URALLA SHIRE COUNCIL

ROCKY AND URALLA CREEKS FLOOD STUDY

FINAL REPORT

(Adopted by Council 23 June 2014)

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Version 4
Authorised for Release **Copy of**

30/6/2014

DOCUMENT CONTROL SHEET

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Job Name: Rocky and Uralla Creeks Flood Study

Job No.: 12-019

Original Date of Issue: February 2013

DOCUMENT DETAILS

Title:	Rocky and Uralla Creeks Flood Study
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REVISION / CHECKING HISTORY

Version Number	Version Name	Date	Issued By
1	Draft Report - Version 1 (as Progress Report)	June 2012	KWP
2	Draft Report - Version 2	February 2013	KWP
3	Draft Report – Version 3	December 2013	KWP
4	Final Report – Version 4	June 2014	KWP
5			
6			
7			
8			
9			

DISTRIBUTION RECORD

Destination	Version Number								
	1	2	3	4	5	6	7	8	9
Client (bound)			2						
Client (electronic)	1	1	1	1					
OEH (electronic)									
File Copy	1	1	1	1					
Paterson Consultants Library				1					

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GLOSSARY - Terms and Abbreviations

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. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a peak flood discharge of 500 m^3/s or larger occurring in any one year (see average recurrence interval).

annual flood series
is comprised of the highest instantaneous rate of discharge in each year of record. The highest flow in each year is selected, whether it is a major flood or not, and all other floods are neglected.

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 occurrence 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. This is the inverse of AEP and does not reflect the time elapsed between floods.

Floodplain Management Manual
the management of flood liable land development is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act).

disaster plan (DISPLAN)
a step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.

discharge
the rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).

GLOSSARY - Terms and Abbreviations (Cont)

ecologically sustainable development (ESD)
using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act 1993. The use of sustainability and sustainable in this manual are related to ESD.

effective warning time
the time available after receiving advice 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.

flash flooding
flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.

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 (ie) land susceptible to flooding by the probable maximum flood (PMF) event. Note that the term flood liable land now covers the whole of the floodplain, not just that part below the flood planning level, as indicated in the 1986 Floodplain Development Manual (see flood planning area).

flood mitigation standard
the average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.

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.

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 State Emergency Service.

flood planning levels (FPLs)
are the combinations of flood levels and freeboards selected for planning purposes, as determined in floodplain risk management studies and incorporated in floodplain risk management plans. The concept of flood planning levels supersedes the "standard flood event" of the 1986 edition of the Floodplain Development Manual.

GLOSSARY - Terms and Abbreviations (Cont)

flood prone land
is land susceptible to flooding by the probable maximum flood (PMF) event. Flood prone land is synonymous with flood liable land.

flood risk
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.

existing flood risk: the risk a community is exposed to as a result of its location on the floodplain.

future flood risk: the risk a community may be exposed to as a result of new development on the floodplain.

continuing flood risk: 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 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 the 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
a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. It is usually expressed as the difference in height between the adopted flood planning level and the flood used to determine the flood planning level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such and wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as "greenhouse" and climate change. Freeboard is included in the flood planning level.

hazard
a source of potential harm or a 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.

GLOSSARY - Terms and Abbreviations (Cont)

hydraulics
term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.

hydrograph
a graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.

hydrology
term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.

local overland flooding
inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam

Manual or Floodplain Development Manual
The New South Wales Government publication "Floodplain Development Manual", 1986

mathematical/computer models
the mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.

partial flood series
consists of all floods with peak discharges above a selected base value, regardless of the number of such floods occurring each year.

peak discharge
the maximum discharge occurring during a flood event.

probable maximum flood (PMF)
the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation. 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. The extent, nature and potential consequences of flooding associated with the PMF event should be addressed in a floodplain risk management study.

probable maximum precipitation (PMP)
the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to the estimation of the probable maximum flood.

GLOSSARY - Terms and Abbreviations (Cont)

probability
a statistical measure of the expected chance of flooding (see annual exceedance probability).

profile
a graph showing the flood stage at any given location along a water surface profile watercourse at a particular time

rating table
a relationship between flood level (as measured by gauge height) and flood flows, usually derived using actual flow measurements

Reduced Level (RL)
a measured height above Australian Height Datum

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.

runoff
the amount of rainfall which actually ends up as streamflow, also known as rainfall excess.

stage
equivalent to "water level". Both are measured with reference to a specified datum.

stage hydrograph
a graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.

wind fetch
the horizontal distance in the direction of wind over which wind waves are generated.

Organisations

ARTC: Australian Rail Track Corporation Ltd

BOM: Bureau of Meteorology

USC: Uralla Shire Council

DECC: Department of Environment and Climate Change

GLOSSARY - Terms and Abbreviations (Cont)

DLWC:	Department of Land and Water Conservation
DIPNR:	Department of Infrastructure Planning and Natural Resources
DMR:	Department of Main Roads
DWE:	Department of Water and Energy
DWR:	Department of Water Resources
HDWB:	Hunter District Water board
IPCC:	International Panel on Climate Change
MHL:	Manly Hydraulics Laboratory
OEH:	Office of Environment and Heritage
PWD:	NSW Public Works Department
RTA:	Roads and Traffic Authority
SES:	State Emergency Service
WC&IC:	Water Conservation and Irrigation Commission
WRC:	Water Resources Commission

ACKNOWLEDGEMENTS

This study has been undertaken by Paterson Consultants under the auspices of the Uralla Floodplain Risk Management Committee.

The Committee comprises representatives from:

- Elected representatives, Uralla Shire Council;
- Council officers, Uralla Shire Council;
- Nominated officers of State Emergency Services, Office of Environment and Heritage;
- Nominated community representatives.

The study has been funded by the NSW State Government and Uralla Shire Council on a 2:1 contribution basis under the State assisted floodplain management program.

Considerable assistance has been provided by local residents and Uralla Shire Council staff in preparation of this report.

Acknowledgement of their input is made for:

- Local Residents:
  - Mr A Good
  - Mr B Stubberfield
  - Mrs Nelson
  - Mrs Porter

- Council Staff:
  - Mr R Bell
  - Ms E Cumming
  - Mr S Finch
  - Ms S McCaffrey
  - Mr J Wolfenden
  - Mr H McMillan

FOREWORD

The New South Wales Government's Flood Prone Land Policy is directed at providing solutions to existing flooding problems in developed areas as well as ensuring that new development is compatible with the flood hazard and that it does not create additional flooding problems in other areas.

Under the policy, the management of flood-prone land remains the responsibility of local government. The State Government provides specialist technical advice and financial subsidies for studies and capital works to assist councils in the discharge of their floodplain management responsibilities.

The flood policy provides for technical and financial support by the government through the following four sequential stages:

* Stage 1 - Flood study:

  Determines the nature and extent of the flood problem.

* Stage 2 - Floodplain Risk Management Study:

  Evaluates management options for the floodplain in respect of both existing and proposed development.

* Stage 3 - Floodplain Risk Management Plan:

  Involves formal adoption by council of a plan of management for the floodplain.

* Stage 4 - Implementation of the plan:

  Involves construction of flood mitigation works to protect existing development and includes use of local environmental plans to ensure new development is compatible with the flood hazard.

The Rocky and Uralla Creeks Flood Study constitutes part of the first stage of the management process for Uralla. The Rocky and Uralla Creeks Flood Study has been prepared for Uralla Shire Council to determine an appropriate floodplain risk management strategy.

SUMMARY

The Rocky and Uralla Creeks Flood Study has been undertaken to provide flood information for establishment of a floodplain risk management plan for Uralla. The end use of this study will most likely be for the setting of development controls and addressing flood access issues.

The study area covers mainstream flooding from Rocky Creek and Uralla Creek and local overland flow flooding.

The study approach adopted involves:

- collection and assessment of flood data from government resources and resident interviews;

- definition of waterway areas along Rocky Creek and Uralla Creek by ground survey;

- establishment and calibration of an hydrologic model and a riverine hydraulic model to predict design flood levels for the 1% AEP, 5% AEP floods and the Probable Maximum Flood (PMF);

- presentation of design flood information as:

    - flood profiles for each of the design events;
    - tabulated values for each of the flood contours;
    - flood contours over cadastral maps for three of the seven design floods investigated.

Available flood information data comprises:

- previous studies and documents held by various government instrumentalities and Uralla Shire Council;

- flood data derived from site inspection and resident questionnaires.

As noted, available data for use in this flood study is sparse and can be summarised as:

- two daily rainfall stations with records commencing in 1901;

- no available pluviometers relevant to the catchment with respect to catchment size and location;

- no hydrographic stations nearby that can be used for calibration of any hydrological models;

- resident questionnaires and interviews yielded 13 (historical) flood level points that have been measured by ground survey;

- one resident identified the largest historical flood as peaking at 2100 hrs on 23 January 1976.

The two daily rainfall stations have, individually, incomplete records, but comparable rainfalls over periods where both stations have records has allowed a composite complete record to be developed.

Ranking of the one day rainfall shows 24 January 1976 as the highest on record. The two daily rainfalls show 24 January 1976 occurring as the second and third ranked in the ranking list.

A catchment model was established to determine design flood hydrographs from design rainfall. This model showed the standard 3 hour storm as the "critical duration" at the outlet of Rocky Creek (downstream of its confluence with Uralla Creek).

The RORB model indicates the one percent AEP peak outflow from Rocky Creek as 95 cu. metres per second, while the Probable Maximum Flood is indicated as 952 cu metres per second. The Probabilistic version of the Rational Method produced a peak discharge for the design 1% AEP flood at the outlet for Rocky Creek as 146 cu. m/sec. The difference in the design 1% AEP flood levels is noted, as well as the implication that the PMF estimate is outside the usual "rule of thumb" that the PMF would be between three and four times greater than the design 1% AEP event.

Assessment of design flows against other interpretations of the Rational Method give flow estimates lower than the RORB model. It is also noted that the RORB model, in combination with the hydrodynamic model, produces a reasonable representation of the historically recorded flood levels. Accordingly, the RORB design hydrographs have been adopted as the “design flood”.

Given the apparent discrepancy between the PMF estimate and the design 1% AEP estimates, an “Extreme Flood” approach has been adopted for emergency management purposes, where the “Extreme Flood” has been adopted as the Design 1% AEP flood factored by three (3).

An hydrodynamic model of Rocky Creek, Uralla Creek and the un-named tributary from Mackenzie Street, Uralla, to Rocky Creek was established using the MIKE-11 software system.

The model comprises:

- three main creek systems (Uralla Creek, Rocky Creek and the un-named tributary);

- 16 structures which will act as hydraulic controls. Details of each structure were obtained by ground survey.

- creek waterway areas as defined by 64 surveyed river cross-sections. The location of each cross-section was identified by site inspection as necessary to produce an adequate representation of the waterway within MIKE-11.

A comparison between historical flood levels (as noted earlier) and the design flood levels has been adopted as a simplified method of confirmation of the performance of the hydrologic and hydrodynamic models.

The daily rainfall analysis and resident interview suggest the 1976 flood was probably the largest since 1901. Accordingly, the 1976 event would be classed as between a 1% AEP and a 2% AEP event.

The RORB model and MIKE-11 model have been set up with model parameters defined by published text, accepted practice and the consultant's experience. The design 1% flood profile reasonably reflects the available historical flood levels. It was thus concluded that the combination of the RORB model and MIKE-11 model producing design flood levels suitable for use in setting future development controls.

Figures 10, 11 and 12 illustrate flood profiles for the design 1% and 5% AEP floods, while Figure 13 gives the approximate flood extents for the design 1% AEP flood contours.

The flood profiles indicate the afflux (increase in flood levels) due to the structures. The largest affluxes on Uralla Creek are caused by the Maitland Street and Queen Street footbridges.

The culvert beneath the Main Northern Railway on Rocky Creek creates a significant afflux and forces a spillage from Rocky Creek to the un-named tributary immediately east of the railway line. This spillage has the potential to affect one residence.

Mackenzie Street, on the un-named tributary from Warwick Street to Rocky Creek, represents an hydraulic control. Upstream of Mackenzie Street, there is no creek channel and flood waters flow across a wide area. However, downstream of Mackenzie Street, the creek channel is incised. Mackenzie Street and the developments on the northern side of Mackenzie Street represent the area where flood flows transfer from a slow moving wide area to a faster moving confined waterway.

The NSW "Floodplain Development Manual" seeks to classify flood liable land by:

- hydraulic performance as "Floodway", "Flood Storage", and "Flood Fringe";
- flood hazard as "Low Hazard" or "High Hazard".

Both the above criteria are intended to be applied over relatively large contigious areas rather than individual property parcels.

In the Uralla and Rocky Creeks situation, it is noted:

- there are no distinctive "flood storage" areas that are not "floodways";
- the "flood fringe" areas typically only extend by some 4 metres from the inundation limit;
- the "low hazard" areas similarly only extend between 2 and 10 metres from the inundation limit;
- the assessment of "flood fringes" and "low hazard" areas is compromised by the accuracy of the underlying ground elevation model (DEM).

In this instance, the prudent approach is to define the design 1% AEP flood extent as "High Hazard, Floodway" unless it can be demonstrated to be otherwise by local ground survey.

Current floodplain management practice includes application of Flood Planning Levels (FPL) to building development controls over a Flood Planning Area. Based on FPL's in other areas and the flood characteristics of Uralla Creek and Rocky Creek within the study area, Uralla Shire Council has adopted a Flood Planning Level based on the design 1% AEP flood levels plus 0.5 m freeboard.

The Flood Planning Levels and Flood Planning area for Uralla and Rocky Creeks within Uralla are shown on Figure 18.

1. INTRODUCTION

This report presents the results of the Rocky and Uralla Creeks Flood Study.

Uralla Shire Council, through its local land use and management activities in its area of administration is following the Floodplain Management Process, as outlined in the Foreword and promoted by the NSW Government.

The locality of the study area for the Rocky and Uralla Creeks Flood Study, and within the context of the town of Uralla, is illustrated on Figure 1. Figure 2 displays a recent aerial photograph of the study area.

Specifically, the Flood Study covers areas in Uralla zoned:

- Residential Zone R1;
- Low Density Residential R2;
- Local Centre Zone B2;
- Mixed Uses B4;
- Light Industrial Zone IN2;
- Public and Private Recreation RE1 and RE2.

The areas adjacent to the watercourses (Rocky and Uralla Creeks plus an un-named watercourse) are zoned as Zones R1, B2, B4 and IN2.

The catchment areas of Rocky Creek and Uralla Creek are as follows:

- Uralla Creek to confluence with Rocky Creek: 8.38 sq km
- Rocky Creek to confluence with Uralla Creek: 9.17 sq km
- Rocky Creek at study boundary: 18.39 sq km

The study approach is detailed in Chapter 2, while the subsequent chapters detail:

- available background information;
- data collection;
- hydrological investigations;
- riverine investigations;
- design flood data; and
- conclusions.

2. STUDY APPROACH

The end use of the Rocky and Uralla Creeks Flood Study is likely to be:

- setting of site specific development controls along Rocky and Uralla Creeks in the study area;

- setting of floor levels through the Floodplain Risk Management Plan and development controls along Rocky Creek and Uralla Creek in the study area.

A reconnaissance survey of the site and the available data suggests that sparse hydrological data and recorded flood levels will be available. Nonetheless, it is warranted to establish a hydrological model of the catchment (to estimate flood flows) and to establish a riverine model to define flood levels and flood hazard for a variety of design flood events, principally using model parameters for both the hydrological model and riverine hydraulic model from regional parameters, published texts and the consultant's experience to produce meaningful and useful estimates of design flood levels.

Thus, an appropriate study approach, consistent with the above uses and the constraints outlined in Chapter 1, Introduction, and above, was identified as:

- collection of local flood information by resident interview;

- collection of recent flood records held by government sources;

- collection of ground survey to identify river waterway areas;

- use of the hydrology model for Rocky Creek and Uralla Creek to define flood flows;

- development of a riverine hydraulic model for Rocky and Uralla Creeks (through the study area), to define the design flood profiles;

- preparation of design flood profiles for the three design events, namely, 1% AEP, 5% AEP floods plus the Probable Maximum Flood (PMF);

- presentation of design floods as flood surface contours on a cadastral base.

3. AVAILABLE DATA

3.1 Overview

The principal data required for a flood study comprises:

- recorded flood levels;
- recorded flood flows;
- rainfalls;
- topographic data information.

Historical rainfall data is normally available through the Bureau of Meteorology, comprising:

- daily read rain gauges; and

- continuous rainfall versus time recorders (Pluviometers which either store the data on site or transfer the data to a central point using radio technology).

Historical flood data is available through:

- previous studies and documents;
- information on records held by various government agencies; and
- resident interviews.

Regrettably, available historical rainfall data and flood data in Uralla is scant and thus, resort must be made to use of general parameters for any models.

Design rainfall information (that is rainfall-intensity-duration data for various return period storms) is commonly derived from Australian Rainfall and Runoff (Ref. 1). This practice has been followed in this study

3.2 Available Data, Government Agencies

Government agencies that are likely to hold historical data are:

- Bureau of Meteorology (daily rainfall and pluviometer);
- Office of Environment and Heritage (NSW hydrographic station network);
- Roads and Maritime Services (Infrastructure crossings of waterways);
- Australian Rail and Track Corporation (as maintenance contractor / operator for some NSW railways);
- Uralla Shire Council.

Each of the above agencies has been contacted, which yielded the following results:

Bureau of Meteorology

The Bureau has two long term daily rainfall stations in or near the catchment as detailed in Table 1 below.

Table 3.1

Daily Rainfall Stations

Station No.	Name	Period Of Record
056034	Uralla (Dumaresq Street)	May 1901 to present
056028	Uralla (Salisbury Court)	January 1901 to March 2012

Station 056034 "Uralla (Dumaresq Street)" is located some 1.94 kilometres south of the centroid of the Rocky and Uralla Creeks catchment (in the study area) with Station 056028 "Uralla (Salisbury Court)" located some 9.95 kilometres south of the catchment centroid.

The nearest pluviometer is located at Armidale Airport, located some 15 kilometres north of the catchment centroid. Given the lengths of the north-south axis and east-west axis of the study catchment are about 5.7 and 4 kilometres respectively, the Armidale Airport pluviometer is seen as having little relevance to the study catchment. Accordingly, the records of the Armidale station have not been researched.

NSW Railway System

Under current government agency arrangements, the NSW railway system is owned by the NSW Government. Particular lines are leased to ARTC, while ARTC is responsible for maintenance of other lines.

A set of "Working Plans" was maintained for each railway line, which was often annotated by hand with historical flood levels, particularly at railway bridges.

The Main Northern Line runs through Uralla. The "Working Plans" have been sighted and have no flood level information annotated. There appear to be no vertical information available (by way of long section) for the Working Plans (a different practice to other NSW railway lines).

Roads and Maritime Services

The current NSW Government roads agency (Roads and Maritime Services) maintain three major culverts in Uralla, which cross Rocky and Uralla Creeks, as listed in Table 3.2 below. All culverts shown in Table 3.2 are located on the New England Highway.

The calculated flood levels in Table 3.2 are those calculated at the time of the culvert design and are annotated on the design drawings for the culvert works.

Table 3.2

RMS Culverts – New England Highway at Uralla

Location	RMS Distance	Size	Length (m)	Calculated Flood Level (m AHD)
Salisbury Street (Uralla Creek)	SH09	3 cell 3.6 m x 3 m	58.6	995.05
Rocky Creek	SH09 90.34 km north of Tamworth	1 cell 4.5 m x 3 m	22.16	999.24
Rocky Creek	SH09 90.41 km north of Tamworth	4 cell 4.5 m x 3 m	20.67	999.17

Hydrographic Stations

The NSW Office of Environment and Heritage owns the hydrographic network within New South Wales. Unfortunately, there are no hydrographic stations within or near to the study area that could be used to assist in the current study.

3.3 Historical Flood Levels

Local information on recorded flood levels has been sought from Uralla's residents by way of questionnaires and direct interview.

Uralla Shire Council issued 107 questionnaires to the property owners abutting Uralla and Rocky Creeks within the study area.

Figure 3 illustrates the distribution area of the questionnaires, while the questionnaire is produced in Appendix A.

Thirty (30) responses to the questionnaires were received, comprising:

- 27 returned questionnaires;
- one letter;
- one note with photographs;
- one verbal communication.

Review of the returned questionnaires indicated 15 contained reference to flooding. However, only 6 questionnaires contained information that warranted further interview.

Further site inspection with local historian, Mr A Good, provided additional local knowledge.

The above process identified 11 points that warranted ground survey. The surveyed points are listed in Table 3.3 below.

Table 3.3

Historic Flood Levels

Point No.	Creek	Co-ordinates		Flood Level (m AHD)	Comment
1	Rocky Ck.	355982.47	6609522.3	991.34	
2	Uralla Ck.	356103.83	6609374.17	992.25	Flood Peak at approx 2100hrs on 23/1/1976
3	Uralla Ck.	356097.31	6609369.11	992.03	
4	Uralla Ck.	356103.36	6609318.11	991.68	
5	Uralla Ck.	356151.35	6609222.06	992.84	Highest flood since 1988
6	Uralla Ck.	356187.63	6609122.46	994.6	Highest flood above this level
7	Uralla Ck.	356187.95	6609122.58	996.06	Highest flood below this level
8	Uralla Ck.	356195.68	6609028.67	997.39	
9	Uralla Ck.	356200.62	6609025.38	997.39	
10	Uralla Ck	-	-	995.91 and 996.37	Hand annotation on USC plan
11	Rocky Ck.	356259.66	6609551.29	993.05	January 2012 to underside of Alma Park footbridge
12	Rocky Ck	356475.15	6609559.91	996.84	
13	Rocky Ck	356495.82	6609561.48	996.66	
Floor Levels					
		357388.21	6608807.66	1020.63	"Floor Level,16 McKenzie Street"
		357350.34	6608818.36	1019.83	"Floor Level,14 McKenzie Street"
		357325.69	6608816.69	1020.49	"Floor Level,12 McKenzie Street"

The location of the historical flood levels is shown on Figure 4.

The only flood levels recorded in Uralla Shire's files appear to be a hand annotated entry on a drawing of the Salisbury Road culvert on Uralla Creek (Point 10 in Table 3.3), indicating a recorded flood level of RL 995.91 m AHD at the inlet to the Salisbury Road culvert and a recorded flood level of RL 996.37 m AHD, approximately 51 metres upstream of the culvert.

The flood levels identified by residents downstream of Queen Street (Points 2 and 3 in Table 3.3) are considered the most reliable, particularly with reference to the time and date of the highest recorded flood height.

It is noted that flood levels Points 8 and 9 are near Uralla Shire Council's offices, just upstream of the Salisbury Road culvert. The flood levels occurred reportedly in the late 1950's or early 1960's and thus reflect the flood levels created by an earlier bridge across Uralla Creek. The earlier bridge was replaced by the current Salisbury Road culverts.

The similarity between the recorded flood levels at Points No. 8, 9 and 10 suggest all come from a similar event, presumably for the earlier bridge, rather than the current Salisbury Road culvert.

There is also anecdotal evidence that houses in Mackenzie Street have been affected by flooding and the opportunity has been taken to collect the floor level data of 3 buildings in the affected area. From discussions with residents, it appears that the lowest house in Mackenzie Street was raised after it was flood affected.

Whilst many of the returned questionnaires contained no flood level information that warranted ground survey, a recurring theme was the fast rising and short duration of flooding along the subject creeks. This result is not unexpected, given the small nature of the catchments of Rocky Creek and Uralla Creek.

4. HYDROLOGY

4.1 Overview

As noted earlier, the available data on flooding is scant. The data available for hydrological analysis is primarily the daily rainfall stations.

In the absence of any flow measurements, resort must be made to an hydrological model using regional constraints with a check against the traditional Rational Method.

A further check can be made using the riverine hydro-dynamic model, which will principally involve:

- surveyed waterway areas;
- adopted friction resistance.

It is appreciated that the above approach is not a strict calibration and verification, but an approach that seeks an estimate of reliable flood levels, accepting all the variables within the hydrologic analysis and riverine hydraulic analysis.

4.2 Daily Rainfall Stations

The BOM procedures require the daily rainfall gauges at 0900 hrs each day and the recorded rainfall listed as the day of reading. Thus, the daily rainfall records represent the rainfall that has fallen for the 24 hours prior to the reading.

Given the small size of the catchment of Rocky and Uralla Creeks, the period of rainfall of importance is the daily rainfall and the two day rainfall. The two-day rainfall is of interest given that a single storm could span the 0900 hrs reading time and thus be recorded as occurring on two consecutive days.

The BOM daily rainfall stations near the catchment centroid (Stn 056034 Uralla (Dumaresq Street) and Stn 056028 Uralla (Salisbury Court)) have quite long record periods. However, both stations have short periods of missing records.

Inspection of the records of both stations shows:

- the daily rainfall is virtually the same between the two stations, where records are available at both stations;

- data is usually available for one station where the data may be missing from the other;

- a composite daily rainfall record for the catchment can be constructed by using the average of the rainfall recorded at each station and by insertion of the record from one station when the other station record is missing.

The daily and two-daily rainfall data from the “composite record” were ranked in decreasing magnitude to identify the likely flooding dates.

Table 4.1 below indicates the ten largest daily rainfalls in the "composite" record, while Table 4.2 shows the ten largest two day rainfall.

Table 4.1

Ranked Daily Catchment Rainfalls

Rank	Year	Month	Day	Catchment Average Daily Rainfall (mm)
1	1976	1	24	152.8
2	1949	8	27	148.85
3	1955	2	25	106.8
4	1946	1	22	100.2
5	1940	3	19	95.35
6	2004	1	17	92.7
7	1977	2	22	92.5
8	1928	3	27	91.2
9	1903	6	2	88.3
10	2003	2	22	86.6

Table 4.2

Ranked Two Daily Catchment Rainfalls

Rank	Year	Month	Day	Catchment Average Two Daily Rainfall (mm)
1	1949	8	27	228.85
2	1976	1	25	169.6
3	1976	1	24	166
4	1949	8	28	153.8
5	1955	2	25	144.15
6	1946	1	22	141.35
7	1955	2	26	135.1

Rank	Year	Month	Day	Catchment Average Two Daily Rainfall (mm)
8	1964	1	15	134.2
9	1910	1	15	133.75
10	2009	12	29	128.1
11	1964	1	14	126
12	1977	2	22	114.6
13	1928	3	28	112.15
14	2004	1	17	108.8

4.3 Catchment Model

A catchment model is required to produce estimates of design flood discharge hydrographs for estimation of design flood levels.

The rainfall runoff routing model, RORB, has been selected for the Rocky Creek and Uralla Creek Flood Study for a number of reasons, namely:

- the study is principally directed to flood flows;
- the model allows separate sub-catchment flow estimates to be made;
- the rainfall loss models available in RORB follow either an initial loss/continuing loss concept or a proportional loss concept;
- RORB is widely used within Australia and has been generally accepted.

