HOLBROOK FLOODPLAIN RISK MANAGEMENT STUDY & PLAN

GREATER HUME SHIRE COUNCIL

FINAL REPORT

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FINAL REPORT

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Project Holbrook – Floodplain Risk Management Study and Plan	**Project Number** 114040
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ACRONYMS

AAD	Annual Average Damages
ABCB	Australian Building Codes Board
ABS	Australian Bureau of Statistics
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ALS	Airborne Laser Survey (also see LiDAR)
ARI	Average Recurrence Interval
ARTC	Australian Rail Track Corporation
AWE	Average Weekly Earnings
B/C	Benefit Cost Ratio
BCA	Building Codes Australia
BoM	Bureau of Meteorology
CFERP	Community Flood Emergency Response Plan
CMA	Catchment Management Authority
DA	Development Application
DCP	Development Control Plan
DEM	Digital Elevation Model (A grid of terrain elevations usually obtained from ALS)
DRM	Direct Rainfall Method
EP&A Act	Environmental Planning and Assessment Act
EPA	Environmental Protection Authority
ERP	Emergency Response Planning
FPA	Flood Planning Area
FPL	Flood Planning Level
FRMC	Flood Risk Management Committee
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
IPCC	Intergovernmental Panel for Climate Change
LEP	Local Environment Plan
LFP	Local Flood Plan
LGA	Local Government Area
LiDAR	Light Detection and Ranging (also see ALS)
mAHD	Meters above Australian High Datum
MHL	Manly Hydraulics Laboratory
NCC	National Construction Code
OEH	Office of Environment and Heritage
OSD	On Site Detention

PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PWD	Public Works Department
RMS	Roads and Maritime Services (formerly RTA)
SEPP	State Environmental Planning Policy
SES	State Emergency Services
TUFLOW	A one-dimensional (1D) and two-dimensional (2D) hydraulic computer model
WBNM	Watershed Bounded Network Model (hydrologic computer model)
WSUD	Water Sensitive Urban Design

In addition to the above listed Acronyms, a Glossary of terms is presented in Appendix A.

FOREWORD

The NSW State Government's Flood Policy provides a framework to ensure the sustainable use of floodplain environments. The Policy is specifically structured to provide solutions to existing flooding problems in rural and urban areas. In addition, the Policy provides a means of ensuring that any new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood liable land remains the responsibility of local government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist councils in the discharge of their floodplain management responsibilities. The Federal Government may also provide subsidies in some circumstances.

The Policy provides for technical and financial support by the Government through four sequential stages:

1. ***Flood Study***
   - Determine the nature and extent of the flood problem.
2. ***Floodplain Risk Management***
   - Evaluates management options for the floodplain in respect of both existing and proposed development.
3. ***Floodplain Risk Management Plan***
   - Involves formal adoption by Council of a plan of management for the floodplain.
4. ***Implementation of the Plan***
   - Construction of flood mitigation works to protect existing development, use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

This report relates to the Floodplain Risk Management Study and Floodplain Risk Management Plan phases of the process.

The Holbrook Floodplain Risk Management Study & Plan (FRMS&P) presented herein constitutes the second and third stages in the NSW Floodplain Risk Management Program for the township of Holbrook and follows on from the Flood Study prepared in September 2013. WMAwater have been engaged by Greater Hume Shire Council to prepare this FRMS&P under the guidance of Council's Floodplain Risk Management Committee (FRMC).

This report has been prepared with financial assistance from the NSW Government through its Floodplain Management Program. This document does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage.

1. INTRODUCTION AND BACKGROUND

This Study has been prepared by WMAwater on behalf of Greater Hume Shire Council (Council). The Study is composed of two phases:

1. The Holbrook Floodplain Risk Management Study; and
2. The Holbrook Floodplain Risk Management Plan.

This document details; The Holbrook Floodplain Risk Management Study; and The Holbrook Floodplain Risk Management Plan (abbreviated to FRMS&P). This FRMS&P follows on from the Flood Study which defined the design flood behaviour in the township of Holbrook under existing conditions to determine the nature and extent of the existing flood problem.

1.1. Objectives

The main objective of this FRMS&P is to identify floodplain risk, test amelioration strategies for the management of risk and to put forward priorities and approximately costed recommendations in regards to flood risk mitigation at Holbrook.

Council requires consideration of a range of management options to effectively manage existing, future and continuing flood risks at Holbrook. The outcomes from the Floodplain Risk Management Study and Floodplain Risk Management Plan will also assist the SES in preparing a Local Flood Plan for Holbrook.

The Objectives are more specifically described in Section 1.1.1 and 1.1.2 below.

1.1.1. Floodplain Risk Management Study Objectives

The objective of the Floodplain Risk Management Study is to investigate a range of flood mitigation works and measures to address the existing, future and continuing flood problems, in accordance with the NSW Government's Flood Policy. This includes:

- Review of Council's existing environmental planning policies and instruments including Council's long term planning strategies for the Study Area;
- Obtain damage estimates under the range of design floods mention under existing conditions;
- Identification of works, measures and restrictions aimed to reduce the social, environmental and economic impacts of flooding and the losses caused by flooding on development and the community, both existing and future, over the full range of potential flood events;
- To assess the effectiveness of the works and measures for reducing the effect of flooding on the community and development, both existing and future;
- To consider whether the proposed works and measures might produce adverse effects (environmental, social, economic, or flooding) in the floodplain and whether they can be minimised;
- Examination of the present flood warning system, community flood awareness and emergency response measures in the context of the NSW State Emergency Service's developments and disaster planning requirements.

- Examine ways in which the river and floodplain environment may be enhanced by preparing a strategy for vegetation planning that will create a valuable corridor of vegetation without having a detrimental effect on flooding; and
- Identification of modifications required to current policies in the light of investigations.

1.1.2. Floodplain Risk Management Plan Objectives

The Floodplain Risk Management Plan makes a range of recommendations relating to flood mitigation works and measures that address the existing, future and continuing flood problems, in accordance with the NSW Government's Flood Policy. The recommended works and measures presented in the Plan are aimed to:

- Reduce the flood hazard and risk to people and property in the community and to ensure future development is controlled in a manner consistent with the flood hazard and risk;
- Reduce private and public losses due to flooding;
- Protect and, where possible, enhance watercourses/creeks and floodplain environment;
- Be consistent with the objectives of relevant State policies, in particular, the Government's Flood Prone Lands and State Rivers and Estuaries Policies and satisfy the objectives and requirements of the Environmental Planning and Assessment Act, 1979;
- Ensure that the floodplain risk management plan is fully integrated with Council's existing corporate, business and strategic plans, existing and proposed planning proposals, meets Council's obligations under the Local Government Act, 1993 and has the support of the local community;
- Ensure actions arising out of the management plan are sustainable in social, environmental, ecological and economic terms;
- Ensure that the floodplain risk management plan is fully integrated with the local emergency management plan (flood plan) and other relevant catchment management plans;
- Establish a program for implementation and a mechanism for the funding of the plan and should include priorities, staging, funding, responsibilities, constraints, and monitoring; and the
- Preparation of concept design for recommended works with sufficient detail to enable Council to apply for funding and progress to the investigation and design stage.

1.2. The Study Area

The township of Holbrook is located in the Greater Hume Shire Local Government Area (GHSC) situated in the Riverina region of southern New South Wales (NSW). GHSC is surrounded by the LGA's of Wagga Wagga, Urana, Tumut, Corowa, Tumbarumba, Albury and Indigo.

Holbrook is the largest town in the GHSC with a population of 1,260 (2011 census) and is located on the Hume Highway between Tarcutta and Albury (see Figure 1 for Study Area layout).

Holbrook straddles Ten Mile Creek, which has a catchment area of approximately 140 km² at Albury Street. Ten Mile Creek originates near Mount Jergyle in the Woomargama National Park, approximately 15 km south-east of Holbrook. Land use in the catchment is predominately rural with a mixture of both pastoral and cropping land uses. The creek crosses the township at its southern end, running in a north-westerly direction, where it reaches its confluence with Billabong Creek approximately 10 km west of Holbrook.

In the area to the north-east of Holbrook, the tributary of Morgan's Ridge Creek (catchment area of 11 km²) flows south-west before joining Ten Mile Creek approximately 300 m upstream of Albury Street Bridge. A section of Morgan's Ridge Creek from Bowler Street to Ten Mile Creek is a man-made diversion channel. Historically the creek travelled along Bowler Street and into an unnamed flow path to Holbrook's west. This unnamed flowpath still collects overland flow (and in larger floods overflow from Morgan's Ridge Creek) and flows north-west until it joins Ten Mile Creek approximately 1.5 km west of the existing Hume Highway crossing.

The upstream boundary of the hydraulic Study Area extends upstream of the Ten Mile Creek #3 gauging station (410187). In the downstream the hydraulic model extends approximately 5 km west of town.

1.3. Flood History of Holbrook

The October 2010 event is thought to have been the highest Ten Mile Creek flood since at least December 1887 when the Sydney Morning Herald reported floodwaters 0.6 m deep along the main street and in many houses (see Image 1). During the 2010 event multiple houses along Ten Mile Creek were flooded over floor with two homes aged in excess of 120 years being flooded for the first time. This clearly makes flooding which occurred on Ten Mile Creek during the October 2010 flood event larger than that which occurred during the June 1931 flood (Reference 3). During the October 2010 event flood waters covered the majority of the land to the south of the Creek and flowed over Albury Street before re-joining the creek to the west of town.

However, residents report that local flooding from Morgan's Ridge Creek has been higher in the past, with an event in the late 1970's or early 1980's inundating the Returned Serviceman's Club (38 Swift Street) and other Swift Street properties, which did not occur in the October 2010 event. During the 2010 event Morgan's Ridge Creek broke its banks at the bridge on Bowler Street and flowed through an empty lot west of the 30 Bowler Street residence before flowing back into the Creek near the corner of Hume and Gundagai Streets.

The March 2012 event was the second largest Ten Mile Creek event in recent history (however it was likely smaller than the 1931 event) causing areas around Bardwell and Macinnes Streets to flood before flowing north along Albury Street and then back into the Creek upstream of the Albury Street Bridge (near Byng Street). Albury Street was not overtopped during the 2012 event which was recorded to be 0.85 m lower at the Albury Street Bridge than the October 2010 event.

Image 1: December 1887 Holbrook Flood

HEAVY THUNDERSTORM AT GERMANTON.

[By Telegraph.]
(From our own correspondent.)

GERMANTON, Saturday.

On Friday evening a terrific thunderstorm visited the town, accompanied by vivid lightning flashes and hailstones of unusual dimensions. For about two hours the rain fell in torrents, registering two inches ten points. Great destruction was caused among the wheat crops and also in the fruit gardens. Many crops were hardly worth harvesting previously owing to red rust, but this visitation completed the destruction. The flood waters caused considerable damage, accumulating quickly to about two feet in many houses. Some people took refuge upon the tables, while others repaired to the higher ground. The main street is dangerous in many places owing to the deep ruts washed out, particularly near the Presbyterian Church. A stream was running along the main street 2 feet deep. The storm was purely local in character. The oldest residents do not recollect such a storm as that of last night, or none causing such destruction. The bush to-day is covered with fallen timber, and many trees are torn up by the roots.

Note: Holbrook was known as Germanton prior to World War 1
Source: *The Sydney Morning Herald*, Monday 2nd January 1888 p.7

1.4. Previous Reports

Previous reports have been reviewed and summarised in the Flood Study (Reference 2) including:

- Flood Intelligence Collection and Review for Towns and Villages in the Murray and Murrumbidgee Regions following the October 2010 Flood (Reference 3);
- Flood Intelligence Collection and Review for Towns and Villages in the Murray and Murrumbidgee Regions following the March 2012 Flood (Reference 4);
- Holbrook Bypass – Ten Mile Creek and Tip Road Overland Flow Path Flood Impact Assessment Report (Reference 5);
- Memo – October 2010 Holbrook Flood Event Assessment – Revised (Reference 6); and
- Holbrook and Woomargama Drainage Study (Reference 7).

1.5. Available Data for FRMS&P

1.5.1. Albury Street Crest Height Survey

Albury Street was surveyed between Hay and Macinnes Streets to obtain the road crest height of this key hydraulic structure. In the flood study, the crest height was determined using Lidar data, however a more accurate approach was warranted for the FRMS as a number of nearby homes have floor levels similar to the Albury Street crest height. The surveyed levels were input into the revised hydraulic model as a breakline (see Section 3.2).

1.5.2. Holbrook Bypass Design Plans

The Holbrook Bypass was included in design event modelling as part of the flood study. However, at the time of modelling, Ten Mile Creek in-bank topography was unavailable and thus an estimate of channel conveyance was made. 1m contours of the Creek characteristics were provided by RMS via Council for use in this study and were incorporated into the hydraulic model (see Section 3.2).

1.5.3. Floor Level Survey

Floor level survey was performed by Hydrographic & Cadastral Survey Pty. Ltd. for properties which were determined to experience 1% AEP peak flood level depths equal to or exceeding 300 mm adjacent to the building footprint. In total 114 properties (91 residential and 23 non-residential) were surveyed in Holbrook with the location of these properties displayed in Appendix B, Figure B3.

The floor levels of the remaining properties within the 1% AEP extent were estimated by use of ALS data in combination with visual inspection of properties floor level heights from ground by WMAwater engineers. For all other properties in the Study Area up to the PMF extent, floor levels were estimated using ALS data and the average floor height from ground of the surveyed and estimated floor levels.

1.6. Overview of Existing Catchment

1.6.1. Land Use and Demographic Overview

Understanding the social characteristics of the area can help in ensuring that the right risk management practices are adopted. The Census data can provide useful information on categories including dwelling and tenure type, languages spoken, age of population and movement of people into and from the area. Information has been extracted for the 2011 Census. The urban centre of the suburb of Holbrook has a population of 1,260 living in 652 private dwellings.

Of interest is the data on population movement in recent years. Generally residents who have lived in an area for a longer time will have a better understanding of flooding issues in their area than those who have recently moved to the area. Within the last five years 18% of the population has moved to the Holbrook area and in the year prior to the 2011 census 8% of the population moved into the area. This means that the majority of the current population would have experienced one or both of the recent flood events and therefore likely have good awareness of flood risk in the region.

It is useful to consider the tenure of housing. Those living in properties which they own are more likely to be aware of the flood risks and have measures in place to reduce them (where possible). Rental properties are likely to have a higher turnover of people living in them compared to privately owned properties and therefore those people in rental properties may be less aware of the flood risk. In Holbrook 20% of houses are rented.

The languages spoken by the population are also useful to consider as this can have implications in regard to the provision of flood information to the public. In Holbrook less than 1% of the population speak a language other than English at home.

Land use from the LEP 2011 is shown in Figure 2. The majority of Holbrook is comprised of lots zoned RU5 Rural Village areas. The RU5 classification not only allows for residential properties but also commercial/industrial of which there are approximately 135 in Holbrook. Land use outside of the township of Holbrook in the Ten Mile Creek catchment is generally zoned RU1 Primary Production with usage primarily devoted to grazing and cropping endeavours. Special Purpose zones (displayed as 'special' in Figure 2) are distributed throughout the town and allow for infrastructure uses, schools, churches and other community facilities.

Ten Mile Creek is designated as W1 Natural Waterway which has limitations on permitted uses. Zone W1 predominantly aims to allow for boating uses, flood mitigation works, jetties, kiosks, recreation areas and facilities, roads and emergency services facilities. Commercial, industrial and residential land uses are prohibited (LEP 2012). Accordingly, the W1 Natural Waterway zoning is suitable for implementation with the floodway classification (see Section 4.5).

Outside the town boundaries, the only structures on the floodplain are roads and rail, individual farmhouses and other farm related infrastructure. Most roads are unsealed and creek and stream crossings are generally formed by low level causeways.

1.6.2. Key Infrastructure on the Floodplain

Key infrastructure in the floodplain are those that impact on flood levels, for example upstream backwatering (and retention of floodwater) and lower levels in the downstream (relative to the case if the major structure was not there). Some of these may be deliberate flood management measures to control flooding. Holbrook's key infrastructure is summarised in the Flood Study (Reference 2) including location map and photographs. Table 1 below summarises each feature with the locations displayed on Figure 3.

Table 1: Key Infrastructure on the Floodplain

ID	Structure	Comment
1	Albury Street Bridge	The Albury Street Bridge (previously the Hume Highway) is situated in central Holbrook. Prior to construction of the Holbrook Bypass to Albury Street Bridge was the only Ten Mile Creek bridge crossing in the area. The bridge has a manual gauge that is referred to throughout this report on its downstream side.
2	Holbrook Bypass Ten Mile Creek Crossing	The recently constructed Holbrook Bypass is composed of an earthen embankment that spans the Ten Mile Creek floodplain downstream of Holbrook. Construction of the Bypass began post the 2010 flood and was partially complete during the 2012 event. The Ten Mile Creek crossing is dual carriage, single span bridge, which has been constructed above the level of the PMF.
3	Jingellic Road Bridge (Morgans Ridge Creek)	The Jingellic Road Bridge is a single span bridge which is situated at the downstream end of Morgans Ridge Creek. Morgans Ridge Creek enters Ten Mile Creek from the north approximately 400 m upstream of the Albury Street Bridge.
4	Bowler Street Bridge (Morgans Ridge Creek)	The Bowler Street Bridge is a single span bridge which is crosses Morgans Ridge Creek at Bowler Street. Out of bank flooding downstream of this bridge was experienced during the 2010 flood event, possibly due to bridge blockage. Immediately upstream of the road bridge is a footbridge
5	Holbrook RSL Embankment	The Holbrook RSL embankment is situated on Morgan's Ridge Creek north of Bowler Street and extends approximately 150 m on the western side of the Creek. This embankment has presumable been constructed to stop flows exiting Morgan's Ridge Creek and entering the Holbrook RSL.
6	Wallace Street Culverts (Morgans Ridge Creek)	Morgans Ridge Creek passes under Wallace Street near the corner of Vine Street through a set of culverts (3 x 1.2 m pipes).
7	Bruce Street Culverts (Morgans Ridge Creek)	Morgans Ridge Creek passes under Bruce Street through a set of culverts (3 x 1.2 m pipes).
8	Holbrook Bypass - Southern Culverts	Flow from a local catchment to the south of Ten Mile Creek is diverted under the Holbrook Bypass by a series of culverts (3 x 3 m x 1.5 m box culverts) and into the swamp to the west of town.
9	Holbrook Bypass - Northern Culverts	Local overland flow to the north of Ten Mile Creek is diverted under the Holbrook Bypass by a number of culverts of various sizes. These culverts range from 2 x 0.9 m pipes to 5 x 3 m x 1.2 m box culverts.

2. COMMUNITY CONSULTATION

Community consultation is an important element of the floodplain risk management process ultimately facilitating community engagement and acceptance of the overall project. During the Flood Study (Reference 2), community consultation was undertaken to assess the flood experience of the community and gather additional data. Further community consultation has also been undertaken as part of the FRMS&P. To date this has included a questionnaire, a community open day and a number of FMC meetings. Goals of ongoing community consultation are to keep residents informed of progress and in the later stages gain their feedback on potential mitigation and management measures proposed. Final community consultation proposed is in the form of public exhibition of the Floodplain Risk Management Study and Floodplain Risk Management Plan.

It should also be noted that as part of the SES Data Collection Studies (Reference 3 and 4) following the 2010 and 2012 events, considerable consultation was performed including questionnaire distribution and interviews.

2.1. Questionnaire Distribution

A community newsletter and questionnaire (presented in Appendix C) was distributed to residents in Holbrook during September 2014. The newsletter aimed to inform the community of the Holbrook FRMS&P and the survey provided the community with an opportunity to highlight their flood affectation and to provide input into the current study. In particular, the questionnaire was intended to obtain ideas for mitigation works or management plans to reduce flood risk and to determine if the community is interested in Voluntary Purchase (VP) or Voluntary House Raising (VHR) schemes (see Sections 5.4.1 and 5.4.2).

A total of 17 replies (out of 652 distributed) resulted in a return rate of 3% which is low for this kind of study. It is normal that responses predominately come from residents that have been affected by flooding, however 17 is significantly less than the number of residents impacted by the recent events. The reduced return rate may have been due to the questionnaire being focused on obtaining flood risk solutions that many people are possibly not well placed to provide.

A summary of the questionnaire results is presented in Figure 4 with the questionnaire returnee locations displayed in Figure 5. All 17 questionnaire respondents mentioned that they thought flood risk at Holbrook should be ameliorated, particularly for flood risk due to Ten Mile Creek (11 responses). Approximately half of all respondents thought that flooding at a frequency of less than 100 years is acceptable which is generally in line with the aims of the current study. However, six respondents mentioned that they thought any degree of flooding is never acceptable which would require the engineering of mitigation structures to the PMF. It was also found that the majority of people were not interested in VP (3 respondents interested) and VHR (1 respondent interested) schemes.

Generally three topics were the focal point of all returned questionnaires. These were, the impact of the Bypass, creek clearing/maintenance and potential mitigation works. A summary of the key topics discussed in the returned questionnaires is presented below:

The Holbrook Bypass

- Interest as to the impact of the Holbrook Bypass on peak flood levels (investigated in Section 4.2);
- Noted that the Bypass has led to ponding during minor rainfall events to the south of Ten Mile Creek. A request was made for increased drainage along the bypass, west of the caravan park back to Ten Mile Creek to aid in the removal of local flows (see Section 5.3.3.1).

Creek Dredging, Clearing and Maintenance

- A number of questionnaires noted that the channel conveyance of Ten Mile Creek has reduced compared to historic conditions. It was mentioned that Ten Mile Creek was historically deep enough to swim in and that the construction of various structures (such as a stone creek crossing 150 m downstream of the western miniature railway bridge) on the floodplain has led to significant siltation and reduced channel conveyance;
- A number of recommendations were made for the dredging of Ten Mile Creek to increase channel conveyance (see Section 5.3.4.3); and
- The majority of returned questionnaires made requests for the clearing/maintenance and increasing the conveyance capacity of both Ten Mile and Morgans Ridge Creeks (see Section 5.3.4).

Potential Flood Mitigation Works

- Additional culverts under Albury Street south of Ten Mile Creek (near Murray Street) to aid in the drainage of flows from east to west (see Section 4.3);
- Milling of Albury Street to reduce the road crest level, and in particular before additional road resurfacing (see Section 4.3 and 5.3.5.4);
- Realignment of Morgans Ridge Creek culverts near Vine and Wallace Street (see Section 5.3.6); and
- Albury Street drainage improvement to the southern approach of the Ten Mile Creek Bridge to enable the uninterrupted flow of Ten Mile Creek (see Section 4.3).

Further to this, a recommendation was made to obtain survey of Albury Street crest height for input into the hydraulic model. WMAwater put in a variation to the initial survey Brief and obtained survey of the Albury Street crest height (see Section 1.5.1) and this data has been incorporated into the hydraulic model (see Section 3.2).

2.2. Community Consultation Open Day

A WMAwater engineer attended the township of Holbrook on the 14th of October 2014 with the purpose of interviewing residents to gain potential flood mitigation ideas to reduce flood affectation in Holbrook.

The meeting was attended by approximately 10 people with many of these people also returning the questionnaire. Consequently, many of the concerns raised by the returned questionnaires were also discussed at the open day. A list of these topics is presented in Section 2.1, with again particular focus on the clearing and maintenance of Ten Mile Creek.

Another topic of concern was bank erosion on both Ten Mile and Morgan's Ridge Creeks. Two open day attendees commented on significant bank erosion on Morgan's Ridge Creek near Peel Street downstream of Wallace Street. A number of properties are experiencing the encroachment of Morgan's Ridge Creek onto their property with at least one home becoming dangerously close to having its footings compromised by the eroding banks. According to eye witness accounts the bank erosion began during the October 2010 flood and was made worse by subsequent flooding, particularly the March 2012 event.

An attempt has been made to determine who is responsible for stabilising the creek banks to stop further erosion. Initial advice is that it is the landholder's responsibility as the problem occurs on entirely privately owned land. It also appears that it is unlikely that there is any eligibility for grant assistance as part of the Floodplain Management Program (Reference 1). Further work by Local Land Services (LLS) Murray Region has been undertaken to establish the responsibility on the part of Council and what solutions can be achieved to solve the issue. LLS noted that generally they only support erosion works that have a broader public benefit by reducing water quality impacts and natural assets. LLS mentioned that this situation does not fit this category and therefore they will not be able to assist financially unless there is a much broader scale creek project that addresses landscape scale issues. Accordingly, it seems that the initial advice was correct, and it is the landholder's responsibility due to the problem occurring on private land.

A similar problem is occurring on Ten Mile Creek near Kings Street where bank erosion is encroaching onto private property. LLS have again investigated this issue and come to the same conclusions as above.

2.3. Flood Risk Management Committee

The Holbrook Floodplain Risk Management Committee (FRMC) comprises a number of representatives from the local community, including residents, members of Council, the SES and OEH.

Regular meetings have been held (6 in total) in order to inform the FRMC of the study progress regarding data collection and community consultation as well as the modelling of flood mitigation measures. Following review and edits, the draft report requires recommendation to Council for endorsement in order to progress. At this stage exhibition of the draft document would be the normal course of action.

2.4. Public Exhibition of the Draft Final Holbrook FRMS&P

Public exhibition of the Draft Final Holbrook FRMS&P was undertaken to ensure community support of these documents. The Report was available to the public for scrutiny, for the period of one month. Digital copies of the reports were available on the Council website and a hard copy of the report was available at Council Offices and the local library. One submission was received in relation to the Holbrook FRMS&P. The submission related to a range of matters as detailed in the following:

- Albury Street hand over from RMS – Modelling of a range of scenarios was undertaken and documented to assist Council in its handover negotiations with RMS. A number of measures were shown to be viable from a drainage perspective which does not fall under the scope of this report. Council will utilise the modelling information to work towards improvements in drainage at Albury Street.
- Dredging of Ten Mile Creek – This option was considered as Option S2 and was not recommended for a range of reasons which are discussed in Section 5.3.4.3. The development of a vegetation management plan has been recommended in Section 5.3.4.2.
- Use of Stock Route south of town for drainage to swamp west of the Hume Highway – Options in this area were considered and have been recommended in Section 5.3.1.5. It has been recommended that during detailed design, existing infrastructure be considered for use to improve the benefits of this option.
- Figure 7 clarification – The legend on Figure 7 has been amended.
- Figure 15 – The classification of 60 Albury Street has been corrected to residential.

3. FLOOD STUDY SUMMARY AND FLOOD BEHAVIOUR

3.1. Aims and Objectives of the Flood Study

The information and results obtained from the Flood Study (Reference 2) defined existing flood behaviour and provide a firm basis for the development of the FRMS&P. Primarily, the study was developed in order to meet the objective of defining the flood behaviour for the 5-year ARI, 10%, 2%, 1%, 0.5% AEP events and the PMF in Holbrook and to:

- Define flood behaviour in terms of flood levels, depths, velocities, flows and flood extents within the study area;
- Prepare flood extent mapping (for all design events modelled); and to
- Create a modelling system that might be used in the subsequent FRMS&P to test whatever flood mitigation works might be proposed by either the community, OEH, Council or the consultant.

In order to define flood behaviour, the Flood Study developed a hydrological model, WBNM, in conjunction with a 1D/2D hydraulic model, TUFLOW. This methodology is presented in the Flood Study (Reference 2).

3.2. Flood Study Revisions/Updates

Since the Flood Study, two amendments to the hydraulic TUFLOW model have been made and incorporated into the design results:

1. The Ten Mile Creek alignment through the Holbrook Bypass was refined using survey data provided by the RMS; and
2. The Albury Street crest level was surveyed (see Section 1.5.1) and incorporated into the model to ensure that the effect of this significant hydraulic control is accurately reproduced.

These changes had only minor localised effects on the Holbrook 1% AEP peak flood levels with a maximum difference of approximately 0.1 m. An impact map (see Figure 6) has been created which displays the difference in peak flood level between the flood study 1% AEP event and the revised base case. The difference in peak flood level is predominately confined to the Ten Mile Creek channel and does not significantly affect findings from the Flood Study (Reference 1).

3.3. Flood Mechanisms

Three sources of flooding have been identified at Holbrook; flooding from Ten Mile Creek, flooding from Morgan's Ridge Creek and flooding from local overland flows.

The three types of flooding could occur independently or concurrently. However for most events overland flow flooding and flooding in both creeks will occur concurrently, as occurred for both the 2010 and 2012 events.

It is important to recognise that different types of flooding will need different management measures. Furthermore, different flooding mechanisms will require a different emergency response.

3.4. Design Events

The hydraulic model was run for the 5-year ARI, 10%, 2%, 1% and 0.5% AEP events as well as the PMF, for which a number of maps have been produced displaying the flood affected regions (see mapping included in the Flood Study – Reference 2). Please note that these maps have not been reproduced in the current study to account for the changes to the model, as the impact on peak flood levels and extents are relatively insignificant (see Section 3.2). However, all modelling undertaken as part of the current study (mitigation runs, FPA and hydraulic categorisation) has been performed with the updated hydraulic model.

3.4.1. Critical Durations

For design flood events excluding the PMF, the Ten Mile Creek and Morgan's Ridge Creek critical durations at Holbrook are 6 hours. Local flows generated from the local catchment model were determined to have a critical duration of 1 hour.

The critical duration of the PMF at Holbrook was found to be 3 hours for both creek and overland flows.

3.4.2. Peak Flows

The peak flows for Ten Mile Creek at Bardwell Street, upstream of Albury Street for the calibration/validation and design flood events are presented in Table 2.

Table 2: Ten Mile Creek near Bardwell Street - WBNM Model Peak Flows (m³/s)

	5Y	*2012 Event*	10%	5%	2%	1%	*2010 Event*	0.5%	PMF
Holbrook	64	***65***	85	116	154	188	***216***	226	3040

It should be noted that spatial variation in rainfall patterns and the existence of the Holbrook Bypass impacted on peak flood levels of the historic events (Reference 2). Accordingly, the above referenced flows of the historic events are not a good indication of the magnitude of the peak flood levels for these events.

3.4.3. Flood Depths and Levels

Mapping of peak flood depths and level is included in the Flood Study (Reference 2) the map set includes the following:

- Peak flood depths and levels for the design flood events (PMF, 5-year ARI, 10%, 5%, 2%, 1% and 0.5% AEP) (all depths < 200 mm clipped, see paragraph below);
- Flood profiles along Ten Mile Creek for each design flood event;
- Provisional Hazard and Hydraulic Category maps; and
- A summary of the performance of key hydraulic structures.

When establishing inundation patterns and/or peak flood levels, these are based on best available estimates of flood behaviour within the catchment. Inundation from creek and particularly local overland flow may vary depending on the actual rainfall event and local influences, for example; change in topography, blocked structures, road works etc. For the design events depths less than 200 mm have been considered 'drainage' rather than 'flooding' and accordingly, the design results figures only display flood depths in excess of 200 mm.

3.4.4. Flood Travel Time

Flood travel times between the Holbrook #3 and Holbrook manual gauges from the Reference 2 hydrologic model are presented in Table 3. With the exception of the PMF, the flood peak travel time between the two gauges is in the range of about 30-45 minutes.

Based on estimated peak timing at the manual gauge in the October 2010 flood (Reference 3) and an observed peak timing there in the March 2012 flood (Reference 4), the peak travel times for these two events were 60-90 minutes and 120 minutes, respectively. These travel times are a little longer than those derived from the hydrologic model and demonstrate that actual travel times can vary. For many inland creek and river systems, hydrologic modelling produces short response times due to the adopted Australia Rainfall and Runoff 1987 (ARR) temporal patterns. The times in Table 3 may be regarded as minimums.

Table 3: Flood Travel Time – Holbrook #3 gauge to Holbrook manual gauge

Event	Peak flow at Albury Street bridge (m^3/s)	Travel Time (min)
5Y ARI	64	31
10% AEP	85	47
5% AEP	116	38
2% AEP	154	40
1% AEP	188	41
0.5% AEP	226	31
PMF	3,040	14

3.5. Provisional Hydraulic Categories

Hydraulic categorisation of the floodplain is used in the development of the Floodplain Risk Management Plan. The *Floodplain Development Manual* (Reference 1) defines flood prone land to fall into one of the following three hydraulic categories (refer definition in Appendix A);

- Floodway;
- Flood Storage; and
- Flood Fringe.

Floodways are areas of the floodplain where a significant discharge of water occurs during floods and by definition if blocked would have a significant effect on flood flows, velocities or depths. Flood storage are areas of importance for the temporary storage of floodwaters and if filled would significantly increase flood levels due to the loss of flood attenuation. The remainder of the floodplain is defined as flood fringe. There is no technical definition of hydraulic categorisation and different approaches are used by different consultants and authorities.

Based on exploratory work carried out at Henty and reported upon in Appendix I of the Flood Study (Reference 2), provisional floodways were defined on the following basis:

*Floodway = Velocity * Depth > 0.25m^2/s AND Velocity > 0.25m/s OR Velocity > 1m/s*

The remainder of the floodplain outside the Floodway becomes either Flood Storage or Flood Fringe. In the Reference 2 study Flood Storage was defined as the land outside the Floodway if the depth is greater than 0.5 m and Flood Fringe if the depth is less than 0.5 m.

Using this classification system, limited extents in Holbrook are defined as floodway which seems appropriate given the distributed nature of flows in the overbank areas, away from defined watercourses. Nevertheless, there were some residential areas interacting with defined floodways, for example on Macinnes and Bardwell Streets.

A more detailed look at the floodway definition for Holbrook has been undertaken as part of the current study. The investigation takes into account Velocity x Depth criteria, encroachment analysis and percentage flow distribution. The true hydraulic categorisation is presented in Section 4.5.

3.6. Provisional Hydraulic Hazard Classification

The Flood Study (Reference 2) defined provisional flood hazard categories in accordance with the Floodplain Development Manual (Reference 1). Provisional hazards only take account of the hydraulic aspects of flood hazard; depth and velocity (Diagram 1), while true hazard (see Section 4.6) takes into account additional factors such as size of flood, effective warning time, flood readiness, rate of rise of floodwaters, duration of flooding, evacuation problems, effective flood access, type of development within the floodplain, complexity of the stream network and the inter-relationship between flows.

Diagram 1: Provisional Hydraulic Hazard Categories

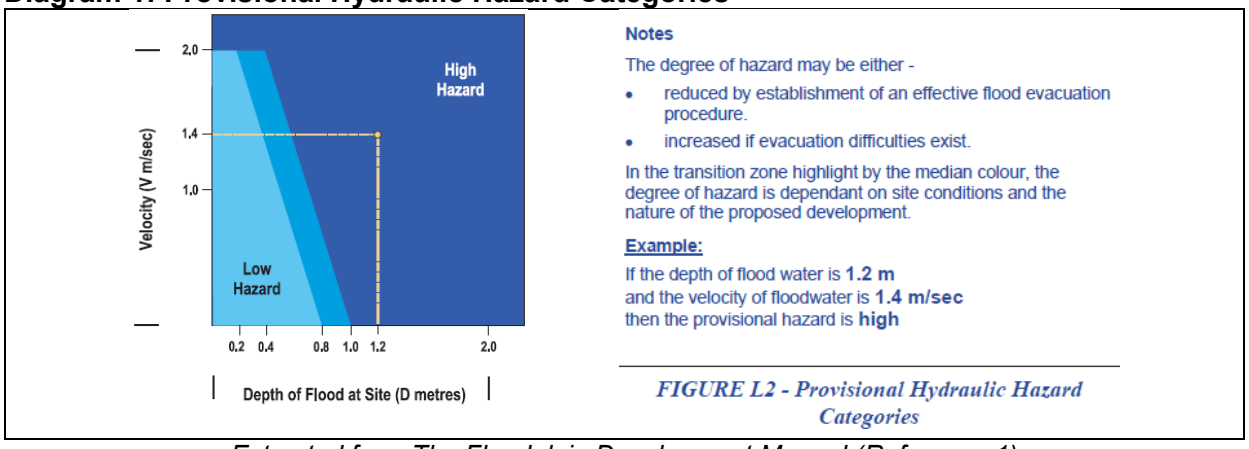

FIGURE L2 - Provisional Hydraulic Hazard Categories

Extracted from The Floodplain Development Manual (Reference 1)

The Flood Study (Reference 2) established high and low provisional hazard areas for the 5% AEP and 1% AEP events and the PMF. 1% AEP event high hazard areas tend to be limited to defined flow paths and the floodway and also those areas where water depth accumulates, such as upstream of farm dams.

3.7. Flood Liable Areas and Infrastructure

The October 2010 flood event provides an indication of flood liability and affected infrastructure as it is slightly larger than the 1% AEP flood.

Results of the Flood Study (Reference 2) indicate that numerous properties will suffer some degree of inundation during the 1% AEP event. Properties on the southern floodplain of Ten Mile Creek, particularly along Macinnes and Bardwell Streets become inundated by events as small as the 5% AEP event. For the 1% AEP flood as many as 30 homes and 8 commercial lots are likely to become inundated above floor and many more will experience significant flooding of property lots (not necessarily over floor level inundation).

In terms of flood risk, the southern floodplain is particularly notable. Flood depths and velocities are the highest in the study area which when combined with the number of properties that are affected and a lack of egress produces significant flood risk. As does the tendency for flood levels to increase significantly for larger and rarer flood events.

Flood affectation due to Morgan's Ridge Creek is less of an issue with the majority of properties not inundated over floor until the PMF. Similarly, flooding due to overland flows from catchments to the north are not likely to cause over floor flooding to residential properties until events much larger than the 0.5% AEP. However a number of industrial and commercial properties to the north-west of town in the industrial precinct between Wallace and Bath Streets may become inundated from events as small as the 5Y ARI.

Further to this other flood liable locations include;

- Jingellic Road;
- Albury Street; and
- Culcairn-Holbrook Road.

The following roads are also cut during the 1% AEP event by Ten Mile Creek flows:

- Jingellic Road;
- Albury Street; and
- Culcairn-Holbrook Road.

During such an event access to the township of Holbrook will be restricted by flooding in these regions. The PMF is found to inundate much of the town and in many locations will be 2 m higher than the 1% AEP event and up to 4 m higher proximate to the Holbrook Bypass. This is indicative of a high risk flood situation.

3.7.1. Hotspots

The Flood Study identified a number of flooding "Hotspots" which are specific areas of interest from a flooding perspective. These include; locations where many residences are liable to flooding, where key drainage assets are not meeting design standards or where key infrastructure, such as major roads, are flood affected. The hotspots, typically SES locations of interest, were identified and discussed in the Flood Study with respect to the behaviour of flooding at each location. The identified hotspots are summarised in Table 4 and displayed in Figure 3. For further information on the hotspots see the Culcairn, Henty and Holbrook Flood Studies (Reference 2).

Table 4: Hotspots

Hot Spot	Name	Comment
1	**Ten Mile Creek southern floodplain**	Flood liability for the 1% AEP event in Holbrook is predominately located on the Ten Mile Creek left floodplain upstream of Albury Street. The majority of residences affected during the 2010 event were located in this region. Flooding in this area occurs when flood waters break out of Ten Mile Creek on the left bank south of Macinnes Street.
2	**Unnamed southern Holbrook catchment**	South of Ten Mile Creek a small unnamed catchment generates flows that travel in a northerly direction before turning west, passing under Albury Street and the Holbrook Bypass before discharging into the swamp. Additional flow that exceeds the culvert's capacity leads to localised ponding and causes flow to travel in a northerly direction along Albury Street (on the eastern side) which results in inundation on Bardwell and Macinnes Streets.
3	**Upstream of the Holbrook Bypass on Ten Mile Creek**	Many residents of Holbrook feel that the introduction of the Holbrook Bypass has significantly affected flooding in the region between the Bypass and Albury Street. The Bypass reduces flow capacity, particularly on the southern floodplain and does lead to elevated flood levels in the region. The impact of the Bypass on flooding in Holbrook has been investigated with the findings provided in Section 4.2.
4	**Morgan's Ridge Creek Flooding**	Morgan's Ridge Creek is responsible for flooding in regions downstream of Wallace Street. Insufficient drainage under the Wallace Street structure causes flood waters to flow west along Wallace Street and also to continue down the Morgan's Ridge Creek floodplain. The Creek also breaks its banks again in a number of locations including the Bowler Street crossing as occurred during the 2010 event flood. This effect leads to floodwaters travelling down Swift and Gundagai Streets and causes flooding in the surrounding properties.

3.8. Future Development and Flooding

A current planning proposal seeks to amend the LEP 2012 land zoning at Holbrook with six areas proposed for rezoning in the study area (locations presented in Figure 1). These proposed rezoning regions have varying degrees of flood liability and an investigation into the suitability of these areas for rezoning has been undertaken in Section 4.4.

