6. Flood Damages

6.1 Introduction

The quantification of flood damages is an important part of the floodplain risk management process. By quantifying flood damages for a range of design events, appropriate management measures can be evaluated in terms of their benefits (reduction in flood damage) versus the cost of implementation.

The cost of flood damage and disruption to a community depend on a number of factors which include:

- Flood magnitude (depth, velocity and duration)
- Type of structures at risk and their susceptibility to damage
- Nature of the development at risk (residential, commercial, industrial)
- Awareness and readiness of the community to flooding
- Effective warning times
- Availability of Evacuation Plans

The potential damage associated with a particular sized flood can be divided into a number of components, which are grouped into two major categories;

- Tangible damages – financial costs of flooding quantified in monetary terms
- Intangible damages – social costs of flooding reflected in increased levels of mental stress, physical illness, inconvenience to people, etc.

Intangible damages are difficult to measure and impossible to meaningfully quantify in dollar terms. For this reason, intangible damages have not been assessed for Blayney and the following damage assessment focuses on tangible damages only. Tangible damages can be further sub-divided into two categories, direct and indirect damages, as illustrated in **Figure 6-1**.

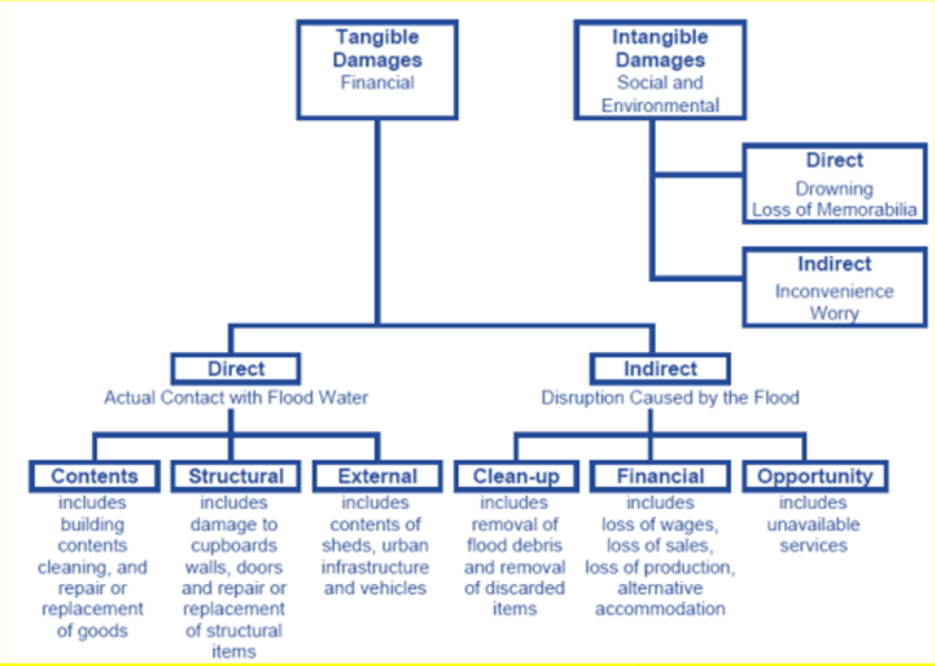


Figure 6-1 : Types of flood damages *(Source: NSW Floodplain Development Manual, 2005)*

Flood damage estimation procedures have been formulated using data collected following real flood events. Information collected includes identification of properties flooded, the extent of flooding, depth of flooding experienced, flooding mechanism etc. This information can then be used to guide and calibrate models used to calculate flood damages for a particular area. One of the most thoroughly studied flood damage assessments was that undertaken at Nyngan, following the flood in 1990.

The most common approach to present flood damage data is in the form of flood-damage curves for a range of property types, i.e. residential, commercial, public property, public utilities etc. These relate flood damage to depth of flooding above a threshold level (usually floor level).

6.2 Approach

Estimation of flood damage has focussed on residential and commercial properties in the Study Area using guidelines issued by the Department of Environment and Climate Change (DECC, October 2007) and recognised damage assessment methodologies. The estimation of damage is based upon flood depth above 'protection level', where protection level relates to the floor level minus 0.5m for properties affected by mainstream flooding, and floor level minus 0.3m for properties affected by overland flooding. It is recommended by DECC (October, 2007) that the freeboard allowance is included to ensure calculation of damage is not under-estimated.

6.2.1 Property Database

A property database was assembled using available survey and contour data. The database includes the following information for each property identified within the PMF extent in Blayney; address, floor level, ground level, modelled flood levels for each event and data source. A total of 185 buildings had floor levels surveyed as part of this study. These buildings were identified as potentially affected by the 1% AEP flood event from the aerial photography. This included 15 commercial buildings, 2 schools and 5 shed/amenity structures. For the PMF event, a large number of properties are potentially impacted. Ground levels for these buildings were estimated based on LiDAR data. Floor levels for each affected property not surveyed were estimated by assuming the floor level is 0.15m above the ground level. Flood levels were assigned to each property based on

the modelled flood surface at the building. The database was used to determine the number and extent of properties inundated above protection level for the range of flood events modelled (20%, 5%, 1%, 0.5% AEP and the PMF).

6.2.2 Residential Damage

Flood damage of residential buildings was calculated using a residential damage spreadsheet developed by the NSW Department of Environment, Climate Change and Water (DECCW, now NSW Office of Environment and Heritage) in 2007. This includes a representative stage-damage curve derived for a typical house on a floodplain to estimate structural, contents and external damage. The amount of damage is based on the flood inundation depth, for a suite of annual exceedance probability events. These values are then summed to provide a total damage for each flood event analysed. The AEP of the Probable Maximum Flood has been estimated using Figure 6 from Book VI of AR&R 2003. The AEP of the PMF event for Blayney was estimated to be 1 in 10^7.

A number of input parameters are required to determine which stage-damage curved will be adopted. The key parameters used in this assessment are shown in **Table 6-1**.

Table 6-1 Parameters adopted in residential damages assessment

Parameter	Adopted Value	Comment
Building Damage Repair Limitation Factor	0.85	Suggested range of 0.85 to 1.00 (short to long duration events). The majority of properties are impacted by overland flooding and the typical flood duration in Blayney is short.
Contents Damage Repair Limitation Factor	0.75	Suggested range of 0.75 to 0.90 (short to long duration events). The majority of properties are impacted by overland flooding and the typical flood duration in Blayney is short.
Effective Warning Time (hrs)	0	While there may be some warning of a flood for the Belubula River, it has been conservatively assumed as 0 hours for Blayney.
Level of flood awareness	Low	Guidelines suggest 'low' is adopted unless 'high' can be justified. While flooding has been experienced in Blayney, it is assumed that the level of awareness of the extent of flooding for large events is low.
House type and size	Single Storey, 240m^2	The houses in Blayney are typically single storey detached dwellings (supported by evidence gathered during site visits and Google Street View). House size was taken to be the recommended average size.

The DECCW stage-damage curves within the spreadsheet are derived for late 2001, and have been updated using an Average Weekly Earnings (AWE) factor to August 2007. AWE is used to update residential flood damage curves rather than the inflation rate measured by the Consumer Price Index (CPI). The most recent AWE value from the Australian Bureau of Statistics (ABS, 2015) at the time of the assessment was November 2015, and a factor of 1.69 was applied to all ordinates in the stage-damage residential stage-damage curves based on the increase from August 2007. Similarly, the spreadsheet was developed for the Sydney urban area. A regional cost variation factor of 1.08 was applied for Blayney based on an interpolation between the value at Bathurst (1.05) and Cowra (1.12), as presented in the Australian Construction Handbook (Rawlinsons, 2016).

6.2.3 Non-residential Building Damage

While the majority of development at risk from flooding in Blayney is residential, there are a number of commercial developments, industrial buildings and community facilities impacted by flooding. To account for the non-residential flood damages in Blayney, typical damage rates were adopted from the Town of Young Floodplain Risk Management Study and Plan (Lyall and Associates 2015). These damage rates are based on the type of enterprise and the floor area of the building. These rates are considered appropriate for potential external and internal damages and clean-up costs for both commercial and industrial damages. They are indexed to a depth of inundation of 2 metres, with floor level being 0% and 1.2m inundation being 70% of the damage costs presented in **Table 6-2**.

The proportion of buildings impacted that are non-residential is minimal and a separate detailed assessment has not been undertaken. Instead, to remain consistent with the residential damages calculations, an equivalent number of residential houses have been estimated for these buildings. In Blayney, no commercial or community buildings are affected by above floor flooding up to the 1% AEP event. It is only in the PMF event that these buildings are affected by above floor flooding. For these buildings, an equivalent number of houses were assumed, according to **Table 6-2**.

Table 6-2 Commercial and industrial flood damage rates

Enterprise type	Flood damage estimate	Examples
Low value enterprise	$280/m^2	**Commercial**: small shops, cafes, joinery, public halls. **Industrial**: auto workshop with concrete floor and minimal goods at floor level, Council or Government Deports, storage areas.
Medium value enterprise	$420/m^2	**Commercial**: food shops, hardware, banks, professional offices, retail enterprises, with furniture/fixtures at floor level which would suffer damage if inundated. **Industrial**: Warehouses, equipment hire.
High value enterprise	$650/m^2	**Commercial**: Electrical shops, clothing stores, bookshops, newsagents, restaurants, schools, showrooms and retailers with goods and furniture, or other high value items at ground or lower floor level. **Industrial**: service stations, vehicle showrooms, smash repairs

6.2.4 Vehicle Damage

An estimation of vehicle damage has been excluded from this assessment. Significant damage can be attributed to vehicles but these can be readily moved from the path of flood waters and have not been included in the flood damages calculations.

6.3 Estimated Tangible Flood Damages

An estimation of the number of properties impacted, number of properties with above floor flooding and total damage costs for each modelled flood event for the Blayney township was undertaken. The assessment was performed with the recommended protection level of 0.5m for mainstream flooding and 0.3m for overland flooding, and by using nominal floor levels also. External damages are assumed to start accumulating when floodwater is within 0.5m of the nominal floor level or floor level minus protection level. The results are provided in **Table 6-3**.

The most convenient way to express flood damage for a range of flood events is by calculating the Annual Average Damage (AAD). The AAD value is determined by multiplying the damages that can occur in a given flood by the probability of that flood actually occurring in a given year, and then summing across a range of floods. This method allows smaller floods, which occur more frequently to be given a greater weighting than the larger catastrophic floods. The AAD for the existing case then provides a benchmark by which to assess the merit of flood management options. The AAD for the existing situation for Blayney is $2.53 Million for residential and $0.14 Million for non-residential properties based on nominal flood levels. The AAD is $7.52 Million for residential and $0.47 Million for non-residential properties based on nominal flood levels with the freeboard applied.

Table 6-3 : Estimated Tangible Flood Damage for Blayney

Flood Event AEP	Nominal Flood Levels		Nominal Flood Levels Plus Freeboard	
	Number of properties flooded above floor level	Estimated Flood Damage $ Million	Number of properties flooded above protection level	Estimated Flood Damage $ Million
Residential				
20%	50	6.00	258	18.92
5%	65	7.80	316	23.31
1%	95	11.60	436	32.25
0.5%	132	13.15	456	33.92
PMF	526	43.66	698	59.92
Non-residential				
20%	5	0.23	8	1.03
5%	8	0.38	12	1.48
1%	11	0.64	19	2.32
0.5%	11	0.72	20	2.51
PMF	43	11.93	45	14.83

6.4 Summary

Flood damage in Blayney is primarily attributed to residential dwellings that are impacted by overland flooding. There are 55 properties that are estimated to experience above floor flooding for the 20% AEP event and this number increases to 106 properties for the 1% AEP event. In the PMF, 569 properties are estimated to experience above floor flooding, with damages reaching $55 million. The flood damages for the 20% to 1% AEP events, however, range from $6.23 Million to $12.24 Million when considering flood damages using nominal flood levels only. The AAD for Blayney based on nominal flood levels is $2.66 Million. The AAD is estimated at $7.52 Million based on nominal flood levels with the freeboard applied (0.3m for overland flooding and 0.5m for mainstream flooding).

