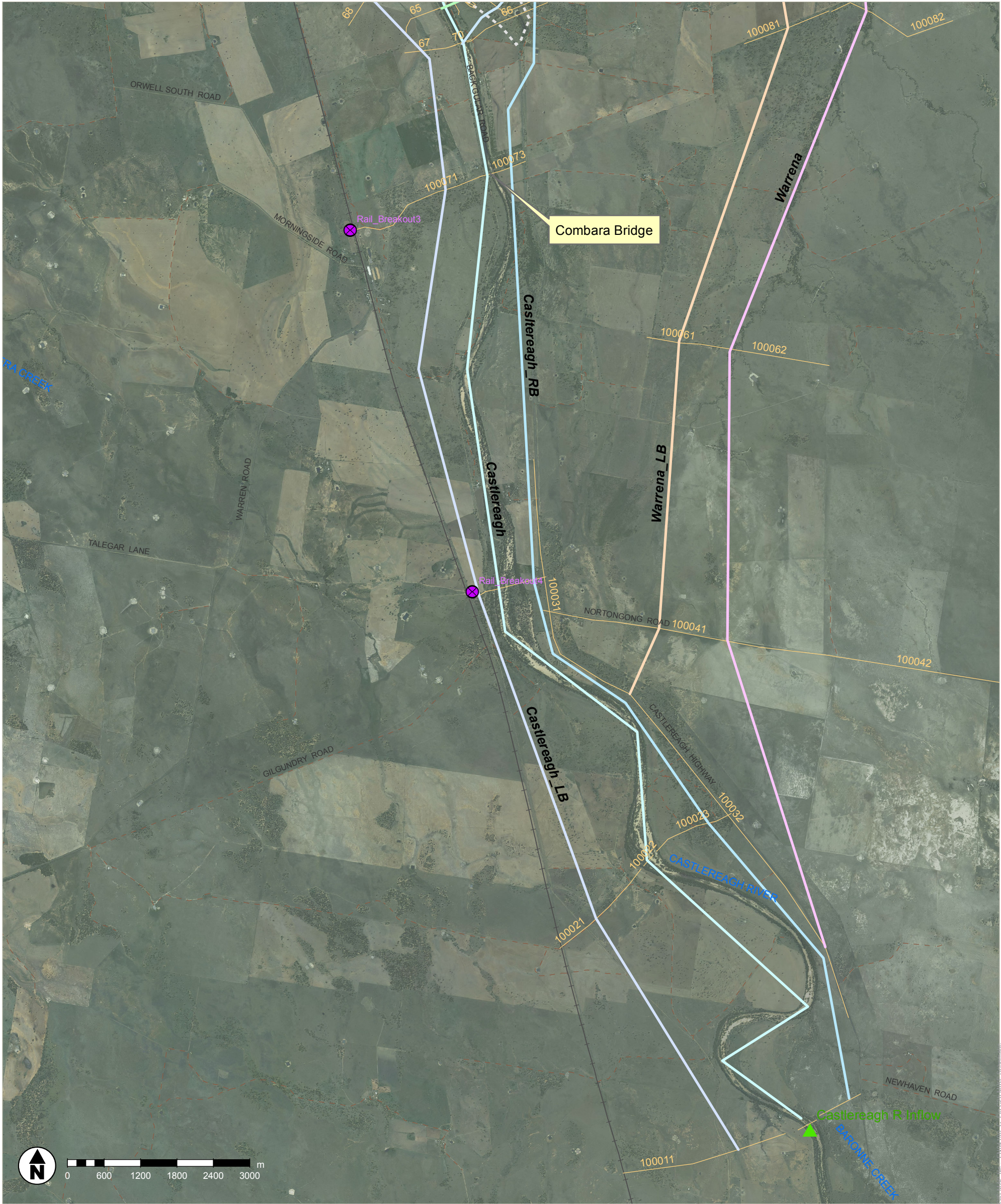
- 6mile\_Breakout
- 9MILE\_Breakout
- Airport
- Barton\_St
- Bend
- Bertram\_St
- Bypass\_Railway\_St
- Castlereagh\_RB
- Castlereagh
- Castlereagh\_LB
- Durham\_St
- Eurimie\_Ck
- Geamoney\_Breakout
- McMahon\_St
- Quanmoona\_St
- Railway\_St
- Reid\_St
- Warrena
- Warrena\_LB
- Wilga\_Glen\_Rd
- MIKE11 Cross Section
- Study Area

Data Sources: LPI, Council.

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SCALE		A3	
SHEET	1 of 1	GDA 1994 MGA Zone 55	
TITLE		Updated MIKE11 Model Schematic	
PROJECT		Flood Study for West Coonamble	
CLIENT		Coonamble Shire Council	
DRAWN	PROJECT #	MAP #	REV VER
AH	IA013100	FIGURE C-2a	1 1
CHECK	DATE		
AH	18/05/2015		





Legend

MIKE11 Flowpath		
	Bypass_Railway_St	
	Castlereagh_RB	
	Castlereagh	
	Castlereagh_LB	
	Durham_St	
	Eurimie_Ck	
	Geamoney_Breakout	

Data Sources: LPI, Council.		COPYRIGHT : The concepts and information contained in this document are the intellectual property of Jacobs. Use or copying of the document in whole or in part without written permission of Jacobs constitutes an infringement of copyright.	
SCALE		A3	
SHEET		1 of 1	
TITLE		Updated MIKE11 Model Schematic	
PROJECT		Flood Study for West Coonamble	
CLIENT		Coonamble Shire Council	
DRAWN		PROJECT #	MAP #
AH		IA013100	FIGURE C-2b
CHECK		DATE	REV VER
AH		18/05/2015	1 1



