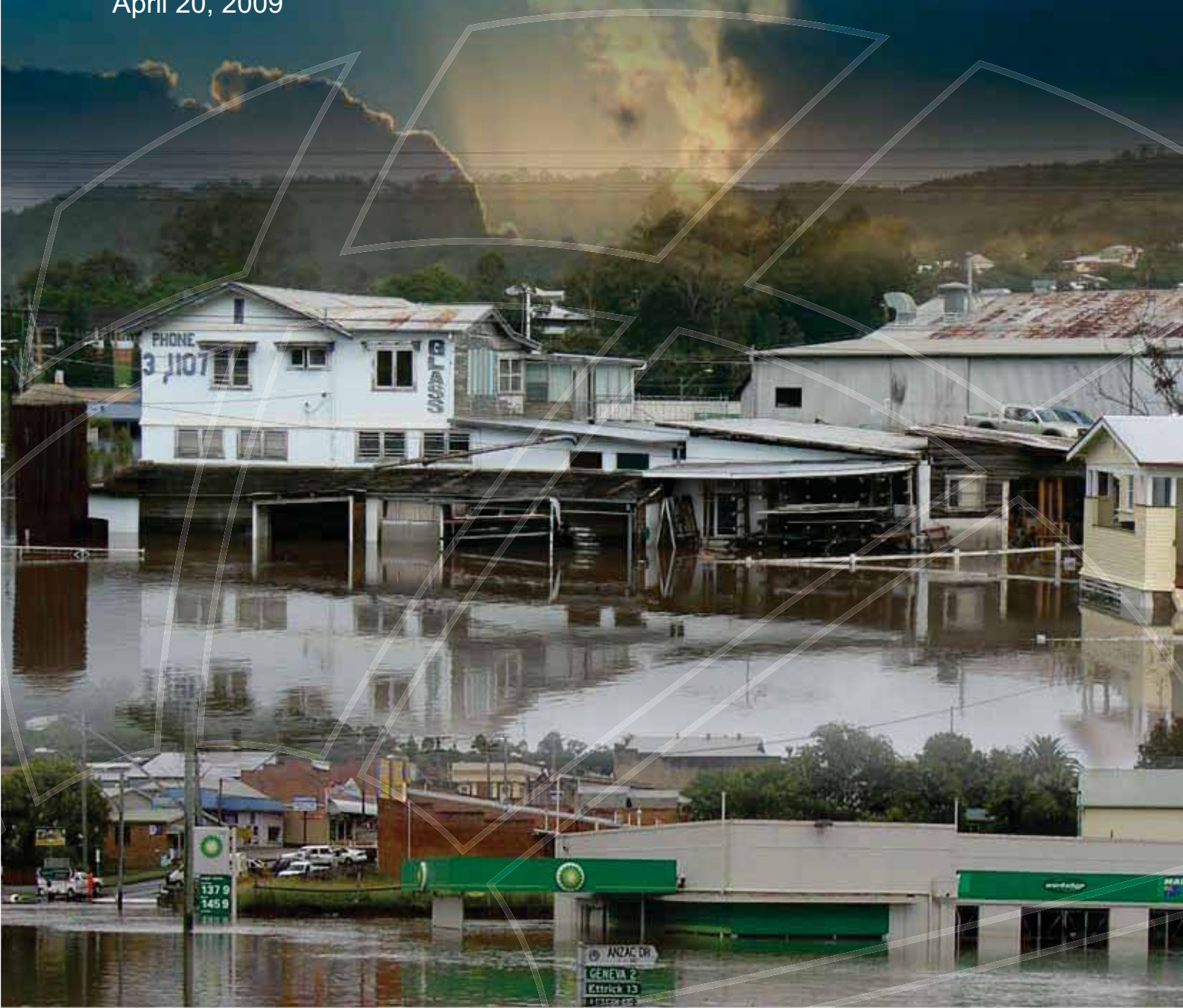




# Kyogle Council Kyogle Floodplain Risk Management Plan

Adopted  
April 20, 2009



Department of **Environment & Climate Change** NSW

# Kyogle Floodplain Risk Management Plan Adopted

Prepared For: Kyogle Council

Prepared By: BMT WBM Pty Ltd (Member of the BMT group of companies)

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|                   |   |
|-------------------|---|
| <b>Title :</b>    | Kyogle Floodplain Risk Management Plan  |
| <b>Author :</b>   | Chris Huxley  |
| <b>Synopsis :</b> | The Kyogle Floodplain Risk Management Plan is a document to be used by Kyogle Council to assist in implementation of the outcomes of the Kyogle Floodplain Risk Management Study. |

### REVISION/CHECKING HISTORY

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## FOREWORD

The NSW Government's Flood Prone Land Policy is directed towards providing solutions to existing flooding problems in developed areas whilst ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in neighbouring areas. The primary objective of the policy is:

**“to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods.”**

The Floodplain Development Manual (NSW Government, 2005) provides a framework for implementing the policy to achieve this primary objective. The policy also recognises the benefits of floodplain occupation and the particular social, economic and ecological attributes of flood prone land.

Under the policy, the management of flood prone land is, primarily, the responsibility of local councils. The NSW Government, through the Department of Environment and Climate Change (DECC), provides technical advice on all flooding matters to assist councils in the discharge of their floodplain management responsibilities and subsidises floodplain management studies, works and measures. The NSW floodplain risk management process (as outlined in the Manual) is described below.

### Floodplain Risk Management Process in NSW

| Stage |                                  | Description   |
|-------|----------------------------------|---|
| 1     | Data Collection                  | Compilation of existing data and collection of additional data  |
| 2     | Flood Study                      | The nature and extent of the flood problem are determined.  |
| 3     | Floodplain Risk Management Study | Management options for the floodplain are investigated in respect to both existing and proposed developments. These options are evaluated based on the impact on flood risk, while considering social, ecological and economic factors. |
| 4     | Floodplain Risk Management Plan  | Preferred management options are documented in a plan. The plan is publicly exhibited and subject to revision in light of responses.  |
| 5     | Implementation of the Plan       | Involves formal adoption by Council of the floodplain risk management plan and a process of implementation for the selected flood, response and property modification options.  |

This study represents stage four of the floodplain risk management process for Kyogle. It has been prepared for Kyogle Council to define a series of actions which, if implemented, help to reduce the impact of flooding in Kyogle by controlling the flood risk and reducing flood damages. Council will use the Plan as a resource in implementing the selected options.

The Plan is designed to be a 'stand alone' document, which briefly outlines the issues and details the recommended management actions to be implemented following formal adoption by Kyogle Council. More detailed discussion of the floodplain management options is contained in the Kyogle Floodplain Risk Management Study (BMT WBM, 2009).

## Summary

### The Study Area

Kyogle is situated at the confluence of the Richmond River and Fawcetts Creek within the Richmond River Valley of New South Wales. The Richmond River flows in a general south-easterly direction from its source on the Queensland/New South Wales border in the McPherson Ranges, as shown in Figure 1-1. Fawcetts Creek is an easterly tributary comprising 129.1km<sup>2</sup> of the 886.2km<sup>2</sup> total catchment area upstream of the study area.

The Richmond River is initially a series of steep mountain streams, which combine forming a major flow path at Wiangaree. Downstream of Wiangaree bed slopes decrease, the floodplain becomes more pronounced and the river exhibits meandering patterns. It is not until downstream of Kyogle township that major floodplains start to develop. Fawcetts Creek has a similar terrain profile.

The major urban areas of the Kyogle Township are located on higher ground to the south-east of the confluence of the watercourses. The suburb of Geneva, located on the western side of the Richmond River, is also mostly on higher ground. However a considerable number of properties in the area known as “The Flats”, which is bounded to the north by Fawcetts Creek and to the west by the Richmond River, are located on flood prone land. Properties along the western side of Fawcett St in the north of Kyogle are also subject to flooding.

### History of Flooding

During the major flood that occurred along the entire length of the Richmond River on the 20<sup>th</sup> of February 1954, 10 people lost their lives within Kyogle. Additionally, 10 houses were swept away and a further 159 homes were damaged by floodwaters.

Since this time, flood events of a smaller magnitude have been experienced in 1974, 1976, 1978, 1980, 1987, 1989, 1996, 2001 and 2008. The 2008 event represents the second largest flood on record. During the 2008 event, inundation of approximately 100 properties occurred. Fortunately, no lives were lost. This is possibly in part related to the timing of the event, which reached its peak level at midday on the 5<sup>th</sup> of January. The 2008 flood event highlighted the need for flood management in the Kyogle area.

### Kyogle Flood Study

Existing flood behaviour in Kyogle resulting from a combined Richmond River/Fawcetts Creek flood event has been defined in the Kyogle Flood Study, (WBM, 2004). The outputs and results from the flood study allow management options to be assessed. This includes flood, property and response modification measures. Using the flood model developed as part of the Kyogle Flood Study (WBM Pty Ltd, 2004) the advantages and disadvantages of the various modification measures can be carried out with confidence.

### Kyogle Floodplain Risk Management Study

The Kyogle Floodplain Risk Management Study was completed in 2009 (BMT WBM, 2009). During the process of that study, many options aimed at reducing the flood risk to Kyogle were considered

and investigated. Reduction of existing, future and continuing flood risk was considered via three broad types of options: flood modification, property modification and response modification measures.

Flood modification measures are those options that alter the physical behaviour of the flood. Property modification measures are those measures that seek to alter existing and/or future property to reduce the number of buildings that are inundated and thus damaged. Response modification measures aim to increase the ability of people to respond appropriately in times of flood and/or enhancing the flood warning and evacuation procedures in an area.

### Proposed Scheme (Scheme B)

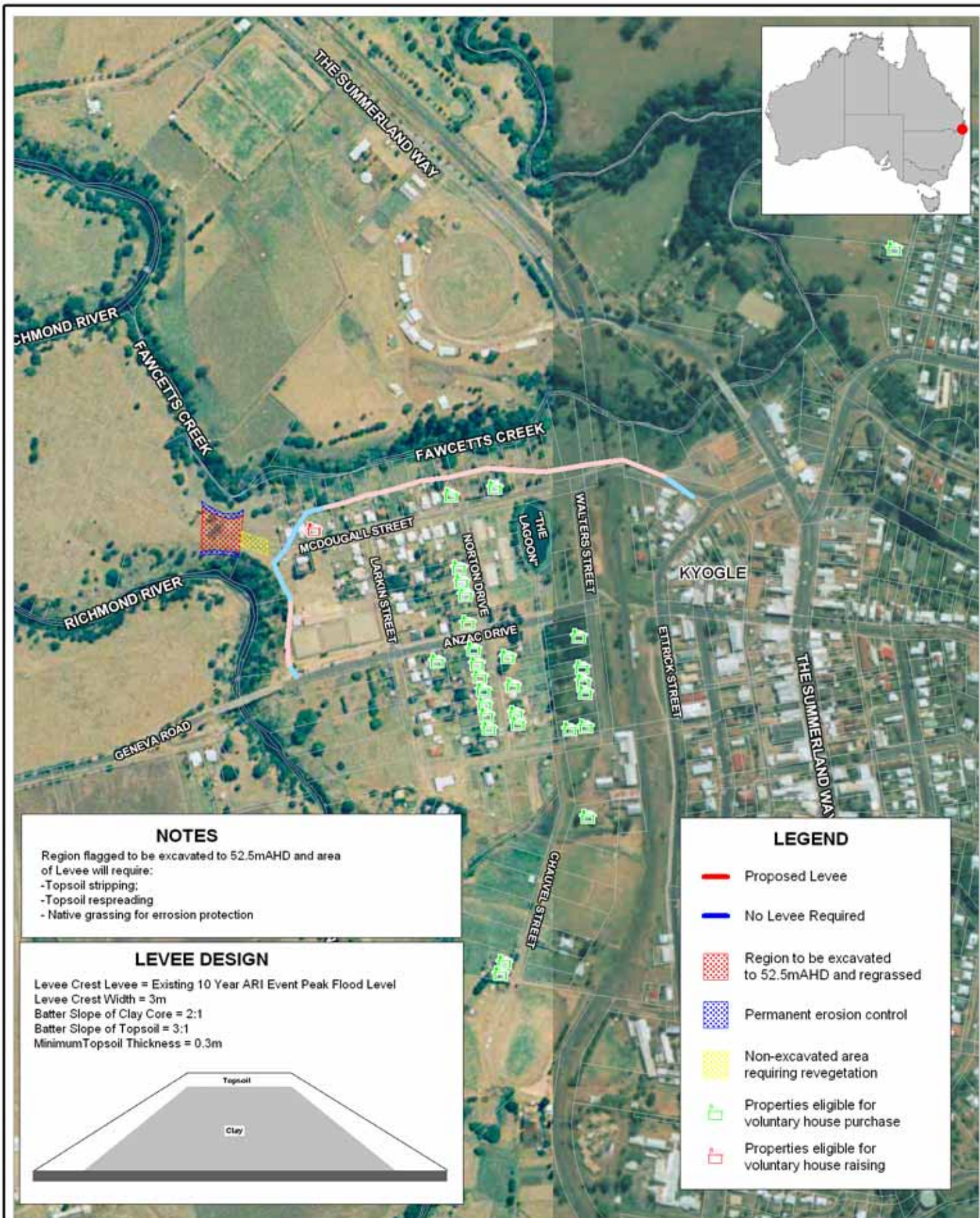
Of the measures considered and investigated during the Floodplain Risk Management Study (BMT WBM, 2009), the Floodplain Management Committee recommended that the following measures be included in the Floodplain Management Scheme used to develop this Floodplain Management Plan:

- 10% AEP partial ring levee of “the Flats”;
- Additional Fawcetts Creek flood breakout;
- Voluntary house purchase of eligible properties;
- Voluntary house raising of eligible properties;
- Development controls, and
- Response modification measures.

A summary of costs and benefits is provided below.

| Measure  | Cost  | Benefit   | BC Ratio                  |
|--|---|---|---------------------------|
| <b>10% AEP Partial Ring Levee<br/>+<br/>Additional Fawcetts Creek Floodway</b> | \$1,450,000                                     | \$1,825,000<br>+<br>Reduction in flood risk to residents of “the Flats”<br>+<br>Intangibles | 1.25 + Intangibles        |
| <b>Voluntary House Purchase</b>  | \$5,600,000                                     | \$1,310,000<br>+<br>Intangibles   | 0.23 + Intangibles        |
| <b>Voluntary House Raising</b>   | \$41,250  | \$30,400<br>+<br>Intangibles  | 0.74 + Intangibles        |
| <b>Development Controls</b>  | Council’s Normal Operating Budget               | Reduction of <i>future</i> damages – not possible to quantify.                              | Not possible to determine |
| <b>Response Modification Measures</b>  | \$109,500                                       | Reduction of <i>future</i> flood risk – not possible to quantify.                           | Not possible to determine |
| <b>Total</b>   | \$7,200,750 + Council’s normal operating budget | \$3,165,000 + Intangibles   | 0.44+ Intangibles         |





Title:  
**Kyogle Floodplain Management Measures Layout**

Figure:  
**S-1**

Rev:  
**A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.



0 100m 200m  
 Approx. Scale

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Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FMP\FLD\_Plan\_000\_Flood\_Manage\_Measure.WOR

The ultimate outcome of the Kyogle Floodplain Risk Management Study was the formulation and selection of the floodplain management scheme for incorporation into this Plan. The scheme is a combination of the floodplain management measures approved by the Committee. The Plan defines a series of measures which, if implemented, reduce the impact of flooding in Kyogle area by controlling the flood risk and reducing flood damages.

## Funding Constraints

The implementation of the floodplain management scheme outlined in this document is partly subject to the allocation of funding by the State Government. However, Council should endeavour to implement some of the initiatives outlined in the plan regardless of the level of funding from the State Government. The following floodplain management measures can be initiated (*either in part or in full*) following the adoption of the Plan by Council without waiting for State Government funding:

- **Development Controls (*in full*):** This measure does not require any funding from the State Government. It is anticipated that the cost of implementing this measure is met by Council within its normal operating budget. However, Council does need to be aware that the development controls proposed within this Floodplain Risk Management Plan document accounts for the flood modification measures, namely the additional Fawcetts Creek floodway and the 10% AEP partial ring levee being completed.
- **Kyogle Response Modification Measures (*in part*):** Funding of this measure will not require state government funding assistance. However, a portion of this measure will be driven by response protocols and community education. Council and the SES are able to commence these actions prior to government funding.

## Overall Benefits

The **Flood Modification Measures**, including the 10% AEP Partial Ring Levee and the Additional Fawcetts Creek flood breakout will reduce flood risk to residents of “the Flats”.

Currently, flood breakout through the lagoon area occurs approximately every two to five years. This results in the isolation of “the Flats” from flood-free higher ground by fast flowing floodwaters. This poses an extreme risk to residents of “the Flats” during large events and resulted in the loss of life during the 1954 flood event.

The proposed levee will increase the flood immunity for residents of “the Flats” from the 50%-20% AEP flood event to greater than the 10% AEP event. During flood events larger than the 10% AEP event (when levee overtopping is predicted to occur) the levee structure will increase flood warning and evacuation time for “the Flats” by 2 to 4 hours to 10 to 12 hours depending on the magnitude of the event. Additionally flood flows passing through “the Flats” during moderate sized flood events will be significantly reduced.

The Additional Fawcetts Creek Flood Breakout provides an outlet for floodwaters from Fawcetts Creek into the Richmond River. The additional flood breakout reduces flood levels in Fawcetts Creek. In combination with the partial ring levee the additional Fawcetts Creek flood breakout successfully offsets the possible increase in flood levels to residents upstream of the proposed partial ring levee of “the Flats”.



The **Development Control Plan** ensures that any new developments have some consideration of flood hazard, flood levels, and inundation extents in their design. This results in a reduction in future risk to life and limb and a lowering of the health, social, and psychological trauma associated with flooding. The future risk of monetary damages to property is also reduced.

The **Kyogle Response Modification Measures** will ensure that residents and authorities are able to respond quickly and appropriately following flood warning for a Richmond River flood event. These measures will minimise flood damages and trauma associated with flooding.

## Prioritisation of Scheme Components

The recommended prioritisation of scheme components and approximate costs are provided in the table below.

**Floodplain Management Scheme Priorities**

| Measure  | Priority            | Cost  | BC Ratio                        | Funding Responsibility                | Section |
|--|---------------------|---|---------------------------------|---------------------------------------|---------|
| <b>10% AEP Partial Ring Levee + Additional Fawcetts Creek Floodway</b> | High                | \$1,450,000                                     | 1.25 + Intangibles              | Council, State and Federal Government | 3       |
| <b>Voluntary House Purchase</b>  | Medium & Ongoing    | \$5,600,000                                     | 0.23 + Intangibles              | Council, State and Federal Government | 4       |
| <b>Voluntary House Raising</b>   | High & Ongoing      | \$41,250  | 0.74 + Intangibles              | Property owner and State Government   | 5       |
| <b>Development Controls</b>  | Immediate & Ongoing | Council's Normal Operating Budget               | Not possible to determine       | Council                               | 6       |
| <b>Response Modification Measures</b>                                  | Immediate & Ongoing | \$109,500                                       | Not possible to determine       | Council and State Government          | 7       |
| <b>TOTAL</b>   | -                   | \$7,200,750 + Council's normal operating budget | 0.44 <sup>1</sup> + Intangibles | -                                     | -       |

## Review of Plan

The recommended actions proposed in this Plan are not set in concrete. They need to be reviewed and fine-tuned over time, taking into account the relative success of implemented actions and feedback from the community. It is intended that the progress in implementing the plan will be reviewed annually, while the entire plan will be reviewed and updated every five to ten years.

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## GLOSSARY

|  |   |
|--|---|
| <b>Annual Exceedance Probability (AEP)</b> | The chance of a flood of a given size (or larger) occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m <sup>3</sup> /s has an AEP of 5%, it means that there is a 5% chance (i.e. a 1 in 20 chance) of a peak discharge of 500 m <sup>3</sup> /s (or larger) occurring in any one year. (see also Average Recurrence Interval) |
| <b>Australian Height Datum (AHD)</b>       | National survey datum corresponding approximately to mean sea level.  |
| <b>Average Recurrence Interval (ARI)</b>   | 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 20yr ARI design flood will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event. (see also Annual Exceedance Probability) |
| <b>catchment</b>                           | The catchment at a particular point is the area of land that drains to that point.  |
| <b>design floor level</b>                  | The minimum (lowest) floor level specified for a building.  |
| <b>design flood</b>                        | A hypothetical flood representing a specific likelihood of occurrence (for example the 100 year or 1% probability flood). The design flood may comprise two or more single source dominated floods.   |
| <b>development</b>                         | Existing or proposed works that may or may not impact upon flooding. Typical works are filling of land, and the construction of roads, floodways and buildings.   |
| <b>discharge</b>                           | The rate of flow of water measured in terms of volume over time (i.e. the amount of water moving past a point). Discharge and flow are interchangeable.   |
| <b>DTM</b>                                 | Digital Terrain Model - a three-dimensional model of the ground surface.  |
| <b>DEM</b>                                 | Digital Elevation Model - a three-dimensional model of the ground surface. Often used interchangeably with DTM.   |
| <b>effective warning time</b>              | The available time that a community has from receiving a flood warning to when the flood reaches them.  |
| <b>emergency management</b>                | A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.   |
| <b>flash flooding</b>                      | 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.   |
| <b>flood</b>                               | Relatively high river or creek flows, which overtop the natural or artificial banks, and inundate floodplains and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.   |



|  |   |
|--|---|
| <b>flood awareness</b>                 | An appreciation of the likely threats and consequences of flooding and an understanding of any flood warning and evacuation procedures. Communities with a high degree of flood awareness respond to flood warnings promptly and efficiently, greatly reducing the potential for damage and loss of life and limb. Communities with a low degree of flood awareness may not fully appreciate the importance of flood warnings and flood preparedness and consequently suffer greater personal and economic losses.                  |
| <b>flood education</b>                 | Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand the likely threats and be prepared in the event of a flood.  |
| <b>flood damage</b>                    | The tangible and intangible costs of flooding.  |
| <b>flood behaviour</b>                 | The pattern / characteristics / nature of a flood.  |
| <b>flood fringe</b>                    | Land that may be affected by flooding but is not designated as floodway or flood storage.   |
| <b>flood hazard</b>                    | The potential risk to life and limb and potential damage to property resulting from flooding. The degree of flood hazard varies with circumstances across the full range of floods.   |
| <b>flood level</b>                     | The height or elevation of floodwaters relative to a datum (typically the Australian Height Datum). Also referred to as “stage”.  |
| <b>flood liable land</b>               | See flood prone land  |
| <b>floodplain</b>                      | Land adjacent to a river or creek that is periodically inundated due to floods. The floodplain includes all land that is susceptible to inundation by the probable maximum flood (PMF) event.   |
| <b>floodplain management</b>           | The co-ordinated management of activities that occur on the floodplain.   |
| <b>floodplain management measures</b>  | A range of techniques that are aimed at reducing the impact of flooding. This can involve reduction of: flood damages, disruption and psychological trauma.   |
| <b>floodplain risk management plan</b> | A document outlining a range of actions aimed at improving floodplain management. The plan is the principal means of managing the risks associated with the use of the floodplain. A floodplain risk management plan needs to be developed in accordance with the principles and guidelines contained in the NSW Floodplain Development Manual. The plan will usually contain both written and diagrammatic information describing how particular areas of the floodplain are to be used and managed to achieve defined objectives. |
| <b>floodplain management scheme</b>    | A floodplain management scheme comprises a combination of floodplain management measures. In general, one scheme is selected by the floodplain management committee and is incorporated into the plan.  |

|   |  |
|---|--|
| <b>Flood Planning Levels (FPL)</b>        | Flood planning levels selected for planning purposes are derived from a combination of the adopted flood level plus freeboard, as determined in floodplain management studies and incorporated in floodplain risk management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also take into account the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of landuse and for different flood plans. The concept of FPLs supersedes the “standard flood event”. As FPLs do not necessarily extend to the limits of flood prone land, floodplain risk management plans may apply to flood prone land beyond that defined by the FPLs. |
| <b>flood prone land</b>                   | Land susceptible to inundation by the probable maximum flood (PMF) event. Under the merit policy, the flood prone definition should not be seen as necessarily precluding development. Floodplain Management Plans should encompass all flood prone land (i.e. the entire floodplain).   |
| <b>flood proofing</b>                     | Measures taken to improve or modify the design, construction and alteration of buildings to minimise or eliminate flood damages and threats to life and limb.  |
| <b>flood source</b>                       | The source of the floodwaters.   |
| <b>flood storages</b>                     | Floodplain areas that are important for the temporary storage of floodwaters during a flood.   |
| <b>floodway</b>                           | A flow path (sometimes artificial) that carries significant volumes of floodwaters during a flood.   |
| <b>freeboard</b>                          | A factor of safety usually expressed as a height above the adopted flood level thus determining the flood planning level. Freeboard tends to compensate for factors such as wave action, localised hydraulic effects and uncertainties in the design flood levels.   |
| <b>historical flood</b>                   | A flood that has actually occurred.  |
| <b>hydraulic</b>                          | The term given to the study of water flow in rivers, estuaries and coastal systems.  |
| <b>hydrograph</b>                         | A graph showing how a river or creek’s discharge changes with time.  |
| <b>hydrology</b>                          | The term given to the study of the rainfall-runoff process in catchments.  |
| <b>local overland flooding</b>            | Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.  |
| <b>local drainage</b>                     | Smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.   |
| <b>mainstream flooding</b>                | Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.   |
| <b>peak flood level, flow or velocity</b> | The maximum flood level, flow or velocity occurring during a flood event.  |
| <b>Probable Maximum Flood (PMF)</b>       | An extreme flood deemed to be the maximum flood likely to occur.   |

|   |   |
|---|---|
| <b>Probable Maximum Precipitation (PMP)</b> | The PMP is 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 PMF estimation.  |
| <b>probability</b>                          | A statistical measure of the likely frequency or occurrence of flooding.  |
| <b>runoff</b>                               | The amount of rainfall from a catchment that actually ends up as flowing water in the river or creek.   |
| <b>stage</b>                                | See flood level.  |
| <b>stage hydrograph</b>                     | A graph of water level over time.   |
| <b>TUFLOW</b>                               | Hydrodynamic modelling software package developed by BMT WBM.   |
| <b>velocity</b>                             | The speed at which the floodwaters are moving. Typically in 2D model studies, modelled velocities in a river or creek are quoted as the depth averaged velocity, i.e. the average velocity over the depth. In other situations, such as for 1D components of the model, velocities can be quoted as depth <u>and</u> width averaged velocities i.e. the average velocity across the whole river or creek section. |
| <b>water level</b>                          | See flood level.  |
| <b>Kyogle Flood Study</b>                   | Study undertaken by WBM Pty Ltd on behalf of Kyogle Council and completed in February 2004. Reference: WBM (2004).  |

## LIST OF ABBREVIATIONS

|                        |  |
|------------------------|--|
| <b>1D / 2D</b>         | One dimensional / Two dimensional  |
| <b>AAD</b>             | Annual Average Damages   |
| <b>AEP</b>             | Annual Exceedance Probability  |
| <b>AHD</b>             | Australian Height Datum  |
| <b>ARI</b>             | Average Recurrence Interval  |
| <b>AR&amp;R</b>        | Australian Rainfall and Runoff   |
| <b>CBD</b>             | central business district  |
| <b>cm</b>              | centimetre   |
| <b>cumecs</b>          | cubic metres per second  |
| <b>DA</b>              | Development Application  |
| <b>DCP</b>             | Development Control Plan   |
| <b>DIPNR</b>           | Department of Infrastructure, Planning and Natural Resources (formerly DLWC).                  |
| <b>DNR</b>             | Department of Natural Resources (formerly DIPNR)   |
| <b>DLWC</b>            | Department of Land and Water Conservation  |
| <b>DECC</b>            | Department of Environment & Climate Change (formerly DNR)                                      |
| <b>DEM</b>             | Digital Elevation Model  |
| <b>DTM</b>             | Digital Terrain Model  |
| <b>EIS</b>             | Environmental Impact Study   |
| <b>FPL</b>             | Flood Planning Level   |
| <b>FPRMS</b>           | Floodplain Risk Management Study   |
| <b>GIS</b>             | Geographic Information System  |
| <b>km</b>              | Kilometre  |
| <b>LGA</b>             | Local Government Area  |
| <b>LEP</b>             | Local Environmental Plan   |
| <b>m</b>               | Metre  |
| <b>m<sup>3</sup>/s</b> | cubic metres per second  |
| <b>mAHD</b>            | Elevation in metres relative to the Australian Height Datum                                    |
| <b>PMF</b>             | Probable Maximum Flood   |
| <b>PWD</b>             | NSW Public Works (or Public Works Department)<br>(now Department of Public Works and Services) |



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|            |                                    |
|------------|------------------------------------|
| <b>REP</b> | Regional Environmental Plan        |
| <b>RTA</b> | Roads and Traffic Authority of NSW |
| <b>SES</b> | NSW State Emergency Services       |

# 1 INTRODUCTION

## 1.1 Background

Kyogle is situated at the confluence of the Richmond River and Fawcetts Creek within the Richmond River Valley of New South Wales. The Richmond River flows in a general south-easterly direction from its source on the Queensland/New South Wales border in the McPherson Ranges, as shown in Figure 1-1. Fawcetts Creek is an easterly tributary comprising 129.1km<sup>2</sup> of the 886.2km<sup>2</sup> total catchment area upstream of the study area.

The Richmond River is initially a series of steep mountain streams, which combine forming a major flow path at Wiangaree. Downstream of Wiangaree bed slopes decrease, the floodplain becomes more pronounced and the river exhibits meandering patterns. It is not until downstream of the Kyogle township that major floodplains start to develop. Fawcetts Creek has a similar terrain profile.

The major urban areas of the Kyogle Township are located on higher ground to the south-east of the confluence of the watercourses. The suburb of Geneva, located on the western side of the Richmond River, is also mostly on higher ground. However a considerable number of properties in the area known as 'The Flats', which is bounded to the north by Fawcetts Creek and to the west by the Richmond River, are located on flood prone land. Properties along the western side of Fawcett St in the north of Kyogle are also subject to flooding.

During the major flood that occurred along the entire length of the Richmond River on the 20<sup>th</sup> of February 1954, 10 people lost their lives within Kyogle. Additionally, 10 houses were swept away and a further 159 homes were damaged by floodwaters.

Since this time, flood events of a smaller magnitude have been experienced in 1974, 1976, 1978, 1980, 1987, 1989, 1996, 2001 and 2008. The 2008 event represents the second largest flood on record. During the 2008 event inundation of approximately 100 properties occurred. Fortunately, no lives were lost. This is possible in part related to the timing of the event, which reached its peak level at midday on the 5<sup>th</sup> of January. The 2008 flood event highlighted the need for flood management in the Kyogle area.

## 1.2 Need for Floodplain Management in Kyogle

Historically, various areas of Kyogle have experienced high flood risk during small to moderate sized flood events. In "the Flats" flooding occurs on average approximately every two to five years (equivalent to the 50% and 20% AEP events). Design event modelling shows that during the 10% AEP event significant inundation of "the Flats" occurs. This results in the inundation of numerous properties. During events equal to and greater than the 5% AEP event, the entire "Flats" area is inundated. This poses a substantial flood risk to the residents of the 65 properties located in "the Flats".

In other parts of Kyogle, properties are also inundated during small to moderate sized events, incurring significant flood damages. Fortunately, these properties have access to high, flood free ground which reduces the flood risk to the residents of these properties. Table 1-1 lists the number of properties inundated for the full range of design events.

Table 1-1 Kyogle Property Inundation Totals

| AEP Flood Event | Number of Properties Inundated |                                    |       |
|-----------------|--------------------------------|------------------------------------|-------|
|                 | Residential Properties         | Commercial / Industrial Properties | Total |
| <b>PMF</b>      | 146                            | 42                                 | 188   |
| <b>0.2%</b>     | 111                            | 31                                 | 142   |
| <b>1%</b>       | 101                            | 21                                 | 122   |
| <b>2%</b>       | 92                             | 20                                 | 112   |
| <b>5%</b>       | 71                             | 12                                 | 83    |
| <b>10%</b>      | 28                             | 8                                  | 36    |
| <b>20%</b>      | 1                              | 4                                  | 5     |
| <b>50%</b>      | 0                              | 0                                  | 0     |

To improve flood safety in flood prone areas, floodplain management measures have been assessed to reduce the flood risk to all residence. Similarly, in compliance with state government policies, where eligible, management measures reducing flood damage have also been assessed. These assessments have been documented in the Kyogle Floodplain Risk Management Study (BMT WBM, 2009). This document, the Kyogle Floodplain Management Plan, outlines the required actions needed to implement the selected floodplain management measures.

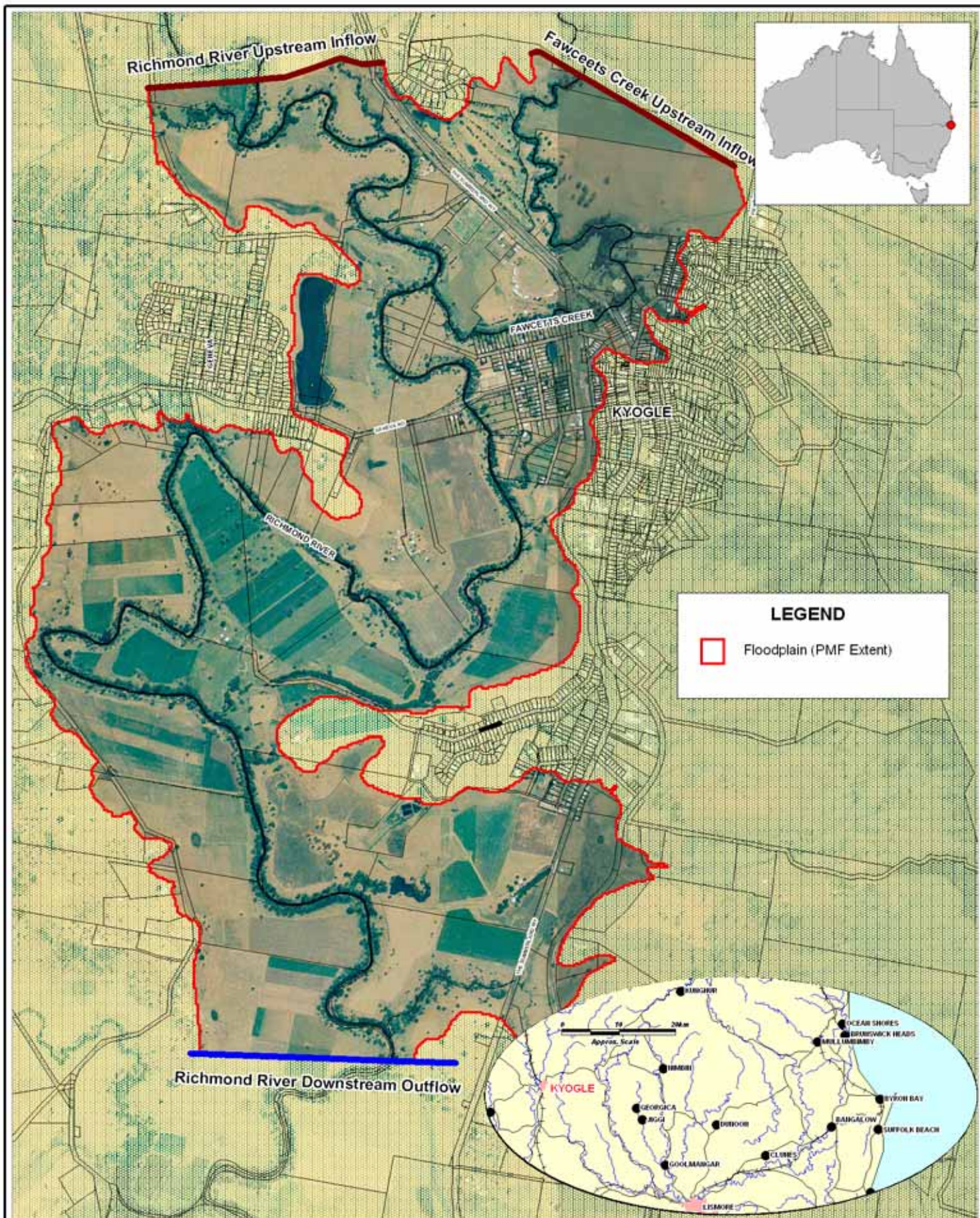
### 1.3 Objectives

The objectives of the Kyogle Floodplain Risk Management Plan are:

- To detail cost effective floodplain management measures for the Kyogle township area;
- To present a brief economic analysis of the proposed floodplain management scheme, including an overall benefit-cost ratio;
- To develop an implementation plan for the proposed scheme and present a program to illustrate the proposed actions and annual cost estimates associated with the implementation of the measures; and
- To take into account the funding from Council and both the State and Commonwealth Governments when estimating the cost for implementation.

The formulation of this Floodplain Risk Management Plan has been based on the framework outlined in the Floodplain Development Manual (DIPNR, 2005).





Title:  
**Study Area**

Figure:  
**1-1**

Rev:  
**A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.



0 0.5 1km  
Approx. Scale



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## **2 FLOODPLAIN MANAGEMENT IN KYOGLE**

### **2.1 Kyogle Flood Study**

The Kyogle Flood Study was undertaken for Kyogle Council by WBM Pty Ltd (now BMT WBM Pty Ltd) and completed in February 2004 (WBM, 2004). The purpose of the Flood Study was to define the existing flood behaviour and risk to the town of Kyogle. The Flood Study represents a significant component of the overall Floodplain Risk Management Process.

#### **2.1.1 Flood Study Stages**

The study was undertaken in the following stages:

- Compilation and review of available information;
- Site inspections and resident survey;
- Identification of historical changes to topography;
- Collection of historical flood information;
- Collection of topographic survey data;
- Development of computer models;
- Calibration of models to the March 2001, May 1996 and April 1989 flood events;
- Establishment of design flood conditions;
- Presentation of design flood results— peak flood levels, depths, velocities and provisional hazards.

#### **2.1.2 Historical Flood Information**

Historical flood information was obtained through consultation with local residents over the period 6-8 November 2001. This included:

- Personal interviews with 18 residents;
- Discussion and tour of historical flood marks with personnel from Kyogle Council and a representative from the Kyogle Floodplain Management Committee, Mr Murphy Stanfield;
- Independent touring of the catchment.

The resident survey had several benefits including:

- Input to the study team through local knowledge and personal experiences in flooding patterns;
- Developing a better understanding of flood behaviour in the area and an appreciation of flooding issues, thereby improving the quality of hydraulic modelling;

The information provided by residents on flood behaviour of the Richmond River, Fawcetts Creek and the associated floodplains was found to be invaluable in developing and understanding the flooding characteristics of the river. Additionally, a number of flood heights were identified during the public interviews. These flood marks were surveyed for use in model calibration.

### 2.1.3 Topography

A Digital Terrain Model (DTM) was developed to represent the ground topography for the Richmond River and the town of Kyogle. Datasets used to create the DTM are outlined in Table 2-1.

**Table 2-1 Topographic Information**

| Source                           | Description   | Model Application                                 |
|----------------------------------|---|---|
| Central Mapping Authority of NSW | 1:4,000 orthophoto mapping  | Topography base (DEM) for 2D section of the model |
| Water Studies                    | Ground survey cross-sections by Hosie, Hosie and Butler dated 1982.                         | Assistance in developing the DEM                  |
| Kyogle Council                   | Sewerage plans with surface contour information dated 1938                                  | Assistance in developing the DEM                  |
| Ground Survey from Aspect North  | Survey of sewer invert levels to establish the datum of above                               | Assistance in developing the DEM                  |
| Ground Survey from Aspect North  | Water supply weir crest   | Model representation of the weir                  |
| Ground Survey from Aspect North  | Cross-sections of the Richmond River and floodplain upstream and downstream of the 2D model | Development of the 1D hydraulic model components  |
| DLWC Grafton (Now DECC)          | Satellite data at a grid spacing of 25m   | Comparison with 1D hydraulic model components     |

### 2.1.4 Computer Models

Computer models are the most accurate, cost-effective and efficient tools to model a river's flood behaviour. During the flood study, two types of models were used:

- A hydrologic model used to simulate the catchment rainfall-runoff processes, producing the river/creek flows. The modelling software program RAFTS was used during the hydrology assessment. The hydrologic model covered the catchment of the Richmond River, Fawcetts Creek and Horsestation Creek to McDonalds Creek downstream of the Horsestation Creek/Richmond River confluence.
- Using the river/creek flow inputs derived during the hydrology modelling, a hydraulic model was used to simulate the flow behaviour in the river and over the floodplains in Kyogle and its surrounds. The modelling software, TUFLOW, was used to set up a 2D/1D hydraulic model of the study area. The model is a mixture of 1D and 2D domains with the 2D domain covering the key areas of interest. The hydraulic model produces the following output; flood levels, flow discharges, flow velocities and flood hazard categorisations.

Information on the topography and characteristics of the catchments, river and floodplains were input to the models. The models were calibrated to the March 2001, May 1996 and April 1989 flood events. These calibration events represent small to moderate sized events. Due to the lack of available data, calibration of the computer models to a major flood event (i.e. greater than 5% AEP) was not possible.

The calibration of the above mentioned flood events illustrated the model's ability to reproduce historic flood patterns collected during data collation and community consultation. Comparisons with comments on flooding patterns received during the historic flood information survey were also consistent with the hydraulic model's performance.

### 2.1.5 Design Floods

The calibrated hydrologic and hydraulic models were modified as necessary to represent present day conditions, including topographical and land use changes. The models were then used to define present day design flood conditions.

Design floods are statistical-based events that have a particular probability of occurrence. For example, the 1% Annual Exceedance Probability (AEP) event is the best estimate of a flood that has a 1% (i.e. 1 in 100) chance of occurring in any one year (on average). Table 2-2 relates various AEP events to the equivalent Average Recurrence Interval (ARI) events. Design floods are based on statistical analysis of recorded rainfalls. The Australian standard for estimating design flood events is Australian Rainfall and Runoff (AR&R, 1987). AR&R (1987) contains results of statistical analysis of rainfall records across all of Australia and these are typically used to determine design rainfall events for the region of interest.

The design flood results were presented in graphical format showing depths, flood levels and velocities around Kyogle. Provisional hazard categories were also mapped.