Although this damage assessment is based upon tangible damages only, it is worthy to note that intangible damages could be significant for Blayney. This is due to the duration of flooding being more than a day and lack of warning of an event occurring. While flood damage estimates for Blayney are indicative only, they are useful in the evaluation of flood management options, aimed at reducing flood damage estimates while being economically viable to implement.

7. Review of Potential Floodplain Risk Management Measures

7.1 Overview

This section provides a review of available measures for flood management in Blayney. A number of floodplain measures were selected based on feedback from the community. A detailed assessment of these is included in **Section 8**.

7.2 Floodplain Risk Management Options

One of the objectives of this Floodplain Risk Management Study is to identify and compare various floodplain risk management options to deal with existing flood risk in the study area, considering and assessing their social, economic, ecological and cultural impacts and their ability to mitigate flood impacts. A Floodplain Risk Management Option can be formulated by a combination of Floodplain Risk Management Measures for the study area.

The *Floodplain Development Manual* (NSW Government, 2005) describes floodplain risk management measures in three broad categories:

- **Property modification measures** involve modifying existing properties (for example, house-raising) and/or imposing controls on new property and infrastructure development (for example, floor height restrictions)
- **Response modification measures** involve modifying the response of the population at risk to better cope with a flood event (for example improving community flood readiness)
- **Flood modification measures** involve modifying the behaviour of the flood itself (for example, construction of a levee to exclude floodwaters from an area)

A summary of the potential floodplain risk management measures is provided in **Figure 7-1**.

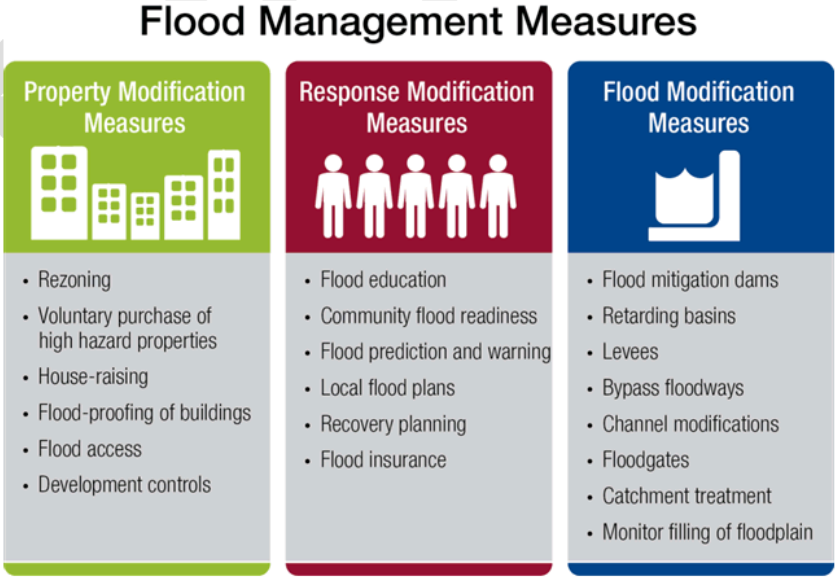


Figure 7-1 : Floodplain risk management measures

8. Floodplain Risk Management Measures

8.1 Flood Modification measures

8.1.1 Flood retarding basin

An option of retaining floodwaters in basins was considered for the town of Blayney through a review of the topographic data, nature of flooding and land use. These basins would retard a significant portion of the rainfall runoff generated from catchments which drain through the town of Blayney and discharge into the Belubula River/ Abattoir Creek. In total nine (9) potential basin sites (refer to **Table 8-1**and **Figure 8-1**) were identified. Eight of these basins would be located upstream of the urban area and store floodwaters which would be released at a much lower rate. Only one small basin is proposed within the urban area. The following assumptions were made for the basins:

- Maximum height of embankment is up to 1.5m high;
- A 0.3m diameter pipe forms the low flow outlet; and
- No spills from the basin in the 0.5% AEP event.

Table 8-1 Basin areas and peak flood depths

Basin Number	Basin Area (ha)	5% AEP - Peak flood depth (m)	1% AEP - Peak flood depth (m)	0.5% AEP - Peak flood depth (m)
1	1.81	0.84	1.16	1.18
2	2.37	0.32	0.39	0.42
3	1.53	0.76	1.13	1.23
4	1.79	0.18	0.24	0.25
5	2.62	0.40	0.59	0.64
6	0.55	0.65	1.02	1.21
7	0.98	1.21	1.46	1.48
8	3.66	0.35	0.48	0.50
9	0.32	0.94	1.22	1.43

The basins were represented in the TUFLOW model and the model was run for a range of storm durations for the 5%, 1% and 0.5% AEP events. Peak flood depths in the basins for the 5%, 1% and 0.5% AEP events are shown in **Table 8-1**. Changes in peak flood depths within the township for the 1% AEP event are shown in **Figure 8-1**. Reduction in peak flood depths up to 0.1m occurs on extensive areas within the township in the 1% AEP event. Peak flood depths are reduced between 0.1 to 0.2m in a few localised areas. Peak flood depths are reduced up to 0.5m in isolated areas.

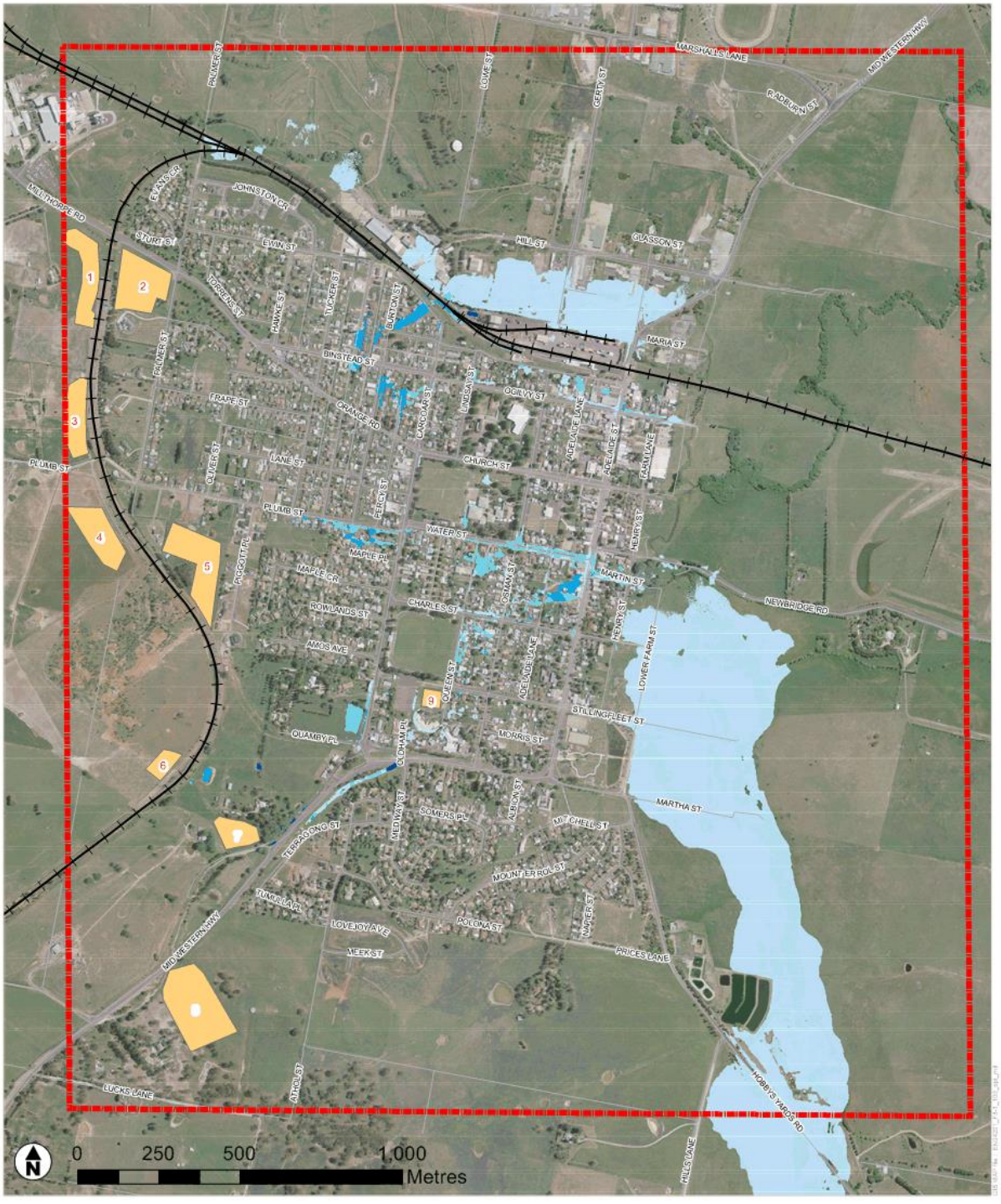
The AAD for Blayney based on nominal flood levels with adopted freeboards with the proposed basins is estimated at $5.4 Million which is approximately 71% of the AAD under the existing conditions.

The proposed basins would require approximately 16 ha of land and it would cost approximately $5.2 Million (assuming $0.30 Million/ha cost for construction in Sydney and 8% more cost for Blayney than Sydney) excluding the cost involved in acquiring the land.

Based on the savings in AAD, a Net Present Value (NPV) of the savings was estimated at $79.5 Million for protection against nominal flood levels with the adopted freeboards assuming a 7% discount rate and 50 year life of the proposed flood retarding basin. The Benefit cost ratio for the flood retarding basins is very attractive.

8.1.2 Upgrade of railway bridges

Railway bridges across the Belubula River and Abattoir Creek are major hydraulic controls. A sensitivity analysis was undertaken by doubling the existing waterways area at the two bridges for the 1% AEP event. Augmentation of waterway areas at both bridges would reduce 1% AEP flood level in Abattoir Creek downstream of Mid Western Highway up to a maximum of 0.3m. In the case of the Belubula River, the 1% AEP peak water level at the railway bridge is reduced up to a maximum of 0.4m and peak water levels downstream of the bridge are increased up to 0.15m. Given that almost all properties impacted by flooding in the Belubula River are located downstream of the railway bridge, augmenting the bridge waterway areas would aggravate flooding further. Hence, this option is not considered further in recognition of the negative impacts downstream and operational constraints of the railway and huge costs involved in duplicating the existing waterway areas at the two bridges.



Legend

lood le el di ere ce	
-0.3	
-0.2 to -0.3	
-0.1 to -0.2	
-0.05 to -0.1	
-0.01 to -0.05	
No change	
Proposed Basins	
Railway	
Study Area	

JACOBS

Data Sources: LPI, Council

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

SCALE	A3
SHEET	1 of 1
	GDA 1994 MGA Zone 55
TITLE	Difference in peak 1 AEP flood le els with proposed basins
PROJECT	Blayney FRMS
CLIENT	Blayney Shire Council
DRAWN MR	PROJECT # EN04201
MAP #	Figure -1
REV.	1
VER	1
CHECK AH	DATE 23/09/2016

8.1.3 Upgrade of stormwater system

Overland flooding is the main source of flood damages for the town of Blayney. It is noted in the Blayney Flood Study Report (Jacobs 2015) that a selected number of main branches in the overall stormwater network were represented in the TUFLOW model and typically, the selected branches were aligned with the main overland flow paths in the study area. A number of upgrade options was considered for three areas which did not result in discernible improvement in overland flood behaviour. The existing stormwater network needs to be assessed first prior to investigating options involving stormwater upgrade. In addition, there are opportunities to implement principles of water sensitive urban design to manage both quantity and quality of stormwater runoff. It is recommended that Council develops a stormwater management strategy to address both the quantity and quality of stormwater runoff.

8.1.4 Removal of willows

Willows are present along the Belubula River and its tributaries and one respondent identified removal of willows as a flood mitigation measure.

Willows can have a significant impact on channel morphodynamics, this displays alterations to flow hydraulics caused by their establishment within the channel or at its margins. Willows established on channel bed obstruct channel flow and thus has the potential to reduce bankfull capacity. In the case of the Belubula River and Abattoir Creek, widespread overbank flooding occurs in the 20% AEP event and the floodplain is the major carrier of flood flow during significant flood events. Hence willows are expected to have limited influence on movement of floodwaters during significant flood events. A detailed assessment on impacts on willows in the Macquarie River at Marebone was undertaken by Sinclair Knight Merz (at present, Jacobs) in 2008 for the then Department of Environment & Climate Change. Key outcomes from the study are summarised in the following paragraphs.