Figure C-3 : Q-H Relationship - AIRPORT

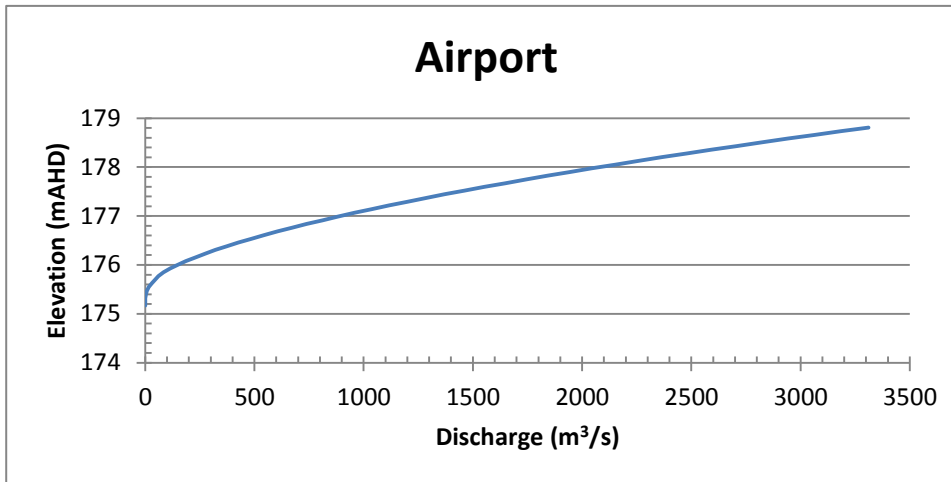


Figure C-4 : Q-H Relationship – CASTLEREAGH\_LB

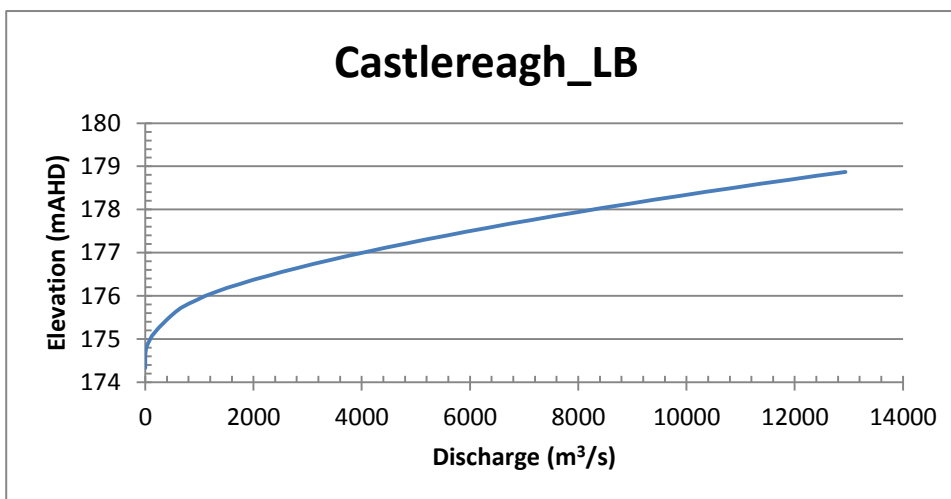


Figure C-5 : Q-H Relationship – EURIMIE\_CK

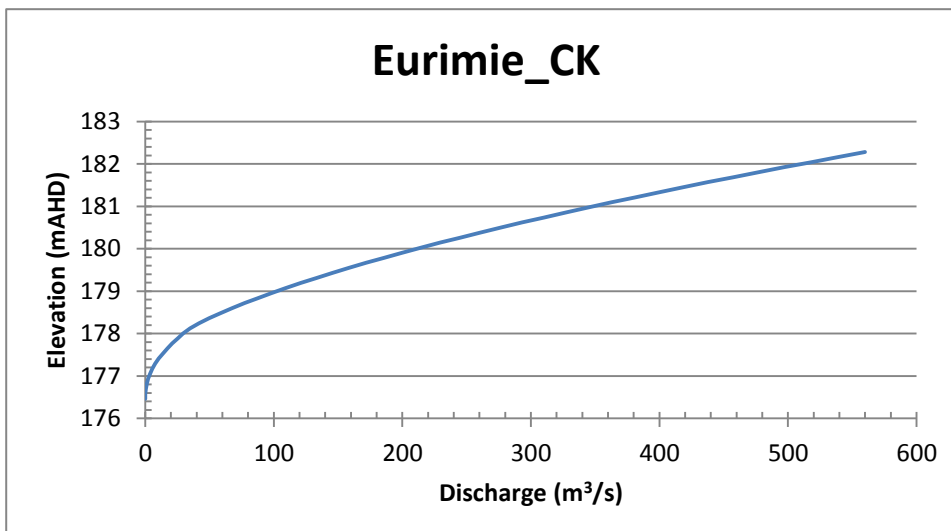




Figure C-6 : Q-H Relationship – GEAMONEY\_BREAKOUT

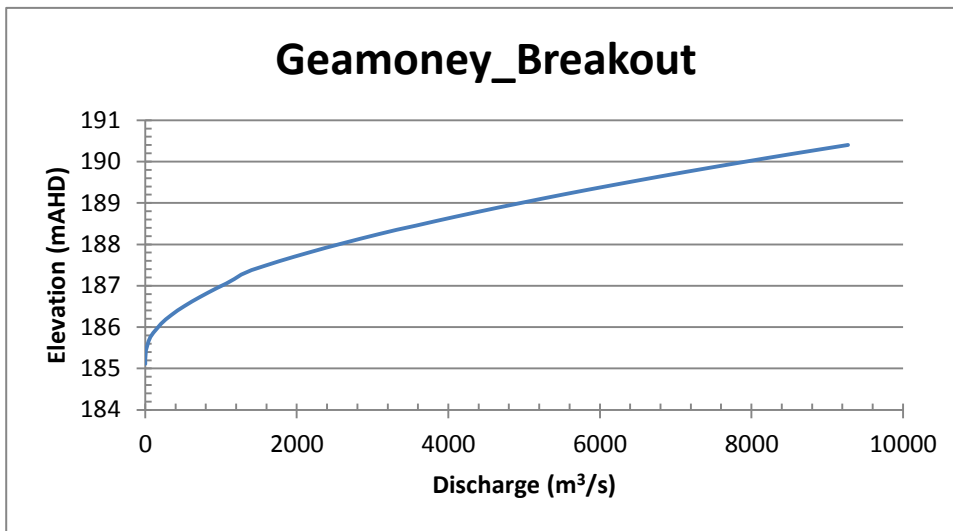


Figure C-7 : Q-H Relationship – RAIL\_BREAKOUT1

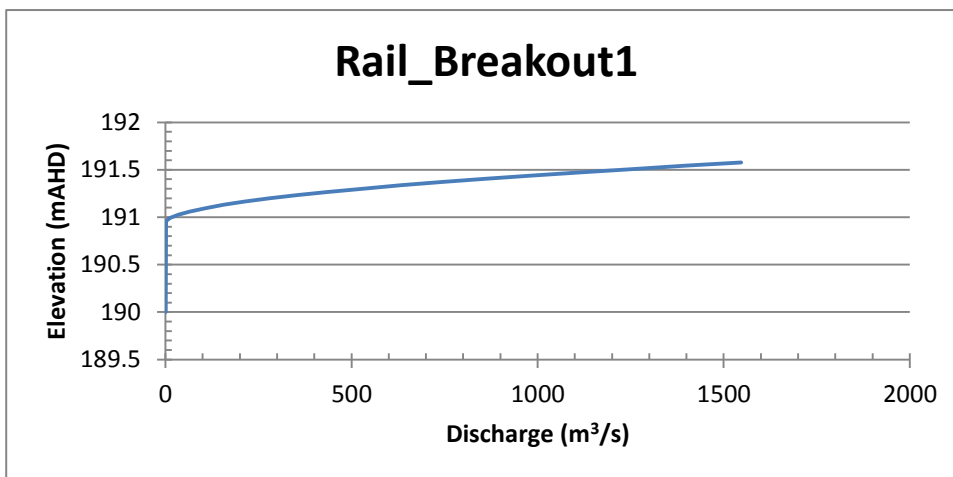


Figure C-8 : Q-H Relationship - RAIL\_BREAKOUT2

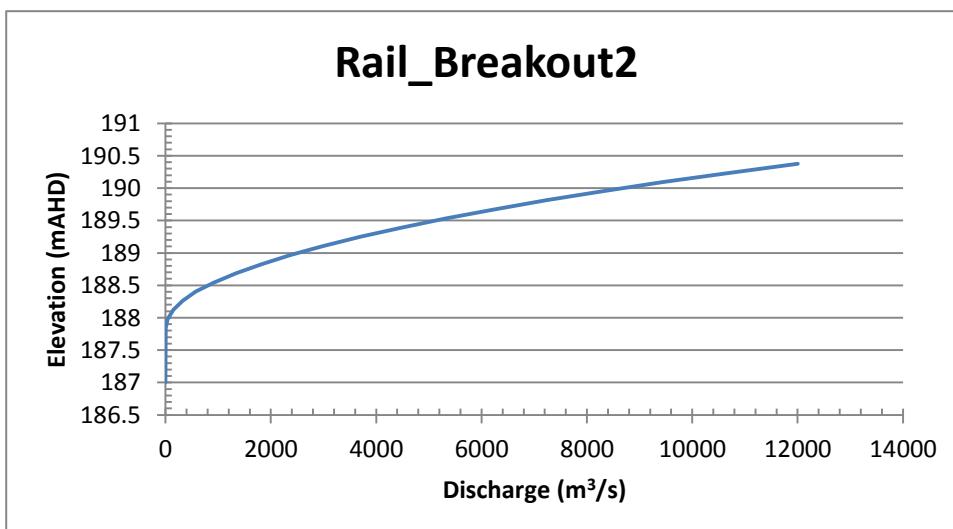




Figure C-9 : Q-H Relationship - RAIL\_BREAKOUT3

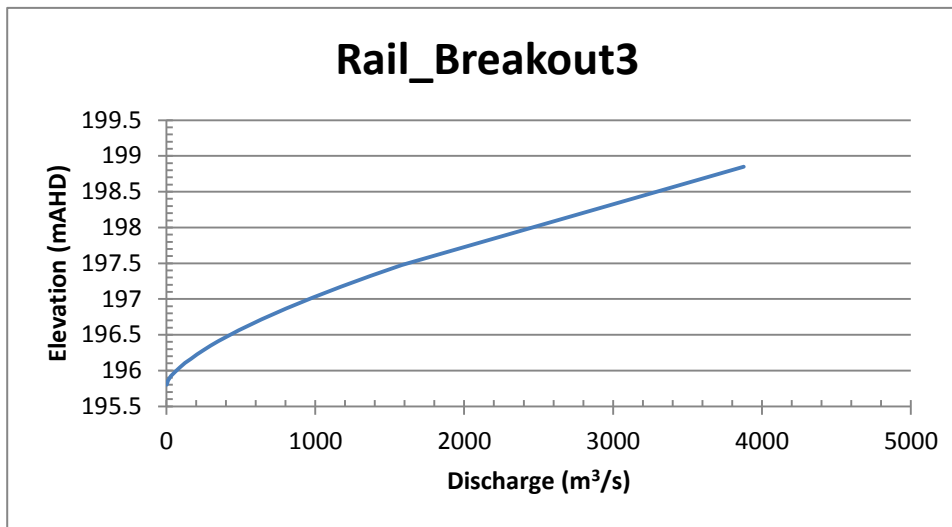


Figure C-10 : Q-H Relationship - RAIL\_BREAKOUT4

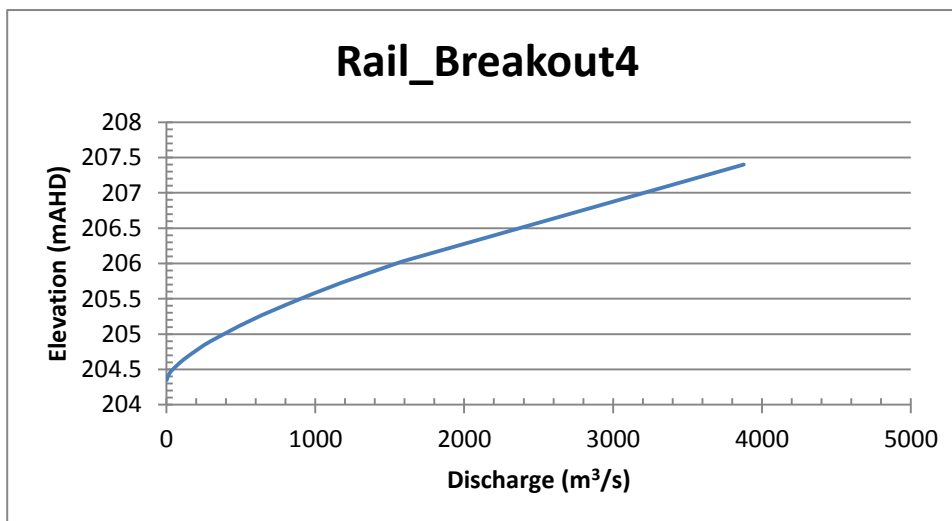




Table C-1 : Modelled Peak Water Levels

MIKE11 Flowpath	MIKE11 Chainage (m)	Cross Section <sup>1</sup>	Peak Water Level (mAHD)				Remarks
			5% AEP	1% AEP	0.5% AEP	Extreme	
6Mile_Breakout	170	73	194.98	195.06	195.09	195.22	
6Mile_Breakout	320	75	194.45	194.51	194.53	194.65	
6Mile_Breakout	350	77	194.30	194.36	194.39	194.52	
6Mile_Breakout	400	78	194.12	194.20	194.22	194.35	
6Mile_Breakout	610	179	193.59	193.65	193.70	194.01	
6Mile_Breakout	1260	80	192.51	193.08	193.26	193.84	
6Mile_Breakout	1630	174	191.84	192.31	192.47	192.98	
6Mile_Breakout	1990	82	191.15	191.52	191.66	192.08	
6Mile_Breakout	2550	175	190.41	190.77	190.90	191.30	
6Mile_Breakout	3320	83	189.52	189.91	190.03	190.45	
6Mile_Breakout	3910	176	188.88	189.25	189.37	189.77	
6Mile_Breakout	4500	84	188.21	188.59	188.70	189.03	
6Mile_Breakout	4850	184	187.78	188.08	188.18	188.49	
6Mile_Breakout	5310	85	187.04	187.38	187.49	187.84	
6Mile_Breakout	5800	183	186.31	186.71	186.83	187.19	
6Mile_Breakout	6230	194	185.73	186.13	186.26	186.65	
6Mile_Breakout	7070	182	184.77	185.17	185.32	185.83	
6Mile_Breakout	7530	86	184.24	184.71	184.88	185.49	
6Mile_Breakout	8180	181	183.83	184.37	184.55	185.23	
6Mile_Breakout	8640	87	183.62	184.16	184.34	185.03	
6Mile_Breakout	9270	89	183.21	183.74	183.93	184.66	
6Mile_Breakout	10030	88	182.67	183.27	183.46	184.25	
9mile_Breakout	825	196	193.67	194.43	194.72	195.83	
Airport	400	140	182.55	182.56	182.56	182.59	
Airport	830	141	181.65	181.66	181.67	181.69	
Airport	930	142	181.54	181.55	181.55	181.57	
Airport	1160	143	180.84	180.84	180.83	180.83	
Airport	1870	144	179.66	179.75	179.77	179.84	
Airport	2060	146	179.66	179.75	179.77	179.84	
Airport	2190	147	179.66	179.75	179.77	179.84	
Airport	2265	199	179.65	179.74	179.76	179.84	
Airport	2420	200	179.59	179.68	179.69	179.76	
Airport	2600	201	179.51	179.59	179.60	179.66	
Airport	2700	202	179.50	179.57	179.59	179.65	
Airport	2780	203	179.49	179.56	179.57	179.63	
Airport	2820	204	179.48	179.55	179.57	179.62	
Airport	3100	205	179.42	179.47	179.48	179.52	
Airport	3320	152	178.58	178.61	178.62	178.63	
Airport	3380	217	178.11	178.14	178.15	178.17	
Airport	3650	153	177.87	177.91	177.91	177.94	
Airport	3930	154	177.65	177.69	177.70	177.73	
Airport	3960	155	177.64	177.68	177.69	177.73	



MIKE11 Flowpath	MIKE11 Chainage (m)	Cross Section <sup>1</sup>	Peak Water Level (mAHD)				Remarks
			5% AEP	1% AEP	0.5% AEP	Extreme	
Airport	4680	216	176.97	177.03	177.04	177.10	
Airport	5110	156	176.47	176.50	176.51	176.53	
Airport	5550	157	176.21	176.23	176.24	176.25	
Airport	6320	161	175.48	175.50	175.50	175.52	
Barton_St	0	1039	180.68	180.68	180.68	180.68	
Barton_St	720	1037	180.34	180.34	180.34	180.34	
Bend	340	118	185.06	185.06	185.06	185.17	
Bend	660	117	184.93	184.95	184.95	184.98	
Bend	1000	107	183.90	183.95	183.97	184.06	
Bend	1470	119	183.83	183.87	183.89	183.94	
Bend	1890	109	183.58	183.59	183.59	183.62	
Bend	2280	114	183.23	183.24	183.24	183.27	
Bend	2740	116	182.22	182.22	182.20	182.22	
Bend	3290	127	181.67	181.71	181.72	181.76	
Bend	3500	129	180.87	180.90	180.91	180.94	
Bend	3940	130	179.46	179.55	179.59	179.71	
Bertram_St	0	1040	175.82	175.82	175.82	176.26	