RORB requires several inputs as follows:

- a sub-catchment structure which, in RORB, comprises of various sub-catchment areas and a series of notional "storages" to represent the waterway structure and linkages;
- several catchment parameters to control behaviour of the notional storage, which, in RORB, are identified as "k_c" and "m";
- design rainfall (or actual rainfall) to be applied to the sub-catchment model using rainfall intensity and rainfall temporal patterns;

- specification of a rainfall loss model to represent the difference between rainfall applied to the catchment and the rainfall volume that appears as runoff at the catchment outlet.

The RORB model for the Rocky Creek and Uralla Creek Flood Study comprises:

- 18 sub-catchments; and
- 26 notional storages.

The layout of the RORB model appears on Figure 5, while the data coding of the model appears in Appendix C.

It is noted that there are a number of farm dams scattered throughout the catchment. These dams have not been specifically included within the RORB model and thus are implicitly assumed to provide no flood routing for the system. This approach has been taken, given:

- the farm dams are not under Uralla Shire Council's control, nor can they be expected to have consistent high quality construction standards;

- the farm dams can be expected to be operated as water supply structures and kept "as full as possible";

- the structures cannot be relied upon to provide consistent flood routing performance.

Given the lack of historical flood flow data, regional parameters have been used for the RORB model, derived from Australian Rainfall and Runoff (ARR, Reference 1) using the Kleemola's (1987) relationship (Equation 3.20, Book 4).

The Kleemola (1987) relationship is in the form:

$k_c = 1.22\ A^{0.46}$ where A is catchment area in sq. km.

The adopted parameters for the RORB model were:

- $k_c = 4.65$ (based on Kleemola 1987)
- $m = 0.8$ (the usually adopted value).

4.4 Design Flood Flows

In situations such as Uralla, design flood flows and flow hydrographs are defined by application of design rainfall intensities, applied using a specified rainfall temporal pattern.

Design rainfall for the catchment was derived using the Intensity-Frequency-Duration (IFD) data for Uralla, derived from ARR –Volume 2 (Ref. 2). The adopted IFD data appears in Appendix B. The design rainfall temporal patterns have also been derived from ARR (Reference 2) as applying for Zone 2 (identified in Reference 2). Given the proximity of Uralla to the divide between coastal and western regions, the more intense coastal design storms have been used.

In the absence of a number of reliable pluviometer records and historical flood discharge hydrographs, it is not possible to assign either particular initial and continuing losses nor a proportional runoff coefficient for this catchment. Accordingly, an initial loss of 10 millimetres and continuing loss of 2.5 millimetres per hour have been adopted for the design storms.

The design rainfall comprises a design rainfall total distributed in time as defined by the design rainfall temporal patterns. Standard practice is to test a variety of temporal patterns to identify the storm duration creating the largest peak discharge (identified as the "critical duration"). It should be noted that the "critical duration" may be identified by the hydrodynamic model as producing the highest peak flood levels at a location, though this is not expected to be the case in the Rocky Creek and Uralla Creek Flood Study.

Table 4.3 below identifies the peak flood for Rocky Creek and Uralla Creek at their confluence and at the catchment outlet for design storm durations between 45 minutes and 12 hours for the design 1% AEP flood event. The values in Table 4.3 represent a fully rural catchment, while for the design hydrographs in the hydrodynamic model, the RORB model was modified to include the urban development of Uralla.

Table 4.3

Peak Flood Flow Estimates (Design 1% AEP flood)

Storm Duration	Flood Discharge		
	Rocky Creek (cu. m/sec)	Uralla Creek (cu. m/sec)	Catchment Outlet (cu. m/sec)
45 mins	40.7	34.4	57.9
1 hr	43.9	39.5	67.1
2 hr	47.5	50.6	87.5
3 hr	45.0	50.3	91.4
6 hr	44.6	48.7	90.7
9 hr	45.6	48.8	91.6
12 hr	39.8	37.7	78.0

Review of the peak discharges in table 4.3 suggests that the "critical duration" for Rocky Creek and Uralla Creek will be 2 hours.

Table 4.4 below illustrates the peak discharges for the two hour and three hour duration rainfall events for return periods of 5% and 1% AEP (frequencies as required by the study brief).

<u>Table 4.4</u>

Design Peak Discharges

Storm Duration	Frequency (% AEP)	Design Peak Discharge		
		Rocky Creek (cu. m/sec)	Uralla Creek (cu m/sec)	Catchment Outlet (cu. m/sec)
2 hr	5	29.0	32.2	59.0
2 hr	1	47.5	50.6	62.8
3 hr	5	29.8	33.3	61.8
3 hr	1	45.0	57.0	95.0

Figure 6 illustrates the design hydrographs for Rocky Creek and Uralla Creek at their confluence and at the catchment outlet.

4.5 Probable Maximum Flood

Broadly, the Probable Maximum Flood (PMF) is derived by application of the Probable Maximum Precipitation (PMP) to a specific catchment using the PMP spatial and temporal distributions.

Probable Maximum Precipitation (PMP) is defined by the World Meteorological Organization (1986) as *"the greatest depth of precipitation for a given duration meteorologically possible for a given size storm area at a particular location at a particular time of year"*.

PMP estimation for catchments up to 1000 sq kilometres is detailed in the Bureau of Meteorology publication "Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method" Reference 4).

Reference 4 notes "The PMF is one of a range of conceptual flood events used in the design of hydrological structures".

In a floodplain risk management sense, the PMF is treated essentially as an absolute upper limit for flooding inundation and flood extents.

Reference 4 also notes: "The low density of the rain gauge networks, particularly the pluviograph network, has resulted in few severe short-duration rainstorms having been recorded or documented in Australia. This is particularly the case in the sparsely populated part of the continent away from the coastal fringe and is a severe limitation on the estimation of short duration probable maximum precipitation in Australia".

The PMP rainfall depths for catchments of the same size as Rocky Creek and Uralla Creek are listed in Table 4.5.

Table 4.5

Short Duration PMP Rainfall

Storm Duration (hrs)	Catchment Type	PMF Rainfall (mm)
1	Rough	290
2	“	470
3	“	590
4	“	680
5	“	760
6	“	810
1	Smooth	290
2	“	430
3	“	460
4	“	520
5	“	570
6	“	810

In consideration of the spatial and temporal distributions, Reference 4 uses a combination of concentric ellipses, each with separate PMP rainfalls, distributed over the catchment. The standard temporal pattern creates a single burst storm with the most intense rainfall falling in the period from 25 percent of the total storm duration to 50 percent.

The PMF flow estimates have been derived using the ellipse method for spatial distribution of rainfall over the Uralla and Rocky Creek Catchment.

Testing of the catchment response (using the RORB model) for storm durations of 1, 2, 3, 4, 5 and 6 hours shows the 2 hour storm as “critical”.

The estimated peak discharges for the PMF for the study catchments are given in Table 4.6 for a situation where the catchment is classified as “smooth” or “rough” (in accordance with Reference 4).

Table 4.6

Peak PMF Discharges
(for 2 hour duration storm)

Catchment Description	Peak Flows (cu. m/sec)		
	Rocky Creek	**Uralla Creek**	**Catchment Outlet**
Rough	613	540	1,137
Smooth	511	453	952

It is noted that the peak PMF flows quoted in Table 4.6 above are substantially larger than the design 1% AEP flows quoted earlier in Table 4.3. The usual "rule of thumb" in floodplain management is to expect that the PMF will be three or four times greater than the design 1% AEP flood event. The difference in design discharges between the PMF and design 1% AEP event is not viewed with major concern, in that:

- the design 1% AEP rainfalls are derived from a significantly larger data base than the PMP estimates;

- Reference 4 notes that the Australian data for severe short duration rainstorms is scant;

- in reality, current floodplain risk management practice is to use the PMF event as a limit for emergency planning;

- current land use and development controls in floodplain risk management programs are usually directed to the design 1% AEP event unless special site constraints apply.

Given that the PMF rainfall is based on extrapolation of recorded events, both in Australia and USA, for much larger catchments and different topography, it appears the PMF rainfall estimates for small catchments such as Uralla and Rocky Creeks may be too high. Accordingly, for emergency management purposes, an approach using an “Extreme Flood” has been followed with the “Extreme Flood” specified as design 1% AEP flood factored by three (3).

4.6 Design Checks

Given the lack of any flow gauging or flow hydrographs, the only design check, in current usage, on the RORB model results, as outlined in the previous section, is the Probalistic Rational Method (Reference 4). The design discharges calculated by the method appear in Table 4.7 below, while the calculation sheet appears in Appendix C.

Table 4.7

Peak Flow Estimates – Rational Method

Frequency (% AEP)	Flood Discharge		
	Rocky Creek (cu. m/sec)	Uralla Creek (cu m/sec)	Catchment Outlet (cu. m/sec)
5	45	47	94
1	78	82	146

It is noted (by comparison of Tables 4.4 and 4.5) that the RORB hydrograph estimates are in the order of 65 percent of the Rational Method estimates. This discrepancy was initially viewed with concern, given that the runoff coefficients used in the Rational Method are, in reality, a closure term between design rainfall and observed flood frequency. Consequently, the runoff coefficient used incorporates all of the errors inherent in the base data. Further checks were made using the "traditional" Rational Method (Australian Rainfall and Runoff, 1977) and the as-yet unpublished new version of the Probalistic Rational Method, which is to be used in the current (2013) revision to Australian Rainfall and Runoff.

Table 4.8 below gives a comparison between all methods for the catchment outlet (Rocky Creek).

Table 4.8

Comparison of Peak Flow Estimates

Estimation Method	Peak Flow @ Rocky Creek Outlet	
	5% AEP (cu. m/sec)	1% AEP (cu. m/sec)
RORB model	62.8	95
Probalistic Rational Method (ARR – 1988)	94	146
"Traditional" Rational Method (ARR – 1977, ARR – 1957)	41	70
Unpublished Probalistic Rational Method (ARR – 2013 revision)	29	54

In the Uralla situation, without any flow gauging or historical flood frequency, it is not possible to derive better runoff coefficients than those published in AR&R (Reference 3) for the Probalistic Rational Method or derive a more appropriate data base for the unpublished version of the Probalistic Rational Method (ARR – 2013 revision).

Later in this report, use of an hydraulic model is described to predict design flood levels from design flood flows. The RORB model design hydrographs have been "adopted" given that the combination of RORB (using regional parameters) and the hydrodynamic model (using "reasonable" model parameters) gives a "reasonable" fit to recorded flood level data.

The appropriate floodplain management response is to incorporate allowances in the freeboards specified to create Flood Planning Levels above the design flood levels, as opposed to simply adjusting the design flood levels.

5. HYDRODYNAMIC INVESTIGATIONS

5.1 Overview

The riverine systems of Rocky Creek and Uralla Creek are generally incised channels with small floodplain areas beside the channels. All the creeks display some "head cutting" type erosion.

Given the limited historical flood information (both in terms of flood levels and discharges), a numerical hydrodynamic model is required to predict design flood levels from design flood hydrographs.

In this instance, the MIKE-11 software package has been selected as the hydrodynamic model. MIKE-11 is marketed by the Danish Hydraulic Institute and is used extensively world- wide. The software relies on solutions of mass and momentum conservation in the river flow using an efficient finite difference solution technique. MIKE-11 is well suited to the Uralla situation in that Uralla Creek and Rocky Creek are essentially long and narrow river systems at quite steep grades (for a river system).

There is insufficient data (historical flood levels, historical rainfall or historical river flows) to enable a strict calibration and verification routine to be established.

The critical areas within MIKE-11 are essentially:

- Topography;
- Boundary Conditions;
- Initial Conditions.

Thus, the procedure for development of design flood levels is essentially:

- definition of topography by way of river cross-sections that have been measured by ground survey;

- definition of inflow boundary conditions using outputs from the hydrology model detailed in the previous chapter;

- definition of friction resistance in the river channels (in this instance, by parameter Mannings ‘n’) based on published texts (References 6, 7 and 8) and the consultant’s experience;

- definition of initial conditions by use of a steady state model (HEC-RAS) using the same cross-sections as MIKE-11 and by “draw down” techniques;

- comparison of design flood levels against the limited historical data and by sensitivity testing.

5.2 MIKE-11 Hydrodynamic Model

As noted earlier, the critical items for the establishment of the MIKE-11 model are:

- topography;
- boundary conditions;
- initial conditions.

The topography of the river system has been defined by ground survey for 64 riverine cross-sections, as shown on Figure 7.

There are 16 bridges, culverts and causeways across Rocky and Uralla Creeks which have the potential to affect flood levels. Each structure has been surveyed to define the hydraulic characteristics of the structure in MIKE-11. Such details include:

- bridge or culvert invert levels;
- bridge or culvert obvert levels;
- pipe diameter or box culvert sizing;
- bridge deck levels;
- road levels across the structure.

The location of the bridge and culvert structures is also shown on Figure 7, together with identification names adopted simply for the purposes of this study.

The MIKE-11 model established for Uralla and Rocky Creeks comprises three main channels, namely:

- Uralla Creek;
- Rocky Creek;
- un-named tributary (identified purely for this study as Mackenzie tributary).

The MIKE-11 model also contains two minor tributaries, one linking Rocky Creek with the Mackenzie tributary and another from Warwick Street to the Mackenzie tributary.

The layout of the MIKE-11 model over the cadastral plan of Uralla is shown on Figure 8. Figure 9 shows a schematic of the model. The model contains numerous minor channels, weirs, bridges and culverts, which are required to model the 16 significant hydraulic structures.

5.3 Model Calibration and Verification

As noted earlier in this report, there is not sufficient historical information available to undertake a complete calibration and verification of the RORB hydrological model or the MIKE-11 hydrodynamic model either separately or jointly.

A comparison between historical flood levels (as noted earlier) and the design flood levels has been adopted as a simplified method of confirmation of the performance of the hydrologic and hydrodynamic models.

The resident surveys and the analysis of the daily rainfall records suggest the flood event on 23 January 1976 was probably the largest event since 1900 at Uralla. Acceptance that the 1976 event will probably rank first or second on an historical ranking (if such a ranking was available) would indicate a return period of between 112 year ARI (Average Recurrence Interval, 0.9% AEP) and 56 year ARI (1.8% AEP). Thus, the 1976 flood would have a recurrence frequency between 1% AEP and 2% AEP.

The simplified approach thus undertaken, setting the model parameters in both the RORB model and the MIKE-11 model, is based on published texts and the consultant's experience.

Figures 10 and 11 show the design 1% AEP flood profiles adequately represent the historical flood levels.

The above approach is also mindful that the end use of the design flood levels will principally be for setting "Flood Planning Levels" by adding an appropriate freeboard to the design flood levels. An appropriate freeboard allowance can be set to incorporate uncertainty in design flood flow estimates and design flood levels.

During the testing of the MIKE-11 model, significant numerical instabilities in the predicted flood levels along Rocky Creek and the Mackenzie tributary prevented satisfactory running of the MIKE-11 model. The models indicated the location of the instabilities at the structures near the confluence of Rocky Creek and the Mackenzie tributary (namely, railway bridge, railway culvert, Barley Fields Road culverts and the spillage from Rocky Creek to Mackenzie tributary, immediately east of the railway line). The source of the instabilities was tracked to the flow transitions at Mackenzie Street from a broad shallow flow to an incised channel.

The numerical issue was resolved by:

- insertion of additional surveyed cross-sections;
- use of several successive runs to obtain improving initial conditions;
- successive runs to avoid propagation of numerical errors in the initial conditions.

6. DESIGN FLOOD LEVELS

Design flood levels were derived for both the 1% AEP flood and 5% AEP flood.

The design flood levels are presented in three ways, namely:

- by way of long sections along the three main creeks, as shown on Figures 10, 11 and 12;
- as a plan view showing the design 1% AEP flood contours plus approximate flood extents; and
- as tabulated values for peak flood level versus model distance (Appendix D) and peak flood discharge versus model distance (Appendix E).

In the hydrology section of this report, it was noted that the "critical duration" of the Uralla Creek and Rocky Creek catchment was about 3 hours. In the production of the design flood levels, both the 2 hour and 3 hour storm events were tested. In some areas, the 2 hour storm actually produced higher flood levels. In all instances, the higher of either the 2 hour storm or the 3 hour storm has been adopted as the "design flood" level.

With respect to the design flood profiles on Figures 10, 11 and 12, it is noted that:

- the creeks are relatively steep in riverine terms, with slopes of 0.85 percent, 1.5 percent and 1.7 percent for Uralla Creek, Rocky Creek and the Mackenzie tributary respectively;
- the difference between the design 1% and design 5% events along Uralla Creek is in the order of 0.4 m to 0.6 m generally;
- the design 1% AEP flood is marginally lower than the identified 1976 flood levels in Uralla Creek downstream of Queen Street;
- the profile for Uralla Creek shows the afflux (increase in flood levels) caused by the various footbridges across Uralla Creek, with the worst impacts created by the Queen Street footbridge, followed by the Maitland Street footbridge;
- along Rocky Creek, the difference between the design 1% and design 5% events is in the range of 0.3 to 0.6 metres;
- the Rocky Creek profile shows the substantial afflux caused by the culvert beneath the railway line. The afflux is sufficient to force a spillage of floodwaters from Rocky Creek to the Mackenzie tributary immediately east of the railway line. Such spillage will threaten one existing residence.

- the Mackenzie tributary has no major road crossings, however, the existing farm dam downstream of Mackenzie Street is shown to create an afflux, although the upstream propagation of this afflux is limited by the steepness of the creek system;

- Mackenzie Street represents a significant point in the system, as there is a transfer of flow from a wide shallow flow depth upstream of Mackenzie Street to a more confined incised creek channel downstream of Mackenzie Street;

- the differences between the design 1% AEP and 5% AEP flood levels along the Mackenzie tributary, at about 0.2 metres, are less than along Uralla Creek and Rocky Creek.

Review of the design 1% AEP flood extents on Figure 13 shows:

- the flood extents are generally confined to the creek channels;

- the flood extents are increased by the afflux created at the structures indicated above;

- the spill from Rocky Creek to Mackenzie tributary east of the railway line does create a relatively wide floodway.

It should be noted that the approximate flood extents have been defined by interpolation of the design flood levels (specified at one metre intervals) from a digital elevation model (DEM) that was used to produce Uralla Shire Council's two metre contour maps. Nominal accuracy of the two metre contour maps will be plus/minus one metre (half a contour interval). Comparison between the DEM and the ground survey of cross-sections shows, typically, differences of 0.5 metres or less where the ground is clearly visible in the aerial photography. In areas where vegetation cover obscures a clear ground view, the differences are significant, being at least one metre and in one location, up to 15 metres. Accordingly, caution should be exercised in transferring the flood extents shown to ground position on individual properties.

7. CLIMATE CHANGE AND SENSITIVITY ANALYSIS

The OEH draft guidelines for assessment of climate change suggest use of sensitivity testing for changes in mean sea level and changes in design rainfall. Clearly, sea level change is not relevant at Uralla. Changes in design rainfall are postulated as being induced by climate changes. This issue is addressed by sensitivity testing with increase in rainfall of 10 percent, 20 percent and 30 percent.

At Uralla, design rainfall has been converted to flood flows by removal of rainfall losses. However, in this situation, the rainfall losses are a small component of the total rainfall. Accordingly, design rainfall increases of 10, 20 and 30 percent have been tested by increasing the design flood hydrographs by 10, 20 and 30 percent respectively.

Figures 14, 15 and 16 show the flood profiles for Uralla Creek, Rocky Creek and the Mackenzie tributary for the design 1% AEP flood with increased flows of 10 percent, 20 percent and 30 percent respectively.

Review of Figures 14, 15 and 16 show that, along Uralla Creek, the difference between the design 1% AEP flood and the design event increased by 30 percent is in the order of 0.2 to 0.3 metres generally, although the differences are accentuated at the structures causing afflux. Along Rocky Creek, the differences between the design 1% AEP flood and the design event increased by 30 percent range between 0.2 m and 0.4 metres.

Review of the design flood discharges for the various creeks (as tabulated in Appendix E) shows there is very little flood routing as the flood wave passes down the creek systems. Thus, flood levels are principally controlled by flood discharge and channel friction. Channel friction, flood discharge and flood level are linked through the "Mannings 'n' equation", which is an experimentally proven relationship.

Thus, in this situation, a 30 percent increase in channel friction (as represented by Mannings 'n') will produce similar flood levels to a 30 percent increase in design discharge. This similarity was demonstrated in the Karuah River Flood Study (Reference 5), where flood levels are essentially controlled by friction, by testing of both increases to design discharges and Mannings 'n'.

Accordingly, in the Rocky and Uralla Creeks situation, the sensitivity testing for changes in friction (Mannings 'n' values) of 10, 20 and 30 percent will produce similar flood profiles to 10, 20 and 30 percent increases in design discharges.

8. FLOOD HAZARD

8.1 Flood Hazard

The NSW Floodplain Development Manual (Ref. 9) seeks to identify flood liability on the basis of:

- riverine hydraulic categories of "floodway", "flood storage" and "flood fringe";

- flood hazard as "Low Hazard", or "High Hazard" based on a combination of flood depth and flood velocity (Refer Figure L2 "Provisional Hydraulic Hazard Categories", Reference 9)

Review of the flood extents shows there are virtually no areas that would be considered as "flood storage" as separate from "floodway".

Similarly, "flood fringe" can be defined as where flood depths are less than 0.3 metres. Plotting of the areas of "flood fringe" shows such areas are not more than 4 metres from the design 1% AEP flood extent.

In consideration of the "flood storage" and "flood fringe" definitions and the identified accuracy of the ground DEM, the appropriate conclusion is that the flood extent of the design 1% AEP event should be defined as "floodway".

As noted above, provisional flood hazard is defined by flood depth and flood velocity.

Review of the flood depth and velocity components at each surveyed cross-section shows the "Low Hazard" areas are very small, with distances between the flood extent and "High Hazard" zones ranging between 2 to 10 metres and averaging approximately 5 metres. The location of the small "Low Hazard" areas is also unsure because the calculation of "Low Hazard" is distorted by the accuracy for the ground digital elevation model.

The prudent approach is thus to define the flood extent of the design 1% AEP flood as "High Hazard Floodway" unless it can be demonstrated by local ground survey to be otherwise.

Figure 17 identifies the design 1% AEP flood extents as "High Hazard, Floodway" with the extent of the "Extreme Flood" for emergency management purposes.

8.2 Flood Planning Area

Current floodplain management practice includes creation of Flood Planning Levels to be applied to buildings within a "flood planning area".

Following consideration of Flood Planning Levels in other local government areas and the identified flood behaviour along Uralla and Rocky Creeks, Uralla Shire Council has adopted (for Uralla), a Flood Planning Level (FPL) defined as the design 1% AEP flood level plus 0.5 m freeboard. The flood planning area has been defined as where the Flood Planning Level exceeds ground levels. One constraint for buildings within the flood planning area is that building controls might be applied for building floor levels and building features for those parts of the building below the Flood Planning Level.

Figure 18 illustrates the Flood Planning Levels and the extent of the Flood Planning Area along Uralla Creek and Rocky Creek within the study area.

9. CONCLUSIONS

The study area involves generally the two main watercourses through Uralla (Rocky Creek and Uralla Creek) and an un-named tributary through generally undeveloped land from Mackenzie Street to the tributary's confluence with Rocky Creek between the New England Highway and the Main Northern Railway.

The end use of this flood study will most likely be as a basis for setting development controls.

There is scant historical flood data available. The daily rainfall records (with records since 1901) have indicated the largest one day rainfall as being read on 24 January 1976.

Resident questionnaires and interviews yielded some 11 historical records. One long term resident identified the largest flood peak as occurring at about 2100 hrs on 23 January 1976, which is consistent with the daily rainfall stations.

Peak design flood discharges were estimated using a RORB rainfall runoff routing model and the Probabilistic Rational Method. There are differences between the discharge estimates of these methods and checks have been undertaken using other interpretations of the Rational Method. It is concluded that the RORB model provides a reasonable representation of the "design flood".

Design flood profiles for the 1% AEP and 5% AEP flood have been produced in a long-section profile format and tabulated values (in appendices).

These design values were derived from a MIKE-11 model of the system. The design 1% AEP flood profile reasonably reflects the historical flood level, sufficient to be confident the MIKE-11 model is producing the correct results.

The design flood profiles indicate the significant affluxes caused by the various structures across the creeks, notably the Queen Street and Maitland Street footbridges over Uralla Creek and the culvert beneath the Main Northern Railway on Rocky Creek.

The railway culvert is significant in that it causes a spillage from Rocky Creek to the un-named tributary immediately east of the railway. The spillage may affect one residence.

The flood extents for the design 1% AEP flood have been defined from design flood levels and a digital ground elevation model derived from the aerial photography used to produce Uralla Shire Council's available 2 m contour maps. The likely accuracy of the ground contour maps implies caution should be used in applying the flood extents shown to individual properties.

Sensitivity testing with design flood flow increases of 10 percent, 20 percent and 30 percent show design flood level increases between 0.3 m and 0.5 metres. The flood extents for such increases will be generally confined to the creek channels. The increases in design flood levels by increasing the assumed friction in the creek channels will produce results similar to the increases in design flows.

In this flooding situation, 0.5 m freeboard would provide the minimum allowance for hydrological and hydraulic uncertainty for the design 1% AEP flood.

Uralla Shire Council has adopted the Flood Planning Levels in the study area as the design 1% AEP flood plus 0.5 m freeboard. Figure 18 illustrates the Flood Planning Levels and, by comparison with available ground levels, the extent of the Flood Planning area.

REFERENCES

1. Institution of Engineers Australia, "*Australian Rainfall and Runoff, Book 5, Estimation of Design Flood Hydrographs*", 2001 edition.

2. Institution of Engineers Australia, *"Australian Rainfall and Runoff"*, 1987, Volume 2.

3. Institution of Engineers Australia, *"Australian Rainfall and Runoff, Book 4, Estimation of Design Peak Discharges"*, 2001 edition.