The scope of the 2008 study involved desktop reviews, site investigations and flood modelling. The desktop assessment included a review of photographs of willows captured from a helicopter in 2005. The following observations were made from a review of the photographs:

- Willow infestations were more pronounced in sinuous reaches and less a problem in the straight reaches of the Macquarie River.
- Further study would be required of earlier aerial photography to determine if the sinuous reaches where willow infestation are more evident, were also more sinuous prior to willow establishment and determine the extent of channel changes that took place since establishment.
- It is possible that sinuosity increased in sections of the channel where willows established and the effect they caused in altering channel hydraulics, greater bank scour and development of meanders. The increase in sinuosity arises due to the deflection of flows caused by willows established within the channel bed and at the margins. Accelerated scour of banks and growth of meanders occur to compensate the willow blockage.

The general impression gained from the site investigations was that the channel adjusts fairly rapidly to encroachment and quickly reinstates its former cross sectional area. During the site inspection, three main types of willow encroachment were observed:

- Willows encroach from inside bend with channel adjustment on outer bank. The pointbar is deposited such that the inside bankline migrates laterally and effectively follows the willows across the channel.
- Willows encroach from inside bend usually with some adjustment of the outer bank but this time their rate of encroachment outstrips the rate of pointbar development and they give rise to a vegetated mid-channel bar with the low flow bifurcated around them.
- Willows encroach from both sides, usually on a straight reach, to narrow the waterway. Channel adjustments appeared to be local incision of the bed and bank toes to retain cross sectional area through a deeper and narrower channel.

The hydraulic modelling undertaken for the study indicated negligible improvement in bankfull capacity due to removal of willows. There was however a slight increase in peak flow velocity. As noted above, the channel is

able to accommodate its morphology so that hydraulic capacity is not compromised by willow encroachment but at the price of loss of agricultural lands on the opposite bank to the willows. In addition, willows have significant impact on river health, and if no action is taken further encroachment and establishment of willows in areas presently unaffected can be expected to occur. The likely endpoint if untreated will be a monoculture of willows through this section of the Macquarie River.

On the basis of the above, it is recommended that Blayney Shire Council in association with The Central West Acclimatisation Society would continue to remove willows from the Belubula River and its tributaries in consultation with Central Tablelands Local Land Services and the OEH from the Belubula River. Removal of willows would improve the health of the waterways.

8.1.5 Improved flood access to the retirement village

Shallow flooding occurs in the 20% AEP event along Henry Street and access to the retirement village located on Henry Street between Church Street and Burns Street is lost during larger flood events. This section of Henry Street is classified as floodway and two units within the retirement village are subject to above floor flooding in the 1% AEP event. Both Burns Street and Church Street are overland flowpaths and raising the section of Henry Street between Church and Burns Street would impede overland flooding and drainage from the retirement village would be problematic. Vehicular access to the retirement village during significant flood event would be hazardous. Internal walkways within the village are to be used to evacuate to Church Street.

8.2 Property Modification Measures

8.2.1 Voluntary purchase

There are two residential properties in Blayney which are located on high hazard area. One property encroaches the floodway and the other property is located on flood storage area. Both properties may be considered for voluntary purchase.

8.2.2 House raising

There are 87 residential properties which are subject to above floor flooding in Blayney in the 1% AEP event and seven of the residential properties are impacted in the 1% AEP event due to flooding in the Belubula River. Whilst it would be possible to mitigate flooding to properties subject to overland flooding by flood modification measures (eg. flood retarding basins and upgrade of stormwater network), three properties (including two properties identified for voluntary house purchase) which are impacted by mainstream flooding, voluntary house raising is considered the most feasible option.

8.2.3 Flood proofing

Flood proofing measures may also be applied to the houses that experience above floor flooding up to the 1% AEP event. This may take the form of measures such as making lower levels water tight or providing bunding around houses to divert floodwaters around the building. These options, however, are not considered feasible due to potential impacts on neighbouring properties.

8.3 Response Modification Measures

8.3.1 Local flood plan

Having a local flood plan is important for the community and State Emergency Service (SES) to be prepared when there is a flood. The plan would outline preparedness measures and the response to flooding in the area. The strategies and personnel responsible for their implementation would be detailed along with the plan for recovery afterwards. A local flood plan may prove to be a valuable resource in times of flood in order to coordinate a strategy to reduce flood risks. A Local Flood Plan for the Shire of Blayney is available and the SES needs to update the Plan using information available in this report and the Blayney Flood Study Report (Jacobs 2015).

8.3.2 Flood education and awareness

Flood education and awareness should be promoted throughout the town of Blayney. Residents living on an overland flow path should be aware of this and have personal safety plans in place in case of a flood. This is most effectively implemented through signposting. On all roads that experience a high flood hazard during the 1% AEP event, flood signage should be implemented. This includes a "Road subject to flooding" sign, along with a flood depth indicator. Signposting alerts residents to the issues of flooding in the local area and provides information about real time flooding conditions during an event and helps people manage where they travel. Additionally, Council or SES may run educational workshops or distribute information sheets to help people plan and prepare for a flood. Knowledge about local flooding issues is a valuable tool to equip the public with.

Section 149 certificate issued by Council could be used to inform property owners about flood risk to their properties.

8.3.3 Development control planning

Development controls should be in place and applicable to the flood planning area (FPA). Minimum floor levels should be set at least, 0.5m for areas subject to mainstream flooding and elsewhere a 0.3m freeboard above the adopted 1% AEP flood level. No new development or re-development allowed on floodways and Main Overland Flowpath. New residential buildings should be constructed using flood-compatible materials to withstand hydrostatic pressures and debris load. Allowance for the passage of water should be considered, including the porous fencing. All new developments/redevelopments should be assessed in light of the findings presented in the 'Blayney Flood Study Report' (Jacobs, 2015) and in this Floodplain Risk Management Study (Jacobs, 2016).

8.3.4 Flood warning

A flood warning system for Blayney has the potential to reduce flood risk. Overland flooding in Blayney is generally very shallow and there are minimal areas where a high flood risk is present. Overland flooding as a result of catchment flows will also occur within a short space of time, providing very little warning.

Flood warnings are issued by the Bureau of Meteorology to advise that flooding is occurring or expected to occur in a geographical area based on defined criteria. Flood warnings may include either qualitative or quantitative predictions or may include a statement about future flooding that is more generalised. The type of prediction provided depends on the quality of real-time rainfall and river level data, the capability of rainfall and hydrological forecast models and the level of service required.

A quantitative or qualitative flood warning of **Minor**, **Moderate** or **Major** flooding is provided in areas where the Bureau has specialised warning systems. They provide advanced warning about the locations along river valleys where flooding is expected, the likely class of flooding and when it is likely to occur. Predictions of expected water levels and the timing of flood peaks are provided at key forecast locations.

The Bureau also provides generalised flood warnings when there is not enough data to make specific predictions or in the developing stages of a flood. They typically rely on forecast rainfall and knowledge of historical flood response. Generalised warnings contain statements advising that flooding is expected in particular river valleys but do not provide information about flood class nor precise locations.

As part of its Severe Weather Warning Service, the Bureau also provides warnings for severe weather that may cause flash flooding. SES needs to consider providing flash flood warnings in Blayney.

8.3.5 Improved flood evacuation

Flood evacuation from Blayney is under the control of the SES and the SES needs to update the current evacuation planning based on information presented in this report.

9. Draft Floodplain Risk Management Plan

9.1 Recommended Measures for Blayney

Measures considered	Required Funding	Features of the Measure	Recommended Priority Rankings
1. Update the Local Flood Plan for Blayney.	SES costs	• SES to update the flood intelligence for the town of Blanyey and monitor flood behaviour in Abattoir Creek and the Belubula River. • SES to update the Local Flood Plan for Blayney utilising information in this study and the Blayney Flood Study Report (Jacobs 2015).	**High Priority:** this measure has a high priority for inclusion in the FRMP. It does not require Government funding and it has a high priority in terms of managing flood risk to people.
2. Implement controls over future residential development/ re-development in flood prone areas in Blayney.	Council costs	• Floor levels of new residential developments are to be located at the adopted Flood Planning Level (1% AEP flood levels plus the adopted freeboard). • No development or re-development is to be approved on floodways and Major Overland Flowpaths identified in the Blayney Floodplain Risk Management Study (Jacobs 2016). • All new residential buildings within the Flood Planning Area are to be constructed using flood compatible materials to withstand hydrostatic pressures and debris load • Council to provide information on flooding in Section 149 certificate • A cumulative flood impact assessment is to be undertaken for all development applications involving significant earthworks within the Blayney Flood Planning Area. • Evaluation of development proposals to use data presented in the Blayney Flood Study Report (Jacobs 2015) and in this FRMS, 2016	**High Priority:** this measure has a high priority for inclusion in the FRMP. It does not require additional local Government funding.

Measures considered	Required Funding	Features of the Measure	Recommended Priority Rankings
		• Council to develop a stormwater management strategy to implement principles of water sensitive urban design for the town of Blayney.	
3. Provide flood signage and flood depth indicators at major roads crossing to enhance flood education and preparedness.	$15,000	• Provide flood signage and flood depth indicators at major roads crossing within the study area (approximately 30 signs)	**High Priority:** this measure would improve flood education and flood preparedness for residents and has a high priority in terms of managing flood risk to people.
4. Protect existing development from overland flooding.	$0.20 Million	• Initial investigations and assessments required in the preparation of concept design and cost estimates for the required works involving flood retarding basins.	**High Priority:** this measure would ensure that concept design and cost estimates are prepared to improve flood affection to existing developments from overland flooding.
5. Voluntary house purchase/ voluntary house raising	$0.65 Million	• Initial investigation to identify willingness of owners for voluntary house purchase/raising of two residential properties and voluntary house raising of one residential property impacted by mainstream flooding. • Capital costs of voluntary purchase and demolition and landscaping of two properties and voluntary house raising of one residential property.	**Medium Priority:** this measure would ensure that no residential buildings are damaged in the 1% AEP event by mainstream flooding. A high priority is to be given to the initial investigation so that the preference of property owners are known and the cost of managing flood risk to properties can be finalized.

10. Acknowledgement

The study was carried out by Jacobs Group Australia Pty Ltd with funding provided from Blayney Shire Council and the Commonwealth and NSW Governments, through the NSW Office of Environment and Heritage.

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

- Residents of Blayney;
- Councillors and Council staff from Blayney Shire Council;
- Members of the Floodplain Management Committee, and
- Office of Environment and Heritage.