Future development within the FPA is not permitted with the NSW Environment Planning Assessment Act 1979 (EP&A Act) stating in Clause (5) of Direction 4.3:

> *(5) A planning proposal must not rezone land within the flood planning areas from Special Use, Special Purpose, Recreation, Rural or Environmental Protection Zones to a Residential, Business, Industrial, Special Use or Special Purpose Zone.*

Further details pertaining to Planning to the planning aspects of this study are presented in Sections 4.10 and 5.6.

4. FLOODPLAIN RISK MANAGEMENT STUDY

4.1. Objectives of the Floodplain Risk Management Study

The primary objective of the Floodplain Risk Management Study is to investigate a range of flood mitigation works and measures to address the existing, future and continuing flood problems, in accordance with the NSW Government's Flood Policy, as detailed in the Floodplain Development Manual (Reference 1). Other objectives include:

- Review Council's existing environmental planning policies and instruments including Council's long term planning strategies for the study area;
- Identify works, measures and restrictions aimed at reducing the social, environmental and economic impacts of flooding and the losses caused by flooding on development and the community, both existing and future, over the full range of potential flood events;
- To assess the effectiveness of these works and measures for reducing the effects of flooding on the community and development, both existing and future;
- To consider whether the proposed works and measures might produce adverse effects (environmental, social, economic, or flooding) on the floodplain and whether they can be minimised;
- Examination of the present flood warning system, community flood awareness and emergency response measures in the context of the NSW State Emergency Service's developments and disaster planning requirements.
- Examine ways in which the river and floodplain environment may be enhanced by preparing a strategy for vegetation planning that will create a valuable corridor of vegetation without having a detrimental effect on flooding;
- Identification of modifications required to current policies in the light of investigations; and
- Undertake effective community consultation and participation throughout the Study.

Further to this, this section considers the true hydraulic categorisation, true flood hazard classification, impacts of flooding to properties in Holbrook and key access issues. It also considers existing floodplain management at Holbrook in terms of both policy and planning as well as flood response. Structural flood management features are also considered. Potential options to reduce flood risks are discussed in Section 5.

A number of issues highlighted by the community consultation process (see Section 2.1) have also been investigated. These include:

- The impact that the Holbrook Bypass has on peak flood levels has also been investigated with the findings presented in Section 4.2;
- Drainage issues along Albury Street south of Ten Mile Creek (see Section 2.1) which in some instances have the potential to cause over floor inundation. WMAwater have worked with Council to provide information to RMS to undertake these works prior to RMS releasing their responsibility of Albury Street (previously the Hume Highway) to Council. Further details of this work are present in Section 4.3.

Further to this, six rezoning regions are proposed throughout the study area. These proposed rezoning regions have varying degrees of flood liability and further details are presented in the Flood Study (Reference 2). Further comment/investigation has also been provided in Section 4.4.

4.2. Impact of the Holbrook Bypass on Peak Flood Levels

A key concern of the community is the potential for the Holbrook Bypass to increase peak flood levels. To investigate the impact of the Bypass, the 1% AEP event has been run with the Bypass embankment and bridges removed. Figure 7 displays the difference in peak flood levels for the 1% AEP event due to construction of the Bypass. It can be seen that the Holbrook Bypass does cause increases in peak flood levels in excess of 0.3 m immediately upstream of the Bypass. However, increases in peak flood level quickly subside as distance upstream of the Bypass is increased. The maximum increase in peak flood level due to the Bypass at a residential property is less than 0.03 m, however the large majority of homes do not experience any impact. The flood extent of the 1% AEP flood event does not change significantly. Accordingly, the objectives of the Reference 5 environmental assessment have been met. These objectives were:

- Land without buildings or sensitive structures: minimise impacts;
- Land where buildings or sensitive structures are already below the 100 year ARI flood level: minimise and manage impacts; and
- Land where buildings or sensitive structures previously not inundated in the 100 year ARI event would be at increased risk of inundation: no additional impacts.

It should be noted that larger floods are expected to produce larger increases in peak flood level. However, placement of the Bypass downstream of the town is advised as it removes the risk of catastrophic overtopping failure upstream of the township.

4.3. Albury Street Holbrook - RMS Release of Responsibility to Council

With the construction of the Holbrook Hume Highway Bypass, RMS are preparing to release responsibility of Albury Street (previously the Hume Highway) to Council. Prior to this handover, RMS are obligated to undertake required resurfacing and drainage works.

At the request of Council, WMAwater have considered various flood mitigation works as part of this study with the aim of incorporating these works into the work performed by RMS prior to releasing responsibility of the Road. This handover of responsibility is due to occur before completion of this study. Accordingly, WMAwater have provided two letters to assist Council in determining what works should be performed by RMS to ameliorate flood risk prior to this handover. These letters are contained in Appendix D.

It should be noted that a number of these mentioned mitigation works are based on recommendations made as part of the Community Consultation program (see Section 2.1).

4.4. Proposed Rezoning Regions Planning Measures

Holbrook township is experiencing growth at the rate of 4.6% (GH LES 2010 – Habitat Planning) and the Council is responding to this growth by considering rezoning a number of areas within the township. Predominantly rural land (RU1) is being reviewed and assessed to identify areas that can support future residential development. One residential (R5) region on the Ten Mile Creek floodplain is being considered for 'down zoning' to RU1 to reduce flood risk.

Council is currently considering the rezoning of five sites as presented in Table 5 with the locations displayed in Figure 1 and Figure 2.

Table 5: Proposed Rezoning Areas

Zone Id	Current Zoning	Proposed Zoning	Area (ha)	Proposed Rezoning Suitability
0	RU1 Primary Production	R5 Large Lot Residential	26.6	Yes
1	RU1 Primary Production	R5 Large Lot Residential	3.4	No
2	RU1 Primary Production	R5 Large Lot Residential	79.8	Yes*
3	R5 Large Lot Residential	RU1 Primary Production	26.8	Yes
4	RU1 Primary Production	R5 Large Lot Residential	18.6	Yes

* Not all areas of the proposed rezoning region are suitable for rezoning. Regions within the Holbrook FPA cannot be rezoned to a zone type that can lead to increased development (see Section 4.10.1, Clause (5) of Direction 4.3 of the EP&A act).

Each site has been analysed for their suitability for rezoning with details presented below. As part of this analysis, Figure 8 illustrates the rezoning areas currently under consideration with the Holbrook FPA overlaid.

It is important to note that not all areas that are suitable for rezoning are flood free and accordingly it is recommended that the following is address before future development is undertaken:

- Consider ease/need for egress in relation to larger/rarer floods;
- Consider and apply appropriate flood proofing controls to industrial development within the FPA and more specifically the floodway; and
- Set minimum floor heights for dwellings in the Flood Planning Area (FPA).

Rezoning Area #0

Rezoning Area #0 is situated on the Morgans Ridge Creek floodplain (see Figure 8) and has an area of 26.6 ha. Examination of the Holbrook FPA indicates that the proposed rezoning area is outside of the FPA extent (see Figure 8). Therefore rezoning of this area is not in disagreement with Clause (5) of Direction 4.3 of the EP&A Act (see Section 4.10.1), and from a flooding perspective this land is suitable for rezoning to R5 Large Lot Residential. It should be noted that the proposed rezoning area, whilst not within the FPA extent, is flood affected and accordingly consideration of the various factors listed below should be taken into account.

Rezoning Area #1

Rezoning Area #1 is situated to the south-east of Holbrook between Jingellic Rd and Ten Mile Creek and has an area of 3.4 ha. Examination of the Holbrook FPA indicates that the proposed rezoning area is situated within the Holbrook FPA extent (see Figure 8). Rezoning Area #1 is currently zoned as RU1 and in accordance with Clause (5) of Direction 4.3 of the EP&A Act (see Section 4.10.1) this land cannot be rezoned as R5 Large Lot Residential and is therefore unsuitable for future development.

Rezoning Area #2

Rezoning Area #2 is situated to the south-east of Holbrook between Jingellic Rd and Ten Mile Creek and has an area of 79.8 ha. Examination of the Holbrook FPA indicates that the majority of the proposed rezoning area is outside of the FPA extent (see Figure 8), with the exception of regions bordering Ten Mile Creek. Therefore rezoning of this area is not in disagreement with Clause (5) of Direction 4.3 of the EP&A Act (see Section 4.10.1), and from a flooding perspective this land is suitable for rezoning to R5 Large Lot Residential. It should be noted that the proposed rezoning area, whilst not within the FPA extent, is flood affected and accordingly consideration of the various factors listed below should be taken into account.

Rezoning Area #3

Rezoning Area #3 is situated to the south of MacInnes Street on the Ten Mile Creek southern floodplain. The proposed rezoning will 'down zone' the region from R5 Large Lot Residential to RU1 Primary Production which will stop future development. This area is highly flood affected (see Hotspot #1, Section 3.7.1) and it is recommended that rezoning from the current R5 classification to RU1 Primary Production be undertaken to ensure that no future development occurs.

Rezoning Area #4

Rezoning Area #4 is situated between Railway Parade and the Holbrook Bypass (see Figure 1) and has an area of 18.8 ha. Examination of the Holbrook FPA indicates that the proposed rezoning area is outside of the FPA extent (see Figure 8). Therefore rezoning of this area is not in disagreement with Clause (5) of Direction 4.3 of the EP&A Act (see Section 4.10.1), and from a flooding perspective this land is suitable for rezoning to R5 Large Lot Residential. It should be noted that the proposed rezoning area, whilst not within the FPA extent, is flood affected and accordingly consideration of the various factors listed below should be taken into account.

4.5. True Hydraulic Categorisation

The Flood Study (Reference 2) defined the provisional hydraulic categorisation while the FRMS&P revised this to identify the true hydraulic categorisation.

Appendix E details the methods used to determine the floodway at Holbrook. Once the floodway was defined the remainder of the floodplain outside the floodway becomes either flood storage or flood fringe. In this study Flood Storage was defined as the land outside the Floodway if the depth is greater than 0.5 m and Flood Fringe if the depth is less than 0.5 m.

Hydraulic categorisation for the 5% and 1% AEP events and the PMF are presented in Figure 10 to Figure 12. The investigation into appropriate criteria for defining the Holbrook floodway is provided in Appendix E.

Using the methodology presented in Appendix E, the floodway is mainly contained to the Ten Mile Creek in-bank areas with the exception of the Holbrook southern floodplain along Macinnes and Bardwell Streets. Multiple residential lots are defined within the Ten Mile Creek floodway in this region. The Morgan's Ridge Creek floodway is generally defined by the top of bank of the creek and channel. Holbrook overland flows were determined to not produce a significant floodway due to the relatively slow velocities and shallow depths in the region.

4.6. True Flood Hazard Classification

The Flood Study (Reference 2) defined the provisional hydraulic hazard while the FRMS&P is required to consider the true flood hazard. The Flood Study (Reference 2) found that high provisional hydraulic hazard tends to be limited to defined flow paths and also those areas where water depths accumulate. However, provisional high hazard regions are generally not in the populated areas of Holbrook for the 1% AEP event.

To assess the true flood hazard all adverse effects of flooding have to be considered. As well as considering the provisional (hydraulic) hazard it also incorporates other criteria such as threat to life, danger and difficulty in evacuating people and possessions and the potential for damage, social disruption and loss of production and those detailed in Table 6.

Table 6: Hazard Classification

Criteria	Weight [1]	Comment
Size of the flood	Medium	The size or magnitude of the flood can affect depths and velocities. Relatively low flood hazard is associated with more frequent minor floods while the less frequent major floods are more likely to present a high hazard situation. In the PMF, much of the Ten Mile Creek southern floodplain would experience depths and velocities that could pose a risk to the structural stability of buildings (after Reference 8), and the same is true for areas on the western side of the Ten Mile Creek northern floodplain, towards the Holbrook Bypass embankment.
Depth and velocity of floodwaters	High	The provisional hazard is the product of depths and velocity of flood waters. These can be influenced by the magnitude of the flood event. Generally at Holbrook, high velocities and depths are confined to the Creek channel during the 1% AEP event. However, events larger than this do experience significant depths and velocities in populated areas on the Ten Mile Creek southern floodplain.
Rate of rise of floodwaters	Medium	Rate of rise of floodwaters is relative to catchment size, soil type, slope and land use cover. It is also influenced by the spatial and temporal pattern of rainfall during events. At Holbrook, the rate of rise can be quite rapid due to the relatively small catchment size and due to the sudden break out of flood waters at the eastern end of Macinnes and Bardwell Streets. This adds to the level of associated risk.

Criteria	Weight [1]	Comment
Duration of flooding	Low	The greater the duration of flooding the more disruption to the community and potential flood damages. A short period of inundation may allow some materials to dry and recover whereas a long duration may cause damages beyond repair. At Holbrook the flooding duration is relatively short.
Effective warning and evacuation time	High	This is dependent on the rate at which waters rise, an effective flood warning system and the awareness and readiness of the community to act. No BoM flood warnings are issued for the streams and creeks in the Greater Hume LGA therefore specific warning is limited. In addition to this, the upstream stream gauge (Ten Mile Creek @ Holbrook #3 Gauge, 410187) provides limited warning (see Section 5.5.1).
Flood awareness and readiness of the community	Medium	The community of Holbrook has a degree of flood awareness but it is likely to be limited to those people aware of the more recent events. Recent flooding events and community consultation undertaken as part of the current flood risk management process (of which this report forms part) has raised awareness of the flood problem. The awareness of the community has a medium weight in considering flood hazard as a more aware community will be able to better prepare and therefore potentially evacuate before hazards become high. General community awareness tends to reduce as the time between flood events lengthens and people become less prepared for the next flood event. Even a flood aware community is unlikely to be wise to the impacts of a larger, less frequent event. In areas where flood warning is limited it is more important for a community to be flood aware so that individual can notice the signs of the onset of flooding and prepare themselves.
Effective flood access	High	Access is affected by the depths and velocities of flood waters, the distance to higher ground, the number of people using and the capacity of evacuation routes and good communication. A number of roads in and out of Holbrook could become hazardous and even impassable during flooding, particularly in larger events. This is particularly true for regions on the Ten Mile Creek southern floodplain which could form a low flood island during flood.
Evacuation problems	High	Evacuation problems could also be exacerbated by the time of day during which flooding occurs. For example flooding overnight may be more difficult for residential areas. The number of people to be evacuated and limited resources of the SES and other rescue services can make evacuation difficult. Mobility of people, such as the elderly, children or disabled, who are less likely to be able to move through floodwaters and on-going bad weather conditions is a consideration.
Type of development	Low	The type of flood prone development will to some degree correspond to the level of occupant awareness, mobility of people as well as population density. Longer term home owners would likely have a better level of flood awareness than a guest at a hotel while residents from an residential care home are likely to be less mobile than average.

Criteria	Weight [1]	Comment
Additional Concerns	Low/ medium	The impact of debris in overland flow flooding is unlikely to be a significant factor due to the low flood depths and/or velocities. However, there is always concern over floating debris causing injury to wading pedestrians or structural damages to property. This could affect people evacuating homes on the Ten Mile Creek southern floodplain. Floating debris, vehicles or other items can increase hazard. In Ten Mile Creek where velocities are high, large debris can block structures, such as the Albury Street Bridge, causing damage and increases in flood levels upstream of the blockage.

[1] Relative weighting in assessing the hazard for Holbrook determined by interrogation of Reference 2 results

The flood hazard for the study area varies by location based on the relative depths, velocities and effective flood access. Flood hazard will vary depending on the magnitude of the event, and therefore its AEP.

Consideration was given to upgrading the low provisional hydraulic hazard mapped for the Ten Mile Creek southern floodplain to high true hazard, given the likely rapid rise with limited warning time, difficulty of access to high ground north of Ten Mile Creek, and the potential for highly hazardous conditions during extreme flooding. But to upgrade such a large area to high hazard was considered overly risk averse, especially since measures to reduce the risk – including a levee and improvements to flood warning – are being considered as part of this study.

The only substantial area upgraded to high hazard is the 'swamp' located in the southwest part of the study area, a portion of which is already mapped as provisional high hydraulic hazard in the 1% AEP event.

Elsewhere, only minor amendments (increased hazard classification of low hazard areas totally surrounded by high hazard areas) to the provisional flood hazard have been made with the true flood hazard for the 1% AEP event displayed in Figure 13.

There may be some localised areas subject to higher hazard where flood velocities are high, such as near obstructions to flow or culverts and drains that would not be identified at the current scale of the result mapping.

If the proposed levee on the southern floodplain is constructed, the true hazard would need to be remapped. In such a scenario, it is likely that the area upstream of the levee where levels significantly increase would be mapped as high hazard.

4.7. Impacts of Flooding

4.7.1. Residential Properties

Residential properties suffer damages from flooding in a number of ways. Direct damages include loss of property contents and/or damage to the structure of the property. Indirect damage costs can be incurred when property occupiers live elsewhere while repairs are being made. A flood damages assessment was undertaken for 601 residential properties. Surveyed floor level data was not available for all properties. Therefore in some cases floor level estimates were made by site visit and ALS data (see Section 1.5.3). A summary of the flood damages assessment is provided in the following sections with full details included in Appendix F.

4.7.1.1. Number of Inundated Residential Properties

The floor level survey and design results (Reference 2) were used to identify over floor flood affectation for residential properties and to determine what AEP is responsible for over floor flooding in the first instance. Figure 15 presents the design event during which residential properties are first inundated above floor level while Table 7 below details the total number of properties flooded in each design event. The number of flood affected residential properties during the March 2012 and October 2010 events is also present in Table 7.

Table 7: Number of Flood Prone Residential Properties

Event	No. Properties Affected	No. Flooded Above Floor Level
5-year ARI	14	3
10% AEP	18	4
March 2012	38	9
5% AEP	59	11
2% AEP	97	28
1% AEP	130	41
October 2010	115	43
0.5% AEP	151	54
PMF	543	445

NOTE: Properties affected are those where there is flooding above ground level within the property boundary (ie the lot). This does not necessarily mean that any buildings on the property are flooded or that the entire lot is inundated.

Although the majority of residential floor levels are not inundated until the PMF event, a substantial number are inundated above floor in smaller events. Two secondary residences (i.e. granny flat type structures) on Hume Street are identified as being flooding in the 5 year ARI event as well as an additional residence on Macinnes Street. The majority of flood affectation in Holbrook for the 1% AEP flood is to properties situated on the Ten Mile Creek southern floodplain (see Figure 15) with 32 (of 41) properties flooded over floor during this event being situated in this region. Residential lot over floor flood liability due to Morgan's Ridge Creek is relatively minor.

The Flood Study (Reference 2) determined the probability of the October 2010 Ten Mile Creek flood event to be 1% - 0.5% AEP, which is reflected in the number of properties flooded above floor. However, the number of flood affected lots was less than what would be expected in the 1% AEP event, and this is due to the October 2010 Morgan's Ridge Creek flood event having a more frequent probability than the associated Ten Mile Creek event. Similarly, the Flood Study determined the March 2012 flood event to have a probability between 10% - 5% AEP, again correlating well with number of properties flooded above flood in the upper and lower bound design events.

4.7.1.2. Residential Flood Damages Assessment

In assessing various mitigation measures it is important to compare them using a suitable metric. By applying a monetary value to property damages and then comparing damage estimates for the existing situation with assumed mitigation work (approximately costed) a benefit/cost (B/C) ratio can be calculated which is readily comparable. A flood damages assessment was undertaken for 543 residential properties likely to be affected in the PMF event in order to identify potential flood damages for a range of design events. A summary of the assessment is provided in the following sections with full details included in Appendix F.

Table 8 shows the potential damages for a range of design events and the Annual Average Damage (AAD). This forms the base case scenario against which damages from a number of mitigation measures can be assessed. Investigation into variation of damage values and B/C ratios for various flood mitigation management options are presented in Section 5.3 for preferred management options.

Table 8: Potential Residential Damages for Holbrook

Event	No. Flooded Above Floor Level	Total Damages for Event	Event Contribution to AAD (%)
5-year ARI	3	$ 235,000	12
10% AEP	4	$ 323,000	9
5% AEP	11	$ 953,000	11
2% AEP	28	$ 1,979,000	15
1% AEP	41	$ 3,007,000	8
0.5% AEP	54	$ 3,819,000	6
PMF	445	$ 44,022,000	40
Average Annual Damages (AAD)		**$ 300,000**	

The event damages due to residential property flooding for the October 2010 and March 2012 flood events are estimated to be $3.1 million and $620,000 respectively.

4.7.2. Non-Residential - Commercial, Industrial and Agricultural Activities

There is little specifically zoned commercial land in Holbrook (Figure 2), rather the main developed area is zoned RU5 Rural Village. This allows for a range of land uses, services and facilities that are associated with a rural village and includes some small commercial properties. The majority of non-residential properties are situated on Albury Street, which is also where the most non-residential lot flood affectation occurs. Commercial damages would also be sustained in agricultural areas zoned as RU1 Primary Production. These areas are predominantly used for grazing and cropping.

Non-residential properties are affected either directly by flood damage or indirectly by loss of business due to restricted customer and/or employee access. Costs vary significantly dependent on the type of activity;

- Type of business – stock based or not, costs of damages to goods;
- Duration of flooding – affects how long a business may be closed for, not just whether the business itself if closed, but when access to it is restored;
- Ability to move stock or assets before onset of flooding - some large machinery will not be able to be moved and in other instances there may be no sufficient warning time to move stock to dry locations; and
- Ability to transfer business to a temporary location.

The magnitude of flood damages to agricultural activities can be largely dependent on the depth and duration of flooding. Longer duration flooding can damage crops and ground leading to loss of harvest or suitable grazing lands. Although grazing animals such as sheep and cattle may be able to be moved this would often be to less suitable grazing land.

An explanation of the methods used to assess commercial damages is provided in Appendix F.

4.7.1.3. Number of Inundated Non-Residential Properties

The floor level survey and design results (Reference 2) were used to identify over floor flood liability and first event to cause the same for non-residential properties in Holbrook. Figure 15 shows the design event during which non-residential properties are first inundated above floor level while Table 9 below details the total number of non-residential properties flooded in each design event. The number of flood affected residential properties during the March 2012 and October 2010 events is also present in Table 9.

Table 9: Number of Flood Prone Non-Residential Properties

Event	No. Properties Affected	No. Flooded Above Floor Level
5-year ARI	4	1
10% AEP	7	3
5% AEP	18	9
March 2012	20	11
2% AEP	33	17
October 2010	38	21
1% AEP	42	24
0.5% AEP	48	26
PMF	113	90

NOTE: Properties affected are those where there is flooding above ground level within the property boundary (ie the lot). This does not necessarily mean that any buildings on the property are flooded or that the entire lot is inundated.

Approximately one third of non-residential properties in Holbrook (of approximately 130 in total) are flooded over floor in the 1% AEP flood and 9 are flooded over floor in the 5% AEP event. The majority of these properties are situated on Albury Street.

4.7.1.4. Non-Residential Flood Damages Assessment

A flood damages assessment was undertaken for 113 PMF flood liable non-residential properties to calculate flood damages for a range of design events. A summary of the assessment is provided in the following sections with full details included in Appendix F.

Table 10 shows the potential damages for a range of design events and the Annual Average Damage (AAD). This forms the base case scenario against which damages from a number of mitigation measures can be assessed. Discussion on the changes to damages values through various flood management options and the B/C analysis have been discussed in Section 5.3 for the preferred management options.

Table 10: Potential Non-Residential Damages for Holbrook

Event	No. Flooded Above Floor Level	Total Damages for Event	Event Contribution to AAD (%)
5-year ARI	1	$ 46,000	5
10% AEP	3	$ 193,000	8
5% AEP	9	$ 643,000	14
2% AEP	17	$ 1,546,000	21
1% AEP	24	$ 2,193,000	12
0.5% AEP	26	$ 2,961,000	8
PMF	90	$ 16,555,000	32
Average Annual Damages (AAD)		**$ 153,000**	

The event damages due to non-residential property flooding for the October 2010 and March 2012 flood events are estimated to be $2.0 million and $800,000 respectively.

4.7.3. Public Infrastructure and Other Land Uses

Public sector (non-building) damages include; recreational/tourist facilities; water and sewerage supply; gas supply; telephone supply; electricity supply including transmission poles/lines, sub-stations and underground cables; rail; roads and bridges including traffic lights/signs; and costs to employ emergency services and assist in cleaning up. Public sector damages can contribute a significant proportion to total flood costs but are difficult to accurately calculate or predict.

Costs to Councils from flooding typically comprise;

- Clean-up costs;
- Erosion and siltation;
- Drain cleanout and maintenance;
- Removing fallen trees;
- Inundation of Council buildings;
- Direct damage to roads, bridges and culverts;
- Removing vehicles washed away;
- Assistance to ratepayers;
- Increases in insurance premiums;
- Closures of streets;
- Loss of working life of road pavements; and
- Operational costs in the lead up to and during flood events.

4.7.3.1. Electricity

The Holbrook electrical zone sub-station is situated on Jingellic Road approximately 1 km east of town. The region surrounding the substation is flooded by events as small as the 2% AEP however flood depths during the 1% AEP flood are typically less than 0.2 m.

Liaison with Essential Energy has revealed that bunding with a minimum level of 0.5 m above surrounding ground level protects the majority of infrastructure. Accordingly the zone substation was not flooded during the October 2010 flood event which had an approximate 150 year ARI.

During a flood, personnel from the Essential Energy Wagga Depot form an emergency response team that work in conjunction with the NSW SES to perform a risk assessment of the infrastructure. If the infrastructure is deemed to be at hazard, network operators have the ability to shut off the power to the substation remotely. However, it is reported that typically power is not shut off until there is risk of physical damages to the infrastructure.

Flooding of the substation that could cause risk to life or loss of power is unlikely to occur for events smaller than the 0.2% AEP. In the event of a flood, Essential Energy should be notified so that an emergency response team can be assembled.

4.7.3.2. Sewerage

The Holbrook sewerage treatment plant is situated on Bath Street east of the Holbrook Bypass. The sewerage plant is situated above the level of the PMF and is therefore not flood liable.

4.7.3.3. Schools

Holbrook has two schools, St Patrick's Primary School and Holbrook Public School which are situated at 145 and 146 Albury Street respectively. Neither of these schools are flood affected in the 1% AEP flood event, however, access to both schools would likely be restricted during such an event due to the depth of flow on the surrounding roads. During the PMF, the grounds of both schools are flooded, however neither school is flooded over floor during such an event.

Flooding to the school, and to similar institutions, would have different impacts depending on the time of day. During school hours response would be more critical due to the number of persons on the site. Although flooding at both schools is unlikely, it is important that the schools have effective flood plans.

4.7.3.4. Operations Centres

Greater Hume Shire has recently endorsed Volume 1 of the Greater Hume Local Flood Plan (LFP). The LFP (Clause 3.5.2) records the NSW SES Holbrook Operations Centre at (No. 16) Wallace Street, Holbrook.

An inspection of flood behaviour indicates that this building could be subject to above floor flooding in relatively frequent *local* flooding (not Ten Mile Creek) events but that the depths even up to the 0.5% AEP event would not exceed more than about 0.1 m over floor. However, the depths in the PMF would approach 2.0 m over floor and access to the operations centre would also be compromised.

4.7.3.5. Evacuation Centres

The Greater Hume Local Flood Plan (Volume 1, Section 3.18.42) lists the Holbrook Community Resource Centre in Library Court (off Bowler Street) as the preferred evacuation centre. This site was used for this purpose during the October 2010 flood.

From a flooding perspective, the Holbrook Community Resource Centre is an acceptable site for an evacuation centre. It is not expected to be flooded above floor even in the PMF. However, access along Bowler Street could be compromised and the building could be an island (surrounded by shallow water) in a PMF from local flooding. There would be overland access to flood-free ground at the rear of St Patricks Catholic Primary School.

4.8. Road Inundation and Access

Understanding flood access issues is critical to effective evacuation and flood response planning.

During the October 2010 flood, access to Holbrook was cut on all sides: to the north, Wagga-Holbrook Road at several locations; to the north-east, the Hume Highway at Little Billabong; to the east, Jingellic Road at Serpentine and Wantagong Creeks; to the south, the Hume Highway at Mullengandra; and to the west, Culcairn-Holbrook Road at several locations (Reference 3).

The Flood Study (Reference 2) modelled peak flows, flood levels and velocities within Holbrook. A selection of flood depths at road low-points is presented in Table 11. Evacuation from the southern floodplain of Ten Mile Creek to the nominated evacuation centre can be compromised in relatively frequent events by inundation of Albury Street. Access to the hospital towards the eastern end of Bowler Street can be compromised for a short time due to flooding of Morgan's Ridge Creek in events as frequent as the 5% AEP.

Table 11: Flood Depths at Road Crossings

Event	Albury Street near Hay Street (m)	Albury Street near Bardwell Street (m)	Bowler Street at Morgan's Ridge Creek (m)	Cnr Young and Swift Streets (m)
5-year ARI	n/a	n/a	n/a	n/a
10% AEP	n/a	n/a	n/a	n/a
5% AEP	n/a	0.15	0.19	0.12
2% AEP	0.16	0.24	0.27	0.18
1% AEP	0.27	0.31	0.30	0.21
0.5% AEP	0.37	0.37	0.33	0.25
PMF	2.32	2.41	0.66	2.37

Research undertaken for the revision of ARR shows that vehicles can become unstable in shallow depths (~0.1 m) where velocities approach 3 m/s. Small cars can float in still water depths of only 0.3 m (Reference 9). In addition, once flooding has subsided, structural damage could make access over a bridge unsafe.

Information about the depths and velocities of road inundation and likely timing of road closures can aid flood response planning, and ensure that evacuation occurs in a timely fashion before conditions deteriorate and hinder the evacuation process, requiring rescue boats and helicopters.

Council manages all roads within the Shire other than the Hume Highway and Olympic Way, which are managed by RMS. Both Council and the RMS have primary responsibility for closing and reopening flooded roads, though the NSW Police Force also has this authority. NSW SES may assist these organisations where resources allow.

4.9. Evacuation Constraints

In order to assist in the planning and implementation of response strategies, the NSW SES in conjunction with OEH has developed guidelines to classify communities according to the ease of evacuation (Reference 10). These flood Emergency Response Planning (ERP) classifications are mapped for various design floods by considering the inundation of land, roads and overland evacuation routes. Based on the guidelines, communities are classified as either: Flood Islands; Rising Road Access; Overland Escape Route; Trapped Perimeter or Indirectly Affected areas. The classification relates directly to the operational questions of evacuation, rescue and resupply (Table 12).

Table 12: Emergency Response Planning Classification of Communities

	EMERGENCY RESPONSE		
Classification	Resupply	Rescue/Medivac	Evacuation
High flood island	Yes	Possibly	Possibly
Low flood island	No	Yes	Yes
Area with rising road access	No	Possibly	Yes
Area with overland escape routes	No	Possibly	Yes
Low trapped perimeter	No	Yes	Yes
High trapped perimeter	Yes	Possibly	Possibly
Indirectly affected areas	Possibly	Possibly	Possibly

Provisional ERP classification was undertaken for the 5% AEP, 1% AEP and PMF events with the classified regions presented in the Flood Study (Reference 2). The NSW SES also gave consideration to these classifications as part of the drafting of Volume 2 of the Local Flood Plan undertaken as part of the post-March 2012 flood intelligence review (Reference 4).

Flood maps suggest that evacuation from South Holbrook would not be affected by flooding in the 5 year ARI and 10% AEP events. In the 5% AEP event, water could inundate Macinnes Street, Bardwell Street, Albury Street south of Murray Street and Hay Street to depths that could compromise safe evacuation, creating High Flood Islands, though other areas north of Murray Street appear to retain Rising Road Access to the evacuation centre in Library Court. In the 2% AEP event, South Holbrook is classified as either High Flood Island or, especially for areas south of Murray Street, as Low Flood Island, since much land there would be inundated. In the 1% AEP event, the High Flood Islands are shrinking with much of South Holbrook now inundated (Low Flood Island). In the 0.5% AEP event, this situation is amplified, although 47 houses in South Holbrook are still expected to be above the flood level at this magnitude, albeit mostly surrounded by floodwater. In the PMF, all of South Holbrook would be a Low Flood Island.

Flooding in the main part of Holbrook located north of Ten Mile Creek is mainly driven by local overland flooding plus flooding from Morgan's Ridge Creek (Reference 2). The depths of flooding are typically lower than flooding from Ten Mile Creek. In the 5% AEP event, most properties north of Ten Mile Creek would have uninterrupted (Rising Road) access to the evacuation centre in Library Court, with the possible exception of some properties on the eastern and northern fringes of the town which could be isolated (High Trapped Perimeter) due to creek water rising above Corrys Lane, Wallace Street and Bowler Street. In the 2% AEP event, inundation is slightly more extensive though still largely confined to street gutters and so not expected to interrupt access, with the possible exception of areas southeast of the intersection of Young and Swift Streets (see Table 11), where flooding from Morgan's Ridge Creek could cut access. In the 1% AEP and 0.5% AEP events, the situation would change only a little, with slightly more extensive inundation along the Morgan's Ridge Creek floodplain, but with most properties still evidently able to access the evacuation centre, and with the town centre evidently still having connection to the Holbrook Bypass via Wagga-Holbrook Road. In the PMF, the Holbrook Bypass presents an obstacle to Ten Mile Creek flows, which back up to considerable depths in the western part of 'North' Holbrook. Nevertheless, an inspection of road and flood gradients indicates that there is a rising road gradient from the western ends of Wallace, Bowler and Young Streets towards Albury Street and towards the Holbrook Community Resource Centre evacuation centre or St Patricks Catholic

Primary School (itself located on a High Flood Island), so this area is more properly considered as a Rising Road Access area than as a Low Flood Island even though the time to evacuate in a PMF would be very short.

4.10. Legislative and Planning Management

4.10.1. State Legislative and Planning Context

It is important to understand the state legislation that overarches all local legislation to enable appropriate floodplain risk management measures to be proposed that are in keeping with both state and local statutory requirements. This section discusses the state legislation that influences planning in relation to flood risk at the local government level.

The NSW Environmental Planning and Assessment Act 1979 (EP&A Act) provides the framework for regulating and protecting the environment and controlling development.

Pursuant to Section 117(2) of the EP&A Act, the Minister has directed that Councils have the responsibility to facilitate the implementation of the NSW Government's Flood Prone Land Policy. Specifically, Direction 4.3 states:

Objectives

(1) The objectives of this direction are:

(a) to ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005, and

(b) to ensure that the provisions of an LEP on flood prone land is commensurate with flood hazard and includes consideration of the potential flood impacts both on and off the subject land.

Clause (3) of Direction 4.3 states:

(3) This direction applies when a relevant planning authority prepares a planning proposal that creates, removes or alters a zone or a provision that affects flood prone land.

Clauses (4)-(9) of Direction 4.3 state:

(4) A planning proposal must include provisions that give effect to and are consistent with the NSW Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas).

(5) A planning proposal must not rezone land within the flood planning areas from Special Use, Special Purpose, Recreation, Rural or Environmental Protection Zones to a Residential, Business, Industrial, Special Use or Special Purpose Zone.

(6) A planning proposal must not contain provisions that apply to the flood planning areas which:

(a) permit development in floodway areas,

(b) permit development that will result in significant flood impacts to other properties,

(c) permit a significant increase in the development of that land,

(d) are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services, or

(e) permit development to be carried out without development consent except for the purposes of agriculture (not including dams, drainage canals, levees, buildings or structures in floodways or high hazard areas), roads or exempt development.

(7) A planning proposal must not impose flood related development controls above the residential flood planning level for residential development on land, unless a relevant planning authority provides adequate justification for those controls to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).

(8) For the purposes of a planning proposal, a relevant planning authority must not determine a flood planning level that is inconsistent with the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas) unless a relevant planning authority provides adequate justification for the proposed departure from that Manual to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).

(9) A planning proposal may be inconsistent with this direction only if the relevant planning authority can satisfy the Director-General (or an officer of the Department nominated by the Director-General) that:

(a) the planning proposal is in accordance with a floodplain risk management plan prepared in accordance with the principles and guidelines of the Floodplain Development Manual 2005, or

(b) the provisions of the planning proposal that are inconsistent are of minor significance.

4.10.1.1. NSW Flood Prone Land Policy

The primary objectives of the NSW Government's Flood Prone Land Policy are:

- to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone land, and
- to reduce public and private losses resulting from floods whilst utilising ecologically positive methods wherever possible.

The NSW Floodplain Development Manual 2005 (the Manual), relates to the development of flood prone land for the purposes of Section 733 of the Local Government Act 1993 and incorporates the NSW Flood Prone Land Policy.

The Manual outlines a merits approach based on floodplain management. At the strategic level, this allows for the consideration of social, economic, cultural, ecological and flooding issues to determine strategies for the management of flood risk.

The Manual recognises differences between urban and rural floodplain issues. Although it maintains that the same overall floodplain management approach should apply to both, it recognises that a different emphasis is required to address issues particular to a rural floodplain. These issues include:

- The large area of land under investigation;
- The complexity of flood behaviour;
- The impacts of protection works for valuable crops on flood behaviour;
- The period of inundation;
- The uncertainties associated with flood related data, and
- The environmental values associated with flood dependent ecosystems on a rural floodplain.

4.10.1.2. Section 149 Planning Certificates

Section 149 of the EP&A Act states:

(1) A person may, on payment of the prescribed fee, apply to a council for a certificate under this section (a planning certificate) with respect to any land within the area of the council.

(2) On application made to it under subsection (1), the council shall, as soon as practicable, issue a planning certificate specifying such matters relating to the land to which the certificate relates as may be prescribed (whether arising under or connected with this or any other Act or otherwise).

(3) (Repealed)

(4) The regulations may provide that information to be furnished in a planning certificate shall be set out in the prescribed form and manner.

The Environmental Planning and Assessment Regulation 2000 prescribes the matters which must be included in a s.149 Planning Certificate, including whether a parcel of land is subject to controls relating to flooding.

4.10.1.3. State Environmental Planning Policy (Exempt and Complying Development Codes (2008))

The aims of State Environmental Planning Policy (Exempt and Complying Development) 2008 are:

This Policy aims to provide streamlined assessment processes for development that complies with specified development standards by:

(a) providing exempt and complying development codes that have State-wide application, and

(b) identifying, in the exempt development codes, types of development that are of minimal environmental impact that may be carried out without the need for development consent, and

(c) identifying, in the complying development codes, types of complying development that may be carried out in accordance with a complying development certificate as defined in the Act, and

(d) enabling the progressive extension of the types of development in this Policy, and

(e) providing transitional arrangements for the introduction of the State-wide codes, including the amendment of other environmental planning instruments.

4.10.1.4. General Housing Code

Part 3 of the SEPP relates to the *"General Housing Code"*.

Division 1 of Part 3 of the SEPP, which comprises clauses 3.1-3.6 of the SEPP, relates to:

Development that is complying development under this code

Clause 3.1 states:

3.1 Land to which code applies

This code applies to development that is specified in clauses 3.2-3.5 on any lot in Zone R1, R2, R3, R4 or RU5 that:

(a) has an area of at least 200 m^2, and

(b) has a width, measured at the building line fronting a primary road, of at least 6m.

Clause 3.2 of the SEPP states:

3.2 New single storey and two storey dwelling houses

The erection of a new single storey or two storey dwelling house is development specified for this code.

Clauses 3.3-3.5 generally relate to single and two storey dwelling houses and ancillary development.

Division 2 of Part 3 of the SEPP contains:

Development standards for this code

Subdivision 9 contains:

Development standards for particular land

Subdivision 9 contains Clause 3.36C of the SEPP which relates to development standards for the General Housing Code on *"flood control lots"*.

A *"flood control lot"* is defined in the SEPP as:

> ***flood control lot*** *means a lot to which flood related development controls apply in respect of development for the purposes of industrial buildings, commercial premises, dwelling houses, dual occupancies, multi dwelling housing or residential flat buildings (other than development for the purposes of group homes or seniors housing).*
>
> ***Note.*** *This information is a prescribed matter for the purpose of a certificate under section 149 (2) of the Act.*

As such, a *"flood control lot"* is a lot where the Council has provided for flood related development controls, which are all lots with notation on a s.149 Planning Certificate that flood related development controls apply. This is generally land which falls within the *"Flood Planning Area"*.