**Table 2-2 Design Event Categories**

| <b>Annual Exceedance Probability (AEP)</b> | <b>Approximate Average Recurrence Interval (ARI)</b> |
|--|--|
| 1%   | 100 year   |
| 2%   | 50 year  |
| 5%   | 20 year  |
| 10%  | 10 year  |
| 20%  | 5 year   |
| 50%  | 2 year   |

### 2.1.6 Key Discussion Points

Several points are worth noting in relation to the predicted design flood behaviour for Kyogle:

- "The Flats" experiences significant flooding in a smaller than the 10% AEP flood event. The 20% AEP flood results indicate minor flooding of "the Flats". This is in line with the historical record of the area being flooded on average every two to five years;
- The Fawcetts Creek floodplain area upstream of the railway line experiences generally low flows and velocities (outside the creek banks) for all floods up to a 5% AEP flood and consequently, a very flat flood gradient.
- "The Flats" experiences very high velocity-depth products in the 5% AEP flood and all larger flood events;

- Geneva Bridge results in only a moderate amount of afflux (i.e. 0.2m to 0.4m) in flood events greater than the 5% AEP flood. For smaller flood events, there is negligible afflux resulting from the bridge;
- The breakout of flood waters across the floodplain west of Highfields tends to marginally flatten out the flood gradient in the larger flood events;
- There are a number of locations on the floodplain which experience high flows resulting from the Richmond River short-cutting its flow path across the floodplain;
- Significant reverse flow is experienced in Fawcetts Creek for the first half of a typical flood event. The flows close to the junction with the Richmond River show reverse flow, which results in the filling up of the floodplain storage of Fawcetts Creek. Following the peak of the flood, the reverse flow reduces to zero and then Fawcetts Creek begins to flow in a forward direction as the floodplain area drains.

## 2.2 Kyogle Floodplain Risk Management Study

**The primary objective of the Floodplain Risk Management Study was to provide information that would lead to the formulation of this Floodplain Risk Management Plan.**

The existing flood behaviour in Kyogle resulting from combined Richmond River and Fawcetts Creek flood events was defined in the Kyogle Flood Study (WBM, 2004). The outputs and results from the flood study allow management options to be assessed. This includes flood, property and response modification measures. Using the flood model developed as part of the Kyogle Flood Study (WBM Pty Ltd, 2004) the assessment of advantages and disadvantages of the various modification measures can be carried out with confidence. The Floodplain Risk Management Study provides such assessments and the Floodplain Risk Management Plan details the actions arising from the Study.

### 2.2.1 Data Acquisition

A property survey of all properties located within the Probable Maximum Flood (PMF) extent was undertaken by Kyogle council. In total 199 properties were surveyed. Of these 151 properties were residential, 40 were commercial and the 8 were publicly owned.

### 2.2.2 Additional Modelling

In January 2008, during the preparation of the Kyogle Floodplain Risk Management Study the Richmond Valley experienced a major flood event. Within Kyogle, the event was the second largest on record. During and after the flood event detailed rainfall and flood height information was collected.

During the Kyogle flood study, model calibration was undertaken for a variety of small to moderate sized flood events. The larger flood events, such as the 1954 flood event, were not available as model validation events due to limited flood and rainfall data.

Due to the abundant flood information, it was decided to use the January 2008 event data to validate the hydraulic model developed as part of the Kyogle Flood Study (WBM, 2004). Prior to this assessment, the Kyogle flood model had only been validated for small to moderately sized flood events. The model had never been calibrated to an event as large as the 2008 event. Preliminary assessments identified several areas where improvements to the existing 2004 model could be made



based on the 2008 event validation/calibration. The hydrology and hydraulic models were subsequently updated and further verified using the 1989, 1996 and 2001 flood events.

Using the recalibrated hydraulic model, the design event modelling undertaken as part of the Kyogle Flood Study (WBM, 2004) was revised. Subsequent assessment of the Kyogle Floodplain Risk Management Study Schemes was undertaken using the revised flood model.

### **2.2.3 Community Consultation**

Throughout the course of the study, numerous committee meetings were held to update the committee on study progress and to receive feedback from committee members on study issues. In addition to the resident survey conducted at the commencement of the Flood Study, two community open sessions were also held in Kyogle. They allowed the community to review work undertaken and provide feedback on accuracy and direction of the study.

### **2.2.4 Flood Damages Assessment**

To allow the effectiveness of management measures to be assessed, the monetary damages resulting from combined Richmond River/Fawcetts Creek flooding in the Kyogle township were estimated. These damages establish the socio-economic costs of flooding and help quantify the benefits of mitigation measures (e.g. partial ring levee).

Flood damages are classified as tangible or intangible, depending on whether it is practical to assign monetary value to the damage. Intangible damages arise from adverse social and environmental effects caused by flooding and include factors such as personal injury, stress and anxiety. Tangible damages are monetary losses directly attributable to flooding. For example, damage to material items (e.g. houses) and disruptions to physical and economic activities, such as the loss of sales and reduced productivity.

The existing total flood damages for the Kyogle township based on the revised flood model results are summarised in Table 2-3. The procedure used to calculate these flood damages is explained in the Kyogle Floodplain Risk Management Study (BMT WBM, 2009). Based on the flood damages assessment, the average annual damages for Kyogle is \$612,000 (2008\$)

**Table 2-3 Summary of Tangible Flood Damages for Kyogle**

| ARI Event (yr)                  | AEP (%) | Residential    |              |                             | Commercial/Industrial |              |                             | Infrastructure |        |                             | Total Damages |
|---------------------------------|---------|----------------|--------------|-----------------------------|-----------------------|--------------|-----------------------------|----------------|--------|-----------------------------|---------------|
|                                 |         | No. Properties | Damage       | Average Damage per Property | No. Properties        | Damage       | Average Damage per Property | No. Properties | Damage | Average Damage per Property |               |
| PMF                             | 0       | 146            | \$10,465,296 | \$71,680                    | 42                    | \$11,287,296 | \$268,745                   | \$494,160      | 10     | \$49,416                    | \$22,246,752  |
| 500                             | 0.2     | 111            | \$5,840,142  | \$52,614                    | 31                    | \$6,871,096  | \$221,648                   | \$81,160       | 2      | \$40,580                    | \$12,792,398  |
| 100                             | 1       | 101            | \$4,003,831  | \$39,642                    | 21                    | \$4,436,028  | \$211,239                   | \$-            | -      | -                           | \$8,439,859   |
| 50                              | 2       | 92             | \$2,910,645  | \$31,637                    | 20                    | \$3,551,159  | \$177,558                   | \$-            | -      | -                           | \$6,461,804   |
| 20                              | 5       | 71             | \$1,739,994  | \$24,507                    | 12                    | \$1,961,079  | \$163,423                   | \$-            | -      | -                           | \$3,701,073   |
| 10                              | 10      | 28             | \$624,567    | \$22,306                    | 8                     | \$839,653    | \$104,957                   | \$-            | -      | -                           | \$1,464,220   |
| 5                               | 20      | 1              | \$8,508      | \$8,508                     | 4                     | \$305,875    | \$76,469                    | \$-            | -      | -                           | \$314,383     |
| 2                               | 50      | 0              | \$-          | -                           | 0                     | \$-          | -                           | \$-            | -      | -                           | \$-           |
| Annual Average Damages (2008\$) |         |                |              |                             |                       |              |                             |                |        |                             | \$612,000     |

### 2.2.5 Flood Hazard Assessment

Flood hazard is the term used to describe the potential risk to life and limb and potential damage to property resulting from flooding. The degree of flood hazard varies both in time and place across the floodplain. Floodwaters are deep and fast flowing in some areas, whilst at other locations they are shallow and slow moving. It is important to determine and understand the variation in the degree of hazard and flood behaviour across the floodplain.

The NSW Floodplain Development Manual (NSWG, 2005) defines flood hazard categories based on the product of velocity and depth. The manual states that for low hazard conditions, people and possessions could be evacuated by trucks and/or wading. The risk to life is considered to be low. For high hazard conditions, floodwaters could cause damage to structures and evacuation by trucks would be difficult. Furthermore, able-bodied adults would have difficulty wading in such floodwaters. The risk to life is considered to be high. Figure 2-1 defines the categorisation used for the mapping of the Flood Hazards for the Kyogle Flood Risk Management Study (BMT WBM, 2009).

Based on the flood hazard categories outlines in Figure 2-1 the DCP hazard category zones listed in Table 2-4 have been defined for the Kyogle Risk Management Study.

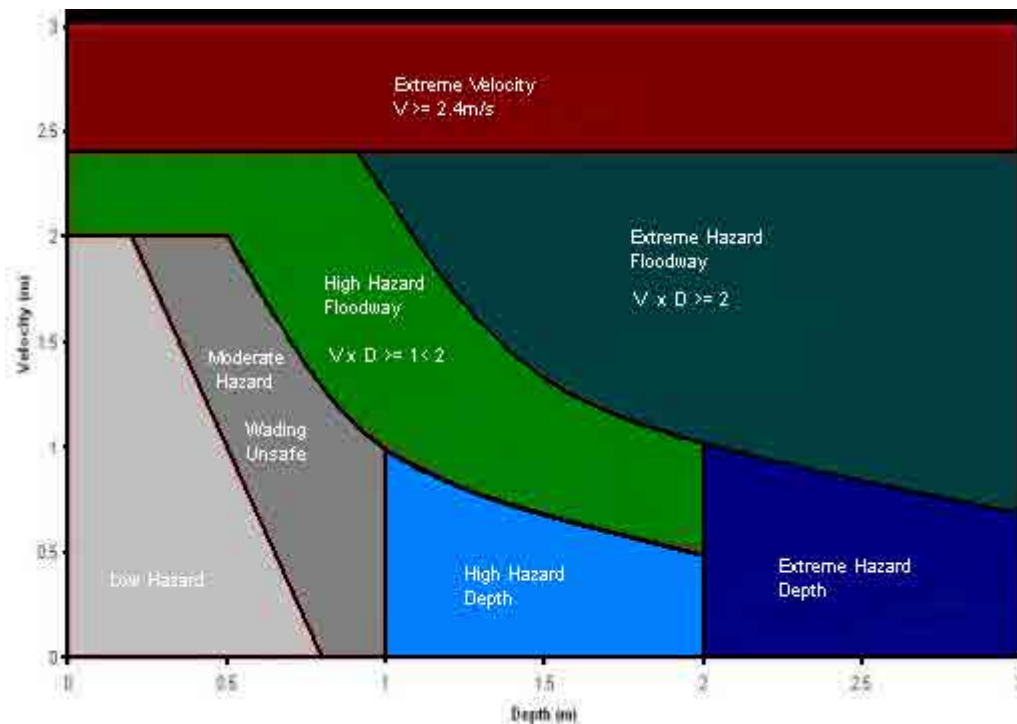


Figure 2-1 Kyogle Flood Hazard Categories

Table 2-4 Kyogle Flood Hazard Category Zones

| Flood Hazard Category Zone   | General Name         | Technical Hazard Composition  |
|------------------------------|----------------------|---|
| N/A                          | No Hazard            | Outside Flood Prone Area<br>Note: The "Flood Prone Area" is defined as the extent of inundation for the PMF event.  |
| A                            | Flood Fringe         | All areas between the outer boundary of 1% AEP event Medium Hazard Wading and the PMF Flood Extent are to be classified as "Flood Fringe". This will incorporate <b>some</b> portions of the following zones: <ul style="list-style-type: none"> <li>- PMF Extreme Hazard Velocity</li> <li>- PMF Extreme Hazard Floodway</li> <li>- PMF High Hazard Floodway</li> <li>- PMF Extreme Hazard Depth</li> <li>- PMF High Hazard Depth</li> <li>- PMF Medium Hazard</li> <li>- PMF and 100 year ARI event Low Hazard</li> </ul> |
| B                            | High Hazard Depth    | 1% AEP event High Hazard Depth and Medium Hazard  |
| C                            | High Hazard Floodway | 1% AEP event High Hazard Floodway   |
| D                            | Extreme Hazard       | 1% AEP event Extreme Hazard Depth, Extreme Hazard Floodway, Extreme Hazard Velocity and Data Not Available*   |
| <b>Additional Constraint</b> |                      |   |
| E                            | Rare Extreme Hazard  | PMF Extreme Hazard Velocity, PMF Extreme Hazard Floodway and Data Not Available*  |

\* In bank areas of the Richmond river and Fawcetts Creek

K:\B15289.k.clb.Kyogle\5.Flood Management Options\Property\_Modification\DCP\Planning\_Control\_Matrices\_001.xls\Hazard Categories

## 2.2.6 Assessment of Floodplain Management Measures

The Floodplain Management Committee identified a number of floodplain management measures worthy of assessment. Each measure was grouped into one of three categories according to recommendations in the Floodplain Development Manual (DIPNR, 2005):

- 1 **Flood Modification Measures** - designed to alter the behaviour of the flood itself by reducing flood levels and/or velocities, or by excluding floodwaters from areas at risk.
- 2 **Property Modification Measures** - modifications to existing buildings to reduce the risk of flooding and/or imposition of controls on property and infrastructure development.
- 3 **Response Modification Measures** - aimed at increasing the ability of people to respond appropriately in times of flood and/or enhancing the flood warning and evacuation procedures in an area.

The floodplain management measures investigated as part of the Kyogle Floodplain Risk Management Study are described below.

### Flood Modification Measures

- **Measure 1:** Additional Fawcetts Creek flood breakout
- **Measure 2:** Formulated channel through “the Lagoon” (“The Flats”)
- **Measure 3:** Formulated floodway between the Richmond River and Geneva
- **Measure 4:** Kyogle Levee

### Property Modification Measures

- **Measure 5:** Voluntary House Purchase
- **Measure 6:** Voluntary House Raising
- **Measure 7:** Development Controls

### Response Modification Measures

- **Measure 8: Kyogle Flood Warning System**, consisting of
  - 8.1 Community Flood Awareness and Preparedness
  - 8.2 Flood Predictions and Warnings
  - 8.3 Emergency Response Planning for Floods.

Table 2-5 Summary of Floodplain Management Measure Assessment

| Measure  | Option | Description   | Investigation Details                             | Benefit- Cost Ratio | Hydraulic Impacts  | Recommendation of the Committee  |
|--|--------|---|---|---------------------|--|--|
| 1. Additional Fawcetts Creek Flood Breakout                  | 1a     | Construction of an additional Fawcetts Creek flood breakout with the purpose of shortcutting Fawcett Creek floodwaters into the Richmond River during moderate to large flood events. Measure 1 is proposed to be located at the southern end of MacDougall Street at the narrow section of land separating Fawcetts Creek and the Richmond River before their confluence. The structural works involves lowering a 30m wide section of land to 52.5 mAHd | Preliminary hydraulic assessment undertaken only. | -                   | Minor reduction in peak flood levels for all events in the lower Fawcetts Creek catchment  | -  |
|  | 1b     | Similar design to Measure 1a. However the structural works involves lowering a 50m wide section of land to 52.5 mAHd  | Full assessment completed                         | 1.3                 | Significant reduction in peak flood levels for all events in the lower Fawcetts Creek catchment. Increased flood warning for residents of "the Flats". No reduction in flood risk for residents of "the Flats" due to high velocity flows. | Include in selected scheme due to BC ratio greater than 1 and positive hydraulic impacts |
|  | 1c     | Similar design to Measure 1a. However the structural works involves lowering a 70m wide section of land to 52.5 mAHd  | Preliminary hydraulic assessment undertaken only. | -                   | Minor increase in peak flood level reduction compared with 1b  | -  |
| 2. Formulised Channel through the "lagoon"                   | 2a     | Formulising of a channel through the lagoon drawing water from Fawcetts Creek in small to moderate sized flood events. Anzac road was raised with a bridge over the proposed channel using 3 2mx2m box culverts   | Preliminary hydraulic assessment undertaken only. | -                   | Increase in peak flood levels upstream of proposed Measure   | -  |
|  | 2b     | The number of culverts used to bridge the proposed channel in Measure 2a was increase from 3 to 6   | Preliminary hydraulic assessment undertaken only. | -                   | Increase in peak flood levels upstream of proposed Measure   | -  |
|  | 2c     | The number of culverts used to bridge the proposed channel in Measure 2a was increase from 3 to 10  | Full assessment completed                         | 0.23                | Minimal hydraulic impact   | Rejected- excluded from scheme due to low BC ratio                                       |
| 3. Formulised floodway between the Richmond River and Geneva | 3a     | Formulising of a 20m wide 2m deep channel running from the Richmond River, alongside Lake Harrison, under Geneva Rd via 4 1.5mx1.5m box culverts before ending on the floodplain downstream of Geneva Rd.   | Full assessment completed                         | 0.04                | Minimal hydraulic impact   | Rejected- excluded from scheme due to low BC ratio and little hydraulic impact           |

| Measure                     | Option | Description  | Investigation Details  | Benefit-Cost Ratio | Hydraulic Impacts   | Recommendation of the Committee  |
|-----------------------------|--------|--|--|--------------------|---|--|
| 4. Kyogle Levee             | 4a     | Partial ring levee of "the Flats" at the existing 10% AEP flood level  | Full assessment completed                                      | 0.8                | "The Flats" remain flood free up until the 10% AEP event.<br>Significant reduction in flood levels and flood velocities on lee side of levee up to 5% AEP event.<br>Significant increase in flood warning time for all events | Included in selected scheme due to beneficial reduction in flood risk for residents of "the Flats" |
|                             | 4b     | Partial ring levee of "the Flats" at the existing 5%AEP flood level  | Preliminary hydraulic assessment and BC ratio undertaken only. | -                  | "The Flats" remain flood free up until the 5% AEP event.<br>Significant increase in flood warning time for all events   | Rejected- land easement requirements are too large   |
|                             | 4c     | Partial ring levee of "the Flats" at the existing 2%AEP flood level  | Preliminary hydraulic assessment and BC ratio undertaken only. | -                  | "The Flats" remain flood free up until the 2% AEP event.<br>Significant increase in flood warning time for all events   | Rejected- land easement requirements are too large   |
|                             | 4d     | Full ring levee of "the Flats" at the existing 10% AEP flood level   | Preliminary hydraulic assessment undertaken only.              | -                  | Same as 4a  | Rejected- no additional hydraulic benefit compared with 4a   |
|                             | 4e     | Full ring levee of "the Flats" at the existing 5%AEP flood level   | Preliminary hydraulic assessment undertaken only.              | -                  | Same as 4b  | Rejected- land easement requirements are too large   |
|                             | 4f     | Full ring levee of "the Flats" at the existing 2%AEP flood level   | Preliminary hydraulic assessment undertaken only.              | -                  | Same as 4c  | Rejected- land easement requirements are too large   |
| 5. Voluntary House Purchase | 5a     | Voluntary purchase of all houses in "the Flats" and those existing houses located within high hazard floodway zones  | Full assessment completed                                      | 0.21               | -   | -  |
|                             | 5b     | Voluntary purchase of existing houses located within high hazard floodway zones (accounting for changed flood behaviour resulting from combined implementation of 1b and 4a) | Full assessment completed                                      | 0.74               | -   | Include in selected scheme   |

| Measure                        | Option | Description   | Investigation Details     | Benefit- Cost Ratio | Hydraulic Impacts | Recommendation of the Committee   |
|--------------------------------|--------|---|---------------------------|---------------------|-------------------|---|
| 6. Voluntary House Raising     | 6a     | Voluntary house raising of those houses inundated above floor level in the 5% AEP event | Full assessment completed | 0.85                | -                 | Include in selected scheme  |
| 7. Development Controls        | 7a     | Detailed develop controls based on a proposed development control matrix                | Full assessment completed | -                   | -                 | Include in selected scheme  |
| 8. Kyogle Flood Warning System | 8a     | Flood Related Brochures   | Full investigation        | -                   | -                 | Included in selected Scheme   |
|                                | 8b     | Historic Flood Markers  | Full investigation        | -                   | -                 | Included in selected Scheme   |
|                                | 8c     | Flood Totem   | Full investigation        | -                   | -                 | Rejected due to a lack of compatibility with neighbouring councils within the Richmond Valley |
|                                | 8d     | Floodplain Management Committee   | Full investigation        | -                   | -                 | Included in selected Scheme   |
|                                | 8e     | Flood Depth Maps  | Full investigation        | -                   | -                 | Included in selected Scheme   |
|                                | 8f     | Flood Velocity Depth Maps   | Full investigation        | -                   | -                 | Included in selected Scheme   |
|                                | 8g     | Automated Telephone/SMS Flood Warnings  | Full investigation        | -                   | -                 | Included in selected Scheme   |

## 2.3 Role of the Floodplain Management Committee

A Floodplain Management Committee (referred to throughout this document as “the Committee”) was formed prior to the commencement of the Kyogle Flood Study in 2002. The main function of the Committee has been to oversee the Floodplain Management Study and to ensure that issues important to the Kyogle community have been addressed. The Committee comprises:

- local residents;
- local councillors;
- Council representatives;
- DECC representatives;
- SES representatives.

A series of discussion papers were presented and reviewed during the course of the Kyogle Floodplain Management Study. These discussion papers represent the collective ideas of the consultant (BMT WBM Pty Ltd), the Kyogle Floodplain Management Committee and the Kyogle community. The discussion papers outlined the essential information about each floodplain management measure and, based on this information, the Committee decided whether individual measures were to be incorporated into the Floodplain Management Scheme.

## 2.4 The Kyogle Floodplain Management Scheme

The ultimate outcome of the Kyogle Floodplain Risk Management Study was the formulation and selection of the **floodplain management scheme** that forms the basis of this Floodplain Risk Management Plan. A floodplain management scheme is a combination of the floodplain management measures approved by the Committee.

A total of six (6) measures were recommended by the Committee, and the composition of the scheme is as follows:

- 10% AEP partial ring levee of “the Flats”;
- Additional Fawcetts Creek flood breakout;
- Voluntary house purchase of eligible properties;
- Voluntary house raising of eligible properties;
- Development controls, and
- Response modification measures.



## 2.5 Overview of the Floodplain Management Scheme

Table 2-6 summarises the proposed floodplain management measures included in the proposed floodplain management scheme. The floodplain management measures are grouped according to their priority where:

|           |   |
|-----------|---|
| Immediate | Measures implemented immediately or as soon as possible (ASAP)                          |
| High      | Measures implemented within one to three (1 to 3) years                                 |
| Medium    | Measures implemented within three to six (3 to 6) years                                 |
| Low       | Long-term measures (implementation after five (5) years or when the opportunity arises) |
| On-going  | On-going measures   |

**Table 2-6 Floodplain Management Measure Priorities**

| Measure   | Priority            | Cost   | BC Ratio                              |
|---|---------------------|--|---------------------------------------|
| 10% AEP Partial Ring Levee<br>+<br>Additional Fawcetts Creek Floodway | High                | \$1,450,000  | 1.25 + Intangibles                    |
| Voluntary House Purchase  | Medium & Ongoing    | \$5,600,000  | 0.23 + Intangibles                    |
| Voluntary House Raising   | High & Ongoing      | \$41,250   | 0.74 + Intangibles                    |
| Development Controls  | Immediate & Ongoing | Council's Normal Operating Budget                      | Not possible to determine             |
| Response Modification Measures  |                     | \$109,500  | Not possible to determine             |
| <b>TOTAL</b>  |                     | <b>\$7,200,750 + Council's normal operating budget</b> | <b>0.42<sup>1</sup> + Intangibles</b> |

<sup>1</sup> BC Ratio based on measures with a BC Ratio only

## 2.6 Funding Constraints

The implementation of the floodplain management scheme outlined in this document is partly subject to the allocation of funding by the State Government. However, Council should endeavour to implement some of the initiatives outlined in the plan regardless of the level of funding from the State Government. The following floodplain management measures can be initiated (*either in part or in full*) following the adoption of the Plan by Council without waiting for State Government funding:

- **Development Controls (*in full*):** This measure does not require any funding from the State Government. It is anticipated that the cost of implementing this measure is met by Council within its normal operating budget. However, Council does need to be aware that the development controls proposed within this Floodplain Risk Management Plan document account for the flood modification measures, namely the additional Fawcetts Creek floodway and the 10% AEP partial ring levee being completed.
- **Kyogle Response Modification Measures (*in part*):** Funding of this measure will not require state government funding assistance. Council and the SES are able to commence these actions prior to government funding.

## 2.7 Overall Benefits

The **Flood Modification Measures**, including the 10% AEP Partial Ring Levee and the Additional Fawcetts Creek flood breakout will reduce flood risk to residents of “the Flats”.

Currently, flood breakout through the lagoon area occurs approximately every two to five years. This results in the isolation of “the Flats” from flood-free higher ground by fast flowing floodwaters. This poses an extreme risk to residents of “the Flats” during large events and resulted in the loss of life during the 1954 flood event.

The proposed levee will increase the flood immunity for residents of “the Flats” from the 50%-20% AEP flood event to greater than the 10% AEP event. During flood events larger than the 10% AEP event (when levee overtopping is predicted to occur) the levee structure will increase flood warning and evacuation time for “the Flats” by 2 to 4 hours to 10 to 12 hours. Additionally flood flows passing through “the Flats” during moderate sized flood events will be significantly reduced.

The Additional Fawcetts Creek Flood Breakout provides an outlet for floodwaters from Fawcetts Creek into the Richmond River. The additional flood breakout reduces flood levels in Fawcetts Creek. In combination with the partial ring levee the additional Fawcetts Creek flood breakout successfully offsets the possible increase in flood levels to residents upstream of the proposed partial ring levee of “the Flats”.

The **Development Control Plan** ensures that any new developments have some consideration of flood hazard, flood levels, and inundation extents in their design. This results in a reduction in future risk to life and limb and a lowering of the health, social, and psychological trauma associated with flooding. The future risk of monetary damages to property is also reduced.

The **Kyogle Response Modification Measures** will ensure that residents and authorities are able to respond quickly and appropriately following flood warning for a Richmond River flood event. These measures will minimise flood damages and trauma associated with flooding.

## 2.8 Economic Analysis

Indicative monetary costs were established, where feasible, for measures not expected to fall within normal operating budgets of the Council or SES.

A breakdown of cost estimates by priority is provided in Table 2-7.

**Table 2-7 Breakdown of Cost Estimates by Priority (2008\$)**

| Priority   | Measure                              | Resident        | Kyogle Council     | State Government   | Federal Government | Total              |
|--|--------------------------------------|-----------------|--------------------|--------------------|--------------------|--------------------|
| Immediate Priority (ASAP)                              | Flood Warning and Emergency Planning | \$0             | \$109,500          | \$0                | \$0                | \$109,500          |
| High Priority (1 to 3 years)                           | Flood Modification Measures          | \$0             | \$485,000          | \$485,000          | \$485,000          | \$1,450,000        |
|  | Voluntary House Raising              | \$13,750        | \$0                | \$27,500           | \$0                | \$41,250           |
| Medium Priority (3 to 6 years)                         | -                                    | \$0             | \$0                | \$0                | \$0                | \$0                |
| Low Priority (>5 years or when the opportunity arises) | -                                    | \$0             | \$0                | \$0                | \$0                | \$0                |
| Ongoing (when the opportunity arises)                  | Voluntary House Purchase             | \$0             | \$1,867,000        | 1,867,000          | 1,867,000          | \$5,600,000        |
| <b>Total Indicative Cost</b>                           |                                      | <b>\$13,750</b> | <b>\$2,531,500</b> | <b>\$2,449,500</b> | <b>\$2,422,000</b> | <b>\$7,200,750</b> |

The indicative monetary cost estimate of the scheme is \$7,200,750 (2008 dollars) with a Benefit-Cost ratio of approximately 0.42.

All of the measures in the scheme have intangible benefits to which it is difficult to assign monetary value. These intangible benefits need to be considered when evaluating the benefits of the scheme.

## 2.9 Implementation Program

The implementation program for tasks are provided in the "Process for Implementation" tables for each measure as listed in Table 2-8.

**Table 2-8 Process for Implementation Tables**

| <b>Measure</b>                 | <b>Page</b> |
|--------------------------------|-------------|
| Flood Modification Measures    | 3-4         |
| Voluntary House Purchase       | 4-4         |
| Voluntary House Raising        | 5-4         |
| Development Controls           | 6-4         |
| Response Modification Measures | 7-4         |

## **2.10 Review of Plan**

The recommended actions proposed in this Floodplain Risk Management Plan are not set in concrete. They need to be reviewed and fine-tuned over time, taking into account the relative success of implemented actions and feedback from the community. It is intended that the progress in implementing the plan will be reviewed by the Committee annually, while the entire plan will be reviewed and updated every five to ten years.

## 3 FLOOD MODIFICATION MEASURES

### 3.1 Aim

*To protect residents in “the Flats” from high velocity deep flowing waters during small to moderate flood events.*

*To increase flood warning time for residents in “the Flats” during large flood events*

### 3.2 Discussion

The partial ring levee aims to reduce flood risk for residents located downstream of the proposed levee. The levee will raise the breakout immunity of floodwaters flowing from Fawcetts Creek through the lagoon area. Currently, flood breakout through the lagoon area occurs approximately every two to five years. This results in the isolation of “the Flats” from flood-free higher ground by fast flowing floodwaters. This poses a high flood risk to residents of “the Flats”.

The partial ring levee will significantly reduce flood flows passing through “the Flats” during small to moderate sized flood events. The levee will also increase the flood immunity for residents of “the Flats” to be greater than the 10% AEP event.

### 3.3 Proposal

Based on assessments undertaken as part of the Kyogle Floodplain Risk Management Study (BMT WBM, 2009), two flood modification measures have been selected for inclusion in the Kyogle Floodplain Risk Management Plan.

These flood modification measures are intended to be constructed in combination (i.e. Not in isolation) and include the design of a:

- Partial ring levee, providing protection for “the Flats”; and an
- Additional flood breakout for Fawcetts Creek.

#### 3.3.1 Levee Design

The selected levee design consists of a partial ring levee with a crest level designed to the existing 10% AEP event peak flood level. The levee extends from the high ground adjacent to the North Coast Railway Line at the intersection of Ettrick and MacDougall Streets to the higher ground at the approach for the Geneva Bridge. The levee has been designed to be of earthen construction with a crest width of 3m and 1:3 batter slopes (vertical/horizontal). Design details for the levee are provided in Figure 3-1 to Figure 3-2.

One of the main features of the levee design is the lack of levee protection provided downstream of the Geneva Bridge. This is possible due to the existing ground level along Anzac Drive and Larkin Street being above the 10% AEP event peak flood level when breakout flows through the lagoon are blocked by the proposed levee. These roads provide sufficient protection from backwater flows. As such a levee downstream of the Geneva Bridge is not required.

The levee opening downstream of the Geneva Bridge has been designed to assist in controlled overtopping of the main length of levee, along Fawcetts Creek. During the 10% AEP flood event, backwater inundation of the Chauvel Street drainage channel will occur. This design allows low velocity backwater to fill in “the Flats” prior to overtopping of the levee structure from Fawcetts Creek. This design has two advantages:

- Structural failure due to scour of the levee structure is less likely to occur if overtopping of the levee along Fawcetts Creek is to occur.
- The backwater inundation behind the levee structure will act as a warning to residents of the “the Flats” that evacuation is required prior to the possible breach of the levee structure during major events. When initial inundation behind the levee does occur, the floodwaters will be typically low in velocity, reducing the flood risk to those caught in the floodwater.

Additionally, compared with the full ring levee, the partial ring levee design provides significant cost savings. The capital and ongoing maintenance cost savings for the partial ring levee result from the following features:

- Less fill requirements during construction;
- Less flap-gated culvert requirements to provide drainage through the levee system;
- No pump station is required for the partial ring levee. The natural drainage slope from the lagoon to the Richmond River will drain the partial ring levee; and
- Reduced annual maintenance costs associated with the checking of the flap gated culverts, pump station and levee aesthetics (grass trimming).

### **3.3.2 Additional Flood Breakout for Fawcetts Creek**

The additional flood breakout for Fawcetts Creek provides an outlet for floodwaters from Fawcetts Creek into the Richmond River. The additional flood breakout will only become operational during events greater than the 50% AEP event. This additional flood breakout reduces flood levels in Fawcetts Creek adjacent to MacDougal Street, where the major breakout through the lagoon area of “the Flats” occurs. The reduction in flood levels in this location increases the flood immunity for the residents of “the Flats”, reducing flood risk slightly.

As discussed in the Kyogle Floodplain Risk Management Study (BMT WBM, 2009), in isolation, the additional Fawcetts Creek flood breakout does have some benefit. The additional flood breakout reduces flood damages and increases flood warning times for residents of “the Flats”. However, in isolation the additional flood breakout does not prevent high velocity flows passing through the lagoon area. This necessitates the inclusion of the proposed partial ring levee in the scheme design.

The additional flood breakout for Fawcetts Creek is to be located at the western end of MacDougall Street. The flood breakout has a design width of 50m. The finished level of the channel is to be excavated to 52.5 mAHD. To accommodate for high velocity flows the additional flood breakout for Fawcetts Creek has been designed with permanent erosion protection.

In general, the inclusion of the additional flood breakout lowers flood levels along Fawcett Creek adjacent to the proposed levee mentioned above. Depending on the magnitude of the flood event, in combination with the partial ring levee, this has two major impacts.

- During smaller events this significantly reduces flood levels in Fawcetts Creek which in turn increases the flood immunity of the proposed levee along McDougall Street to be greater than the 10% AEP event.
- During larger events (greater than the 5% AEP event) the floodway assists to reduce the possible increase in flood levels upstream in the Fawcetts Creek catchment, resulting from the levee blocking the existing flood flow path through “the Flats”.

The design features for the two flood modification measures, mentioned above, are shown in Figure 3-1 to Figure 3-4.

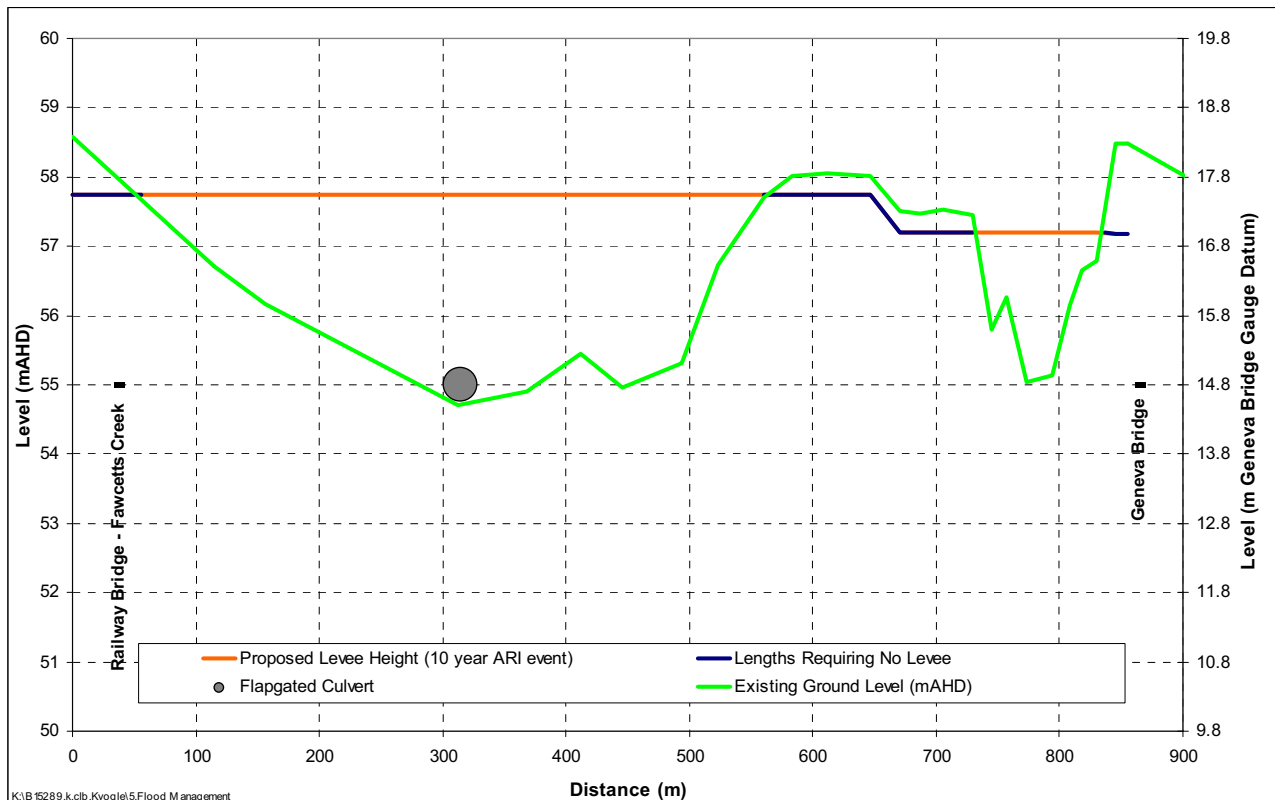


Figure 3-1 Levee Long-Section

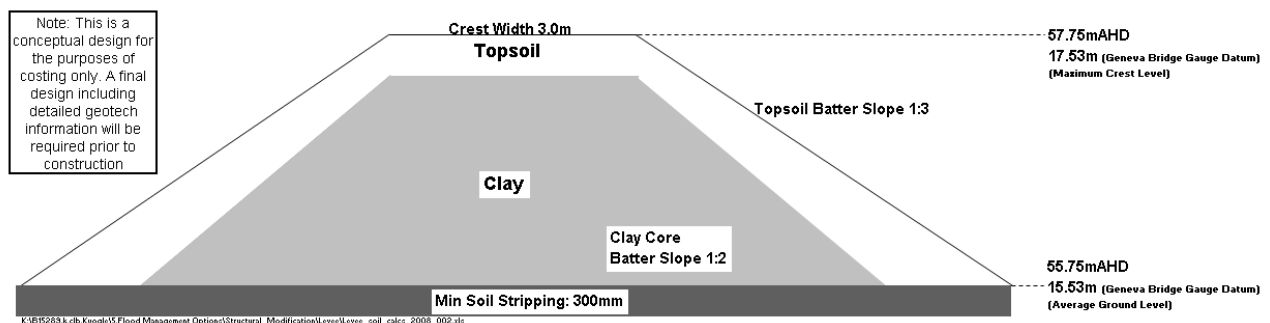
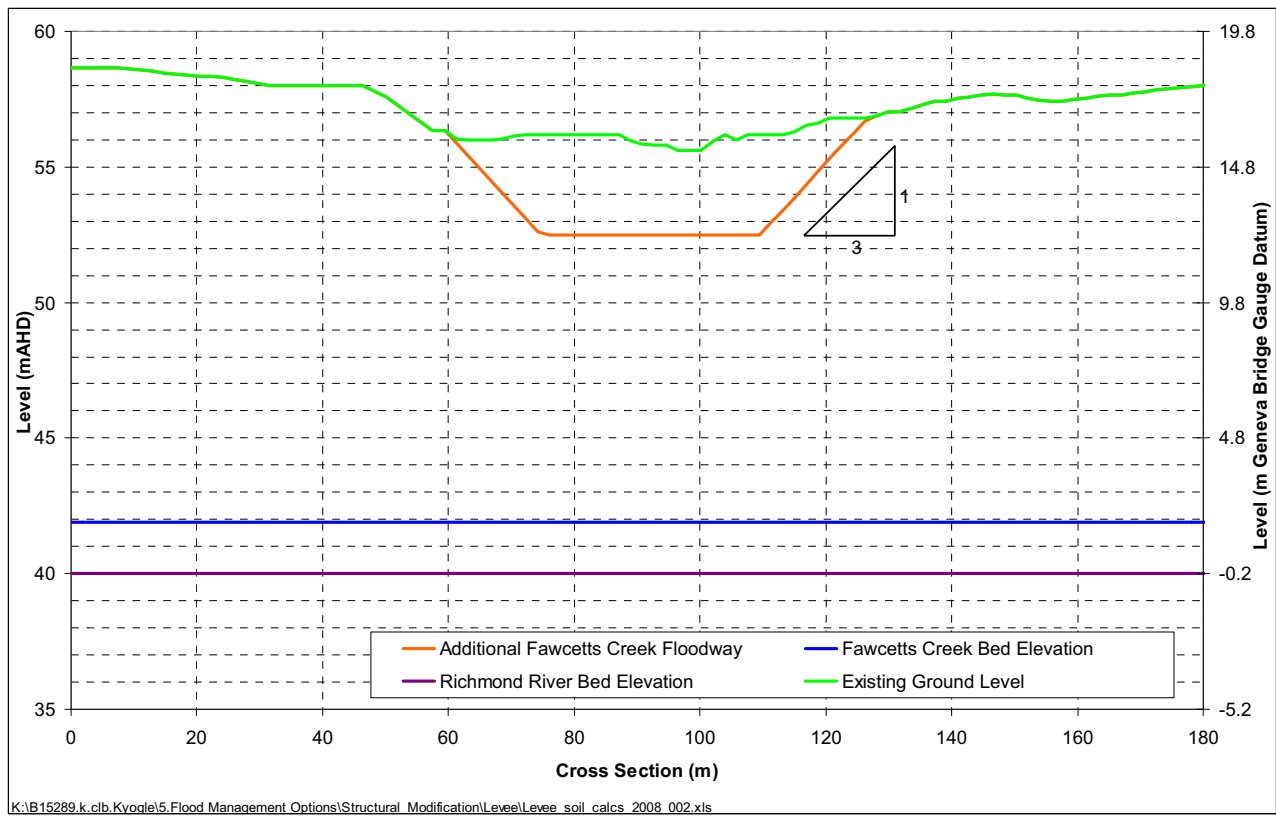
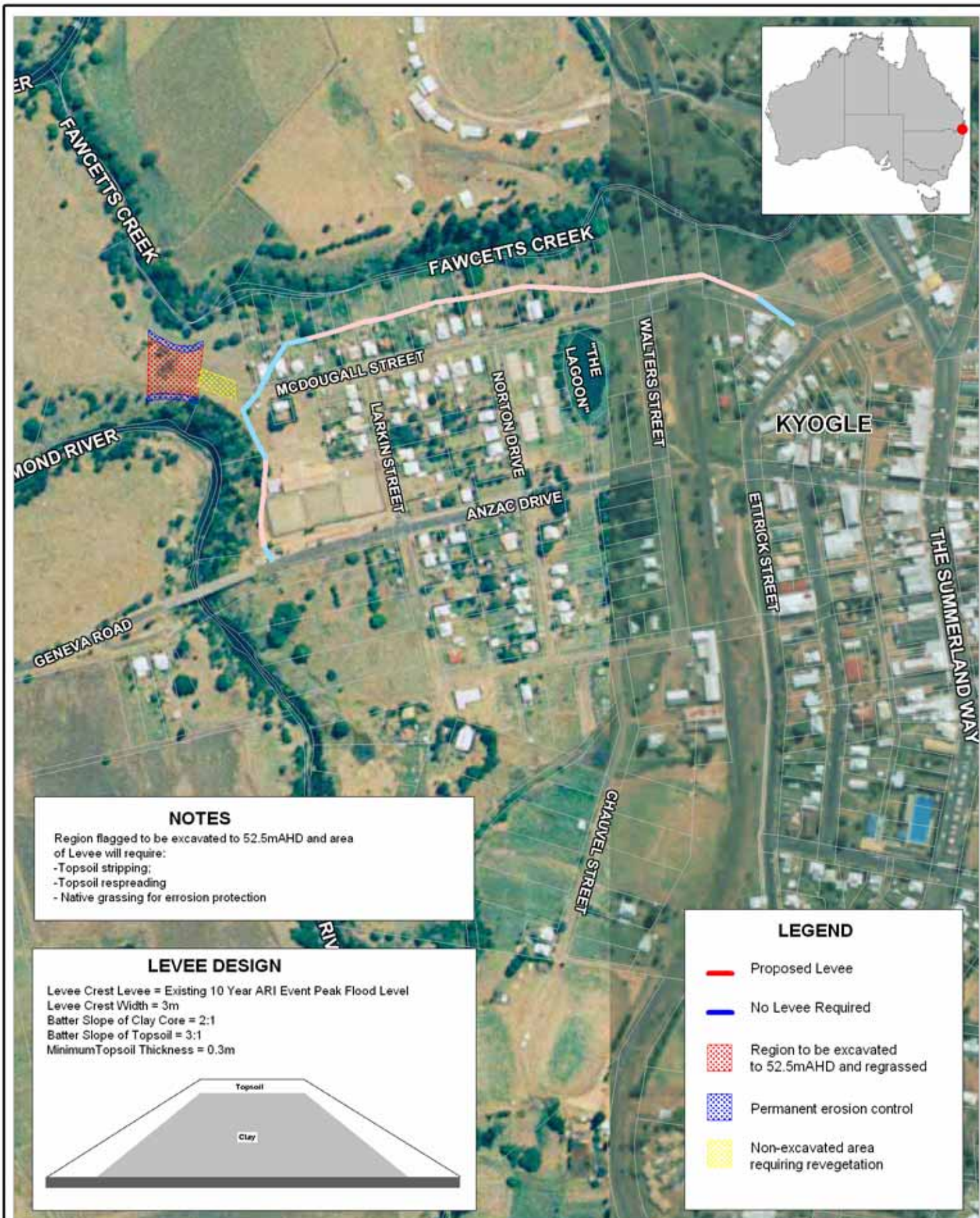


Figure 3-2 Typical Levee Cross-Section



**Figure 3-3 Additional Fawcetts Creek Floodway Cross-Section**





Title:  
**Flood Modification Measures Layout**

Figure:  
**3-4**

Rev:  
**A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.