11. References

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12. Glossary

Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrences of a flood as big as or larger than the selected event. For example, floods with a discharge as great as or greater than the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
Development	Is defined in Part 4 of the EP&A Act In fill development: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. New development: refers to development of a completely different nature to that associated with the former land use. Eg. The urban subdivision of an area previously used for rural purposes. New developments involve re-zoning and typically require major extensions of exiting urban services, such as roads, water supply, sewerage and electric power. Redevelopment: refers to rebuilding in an area. Eg. As urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either re-zoning or

	major extensions to urban services.
DRAINS	DRAINS is a comprehensive program for designing and analysing urban stormwater drainage systems
Effective Warning Time	The time available after receiving advise of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
Flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
Flood liable land	Is synonymous with flood prone land (i.e.) land susceptibility to flooding by the PMF event. Note that the term flooding liable land covers the whole floodplain, not just that part below the FPL (see flood planning area)
Floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is flood prone land.
Floodplain risk management options	The measures that might be feasible for the management of particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
Floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually include both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defines objectives.
Flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at state, division and local levels. Local flood plans

	are prepared under the leadership of the SES.
Flood planning levels (FPLs)	Are the combination of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the "designated flood" or the "flood standard" used in earlier studies.
Flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings and structures subject to flooding, to reduce or eliminate flood damages.
Flood readiness	Readiness is an ability to react within the effective warning time.
Flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. Existing flood risk: the risk a community is exposed to as a result of its location on the floodplain. Future flood risk: the risk a community may be exposed to as a result of new development on the floodplain. Continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
Flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas

Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
Full supply level (FSL)	The normal maximum operating water level of a water storage when not affected by floods. This water level corresponds to 100% capacity.
Hazard	A source of potential harm or situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community.
Local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
m AHD	Metres Australian Height Datum (AHD)
m/s	Metres per second. Unit used to describe the velocity of floodwaters.
m^3/s	Cubic metres per second or "cusecs". A unit of measurement of creek or river flows or discharges. It is the rate of flow of water measured in terms of volume per unit time.
ML	Megalitres. Unit used to describe large volumes.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
Modification measures	Measures that modify the flood, the property or the response to flooding.
Overland flow path	The path that floodwaters can follow as they are conveyed towards the main flow channel or if they leave the confines of the main flow

	channel. Overland flow paths can occur through private property or along roads.
Probable Maximum Flood (PMF)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation couplet with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
RORB	A computer program used in the estimation of rainfall runoff
Runoff	The amount of rainfall which actually ends up as a streamflow, also known as rainfall excess.
Stage	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
SES	State Emergency Service of New South Wales.
Stage hydrograph	A graph that shows how the water level at particular location changes with time during a flood. It must be referenced to a particular datum.
XP-RAFTS	A computer program used in the estimation of rainfall runoff

Appendix A. Questionnaire

Flood Study for the Town of Blayney

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

The study is aimed at addressing the flooding issues due to riverine (Belubula River and its tributaries) and overland flooding and their combined impacts on flooding within the Town of Blayney. The Consultant would like to receive feedback from the community on a number of issues and topics already highlighted by the Council with regard to flooding in the Town of Blayney.

If you cannot answer any question in the questionnaire, or do not wish to answer a question, then leave it unanswered and proceed to the next question. **Your input to this important study will be greatly appreciated.** If you need additional space, please add sheets. **Please send your response** to this questionnaire **by 31 August 2013 using the attached reply paid envelope**.

If you would prefer to provide a letter with your comments to the Consultant, this would also be welcomed. Contact details of the Consultant's Project Manager are provided below:

Akhter Hossain
P O Box 164
St Leonards, NSW 1590
email: ahossain@globalskm.com

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

Quest-ion No.	Question and Answer
1.	**Do you live (reside) or have lived in the study area shown on Map 1?** A Yes (Please provide your address and put an 'X' on the relevant map) .... B No (Go to Question 3)
2.	**Do you own or rent your residence in the study area shown on Map 1?** A Own B Rent C How long have you lived in the study area? (Please write number of years)……..... ***If you are not sure whether you are in the map or not, please provide address
3.	**Do you own or manage a business in the study area?** A Yes, For how many years? …… B No (go to Question 5)
4.	**What kind of business is yours?**

Quest-ion No.	Question and Answer
	A Home based business B Shop/commercial premises C Light industrial D Heavy industry E Others, please write type of business ……
5.	**Have you had any experience of flooding (due to both Belubula River/ Farm Creek and/or storm events as well) in and around where you live or work?** A Yes B No (Go to Question 15)
6.	**How deep was the floodwater (from both Belubula River/ Farm Creek and/or storm water as well) in the worst flood/ storm event that you experienced?** Please estimate the depth ……..... What was the year of this flood?…… Where was this flood? A At your house? B At work? C Elsewhere? Please provide the street address for this flood? …….....
7.	**How long did the floodwaters stay up?** A Less than 2 hours B less than 6 hours C Approximately 1 day
8.	**What damage resulted from this flood in your residence?** (Please indicate either "none", "minor", "moderate" or "major". A Damage to garden, lawns or backyard B Damage to external house walls C Damage to internal parts of house (floor, doors, walls etc) D Damage to possessions (fridge, television etc) E Damage to car F Damage to garage G Other damage, please list……. H What was the cost of the repairs, if any?…….....
9.	**What damage resulted from this flood in your business?** (Please indicate either "none", "minor", "moderate" or "major".) A Damage to surroundings B Damage to building C Damage to stock D Other damages, please list…….. E What was the cost of the repairs, if any?…….
10.	**Was vehicle access to/from your property disrupted due to floodwaters during the worst flooding/ storm event?** A Not affected B Minor disruption (roads flooded but still driveable) C Access cut off
11.	**Did you or members of your family required assistance from SES during flood events?**

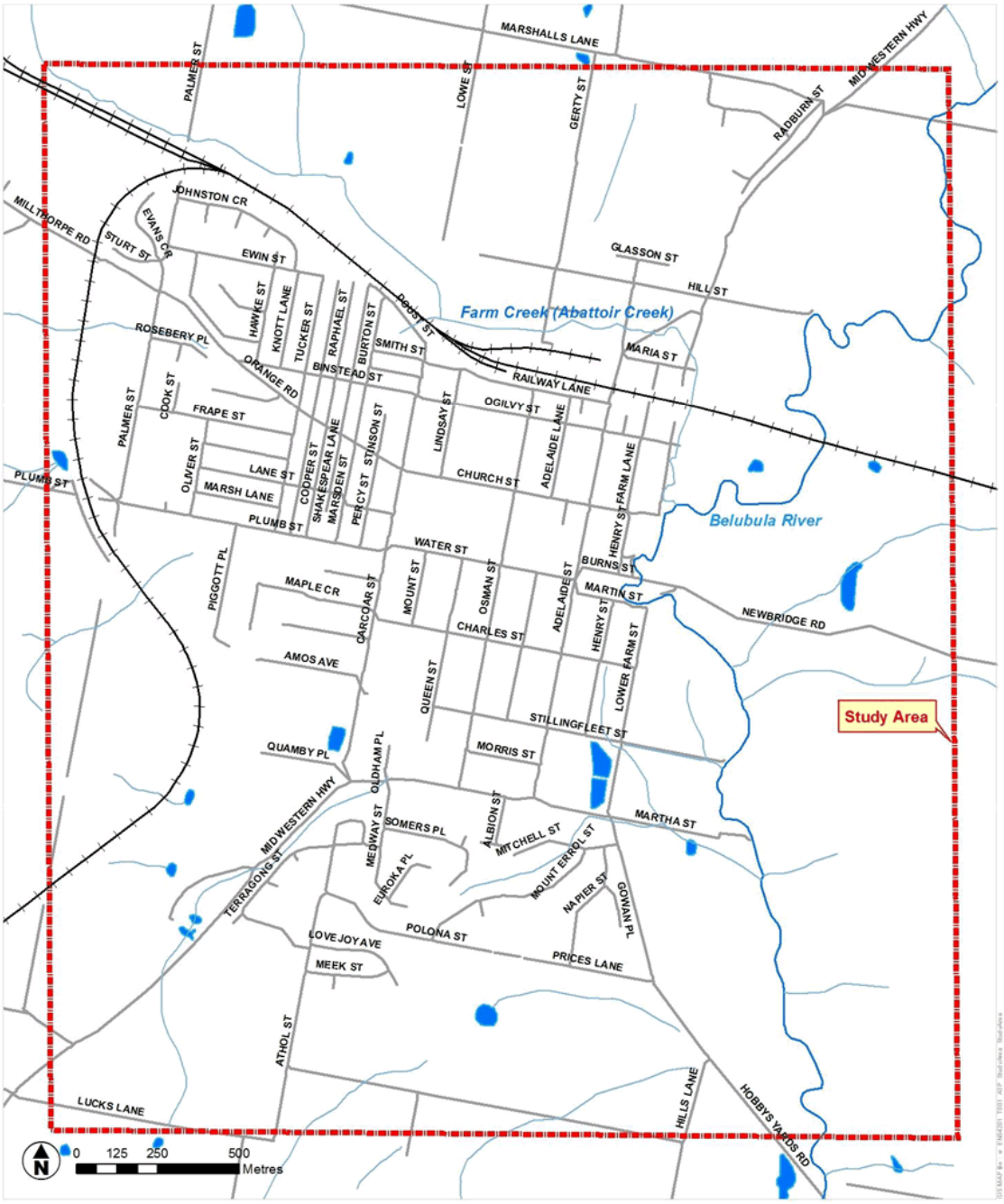
2

Questionnaire for the Town of Blayney

Quest-ion No.	Question and Answer
	A No B Yes, Please specify how many times (in total) members of your family required assistance? .....
12.	**What information can you provide on past floods/ storm events that created flooding?** (You can tick more than one item). Please write any descriptions at the end of the questionnaire A No information B Information on extent or depth of floodwater at particular locations, newspaper clippings or other images on the past floods C Any permanent marks indicating maximum flood level for particular floods D Memory of flow directions, depth or velocities
13.	**Do you consider that flooding of your property has been made worse by works on other properties, or by the construction of roads or other structures?** A Yes (please provide further details and attach extra pages if necessary. Please provide a sketch if possible). B Unsure C No
14.	**Do you have any photographs of past floods that would be useful for the consultant to help him understand the area flooded or other flood effects and are you willing to provide copies?** If possible please attach the photographs (with dates and location) which will be copied and returned. A Yes (either attach or the consultant will contact you to arrange for a copy to be made and returned) B No
15.	**Do you expect to undertake any further development on your land in the future?** A No B Minor extensions C New building D Unsure E Other (please specify) _____
16.	**Please rank the following development types according to what you consider should be assigned greatest priority in protecting from flooding** (1 = greatest priority to 7 = least priority). **Please identify specific items if necessary**. A Commercial B Heritage items, please specify _____ C Residential D Community facilities (schools, halls, etc.) _____ E Critical utilities (power substations, telephone exchanges, etc.) _____ F Emergency facilities (Hospital, Police Station, etc.) _____ G Recreation areas and facilities _____
17.	**Please rank the following by placing numbers from 1 to 6 (1 = greatest priority to 6 = least priority) next to A, B, C, D, E and F.** A Protecting residents/business from flooding B Protecting land of residents/businesses from flooding

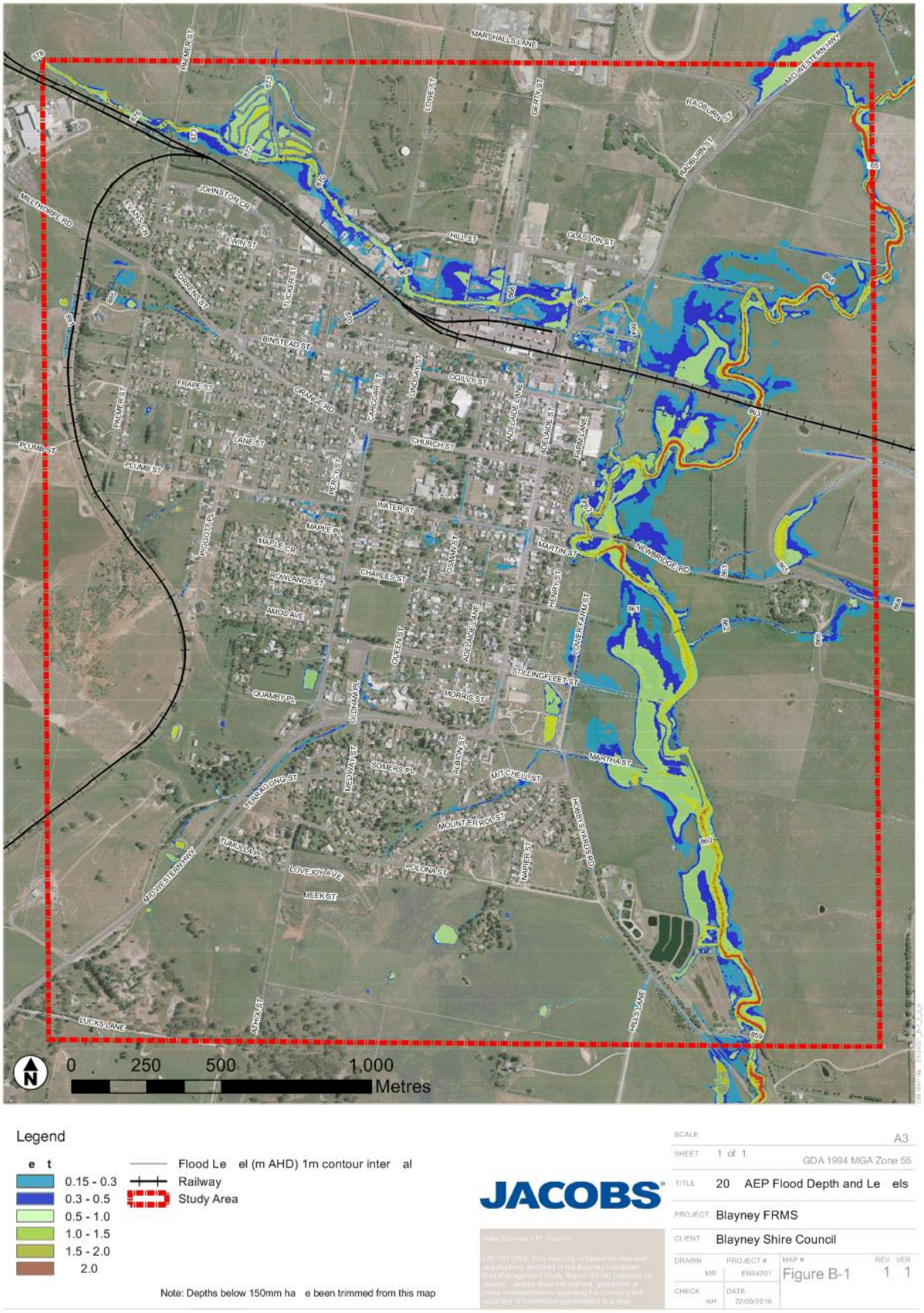
Quest-ion No.	Question and Answer
	C Maintaining an emergency flood free access D Providing flood signage for public safety E Support from SES F Providing flood warning
18.	**Do you wish to comment on any other issues associated with this study? Please add comments at the end of the questionnaire or please indicate your willingness to answer questions over the phone?** _____ _____ _____ _____
19.	**Do you wish to remain on the mailing list for further details, Newsletters etc?** A Yes (please provide contact details, see next question) B No
20.	If you would like, please provide details of where you live and how we can contact you if we need to follow up on some details or seek additional comment. **Name:** _____ **Address:** _____ _____ **Telephone: .....** **Fax: .....** **Email:…….....**
	Space for additional comments _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____