Bertram_St	780	1038	180.20	180.20	180.20	180.20	
Bypass_Railway_St	250	149	179.41	179.47	179.48	179.52	
Bypass_Railway_St	315	197	179.42	179.47	179.48	179.52	
Bypass_Railway_St	480	150	179.42	179.47	179.48	179.52	
Bypass_Railway_St	500	198	179.42	179.47	179.48	179.52	
Bypass_Railway_St	560	151	179.42	179.47	179.48	179.52	
Castlereagh	10000	100012	215.57	216.42	216.72	218.34	
Castlereagh	16900	100022	208.93	209.55	209.78	210.76	
Castlereagh	20700		205.81	206.39	206.64	207.58	"Horans"
Castlereagh	22400	100052	204.59	205.20	205.49	206.58	
Castlereagh	29300		198.53	198.81	198.94	199.47	U/S Combara Br
Castlereagh	29320	100072	198.48	198.75	198.88	199.40	D/S Combara Br
Castlereagh	31520	70	195.73	195.86	195.91	196.15	
Castlereagh	32180	72	195.02	195.11	195.15	195.30	
Castlereagh	32540	69	194.70	194.78	194.81	194.97	
Castlereagh	33350	44	194.21	194.28	194.31	194.44	
Castlereagh	34320	97	193.51	193.56	193.58	193.67	
Castlereagh	35595	98	192.36	192.41	192.42	192.50	
Castlereagh	36705	99	191.36	191.40	191.41	191.48	
Castlereagh	37620	100	190.65	190.68	190.69	190.74	
Castlereagh	38100	108	190.28	190.31	190.32	190.37	
Castlereagh	38740	102	189.56	189.58	189.59	189.63	
Castlereagh	39110	104	189.18	189.20	189.21	189.25	
Castlereagh	39530	121	188.74	188.76	188.77	188.80	
Castlereagh	40030	167	188.28	188.30	188.31	188.34	
Castlereagh	40670	106	187.58	187.60	187.61	187.64	



MIKE11 Flowpath	MIKE11 Chainage (m)	Cross Section <sup>1</sup>	Peak Water Level (mAHD)				Remarks
			5% AEP	1% AEP	0.5% AEP	Extreme	
Castlereagh	41130	166	187.18	187.20	187.21	187.24	U/S Aberford St Bridge D/S Aberford St Bridge
Castlereagh	41680	105	186.78	186.80	186.80	186.83	
Castlereagh	42080	163	186.41	186.43	186.43	186.45	
Castlereagh	42430	110	186.24	186.25	186.26	186.29	
Castlereagh	42780	164	185.90	185.92	185.93	185.95	
Castlereagh	43300	165	185.46	185.47	185.48	185.50	
Castlereagh	43700	168	185.19	185.21	185.21	185.24	
Castlereagh	44400	169	184.61	184.62	184.63	184.66	
Castlereagh	44900	170	183.90	183.92	183.92	183.97	
Castlereagh	45720	1019	182.83	182.84	182.85	182.97	
Castlereagh	46270	1025	182.44	182.46	182.47	182.61	
Castlereagh	46870	1053	181.99	182.01	182.02	182.18	
Castlereagh	47430	1054	181.43	181.45	181.46	181.71	
Castlereagh	47740	1055	181.05	181.08	181.10	181.37	
Castlereagh	48110	10102	180.61	180.64	180.65	180.98	
Castlereagh	48130		180.54	180.56	180.59	180.93	
Castlereagh	48450	1056	180.33	180.35	180.39	180.81	
Castlereagh	48710	1016	179.95	179.99	180.05	180.63	
Castlereagh	49070	1021	179.11	179.34	179.54	180.50	
Castlereagh	49500	10091	178.51	179.09	179.38	180.46	
Castlereagh	50900	1008	177.30	177.69	177.90	178.77	
Castlereagh_LB	10000	100011	213.50	215.14	215.42	216.45	
Castlereagh_LB	14400	100021	208.9	209.60	209.93	211.42	
Castlereagh_LB	20100	100051	203.65	205.20	205.49	206.60	
Castlereagh_LB	26300	100071	196.38	196.72	196.86	197.50	
Castlereagh_LB	28660	67	194.44	194.98	195.18	195.95	
Castlereagh_LB	29180	65	193.54	194.03	194.21	194.89	
Castlereagh_LB	29850	68	192.47	192.89	193.06	193.70	
Castlereagh_LB	30830	90	191.48	191.90	192.06	192.68	
Castlereagh_LB	31620	91	190.89	191.22	191.33	191.78	
Castlereagh_LB	32890	92	189.98	190.37	190.47	190.92	
Castlereagh_LB	33950	93	188.43	188.63	188.69	188.98	
Castlereagh_LB	34920	94	187.34	187.52	187.58	187.79	
Castlereagh_LB	36060	195	186.74	186.93	187.00	187.28	
Castlereagh_LB	36910	103	186.66	186.84	186.91	187.17	
Castlereagh_LB	38130	122	185.87	185.97	186.01	186.16	
Castlereagh_LB	38430	111	184.92	185.07	185.15	185.36	
Castlereagh_LB	38860	123	184.05	184.12	184.15	184.28	
Castlereagh_LB	39170	112	183.57	183.77	183.79	183.90	
Castlereagh_LB	39870	113	181.68	181.82	181.87	182.05	
Castlereagh_LB	40440	124	180.60	180.70	180.74	180.87	
Castlereagh_LB	40750	125	180.04	180.12	180.16	180.29	
Castlereagh_LB	40770	126	180.00	180.08	180.11	180.25	