4. Bureau of Meteorology. *"The Estimation of Probable Maximum Precipitation in Australia – Generalised Short Duration Method"*, June 2003

5. Paterson Consultants Pty Limited, *"Karuah River Flood Study"*, November 2010, Great Lakes Council.

6. Chow, Ven Te, *"Open Channel Hydraulics"*, McGraw Hill 1959

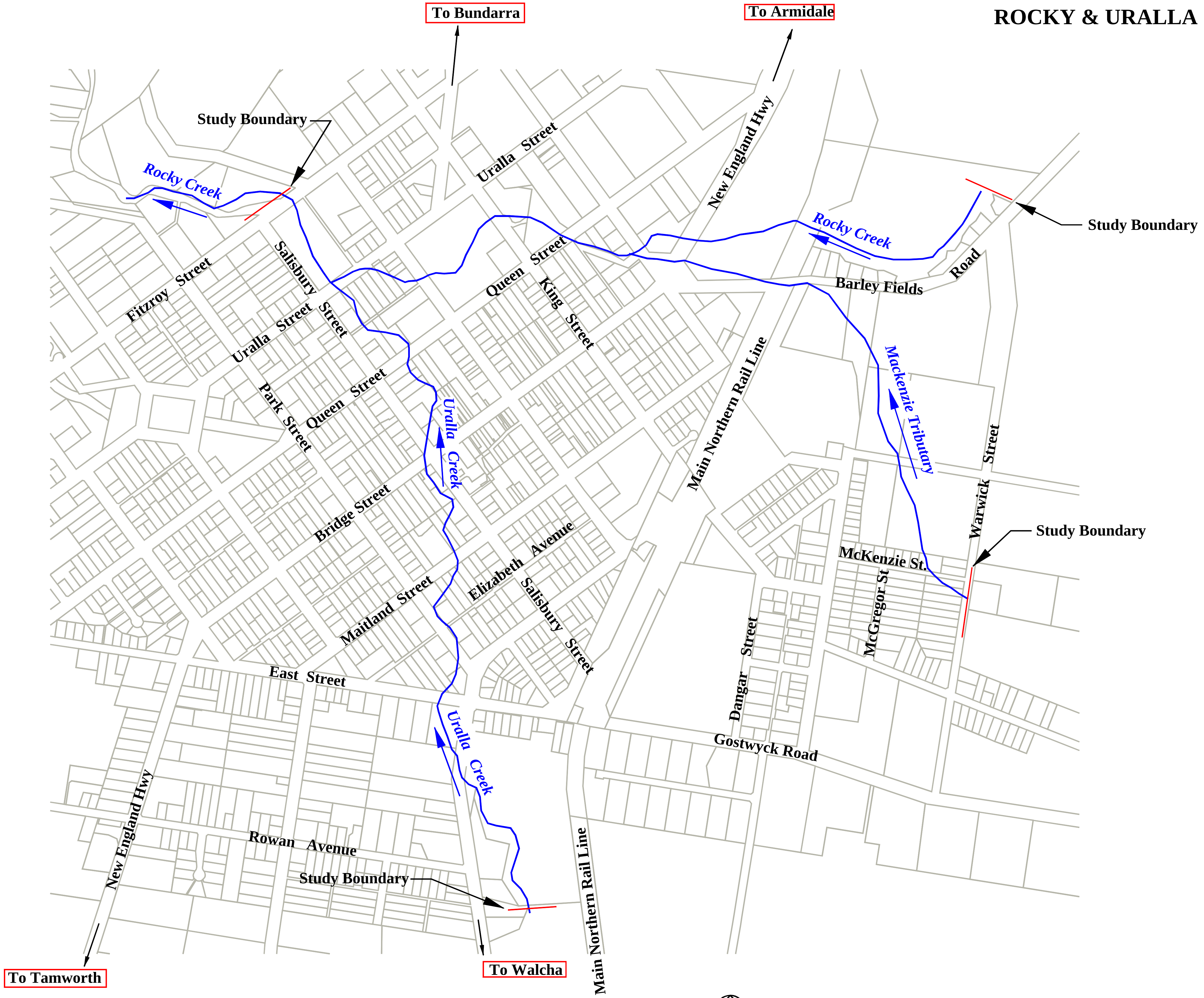
7. French, Richard H, *"Open-channel Hydraulics"*, McGraw Hill 1986

8. Environmental Agency, Scottish Govt, *"Conveyance and Afflux Estimation System"* 2008

9. NSW Government, "Floodplain Development Manual", April 2005

FIGURES

URALLA SHIRE COUNCIL
ROCKY & URALLA CREEKS FLOOD STUDY

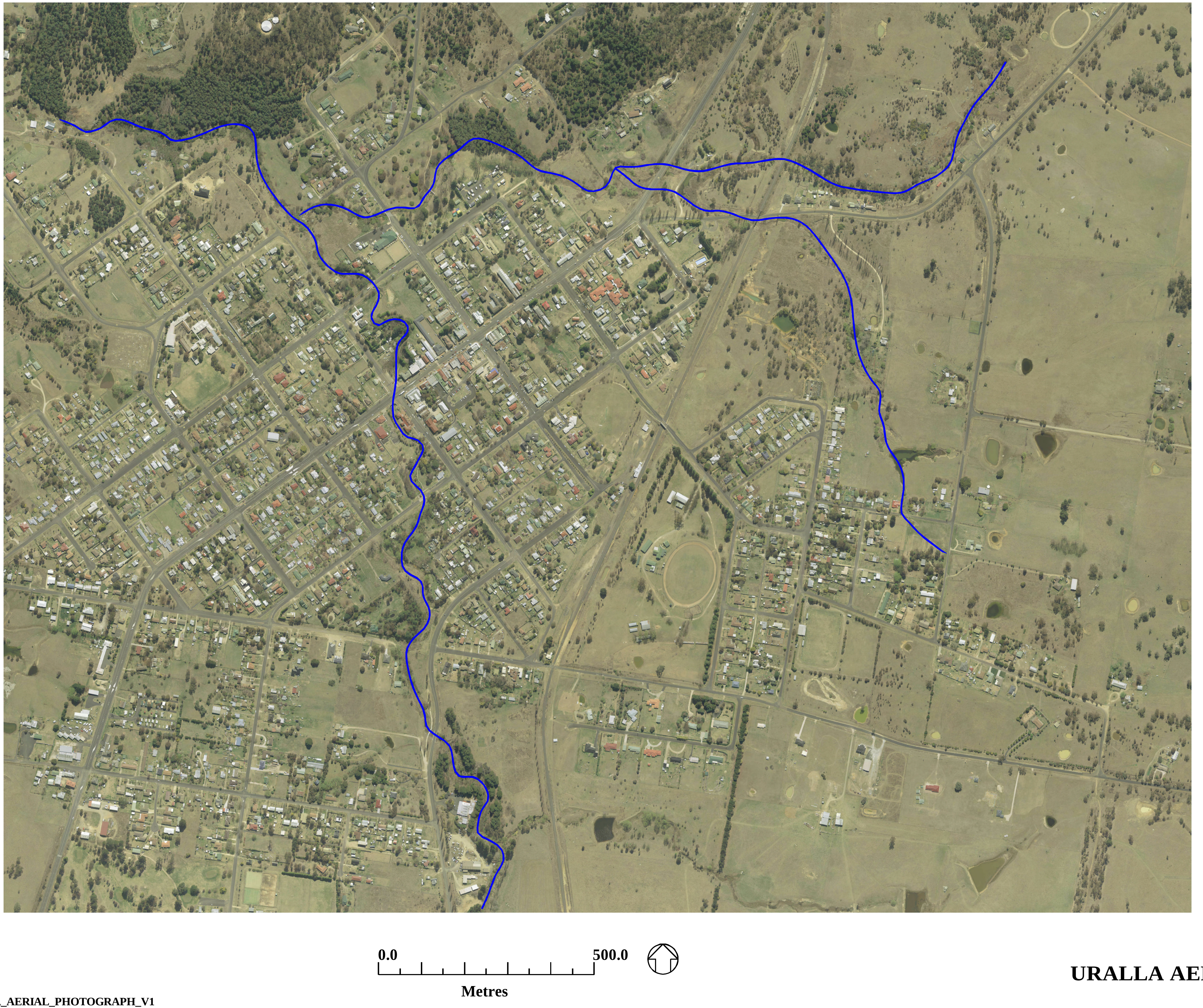


0.0 500.0
Metres

FIGURE 1
URALLA LOT PLAN

DATE: 23 MAY 2012
DISK REF: 12-019
FILE REF: 12019_1_URALLA_LOT_PLAN_V2

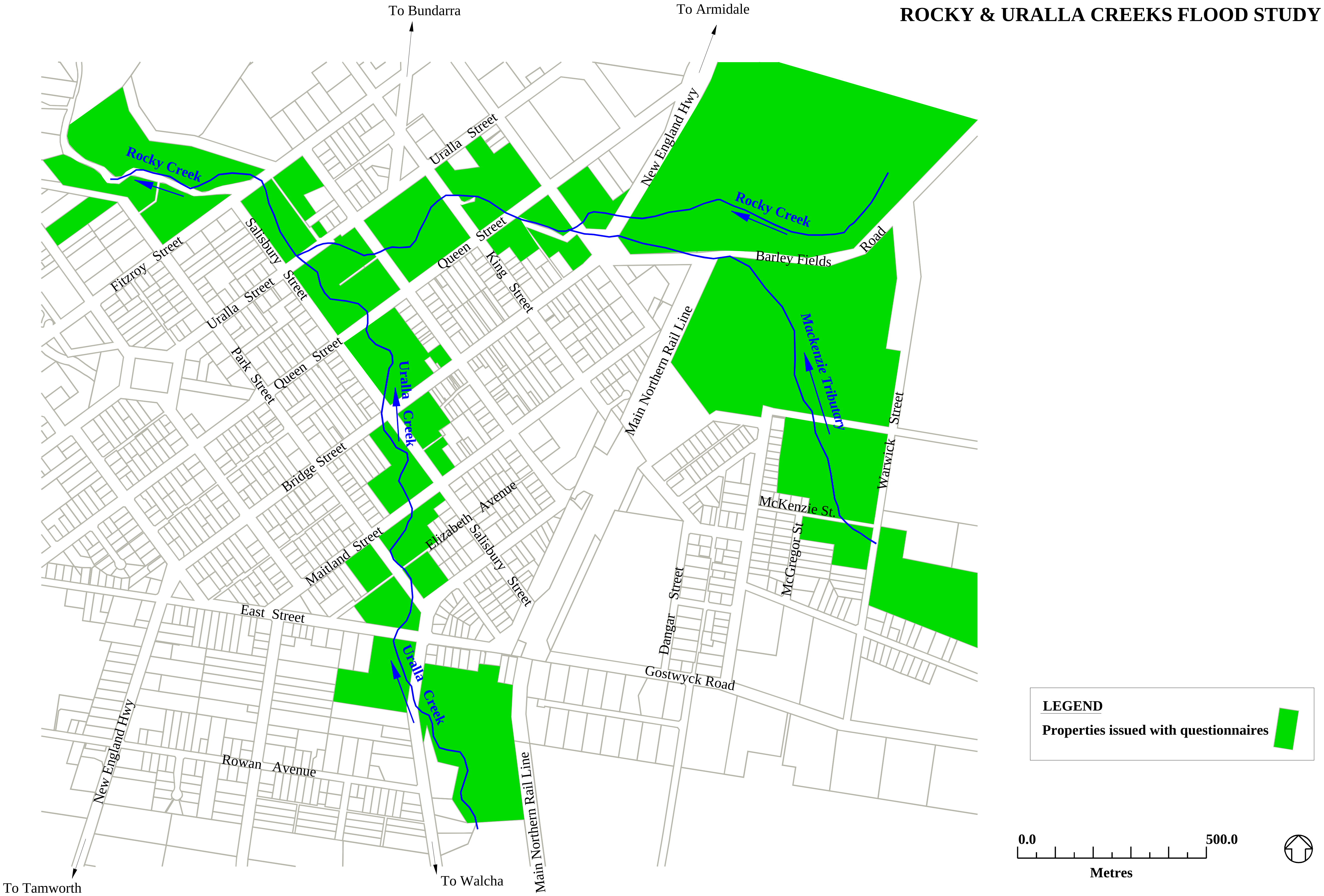
30/6/2014



DATE: 23 MAY 2012
DISK REF: 12-019
FILE REF: 12019_2_URALLA_AERIAL_PHOTOGRAPH_V1

FIGURE 2
URALLA AERIAL PHOTOGRAPH

URALLA SHIRE COUNCIL
ROCKY & URALLA CREEKS FLOOD STUDY

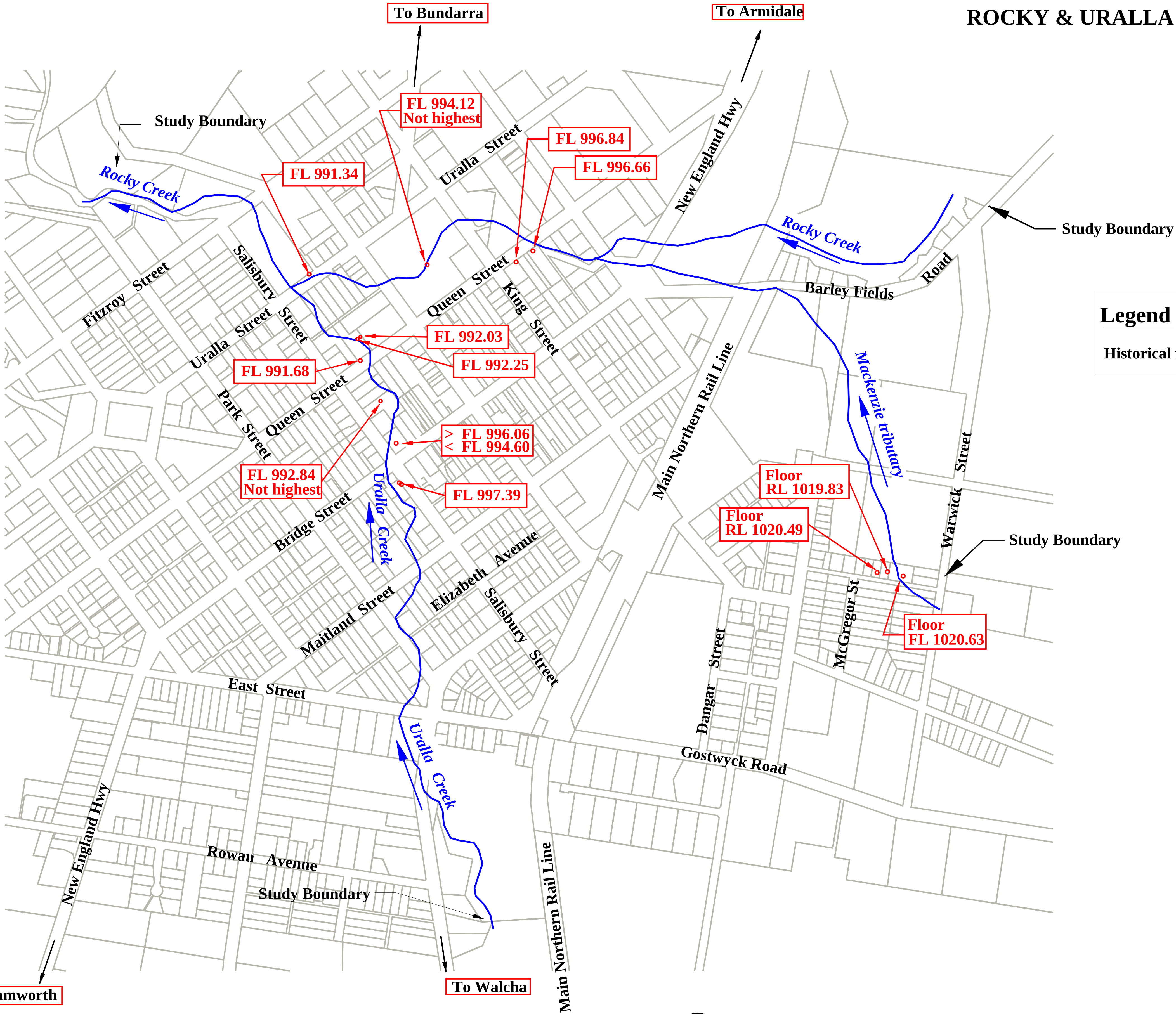


DATE: 16 OCT 2013
DISK REF: 12-019
FILE REF: 12019_3_DISTRIBUTION_OF_QUESTIONNAIRES_V3

30/6/2014

FIGURE 3
DISTRIBUTION OF QUESTIONNAIRES

URALLA SHIRE COUNCIL
ROCKY & URALLA CREEKS FLOOD STUDY



Legend

Historical flood level (m AHD) FL 991.34

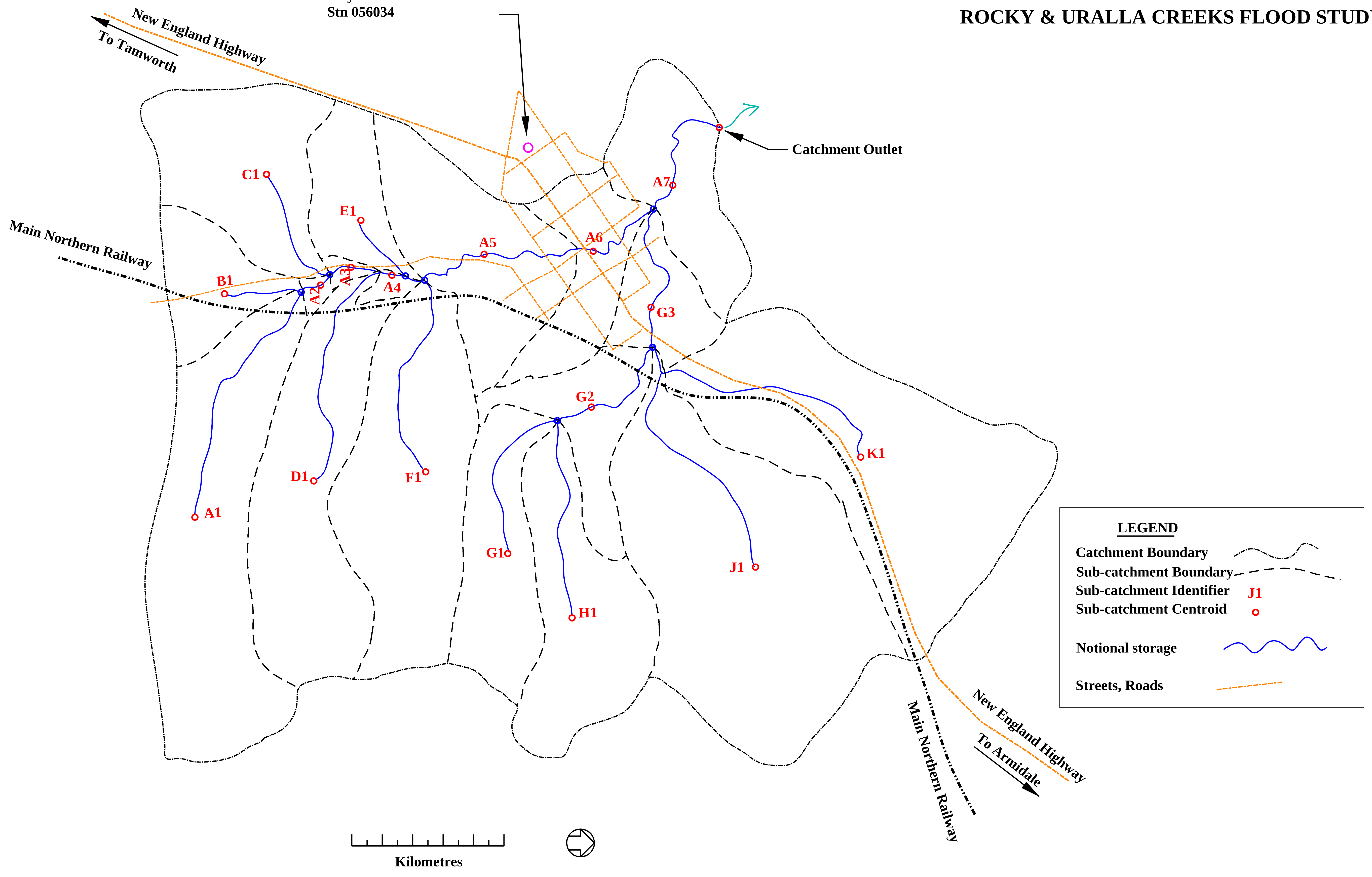
DATE: 18 JANUARY 2013
DISK REF: 12-019
FILE REF: 12019_4_HISTORICAL_FLOOD_LEVELS_V2