Map 1 – Study Area for the Town of Blayney



Do you have any information about flooding in your area?

Appendix B. Flood Maps and Peak Water Level profiles



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Flood Le el (m AHD) 1m contour inter al
Railway
Study Area

Note: Depths below 150mm ha e been trimmed from this map

JACOBS

SCALE	A3
SHEET	1 of 1
	GDA 1994 MGA Zone 55
TITLE	20 AEP Flood Depth and Le els
PROJECT	Blayney FRMS
CLIENT	Blayney Shire Council
DRAWN MR	PROJECT # EN04201
MAP #	Figure B-1
REV	1
VER	1
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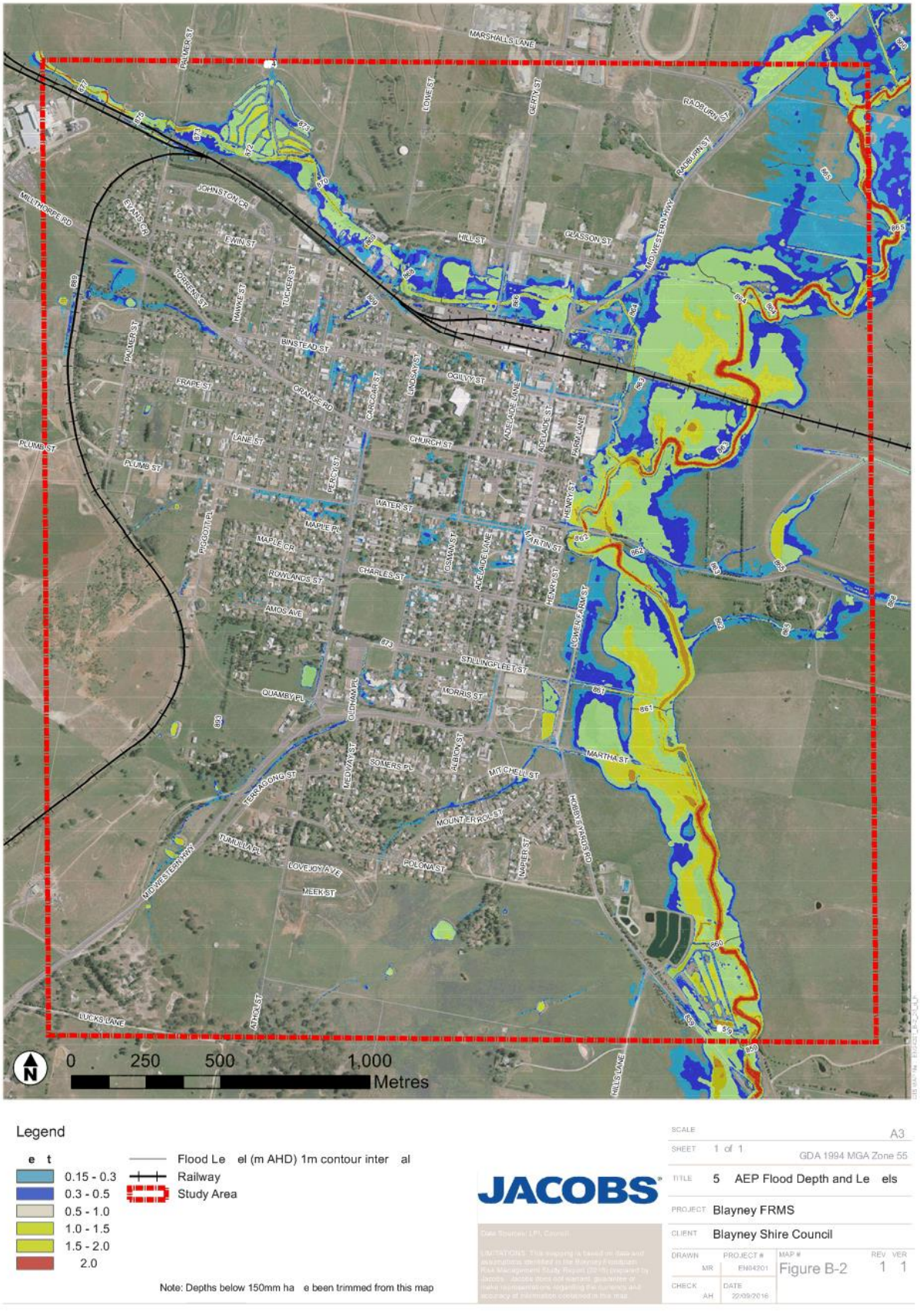

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Flood Le el (m AHD) 1m contour inter al
Railway
Study Area

Note: Depths below 150mm ha e been trimmed from this map

JACOBS

SCALE	A3
SHEET	1 of 1
	GDA 1994 MGA Zone 55
TITLE	5 AEP Flood Depth and Le els
PROJECT	Blayney FRMS
CLIENT	Blayney Shire Council
DRAWN MR	PROJECT # EN04201
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VER	1
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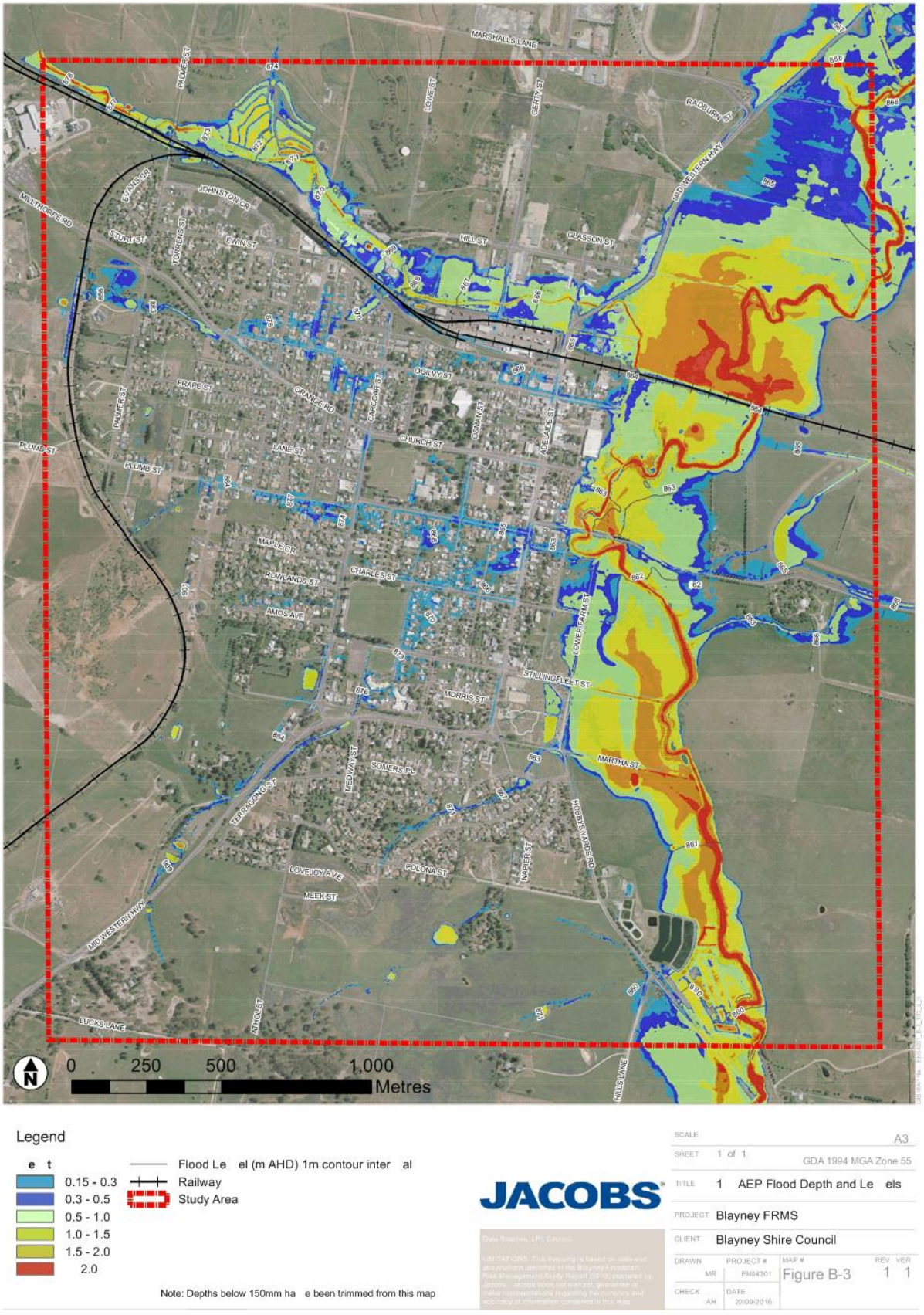
MARSHALLS LANE
RADBURN ST
MID WESTERN HWY
MILLTHORPE RD
STUART ST
JOHNSTON CR
WILL ST
GLASSON ST
OCILVY ST
FRAPE ST
CRANFORD RD
CARCOMA ST
CHURCH ST
ADELAIDE ST
PLUMB ST
MAPLE CR
ROWLANDS ST
CHARLES ST
AMOS AVE
ST LUNGFLEET ST
MORRIS ST
MARTHA ST
SOMERS PL
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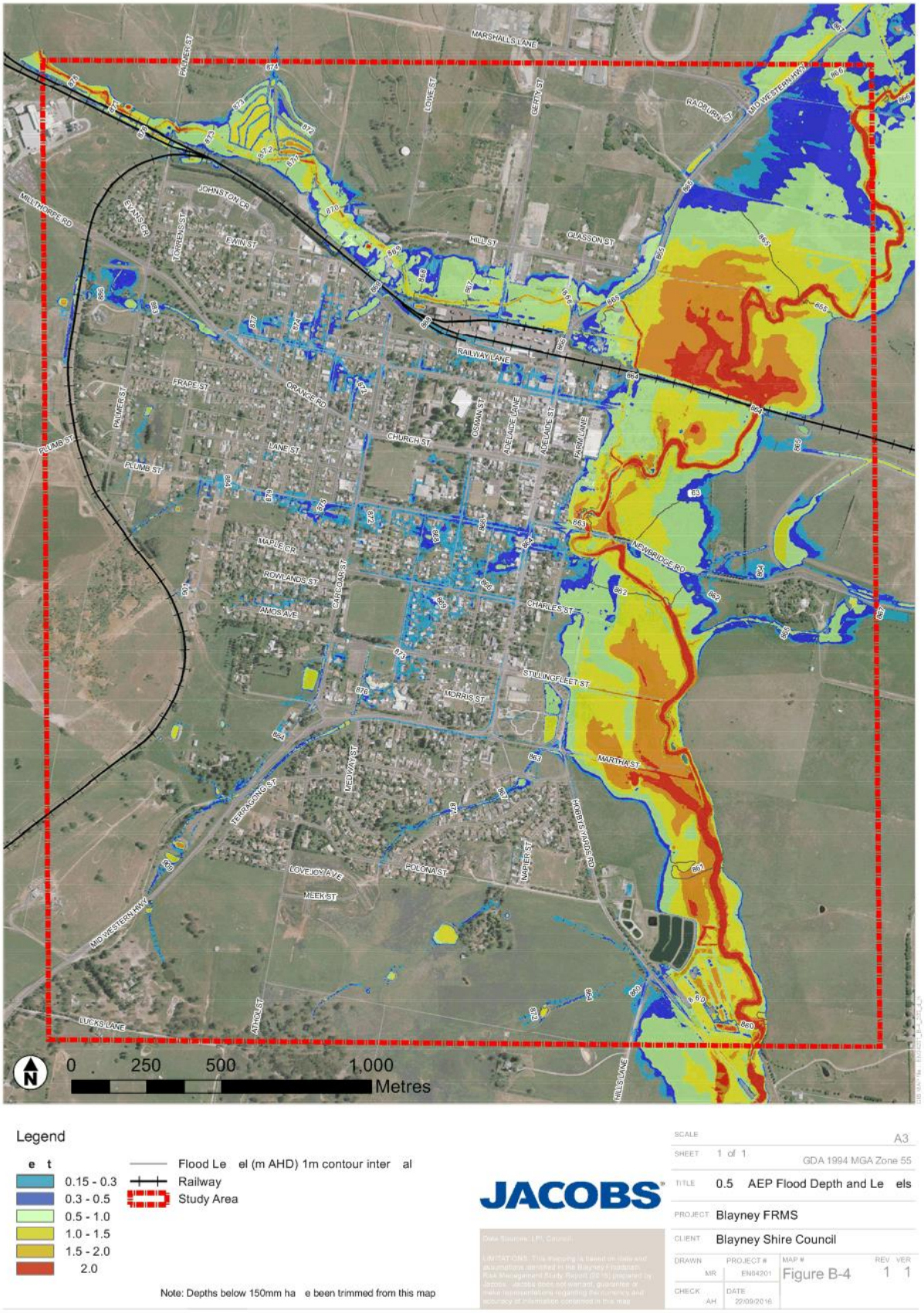
Railway
Study Area
Note: Depths below 150mm ha e been trimmed from this map
JACOBS
A3
1 of 1
GDA 1994 MGA Zone 55
1 AEP Flood Depth and Le els
Blayney FRMS
Blayney Shire Council
Figure B-3