0 100m 200m  
 Approx. Scale

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Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_002\_Flood\_Mod\_Design.WOR

The proposed flood modification measures lower peak flood levels in “the Flats” and along Fawcetts Creek significantly. As is expected, the number of inundated properties is reduced. Table 3-1 gives a breakdown of the number of inundated properties for the proposed flood modification measure compared with the existing base case modelling.

The average annual benefit and total benefit of the proposed flood modification measures were found to be approximately \$132,200 and \$1,824,400 respectively. Total benefit was calculated based on a net present worth factor of 13.8, based on a 7% discount rate and a 50 year economic design life.

The total flood damages and the annual average damages calculations comparing the existing case with the proposed scheme are provided in Table 3-2.

**Table 3-1 Flood Modification Measures - Reduction in Number of Properties Damaged**

|   | Existing Case | Flood Modification Measure | Change in Number of Properties Inundated |
|---|---------------|----------------------------|--|
| <b>Number of Dwellings Inundated</b>                        |               |                            |  |
| ...in the PMF event   | 146           | 146                        | 0  |
| ...in the 0.2% AEP event                                    | 111           | 110                        | -1                                       |
| ...in the 1% AEP event                                      | 101           | 98                         | -3                                       |
| ...in the 2% AEP event                                      | 92            | 91                         | -1                                       |
| ...in the 5% AEP event                                      | 71            | 54                         | -17                                      |
| ...in the 10% AEP event                                     | 28            | 12                         | -16                                      |
| ...in the 20% AEP event                                     | 1             | 0                          | -1                                       |
| ...in the 50% AEP event                                     | 0             | 0                          | 0  |
| <b>Number of Commercial/Industrial Properties Inundated</b> |               |                            |  |
| ...in the PMF event   | 42            | 42                         | 0  |
| ...in the 0.2% AEP event                                    | 31            | 30                         | -1                                       |
| ...in the 1% AEP event                                      | 21            | 20                         | -1                                       |
| ...in the 2% AEP event                                      | 20            | 19                         | -1                                       |
| ...in the 5% AEP event                                      | 12            | 10                         | -2                                       |
| ...in the 10% AEP event                                     | 8             | 6                          | -2                                       |
| ...in the 20% AEP event                                     | 4             | 2                          | -2                                       |
| ...in the 50% AEP event                                     | 0             | 0                          | 0  |

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**Table 3-2 Flood Modification Measures: Average Annual Damages (AAD) Comparison**

| ARI Event (yr)                | AEP   | Existing Case          |                                 | Proposed Scheme<br>Flood Modification Measures Only |                                 |
|-------------------------------|-------|------------------------|---------------------------------|---|---------------------------------|
|                               |       | Total Damages (2008\$) | Average Annual Damages (2008\$) | Total Damages (2008\$)                              | Average Annual Damages (2008\$) |
| PMF                           | 0%    | \$22,246,752           | \$35,000                        | \$22,167,824  | \$34,700                        |
| 500                           | 0.20% | \$12,792,398           | \$84,900                        | \$12,512,631  | \$81,600                        |
| 100                           | 1%    | \$8,439,859            | \$74,500                        | \$7,887,647   | \$69,800                        |
| 50                            | 2%    | \$6,461,804            | \$152,400                       | \$6,074,115   | \$135,500                       |
| 20                            | 5%    | \$3,701,073            | \$129,100                       | \$2,959,793   | \$94,300                        |
| 10                            | 10%   | \$1,464,220            | \$88,900                        | \$810,983   | \$46,400                        |
| 5                             | 20%   | \$314,383              | \$47,200                        | \$116,898   | \$17,500                        |
| <b>Average Annual Damage</b>  |       |                        | <b>\$612,000</b>                |   | <b>\$479,800</b>                |
| <b>Average Annual Benefit</b> |       |                        |                                 |   | <b>\$132,200</b>                |
| <b>Total Benefit</b>          |       |                        |                                 |   | <b>\$1,824,400</b>              |

\*Net Present Worth Factor = 13.8 - based on 7% discount rate and 50 year life

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The costs associated with the construction of the proposed flood modification measures are outlined in Table 3-3. The cost estimates are based on values provided in the Australian Construction Handbook (Rawlinsons, 2006) and correspondence with personnel from Richmond River County Council (RRCC). Personnel from the RRCC were consulted regarding the cost of the levee design based on their experience during the construction of the Lismore levee system between 2001 and 2005. The cost estimates based on the Australian Construction Handbook (Rawlinsons, 2006) were converted to 2008 dollars based on the national CPI increase of 1.08 from 2006 to 2008.



Table 3-3 Flood Modification Measures Costing

| Item   | Unit           | Quantity | Unit Cost (2008\$) | Cost (2008\$)      |
|--|----------------|----------|--------------------|--------------------|
| <b>Capital Costs -Additional Fawcetts Creek Flood Breakout</b>   |                |          |                    |                    |
| Establishment  | Item           | 1        | \$10,000           | \$10,000           |
| Flood Breakout Design  | Item           | 1        | \$15,000           | \$15,000           |
| Topsoil Stripping  | m <sup>3</sup> | 500      | \$1.70             | \$850              |
| Excavation   | m <sup>3</sup> | 6390     | \$22               | \$140,580          |
| Respreading Topsoil  | m <sup>3</sup> | 500      | \$38               | \$18,850           |
| Disposing of Spoil<br>(Assuming spoil will be used in levee construction)                                    | m <sup>3</sup> | 6390     | \$1.08             | \$6,901            |
| Native Grassing  | m <sup>2</sup> | 2510     | \$9.00             | \$22,590           |
| Revegetate Disturbed Areas   | m <sup>2</sup> | 170      | \$6.00             | \$1,020            |
| Pastoral Land Purchase   | m <sup>2</sup> | 2510     | \$6.50             | \$16,315           |
| Erosion Control During Construction  | Item           | 1        | \$2,150            | \$2,150            |
| Permanent Erosion Control  | m <sup>3</sup> | 200      | \$215              | \$43,000           |
| Rock Scour Protection  | m <sup>3</sup> | 200      | \$75               | \$15,000           |
| Liaison with services authorities<br>(assuming no relocation of services required)                           | Item           | 1        | \$2,000            | \$2,000            |
| <b>TOTAL Capital -Additional Fawcetts Creek Flood Breakout</b>   |                |          |                    | <b>\$294,256</b>   |
| <b>Maintenance Costs -Additional Fawcetts Creek Flood Breakout</b>   |                |          |                    |                    |
| Garden Maintenance (mowing)  | hour           | 22.5     | \$100              | \$2,250            |
| Flood Debris Clearing  | hour           | 2        | \$100              | \$200              |
| Annual maintenance   | year           | 7.5      | \$100              | \$750              |
| <b>Total Maintenance -Additional Fawcetts Creek Flood Breakout</b> <i>Net Present Worth Multiplier=13.8</i>  |                |          |                    | <b>\$44,162</b>    |
| <b>Capital Costs - Partial Ring Levee</b>  |                |          |                    |                    |
| Establishment  | Item           | 1        | \$15,000           | \$10,000           |
| Levee Design   | Item           | 1        | \$20,000           | \$15,000           |
| Topsoil Stripping  | m <sup>3</sup> | 2076     | \$1.70             | \$3,529            |
| Required Clay Fill<br>(Assuming spoil from Fawcetts Creek Additional Flood Breakout is not suitable for use) | m <sup>3</sup> | 8182     | \$20               | \$163,648          |
| Required Clay Excavation   | m <sup>3</sup> | 853      | \$21.50            | \$18,341           |
| Erosion Control During Construction  | Item           | 1        | \$6,450            | \$6,450            |
| Additional Topsoil   | m <sup>3</sup> | 2855     | \$3.00             | \$8,564            |
| Respreading Topsoil  | m <sup>3</sup> | 4931     | \$38               | \$185,887          |
| Native Grassing  | m <sup>2</sup> | 10647    | \$9.00             | \$95,826           |
| Flap gated Culvert (600 mm dia)  | Item           | 1        | \$1,000            | \$1,000            |
| <i>Note: Partial Ring Levee costing does not include purchase of residential land for levee easement</i>     |                |          |                    |                    |
| <b>TOTAL Capital - Partial Ring Levee</b>  |                |          |                    | <b>\$501,795</b>   |
| <b>Maintenance Costs -Partial Ring Levee</b>   |                |          |                    |                    |
| Garden Maintenance (mowing)  | hour/year      | 97.5     | \$100              | \$9,750            |
| Flood Debris Clearing  | hour/year      | 2        | \$100              | \$200              |
| Annual Maintenance   | year           | 15       | \$100              | \$1,500            |
| <b>Total Maintenance -Partial Ring Levee</b> <i>Net Present Worth Multiplier=13.8</i>                        |                |          |                    | <b>\$158,018</b>   |
| Traffic Management During Construction   | Item           | 15       | \$2,150            | \$32,250           |
| Indirect Project Costs (15% of total capital costs)  | Item           | 1        | 15%                | \$119,408          |
| <b>Total</b>   |                |          |                    | <b>\$1,332,640</b> |
| <b>TOTAL (with 25% Contingency)</b>  |                |          |                    | <b>\$1,437,400</b> |

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### 3.4 Summary

|                                    | 2008\$                  |
|------------------------------------|-------------------------|
| <b>Monetary Benefit</b>            | <b>\$1,825,000</b>      |
| <b>Monetary Cost</b>               | <b>\$1,450,000*</b>     |
| <b>Monetary Benefit-Cost Ratio</b> | <b>1.25</b>             |
| <b>Intangible Benefits</b>         | <b>High<sup>#</sup></b> |

\* Cost includes 25% contingency.

<sup>#</sup> The flood modification measure will significantly lower the health, social, and psychological trauma associated with flooding in "the Flats". The intangible benefit is **high**.

### 3.5 Process for Implementation

Table 3-4 outlines the planned process of implementation for the proposed flood modification measures.

**Table 3-4 Flood Modification Measures Implementation**

| Task  | Responsible Agency | Time for Completion* |
|---|--------------------|----------------------|
| 1 Finalise approvals  | Council            | 3 months             |
| 2 Detailed design to be undertaken.<br>(Note: Survey of site is currently 80% complete and design parameters are known) | Council            | 6 months             |
| 3 Apply for funding for construction and procurement process  | Council            | 1 years              |
| 4 Undertake works   | Council            | 2 years              |

### 3.6 Proposed Funding Scheme

Funding for floodplain management measures is typically funded in a ratio of one third ( $\frac{1}{3}$ ) Council and two thirds ( $\frac{2}{3}$ ) NSW Government. Based on this funding split, Table 3-5 outlines the funding scheme for the proposed flood modification measures.

**Table 3-5 Flood Modification Funding Scheme**

| Council Contribution | Government Contribution |
|----------------------|-------------------------|
| \$485,000            | \$970,000               |

## 4 VOLUNTARY HOUSE PURCHASE

### 4.1 Aim

*To remove risk to life-and-limb whilst reducing flood damage by purchasing houses located in highly flood prone areas.*

### 4.2 Discussion

Voluntary House purchase aims to reduce risk to life-and-limb whilst reducing flood damage by purchasing houses located in highly flood prone areas. Such measures can only be undertaken on a voluntary basis with the property owner.

During implementation of the voluntary purchase scheme, the purchase price for the property will be based on a market valuation established by the NSW Department of Commerce.

Following the purchase, the property will be placed under council care. The buildings located on the eligible lots will be removed and the property will be rezoned for flood compatible use (such as parkland).

Only properties located in areas classified as high hazard floodway are eligible for voluntary house purchase.

### 4.3 Proposal

Based on the flood behaviour, accounting for the implementation of the proposed flood modification measures outlined in Section 3, 28 houses are eligible for voluntary house purchase. All but one of these properties is located in "the Flats". The remaining property is located along Fawcetts Street. Figure 4-1 shows the locations of these properties.

Costing estimates for this property modification measure have been calculated based on an average property purchase price of \$200,000 (2008\$)

The monetary benefits of house purchase arise from the reduction in the level of flood damage incurred by the town. By reducing the extent of flood damage, monetary savings can be made in the following areas:

- Reduction in house damage; and
- Reduction in property damage (e.g. garden damage).

The direct monetary benefit of the proposed voluntary house purchase is shown in Table 4-1.

In addition to the monetary benefits, there are a number of health, social, and psychological benefits resulting from voluntary house purchase. This includes spared trauma associated with people having their homes inundated by flood waters or possibly even having to deal with the trauma associated with the loss of life. These are not easily quantifiable in monetary terms but should be recognised as important benefits.

Table 4-1 Voluntary House Purchase: Average Annual Damages (AAD) Comparison

| ARI Event (yr)  | AEP   | Flood Modification Measures Only |                                  | Flood Modification Measures + Voluntary House Purchase |                                  |
|---|-------|----------------------------------|----------------------------------|--|----------------------------------|
|   |       | Total Damages (2008 \$)          | Average Annual Damages (2008 \$) | Total Damages (2008 \$)                                | Average Annual Damages (2008 \$) |
| PMF   | 0%    | \$22,167,824                     | \$34,700                         | \$19,926,690   | \$30,700                         |
| 500   | 0.20% | \$12,512,631                     | \$81,600                         | \$10,748,804   | \$69,100                         |
| 100   | 1%    | \$7,887,647                      | \$69,800                         | \$6,537,310  | \$57,500                         |
| 50  | 2%    | \$6,074,115                      | \$135,500                        | \$4,967,382  | \$107,000                        |
| 20  | 5%    | \$2,959,793                      | \$94,300                         | \$2,164,042  | \$68,500                         |
| 10  | 10%   | \$810,983                        | \$46,400                         | \$574,179  | \$34,600                         |
| 5   | 20%   | \$116,898                        | \$17,500                         | \$116,898  | \$17,500                         |
| <b>Average Annual Damage</b>  |       |                                  | <b>\$479,800</b>                 |  | <b>\$384,900</b>                 |
| <b>Average Annual Benefit</b>   |       |                                  |                                  |  | <b>\$94,900</b>                  |
| <b>Total Benefit</b>  |       |                                  |                                  |  | <b>\$1,310,200</b>               |
| *Net Present Worth Factor = 13.8 - based on 7% discount rate and 50 year life |       |                                  |                                  |  |                                  |

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Based on an assumed average property cost of \$200,000, the total cost to purchase the 28 properties amounts to an estimated \$5,600,000. Based on the funding arrangement with the state and federal government the Kyogle Council would be required to contribute \$1,867,000 to purchase the eligible properties in “the Flats” and Fawcetts Street.

Based on a purchase rate of one property per year, the purchase of properties eligible for voluntary purchase may take up to 30 years to complete. The Committee recognises that a clear priority could be given to the purchase of the eligible houses on the properties within “the flats” on the eastern side of Norton Street, and the northern side of Willis Street. These areas are within the main floodway where risk to life and property is at its greatest. Council should try to initiate voluntary purchase of these houses as a first priority within this scheme component, wherever possible.

## 4.4 Summary

|                                    | 2008\$                  |
|------------------------------------|-------------------------|
| <b>Monetary Benefit</b>            | <b>\$1,310,000</b>      |
| <b>Monetary Cost</b>               | <b>\$5,600,000</b>      |
| <b>Monetary Benefit-Cost Ratio</b> | <b>0.23</b>             |
| <b>Intangible Benefits</b>         | <b>High<sup>#</sup></b> |

<sup>#</sup> By removing residents from high hazard floodway locations flood risk will be significantly reduced. In terms of intangible benefits, voluntary house purchase is used to avoid possible loss of life. Additionally, by reducing the number of properties located in high flood risk areas the health, social, and psychological trauma associated with flooding will be significantly reduced.

## 4.5 Process for Implementation

Table 4-2 outlines the planned process of implementation for the proposed flood modification measures.

**Table 4-2 Voluntary House Purchase Measures Implementation**

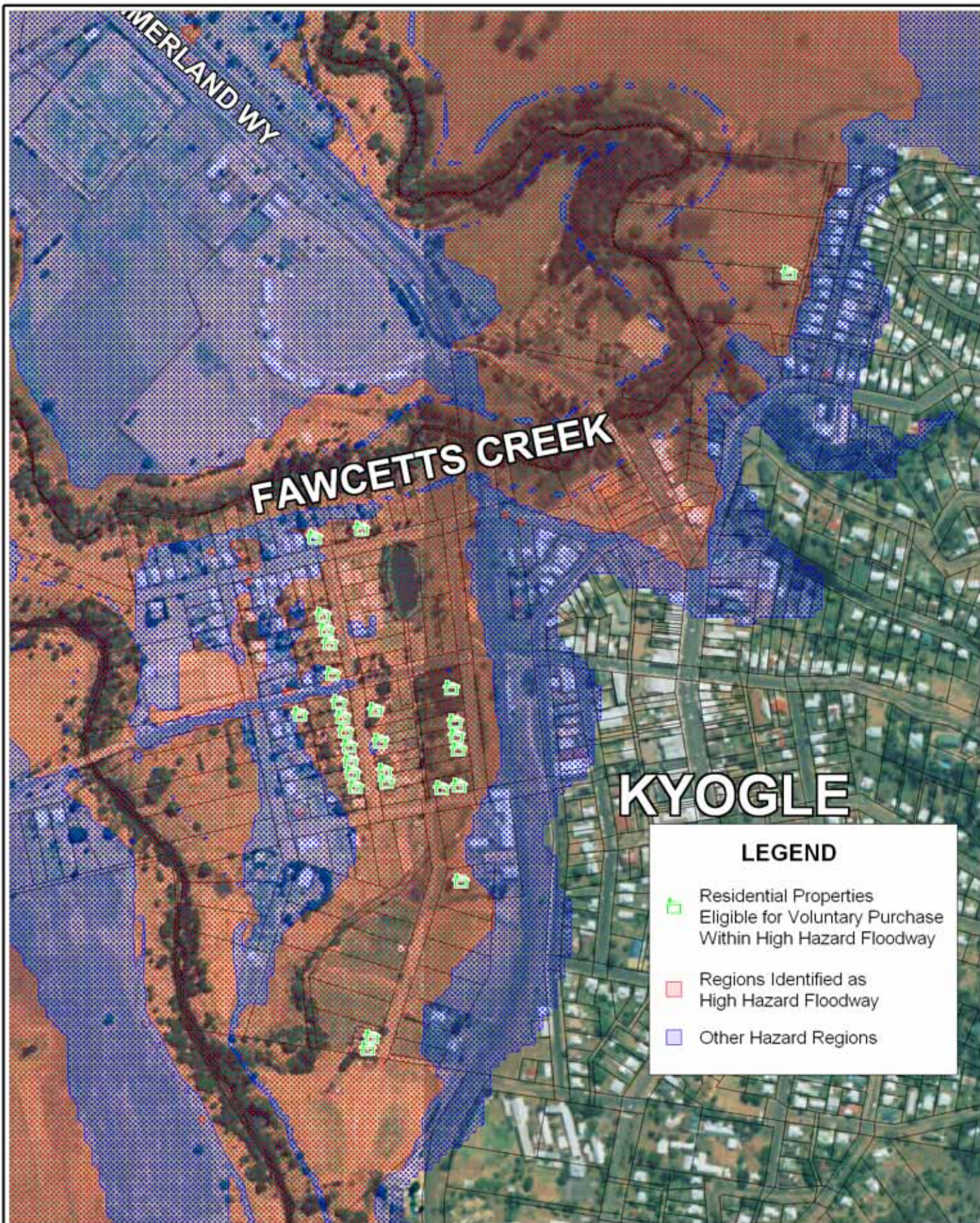
| <b>Task</b>  | <b>Responsible Agency</b> | <b>Time for Completion*</b> |
|--|---------------------------|-----------------------------|
| 1 Make the necessary applications for project commencement.                              | Council                   | 6 Months                    |
| 2 Undertake works<br>(subject to available council funding and property owner agreement) | Council                   | Up to 30 years              |

## 4.6 Proposed Funding Scheme

Funding for voluntary house purchase is funded in a ratio of one third ( $\frac{1}{3}$ ) Council and two thirds ( $\frac{2}{3}$ ) NSW Government.

| <b>Council Contribution</b> | <b>Government Contribution</b> |
|-----------------------------|--------------------------------|
| \$1,865,000                 | \$3,735,000                    |





Title:  
**Residential Houses Eligible for Voluntary Purchase**

Figure:

**4-1**

Rev:

**A**

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Approx. Scale



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## 5 VOLUNTARY HOUSE RAISING

### 5.1 Aim

*To reduce flood damage to houses by raising the habitable floor level of individual buildings.*

### 5.2 Discussion

Voluntary house raising aims to reduce the flood damage to houses by raising the habitable floor level of individual buildings to a specified level. Thus, the number of houses that are inundated during a flood event may be reduced. Such measures can only be undertaken on a voluntary basis. Voluntary house raising is a suitable management measure only for houses in **low hazard areas** of the floodplain (NSWG, 2005).

### 5.3 Proposal

Based on the following datasets, one house in “the Flats” at the western end of McDougal Street (60 McDougal Street) was identified as being eligible for government subsidising for voluntary house raising:

- 1 5% AEP event peak flood levels – Accounting for the implementation of the proposed flood modification measures;
- 2 Flood hazard categories, – Accounting for the implementation of the proposed flood modification measures; and
- 3 Property survey data provided by Kyogle Council in 2005 (WBM 2005).

Figure 5-1 identifies the one eligible property for voluntary purchase.

The reduction in average annual damage and the total benefit of the proposed voluntary house raising is given in Table 5-1.

**Table 5-1 Voluntary House Raising: Average Annual Damages (AAD) Comparison**

| ARI Event (yr)   | AEP   | Flood Modification Measures Only |                         | Flood Modification Measures + Voluntary House Raising |                                  |
|--|-------|----------------------------------|-------------------------|---|----------------------------------|
|  |       | Total Damages (2008 \$)          | Total Damages (2008 \$) | Total Damages (2008 \$)                               | Average Annual Damages (2008 \$) |
| PMF  | 0%    | \$22,167,824                     | \$34,700                | \$22,158,987  | \$34,600                         |
| 500  | 0.20% | \$12,512,631                     | \$81,600                | \$12,491,024  | \$81,400                         |
| 100  | 1%    | \$7,887,647                      | \$69,800                | \$7,864,311   | \$69,500                         |
| 50   | 2%    | \$6,074,115                      | \$135,500               | \$6,040,730   | \$134,600                        |
| 20   | 5%    | \$2,959,793                      | \$94,300                | \$2,934,915   | \$93,600                         |
| 10   | 10%   | \$810,983                        | \$46,400                | \$ 810,983  | \$46,400                         |
| 5  | 20%   | \$116,898                        | \$17,500                | \$116,898   | \$17,500                         |
| <b>Average Annual Damage</b>   |       |                                  | <b>\$479,800</b>        |   | <b>\$477,600</b>                 |
| <b>Average Annual Benefit</b>  |       |                                  |                         |   | <b>\$2,200</b>                   |
| <b>Total Benefit</b>   |       |                                  |                         |   | <b>\$30,400</b>                  |
| <i>*Net Present Worth Factor = 13.8 - based on 7% discount rate and 50 year life</i> |       |                                  |                         |   |                                  |

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The property survey provided by Kyogle Council contains information defining house size for each property. This information has been used to provide a more accurate indication of house raising costs. The costs associated with raising a small, medium and large house was estimated by obtaining average prices from Lismore-based house raising companies. Contingencies of 25% were added to the average prices. Floor levels of inundated residential houses were considered to be raised to the 1% AEP event peak flood level with an additional allowance of 0.5m freeboard.

**Table 5-2 Voluntary House Raising Cost Estimate**

| House Size | Number of Houses Raised | Estimated Cost of House Raising /House | Total Cost of House Raising |
|------------|-------------------------|--|-----------------------------|
| Small      | 0                       | \$35,000                               | \$0                         |
| Medium     | 1                       | \$41,250                               | \$41,250                    |
| Large      | 0                       | \$47,500                               | \$0                         |
| Total      | 1                       | \$41,250                               | \$41,250                    |

## 5.4 Summary

|                                    |                 |
|------------------------------------|-----------------|
|                                    | 2008\$          |
| <b>Monetary Benefit</b>            | <b>\$30,400</b> |
| <b>Monetary Cost</b>               | <b>\$41,250</b> |
| <b>Monetary Benefit-Cost Ratio</b> | <b>0.74</b>     |
| <b>Intangible Benefits</b>         | <b>Low</b>      |

## 5.5 Process for Implementation

Table 5-3 outlines the planned process of implementation for the proposed flood modification measures.

**Table 5-3 Voluntary House Raising Measures Implementation**

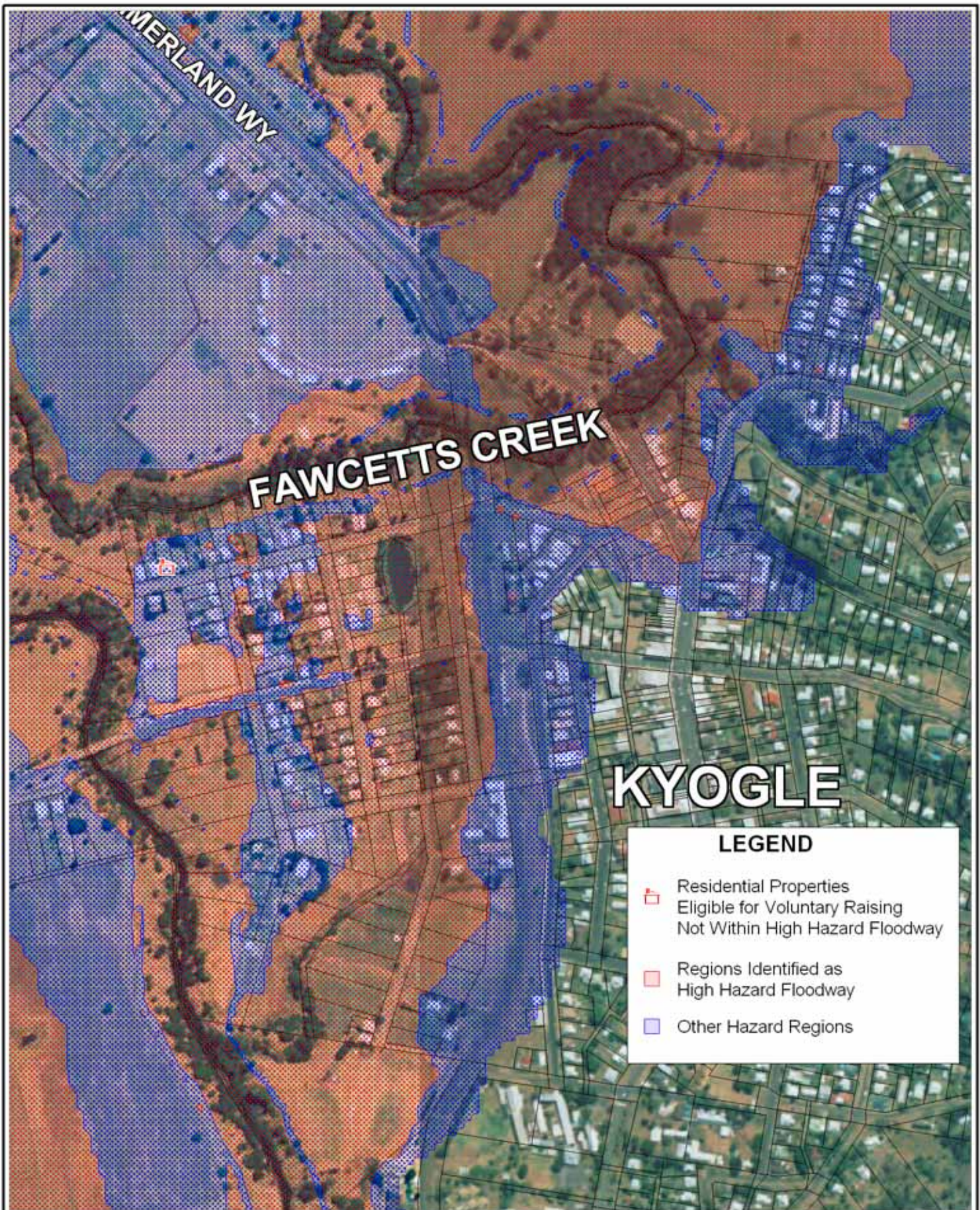
| <b>Task</b>   | <b>Responsible Agency</b> | <b>Time for Completion*</b>                                |
|---|---------------------------|--|
| 1 Make the necessary applications for project commencement. | Property Owner            | No Limit   |
| 2 Undertake works<br>(subject to property owner agreement)  | Council                   | Comence within 2 years of Development Application approval |

## 5.6 Proposed Funding Scheme

Funding for voluntary house raising is funded in a ratio of one third ( $\frac{1}{3}$ ) the property owner and two thirds ( $\frac{2}{3}$ ) NSW Government.

| <b>Property Owner Contribution</b> | <b>Government Contribution</b> |
|------------------------------------|--------------------------------|
| \$13,750                           | \$27,500                       |





Title:  
**Residential Houses Eligible for Voluntary Raising**

Figure:

**5-1**

Rev:

**A**

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Approx. Scale



Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_003\_Vol\_Raise.WOR



## 6 DEVELOPMENT CONTROL PLAN

### 6.1 Aim

*To minimise the risk to life and limb and damage to property resulting from flooding by controlling development on the floodplain.*

### 6.2 Discussion

Development controls are used to manage future flood risk. This is achieved by setting various design requirements for new developments located in flood liable lands. An excerpt from the Kyogle Floodplain Risk Management Study (BMT WBM, 2009) has been included in Appendix A outlining the methodology used to define the proposed Development Control Plan (DCP) categories and flood planning levels.

### 6.3 Proposal

In conjunction with the flood modification measure, voluntary house purchase and voluntary house raising, outlined in Sections 3 to 5, a specific DCP has been developed.

The DCP uses three development zones, Urban, Flood Compatible and Rural. The Flood Compatible Zone applies to properties in “the Flats” which are purchased by the Kyogle Council under the voluntary purchase scheme. These DCP Zones are shown in Figure A-2

The additional flood hazard categories and flood planning level information required when applying the DCP matrix are provided Appendix A. The information in these figures accounts for change in flood behaviour resulting from the inclusion of the proposed flood modification measures. The proposed DCP matrix is also given in Appendix A.

## 6.4 Summary

|   | 2008\$                 |
|---|------------------------|
| <b>Monetary Benefit</b>   | ^                      |
| <b>Monetary Cost</b>  | *                      |
| <b>Monetary Benefit-Cost Ratio</b>  | ^                      |
| <b>Additional Residential Buildings Protected (in the 100 year ARI event)</b>   | All future development |
| <b>Additional Commercial/Industrial Buildings Protected (in the 100 year ARI event)</b>   | All future development |
| <b>Intangible Benefits</b>  | High <sup>#</sup>      |
| *Cost to be met by Council within its normal operating budget   |                        |
| ^Cannot be determined – the aim of development control planning is to control future development and reduce future flood damages and it is not possible to quantify the monetary benefits that arise from this  |                        |
| <sup>#</sup> Controls on new development lower the health, social, and psychological trauma associated with flooding. In addition, it is less likely that people residing in new dwellings require evacuation and they may not need to remove their possessions except in rare events. All of these factors help reduce the impact of flooding. The intangible benefit in the long-term is high.. |                        |

## 6.5 Process for Implementation

**Table 4 Development Control Plan Implementation**

| Task  | Responsible Agency | Time for Completion*      |
|---|--------------------|---------------------------|
| 1 Adopt the Development Control Plan  | Council            | Upon adoption of the Plan |
| 2 Assess the flood planning requirements of development applications using the procedure presented in Appendix A. | Council            | Ongoing                   |

## 6.6 Proposed Funding Scheme

There is no monetary cost for the **Development Control Planning** measure. It is anticipated that the cost of implementing the measure will be met by Council within its normal operating budget.

## 7 RESPONSE MODIFICATION MEASURES

### 7.1 Background

Under New South Wales law, the primary responsibility for emergency response in Kyogle Shire rests with the State Emergency Service (SES).

There are many factors which determine the success or otherwise of the flood warnings and the assistance that the SES are able to provide. These factors may be divided into the four main groupings, which include:

- 1 Community **awareness**;
- 2 Quality of flood information **received** by the SES from the BoM and other sources;
- 3 Ability of the SES to **interpret** this information; and the
- 4 Ability of the SES to **respond** to their assessment by providing advice and assistance to the community.

Each of these key areas is discussed in detail in the following sections.

### 7.2 Aim

*To improve:*

- a) *Flood awareness in the Kyogle community;*
- b) *Flood information received by the SES;*
- c) *The SES' ability to interpret flood information; and*
- d) *The SES' ability to provide advice and assistance to the community*

### 7.3 Flood Awareness

Community awareness and preparedness is an important factor in determining the success of flood warnings and response. A flood aware community is able to understand flood warnings, how they relate to their particular situation and how to respond appropriately.

#### 7.3.1 Proposal

The following actions are proposed to increase flood awareness in Kyogle:

- Dissemination of flood related brochures and booklets to the entire township. The brochures should be distributed annually at the beginning of the wet season (October). Any new residents should receive the brochure irrespective of the time of year. Within the content of the flyer should be contact details and helpful tips on what to do in a flood situation.
- Permanent marking of historic flood levels (e.g. 2008, 1999, 1989, 1954) in numerous highly visible locations around Kyogle. Locations such as power poles adjacent to Fawcetts Creek



on the Summerland Way near the town centre of Kyogle or signage on the Anzac Park toilet block are ideal for this purpose.

- Construction of a permanent flood education billboard in the Visitor Information Center and Amphitheatre site documenting the flood history of Kyogle. Adjacent to the billboard, a flood totem marking historic flood levels will be erected.

Additionally, the specific flood awareness strategies outlined in the Kyogle Local Flood Plan (SES, 2003) should be continued. The flood awareness strategies listed in the document include:

- Talks and displays orientated to community organisations and schools; and
- Publicity given to the Kyogle Local Flood Plan and to flood-orientated SES activities through local media outlets, including articles in local newspapers about the flood threat and appropriate response.

Based on advice provided by Kyogle Council, the total cost for the proposed flood awareness measure is \$21,760. Table 7-1 outlines the costs for the proposed flood awareness measures.

**Table 7-1 Flood Awareness Measures Cost Estimate**

| <b>Flood Awareness Measure</b>                    | <b>Capital cost</b> | <b>Maintenance Cost</b>                           | <b>Total Cost</b>  |
|---|---------------------|---|--|
| <b>Flood Related Brochures</b>                    | \$5,000             | \$100/year  | \$6,380<br>(Based on net present worth multiplier of 13.8 for maintenance costs) |
| <b>Permanent Marking of Historic Flood Levels</b> | \$5,000             | \$0   | \$5,000  |
| <b>Flood Education Bill Board</b>                 | \$6,000             | \$200/year<br>(accounting for possible vandalism) | \$8,760<br>(Based on net present worth multiplier of 13.8 for maintenance costs) |
| <b>Flood Totem (Historic Flood Marks)</b>         | \$8,000             | \$0   | \$8,000  |
| <b>Total</b>                                      |                     |   | \$28,140   |

## 7.4 Flood Data Collection

Currently there is an extensive rainfall and stream gauge network upstream of Kyogle. It is believed that the current flood warning system is sufficient to meet Kyogle's flood warning requirements. This is based on the understanding that the Kyogle SES will continue to provide backup river data to supplement the existing rain/river monitoring network used by the BoM for their flood warning.

### 7.4.1 Proposal

No actions are currently proposed

## 7.5 Flood Information Interpretation

Interpretation of flood information is of vital importance to the SES if emergency response actions are to be implemented effectively. If flood warning is given to residents too late during a flood event the risk of life to residents at risk (especially in the “Flats”) will be significant.

Accurate interpretation of flood information will assist the SES to carry out flood response actions efficiently, providing greater safety to residence at risk.

### 7.5.1 Proposal

A formalised method categorising different regions of Kyogle into “emergency response sectors” has been developed to assist the SES during interpretation of real time flood information.

Additionally, two sets of flood depth and velocity depth maps have been plotted corresponding to river gauge levels at the Richmond River Geneva Bridge gauge. The first set of figures, present flood information for the existing catchment state (prior to the construction of the proposed flood modification measure). The second set of figures provides flood information for the floodplain after the completion of the proposed flood modification measure. These figures are provided in Appendix B.

This additional data will provide the SES with useful information linked to specific gauge heights. There are no cost requirements to implement the use of these flood information figures.

## 7.6 Public Flood Warning

Once the SES has assessed the data received, their primary role is then to inform the community. Flood information is currently distributed to the community in the following ways:

- Door knocks of low lying houses in Kyogle;
- Telephone;
- Public address from emergency service vehicles;
- Radio broadcasts on 2NR, 2NRCCR-FM, 2LM, ZZZ and COW FM. (The radio stations to be notified should reflect the Local Emergency Management Committee Disaster Plan and associated procedures, and should coincide with Council road closure notifications wherever possible); and
- Television broadcasts on NBN and PRIME Television.

The SES has advised that the approaches used for warning the community depends on the size of flood, the rate of rise and the time of day / week.

### 7.6.1 Proposal

To assist the SES’s dissemination of flood warnings a commercially available package using an automated telephone/SMS system has been proposed.

The package has the ability to automatically dial a list of pre-recorded telephone numbers. This list could be divided into different areas in the catchment. When the call is answered a recorded

message is played. For example, if the call is made from Kyogle township, the recorded message may state something similar to:

*"Hello. This is a Kyogle SES Flood Warning Recorded Message. A minor flood is expected to peak in Kyogle at 2pm this afternoon. Flood levels are expected to reach 14m at the Richmond River Geneva Bridge Gauge. Repeating... A minor flood is expected to peak in Kyogle at 2pm this afternoon. Flood levels are expected to reach 14m at the Richmond River Geneva Bridge Gauge. For more information please tune to Radio Station on 2XX on frequency XXXX kHz or call the flood information line on xxxx xxxx."*

Following completion of all calls, the package waits a designated period before dialling the unanswered numbers again. It appears that the automated telephone package is also able to answer incoming calls as a flood information line and provide further recorded details on the expected flooding.

SMS messages containing the same information can also be distributed via the same package. However, using the SMS messaging service there is no way of knowing if the recipient successfully received the message. This may occur if telecommunication towers are out of operation (due to storm damage) or the recipient is out of range.

Based on quotes provided by OnCall Communications the costs to set up and use the telephone/SMS service are provided in Table 7-2.