MIKE11 Flowpath	MIKE11 Chainage (m)	Cross Section <sup>1</sup>	Peak Water Level (mAHD)				Remarks
			5% AEP	1% AEP	0.5% AEP	Extreme	
Castlereagh_LB	41160	131	179.46	179.55	179.59	179.71	
Castlereagh_LB	41590	132	178.85	178.95	178.98	179.11	
Castlereagh_LB	42140	133	177.95	178.04	178.08	178.21	
Castlereagh_LB	42590	135	177.27	177.35	177.38	177.49	
Castlereagh_LB	43120	134	176.56	176.63	176.66	176.76	
Castlereagh_LB	43210	136	176.21	176.31	176.35	176.47	
Castlereagh_LB	43900	138	175.34	175.44	175.48	175.64	
Castlereagh_LB	44160	139	175.06	175.16	175.20	175.35	
Castlereagh_RB	10000	100013	214.48	215.89	216.24	217.69	
Castlereagh_RB	15300	100023	208.33	209.24	209.43	210.07	
Castlereagh_RB	20400	100053	203.82	205.19	205.47	206.53	
Castlereagh_RB	27200	100073	196.76	197.40	197.58	198.23	
Castlereagh_RB	29640	66	193.54	194.70	195.05	196.37	
Castlereagh_RB	29790	178	193.52	194.66	195.01	196.31	
Castlereagh_RB	30410	180	193.39	194.36	194.66	195.81	
Castlereagh_RB	30750	171	193.02	193.79	194.03	195.03	
Castlereagh_RB	31100	177	192.79	193.48	193.69	194.57	
Castlereagh_RB	32975	189	190.35	190.75	190.87	191.34	
Castlereagh_RB	35500	10013	186.02	186.32	186.42	186.86	
Castlereagh_RB	36950	173	184.47	184.94	185.09	185.77	
Castlereagh_RB	37400	190	183.90	184.40	184.57	185.30	
Castlereagh_RB	37900	191	183.59	184.10	184.28	185.02	
Castlereagh_RB	38470	192	182.87	183.53	183.73	184.55	
Castlereagh_RB	39180	193	182.50	183.16	183.36	184.21	
Castlereagh_RB	39730	22	182.29	182.88	183.06	183.92	
Castlereagh_RB	41400	185	180.71	181.31	181.66	183.02	
Castlereagh_RB	42000	1018	180.47	181.08	181.42	182.83	
Castlereagh_RB	42600	10201	180.34	180.91	181.24	182.71	
Castlereagh_RB	43700	1001	179.60	180.49	180.89	182.20	
Durham_St	0	1022	180.99	180.99	180.99	180.99	
Durham_St	255	1023	180.35	180.35	180.35	180.35	
Eurimie_Ck	0	1011	180.13	180.15	180.18	180.59	
Eurimie_Ck	380	1012	179.87	179.90	179.94	180.47	
Eurimie_Ck	650	1013	179.74	179.78	179.83	180.43	
Eurimie_Ck	880	1015	179.67	179.71	179.76	180.40	
Eurimie_Ck	1140	10101	179.46	179.51	179.59	180.37	
Eurimie_Ck	1210	187	179.36	179.39	179.44	180.14	
Eurimie_Ck	1540	158	179.09	179.14	179.21	180.02	
Eurimie_Ck	1790	186	178.85	178.90	178.97	179.78	
Eurimie_Ck	2300	159	178.33	178.40	178.50	179.37	
Eurimie_Ck	2940	162	178.03	178.11	178.21	179.04	
Eurimie_Ck	3490	160	177.85	177.91	177.99	178.71	
Geamoney_Breakout	820	95	186.71	186.75	186.76	186.81	



MIKE11 Flowpath	MIKE11 Chainage (m)	Cross Section <sup>1</sup>	Peak Water Level (mAHD)				Remarks
			5% AEP	1% AEP	0.5% AEP	Extreme	
Geamoney_Breakout	915	96	185.98	186.08	186.10	186.20	
McMahon_St	0	1043	180.69	180.69	180.69	180.69	
McMahon_St	660	1046	179.68	179.68	179.68	179.68	
Quanmoona_St	0	1029	179.41	179.47	179.48	179.52	
Quanmoona_St	470	1031	179.41	179.47	179.48	179.52	
Railway_St	0	1026	181.90	181.90	181.90	181.90	
Railway_St	190	1027	180.20	180.20	180.20	180.20	
Railway_St	410	1028	179.41	179.47	179.48	179.52	
Railway_St	990	1050	179.93	179.93	179.93	180.10	
Railway_St	1500	1052	179.42	179.42	179.42	179.42	
Railway_St	2010	206	178.92	178.92	178.92	178.92	
Railway_St	2055	207	178.33	178.33	178.33	178.33	
Railway_St	2115	209	178.24	178.24	178.25	178.25	
Railway_St	2210	210	178.10	178.10	178.10	178.10	
Railway_St	2260	212	176.97	177.03	177.04	177.10	
Railway_St	2510	213	176.97	177.03	177.04	177.10	
Railway_St	2730	214	176.97	177.03	177.04	177.10	
Railway_St	3000	215	176.97	177.03	177.04	177.10	
Reid_St	0	1032	179.93	179.94	179.93	180.10	
Reid_St	640	1049	179.93	179.94	179.93	180.10	
Warrena	0	100032	212.61	212.99	213.26	214.22	
Warrena	5300	100042	204.86	205.39	205.54	206.18	
Warrena	10000	100062	198.27	200.18	200.48	201.40	
Warrena	16000	100082	190.49	193.49	194.14	195.44	
Warrena	20700	100142	184.40	188.44	188.69	189.85	
Warrena	28400	10202	180.47	181.17	181.44	182.80	
Warrena	31310	1002	179.60	180.49	180.89	182.20	
Warrena	31750	1005	179.36	180.23	180.62	181.89	
Warrena	32450	1004	179.05	179.87	180.24	181.42	
Warrena	32750	1003	178.86	179.65	180.00	181.15	
Warrena	33090	1061	178.64	179.34	179.67	180.82	
Warrena	33500	10092	178.51	179.09	179.38	180.46	
Warrena_LB	0	100031	205.25	206.06	206.33	207.15	
Warrena_LB	1100	100041	204.87	205.47	205.63	206.26	
Warrena_LB	5800	100061	199.79	200.64	200.86	201.51	
Warrena_LB	11300	100081	194.01	194.70	194.83	195.43	
Warrena_LB	16300	100141	187.54	188.10	188.23	188.72	
Warrena_LB	22600	10171	181.32	181.83	182.17	183.40	
Wilga_Glen_Rd	0	1057	183.81	183.81	183.81	183.82	
Wilga_Glen_Rd	577	1059	182.51	182.51	182.51	182.51	
Wilga_Glen_Rd	1305	1060	181.67	181.71	181.72	181.76	

<sup>1</sup> Refer to **Figure C-2a** and **Figure C-2b** for location of cross section