Clause 3.36C states:

> ***3.36C Development standards for flood control lots***
>
> *(1) This clause applies:*
>
> *(a) to all development specified for this code that is to be carried out on a flood control lot, and*
>
> *(b) in addition to all other development standards specified for this code.*
>
> *(2) The development must not be on any part of a flood control lot unless that part of the lot has been certified, for the purposes of the issue of the relevant complying development certificate, by the council or a professional engineer who specialises in hydraulic engineering as not being any of the following:*
>
> *(a) a flood storage area,*
>
> *(b) a floodway area,*
>
> *(c) a flow path,*
>
> *(d) a high hazard area,*
>
> *(e) a high risk area.*
>
> *(3) The development must, to the extent it is within a flood planning area:*
>
> *(a) have all habitable rooms no lower than the floor levels set by the council for that lot, and*
>
> *(b) have the part of the development at or below the flood planning level constructed of flood compatible material, and*

(c) be able to withstand the forces of floodwater, debris and buoyancy up to the flood planning level (or if on-site refuge is proposed, the probable maximum flood level), and

(d) not increase flood affectation elsewhere in the floodplain, and

(e) have reliable access for pedestrians and vehicles from the development, at a minimum level equal to the lowest habitable floor level of the development, to a safe refuge, and

(f) have open car parking spaces or carports that are no lower than the 20-year flood level, and

(g) have driveways between car parking spaces and the connecting public roadway that will not be inundated by a depth of water greater than 0.3m during a 1:100 ARI (average recurrent interval) flood event.

(4) A standard specified in subclause (3) (c) or (d) is satisfied if a joint report by a professional engineer who specialises in hydraulic engineering and a professional engineer who specialises in civil engineering confirms that the development:

(a) can withstand the forces of floodwater, debris and buoyancy up to the flood planning level (or if on-site refuge is proposed, the probable maximum flood level), or

(b) will not increase flood affectation elsewhere in the floodplain.

(5) If a word or expression used in this clause is defined in the Floodplain Development Manual, the word or expression has the same meaning as it has in that Manual unless it is otherwise defined in this clause.

(6) In this clause:

***flood compatible material** means building materials and surface finishes capable of withstanding prolonged immersion in water.*

***Floodplain Development Manual** means the Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005.*

***flow path** means a flow path identified in the council's flood study or floodplain risk management study carried out in accordance with the Floodplain Development Manual.*

***high hazard area** means a high hazard area identified in the council's flood study or floodplain risk management study carried out in accordance with the Floodplain Development Manual.*

***high risk area** means a high risk area identified in the council's flood study or floodplain risk management study carried out in accordance with the Floodplain Development Manual.*

4.10.1.5. Rural Housing Code

Part 3A of the SEPP contains the *"Rural Housing Code"*.

Division 1 of Part 3A of the SEPP defines:

> ***Development that is complying development under this code***

Clauses 3A.1 and 3A.2 state:

> ***3A.1 Land to which code applies***
>
> *This code applies to development that is specified in clauses 3A.2-3A.5 on lots in Zones RU1, RU2, RU3, RU4, RU6 and R5.*
>
> ***3A.2 New single storey and two storey dwelling houses***
>
> *(1) The erection of a new single storey or two storey dwelling house is development specified for this code if the development is erected on a lot:*
>
> *(a) in Zone RU1, RU2, RU4 or RU6 that has an area of at least 4,000m^2, or*
>
> *(b) in Zone R5.*
>
> *(2) This clause does not apply if the size of the lot is less than the minimum lot size for the erection of a dwelling house under the environmental planning instrument applying to the lot.*

Clause 3A.38 contains:

> ***Development standards for flood control lots***

The development standards contained in clause 3A.38 are the same as those contained in clause 3.36 as detailed above.

4.10.1.6. Summary of State Legislative and Planning Polices

From the above discussion of both the General Housing Code and the Rural Housing Code, it is clear that, unless a lot affected by flooding is included as a *"flood control lot"*, a s.149 notification is not required and, as a result, planning controls relating to flooding do not apply and a Complying Certificate can be granted without having regard to any Council flood controls. This scenario has considerable implications with regard to Council deciding whether a lot which is flood affected is included in the Floor Planning Area.

4.10.2. Local Council Policy

Updated and relevant planning controls are important in flood risk management. Appropriate planning restrictions, ensuring that development is compatible with flood risk, can significantly reduce flood damages. Planning instruments can be used as tools to guide new development away from high flood risk locations and ensure that new development does not increase flood risk elsewhere. They can also be used to develop appropriate evacuation and disaster management plans to better reduce flood risks to the existing population. Councils use Local Environmental Plans (LEPs) and Development Control Plans (DCPs) to govern control on development with regards to flooding. Plans and Polices have been discussed below and later have been reviewed in regards to flood risk management to identify where improvements might be made (see Section 5.6).

A LEP guides land use and development by zoning all land, identifying appropriate land uses that are allowed in each zone, and controlling development through other planning standards and Development Planning Controls (DCPs). LEPs are made under the EP&A Act 1979 which contains mandatory provisions on what they must contain and the steps a Council must go through to prepare them. In 2006 the NSW Government initiated the Standard Instrument LEP program and produced a new standard format which all LEPs should conform to. Greater Hume Shire Council's LEP was adopted in 2012 and was prepared under the Standard Instrument LEP program.

4.10.2.1. Greater Hume Local Environment Plan 2012 (LEP 2012)

Clause 6.1A of LEP 2012 relates to flood planning and states:

> ***6.1A Flood planning***
>
> *(1) The objectives of this clause are as follows:*
>
> *(a) to minimise the flood risk to life and property associated with the use of land,*
>
> *(b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,*
>
> *(c) to avoid significant adverse impacts on flood behaviour and the environment.*
>
> *(2) This clause applies to land at or below the flood planning level.*

(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:

(a) is compatible with the flood hazard of the land, and

(b) will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

(c) incorporates appropriate measures to manage risk to life from flood, and

(d) will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and

(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

(4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005, unless it is otherwise defined in this clause.

(5) In this clause, flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.

4.10.2.2. Greater Hume Development Control Plan 2013

Chapter 8 of the Greater Hume DCP 2013 deals with flood liable land.

Chapter 8 contains a number of objectives for development, some of which relate to outdated definitions or documents which has been repealed, for example, objective (l) is:

(l) deal consistently with applications for development on flood affected land, generally in accordance with the Floodplain Management Manual: The Management of Flood Liable Land issued by the New South Wales Government 2005;

A number of recommended amendments to Chapter 8 of the DCP including use of the 1% AEP design flood level plus freeboard are given in Section 5.6 and a draft policy is presented in Appendix G.

5. FLOODPLAIN RISK MANAGEMENT MEASURES

5.1. Identifying Floodplain Risk Management Measures

This FRMS aims to identify and assess risk management measures which could be put in place to mitigate flooding risk and reduce flood damages. This section sets out a number of measures which could be of benefit to Holbrook. As well as the hydraulic impacts, flood risk management measures are assessed against the legal, structural, environmental, social and economic conditions or constraints of the local area. In the following sections a range of management options have been considered to effectively manage existing and future flood risks at Holbrook.

5.2. Risk Management Measures Categories

The 2005 NSW Government's Floodplain Development Manual (Reference 1) separates risk management measures into three broad categories.

Flood modification measures modify the physical behaviour of a flood including depth, velocity and redirection of flow paths. Typical measures include flood mitigation dams, retarding basins, channel improvements, levees or defined floodways. Pit and pipe improvement and even pumps may also be considered where practical.

Property modification measures modify the existing land use and development controls for future development. This is generally accomplished through such means as flood proofing, house raising or sealing entrances, strategic planning such as land use zoning, building regulations such as flood-related development controls, or voluntary purchase/voluntary house raising.

Response modification measures modify the response of the community to flood hazard by educating flood affected property owners about the nature of flooding so that they can make better informed decisions. Examples of such measures include provision of flood warning and emergency services, improved information, awareness and education of the community and provision of flood insurance.

Table 13 provides a summary of typical floodplain risk management measures that have been assessed for the current study. It should be noted that many of these management measures are not appropriate for Holbrook and have not been recommended.

Table 13: Flood Risk Management Measures

Flood Modification	Property Modification	Response Modification
Levees (Lv)	Land zoning	Community awareness
Temporary Defences (TD)	Voluntary purchase	Flood warning
Channel Construction (CC)	Building & development controls	Evacuation planning
Channel Modification (CM)	Flood proofing	Evacuation access
Major Structure Modification (MSM)	House raising	Flood plan / recovery plan
Drainage Network Modification (DNM)	Flood access	
Drainage Maintenance (DM)		
Retarding Basins (RB)		

5.3. Flood Modification Measures

The purpose of flood modification measures is to modify the behaviour of the flood itself by reducing flood levels or velocities by excluding water from areas under threat. These measures usually involve structural works, most often permanent but temporary structures can be deployed where sufficient flood warning is available. This section considers management measures which modify flood behaviour on a wider scale. Flood modification measures at the individual property scale are discussed in Section 5.4.4.

Table 14 lists the modelled modification options and Figure H 1 (Appendix H) displays spatial locations of the modelled options.

Table 14: Flood Modification Measures Tested

Option	Description	Type*	Report Section
EL	North-south aligned levee bordering TMC, south-east of Holbrook.	(Lv)	5.3.1.1
SL	Levee parallel to Macinnes St and along TMC, flow passing over Albury St north of the Bypass off-ramp.	(Lv)	5.3.1.2
CL	Levee parallel to Macinnes St and along TMC and joining Bypass off-ramp. Culverts under Bypass off-ramp.	(Lv) / (CM) (DNM)	5.3.1.3
BL	Levee along Hay Street	(Lv)	5.3.1.4
ML	Levee along Morgans Ridge Creek north of Bowler St	(Lv)	5.3.1.6
VL	Bowler Street Embankment	(Lv)	5.3.1.7
C1	Channel on Ten Mile Creek floodplain upstream Holbrook Bypass	(CC)	5.3.3.1
C2	Golf course drainage channels for excess MRC flows	(CC)	5.3.3.2
S1	Clearing of debris in TMC	(CM)	5.3.4.2
S2	Dredging TMC	(CM)	5.3.4.3
S3	Increased capacity of Bardwell St drain, downstream Albury St	(CM)	5.3.4.4
S5	Increased MRC conveyance capacity	(CM)	5.3.4.5
A1	Raising Albury Street Bridge by 0.5 m	(MSM)	5.3.5.1
A2	Raising Albury Street Bridge by 1.0 m	(MSM)	5.3.5.2
A3	Doubling the length of the Albury Street Bridge	(MSM)	5.3.5.3
A4	Lowering Albury Street by 0.15m	(MSM)	5.3.5.4
A5	Lowering Albury Street between Bardwell and Macinnes Streets	(MSM)	5.3.5.5
A6	Removing pedestrian bridge along Bowler Street	(MSM)	5.3.5.6
A7	Increasing MRC culvert capacity at Wallace Street	(DNM)	5.3.6

* See Table 13 for Type classification description

Flood impact maps have been produced to display the effect that the various mitigation structures have on flood behaviour. These maps display the difference in peak flood level between the 1% AEP design event and the same event with the mitigation structure implemented. Impact maps have only been presented where significant impacts have been produced.

Mitigation options that were determined to provide significant benefits in terms of reduction in private property inundation have had damages assessments undertaken such that a Cost/Benefit ratio could be produced.

5.3.1. Levees and Bunds

DESCRIPTION

Levees involve the construction of raised embankments between the watercourse and flood affected areas so as to prevent the ingress of floodwater up to a design height. Levees usually take the form of earth embankments but can also be constructed of concrete walls or similar where there is limited space or other constraints. They are more commonly used on large river systems, for example on the Murrumbidgee River at Wagga Wagga or the Murray River at Albury, but can also be found on small creeks in urban areas and in overland flow situations where they usually take the form of smaller bunds.

Flood gates, flap valves and pumps are often associated with levees to prevent backing up of drainage systems in the area protected by a levee and/or to remove ponding of local water behind the levee.

Localised levees or bunding can be applied around individual properties. Such measures are considered minor property adjustments and are discussed in Section 5.4.4.

DISCUSSION

Once constructed, levee systems generally have a low maintenance cost although the levee system needs to be inspected on a regular basis for erosion or failure. Although a levee can keep out flood waters, flooding can occur within the levee due to local runoff being unable to drain. In addition, as the levee causes a displacement of water from one area of the floodplain to another they should be carefully designed using hydraulic modelling techniques so as to ensure the levee does not increase flood risk to an adjacent area.

The design height of the levee is the event for which it prevents flooding and usually also includes a freeboard to allow for settlement of the structure overtime or variations in flood levels due to the behaviour of the flood event, wave action from passing vehicles or watercraft and effects of wind. A freeboard analysis has been performed to determine the suitable allowance for freeboard (see

Various levee alignments have been considered for Holbrook to mitigate flooding from both Ten Mile and Morgan's Ridge Creek flooding. These include:

1. Option EL – TMC East Levee (see Section 5.3.1.1);
2. Option SL – TMC South Levee (see Section 5.3.1.2);
3. Option CL – TMC South Levee with Caltex site (see Section 5.3.1.3);
4. Option BL – TMC Hay Street Levee (see Section 5.3.1.4);
5. Option ML – Holbrook Returned Servicemen's Club MRC Levee Extension (see Section 5.3.1.6); and
6. Option VL – MRC Bowler St Embankment (see Section 5.3.1.7).

Further details of these structures are presented in the following sections and their locations displayed in Figure H 1.

5.3.1.1. Option EL – Ten Mile Creek East Levee

Mitigation Option EL involves the implementation of a levee parallel to Ten Mile Creek (i.e. running north-south) to the south-east of Bardwell Street and Macinnes Street. This levee was designed to confine flood waters to the Creek and prevent the flow breakout described in Section 3.7.1 and as Hotspot 1 in the Flood Study (Reference 2), thus reducing flooding of properties on the Ten Mile Creek southern floodplain. The tested levee alignment was approximately 800 m long with a maximum crest height of 1.75 m above surrounding ground level (determined using the 1% AEP flood event and assuming 0.75 m freeboard, see Appendix I for freeboard selection details).

The Option EL impact map for the 1% AEP event is presented in Figure H 2. It shows that a large area of land inside of the levee experiences reduced peak flood levels, particularly in the vicinity of Bardwell and Macinnes Streets upstream of Albury Street. Reductions in peak flood level of up to 0.5 m were present, leaving much of the area no longer flood affected in the 1% AEP event, which is significant as this region was badly affected in the October 2010 flood. However, outside the levee and further downstream, increases in peak flood level occurred with some regions experiencing 0.3 m increases in flood level. This adversely affects numerous houses by increasing their flood liability.

Due to the number of properties that experience increased peak flood levels and the degree to which they are affected, Option EL does not warrant further investigation.

5.3.1.2. Option SL – Ten Mile Creek South Levee

Option SL investigated the construction of a levee parallel to Macinnes Street (see Figure H3) and Ten Mile Creek near the eastern end of Barwell Street, designed to prevent the flow breakout described in Section 3.7.1 and as Hotspot 1 in the Flood Study (Reference 2) from passing through populated areas. Instead, flow is diverted across the Ten Mile Creek floodplain south of Macinnes Street. The levee alignment has a design length of 1.5 km and an average height of approximately 0.8 m. Downstream of Albury Street the alignment allowed flood waters to flow into the existing drainage channel proximate to Bardwell Street which inadvertently flooded the Caravan Park and proposed Caltex Service Station.

The Option SL impact map for the 1% AEP event is presented in Figure H 3. The levee reduces flooding in southern Holbrook, particularly along Macinnes and Bardwell Streets where large areas of previously flood affected land are no longer flooded. Flooding does still occur in the region as flood waters enter from the north near Hay Street. Some increases in peak flood levels do occur proximate to residential properties along Jingellic Road, however these are less than 0.1 m in all instances. However, it was noted that the Option SL levee did not accommodate for the site of a proposed Caltex service station, which lay outside the levee. Flood levels in this location were increased by up to 0.3 m.

Accordingly, the original levee alignment was revised such that the proposed Caltex service station and the Holbrook Caravan Park were also afforded protection (see Section 5.3.1.3) and it was determined that mitigation Option SL does not warrant further investigation.

5.3.1.3. Option CL – Ten Mile Creek South Levee with Caltex Site Protection

Option CL adopted the Option SL levee alignment (see Section 5.3.1.2), however the levee was modified along Albury Street to ensure that the Caltex site and caravan park were contained within the levee. This was achieved by extending the levee alignment to the Holbrook Bypass southern off-ramp. To allow flow across the southern floodplain, such that the breakout flow path is not completely obstructed, six culverts (6 x 2.4 m x 1.2 m BC) transfer floodwaters through the Holbrook Bypass off-ramp to downstream of Albury Street. Additionally, the Holbrook Bypass service road was also lowered to assist in flow conveyance. Other elevated areas (presumably fill storage mounds present at the time the ALS data was obtained) were lowered to prevent obstruction of the flow path along the outside of the levee. Further details of these mitigation measures are presented in Figure H 4.

The Option CL impact map for the 1% AEP event is presented in Figure H 4. Significant flood mitigation is possible for the 1% AEP event with reductions in peak flood levels of up to 0.5 m in some areas and large regions no longer flood affected. Increased peak flood levels of up to 0.6 m occurred outside the levee, however this was confined to non-urban areas. A number of homes do experience minor increases in peak flood levels, however these are less than 0.1 m increases.

Option CL has been considered for further investigation and has been modelled with Option BL to further improve flood protection. This is investigated further in Section 5.3.1.5.

5.3.1.4. Option BL – TMC Hay Street Levee

Option BL investigated the construction of a levee along Hay Street and blockage of minor flow paths from the fields, north of Bardwell Street. This levee protects Holbrook from floodwaters entering from Ten Mile Creek from the north upstream of the Albury Street Bridge. The levee is 200 m in length with an average height of 1.85 m (determined using the 1% AEP flood event and assuming 0.75 m freeboard, see Appendix I for freeboard selection details).

Option BL does provide some flood mitigation, however significant flooding to properties on the Ten Mile Creek southern floodplain at Holbrook still occurs as the majority of flood waters in the region come from the flow breakout described in Section 3.7.1 and as Hotspot 1 in the Flood Study (Reference 2). Accordingly, this option in its self is not recommended for further investigation, however further investigation into the combined modelling with Option CL has been undertaken. Further details of the combined Options CL / BL are presented in Section 5.3.1.5.

5.3.1.5. Combined Option CL / BL - Ten Mile Creek Southern Floodplain Levee System

The combination of Options CL (see Section 5.3.1.3) and BL (see Section 5.3.1.4) have been investigated to mitigate flooding on the Ten Mile Creek southern floodplain at Holbrook. It was found that the combination of these two levees eliminates property flood affection due to Ten Mile Creek for the region for events up to and including the 1% AEP flood event.

A key feature of the implementation of this levee is that residents are able to evacuate during a Ten Mile Creek flood event, either via the Holbrook Bypass on-ramp or via the Albury Street Bridge. This significantly reduces risk to life as people are not exposed to high hazard flows during evacuation as occurred during the October 2010 flood event. It also reduces the requirements on the SES and other rescue personnel thus further decreasing risk to life.

The combined Option CL / BL impact map for the 1% AEP event is presented in Figure H 5. Flooding due to local flows is a potential minor issue, however this will not be exacerbated with construction of the levee as the downstream end of town is not constricted by the levee. In addition, recommended works to Albury Street described in Section 4.3 would assist in reducing flood affection due to local flows.

Increases in peak flood levels outside of the levee are less than 0.1 m in the vicinity of residential properties and are unlikely to adversely affect homes in this region. An investigation into floor level and flood affectation of properties outside of the levee indicates that increases of less than 0.1 m are expected due to construction of the Option CL/BL levee in both the 1% and 0.5% AEP events. Additionally, homes in this region will not be flooded over floor by either event with construction of this option.

A damages assessment was undertaken to determine the B/C ratio for implementation of the combined Option CL / BL. The estimated residential and non-residential damages are displayed in Table 15 and Table 16 below.

Table 15: Combined Options CL / BL - Estimated Residential Damages for Holbrook

Event	No. Flooded Above Floor Level	Total Damages for Event	No. of Properties No Longer Flooded Over Floor
5-year ARI	3	$ 235,000	0
10% AEP	3	$ 256,000	1
5% AEP	6	$ 505,000	5
2% AEP	14	$ 1,119,000	14
1% AEP	16	$ 1,366,000	25
0.5% AEP	48	$ 3,239,000	6
PMF	443	$ 43,772,000	2
Average Annual Damages (AAD)		**$ 244,000**	

Table 16: Combined Options CL / BL - Estimated Non-Residential Damages for Holbrook

Event	No. Flooded Above Floor Level	Total Damages for Event	No. of Properties No Longer Flooded Over Floor
5-year ARI	1	$ 46,000	0
10% AEP	3	$ 193,000	0
5% AEP	9	$ 635,000	0
2% AEP	12	$ 1,045,000	5
1% AEP	16	$ 1,334,000	8
0.5% AEP	26	$ 2,919,000	0
PMF	90	$ 16,555,000	0
Average Annual Damages (AAD)		**$ 136,000**	

The estimated cost of implementation for the combined Options CL/BL is estimated to be $1,666,000. The combined AAD (residential and non-residential) is $380,000 which is a $73,000 reduction in AAD with implementation of the combined Option CL/BL. By estimating the expected damages for the next 50 years assuming implementation of the above mentioned options a B/C ratio of 0.7 has been calculated. It should be noted that 77% ($56,000) of the reduction in AAD is due to reduced flood affectation of residential properties.

Information on the preliminary costing and design of the combined Options CL/BL are contained in Appendix I.

SUMMARY

Implementation of the Combined Option CL/BL reduces flood risk at Holbrook by significantly reducing flood affectation and by allowing evacuation of residents during Ten Mile Creek flooding. The proposed mitigation measures provides a B/C ratio of 0.7, which indicates it is not of financial benefit, however intangible benefits such as risk to life and reduced flood related stress and anxiety are not accounted for in this calculation. Accordingly, Option CL/BL is considered the most viable option for reducing flood risk on the Ten Mile Creek southern floodplain at Holbrook. During detailed design stages the design should consider the viability of use of existing infrastructure, including the stock route and existing culverts under the highway.

RECOMMENDATIONS

The following measures are recommended:

► Recommended that detailed costing and design be undertaken for the combined **OPTION CL/BL.**

5.3.1.6. Option ML – Holbrook Returned Servicemen's Club MRC Embankment Extension

Option ML investigated extending an existing embankment situated on the western bank of the Morgan's Ridge Creek near Bowler Street, north an additional 200 m. This embankment was designed to contain floodwaters within the Creek channel and prevent water from entering nearby properties to the west. The total length of the embankment is approximately 350 m with the extended portion of the embankment having a length of 200 m. The embankment has an average height of 0.75 m (determined using the 1% AEP flood event and assuming 0.75 m freeboard, see Appendix I for freeboard selection details).

The Option ML impact map for the 1% AEP event is presented in Figure H 6. In the 1% AEP event, the embankment provides only minor reductions (up to 0.05 m) in peak flood levels in regions to the west. Similar increases in peak flood level are experienced to the east of the embankment. The embankment only provides minor decreases in peak flood level as a significant portion of the total flow for the region comes down Peel and Swift Streets. This allows water behind the embankment before it can be blocked from Morgan's Ridge Creek.

Due to the lack of significant impacts provided by Option ML, further investigation of this Option is not warranted.

5.3.1.7. Option VL – Bowler Street Embankment

Option VL investigated creating an embankment on the south side of Bowler Street (near 30 Bowler Street), to prevent Morgans Ridge Creek floodwaters from entering the vacant lot and flooding nearby properties. The levee is 80 m in length with an average height of 0.1 m.

Option VL was tested for the 1% AEP event. It was found that the levee eliminates flooding within the vacant lot however the levee has no impact on the surrounding properties. Accordingly, this could be investigated further by the land owner as it is classified as a minor property adjustment (see Section 5.4.4). As a result, Option VL is not a viable flood modification measure.

SUMMARY

Various levee alignments on the Ten Mile Creek southern floodplain have been investigated. The majority of tested Options were unable to effectively mitigate the full impact of flooding or created unacceptable impacts outside of the levee.

However, the combined Option CL/BL would provide protection from Ten Mile Creek flows and is financially viable. This Option has a cost/benefit ratio greater than one and is recommended for implementation.

5.3.2. Temporary Flood Barriers

DESCRIPTION

Temporary flood barriers include demountable defences, wall systems and sandbagging which is deployed before the onset of flooding.

DISCUSSION

Demountable defences can be used to protect large areas and are often used as a means to assist in current mitigation measures rather than as sole protection measures. For example they are best used to fill in gaps in levees or raising them as the risk of levee overtopping develops. The effectiveness of these measures relies on sufficient warning time and the ability of a workforce to install. They are more likely to be used for mainstream fluvial flooding from rivers which have sufficient warning time and are not a suitable technique for overland flooding.

The use of temporary measures in protecting individual properties, such as sandbagging, is discussed in Section 5.4.3.

SUMMARY

In Holbrook, demountable defences are unlikely to be able to be used to reduce flood risk and inundation due to the lack of suitable locations for their placement and insufficient warning time.

5.3.3. Channel Construction

DESCRIPTION

Channels can be an effective way to transfer and confine flow in a flooding situation and can aid in reducing peak flood levels, extents and duration.

DISCUSSION

An investigation into mitigation strategies for both Ten Mile and Morgan's Ridge Creek flow breakouts lead to the modelling of various channels to assist in the removal of flood waters and reduction of peak flood levels. Two scenarios, Options C1 and C2, were modelled with the former aimed at removing floodwaters on the Ten Mile Creek southern floodplain and the latter to assist in Morgan's Ridge Creek drainage. Details of these options are investigated in the following sections.

5.3.3.1. Option C1 – 10 m Wide Channel along Holbrook Bypass

Option C1 was implemented by constructing a 0.5m deep by 10m wide channel parallel and to the east of the Holbrook bypass. This measure was suggested in the Community Consultation (see Section 2.1) and aimed to channel and confine the flow breakout described in Section 3.7.1 and as Hotspot 1 in the Flood Study (Reference 2) and reduce peak flood levels upstream.

Mitigation Option C1 was tested for the 1% AEP event and was shown to be ineffective with no significant change in peak flood levels. The Option C1 channel would likely assist in the removal of floodwaters from the region upstream of the Holbrook Bypass, proximate to the caravan park, and reduce the duration of inundation however, it would not reduce the flood liability of residential properties.

Due to the lack of significant impacts provided by Option C1, further investigation of this Option is not warranted. However, Council may wish to investigate this further as part of their stormwater drainage plans.

5.3.3.2. Option C2 – Channel to carry overflow from Morgan's Ridge Creek

Two channels through the Holbrook Golf Course were created to accommodate floodwater breakouts from Morgan's Ridge Creek downstream of Wallace Street. These channels are 0.5 m deep by 5 m wide, and channel floodwaters through the Golf course from Wallace to Bowler Street.

Option C2 was tested for the 1% AEP event and the results are shown in Figure H 7. The golf course is no longer flood affected in the areas near these two channels however properties downstream of these channels experienced increased peak flood levels of up to 0.1 m. It was found that this option has did little to mitigate flooding for properties in the vicinity and as a result, it has not been considered for further investigation.

SUMMARY

The construction of additional channels in Holbrook to confine floodwaters from Ten Mile and Morgan's Ridge Creek breakouts were found to be ineffective in regards to reducing over floor inundation. Modifications to existing channels prove more slightly more effective and this is investigated in the following section (see Section 5.3.4).

5.3.4. Channel Modifications

DESCRIPTION

Channel modification includes a range of measures from increasing the size of a channel, straightening, concrete lining, removal of obstructing structures, dredging and vegetation clearing. In some instances 'naturalising' the channel upstream can reduce peak levels downstream by slowing flows and making better use of flood storage. On the other hand, straightening and channelling the flow can improve flooding by removing flood waters from an area more efficiently. However, such measures may also increase flood levels in adjacent or downstream locations.

DISCUSSION

A number of issues relating to existing flow channels have been discussed as part of the community consultation program (see Section 2). Residents have raised concerns with the amount of debris in Ten Mile Creek and also the possibility of dredging the Creek. These have been modelled as Options S1 and S2 respectively and are investigated further in the following sections.

In addition to Ten Mile Creek dredging and clearing, the cross sectional area of Morgan's Ridge Creek (Option S5) and the Bardwell Street drain (Option S3) have been increased to improve channel conveyance capacity. The impacts of these Options have also been assessed in the following sections.

5.3.4.1. Strategy for Vegetation Planting

Vegetation management planning should be investigated from a Ten Mile Creek catchment wide perspective in the first instance and then in a more localised manner for Holbrook. A catchment wide investigation is beyond the scope of the current study, however should be considered by Council in conjunction with Local Land Services (LLS) for the future.

The Murray LLS are responsible for Ten Mile Creek at Holbrook. Council should liaise with LLS to determine to what degree Ten Mile Creek can be cleared of vegetation, however there is generally no problem with removal of exotic trees and vegetation such as willows. Clearing or dredging on a broad scale would also require approval of various other state government organisations such as Fisheries and Office of Water. The Roads and Maritime Service (RMS) have authority from the Environmental Protection Authority (EPA) to remove debris built up against structures.

Council should request a strategy for vegetation planting of Ten Mile Creek to examine ways in which the river and floodplain environment may be enhanced to create a valuable corridor of vegetation without having a detrimental effect on flooding. As noted above, clearing of vegetation can be beneficial to reduce flood levels and reduce the risk of blockage of downstream structures. A suitable strategy for vegetation planting would need to balance the need for native vegetation and a thriving riparian corridor whilst managing the build-up of or clearance of vegetation to avoid unwanted effects on flood behaviour.

Management of vegetation can reduce flood levels by increasing the flow area within the channel by reducing potential for obstruction and blockage. Vegetation thinning on a regular basis to prevent build up is recommended. However, the impact of such works is generally minimal as shown in Section 5.3.4.2.

5.3.4.2. Option S1 – Reduction of Roughness in Ten Mile Creek Channel (Channel Clearing)

Option S1 was implemented by reducing the Ten Mile Creek channel roughness from a Mannings ‘n’ of 0.05 to 0.03 to simulate clearing of the channel from its current state to well-kept grass channel (an exaggeration of what is actually possible). This measure, as suggested in the Community Consultation (see Section 2.1), was used to show the impact that channel clearing and the associated increased channel efficiency has on peak flood levels.

The Option S1 impact map for the 1% AEP event is presented in Figure H 8. It was found that a decrease in peak flood level of up to 0.2 m occurs within the Ten Mile Creek in-bank, however for populated regions in the township of Holbrook flood levels did not decrease by more than 0.1 m. Downstream of Holbrook, peak flood levels are increased by more than 0.3 m, however no properties are affected by these impacts.

Option S1 shows that even if the creek were to be cleared of vegetation and replaced with well-kept grass the impact on peak flood levels is relatively minor for populated regions. However, it is recommended that the strategies mentioned in Section 1 be pursued by Council so that further increases to vegetation density do not occur.

5.3.4.3. Option S2 – Increasing the conveyance Ten Mile Creek Channel

Option S2 was used to simulate dredging of the Ten Mile Creek channel through Holbrook as requested as part of the Community Consultation (see Section 2.1). The Creek invert was lowered by 1 m from its current state and was made 15 m wider (an exaggeration of what is actually possible). It was assessed whether increasing the creek conveyance through dredging of the creek channel would reduce peak flood levels in Holbrook.

The Option S2 impact map for the 1% AEP event is presented in Figure H 9. Dredging of Ten Mile Creek would provide minor reductions to peak flood levels, however in populated regions this reduction would be less than 0.1 m.

Option S2 is not recommended for further investigation due to the relatively small impact on flood levels for the 1% AEP event and due to the difficulties associated with obtaining permission to undertake such works (see Section 1). Additionally, the combined Option CL / BL (see Section 5.3.1.5) provides much better protection of residential properties on the Ten Mile Creek southern floodplain at Holbrook.

Furthermore, due to regional soil types and lack of upstream vegetation, siltation on Ten Mile Creek has been historically reported as problematic. It has been noted that the Ten Mile Creek gauging station experienced significant siltation during the 2010 flood event which lead to the station malfunctioning. It is likely that future flood events would redeposit the silt from sources upstream thus removing the benefit of creek dredging.

5.3.4.4. Option S3 – Increasing width of drain on south-western side of Bardwell Street

The Bardwell Street drainage channel is situated downstream of Albury Street, parallel to Bardwell Street. The existing drain along Bardwell Street was doubled in width to investigate the impact of the channels capacity on peak flood levels. This measure was tested for the 1% AEP event. It was found that Option S3 had no significant impact on peak flood levels in the vicinity. As a result, this scenario has not been considered further. However, Council may wish to investigate this further as part of their stormwater drainage plans.

5.3.4.5. Option S5 – Increasing the conveyance of Morgan's Ridge Creek

The width of the Morgan's Ridge Creek channel was approximately doubled to a width of 10 m to determine the impact of the Çreek's conveyance on peak flood levels in the area. A number of residents who submitted community questionnaires suggested this scenario as a mitigation option (see Section 2.1).

The Option S5 impact map for the 1% AEP event is presented in Figure H 10. The results of this option showed decreased peak flood levels of up to 0.3 m in the immediate vicinity of the creek (see Figure H 10), however the average impact is typically less than 0.1 m. A number of properties along Gundagai Street between Hume Street and Jingellic Road had decreased peak flood levels of up to 0.2 m.

Reductions in peak flood levels expected with implementation of this Option will not provide significant decreases in flood damages as the majority of flood affected buildings in this area are not flooded over floor until flood levels exceed the 0.5% AEP event. Acquisition of privately owned land and costly civil works make the estimated cost of construction much greater than any reduction provided to AAD. Due to the minor benefit associated with implementation of this Option and the expensive construction costs this scenario has not been considered further. However, Council may wish to investigate this further as part of their stormwater drainage plans.

SUMMARY

Management of vegetation in both Ten Mile and Morgan's Ridge Creeks will have some benefits in reducing flood levels and preventing further build-up of debris and siltation of the Creek however should be considered carefully with the implications of environment effects.

Increasing existing major drainage infrastructure was generally shown to be ineffective. Option S5 did show some reduction in peak flood levels however will not be considered further due to an expected low cost/benefit ratio.

RECOMMENDATIONS

The following measures are recommended:

► Management of vegetation in Ten Mile and Morgan's Ridge Creeks to prevent blockage impacts on flood behaviour.

5.3.5. Major Structure Modification

DESCRIPTION

Hydraulic controls such as bridges or major culverts on significant waterways can affect upstream flood levels due to backwatering effects. By increasing hydraulic conveyance, flood levels upstream of a structure can be decreased. Generally the most effective way of increasing hydraulic conveyance is by increasing a structures cross sectional area (normal to the flow direction). This is often done by lengthening a bridge or raising the deck level.

DISCUSSION

A number of significant hydraulic structures that affect flood behaviour are situated in the study area. As part of the Community Consultation (see Section 2.1) and at the request of Council, a number of scenarios of increased conveyance capacity of the Albury Street Bridge have been modelled. These include:

1. Option A1 – Raising Albury Street Bridge by 0.5 m (see Section 5.3.5.1);
2. Option A2 – Raising Albury Street Bridge by 1.0 m (see Section 5.3.5.2); and
3. Option A3 – Doubling the length of the Albury Street Bridge (see Section 5.3.5.3).

Additionally, the Community Consultation processes requested that the impact of milling of Albury Street on the Ten Mile Creek floodplain be examined. Two Options were modelled:

1. Option A4 – Lowering the Albury Street Crest height on the Ten Mile Creek floodplain (see Section 5.3.5.4); and
2. Option A5 – Lowering the Albury Street Crest height between Bardwell and Macinnes Streets (see Section 5.3.5.5).

Finally, two structures on Morgan's Ridge Creek have also been adjusted and modelled. The footbridge immediately upstream of Bowler Street has been removed (Option A6, see Section 5.3.5.6) and at the request of the community (see Section 2.1) the culverts under Wallace Street have been modelled with increased conveyance capacity (Option A7, see Section 5.3.1.7).

It is important to note that the findings from the Albury Street Bridge and Albury Street investigations have been summarised in two letters provided to Council that provide recommendations and information to be used in liaison with RMS (see Section 4.3). These letters are contained in Appendix D.

5.3.5.1. Option A1 – Raising the Albury Street Bridge by 0.5 m

The level of the Albury Street Bridge was raised by 0.5 m to increase flow conveyance and reduce backing up of floodwaters upstream of the Bridge during a flood event.

It was found that this scenario did not have a significant impact on peak flood levels experienced in the 1% AEP event. Reductions in flood levels (up to 0.05 m) were experienced in the immediate vicinity of the bridge and negligible impacts were found in the remaining study area. Option A1 was also tested in conjunction with the combined Options CL / BL to try and reduce flood impacts associated with the levee system, however it was shown to be ineffective.

Option A1 is not recommended for further investigation due to the minor decrease in peak flood levels within the study area.

5.3.5.2. Option A2 – Raising the Albury Street Bridge by 1.0 m

The level of the Albury Street Bridge was raised by 1.0 m to increase flow conveyance and reduce backing up of floodwaters upstream of the Bridge during a flood event.

It was found that, similar to Option A1, this scenario did not have a significant impact on peak flood levels in the 1% AEP event with the exception of the area in the immediate vicinity of the bridge. Again, Option A2 was also tested in conjunction with the combined Options CL / BL to try and reduce flood impacts associated with the levee system, however it was shown to be ineffective.

Option A2 is not recommended for further investigation due to the minor decrease in peak flood levels within the study area.

5.3.5.3. Option A3 – Doubling the length of the Albury Street Bridge

As suggested in the community consultation process (see Section 2.1), the effective flow area of the Albury Street bridge at Ten Mile Creek was increased. The community consultation recommended that additional culverts be added to the bridge approach, however the capacity of the entire bridge has been increased instead. This is a conservative approach which would allow greater decreases in peak flood levels upstream.

Option A3 was tested for the 1% AEP event. It was found that moderate reductions in peak flood level (up to 0.2 m) would be experienced upstream of the bridge however only a small number of surrounding properties would experience a decrease in peak flood level, with a maximum decrease of 0.1 m. Again, Option A3 was also tested in conjunction with the combined Options CL / BL to try and reduce flood impacts associated with the levee system, however it was shown to be ineffective.

Option A3 is not recommended for further investigation due to the minor decrease in peak flood levels for upstream properties and the likely high cost of construction.

5.3.5.4. Option A4 – Lowering Albury Street by 0.15m

Option A4 was used to simulate the milling of the Albury Street crest height. This involved lowering the portion of Albury Street situated on the Ten Mile Creek floodplain (Macinnes street to the Albury Street Bridge) by 0.15 m. This scenario was suggested in feedback from the Community Consultation (see Section 2.1) as it has been reported that a number of properties on the upstream side of Albury Street have floor levels close to the existing road crest level. This has led to over floor flooding during local rainfall events which has been compounded by traffic along Albury Street creating bow waves.

When this scenario was tested for the 1% AEP event, there was no reduction in peak flood levels as a result of lowering the road. However, smaller events, particularly those that do not quite overtop the Albury Street Crest height would be provided with some benefit. Accordingly, a number of recommendations have been made in letters provided to Council (see Section 4.3).

5.3.5.5. Option A5 – Lowering Albury Street between Bardwell and Macinnes Streets

Option A5 examined lowering a section of Albury Street between Bardwell and Macinnes Streets to allow the flow breakout described in Section 3.7.1 and as Hotspot 1 in the Flood Study (Reference 2) to pass freely into the Bardwell Street drain (see Section 5.3.4.4). Lowering this section of the road was aimed to allow flood waters to flow over the road without travelling north to properties along the eastern side of Albury Street.

This measure was tested for the 1% AEP event however it did not have an impact on peak flood levels. Smaller events, particularly those that do not quite overtop the Albury Street Crest height would be provided with some benefit from this Option, however the recommended combined Option CL / BL (see Section 5.3.1.5) negates the need for these works. Accordingly, Option A5 has not been considered further.

5.3.5.6. Option A6 – Removing Bowler Street Pedestrian Bridge

Option A6 investigated removing the pedestrian bridge over Morgan's Ridge Creek at Bowler Street to prevent water backing up against the road bridge and subsequently against the pedestrian bridge.

It was found that Option A6 provided no reduction in peak flood level for the 1% AEP event. As a result, further investigation of this Option is not warranted.

SUMMARY

Major flow obstructions, such as inadequately designed roads and bridges, restrict flow conveyance capacity and cause increased peak flood levels. However, an investigation into increasing the conveyance capacity of the Albury Street Bridge over Ten Mile Creek showed only limited mitigation is possible through modifications of this structure.

It was noted however that some benefit from a drainage aspect would be obtained by lowering the Albury Street crest level, particularly for homes immediately upstream of the Road. Due to the impending release of responsibility of Albury Street to Council from RMS, WMAwater have provided advice in the form of a letter such that works can be undertaken before this handover occurs (see Section 4.3).

5.3.6. Drainage Network Modifications

DESCRIPTION

Modification of the existing drainage by installation of larger or more pipes or installation of retarding basins to detain and slowly release flood waters (see Section 5.3.9) can increase system capacity. Drainage network modifications can also be used to divert flows from one area to another.