**Table 7-2 Flood Warning Cost Estimate**

| Service Provider      | Service   | Cost        | Total Cost Annually                    |
|-----------------------|---|-------------|--|
| OnCall Communications | Set Up  | \$1050      | \$1050 (One off payment)               |
|                       | Monthly Service Fee (0-500 calls)                                 | \$400/month | \$4,800                                |
|                       | Emergency Event Call Cost (per call)                              | \$0.08      | \$40.00<br>(call volume = 500 calls)   |
|                       | SMS Call Cost   | \$0.0205    | \$10.25<br>(message volume =500 calls) |
|                       | <b>Total Cost = \$81,420</b><br>Net Present Worth Multiplier=13.8 |             |  |

## 7.7 Summary

|  |                         |
|--|-------------------------|
|  | <b>2008\$</b>           |
| <b>Monetary Benefit</b>  | ^                       |
| <b>Monetary Cost</b>   | <b>\$109,500</b>        |
| <b>Monetary Benefit-Cost Ratio</b>   | ^                       |
| <b>Intangible Benefits</b>   | <b>High<sup>#</sup></b> |
| <p>^Cannot be determined – the aim of response modification measures are to reduce flood risk by improving flood awareness, flood information and the SES' ability to provide assistance. It is not possible to quantify the monetary benefits that arise from the proposed flood response modification measures.</p> <p><sup>#</sup> Improvement in flood warning, response and preparedness will result in more people able to remove themselves and possessions from the danger of floodwaters. The intangible benefits are <b>high</b></p> |                         |

## 7.8 Process for Implementation

| Task  | Responsible Agency | Time for Completion*                             |
|---|--------------------|--|
| 1 Review SES Flood Plan in light of the Floodplain Management Plan and update as necessary  | SES                | 6 months   |
| 2 Dissemination of flood related brochures and booklets to entire township  | Council            | 1 year and ongoing                               |
| 3 Permanent marking of historic flood levels (eg. 2008, 1999, 1989, 1954) in numerous highly visible locations around Kyogle  | Council/DECC       | 1 year   |
| 4 Construction of a permanent flood education billboard and flood totem   | Council/DECC       | 1 year and ongoing (maintenance)                 |
| 5 Talks and displays orientated to community organisations and schools  | SES                | ongoing  |
| 6 Publicity given to the Kyogle Local Flood Plan and to flood-orientated SES activities through local media outlets, including articles in local newspapers about the flood threat and appropriate response | SES                | ongoing  |
| 7 Setup of On Call Communication automated flood warning system (telephone/SMS)   | Council /SES       | 6 months and ongoing (telephone number database) |

## 7.9 Proposed Funding Scheme

Partial funding of the proposed floodplain response modification measures is eligible for government subsidy. Two-thirds ( $\frac{2}{3}$ ) State Government subsidy is eligible for the cost associated with:

- Permanent marking of historic levels;
- Construction of the Flood Education Billboards; and
- Construction of the flood totem (historic flood marks)

The Kyogle Council will be required to meet the remaining costs associated with the floodplain response modification measures.

| Council Contribution | Government Contribution |
|----------------------|-------------------------|
| \$12,500             | \$97,000                |

## 8 REFERENCES

**BMT WBM Pty Ltd (2009).** "Kyogle Floodplain Risk Management Study", for Kyogle Shire Council, January 2009.

**DIPNR (2004),** "Floodplain Management Guideline No 4 – Residential Flood Damage Calculation (Draft)", NSW Department of Infrastructure, Planning and Natural Resources, 4 February 2004.

**DIPNR (2005),** "Floodplain Development Manual: the management of flood liable land", Department of Infrastructure, Planning and Natural Resources, NSW Government, April 2005

**NSWG (2005),** "Floodplain Development Manual: the management of flood liable land", New South Wales Government, Department of Infrastructure, Planning and Natural Resources, April 2005.

**WBM Pty Ltd (2004).** "Kyogle Flood Study", WBM Oceanics Australia for Kyogle Shire Council, R.B13404.001.03, February 2004.

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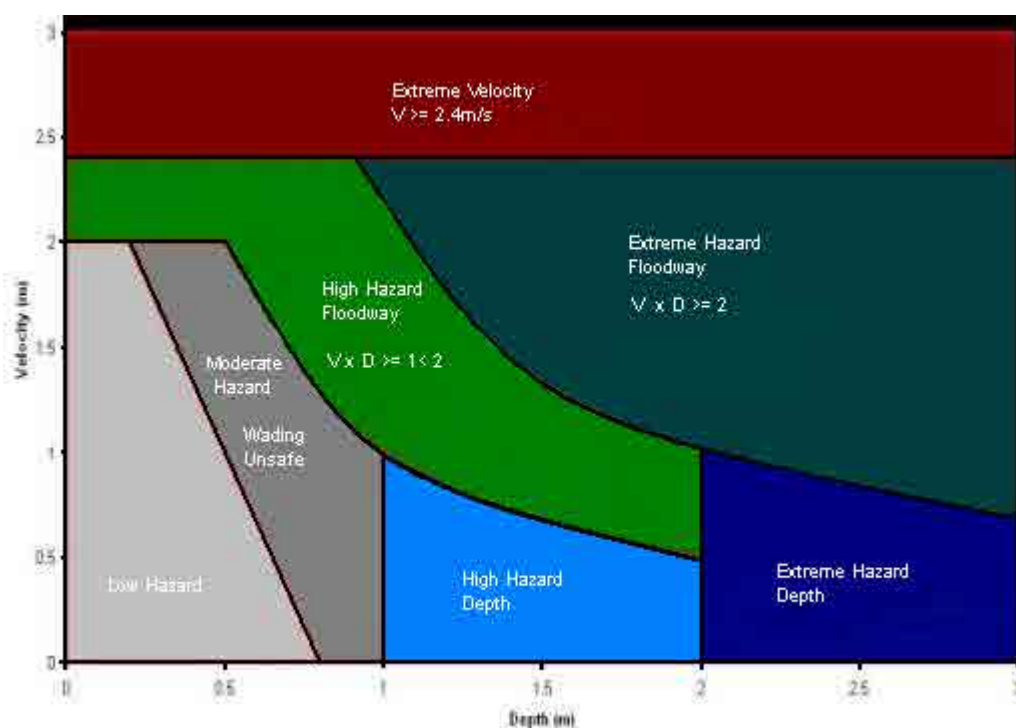
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## APPENDIX A: DEVELOPMENT CONTROLS FOR KYOGLE TOWNSHIP

Flood Hazard mapping is used to describe the potential risk to life and limb and potential damage to property resulting from flooding. The degree of flood hazard varies both in time and place across the floodplain. Floodwaters are deep and fast flowing in some areas, whilst at other locations they are shallow and slow moving. It is important to determine and understand the variation in degree of hazard and flood behaviour across the floodplain over the full range of potential floods.

The NSW Floodplain Development Manual (NSWG, 2005) defines flood hazard categories based on the product of velocity and depth. The manual states that for low hazard conditions, people and possessions could be evacuated by trucks and/or wading. The risk to life is considered to be low. For high hazard conditions, floodwaters could cause damage to structures and evacuation by trucks would be difficult. Furthermore, able-bodied adults would have difficulty wading in such floodwaters. The risk to life is considered to be high. Figure A-1 defines the categorisation used for the mapping of the Flood Hazards for the Kyogle Flood Risk Management Study.



**Figure A-1 Kyogle Flood Hazard Categories**

Based on the flood hazard categories outlines in Figure A-1 the DCP hazard category zones listed in Table A-1 have been defined for the Kyogle Risk Management Study.

Table A-1 Kyogle DCP Hazard Category Zones

| Flood Hazard Category Zone   | General Name         | Technical Hazard Composition   |
|------------------------------|----------------------|--|
| N/A                          | No Hazard            | Outside Flood Prone Area<br>Note: The "Flood Prone Area" is defined as the extent of inundation for the PMF event.   |
| A                            | Flood Fringe         | All areas between the outer boundary of 1% AEP event Medium Hazard Wading and the PMF Flood Extent are to be classified as "Flood Fringe". This will incorporate <b>some</b> portions of the following zones:<br><ul style="list-style-type: none"> <li>- PMF Extreme Hazard Velocity</li> <li>- PMF Extreme Hazard Floodway</li> <li>- PMF High Hazard Floodway</li> <li>- PMF Extreme Hazard Depth</li> <li>- PMF High Hazard Depth</li> <li>- PMF Medium Hazard</li> <li>- PMF and 1% AEP event Low Hazard</li> </ul> |
| B                            | High Hazard Depth    | 1% AEP event Extreme Hazard Depth, High Hazard Depth and Medium Hazard   |
| C                            | High Hazard Floodway | 1% AEP event High Hazard Floodway  |
| D                            | Extreme Hazard       | 1% AEP event Extreme Hazard Floodway, Extreme Hazard Velocity and Data Not Available*  |
| <b>Additional Constraint</b> |                      |  |
| E                            | Rare Extreme Hazard  | PMF Extreme Hazard Velocity, PMF Extreme Hazard Floodway and Data Not Available*   |

K:\B15289.k.clb.Kyogle\5.Flood Management Options\Property\_Modification\DCP\Planning\_Control\_Matrices\_001.xls\Hazard Categories

\*Data Not Available – This category is located within the river and exists due to this area being modeled in the 1d domain of the hydraulic model (WBM, 2005). As such hazard categorization was not possible. However it is appropriate to consider the area as Extreme Hazard for the purposes of the DCP

## Flood Planning Level

In recognition of all the factors considered and discussed in the Property Modification Measures section of the Kyogle Floodplain Risk Management Study (BMT WBM Pty Ltd, 2008), the following recommendation on the FPL are made.

### FPL for Residential Property

It is recommended that the risk exposure accepted by the community is similar to the typical 1% AEP (100 year ARI). As such, the residential FPL for the urban and rural areas surrounding Kyogle are recommended as being set to the 1% AEP event with an additional 0.5m freeboard.

### FPLs for Commercial & Industrial Property

Appropriate FPLs for commercial and industrial properties relate to economic benefits versus costs. Typically, business is more flexible in managing risk and recovering financially from flooding. This sometimes results in commercial and industrial properties having a lower FPL than residential property. This is a factor for Council and future business owners to consider. Future business owners may be prepared to accept a greater risk for a smaller establishment cost.

An additional factor for consideration is the potential inequity associated with new commercial/industrial properties having to compete with existing businesses, which may have lower fill and floor level requirements.

For the purpose of this discussion paper, it is assumed that the commercial and industrial properties be subject to a FPL of the 1% AEP event flood level. This allows new businesses to establish with similar floor levels to existing businesses.

## **FPLs for Critical Property**

Critical property includes emergency services/response buildings (for example, hospitals, SES headquarters, and police stations). It also includes critical infrastructure such as major telephone exchanges and electricity substations. Critical property may also include facilities that may have special evacuation needs such as aged care homes and childcare centres. Schools and larger community centres may also receive a special classification due to the potential for them to be used as evacuation centres. The following summarises the recommendations made in relation to FPLs for these critical properties:

- Emergency Services/Critical Infrastructure:
  - Minimum fill and floor levels to be equal to or greater than the PMF;
  - New buildings not permitted in any high or extreme hazard area;
  - Should have good access in the PMF event and ideally should not be isolated from the main urban areas during the PMF event.
- Community Service Building/Special Evacuation Needs:
  - If practical, minimum fill and floor levels to be equal to or greater than the PMF;
  - New buildings not permitted in any high or extreme hazard area;
  - If practical, should have good access in the PMF event and ideally should not be isolated from the main urban areas during the PMF event.

## **FPLs for Ancillary Buildings**

Small ancillary buildings such as sheds and carports do not typically need to comply with the FPLs determined for other buildings. However, flood damage to structure and contents can still occur if these buildings are located in areas that experience frequent flooding. It is better to avoid this where possible to minimise damage and financial burden. It is recommended that ancillary buildings have a floor level greater than or equal to the 10% AEP event flood level with an additional 0.3m freeboard. It is also recommended that these be not permitted in high hazard floodway or extreme hazard areas.

## **FPLs for Building Extensions**

Building extensions are treated separately from new building construction in order to allow residents some right to extend an existing residence without being subject to a FPL, which may result in the extension being unworkable (e.g. floor levels much higher than the existing building). The recommendations for building extensions are based on an example from Councils in the northern rivers of NSW and are proposed as follows:

- In low hazard areas, all floor levels to be as close to the FPL (habitable or other) as practical and not less than the floor level of the existing building being extended. If the extended weatherproof area exceeds 50% of the existing weatherproof area, the extension is treated as a new building.

The extended weatherproof area is measured as the cumulative area of any previous extensions plus the proposed extension.

- In high hazard depth and rare extreme hazard areas, as above with the maximum percentage increase in extended weatherproof area to be:
  - (a) 50% - if the extension's floor level is less than one (1) metre below the 100 year flood level;
  - (b) 25% - if the extension's floor level is greater than two (2) metres below the 100 year flood level; or
  - (c) pro-rata between 50% and 25% for floor levels from one (1) metre to two (2) metres below the 100 year flood level.
- In high hazard floodway or extreme hazard areas, building extensions are not permitted.

### FPL Summary of Recommendations

In summary, the FPLs recommended are provided in Table A-2. Each of these is assigned a FPL code from 1 to 4 as shown in Figure A-3 to Figure A-8.

**Table A-2 Summary of FPLs**

| <b>Flood Planning Level</b> | <b>Description</b>                              | <b>General Applicability</b>                              |
|-----------------------------|---|---|
| FPL1                        | 10% AEP Event Peak Flood Level + 0.3m freeboard | Ancillary Buildings Floor Level                           |
| FPL2                        | 1% AEP Event Peak Flood Level                   | Commercial & Industrial Buildings Fill & Floor Level      |
| FPL3                        | 1% AEP Event Peak Flood Level + 0.5m freeboard  | Residential Building Floor Level in Urban and Rural Areas |
| FPL4                        | PMF Event Peak Flood Level                      | Critical Property Floor & Fill & Access Level             |

### Development Control For Wiangaree

To-date comprehensive hydraulic modelling of the Wiangaree township has not been undertaken. Flood mapping of the area is available in the "Richmond Valley Floodplain Atlas" (Sinclair Knight & Partners Pty Ltd, 1982) and "Far North Coast Regional Strategy" (NSW Government department of Planning, pp22, 2006). However, these maps are not suitable for DCP hazard definition purposes. Due to this, Kyogle Council has assigned appropriate flood planning levels for urban areas of Wiangaree based on historic flood levels recorded at the Wiangaree gauge, shown in Figure A-9.

Historically the largest flood event to occur in Wiangaree occurred in February 1954, with a recorded flood level of 17.11m-gauge datum (78.51mAHD). The recorded flood level for the January 2008 event was significantly less, at 16.67m gauge datum (78.07 mAHD).

Based on the historical data Kyogle Council has assigned the following flood planning levels to the township of Wiangaree, as shown in Table A-1.

Table A-3 Wiangaree FPLs

| Flood Planning Level | Level (Gauge Datum) | Level (mAHD) |
|----------------------|---------------------|--------------|
| FPL1                 | NA                  | NA           |
| FPL2                 | 17.61               | 79.0         |
| FPL3                 | 18.11               | 79.5         |
| FPL4                 | 18.61               | 80.0         |

Wiangaree village has uniformly been assigned a hazard categorisation of “High Hazard Depth”. Additionally the primary and Rare Extreme Hazard extents have been set to 18.61m gauge datum, equivalent to 80.0mAHD. The extent of this zone is shown in Figure A-10. The corresponding development control matrix for Wiangaree is outlined in Table A-9.

## Development Controls for Areas Other than Kyogle Township and Wiangaree

Coarse flood mapping of the areas other than those mapped in the Kyogle Flood Study (WBM, 2004) is available in the “Richmond Valley Floodplain Atlas” (Sinclair Knight & Partners Pty Ltd, 1982) and “Far North Coast Regional Strategy” (NSW Government department of Planning, pp22, 2006).

In these areas it is the responsibility of the owner or developer to ascertain whether a development site is flood liable. It is possible that for some sites, council officers may have some local knowledge of flood liability, but, this information is not documented or checked and must not be relied upon by developers and owner

Council should assess whether the proposed development may fall within potential flood prone land. If so, Council should request the proponent is to provide a flood assessment prepared by a suitably qualified hydraulic engineer to confirm or otherwise that the subject site is flood prone.

If the initial assessment determines that the subject land is flood prone the proponent shall lodge a flood assessment or flood study in sufficient detail to define the flood behaviour at the subject site – this shall be prepared by a suitably qualified hydraulic engineer.

## Construction Materials

Construction materials are graded into four classes according to their resistance to flood waters. These grades are:

- 1 **Most suitable** - materials or products which are relatively unaffected by submersion and unmitigated flood exposure and are the best available for the particular application
- 2 **Second preference** - where the ‘most suitable’ materials are unavailable or economic considerations prohibit their use, these materials or products are considered the next best choice to minimise damage caused by flooding
- 3 **To be avoided** - as for ‘second preference’ but considered to be more liable to damage under flood conditions

- 4 **Not permitted** - these materials or products are seriously affected by flood waters and in general have to be replaced if submerged

Buildings should be constructed using the 'most suitable' materials as far as practical – refer Table A-4. Second and lower class materials will only be considered where circumstances are warranted.

### Application of the Development Control Plan Matrix

| Task | Description  |
|------|--|
| 1    | Define development land use type.  |
| 2    | Define development location.   |
| 3    | Identify development location within DCP Zone – refer to Figure A-2.   |
| 4    | Refer to appropriate Flood Planning Matrix based on DCP Zone – refer to Table A-5 to Table A-8.  |
| 5    | Identify flood hazard category for location of development – refer to Figure A-3 and Figure A-4.   |
| 6    | Use Flood Planning Matrix to define suitability of development based on land use type and flood hazard.  |
| 7    | If land is found to be not suitable for development – development request is rejected.   |
| 8    | If land is found to be suitable for development use Flood Planning Matrix to define appropriate flood planning levels and structural requirements. |
| 9    | Refer to Figure A-5 to Figure A-8 for identification of flood planning level for site.   |

Table A-4 Flood Proofing Materials

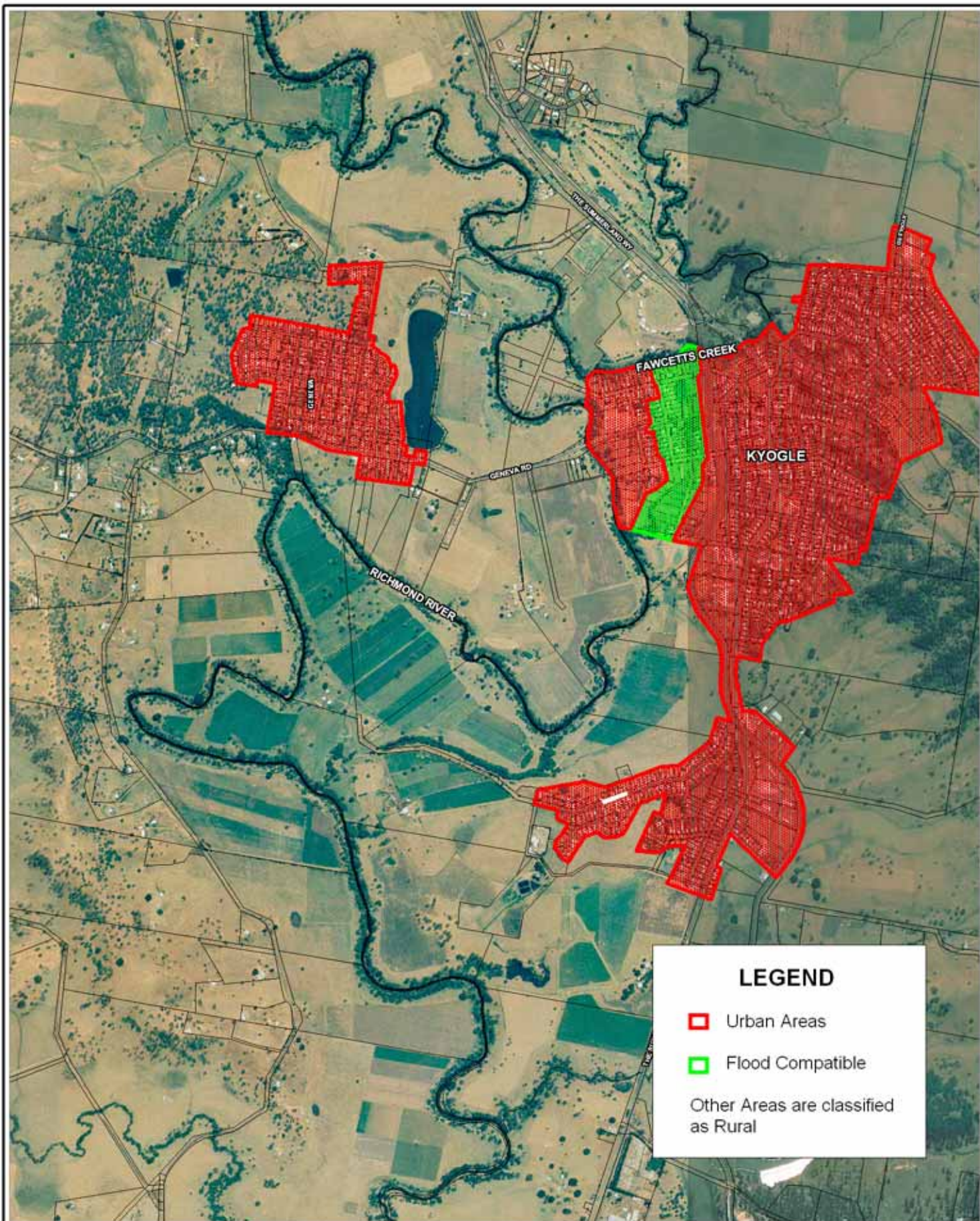
| ORDER OF PREFERENCE              |  |  |   |   |
|----------------------------------|--|--|---|---|
| component                        | most suitable  | second preference  | to be avoided   | not permitted   |
| flooring and sub-floor structure | <ul style="list-style-type: none"> <li>concrete slab-on-ground monolithic construction</li> </ul> <p><u>Note:</u> clay filling is not permitted beneath slab-on-ground construction which could be inundated</p> <p>suspension reinforced concrete slab</p>  | <ul style="list-style-type: none"> <li>timber floor (T&amp;G boarding, marine plywood) full epoxy sealed on joints</li> </ul>  | <ul style="list-style-type: none"> <li>timber floor (T&amp;G boarding, marine plywood) with ends only epoxy sealed on joints and provision for side clearance for board swelling</li> </ul> | <ul style="list-style-type: none"> <li>timber floor close tog round with surrounding base</li> <li>timber flooring with ceilings or soffit linings</li> <li>timber flooring with seal on top only</li> </ul>  |
| floor covering                   | <ul style="list-style-type: none"> <li>clay tile</li> <li>concrete, precast or in situ</li> <li>concrete tiles</li> <li>epoxy, formed-in-place</li> <li>mastic flooring formed-in-place</li> <li>rubber sheets with chemical set adhesives</li> <li>silicone floors formed-in-place</li> <li>vinyl sheets with chemical set adhesives</li> </ul> | <ul style="list-style-type: none"> <li>cement/bituminous formed-in-place</li> <li>cement/latex formed-in-place</li> <li>rubber tiles, with chemical set adhesive</li> <li>terrazzo</li> <li>vinyl tile with chemical set adhesive</li> <li>vinyl tiles asphaltic adhesive</li> <li>loose rugs</li> <li>ceramic tiles with acid and alkali resistant grout</li> </ul> | <ul style="list-style-type: none"> <li>asphalt tiles with asphaltic adhesive</li> <li>loose fit nylon or acrylic carpet with closed cell rubber underlay</li> </ul>                         | <ul style="list-style-type: none"> <li>asphalt tiles</li> <li>carpeting, glue-down type or fixed with smooth-edge or jute felts</li> <li>ceramic tiles</li> <li>chipboard / particleboard</li> <li>cork</li> <li>linoleum</li> <li>PVA emulsion cement</li> <li>rubber sheets or tiles</li> <li>vinyl sheets or tiles</li> <li>vinyl sheets or tiles coated on cork or wood backings fibre</li> </ul> |
| wall structure (up to FPL)       | <ul style="list-style-type: none"> <li>solid brickwork, blockwork, reinforced concrete or mass</li> </ul>  | <ul style="list-style-type: none"> <li>two skins of brickwork or blockwork with inspection</li> </ul>  | <ul style="list-style-type: none"> <li>brick or blockwork veneer construction with inspection</li> </ul>  | <ul style="list-style-type: none"> <li>inaccessible cavities</li> <li>large window openings</li> </ul>  |

|   |   |   |  |   |
|---|---|---|--|---|
| roof structure (where FPL is above the ceiling level) | <ul style="list-style-type: none"> <li>reinforced concrete construction</li> <li>galvanised metal construction</li> </ul>   | <ul style="list-style-type: none"> <li>timber trusses with galvanised fittings</li> </ul>   | <ul style="list-style-type: none"> <li>traditional timber roof construction</li> </ul>   | <ul style="list-style-type: none"> <li>inaccessible flat roof construction</li> <li>ungalvanised steelwork e.g lintels, arch bay tie rods, beams, etc.</li> <li>unsecured roof tiles</li> </ul>   |
| doors   | <ul style="list-style-type: none"> <li>solid panel with water proof adhesives</li> <li>flush door with marine ply filled with closed cell foam</li> <li>painted metal construction</li> <li>aluminium or galvanised steel frame</li> </ul>  | <ul style="list-style-type: none"> <li>flush panel or single panel with marine plywood and water proof adhesive</li> <li>T&amp;G lined door, framed ledged and braced</li> <li>painted steel</li> <li>timber frame fully epoxy</li> </ul> | <ul style="list-style-type: none"> <li>flywire screens</li> <li>standard timber frame</li> </ul>   | <ul style="list-style-type: none"> <li>hollow core ply with PVA adhesive and honeycomb paper core</li> </ul>  |
| wall and ceiling linings                              | <ul style="list-style-type: none"> <li>villaboard</li> <li>brick - face or glazed in waterproof mortar</li> <li>concrete</li> <li>concrete block</li> <li>steel with waterproof application</li> <li>stone - natural, solid or veneer</li> <li>waterproof grout</li> <li>glass blocks</li> <li>glass</li> <li>plastic sheeting or walls with</li> </ul> | <ul style="list-style-type: none"> <li>brick - common</li> <li>plastic wall tiles</li> <li>metals - non ferrous</li> <li>rubber mouldings and trim</li> <li>wood - solid or exterior grade plywood fully sealed</li> </ul>                | <ul style="list-style-type: none"> <li>chipboard - exterior grade</li> <li>hardboard - exterior grade</li> <li>wood - solid (boards and trim) with allowance for swelling</li> <li>wood, plywood - exterior grades</li> <li>fibrous plaster board</li> </ul> | <ul style="list-style-type: none"> <li>chipboard</li> <li>fireboard panels</li> <li>mineral boards</li> <li>paperboard</li> <li>plasterboard, gypsum plaster</li> <li>wall coverings - paper, burlap</li> <li>cloth types</li> <li>wood - standard plywood</li> <li>strawboard</li> </ul> |
| insulation  | <ul style="list-style-type: none"> <li>foam or closed cell type</li> </ul>  | <ul style="list-style-type: none"> <li>reflective insulation</li> </ul>   | <ul style="list-style-type: none"> <li>bat or blanket types</li> </ul>   | <ul style="list-style-type: none"> <li>open cell fibre types</li> </ul>   |
| windows   | <ul style="list-style-type: none"> <li>aluminium frame with stainless steel or brass rollers</li> </ul>   | <ul style="list-style-type: none"> <li>epoxy sealed timber waterproof glues with stainless steel or brass fittings</li> <li>galvanised or painted steel</li> </ul>  |  | <ul style="list-style-type: none"> <li>timber with PVA glues, mild steel fittings</li> </ul>  |
| nails, bolts, hinges and fittings                     | <ul style="list-style-type: none"> <li>brass, nylon or stainless steel</li> <li>removable pin hinges</li> </ul>   |   | <ul style="list-style-type: none"> <li>mild steel</li> </ul>   |   |



|   |   |   |  |  |
|---|---|---|--|--|
| roof structure (where FPL is above the ceiling level) | <ul style="list-style-type: none"> <li>reinforced concrete construction</li> <li>galvanised metal construction</li> </ul>   | <ul style="list-style-type: none"> <li>timber trusses with galvanised fittings</li> </ul>   | <ul style="list-style-type: none"> <li>traditional timber roof construction</li> </ul>   | <ul style="list-style-type: none"> <li>inaccessible flat roof construction</li> <li>ungalvanised steelwork e.g lintels, arch bay tie rods, beams, etc.</li> <li>unsecured roof tiles</li> </ul>  |
| doors   | <ul style="list-style-type: none"> <li>solid panel with water proof adhesives</li> <li>flush door with marine ply filled with closed cell foam</li> <li>painted metal construction</li> <li>aluminium or galvanised steel frame</li> </ul>  | <ul style="list-style-type: none"> <li>flush panel or single panel with marine plywood and water proof adhesive</li> <li>T&amp;G lined door, framed ledged and braced</li> <li>painted steel</li> <li>timber frame fully epoxy</li> </ul> | <ul style="list-style-type: none"> <li>flywire screens</li> <li>standard timber frame</li> </ul>   | <ul style="list-style-type: none"> <li>hollow core ply with PVA adhesive and honeycomb paper core</li> </ul>   |
| wall and ceiling linings                              | <ul style="list-style-type: none"> <li>villaboard</li> <li>brick - face or glazed in waterproof mortar</li> <li>concrete</li> <li>concrete block</li> <li>steel with waterproof application</li> <li>stone - natural, solid or veneer</li> <li>waterproof grout</li> <li>glass blocks</li> <li>glass</li> <li>plastic sheeting or walls with</li> </ul> | <ul style="list-style-type: none"> <li>brick - common</li> <li>plastic wall tiles</li> <li>metals - non ferrous</li> <li>rubber mouldings and trim</li> <li>wood - solid or exterior grade plywood fully sealed</li> </ul>                | <ul style="list-style-type: none"> <li>chipboard - exterior grade</li> <li>hardboard - exterior grade</li> <li>wood - solid (boards and trim) with allowance for swelling</li> <li>wood, plywood - exterior grades</li> <li>fibrous plaster board</li> </ul> | <ul style="list-style-type: none"> <li>chipboard</li> <li>fibreboard panels</li> <li>mineral boards</li> <li>paperboard</li> <li>plasterboard, gypsum plaster</li> <li>wall coverings - paper, burlap</li> <li>cloth types</li> <li>wood - standard plywood</li> <li>strawboard</li> </ul> |
| insulation  | <ul style="list-style-type: none"> <li>foam or closed cell type</li> </ul>  | <ul style="list-style-type: none"> <li>reflective insulation</li> </ul>   | <ul style="list-style-type: none"> <li>bat or blanket types</li> </ul>   | <ul style="list-style-type: none"> <li>open cell fibre types</li> </ul>  |
| windows   | <ul style="list-style-type: none"> <li>aluminium frame with stainless steel or brass rollers</li> </ul>   | <ul style="list-style-type: none"> <li>epoxy sealed timber waterproof glues with stainless steel or brass fittings</li> <li>galvanised or painted steel</li> </ul>  |  | <ul style="list-style-type: none"> <li>timber with PVA glues, mild steel fittings</li> </ul>   |
| nails, bolts, hinges and fittings                     | <ul style="list-style-type: none"> <li>brass, nylon or stainless steel</li> <li>removable pin hinges</li> </ul>   |   | <ul style="list-style-type: none"> <li>mild steel</li> </ul>   |  |





Title:  
**Kyogle DCP Zones**

Figure:

**A-2**

Rev:

**A**

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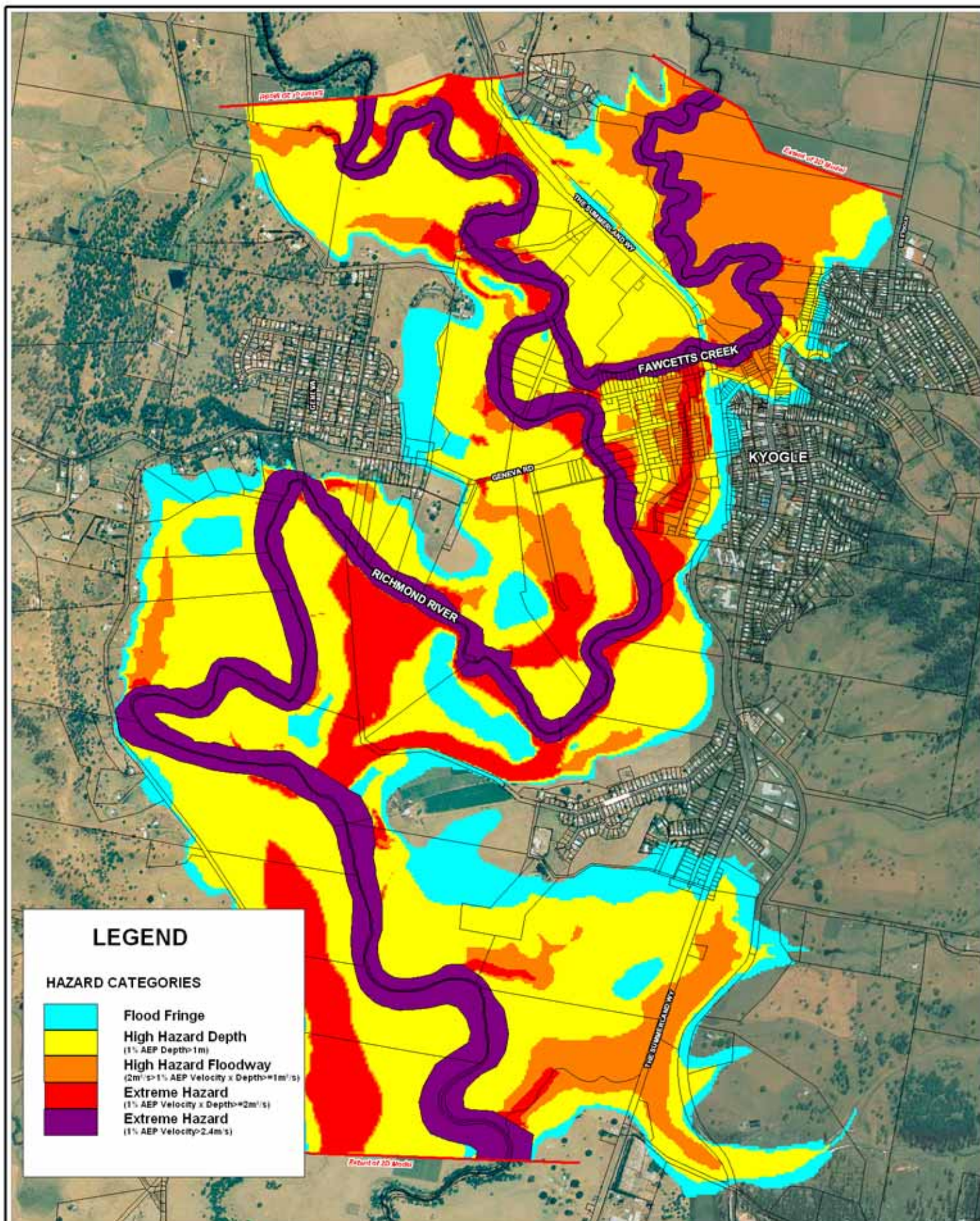
0 0.5 1km  
Approx. Scale



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Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_004\_DCP\_Zones.WOR





## LEGEND

### HAZARD CATEGORIES

|  |  |
|--|--|
|  | <b>Flood Fringe</b>  |
|  | <b>High Hazard Depth</b><br>(1% AEP Depth > 1m)                        |
|  | <b>High Hazard Floodway</b><br>(2m/s > 1% AEP Velocity x Depth > 1m/s) |
|  | <b>Extreme Hazard</b><br>(1% AEP Velocity x Depth > 2m/s)              |
|  | <b>Extreme Hazard</b><br>(1% AEP Velocity > 2.4m/s)                    |

Title:  
**Kyogle Primary Hazard Category Zones**

Figure:

**A-3**

Rev:

**A**

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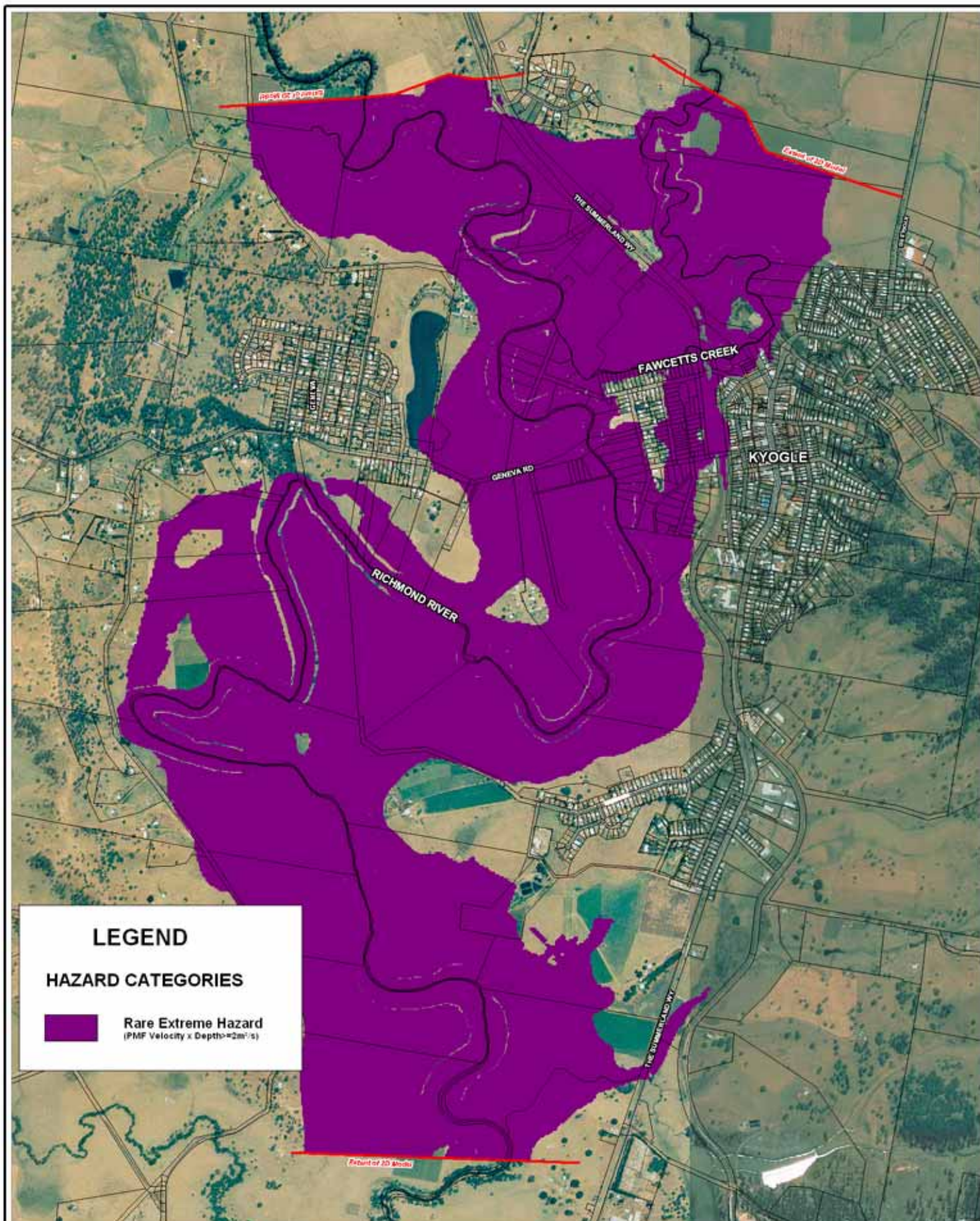
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Approx. Scale



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Title:  
**Kyogle DCP Additional Constraint Zone  
Rare Extreme Hazard**

Figure:  
**A-4**

Rev:  
**A**

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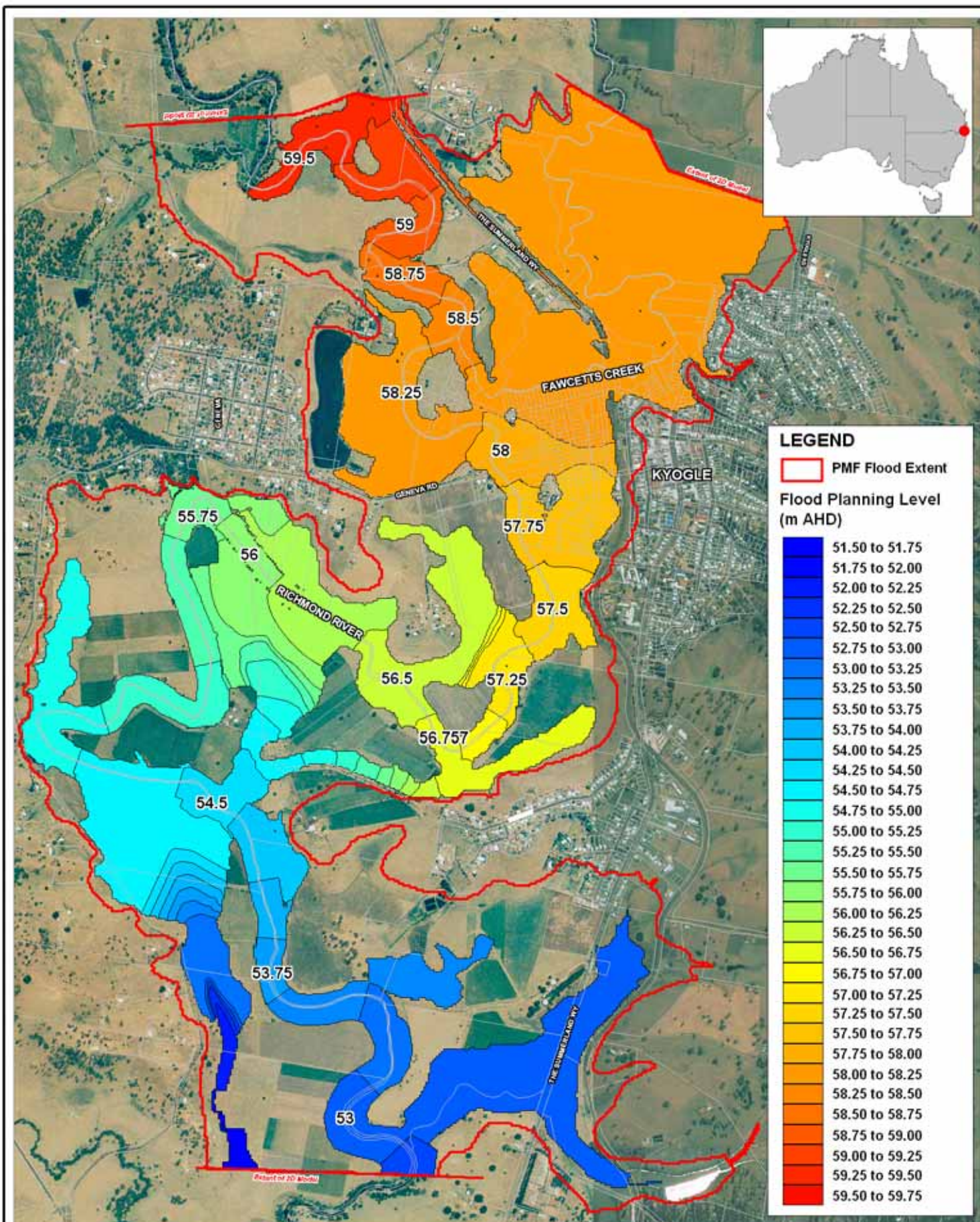
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Approx. Scale



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Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_006\_Post\_Levee\_Extreme\_Hazard.WOR





Title:

# **Flood Planning Level 1 (FPL1) Ancillary Building Floor Level (10%AEP +0.3m Freeboard)**

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0 0.5 1km  
Approx. Scale

Figure:

A-5

Rev:

A

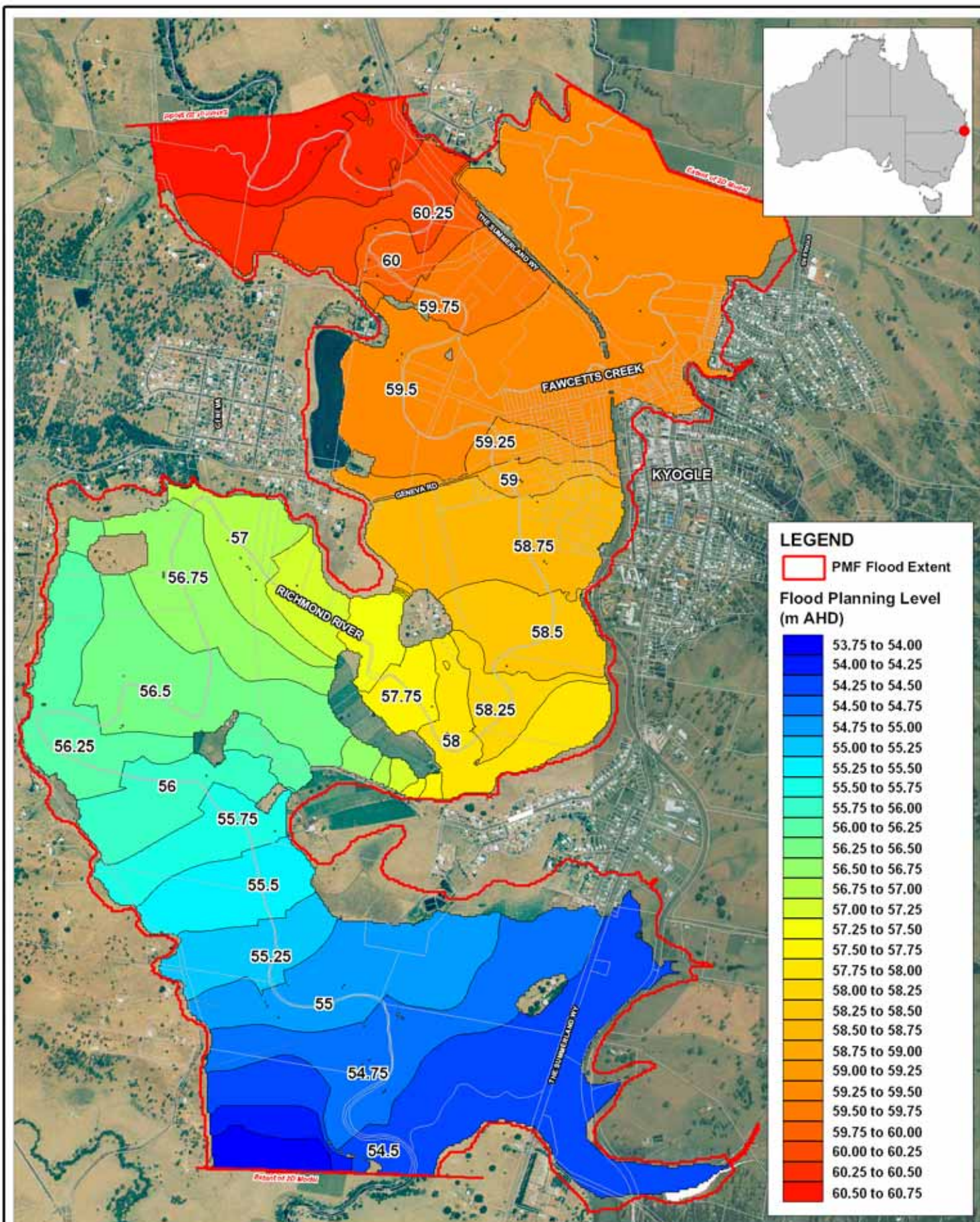


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Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMS\FLD\_Study\_007\_Post\_Levee\_FPL1.WOR





Title:

## Flood Planning Level 2 (FPL2) Commercial and Industrial Building Floor Level (1%AEP)

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0 0.5 1km  
Approx. Scale

Figure:

A-6

Rev:

A

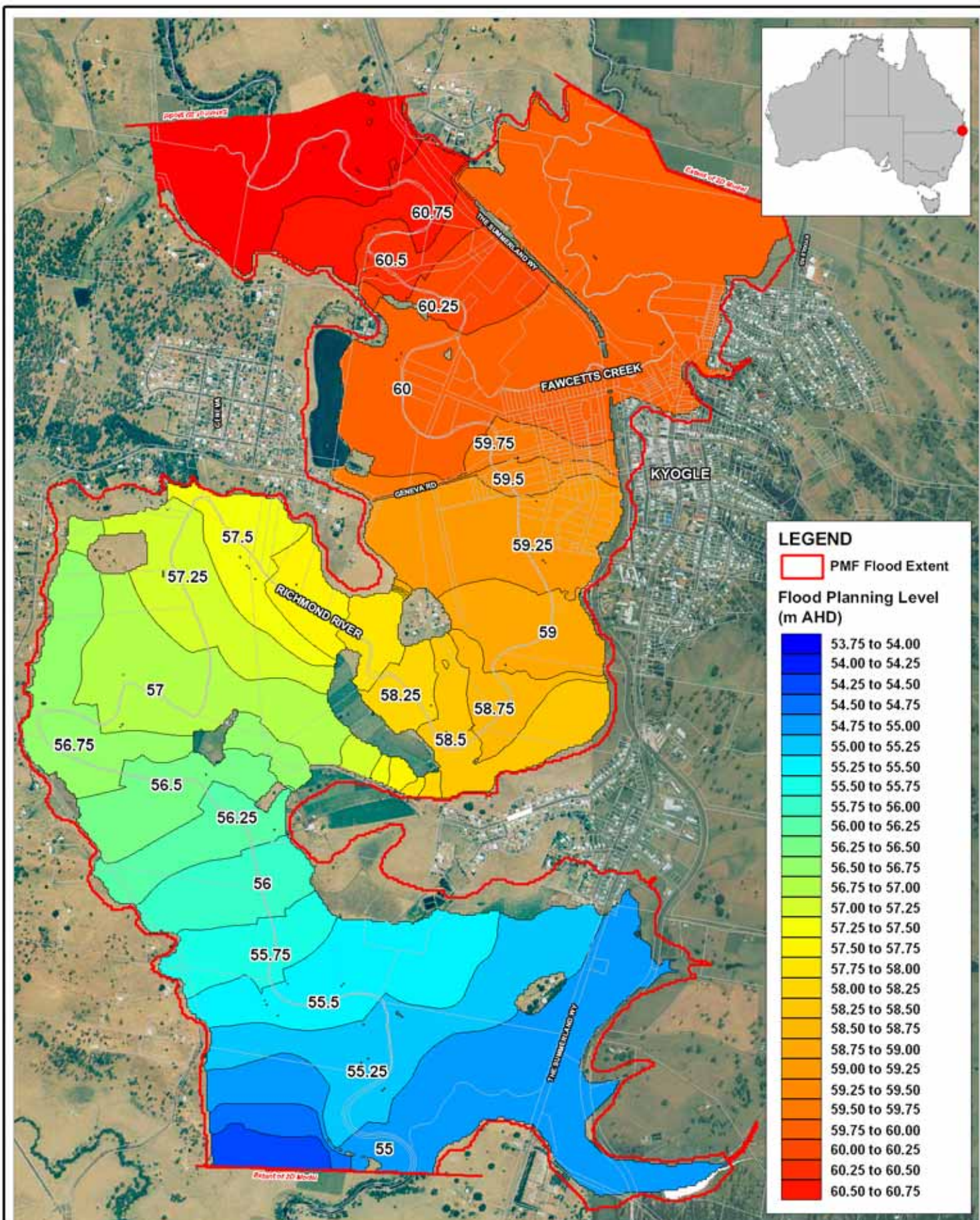


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Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FMP\FLD\_008\_Plan\_Post\_Levee\_FPL2.WOR





Title:

# **Flood Planning Level 3 (FPL3) Residential Building Floor Level (1% AEP +0.5m Freeboard)**

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0 0.5 1km  
Approx. Scale

Figure:

A-7

Rev:

A

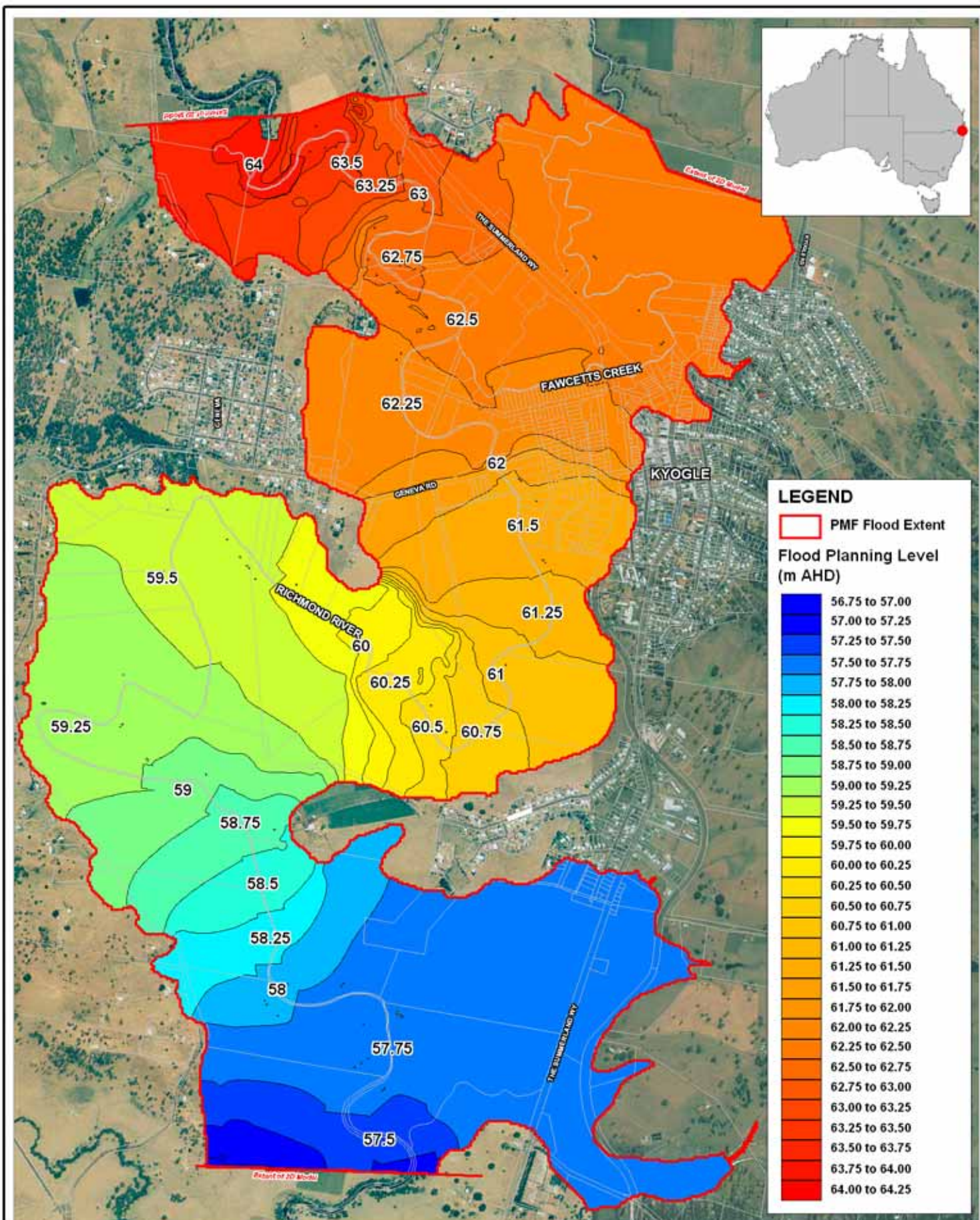


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Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FMP\FLD\_Plan\_009\_Post\_Levee\_FPL3.WOR





Title:

# **Flood Planning Level 4 (FPL4) Critical Property Floor and Access Level (PMF Level)**

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0 0.5 1km  
Approx. Scale

Figure:

A-8

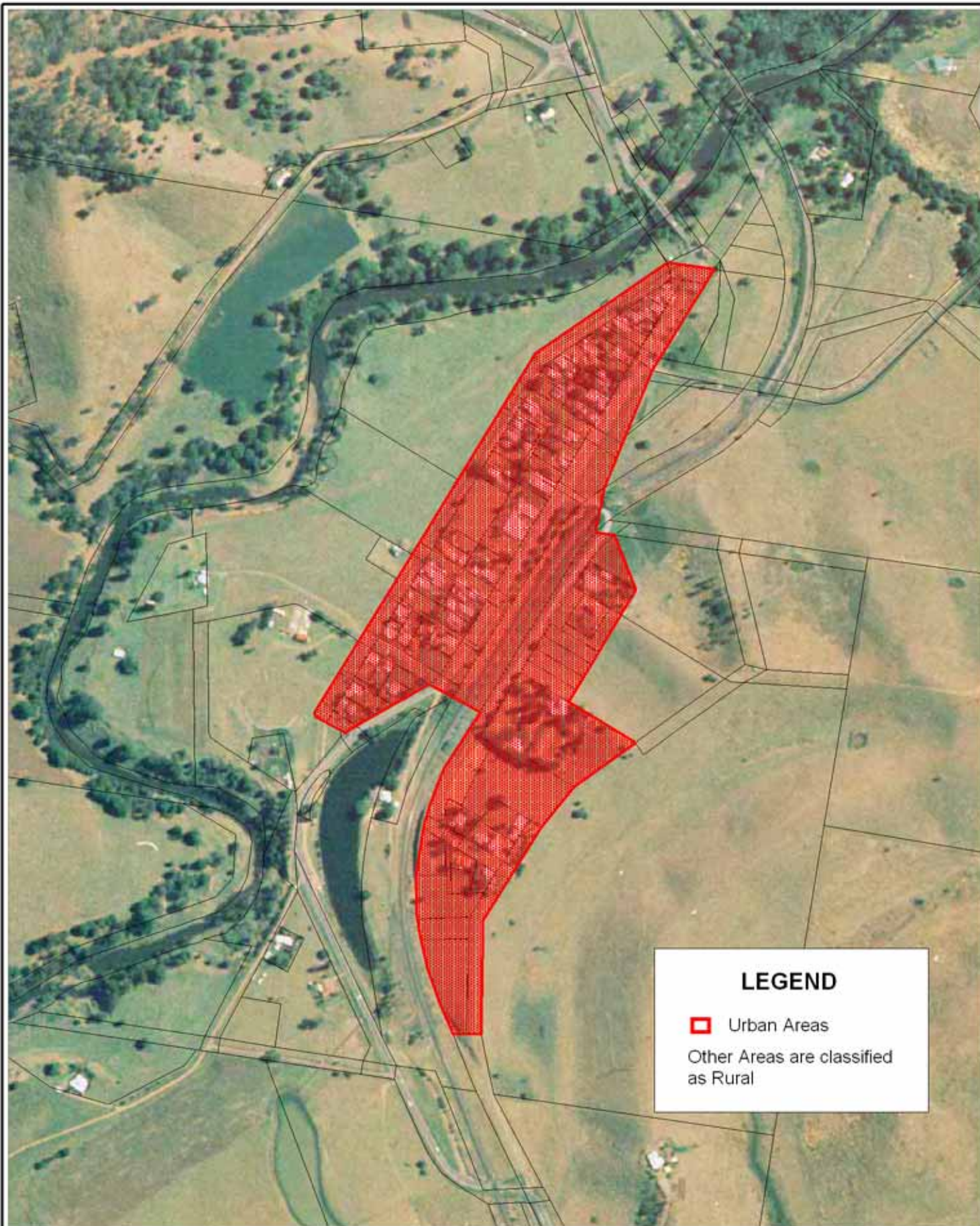
Rev:

A



Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FMP\FLD\_010\_Plan\_Post\_Levee\_FPL4.WOR





Title:  
**Wiangaree DCP Zones**

Figure:  
**A-9**

Rev:  
**A**

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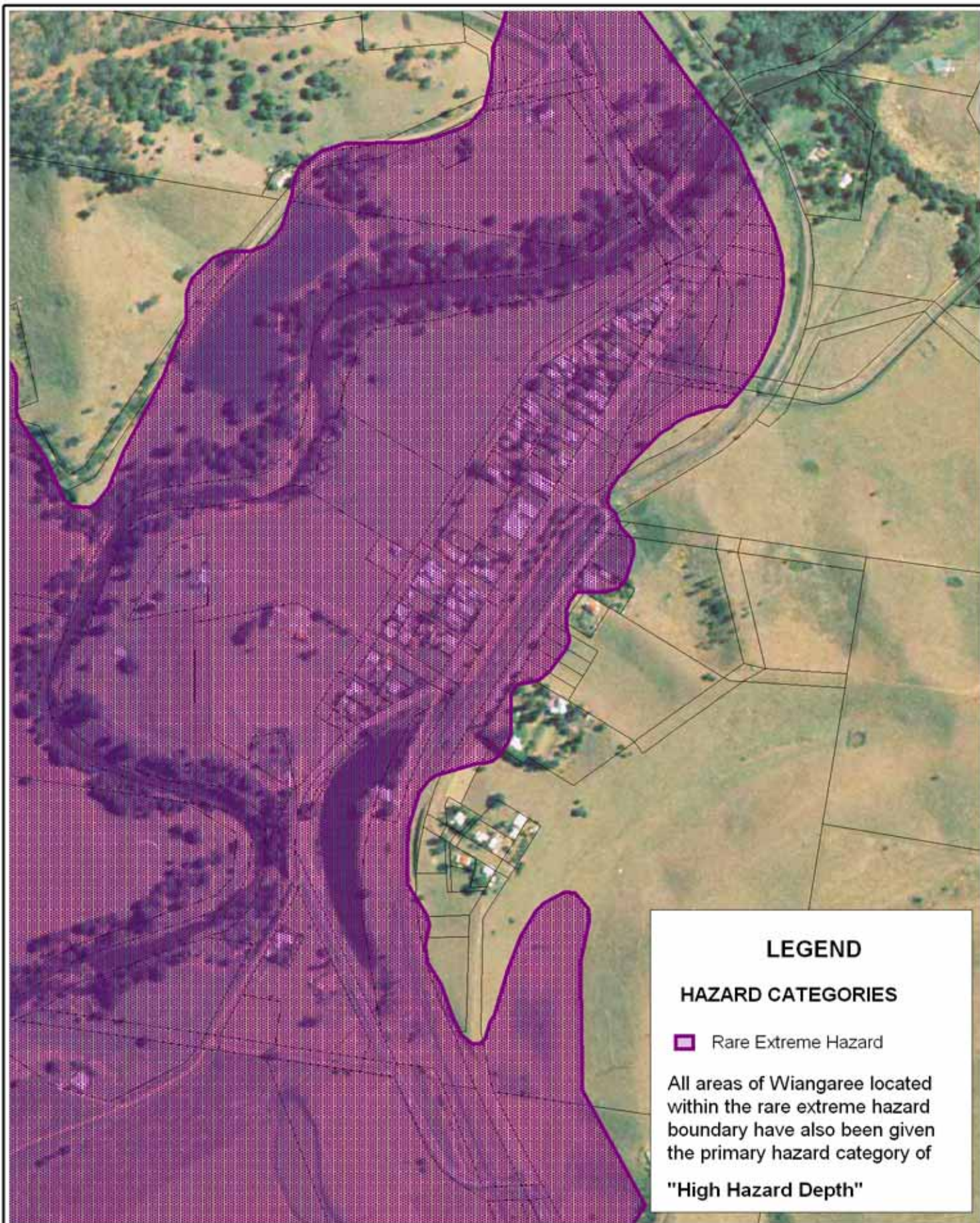


0 150m 300m  
Approx. Scale



Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_047\_Wiangaree DCP\_Zones.WOR





## LEGEND

### HAZARD CATEGORIES

 Rare Extreme Hazard

All areas of Wiangaree located within the rare extreme hazard boundary have also been given the primary hazard category of "High Hazard Depth"

Title:

## Wiangaree Primary and Rare Extreme Hazard Category Zones

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0 150m 300m  
Approx. Scale

Figure:

A-10

Rev:

A



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# FLOOD PLANNING MATRIX

**TABLE A-5: RESIDENTIAL, COMMERCIAL AND INDUSTRIAL DEVELOPMENT WITHIN KYOGLE URBAN AREAS**

| Controls                                     | Development / Building Type                                  | No Hazard | Flood Hazard Category |                        |                           |                     | Additional Constraint <sup>2</sup> |
|--|--|-----------|-----------------------|------------------------|---------------------------|---------------------|------------------------------------|
|  |  |           | A<br>Flood Fringe     | B<br>High Hazard Depth | C<br>High Hazard Floodway | D<br>Extreme Hazard | E<br>Rare Extreme Hazard           |
| <b>Land Use Suitability &amp; Fill Level</b> | Existing Lot - New Development                               | N/A       | L1                    | L1                     |                           |                     | L1                                 |
|  | Ancillary Building/Public Amenity (eg. Shed/Shelter/Toilet)  | N/A       | L1                    | L1                     | L1                        |                     | L1                                 |
|  | Subdivision  | N/A       | L2                    | L2                     | L2                        |                     |                                    |
|  | Other Developments (eg. levees, roads, dams, bridge etc)     | N/A       | L3                    | L3                     | L3                        | L3                  | L3                                 |
|  | New Other Community Service (School, etc)                    | N/A       | L4                    |                        |                           |                     |                                    |
|  | /Special Evacuation Needs (eg. aged care)                    | N/A       |                       |                        |                           |                     |                                    |
| <b>Floor Level</b>                           | New Emergency Services (eg. hospitals, etc)                  | N/A       | L5                    |                        |                           |                     |                                    |
|  | /Critical Infrastructure (eg. major telephone exchange, etc) | N/A       |                       |                        |                           |                     |                                    |
|  | New Ancillary Building (eg. shed, carport)                   | N/A       | F1                    | F1                     | F1                        |                     | F1                                 |
|  | New Commercial or Industrial Building                        | N/A       | F2                    | F2                     | F2                        |                     | F2                                 |
|  | New Habitable Building                                       | N/A       | F3                    | F3                     | F3                        |                     | F3                                 |
|  | Building Extension   | N/A       | F4a                   | F4b                    |                           |                     | F4a                                |
| <b>Building Components</b>                   | New Emergency Services (eg. hospitals, etc)                  | N/A       | F5                    |                        |                           |                     |                                    |
|  | /Critical Infrastructure (eg. major telephone exchange, etc) | N/A       |                       |                        |                           |                     |                                    |
|  | New Other Community Service (School, etc)                    | N/A       | F5a                   |                        |                           |                     |                                    |
|  | /Special Evacuation Needs (eg. aged care)                    | N/A       |                       |                        |                           |                     |                                    |
|  | Small-scale Development (eg. shed, toilets, shelter)         | N/A       | B1                    | B1                     | B1                        |                     | B1                                 |
|  | Medium-scale Development (eg. house, building extension)     | N/A       | S1                    | S2                     | S2                        |                     | S3                                 |
| <b>Soundness</b>                             | Large-scale Development (eg. levee, raised road, bridge)     | N/A       | S1                    | S2                     | S2                        | S2                  | S3                                 |
|  | Existing Lot - New Development                               | N/A       | I1                    | I2                     |                           |                     | I2                                 |
|  | Ancillary Building/Public Amenity (eg. Shed/Shelter/Toilet)  | N/A       | I1                    | I2                     | I2                        |                     | I2                                 |
|  | Subdivision  | N/A       | I2                    | I3                     | I3                        |                     | I3                                 |
|  | Building Extension   | N/A       | I1                    | I1                     | I2                        |                     | I2                                 |
|  | Other Developments (road raising, bridge, levee)             | N/A       | I2                    | I2                     | I3                        |                     | I3                                 |
| <b>Flood Impact</b>                          | Existing Lot - New Development                               | N/A       | E1                    | E1                     |                           |                     | E1                                 |
|  | Ancillary Building/Public Amenity (eg. Shed/Shelter/Toilet)  | N/A       | E1                    | E1                     | E1                        |                     | E1                                 |
|  | Subdivision  | N/A       | E2                    | E2                     | E2                        |                     |                                    |
|  | Emergency Services (eg. hospitals, etc)                      | E3        | E3                    |                        |                           |                     |                                    |
|  | /Critical Infrastructure (eg. major telephone exchange, etc) |           |                       |                        |                           |                     |                                    |
|  | Other Community Service (School, etc)                        | E3a       | E3a                   |                        |                           |                     |                                    |
| <b>Evacuation &amp; Access</b>               | /Special Evacuation Needs (eg. aged care)                    |           |                       |                        |                           |                     |                                    |
|  | Existing Lot - New Development                               | N/A       | A2                    | A2                     | A2                        |                     | A2                                 |
|  | Ancillary Building/Public Amenity (eg. Shed/Shelter/Toilet)  | N/A       |                       |                        |                           |                     |                                    |
|  | Subdivision  | N/A       |                       |                        |                           |                     |                                    |
|  | Emergency Services (eg. hospitals, etc)                      | E3        | E3                    |                        |                           |                     |                                    |
|  | /Critical Infrastructure (eg. major telephone exchange, etc) |           |                       |                        |                           |                     |                                    |
| <b>Flood Awareness, etc</b>                  | Other Community Service (School, etc)                        | E3a       | E3a                   |                        |                           |                     |                                    |
|  | /Special Evacuation Needs (eg. aged care)                    |           |                       |                        |                           |                     |                                    |
|  | Existing Lot - New Development                               | N/A       | A2                    | A2                     | A2                        |                     | A2                                 |
|  | Ancillary Building/Public Amenity (eg. Shed/Shelter/Toilet)  | N/A       |                       |                        |                           |                     |                                    |
|  | Subdivision  | N/A       |                       |                        |                           |                     |                                    |
|  | Emergency Services (eg. hospitals, etc)                      | E3        | E3                    |                        |                           |                     |                                    |
|  | /Critical Infrastructure (eg. major telephone exchange, etc) |           |                       |                        |                           |                     |                                    |
|  | Other Community Service (School, etc)                        | E3a       | E3a                   |                        |                           |                     |                                    |
|  | /Special Evacuation Needs (eg. aged care)                    |           |                       |                        |                           |                     |                                    |

Note 1: Refer to Figure 2-2 showing the area specified as "Urban Areas" for the purpose of these controls

Note 2: In addition to being assigned one of the standard flood hazard categories, a site may be classified as a "Rare Extreme Hazard".

In this instance, the most stringent of the two controls is to be used.

Note 3: For properties located on lots exhibiting multiple hazard categories the location of the proposed developed should be used to define the appropriate Fill Level, Floor Level, Structural Soundness and Flood Impact. The higher hazard category should be considered when assessing Evacuation Access and Flood Awareness

N/A Controls Not Applicable

Unsuitable Land Use - Not considered suitable for development

## LAND USE SUITABILITY & MINIMUM FILL LEVEL

**L1** Consider for development subject to the controls below. No minimum fill level required.

**L2** Consider for development subject to the controls below. For residential areas, the minimum fill level to be greater than or equal to the 100 year ARI event peak flood level (FPL2). For commercial and industrial areas, the minimum fill level to be greater than or equal to the 100 year ARI event peak flood level (FPL2).

**L3** Consider for development subject to the controls below. No minimum fill level required.

**L4** Consider for development subject to the controls below.

Council to give consideration on the benefits of using the development during and after a flood emergency.

If the site is to be used for a flood emergency, the minimum fill level should preferably be greater than or equal to PMF event peak flood level (FPL4)

**L5** Consider for development subject to the controls below. Minimum fill level greater than or equal to PMF event peak flood level (FPL4).

## MINIMUM FLOOR LEVEL

**F1** All floor levels to be greater than or equal to 10 year ARI event peak flood level + 0.3m (FPL1).

**F2** All floor levels to be greater than or equal to 100 year ARI event peak flood level (FPL2).

**F3** All floor levels to be greater than or equal to 100 year ARI event peak flood level + 0.5m freeboard (FPL3).

**F4a** All floor levels to be as close to the minimum floor level above (habitable or other) as practical and not less than the floor level of the existing building being extended. If the extended weatherproof area exceeds 50% of the existing weatherproof area, the extension is treated as a new building. The extended weatherproof area is measured as the cumulative area of any previous extensions plus the proposed extension.

**F4b** As for F5a with the maximum percentage increase in extended weatherproof area to be:

(a) 50% if the extension's floor level is less than one (1) metre below 100 Year ARI event peak flood level (FPL2);

(b) 25% if the extension's floor level is greater than two (2) metres below 100 Year ARI event peak flood level (FPL2); or

(c) pro-rata between 50% and 25% for floor levels from one (1) metre to two (2) metres below 100 year ARI Event Peak Flood Level (FPL2)

**F5** All floor levels to be greater than or equal to PMF event peak flood level (FPL4).

**F5a** If practical, some or all floor levels to be greater than or equal to PMF event peak flood level (FPL4), so that these buildings will be available for accommodation / storage during and after a flood emergency.

## BUILDING COMPONENTS

**B1** Buildings to have flood compatible material below the higher of (a) the minimum floor level or (b) 100 year ARI event peak flood level + 0.5m freeboard. (FPL3)

## STRUCTURAL SOUNDNESS

**S1** No structural soundness requirements for the force of floodwater, debris & buoyancy.

**S2** Engineers report to prove that structures subject to a flood up to 100 year ARI event + 0.5m freeboard (FPL3) can withstand the force of floodwater, debris & buoyancy.

**S3** Engineers report to prove that structures subject to a flood up to the PMF event (FPL4) can withstand the force of floodwater, debris & buoyancy.

## FLOOD IMPACT

**I1** No action required

**I2** The flood impact of the development to be considered by Council, with Council having the right to request an engineer's report (see I3 below).

**I3** Engineers report required to prove that the development will not result in adverse flood impact elsewhere.

## EVACUATION/ACCESS

**E1** Council to provide information on flood evacuation strategy

**E2** Reliable access for pedestrians and transport required for 100 year ARI event peak flood level (FPL2). Council to provide information on flood evacuation strategy.

**E3** Emergency service site - should have good access up to PMF event peak flood level (FPL4) and preferably not cut-off from the main residential area(s). Council to evaluate suitability of site in this respect.

**E3a** If site to be used during and after a flood emergency (see F6a above), should have good access up to PMF event peak flood level (FPL4). and preferably not cut-off from the main residential area(s).

## FLOOD AWARENESS

**A1** No action required.

**A2** S149(2) Certificates to notify possible affectation by a flood in the Richmond River or Fawcetts Creek. The severity of flooding can be determined by comparison of surveyed levels of the site with predicted flood heights, and also the flood hazard.

# FLOOD PLANNING MATRIX

TABLE A-6: DEVELOPMENT IN RURAL AREAS

|                                   |  |           |  | Flood Hazard Category |                        |                           |                     | Additional Constraint <sup>2</sup> |
|-----------------------------------|--|-----------|--|-----------------------|------------------------|---------------------------|---------------------|------------------------------------|
| Controls                          | Development / Building Type  | No Hazard | Applicability  | A<br>Flood Fringe     | B<br>High Hazard Depth | C<br>High Hazard Floodway | D<br>Extreme Hazard | E<br>Rare Extreme Hazard           |
| Land Use Suitability & Fill Level | Existing Lot - New Development   | N/A       | Should Council consider that the proposed development is within a potentially flood prone region, not within the Kyogle Flood Study area, Council will request that a flood study is undertaken. The flood study will determine the flood levels and hazards described in this matrix. | L1                    | L1                     |                           |                     | L1                                 |
|                                   | Ancillary Building/Public Amenity (eg. Shed/Shelter/Toilet)  | N/A       |  | L1                    | L1                     | L1                        |                     | L1                                 |
|                                   | Subdivision  | N/A       |  | L2                    | L2                     | L2                        |                     |                                    |
|                                   | Other Developments (eg. levees, roads, dams, bridge etc)   |           |  | L3                    | L3                     | L3                        | L3                  | L3                                 |
|                                   | New Other Community Service (School, etc) /Special Evacuation Needs (eg. aged care)                      | N/A       |  | L3                    |                        |                           |                     |                                    |
|                                   | New Emergency Services (eg. hospitals, etc) /Critical Infrastructure (eg. major telephone exchange, etc) | N/A       |  | L4                    |                        |                           |                     |                                    |
|                                   |  |           |  |                       |                        |                           |                     |                                    |
|                                   |  |           |  |                       |                        |                           |                     |                                    |
|                                   |  |           |  |                       |                        |                           |                     |                                    |
|                                   |  |           |  |                       |                        |                           |                     |                                    |
| Floor Level                       | New Ancillary Building (eg. shed, carport)   | N/A       |  | F1                    | F1                     | F1                        |                     | F1                                 |
|                                   | New Commercial or Industrial Building  | N/A       |  | F2                    | F2                     | F2                        |                     | F2                                 |
|                                   | New Habitable Building   | N/A       |  | F3                    | F3                     | F3                        |                     | F3                                 |
|                                   | Building Extension   | N/A       |  | F4a                   | F4b                    |                           |                     | F4a                                |
|                                   | New Emergency Services (eg. hospitals, etc) /Critical Infrastructure (eg. major telephone exchange, etc) | N/A       |  | F5                    |                        |                           |                     |                                    |
|                                   | New Other Community Service (School, etc) /Special Evacuation Needs (eg. aged care)                      | N/A       |  | F5a                   |                        |                           |                     |                                    |
| Building Components               |  | N/A       |  | B1                    | B1                     | B1                        |                     | B1                                 |
| Structural Soundness              | Small-scale Development (eg. shed, toilets, shelter) <sup>1</sup>  | N/A       |  | S1                    | S2                     | S2                        |                     | S3                                 |
|                                   | Medium-scale Development (eg. house, building extension)   | N/A       |  | S1                    | S2                     | S2                        |                     | S3                                 |
|                                   | Large-scale Development (eg. levee, raised road, bridge)   | N/A       |  | S1                    | S2                     | S2                        | S2                  | S3                                 |
| Flood Impact                      | Small-scale Development (eg. shed, toilets, shelter)   | N/A       |  | I1                    | I1                     | I2                        |                     | I1                                 |
|                                   | Medium Scale Development (eg. new bldg,bldg extension)   | N/A       |  | I2                    | I3                     | I3                        |                     | I2                                 |
|                                   | Large-scale Development (eg. levee, raised road, bridge)   | N/A       |  | I1                    | I3                     | I3                        | I3                  | I3                                 |
| Evacuation & Access               | Habitable Building   | N/A       |  | E1                    | E1                     |                           |                     | E1                                 |
|                                   | Ancillary Building/Public Amenity (eg. Shed/Shelter/Toilet)  | N/A       |  | E1                    | E1                     | E1                        |                     | E1                                 |
|                                   | Subdivision  | N/A       |  | E2                    | E2                     | E2                        |                     |                                    |
|                                   | New Emergency Services (eg. hospitals, etc) /Critical Infrastructure (eg. major telephone exchange, etc) | E3        |  | E3                    |                        |                           |                     |                                    |
|                                   | New Other Community Service (School, etc) /Special Evacuation Needs (eg. aged care)                      | E3a       |  | E3a                   |                        |                           |                     |                                    |
|                                   |  |           |  |                       |                        |                           |                     |                                    |
| Flood Awareness, etc              |  | N/A       |  | A1                    | A2                     | A2                        |                     | A2                                 |

Note 1: Small-scale development implies development on rural land that is small relative to the width of the floodplain and is not part of a planned large-scale development.

Note 2: In addition to being assigned one of the standard flood hazard categories, a site may be classified as a "Rare Extreme Hazard".

In this instance, the most stringent of the two controls is to be used.

Note 3: For properties located on lots exhibiting multiple hazard categories the location of the proposed developed should be used to define the appropriate Fill Level, Floor Level, Structural Soundness and Flood Impact. The higher hazard category should be considered when assessing Evacuation Access and Flood Awareness

|  |  |
|--|--|
| N/A  | Controls Not Applicable  |
|  | Unsuitable Land Use - Not considered suitable for development  |
| <b>LAND USE SUITABILITY &amp; MINIMUM FILL LEVEL</b> |  |
| L1   | Consider for development subject to the controls below. No minimum fill level required.  |
| L2   | Consider for development subject to the controls below. For residential areas, the minimum fill level to be greater than or equal to the 100 year ARI event peak flood level (FPL2). For commercial and industrial areas, the minimum fill level to be greater than or equal to the 100 year ARI event peak flood level (FPL2).  |
| L3   | Consider for development subject to the controls below. No minimum fill level required.  |
| L4   | Consider for development subject to the controls below.<br>Council to give consideration on the benefits of using the development during and after a flood emergency.<br>If the site is to be used for a flood emergency, the minimum fill level should preferably be greater than or equal to PMF event peak flood level (FPL4)   |
| L5   | Consider for development subject to the controls below. Minimum fill level greater than or equal to PMF event peak flood level (FPL4).   |
| <b>MINIMUM FLOOR LEVEL</b>                           |  |
| F1   | All floor levels to be greater than or equal to 10 year ARI event peak flood level + 0.3m (FPL1).  |
| F2   | All floor levels to be greater than or equal to 100 year ARI event peak flood level (FPL2).  |
| F3   | All floor levels to be greater than or equal to 100 year ARI event peak flood level + 0.5m freeboard (FPL3).   |
| F4a  | All floor levels to be as close to the <i>minimum floor level</i> above (habitable or other) as practical and not less than the floor level of the existing building being extended. If the extended weatherproof area exceeds 50% of the existing weatherproof area, the extension is treated as a new building. The extended weatherproof area is measured as the cumulative area of any previous extensions plus the proposed extension.  |
| F4b  | As for F5a with the maximum percentage increase in extended weatherproof area to be:<br>(a) 50% if the extension's floor level is less than one (1) metre below 100 Year ARI event peak flood level (FPL2);<br>(b) 25% if the extension's floor level is greater than two (2) metres below 100 Year ARI event peak flood level (FPL2); or<br>(c) pro-rata between 50% and 25% for floor levels from one (1) metre to two (2) metres below 100 year ARI Event Peak Flood Level (FPL2) |
| F5   | All floor levels to be greater than or equal to PMF event peak flood level (FPL4)  |
| F5a  | If practical, some or all floor levels to be greater than or equal to PMF event peak flood level (FPL4), so that these buildings will be available for accommodation / storage during and after a flood emergency.   |
| <b>BUILDING COMPONENTS</b>                           |  |
| B1   | Buildings to have flood compatible material below the higher of (a) the minimum floor level or (b) 100 year ARI event peak flood level + 0.5m freeboard. (FPL3)  |
| <b>STRUCTURAL SOUNDNESS</b>                          |  |
| S1   | No structural soundness requirements for the force of floodwater, debris & buoyancy.   |
| S2   | Engineers report to prove that structures subject to a flood up to 100 year ARI event + 0.5m freeboard (FPL3) can withstand the force of floodwater, debris & buoyancy.  |
| S3   | Engineers report to prove that structures subject to a flood up to the PMF event (FPL4) can withstand the force of floodwater, debris & buoyancy.  |
| <b>FLOOD IMPACT</b>                                  |  |
| I1   | No action required   |
| I2   | The flood impact of the development to be considered by Council, with Council having the right to request an engineer's report (see I3 below).   |
| I3   | Engineers report required to prove that the development will not result in adverse flood impact elsewhere.   |
| <b>EVACUATION/ACCESS</b>                             |  |
| E1   | Council to provide information on flood evacuation strategy  |
| E2   | Reliable access for pedestrians and transport required for 100 year ARI event peak flood level (FPL2). Council to provide information on flood evacuation strategy.  |
| E3   | Emergency service site - should have good access up to PMF event peak flood level (FPL4) and preferably not cut-off from the main residential area(s). Council to evaluate suitability of site in this respect.  |
| E3a  | If site to be used during and after a flood emergency (see F6a above), should have good access up to PMF event peak flood level (FPL4). and preferably not cut-off from the main residential area(s).  |
| <b>FLOOD AWARENESS</b>                               |  |
| A1   | No action required.  |
| A2   | S149(2) Certificates to notify possible affectation by a flood in the Richmond River or Fawcetts Creek.<br>The severity of flooding can be determined by comparison of surveyed levels of the site with predicted flood heights, and also the flood hazard.  |

# FLOOD PLANNING MATRIX

TABLE A-7: DEVELOPMENT WITHIN KYOGLE "FLOOD COMPATIBLE LAND"

| Controls                                     | Development / Building Type                                  | No Hazard | Flood Hazard Category |                        |                           |                     | Additional Constraint <sup>2</sup> |
|--|--|-----------|-----------------------|------------------------|---------------------------|---------------------|------------------------------------|
|  |  |           | A<br>Flood Fringe     | B<br>High Hazard Depth | C<br>High Hazard Floodway | D<br>Extreme Hazard | E<br>Rare Extreme Hazard           |
| <b>Land Use Suitability &amp; Fill Level</b> | Existing Lot - New Development                               | N/A       |                       |                        |                           |                     |                                    |
|  | Ancillary Building/Public Amenity (eg. Shed/Shelter/Toilet)  | N/A       | L1                    | L1                     | L1                        |                     | L1                                 |
|  | Subdivision  | N/A       |                       |                        |                           |                     |                                    |
|  | Other Developments (eg. levees, roads, dams, bridge etc)     | N/A       | L3                    | L3                     | L3                        | L3                  | L3                                 |
|  | New Other Community Service (School, etc)                    | N/A       |                       |                        |                           |                     |                                    |
|  | /Special Evacuation Needs (eg. aged care)                    | N/A       |                       |                        |                           |                     |                                    |
|  | New Emergency Services (eg. hospitals, etc)                  | N/A       |                       |                        |                           |                     |                                    |
| <b>Floor Level</b>                           | /Critical Infrastructure (eg. major telephone exchange, etc) | N/A       |                       |                        |                           |                     |                                    |
|  | New Ancillary Building (eg. shed, carport)                   | N/A       | F1                    | F1                     | F1                        |                     | F1                                 |
|  | New Commercial or Industrial Building                        | N/A       |                       |                        |                           |                     |                                    |
|  | New Habitable Building                                       | N/A       |                       |                        |                           |                     |                                    |
|  | Building Extension   | N/A       | F4a                   | F4b                    |                           |                     | F4a                                |
|  | New Emergency Services (eg. hospitals, etc)                  | N/A       |                       |                        |                           |                     |                                    |
|  | /Critical Infrastructure (eg. major telephone exchange, etc) | N/A       |                       |                        |                           |                     |                                    |
| <b>Building Components</b>                   | New Other Community Service (School, etc)                    | N/A       |                       |                        |                           |                     |                                    |
|  | /Special Evacuation Needs (eg. aged care)                    | N/A       |                       |                        |                           |                     |                                    |
|  |  | N/A       | B1                    | B1                     | B1                        |                     | B1                                 |
| <b>Structural Soundness</b>                  | Small-scale Development (eg. shed, toilets, shelter)         | N/A       | S1                    | S2                     | S2                        |                     | S3                                 |
|  | Medium-scale Development (eg. house, building extension)     | N/A       |                       |                        |                           |                     |                                    |
|  | Large-scale Development (eg. levee, raised road, bridge)     | N/A       | S1                    | S2                     | S2                        | S2                  | S3                                 |
| <b>Flood Impact</b>                          | Existing Lot - New Development                               | N/A       |                       |                        |                           |                     |                                    |
|  | Ancillary Building/Public Amenity (eg. Shed/Shelter/Toilet)  | N/A       | I1                    | I2                     | I2                        |                     | I2                                 |
|  | Subdivision  | N/A       |                       |                        |                           |                     |                                    |
|  | Building Extension   | N/A       | I1                    | I1                     | I2                        |                     | I2                                 |
|  | Other Developments (road raising, bridge, levee)             | N/A       | I2                    | I2                     | I3                        |                     | I3                                 |
| <b>Evacuation &amp; Access</b>               | Existing Lot - New Development                               | N/A       |                       |                        |                           |                     |                                    |
|  | Ancillary Building/Public Amenity (eg. Shed/Shelter/Toilet)  | N/A       | E1                    | E1                     | E1                        |                     | E1                                 |
|  | Subdivision  | N/A       |                       |                        |                           |                     |                                    |
|  | Emergency Services (eg. hospitals, etc)                      | E3        |                       |                        |                           |                     |                                    |
|  | /Critical Infrastructure (eg. major telephone exchange, etc) | E3        |                       |                        |                           |                     |                                    |
|  | Other Community Service (School, etc)                        | E3a       |                       |                        |                           |                     |                                    |
| <b>Flood Awareness, etc</b>                  | /Special Evacuation Needs (eg. aged care)                    | N/A       |                       |                        |                           |                     |                                    |
|  |  | N/A       | A2                    | A2                     | A2                        |                     | A2                                 |

Note 1: Refer to Figure 2-2 showing the area specified as "The Flats" for the purpose of these controls

Note 2: In addition to being assigned one of the standard flood hazard categories, a site may be classified as a "Rare Extreme Hazard".