[signature] 30/6/2014

FIGURE 4
HISTORICAL FLOOD LEVELS

URALLA SHIRE COUNCIL

ROCKY & URALLA CREEKS FLOOD STUDY

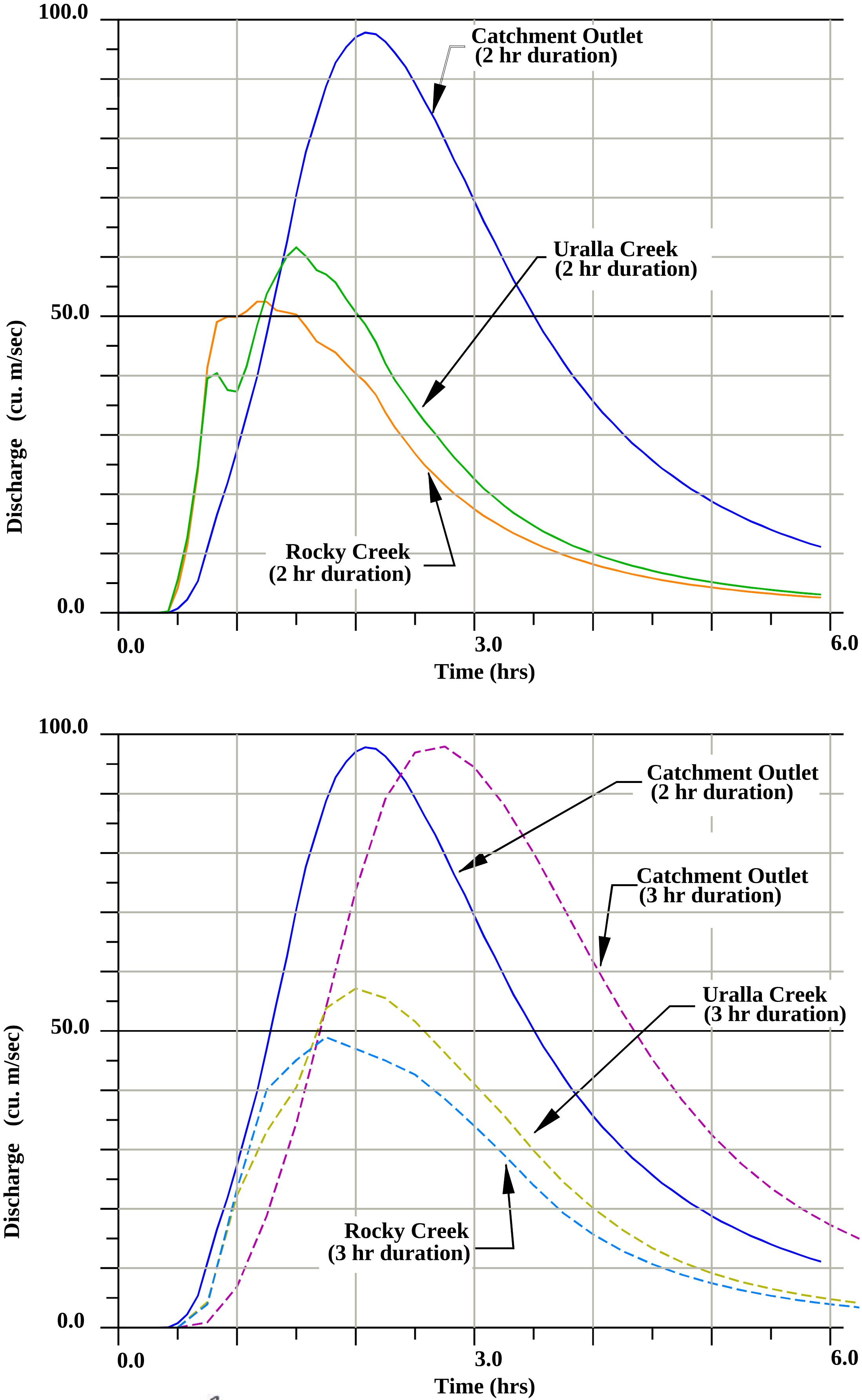


DATE: 24 MAY 2012
DISK REF: 12-019
FILE REF: 12019_5_CATCHMENT_MODEL_V2

30/6/2014

FIGURE 5
CATCHMENT MODEL

URALLA SHIRE COUNCIL
ROCKY & URALLA CREEKS FLOOD STUDY

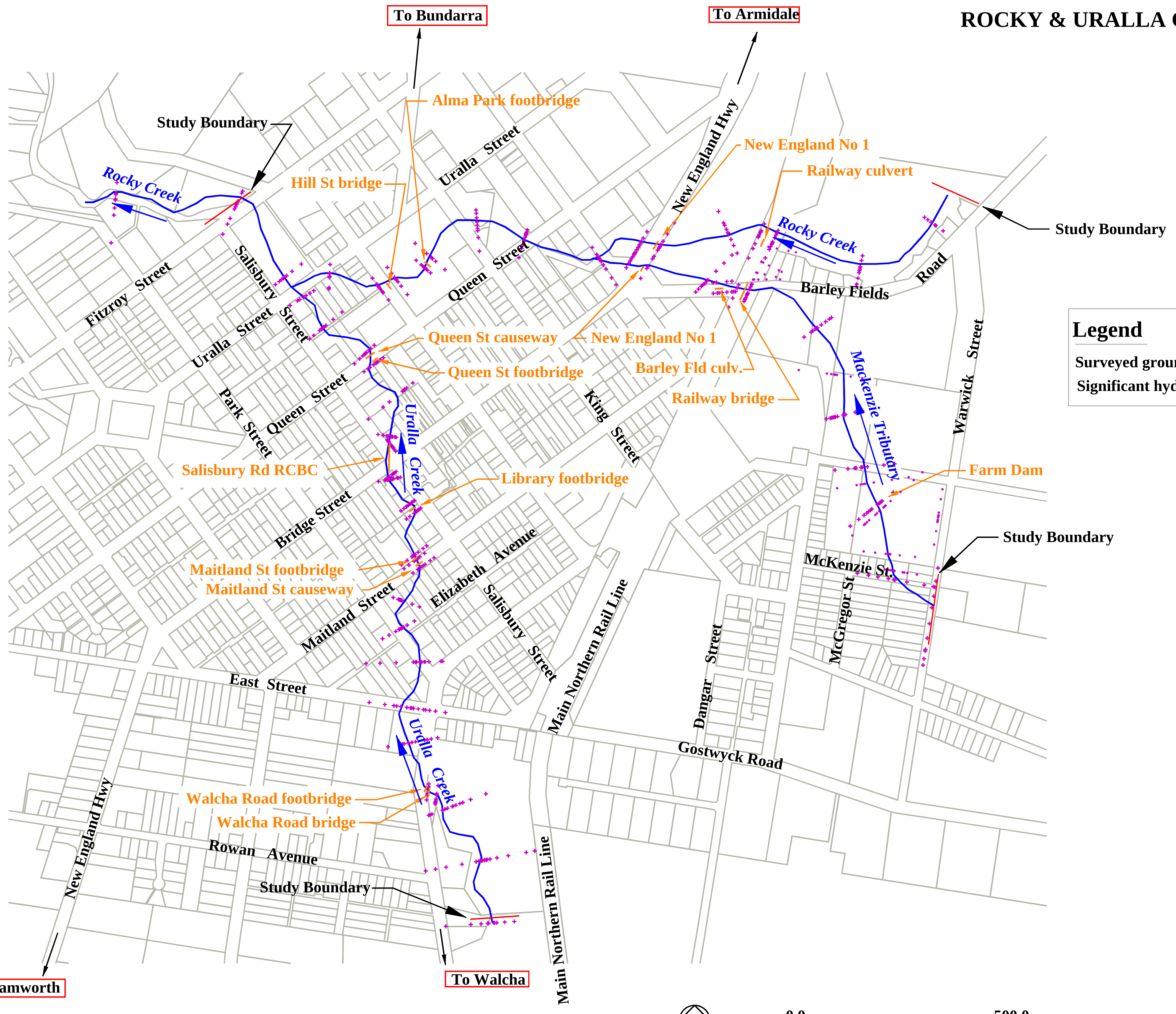


DATE: 24 OCT 2013
DISK REF: 12-019
FILE REF: 12019_6_DESIGN_HYDROGRAPH_V4

30/6/2014

FIGURE 6
1% AEP DESIGN HYDROGRAPHS

URALLA SHIRE COUNCIL
ROCKY & URALLA CREEKS FLOOD STUDY

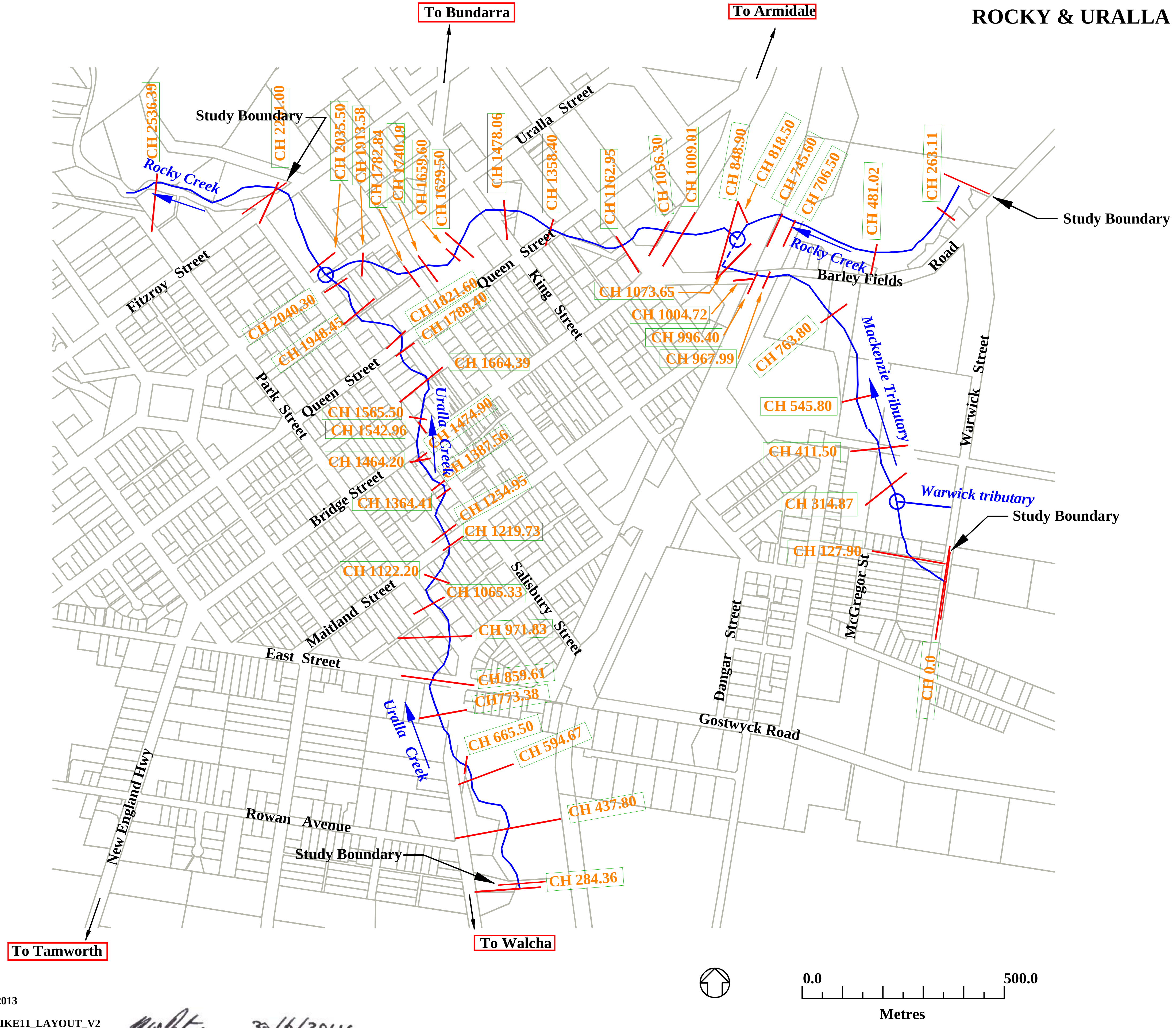


DATE: 21 January 2013
DISK REF: 12-019
FILE REF: 12019_7_Location_of_cross-sections_V2

30/6/2014

FIGURE 7
LOCATION OF CROSS-SECTIONS

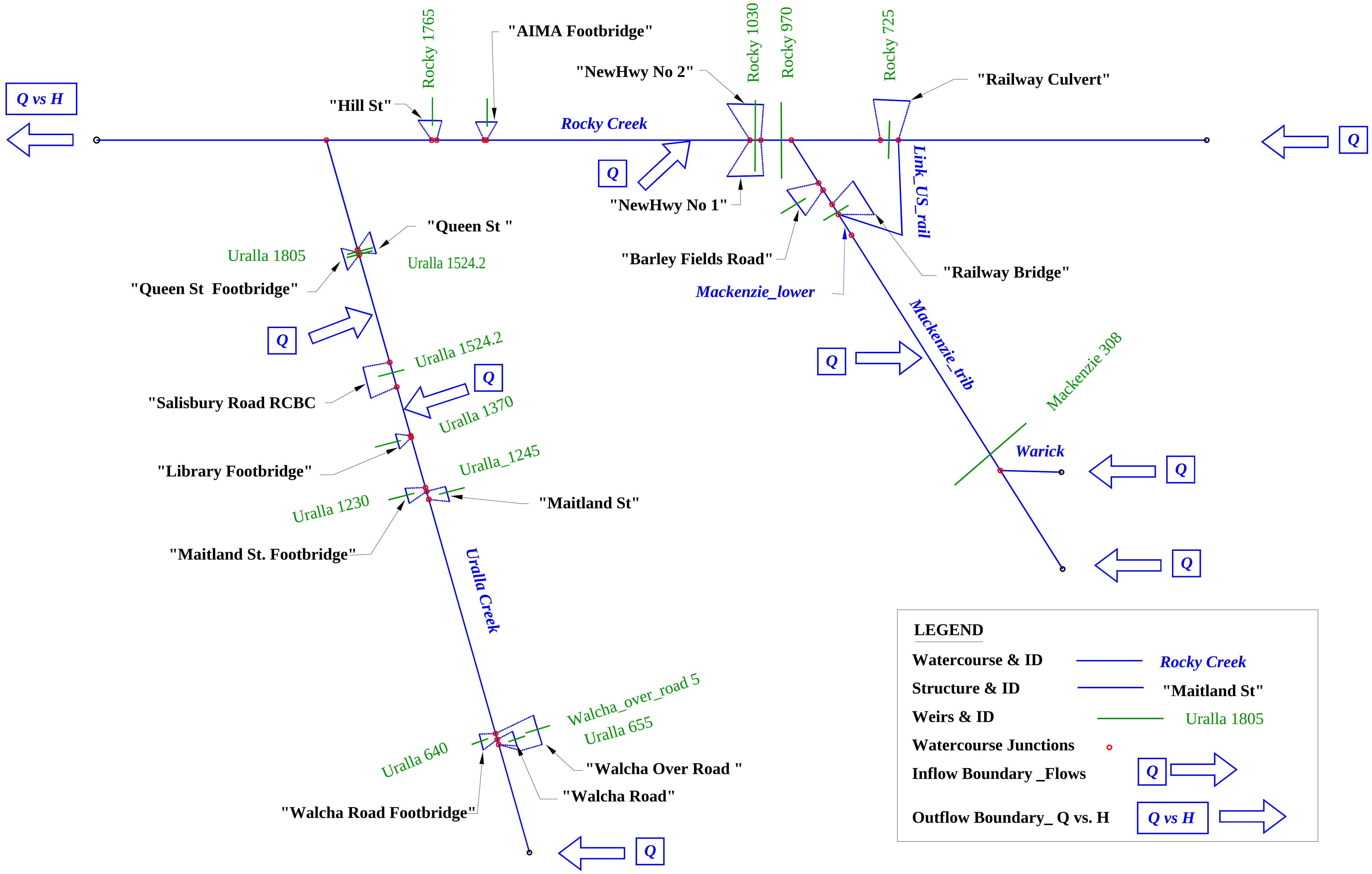
URALLA SHIRE COUNCIL
ROCKY & URALLA CREEKS FLOOD STUDY



DATE: 21 JANUARY 2013
DISK REF: 12-019
FILE REF: 12019_8_MIKE11_LAYOUT_V2

30/6/2014

FIGURE 8
MIKE-11 LAYOUT

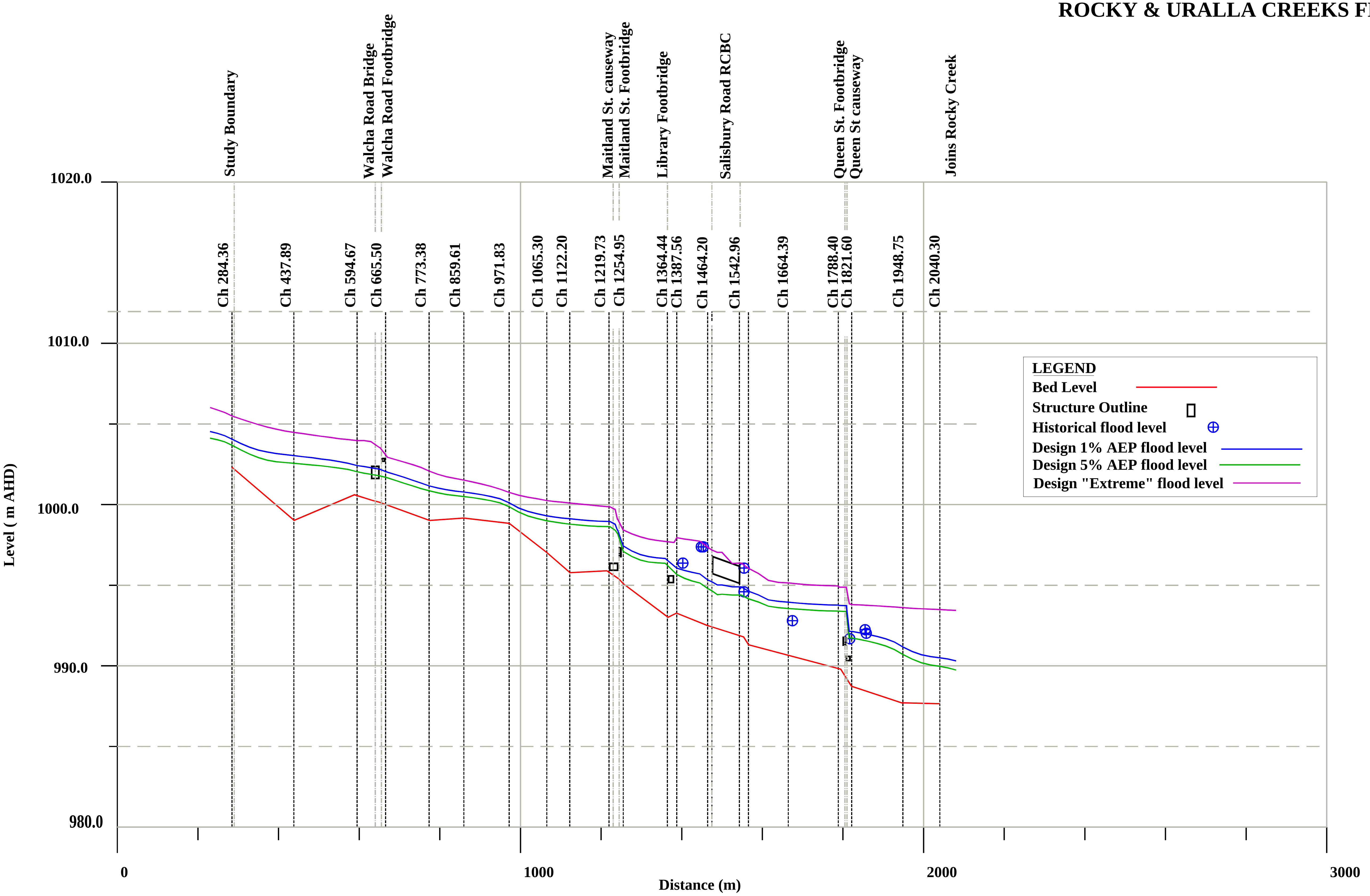


DATE: 11 February 2012
DISK REF: 12-019
FILE REF: 12019_9_MIKE-11 Schematic_v1

30/6/2014

FIGURE 9
MIKE-11 SCHEMATIC

URALLA SHIRE COUNCIL
ROCKY & URALLA CREEKS FLOOD STUDY

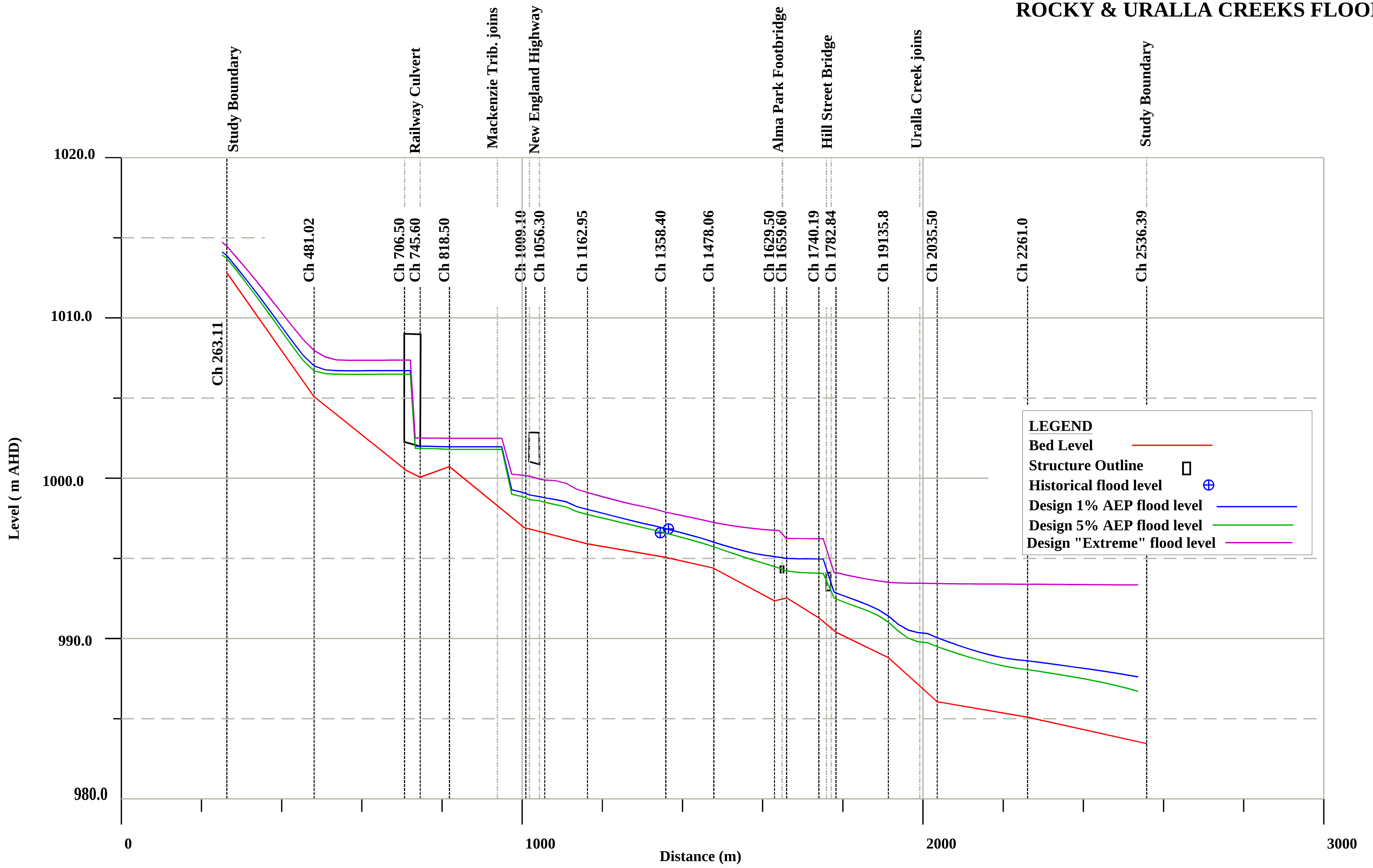


DATE: 17 October 2013
DISK REF: 12-019
FILE REF: 12019_10_DESIGN 1% & 5% AEP LEVELS - URALLA CREEK_V2

30/6/2014

FIGURE 10
DESIGN 1% & 5% AEP FLOOD LEVELS - URALLA CREEK

URALLA SHIRE COUNCIL
ROCKY & URALLA CREEKS FLOOD STUDY

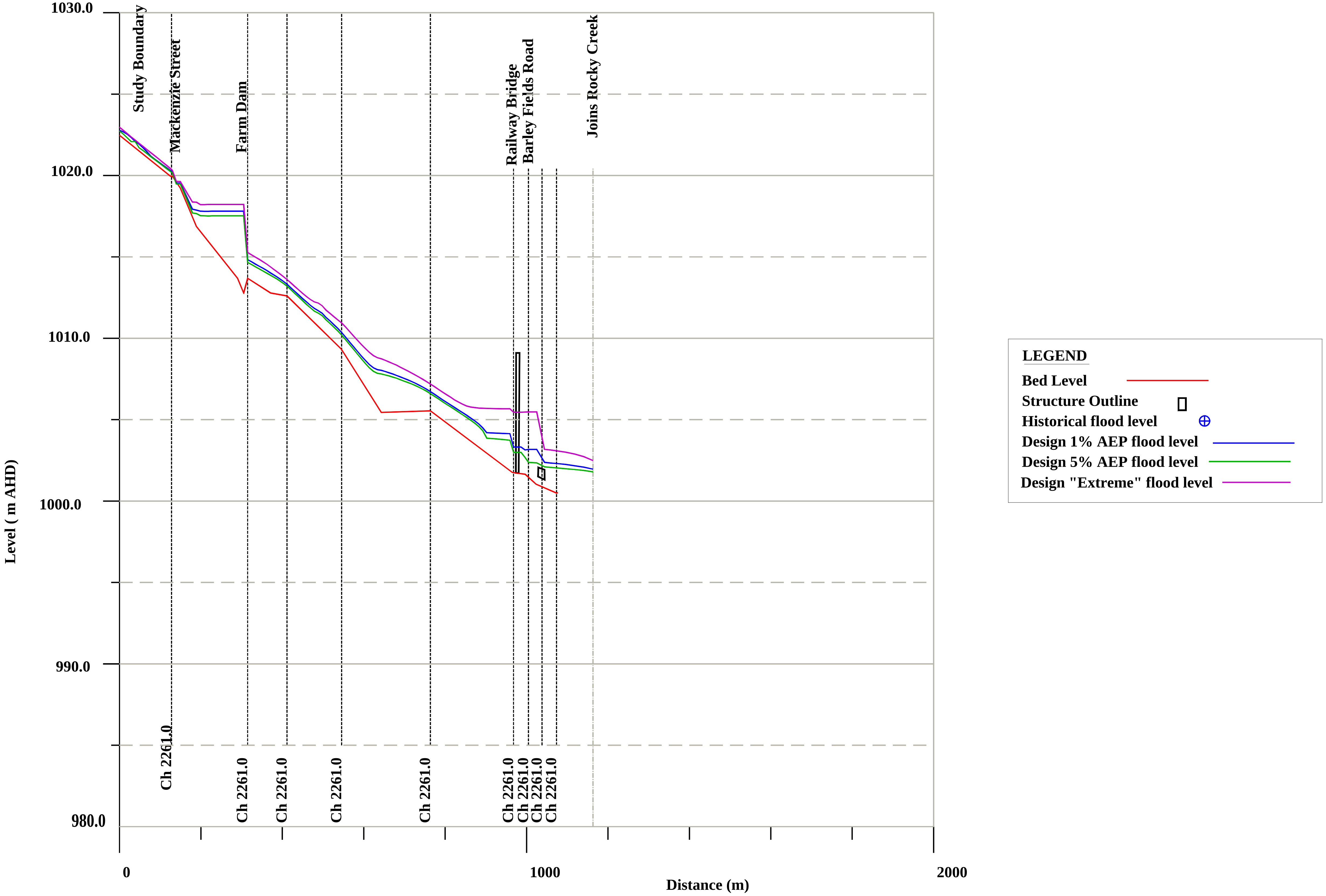


DATE: 17 October 2013
DISK REF: 12-019
FILE REF: 12019_11_Design 1% & 5% AEP Flood levels _ Rocky Creek_v2

30/6/2014

FIGURE 11
DESIGN 1% & 5% AEP FLOOD LEVELS - ROCKY CREEK

URALLA SHIRE COUNCIL
ROCKY & URALLA CREEKS FLOOD STUDY

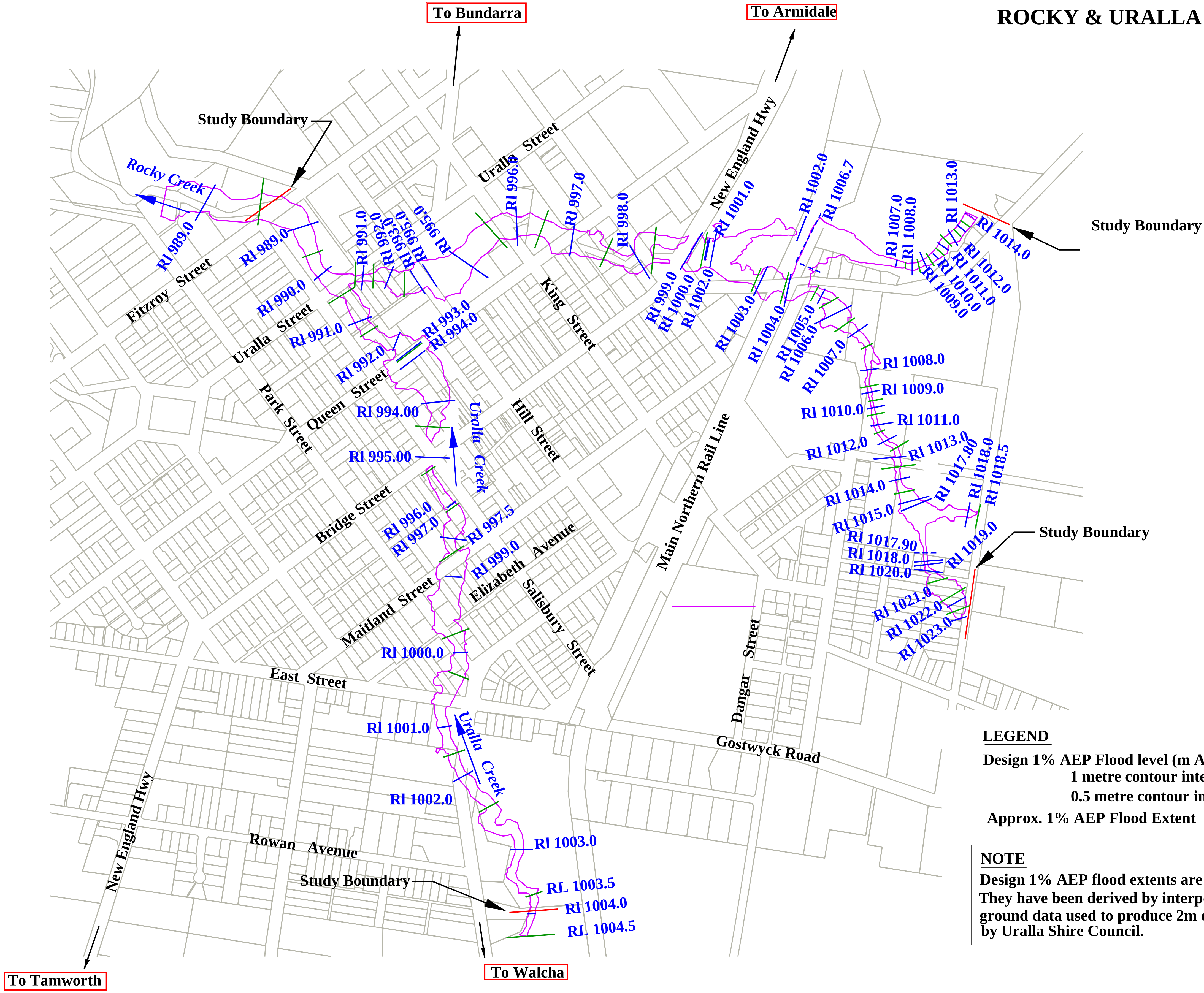


DATE: 17 October 2013
DISK REF: 12-019
FILE REF: 12019_12_DESIGN 1% & 5% AEP LEVELS - MACKENZIE_TRIB_V2

30/6/2014

FIGURE 12
DESIGN 1% & 5% AEP FLOOD LEVELS - MACKENZIE TRIB.

URALLA SHIRE COUNCIL
ROCKY & URALLA CREEKS FLOOD STUDY



LEGEND

Design 1% AEP Flood level (m AHD)
1 metre contour interval — Rl 1000.0
0.5 metre contour interval
Approx. 1% AEP Flood Extent

NOTE

Design 1% AEP flood extents are approximate only. They have been derived by interpolation from existing ground data used to produce 2m contour plans held by Uralla Shire Council.