DISCUSSION

Existing culvert on Morgan's Ridge Creek that transfer flow under Wallace Street have been recommended for detailed examination as part of the Community Consultation process (see Section 2.1). It was reported that these culverts are aligned incorrectly. Section 5.3.6 investigates Option A7 which tests the culverts sensitivity to changes in conveyance capacity.

5.3.6.1. Option A7 – Increasing culvert capacity at Wallace Street

Option A7 investigated increasing the capacity of the Morgan's Ridge Creek culverts beneath Wallace Street. This Option has been modelled as a result of the Community Consultation process (see Section 2.1). The capacity of the existing culverts were doubled and tested for the 1% AEP event.

The Option A7 impact map for the 1% AEP event is presented in Figure H 11. The area to the northern side of Wallace Street and along Peel Street showed minor decreases in peak flood levels (less than 0.05 m). There was also a minor increase in peak flood level for some areas, particularly within the Morgan's Ridge Creek in-bank.

Due to the insignificant decrease in peak flood level associated with Option A7, further investigation is not warranted.

SUMMARY

Increasing culvert capacity allows more water to pass through an obstruction such as Wallace Street on Morgan's Ridge Creek. However, in the case of Option A7 the increase in culvert flow conveyance does not significantly reduce peak flood levels, or the number of properties flooded above floor. This is likely due to the downstream channel conveyance capacity being insufficient to pass the additional flow.

5.3.7. Combined Mitigation Options

DISCUSSION

To optimise investigated flood mitigation Options in Holbrook many of the measures discussed thus far in Section 5 have also been considered in combination with each other. Table 17 outlines the various combinations of mitigation Options investigated and discusses their impact.

Table 17: Investigated Combined Options

Options	Sections	Impact
CL, BL, A2	5.3.1.3, 5.3.1.4, 5.3.5.2	No significant impact beyond CL and BL combination (see Section 5.3.1.5)
SL, BL, A2	5.3.1.2, 5.3.1.4, 5.3.5.2	Option SL superseded by Option CL No significant impact beyond SL and BL combination (see Section 5.3.1.5)
SL, BL, A3	5.3.1.2, 5.3.1.4, 5.3.5.3	Option SL superseded by Option CL No significant impact beyond SL and BL combination (see Section 5.3.1.5)
SL, A3	5.3.1.2, 5.3.5.3	Option SL superseded by Option CL No significant impact beyond Option SL (see Section 5.3.1.2)
SL, A2	5.3.1.2, 5.3.5.2	Option SL superseded by Option CL No significant impact beyond Option SL (see Section 5.3.1.2)
SL, A5	5.3.1.2, 5.3.5.5	Option SL superseded by Option CL No significant impact beyond Option SL (see Section 5.3.1.2)
EL, A1	5.3.1.1, 1	Option EL superseded by Option CL No significant impact beyond Option EL (see Section 5.3.1.2)
EL, A2	5.3.1.1, 5.3.5.2	Option EL superseded by Option CL No significant impact beyond Option EL (see Section 5.3.1.2)
EL, A3	5.3.1.1, 5.3.5.3	Option EL superseded by Option CL No significant impact beyond Option EL (see Section 5.3.1.2)

SUMMARY

Examination of various combinations of mitigation Options were shown to not significantly improve positive flood impacts. Due to the often high cost of construction of many of these options, implementation of these combination is not advised.

5.3.8. Drainage Maintenance

DESCRIPTION

Maintenance of the drainage network is important to ensure that it is operating with maximum efficiency and to reduce risk of blockage or failure. Maintenance involves regularly removing unwanted vegetation and other debris from the drainage network. Vegetation maintenance within the Ten Mile Creek channel is discussed in Section 5.3.4.1.

DISCUSSION

The Community Consultation process (see Section 2.1) highlighted the community's concerns about Creek and channel maintenance. The introduction of maintenance protocols or policies would ensure that drainage assets are effectively managed and regularly maintained such that they will perform as required particularly on those rare occasions when they are needed. This is complicated for the Holbrook Bypass as is owned by RMS. RMS is responsible for this drainage structure and Council should liaise with this authority.

SUMMARY

Regular maintenance can reduce risk of blockage of structures during flood events and ensure that flood waters are drained efficiently. It would be beneficial for Council to maintain a record of drainage infrastructure within the LGA and of the authority, organisation or body responsible for its maintenance.

RECOMMENDATIONS

The following measures are recommended:

► Identify policies for general maintenance of drains and channels and determination of protocols for ownership maintenance and development / upgrade of infrastructure.

► Develop a database of all drainage infrastructure and its owner and authority, organisation or body responsible for its maintenance.

5.3.9. Retarding Basins

DESCRIPTION

Retarding basins work by storing runoff and releasing it after the event peak. These measures are appropriate for use in controlling flooding by mitigating the effects of increased runoff caused by development and can be either installed as part of a new development to prevent increases in runoff rates, or retrofitted into existing catchment drainage systems to alleviate existing flood problems.

DISCUSSION

These systems are easy to implement when new development is proposed, as Council can place the responsibility on the developer to provide appropriate drainage systems. This is usually implemented through development controls requiring that runoff rates from new developments are not greater than existing rates. Often the 1% AEP event is used as the design event, but flows also need to be restricted back to the pre-development rates for smaller events. Hydraulic structures can be used to restrict the discharges rates from site to a variable rate, dependent on rainfall volumes and the hydraulic head in the retarding basin.

Retarding basins can also have benefits for the community other than flood control. For example, some basins when dry are used as sports fields and recreation grounds, others can be designed to be permanently wet creating scenic wildlife areas. There are also pollution control benefits associated with retention basins allows settlement of particulates and sediments.

Large retarding basins can be a safety hazard. Appropriate safety controls such as fencing and signage should be included as part of the overall asset. In NSW, particularly large basins may be prescribed by the Dam Safety Committee (DSC) which means that the DSC will maintain a continuing oversight of their safety. This is applicable to basins identified as a possible threat to communities downstream in case of failure. Like the rest of the drainage system, retarding basins have maintenance requirements. Regular checks and maintenance will be required by Council or agreements put in place with the developer and land holder. This is particularly applicable to basins identified as being a threat to communities downstream in case of failure.

SUMMARY

Detention basins mitigate flow by storing water for a limited period of time. Retarding basins as a flood mitigation option have been considered for Holbrook, however due to a lack of suitable locations for implementation, have been found as ineffective for the study area.

5.4. Property Modification Measures

Property modification measures refer to the modifications to existing development and/or development controls on property and community infrastructure for future development Flood modification measures which apply at the individual property scale have also been included in this section.

New performance requirements for buildings in flood hazard areas were introduced in the National Construction Code (NCC) in 2013 with The Australian Building Codes Board (ABCB)'s 'Construction of Buildings in Flood Hazard Areas' and the accompanying Handbook (References 18 and 19). This Standard contains requirements to ensure new buildings and structures, located in flood hazard areas do not collapse during a flood when subjected to flood actions and includes consideration of appropriate construction, use of appropriate materials, electrical, plumbing and drainage installation as well as setting floor levels. It applies to residential buildings (Classes 1, 2, 3 and 4) and health care buildings (Classes 9a and 9c). The Standard is not intended to override any land use planning controls imposed by Council or the appropriate authority.

5.4.1. House Raising

DESCRIPTION

House raising has been widely used throughout NSW to eliminate or significantly reduce flooding of habitable floors particularly in lower hazard areas of the floodplain, albeit in limited overall numbers. However it has limited application as it is not suitable for all building types being more suitable for non-brick single storey buildings. House raising is unlikely to be approved in high hazard areas.

DISCUSSION

The benefit of house raising is that it eliminates above floor flooding and consequently reduces flood damages. House raising also provides a safe refuge during a flood, assuming that the building is suitably designed for the water and debris loading. However the potential risk to life is still present if residents choose to enter floodwaters or are unable to leave the house during a medical emergency or larger floods than the design flood occurs particularly in high hazard areas.

The type of construction of a house can make raising an unfeasible option as raising a brick property can be structurally difficult and also incur significantly higher costs than a timber property. Many of the residences in Holbrook are brick construction or slab and floor and therefore house raising is unlikely.

For new development, floor level requirements will negate the need for future raising or properties.

SUMMARY

House raising is not considered to be a viable option for Holbrook due to the large difference in flood level between the 1% AEP event and the PMF. The PMF is between 2 – 4 m higher than the 1% AEP in many locations (see Section 3.7) and house raising could potentially encourage residents to stay in their homes during a flood event which would increase to flood risk. Additionally, many homes are brick construct which are unable to be raised.

In spite of a B/C ratio lower than one, the most cost effective option for reducing flood affectation for Ten Mile Creek flooding in Holbrook is the combined Option CL / BL (see Section 5.3.1.5). Accordingly, no specific houses have been identified for raising. Flood proofing (see Section 5.4.3) is more appropriate and cost effective for flooding at shallow depths especially such properties affected by overland flows.

5.4.2. Voluntary Purchase

DESCRIPTION

Voluntary Purchase (VP) involves the acquisition of flood affected properties, in particular those frequently inundated in high hazard areas, and demolition of the residence to remove it from the floodplain. Removal of properties can help to restore the natural hydraulic capacity of the floodplain; the storage volume and waterway area. Voluntary purchase is mainly used in more hazardous areas over the long term as a means of removing isolated or remaining buildings to free both residents and potential rescuers from the danger and cost of future floods.

Although measures such as flood proofing or raising could reduce flood damages for properties in high risk areas during smaller events, the high hazard means that conditions are unsafe for people and they would still need to be evacuated before the onset of flooding. Voluntary purchase of the properties would allow the areas to be given over to public open space and would remove the high hazard risk to residents here. Voluntary purchase would be the only way of reducing flood risk and hazard for those residents by encouraging them to move to a less flood hazardous area. The purchased properties should be demolished and the land rezoned as appropriate use such as E2 Environmental Conservation or similar in the LEP so that no development may take place. The land can also be defined as floodway in Council's DCP.

DISCUSSION

Voluntary purchase is an effective strategy where it is impractical or uneconomic to mitigate high flood hazard to an existing property and it is more appropriate to cease occupation to meet the above objectives and is often a measure that is used as part of a wider management strategy than on its own. Government funding for voluntary purchase schemes can be made available through the Floodplain Management Program as long as a number of complying criteria are met. Voluntary purchase areas are not classified under any specific land use in the Standard Instrument LEP. However, Council can consider creating Voluntary Purchase zones through their DCP or requiring that voluntary purchase zones apply to all flood prone areas also identified as being high hazard floodway.

The Ten Mile Creek southern floodplain is not eligible for VP as it is predominately classified as low hazard flooding (see Figure 13) for the 1% AEP event. Some properties however are situated in the 1% AEP floodway (see Figure 10) but this in its self is not enough to warrant a VP scheme. It is acknowledged that for much larger events flood risk in this region is extreme and accordingly construction of the combined Option CL / BL levee system (see Section 5.3.1.5) is recommended to aid in flood evacuation for extreme events.

Two properties on the eastern bank of Ten Mile Creek near Jingellic Road have been identified as being on the cusp of the floodway (see Sections 4.5), however these are again not situated in high hazard areas as defined in Section 4.6. Additionally, neither of these residences are flooded over floor until approximately the 0.2% AEP flood. Accordingly no residences in Holbrook are suitable for VP.

CONCLUSION

VP schemes generally have low B/C ratios and are only likely to obtain funding in high risk flooding situations in the 1% AEP flood event. Additionally, such schemes often take many years to obtain sufficient funding to purchase all properties eligible for the scheme. It is recommended that the combined Option CL / BL (see Section 5.3.1.5) be implemented as this will reduce flood risk and negate the need for a VP scheme at Holbrook for a number of properties on the Ten Mile Creek southern floodplain.

RECOMMENDATIONS

The following measures are recommended:

► Define a floodway in Council's DCP where no future residential development should be permissible.

5.4.3. Flood Proofing

DESCRIPTION

Flood proofing is often divided into two categories; wet proofing and dry proofing. Wet proofing assumes that water will enter a building and aims to minimise damages and/or reduce recovery times by choice of materials which are resistant to flood waters and facilitates drainage and ventilation after flooding. Dry proofing aims to totally exclude flood waters from entering a building and is best incorporated into a structure at the construction phase.

As an alternative to retrofitting permanent flood proofing measures to existing properties, temporary flood barrier methods can also be achieved by the use of sandbags in conjunction with plastic sheeting or private flood barriers which fit over doors, windows and vents and are deployed by the occupant before the onset of flooding.

DISCUSSION

Retro fitting permanent flood proofing measures can be difficult and permanent flood proofing is best achieved during construction. Temporary flood proofing can be achieved during flooding although relies on someone to put up flood gates or similar and therefore effective flood warning times and the time of flooding can affect their efficiency.

Whilst it is a requirement of the Floodplain Development Manual (Reference 1) that new residential properties have their floor levels above the 1% AEP event plus a freeboard, commercial properties are not subject to such requirements unless stipulated by Councils. New commercial buildings can be required to be flood proofed to the Flood Planning Level (FPL) when constructed which would include consideration of suitable materials, electrical and other services installation and efficient sealing of any possible entrances for water. Council would make these requirements through the DCP and planning controls. It is recommended that planning controls allow some flexibility for either dry or wet flood proofing to be used, and for temporary flood gate options to also be included in building design for low risk non-habitable development.

Temporary flood barrier measures such as sandbagging and flood barriers can be a cheaper option than retrofitting to existing properties and can be useful in areas where there is frequent shallow flooding. Sandbagging, often used in conjunction with plastic sheeting, can provide a solution for dealing with flooding in smaller areas and at individual properties. Holbrook SES headquarters maintains a small supply of sandbags and back-up supplies are available through the Murrumbidgee SES Region Headquarters. A motorised sandbag-filling machine is available from Wagga Wagga SES Unit and Murrumbidgee Region Headquarters (Reference 10). Whilst sandbags and plastic sheeting seldom prevent the ingress of floodwaters entirely, they can substantially decrease the depth of over floor flooding and decrease foulness of floodwaters, thus aiding the clean-up process. There is little warning time in Holbrook and although the use of temporary measures should not be discouraged they should not be relied on as a solution to flood problems at individual properties.

SUMMARY

Flood proofing is a good solution to reducing flood risk to commercial and industrial properties and should be encouraged for all new development of this type, particularly where floor levels may be low. Consideration of appropriate construction materials is still needed for those residential developments where floor levels will be raised above the 1% AEP flood level but structures can still become inundated below the floor level.

Temporary flood proofing techniques may be deployed although lack of warning time may limit their efficiency and they should be considered as a secondary option to more permanent measures being implemented.

RECOMMENDATIONS

The following measures are recommended:

► Include requirements for flood proofing for new development, wet or dry as appropriate, in development controls. In particular this approach should be the minimal requirement for non-habitable buildings such as commercial or industrial developments where floor levels are not always required above the FPL.

5.4.4. Minor Property Adjustments

DESCRIPTION

In overland flow areas minor property adjustments can be used to manage overland flows through private property and minimise impacts on dwellings by helping to divert local overland flows away from dwellings and access points. Such adjustments can include low level bunding (small levees) around individual properties, amendments to fences or construction of fences which act as deflector levees, modifying gardens and ground levels etc. all of which can affect the local continuity of overland flow paths.

DISCUSSION

It is difficult for Council to enforce property adjustments and furthermore the issue can be complicated by requirements of s149 certificates. In addition, adjustments on one property may have knock on effects on adjoining properties, or require modifications on neighbouring properties to be effective. Some residents have commented that they believe small features on neighbourhood properties have increased flooding on their own property. Therefore any works in flood prone areas which could modify the localised flood behaviour should be shown to have no significant impact on adjoining properties and be subject to approval from Council.

SUMMARY

Minor property adjustments can have localised benefits, however they should be assessed for their impact on neighbouring properties. There are no specific recommendations regarding minor property adjustments for Holbrook, however Council may want to consider some controls on this due to impacts on neighbouring properties.

5.5. Response Modification Measures

Response modification measures aim to reduce risks to life and property in the event of flooding through improvements to flood prediction and warning, through improvements to emergency management capabilities and planning, and through better flood-educated communities.

5.5.1. Flood Warning

DESCRIPTION

The purpose of a flood warning is to provide advice on impending flooding so people can take action to minimise its negative impacts. An effective flood warning system requires integration of a number of components (Reference 11):

- monitoring of rainfall and river flows that may lead to flooding;
- prediction of flood severity and the time of onset of particular levels of flooding;
- interpretation of the prediction to determine the likely flood impacts on the community;
- construction of warning messages describing what is happening and will happen, the expected impact and what actions should be taken;
- dissemination of warning messages;
- response to the warnings by the agencies involved and community members; and
- review of the warning system after flood events.

Where effective flood warnings are provided, risk to life and property can be significantly reduced. Studies have shown that flood warning systems generally have high B/C ratios if sufficient warning time is provided and if the population at risk is aware of the threat and prepared to respond appropriately.

The Ten Mile Creek catchment is relatively small (140 km^2 to Holbrook) so floods tend to rise quickly following the onset of flood-producing rainfall. The critical duration – the duration of the storm that produces the largest flows and highest flood levels in the hydraulic model – is 6 hours for most design events and 3 hours for the PMF. The critical duration for local overland flooding at Holbrook is only 1 hour for most design events (Reference 2).

Warning times would be even shorter, and this locates the catchment within a ‘flash flood’ setting where the provision of an effective flood warning service is problematic. Several challenges to an effective flood warning service have been identified for flash flood catchments (References 12 and 13):

- Flash floods are less predictable than larger scale flooding. Rainfall over small catchments is usually not well predicted by numerical weather prediction models.
- For flash floods, there is little time to develop reliable flood warnings and for effective dissemination and response to the flood warnings. More rapid user response is required, which necessitates specialised communication systems and a high level of public flood awareness and readiness.
- A reliance on rainfall triggers increases the frequency of false alarms.
- The use of water level triggers may not allow sufficient time for response.

For these reasons, the Bureau of Meteorology traditionally has not issued specific flood predictions for flash flood catchments. But it does provide more general services that may be of some benefit in alerting the emergency services and community to the threat of flooding:

- General Weather forecast. This may indicate the likelihood of heavy rain from synoptic scale events, typically with more than 24 hours' notice.
- Flood Watch. This is issued by the NSW Flood Warning Centre, typically providing 24 to 48 hours' notice that flooding is possible based upon current catchment conditions and future rainfall, which is predicted by computer models of the atmosphere.
- Severe Weather Warning. This is issued for synoptic scale events when torrential rain and/or flash flooding (or other hazardous phenomena) are forecast.
- Severe Thunderstorm Warning. This is issued by the Severe Weather Team, typically providing 0.5 to 2 hours' notice of impending severe storms. These forecasts are based upon radar and, if available, data from field stations, reports from storm spotters, as well as an analysis of the synoptic situation.

The severe floods of October 2010 and March 2012 were preceded by Severe Weather Warnings for flash flooding, and a Flood Watch for the Murrumbidgee catchment was also issued in advance of the March 2012 event. However, there were no formal, specific warnings of flooding for Holbrook.

NSW SES may issue Local Flood Advices for locations like Holbrook not covered by Bureau Flood Warnings, but there is no indication that these were issued prior to the October 2010 and March 2012 floods. NSW SES may also issue Evacuation Warnings, advising that people should prepare to evacuate an area. These may be followed by Evacuation Orders, requiring the evacuation of all persons from an area, issued through door knock, radio, automated telephone, SMS and/or other forms of media. Once the risk has subsided an All Clear is issued.

DISCUSSION

Consideration has been given to the need and opportunity for providing earlier and targeted warnings for Holbrook.

The need is particularly pressing for the southern floodplain of Ten Mile Creek where in the PMF about 85 dwellings and 19 non-residential buildings are expected to be flooded over floor, to depths and velocities that would threaten the structural stability of the buildings, and where flooding of road low-points could first isolate then inundate properties (i.e. a dangerous Low Flood Island setting). Using the NSW SES Timeline Evacuation Model tool suggests that at least 3.3 hours would be required to fully evacuate the southern floodplain, including standard allowances for warning acceptance, warning lag and traffic safety factors (see Table 18). This does not include allowances for mobilisation of NSW SES personnel, for the decision to issue an Evacuation Order or for dissemination of the Evacuation Order, which would likely add to the time required.

Table 18: Evacuation Timeline Model Calculation for South Holbrook

Time required to evacuate		
Number of vehicles		**Data source**
Residential		
Number of dwellings	85	WMAwater
Vehicles per dwelling	1.63	2011 Census
% Census respondents not reporting	7.2%	2011 Census
Residential vehicles	149	Calculated
Commercial		
Number of business premises	19	WMAwater
Vehicles per business	1	Estimate
Commercial vehicles	19	Calculated
Total vehicles (TV)	168	Calculated
Evacuation route		
Number of lanes	1	Field trip
Evacuation route capacity (RC) (veh/hr)	600	SES
Evacuation timing (hrs)		
Warning acceptance factor (WAF)	1	SES
Warning lag factor (WLF)	1	SES
Travel time (TT) =TV/RC	0.3	Calculated
Traffic safety factor (TSF)	1	SES
Total time required to evacuate (TR) = WAF+WLF+TT+TSF	3.3	Calculated
Time available to evacuate (hrs)		
BOM forecast time	0	State Flood Plan
Flood travel time	1	Oct 2010 flood
Total time available (TA)	1	Calculated
Time deficit or surplus (hrs)		
Time = TA – TR	–2.3	Calculated

Opportunities for increasing the time available include using the existing NSW Office of Water (NOW) stream gauge (Holbrook #3 – No. 410187), which is located about 5.6 km upstream of the manual gauge at the Albury Street Bridge. This recorder could be configured such that an SMS is issued to NSW SES personnel when pre-programmed levels are reached during a rising flood. A 'danger' trigger level of 2.7 m was put forward in the flood intelligence report, based on the observed flood travel time and consequences at Holbrook (see Section 3.4.4). An extra hour or so warning would not be sufficient to produce a time surplus for the evacuation of South Holbrook (Table 18). In addition, the NOW hydrographer indicates that presently water levels are polled only every 30 minutes or so through the Hydrotel system (though there is potential to upgrade the on-site logger). The gauge is also located on a dynamic river channel with a propensity for silting up, so could potentially fail to report a rising flood. But despite the limitations, it would be relatively straight forward to configure Hydrotel to issue SMS at a pre-determined level. There might also be potential for installing a higher level flood warning sensor such that the orifice is less prone to siltation.

A water level recorder located further upstream could provide longer warning, but three arms draining major sub-catchments join only about 2.4 km upstream of the existing NOW gauge, so a new gauge would ideally be located below that junction but would provide little additional warning. The channel is also unstable there too.

Another possibility would be to install manual depth indicators at three crossings (Back Creek, Devils Creek and Ten Mile Creek) along Annandayle Road, which is located upstream of the junction described above. Following issuance of a Flood Watch or Severe Weather Warning, or during heavy rain, the NSW SES could periodically monitor these depth indicators (provided safe to do so) and over time develop coarse intelligence to better inform flood predictions for Holbrook.

Council and NSW SES could also maintain an informal flood prediction system drawing upon the observations of landholders in the catchment. For example, the 'Annandayle' homestead is strategically located along Ten Mile Creek upstream of the existing NOW gauge, and 'Yarra Glen' is located some 5.1 km upstream of Annandayle.

Consideration is also given to upgrading rain gauges to provide earlier warning. For the October 2010 and March 2012 floods, some daily rainfalls were available for the Ten Mile Creek catchment (References 3 and 4), but these are of little value for real-time flood warning for a catchment where the critical duration is much less than 24 hours. In fact, the maximum daily rainfall at 'Yarra Glen' was higher for the March 2012 event (112 mm) than for the October 2010 event (76 mm), despite much more severe flooding in the earlier event. This also points to the need for a good spatial distribution of rain gauges if all parts of the catchment are to be covered. It would be relatively straight forward to install a new pluviometer at the site of the existing NOW water level recorder at 410187. This would take advantage of the existing communications infrastructure and would be useful for future hydrological model calibration as well as for flood prediction. Ideally another four pluviometers with communications would be installed to provide coverage of Back Creek, Devils Creek, (upper) Ten Mile Creek and Morgan's Ridge Creek catchments, at a cost in the order of $10K each plus $2K each per annum for maintenance. Theoretically, this network of pluviometers could provide inputs to a hydrologic model that could be run during a flood to estimate the magnitude of flooding at Holbrook. But because of the deficiency of sub-daily rainfall data available for model calibration, there is uncertainty about the modelled flows (Reference 2). More significantly, the warning time provided by observed rainfall may still be insufficient to provide a time surplus for safe evacuation. Another factor is that decisions made on the basis of rainfall observations (or even more so for *forecast* rainfall) carry greater uncertainty. Evacuations based on uncertain triggers 'may be theoretically defensible in a purely risk-avoidance context but are likely to be viewed as socially and economically unsustainable' (Reference 14). Frequent 'false alarms' could lead to a situation where warnings are ignored by most of the community.

For Holbrook, it is considered that an appropriate scale of investment for the improvement of flood predictions is alarming the existing NOW water level recorder at 410187, installing a pluviometer at the same site, and installing manual depth indicators at the creek crossings along Annandayle Road, to be monitored by NSW SES personnel when floods are threatening. There would also be benefit in maintaining a network of flood observers in the Ten Mile Creek catchment, providing intelligence as a flood is rising (this would also benefit from providing manual gauges to enable quantitative descriptions of flood magnitude).

The Flood Warning manual (Reference 11) also makes the point that especially in flash flood situations, there is value in setting up warning messages before flooding occurs. The NSW SES could draft a series of messages for various scenarios, which would enable more rapid broadcast and dissemination during a flood emergency.

An important question is how the people affected by flooding can best be given the appropriate information. The potential for fast rising floods means that door-knocking and telephone 'trees' may be too slow to reach everyone in time. An automated telephone dial-out system is recommended for owners of buildings in the floodplain, especially in South Holbrook. The ability of such a system to quickly reach a large number of subscribers is highly beneficial for flash flood situations. It would also be vital in the case of a likely levee-overtopping event.

SUMMARY

As a flash flood catchment, the provision of an effective flood warning service for the Ten Mile Creek catchment to Holbrook is difficult. Various options have been considered to improve flood prediction times, with the following measures considered most appropriate: alarming the existing NOW water level recorder and installing a pluviometer at the same site; installing flood depth indicators along Annandayle Road; and maintaining a network of flood observers. There are also opportunities to improve other aspects of the total flood warning system, including the preparation of a suite of sample warning messages ready for broadcast, and the construction and maintenance of an automatic dial-out system for the efficient delivery of information and instructions during flood emergencies.

RECOMMENDATIONS

The following measures are recommended:

► Enhance the flood prediction capability of the existing NOW gauge at site 410187 by: alarming the existing gauge to provide SMS to emergency services personnel when pre-determined triggers are reached; installing a higher level sensor to reduce the likelihood of siltation of the orifice during a flood; and installing a pluviometer (NOW, NSW SES and Council);

► Install flood depth indicators at Annandayle Road crossings of Back Creek, Devils Creek and Ten Mile Creek, and monitor these indicators when there is threat of flood (NSW SES)

► Maintain a flood observer network in the Ten Mile Creek catchment (NSW SES)

► Progressively develop relationships between flood depth indicators/observer stations and downstream water level recorders (NSW SES)

► Pre-prepare a suite of flood warning messages (NSW SES)

► Construct and maintain a telephone dial-out system for the rapid dissemination of flood information and instructions (NSW SES)

5.5.2. Flood Emergency Management Planning

DESCRIPTION

Effective planning for emergency response is a vital way of reducing risks to life and property, particularly for infrequent floods that are not managed through flood or property modification.

The NSW State Emergency Service (SES) is the legislated combat agency for floods in NSW and is responsible for the control of flood operations. This role is undergirded by detailed flood planning. NSW SES maintains the Greater Hume Local Flood Plan (Reference 10) and flood intelligence cards for key stream gauges.

Residents living in and proprietors working in the floodplain can also prepare individual plans tailored to their situation.

DISCUSSION

The Greater Hume Local Flood Plan (LFP) (Reference 10) is a sub-plan of the Greater Hume Shire Council Local Emergency Management Plan. Volume 1 of the LFP was endorsed in March 2013 and outlines responsibilities and procedures for preparing for, responding to and recovering from floods within the Shire.

Clause 3.5.2 of Volume 1 of the LFP lists the NSW SES Holbrook Operations Centre as at Wallace Street, Holbrook. Section 4.7.3.4 outlined the flood risk at this location. An extreme flood would inundate the floor of the operations centre to such a depth that the operations centre could no longer function. This risk could be noted in the LFP.

Clause 3.18.42 of Volume 1 of the LFP lists the Holbrook Community Resource Centre in Library Court, Holbrook, as suitable for use as a flood evacuation centre. Section 4.7.3.5 outlined the flood risk at this location. It is not expected to be flooded above floor in the PMF though access could be compromised. St Patricks Catholic Primary School fronting Albury Street appears to be a slightly more advantageous location for an evacuation centre in terms of its flood affectation. This could be noted in the LFP.

Clause 3.17 of Volume 1 of the LFP addresses the management of flood rescue operations, recognising that there may be a residual population which does not evacuate during the early stages of flooding and which subsequently requires rescue. While there are opportunities for improving flood warning systems and levels of community awareness and readiness to promote timely evacuation, the reality is that many people may not evacuate in a timely fashion and in an extreme flood could be trapped in houses with water rising. It is understood that at the present time Holbrook does not have a flood boat and members are not trained in flood rescue. The closest unit with this capability is located at Albury about one hour away, though some consideration has been given to stationing a boat at Culcairn about 30 minutes away. In the recent floods, Fire and Rescue NSW and the NSW Rural Fire Service assisted flood operations with high clearance vehicles. It is recommended that NSW SES give further consideration to resourcing the Holbrook unit so that it is able to respond efficiently to any urgent demands for rescue, particularly in South Holbrook, and that this be reflected in the LFP (probably in the relevant annex of Volume 2).

In some jurisdictions in NSW, particularly for flash flood situations where safe evacuation is difficult to guarantee and where flood durations are typically short, the planning authority requires for new houses in the floodplain that either 1) evacuation to high land can be assured or 2) a structurally sound building contains a PMF refuge so that trapped residents can temporarily evacuate upstairs in a severe flood. This approach could be considered for Holbrook, because its implementation would gradually reduce risk to life as urban renewal occurs. However, it is suspected that the cost implications of requiring self-contained 'shelter-in-place' could be prohibitive for residents where the median income is well below the NSW average. One alternative is for Council to consider constructing a community building that could function as an emergency evacuation shelter for South Holbrook. It is possible that the first storey of the Woolpack Museum could provide this function, but its structural integrity in an extreme flood has not been assessed, and the limited time suggests that people who delay evacuation might have difficulty accessing it. Under current conditions, timely evacuation from houses in the southern floodplain is imperative because in the PMF the combination of depths and velocities there presents an 'extreme' hazard to structures, and if residents wait to see the magnitude of a flood, it might be too late to evacuate.

Other recommended minor amendments to Volume 1 of the LFP are as follows:

- Clause 1.3.3: Billabong Creek is *not* a tributary of the Murrumbidgee River but rather of the Edward River, which subsequently joins the Murray River;
- Clause 3.8.4: NSW Office of Water now makes data available via a free mobile app for iPhone and Android; and
- Attachment 3 needs to show all relevant watercourses (and ideally, water level recorders) in the LGA, including Ten Mile Creek.

Volume 2 of the LFP has yet to be finalised and includes Annexes describing the flood threat, effects on the community and response arrangements for each sector such as property protection, evacuation, rescue and resupply. Volume 2 of the post-March 2012 flood intelligence review (Reference 4) included draft updates to Volume 2 of the LFP template to incorporate findings from the flood intelligence review and preliminary results of the Flood Study. As part of this FRMS&P, further amendments to the draft LFP have been made (to the same scope as for Reference 4), drawing on the results of the finalised Flood Study and the assessment of flood problems undertaken as part of this FRMS&P. It is recommended that NSW SES review the proposed changes and complete Volume 2 of the LFP. If any flood mitigation works are implemented as a result of this FRMS&P (e.g. levee to protect dwellings in South Holbrook), the LFP will require additional updates.

Findings of the Flood Study and FRMS&P that need to be incorporated into the LFP include:

- Design flood extents, depths, velocities, hazard and travel times;
- Predicted building inundation in design floods up to PMF;
- Predicted road inundation in design floods up to PMF; and
- Evacuation constraints in design floods up to PMF.

Also as part of the post-March 2012 flood intelligence review (Reference 4), the draft flood intelligence cards prepared for the Holbrook No. 3 and Holbrook manual gauges following the October 2010 flood (Reference 3) were updated. These have again been updated as part of this FRMS&P, with the draft amendments included in Appendix J. It is recommended that NSW SES review the proposed changes.

As well as updating the Greater Hume Local Flood Plan, there would be benefit in NSW SES and Council encouraging and helping key floodplain exposures to prepare and update their own flood emergency response plans. The process of preparing plans would in itself be an important process of raising awareness and preparedness, and could be linked to a Business FloodSafe breakfast (see Section 5.5.3). Among the higher priorities for flood plans are:

- Miniature Railway, Ten Mile Creek Gardens;
- Holbrook Motor Village Tourist Park, Bardwell Street;
- Jolly Swagman Motel, Albury Street;
- Glenndale Park Motel, Albury Street;
- Holbrook Police Station, Albury Street;
- National Museum of Australia Pottery, Albury Street;
- Woolpack Inn Museum, Albury Street; and
- Holbrook Hospital, Bowler Street.

SUMMARY

Planning for flooding is a vital way of reducing flood risks to life and property. Plans need to be reviewed after flooding and after new information is made available from flood investigations. NSW SES has the lead role in planning for and responding to floods. There is a need to update the Greater Hume Local Flood Plan and relevant flood intelligence cards. But best practice teaches that people will respond more effectively when households and businesses are also engaged in planning to respond to floods.

RECOMMENDATIONS

The following measures are recommended:

► Resource Holbrook SES unit appropriately so that it can perform a flood rescue function in South Holbrook at short notice (NSW SES);

► Consider provision of an accessible community building in South Holbrook that could function as an emergency shelter in an extreme flood (Council);

► Review draft updates and complete Greater Hume Local Flood Plan, drawing on flood intelligence from the Flood Study (Reference 2) and this FRMS&P (NSW SES);

► Review draft updates to the flood intelligence cards for the Holbrook #3 and Holbrook manual gauges (NSW SES);

► Assist floodplain residents and proprietors to prepare tailored individual flood emergency plans (NSW SES and Council).

5.5.3. Community Flood Education

DESCRIPTION

Actual flood damages can be reduced, and safety increased, where communities are flood-ready:

> *'People who understand the environmental threats they face and have considered how they will manage them when they arise will cope better than people who lack such comprehension… Many people who live and work in flood liable areas have little idea of what flooding could mean to them – especially in the case of large floods of severities well beyond their experience or if a long period has elapsed since flooding last occurred. It falls to the combat agency, with assistance from councils and other agencies, to raise the level of flood consciousness and to ensure that people are made ready for flooding. In other words, flood-ready communities must be purposefully created. Once created, their flood-readiness must be purposefully maintained and enhanced.'* (Reference 15)

Based on learnings from recent disasters, the focus of community disaster education has now turned from a concentration on raising awareness and preparedness to building community resilience through learning. Simply disseminating information to the community does not necessarily trigger changed attitudes and behaviours. Flood education programs are most effective when they:

- Are participatory i.e. not consisting only of top-down provision of information but where the community has input to the development, implementation and evaluation of education activities;

- Involve a range of learning styles including experiential learning (e.g. field trips, flood commemorations), information provision (e.g. via pamphlets, DVDs, the media), collaborative group learning (e.g. scenario role plays with community groups) and community discourse (e.g. forums, post-event de-briefs);
- Are aligned with structural and other non-structural methods used in floodplain risk management and with emergency management measures such as operations and planning; and
- Are ongoing programs rather than one-off, unintegrated 'campaigns', with activities varied for the learner.

It is difficult to accurately assess the benefits of a community flood education program but the consensus is that the benefits far outweigh the costs. Nevertheless, sponsors must appreciate that ongoing funding is required to sustain gains that have been made.

DISCUSSION

Current levels of flood awareness in Holbrook are relatively high, being within five years of the severe flood of October 2010 when at least 25 houses and 13 non-residential buildings were flooded over floor (Reference 3). Lesser floods in February 2011 and March 2012 would have taught the community that the October 2010 flood was not a 'one-off'. Nevertheless, Census data indicate that 39% of residents lived in a different address 5 years prior to the 2011 Census. Some 40% of respondents to a questionnaire issued with the Flood Study indicated that they had no flood experience (Reference 2). Population turnover and the progress of time mean that over time the community's remembrance of the floods of 2010-12 will gradually decline and their readiness to respond appropriately to future flood emergencies will wane. This means that there is a need to build flood readiness for people unfamiliar with flooding and to maintain flood readiness through ongoing flood education.

Table 19 provides a list of methods to build and sustain flood readiness, which may be developed and supported by NSW SES and Council. These include methods both to inform and to prepare the community, with the objective of building resilience.

Table 19: Methods to Increase Flood Awareness and Preparedness

Method	Comment
S149 certificate notifications	Section 149 planning certificates should record whether the land is subject to any planning and development controls due to its flood affectation. Council also has opportunity to provide more detailed information about the land's flood affectation under S149(5) of the EP&A Act 1979. This information may be particularly valued by prospective purchasers but has a limited reach and is typically issued only upon request and payment of a fee.

Method	Comment
Letter/certificate/ pamphlet from Council	These may be sent annually with a rates notice or separately. A Council database of flood liable properties makes this a relatively inexpensive and effective measure. The intention of flood certificates is to inform individual property owners of the flood situation (flood levels, ground levels) at their particular property. It is the site-specific nature of this advice that offers a chance of overcoming the scepticism typical of a community that has not experienced serious flooding for some years. Only after floodplain occupants accept that they could have a problem are they ready to take on board ideas about addressing that problem. A pamphlet can inform residents of the on-going implementation of the Floodplain Risk Management Plan and provide tips to respond appropriately to flooding (e.g. evacuate early; never drive, ride or walk through floodwater). Proactive and regular issuance is desirable.
Council website	Council already provides an 'emergency information' portal on its website. An additional flood management portal would be of value to describe the floodplain management process and include Flood Studies and Floodplain Risk Management Studies, a history of flooding in Greater Hume LGA, procedures for how to obtain flood information, answers to frequently asked questions (FAQs), and advice on becoming flood prepared. The portal could also provide links to Bureau of Meteorology warnings and NSW Office of Water gauge heights.
Community Working Group	Council could initiate a Community Working Group framework to provide a valuable two way conduit between the local residents and Council.
School project	School students can learn about historical floods by interviewing older residents and documenting what happened. A project could also involve talks from various authorities (e.g. NSW SES) and can be combined with topics relating to water quality, drainage management, etc.
Articles in local newspapers	Ongoing articles in the newspapers will ensure that the flood issues are not forgotten. Historical features (e.g. see Image 1) and remembrance of past events are interesting for local residents and can provoke preparedness for future events.
Library display	The library could collect historical flood photos and stories to prepare a display, which could be accompanied by appropriate flood safety messages. The Adelong Alive Museum prepared an impressive display featuring the October 2010 flood.
Mobile display	Such a display as described above could also be used at local festivals and for school visitations, accompanied by NSW SES staff, who should be trained to encourage and equip households to prepare flood emergency plans.
NSW SES FloodSafe Guide	Now that a Flood Study has been prepared, and given the experiences of major floods in the recent past, once the Local Flood Plan is finalised, it would be timely to prepare a FloodSafe guide for Holbrook describing flood behaviours in historical and design floods, and listing appropriate actions. If major flood mitigation works will be implemented following this FRMS&P, it would be advisable to wait until these are done.
NSW SES Business FloodSafe Breakfast	The NSW SES has prepared a FloodSafe Business template, which businesses can use to plan for flooding. A breakfast barbeque could be convened at an appropriate location to promote completion of plans and to provide site-specific flood information.

Method	Comment
'Meet the street' events	'Meet-the-street' events involve NSW SES and Council setting up a 'stall' at an appropriate and visible location at a time that people will be at home. The event would be advertised through a specific letter box drop to the targeted neighbourhood or vulnerable site. The stall could consist of flood maps on boards, NSW SES banners, NSW SES materials (e.g. Holbrook FloodSafe guide when available) to hand out. These materials are used to engage with people and make them aware of flood risk, encourage preparedness behaviours (e.g. develop emergency plans) and help them understand what to do during and after a flood. A meeting could also encourage property owners to develop self-help networks and particularly people checking on neighbours if a flood is imminent. Longer-term residents with flood experience could be used to help provide other residents with an understanding of previous floods and how to prepare for future flooding.
Historical flood markers and flood depth markers	Signs or marks can be prominently displayed on telegraph poles or similar to indicate the level reached in historical and design floods. Depth indicators advise of potential hazards, particularly to drivers. These are inexpensive and effective but in some flood communities are not well accepted as it is perceived that they affect property values. Flood marker poles could be installed in the Ten Mile Creek Gardens (away from private property) to show the height flood waters reached in the 2010, 2011 and 2012 events.