In this instance, the most stringent of the two controls is to be used.

|  |  |
|--|--|
| N/A  | Controls Not Applicable  |
|  | Unsuitable Land Use - Not considered suitable for development  |
| <b>LAND USE SUITABILITY &amp; MINIMUM FILL LEVEL</b> |  |
| L1   | Consider for development subject to the controls below. No minimum fill level required.  |
| L2   | Consider for development subject to the controls below. For residential areas, the minimum fill level to be greater than or equal to the 100 year ARI event peak flood level (FPL2). For commercial and industrial areas, the minimum fill level to be greater than or equal to the 100 year ARI event peak flood level (FPL2).  |
| L3   | Consider for development subject to the controls below. No minimum fill level required.  |
| L4   | Consider for development subject to the controls below. Council to give consideration on the benefits of using the development during and after a flood emergency. If the site is to be used for a flood emergency, the minimum fill level should preferably be greater than or equal to PMF event peak flood level (FPL4)   |
| L5   | Consider for development subject to the controls below. Minimum fill level greater than or equal to PMF event peak flood level (FPL4).   |
| <b>MINIMUM FLOOR LEVEL</b>                           |  |
| F1   | All floor levels to be greater than or equal to 10 year ARI event peak flood level + 0.3m (FPL1).  |
| F2   | All floor levels to be greater than or equal to 100 year ARI event peak flood level (FPL2).  |
| F3   | All floor levels to be greater than or equal to 100 year ARI event peak flood level + 0.5m freeboard (FPL3).   |
| F4a  | All floor levels to be as close to the <i>minimum floor level</i> above (habitable or other) as practical and not less than the floor level of the existing building being extended. If the extended weatherproof area exceeds 50% of the existing weatherproof area, the extension is treated as a new building. The extended weatherproof area is measured as the cumulative area of any previous extensions plus the proposed extension.  |
| F4b  | As for F5a with the maximum percentage increase in extended weatherproof area to be:<br>(a) 50% if the extension's floor level is less than one (1) metre below 100 Year ARI event peak flood level (FPL2);<br>(b) 25% if the extension's floor level is greater than two (2) metres below 100 Year ARI event peak flood level (FPL2); or<br>(c) pro-rata between 50% and 25% for floor levels from one (1) metre to two (2) metres below 100 year ARI Event Peak Flood Level (FPL2) |
| F5   | All floor levels to be greater than or equal to PMF event peak flood level (FPL4)  |
| F5a  | If practical, some or all floor levels to be greater than or equal to PMF event peak flood level (FPL4), so that these buildings will be available for accommodation / storage during and after a flood emergency.   |
| <b>BUILDING COMPONENTS</b>                           |  |
| B1   | Buildings to have flood compatible material below the higher of (a) the minimum floor level or (b) 100 year ARI event peak flood level + 0.5m freeboard. (FPL3)  |
| <b>STRUCTURAL SOUNDNESS</b>                          |  |
| S1   | No structural soundness requirements for the force of floodwater, debris & buoyancy.   |
| S2   | Engineers report to prove that structures subject to a flood up to 100 year ARI event + 0.5m freeboard (FPL3) can withstand the force of floodwater, debris & buoyancy.  |
| S3   | Engineers report to prove that structures subject to a flood up to the PMF event (FPL4) can withstand the force of floodwater, debris & buoyancy.  |
| <b>FLOOD IMPACT</b>                                  |  |
| I1   | No action required   |
| I2   | The flood impact of the development to be considered by Council, with Council having the right to request an engineer's report (see I3 below).   |
| I3   | Engineers report required to prove that the development will not result in adverse flood impact elsewhere.   |
| <b>EVACUATION/ACCESS</b>                             |  |
| E1   | Council to provide information on flood evacuation strategy  |
| E2   | Reliable access for pedestrians and transport required for 100 year ARI event peak flood level (FPL2). Council to provide information on flood evacuation strategy.  |
| E3   | Emergency service site - should have good access up to PMF event peak flood level (FPL4) and preferably not cut-off from the main residential area(s). Council to evaluate suitability of site in this respect.  |
| E3a  | If site to be used during and after a flood emergency (see F6a above), should have good access up to PMF event peak flood level (FPL4). and preferably not cut-off from the main residential area(s).  |
| <b>FLOOD AWARENESS</b>                               |  |
| A1   | No action required.  |
| A2   | S149(2) Certificates to notify possible affectation by a flood in the Richmond River or Fawcetts Creek. The severity of flooding can be determined by comparison of surveyed levels of the site with predicted flood heights, and also the flood hazard.   |

# FLOOD PLANNING MATRIX

TABLE A-8: : SCHEME B - OTHER LAND USE

|                                   |   | No Hazard | Flood Hazard Category |                        |                           |                     | Additional Constraint <sup>2</sup>    |
|-----------------------------------|---|-----------|-----------------------|------------------------|---------------------------|---------------------|---------------------------------------|
| Controls                          | Development / Building Type                                       |           | A<br>Flood Fringe     | B<br>High Hazard Depth | C<br>High Hazard Floodway | D<br>Extreme Hazard | E<br>Rare Extreme Hazard <sup>2</sup> |
| Land Use Suitability & Fill Level | (not used)  |           |                       |                        |                           |                     |                                       |
|                                   | Ancillary Building/Public Amenity (eg. Shed/Shelter/Toilet)       | N/A       | L1                    | L1                     | L1                        |                     | L1                                    |
|                                   | (not used)  |           |                       |                        |                           |                     |                                       |
|                                   | Other Developments (eg. levees, roads, dams, bridge etc)          | N/A       | L3                    | L3                     | L3                        | L3                  | L3                                    |
| Floor Level                       | (not used)  |           |                       |                        |                           |                     |                                       |
|                                   | (not used)  |           |                       |                        |                           |                     |                                       |
|                                   | (not used)  |           |                       |                        |                           |                     |                                       |
|                                   | (not used)  |           |                       |                        |                           |                     |                                       |
|                                   | (not used)  |           |                       |                        |                           |                     |                                       |
|                                   | (not used)  |           |                       |                        |                           |                     |                                       |
| Building Components               |   | N/A       | B1                    | B1                     | B1                        |                     | B1                                    |
| Structural Soundness              | Small-scale Development (eg. shed, toilets, shelter) <sup>1</sup> | N/A       | S1                    | S2                     | S2                        |                     | S3                                    |
|                                   | (not used)  |           |                       |                        |                           |                     |                                       |
| Flood Impact                      | Large-scale Development (eg. levee, raised road, bridge)          | N/A       | S1                    | S2                     | S2                        | S2                  | S3                                    |
|                                   | Small-scale Development (eg. shed, toilets, shelter) <sup>1</sup> | N/A       | I1                    | I1                     | I2                        |                     | I1                                    |
|                                   | (not used)  |           |                       |                        |                           |                     |                                       |
| Evacuation & Access               | Large-scale Development (eg. levee, raised road, bridge)          | N/A       | I1                    | I3                     | I3                        | I3                  | I3                                    |
|                                   | (not used)  |           |                       |                        |                           |                     |                                       |
|                                   | (not used)  |           |                       |                        |                           |                     |                                       |
|                                   | (not used)  |           |                       |                        |                           |                     |                                       |
| Flood Awareness, etc              |   | N/A       | A1                    | A2                     | A2                        |                     | A2                                    |

Note 1: Small-scale development implies development on rural land that is small relative to the width of the floodplain and is not part of a planned large-scale development.

Note 2: In addition to being assigned one of the standard flood hazard categories, a site may be classified as a "Rare Extreme Hazard".  
In this instance, the most stringent of the two controls is to be used.

|  |  |
|--|--|
| N/A  | Controls Not Applicable  |
|  | Unsuitable Land Use - Not considered suitable for development  |
| <b>LAND USE SUITABILITY &amp; MINIMUM FILL LEVEL</b> |  |
| L1   | Consider for development subject to the controls below. No minimum fill level required.  |
| L2   | Consider for development subject to the controls below. For residential areas, the minimum fill level to be greater than or equal to the 100 year ARI event peak flood level (FPL2). For commercial and industrial areas, the minimum fill level to be greater than or equal to the 100 year ARI event peak flood level (FPL2).  |
| L3   | Consider for development subject to the controls below. No minimum fill level required.  |
| L4   | Consider for development subject to the controls below.<br>Council to give consideration on the benefits of using the development during and after a flood emergency.<br>If the site is to be used for a flood emergency, the minimum fill level should preferably be greater than or equal to PMF event peak flood level (FPL4)   |
| L5   | Consider for development subject to the controls below. Minimum fill level greater than or equal to PMF event peak flood level (FPL4).   |
| <b>MINIMUM FLOOR LEVEL</b>                           |  |
| F1   | All floor levels to be greater than or equal to 10 year ARI event peak flood level + 0.3m (FPL1).  |
| F2   | All floor levels to be greater than or equal to 100 year ARI event peak flood level (FPL2).  |
| F3   | All floor levels to be greater than or equal to 100 year ARI event peak flood level + 0.5m freeboard (FPL3).   |
| F4a  | All floor levels to be as close to the <i>minimum floor level</i> above (habitable or other) as practical and not less than the floor level of the existing building being extended. If the extended weatherproof area exceeds 50% of the existing weatherproof area, the extension is treated as a new building.<br>The extended weatherproof area is measured as the cumulative area of any previous extensions plus the proposed extension.                                       |
| F4b  | As for F5a with the maximum percentage increase in extended weatherproof area to be:<br>(a) 50% if the extension's floor level is less than one (1) metre below 100 Year ARI event peak flood level (FPL2);<br>(b) 25% if the extension's floor level is greater than two (2) metres below 100 Year ARI event peak flood level (FPL2); or<br>(c) pro-rata between 50% and 25% for floor levels from one (1) metre to two (2) metres below 100 year ARI Event Peak Flood Level (FPL2) |
| F5   | All floor levels to be greater than or equal to PMF event peak flood level (FPL4)  |
| F5a  | If practical, some or all floor levels to be greater than or equal to PMF event peak flood level (FPL4), so that these buildings will be available for accommodation / storage during and after a flood emergency.   |
| <b>BUILDING COMPONENTS</b>                           |  |
| B1   | Buildings to have flood compatible material below the higher of (a) the minimum floor level or (b) 100 year ARI event peak flood level + 0.5m freeboard. (FPL3)  |
| <b>STRUCTURAL SOUNDNESS</b>                          |  |
| S1   | No structural soundness requirements for the force of floodwater, debris & buoyancy.   |
| S2   | Engineers report to prove that structures subject to a flood up to 100 year ARI event + 0.5m freeboard (FPL3) can withstand the force of floodwater, debris & buoyancy.  |
| S3   | Engineers report to prove that structures subject to a flood up to the PMF event (FPL4) can withstand the force of floodwater, debris & buoyancy.  |
| <b>FLOOD IMPACT</b>                                  |  |
| I1   | No action required   |
| I2   | The flood impact of the development to be considered by Council, with Council having the right to request an engineer's report (see I3 below).   |
| I3   | Engineers report required to prove that the development will not result in adverse flood impact elsewhere.   |
| <b>EVACUATION/ACCESS</b>                             |  |
| E1   | Council to provide information on flood evacuation strategy  |
| E2   | Reliable access for pedestrians and transport required for 100 year ARI event peak flood level (FPL2). Council to provide information on flood evacuation strategy.  |
| E3   | Emergency service site - should have good access up to PMF event peak flood level (FPL4) and preferably not cut-off from the main residential area(s).<br>Council to evaluate suitability of site in this respect.   |
| E3a  | If site to be used during and after a flood emergency (see F6a above), should have good access up to PMF event peak flood level (FPL4).<br>and preferably not cut-off from the main residential area(s).   |
| <b>FLOOD AWARENESS</b>                               |  |
| A1   | No action required.  |
| A2   | S149(2) Certificates to notify possible affection by a flood in the Richmond River or Fawcetts Creek.<br>The severity of flooding can be determined by comparison of surveyed levels of the site with predicted flood heights, and also the flood hazard.  |

# FLOOD PLANNING MATRIX

**TABLE A-9: RESIDENTIAL, COMMERCIAL AND INDUSTRIAL DEVELOPMENT WITHIN WIANGAREE URBAN AREAS**

| Controls                                     | Development / Building Type                                  | No Hazard | Flood Hazard Category |                        |                           |                     | Additional Constraint <sup>2</sup> |
|--|--|-----------|-----------------------|------------------------|---------------------------|---------------------|------------------------------------|
|  |  |           | A<br>Flood Fringe     | B<br>High Hazard Depth | C<br>High Hazard Floodway | D<br>Extreme Hazard | E<br>Rare Extreme Hazard           |
| <b>Land Use Suitability &amp; Fill Level</b> | Existing Lot - New Development                               | N/A       |                       | L1                     |                           |                     | L1                                 |
|  | Ancillary Building/Public Amenity (eg. Shed/Shelter/Toilet)  | N/A       |                       | L1                     |                           |                     | L1                                 |
|  | Subdivision  | N/A       |                       | L2                     |                           |                     |                                    |
|  | Other Developments (eg. levees, roads, dams, bridge etc)     | N/A       |                       | L3                     |                           |                     | L3                                 |
|  | New Other Community Service (School, etc)                    | N/A       |                       |                        |                           |                     |                                    |
|  | /Special Evacuation Needs (eg. aged care)                    | N/A       |                       |                        |                           |                     |                                    |
|  | New Emergency Services (eg. hospitals, etc)                  | N/A       |                       |                        |                           |                     |                                    |
| <b>Floor Level</b>                           | /Critical Infrastructure (eg. major telephone exchange, etc) | N/A       |                       |                        |                           |                     |                                    |
|  | New Ancillary Building (eg. shed, carport)                   | N/A       |                       | F1                     |                           |                     | F1                                 |
|  | New Commercial or Industrial Building                        | N/A       |                       | F2                     |                           |                     | F2                                 |
|  | New Habitable Building                                       | N/A       |                       | F3                     |                           |                     | F3                                 |
|  | Building Extension   | N/A       |                       | F4b                    |                           |                     | F4a                                |
|  | New Emergency Services (eg. hospitals, etc)                  | N/A       |                       |                        |                           |                     |                                    |
|  | /Critical Infrastructure (eg. major telephone exchange, etc) | N/A       |                       |                        |                           |                     |                                    |
| <b>Building Components</b>                   | New Other Community Service (School, etc)                    | N/A       |                       |                        |                           |                     |                                    |
|  | /Special Evacuation Needs (eg. aged care)                    | N/A       |                       |                        |                           |                     |                                    |
|  | Building Components  | N/A       |                       | B1                     |                           |                     | B1                                 |
|  | Structural   | N/A       |                       | S2                     |                           |                     | S3                                 |
| <b>Soundness</b>                             | Small-scale Development (eg. shed, toilets, shelter)         | N/A       |                       | S2                     |                           |                     | S3                                 |
|  | Medium-scale Development (eg. house, building extension)     | N/A       |                       | S2                     |                           |                     | S3                                 |
|  | Large-scale Development (eg. levee, raised road, bridge)     | N/A       |                       | S2                     |                           |                     | S3                                 |
| <b>Flood Impact</b>                          | Existing Lot - New Development                               | N/A       |                       | I2                     |                           |                     | I2                                 |
|  | Ancillary Building/Public Amenity (eg. Shed/Shelter/Toilet)  | N/A       |                       | I2                     |                           |                     | I2                                 |
|  | Subdivision  | N/A       |                       | I3                     |                           |                     | I3                                 |
|  | Building Extension   | N/A       |                       | I1                     |                           |                     | I2                                 |
|  | Other Developments (road raising, bridge, levee)             | N/A       |                       | I2                     |                           |                     | I3                                 |
| <b>Evacuation &amp; Access</b>               | Existing Lot - New Development                               | N/A       |                       | E1                     |                           |                     | E1                                 |
|  | Ancillary Building/Public Amenity (eg. Shed/Shelter/Toilet)  | N/A       |                       | E1                     |                           |                     | E1                                 |
|  | Subdivision  | N/A       |                       | E2                     |                           |                     |                                    |
|  | Emergency Services (eg. hospitals, etc)                      | E3        |                       |                        |                           |                     |                                    |
|  | /Critical Infrastructure (eg. major telephone exchange, etc) | E3a       |                       |                        |                           |                     |                                    |
|  | Other Community Service (School, etc)                        | E3a       |                       |                        |                           |                     |                                    |
|  | /Special Evacuation Needs (eg. aged care)                    | E3a       |                       |                        |                           |                     |                                    |
| <b>Flood Awareness, etc</b>                  |  | N/A       |                       | A2                     |                           |                     | A2                                 |

Note 1: Refer to Figure 2-2 showing the area specified as "Urban Areas" for the purpose of these controls

Note 2: In addition to being assigned one of the standard flood hazard categories, a site may be classified as a "Rare Extreme Hazard".

In this instance, the most stringent of the two controls is to be used.

Note 3: For properties located on lots exhibiting multiple hazard categories the location of the proposed developed should be used to define the appropriate Fill Level, Floor Level, Structural Soundness and Flood Impact. The higher hazard category should be considered when assessing Evacuation Access and Flood Awareness

N/A Controls Not Applicable

Unsuitable Land Use - Not considered suitable for development

## LAND USE SUITABILITY & MINIMUM FILL LEVEL

**L1** Consider for development subject to the controls below. No minimum fill level required.

**L2** Consider for development subject to the controls below. For residential areas, the minimum fill level to be greater than or equal to the 100 year ARI event peak flood level (FPL2). For commercial and industrial areas, the minimum fill level to be greater than or equal to the 100 year ARI event peak flood level (FPL2).

**L3** Consider for development subject to the controls below. No minimum fill level required.

**L4** Consider for development subject to the controls below.  
Council to give consideration on the benefits of using the development during and after a flood emergency.  
If the site is to be used for a flood emergency, the minimum fill level should preferably be greater than or equal to PMF event peak flood level (FPL4)

**L5** Consider for development subject to the controls below. Minimum fill level greater than or equal to PMF event peak flood level (FPL4).

## MINIMUM FLOOR LEVEL

**F1** All floor levels to be greater than or equal to 10 year ARI event peak flood level + 0.3m (FPL1).

**F2** All floor levels to be greater than or equal to 100 year ARI event peak flood level (FPL2).

**F3** All floor levels to be greater than or equal to 100 year ARI event peak flood level + 0.5m freeboard (FPL3).

**F4a** All floor levels to be as close to the *minimum floor level* above (habitable or other) as practical and not less than the floor level of the existing building being extended. If the extended weatherproof area exceeds 50% of the existing weatherproof area, the extension is treated as a new building.  
The extended weatherproof area is measured as the cumulative area of any previous extensions plus the proposed extension.

**F4b** As for F5a with the maximum percentage increase in extended weatherproof area to be:  
(a) 50% if the extension's floor level is less than one (1) metre below 100 Year ARI event peak flood level (FPL2);  
(b) 25% if the extension's floor level is greater than two (2) metres below 100 Year ARI event peak flood level (FPL2); or  
(c) pro-rata between 50% and 25% for floor levels from one (1) metre to two (2) metres below 100 year ARI Event Peak Flood Level (FPL2)

**F5** All floor levels to be greater than or equal to PMF event peak flood level (FPL4)

**F5a** If practical, some or all floor levels to be greater than or equal to PMF event peak flood level (FPL4), so that these buildings will be available for accommodation / storage during and after a flood emergency.

## BUILDING COMPONENTS

**B1** Buildings to have flood compatible material below the higher of (a) the minimum floor level or (b) 100 year ARI event peak flood level + 0.5m freeboard. (FPL3)

## STRUCTURAL SOUNDNESS

**S1** No structural soundness requirements for the force of floodwater, debris & buoyancy.

**S2** Engineers report to prove that structures subject to a flood up to 100 year ARI event + 0.5m freeboard (FPL3) can withstand the force of floodwater, debris & buoyancy.

**S3** Engineers report to prove that structures subject to a flood up to the PMF event (FPL4) can withstand the force of floodwater, debris & buoyancy.

## FLOOD IMPACT

**I1** No action required

**I2** The flood impact of the development to be considered by Council, with Council having the right to request an engineer's report (see I3 below).

**I3** Engineers report required to prove that the development will not result in adverse flood impact elsewhere.

## EVACUATION/ACCESS

**E1** Council to provide information on flood evacuation strategy

**E2** Reliable access for pedestrians and transport required for 100 year ARI event peak flood level (FPL2). Council to provide information on flood evacuation strategy.

**E3** Emergency service site - should have good access up to PMF event peak flood level (FPL4) and preferably not cut-off from the main residential area(s).  
Council to evaluate suitability of site in this respect.

**E3a** If site to be used during and after a flood emergency (see F6a above), should have good access up to PMF event peak flood level (FPL4).  
and preferably not cut-off from the main residential area(s).

## FLOOD AWARENESS

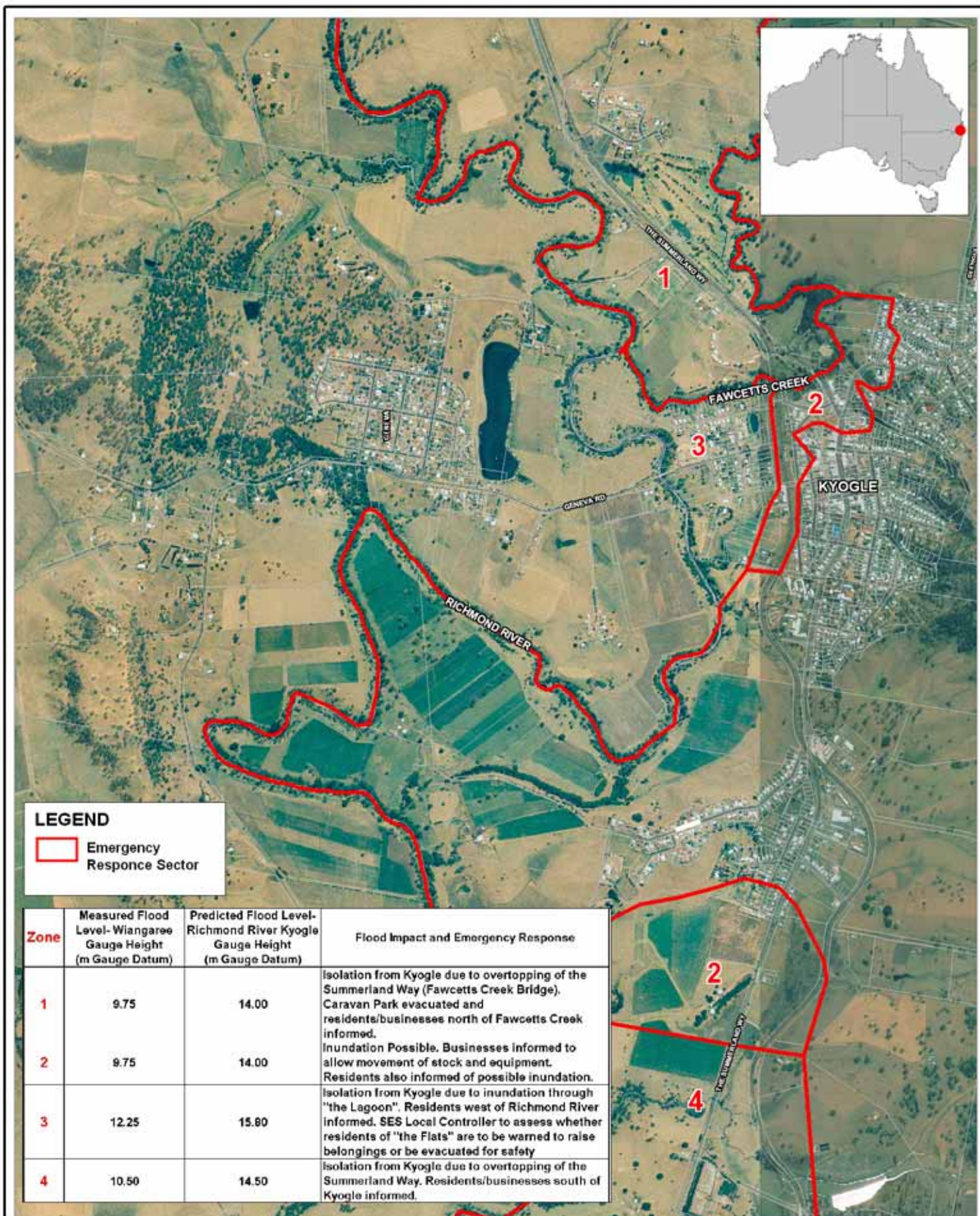
**A1** No action required.

**A2** S149(2) Certificates to notify possible affectation by a flood in the Richmond River or Fawcetts Creek.  
The severity of flooding can be determined by comparison of surveyed levels of the site with predicted flood heights, and also the flood hazard.

## APPENDIX B: EMERGENCY RESPONSE FIGURES

Emergency response figures have been developed to assist the SES during their flood response actions. Figure B-1 identifies the emergency response sectors defined as part of the Kyogle Floodplain Risk Management Study (BMT WBM, 2008). Figure B-2 to Figure B-13 provides flood information for the current catchment state, prior to the construction of the proposed flood modification measures. Figure B-15 and Figure B-26 provides flood information for the future catchment state, accounting for the construction of the proposed flood modification measures.





Title:  
**Pre-levee  
Emergency Response Sectors**

Figure:  
**B-1**

Rev:  
**A**

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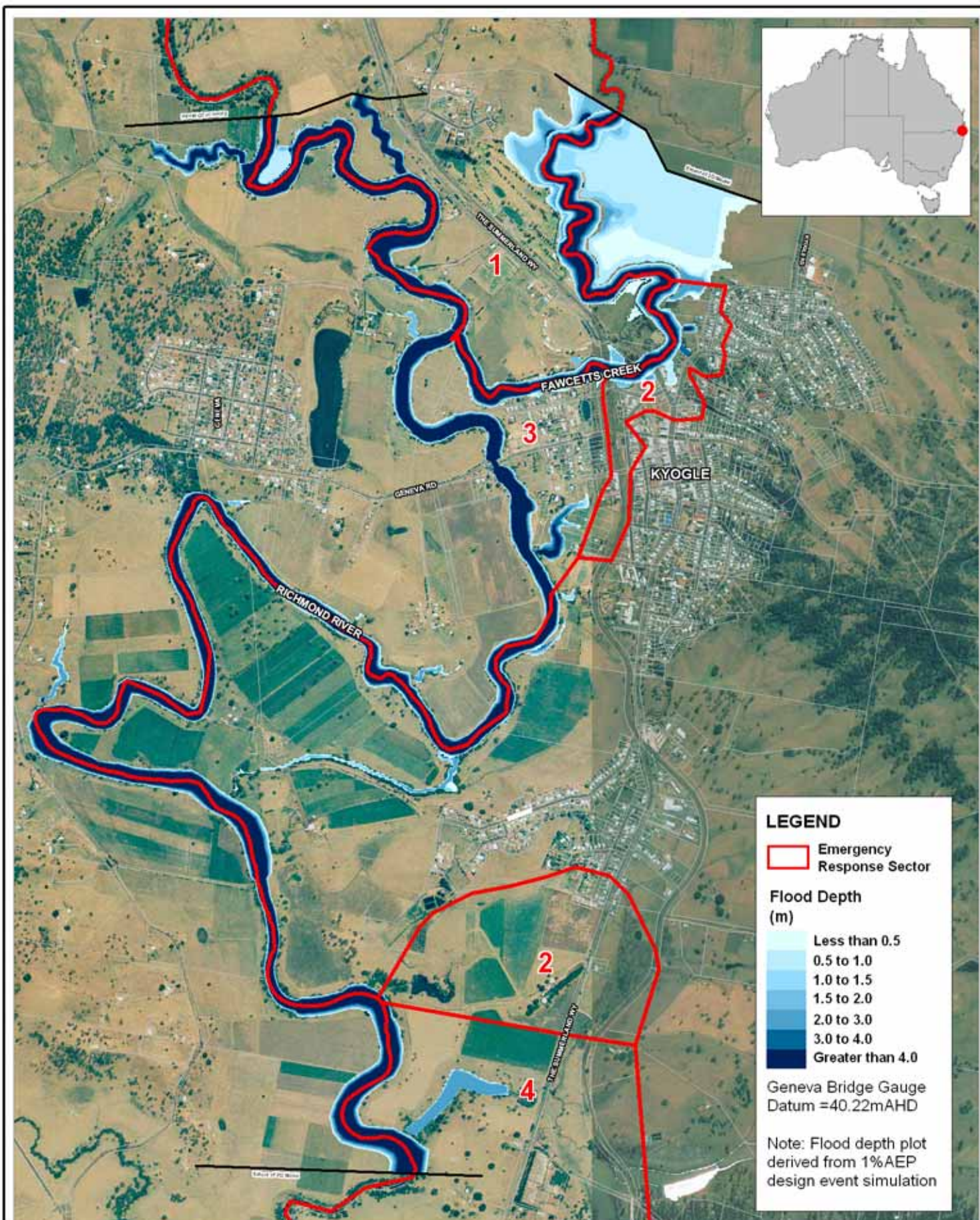


0 0.5 1km  
Approx. Scale



Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_011\_Pre\_Levee\_Emergency\_Zones.WOR





Title:

## Pre-Levee Emergency Response Flood Depth Geneva Bridge Gauge = 14.0m

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0 0.5 1km  
Approx. Scale

Figure:

B-2

Rev:

A

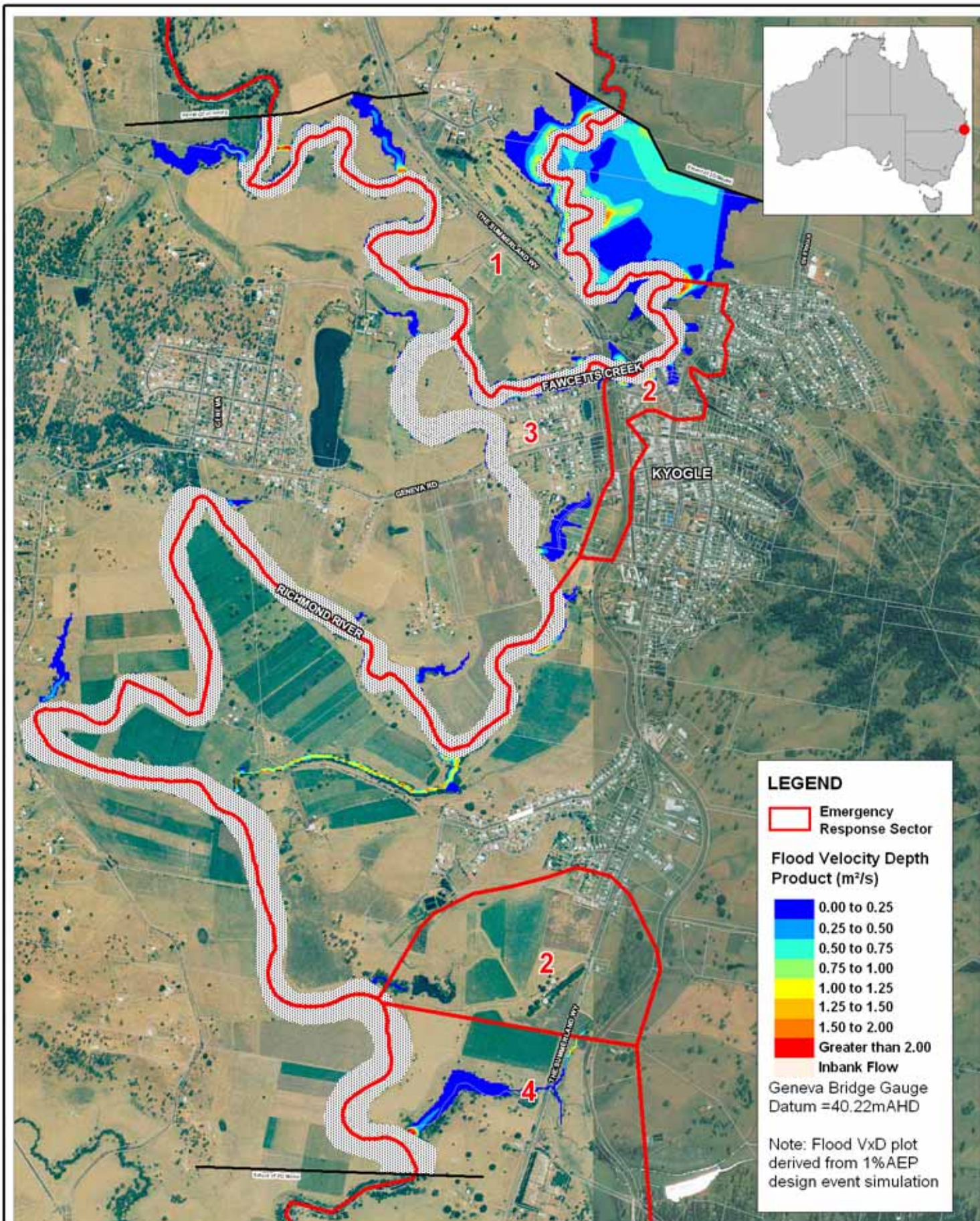


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Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_012\_Pre\_Levee\_Emergency\_Depth14m.WOR





Title:

## Pre-Levee Emergency Response Flood Velocity x Depth Geneva Bridge Gauge = 14.0m

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0 0.5 1km  
Approx. Scale

Figure:

B-3

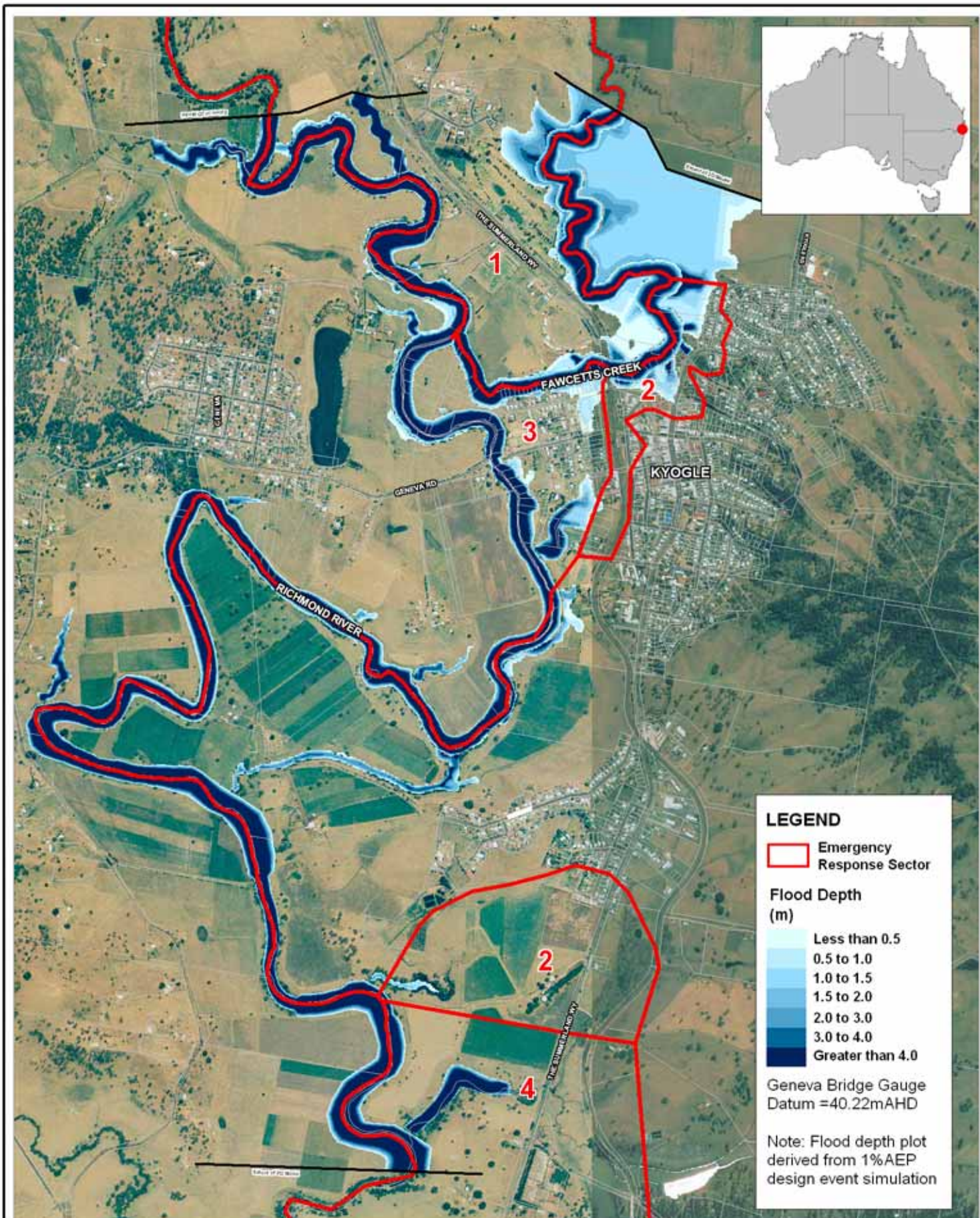
Rev:

A



Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FMP\FLD\_Plan\_018\_Pre-Levee\_Emergency\_VD14m.WOR





Title:  
**Pre-Levee Emergency Response Flood Depth  
 Geneva Bridge Gauge = 15.0m**

Figure:  
**B-4**

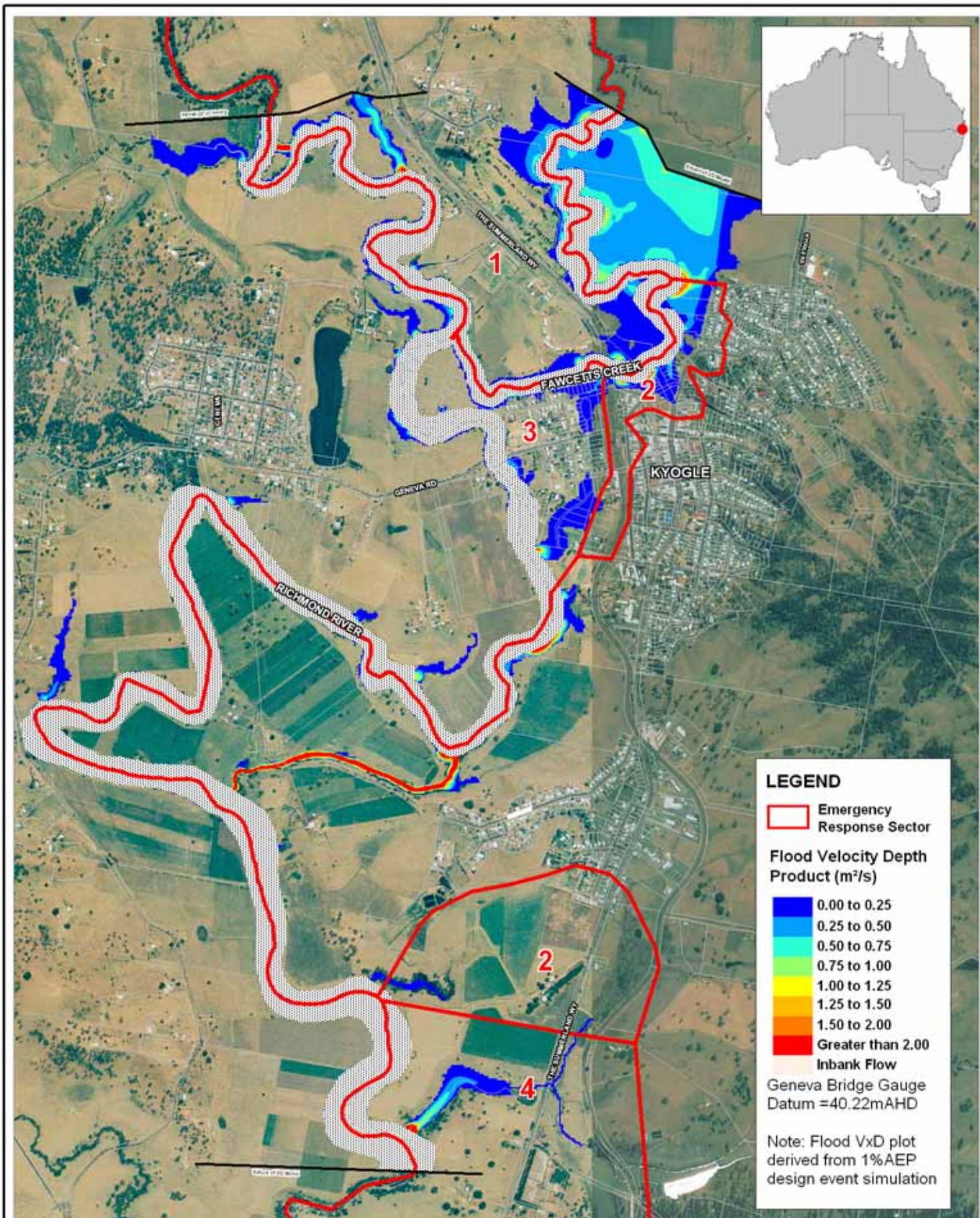
Rev:  
**A**

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0 0.5 1km  
 Approx. Scale





Title:

## Pre-Levee Emergency Response Flood Velocity x Depth Geneva Bridge Gauge = 15.0m

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0 0.5 1km  
Approx. Scale

Figure:

B-5

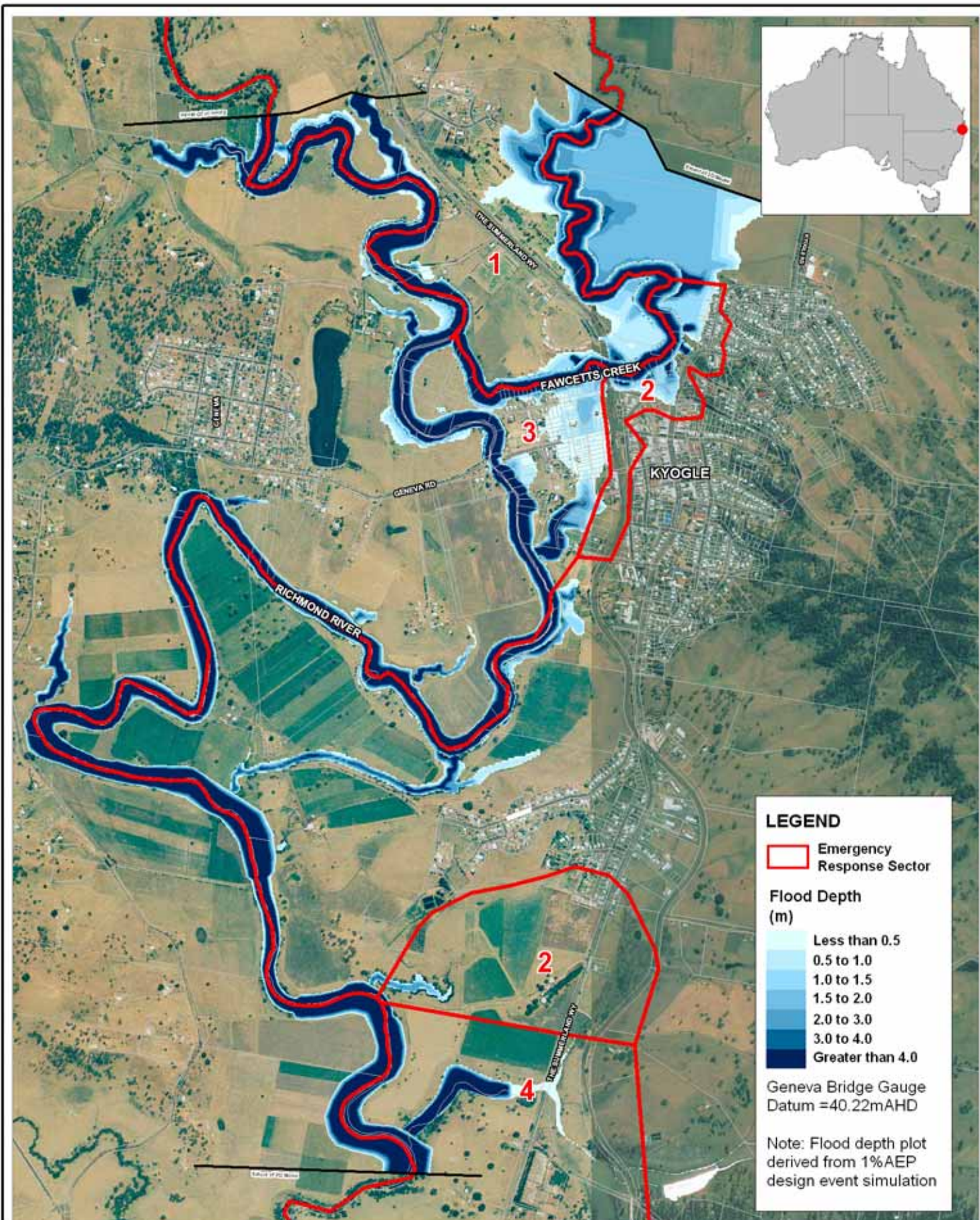
Rev:

A



Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_019\_Pre-Levee\_Emergency\_VD15m.WOR





Title:  
**Pre-Levee Emergency Response Flood Depth**  
**Geneva Bridge Gauge = 16.0m**

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0 0.5 1km  
 Approx. Scale

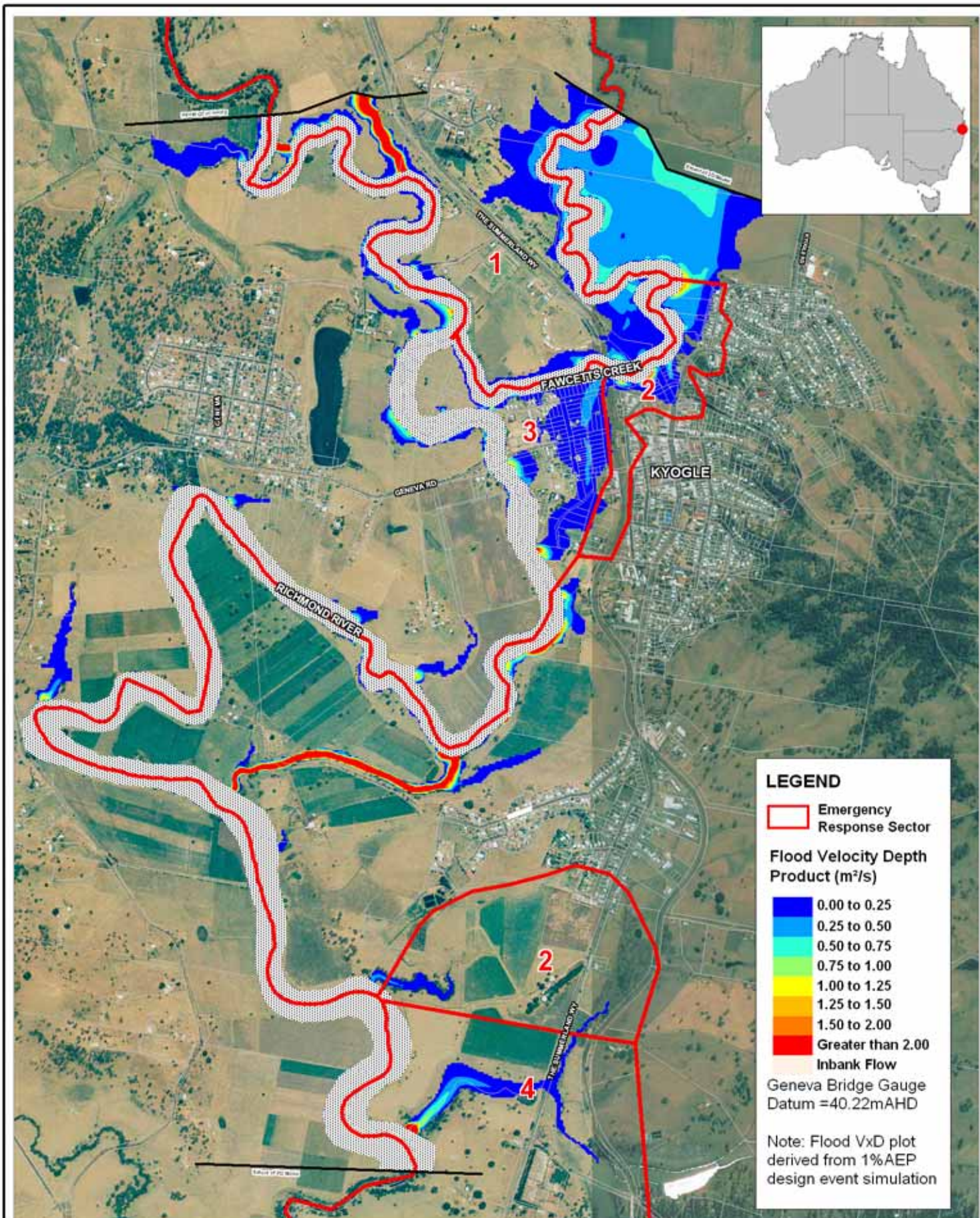
Figure:  
**B-6**

Rev:  
**A**



Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_014\_Pre-Levee\_Emergency\_Depth16m.WOR





Title:

## Pre-Levee Emergency Response Flood Velocity x Depth Geneva Bridge Gauge = 16.0m

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0 0.5 1km  
Approx. Scale

Figure:

B-7

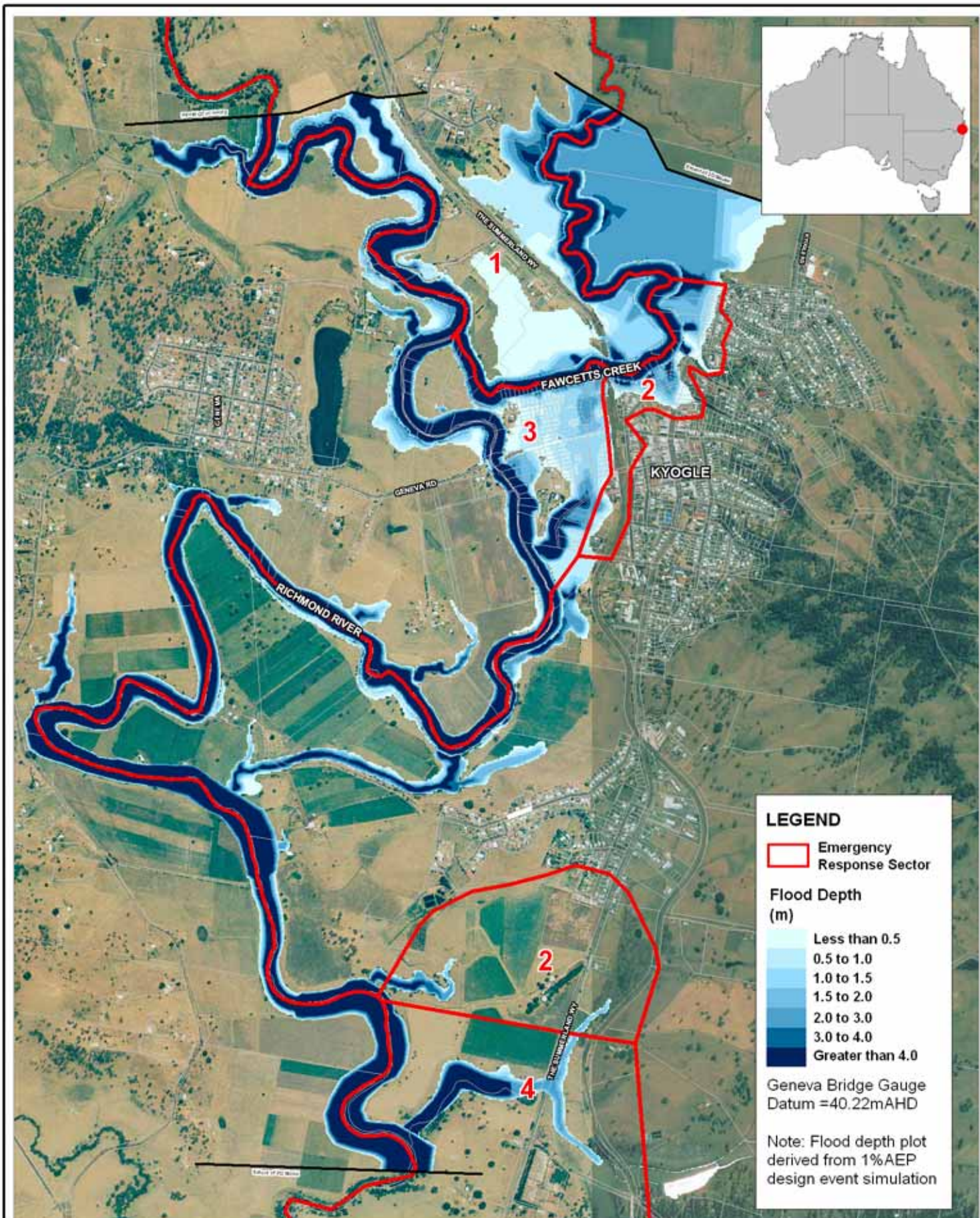
Rev:

A

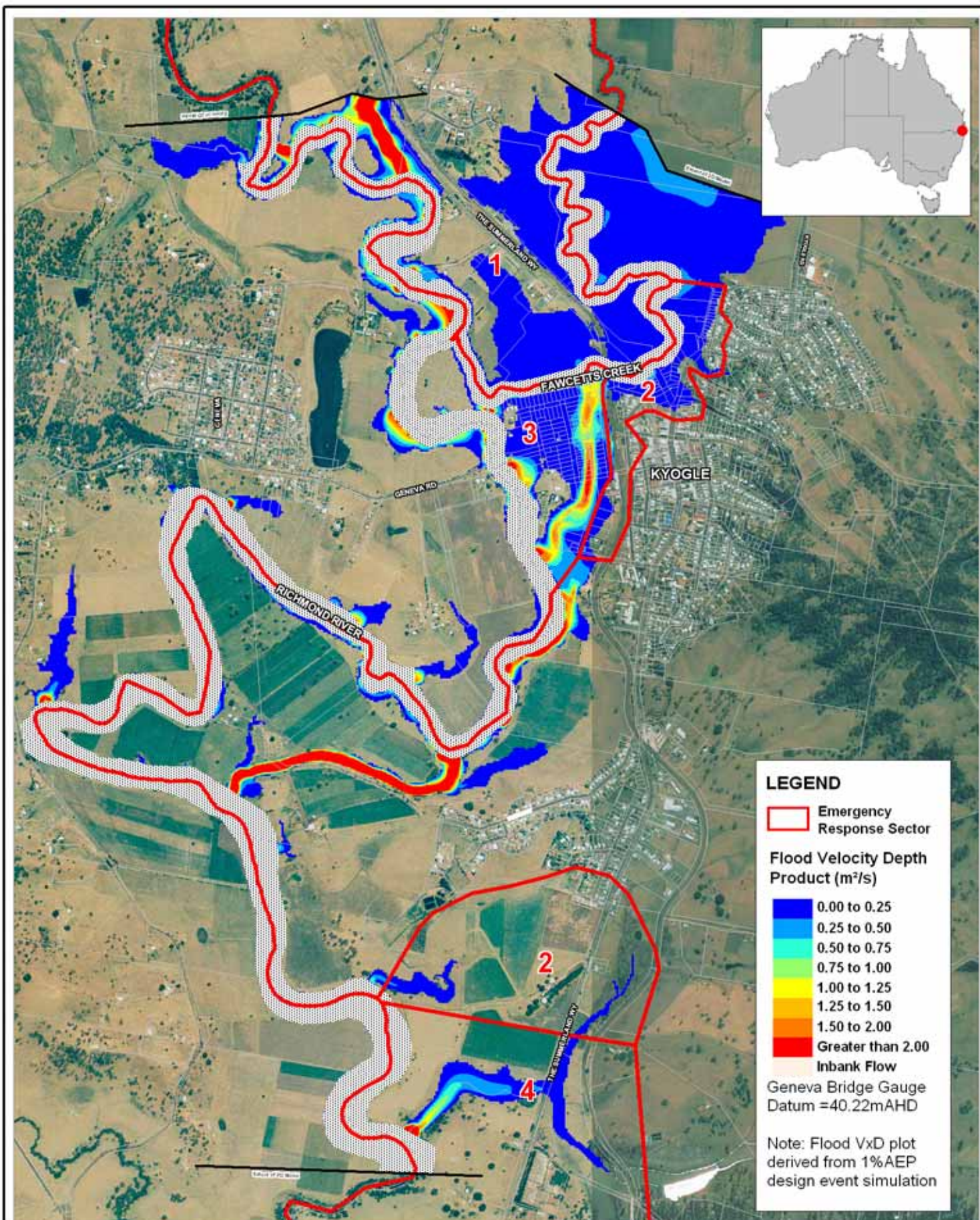


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Title:

## Pre-Levee Emergency Response Flood Velocity x Depth Geneva Bridge Gauge = 17.0m

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0 0.5 1km  
Approx. Scale

Figure:

B-9

Rev:

A

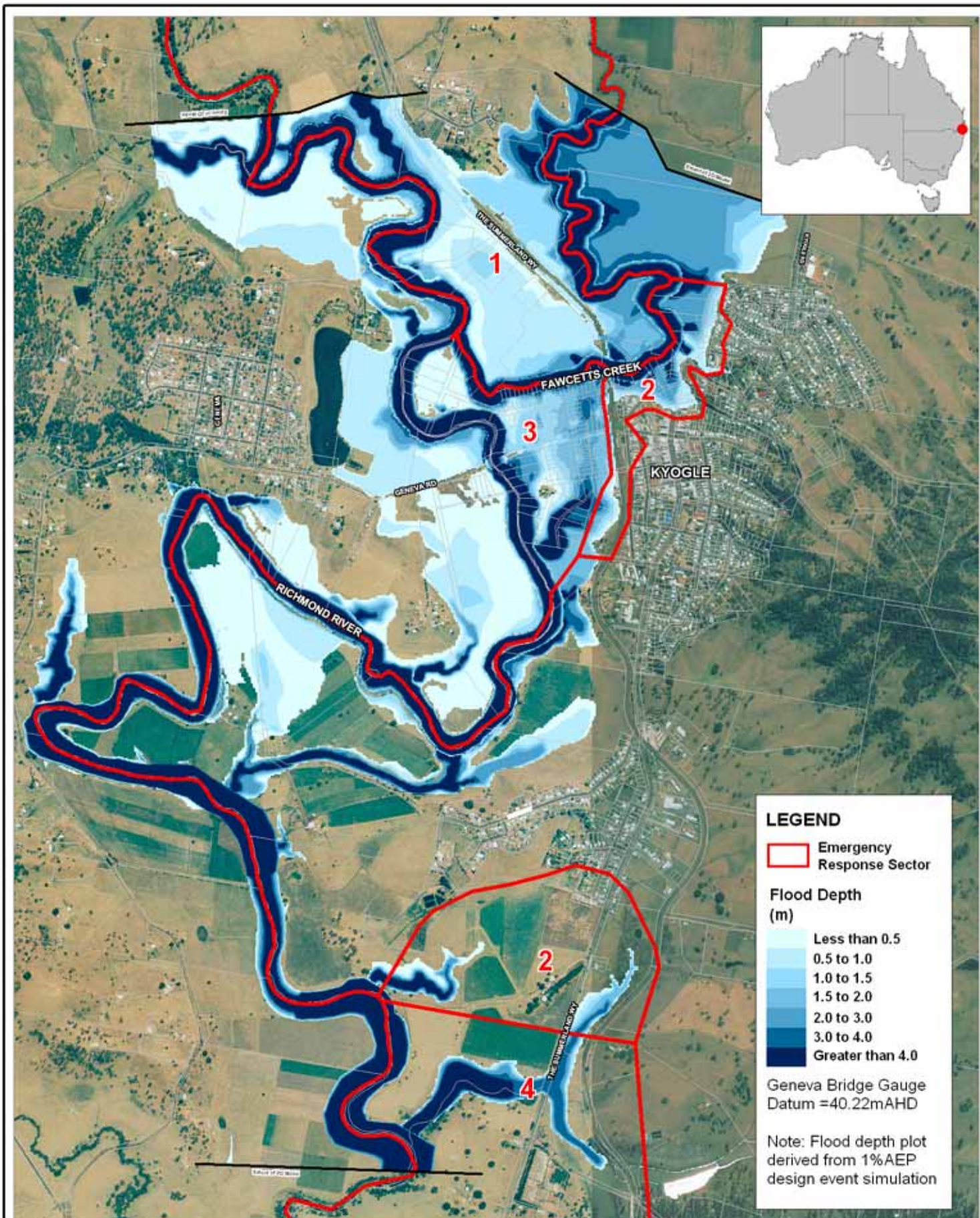


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Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_030\_Pre-Levee\_Emergency\_VD17m.WOR





Title:

# Pre-Levee Emergency Response Flood Depth Geneva Bridge Gauge = 18.0m

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0 0.5 1km  
Approx. Scale

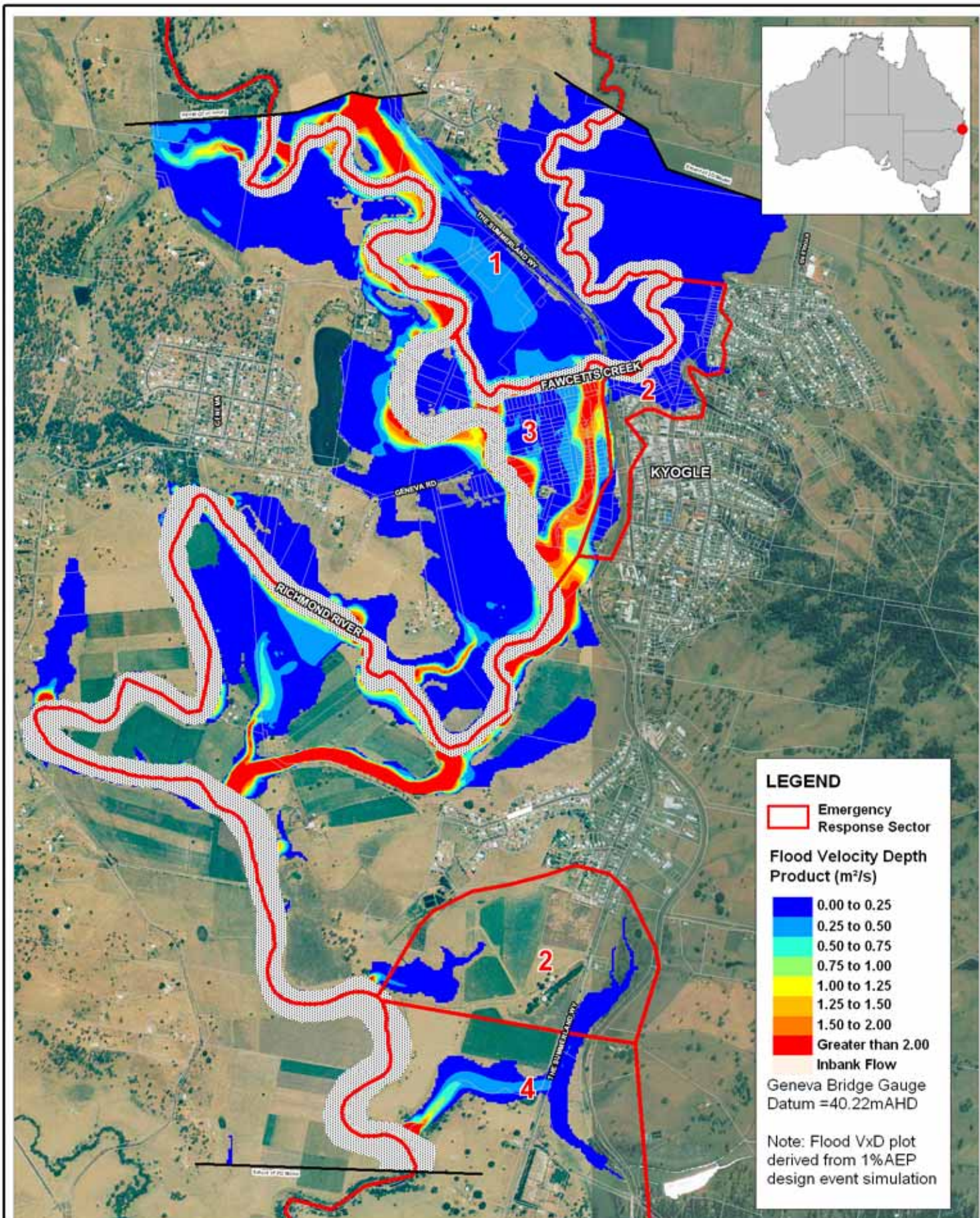
Figure:  
**B-10**

Rev:  
**A**



Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_016\_Pre\_Levee\_Emergency\_Depth18m.WOR





Title:

## Pre-Levee Emergency Response Flood Velocity x Depth Geneva Bridge Gauge =18.0m

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0 0.5 1km  
Approx. Scale

Figure:

B-11

Rev:

A

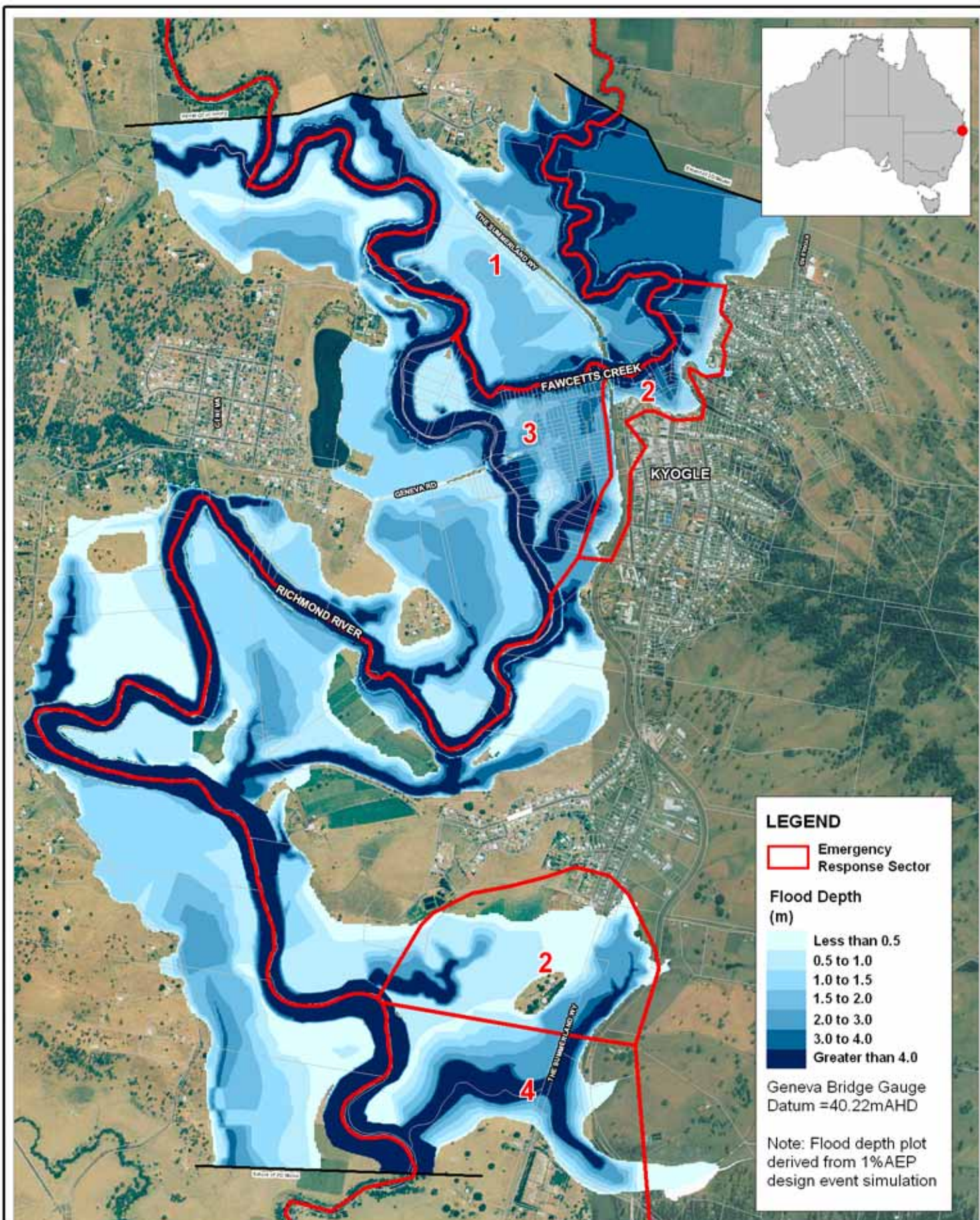


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Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_031\_Pre\_Levee\_Emergency\_VD18m.WOR





Title:

# Pre-Levee Emergency Response Flood Depth Geneva Bridge Gauge = 19.0m

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0 0.5 1km  
Approx. Scale

Figure:

B-12

Rev:

A

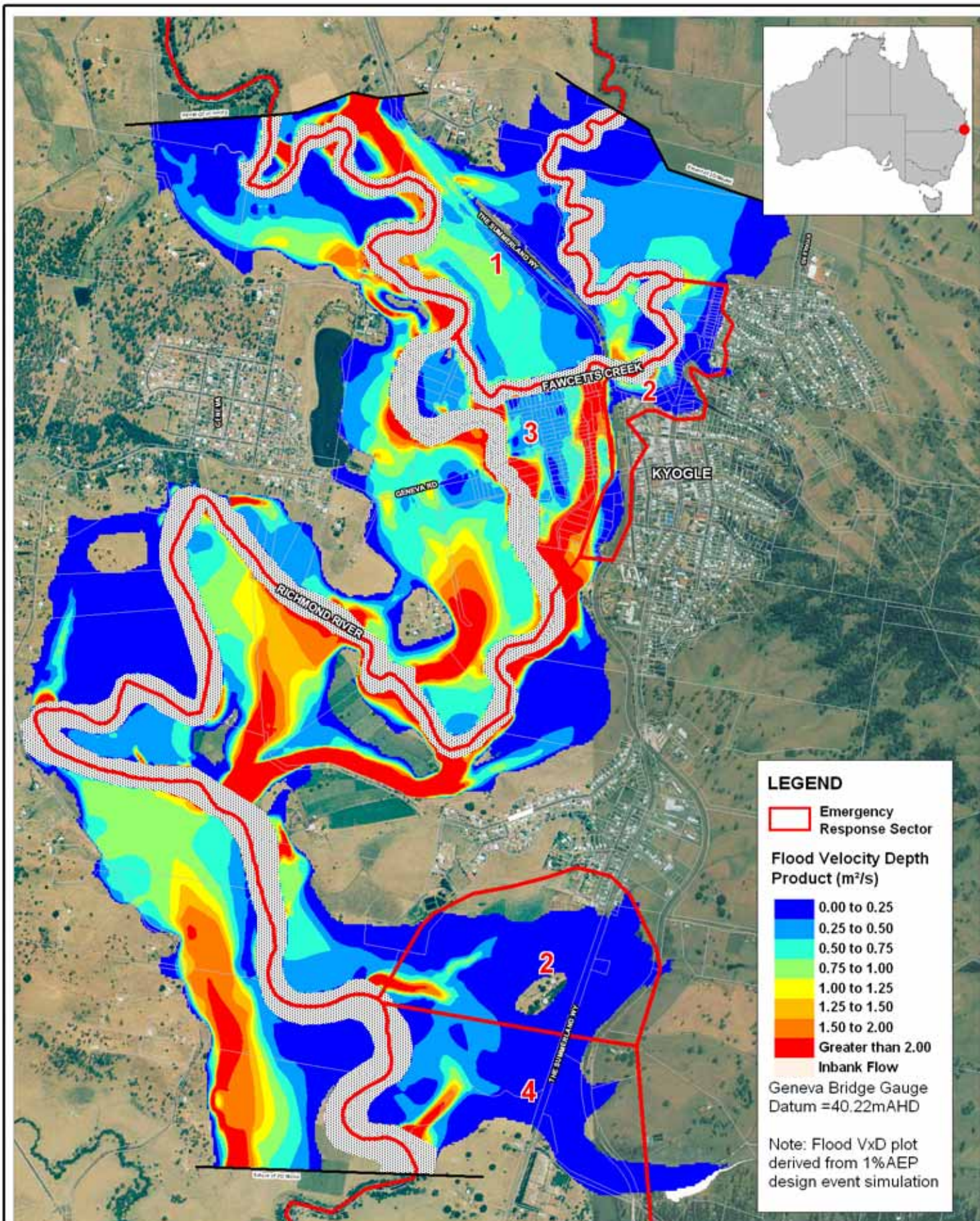


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Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FMP\FLD\_Plan\_017\_Pre\_Levee\_Emergency\_Depth19m.WOR





Title:

# **Pre-Levee Emergency Response Flood Velocity x Depth Geneva Bridge Gauge = 19.0m**

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0 0.5 1km  
Approx. Scale

Figure:

**B-13**

Rev:

**A**

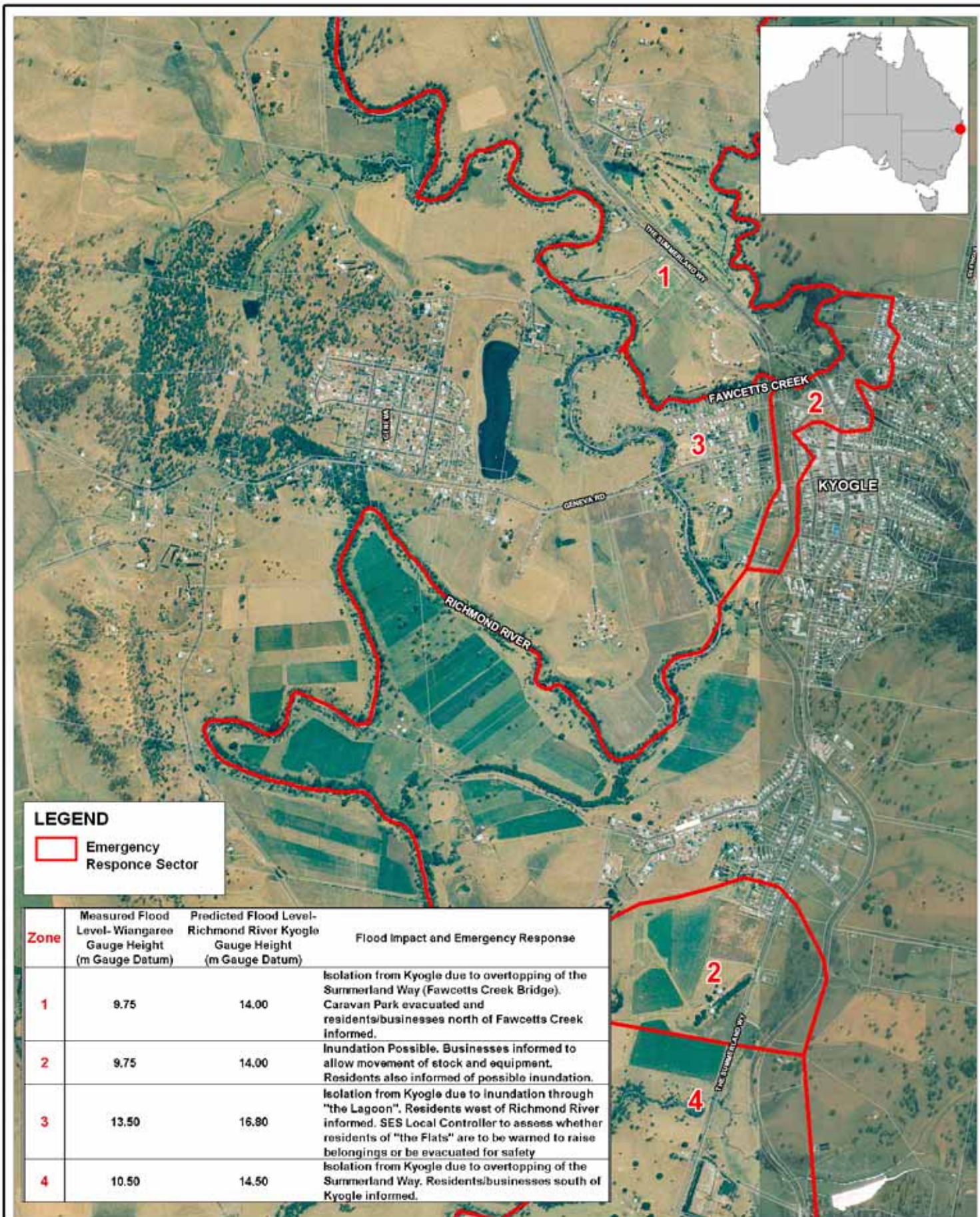


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Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_032\_Pre-Levee\_Emergency\_VD19m.WOR





Title:  
**Post-Levee  
Emergency Response Sectors**

Figure:  
**B-14**

Rev:  
**A**

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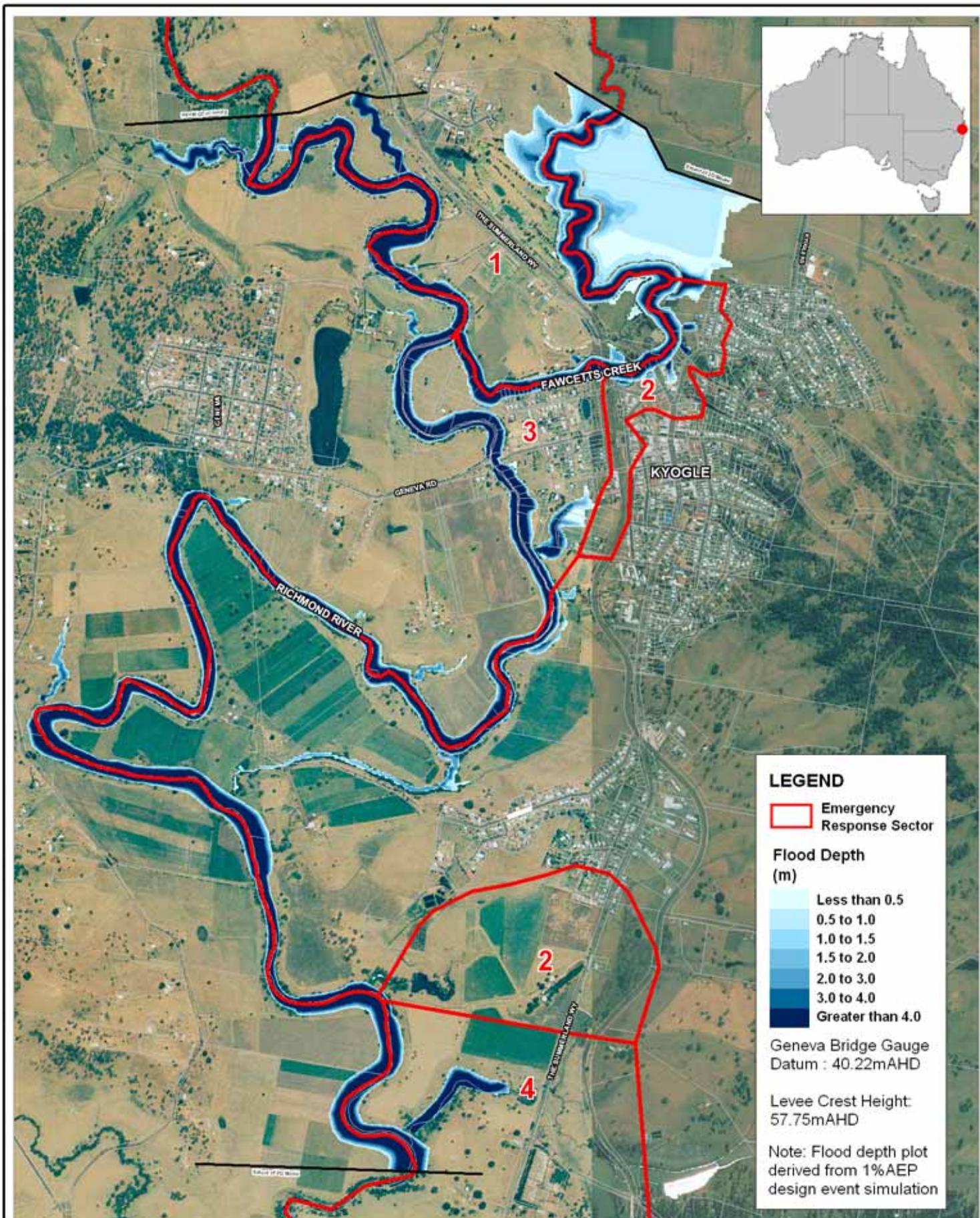


0 0.5 1km  
Approx. Scale



Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FMP\FLD\_Plan\_033\_Post\_Levee\_Emergency\_Zones.WOR





Title:  
**Post-Levee Emergency Response Flood Depth  
Geneva Bridge Gauge =14.0m**