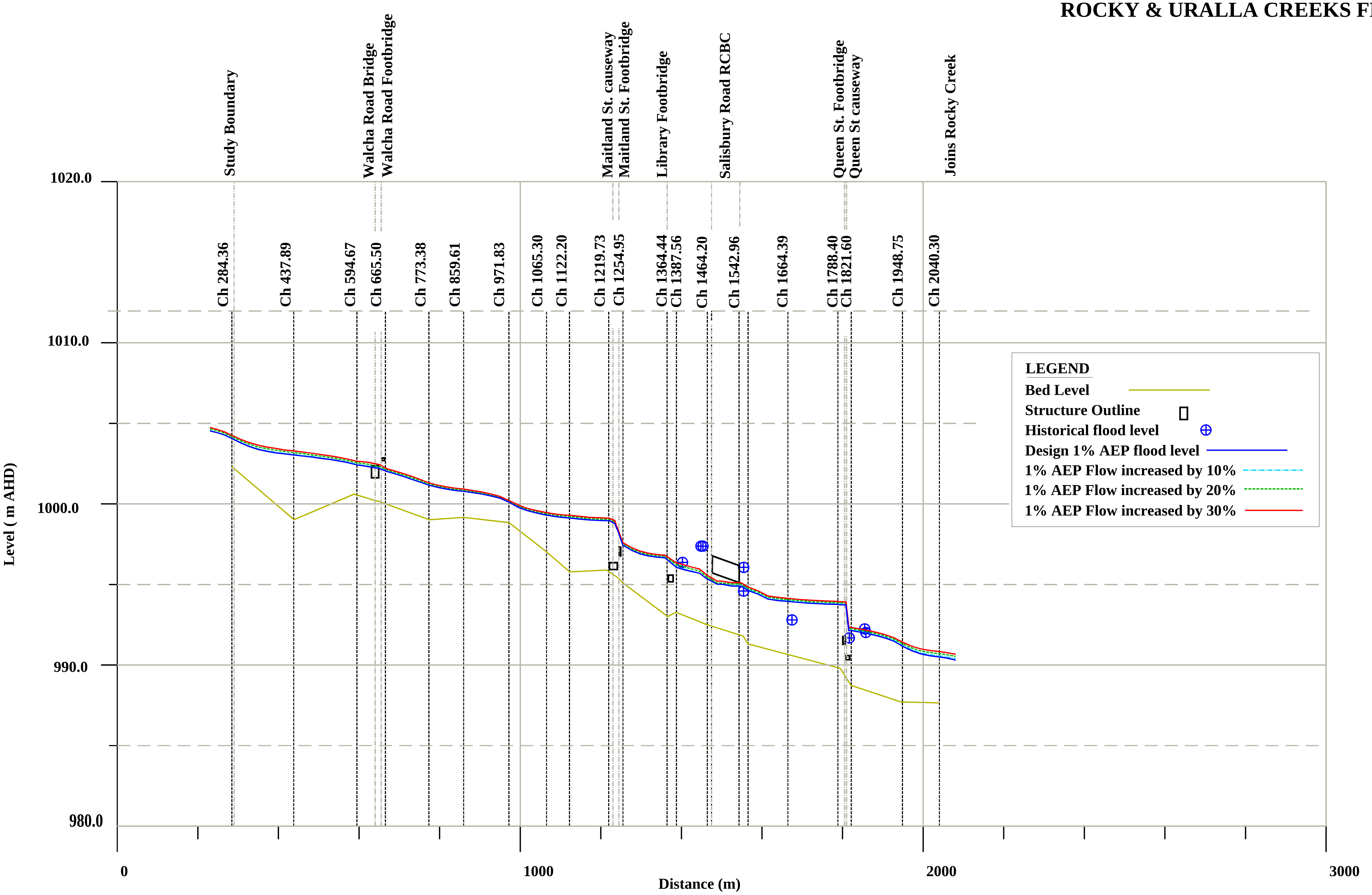
0.0 500.0
Metres

FIGURE 13
DESIGN 1% AEP FLOOD EXTENTS

DATE: 30 June 2014
DISK REF: 12-019
FILE REF: 12019_13_DESIGN_1%_AEP_FLOOD_EXTENTS_V3

30/6/2014

URALLA SHIRE COUNCIL
ROCKY & URALLA CREEKS FLOOD STUDY

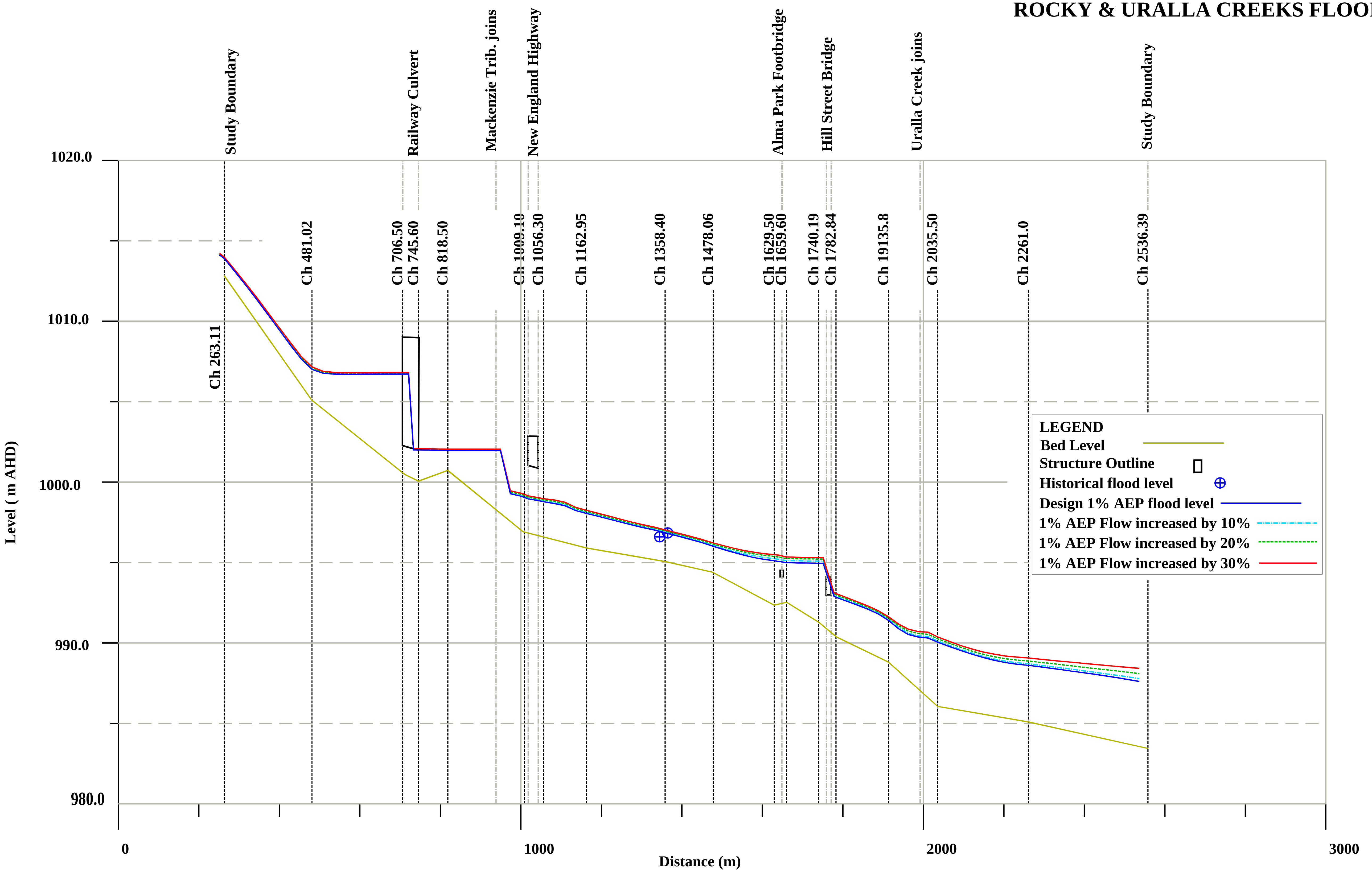


DATE: 17 OCT 2013
DISK REF: 12-019
FILE REF: 12019_14_SENSITIVITY_TESTING_URALLA_CK_V2

30/6/2014

FIGURE 14
SENSITIVITY TESTING - URALLA CREEK

URALLA SHIRE COUNCIL
ROCKY & URALLA CREEKS FLOOD STUDY

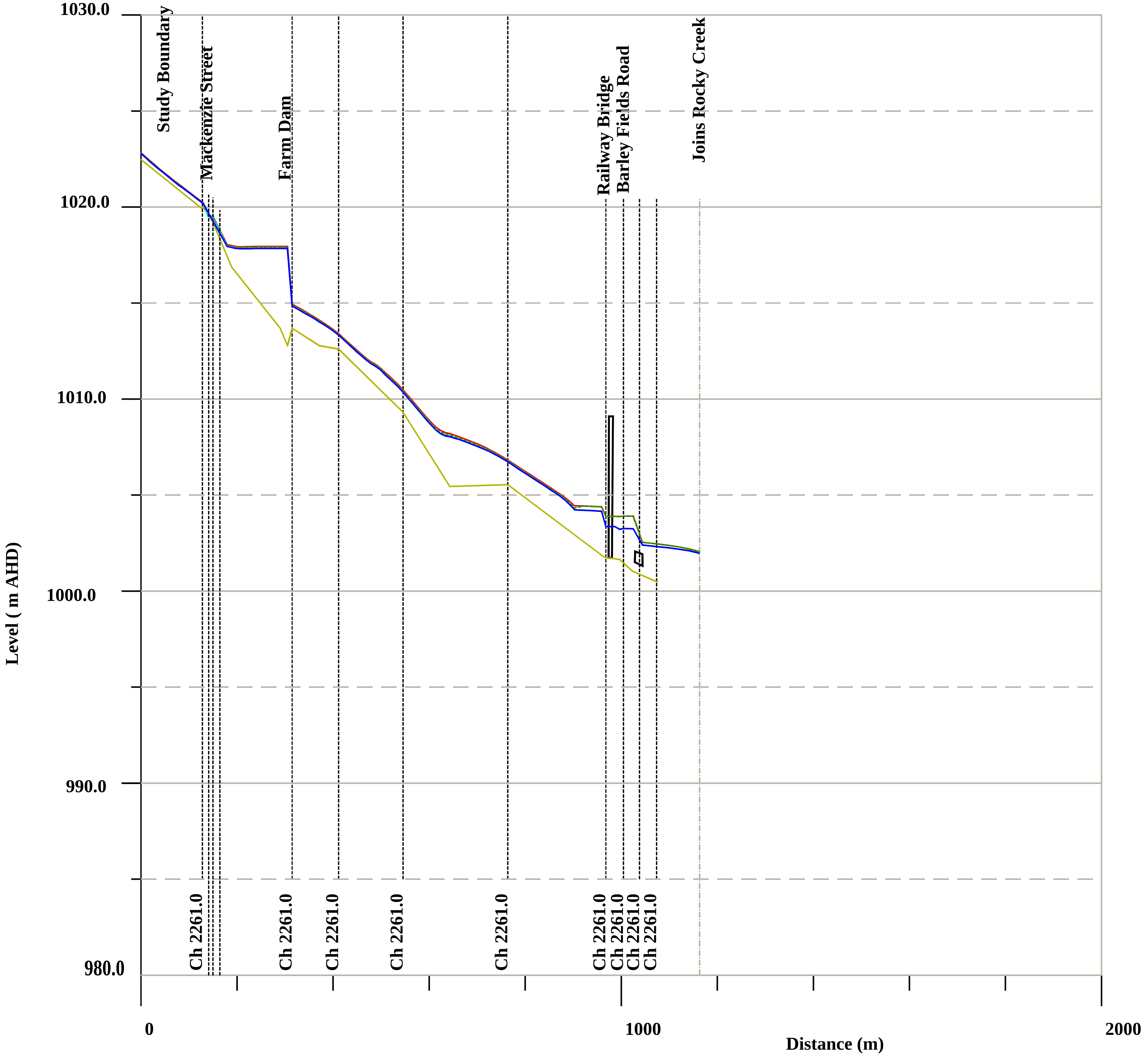


DATE: 17 October 2013
DISK REF: 12-019
FILE REF: 12019_15_Sensitivity testing_Rocky Creek_v2

30/6/2014

FIGURE 15
SENSITIVITY TESTING - ROCKY CREEK

URALLA SHIRE COUNCIL
ROCKY & URALLA CREEKS FLOOD STUDY



LEGEND

Bed Level
Structure Outline
Historical flood level
Design 1% AEP flood level
1% AEP Flow increased by 10%
1% AEP Flow increased by 20%
1% AEP Flow increased by 30%

NOTE

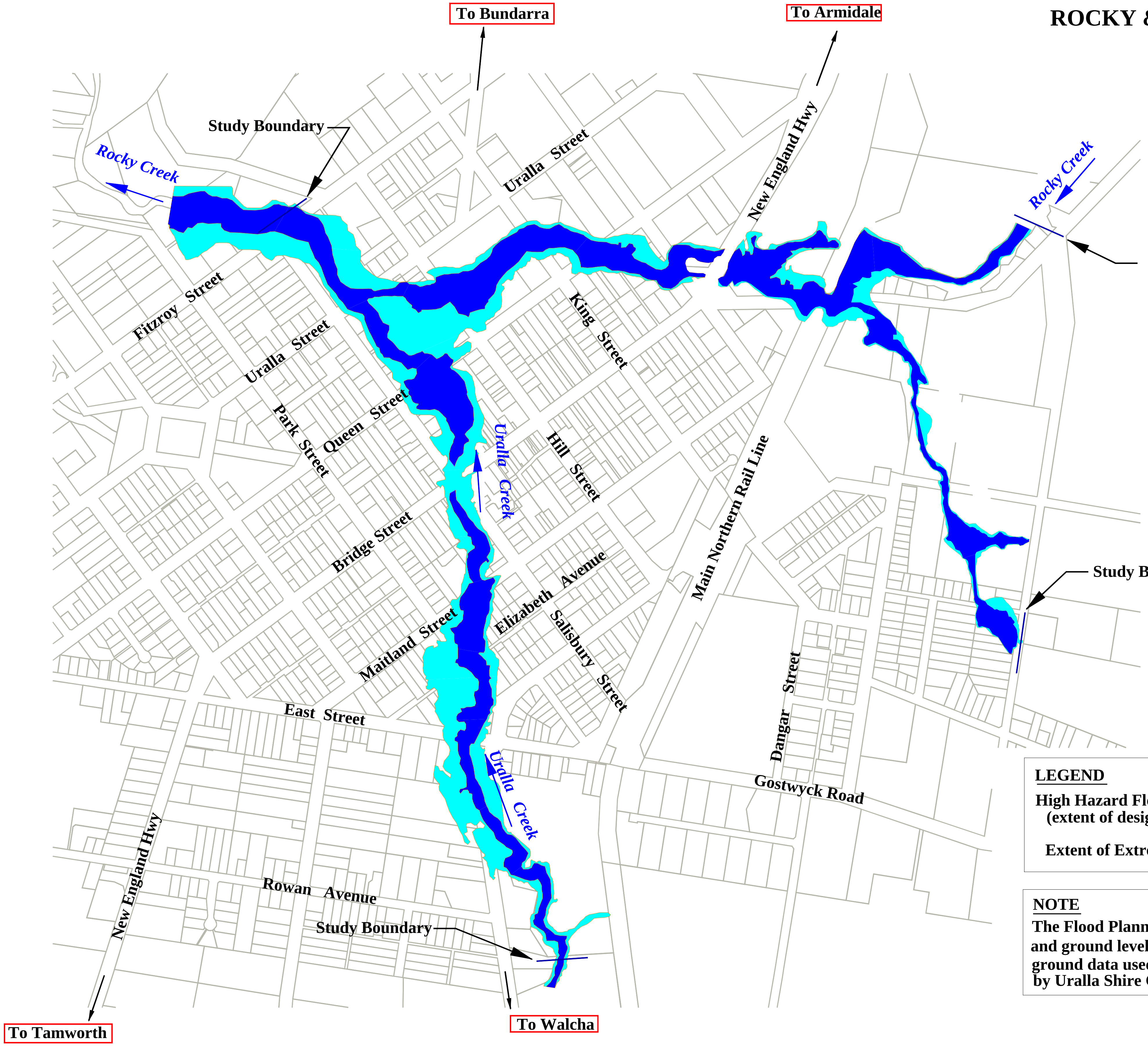
This drawing shows a comparison between various flows for the 3 hour duration 1% AEP flood.
The adopted 1% AEP flood levels are higher and derived from a shorter duration event

DATE: 24 OCT 2013
DISK REF: 12-019
FILE REF: 12019_16_SENSITIVITY_TESTING_MACKENZIE TRIB_V3

30/6/2014

FIGURE 16
SENSITIVITY TESTING - MACKENZIE TRIB.

URALLA SHIRE COUNCIL
ROCKY & URALLA CREEKS FLOOD STUDY



LEGEND

High Hazard Floodway
(extent of design 1% AEP event)

Extent of Extreme Flood

NOTE

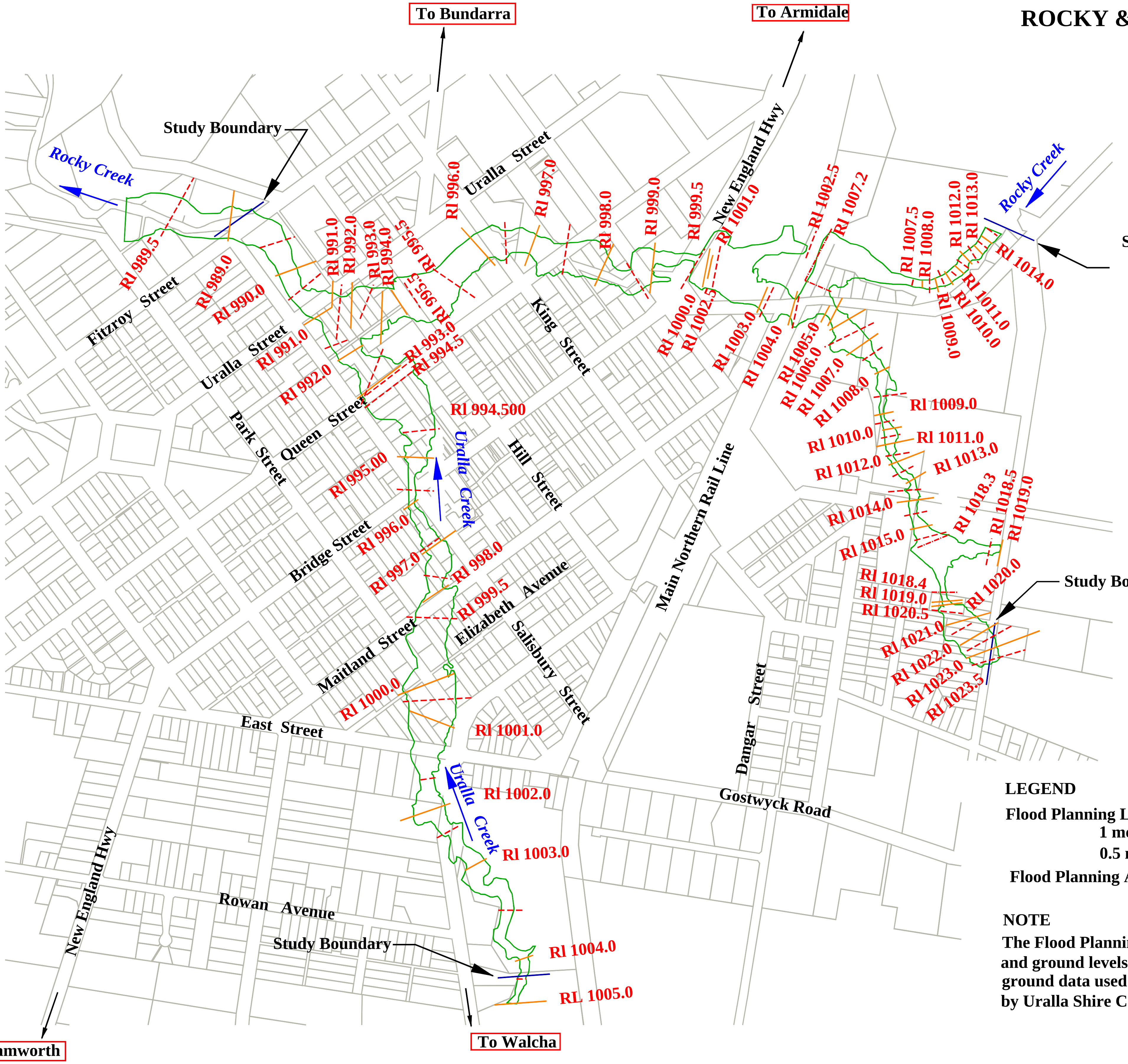
The Flood Planning Area is based on Flood Planning Levels and ground levels derived by interpolation from existing ground data used to produce 2m contour plans held by Uralla Shire Council.

DATE: 24 October 2013
DISK REF: 12-019
FILE REF: 12019_17_FLOOD_HAZARD_V1

30/6/2014

FIGURE 17
FLOOD HAZARD

URALLA SHIRE COUNCIL
ROCKY & URALLA CREEKS FLOOD STUDY



LEGEND

Flood Planning Level (m AHD)

1 metre contour interval	Rl 1000.0
0.5 metre contour interval	
Flood Planning Area	

NOTE

The Flood Planning Area is based on Flood Planning Levels and ground levels derived by interpolation from existing ground data used to produce 2m contour plans held by Uralla Shire Council.

DATE: 22 October 2013
DISK REF: 12-019
FILE REF: 12019_18_FLOOD_PLANNING_LEVELS_V1

[signature] 30/6/2014

FIGURE 18
FLOOD PLANNING LEVELS

APPENDICES

APPENDIX A

RESIDENT QUESTIONNAIRE

COMMUNITY FLOOD DATA QUESTIONNAIRE

Please help us by completing and returning this questionnaire by **Friday, 8 June, 2012.**

How to complete the survey

Please indicate your answer by:

- placing a tick in one of the boxes (□);
- providing written details in the space provided.........).

The questions in this survey are based on a standard questionnaire used across the State. Please answer each to the best of your ability and as it applies to your experience. If a question does not apply, or you do not know the answer, please indicate this and move on to the next question.

If you run out of space for any question please attach additional pages to the questionnaire.

If you have non-adjoining properties that were affected, please fill out a separate questionnaire for each property. Please contact Uralla Shire Council if you require additional questionnaires.

If you would like any help filling out the questionnaire, or would like clarification regarding any of the questions, please do not hesitate to contact Council on 6778 6300.

SECTION A – BACKGROUND

1. Please provide your property address:

Owner Name:

Property Title:

Property Address:

Name or business/organisation ....

2. On the map, please mark the lots that have been affected by creek flooding in the past.

(If none of these lots were affected by flooding, but you were affected by road closures or have other information about the January 2012 flooding please answer the questionnaire where relevant or attach your information on a separate page.)

3. **What is the property type?**
   - ☐ Residential
   - ☐ Commercial. Please indicate nature of activity: ……………………………………………………………
   - ☐ Industrial. Please indicate nature of activity: ……………………………………………………………
   - ☐ Farm. Please indicate nature of farming activity: ……………………………………………………………
   - ☐ Other. Please specify: ……………………………………………………………………………………

4. **Are you the:**
   - ☐ Owner residing or conducting business at property?
   - ☐ Tenant?
   - ☐ Owner not residing nor conducting business at property?
   - ☐ Secretary or Body Corporate?
   - ☐ Other - I observed flooding at this location
   - ☐ Other - Please specify ……………………………………………………………

5. **Since what year have you lived at, worked at or owned this property?** ……………… *(e.g. 1982)*

SECTION B – FLOOD BEHAVIOUR

5. **Have you previously experienced or observed flooding at this address?**

   ☐ No ☐ Yes

   When was the highest flood event? ………………………… *(month/year if possible)*

   What other large floods do you remember? (for example: January 1976, February 2003, January 2004)……………………………………………………………………

   ………

6. **During large flood events, what parts of the property are affected, and to what maximum depths?**

Location	Affected?		Depth of inundation *(indicate whether in cm, mm or feet)*
Above floor of main building (eg. house)	☐ No	☐ Yes	
Above floor of other buildings (eg. garage)	☐ No	☐ Yes	
Above ground in yard next to main building	☐ No	☐ Yes	
Above road adjacent to property	☐ No	☐ Yes	
Other (please specify): ………………………	☐ No	☐ Yes	

7a) **Do you have any marks indicating the maximum height that water reached, or are you able to indicate the level reached by the flood (eg. to top step, or the like)?**

   ☐ Yes ☐ No

7b) **Would you permit our surveyor to measure the flood marks at a suitable, agreed time?**

   ☐ Yes ☐ No

8. **At what time was the highest water level reached?**

   Date ……………… Time ……………… am/pm *(circle which applies)*

   How sure of this time are you?

   ☐ Within 30 minutes ☐ Within 1 hour ☐ Don't know/Unsure

9. **How quickly did the water rise?**

☐ Fast (over minutes) ☐ Slow (over hours) ☐ Slower (over days)

Estimated rate of rise ……………… metres per hour

10. **How long did floodwater last on the property?**

………………… hours/days *(circle which applies)*

11. **At about what speed was the floodwater flowing at or surrounding this address?**

☐ Fast (running speed or faster) ☐ Slow (walking speed) ☐ Not Moving

Estimated speed …………………… metres per second

12. **Where did the floodwater come from?**

☐ river or creek
☐ storm water drain
☐ street or road
☐ neighbouring land
☐ other. Please specify: ……………………………………………………………………………………

13. **Did waves or surges occur during the flooding at this address?**

☐ No ☐ Yes

If yes, were waves or surges caused by vehicles driving through floodwater ?

☐ No ☐ Yes

If no, what do you think caused them? ....

14. **Did any blockages of bridges, culverts or drains appear to contribute to the inundation problem?**

☐ No ☐ Yes

If yes, what was the nature of the blockage? ....

Where was the blockage observed? ....

When did you first notice the blockage? Date .... Time .... am/pm

15. **Please describe any other influences on the flooding we should be aware of e.g. levee banks.**

....

16. **Do you have any photographs, videos or other information about flooding in your area, which you would be prepared to share with Council?**

☐ No ☐ Yes

Description (eg photos, videos) ....

....

17. **Do you have any rainfall records for the storm event?**

☐ No ☐ Yes

If yes, what type of records do you have?

Automated weather station that records rainfall accumulation: ☐ No ☐ Yes

Rain gauge: ... ... ☐ No ☐ Yes

Please attach daily rainfall depths if possible (indicate whether in mm, cm, points or inches), otherwise you may show depths on the table.

Date	Rainfall depth at 0900 hrs each day *(indicate whether in mm, cm, points or inches)*	Date	Rainfall depth at 0900 hrs each day *(indicate whether in mm, cm, points or inches)*

18. Can you provide below a sketch map of your property and where flooding/stormwater flowed or reached. Indicate your property compared to surrounding properties, your street, and where the water came from and went to. If possible, please indicate the extent of water in your property, and where local roads were cut. *(Please attach a separate page if required).*

SECTION C – FLOOD RESPONSES

19. Did you use sandbags to prevent floodwater entering buildings at this address?

☐ No ☐ Yes

If yes, at what locations were they used to prevent entry of floodwater? e.g. residence, garage

....