Table C-2 : Modelled Peak Discharges

MIKE11 Flowpath	MIKE11 Chainage (m)	Peak Discharge(m <sup>3</sup> /s)				Remarks
		5% AEP	1% AEP	0.5% AEP	Extreme	
6MILE_BREAKOUT	100	84	123	140	202	
6MILE_BREAKOUT	245	87	118	131	202	
6MILE_BREAKOUT	335	87	118	131	202	
6MILE_BREAKOUT	375	87	118	131	202	
6MILE_BREAKOUT	505	87	118	131	202	
6MILE_BREAKOUT	935	87	118	131	202	
6MILE_BREAKOUT	1445	182	600	794	1,644	
6MILE_BREAKOUT	1810	182	600	794	1,644	
6MILE_BREAKOUT	2270	182	600	794	1,644	
6MILE_BREAKOUT	2935	182	599	794	1,644	
6MILE_BREAKOUT	3615	208	635	834	1,703	
6MILE_BREAKOUT	4205	208	635	833	1,703	
6MILE_BREAKOUT	4675	208	635	833	1,703	
6MILE_BREAKOUT	5080	208	635	833	1,702	
6MILE_BREAKOUT	5555	208	635	833	1,702	
6MILE_BREAKOUT	6015	208	635	833	1,703	
6MILE_BREAKOUT	6650	208	635	833	1,702	
6MILE_BREAKOUT	7300	207	634	832	1,700	
6MILE_BREAKOUT	7855	207	634	832	1,699	
6MILE_BREAKOUT	8410	206	633	831	1,697	
6MILE_BREAKOUT	8955	214	594	766	1,614	
6MILE_BREAKOUT	9650	214	594	765	1,612	
6MILE_BREAKOUT	10340	213	594	765	1,609	
9MILE_BREAKOUT	100	176	246	283	422	
9MILE_BREAKOUT	330	176	246	283	420	
9MILE_BREAKOUT	560	176	245	282	415	
9MILE_BREAKOUT	625	176	245	281	413	
9MILE_BREAKOUT	737.5	176	244	281	411	
9MILE_BREAKOUT	1145	175	243	280	404	
BARTON_ST	360	0	0	0	0	
BARTON_ST	780	0	0	0	0	
BERTRAM_ST	390	0	0	0	0	
BERTRAM_ST	840	0	0	0	0	
CASTLEREAGH	9750	2,268	4,922	6,399	14,768	Upstream Inflow
CASTLEREAGH	10500	2,187	2,787	3,089	5,073	
CASTLEREAGH	11500	2,184	2,786	3,088	5,071	
CASTLEREAGH	12500	2,180	2,785	3,086	5,069	
CASTLEREAGH	13500	2,178	2,784	3,085	5,066	
CASTLEREAGH	14483.33	2,213	3,202	3,576	5,602	
CASTLEREAGH	15450	2,212	3,202	3,576	5,599	
CASTLEREAGH	16416.67	2,211	3,201	3,576	5,601	
CASTLEREAGH	17250	2,210	3,310	3,907	6,870	
CASTLEREAGH	17950	2,209	3,310	3,908	6,868	
CASTLEREAGH	18650	2,208	3,308	3,907	6,866	
CASTLEREAGH	19425	2,159	2,917	3,243	4,485	
CASTLEREAGH	20275	2,159	2,912	3,241	4,481	
CASTLEREAGH	21125	2,158	2,909	3,238	4,478	
CASTLEREAGH	21975	2,157	2,907	3,237	4,476	
CASTLEREAGH	22892.86	1,995	2,589	2,877	4,058	
CASTLEREAGH	23878.57	1,995	2,587	2,876	4,056	
CASTLEREAGH	24864.29	1,994	2,587	2,875	4,056	
CASTLEREAGH	25850	1,994	2,587	2,875	4,056	
CASTLEREAGH	26835.71	1,994	2,586	2,875	4,056	
CASTLEREAGH	27821.43	1,994	2,586	2,875	4,056	
CASTLEREAGH	28807.14	1,994	2,586	2,875	4,055	
CASTLEREAGH	29310	1,187	1,333	1,405	1,715	Combara Bridge



MIKE11 Flowpath	MIKE11 Chainage (m)	Peak Discharge(m³/s)				Remarks
		5% AEP	1% AEP	0.5% AEP	Extreme	
CASTLEREAGH	29686.67	1,187	1,333	1,405	1,715	
CASTLEREAGH	30420	1,187	1,333	1,405	1,715	
CASTLEREAGH	31153.33	1,187	1,333	1,405	1,715	
CASTLEREAGH	31850	1,011	1,082	1,113	1,268	
CASTLEREAGH	32360	923	965	983	1,066	
CASTLEREAGH	32945	923	965	983	1,066	
CASTLEREAGH	33835	923	965	983	1,066	
CASTLEREAGH	34638.75	868	892	902	947	
CASTLEREAGH	35276.25	868	892	902	947	
CASTLEREAGH	35872.5	851	868	876	908	
CASTLEREAGH	36427.5	851	868	876	908	
CASTLEREAGH	37162.5	851	868	876	908	
CASTLEREAGH	37860	820	832	837	858	
CASTLEREAGH	38420	820	832	837	858	
CASTLEREAGH	38925	803	812	815	831	
CASTLEREAGH	39320	803	812	815	831	
CASTLEREAGH	39780	803	812	815	831	
CASTLEREAGH	40350	797	804	807	820	
CASTLEREAGH	40900	797	804	807	820	
CASTLEREAGH	41405	797	804	807	820	
CASTLEREAGH	41880	787	794	796	806	
CASTLEREAGH	42255	787	794	796	806	
CASTLEREAGH	42605	787	793	796	806	
CASTLEREAGH	43040	784	790	792	800	
CASTLEREAGH	43500	784	790	792	800	
CASTLEREAGH	44050	782	787	789	797	
CASTLEREAGH	44650	772	776	778	784	
CASTLEREAGH	45310	772	776	778	784	
CASTLEREAGH	45995	772	776	779	786	
CASTLEREAGH	46420	772	776	778	784	
CASTLEREAGH	46720	772	776	778	784	
CASTLEREAGH	47010	772	776	778	784	
CASTLEREAGH	47290	772	776	778	786	
CASTLEREAGH	47585	772	776	779	797	
CASTLEREAGH	47925	772	776	788	794	
CASTLEREAGH	48120	772	776	788	794	Aberford St Bridge
CASTLEREAGH	48290	772	776	781	800	
CASTLEREAGH	48580	748	752	753	757	
CASTLEREAGH	48890	748	752	753	757	
CASTLEREAGH	49285	748	752	752	754	
CASTLEREAGH	49850	1,321	2,640	3,581	8,526	Warrena Creek joins
CASTLEREAGH	50550	1,321	2,640	3,581	8,525	
CASTLEREAGH	51400	1,321	2,639	3,580	8,523	
CASTLEREAGH	52400	1,321	2,639	3,580	8,509	
CASTLEREAGH	53400	1,322	2,641	3,578	8,460	
CASTLEREAGH	54400	1,320	2,617	3,567	8,361	
CASTLEREAGH	55400	1,324	2,543	3,547	8,264	
CASTLEREAGH	56400	1,312	2,470	3,531	8,210	
CASTLEREAGH_LB	10440	0	1,065	1,844	6,074	
CASTLEREAGH_LB	11320	0	1,063	1,839	6,060	
CASTLEREAGH_LB	12200	0	1,056	1,835	6,058	
CASTLEREAGH_LB	13080	0	1,055	1,833	6,059	
CASTLEREAGH_LB	13960	0	1,053	1,831	6,053	
CASTLEREAGH_LB	14875	0	936	1,488	4,709	
CASTLEREAGH_LB	15825	0	933	1,486	4,702	
CASTLEREAGH_LB	16775	-1	931	1,482	4,700	
CASTLEREAGH_LB	17725	-1	930	1,482	4,697	
CASTLEREAGH_LB	18675	-3	928	1,480	4,694	



MIKE11 Flowpath	MIKE11 Chainage (m)	Peak Discharge(m <sup>3</sup> /s)				Remarks
		5% AEP	1% AEP	0.5% AEP	Extreme	
CASTLEREAGH_LB	19625	-6	928	1,480	4,693	
CASTLEREAGH_LB	20542.86	66	605	872	2,345	
CASTLEREAGH_LB	21428.57	66	605	873	2,345	
CASTLEREAGH_LB	22314.29	65	604	873	2,345	
CASTLEREAGH_LB	23200	65	605	872	2,344	
CASTLEREAGH_LB	24085.71	67	604	872	2,343	
CASTLEREAGH_LB	24971.43	65	605	872	2,342	
CASTLEREAGH_LB	25857.14	65	603	871	2,340	
CASTLEREAGH_LB	26693.33	591	1,176	1,454	2,816	
CASTLEREAGH_LB	27480	591	1,173	1,452	2,814	
CASTLEREAGH_LB	28266.67	590	1,173	1,452	2,812	
CASTLEREAGH_LB	28920	590	1,177	1,460	2,862	
CASTLEREAGH_LB	29515	590	1,176	1,460	2,862	
CASTLEREAGH_LB	30340	590	1,177	1,459	2,863	
CASTLEREAGH_LB	31225	590	1,175	1,458	2,861	
CASTLEREAGH_LB	31937.5	615	963	1,086	1,737	
CASTLEREAGH_LB	32572.5	614	963	1,086	1,738	
CASTLEREAGH_LB	33155	631	985	1,111	1,777	
CASTLEREAGH_LB	33685	630	986	1,111	1,777	
CASTLEREAGH_LB	34435	229	323	353	509	
CASTLEREAGH_LB	35205	99	150	174	279	
CASTLEREAGH_LB	35775	99	148	172	278	
CASTLEREAGH_LB	36485	113	167	192	304	
CASTLEREAGH_LB	37215	113	167	192	304	
CASTLEREAGH_LB	37825	113	167	192	304	
CASTLEREAGH_LB	38280	113	167	192	304	
CASTLEREAGH_LB	38645	113	167	192	304	
CASTLEREAGH_LB	39150	113	167	192	304	Railway
CASTLEREAGH_LB	39520	113	167	192	304	
CASTLEREAGH_LB	40155	113	167	192	304	
CASTLEREAGH_LB	40595	113	167	192	304	
CASTLEREAGH_LB	40760	113	167	192	304	
CASTLEREAGH_LB	40965	113	167	192	304	
CASTLEREAGH_LB	41375	124	181	207	323	
CASTLEREAGH_LB	41865	124	181	207	323	
CASTLEREAGH_LB	42365	124	180	207	323	
CASTLEREAGH_LB	42855	124	180	207	323	
CASTLEREAGH_LB	43140	124	180	207	323	Quambone Road
CASTLEREAGH_LB	43555	124	180	207	323	
CASTLEREAGH_LB	44030	123	180	206	323	
CASTLEREAGH_RB	10400	81	1,065	1,461	3,616	
CASTLEREAGH_RB	11200	82	1,062	1,458	3,612	
CASTLEREAGH_RB	12000	77	1,062	1,458	3,609	
CASTLEREAGH_RB	12883.33	30	627	895	2,174	
CASTLEREAGH_RB	13850	30	626	895	2,173	
CASTLEREAGH_RB	14816.67	30	625	894	2,175	
CASTLEREAGH_RB	15716.67	28	283	387	943	
CASTLEREAGH_RB	16550	28	283	387	942	
CASTLEREAGH_RB	17383.33	26	283	386	941	
CASTLEREAGH_RB	18233.33	54	370	479	951	
CASTLEREAGH_RB	19100	53	369	478	950	
CASTLEREAGH_RB	19966.67	53	369	478	949	
CASTLEREAGH_RB	20885.71	138	605	797	1,823	
CASTLEREAGH_RB	21857.14	138	605	796	1,824	
CASTLEREAGH_RB	22828.57	137	604	796	1,823	
CASTLEREAGH_RB	23800	137	604	796	1,822	
CASTLEREAGH_RB	24771.43	136	604	795	1,822	
CASTLEREAGH_RB	25742.86	136	604	795	1,822	