SUMMARY

Although recent flood events and the flood risk management process have raised community flood awareness, this is expected to wane over time. For Holbrook, flooding of a similar magnitude to the October 2010 flood had probably not occurred since 1887. If there are long periods without damaging flooding, it is difficult to maintain the community's interest and preparedness. This could be accentuated if a levee is built to protect South Holbrook up to the 100 year ARI flood (plus freeboard) because if the levee is appropriately maintained, only infrequently would it be expected to be overtopped. Ongoing flood education will be required to build and maintain flood resilience and to prepare the community for larger and faster-rising floods than it has previously experienced. Particular attention may be required to persuade the community to evacuate early from South Holbrook, since delaying evacuation until the magnitude of floods becomes visible may not provide sufficient time for safe travel to the evacuation centre. Also, given regular loss of life in Australia from people attempting to cross floodwater or play in floodwater, messages to discourage people from engaging in these unsafe behaviours are desirable.

Council will need to develop a program from the above measures after taking into account the views of the local community, funding considerations and other education programs within the LGA. However, for the purposes of this FRMS&P, we recommend that the following measures be given a high priority:

- Regular issuance of flood certificates and pamphlets to landowners within the floodplain;
- Preparation of a library flood photo and story display;
- Commemoration of the 10th anniversary of the October 2010 flood;
- Preparation of a Holbrook FloodSafe guide;
- Arrangement of a Business FloodSafe breakfast for Holbrook;
- Meet-the-street meetings for Bardwell/Macinnes Streets and Albury Street;

- Installation of a historical flood marker post in Ten Mile Creek Gardens;
- If a levee is built to protect South Holbrook, preparation of a tailored resource similar to the American Society of Civil Engineer's 'So You Live Behind a Levee' pamphlet, to make clear that no levee is flood-proof and that preparedness is still required.

RECOMMENDATIONS

The following measures are recommended:

► Engage with community to prepare an ongoing flood education program, with appropriate methods for program evaluation (NSW SES and Council);

► Regularly issue flood certificates and pamphlets to landowners within the floodplain (Council);

► Prepare a library photo and story display (Council and NSW SES);

► Commemorate the 10th anniversary of the 2010 flood (NSW SES and Council);

► Prepare a Holbrook FloodSafe guide (NSW SES and GHSC);

► Host a Business FloodSafe breakfast for Holbrook's businesses (NSW SES and GHSC);

► Arrange meet-the-street meetings for Bardwell/Macinnes Streets and Albury Street (NSW SES and GHSC);

► Install a flood marker pole at the Ten Mile Creek Gardens showing the height of historical flood events (GHSC);

► If required, direct education efforts towards overcoming the complacency that can arise for communities partly protected by levees (NSW SES).

5.6. Planning and Future Development Control Measures

5.6.1. Land Use Zoning

DESCRIPTION

Appropriate land use planning can assist in reducing future flood risk and ensure development on flood affected areas is flood compatible. Appropriate land use controls in flood affected areas can prevent inappropriate development from occurring and thus reduce flood risk. Land use zones are generally governed by a Local Environmental Plan (LEP). To make any significant changes to the provisions of an LEP, a planning proposal must be prepared. Residential uses and sensitive land uses such as seniors living facilities, hospitals and child care centres etc. should not be permitted in the floodway or high hazard areas.

Council should consider appropriate controls, including floor levels and/or flood proofing, for commercial and industrial development if permitted on the floodway and ensure that development does not cause flood issues to be offset elsewhere. Ratified flood data and mapping should be utilised to inform the Flood Planning Area and levels set for all residential development on land which is located within the FPA (see Section 5.6.3).

DISCUSSION

The current land use zones for Holbrook are presented in Figure 2. The construction of the Holbrook bypass has impacted both the program and pattern of flooding. Ratified data and modelling now provide a best estimate of the FPA (see Section 5.6.3).

Flood Hazard categories have been further considered in relation to contextual issues (i.e. high depths and short warning time frames) which can cause potential problems in terms of evacuation.

Figure 80 of the Flood Study, reproduced herein as Figure 14 shows the flood Emergency Response Classifications (ERC) which designate areas for which evacuation may be constrained during a flood event. These "constrained evacuation" areas need careful consideration in terms of existing undeveloped lands and lands subject to planning proposals for rezoning.

Some ways of dealing with "constrained evacuation" areas should include:

1. Rezoning existing undeveloped land to better reflect flood characteristics.
2. Placing a moratorium on any further planning proposals in flood affected areas.
3. Requiring new dwellings to include refuge structures which will be accessible in a PMF event.
4. Include a community refuge as part of any future community building in precincts with "constrained evacuation".

Council should review existing zones against flood information and maps to ensure that current permissible uses are still appropriate (e.g. in north western Holbrook adjacent to the bypass) or apply flood controls including floor levels or flood proofing where required.

Council should, having regard to Direction 4.3 from the Minister, review any existing planning proposals to account for updated flood planning information and mapping (see Section 4.4).

Flood controls and floor levels should be introduced into the Council's DCP to ensure appropriate management of flood affected land in accordance with existing State policies.

SUMMARY

Appropriate land use planning can assist in reducing future flood risk and ensure development in flooded areas is flood compatible. Residential uses and sensitive land uses such as aged care facilities, hospitals and child care centres etc. should not be permitted in the floodway or high hazard areas. Council should consider appropriate controls including floor levels and or flood proofing for commercial or industrial development if permitted on the flood way and ensure that such development does not cause flood issues to be offset elsewhere. Ratified flood data and mapping should be utilised to inform the FPA and levels set for all residential development on land that exists in the FPA.

Flood data and mapping should be used strategically in the planning process to inform existing zoned areas and proposed rezoning areas in Holbrook.

RECOMMENDATIONS

The following measures are recommended:

►Reconsider existing zones against current flood data and mapping, introduce flood controls or floor levels where appropriate or back zone if land is identified in the flood way.

►Council consider either restricting future development or requiring refuge provision in precincts with known “constrained evacuation” areas.

5.6.2. Flood Planning Levels

DESCRIPTION

Flood Planning Levels (FPLs) are an important tool in floodplain risk management. Appendix K of the Floodplain Development Manual (the Manual) provides a comprehensive guide to the purpose and determination of FPLs. The FPL provides a development control measure for managing future flood risk and is derived from a combination of a flood event and a freeboard.

The Manual states that, in general, the FPL for a standard residential development would be the 1% AEP event plus a freeboard which is typically 500 mm.

According to the Manual, the purpose of the freeboard is to provide reasonable certainty that the reduced flood risk exposure provided by selection of a particular flood as the basis of an FPL, is actually provided given the following factors:

- Uncertainty in estimating flood levels;
- Differences in water level because of local factors;
- Increases due to wave action, and
- The cumulative effect of subsequent infill development on existing zoned land.

Typically, the FPL is used to define the minimum level at which habitable floor levels should be constructed.

DISCUSSION

The Floodplain Development Manual states that the FPL for standard residential development is the 1% AEP flood event plus a freeboard which is typically 500 mm. Depending on the nature of the development and the level of flood risk, individual FPLs can be adopted for a local area within a greater floodplain area. For example in areas prone only to shallow overland flooding, application of the 500 mm freeboard can be excessive. Selecting the appropriate FPL for a particular floodplain involves trading off the social and economic benefits of a reduction in the frequency, inconvenience, damage and risk to life caused by flooding against the social, economic and environmental costs of restricting land use in flood prone areas and of implementing management measures.

The FPL can be varied depending on the use, and the vulnerability of the building/development to flooding. For example, residential development could be considered more vulnerable due to people being present, whilst commercial development could be considered less vulnerable, or it could be accepted that commercial property owners are willing to take a higher risk. For developments more vulnerable to flooding (hospitals, schools, electricity sub-stations, seniors housing and the like) consideration should be given to events rarer than the 1% AEP when determining their FPL and either consider the PMF or situating those developments outside the floodplain where possible.

For the less vulnerable commercial and industrial developments, flood proofing (see Section 5.4.3) a building can be considered where raising floor levels is not an option or not feasible, but should not be allowed for residential developments or more vulnerable uses. For example, it could be a requirement that residential dwellings are to have floor levels above the FPL, whilst commercial properties could have lower floor levels but be subject to other controls such as flood proofing to the level of the FPL.

For Holbrook, the 1% AEP flood level plus 500 mm freeboard is recommended for use as the FPL. For industrial and commercial areas, the Council can either set their own floor height or require flood proofing where the FPA applies to industrial or commercial land.

More sensitive land uses such as nursing homes, hospitals and child care centres and the like should ideally be located outside of the FPA.

SUMMARY

The FPL should be used to set finished floor level requirements for residential development. Less vulnerable uses such as commercial developments could be subject to lower floor level requirements but it is recommended that they should be subject to flood proofing to the FPL where floor levels are lower. More vulnerable developments and critical infrastructure should be subject to more stringent requirements if possible. An FPL of 1% AEP plus 0.5 m is considered appropriate for Holbrook.

The benefits and consequences of different criteria for setting both the FPA and FPL should be considered together as it is important both are compatible.

RECOMMENDATIONS

The following measures are recommended:

► The FPL should be set as the 1% AEP event plus 0.5 m for residential areas within Holbrook and subject to the FPA.

► Council can decide on floor level requirements for non-residential developments at their discretion but should take into account proximity to major overland flow routes, flood hazard at the subject site and surrounding area etc.

► For commercial or industrial developments where finished floor levels are not set at the FPL, flood proofing measures will be required to the FPL.

► More vulnerable developments within Holbrook such as hospitals, schools, services including power should at the very least have floor levels and access at the FPL or PMF level, whichever is higher.

5.6.3. Flood Planning Area

DESCRIPTION

The Flood Planning Area (FPA) is an area to which flood planning controls are applied. An FPA map is a required outcome of the FRMS&P.

It is important to define the boundaries of the FPA to ensure flood related planning controls are applied where necessary and not to those lots unaffected by flood risk. Typically, and as per the Floodplain Development Manual, the FPA will be based on the flood extent formed by the 1% AEP mainstream flooding event plus freeboard (typically 500 mm) and, therefore, extended further than the extent of the 1% AEP event. Planning controls may, therefore, be applied to development which is not necessarily within the 1% AEP flood extent but is in the FPA. The purpose of extending the FPA past the 1% AEP flood extent is to allow for any future increases in flood extent due to climate change, as well as an allowance for differences between flood behaviour during events, however, where flooding is from overland flows, this criteria may not be appropriate and an alternative, more appropriate, criteria needs to be defined.

The NSW Standard Instrument LEP does not include a specific land use zone classification for flood prone land, rather it permits a Flood Planning Area map to be included as a layer imposed across all land use zones.

DISCUSSION

The FPA as defined by the Floodplain Development Manual (1% AEP + freeboard) is suitable for areas of mainstream flooding such as those affected by Ten Mile Creek. However, it is not appropriate for areas subject to flooding from overland flows which do not reach the depths that occur from mainstream flooding and additionally, where depths do not tend to increase significantly for rarer events.

Current thinking and emerging policy for defining the FPA in areas subject to overland flow, recommends the following criteria be applied:

1. Unless on a defined watercourse, flooding is described as "overland flow" and not "mainstream" flooding.

2. All overland flow flood depths less than 200 mm are discounted as "drainage". That is, overland flow flood depths less than 200 mm are considered too unsubstantial to be called flooding, given the relatively shallow depth.

3. If flood liability is due to overland flows and not mainstream flooding, only those lots which are impacted by substantial floodwaters (for example more than 20% of the lot affected by depths greater than 200 mm) are selected for inclusion in the FPA.

The FPA for areas affected by overland flow at Holbrook has been defined based on the previous criteria.

It should be noted that Morgan's Ridge Creek has been treated as overland flow flooding for the purposes of determining the FPA. Whilst flooding in Morgan's Ridge Creek would typically be considered as mainstream flooding due to the defined channel, determining the Morgan's Ridge Creek FPA through the methods described in the Floodplain Development Manual (1% AEP + freeboard) is inappropriate for the following reasons:

- Similar to overland flow flooding, Morgan's Ridge Creek flood events do not scale significantly for rarer events. For example the difference in flood level between the 1% AEP and the PMF is 0.9 m compared to the 2.5 m difference in flood level for the same two events on Ten Mile Creek. Furthermore, the difference in peak flood level between the 1% AEP and 0.5% AEP is typically 0.15 m.
- Additionally, Morgan's Ridge Creek downstream of Wallace Street is a diverted manmade channel which has led to atypical topography on the surrounding floodplain. Due to Morgan's Ridge Creek being diverted away from the original flow path through higher terrain, the Creek's overbank to the west slopes away from the main channel. Using the Floodplain Development Manual method of defining the FPA by raising the 1% AEP flood level by some freeboard leads to the majority of the town to be tagged as within the FPA as there is no bank on the western side to define the FPA extent.

SUMMARY

Defining the FPA is crucial as the FPA is a key concept referred to in the LEP. The Ten Mile Creek FPA is defined on the basis of the Floodplain Development Manual and regions affected by overland flow and Morgan's Ridge Creek flooding have been defined using the methodology described in points 1 – 3 listed above.

The Holbrook FPA map is presented in Figure 16.

RECOMMENDATIONS

The following measures are recommended:

► Include the FPA as defined in this study in the DCP (as per Figure 16).

5.6.4. Update Flood Related Planning Policies and Development Controls

DESCRIPTION

Appropriate planning restrictions, ensuring that development is compatible with flood risk, can significantly reduce flood damages. Planning instruments can be used as tools to:

- Guide new development away from high flood risk locations;
- Ensure that new development does not increase flood risk elsewhere; and
- Develop appropriate evacuation and disaster management plans to better reduce flood risks to the existing population.

DISCUSSION

Following a review of the LEP 2012 and Council's current policy regarding flooding the following measures are recommended;

Greater Hume Local Environmental Plan 2012

Council may wish to review land zoning within areas defined as floodway (see Section 4.5) to prevent inappropriate development in these areas.

Flood Policy/DCP

A DCP should be created and it should include the FPA map (see Figure 16). In addition to the objectives already stated and considerations included within Chapter 8 of the Greater Hume DCP 2013, it is recommended the Policy should consider:

- Controls on development in flood prone land;
- Controls on development outside the FPA but where development could exacerbate flood risk elsewhere; and
- Controls on drainage easements.

Key considerations for the Flood Policy are listed below. Many of these have been discussed within this report.

<u>For developments with the FPA</u>

- Building floor levels - consideration for different development types;
- Flood Proofing;
- Impact of development on adjacent or surrounding properties; and
- Consideration of hazard at the site and development type.

For all developments within the catchment regardless of flood affectation (could be in a separate OSD or drainage policy)

- Development drainage - limit discharge to that of pre-development site;
- Water quality; and
- Responsibility for maintenance and compliance.

Specific text inclusions suggested for a flood management DCP are provided in Appendix G. The DCP should be prepared to be applicable to all flood prone land within the LGA, rather than only specific to Holbrook to provide a consistent approach for development with the LGA. Any recommendations or suggestions in the FRMS&P with regard to planning and policy should be revised and approved by Council planners.

SUMMARY

Up to date planning controls are vital in managing flood risk and Council should update the DCP by introducing a Flood Policy comprising controls on development in flood prone land as well as controls to ensure development, whether or not in flood prone land, will impact on flood behaviour elsewhere. Crucial is inclusion of the FPA in the DCP as a means of determining to which property flood related development controls will apply.

RECOMMENDATIONS

The following measures are recommended:

► Introduce a Flood Policy comprising controls on development in flood prone land, drainage requirements from all new developments (a draft policy is included in Appendix G). Include the FPA in the flooding DCP.

5.6.5. Modification to the S149 Certificates

DESCRIPTION

The Environmental Planning and Assessment Regulation 2000 (the Regulation), at Clause 279 and Schedule 4, prescribes that Councils must provide a disclosure document whereby any interested party can learn the zone and any other planning controls that may apply to a parcel of land.

Schedule 4 of the Regulation prescribes the format of the Planning Certificate. Part 7A of Schedule 4 states:

> ***7A Flood related development controls information***
>
> *(1) Whether or not development on that land or part of the land for the purposes of dwelling houses, dual occupancies, multi dwelling housing or residential flat buildings (not including development for the purposes of group homes or seniors housing) is subject to flood related development controls.*
>
> *(2) Whether or not development on that land or part of the land for any other purpose is subject to flood related development controls.*

(3) Words and expressions in this clause have the same meanings as in the standard instrument set out in the Standard Instrument (Local Environmental Plans) Order 2006.

Legal reviews of the effectiveness of s.149 Planning Certificates have suggested it would be appropriate to also provide information as to the scale of the risk (low moderate or high) and also whether flooding applies generally to the area or more specifically to the land the subject of the certificate.

DISCUSSION

Because of the wide range of different flood conditions across NSW, there is no standard way of conveying flood related information. As such, Councils are encouraged to determine the most appropriate way to convey information for their areas of responsibility. This will depend on:

- The type of flooding;
- Whether flooding is from major rivers or local overland flooding; and
- The extent of flooding (whether widespread or relatively confined).

It should be noted that the s.149 Planning Certificate only relates to the subject land and not any specific building on the property.

While the legislation currently does not mandate revealing the extent of flood inundation in an s.149(2) Planning Certificate, there is scope within an s.149(5) Planning Certificate for providing this additional type of information.

There can be a general perception from the public that insurance companies, lending authorities or other organisations may disadvantage flood liable properties that have only a very small part of their property inundated by floodwaters. Some Councils have addressed this concern by adding information in s.149(5) Planning Certificates to show the percentage of the property inundated as well as floor levels and other flood related information. In addition, the hazard category could be provided, and also advice regarding climate change increases in flood level.

The compulsory s.149(2) Planning Certificate should include, in terms of flood risk:

- Whether or not the property is in the FPA;
- Any development controls due to the property being within the FPA;
- Responsibility for maintenance and compliance for OSD features; and
- Highlight any drainage easements through the property and controls that apply.

Some Councils include detailed flooding information in s.149(5) Planning Certificates as standard practice. This ensures that residents are made fully aware of flood risks before purchasing a property. However, people who are current property owners often feel that this information devalues their properties and would rather not know. Flood related information in s.149(5) Planning Certificates should include:

- Flood levels / depths over the property;
- Percentage of property which is flood affected;
- The likelihood of flooding;

- Floor levels (from Council's floor level survey if available); and
- Potential flood hazard.

SUMMARY

As Council information for s.149 Planning Certificates and Development Restriction Certificates is obtained mainly from computerised databases and maps, Council should investigate ways to make property-based flooding information more accessible via its web-site.

Data from the hydraulic modelling used in this FRMS&P should be incorporated into Council's s.149 Planning Certificate database. All residents should be advised by personalised mail from Council if their land is affected. Council should determine the appropriate event for advising residents that the same criteria is used as in establishing the FPA.

RECOMMENDATIONS

The following measures are recommended:

► Update and re-issue s149 certificates based on this FRMS. It is encouraged that full details are provided in Part(5) as standard practice when a Part(2) is requested.

► Provide flooding information on Councils website.

6. FLOODPLAIN RISK MANAGEMENT PLAN

This section comprises the Floodplain Management Plan and forms a framework identifying aims, objectives and a guide to the list of strategies by which the plan will be implemented. Any recommendations in terms of policy should be reviewed and approved by Council's planners.

6.1. Aims and Objectives

The primary objective of the Floodplain Management Plan is to recommend a range of property, response and flood modifications that address the existing and future flood problems, in accordance with the Floodplain Development Manual (Reference 1). The recommended works and measures presented in the Plan will:

- Reduce the flood hazard and risk to people and property in the existing community and to ensure future development is controlled in a manner consistent with the flood hazard and risk;
- Reduce private and public losses due to flooding;
- Protect and, where possible, enhance the river and floodplain environment;
- Be consistent with the objectives of relevant State policies, in particular, the Government's Flood Prone Lands and State Rivers and Estuaries Policies and satisfy the objectives and requirements of the Environmental Planning and Assessment Act, 1979;
- Ensure that the floodplain risk management plan is fully integrated with Council's existing corporate, business and strategic plans, existing and proposed planning proposals, meets Council's obligations under the Local Government Act, 1993 and has the support of the local community;
- Ensure actions arising out of the management plan are sustainable in social, environmental, ecological and economic terms;
- Ensure that the floodplain risk management plan is fully integrated with the local emergency management plan (Local Flood Plan) and other relevant catchment management plans; and
- Establish a program for implementation and a mechanism for the funding of the plan and should include priorities, staging, funding, responsibilities, constraints, and monitoring.

6.2. Identification of Actions Suitable For Implementation

The following matrix (Table 20) identifies the practical options which have been identified to the Holbrook Floodplain Risk Management Committee for further approval. Those options or strategies approved by the Committee will be further investigated.

Table 20: Measures Recommended for Implementation – Risk Management Options Matrix

Measure	Description	Priority	Benefits	Concerns	Implementation, Costs and Funding
FLOOD MODIFICATION MEASURES					
Ten Mile Creek Southern Floodplain Levee System – Option CL/BL (Section 5.3.1.5)	This combined levee option combines the Option CL levee (see Section 5.3.1.3) that runs parallel to Macinnes Street and Option BL levee (see Section 5.3.1.4) that runs parallel to Hay Street to protect the Holbrook Southern Floodplain from Ten Mile Creek flooding for events up to and including the 1% AEP flood.	High Consider for detailed design and costing	B/C = 0.7 The combined Option CL/BL eliminates property flood affection due to Ten Mile Creek on the Holbrook Southern floodplain for events up to and including the 1% AEP flood event. A key feature of the implementation of this levee is that residents are able to evacuate during a Ten Mile Creek flood event, either via the Holbrook Bypass on-ramp or via the Albury Street Bridge. This significantly reduces risk to life as people are not exposed to high hazard flows during evacuation as occurred during the October 2010 flood event. It also reduces the requirements on the NSW SES and other rescue personnel thus further decreasing risk to life. Flood warning and evacuation time is also increased.	The cost of construction of the levee is significant and has a B/C ratio less than one.	Council would be responsible for costs and implementation. Some funding may be available through the Floodplain Risk Management Program.
Strategy for Ten Mile and Morgan's Ridge Creeks vegetation management (Section 5.3.4.5)	Clearing of debris and overgrown vegetation from the Creek.	Medium	Can minimise build-up of debris and hence channel blockage.	Environmental concerns over loss of riparian corridor, habitats and native vegetation.	Council would be responsible for costs and implementation. The Murray LLS would also need involvement. Approval from the relevant government bodies is necessary in some cases and clearance will be limited by legislation.
Drainage maintenance (section 5.3.8)	Council should regularly address drainage maintenance including unblocking and repairing where necessary.	High	Will maintain drainage efficiency in Holbrook and prevent additional flooding caused by blockage of channels or structures.	Structures not under the jurisdiction of Council, including those maintained by RMS may not be efficiently maintained.	Council will be responsible for costs and regular maintenance apart from those structures under the jurisdiction of RMS.
Drainage Assets Database (Section 5.3.8)	Develop database of all drainage assets and notify body responsible for their maintenance.	Low	Would allow Council to better maintain the drainage in the area and reduce responsibility issues.	Needs to be maintained.	Council would be responsible for costs and implementation of the database as well as RMS to establish details of their infrastructure. The Murray LLS would also need involvement.
PROPERTY MODIFICATION MEASURES					
Flood proofing (section 5.4.3)	Prementant or temporary measures can be used. Possible to retrofit to existing buildings but can be a requirement for new development.	Low	Can reduce damages to properties in flood prone areas.	Can be difficult and costly to retrofit. Temporary measures require time for installation and warning is limited in Holbrook.	Requirements for new development to be flood proofed can be included in the Flood Management DCP.

Measure	Description	Priority	Benefits	Concerns	Implementation, Costs and Funding
RESPONSE MODIFICATION MEASURES					
Alarm existing NOW stream gauge at site 410187 and install a pluviometer (Section 5.5.1)	The existing NSW Office of Water (NOW) stream gauge (Holbrook #3 – No. 410187), which is located about 5 km upstream of Holbrook could be configured such that an SMS is issued to NSW SES personnel when pre-programmed levels are reached during a rising flood. Additionally, installation of a pluviometer rainfall gauge at the site of the existing gauge is recommended.	Medium	Automation of the Holbrook #3 gauge could potentially provide an additional 1 hour warning time of an impending flood. Installation of a pluviometer rainfall gauge at the existing gauge site would be relatively straight forward and would be useful for future hydrologic model calibration as well as for flood prediction.	An additional hour's warning time would not be sufficient to produce a time surplus for the evacuation of the Holbrook Southern Floodplain. However, if implemented in conjunction with the Ten Mile Creek Southern Floodplain Levee System (see Section 5.3.1.5) available warning time could be further increased allowing for evacuation of the Southern Floodplain. Presently water levels are recorded only every 30 minutes, however there is potential to upgrade the on-site logger. The gauge is also located on a dynamic river channel with a propensity for silting up, so could potentially fail to report a rising flood.	Council in conjunction with NOW and NSW SES will be responsible for costs and regular maintenance.
Install manual depth indicators on Annandayle Road (Section 5.5.1)	Installation of manual depth indicators at three crossings (Back Creek, Devils Creek and Ten Mile Creek) along Annandayle Road.	Low	Installation of manual depth indicators would reduce risk to motorists driving during period of heavy rainfall. Additionally, following issuance of a Flood Watch or Severe Weather Warning, or during heavy rain, the NSW SES could periodically monitor these depth indicators and over time develop coarse intelligence to better inform flood predictions for Holbrook.	None.	Council will be responsible for costs and regular maintenance of the manual gauges. The NSW SES in conjunction with would be responsible monitoring these gauges in times of heavy flow.
Maintain the flood observer network on Ten Mile Creek (Section 5.5.1)	The NSW SES currently operate a network of flood observes in the Ten Mile Creek catchment. The flood observers provide intelligence as a flood is rising which can be useful for the NSW SES. It should be ensured that all emergency operations agencies, such as NSW SES and police etc. and the local community, liaise and coordinate effectively during a flood event.	Medium	Potential for faster and more accurate information on impending floods. Better coordinated emergency response with more personnel available to assist.	None.	NSW SES are the responsible for organisation.

Measure	Description	Priority	Benefits	Concerns	Implementation, Costs and Funding
Preparation for potential future floods to increase flood warning: • Relationships between observed levels • Warning messages • Telephone dial-out system See Section 5.5.1 for more information.	Various measures can be undertaken to increase flood warning time. This includes: • Progressively develop relationships between flood depth indicators / observer stations and downstream water level recorders. • Pre-prepare flood warning messages for communication during periods of flood. • Construct and maintain a telephone dial-out system for the rapid dissemination of flood information and instructions.	Medium	Preparation for future flood events will greatly increase flood warning time and risk of error by reducing decision making requirements during an event.	None.	NSW SES are the responsible for implementation and funding.
Resource Holbrook NSW SES Unit for flood rescue function (Section 5.5.2)	Due to the rapid rate of rise of Ten Mile Creek and the potential for residents on the Holbrook Southern Floodplain to become isolated during larger flood events, Holbrook NSW SES Unit should have the capability to undertake flood rescue at short notice.	Medium	People at risk during flooding of the Holbrook Southern Floodplain will have timely assistance when considering the fast flood response time of the Ten Mile Creek catchment.	None.	NSW SES are the responsible for implementation and funding.
Holbrook Southern Floodplain emergency shelter (Section 5.5.2)	Construction of a community building that could function as an emergency evacuation shelter for the Holbrook Southern Floodplain should be considered. The building must maintain structural integrity in an extreme flood and have reliable access during flood.	Low	Under current conditions, timely evacuation from houses on the Holbrook Southern Floodplain is imperative because in the PMF the combination of depths and velocities there presents an 'extreme' hazard to structures, and if residents wait to see the magnitude of a flood, it might be too late to evacuate. An emergency shelter on the Holbrook Southern Floodplain would provide residents that cannot evacuate in time safety during extreme flood events.	The shelter would require a day to day use and would likely be quite expensive.	Council would be responsible construction and maintenance costs.
Review and update the Greater Hume Local Flood Plan and Flood Intelligence Cards (Section 5.5.2).	Local Flood Plan sets out measures to take before and during flooding. FIC's provide usable flood intelligence that can be used to inform emergency procedure.	High	Provide more information such that informed decision can be made during a flood and allow from flood preparedness. Latest information from the Flood Study and the FRMS&P can be included. FICs for the Holbrook #3 and Holbrook manual gauges provide emergency procedure leading to increased efficiency and reduced flood risk.	Need for strong communication with communities of concern.	NSW SES are responsible for maintaining the Local Flood Plan the FICs.
Encourage floodplain exposures to develop flood emergency plans (Section 5.5.2)	Key floodplain exposures that are at risk of flooding due to their locations on the floodplain and should prepare for potential flooding by preparing flood emergency plans.	Medium	Reduce flood risk for locations situated in the highest risk areas.	None.	Council and the NSW SES have shared responsibility.

Measure	Description	Priority	Benefits	Concerns	Implementation, Costs and Funding
Undertake a community flood education program (Section 5.5.3).	A community flood education program with the following components should be undertaken: • Engage with the community to prepare an ongoing flood education program. • Regularly issue flood certificates and pamphlets to residents on the floodplain. • Prepare a library photo and story display about the 2010 flood. • Commemorate the 10th anniversary of the 2010 flood. • Prepare a Holbrook FloodSafe guide. • Host a Business FloodSafe breakfast. • Organise community days for the NSW SES and residents of the Holbrook Southern Floodplain. • Install a historic flood marker pole in Holbrook.	On going	Continuing awareness of the community leads to better preparedness and therefore fewer damages during a flood event.	People begin to ignore advice and information if too much is given, particularly if they believe there is little risk of flooding.	Council and NSW SES. Can be variable depending on the methods used. Can be incorporated with other Council information provision to reduce costs.
PLANNING AND FUTURE DEVELOPMENT					
Define a floodway in Council's DCP (Section 5.4.2 and 5.6.1)	Define a floodway in Council's DCP where no future residential development is permissible. Reconsider existing zones against current flood data and mapping, introduce flood controls or floor levels where appropriate or back zone if land is identified in the flood way.	Medium	Reduced flood risk and development impacts is possible by ensuring that development does not occur in the floodway.	None.	Council are responsible for amending the DCP.
Consider precincts with known 'constrained evacuation' (Section 5.6.1)	Council consider either restricting future development or requiring refuge provision in precincts with known "constrained evacuation" areas	Medium	Reduced risk to life during extreme flood events and reduced requirement on the NSW SES.	None.	Council are responsible for amending the DCP.
Define the Flood Planning Level (Section 5.6.2)	A requirement of the Floodplain Development Manual. Used to set requirements for floor levels and flood proofing in development controls.	High	For residential properties it ensures habitable floor levels are above the 1% AEP flood level (plus 0.5 m freeboard) and therefore reduced flood damages. For commercial, and other less vulnerable land uses, the FPL can be used to set requirements for minimum floor level or elevation to which flood proofing must be provided.	Can have implications with requirements for maximum building heights and access to buildings for the less able.	Will be implemented through amendments to the DCP through a Flood Policy. Council to make decision on FPL for uses other than residential although recommendations have been given in this report.

Measure	Description	Priority	Benefits	Concerns	Implementation, Costs and Funding
Redefine the Flood Planning Area and incorporate into Council's DCP (Section 5.6.3)	A requirement of the Floodplain Development Manual. The FPA is required to identify all properties to which flood related development controls will apply. More vulnerable developments within Holbrook such as hospitals, schools, services including power should be preferably situated outside the PMF flood extent or at the very least have floor levels and access at the FPL or PMF level, whichever is higher.	High	Provides a clear method of identifying properties subject to flood related development controls.	There is a need to include properties impacted by both mainstream and overland flow. Also good communication with residents about process is key.	The revised FPA map should be included in Councils DCP.
Update and Re-issue S149 certificates (section 5.6.5**)**	Issued to residents to identify any hazards at their property and development controls that apply.	Medium	Can inform of the flood risk at each property and if Part 5 is also included supply additional information such as the type of flooding affecting the property or whether the property is in a high hazard area or floodway. Ensures residents aware of development controls, such as minimum floor levels, at their property. Can also inform residents of drainage easements through properties and their responsibilities.	Part 2 is compulsory. Some residents do not like the additional information provided under Part 5 and believe it can affect insurance premiums and value of land.	To be implemented by Council. Would follow on from adoption of a revised DCP for flooding.
Provide flood information on Council's website (Section 5.6.5**)**	Provide flood information on Council's website.	Low	Easily accessible information for the community which will typically reduce Council's workload to produce such information on demand.	None.	To be implemented by Council.

7. ACKNOWLEDGEMENTS

WMAwater wish to acknowledge the assistance of the Greater Hume Shire Council staff and the FRMC in carrying out this study as well as the residents of Holbrook. We would also like to acknowledge the excellent work carried out by Stephen Yeo as part of The Flood Intelligence collection (References 3 and 4) as well as OEH and SES for managing and financing the work.

Greater Hume Shire Council has prepared this document with financial assistance from the NSW Government through its Floodplain Management Program. This document does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage.

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Figures

FIGURE 1
HOLBROOK STUDY AREA

Millswood Road
Holbrook Wagga Road
Tip Road
Corrys Lane
Bond Street
Spring Street
Fleet Street
Hume Highway
Bath Street
Racecourse Road
Peel Street
Vine Street
Bruce Street
Morgans Ridge
Wallace Street
Railway Parade
Webb Street
Croft Street
Swift Street
Culcairn Holbrook Road
Young Street
Bowler Street
Wilson Street
Halford Drive
Murray Street
Albury Street
Nyhan Street
Bardwell Street
Ten Mile Creek
Malabar Road
Jingellic Road
0
1
2
3
4

Bond Street
Raymond Street
Spring Street
Fleet Street
Hume Highway
Steel Street
Peel Street
Vine Street
McLaurin Crescent
Ford Street
Wallace Street
Murdoch Place
Spurr Street
Webb Street
Stirbeck Street
Croft Street
Welton Street
Frampton Street
Thorpe Street
Ross Street
Swift Street
Peel Street
Bowler Street
Purtell Street
Yarra Street
King Street
Wilson Street
Library Lane
Hume Street
Young Street
Gundagai Street
Halford Drive
Hay Street
Murray Street
Albury Street
Byng Street
Nyhan Street
Nolan Street
Bardwell Street
William Street
Macinnes Street
Jingellic Road

N

Sensitivity Analysis Points
Holbrook Bypass
Land Proposed for Rezoning
Holbrook #3 Gauge
Manual Gauge
Roads
Study Area
Creeks

0 0.25 0.5 1 1.5 2 km

Holbrook #3 Gauge

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FIGURE 2
HOLBROOK LEP 2011
LAND USE

Holbrook Bypass
Land Proposed for Rezoning
Roads
Study Area

LEP Zones
E2
R5
RE2
RU1
RU5
SP2
Wetlands/Creeks
Special

0 0.25 0.5 1 1.5 2 km

N

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FIGURE 3
HOLBROOK
KEY LOCATIONS AND FLOOD HOTSPOTS

Diggers Lane
Tip Road
Culcairn Holbrook Road
Young Street
Wallace Street
Murdoch Place
Spurr Street
Raymond Street
Spring Street
Fleet Street
Steel Street
Hume Highway
Peel Street
Vine Street
McLaurin Cresent
Bruce Street
Railway Parade
Webb Street
Stirbeck Street
Croft Street
Welton Street
Frampton Street
Thorpe Street
Swift Street
Ross Street
Bowler Street
Purtell Street
Yarra Street
King Street
Wilson Street
Albury Street
Library Lane
Hume Street
Gundagai Street
Hay Street
Byng Street
Nolan Street
Murray Street
Nyhan Street
Bardwell Street
Macinnes Street
William Street
Halford Drive
Jingellic Road

1 2 3 4 5 6 7 8 9

Key Hydraulic Structures
Hotspots
Holbrook Bypass
Roads

Depth (m)
0.10 - 0.5
0.5 - 0.75
0.75 - 1.0
1.0 - 2.0
> 2.0

0 0.25 0.5 1 1.5 km

NOTE: Displayed inundation patterns and extents pertain to the 1% AEP event and are based on best available estimates of flood behaviour. Acutal inundation patterns may vary slightly during an event. All depths less than 100 mm have been trimmed from this figure.

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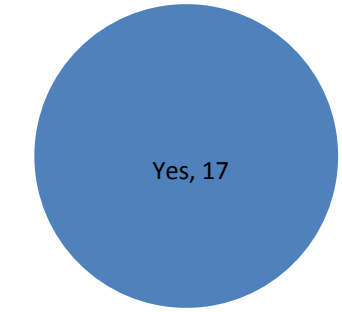
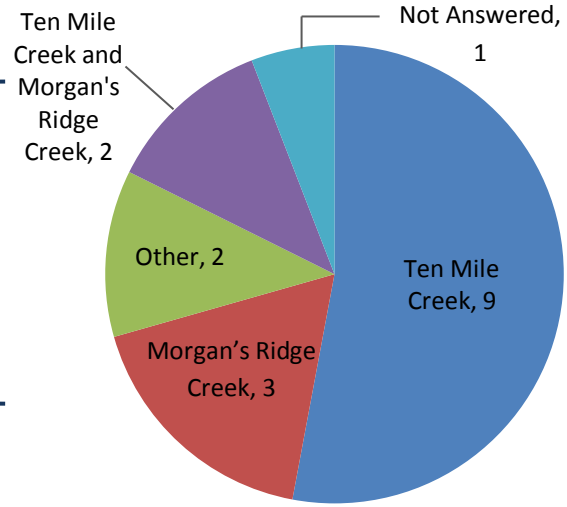
FIGURE 4
COMMUNITY SURVEY RESPONSE SUMMARY
HOLBROOK

Do you think something should be done to reduce flood risk in Holbrook?

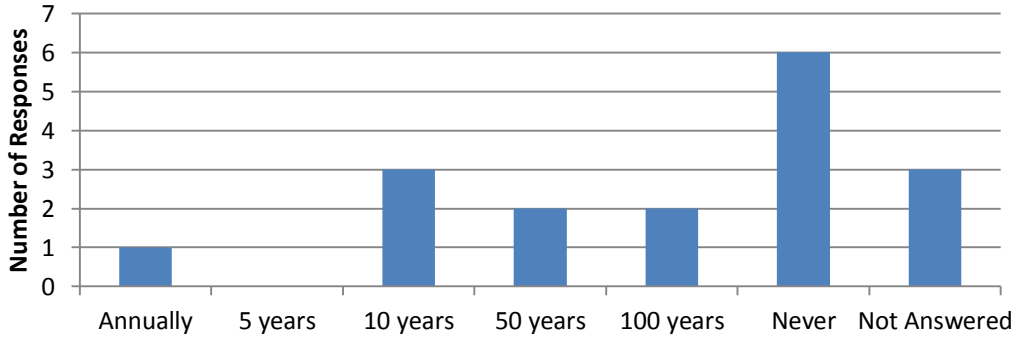


100% of responses believe that something had to be done to reduce flood risk in Holbrook.

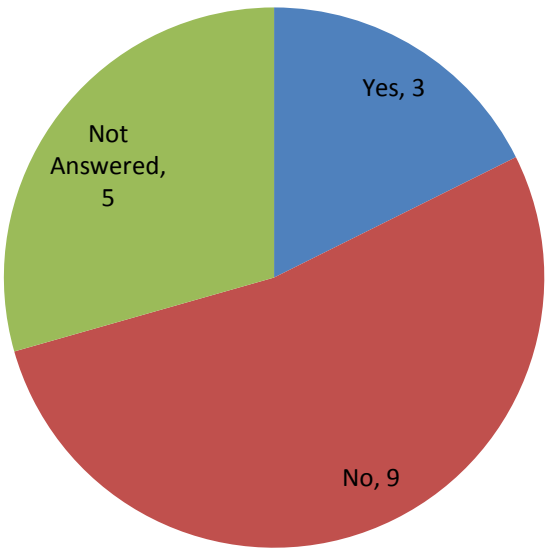
Is the flood risk you are referring to due to: Ten Mile Creek, Morgan's Ridge Creek or Other?



At what frequency would you consider flooding to be "acceptable"?



If eligible, would you be interested in a Voluntary Purchase scheme?



If eligible, would you be interested in a Voluntary House Raising scheme?