If no, why not?

☐ they were not required
☐ you were not able to place them yourself
☐ they were not available
☐ you did not have assistance to place them

20. Did you need to evacuate the property?

☐ No ☐ Yes

If yes, how did you evacuate? ....

....

Were you assisted and if so by which organisation? ....

....

21. Did you require emergency accommodation?

☐ No ☐ Yes

If yes, where did you stay (family/friends/motel/hotel)? ....

How long did you require alternative accommodation for? .... days

22. Was access to your location disrupted due to floodwaters?

☐ No ☐ Minor disruption (roads trafficable)

☐ Access cut within property ☐ Access cut along main roads

If access was cut, on what road(s), approximately where on the road(s), and for how long? ....
....

23. May we may contact you to discuss your flood issues?

Phone: .... (Ask for ....)

Best time to call: ....

22. Are you interested in sitting on the Floodplain Management Committee?

☐ Yes ☐ No

If 'Yes' please provide a contact phone number here ....

23. Would you like to be kept informed about the study and the work of the committee?

☐ Yes ☐ No

If 'Yes' please provide an email address ....

24. Please return the completed questionnaire by <u>Friday, 8 June, 2012</u>:

Return your questionnaire to Uralla Shire Council in the supplied Free Post envelope; or address a blank envelope (no stamp required) to:

The General Manager
Uralla Shire Council
Replied Paid
PO Box 106
Uralla NSW 2358

This project has been made possible by NSW and Commonwealth Government funding under the Natural Disaster Resilience Program.

APPENDIX B

ADOPTED INTENSITY-FREQUENCY-DURATION(IFD) RAINFALL DATA

```
-----------------------------------------------------------
| Program for determining IFD design rainfall information |
|          - based on AR&R(1987) sect 2.3                 |
|         (C) 1988 WP Software (062 815811)               |
-----------------------------------------------------------

*** INPUT DATA ECHO ***

URALLA
 2 year,  1 hour intensity:       25.000000 mm/hr
 2 year, 12 hour intensity:        5.000000 mm/hr
 2 year, 72 hour intensity:        1.340000 mm/hr
50 year,  1 hour intensity:       46.000000 mm/hr
50 year, 12 hour intensity:        8.900000 mm/hr
50 year, 72 hour intensity:        2.450000 mm/hr
Skewness:    3.100000E-01
Geographical factor for 6 minute,  2 yr storm:        4.345000
Geographical factor for 6 minute, 50 yr storm:       16.200000
```

*** OUTPUT IFD TABLE ***

Rainfall Intensity (mm/h) for URALLA

Duration	Average Storm Recurrence Interval (years)						
	1	2	5	10	20	50	100
6m	58.68	77.09	102.35	118.92	141.06	172.18	197.50
7	55.35	72.64	96.22	111.65	132.29	161.25	184.81
8	52.50	68.85	91.00	105.47	124.84	152.00	174.06
9	50.03	65.56	86.49	100.13	118.41	144.02	164.79
10	47.86	62.67	82.53	95.45	112.78	137.03	156.69
11	45.93	60.10	79.01	91.30	107.79	130.85	149.53
12	44.19	57.80	75.87	87.59	103.33	125.33	143.13
13	42.62	55.71	73.02	84.24	99.31	120.35	137.37
14	41.20	53.82	70.44	81.20	95.67	115.84	132.16
15	39.89	52.08	68.08	78.43	92.34	111.73	127.41
16	38.69	50.49	65.92	75.88	89.29	107.97	123.05
17	37.57	49.01	63.92	73.53	86.47	104.50	119.04
18	36.54	47.65	62.07	71.35	83.87	101.29	115.34
20	34.68	45.19	58.74	67.45	79.20	95.54	108.70
25	30.95	40.24	52.07	59.64	69.88	84.08	95.49
30	28.10	36.48	47.02	53.74	62.85	75.46	85.58
35	25.84	33.51	43.04	49.10	57.33	68.70	77.81
40	23.99	31.08	39.80	45.33	52.85	63.23	71.53
45	22.45	29.05	37.11	42.20	49.14	58.69	66.33
50	21.14	27.33	34.82	39.54	45.99	54.87	61.95
55	20.01	25.84	32.86	37.27	43.30	51.59	58.20
60	19.02	24.55	31.14	35.28	40.96	48.74	54.95
75	16.55	21.34	27.05	30.62	35.53	42.25	47.60
90	14.74	19.01	24.06	27.23	31.57	37.53	42.27
2.0h	12.26	15.80	19.97	22.57	26.15	31.05	34.96
3.0	9.42	12.13	15.30	17.27	19.99	23.71	26.66
4.0	7.81	10.05	12.65	14.27	16.51	19.56	21.98
5.0	6.76	8.69	10.92	12.31	14.23	16.85	18.93
6.0	6.00	7.71	9.69	10.91	12.61	14.92	16.75
8.0	4.98	6.39	8.02	9.03	10.42	12.32	13.82
10.0	4.31	5.53	6.93	7.79	8.99	10.62	11.91
12.0	3.83	4.91	6.15	6.91	7.97	9.41	10.55
14.0	3.44	4.42	5.53	6.22	7.18	8.48	9.51
16.0	3.14	4.03	5.05	5.68	6.56	7.75	8.69
18.0	2.89	3.71	4.66	5.24	6.05	7.15	8.03
20.0	2.69	3.45	4.33	4.88	5.63	6.66	7.47
22.0	2.51	3.23	4.05	4.57	5.27	6.24	7.00
24.0	2.36	3.04	3.81	4.30	4.96	5.88	6.60
36.0	1.76	2.27	2.86	3.22	3.73	4.42	4.97
48.0	1.42	1.83	2.30	2.60	3.01	3.57	4.02
60.0	1.19	1.53	1.93	2.19	2.53	3.01	3.39
72.0	1.02	1.32	1.67	1.88	2.18	2.59	2.92

APPENDIX C

RORB MODEL LISTING

```
Rocky Creek Uralla, adjusted for Mike+_11 input as of 13/12/2012
0,     not all reaches in natural condition
1,1,1.75,-99      sub area A1
3,    store A1
1,1,0.5,-99 sub area B1
4,    add A1 to B1
5,1,0.1,-99
2,1,0.1,-99 sub area A2
3,    store A2
1,1,0.41,-99      sub area C1
4,    add A2 to C1
5,1,0.1,-99
2,1,0.2,-99 sub area A3
3,    store A3
1,1,1.6,-99 sub area D1
4,    add A3 to D1
5,1,0.1,-99
2,1,0.1,-99 sub area A4
3,    store A4
1,1,0.55,-99      sub area E1
3,    store E1
1,1,1.6,-99 sub area F1
4,    add E1 to F2
4,    add A4 to E1 and F1
5,2,0.4,0.6,-99
2,2,0.6,0.6,-99   sub area A5
5,2,0.2,1.4,-99
7,
m11_uralla_0
2,2,0.3,1.4,-99   sub area A6
7,
m11_uralla_1520 (sub catchment A6)
3,    store A6
1,1,1.36,-99      sub area H1
7,
m11_Mackenzie_0
3,    store H1
1,1,1.17,-99      sub area G1
7,
m11_Mackenzie_300
4,    add H1 to G1
5,1,0.2,-99
3,    store H1+G1
1,1,0.76,-99 sub area G2
7,
m11_Mackenzie_dsitributed
4,    add G2 to H1_G1
5,1,0.5,-99
3,    store G2_H1_G1
1,1,1.75,-99      sub area K1
3,    store K1
1,1,1.75,-99      sub area J1
4,    add J1 to K1
7,
m11_Rocky_0
4,    add G2 to J1 and K1
7,
m11_Rocky_1050
5,1,0.3,-99
2,1,0.78,-99      sub area G3
7,
d/s_m11_Rocky_1050
4,    add A6 to G3
```

```
5,1,0.2,-99
2,1,0.78,-99      sub area A7
7,
outlet
0,
C sub-area areas
1.97,0.5,0.04,1.07,0.04,1.54,0.05,0.48,1.7,1.06,0.69,1.17,0.85,0.58,2.53,2.82,0.43
,0.81,-99
0,-99 all pervious
```

APPENDIX D

DESIGN FLOOD LEVELS

DESIGN FLOOD LEVELS - URALLA CREEK

Creek	Chainage	Flood Levels (m AHD)		
		5% AEP	1% AEP	Extreme Event
URALLA_CK	230.35	1004.12	1004.53	1006.02
URALLA_CK	248.35	1004.02	1004.42	1005.87
URALLA_CK	266.36	1003.89	1004.27	1005.71
URALLA_CK	284.36	1003.68	1004.06	1005.50
URALLA_CK	306.29	1003.39	1003.79	1005.31
URALLA_CK	328.23	1003.13	1003.56	1005.13
URALLA_CK	350.16	1002.91	1003.38	1004.96
URALLA_CK	372.09	1002.75	1003.26	1004.81
URALLA_CK	394.02	1002.66	1003.17	1004.68
URALLA_CK	415.96	1002.61	1003.10	1004.56
URALLA_CK	437.89	1002.56	1003.04	1004.48
URALLA_CK	460.29	1002.51	1002.97	1004.40
URALLA_CK	482.68	1002.46	1002.91	1004.32
URALLA_CK	505.08	1002.41	1002.83	1004.24
URALLA_CK	527.48	1002.34	1002.76	1004.17
URALLA_CK	549.88	1002.27	1002.67	1004.09
URALLA_CK	572.27	1002.18	1002.56	1004.03
URALLA_CK	594.67	1002.04	1002.42	1003.97
URALLA_CK	611.84	1001.95	1002.36	1003.97
URALLA_CK	629.00	1001.88	1002.29	1003.91
URALLA_CK	630.00	1001.87	1002.28	1003.89
URALLA_CK	650.00	1001.79	1002.20	1003.54
URALLA_CK	651.85	1001.78	1002.19	1003.53
URALLA_CK	651.92	1001.78	1002.18	1003.53
URALLA_CK	670.00	1001.66	1002.01	1002.94
URALLA_CK	671.00	1001.65	1002.00	1002.93
URALLA_CK	691.48	1001.49	1001.85	1002.78
URALLA_CK	711.95	1001.32	1001.69	1002.63

Creek	Chainage	Flood Levels (m AHD)		
		5% AEP	1% AEP	Extreme Event
URALLA_CK	732.43	1001.16	1001.51	1002.48
URALLA_CK	752.90	1001.00	1001.34	1002.31
URALLA_CK	773.38	1000.86	1001.16	1002.08
URALLA_CK	794.94	1000.73	1001.03	1001.88
URALLA_CK	816.49	1000.63	1000.92	1001.73
URALLA_CK	838.05	1000.56	1000.84	1001.62
URALLA_CK	859.61	1000.50	1000.78	1001.52
URALLA_CK	882.05	1000.43	1000.70	1001.40
URALLA_CK	904.50	1000.34	1000.61	1001.27
URALLA_CK	926.94	1000.24	1000.50	1001.13
URALLA_CK	949.39	1000.11	1000.36	1000.96
URALLA_CK	971.83	999.87	1000.11	1000.76
URALLA_CK	995.21	999.54	999.79	1000.58
URALLA_CK	1018.58	999.29	999.58	1000.46
URALLA_CK	1041.95	999.13	999.43	1000.36
URALLA_CK	1065.33	999.00	999.30	1000.25
URALLA_CK	1084.29	998.92	999.23	1000.19
URALLA_CK	1103.24	998.85	999.17	1000.15
URALLA_CK	1122.20	998.79	999.12	1000.10
URALLA_CK	1146.58	998.73	999.06	1000.04
URALLA_CK	1170.96	998.68	999.01	999.98
URALLA_CK	1195.35	998.65	998.97	999.92
URALLA_CK	1219.73	998.64	998.95	999.86
URALLA_CK	1221.71	998.63	998.95	999.86
URALLA_CK	1235.00	998.40	998.78	999.70
URALLA_CK	1240.26	998.21	998.43	999.10
URALLA_CK	1241.00	998.21	998.43	999.10
URALLA_CK	1255.00	997.08	997.42	998.41
URALLA_CK	1256.00	997.08	997.42	998.41

Creek	Chainage	Flood Levels (m AHD)		
		5% AEP	1% AEP	Extreme Event
URALLA_CK	1276.60	996.78	997.12	998.18
URALLA_CK	1297.20	996.56	996.90	998.00
URALLA_CK	1317.80	996.44	996.77	997.86
URALLA_CK	1338.40	996.39	996.70	997.78
URALLA_CK	1359.00	996.36	996.66	997.72
URALLA_CK	1380.00	995.36	995.48	997.65
URALLA_CK	1381.00	995.36	995.48	997.66
URALLA_CK	1387.56	995.67	996.06	997.95
URALLA_CK	1406.72	995.43	995.92	997.86
URALLA_CK	1425.88	995.26	995.80	997.80
URALLA_CK	1445.04	995.14	995.70	997.73
URALLA_CK	1464.20	994.80	995.33	997.36
URALLA_CK	1474.90	994.65	995.21	997.18
URALLA_CK	1488.48	994.41	995.02	997.04
URALLA_CK	1500.00	994.44	995.02	997.04
URALLA_CK	1525.00	994.39	994.90	996.35
URALLA_CK	1542.96	994.39	994.90	996.37
URALLA_CK	1547.56	994.39	994.90	996.37
URALLA_CK	1565.50	994.16	994.63	996.05
URALLA_CK	1590.22	993.96	994.40	995.73
URALLA_CK	1614.94	993.70	994.09	995.30
URALLA_CK	1639.67	993.61	994.00	995.18
URALLA_CK	1664.39	993.56	993.95	995.14
URALLA_CK	1689.19	993.51	993.89	995.08
URALLA_CK	1713.99	993.47	993.84	995.03
URALLA_CK	1738.80	993.43	993.81	995.00
URALLA_CK	1763.60	993.41	993.78	994.97
URALLA_CK	1788.40	993.40	993.77	994.95
URALLA_CK	1790.00	993.39	993.75	994.88

Creek	Chainage	Flood Levels (m AHD)		
		5% AEP	1% AEP	Extreme Event
URALLA_CK	1792.00	993.39	993.75	994.88
URALLA_CK	1802.00	993.38	993.74	994.88
URALLA_CK	1808.00	993.38	993.74	994.88
URALLA_CK	1808.24	993.38	993.74	994.88
URALLA_CK	1815.52	991.72	992.13	993.85
URALLA_CK	1821.60	991.73	992.14	993.80
URALLA_CK	1842.79	991.63	992.04	993.78
URALLA_CK	1863.98	991.52	991.94	993.75
URALLA_CK	1885.18	991.39	991.82	993.72
URALLA_CK	1906.37	991.23	991.67	993.68
URALLA_CK	1927.56	991.01	991.48	993.65
URALLA_CK	1948.75	990.70	991.17	993.61
URALLA_CK	1971.64	990.42	990.89	993.57
URALLA_CK	1994.53	990.19	990.69	993.54
URALLA_CK	2017.41	990.05	990.57	993.51
URALLA_CK	2040.30	989.97	990.50	993.49
URALLA_CK	2060.24	989.87	990.42	993.46
URALLA_CK	2080.17	989.74	990.31	993.44

DESIGN FLOOD LEVELS - ROCKY CREEK

Creek	Chainage	Flood Levels (m AHD)		
		5% AEP	1% AEP	Extreme Event
ROCKY_CK	251.43	1013.92	1014.11	1014.72
ROCKY_CK	263.11	1013.72	1013.90	1014.48
ROCKY_CK	290.35	1012.87	1013.06	1013.69
ROCKY_CK	317.59	1011.98	1012.20	1012.89
ROCKY_CK	344.83	1011.07	1011.31	1012.06
ROCKY_CK	372.07	1010.14	1010.40	1011.20
ROCKY_CK	399.30	1009.19	1009.47	1010.34
ROCKY_CK	426.54	1008.24	1008.54	1009.48
ROCKY_CK	453.78	1007.34	1007.66	1008.65
ROCKY_CK	481.02	1006.70	1007.00	1007.97
ROCKY_CK	508.96	1006.52	1006.76	1007.56
ROCKY_CK	536.90	1006.49	1006.71	1007.38
ROCKY_CK	564.84	1006.48	1006.70	1007.36
ROCKY_CK	592.78	1006.48	1006.70	1007.36
ROCKY_CK	620.73	1006.48	1006.71	1007.36
ROCKY_CK	648.67	1006.49	1006.71	1007.36
ROCKY_CK	676.61	1006.49	1006.71	1007.37
ROCKY_CK	704.55	1006.49	1006.71	1007.37
ROCKY_CK	706.50	1006.49	1006.71	1007.37
ROCKY_CK	721.00	1006.49	1006.71	1007.37
ROCKY_CK	733.00	1001.87	1002.00	1002.51
ROCKY_CK	745.60	1001.87	1002.00	1002.51
ROCKY_CK	745.62	1001.87	1002.00	1002.51
ROCKY_CK	769.90	1001.85	1001.99	1002.50
ROCKY_CK	794.20	1001.83	1001.97	1002.50
ROCKY_CK	818.50	1001.80	1001.96	1002.49
ROCKY_CK	833.70	1001.80	1001.96	1002.49
ROCKY_CK	848.90	1001.80	1001.96	1002.49

Creek	Chainage	Flood Levels (m AHD)		
		5% AEP	1% AEP	Extreme Event
ROCKY_CK	873.97	1001.80	1001.96	1002.49
ROCKY_CK	899.04	1001.80	1001.96	1002.49
ROCKY_CK	924.12	1001.80	1001.96	1002.49
ROCKY_CK	949.19	1001.80	1001.96	1002.49
ROCKY_CK	974.00	999.00	999.28	1000.25
ROCKY_CK	999.00	998.86	999.13	1000.19
ROCKY_CK	1009.01	998.78	999.05	1000.16
ROCKY_CK	1018.83	998.66	998.95	1000.12
ROCKY_CK	1020.00	998.66	998.95	1000.12
ROCKY_CK	1043.84	998.59	998.85	999.94
ROCKY_CK	1056.30	998.50	998.78	999.89
ROCKY_CK	1082.96	998.35	998.67	999.85
ROCKY_CK	1109.63	998.21	998.53	999.68
ROCKY_CK	1136.29	997.92	998.23	999.31
ROCKY_CK	1162.95	997.74	998.05	999.11
ROCKY_CK	1190.87	997.57	997.88	998.91
ROCKY_CK	1218.79	997.41	997.70	998.72
ROCKY_CK	1246.71	997.24	997.52	998.54
ROCKY_CK	1274.64	997.08	997.35	998.37
ROCKY_CK	1302.56	996.91	997.18	998.23
ROCKY_CK	1330.48	996.76	997.03	998.08
ROCKY_CK	1358.40	996.58	996.85	997.88
ROCKY_CK	1388.31	996.37	996.66	997.73
ROCKY_CK	1418.23	996.17	996.46	997.57
ROCKY_CK	1448.15	995.96	996.25	997.41
ROCKY_CK	1478.06	995.72	996.01	997.24
ROCKY_CK	1503.30	995.50	995.81	997.12
ROCKY_CK	1528.54	995.29	995.63	997.02
ROCKY_CK	1553.78	995.08	995.46	996.93

Creek	Chainage	Flood Levels (m AHD)		
		5% AEP	1% AEP	Extreme Event
ROCKY_CK	1579.02	994.87	995.31	996.86
ROCKY_CK	1604.26	994.68	995.20	996.80
ROCKY_CK	1629.50	994.49	995.11	996.75
ROCKY_CK	1639.00	994.40	995.07	996.73
ROCKY_CK	1641.00	994.40	995.07	996.73
ROCKY_CK	1659.00	994.22	995.00	996.25
ROCKY_CK	1661.00	994.21	995.00	996.25
ROCKY_CK	1687.40	994.13	994.98	996.24
ROCKY_CK	1713.79	994.10	994.97	996.23
ROCKY_CK	1740.19	994.08	994.96	996.22
ROCKY_CK	1750.00	994.07	994.96	996.22
ROCKY_CK	1751.00	994.07	994.96	996.22
ROCKY_CK	1778.00	992.53	992.91	994.12
ROCKY_CK	1782.84	992.47	992.84	994.11
ROCKY_CK	1785.00	992.45	992.82	994.11
ROCKY_CK	1810.72	992.20	992.59	993.95
ROCKY_CK	1836.43	991.97	992.35	993.82
ROCKY_CK	1862.15	991.73	992.10	993.70
ROCKY_CK	1887.86	991.44	991.81	993.60
ROCKY_CK	1913.58	991.02	991.40	993.50
ROCKY_CK	1938.10	990.47	990.89	993.47
ROCKY_CK	1962.63	990.03	990.53	993.45
ROCKY_CK	1987.16	989.80	990.37	993.45
ROCKY_CK	2011.68	989.74	990.31	993.44
ROCKY_CK	2035.50	989.49	990.05	993.43
ROCKY_CK	2063.69	989.25	989.79	993.42
ROCKY_CK	2091.88	989.02	989.54	993.41
ROCKY_CK	2120.06	988.80	989.31	993.41
ROCKY_CK	2148.25	988.61	989.10	993.40

Creek	Chainage	Flood Levels (m AHD)		
		5% AEP	1% AEP	Extreme Event
ROCKY_CK	2176.44	988.43	988.92	993.40
ROCKY_CK	2204.63	988.27	988.78	993.40
ROCKY_CK	2232.81	988.15	988.68	993.39
ROCKY_CK	2261.00	988.06	988.61	993.39
ROCKY_CK	2288.54	987.96	988.52	993.39
ROCKY_CK	2316.08	987.85	988.43	993.38
ROCKY_CK	2343.62	987.74	988.34	993.38
ROCKY_CK	2371.16	987.62	988.24	993.37
ROCKY_CK	2398.70	987.50	988.15	993.37
ROCKY_CK	2426.23	987.37	988.05	993.36
ROCKY_CK	2453.77	987.23	987.95	993.36
ROCKY_CK	2481.31	987.07	987.84	993.35
ROCKY_CK	2508.85	986.90	987.73	993.35
ROCKY_CK	2536.39	986.71	987.61	993.35

DESIGN FLOOD LEVELS - MACKENZIE TRIBUTARY

Creek	Chainage	Flood Levels (m AHD)		
		5% AEP	1% AEP	Extreme Event
MACKENZIE_TRIB	0.00	1022.73	1022.78	1022.97
MACKENZIE_TRIB	9.62	1022.54	1022.67	1022.77
MACKENZIE_TRIB	19.23	1022.31	1022.53	1022.57
MACKENZIE_TRIB	28.85	1022.08	1022.33	1022.37
MACKENZIE_TRIB	38.46	1022.08	1022.10	1022.18
MACKENZIE_TRIB	48.08	1021.70	1021.93	1021.98
MACKENZIE_TRIB	57.69	1021.54	1021.71	1021.79
MACKENZIE_TRIB	67.31	1021.35	1021.46	1021.59
MACKENZIE_TRIB	76.92	1021.16	1021.19	1021.40
MACKENZIE_TRIB	86.54	1020.98	1021.00	1021.21
MACKENZIE_TRIB	96.15	1020.80	1020.83	1021.02
MACKENZIE_TRIB	105.77	1020.61	1020.65	1020.82
MACKENZIE_TRIB	115.38	1020.43	1020.48	1020.63
MACKENZIE_TRIB	125.00	1020.25	1020.30	1020.43
MACKENZIE_TRIB	130.00	1020.15	1020.20	1020.31
MACKENZIE_TRIB	139.66	1019.48	1019.54	1019.64
MACKENZIE_TRIB	149.32	1019.48	1019.54	1019.63
MACKENZIE_TRIB	159.24	1017.54	1017.63	1017.52
MACKENZIE_TRIB	169.16	1017.67	1017.88	1018.03
MACKENZIE_TRIB	179.08	1017.70	1017.93	1018.37
MACKENZIE_TRIB	189.00	1017.66	1017.87	1018.36
MACKENZIE_TRIB	198.68	1017.53	1017.81	1018.21
MACKENZIE_TRIB	208.37	1017.52	1017.80	1018.21
MACKENZIE_TRIB	218.05	1017.51	1017.80	1018.22
MACKENZIE_TRIB	227.74	1017.52	1017.81	1018.22
MACKENZIE_TRIB	237.43	1017.52	1017.81	1018.22
MACKENZIE_TRIB	247.11	1017.52	1017.81	1018.22
MACKENZIE_TRIB	256.80	1017.52	1017.81	1018.22

Creek	Chainage	Flood Levels (m AHD)		
		5% AEP	1% AEP	Extreme Event
MACKENZIE_TRIB	266.48	1017.52	1017.81	1018.22
MACKENZIE_TRIB	274.32	1017.52	1017.81	1018.22
MACKENZIE_TRIB	282.16	1017.52	1017.81	1018.22
MACKENZIE_TRIB	290.00	1017.52	1017.81	1018.22
MACKENZIE_TRIB	297.50	1017.52	1017.81	1018.22
MACKENZIE_TRIB	305.00	1017.52	1017.81	1018.22
MACKENZIE_TRIB	314.87	1014.66	1014.83	1015.27
MACKENZIE_TRIB	324.28	1014.53	1014.70	1015.13
MACKENZIE_TRIB	333.69	1014.40	1014.56	1014.99
MACKENZIE_TRIB	343.11	1014.27	1014.43	1014.85
MACKENZIE_TRIB	352.52	1014.13	1014.30	1014.70
MACKENZIE_TRIB	361.93	1014.00	1014.16	1014.55
MACKENZIE_TRIB	371.34	1013.87	1014.01	1014.38
MACKENZIE_TRIB	379.38	1013.75	1013.89	1014.23
MACKENZIE_TRIB	387.42	1013.63	1013.76	1014.08
MACKENZIE_TRIB	395.46	1013.50	1013.62	1013.93
MACKENZIE_TRIB	403.50	1013.36	1013.48	1013.77
MACKENZIE_TRIB	411.54	1013.20	1013.32	1013.61
MACKENZIE_TRIB	421.13	1012.98	1013.10	1013.40
MACKENZIE_TRIB	430.72	1012.75	1012.88	1013.18
MACKENZIE_TRIB	440.31	1012.53	1012.66	1012.97
MACKENZIE_TRIB	449.90	1012.31	1012.44	1012.76
MACKENZIE_TRIB	459.49	1012.08	1012.23	1012.56
MACKENZIE_TRIB	469.08	1011.87	1012.02	1012.38
MACKENZIE_TRIB	478.67	1011.67	1011.84	1012.24
MACKENZIE_TRIB	488.26	1011.55	1011.70	1012.16
MACKENZIE_TRIB	497.85	1011.39	1011.54	1012.00
MACKENZIE_TRIB	507.44	1011.13	1011.28	1011.73
MACKENZIE_TRIB	517.03	1010.91	1011.07	1011.53