MIKE11 Flowpath	MIKE11 Chainage (m)	Peak Discharge(m³/s)				Remarks
		5% AEP	1% AEP	0.5% AEP	Extreme	
CASTLEREAGH_RB	26714.29	135	603	794	1,821	Tooraweenah Road
CASTLEREAGH_RB	27606.67	191	848	1,130	2,521	
CASTLEREAGH_RB	28420	191	848	1,130	2,520	
CASTLEREAGH_RB	29233.33	190	846	1,128	2,516	
CASTLEREAGH_RB	29715	190	845	1,128	2,516	
CASTLEREAGH_RB	30100	190	845	1,128	2,516	
CASTLEREAGH_RB	30580	357	1,088	1,408	2,909	
CASTLEREAGH_RB	30925	257	605	744	1,467	
CASTLEREAGH_RB	31568.75	257	605	743	1,467	
CASTLEREAGH_RB	32506.25	257	605	743	1,466	
CASTLEREAGH_RB	33395.83	257	604	742	1,454	
CASTLEREAGH_RB	34237.5	257	604	742	1,454	
CASTLEREAGH_RB	35079.17	257	604	742	1,454	
CASTLEREAGH_RB	35862.5	257	604	741	1,453	
CASTLEREAGH_RB	36587.5	256	604	741	1,452	
CASTLEREAGH_RB	37175	256	604	741	1,451	
CASTLEREAGH_RB	37650	256	603	740	1,450	
CASTLEREAGH_RB	38185	256	651	815	1,544	
CASTLEREAGH_RB	38825	256	651	815	1,542	
CASTLEREAGH_RB	39455	255	651	815	1,539	
CASTLEREAGH_RB	40190	468	1,245	1,580	3,143	
CASTLEREAGH_RB	41025	467	1,271	1,965	5,722	
CASTLEREAGH_RB	41700	465	1,268	1,960	5,700	
CASTLEREAGH_RB	42300	460	1,337	2,062	4,901	
CASTLEREAGH_RB	42900	457	1,334	2,059	4,845	
CASTLEREAGH_RB	43210	454	1,331	2,055	4,758	
CASTLEREAGH_RB	43460	429	1,279	1,956	4,590	
DURHAM_ST	127.5	0	0	0	0	
DURHAM_ST	598	0	0	0	0	
DURHAM_ST	980.5	-5	-4	-4	-5	
EURIMIE_CK	190	24	26	29	78	
EURIMIE_CK	515	24	26	29	78	
EURIMIE_CK	765	24	26	29	78	
EURIMIE_CK	1010	24	26	29	77	
EURIMIE_CK	1175	24	26	29	77	
EURIMIE_CK	1375	24	26	29	77	
EURIMIE_CK	1665	24	26	29	77	
EURIMIE_CK	2045	24	26	29	77	
EURIMIE_CK	2620	24	26	29	77	
EURIMIE_CK	3215	24	26	29	77	
GEAMONEY_BREAKOUT	410	159	209	217	279	
GEAMONEY_BREAKOUT	850	159	209	217	279	
MCPAHON_ST	330	0	0	0	0	
MCPAHON_ST	720	0	0	0	0	
QUANMOONA_ST	235	-2	-2	-2	-2	
QUANMOONA_ST	535	-2	-2	-2	-2	
RAIL_BREAKOUT1	50	28	248	412	1,182	
RAIL_BREAKOUT1	110	27	248	412	1,182	
RAIL_BREAKOUT1	160	13	248	412	1,182	
RAIL_BREAKOUT2	50	401	662	759	1,267	
RAIL_BREAKOUT2	110	401	662	759	1,267	
RAIL_BREAKOUT2	160	401	662	759	1,267	
RAIL_BREAKOUT3	50	188	428	546	1,157	
RAIL_BREAKOUT3	110	188	428	546	1,157	
RAIL_BREAKOUT3	160	188	428	546	1,157	
RAIL_BREAKOUT4	50	0	399	644	1,890	
RAIL_BREAKOUT4	110	0	399	644	1,890	
RAILWAY_ST	95	0	0	0	0	



MIKE11 Flowpath	MIKE11 Chainage (m)	Peak Discharge(m <sup>3</sup> /s)				Remarks
		5% AEP	1% AEP	0.5% AEP	Extreme	
RAILWAY_ST	300	0	0	0	0	
RAILWAY_ST	555	2	2	2	2	
RAILWAY_ST	845	0	0	0	0	
RAILWAY_ST	1115	0	0	0	0	
RAILWAY_ST	1370	0	0	0	0	
RAILWAY_ST	1625	0	0	0	0	
RAILWAY_ST	1800	0	0	0	0	
RAILWAY_ST	1930	0	0	0	0	
RAILWAY_ST	2032.5	0	0	0	0	
RAILWAY_ST	2095	0	0	0	0	
RAILWAY_ST	2162.5	0	0	0	0	
RAILWAY_ST	2220	0	0	0	0	
RAILWAY_ST	2385	0	0	0	0	
RAILWAY_ST	2620	0	0	0	0	
RAILWAY_ST	2865	0	0	0	0	
RAILWAY_ST	3160	0	0	0	0	
REID_ST	320	0	0	0	0	
REID_ST	700	0	0	0	0	
WARRENA	441.67	0	17	71	893	
WARRENA	1325	0	19	72	895	
WARRENA	2208.33	0	19	71	895	
WARRENA	3091.67	0	17	70	892	
WARRENA	3975	0	13	69	893	
WARRENA	4858.33	0	13	69	892	
WARRENA	5770	13	526	898	3,510	
WARRENA	6710	12	525	897	3,505	
WARRENA	7650	11	525	898	3,504	
WARRENA	8590	11	524	891	3,502	
WARRENA	9530	10	523	888	3,498	
WARRENA	10500	10	523	887	3,595	
WARRENA	11500	10	522	886	3,592	
WARRENA	12500	10	522	887	3,588	
WARRENA	13500	10	522	884	3,584	
WARRENA	14500	10	521	879	3,579	
WARRENA	15500	9	519	876	3,578	
WARRENA	16470	9	519	900	3,375	
WARRENA	17410	9	518	902	3,376	
WARRENA	18350	9	518	894	3,375	
WARRENA	19290	9	518	875	3,372	
WARRENA	20230	9	517	873	3,374	
WARRENA	20705	9	540	873	3,350	
WARRENA	21192.5	9	516	873	3,346	
WARRENA	22157.5	9	515	873	3,343	
WARRENA	23122.5	9	515	871	3,338	
WARRENA	24087.5	9	513	870	3,330	
WARRENA	25052.5	9	510	869	3,325	
WARRENA	26017.5	96	659	1,091	3,574	
WARRENA	26505	97	629	882	2,106	
WARRENA	26982.5	97	629	882	2,107	
WARRENA	27927.5	323	830	1,185	2,539	
WARRENA	28885	319	754	992	3,326	
WARRENA	29855	312	743	971	3,297	
WARRENA	30825	302	707	924	3,272	
WARRENA	31530	583	1,894	2,838	7,830	
WARRENA	32100	583	1,894	2,837	7,830	
WARRENA	32455	582	1,893	2,836	7,829	Warrana Weir
WARRENA	32605	582	1,893	2,835	7,828	
WARRENA	32755	582	1,893	2,834	7,828	
WARRENA						