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0 0.5 1km  
Approx. Scale

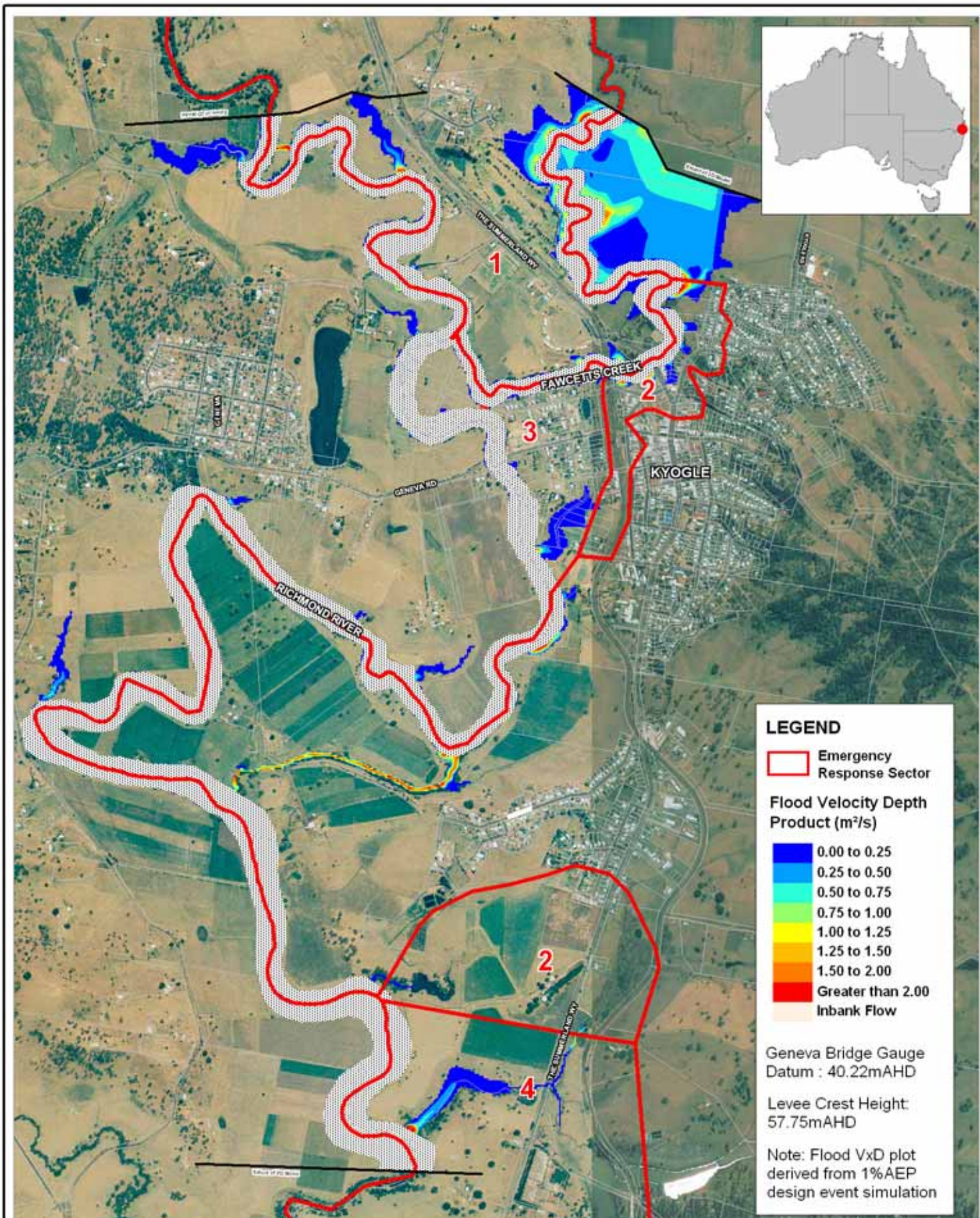
Figure:  
**B-15**

Rev:  
**A**



Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FMP\FLD\_Plan\_034\_Post\_Levee\_Emergency\_Depth14m.WOR





Title:

# Post-Levee Emergency Response Flood Velocity x Depth Geneva Bridge Gauge =14.0m

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0 0.5 1km  
Approx. Scale

Figure:

B-16

Rev:

A

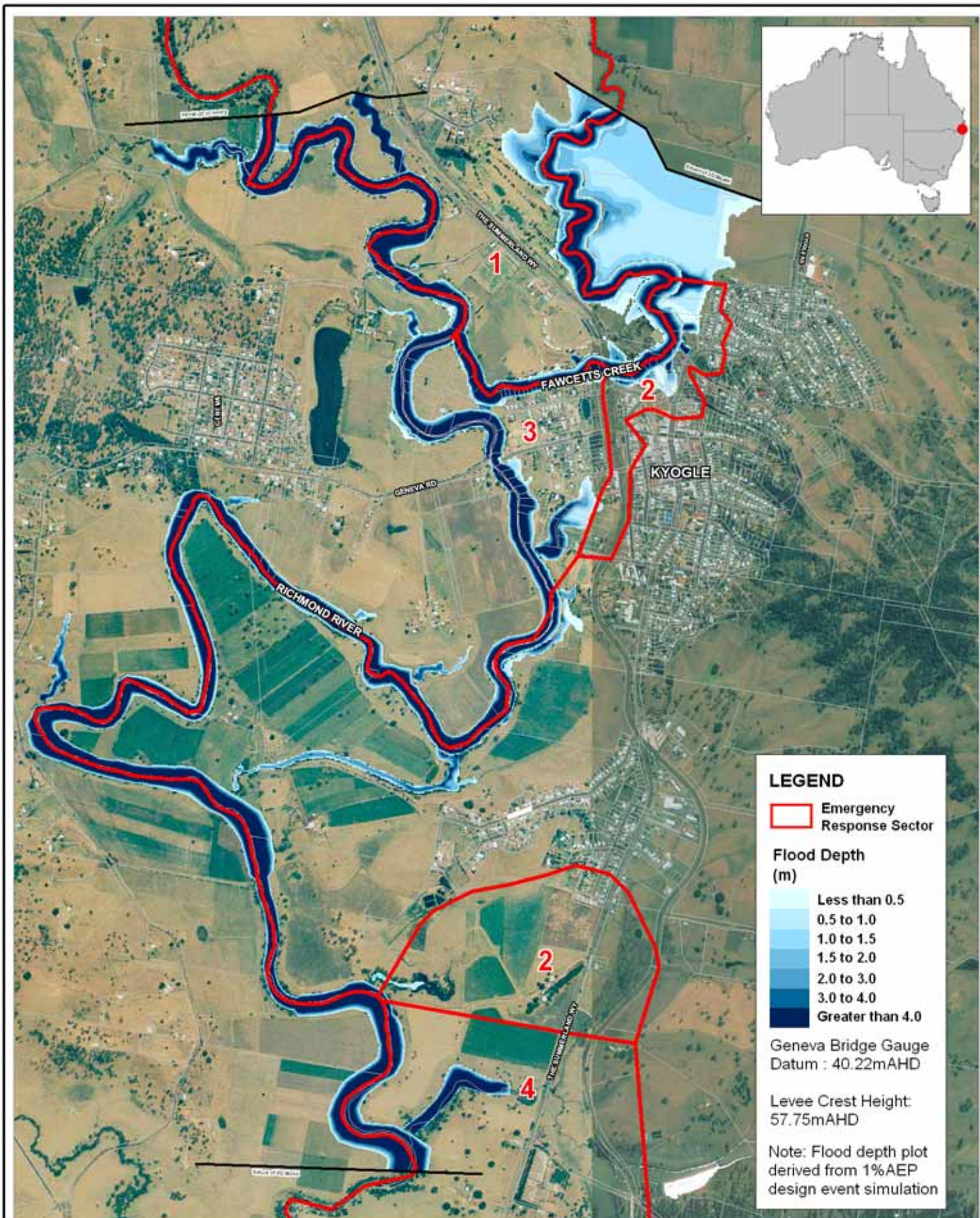


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Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_040\_Post\_Levee\_Emergency\_VD14m.WOR





Title:  
**Post-Levee Emergency Response Flood Depth  
 Geneva Bridge Gauge =15.0m**

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0 0.5 1km  
 Approx. Scale

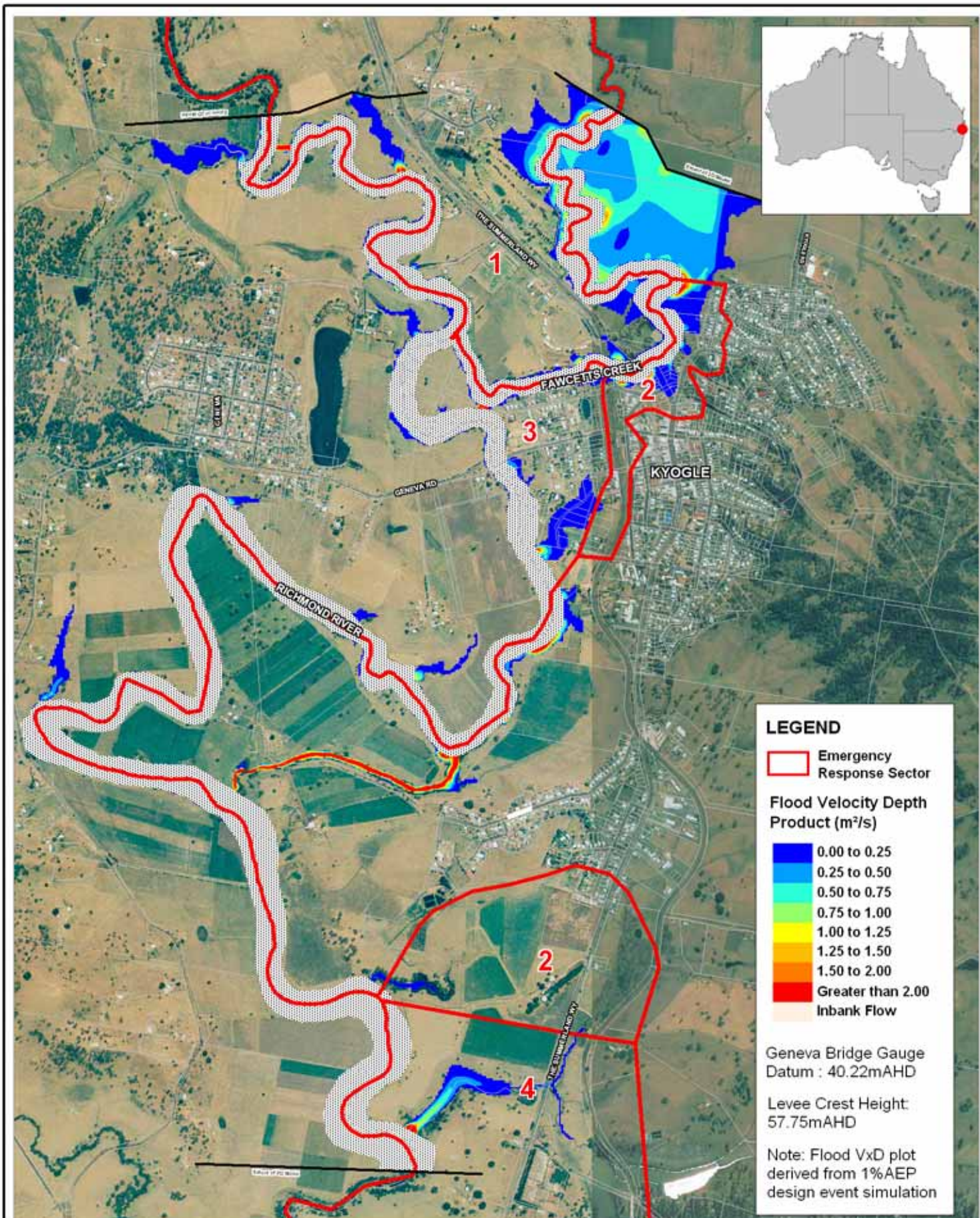
Figure:  
**B-17**

Rev:  
**A**



Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FMP\FLD\_Plan\_035\_Post\_Levee\_Emergency\_Depth15m.WOR





Title:

## Post-Levee Emergency Response Flood Velocity x Depth Geneva Bridge Gauge =15.0m

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0 0.5 1km  
Approx. Scale

Figure:

B-18

Rev:

A

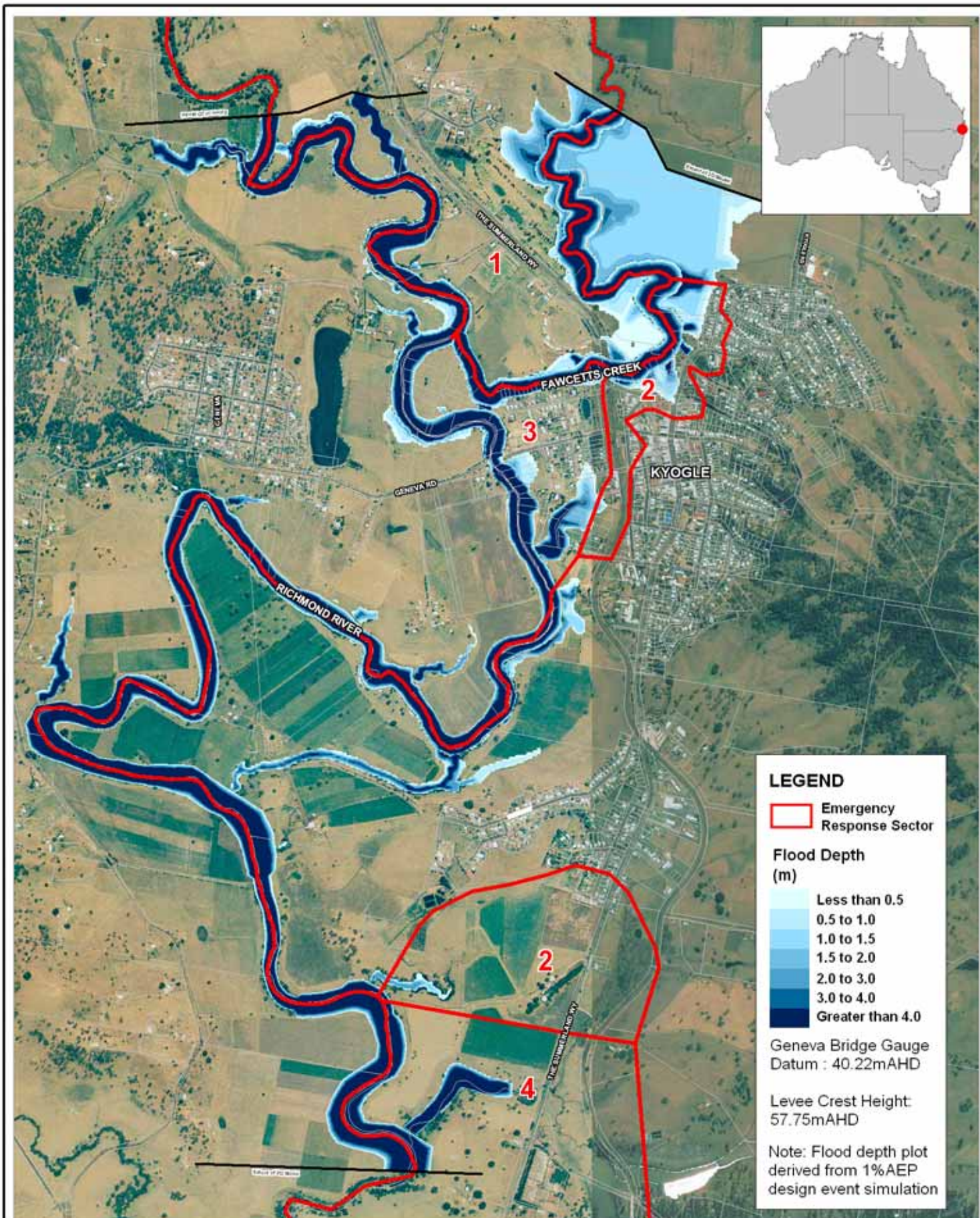


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Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_041\_Post\_Levee\_Emergency\_VD15m.WOR





Title:  
**Post-Levee Emergency Response Flood Depth  
 Geneva Bridge Gauge =16.0m**

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0 0.5 1km  
 Approx. Scale

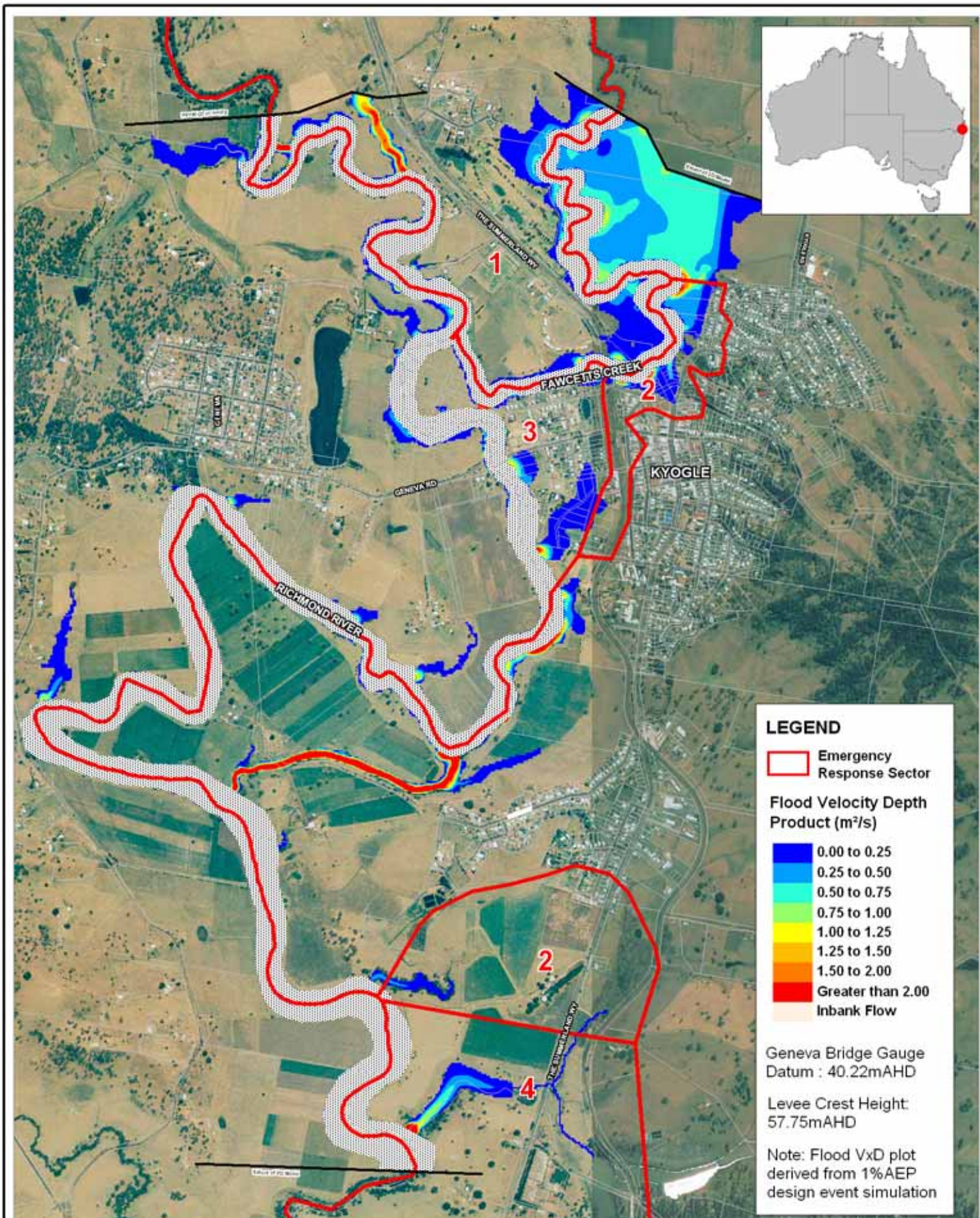
Figure:  
**B-19**

Rev:  
**A**



Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FMP\FLD\_Plan\_036\_Post\_Levee\_Emergency\_Depth16m.WOR





Title:

## Post-Levee Emergency Response Flood Velocity x Depth Geneva Bridge Gauge = 16.0m

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0 0.5 1km  
Approx. Scale

Figure:

B-20

Rev:

A

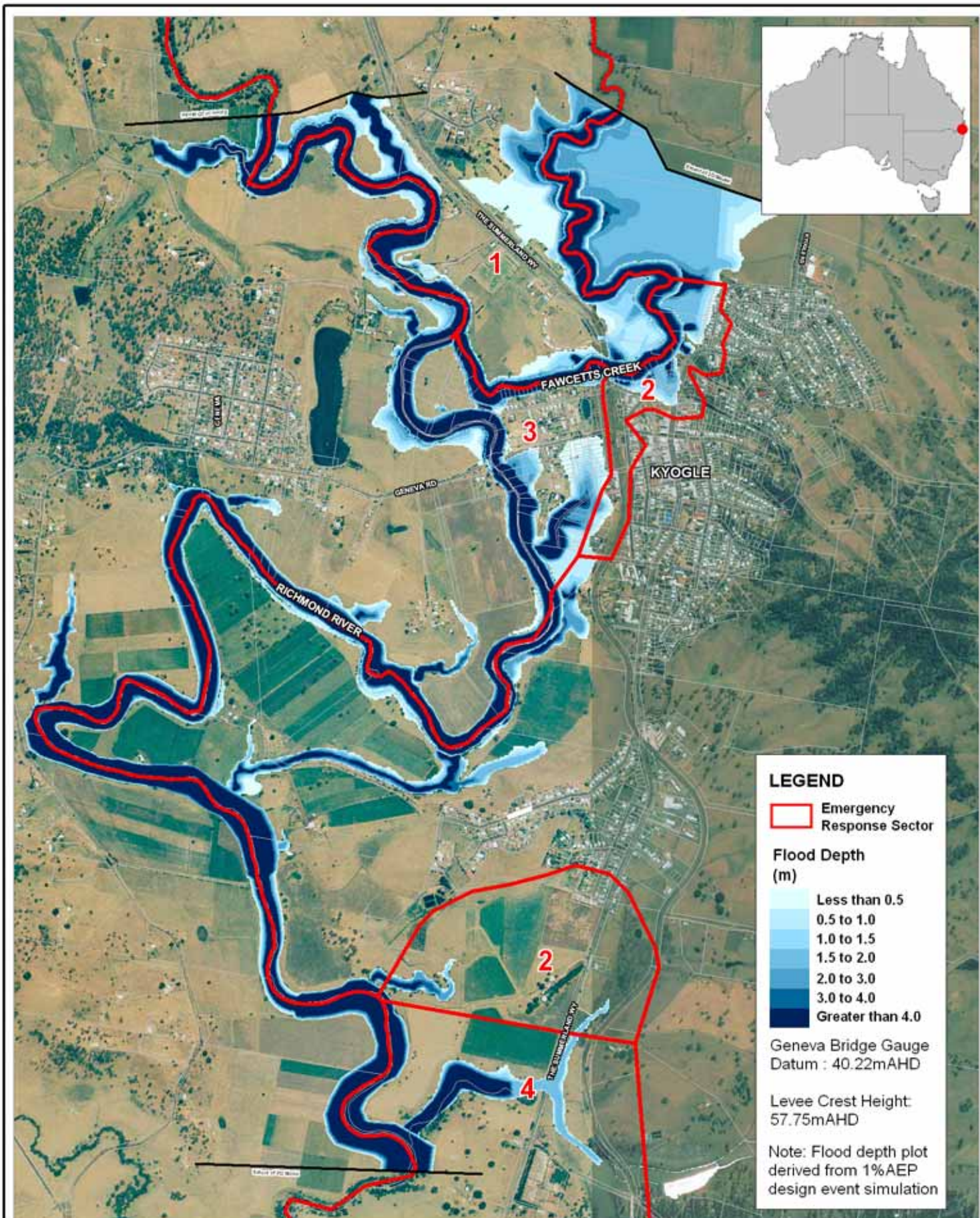


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Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_042\_Post\_Levee\_Emergency\_VD16m.WOR





Title:  
**Post-Levee Emergency Response Flood Depth  
Geneva Bridge Gauge =17.0m**

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0 0.5 1km  
Approx. Scale

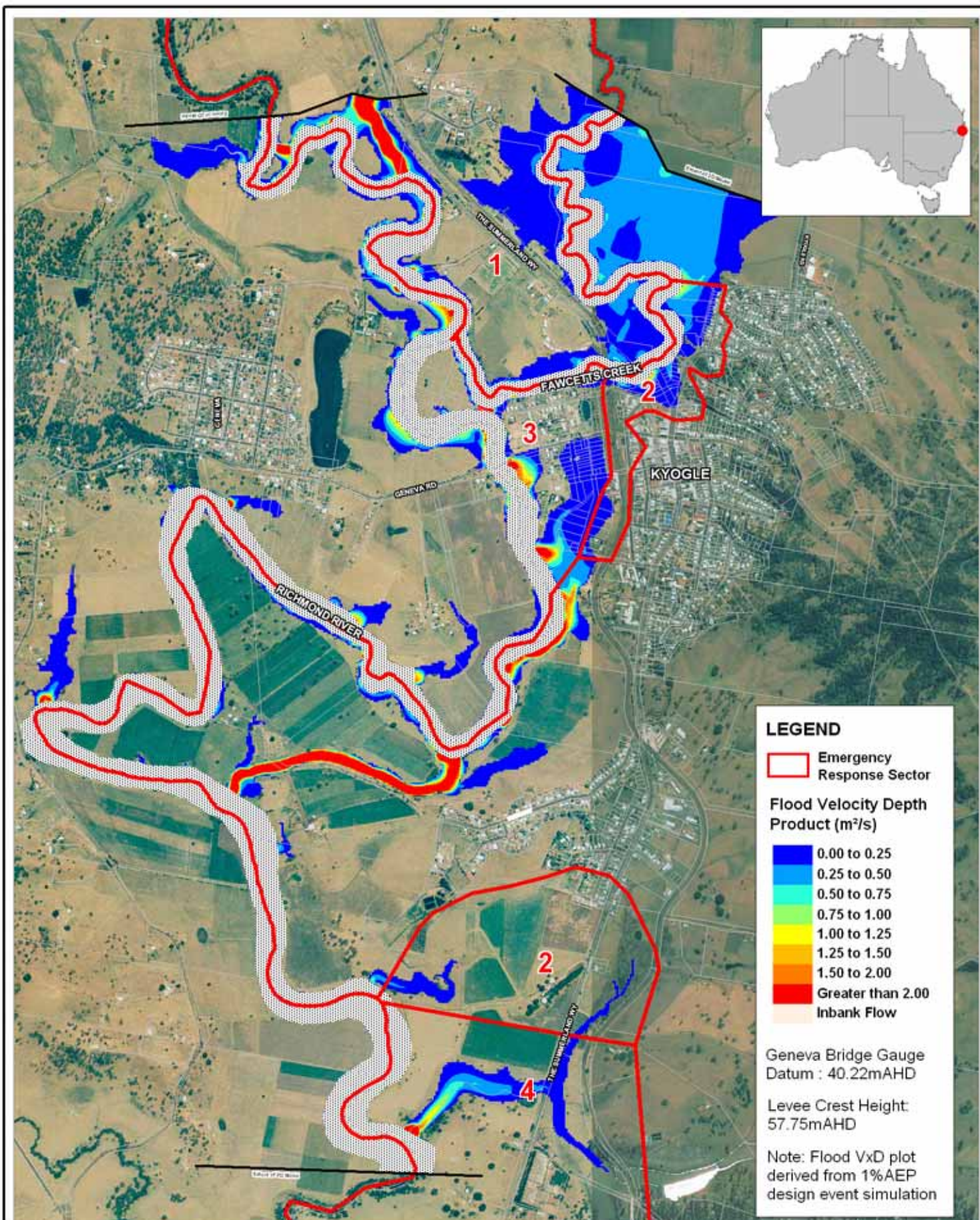
Figure:  
**B-21**

Rev:  
**A**



Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FMP\FLD\_Plan\_037\_Post\_Levee\_Emergency\_Depth17m.WOR





Title:

## Post-Levee Emergency Response Flood Velocity x Depth Geneva Bridge Gauge = 17.0m

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0 0.5 1km  
Approx. Scale

Figure:

B-22

Rev:

A

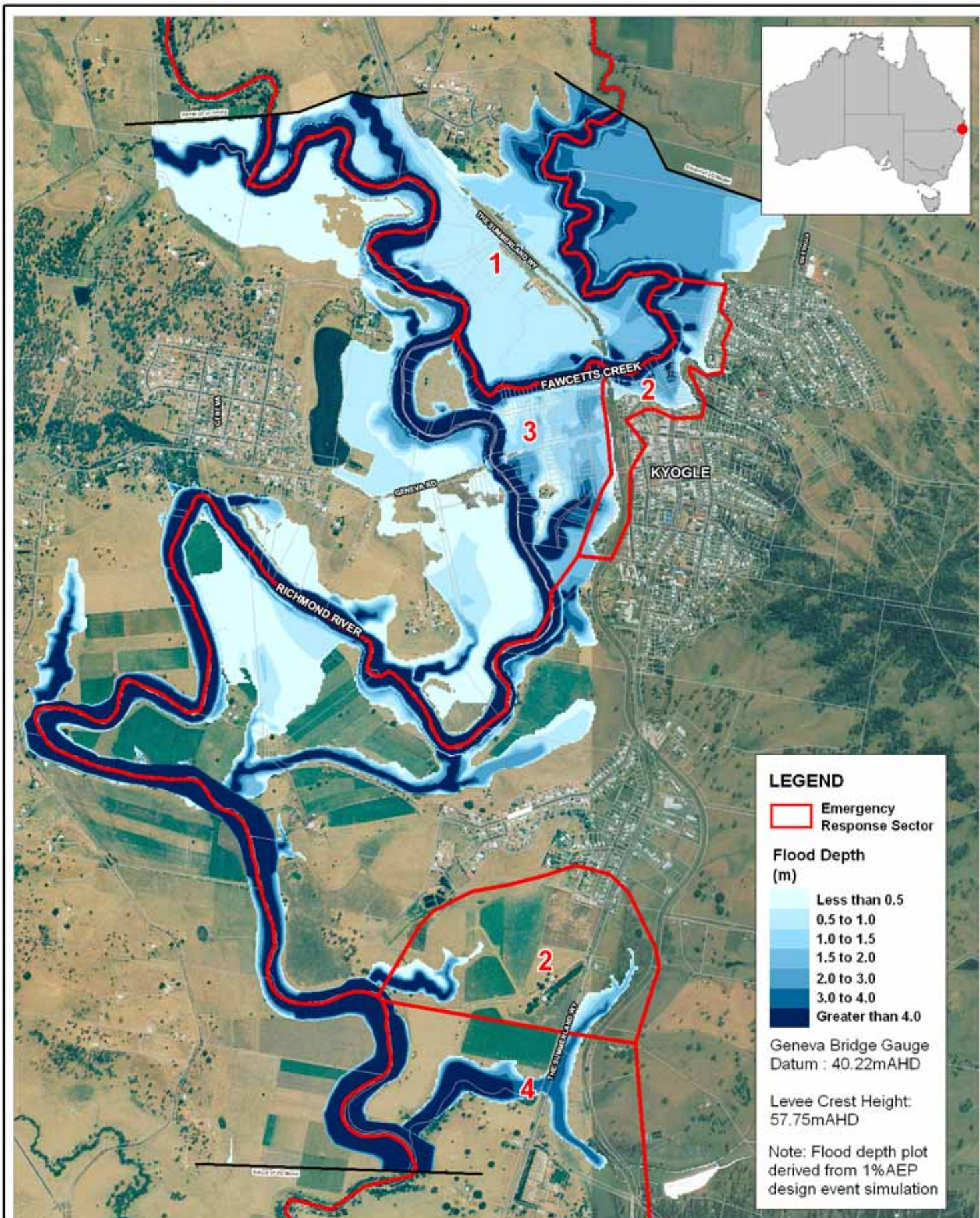


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Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_043\_Post\_Levee\_Emergency\_VD17m.WOR





Title:  
**Post-Levee Emergency Response Flood Depth  
 Geneva Bridge Gauge =18.0m**

Figure:  
**B-23**

Rev:  
**A**

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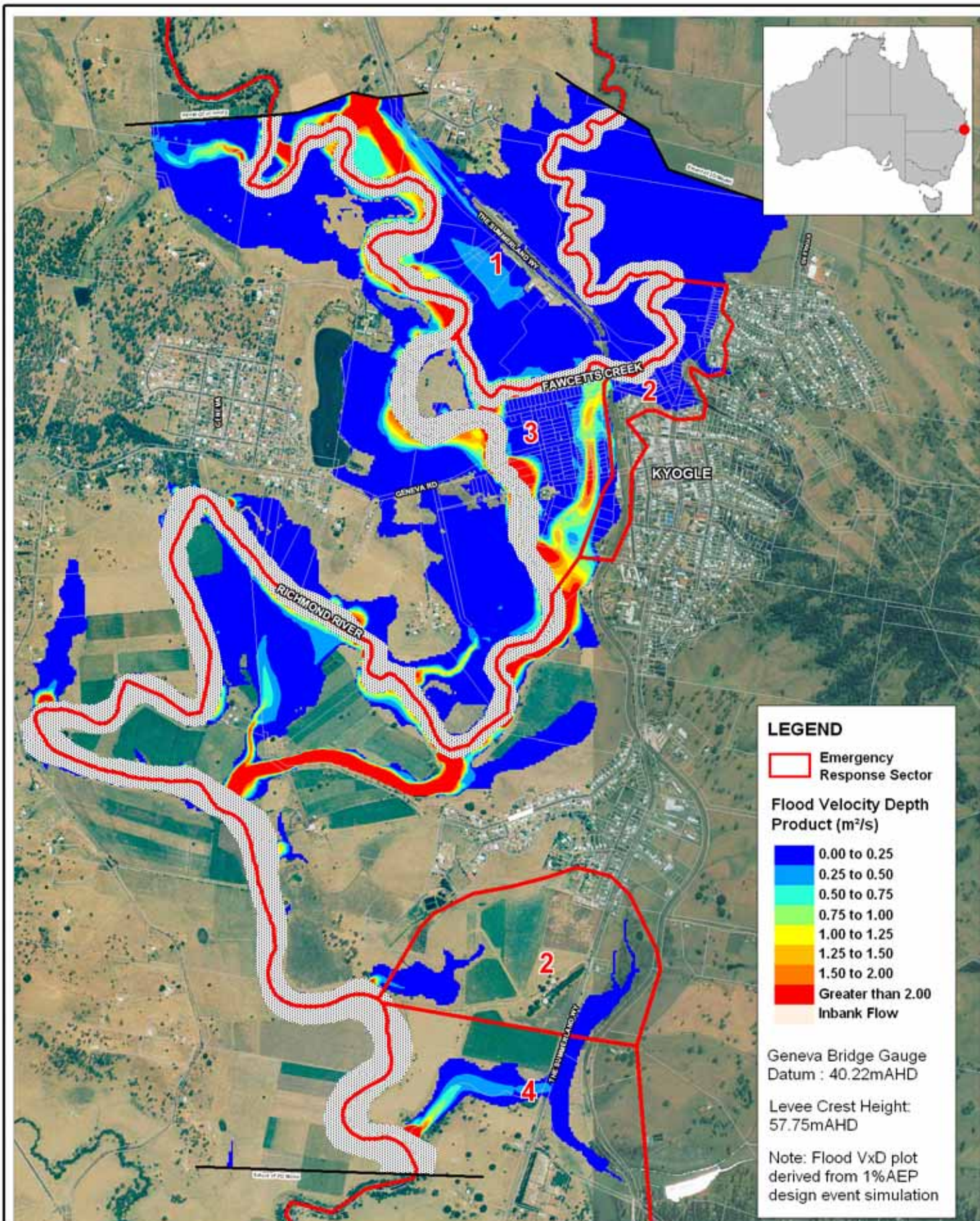


0 0.5 1km  
 Approx. Scale



Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_038\_Post\_Levee\_Emergency\_Depth18m.WOR





Title:

## Post-Levee Emergency Response Flood Velocity x Depth Geneva Bridge Gauge = 18.0m

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0 0.5 1km  
Approx. Scale

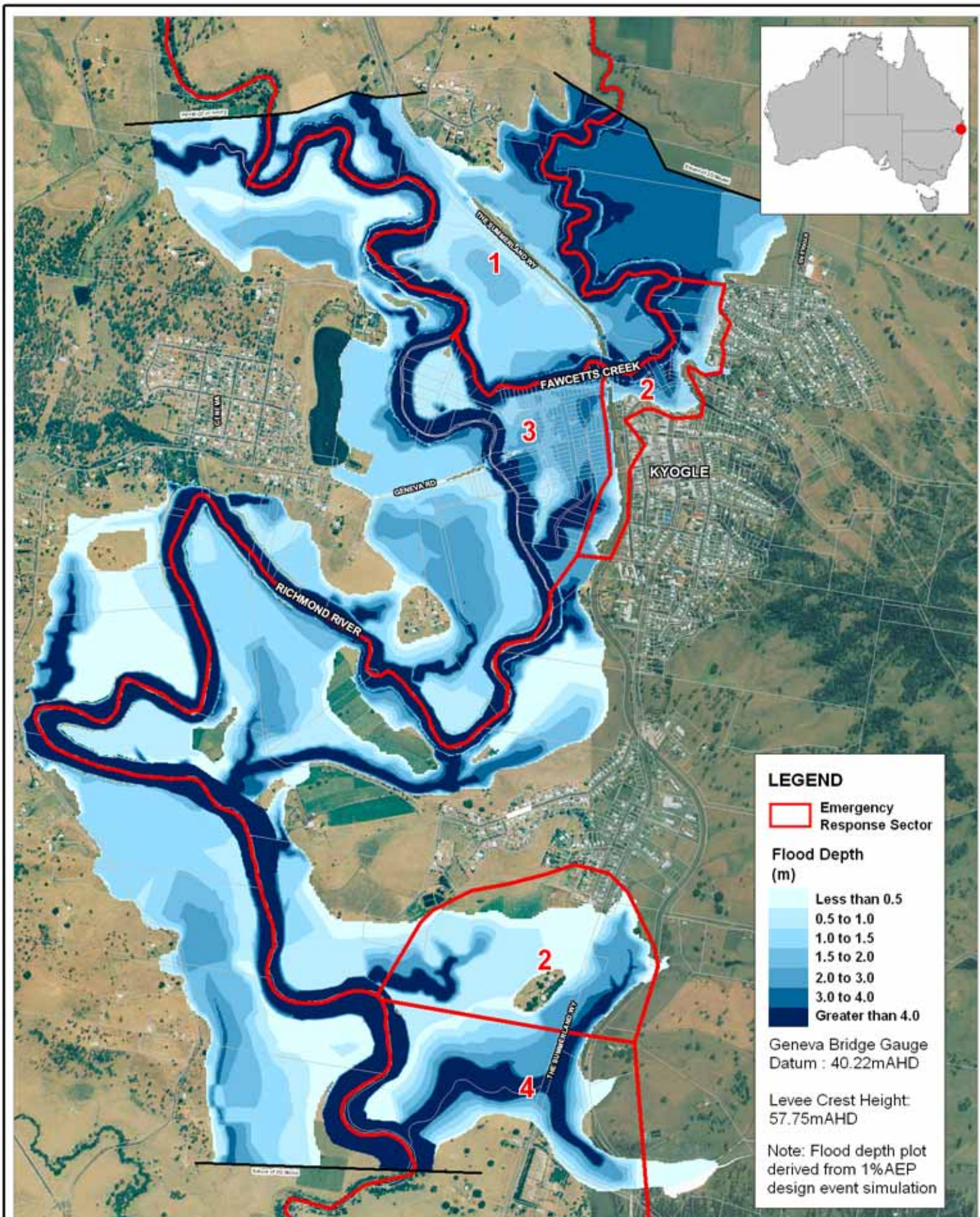
Figure:

**B-24**

Rev:

**A**





Title:

# Post-Levee Emergency Response Flood Depth Geneva Bridge Gauge =19.0m

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0 0.5 1km  
Approx. Scale

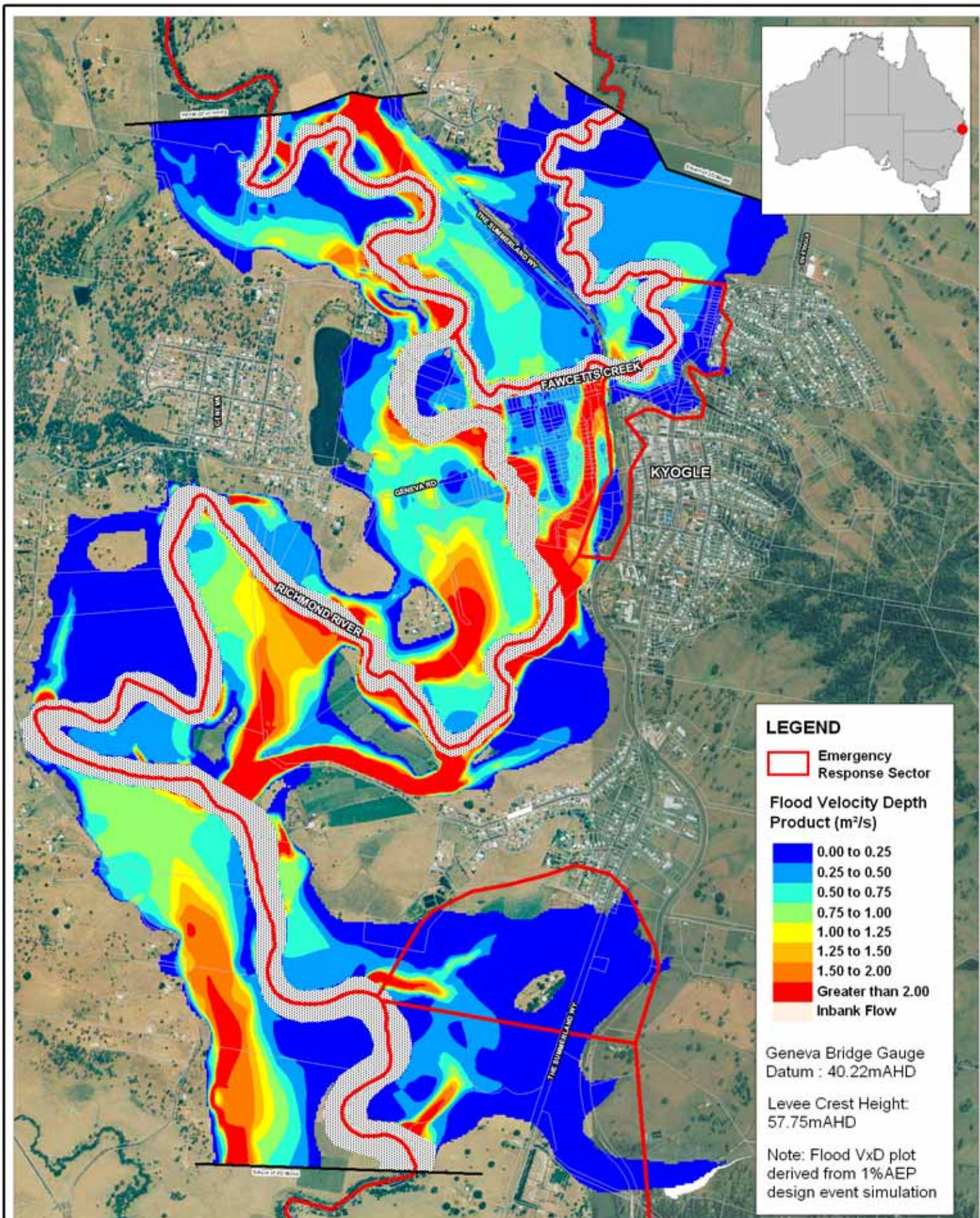
Figure:  
**B-25**

Rev:  
**A**



Filepath : I:\B15289\_I\_BRH Kyogle CLB\DRG\FPMP\FLD\_Plan\_039\_Post\_Levee\_Emergency\_Depth19m.WOR





Title:

# Post-Levee Emergency Response Flood Velocity x Depth Geneva Bridge Gauge = 19.0m

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0 0.5 1km  
Approx. Scale

Figure:

B-26

Rev:

A



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