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Flood Le el (m AHD) 1m contour inter al
Railway
Study Area

Note: Depths below 150mm ha e been trimmed from this map

JACOBS

SCALE A3
SHEET 1 of 1 GDA 1994 MGA Zone 55
TITLE 0.5 AEP Flood Depth and Le els
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CLIENT Blayney Shire Council
DRAWN MR PROJECT # EN64201 MAP # Figure B-4 REV 1 VER 1
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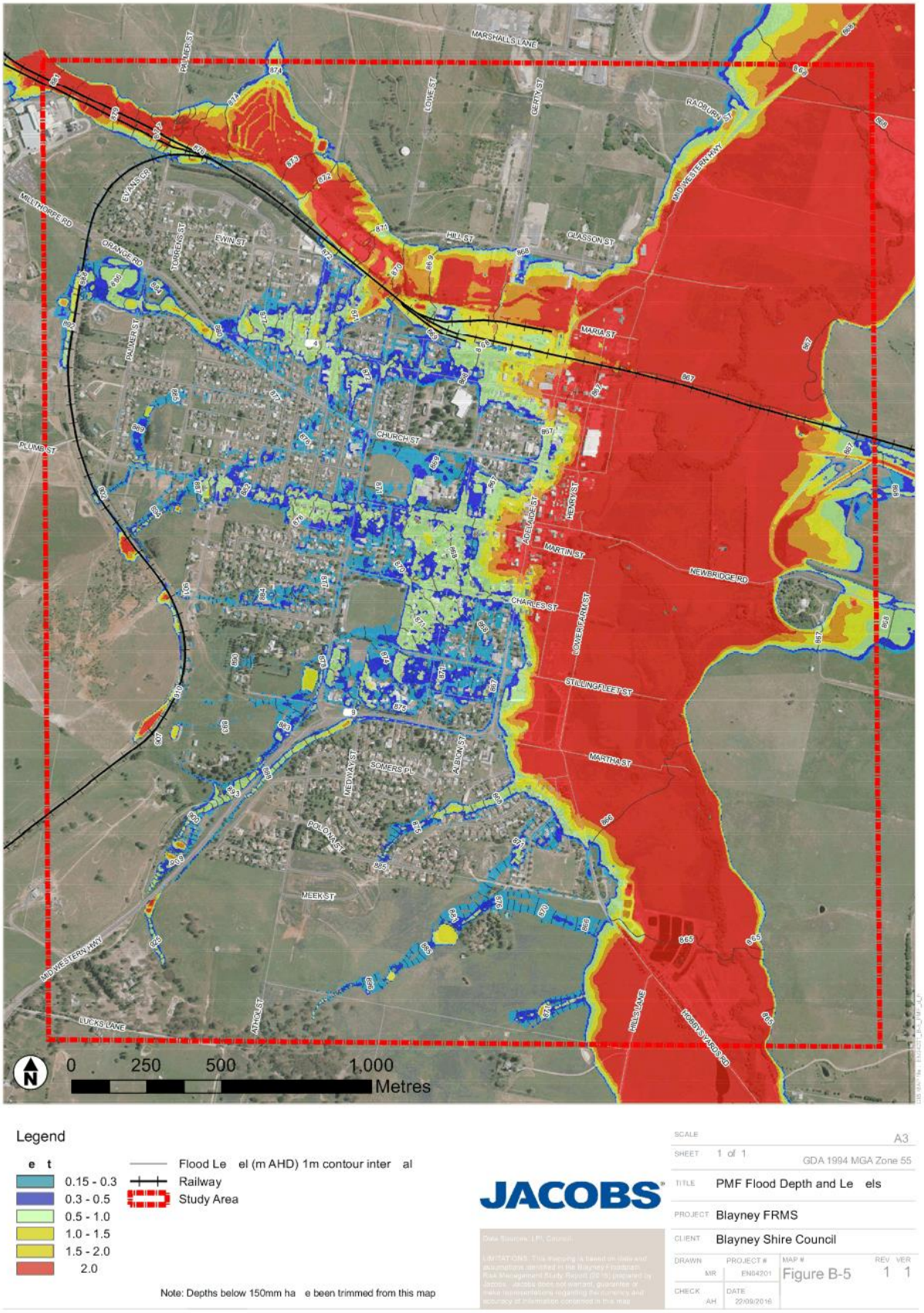

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2.0

Flood Le el (m AHD) 1m contour inter al
Railway
Study Area

Note: Depths below 150mm ha e been trimmed from this map

JACOBS

SCALE	A3
SHEET	1 of 1
	GDA 1994 MGA Zone 55
TITLE	PMF Flood Depth and Le els
PROJECT	Blayney FRMS
CLIENT	Blayney Shire Council
DRAWN MR	PROJECT # EN04201
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VER	1
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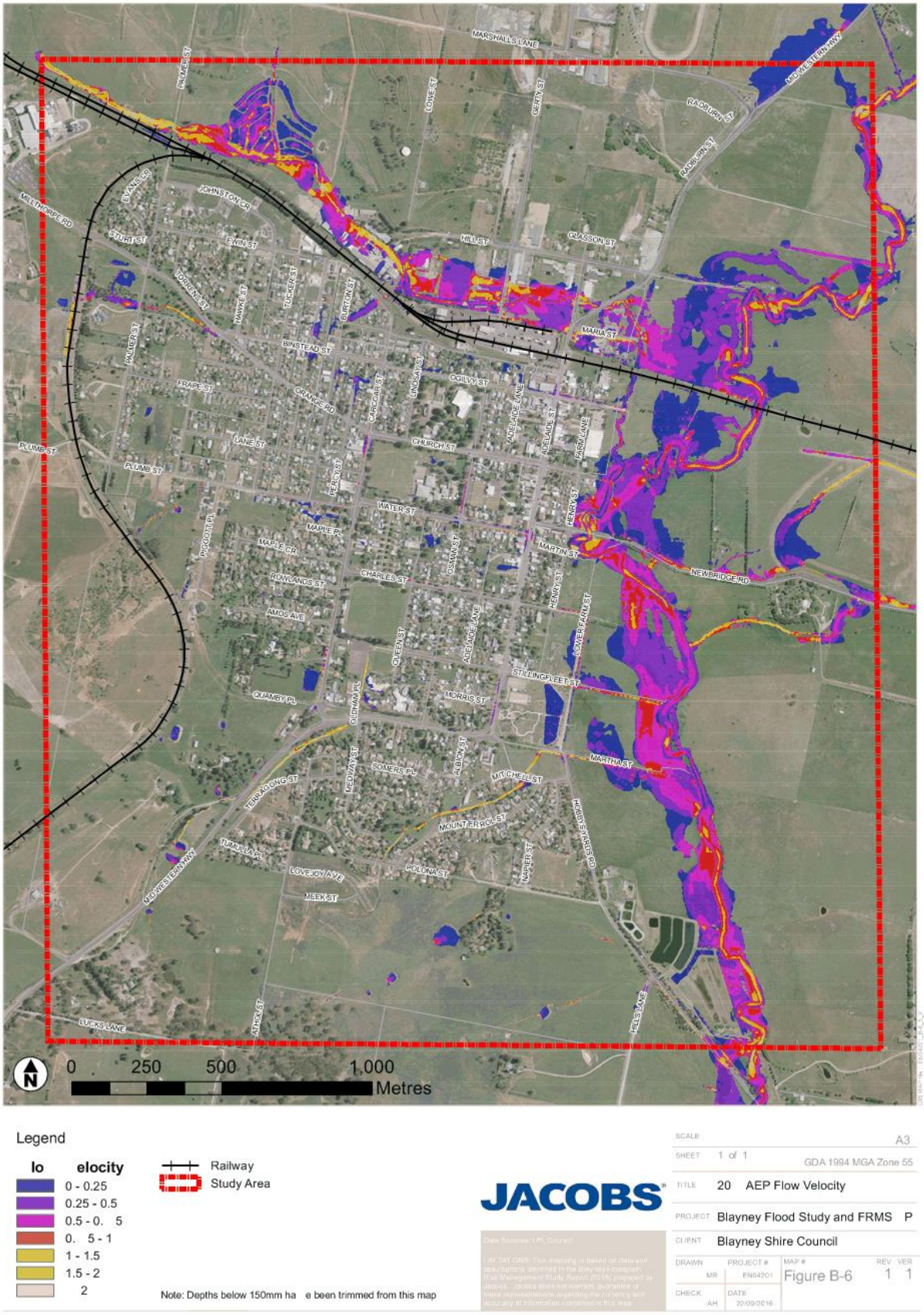