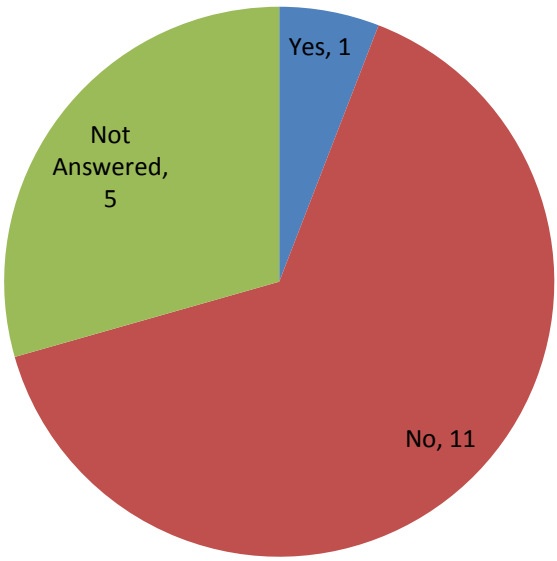


FIGURE 5
COMMUNITY CONSULTATION RESPONDENTS
HOLBROOK

Bath Street
Bath Street
Racecourse Road
Millswood Road
Tip Road
Diggers Lane
Bond Street
Spring Street
Prospect Street
Fleet Street
Steel Street
Steel Street
Rankin Street
Ford Street
Vine Street
McLaurin Cresent
Bruce Street
Peel Street
Raymond Street
Hume Highway
Wallace Street
Wallace Street
Wallace Street
Murdoch Place
Spurr Street
Railway Parade
Webb Street
Stirbeck Street
Croft Street
Welton Street
Frampton Street
Thorpe Street
Ross Street
Ross Street
Swift Street
Peel Street
Bowler Street
Bowler Street
Bowler Street
Culcairn Holbrook Road
Young Street
Webb Street
Purtell Street
Yarra Street
King Street
King Street
Wilson Street
Wilson Street
Library Lane
Albury Street
Hume Street
Hume Street
Gundagai Street
Young Street
Halford Drive
Hay Street
Murray Street
Byng Street
Murray Street
Nyhan Street
Byng Street
Nolan Street
Bardwell Street
Bardwell Street
Jingellic Road
Macinnes Street
William Street

N

Questionnaire Response
Holbrook Bypass
Roads

0 0.125 0.25 0.5 0.75 1 km

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FIGURE 6
HOLBROOK
COMPARISON OF UPDATED MODEL TO PREVIOUS MODEL
1% AEP FLOOD EVENT

Culcairn Holbrook Road
Young Street
Railway Parade
Webb Street
Purtell Street
King Street
King Street
Wilson Street
Ten Mile Creek
Murray Street
Nyhan Street
Nyhan Street
Albury Street

N

Holbrook Bypass
Roads
Creeks

Impact (m)
< -0.2
-0.2 - -0.1
-0.1 - -0.05
-0.05 - 0.05
0.05 - 0.1
0.1 - 0.15
> 0.15
No Longer Flooded
Newly Flooded

This figure displays the difference in peak flood level between the 1% AEP event determine as part of the Reference 1 Flood Study and the revised 1% AEP event determined as part of the current study. The warmer colours (yellow to red) indicate where peak flood level are higher in the current study than previously and the cooler colours (shades of blue) indicate where levels are lower. The purple areas are areas that were previously not flooded but are now flooded due to the model's revision.

0 50 100 200 300 400 500
Meters

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FIGURE 7
HOLBROOK BYPASS FLOOD IMPACT ASSESSMENT
1% AEP FLOOD EVENT

Holbrook Bypass
Cadastre

Change in Flood Level (m)

- > 0.3
- 0.3 - 0.2
- 0.2 - 0.1
- 0.1 - 0.05
- 0.05 - 0.02
- No Impact
- -0.02 - -0.05
- -0.05 - -0.1
- -0.1 - -0.2
- -0.2 - -0.3
- < -0.3
- Newly Flooded
- No Longer Flooded

This figure displays the change in peak flood level with construction of the Holbrook Bypass. The warmer colours (yellow to red) indicate an increase in peak flood level due to construction of the Bypass and the cooler colours (shades of blue) indicate a decrease. The black areas are no longer flooded and the purple areas are areas that were previously not flooded but are now flooded due to construction of the Bypass.

0 250 500 1,000 1,500 2,000 Meters

0 0.05 0.1 0.2 0.3 0.4 Km

N

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FIGURE 8
PROPOSED DEVELOPMENT AREAS
HOLBROOK FLOOD PLANNING AREA

Burges Lane
Racecourse Road
Bath Street
Rankin Street
Ford Street
Bruce Street
Vine Street
Peel Street
Fleet Street
Spring Street
Bond Street
Millswood Road
Tip Road
Cuicairn Holbrook Road
Mountain Creek Road
Raymond Street
Hume Highway
Wallace Street
Spurr Street
Swift Street
Wallace Street
Railway Parade
Webb Street
Stirbeck Street
Croft Street
Welton Street
Frampton Street
Thorpe Street
Ross Street
Yarra Street
Bowler Street
Young Street
Wilson Street
Hume Street
Gundagai Street
Halford Drive
Albury Street
Murray Street
Byng Street
Bardwell Street
William Street
Macinnes Street
Malabar Road
Jingellic Road

N

Holbrook Bypass
Roads
Holbrook FPA
Land Proposed for Rezoning

0 0.25 0.5 1 1.5 2 km

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FIGURE 9
PROPOSED DEVELOPMENT AREAS
HOLBROOK HYDRAULIC HAZARD

Burges Lane
Racecourse Road
Bath Street
Rankin Street
Ford Street
Bruce Street
Millswood Road
Tip Road
Culcairn Holbrook Road
Bond Street
Spring Street
Fleet Street
Hume Highway
Peel Street
Vine Street
Raymond Street
Wallace Street
Spurr Street
Railway Parade
Webb Street
Stirbeck Street
Croft Street
Welton Street
Frampton Street
Thorpe Street
Swift Street
Wallace Street
Mountain Creek Road
Ross Street
Yarra Street
Bowler Street
Young Street
Wilson Street
Hume Street
Gundagai Street
Halford Drive
Albury Street
Murray Street
Byng Street
Bardwell Street
Macinnes Street
William Street
Malabar Road
Jingellic Road

N

Holbrook Bypass
Roads
Land Proposed for Rezoning

True Hydraulic Hazard
Low Hazard
High Hazard

0 0.25 0.5 1 1.5 2 km

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FIGURE 10
HYDRAULIC CATEGORISATION
1% AEP EVENT

Railway Parade
Webb Street
Webb Street
Stirbeck Street
Purtell Street
Croft Street
King Street
Welton Street
Wilson Street
Library Lane
Albury Street
Swift Street
Swift Street
Ross Street
Bowler Street
Bowler Street
Bowler Street
Bowler Street
Bowler Street
Yarra Street
Hume Street
Hume Street
King Street
Young Street
Young Street
Young Street
Young Street
Gundagai Street
Murray Street
Murray Street
Murray Street
Hay Street
Albury Street
Byng Street
Nyhan Street
Nolan Street
Bardwell Street
Bardwell Street
Bardwell Street
Byng Street
Byng Street
Nolan Street
Macinnes Street
Macinnes Street
William Street
Jingellic Road
Jingellic Road
Halford Drive

N

Holbrook Bypass
Roads
Hydraulic Categorisation
Flood Fringe
Flood Storage
Floodway

0 75 150 300 450 600
m

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FIGURE 11
HYDRAULIC CATEGORISATION
5% AEP EVENT

Railway Parade
Webb Street
Webb Street
Stirbeck Street
Croft Street
Welton Street
Library Lane
Albury Street
Swift Street
Swift Street
Ross Street
Bowler Street
Bowler Street
Bowler Street
Bowler Street
Bowler Street
Purtell Street
Yarra Street
King Street
Hume Street
Hume Street
Wilson Street
King Street
Young Street
Young Street
Young Street
Gundagai Street
Young Street
Murray Street
Murray Street
Hay Street
Albury Street
Byng Street
Nyhan Street
Murray Street
Murray Street
Nolan Street
Nolan Street
Jingellic Road
Bardwell Street
Byng Street
Byng Street
Bardwell Street
Bardwell Street
Macinnes Street
Macinnes Street
William Street
Jingellic Road
Jingellic Road
Halford Drive

N

Holbrook Bypass
Roads
Hydraulic Categorisation
Flood Fringe
Flood Storage
Floodway

0 75 150 300 450 600
m

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FIGURE 12
HYDRAULIC CATEGORISATION
PMF EVENT

Holbrook Bypass
Roads
Hydraulic Categorisation
Flood Fringe
Flood Storage
Floodway

0 75 150 300 450 600 m

N

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FIGURE 13
TRUE HYDRAULIC HAZARD
HOLBROOK
1% AEP

N

Holbrook Bypass
Reporting Area
True Hydraulic Hazard
Low Hazard
High Hazard

0 0.25 0.5 1 1.5 km

0 0.5 1 2 3 4 Km

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FIGURE 14
FLOOD ERP CLASSIFICATIONS
HOLBROOK

ZONE C
ZONE C
ZONE C
ZONE B
ZONE A
ZONE C
ZONE B

ZONE A: RISING ROAD ACCESS FOR 5%, 1% AND PMF EVENT

ZONE B: HIGH FLOOD ISLAND FOR 5% AND 1% AEP EVENTS. LOW FLOOD ISLAND FOR PMF EVENT

ZONE C: AREA WITH OVERLAND ESCAPE ROUTE FOR 5% AND 1% AEP AND PMF EVENTS

N

Holbrook Bypass

ERP ZONE

- NOT FLOOD AFFECTED
- ZONE A
- ZONE B
- ZONE C
- 5% Flood Extent
- PMF Flood Extent

1% AEP Flood Depth

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 2
- > 2

0 0.25 0.5 1 1.5 2 km

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FIGURE 15
HOLBROOK FIRST INUNDATED OVER FLOOR

N

Residential
- 5Y
- 10Y
- 20Y
- 50Y
- 100Y
- 200Y
- PMF

Non-residential
- 5Y
- 10Y
- 20Y
- 50Y
- 100Y
- 200Y
- PMF

Holbrook Bypass

0 0.25 0.5 1 1.5 2 km

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FIGURE 16
HOLBROOK FLOOD PLANNING AREA

Burges Lane
Culcairn Holbrook Road
Mountain Creek Road
Tip Road
Millswood Road
Bond Street
Spring Street
Fleet Street
Bath Street
Rankin Street
Ford Street
Raymond Street
Hume Highway
Peel Street
Vine Street
Bruce Street
Wallace Street
Spurr Street
Railway Parade
Webb Street
Stirbeck Street
Croft Street
Welton Street
Frampton Street
Thorpe Street
Swift Street
Ross Street
Yarra Street
Bowler Street
Young Street
Wilson Street
Hume Street
Albury Street
Gundagai Street
Halford Drive
Murray Street
Byng Street
Bardwell Street
Macinnes Street
William Street
Malabar Road
Jingellic Road
Nyhan Street
Hay Street
Nolan Street
King Street
Albury Street
Swift Street
Hume Street
Gundagai Street

N

Holbrook Bypass
Roads
Holbrook FPA

0 0.25 0.5 1 1.5 2 km

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Appendix A

A. Appendix A: Glossary

Taken from the Floodplain Development Manual (April 2005 edition)

acid sulfate soils	Are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by Acid Sulfate Soil Management Advisory Committee.
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m^3/s or larger event occurring in any one year (see ARI).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
caravan and moveable home parks	Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.
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.
consent authority	The Council, government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, as having the function to determine an application.
development	Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act). **infill 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. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power. **redevelopment:** refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.
disaster plan (DISPLAN)	A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.

discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act 1993. The use of sustainability and sustainable in this manual relate to ESD.
effective warning time	The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	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.
flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
flood	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 awareness	Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood education	Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves an their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
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 susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level (see flood planning area).
flood mitigation standard	The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.
floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
floodplain risk management options	The measures that might be feasible for the management of a 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 includes both written and diagrammetic information describing how particular areas of flood prone land are to be used and managed to achieve defined 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 State Emergency Service.

flood planning area	The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the flood liable land concept in the 1986 Manual.
Flood Planning Levels (FPLs)	FPLs are the combinations 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 standard flood event in the 1986 manual.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
flood prone land	Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.
flood readiness	Flood 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 the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.
freeboard	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.
habitable room	**in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. **in an industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Manual.
hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.

hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
local drainage	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
major drainage	Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves: the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or major overland flow paths through developed areas outside of defined drainage reserves; and/or the potential to affect a number of buildings along the major flow path.
mathematical/computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
merit approach	The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains. The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs.
minor, moderate and major flooding	Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood: **minor flooding:** causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded. **moderate flooding:** low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered. **major flooding:** appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.
modification measures	Measures that modify either the flood, the property or the response to flooding.
peak discharge	The maximum discharge occurring during a flood event.

Probable Maximum Flood (PMF)	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.
Probable Maximum Precipitation (PMP)	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.
probability	A statistical measure of the expected chance of flooding (see AEP).
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
stage	Equivalent to water level. Both are measured with reference to a specified datum.
stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
survey plan	A plan prepared by a registered surveyor.
water surface profile	A graph showing the flood stage at any given location along a watercourse at a particular time.
wind fetch	The horizontal distance in the direction of wind over which wind waves are generated.

Appendix B

FLOOR LEVEL SURVEY FOR CULCAIRN, HENTY AND HOLBROOK FLOODPLAIN RISK MANAGEMENT STUDIES

1. Background

WMAwater are preparing the Culcairn, Henty and Holbrook Floodplain Risk Management Studies on behalf of Greater Hume Shire Council. Part of this work involves obtaining floor levels of all potential flood liable buildings (habitable and commercial buildings but not sheds or garages) within the study area (attached plans). To undertake the survey WMAwater seeks to appoint a suitably qualified and experienced surveyor to obtain building information for the properties as shown on the attached figures and tables.

You are invited to provide a quotation by **Friday 29th August**, detailing your fixed price proposal and timeframe for completion to undertake the works as described below.

2. Floor Level Survey

Complete the attached example Table 1 for each of the properties/buildings.

The following number of properties will be surveyed:

- Culcairn – 117 buildings
- Henty – 12 buildings
- Holbrook – 108 buildings

In addition to the above listed properties an estimated 10 not yet identified utilities situated within these towns will also require survey. This should be factored into your quote and the locations of these will be provided at a later date. Including these 10 utilities there are total of 247 properties that require survey.

The requested properties with buildings that need to be surveyed are identified on the attached figures and tabulated address lists. These can also be provided in the form of GIS layers (Mapinfo and ArcGIS format) if required. The number of properties does not necessarily indicate the exact number of buildings to be surveyed; this is particularly important for commercial areas. In some instances several properties may span one building or there may be several buildings on each property. Please ensure that where there is more than one building on a property, all commercial, industrial and residential buildings are surveyed (and identified as residential, commercial/industrial or other). Any small sheds or garages do not need to be included. This is not expected to significantly affect the number of properties to be surveyed as the majority of buildings in these towns are stand alone homes.

We have provided the following information to assist you with your quotation:

- Figures showing the properties to be surveyed in each town (this can be provided in GIS format if required - MapInfo or ArcGIS);
- Address lists for each town of the properties that require survey; and
- Example table for format of floor level information.

It is not expected that private property will need to be accessed to complete the proposed works. However please note that the surveyor is to follow all OEH/Council protocols for entering private property and the relevant Occupational Health and Safety requirements for working in traffic. In addition to this, all properties not surveyed will need to detail the reason why survey has not been performed. If a level is taken at a location other than the floor level this must also be noted with details provided.

3. Deliverables

The following deliverables are required for each survey.

- Completed Table 1 in a spreadsheet to include;
    - WMA property ID;
    - Number of buildings on property (small sheds / garages do not need to be included);
    - Property name, number and street address;
    - XY co-ordinate of survey point in MGA56;
    - Indicative ground level of property (taken at the same location as floor level survey mark or as close as possible) in mAHD;
    - Lowest floor level (lowest habitable level if residential) in mAHD;
    - If residential;
        - Habitable floor level;
        - Number of storeys;
        - Comment if habitable uses on ground floor;
        - House size (observational estimate);
        - Floor and Wall construction.
    - If non-residential;
        - Type of use, Commercial, Industrial, Public etc;
        - Name / nature of business or use;
        - Lowest floor level;
        - Approximate floor area;
        - Floor and Wall construction.

For residential blocks where one floor level applied to the block, the number of ground floor properties needs to be noted. Likewise for commercial office blocks, the number of ground floor companies needs to be noted.

4. Projection and Datum

All data is required in the Map Grid of Australia (MGA) Zone 55 projected Cartesian coordinate system, based on the Geocentric Datum of Australia (GDA) 1994 geocentric coordinate system. An easting and northing is required for each survey point. All survey levels will be in metres reduced to Australian Height Datum (m AHD).

5. Tender Requirements

Please provide a fixed price quotation to undertake the above work together with a timetable for completion via email to **richards@wmawater.com.au by Friday 29th August**. Please contact the undersigned if you require any further clarification.

Zac Richards – Project Engineer
WMAwater, Level 2, 160 Clarence Street, SYDNEY, NSW 2000
Telephone: (02) 9299 2855
Email: richards@wmawater.com.au

ATTACHMENTS:

- Figure 1 – Culcairn properties map
- Figure 2 – Henty properties map
- Figure 3 – Holbrook properties map
- Table 1 – Example of data format for completion
- Table 2 – Culcairn properties list
- Table 3 – Henty properties list
- Table 4 – Holbrook properties list

FIGURE 01
CULCAIRN
FLOOR LEVEL SURVEY

Hamilton Street
Lions Place
Thomas Place
Railway Parade
Melville Street
Olympic Highway
Hopetoun Street
Gordon Street
Munro Street
Hoy Street
Melrose Street
Princes Street
Fifield Close
Elizabeth Street
Queen Street
Douglas Street
Douglas Street
Victoria Street
Victoria Street
Black Street
Henty Street
Henty Street
Federal Street
Albert Street
Balfour Street
Balfour St (Service Rd)
Stock Route
Kimdeen Street
McBean Street
Henty Street
Federal Street
Balfour Street
Edward Street
Gordon Street
Gamble Street
Donald Street
Fraser Street
Blair Street
Railway Parade
Munro Street
King Street
King Street
King Street
Wattle Street
Walbundrie Road
South Street
Jubilee Park Road
Waterworks Road

N

Properties
Roads
Cadastre

0 0.25 0.5 1 1.5
km

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FIGURE 02
HENTY
SURVEY PROPERTIES

Angaston Road
Grubben Road
West Showground Road
Henty Pleasant Hills Road
Buckargingah Creek
Olympic Highway
Comer Street
Barisch Avenue
Elm Street
Comer Street
Railway Parade
Fox Street
Graham Street
Keighran Street
Smart Street

N

Properties
Roads
Creek
Cadastre

0 0.05 0.1 0.2 0.3 km

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FIGURE 03
HOLBROOK
SURVEY PROPERTIES

Mountain Creek Road
Culcairn Holbrook Road
Tip Road
Diggers Lane
Millswood Road
Bond Street
Spring Street
Fleet Street
Steel Street
Bath Street
Rankin Street
Ford Street
Racecourse Road
Bruce Street
Morgans Ridge Creek
Raymond Street
Wallace Street
Murdoch Place
Spurr Street
Railway Parade
Webb Street
Stirbeck Street
Croft Street
Welton Street
Frampton Street
Thorpe Street
Swift Street
Peel Street
Vine Street
Ross Street
Young Street
King Street
Wilson Street
Hume Highway
Hume Street
Bowler Street
Halford Drive
Gundagai Street
Hay Street
Young Street
Murray Street
Ten Mile Creek
Nyhan Street
Byng Street
Bardwell Street
Macinnes Street
William Street
Hume Freeway
Malabar Road
Jingellic Road

N

Properties
Roads
Creeks

0 0.25 0.5 1 1.5 2 km

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Table 1 - Format for Provision of Floor Level Data

									RESIDENTIAL BUILDINGS						NON RESIDENTIAL BUILDINGS						
WMA ID	Total number of buildings	Comment	Street Number	Street Name	Sub-Area	Easting	Northing	Indicative Ground Level (m AHD)	Lowest Habitable Floor Level (m AHD)	Number of Storeys	Do people live on the Ground Floor (Y or N)	**House Size** - Small (S), Medium (M), Large (L)	**Floor Construction** Pier (P) or Slab (S) Other - describe	**Wall Construction** Brick stone or rendered (B), Clad (C) , Mixed (M)	Type (commercial = C, industrial = I, public = P)	Name and Nature of Use/Business eg. Bob's Nursery, toilet block	Lowest Floor Level (m AHD)	Approximate Floor Area (m^2)	**Floor Construction** Pier (P) or Slab (S) Other - describe	**Wall Construction** Brick stone or rendered (B), Clad (C) , Mixed (M)	
HOL1	1		31	Smith Street	Holbrook	349719.030	6298859.741	152.53	152.81	1	Y	L	S	B							
HOL2	1		36	Smith Street	Holbrook	349719.030	6298859.741	156.35	154.19	1	Y	L	S	B							
HOL3	2	building 1	38a	Smith Street	Holbrook	349719.030	6298859.741	152.86	153.25	2	Y	L	S	M							
		building 2	38b	Smith Street		349719.030	6298859.741	152.83	153.45	2	Y	L	S	M							
HOL5	2		67	Jones Road	Holbrook	349719.030	6298859.741	152.50							C	BOB'S ELECTRICAL	154.47	225	S	M	second building is shed
HOL6	1		11	Jones Road	Holbrook	349719.030	6298859.741	152.50							C	CENTRAL COAST STAIRS	152.84	1000	S	M	
HOL7	1		15	Jones Road	Holbrook	349719.030	6298859.741	152.08							I	CUSTOM STAINLESS DESIGN	152.30	800	S	B	
HOL8	1		2A	Newcastle Street	Holbrook	349719.030	6298859.741	162.40	162.91	1	Y	L	P	C							
HOL10	1		31	Newcastle Street	Holbrook	349719.030	6298859.741	152.19	152.79	2	Y	S	P	B							
HOL11	1	flats - 5 units on ground floor	1	Bob Street	Holbrook	349719.030	6298859.741	153.26	153.98	56	Y	S	S	C							All units on ground floor have same floor level

Table 2

Culcairn Property Addresses

ID	X	Y	Address	ID	X	Y	Address
CUL1	503992	6052908	16 MUNRO STREET	**CUL73**	503671	6053597	11 MELROSE STREET
CUL2	503888	6052920	VACANT LAND' 22 EDWARD STREET	**CUL74**	503705	6053598	12 MELROSE STREET
CUL3	503655	6053122	24 HENTY STREET	**CUL75**	503768	6053607	14 MELROSE STREET
CUL4	503807	6052940	CULCAIRN HOSPITAL' 53 BALFOUR STREET	**CUL76**	503752	6053645	15 HOPETOUN STREET
CUL5	503997	6052932	18 MUNRO STREET	**CUL77**	503670	6053658	7 HOPETOUN STREET
CUL6	504034	6052925	5 FAHEY CRESCENT	**CUL78**	503610	6053635	1 HOPETOUN STREET
CUL7	504032	6052954	7 FAHEY CRESCENT	**CUL79**	503763	6053735	8 HOPETOUN STREET
CUL8	504145	6053018	81 BALFOUR STREET	**CUL80**	504085	6053466	46 MUNRO STREET
CUL9	504120	6053017	79 BALFOUR STREET	**CUL81**	504141	6053849	84 MUNRO STREET
CUL10	504098	6053014	77 BALFOUR STREET	**CUL82**	504162	6053930	88 MUNRO STREET
CUL11	504137	6052983	17 FEDERAL STREET	**CUL83**	504168	6053950	90 MUNRO STREET
CUL12	504131	6052958	15 FEDERAL STREET	**CUL84**	504170	6053974	90A MUNRO STREET
CUL13	504127	6052935	13 FEDERAL STREET	**CUL85**	504186	6053963	90A MUNRO STREET
CUL14	504119	6052895	9 FEDERAL STREET	**CUL86**	504171	6054016	92 MUNRO STREET
CUL15	504068	6052908	8 FAHEY CRESCENT	**CUL87**	504370	6052288	NILLIMBEK' 165 TAYLORS ROAD
CUL16	504177	6052991	CULCAIRN SWIMMING POOL' FEDERAL STREET	**CUL88**	504398	6052369	NILLIMBEK' 165 TAYLORS ROAD
CUL17	504218	6053183	24 FEDERAL STREET	**CUL89**	504052	6052324	WATTLE STREET
CUL18	504157	6053098	108 BALFOUR STREET	**CUL90**	503662	6052542	1 MELVILLE STREET
CUL19	504034	6053180	30 MUNRO STREET	**CUL91**	503943	6052908	26 EDWARD STREET
CUL20	504147	6053165	19 FEDERAL STREET	**CUL92**	503997	6052965	20 MUNRO STREET
CUL21	503912	6053047	90 BALFOUR STREET	**CUL93**	503525	6052869	6 MELVILLE STREET
CUL22	503869	6053038	86 BALFOUR STREET	**CUL94**	503550	6052897	41 BALFOUR STREET
CUL23	503849	6053035	84 BALFOUR STREET	**CUL95**	503526	6052902	CORNER OF BALFOUR AND MELVILLE STREETS
CUL24	503829	6053035	82 BALFOUR STREET	**CUL96**	503660	6052927	45 BALFOUR STREET
CUL25	503804	6053105	18 GORDON STREET	**CUL97**	503614	6052912	CULCAIRN PUBLIC SCHOOL' BALFOUR STREET
CUL26	503802	6053079	16 GORDON STREET	**CUL100**	503467	6052877	RAILWAY PARADE
CUL27	503836	6053108	29 HENTY STREET	**CUL101**	503280	6052593	CULCAIRN CARAVAN PARK' OLYMPIC HIGHWAY
CUL28	503856	6053112	31 HENTY STREET	**CUL102**	502928	6052585	5 SOUTH STREET
CUL29	503878	6053114	33 HENTY STREET	**CUL103**	503056	6052564	7 SOUTH STREET
CUL30	503897	6053122	35 HENTY STREET	**CUL104**	502417	6052594	WILLESDENE' 101 WALBUNDRIE ROAD
CUL31	503914	6053120	37 HENTY STREET	**CUL105**	502373	6052614	WILLESDENE' 101 WALBUNDRIE ROAD
CUL32	503811	6053151	20 GORDON STREET	**CUL106**	502773	6052349	MALABAR' 2901 OLYMPIC HIGHWAY
CUL33	503835	6053156	20 GORDON STREET	**CUL107**	503108	6052912	18 BALFOUR STREET
CUL34	503831	6053179	20 GORDON STREET	**CUL108**	502919	6052860	2 BALFOUR STREET
CUL35	503860	6053167	38 HENTY STREET EAST	**CUL109**	502949	6052855	8 BALFOUR STREET
CUL36	503631	6052983	66 BALFOUR STREET	**CUL110**	502969	6052909	1 KIRNDEEN STREET
CUL37	503615	6053070	17 HENTY STREET	**CUL111**	503063	6053577	51 MCBEAN STREET
CUL38	503635	6053071	19 HENTY STREET	**CUL112**	503247	6053743	24 HAMILTON STREET
CUL39	503652	6053072	21 HENTY STREET EAST	**CUL113**	503811	6053745	10 HOPETOUN STREET
CUL40	503674	6053077	23 HENTY STREET EAST	**CUL114**	503824	6052575	9 WATTLE STREET
CUL41	503692	6053078	25 HENTY STREET	**CUL115**	503846	6052584	9 WATTLE STREET
CUL42	503738	6053092	23 GORDON STREET	**CUL116**	503881	6052591	11A WATTLE STREET
CUL43	503727	6053061	21 GORDON STREET	**CUL117**	503895	6052594	11A WATTLE STREET
CUL44	503561	6053098	22 MELVILLE STREET	**CUL118**	503925	6052583	13 WATTLE STREET
CUL45	503565	6053123	24 MELVILLE STREET	**CUL119**	503512	6053141	25 MELVILLE STREET
CUL46	503584	6053108	22 MELVILLE STREET				
CUL47	503595	6053112	1 VICTORIA STREET				
CUL48	503592	6053130	1 VICTORIA STREET				
CUL49	503619	6053115	20 HENTY STREET EAST				
CUL50	503635	6053121	22 HENTY STREET				
CUL51	503689	6053128	28 HENTY STREET EAST				
CUL52	503685	6053149	28 HENTY STREET EAST				
CUL53	503672	6053126	26 HENTY STREET EAST				
CUL54	503752	6053208	12 VICTORIA STREET				
CUL55	503701	6053200	8 VICTORIA STREET				
CUL56	503673	6053193	6 VICTORIA STREET				
CUL57	503772	6053218	14 VICTORIA STREET				
CUL58	503574	6053170	26 MELVILLE STREET				
CUL59	503575	6053191	28 MELVILLE STREET				
CUL60	503604	6053265	34 MELVILLE STREET				
CUL61	503631	6053182	2 VICTORIA STREET				
CUL62	503598	6053337	36 MELVILLE STREET				
CUL63	503627	6053375	40 MELVILLE STREET				
CUL64	503635	6053445	2 PRINCES STREET				
CUL65	503595	6053435	44 MELVILLE STREET				
CUL66	503582	6053460	46 MELVILLE STREET				
CUL67	503629	6053524	5 MELROSE STREET				
CUL68	503699	6053529	9 MELROSE STREET				
CUL69	503747	6053537	13 MELROSE STREET				
CUL70	503772	6053551	15 MELROSE STREET				
CUL71	503598	6053564	CULCAIRN MOTOR INN' 2 MELROSE STREET				
CUL72	503591	6053591	CULCAIRN MOTOR INN' 2 MELROSE STREET				

Table 3

Henty Property Addresses

ID	X	Y	Address
HEN1	502338	6070215	'EDEN PARK' 2350 HENTY PLEASANT HILLS ROAD
HEN2	502446	6070178	2363 HENTY PLEASANT HILLS ROAD
HEN3	502647	6070341	'HENTY SHOWGROUND' HENTY PLEASANT HILLS ROAD
HEN4	502341	6070324	2341 HENTY PLEASANT HILLS ROAD
HEN5	502314	6070341	'BUNDERRY' 73 ANGASTON ROAD
HEN6	502527	6070173	2363 HENTY PLEASANT HILLS ROAD
HEN7	503177	6070758	'LOW PLAINS' 5570 OLYMPIC HIGHWAY
HEN8	503199	6070442	5540 OLYMPIC HIGHWAY
HEN9	503205	6070422	5538 OLYMPIC HIGHWAY
HEN10	502730	6069942	ELM STREET
HEN11	503061	6070464	2 ANGASTON ROAD
HEN12	503062	6070532	GRUBBEN ROAD

Table 4

Holbrook Property Addresses

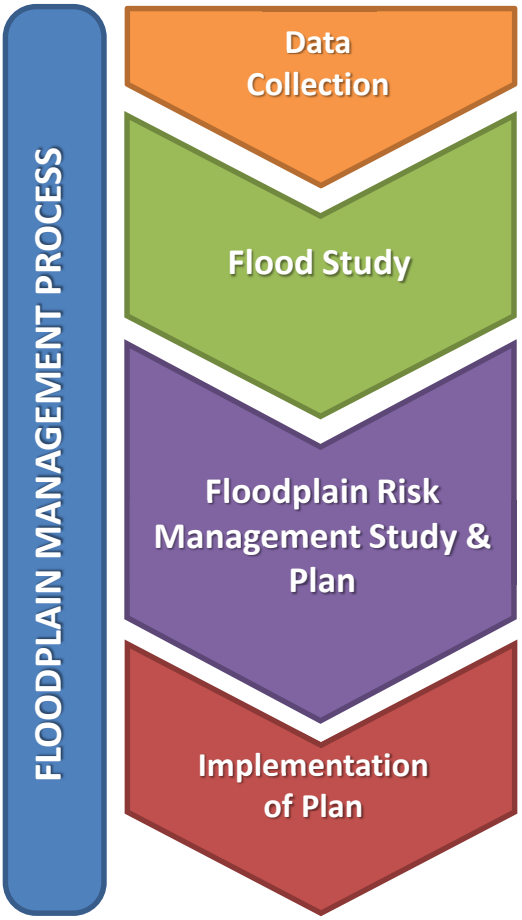
ID	X	Y	Address	ID	X	Y	Address
HOL1	528102	6046836	31 BOWLER STREET	HOL73	528079	6045975	2 BARDWELL STREET
HOL2	528289	6046550	97 ALBURY STREET	HOL74	528102	6045967	2 BARDWELL STREET
HOL3	528286	6046530	89 ALBURY STREET	HOL75	528123	6045974	8 BARDWELL STREET
HOL4	528264	6046479	'HOLBROOK HALL & OLD OFFICES' 40 YOUNG STREET	HOL76	528136	6046019	1 BYNG STREET
HOL5	528344	6046499	78-80 ALBURY STREET	HOL77	528096	6046049	JOLLY SWAGMAN MOTEL' 46 ALBURY STREET
HOL6	528402	6046464	1 SWIFT STREET	HOL78	528121	6046076	JOLLY SWAGMAN MOTEL' 46 ALBURY STREET
HOL7	528602	6046787	53 SWIFT STREET	HOL79	528168	6046080	3 BYNG STREET
HOL8	528594	6046772	51 SWIFT STREET	HOL80	528126	6046151	50 ALBURY STREET
HOL9	528584	6046754	49 SWIFT STREET	HOL81	528109	6046123	48 ALBURY STREET
HOL10	528520	6046400	51 YOUNG STREET	HOL82	528159	6046196	52 ALBURY STREET
HOL11	528496	6046410	49 YOUNG STREET	HOL83	528249	6046210	17 BYNG STREET
HOL12	528477	6046422	47 YOUNG STREET	HOL84	528179	6046237	56 ALBURY STREET
HOL13	528466	6046433	45 YOUNG STREET	HOL85	528182	6046254	60 ALBURY STREET
HOL14	528456	6046445	43 YOUNG STREET	HOL86	528229	6046317	68 ALBURY STREET
HOL15	528475	6046471	10 SWIFT STREET	HOL87	528236	6046336	72 ALBURY STREET
HOL16	528484	6046484	10 SWIFT STREET	HOL88	528252	6046352	76 ALBURY STREET
HOL17	528567	6046485	17 GUNDAGAI STREET	HOL89	528298	6046320	4 HAY STREET
HOL18	528579	6046502	19-21 GUNDAGAI STREET	HOL90	528286	6046331	2 HAY STREET
HOL19	528537	6046572	20 SWIFT STREET	HOL91	527919	6045972	MORRISONS' ALBURY STREET
HOL20	528581	6046559	10 HUME STREET	HOL92	528011	6046071	GLENNDALE PARK MOTEL' 59-65 ALBURY ST
HOL21	528572	6046573	22 SWIFT STREET	HOL93	527938	6046063	2-4 NYHAN STREET
HOL22	528610	6046547	12 HUME STREET	HOL94	527964	6046133	10-12 NYHAN STREET
HOL23	528491	6046504	12 SWIFT STREET	HOL95	527999	6046172	14 NYHAN STREET
HOL24	528650	6046634	11 HUME STREET	HOL96	528036	6046209	10 MURRAY STREET
HOL25	528634	6046633	9 HUME STREET	HOL97	528015	6046220	8 MURRAY STREET
HOL26	528654	6046598	13 HUME STREET	HOL98	527935	6046202	17 NYHAN STREET
HOL27	528635	6046601	11 HUME STREET	HOL99	528369	6045854	31 MCINNES STREET
HOL28	528623	6046613	9 HUME STREET	HOL100	528341	6045943	28 BARDWELL STREET
HOL29	528676	6046773	38 SWIFT STREET	HOL101	528044	6046266	7A MURRAY STREET
HOL30	528731	6046736	65 BOWLER STREET	HOL102	528089	6046238	77 ALBURY STREET
HOL31	528767	6046739	BRIGADOON' 65 BOWLER STREET	HOL103	528107	6046225	77 ALBURY STREET
HOL32	528794	6046730	BOWLER STREET	HOL104	528120	6046241	79 ALBURY STREET
HOL33	528816	6046730	67 BOWLER STREET	HOL105	528130	6046273	HOLBROOK TYRE SERVICE' 81 ALBURY STREET
HOL34	528863	6046750	67A BOWLER STREET	HOL109	528174	6046323	WOOLPACK INN MUSEUM' 83 ALBURY ST
HOL35	527909	6046779	9 PURTELL STREET	HOL111	528317	6046311	6 HAY STREET
HOL36	527745	6046892	1 BOWLER STREET	HOL112	528510	6045862	45 MCINNES STREET
HOL37	527762	6046969	26-28 RAILWAY PARADE				
HOL38	527821	6046907	7-9 BOWLER STREET				
HOL39	528970	6047031	38 PEEL STREET				
HOL40	528987	6047053	40 PEEL STREET				
HOL41	528995	6047072	42 PEEL STREET				
HOL42	529200	6047146	2-8 VINE STREET				
HOL43	529432	6047320	RANKIN STREET				
HOL44	529102	6047110	1 VINE STREET				
HOL45	527594	6047492	PEARDONS MILL' TIP ROAD				
HOL46	527664	6047521	PEARDONS MILL' TIP ROAD				
HOL47	527623	6047529	PEARDONS MILL' TIP ROAD				
HOL48	529896	6044370	WATER PARK' 224 JINGELLIC ROAD				
HOL49	529999	6044248	WATER PARK' 224 JINGELLIC ROAD				
HOL50	528863	6045696	96 JINGELLIC ROAD				
HOL51	528843	6045660	96 JINGELLIC ROAD				
HOL52	528682	6045686	THE OASIS' MCINNES STREET				
HOL53	528695	6045746	THE OASIS' MCINNES STREET				
HOL54	528692	6045730	THE OASIS' MCINNES STREET				
HOL55	528833	6045938	THE OLD PARSONAGE' 78 JINGELLIC ROAD				
HOL56	528508	6045831	45 MCINNES STREET				
HOL57	528486	6045834	43 MCINNES STREET				
HOL58	528469	6045835	41 MCINNES STREET				
HOL59	528451	6045843	39 MCINNES STREET				
HOL60	528428	6045843	37 MCINNES STREET				
HOL61	528404	6045933	32 BARDWELL STREET				
HOL62	528323	6045942	26 BARDWELL STREET				
HOL63	528283	6045944	22 BARDWELL STREET				
HOL64	528262	6045954	18-20 BARDWELL STREET				
HOL65	528267	6046001	21 BARDWELL STREET				
HOL66	528288	6046028	3 NOLAN STREET				
HOL67	528217	6046031	4-6 BYNG STREET				
HOL68	528345	6046268	18 BYNG STREET				
HOL69	528221	6045957	16 BARDWELL STREET				
HOL70	528206	6045963	14 BARDWELL STREET				
HOL71	528183	6045962	10-12 BARDWELL STREET				
HOL72	528152	6045896	11 MCINNES STREET				

Appendix C

Holbrook

Floodplain Risk Management Study & Plan

A Floodplain Risk Management Study and Plan (the Study) is currently being prepared for Holbrook. This is the next phase of the Floodplain Management Process after completion of the Culcairn, Henty and Holbrook Flood Studies (the Flood Study) last year. Greater Hume Shire Council (Council) has appointed WMAwater to undertake this Study.



The Floodplain Management Process

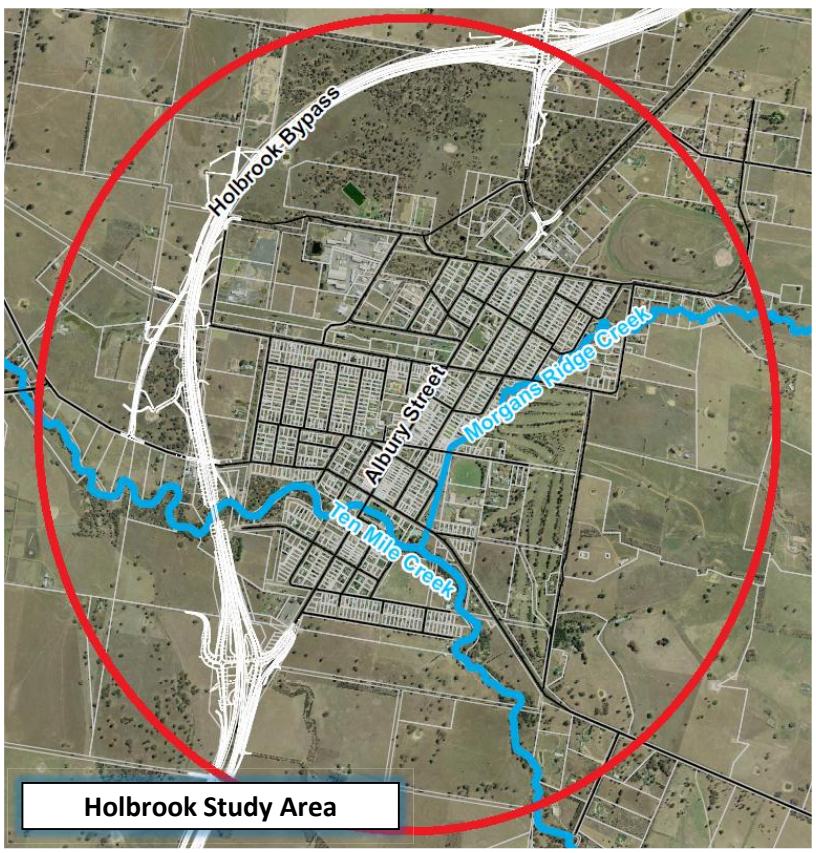
The State Government's Flood Policy aims to reduce the impacts of flooding and flood liability on individual owners and occupiers, and to reduce private and public losses resulting from flooding. Under the Policy, local government is responsible for managing flood liable land.