MIKE11 Flowpath	MIKE11 Chainage (m)	Peak Discharge(m <sup>3</sup> /s)				Remarks
		5% AEP	1% AEP	0.5% AEP	Extreme	
WARRENA	32925	582	1,892	2,834	7,827	
WARRENA	33295	581	1,892	2,835	7,826	
WARRENA_LB	275	0	124	245	1,054	
WARRENA_LB	825	0	124	245	1,053	
WARRENA_LB	1570	0	124	245	1,044	
WARRENA_LB	2510	0	123	245	1,044	
WARRENA_LB	3450	0	122	245	1,042	
WARRENA_LB	4390	0	124	245	1,043	
WARRENA_LB	5330	0	123	245	1,042	
WARRENA_LB	6258.33	0	124	244	945	
WARRENA_LB	7175	0	126	245	945	
WARRENA_LB	8091.67	0	129	245	945	
WARRENA_LB	9008.33	0	132	244	944	
WARRENA_LB	9925	0	135	251	944	
WARRENA_LB	10841.67	0	133	249	944	
WARRENA_LB	11800	0	133	230	1,143	
WARRENA_LB	12800	0	134	236	1,144	
WARRENA_LB	13800	0	138	245	1,143	
WARRENA_LB	14800	0	136	253	1,143	
WARRENA_LB	15800	0	134	252	1,143	
WARRENA_LB	16750	0	132	253	1,170	
WARRENA_LB	17650	0	132	259	1,171	
WARRENA_LB	18550	0	135	256	1,171	
WARRENA_LB	19450	0	141	261	1,169	
WARRENA_LB	20350	0	140	259	1,168	
WARRENA_LB	21250	0	138	250	1,164	
WARRENA_LB	22150	-15	138	248	1,161	
WILGA_GLEN_RD	288.5	2	3	3	3	
WILGA_GLEN_RD	941	2	3	3	3	
WILGA_GLEN_RD	1377.5	-4	-4	-3	-3	



Table C-3 : Modelled Peak Velocities

MIKE11 Flowpath	MIKE11 Chainage (m)	Cross Section <sup>1</sup>	Peak Velocity (m/s)				Remarks
			5% AEP	1% AEP	0.5% AEP	Extreme	
6Mile_Breakout	170	73	0.80	0.88	0.89	1.04	
6Mile_Breakout	320	75	0.78	0.87	0.90	1.05	
6Mile_Breakout	350	77	0.78	0.86	0.89	1.00	
6Mile_Breakout	400	78	0.61	0.69	0.73	0.87	
6Mile_Breakout	610	179	0.76	0.85	0.87	0.89	
6Mile_Breakout	1260	80	0.58	0.57	0.56	0.57	
6Mile_Breakout	1630	174	0.77	1.17	1.28	1.69	
6Mile_Breakout	1990	82	0.49	0.84	0.93	1.25	
6Mile_Breakout	2550	175	0.72	0.59	0.64	1.50	
6Mile_Breakout	3320	83	0.69	0.73	0.79	0.95	
6Mile_Breakout	3910	176	0.61	0.58	0.64	0.83	
6Mile_Breakout	4500	84	0.45	0.61	0.67	0.85	
6Mile_Breakout	4850	184	0.47	0.61	0.65	0.81	
6Mile_Breakout	5310	85	0.46	0.59	0.64	0.79	
6Mile_Breakout	5800	183	0.64	0.65	0.67	0.83	
6Mile_Breakout	6230	194	0.59	0.61	0.66	0.79	
6Mile_Breakout	7070	182	0.58	0.60	0.70	0.75	
6Mile_Breakout	7530	86	0.56	0.63	0.68	0.80	
6Mile_Breakout	8180	181	0.44	0.43	0.43	0.52	
6Mile_Breakout	8640	87	0.52	0.77	0.84	1.01	
6Mile_Breakout	9270	89	0.58	0.52	0.56	0.71	
6Mile_Breakout	10030	88	0.35	0.51	0.55	0.71	
9mile_Breakout	825	196	0.78	0.77	0.77	0.79	
Airport	400	140	0.50	0.52	0.55	0.37	
Airport	830	141	0.20	0.21	0.21	0.22	
Airport	930	142	0.23	0.26	0.28	0.22	
Airport	1160	143	1.19	1.18	1.15	0.81	
Airport	1870	144	0.27	0.26	0.25	0.27	
Airport	2060	146	0.35	0.30	0.29	0.32	
Airport	2190	147	0.04	0.03	0.03	0.04	
Airport	2265	199	0.18	0.20	0.21	0.23	
Airport	2420	200	0.61	0.66	0.68	0.75	
Airport	2600	201	0.20	0.21	0.21	0.24	
Airport	2700	202	0.18	0.19	0.20	0.22	
Airport	2780	203	0.21	0.22	0.23	0.26	
Airport	2820	204	0.22	0.24	0.24	0.27	
Airport	3100	205	0.66	0.62	0.62	0.64	
Airport	3320	152	0.06	0.07	0.08	0.09	
Airport	3380	217	0.26	0.27	0.27	0.29	
Airport	3650	153	0.15	0.15	0.15	0.16	
Airport	3930	154	0.27	0.27	0.28	0.29	



MIKE11 Flowpath	MIKE11 Chainage (m)	Cross Section <sup>1</sup>	Peak Velocity (m/s)				Remarks
			5% AEP	1% AEP	0.5% AEP	Extreme	
Airport	3960	155	0.28	0.30	0.29	0.33	
Airport	4680	216	0.68	0.68	0.68	0.68	
Airport	5110	156	0.24	0.24	0.23	0.24	
Airport	5550	157	0.60	0.44	0.48	0.43	
Airport	6320	161	0.15	0.17	0.17	0.18	
Barton_St	0	1039	0.00	0.00	0.00	0.00	
Barton_St	720	1037	0.00	0.00	0.00	0.00	
Bend	340	118	0.08	0.13	0.15	0.25	
Bend	660	117	-0.10	-0.10	-0.09	-0.10	
Bend	1000	107	0.34	0.42	0.36	0.33	
Bend	1470	119	-0.69	-0.86	-0.23	0.20	
Bend	1890	109	0.39	0.24	0.20	0.30	
Bend	2280	114	-0.17	0.13	0.12	0.13	
Bend	2740	116	0.53	0.54	0.55	0.58	
Bend	3290	127	2.67	2.44	1.92	2.70	
Bend	3500	129	0.30	0.33	0.33	0.33	
Bend	3940	130	2.99	2.99	5.91	5.91	
Bertram_St	0	1040	0.00	0.00	0.00	0.06	
Bertram_St	780	1038	0.00	0.00	0.00	-2.29	
Bypass_Railway_St	250	149	-0.15	-0.18	-0.14	-0.12	
Bypass_Railway_St	315	197	-0.25	-0.25	-0.24	-0.25	
Bypass_Railway_St	480	150	-0.12	-0.05	-0.07	-0.08	
Bypass_Railway_St	500	198	-0.17	-0.10	-0.12	-0.13	
Bypass_Railway_St	560	151	0.53	-0.27	-0.26	-0.24	
Castlereagh	10000	100012	1.71	1.76	1.72	2.12	
Castlereagh	16900	100022	1.29	1.27	1.28	1.39	
Castlereagh	20700		1.00	1.11	1.14	1.23	"Horans"
Castlereagh	22400	100052	1.30	1.50	1.55	1.65	
Castlereagh	29300		1.99	2.09	2.14	2.33	U/S Combara Br
Castlereagh	29320	100072	1.99	2.09	2.14	2.33	D/S Combara Br
Castlereagh	31520	70	2.05	2.21	2.29	2.60	
Castlereagh	32180	72	1.85	1.88	1.90	1.96	
Castlereagh	32540	69	1.63	1.65	1.66	1.70	
Castlereagh	33350	44	1.42	1.44	1.45	1.50	
Castlereagh	34320	97	1.58	1.62	1.64	1.73	
Castlereagh	35595	98	1.50	1.52	1.53	1.57	
Castlereagh	36705	99	1.82	1.83	1.84	1.86	
Castlereagh	37620	100	1.43	1.45	1.46	1.49	
Castlereagh	38100	108	1.47	1.48	1.48	1.50	
Castlereagh	38740	102	1.72	1.73	1.73	1.75	
Castlereagh	39110	104	1.45	1.45	1.45	1.47	
Castlereagh	39530	121	1.88	1.89	1.90	1.92	
Castlereagh	40030	167	1.58	1.59	1.60	1.61	