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Railway
Study Area

Note: Depths below 150mm ha e been trimmed from this map

JACOBS

SCALE	A3
SHEET	1 of 1
	GDA 1994 MGA Zone 55
TITLE	20 AEP Flow Velocity
PROJECT	Blayney Flood Study and FRMS P
CLIENT	Blayney Shire Council
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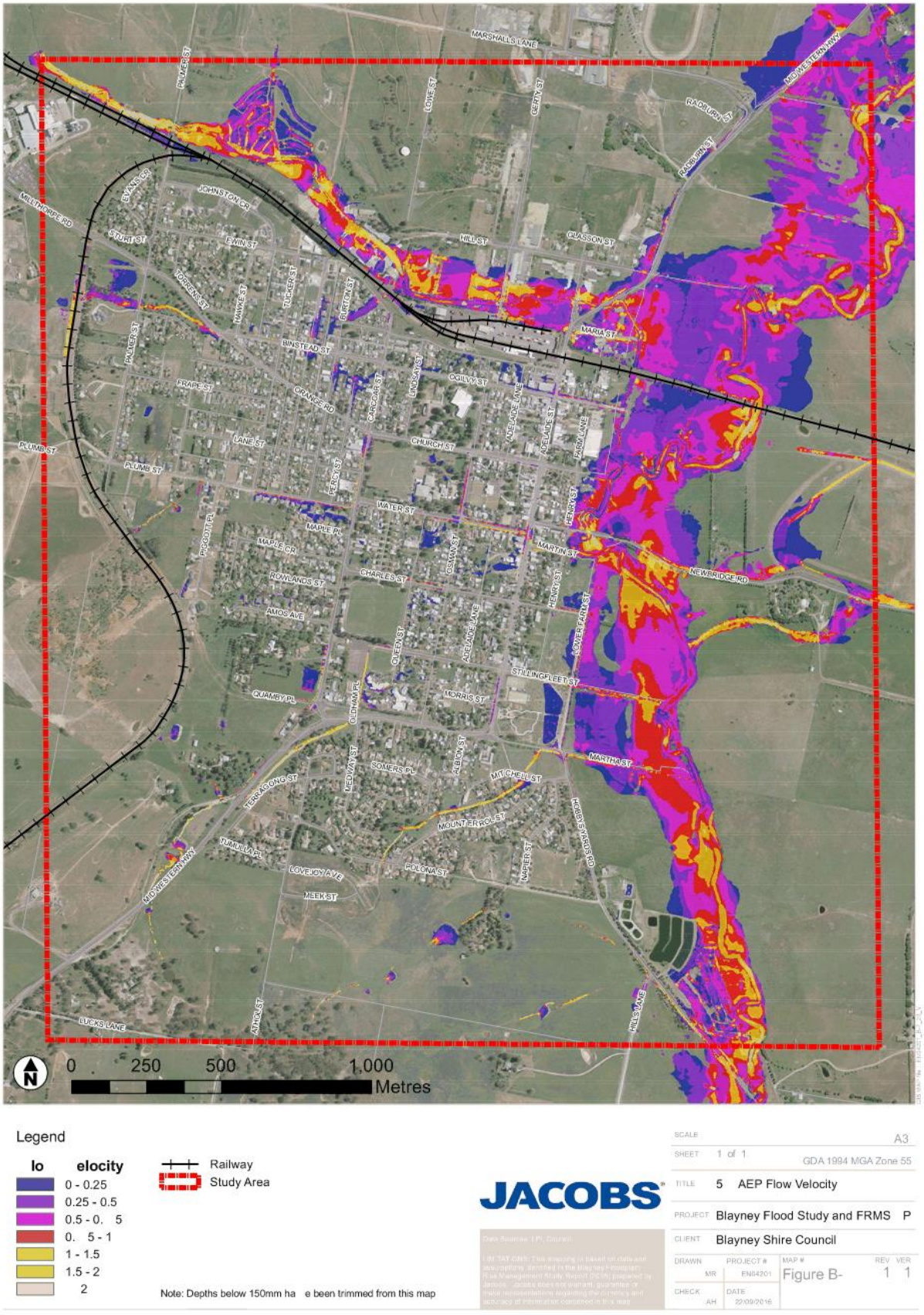

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Railway
Study Area

Note: Depths below 150mm ha e been trimmed from this map

JACOBS

SCALE	A3
SHEET	1 of 1
	GDA 1994 MGA Zone 55
TITLE	5 AEP Flow Velocity
PROJECT	Blayney Flood Study and FRMS P
CLIENT	Blayney Shire Council
DRAWN MR	PROJECT # EN04201
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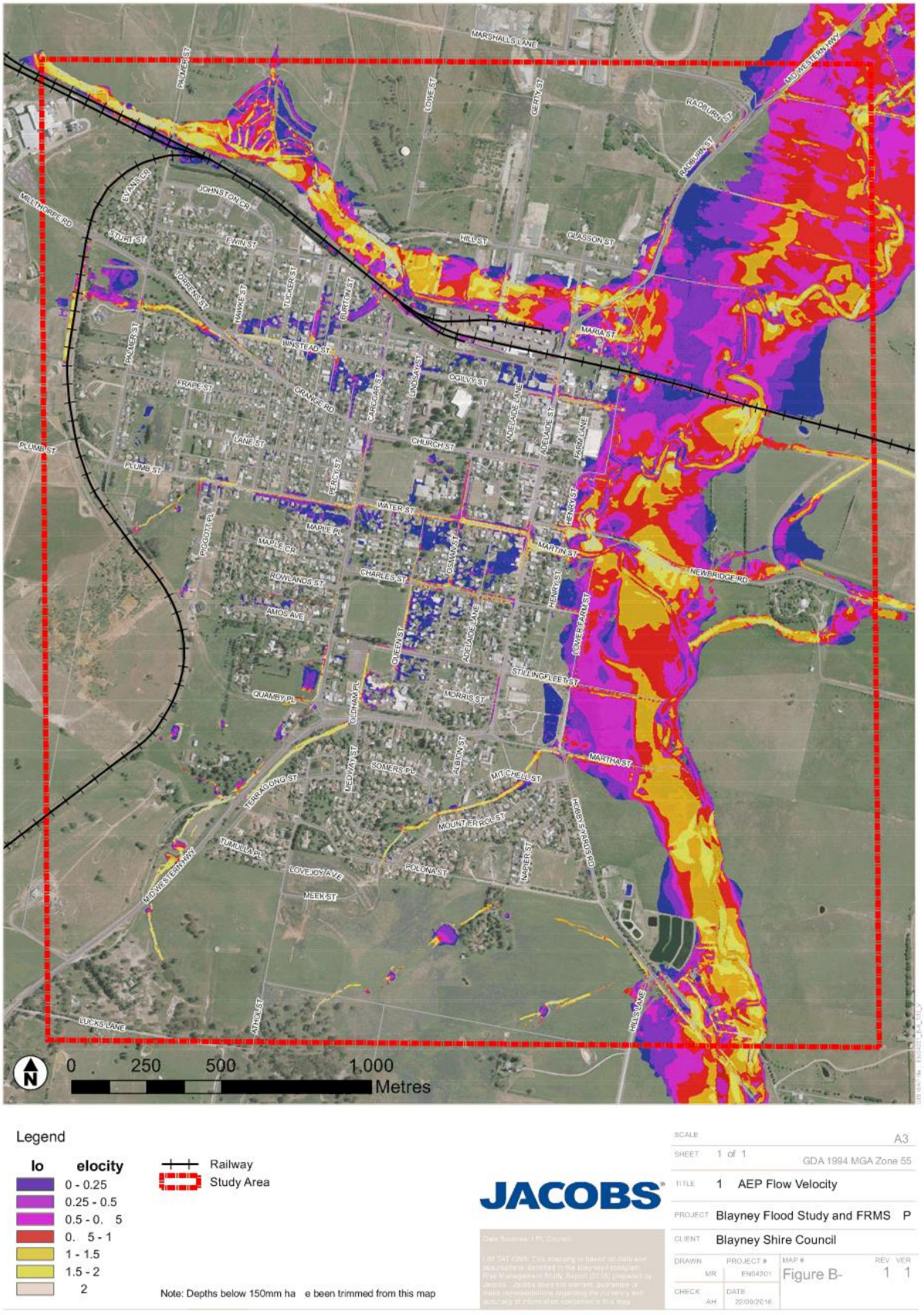

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Railway
Study Area

Note: Depths below 150mm ha e been trimmed from this map

JACOBS

SCALE	A3
SHEET	1 of 1
	GDA 1994 MGA Zone 55
TITLE	1 AEP Flow Velocity
PROJECT	Blayney Flood Study and FRMS P
CLIENT	Blayney Shire Council
DRAWN MR	PROJECT # EN04201
MAP #	Figure B-
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VER	1
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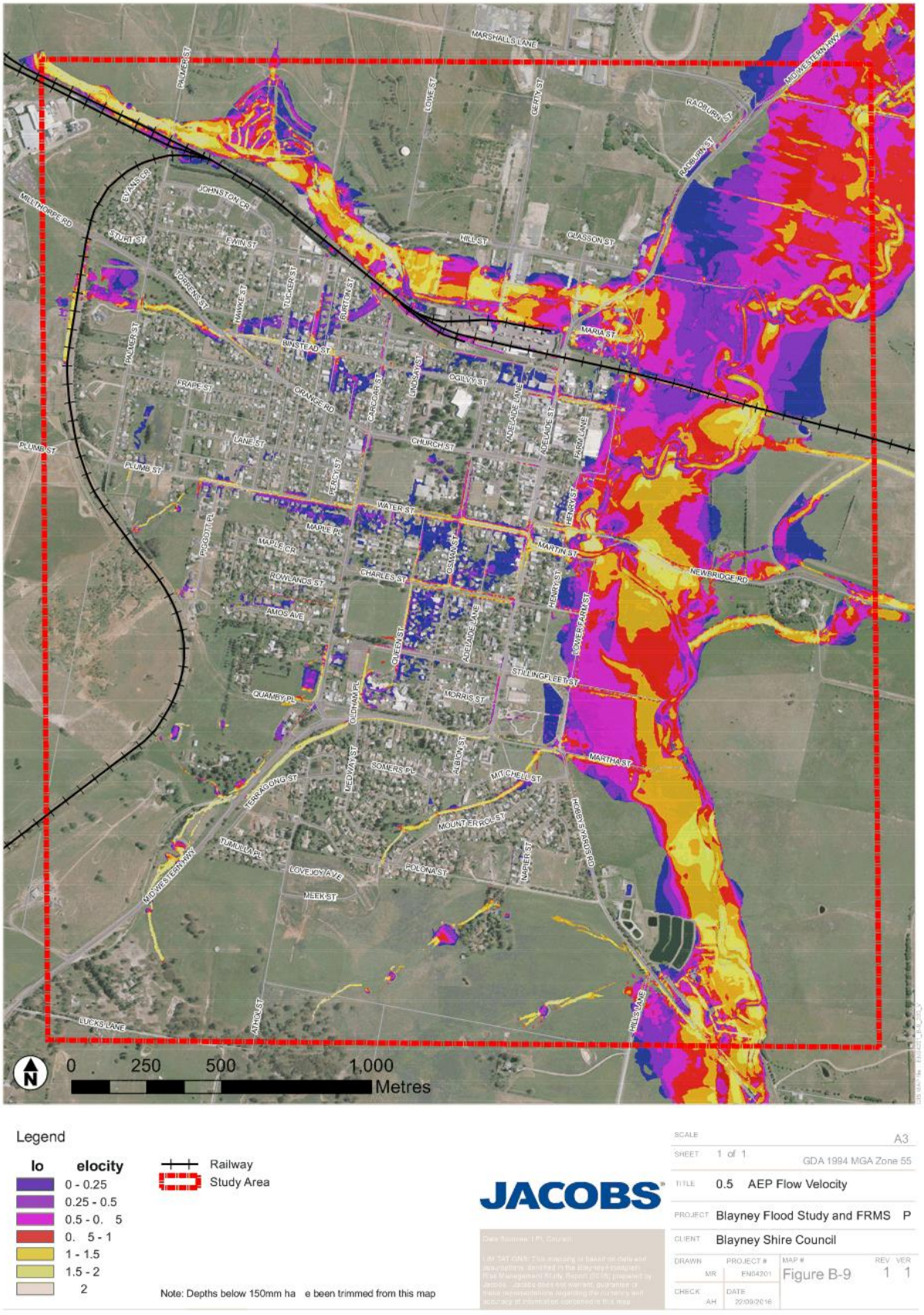