The Policy encourages the development of:

- solutions to existing flood problems in developed areas and
- strategies for ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in existing developed areas.

The State Government's Flood Policy provides for technical and financial support for a number of floodplain management activities. Funding for this study was provided from the State Government's Flood Risk Management Program and Greater Hume Shire Council.

Holbrook Study Area and Flood History



Flooding in Holbrook is primarily due to Ten Mile and Morgan's Ridge Creeks. Ten Mile Creek flows east-west through Holbrook at the southern end of the town and has a catchment area of approximately 140 km² at Albury Street. In the north-east of Holbrook, Morgan's Ridge Creek (11 km² catchment) flows south-west before joining Ten Mile Creek 300 m upstream of the Albury Street Bridge. Both of these creeks have historically been responsible for over floor flooding in Holbrook.

During October 2010 and again in March 2012, record flooding occurred in Holbrook, particularly on Ten Mile Creek. The larger of these two events, the October 2010 flood, inundated approximately 50 homes and businesses over floor level and caused significant damage throughout the town. The Flood Study estimated that this event had an Average Recurrence Interval (ARI) between 100 and 200 years.

Morgan's Ridge Creek also experienced flooding during both these events however flooding during the 1970's and 80's was greater than in either of the two recent flood events.

Holbrook

Floodplain Risk Management Study & Plan

An important aspect of this Study is devising various flood mitigation options that will reduce flood risk, liability and damage. WMAwater engineers have come up with various mitigation measures, however often flood affected communities also will have various ideas of how flood affectation can be reduced. This is where we need your help. Please complete the attached questionnaire and come to our community workshop day at Holbrook.

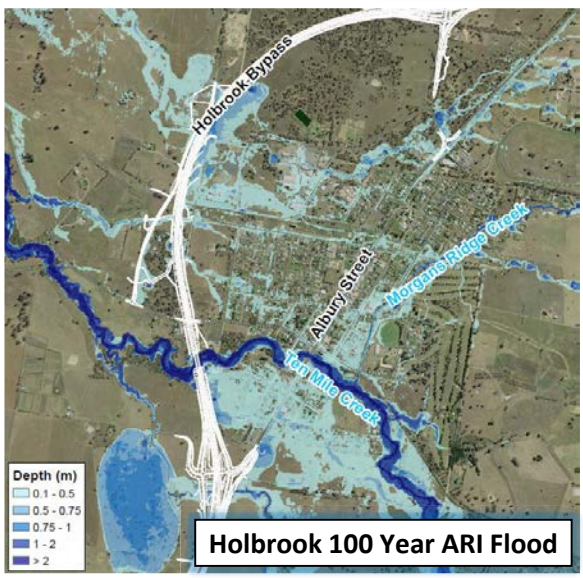
Come along to our Community Workshop

When: **Tuesday 14th October at 2:00 pm to 8:00 pm**

Where: **Holbrook Community Library**
Bowler Street, Holbrook

Flood Mitigation through Computer Modelling

The Flood Study aimed at understanding and determining the nature and extent of flood affectation in Holbrook. As part of this work, detailed computer models were established to model flood behaviour in the Study Area. One of the benefits of these models is that various flood mitigation measures can be tested to determine what works will provide the greatest mitigating effect whilst insuring that there are no negative impacts such as increased flood levels in the surrounding areas.



Holbrook 100 Year ARI Flood

What mitigation works can help reduce flood risks?

Flood Mitigation Works

Various types of flood mitigation works are used to reduce flood affectation. Not all mitigation measures are appropriate for all areas. For example, levees are often used to exclude flood water due to riverine or creek flooding from flood prone areas, however these will often increase flood levels and affectation outside of the levee as well as stopping local runoff from entering the creek, inadvertently causing flooding inside to the levee as well. Accordingly, a detailed investigation of all proposed flood mitigation works must be undertaken using the Flood Study Models.

Levees

Levees are used to exclude flood water from flood prone areas. A well known example of this is at Wagga Wagga where a levee protects the Wagga CBD from Murrumbidgee River flooding. Levees are often constructed of earth embankments such as that protecting the Holbrook RS Club from Morgan's Ridge Creek flooding.


Example earth bank levee

Culverts and Bridges

Culverts and bridges allow water to flow under roads, train tracks or similar obstructions. The use of bridges and culverts helps reduce upstream flood levels until the capacity of the structure is exceeded. In some instances it may be beneficial to increase the conveyance capacity of existing culverts to decrease upstream water levels, however the downstream impacts of such works must also be taken into account.

Drains and Channels

Drains and channels assist in the removal of floodwaters by increasing the rate at which flow is dispersed from a flood affected area. These structures are often situated in existing flow paths and are generally either earthen or concrete lined. A good example of a drainage channel is Morgan's Ridge Creek which in its upper reaches is a natural creek which then is transformed into an earthen channel and finally into a concrete drain before it discharges into Ten Mile Creek.

Holbrook

Floodplain Risk Management Study & Plan

In some instances, flood mitigation works such as those mentioned on the previous page may not be suitable for mitigation of flood risk and affectation. In such situations flood risk management measures may be better suited to reduce risk to life and property.

Property Modification Measures

Voluntary Purchase

Voluntary Purchase (VP) involves the acquisition of flood affected properties situated in high hazard areas, and demolition of the residence to remove it from the floodplain. The New South Wales State Government recognises VP as an effective floodplain risk management measure for existing properties in areas where:

- There are highly hazardous flood conditions from riverine or overland flooding and the principal objective is to remove people living in these properties and reduce the risk to life of residents and potential rescuers.
- A property is located within a floodway and the removal of a building may be part of a floodway clearance program that aims to reduce significant impacts on flood behaviour elsewhere in the floodplain by enabling the floodway to more effectively perform its flow conveyance function.
- Purchase of a property enables other flood mitigation works (such as channel improvements or levee construction) to be implemented because the property will impede construction or may be adversely affected by the works with impacts not able to be offset.

High Hazard Flooding

VP is an effective strategy where it is impractical or uneconomic to mitigate high flood hazard to an existing property and it is more appropriate to cease occupation to meet the above objectives. Government funding for VP schemes can be made available through the Floodplain Management Program as long as a number of complying criteria are met.

It is important to note that all properties involved in a VP scheme are valued by Valuer General of NSW and the property is assessed as though it is flood unencumbered. As part of this Study we are interested in determining the level of community interest in such a scheme. The questionnaire attached to this newsletter provides you with an opportunity to tell us if you would be willing to be involved in the VP process. Please note that the VP process is entirely voluntary and anyone involved in the scheme can withdraw at anytime. Also worth noting, where such a scheme is implemented it is done on a priority basis and such schemes can take many years to be carried out in full.

Voluntary House Raising

Voluntary House Raising (VHR) has been widely used throughout NSW to eliminate or significantly reduce flooding of habitable floors particularly in lower hazard flood areas, albeit in limited overall numbers. VHR is recognised as an effective floodplain risk management measure for both riverine and overland flood conditions. It is generally undertaken:

House Raising

- To reduce the frequency of exposure to flood damage of the house and its contents – reducing the frequency of household disruption, associated trauma and anxiety, and clean up after floods may also have social benefits.
- As a compensatory measure where flood mitigation works adversely affect a house which is generally considered part of the mitigation work rather than a separate VHR scheme.

VHR can be an effective strategy for existing properties in low flood hazard areas where mitigation works to reduce flood risk to properties are impractical or uneconomic. It should be part of an overall floodplain risk management strategy for an area rather than a stand-alone option as it does not deal with issues such as risk to life.

More information on the NSW Government's VP and VHR schemes can be obtained from:

http://www.environment.nsw.gov.au/resources/water/coasts/20130055fmpvolpurchase.pdf
http://www.environment.nsw.gov.au/resources/water/coasts/20130056fmpvolraising.pdf

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Community involvement in the Study is important. The Holbrook Floodplain Management Committee includes members from Council, Office of Environment and Heritage, the State Emergency Services and local residents who will oversee this Study. A questionnaire is included with this newsletter so that your views and ideas can be included in this Study. You are also invited to attend a community workshop where we welcome you to provide input into potential flood management options in more detail as well as to discuss the Study.

How can I have my say?

A questionnaire is enclosed with this newsletter. Please complete this and return to the FREEPOST address in the envelope provided.

Please make sure that all surveys are returned before 24th October 2014 or they may not be counted.

If you have additional information you would like to make available for the Study, or further comments, please attach to your questionnaire response or alternatively email to the contacts below.

The easiest and best way to be heard is to attend the community workshop at Holbrook Library on Tuesday 14th October 2014 between 2 pm and 8 pm.

Feedback from the community will be analysed and considered in this Floodplain Risk Management Study.

The hydraulic models constructed in the Flood Study will be used to assess the impacts of the potential mitigation options raised by the community in more detail and determine if these mitigation ideas are commercially viable. Modelling will also ensure that there are no negative impacts in the surrounding areas. The community workshop will be run in conjunction with this newsletter/questionnaire to provide opportunity for the community to ask questions in an open forum and to assist WMAwater engineers in determining potential mitigation works.

Contacts

If you would like to know more or have any information on flooding which would assist in this Study, please complete the relevant sections on the questionnaire and return using the provided 'postage paid' envelope. Additional information and comment can be attached to the questionnaire when you return it or provided to the contacts below.

Michael Oliver
Manager Infrastructure & Traffic
moliver@greaterhume.nsw.gov.au

Greater Hume Shire Council
40 Balfour Street, Culcairn NSW, 2660

Tel: 02 6029 8588

Zac Richards
Project Engineer
Holbrook@wmawater.com.au

WMAwater
Level 2, 160 Clarence Street
Sydney, NSW 2000

Tel: 02 9299 2855

Holbrook

Floodplain Risk Management Study & Plan

Please complete this questionnaire and return to the FREEPOST address in the envelope provided. Please make sure that all surveys are returned before 24th October 2014 or they may not be counted.

1. Your Details

(Please note your contact details are optional, will be held confidential and will only be used to contact you for more information regarding this study)

Name:

Address:

Telephone:

Email:

2. Can we contact you directly for more information?

☐ Yes ☐ No

If 'Yes', what method of contact would you prefer? e.g. telephone, Email etc.

3. Do you think something should be done to reduce flood risk in Holbrook?

☐ Yes ☐ No ☐ Don't Know

4. Is the flood risk you are referring to due to:

☐ Ten Mile Creek ☐ Morgan's Ridge Creek ☐ Other

If 'Other', please detail the source of flooding.

5. At what frequency would you consider flooding "acceptable"?

☐ Annually ☐ 5 years ☐ 10 years ☐ 50 years ☐ 100 years ☐ Never

Holbrook

Floodplain Risk Management Study & Plan

6. If eligible, would you be interested in a Voluntary Purchase scheme?

☐ Yes ☐ No

7. If eligible, would you be interested in a Voluntary House Raising scheme?

☐ Yes ☐ No

Please note that Questions 6. and 7. are only to obtain an indication of the level of community interest in these schemes. Please feel free to comment on the VP and VHR schemes below.

8. Have you got any ideas to reduce flood risk at Holbrook?

☐ Yes ☐ No

If 'Yes' can you please describe the location of where you think flood risk could be improved (please provide nearest crossroads or known landmarks or alternatively display on the attached map on page 8).

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Please use this page to describe how flood risk may be reduced?

Please use as many details as possible to describe how flood risk may be reduced. Note that you might find the attached map over page useful to aid in your description.

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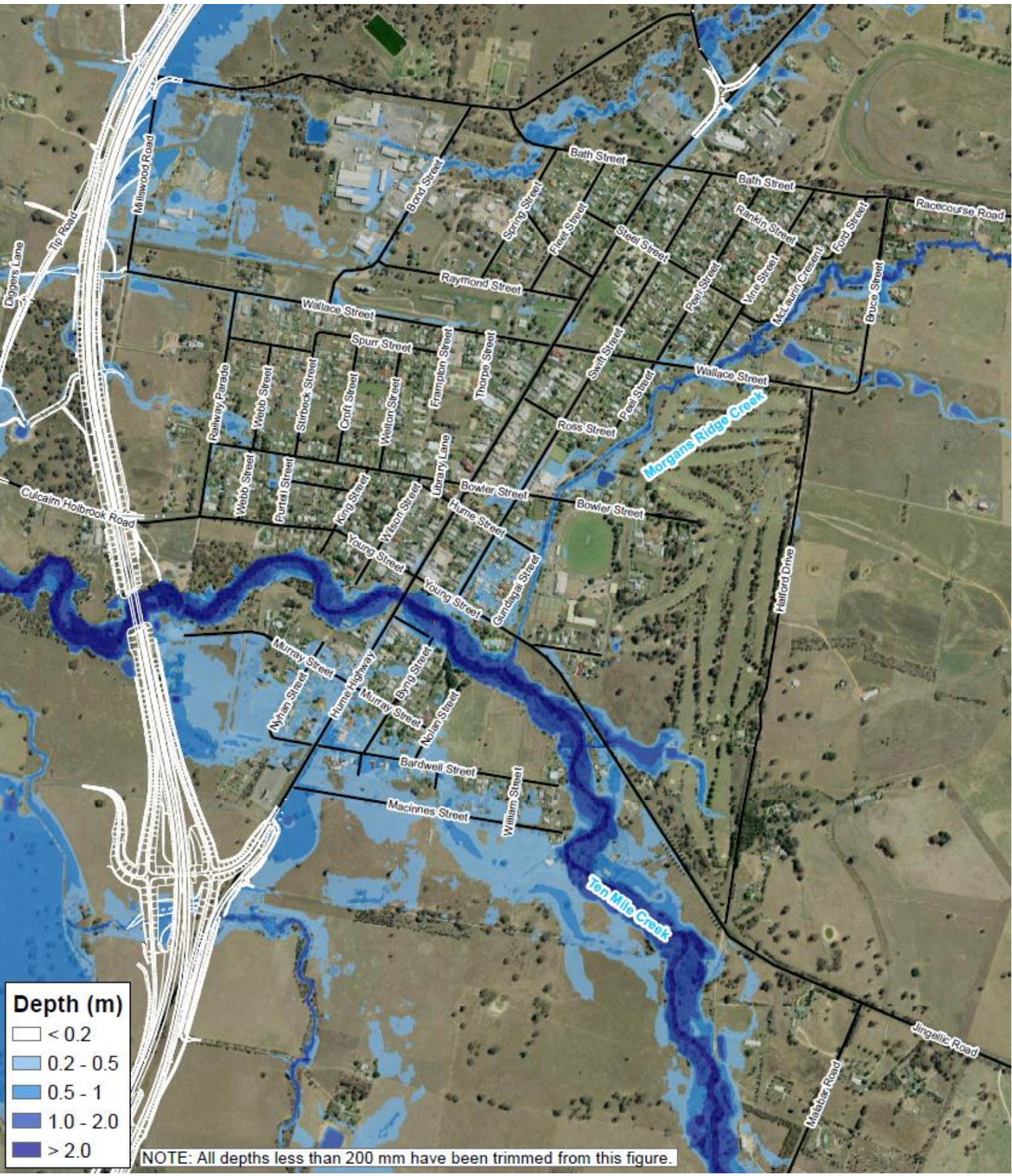
Greater Hume Shire
simply greater

Holbrook 100 year ARI flood depth map – Please indicate how you would reduce flood risk?



Appendix D

Michael Oliver
40 Balfour Road
CULCAIRN NSW
2660

Letter18122014_Albury_Street_RMS_Handover_Works.docx

18 December 2014

Attention: Michael Oliver

Dear Michael,

Re: Albury Street, Holbrook – Recommended Works Pre RMS Release of Responsibility

With the construction of the Holbrook Hume Highway Bypass, RMS are preparing to release responsibility of Albury Street (previously the Hume Highway) to Greater Hume Shire Council. Prior to this handover, RMS are obligated to undertake required resurfacing and drainage works.

At the request of Council, WMAwater have considered various flood mitigation works as part of the Holbrook FRMS&P with the aim of incorporating these works into the work performed by RMS prior to releasing responsibility of the Road. These works include:

1. Raising of Albury Street Bridge by 0.5 m;
2. Raising of Albury Street Bridge by 1.0 m;
3. Doubling the length of the Albury Street Bridge;
4. Adding additional culverts under Albury Street;
5. Increasing the conveyance of existing culverts; and
6. Reducing the crest level of Albury Street on the Ten Mile Creek floodplain.

These scenarios were modelled in the hydraulic model. It was found that none of these scenarios caused significant reductions to peak flood levels in the 1% AEP event.

In terms of flood mitigation, there is little that can be achieved by modifying Albury Street. However, Albury Street has a number of issues during smaller, more frequent rainfall events that could be alleviated with drainage works. There are a number of proximate properties upstream of Albury Street that have floor levels similar to the crest level of the road. During significant rainfall events water ponds on the upstream side of Albury Street and causes over floor inundation. Passing traffic adds to the flood affectation of this area by sending bow waves through these properties. From a drainage perspective a number of measures should be implemented prior to RMS releasing their responsibility for the road. These works include:

1. It is recommended that milling of Albury Street be undertaking such that the crest level of the road is 0.2 m lower than the current road crest level. This would allow water to pass over Albury Street and reduce the depth of ponding.
2. To aid in the removal of floodwaters, the kerb drainage of Albury Street should be improved to divert water to Ten Mile Creek or to the series of culverts under Albury Street near Bardwell Street.
3. If the kerb drainage system cannot be effectively improved, culverts under the road may be able to be constructed, again to reduce ponding on the upstream side of the road.

WMAwater have prioritised communication of this issue with Council so that RMS can be informed of this issue before the proposed work commences.

Yours Sincerely,
WMAwater

Zac Richards
Project Engineer

Michael Oliver
40 Balfour Road
CULCAIRN NSW 2660

Letter23102014_Albury_Road_Resurfacing.docx

23 October 2014

Attention: Michael Oliver

Dear Michael,

Re: Albury Street, Holbrook – Proposed RMS Resurfacing

A notable finding from the recent Holbrook Community Meeting on the 14th October 2014 is that the RMS are reportedly proposing to resurface Albury Street through the township of Holbrook.

Further details of this proposal are not available to WMAwater, however it is likely that any increase in crest height of Albury Street on the Ten Mile Creek floodplain will increase flood levels and affectation in the region.

WMAwater have modelled a 0.15 m increase to the Albury Street crest height to simulate the proposed resurfacing. To determine the impact of road crest level raising, the 5% AEP flood event has been run for the raised road crest scenario and was compared to the 5% AEP existing conditions scenario. The change in peak flood level between the two scenarios is displayed on the impact map, Figure 1. Flood impacts in excess of 0.1 m (up to 0.23 m) affect numerous properties on the upstream side of Albury Street and there is a significant area of previously flood free land that will become inundated. An increase to the Albury Street crest level will also impact of local flow drainage with the potential to increase flood liability.

It is reported that a number of properties on the upstream side of Albury Street have floor levels close to the existing road crest level. Any increase in crest height will likely lead to more severe and frequent overfloor flooding in this area. This problem would be further compounded by traffic along Albury Street creating bow waves.

It is recommended that milling of Albury Street be undertaking before road resurfacing is performed to ensure that the road crest height is not increased.

WMAwater have prioritised communication of this issue with Council so that RMS can be informed of this issue before the proposed work commences.

WMAwater Pty Ltd (Formerly Webb McKeown and Associates) **ABN 14 600 315 053**

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Yours Sincerely,
WMAwater

Zac Richards
Project Engineer

FIGURE 1
FLOOD IMPACT 5% AEP
RAISE ALBURY STREET 0.15M

Murdoch Place
Spurr Street
Wallace Street
Wallace Street
Vine Street
Wallace Street
Tip Road
Railway Parade
Webb Street
Stirbeck Street
Croft Street
Welton Street
Frampton Street
Thorpe Street
Peel Street
Swift Street
Ross Street
Culcairn Holbrook Road
Bowler Street
Webb Street
Purtell Street
Yarra Street
King Street
Library Lane
Bowler Street
Bowler Street
Wilson Street
Hume Street
Hume Street
King Street
Young Street
Young Street
Gundagai Street
Halford Drive
Hay Street
Murray Street
Albury Street
Byng Street
Nyhan Street
Murray Street
Nolan Street
Bardwell Street
Byng Street
Byng Street
Bardwell Street
Macinnes Street
William Street
me Freeway

N

Reporting Area

Change in Flood Level (m)

- -0.2 - -0.1
- -0.1 - -0.01
- No Impact
- 0.01 - 0.1
- 0.1 - 0.2
- > 0.2
- No Longer Flooded
- Newly Flooded

0 0.25 0.5 1 1.5 km

0 0.5 1 2 3 4 Km

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Appendix E

E. Appendix E: Hydraulic Categorisation – Floodway Definition

Introduction

The Holbrook hydraulic categorisation maps for the 5% and 1% AEP events and the PMF are presented in Figure 10 to Figure 12 respectively. The floodway was determined for the 1% AEP events with the same methodology then applied to the 5% AEP and PMF events.

Hydraulic categorisation is the process by which flood behaviour for a given design event is classified into areas of flood storage, flood fringe and floodway. The NSW Floodplain Development Manual 2005 (Reference 1) provides definitions for all three categories, however these are descriptive definitions and aren't suitable for directly calculating/assessing the categories. The definitions as per Reference 1 are provided below for clarity.

> *Floodway*– areas in the floodplain where significant discharge occurs. Often aligned with natural 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.
>
> *Flood Storage* – those parts of the floodplain important for the temporary storage of floodwaters during a flood. Extent and behaviour of flood storage areas may vary greatly for different events and so a range should be examined.
>
> *Flood Fringe* – remaining areas of land in the floodplain after flood storage and floodway have been defined. (NSW FDM, 2005)

Three further definitions that are suitable for directly calculating/assessing the floodway extent and that are widely used to describe the characteristics of the floodway are described below:

1. The extent which comprises a significant proportion of flow in a flow path (80 to 90% is often used as the portion of flow within the floodway); and
2. The extent which if partially blocked causes impacts in excess of 0.1 m to occur upstream of the partial blockage.
3. The Floodplain Risk Management Guidelines (2007) (Reference 20) advise that the minimum width of a floodway is required to be at least as wide as the main channel as determined from the top of bank.

These three definitions have been used to assist in determining the floodway extent at Holbrook.

Defining the floodway is a critical component of the flood risk management work carried out under the NSW Floodplain risk management program. This relates to the fact that the defined floodway extent will typically not be available for further residential development. As such it is imperative that the floodway definition is appropriate and not conservative.

Approach

Generally speaking there is no definitive method and defining a floodway is often an iterative process. In the context of 2D and 1D/2D models, the output used in the mapping tends to be in a raster format. A raster presents flood modelling outputs for each grid cell in a gridded format for the given study area. The velocity depth (VD) product for each cell can, and has in previous studies, been used to define the floodway. For example the Howells et al (Howells) method utilises the VD product and the velocity (V) when assessing hydraulic categories.

The Howells method differentiates the floodway from other hydraulic categories by selecting a VD criteria that exceed a specific threshold. Some subjectivity still exists within the methodology and different regions often require different V and VD criteria to produce suitable results. Testing varying V and VD criteria, to some degree, is comparable to a calibration exercise where the VD product to be used as a threshold for defining floodway is modified until such a time as a suitable floodway is obtained.

Given that the VD product can provide a base for defining the floodway extent for raster results, the next issue with floodway definition is defining what the VD product should be "calibrated" to, to achieve a reasonable floodway definition. In other words, what VD product will define a floodway extent which will satisfy the three floodway definitions mentioned above.

Methodology

In the 2012 paper by Thomas et al., the two previously mentioned floodway definitions were investigated and a remarkable correlation was observed between the 80% - 90% flow criteria and a 0.1 m afflux.

The proposed approach builds on the criteria proposed by Howells et al. in their 2004 paper using various VD and V parameters to estimate the floodway and then verifies results using encroachment analysis similar to that found in Thomas et al. (2012).

In the encroachment analysis all areas not defined as floodway via the Howells method have been totally excluded from the modelling domain and the subsequent impact on flood levels is examined. In other words the encroachment run undertaken as a check, conservatively assumes that all areas outside the floodway are blocked and should development occur outside the floodway zone defined herein the impact is likely to be less than 0.1 m

A summary of VD and V values investigated (VDV criteria) is listed below:

a. VD > 0.25 m^2/s and V>0.25 m/s; or V>1.0 m/s;
b. VD > 0.20 m^2/s and V>0.20 m/s; or V>1.0 m/s;
c. VD > 0.15 m^2/s and V>0.15 m/s; or V>1.0 m/s;

In addition to the Howells method, other methods are also utilised to define the Holbrook floodway and further add to the robustness of results. The top of the main channel bank has been adopted as the minimum floodway width, satisfying the guidelines discussed above. Also, the percentage of flow conveyed in the floodway is investigated to see if it fits the 80% - 90% criteria, as previously mentioned.

The remainder of the floodplain outside the defined Floodway becomes either Flood Storage or Flood Fringe.

In the past, the 20Y ARI flood extent has been used to define the 1% AEP floodway. As a supplementary test, this approach has also been considered in this investigation by comparing the 20Y ARI flood extent (trimmed to remove depths greater than 0.1 m) to the VD and V criteria listed above.

Results

Appendix Figure E 1 displays the afflux associated with the encroachment analysis testing for Holbrook. Regions displayed in red satisfy VDV criteria (b), mentioned previously. This defined floodway was found on encroachment analysis testing to produce an afflux of approximately 0.1 m in the downstream Holbrook area. For the region displayed in green at Albury Street, VDV criteria (c) was used to produce an afflux of approximately 0.1 m. Using there criteria the 2nd floodway definition is satisfied.

In some areas the afflux produced is below 0.1m. The width of the floodway in these regions could not be decreased without excluding the top of the channel bank and therefore not meeting the guidelines previously outlined. By extending the defined floodway to at least as wide as the main channel (as determined from the top of bank) the 3rd floodway definition is satisfied.

The 20Y ARI flood extent slightly overestimated the floodway extent, producing an afflux lower than 0.1m. Thus, the Howells method extent and the top of bank are more appropriate for hydraulic categorisation in Holbrook.

A number of cross sections that measure flow in the model are also displayed in Appendix Figure E 1. For each cross section, the flow distribution (%) both within and outside of the floodway are displayed. It can be seen that the percentage of flow contained within the defined floodway is within 80% – 90% thus satisfying the 1st floodway definition. This adds further robustness to the floodway results.

Conclusions

Defining a floodway is a non-precise process. The goal is to produce floodway extents that match flow behaviour so that the areas which need to be retained for flow are identified whilst other parts of the flood extent can be developed as appropriate. While the allocation of floodway is likely to be a contentious issue that would merit a precise definition, the fact remains that a one size fits all approach still eludes the practitioner. The method presented defines a reasonable floodway extent using VD and V criteria and then confirms the suitability of the defined floodway extent by using afflux testing. The percentage of flow within the floodway was also investigated to see if the 1st floodway definition is satisfied.

The method used in defining the floodway is based on the Howells method but the VD and V thresholds are adjusted according to an encroachment analysis until the 2nd floodway definition is satisfied. When all areas outside the defined floodway are blocked and the resulting afflux is in the region of 0.1 m it can be argued that any development outside this floodway will result in an afflux less than 0.1 m which satisfies our 2nd floodway definition. Additionally, as previously mentioned, the top of bank for the main channel was set as the minimum width of the floodway extent, thus satisfying the 3rd floodway definition.

FIGURE E1
HYDRAULIC CATEGORISATION INVESTIGATION
IMPACT FROM ENCROACHMENT CRITERIA

King Street
Wilson Street
Young Street
Swift Street
Hume Street
Gundagai Street
Young Street
Hay Street
Albury Street
Byng Street
Murray Street
Nyhan Street
Murray Street
Byng Street
Nolan Street
Bardwell Street
Byng Street
Bardwell Street
Macinnes Street
William Street
Jingellic Road

79%
12%
7%
2%
1%
76%
9%
12%
2%

N

% Flow Distribution
Encroachment Criteria V*D>0.15
Encroachment Criteria V*D>0.20

Impact (m)

No longer Flooded
< -0.1
-0.1 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.15
0.15 - 0.25
> 0.25
Newly Flooded

0 50 100 200 300 400 Meters

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Appendix F

F. Appendix F: Flood Damages Assessment

F.1. Quantification of Damages

The quantification of flood damages is an important part of the floodplain risk management process. Flood damages can be defined as actual or potential where actual damage refers to the damage incurred during known flood events while potential damage is an estimation of the damage that could occur. Calculating potential flood damages gives a potential value of damage per property per design flood event and an overall average annual damages value which is the average cost to property owners per year owing to flood damages. By quantifying flood damage for a range of design events, appropriate cost effective management measures can be analysed in terms of their benefits (reduction in damages) versus the cost of implementation. The cost of damage and the degree of disruption to the community caused by flooding depends upon many factors including;

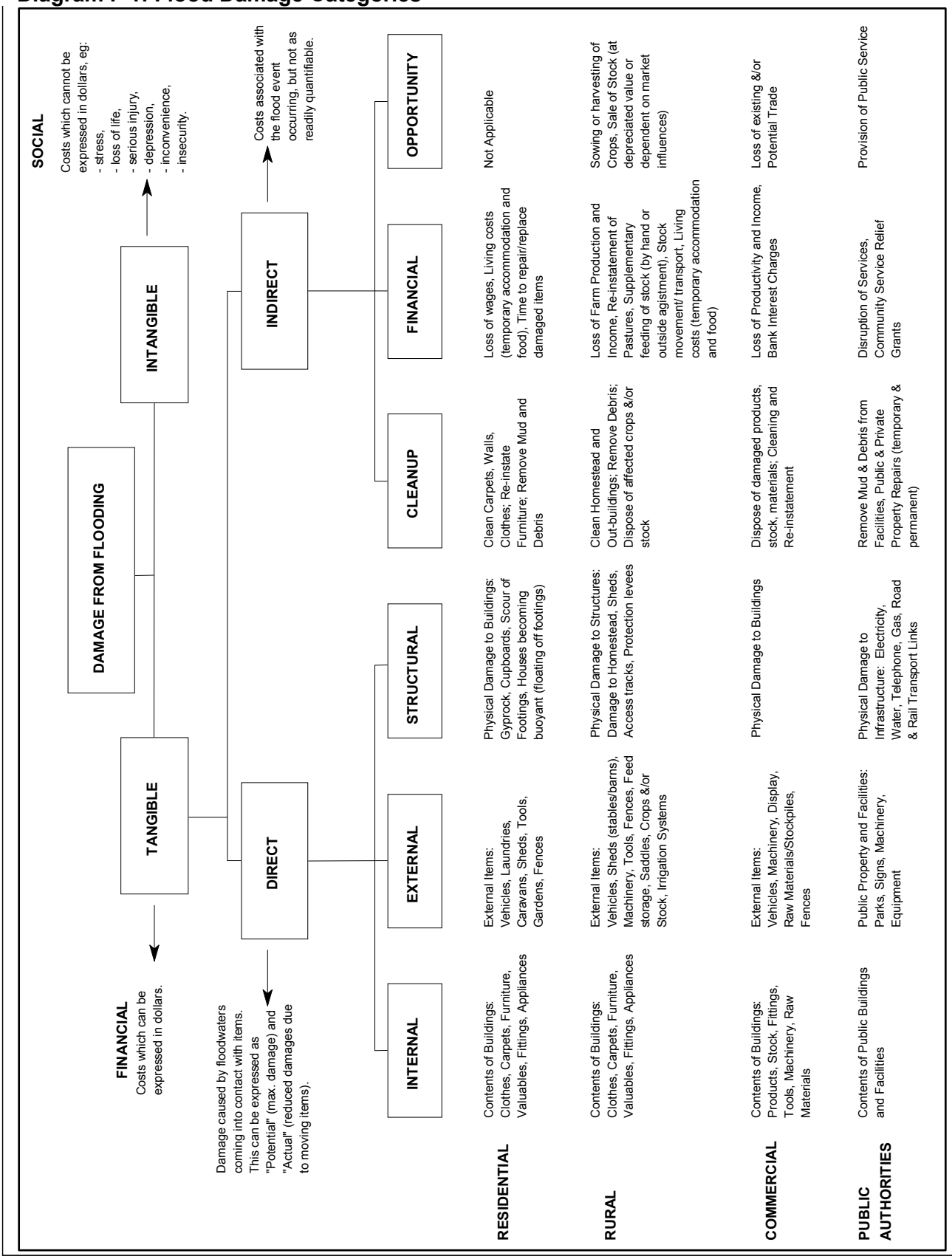
- The magnitude (depth, velocity and duration) of the flood;
- Land use and susceptibility to damages;
- Awareness of the community to flooding;
- Effective warning time;
- The availability of an evacuation plan or damage minimisation program;
- Physical factors such failure of services (sewerage), flood borne debris; and
- The types of asset and infrastructure affected.

The estimation of flood damages tends to focus on the physical impact of damages on the human environment and can be defined as being tangible or intangible. Tangible damages are those for which a monetary value can be easily assigned, while intangible damages are those to which a monetary value cannot easily be attributed. Types of flood damages are shown on Diagram F 1 over.

To undertake the damages assessment floor level data is required. Floor level survey was performed by Hydrographic & Cadastral Survey Pty. Ltd. for 91 residential properties in Holbrook. The floor levels of the remaining properties were estimated. Further details are presented in Section 1.5.3.

The non-residential damages are more complex than residential damages and have different damages associated with flooding. In Holbrook 23 commercial properties were surveyed Damages for commercial properties have been assessed using separate damage curves to residential damages.

Diagram F 1: Flood Damage Categories



F.2. Identifying Flood Affected Properties

The damages assessment does not only look at potential costs due to flooding but also identifies when properties are likely to become flood affected by either flooding on the property or by over floor flooding. Figure 15 of the main report show in which design event buildings are first flooded above floor level.

Diagram F 2 and Diagram F 3 show the number of flood prone residential properties in Holbrook and the number of residential properties liable to above floor flooding. Diagram F 4 and Diagram F 5 show the number of flood prone non-residential properties in Holbrook and the number of non-residential properties liable to above floor flooding.