Creek	Chainage	Flood Levels (m AHD)		
		5% AEP	1% AEP	Extreme Event
MACKENZIE_TRIB	526.62	1010.69	1010.84	1011.33
MACKENZIE_TRIB	536.21	1010.45	1010.61	1011.13
MACKENZIE_TRIB	545.80	1010.19	1010.35	1010.94
MACKENZIE_TRIB	555.55	1009.90	1010.06	1010.69
MACKENZIE_TRIB	565.31	1009.61	1009.77	1010.41
MACKENZIE_TRIB	575.06	1009.32	1009.48	1010.14
MACKENZIE_TRIB	584.82	1009.02	1009.19	1009.87
MACKENZIE_TRIB	594.57	1008.73	1008.90	1009.61
MACKENZIE_TRIB	604.32	1008.44	1008.63	1009.36
MACKENZIE_TRIB	614.08	1008.18	1008.38	1009.13
MACKENZIE_TRIB	623.83	1007.97	1008.18	1008.94
MACKENZIE_TRIB	633.59	1007.85	1008.07	1008.81
MACKENZIE_TRIB	643.34	1007.81	1008.03	1008.74
MACKENZIE_TRIB	652.61	1007.75	1007.96	1008.65
MACKENZIE_TRIB	661.87	1007.69	1007.88	1008.55
MACKENZIE_TRIB	671.14	1007.62	1007.81	1008.45
MACKENZIE_TRIB	680.40	1007.55	1007.72	1008.35
MACKENZIE_TRIB	689.67	1007.46	1007.63	1008.23
MACKENZIE_TRIB	698.94	1007.37	1007.54	1008.11
MACKENZIE_TRIB	708.20	1007.29	1007.45	1007.99
MACKENZIE_TRIB	717.47	1007.20	1007.35	1007.87
MACKENZIE_TRIB	726.74	1007.10	1007.24	1007.74
MACKENZIE_TRIB	736.00	1006.99	1007.12	1007.61
MACKENZIE_TRIB	745.27	1006.87	1007.00	1007.48
MACKENZIE_TRIB	754.53	1006.75	1006.87	1007.34
MACKENZIE_TRIB	763.80	1006.60	1006.72	1007.19
MACKENZIE_TRIB	773.69	1006.44	1006.56	1007.03
MACKENZIE_TRIB	783.59	1006.28	1006.40	1006.86
MACKENZIE_TRIB	793.48	1006.11	1006.23	1006.70

Creek	Chainage	Flood Levels (m AHD)		
		5% AEP	1% AEP	Extreme Event
MACKENZIE_TRIB	803.37	1005.95	1006.07	1006.54
MACKENZIE_TRIB	813.26	1005.79	1005.91	1006.38
MACKENZIE_TRIB	823.16	1005.63	1005.75	1006.22
MACKENZIE_TRIB	833.05	1005.46	1005.59	1006.08
MACKENZIE_TRIB	842.94	1005.30	1005.43	1005.95
MACKENZIE_TRIB	852.84	1005.14	1005.27	1005.84
MACKENZIE_TRIB	862.73	1004.97	1005.10	1005.78
MACKENZIE_TRIB	872.62	1004.79	1004.93	1005.74
MACKENZIE_TRIB	882.51	1004.58	1004.74	1005.71
MACKENZIE_TRIB	892.41	1004.32	1004.50	1005.70
MACKENZIE_TRIB	902.30	1003.86	1004.20	1005.69

DESIGN FLOOD LEVELS - LOWER MACKENZIE

Creek	Chainage	Flood Levels (m AHD)		
		5% AEP	1% AEP	Extreme Event
MACKENZIE_LOWER	903.30	1003.86	1004.20	1005.69
MACKENZIE_LOWER	921.91	1003.83	1004.18	1005.68
MACKENZIE_LOWER	940.52	1003.79	1004.16	1005.67
MACKENZIE_LOWER	959.13	1003.74	1004.14	1005.67
MACKENZIE_LOWER	967.99	1002.99	1003.32	1005.46
MACKENZIE_LOWER	986.32	1002.99	1003.32	1005.46
MACKENZIE_LOWER	996.41	1002.67	1003.14	1005.47
MACKENZIE_LOWER	1004.72	1002.38	1003.17	1005.48
MACKENZIE_LOWER	1024.90	1002.35	1003.17	1005.48
MACKENZIE_LOWER	1044.06	1002.10	1002.38	1003.18
MACKENZIE_LOWER	1058.85	1002.07	1002.34	1003.14
MACKENZIE_LOWER	1073.65	1002.04	1002.31	1003.09
MACKENZIE_LOWER	1096.03	1001.99	1002.25	1003.00
MACKENZIE_LOWER	1118.41	1001.94	1002.17	1002.89
MACKENZIE_LOWER	1140.79	1001.88	1002.08	1002.73
MACKENZIE_LOWER	1163.17	1001.80	1001.96	1002.49

DESIGN FLOOD LEVELS - WARICK

Creek	Chainage	Flood Levels (m AHD)		
		5% AEP	1% AEP	Extreme Event
WARICK	0.00	1018.23	1018.32	1018.36
WARICK	9.69	1018.05	1018.15	1018.29
WARICK	19.37	1017.87	1018.00	1018.25
WARICK	29.06	1017.70	1017.90	1018.24
WARICK	38.74	1017.60	1017.85	1018.23
WARICK	48.43	1017.55	1017.83	1018.23
WARICK	58.11	1017.53	1017.82	1018.23
WARICK	67.80	1017.53	1017.82	1018.22
WARICK	77.49	1017.52	1017.81	1018.22
WARICK	87.17	1017.52	1017.81	1018.22
WARICK	96.86	1017.52	1017.81	1018.22
WARICK	106.54	1017.52	1017.81	1018.22
WARICK	116.23	1017.52	1017.81	1018.22
WARICK	125.91	1017.52	1017.81	1018.22
WARICK	135.60	1017.52	1017.81	1018.22
WARICK	139.00	1017.52	1017.81	1018.22

APPENDIX E

DESIGN FLOOD DISCHARGES

DESIGN FLOOD FLOWS - URALLA CREEK

Creek	Chainage	Flood Flows (cu m/sec)		
		5% AEP	1% AEP	Extreme Event
URALLA_CK	239.35	38.4	59.0	163.0
URALLA_CK	257.36	38.4	59.0	162.9
URALLA_CK	275.36	38.4	58.9	162.8
URALLA_CK	295.33	38.4	58.9	162.7
URALLA_CK	317.26	38.4	58.9	162.7
URALLA_CK	339.19	38.4	58.9	162.6
URALLA_CK	361.13	38.4	58.8	162.5
URALLA_CK	383.06	38.4	58.8	162.5
URALLA_CK	404.99	38.4	58.8	162.4
URALLA_CK	426.92	38.4	58.7	162.4
URALLA_CK	449.09	38.4	58.7	162.3
URALLA_CK	471.49	38.4	58.7	162.2
URALLA_CK	493.88	38.3	58.6	162.1
URALLA_CK	516.28	38.3	58.6	162.0
URALLA_CK	538.68	38.3	58.5	161.9
URALLA_CK	561.07	38.3	58.5	161.8
URALLA_CK	583.47	38.3	58.5	161.7
URALLA_CK	603.25	38.3	58.4	161.6
URALLA_CK	620.42	38.3	58.4	161.5
URALLA_CK	629.50	38.3	58.5	146.4
URALLA_CK	640.00	38.3	58.5	146.4
URALLA_CK	650.92	38.3	58.5	146.3
URALLA_CK	651.85	38.3	58.5	146.4
URALLA_CK	661.00	38.3	58.5	146.4
URALLA_CK	670.50	38.3	58.5	146.4
URALLA_CK	681.24	38.2	58.5	161.6
URALLA_CK	701.71	38.2	58.6	161.6
URALLA_CK	722.19	38.2	58.6	161.6

Creek	Chainage	Flood Flows (cu m/sec)		
		5% AEP	1% AEP	Extreme Event
URALLA_CK	742.67	38.2	58.6	161.7
URALLA_CK	763.14	38.1	58.6	161.7
URALLA_CK	784.16	38.1	58.6	161.8
URALLA_CK	805.72	38.1	58.6	161.8
URALLA_CK	827.27	38.1	58.6	161.8
URALLA_CK	848.83	38.1	58.6	161.9
URALLA_CK	870.83	38.2	58.6	161.9
URALLA_CK	893.28	38.2	58.6	161.9
URALLA_CK	915.72	38.2	58.6	161.9
URALLA_CK	938.16	38.2	58.5	161.9
URALLA_CK	960.61	38.2	58.5	161.9
URALLA_CK	983.52	38.2	58.5	161.9
URALLA_CK	1006.89	38.2	58.5	161.8
URALLA_CK	1030.27	38.2	58.4	161.7
URALLA_CK	1053.64	38.2	58.3	161.6
URALLA_CK	1074.81	38.1	58.3	161.5
URALLA_CK	1093.77	38.1	58.2	161.5
URALLA_CK	1112.72	38.1	58.3	161.4
URALLA_CK	1134.39	38.0	58.3	161.3
URALLA_CK	1158.77	38.0	58.3	161.2
URALLA_CK	1183.16	37.9	58.3	161.2
URALLA_CK	1207.54	37.9	58.3	161.1
URALLA_CK	1220.72	38.0	58.3	161.1
URALLA_CK	1230.00	37.5	57.8	160.4
URALLA_CK	1237.63	37.5	57.8	160.4
URALLA_CK	1240.63	1.0	1.0	1.0
URALLA_CK	1248.00	1.0	1.0	1.0
URALLA_CK	1255.50	1.1	1.1	1.1
URALLA_CK	1266.30	38.0	58.3	161.1

Creek	Chainage	Flood Flows (cu m/sec)		
		5% AEP	1% AEP	Extreme Event
URALLA_CK	1286.90	38.0	58.3	161.1
URALLA_CK	1307.50	38.0	58.3	161.2
URALLA_CK	1328.10	38.0	58.3	161.2
URALLA_CK	1348.70	38.0	58.3	161.4
URALLA_CK	1359.50	0.8	0.8	2.1
URALLA_CK	1370.00	0.6	0.6	0.6
URALLA_CK	1380.50	0.7	0.7	0.7
URALLA_CK	1384.28	56.3	58.3	176.1
URALLA_CK	1397.14	44.5	58.3	161.1
URALLA_CK	1416.30	38.6	58.3	161.4
URALLA_CK	1435.46	38.3	58.4	161.4
URALLA_CK	1454.62	38.3	58.4	161.5
URALLA_CK	1469.55	57.3	87.4	245.5
URALLA_CK	1481.69	57.1	87.4	245.5
URALLA_CK	1494.24	0.4	0.7	55.2
URALLA_CK	1524.18	0.0	0.0	55.2
URALLA_CK	1533.98	0.0	0.0	55.2
URALLA_CK	1545.26	0.1	0.1	55.3
URALLA_CK	1556.53	57.1	87.6	245.6
URALLA_CK	1577.86	57.1	87.6	245.6
URALLA_CK	1602.58	76.2	117.7	329.7
URALLA_CK	1627.31	76.2	117.7	329.7
URALLA_CK	1652.03	76.2	117.6	329.7
URALLA_CK	1676.79	76.2	117.5	329.8
URALLA_CK	1701.59	76.1	117.4	329.8
URALLA_CK	1726.40	76.1	117.4	329.8
URALLA_CK	1751.20	76.1	117.5	329.9
URALLA_CK	1776.00	76.0	117.5	329.9
URALLA_CK	1789.20	76.0	117.5	329.9

Creek	Chainage	Flood Flows (cu m/sec)		
		5% AEP	1% AEP	Extreme Event
URALLA_CK	1791.00	1.2	1.0	1.1
URALLA_CK	1797.00	1.2	1.0	1.1
URALLA_CK	1805.00	1.1	1.1	1.3
URALLA_CK	1808.12	1.0	1.1	1.4
URALLA_CK	1810.00	74.0	115.7	328.3
URALLA_CK	1818.56	75.9	117.5	329.7
URALLA_CK	1832.20	75.9	117.5	329.4
URALLA_CK	1853.39	75.9	117.4	328.9
URALLA_CK	1874.58	75.9	117.3	328.3
URALLA_CK	1895.77	75.9	117.2	327.6
URALLA_CK	1916.96	75.9	117.1	326.9
URALLA_CK	1938.15	75.9	117.0	326.1
URALLA_CK	1960.19	75.9	117.0	325.1
URALLA_CK	1983.08	75.9	117.0	324.2
URALLA_CK	2005.97	75.9	117.0	323.2
URALLA_CK	2028.86	75.9	117.0	322.4
URALLA_CK	2050.27	75.9	116.9	321.6
URALLA_CK	2070.20	75.9	116.9	321.0

DESIGN FLOOD FLOWS - ROCKY CREEK

Creek	Chainage	Flood Flows (cu m/sec)		
		5% AEP	1% AEP	Extreme Event
ROCKY_CK	257.27	23.0	35.1	96.7
ROCKY_CK	276.73	23.0	35.1	96.6
ROCKY_CK	303.97	23.0	35.1	96.6
ROCKY_CK	331.21	23.0	35.1	96.5
ROCKY_CK	358.45	23.0	35.1	96.5
ROCKY_CK	385.68	23.0	35.1	96.4
ROCKY_CK	412.92	23.0	35.1	96.4
ROCKY_CK	440.16	22.9	35.1	96.3
ROCKY_CK	467.40	22.9	35.1	96.3
ROCKY_CK	494.99	22.9	35.1	96.2
ROCKY_CK	522.93	22.9	35.0	96.2
ROCKY_CK	550.87	22.9	35.0	96.1
ROCKY_CK	578.81	22.8	35.0	96.1
ROCKY_CK	606.76	22.8	35.0	96.1
ROCKY_CK	634.70	22.8	34.9	96.1
ROCKY_CK	662.64	22.8	34.9	96.1
ROCKY_CK	690.58	22.7	34.8	96.1
ROCKY_CK	745.62	10.8	11.0	11.8
ROCKY_CK	757.75	10.8	11.0	11.8
ROCKY_CK	782.05	10.8	11.0	11.8
ROCKY_CK	806.35	10.8	11.1	11.8
ROCKY_CK	826.10	10.8	11.1	11.8
ROCKY_CK	841.30	10.8	11.1	11.9
ROCKY_CK	861.44	10.9	11.2	12.0
ROCKY_CK	886.51	10.9	11.3	12.3
ROCKY_CK	911.58	11.1	11.5	12.6
ROCKY_CK	936.65	11.3	11.8	13.0

Creek	Chainage	Flood Flows (cu m/sec)		
		5% AEP	1% AEP	Extreme Event
ROCKY_CK	970.00	37.7	54.6	139.8
ROCKY_CK	986.50	37.7	54.6	139.8
ROCKY_CK	1004.01	37.7	54.6	139.7
ROCKY_CK	1013.92	37.7	54.6	139.7
ROCKY_CK	1050.07	37.7	54.5	139.6
ROCKY_CK	1069.63	37.7	54.5	139.6
ROCKY_CK	1096.29	37.6	54.4	139.5
ROCKY_CK	1122.96	62.8	95.4	278.5
ROCKY_CK	1149.62	62.8	95.4	278.5
ROCKY_CK	1176.91	62.8	95.4	278.5
ROCKY_CK	1204.83	62.8	95.4	278.5
ROCKY_CK	1232.75	62.8	95.4	278.5
ROCKY_CK	1260.68	62.8	95.4	278.5
ROCKY_CK	1288.60	62.8	95.4	278.5
ROCKY_CK	1316.52	62.8	95.4	278.4
ROCKY_CK	1344.44	62.8	95.4	278.4
ROCKY_CK	1373.36	62.8	95.4	278.4
ROCKY_CK	1403.27	62.8	95.4	278.3
ROCKY_CK	1433.19	62.8	95.3	278.3
ROCKY_CK	1463.10	62.8	95.3	278.2
ROCKY_CK	1490.68	62.8	95.3	278.2
ROCKY_CK	1515.92	62.8	95.3	278.1
ROCKY_CK	1541.16	62.8	95.2	278.1
ROCKY_CK	1566.40	62.8	95.1	278.0
ROCKY_CK	1591.64	62.8	95.1	277.9
ROCKY_CK	1616.88	62.8	95.1	277.8
ROCKY_CK	1634.25	62.8	95.0	277.8
ROCKY_CK	1640.00	25.6	27.9	156.9
ROCKY_CK	1650.00	25.6	27.6	156.9

Creek	Chainage	Flood Flows (cu m/sec)		
		5% AEP	1% AEP	Extreme Event
ROCKY_CK	1659.30	25.5	27.2	156.9
ROCKY_CK	1660.30	25.4	27.2	156.9
ROCKY_CK	1674.20	62.8	94.9	277.9
ROCKY_CK	1700.59	62.7	94.8	277.9
ROCKY_CK	1726.99	62.7	94.7	277.9
ROCKY_CK	1745.09	62.6	94.7	277.9
ROCKY_CK	1750.50	62.7	94.1	152.1
ROCKY_CK	1765.00	62.7	94.1	152.1
ROCKY_CK	1780.42	62.7	94.1	151.9
ROCKY_CK	1783.92	62.7	94.1	151.9
ROCKY_CK	1797.86	62.7	94.7	277.6
ROCKY_CK	1823.57	62.7	94.7	277.3
ROCKY_CK	1849.29	62.7	94.7	276.9
ROCKY_CK	1875.01	62.7	94.7	276.4
ROCKY_CK	1900.72	62.7	94.7	275.7
ROCKY_CK	1925.84	62.7	94.7	274.9
ROCKY_CK	1950.37	62.7	94.8	273.8
ROCKY_CK	1974.89	62.7	94.8	272.5
ROCKY_CK	1999.42	62.7	94.9	271.1
ROCKY_CK	2023.59	136.9	207.2	589.7
ROCKY_CK	2049.59	136.9	207.2	588.4
ROCKY_CK	2077.78	136.9	207.2	586.9
ROCKY_CK	2105.97	136.9	207.1	585.7
ROCKY_CK	2134.16	136.9	207.1	584.5
ROCKY_CK	2162.34	136.9	207.1	583.2
ROCKY_CK	2190.53	136.9	207.1	581.8
ROCKY_CK	2218.72	136.9	207.1	580.4
ROCKY_CK	2246.91	136.9	207.0	579.5
ROCKY_CK	2274.77	136.8	206.9	578.5

Creek	Chainage	Flood Flows (cu m/sec)		
		5% AEP	1% AEP	Extreme Event
ROCKY_CK	2302.31	136.8	206.8	577.6
ROCKY_CK	2329.85	136.8	206.7	576.6
ROCKY_CK	2357.39	136.7	206.6	575.8
ROCKY_CK	2384.93	136.7	206.5	575.3
ROCKY_CK	2412.46	136.6	206.4	574.8
ROCKY_CK	2440.00	136.6	206.5	574.3
ROCKY_CK	2467.54	136.5	206.5	573.8
ROCKY_CK	2495.08	136.5	206.5	573.8
ROCKY_CK	2522.62	136.5	206.5	573.8

DESIGN FLOOD FLOWS - MACKENZIE TRIBUTARY

Creek	Chainage	Flood Flows (cu m/sec)		
		5% AEP	1% AEP	Extreme Event
MACKENZIE_TRIB	4.81	6.1	8.9	24.7
MACKENZIE_TRIB	14.40	8.7	14.7	24.7
MACKENZIE_TRIB	24.00	7.5	21.5	24.7
MACKENZIE_TRIB	33.60	6.7	22.7	24.7
MACKENZIE_TRIB	43.20	16.3	18.7	24.6
MACKENZIE_TRIB	52.80	8.4	20.1	24.6
MACKENZIE_TRIB	62.50	8.2	19.1	24.6
MACKENZIE_TRIB	72.10	8.8	15.2	24.6
MACKENZIE_TRIB	81.70	8.8	11.0	24.6
MACKENZIE_TRIB	91.30	8.5	9.1	24.6
MACKENZIE_TRIB	100.00	8.0	9.4	24.6
MACKENZIE_TRIB	110.00	7.8	10.0	24.5
MACKENZIE_TRIB	120.00	7.7	10.7	24.5
MACKENZIE_TRIB	127.00	7.6	11.2	24.5
MACKENZIE_TRIB	134.00	7.5	11.5	24.5
MACKENZIE_TRIB	144.00	7.5	11.8	24.5
MACKENZIE_TRIB	154.00	7.5	11.9	24.5
MACKENZIE_TRIB	164.00	7.5	11.8	24.5
MACKENZIE_TRIB	174.00	7.5	11.8	24.5
MACKENZIE_TRIB	184.00	7.5	11.8	24.5
MACKENZIE_TRIB	193.00	7.4	11.9	24.5
MACKENZIE_TRIB	203.00	7.4	11.9	24.5
MACKENZIE_TRIB	213.00	7.4	12.1	24.5
MACKENZIE_TRIB	222.00	7.4	12.2	24.5
MACKENZIE_TRIB	232.00	7.4	12.4	24.5
MACKENZIE_TRIB	242.00	7.3	12.6	24.5
MACKENZIE_TRIB	251.00	7.3	12.6	24.5

Creek	Chainage	Flood Flows (cu m/sec)		
		5% AEP	1% AEP	Extreme Event
MACKENZIE_TRIB	261.00	7.2	12.4	24.5
MACKENZIE_TRIB	270.00	11.0	15.7	31.0
MACKENZIE_TRIB	278.00	11.0	15.7	31.0
MACKENZIE_TRIB	286.00	11.0	15.7	31.0
MACKENZIE_TRIB	293.00	11.0	15.7	31.0
MACKENZIE_TRIB	301.00	10.9	15.7	31.0
MACKENZIE_TRIB	308.00	10.9	15.6	31.0
MACKENZIE_TRIB	319.00	10.9	15.6	31.0
MACKENZIE_TRIB	328.00	10.9	15.6	31.0
MACKENZIE_TRIB	338.00	10.9	15.6	31.0
MACKENZIE_TRIB	347.00	10.9	15.6	31.0
MACKENZIE_TRIB	357.00	10.9	15.6	31.0
MACKENZIE_TRIB	366.00	10.9	15.6	31.0
MACKENZIE_TRIB	375.00	10.9	15.6	31.0
MACKENZIE_TRIB	383.00	10.9	15.6	31.0
MACKENZIE_TRIB	391.00	10.9	15.6	31.0
MACKENZIE_TRIB	399.00	10.9	15.6	31.0
MACKENZIE_TRIB	407.00	10.9	15.6	31.0
MACKENZIE_TRIB	416.00	10.9	15.6	31.0
MACKENZIE_TRIB	425.00	10.9	15.6	31.0
MACKENZIE_TRIB	435.00	10.9	15.6	31.0
MACKENZIE_TRIB	445.00	10.9	15.6	31.0
MACKENZIE_TRIB	454.00	10.9	15.6	31.0
MACKENZIE_TRIB	464.00	10.9	15.6	31.0
MACKENZIE_TRIB	473.00	10.9	15.6	31.0
MACKENZIE_TRIB	483.00	10.9	15.6	31.0
MACKENZIE_TRIB	493.00	10.9	15.6	31.1
MACKENZIE_TRIB	502.00	15.7	20.4	44.1
MACKENZIE_TRIB	512.00	15.7	20.4	44.1

Creek	Chainage	Flood Flows (cu m/sec)		
		5% AEP	1% AEP	Extreme Event
MACKENZIE_TRIB	521.00	15.7	20.4	44.1
MACKENZIE_TRIB	531.00	15.7	20.4	44.1
MACKENZIE_TRIB	541.00	15.7	20.4	44.1
MACKENZIE_TRIB	550.00	15.7	20.4	44.1
MACKENZIE_TRIB	560.00	15.7	20.4	44.1
MACKENZIE_TRIB	570.00	15.7	20.4	44.1
MACKENZIE_TRIB	579.00	15.7	20.4	44.1
MACKENZIE_TRIB	589.00	15.7	20.4	44.1
MACKENZIE_TRIB	599.00	15.7	20.4	44.1
MACKENZIE_TRIB	609.00	15.7	20.4	44.1
MACKENZIE_TRIB	618.00	15.7	20.4	44.1
MACKENZIE_TRIB	628.00	15.7	20.4	44.1
MACKENZIE_TRIB	638.00	15.7	20.4	44.1
MACKENZIE_TRIB	647.00	15.7	20.4	44.1
MACKENZIE_TRIB	657.00	15.7	20.4	44.1
MACKENZIE_TRIB	666.00	15.7	20.4	44.1
MACKENZIE_TRIB	675.00	15.7	20.4	44.1
MACKENZIE_TRIB	685.00	15.7	20.4	44.1
MACKENZIE_TRIB	694.00	15.7	20.4	44.1
MACKENZIE_TRIB	703.00	15.7	20.4	44.1
MACKENZIE_TRIB	712.00	15.7	20.4	44.1
MACKENZIE_TRIB	722.00	15.7	20.4	44.1
MACKENZIE_TRIB	731.00	15.7	20.4	44.1
MACKENZIE_TRIB	740.00	15.7	20.4	44.1
MACKENZIE_TRIB	749.00	15.7	20.4	44.1
MACKENZIE_TRIB	759.00	15.7	20.4	44.1
MACKENZIE_TRIB	768.00	15.7	20.4	44.1
MACKENZIE_TRIB	778.00	15.7	20.4	44.1
MACKENZIE_TRIB	788.00	15.7	20.4	44.1

Creek	Chainage	Flood Flows (cu m/sec)		
		5% AEP	1% AEP	Extreme Event
MACKENZIE_TRIB	798.00	15.7	20.4	44.1
MACKENZIE_TRIB	808.00	15.7	20.4	44.1
MACKENZIE_TRIB	818.00	15.7	20.4	44.1
MACKENZIE_TRIB	828.00	15.7	20.4	44.1
MACKENZIE_TRIB	838.00	15.6	20.4	44.1
MACKENZIE_TRIB	847.00	15.6	20.4	44.1
MACKENZIE_TRIB	857.00	15.6	20.4	44.1
MACKENZIE_TRIB	867.00	15.6	20.4	44.1
MACKENZIE_TRIB	877.00	15.6	20.4	44.1
MACKENZIE_TRIB	887.00	15.6	20.4	44.1
MACKENZIE_TRIB	897.00	15.6	20.4	44.1

DESIGN FLOOD FLOWS - LOWER MACKENZIE

Creek	Chainage	Flood Flows (cu m/sec)		
		5% AEP	1% AEP	Extreme Event
MACKENZIE_LOWER	912.00	15.6	20.4	44.1
MACKENZIE_LOWER	931.00	15.5	20.3	44.1
MACKENZIE_LOWER	949.00	15.4	20.3	44.1
MACKENZIE_LOWER	991.00	27.2	44.1	128.6
MACKENZIE_LOWER	100.00	27.2	44.1	128.6
MACKENZIE_LOWER	101.00	27.2	44.0	128.5
MACKENZIE_LOWER	103.00	27.2	43.8	71.7
MACKENZIE_LOWER	105.00	27.2	43.8	128.5
MACKENZIE_LOWER	106.00	27.2	43.8	128.4
MACKENZIE_LOWER	108.00	27.2	43.8	128.4
MACKENZIE_LOWER	110.00	27.2	43.8	128.3
MACKENZIE_LOWER	112.00	27.2	43.8	128.3
MACKENZIE_LOWER	115.00	27.1	43.8	128.2