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Railway
Study Area

Note: Depths below 150mm ha e been trimmed from this map

JACOBS

SCALE	A3
SHEET	1 of 1
	GDA 1994 MGA Zone 55
TITLE	0.5 AEP Flow Velocity
PROJECT	Blayney Flood Study and FRMS P
CLIENT	Blayney Shire Council
DRAWN MR	PROJECT # EN04201
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VER	1
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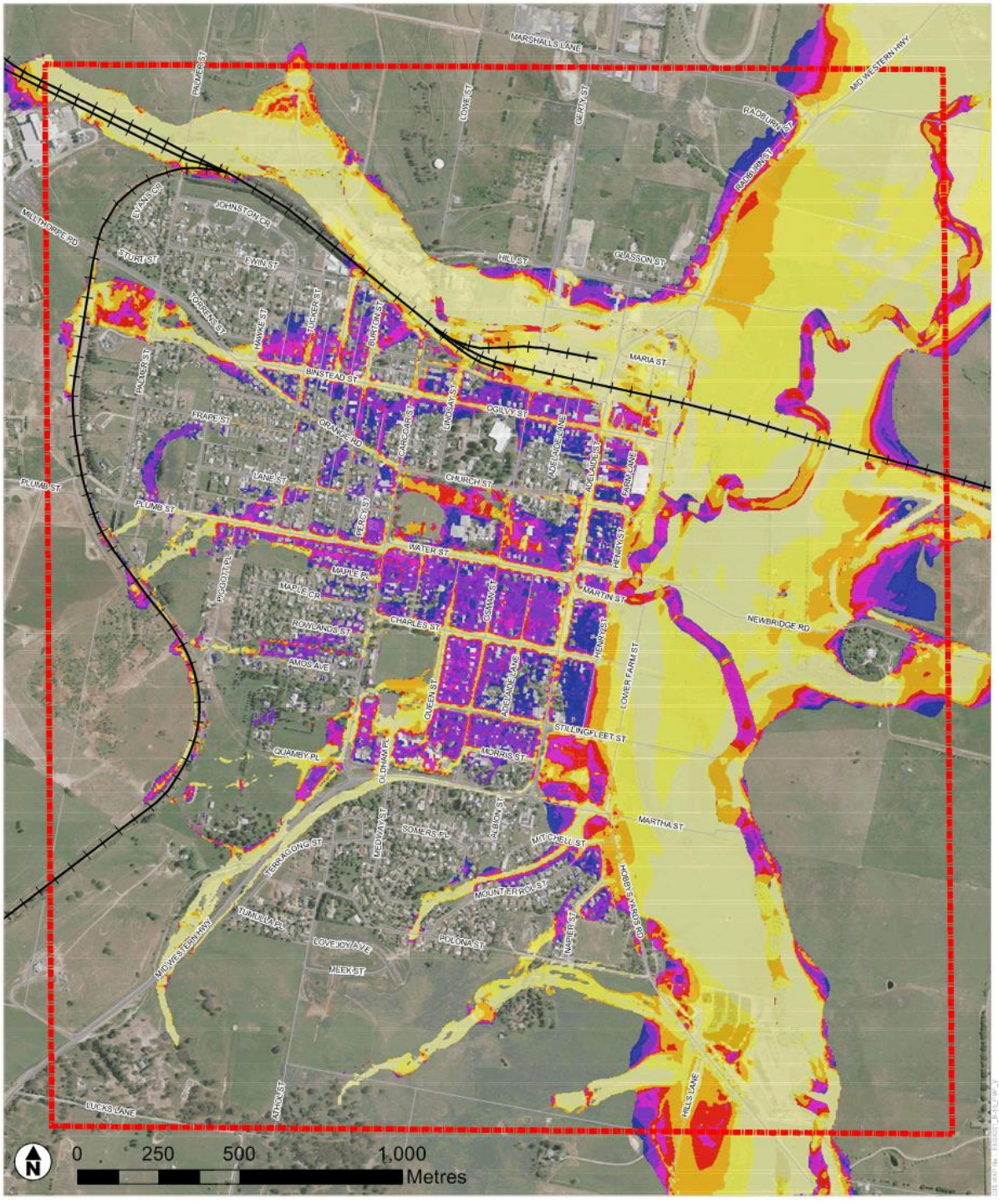

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Railway
Study Area

Note: Depths below 150mm ha e been trimmed from this map

JACOBS

SCALE	A3
SHEET	1 of 1
	GDA 1994 MGA Zone 55
TITLE	PMF Flow Velocity
PROJECT	Blayney Flood Study and FRMS P
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DRAWN MR	PROJECT # EN04201
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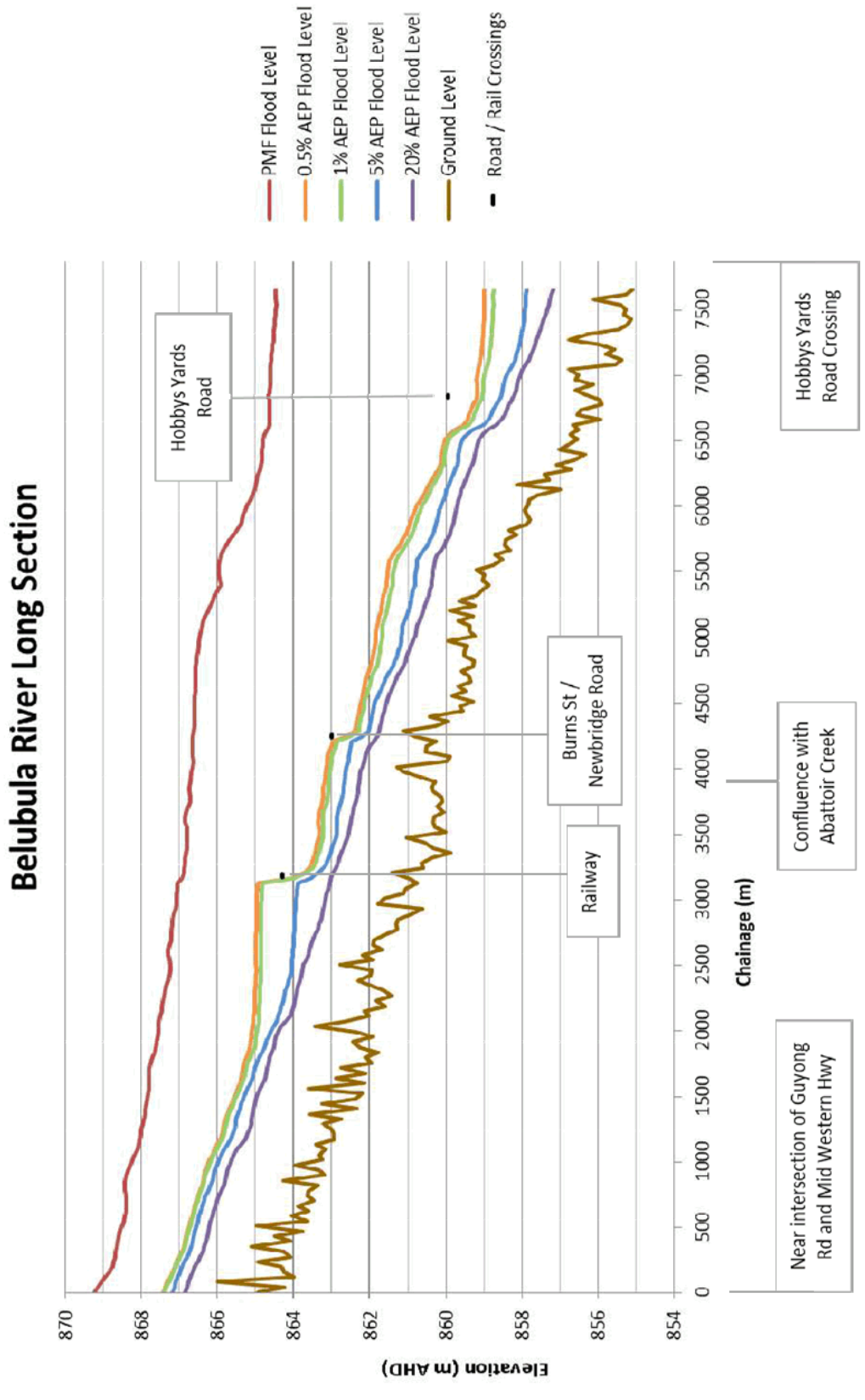

Figure B-11 Modelled Peak Water Level Profiles along the Belubula River

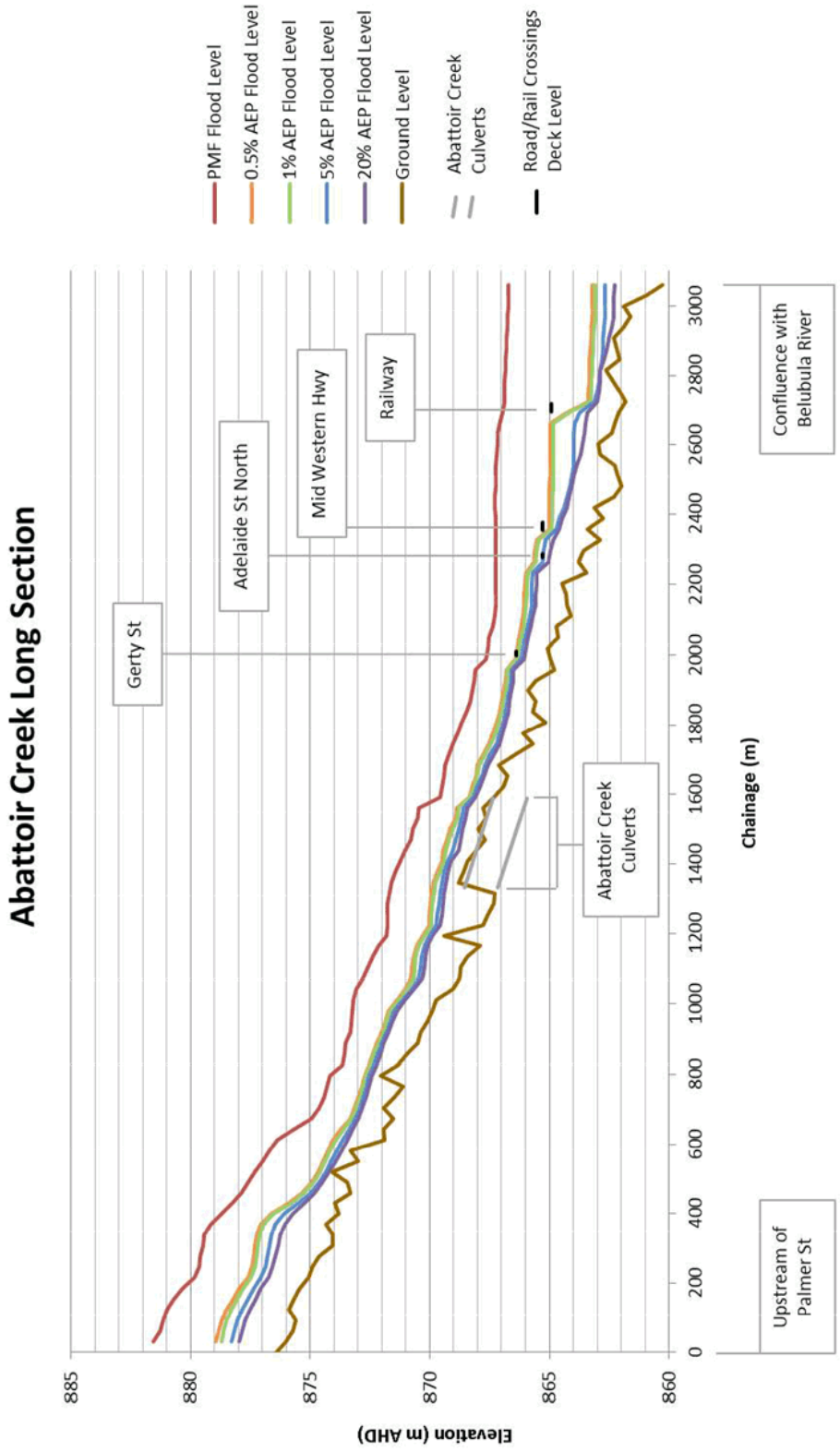

Figure B-12 Modelled Peak Water Le el Profiles along Abattoir Creek