MIKE11 Flowpath	MIKE11 Chainage (m)	Cross Section <sup>1</sup>	Peak Velocity (m/s)				Remarks
			5% AEP	1% AEP	0.5% AEP	Extreme	
Castlereagh	40670	106	1.83	1.84	1.85	1.86	
Castlereagh	41130	166	1.49	1.49	1.50	1.51	
Castlereagh	41680	105	1.55	1.56	1.56	1.58	
Castlereagh	42080	163	1.79	1.80	1.80	1.82	
Castlereagh	42430	110	1.29	1.29	1.31	1.38	
Castlereagh	42780	164	1.70	1.71	1.71	1.72	
Castlereagh	43300	165	1.59	1.58	1.59	1.60	
Castlereagh	43700	168	1.33	1.32	1.33	1.35	
Castlereagh	44400	169	1.70	1.69	1.69	1.70	
Castlereagh	44900	170	2.10	2.09	2.10	2.10	
Castlereagh	45720	1019	1.74	1.74	1.74	1.79	
Castlereagh	46270	1025	1.42	1.42	1.42	1.43	
Castlereagh	46870	1053	2.62	2.63	2.63	2.63	
Castlereagh	47430	1054	1.47	1.47	1.47	1.48	
Castlereagh	47740	1055	2.62	2.62	2.64	2.65	
Castlereagh	48110	10102	2.36	2.37	2.39	3.15	U/S Aberford St Bridge
Castlereagh	48130		2.37	2.38	2.40	3.01	D/S Aberford St Bridge
Castlereagh	48450	1056	1.26	1.27	1.27	1.27	
Castlereagh	48710	1016	1.58	1.58	1.59	1.59	
Castlereagh	49070	1021	2.16	2.18	2.18	2.19	
Castlereagh	49500	10091	1.98	2.09	2.11	2.12	
Castlereagh	50900	1008	1.13	1.14	1.14	1.24	
Castlereagh_LB	10000	100011	0.00	0.87	1.07	1.10	
Castlereagh_LB	14400	100021	0.00	0.80	0.79	1.16	
Castlereagh_LB	20100	100051	-1.43	1.68	2.20	4.13	
Castlereagh_LB	26300	100071	-0.67	-0.46	-0.52	-0.62	
Castlereagh_LB	28660	67	0.74	0.95	1.03	1.37	
Castlereagh_LB	29180	65	0.95	1.24	1.34	1.80	
Castlereagh_LB	29850	68	0.65	0.73	0.79	1.00	
Castlereagh_LB	30830	90	0.65	0.63	0.68	0.83	
Castlereagh_LB	31620	91	0.47	0.64	0.72	1.01	
Castlereagh_LB	32890	92	0.65	0.72	0.74	0.83	
Castlereagh_LB	33950	93	1.10	1.34	1.41	1.66	
Castlereagh_LB	34920	94	1.31	1.31	1.31	1.30	
Castlereagh_LB	36060	195	0.09	0.10	0.11	0.14	
Castlereagh_LB	36910	103	0.37	0.43	0.46	0.56	
Castlereagh_LB	38130	122	0.61	0.66	0.68	0.77	
Castlereagh_LB	38430	111	0.52	0.58	0.59	0.62	
Castlereagh_LB	38860	123	0.56	0.70	0.71	0.74	
Castlereagh_LB	39170	112	0.73	0.72	0.73	0.73	
Castlereagh_LB	39870	113	0.52	0.56	0.58	0.65	
Castlereagh_LB	40440	124	0.38	0.43	0.44	0.51	
Castlereagh_LB	40750	125	0.38	0.42	0.44	0.49	



MIKE11 Flowpath	MIKE11 Chainage (m)	Cross Section <sup>1</sup>	Peak Velocity (m/s)				Remarks
			5% AEP	1% AEP	0.5% AEP	Extreme	
Castlereagh_LB	40770	126	0.42	0.48	0.50	0.60	
Castlereagh_LB	41160	131	0.28	0.32	0.33	0.41	
Castlereagh_LB	41590	132	0.43	0.45	0.47	0.52	
Castlereagh_LB	42140	133	0.32	0.37	0.39	0.47	
Castlereagh_LB	42590	135	0.50	0.50	0.53	0.53	
Castlereagh_LB	43120	134	0.20	0.25	0.27	0.35	
Castlereagh_LB	43210	136	0.33	0.35	0.36	0.41	
Castlereagh_LB	43900	138	0.34	0.39	0.40	0.46	
Castlereagh_LB	44160	139	0.31	0.36	0.37	0.43	
Castlereagh_RB	10000	100013	0.76	2.30	0.98	1.40	
Castlereagh_RB	15300	100023	0.40	1.20	1.36	1.94	
Castlereagh_RB	20400	100053	-0.36	0.63	0.67	0.84	
Castlereagh_RB	27200	100073	-0.38	0.48	0.53	0.73	
Castlereagh_RB	29640	66	0.30	0.45	0.49	0.62	
Castlereagh_RB	29790	178	0.22	0.50	0.58	0.87	
Castlereagh_RB	30410	180	0.52	1.25	1.46	2.22	
Castlereagh_RB	30750	171	0.61	1.20	1.40	2.06	
Castlereagh_RB	31100	177	0.96	1.44	1.59	2.22	
Castlereagh_RB	32975	189	0.79	0.83	1.03	1.19	
Castlereagh_RB	35500	10013	0.68	0.52	0.56	0.66	
Castlereagh_RB	36950	173	0.86	1.16	1.25	1.59	
Castlereagh_RB	37400	190	0.36	0.50	0.54	0.72	
Castlereagh_RB	37900	191	0.91	0.64	0.94	0.82	
Castlereagh_RB	38470	192	0.81	0.80	0.84	1.08	
Castlereagh_RB	39180	193	0.32	0.48	0.53	0.67	
Castlereagh_RB	39730	22	0.47	0.77	0.87	1.14	
Castlereagh_RB	41400	185	0.44	0.60	0.69	1.06	
Castlereagh_RB	42000	1018	0.29	0.64	0.63	0.62	
Castlereagh_RB	42600	10201	0.44	0.45	1.25	0.89	
Castlereagh_RB	43700	1001	0.27	0.37	0.43	0.51	
Durham_St	0	1022	0.00	0.00	0.00	0.00	
Durham_St	255	1023	0.34	0.34	0.11	0.11	
Eurimie_Ck	0	1011	0.45	0.46	0.47	0.44	
Eurimie_Ck	380	1012	0.42	0.34	0.34	0.50	
Eurimie_Ck	650	1013	0.27	0.26	0.27	0.34	
Eurimie_Ck	880	1015	0.32	0.31	0.31	0.43	
Eurimie_Ck	1140	10101	0.30	0.30	0.30	0.40	
Eurimie_Ck	1210	187	0.42	0.40	0.41	0.43	
Eurimie_Ck	1540	158	0.54	0.55	0.57	0.65	
Eurimie_Ck	1790	186	0.59	0.61	0.62	0.80	
Eurimie_Ck	2300	159	0.65	0.66	0.96	1.31	
Eurimie_Ck	2940	162	0.35	0.37	0.38	0.60	
Eurimie_Ck	3490	160	0.57	0.58	0.59	0.83	



MIKE11 Flowpath	MIKE11 Chainage (m)	Cross Section <sup>1</sup>	Peak Velocity (m/s)				Remarks
			5% AEP	1% AEP	0.5% AEP	Extreme	
Geamoney_Breakout	820	95	0.39	0.48	0.50	0.59	
Geamoney_Breakout	915	96	0.40	0.44	0.45	0.48	
McMahon_St	0	1043	0.00	0.00	0.00	0.00	
McMahon_St	660	1046	0.00	0.00	0.00	0.00	
Quanmoona_St	0	1029	0.00	0.00	0.00	0.00	
Quanmoona_St	470	1031	-0.53	-0.53	-0.53	-0.53	
Railway_St	0	1026	0.00	0.00	0.00	0.16	
Railway_St	190	1027	0.92	0.95	0.33	0.33	
Railway_St	410	1028	0.37	0.30	0.08	0.07	
Railway_St	990	1050	-0.08	-0.09	-0.17	-0.28	
Railway_St	1500	1052	0.01	0.01	0.01	0.01	
Railway_St	2010	206	0.00	0.00	0.00	0.00	
Railway_St	2055	207	0.01	0.01	0.01	0.01	
Railway_St	2115	209	0.00	0.00	0.00	0.00	
Railway_St	2210	210	0.00	0.00	0.00	0.00	
Railway_St	2260	212	-0.03	-0.03	-0.03	-0.03	
Railway_St	2510	213	-0.19	-0.18	-0.16	-0.17	
Railway_St	2730	214	-0.14	-0.14	-0.13	-0.14	
Railway_St	3000	215	-0.14	-0.13	-0.13	-0.14	
Reid_St	0	1032	0.00	0.00	0.00	0.00	
Reid_St	640	1049	0.02	0.02	-0.01	0.01	
Warrena	0	100032	0.00	0.48	0.58	1.33	
Warrena	5300	100042	0.14	-0.25	-0.31	0.27	
Warrena	10000	100062	1.42	2.29	0.86	1.26	
Warrena	16000	100082	0.60	1.14	1.19	1.19	
Warrena	20700	100142	0.77	1.97	2.06	2.04	
Warrena	28400	10202	1.52	1.63	1.73	1.36	
Warrena	31310	1002	0.39	0.42	0.45	0.39	
Warrena	31750	1005	0.44	0.61	0.68	0.93	
Warrena	32450	1004	0.38	0.49	0.57	0.84	
Warrena	32750	1003	0.76	0.80	0.86	1.06	
Warrena	33090	1061	0.32	0.54	0.64	0.92	
Warrena	33500	10092	0.49	0.58	-0.70	0.98	
Warrena_LB	0	100031	0.00	0.50	0.43	0.64	
Warrena_LB	1100	100041	0.00	0.52	0.99	0.83	
Warrena_LB	5800	100061	0.00	0.67	0.55	1.04	
Warrena_LB	11300	100081	0.00	1.24	0.88	1.56	
Warrena_LB	16300	100141	0.00	0.34	0.42	0.77	
Warrena_LB	22600	10171	2.10	2.10	0.72	0.72	
Wilga_Glen_Rd	0	1057	0.36	0.37	0.38	0.40	
Wilga_Glen_Rd	577	1059	3.67	3.72	3.66	0.86	
Wilga_Glen_Rd	1305	1060	1.04	1.01	0.84	0.85	

<sup>1</sup> Refer to **Figure C-2a** and **Figure C-2b** for location of cross section