DESIGN FLOOD FLOWS - WARICK

Creek	Chainage	Flood Flows (cu m/sec)		
		5% AEP	1% AEP	Extreme Event
WARICK	4.84	5.0	7.1	6.6
WARICK	14.53	5.0	7.1	6.6
WARICK	24.21	5.0	7.1	6.6
WARICK	33.90	5.0	7.1	6.6
WARICK	43.59	5.0	7.1	6.6
WARICK	53.27	5.0	7.1	6.6
WARICK	62.96	5.0	7.1	6.6
WARICK	72.64	5.0	7.1	6.6
WARICK	82.33	5.0	7.1	6.6
WARICK	92.01	5.0	7.1	6.5
WARICK	101.70	5.0	7.0	6.5
WARICK	111.39	4.9	7.0	6.5
WARICK	121.07	4.9	7.0	6.5
WARICK	130.76	4.9	7.0	6.5
WARICK	137.30	4.9	7.0	6.5

APPENDIX F

SENSITIVITY TESTING

SENSITIVITY TESTING - DESIGN FLOOD LEVELS - URALLA CREEK

Scenario 1: Flow Increased by 10%
Scenario 2: Flow Increased by 20%
Scenario 3: Flow Increased by 30%

Creek	Chainage	Design Flood Levels (m AHD)		
		Scenario 1	Scenario 2	Scenario 3
URALLA_CK	230.35	1004.54	1004.65	1004.74
URALLA_CK	248.35	1004.43	1004.54	1004.62
URALLA_CK	266.36	1004.28	1004.39	1004.47
URALLA_CK	284.36	1004.08	1004.18	1004.26
URALLA_CK	306.29	1003.81	1003.92	1004.01
URALLA_CK	328.23	1003.58	1003.70	1003.80
URALLA_CK	350.16	1003.41	1003.53	1003.64
URALLA_CK	372.09	1003.29	1003.42	1003.53
URALLA_CK	394.02	1003.20	1003.33	1003.44
URALLA_CK	415.96	1003.13	1003.25	1003.35
URALLA_CK	437.89	1003.07	1003.18	1003.29
URALLA_CK	460.29	1003.00	1003.12	1003.22
URALLA_CK	482.68	1002.94	1003.04	1003.15
URALLA_CK	505.08	1002.86	1002.97	1003.07
URALLA_CK	527.48	1002.78	1002.89	1002.99
URALLA_CK	549.88	1002.70	1002.79	1002.89
URALLA_CK	572.27	1002.59	1002.69	1002.78
URALLA_CK	594.67	1002.45	1002.55	1002.65
URALLA_CK	611.84	1002.39	1002.50	1002.62
URALLA_CK	629.00	1002.33	1002.44	1002.56
URALLA_CK	630.00	1002.31	1002.42	1002.54
URALLA_CK	650.00	1002.23	1002.33	1002.45
URALLA_CK	651.85	1002.21	1002.32	1002.44
URALLA_CK	651.92	1002.21	1002.32	1002.44
URALLA_CK	670.00	1002.03	1002.11	1002.18

Creek	Chainage	Design Flood Levels (m AHD)		
		Scenario 1	Scenario 2	Scenario 3
URALLA_CK	671.00	1002.02	1002.10	1002.17
URALLA_CK	691.48	1001.87	1001.95	1002.02
URALLA_CK	711.95	1001.71	1001.79	1001.87
URALLA_CK	732.43	1001.54	1001.62	1001.70
URALLA_CK	752.90	1001.36	1001.43	1001.51
URALLA_CK	773.38	1001.18	1001.25	1001.31
URALLA_CK	794.94	1001.05	1001.11	1001.17
URALLA_CK	816.49	1000.94	1001.00	1001.06
URALLA_CK	838.05	1000.86	1000.92	1000.98
URALLA_CK	859.61	1000.80	1000.86	1000.92
URALLA_CK	882.05	1000.72	1000.78	1000.83
URALLA_CK	904.50	1000.63	1000.68	1000.74
URALLA_CK	926.94	1000.52	1000.57	1000.62
URALLA_CK	949.39	1000.38	1000.43	1000.47
URALLA_CK	971.83	1000.12	1000.18	1000.22
URALLA_CK	995.21	999.81	999.87	999.93
URALLA_CK	1018.58	999.60	999.66	999.72
URALLA_CK	1041.95	999.44	999.51	999.58
URALLA_CK	1065.33	999.32	999.39	999.46
URALLA_CK	1084.29	999.24	999.32	999.38
URALLA_CK	1103.24	999.18	999.26	999.33
URALLA_CK	1122.20	999.13	999.22	999.29
URALLA_CK	1146.58	999.07	999.15	999.23
URALLA_CK	1170.96	999.02	999.10	999.17
URALLA_CK	1195.35	998.99	999.06	999.14
URALLA_CK	1219.73	998.96	999.04	999.11
URALLA_CK	1221.71	998.96	999.03	999.10
URALLA_CK	1235.00	998.80	998.89	998.97
URALLA_CK	1240.26	998.44	998.49	998.54

Creek	Chainage	Design Flood Levels (m AHD)		
		Scenario 1	Scenario 2	Scenario 3
URALLA_CK	1241.00	998.44	998.49	998.54
URALLA_CK	1255.00	997.43	997.51	997.58
URALLA_CK	1256.00	997.43	997.51	997.58
URALLA_CK	1276.60	997.14	997.21	997.29
URALLA_CK	1297.20	996.92	997.00	997.07
URALLA_CK	1317.80	996.79	996.86	996.94
URALLA_CK	1338.40	996.71	996.79	996.86
URALLA_CK	1359.00	996.68	996.76	996.82
URALLA_CK	1380.00	995.48	995.45	995.46
URALLA_CK	1381.00	995.48	995.45	995.46
URALLA_CK	1387.56	996.10	996.23	996.35
URALLA_CK	1406.72	995.96	996.09	996.21
URALLA_CK	1425.88	995.83	995.96	996.08
URALLA_CK	1445.04	995.70	995.83	995.96
URALLA_CK	1464.20	995.33	995.45	995.56
URALLA_CK	1474.90	995.21	995.31	995.42
URALLA_CK	1488.48	995.02	995.09	995.21
URALLA_CK	1500.00	995.02	995.09	995.21
URALLA_CK	1525.00	994.93	995.03	995.11
URALLA_CK	1542.96	994.93	995.03	995.11
URALLA_CK	1547.56	994.93	995.03	995.11
URALLA_CK	1565.50	994.66	994.75	994.84
URALLA_CK	1590.22	994.44	994.53	994.61
URALLA_CK	1614.94	994.12	994.21	994.29
URALLA_CK	1639.67	994.03	994.12	994.20
URALLA_CK	1664.39	993.98	994.06	994.14
URALLA_CK	1689.19	993.92	994.00	994.08
URALLA_CK	1713.99	993.87	993.95	994.03
URALLA_CK	1738.80	993.83	993.92	994.00

Creek	Chainage	Design Flood Levels (m AHD)		
		Scenario 1	Scenario 2	Scenario 3
URALLA_CK	1763.60	993.81	993.89	993.97
URALLA_CK	1788.40	993.79	993.87	993.95
URALLA_CK	1790.00	993.78	993.86	993.93
URALLA_CK	1792.00	993.78	993.86	993.93
URALLA_CK	1802.00	993.77	993.85	993.93
URALLA_CK	1808.00	993.77	993.85	993.93
URALLA_CK	1808.24	993.77	993.85	993.93
URALLA_CK	1815.52	992.16	992.25	992.34
URALLA_CK	1821.60	992.17	992.25	992.33
URALLA_CK	1842.79	992.07	992.16	992.24
URALLA_CK	1863.98	991.97	992.06	992.14
URALLA_CK	1885.18	991.85	991.94	992.02
URALLA_CK	1906.37	991.71	991.80	991.88
URALLA_CK	1927.56	991.52	991.61	991.70
URALLA_CK	1948.75	991.21	991.32	991.42
URALLA_CK	1971.64	990.95	991.06	991.17
URALLA_CK	1994.53	990.75	990.88	991.00
URALLA_CK	2017.41	990.64	990.77	990.90
URALLA_CK	2040.30	990.57	990.71	990.84
URALLA_CK	2060.24	990.49	990.63	990.76
URALLA_CK	2080.17	990.40	990.54	990.67

SENSITIVITY TESTING - DESIGN FLOOD LEVELS - ROCKY CREEK

Scenario 1: Flow Increased by 10%
Scenario 2: Flow Increased by 20%
Scenario 3: Flow Increased by 30%

Creek	Chainage	Design Flood Levels (m AHD)		
		Scenario 1	Scenario 2	Scenario 3
ROCKY_CK	251.43	1014.12	1014.16	1014.21
ROCKY_CK	263.11	1013.91	1013.95	1013.99
ROCKY_CK	290.35	1013.08	1013.12	1013.16
ROCKY_CK	317.59	1012.21	1012.26	1012.31
ROCKY_CK	344.83	1011.33	1011.38	1011.43
ROCKY_CK	372.07	1010.42	1010.48	1010.53
ROCKY_CK	399.30	1009.49	1009.56	1009.62
ROCKY_CK	426.54	1008.57	1008.64	1008.70
ROCKY_CK	453.78	1007.68	1007.75	1007.82
ROCKY_CK	481.02	1007.02	1007.10	1007.16
ROCKY_CK	508.96	1006.77	1006.83	1006.88
ROCKY_CK	536.90	1006.72	1006.77	1006.82
ROCKY_CK	564.84	1006.72	1006.77	1006.81
ROCKY_CK	592.78	1006.72	1006.77	1006.81
ROCKY_CK	620.73	1006.72	1006.77	1006.81
ROCKY_CK	648.67	1006.72	1006.77	1006.82
ROCKY_CK	676.61	1006.72	1006.77	1006.82
ROCKY_CK	704.55	1006.72	1006.77	1006.82
ROCKY_CK	706.50	1006.72	1006.77	1006.82
ROCKY_CK	721.00	1006.72	1006.77	1006.82
ROCKY_CK	733.00	1002.01	1002.05	1002.09
ROCKY_CK	745.60	1002.01	1002.05	1002.09
ROCKY_CK	745.62	1002.01	1002.05	1002.09
ROCKY_CK	769.90	1002.00	1002.04	1002.08
ROCKY_CK	794.20	1001.99	1002.03	1002.06

Creek	Chainage	Design Flood Levels (m AHD)		
		Scenario 1	Scenario 2	Scenario 3
ROCKY_CK	818.50	1001.97	1002.01	1002.05
ROCKY_CK	833.70	1001.97	1002.01	1002.05
ROCKY_CK	848.90	1001.97	1002.01	1002.05
ROCKY_CK	873.97	1001.97	1002.01	1002.05
ROCKY_CK	899.04	1001.97	1002.01	1002.05
ROCKY_CK	924.12	1001.97	1002.01	1002.05
ROCKY_CK	949.19	1001.97	1002.01	1002.05
ROCKY_CK	974.00	999.31	999.39	999.46
ROCKY_CK	999.00	999.16	999.25	999.32
ROCKY_CK	1009.01	999.08	999.16	999.24
ROCKY_CK	1018.83	998.98	999.06	999.14
ROCKY_CK	1020.00	998.98	999.06	999.14
ROCKY_CK	1043.84	998.89	998.96	999.03
ROCKY_CK	1056.30	998.82	998.90	998.97
ROCKY_CK	1082.96	998.73	998.81	998.89
ROCKY_CK	1109.63	998.59	998.67	998.75
ROCKY_CK	1136.29	998.28	998.36	998.43
ROCKY_CK	1162.95	998.11	998.18	998.25
ROCKY_CK	1190.87	997.93	998.00	998.07
ROCKY_CK	1218.79	997.75	997.82	997.89
ROCKY_CK	1246.71	997.57	997.63	997.70
ROCKY_CK	1274.64	997.39	997.46	997.52
ROCKY_CK	1302.56	997.23	997.29	997.36
ROCKY_CK	1330.48	997.08	997.15	997.21
ROCKY_CK	1358.40	996.90	996.97	997.03
ROCKY_CK	1388.31	996.71	996.78	996.84
ROCKY_CK	1418.23	996.51	996.58	996.65
ROCKY_CK	1448.15	996.30	996.38	996.45
ROCKY_CK	1478.06	996.07	996.15	996.22

Creek	Chainage	Design Flood Levels (m AHD)		
		Scenario 1	Scenario 2	Scenario 3
ROCKY_CK	1503.30	995.88	995.97	996.05
ROCKY_CK	1528.54	995.70	995.80	995.89
ROCKY_CK	1553.78	995.55	995.66	995.75
ROCKY_CK	1579.02	995.42	995.54	995.64
ROCKY_CK	1604.26	995.32	995.45	995.55
ROCKY_CK	1629.50	995.24	995.38	995.49
ROCKY_CK	1639.00	995.21	995.35	995.46
ROCKY_CK	1641.00	995.21	995.35	995.46
ROCKY_CK	1659.00	995.12	995.25	995.35
ROCKY_CK	1661.00	995.12	995.25	995.35
ROCKY_CK	1687.40	995.11	995.24	995.33
ROCKY_CK	1713.79	995.09	995.23	995.32
ROCKY_CK	1740.19	995.09	995.22	995.31
ROCKY_CK	1750.00	995.09	995.22	995.31
ROCKY_CK	1751.00	995.08	995.22	995.31
ROCKY_CK	1778.00	992.98	993.06	993.13
ROCKY_CK	1782.84	992.90	992.99	993.06
ROCKY_CK	1785.00	992.88	992.97	993.05
ROCKY_CK	1810.72	992.65	992.73	992.81
ROCKY_CK	1836.43	992.41	992.49	992.56
ROCKY_CK	1862.15	992.16	992.23	992.30
ROCKY_CK	1887.86	991.87	991.94	992.01
ROCKY_CK	1913.58	991.46	991.54	991.63
ROCKY_CK	1938.10	990.97	991.08	991.18
ROCKY_CK	1962.63	990.61	990.74	990.86
ROCKY_CK	1987.16	990.45	990.59	990.71
ROCKY_CK	2011.68	990.40	990.54	990.67
ROCKY_CK	2035.50	990.13	990.26	990.38
ROCKY_CK	2063.69	989.86	989.99	990.11

Creek	Chainage	Design Flood Levels (m AHD)		
		Scenario 1	Scenario 2	Scenario 3
ROCKY_CK	2091.88	989.61	989.74	989.85
ROCKY_CK	2120.06	989.38	989.50	989.63
ROCKY_CK	2148.25	989.17	989.30	989.44
ROCKY_CK	2176.44	989.00	989.14	989.30
ROCKY_CK	2204.63	988.87	989.02	989.19
ROCKY_CK	2232.81	988.77	988.94	989.12
ROCKY_CK	2261.00	988.71	988.88	989.07
ROCKY_CK	2288.54	988.62	988.80	989.00
ROCKY_CK	2316.08	988.54	988.73	988.93
ROCKY_CK	2343.62	988.45	988.65	988.86
ROCKY_CK	2371.16	988.36	988.57	988.80
ROCKY_CK	2398.70	988.27	988.49	988.73
ROCKY_CK	2426.23	988.18	988.41	988.67
ROCKY_CK	2453.77	988.08	988.34	988.60
ROCKY_CK	2481.31	987.99	988.26	988.54
ROCKY_CK	2508.85	987.89	988.18	988.48
ROCKY_CK	2536.39	987.79	988.10	988.42

SENSITIVITY TESTING - DESIGN FLOOD LEVELS - MACKENZIE TRIBUTARY

Scenario 1: Flow Increased by 10%
Scenario 2: Flow Increased by 20%
Scenario 3: Flow Increased by 30%

Creek	Chainage	Design Flood Levels (m AHD)		
		Scenario 1	Scenario 2	Scenario 3
MACKENZIE_TRIB	0.00	1022.79	1022.80	1022.82
MACKENZIE_TRIB	9.62	1022.57	1022.59	1022.61
MACKENZIE_TRIB	19.23	1022.35	1022.38	1022.40
MACKENZIE_TRIB	28.85	1022.14	1022.18	1022.20
MACKENZIE_TRIB	38.46	1021.95	1021.98	1021.99
MACKENZIE_TRIB	48.08	1021.76	1021.77	1021.79
MACKENZIE_TRIB	57.69	1021.56	1021.57	1021.59
MACKENZIE_TRIB	67.31	1021.36	1021.38	1021.40
MACKENZIE_TRIB	76.92	1021.17	1021.20	1021.22
MACKENZIE_TRIB	86.54	1021.00	1021.03	1021.04
MACKENZIE_TRIB	96.15	1020.82	1020.84	1020.85
MACKENZIE_TRIB	105.77	1020.64	1020.65	1020.67
MACKENZIE_TRIB	115.38	1020.45	1020.47	1020.48
MACKENZIE_TRIB	125.00	1020.27	1020.28	1020.30
MACKENZIE_TRIB	130.00	1020.17	1020.18	1020.20
MACKENZIE_TRIB	139.66	1019.51	1019.52	1019.53
MACKENZIE_TRIB	149.32	1019.51	1019.52	1019.53
MACKENZIE_TRIB	159.24	1017.63	1017.63	1017.64
MACKENZIE_TRIB	169.16	1017.90	1017.94	1017.97
MACKENZIE_TRIB	179.08	1017.95	1018.01	1018.05
MACKENZIE_TRIB	189.00	1017.89	1017.95	1017.99
MACKENZIE_TRIB	198.68	1017.84	1017.90	1017.94
MACKENZIE_TRIB	208.37	1017.83	1017.89	1017.93
MACKENZIE_TRIB	218.05	1017.83	1017.89	1017.94
MACKENZIE_TRIB	227.74	1017.83	1017.90	1017.94

Creek	Chainage	Design Flood Levels (m AHD)		
		Scenario 1	Scenario 2	Scenario 3
MACKENZIE_TRIB	237.43	1017.84	1017.90	1017.95
MACKENZIE_TRIB	247.11	1017.84	1017.90	1017.95
MACKENZIE_TRIB	256.80	1017.84	1017.90	1017.95
MACKENZIE_TRIB	266.48	1017.84	1017.90	1017.95
MACKENZIE_TRIB	274.32	1017.84	1017.90	1017.95
MACKENZIE_TRIB	282.16	1017.84	1017.90	1017.95
MACKENZIE_TRIB	290.00	1017.84	1017.90	1017.95
MACKENZIE_TRIB	297.50	1017.84	1017.90	1017.95
MACKENZIE_TRIB	305.00	1017.84	1017.90	1017.95
MACKENZIE_TRIB	314.87	1014.84	1014.90	1014.94
MACKENZIE_TRIB	324.28	1014.71	1014.76	1014.81
MACKENZIE_TRIB	333.69	1014.58	1014.63	1014.68
MACKENZIE_TRIB	343.11	1014.44	1014.50	1014.54
MACKENZIE_TRIB	352.52	1014.31	1014.36	1014.40
MACKENZIE_TRIB	361.93	1014.17	1014.22	1014.26
MACKENZIE_TRIB	371.34	1014.02	1014.07	1014.11
MACKENZIE_TRIB	379.38	1013.90	1013.94	1013.98
MACKENZIE_TRIB	387.42	1013.77	1013.81	1013.85
MACKENZIE_TRIB	395.46	1013.63	1013.67	1013.71
MACKENZIE_TRIB	403.50	1013.49	1013.53	1013.56
MACKENZIE_TRIB	411.54	1013.33	1013.37	1013.40
MACKENZIE_TRIB	421.13	1013.11	1013.15	1013.18
MACKENZIE_TRIB	430.72	1012.89	1012.93	1012.96
MACKENZIE_TRIB	440.31	1012.67	1012.71	1012.75
MACKENZIE_TRIB	449.90	1012.45	1012.50	1012.54
MACKENZIE_TRIB	459.49	1012.24	1012.29	1012.33
MACKENZIE_TRIB	469.08	1012.03	1012.08	1012.12
MACKENZIE_TRIB	478.67	1011.85	1011.91	1011.94
MACKENZIE_TRIB	488.26	1011.71	1011.77	1011.81

Creek	Chainage	Design Flood Levels (m AHD)		
		Scenario 1	Scenario 2	Scenario 3
MACKENZIE_TRIB	497.85	1011.54	1011.61	1011.64
MACKENZIE_TRIB	507.44	1011.29	1011.36	1011.40
MACKENZIE_TRIB	517.03	1011.07	1011.14	1011.19
MACKENZIE_TRIB	526.62	1010.85	1010.92	1010.97
MACKENZIE_TRIB	536.21	1010.62	1010.68	1010.74
MACKENZIE_TRIB	545.80	1010.35	1010.42	1010.48
MACKENZIE_TRIB	555.55	1010.06	1010.13	1010.19
MACKENZIE_TRIB	565.31	1009.78	1009.84	1009.91
MACKENZIE_TRIB	575.06	1009.49	1009.56	1009.62
MACKENZIE_TRIB	584.82	1009.20	1009.27	1009.33
MACKENZIE_TRIB	594.57	1008.91	1008.99	1009.05
MACKENZIE_TRIB	604.32	1008.64	1008.71	1008.78
MACKENZIE_TRIB	614.08	1008.39	1008.47	1008.54
MACKENZIE_TRIB	623.83	1008.19	1008.28	1008.36
MACKENZIE_TRIB	633.59	1008.08	1008.17	1008.25
MACKENZIE_TRIB	643.34	1008.04	1008.12	1008.20
MACKENZIE_TRIB	652.61	1007.97	1008.05	1008.12
MACKENZIE_TRIB	661.87	1007.90	1007.97	1008.04
MACKENZIE_TRIB	671.14	1007.82	1007.89	1007.95
MACKENZIE_TRIB	680.40	1007.73	1007.80	1007.86
MACKENZIE_TRIB	689.67	1007.64	1007.71	1007.77
MACKENZIE_TRIB	698.94	1007.55	1007.62	1007.68
MACKENZIE_TRIB	708.20	1007.46	1007.52	1007.58
MACKENZIE_TRIB	717.47	1007.36	1007.42	1007.47
MACKENZIE_TRIB	726.74	1007.25	1007.30	1007.35
MACKENZIE_TRIB	736.00	1007.13	1007.19	1007.23
MACKENZIE_TRIB	745.27	1007.01	1007.06	1007.10
MACKENZIE_TRIB	754.53	1006.87	1006.92	1006.97
MACKENZIE_TRIB	763.80	1006.73	1006.78	1006.82

Creek	Chainage	Design Flood Levels (m AHD)		
		Scenario 1	Scenario 2	Scenario 3
MACKENZIE_TRIB	773.69	1006.57	1006.62	1006.66
MACKENZIE_TRIB	783.59	1006.40	1006.45	1006.50
MACKENZIE_TRIB	793.48	1006.24	1006.29	1006.34
MACKENZIE_TRIB	803.37	1006.08	1006.13	1006.18
MACKENZIE_TRIB	813.26	1005.92	1005.97	1006.02
MACKENZIE_TRIB	823.16	1005.76	1005.81	1005.86
MACKENZIE_TRIB	833.05	1005.60	1005.65	1005.70
MACKENZIE_TRIB	842.94	1005.44	1005.49	1005.54
MACKENZIE_TRIB	852.84	1005.27	1005.33	1005.38
MACKENZIE_TRIB	862.73	1005.11	1005.17	1005.21
MACKENZIE_TRIB	872.62	1004.94	1005.00	1005.05
MACKENZIE_TRIB	882.51	1004.75	1004.82	1004.87
MACKENZIE_TRIB	892.41	1004.52	1004.60	1004.68
MACKENZIE_TRIB	902.30	1004.23	1004.33	1004.44

SENSITIVITY TESTING - DESIGN FLOOD LEVELS - LOWER MACKENZIE

Scenario 1: Flow Increased by 10%
Scenario 2: Flow Increased by 20%
Scenario 3: Flow Increased by 30%

Creek	Chainage	Design Flood Levels (m AHD)		
		Scenario 1	Scenario 2	Scenario 3
MACKENZIE_LOWER	903.30	1004.23	1004.33	1004.44
MACKENZIE_LOWER	921.91	1004.21	1004.31	1004.43
MACKENZIE_LOWER	940.52	1004.19	1004.29	1004.41
MACKENZIE_LOWER	959.13	1004.16	1004.42	1004.39
MACKENZIE_LOWER	967.99	1003.36	1003.58	1003.89
MACKENZIE_LOWER	986.32	1003.36	1003.58	1003.89
MACKENZIE_LOWER	996.41	1003.22	1003.54	1003.88
MACKENZIE_LOWER	1004.72	1003.26	1003.57	1003.90
MACKENZIE_LOWER	1024.90	1003.25	1003.57	1003.90
MACKENZIE_LOWER	1044.06	1002.40	1002.47	1002.54
MACKENZIE_LOWER	1058.85	1002.36	1002.43	1002.50
MACKENZIE_LOWER	1073.65	1002.32	1002.39	1002.46
MACKENZIE_LOWER	1096.03	1002.26	1002.33	1002.39
MACKENZIE_LOWER	1118.41	1002.19	1002.25	1002.31
MACKENZIE_LOWER	1140.79	1002.10	1002.15	1002.20
MACKENZIE_LOWER	1163.17	1001.97	1002.01	1002.05

SENSITIVITY TESTING - DESIGN FLOOD LEVELS - WARICK

Scenario 1: Flow Increased by 10%
Scenario 2: Flow Increased by 20%
Scenario 3: Flow Increased by 30%

Creek	Chainage	Design Flood Levels (m AHD)		
		Scenario 1	Scenario 2	Scenario 3
WARICK	0.00	1018.33	1018.36	1018.39
WARICK	9.69	1018.16	1018.19	1018.22
WARICK	19.37	1018.01	1018.06	1018.10
WARICK	29.06	1017.92	1017.98	1018.02
WARICK	38.74	1017.88	1017.94	1017.98
WARICK	48.43	1017.86	1017.92	1017.97
WARICK	58.11	1017.85	1017.91	1017.96
WARICK	67.80	1017.84	1017.90	1017.95
WARICK	77.49	1017.84	1017.90	1017.95
WARICK	87.17	1017.84	1017.90	1017.95
WARICK	96.86	1017.84	1017.90	1017.95
WARICK	106.54	1017.84	1017.90	1017.95
WARICK	116.23	1017.84	1017.90	1017.95
WARICK	125.91	1017.84	1017.90	1017.95
WARICK	135.60	1017.84	1017.90	1017.95
WARICK	139.00	1017.84	1017.90	1017.95