Diagram F 2: Number of Flood Prone Residential Properties by Street

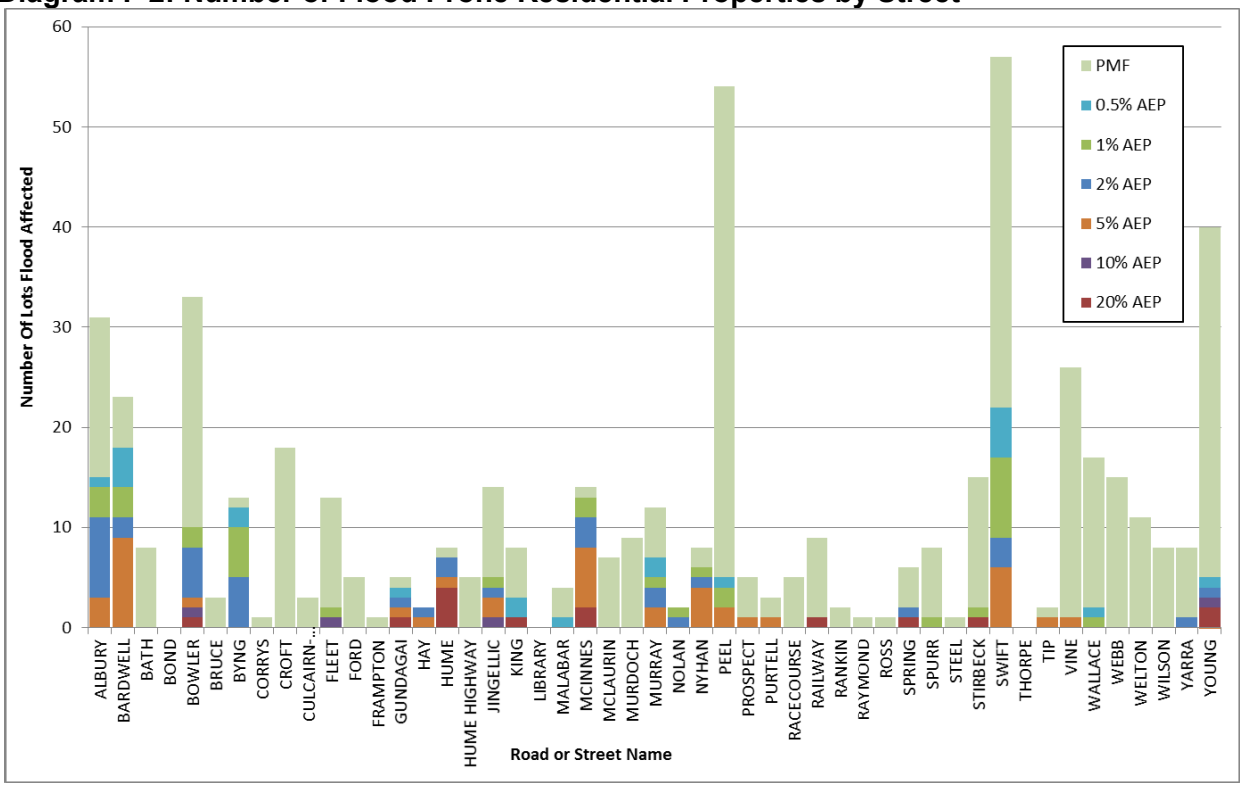


Diagram F 3: Number of Residential Properties Flooded Above Floor Level by Street

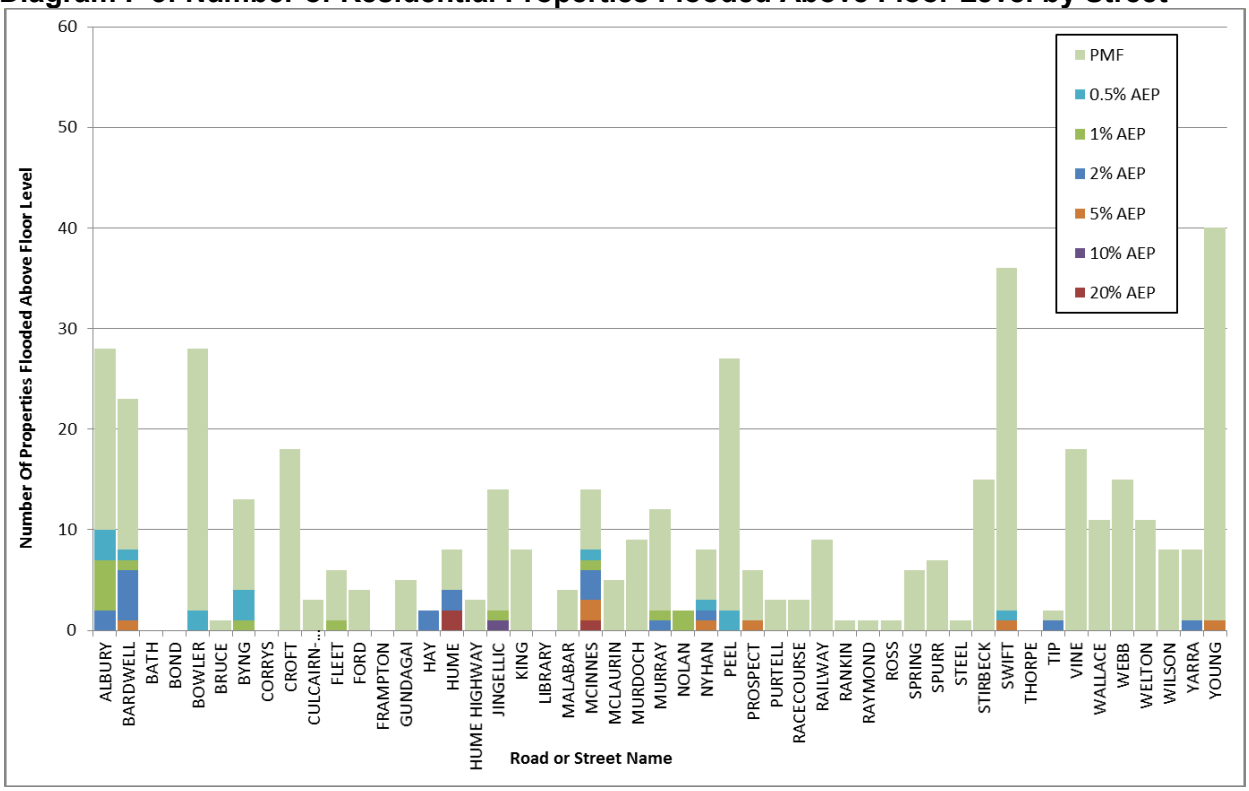


Diagram F 4: Number of Flood Prone Non-Residential Properties by Street

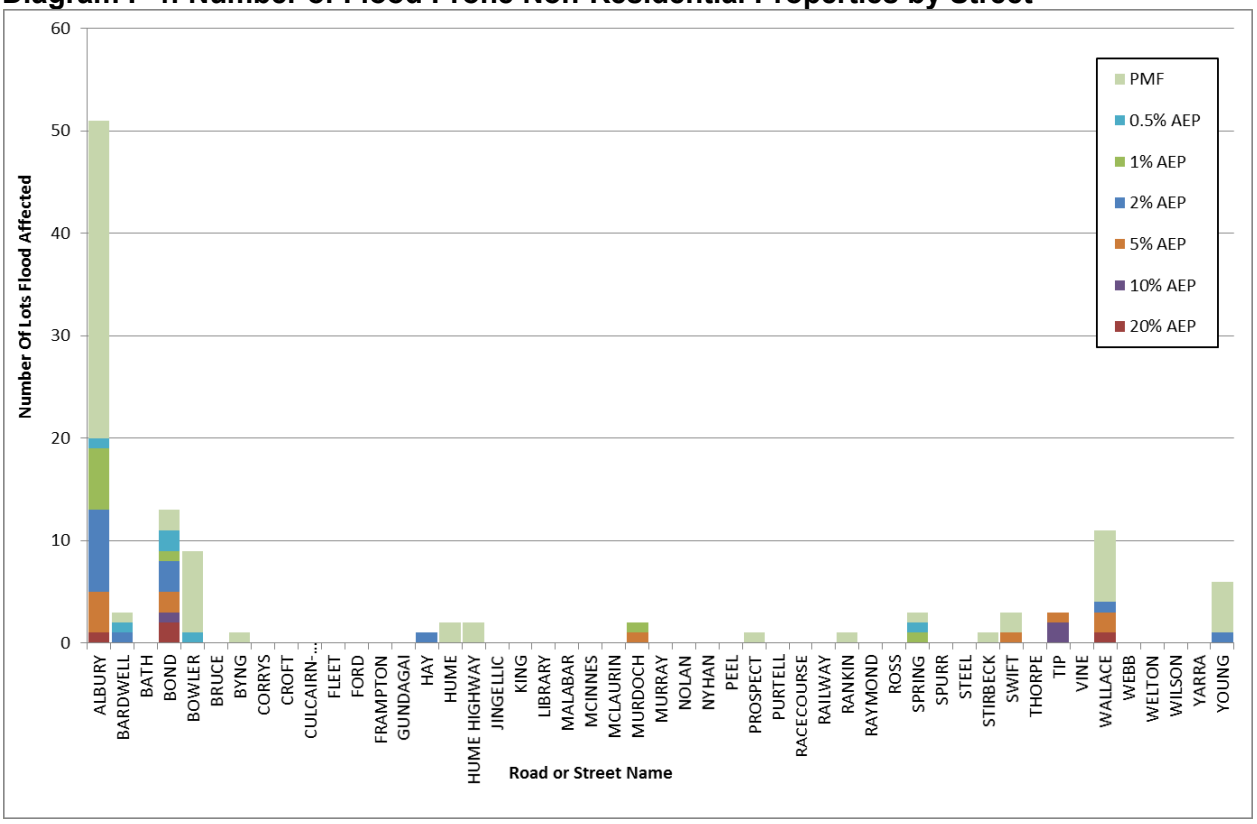
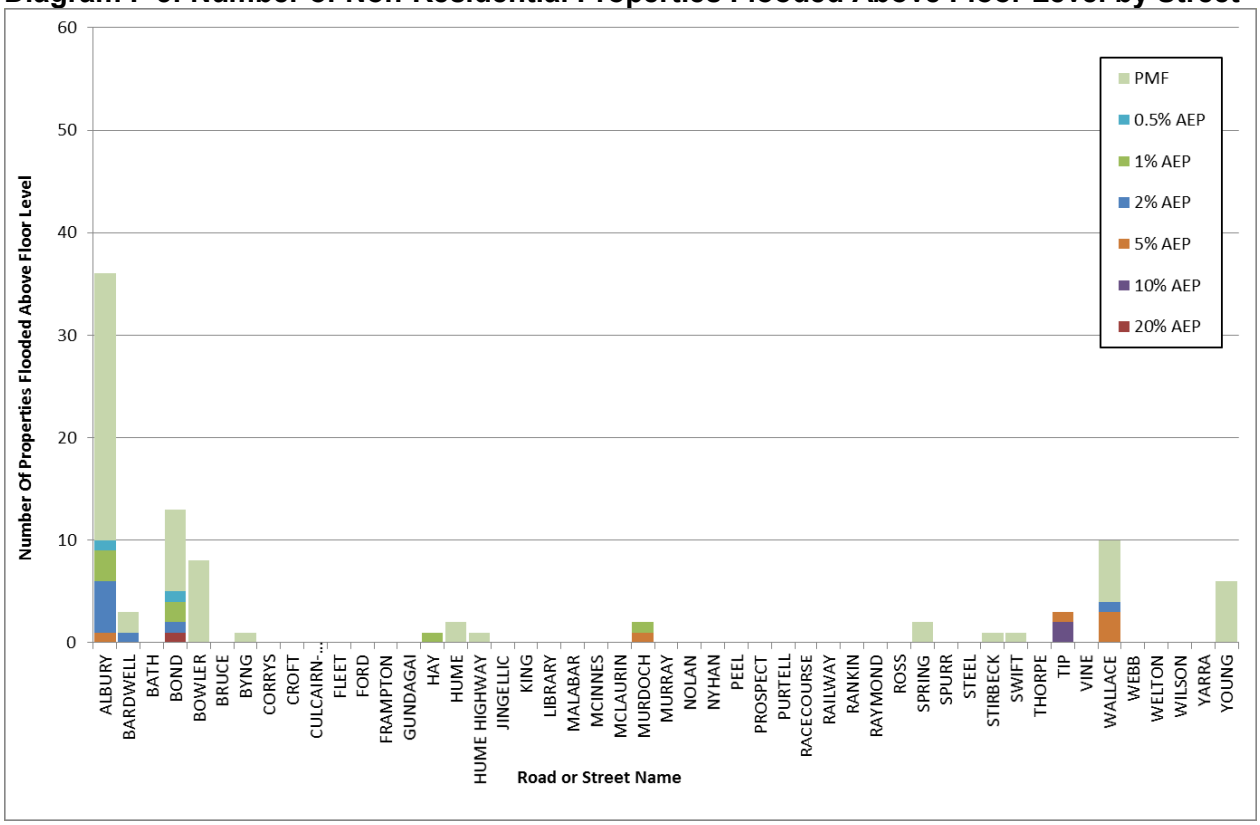


Diagram F 5: Number of Non-Residential Properties Flooded Above Floor Level by Street



F.3. Tangible Flood Damages

Tangible flood damages are comprised of two basic categories; direct and indirect damages (Diagram F 1). Direct damages are caused by floodwaters wetting goods and possessions thereby damaging them and resulting in either costs to replace or repair or in a reduction to their value. Direct damages are further classified as either internal (damage to the contents of a building including carpets, furniture), structural (referring to the structural fabric of a building such as foundations, walls, floors, windows) or external (damage to all items outside the building such as cars, garages). Indirect damages are the additional financial losses caused by the flood for example the cost of temporary accommodation, loss of wages by employees etc.

Given the variability of flooding and property and content values, the total likely damages figure in any given flood event is useful to get a feel for the magnitude of the flood problem, however it is of little value for absolute economic evaluation. However, considering damages estimates is useful when studying the economic effectiveness of proposed mitigation options. Understanding the total damages prevented over the life of the option in relation to current damages, or to an alternative option, can assist in the decision making process.

F.4. Expressing Flood Damages

Average Annual Damages (AAD) is equal to the damage caused by all floods over a period of time divided by the number of years in that period and represents the equivalent average damages that would be experienced by the community on an annual basis. This means that the smaller floods, which occur more frequently, are given a greater weighting than the rare catastrophic floods total potential damage refers to the total damage estimated for a given flood event. Average damage per property is the Total damage estimated for a particular flood event divided by the number of properties flood affected in this event; either by flooding on the yard and/or above floor level of a building.

F.5. Calculating Tangible Flood Damages

The flood damages assessment was undertaken for existing development in accordance with current OEH guidelines (Reference 20) and the Floodplain Development Manual (Reference 1). Potential flood damages were calculated with the use of a height-damage curves which relate the depth of water above the floor with tangible damages. The height-damage curves were established in accordance with OEH guidelines (Reference 20).

For residential damages the values used are based on the recommendations in the guidance with a post late 2001 adjustment factor was applied to increase damage values according to changes in Average Weekly Earnings (AWE) since 2001. Separate curves were established for non-residential damages. The resultant curves are shown in Diagram F 6 and F 7.

Structural damages vary on whether the property is slab/low set or high set. For the purpose of this study, any property with a floor level of 0.5 m or more above ground level was assumed to be high set.

In calculating AAD, it was assumed that there would be no flood damages in events smaller than the 2-year ARI event. The ARI of the PMF has been estimated to be 100,000 years.

As it is usual that commercial and industrial damages are higher than residential damages a multiplier was applied to the total damage per property for each event by adjusting the typical building size value within the curve development calculations. Other factors including the clean-up costs and external damages were adjusted to reflect the differences between commercial and residential properties.

To adjust the residential damage curve to be applicable to non-residential development, the average contents damages for a business was estimated to be $150,000 and the clean-up cost have been estimated at $4,000. This was done to take account the higher costs that businesses would incur compared to residential dwellings when flooded above floor level. The commercial damages curves were also amended to reduce the bench height based on the assumption that many commercial premises would have stock from floor level. External damage was set at $1,250 as per residential properties.

The parameters mentioned above have been kept consistent with the recently completed Lockhart and The Rock FRMS&P (Reference 21).

Diagram F 6: Flood Damages Curves – Residential Property

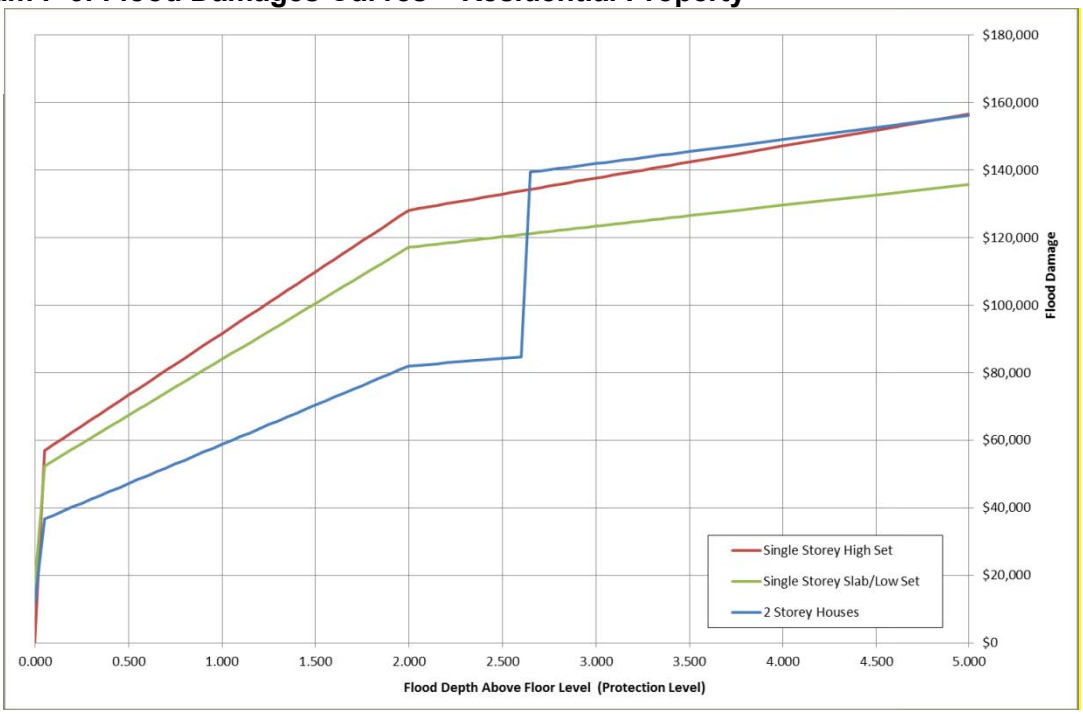
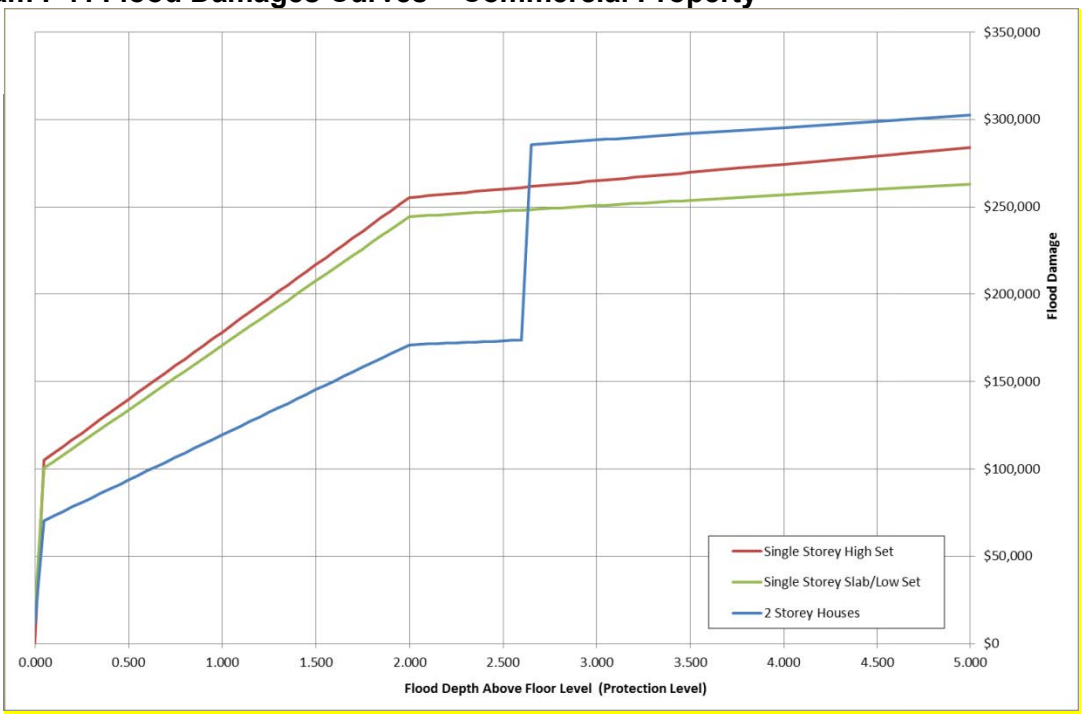


Diagram F 7: Flood Damages Curves – Commercial Property



The OEH guidelines suggest a protection level be applied when calculating damages. This effectively reduces the floor level by the given amount (usually 0.5 m). The level of protection is considered overly conservative and has not been applied in this instance. Applying a level of protection of 0.5 m at Holbrook would increase AAD by 500% and the number of properties flooded above floor level in the 5-year ARI event from 3 to 154. Incorporating this would lead to Council financing flood management measures that provide little benefit.

F.6. Intangible Flood Damages

The intangible damages associated with flooding, by their nature, are inherently more difficult to estimate in monetary terms. In addition to the tangible damages discussed above, additional costs/damages are incurred by residents affected by flooding, such as stress, risk/loss to life, injury, loss of sentimental items etc. It is not possible to put a monetary value on the intangible damages as they are likely to vary dramatically between each flood (from a negligible amount to several hundred times greater than the tangible damages) and depend on a range of factors such as the size of flood, the individuals affected, and community preparedness. However, it is still important that the consideration of intangible damages is included when considering the impacts of flooding on a community.

Post flood damages surveys have linked flooding to stress, ill-health and trauma for the residents. For example the loss of memorabilia, pets, insurance papers and other items without fixed costs and of sentimental value may cause stress and subsequent ill-health. In addition flooding may affect personal relationships and lead to stress in domestic and work situations. In addition to the stress caused during an event (from concern over property damage, risk to life for the individuals or their family, clean up etc.) many residents who have experienced a major flood are fearful of the occurrence of another flood event and the associated damage. The extent of the stress depends on the individual and although the majority of flood victims recover, these effects can lead to a reduction in quality of life for the flood victims.

During any flood event there is the potential for injury as well as loss of life due to causes such as drowning, floating debris or illness from polluted water. Generally, the higher the flood velocities and depths the higher the risk. Holbrook study area generally is classified as low hazard within the built up areas. However, there will always be local high risk (high hazard) areas where flows may be concentrated around buildings or other structures within low hazard areas.

F.7. Benefit/Cost Analyses for Management Options

To assess the full monetary benefits, including taking into account costs of construction and maintenance, Net Present Value (NPV) calculations were used and the B/C ratio established. The B/C approach is used to quantify the economic worth of each option enabling the ranking against other options. A B/C ratio is the benefits expressed in monetary terms, i.e. the reduction in AAD, compared to the actual likely cost of achieving those benefits, i.e. construction and maintenance costs.

The AAD per annum in today's monetary terms was assumed to apply for each year of the NPV damage calculation and was established for each year based on a discount rate of 7% as per the recommendation in the Residential Flood Damages FRM Guidelines (Reference 20). A construction cost was estimated and, using the NPV of the AAD assuming lifetime of 50-years, the B/C ratio was established for each of the options.

Appendix G

G. Appendix G: Draft Flood Management Development Control Plans & Policy

This draft Flood Management Policy has been prepared based on the findings of the Greater Hume Flood Study and Floodplain Risk Management Study. It is recommended that Council use this draft policy in conjunction with the relevant legislation to produce a DCP that achieve Council's aims.

GREATER HUME LGA
DRAFT DEVELOPMENT CONTROL POLICY
FOR FLOOD PRONE AREAS

Flood Management

A flood is an overflow or accumulation of an expanse of water that submerges land. Floods are a natural and inevitable event that communities must learn to live with while minimising risks to public health and safety, property and infrastructure.

This section recognises that there are some flooding risks that require development controls and guidelines in order to reduce or eliminate their impacts.

Objectives

1. To maintain the existing flood regime and flow conveyance capacity.
2. To enable the safe occupation of, and evacuation from, land to which flood management controls apply.
3. To avoid significant adverse impacts upon flood behaviour.
4. To avoid significant adverse effects on the environment that would cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of the river bank/watercourse.
5. To limit uses to those compatible with flow conveyance function and flood hazard.

Controls

General

1. For proposed development, consideration must be given to such matters as the likely depth and nature of possible floodwaters, flood classification of the area (where applicable) and the risk posed to the development by floodwaters.
2. The applicant must demonstrate:
    i) That the development will not increase the flood hazard or risk to other properties and that details have been provided of the structural adequacy of any buildings works associated with the development with regard to the effects of possible floodwaters;
    ii) That the proposed building materials are suitable;
    iii) That the development is sited in the optimum position to avoid floodwaters and allow evacuation; and
    iv) That all electrical services associated with the development are adequately flood proofed.

3. All applications for development must be accompanied by a survey plan including relevant levels to AHD (Australian Height Datum). Consideration must be given to whether structures or filling are likely to affect flood behaviour and whether consultation with other authorities is necessary.
4. Compliance with flood management controls must be balanced by the need to comply with other controls in this DCP.

Controls for land uses on flood prone land identified on the DCP Flood Map

1. A site emergency response flood plan must be prepared in case of a PMF flood.
2. Adequate flood warning systems, signage and exits must be available to allow safe and orderly evacuation without increased reliance upon the State Emergency Service (SES) or other authorised emergency services personnel.
3. Reliable access for pedestrians or vehicles must be provided from the building, commencing at a minimum level equal to the lowest habitable floor level to an area of refuge above the PMF

SCHEDULE 1 – Flood compatible materials

Building component	Flood compatible material
Flooring and sub-floor	• Concrete slab on-ground monolith
	• Suspended reinforced concrete slab
Floor covering	• clay tiles
	• concrete, precast or in situ
	• concrete tiles
	• epoxy, formed-in-place
	• mastic flooring, formed-in-place
	• rubber sheets or tiles with chemicals-set-adhesive
	• silicone floors formed-in-place
	• vinyl sheets or tiles with chemical-set adhesive
	• ceramic tiles, fixed with mortar or chemical-set adhesive
	• asphalt tiles, fixed with water resistant adhesive
Wall structure	• solid brickwork, blockwork, reinforced, concrete or mass concrete
Roofing structure (for situations where the relevant flood level is above the ceiling)	• reinforced concrete construction • galvanised metal construction
Doors	• solid panel with water proof adhesives
	• flush door with marine ply filled with closed cell foam
	• painted metal construction
	• aluminium or galvanised steel frame
Wall and ceiling linings	• fibro-cement board
	• brick, face or glazed
	• clay tile glazed in waterproof mortar
	• concrete
	• concrete block
	• steel with waterproof applications

SCHEDUAL 1: FLOOD compatible materials (cont.)

Wall and ceiling linings (cont.)	• stone, natural solid or veneer, waterproof grout
	• glass blocks
	• glass
	• plastic sheeting or wall with waterproof adhesive
Insulation windows	• foam (closed cell types)
	• aluminium frame with stainless steel rollers or similar corrosion and water resistant material
Nails, bolts, hinges and fittings	• brass, nylon or stainless steel
	• removable pin hinges
	• hot dipped galvanised steel wire nails or similar

Electrical and mechanical equipment
For dwellings constructed on land to which this DCP applies, the electrical and mechanical materials, equipment and installation must conform to the following requirements:

Main power supply
Subject to the approval of the relevant authority the incoming main commercial power service equipment, including all metering equipment, must be located above the relevant flood level. Means must be available to easily disconnect the dwelling from the main power supply.

Wiring
All wiring, power outlets, switches, must be to the maximum extent possible, located above the maximum flood level. All electrical wiring installed below this level must be suitable for continuous underwater immersion and must contain no fibrous components. Each leakage circuit-breaker (core balance relays) must be installed. Only submersible type splices must be used below maximum flood level. All conduits located below the relevant designated flood level must be so installed that they will be self-draining if subjected to flooding.

Equipment
All equipment installed below or partially below the relevant flood level must be capable of disconnection by a single plug and socket assembly.

Reconnection
Should any electrical device and/or part of the wiring be flooded it must be thoroughly cleaned or replaced and checked by an approved electrical contractor before reconnection.

Heating and air conditioning systems
Where viable, heating and air conditioning systems should be installed in areas and spaces of the house above maximum flood level. When this is not feasible, every precaution must be taken to minimise the damage caused by submersion according to the following guidelines:

Fuel
Heating systems using gas or oil as fuel must have a manually operated valve located in the fuel supply line to enable fuel cut-off.

Installation
Heating equipment and fuel storage tanks must be mounted on and securely anchored to a foundation pad of sufficient mass to overcome buoyancy and prevent movement that could damage the fuel supply line. All storage tanks must be vented to an elevation of 600 millimetres above the relevant flood level.

Ducting
All ductwork located below the relevant flood level must be provided with openings for drainage and cleaning. Self-draining may be achieved by constructing the ductwork on a suitable grade. Where ductwork must pass through a water-tight wall or floor below the relevant flood level, a closure assemble operated from above relevant flood level must protect the ductwork

Appendix H

FIGURE H1
SUMMARY OF OPTIONS INVESTIGATED

Option ML
Morgans Ridge Creek Levee

Option A7
Increasing culvert capacity at Wallace Street

Options S4
Elevated Areas Levelled

Options A1, A2 & A3
Raising and widening Albury Street Bridge

Options VL
Bowler Street Levee

Options A6
Remove pedestrian bridge

Option C2
Channels Parallel to Morgans Ridge Creek

Option S5
Increasing conveyance of Morgans Ridge Creek

Option BL
Hay Street Levee

Option S3
Increasing capacity of Bardwell St drain

Option C1
Creating channel parallel to Holbrook Bypass

Options A4 & A5
Lowering Albury Street

Options S1 & S2
Dredging and increasing conveyance of Ten Mile Creek

Options SL
South Levee

Option CL
Macinnes Street Levee

Option CL
Culverts beneath bypass off-ramp

Option CL
Elevated Areas Levelled

Options EL
East Levee

Murdoch Place
Spurr Street
Wallace Street
Vine Street
Bruce S
Tip Road
Railway Parade
Webb Street
Stirbeck Street
Croft Street
Welton Street
Frampton Street
Thorpe Street
Peel Street
Ross Street
Culcairn Holbrook Road
Bowler Street
Yarra Street
Wilson Street
Library Lane
Hume Street
Young Street
Gundagai St
Hay Street
Murray Street
Byng Street
Albury Street
Nyhan Street
Bardwell Street
Macinnes Street
William Street
Jingellic Road

N

Levees
East Levee
South Levee
Drains
Albury Street Bridge
Albury Street
Culverts
Levelled Areas
Morgans Ridge Creek
Ten Mile Creek

0 250 500 1,000
Meters

Green: Options recomended for further investigation
Yellow: Options for discussion
Red: Option not advised

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FIGURE H2
FLOOD IMPACT 1% AEP
OPTION EL
TEN MILE CREEK EAST LEVEE

King Street
Wilson Street
Young Street
Swift Street
Hume Street
Bowler Street
Gundagai Street
Young Street
Hay Street
Halford Drive
Murray Street
Byng Street
Nyhan Street
Murray Street
Bardwell Street
Byng Street
Byng Street
Nolan Street
Bardwell Street
Macinnes Street
William Street
Jingellic Road

N

Holbrook Bypass
Cadastre
Reporting Area
Levee

Change in Flood Level (m)

- < -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.02
- No Impact
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- > 0.3
- No Longer Flooded
- Newly Flooded

This figure displays the change in peak flood level with implementation of this flood mitigation option. The warmer colours (yellow to red) indicate an increase in peak flood level and the cooler colours (shades of blue) indicate a decrease. The black areas are no longer flooded and the purple areas are areas that were previously not flooded but are now flooded due to the option's implementation.

0 250 500 1,000 1,500 Meters

0 0.5 1 2 3 4 Km

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FIGURE H3
FLOOD IMPACT 1% AEP
OPTION SL
TEN MILE CREEK SOUTH LEVEE

King Street
Wilson Street
Young Street
Swift Street
Hume Street
Bowler Street
Gundagai Street
Young Street
Hay Street
Halford Drive
Murray Street
Byng Street
Nyhan Street
Murray Street
Nolan Street
Bardwell Street
Byng Street
Byng Street
Bardwell Street
Macinnes Street
William Street
Jingellic Road

N

Levee
Holbrook Bypass
Reporting Area

Change in Flood Level (m)

- < -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.02
- No Impact
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- > 0.3
- No Longer Flooded
- Newly Flooded

This figure displays the change in peak flood level with implementation of this flood mitigation option. The warmer colours (yellow to red) indicate an increase in peak flood level and the cooler colours (shades of blue) indicate a decrease. The black areas are no longer flooded and the purple areas are areas that were previously not flooded but are now flooded due to the option's implementation.

0 250 500 1,000 1,500
Meters

0 0.5 1 2 3 4
Km

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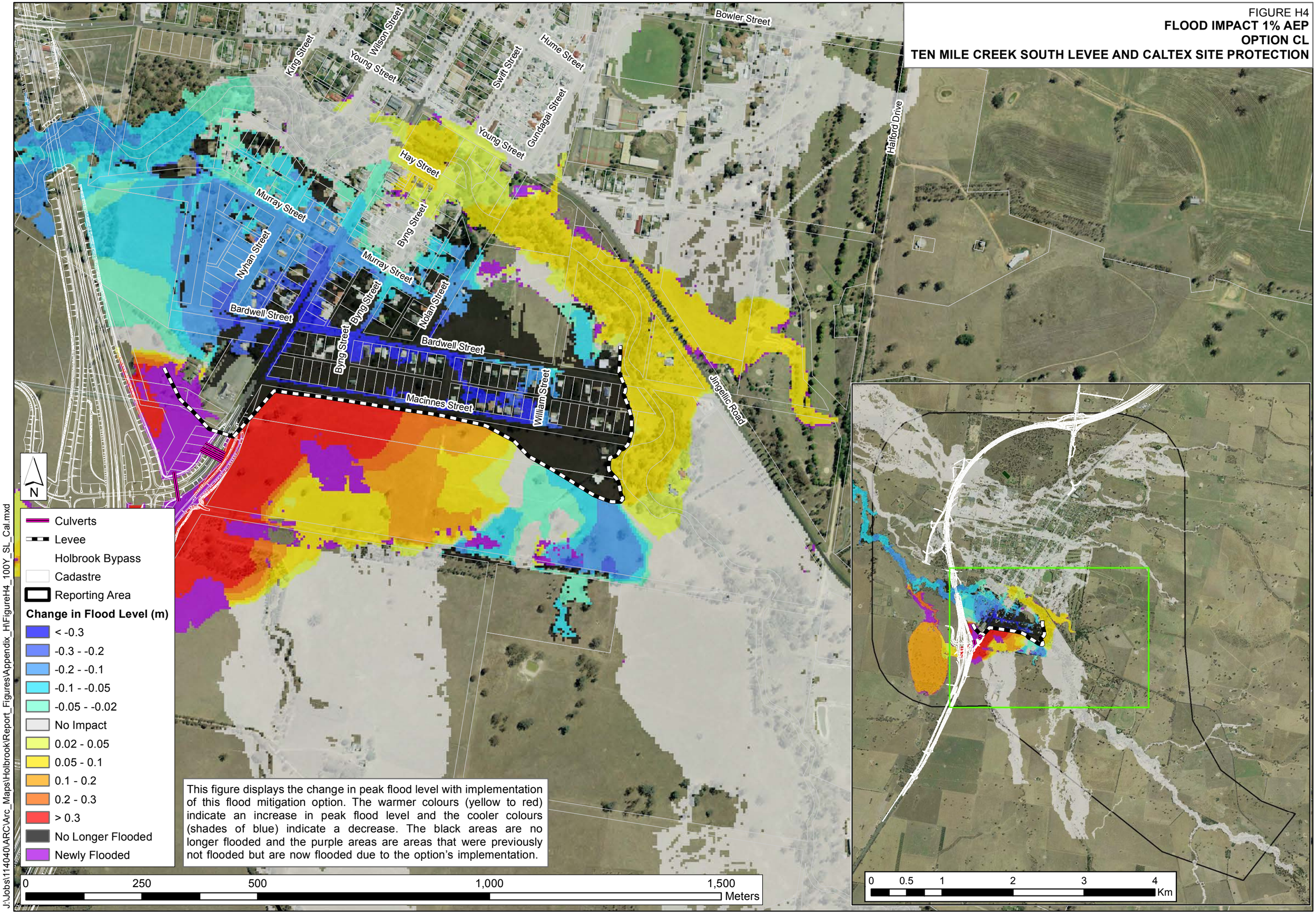
FIGURE H4
FLOOD IMPACT 1% AEP
OPTION CL
TEN MILE CREEK SOUTH LEVEE AND CALTEX SITE PROTECTION



This figure displays the change in peak flood level with implementation of this flood mitigation option. The warmer colours (yellow to red) indicate an increase in peak flood level and the cooler colours (shades of blue) indicate a decrease. The black areas are no longer flooded and the purple areas are areas that were previously not flooded but are now flooded due to the option's implementation.

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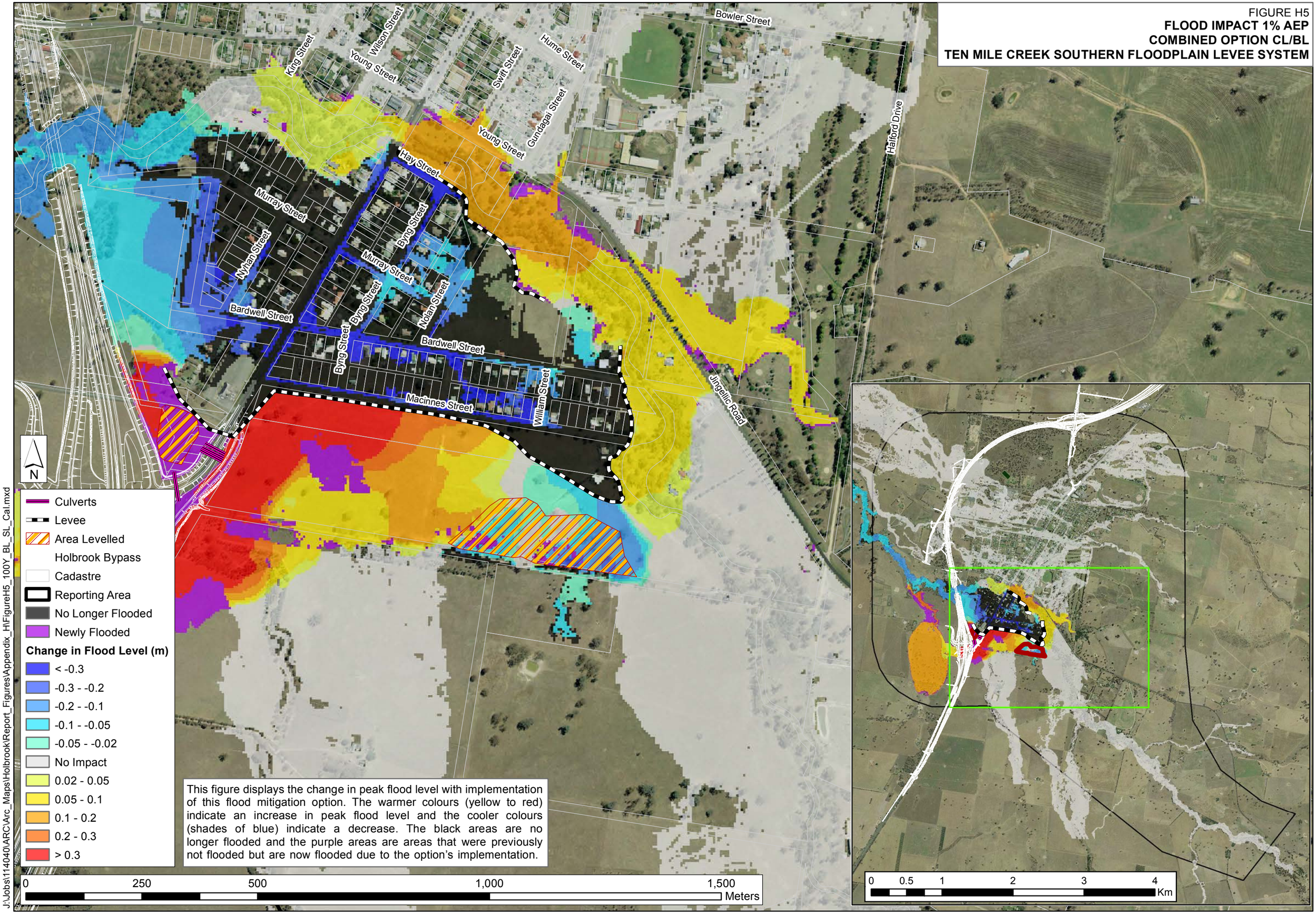
FIGURE H5

FLOOD IMPACT 1% AEP
COMBINED OPTION CL/BL
TEN MILE CREEK SOUTHERN FLOODPLAIN LEVEE SYSTEM



This figure displays the change in peak flood level with implementation of this flood mitigation option. The warmer colours (yellow to red) indicate an increase in peak flood level and the cooler colours (shades of blue) indicate a decrease. The black areas are no longer flooded and the purple areas are areas that were previously not flooded but are now flooded due to the option's implementation.

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FIGURE H6
FLOOD IMPACT 1% AEP
OPTION ML
MORGAN'S RIDGE CREEK EMBANKMENT EXTENSION

Croft Street
Welton Street
Ross Street
Ross Street
Peel Street
Bowler Street
Library Lane
King Street
Bowler Street
Hume Street
Bowler Street
Wilson Street
Hume Street
Albury Street
Hume Street
Young Street
Swift Street
Gundagai Street
Hay Street
Young Street
Jingellic Road

N

Levee
Cadastre
Reporting Area

Change in Flood Level (m)

- < -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.02
- No Impact
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- > 0.3
- No Longer Flooded
- Newly Flooded

This figure displays the change in peak flood level with implementation of this flood mitigation option. The warmer colours (yellow to red) indicate an increase in peak flood level and the cooler colours (shades of blue) indicate a decrease. The black areas are no longer flooded and the purple areas are areas that were previously not flooded but are now flooded due to the option's implementation.

0 50 100 200 300 400 500
Meters

0 0.5 1 2 3 4
Km

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FIGURE H7
FLOOD IMPACT 1% AEP
OPTION C2
MORGAN'S RIDGE CREEK OVERFLOW CHANNEL

Albury Street
Ross Street
Ross Street
Peel Street
Swift Street
Bowler Street
Bowler Street

N

Channels
Cadastre
Reporting Area
Change in Flood Level (m)
< -0.3
-0.3 - -0.2
-0.2 - -0.1
-0.1 - -0.05
-0.05 - -0.02
No Impact
0.02 - 0.05
0.05 - 0.1
0.1 - 0.2
0.2 - 0.3
> 0.3
No Longer Flooded
Newly Flooded

This figure displays the change in peak flood level with implementation of this flood mitigation option. The warmer colours (yellow to red) indicate an increase in peak flood level and the cooler colours (shades of blue) indicate a decrease. The black areas are no longer flooded and the purple areas are areas that were previously not flooded but are now flooded due to the option's implementation.

0 50 100 200 300 400 500 Meters

0 0.5 1 2 3 4 Km

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FIGURE H8
FLOOD IMPACT 1% AEP
OPTION S1
TEN MILE CREEK CHANNEL CLEARING

Ross Street
Railway Parade
Webb Street
Stirbeck Street
Croft Street
Welton Street
Library Lane
Swift Street
Bowler Street
Yarra Street
Purtell Street
King Street
Wilson Street
Hume Street
Culcairn Holbrook Road
Young Street
Gundagai Street
Halford Drive
Hay Street
Murray Street
Albury Street
Byng Street
Nyhan Street
Nolan Street
Bardwell Street
Macinnes Street
William Street

N

Channel Clearing
Cadastre
Reporting Area

Change in Flood Level (m)

- < -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.02
- No Impact
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- > 0.3
- No Longer Flooded
- Newly Flooded

This figure displays the change in peak flood level with implementation of this flood mitigation option. The warmer colours (yellow to red) indicate an increase in peak flood level and the cooler colours (shades of blue) indicate a decrease. The black areas are no longer flooded and the purple areas are areas that were previously not flooded but are now flooded due to the option's implementation.

0 250 500 1,000 Meters

0 0.5 1 2 3 4 Km

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FIGURE H9
FLOOD IMPACT 1% AEP
OPTION S2
TEN MILE CREEK CHANNEL DREDGING

Young Street
Wilson Street
Swift Street
Gundagai Street
Young Street
Hay Street
Murray Street
Byng Street
Nyhan Street
Albury Street
Murray Street
Byng Street
Bardwell Street
Byng Street
Nolan Street
Bardwell Street
Macinnes Street
William Street
Jingellic Road

N

Channel Dredging
Cadastre
Reporting Area

Change in Flood Level (m)

- < -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.02
- No Impact
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- > 0.3
- No Longer Flooded
- Newly Flooded

This figure displays the change in peak flood level with implementation of this flood mitigation option. The warmer colours (yellow to red) indicate an increase in peak flood level and the cooler colours (shades of blue) indicate a decrease. The black areas are no longer flooded and the purple areas are areas that were previously not flooded but are now flooded due to the option's implementation.

0 250 500 1,000 Meters

0 0.5 1 2 3 4 Km

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FIGURE H10
FLOOD IMPACT 1% AEP
OPTION S5
INCREASED MORGAN'S RIDGE CREEK CONVEYANCE CAPACITY

Raymond Street
Wallace Street
Hume Highway
Peel Street
Vine Street
Bruce Street
Spurr Street
Stirbeck Street
Frampton Street
Thorpe Street
Croft Street
Welton Street
Ross Street
Swift Street
Albury Street
Library Lane
Bowler Street
Yarra Street
King Street
Hume Street
Wilson Street
Young Street
Gundagai Street
Hay Street
Jingellic

N

Increased Conveyance
Cadastre
Reporting Area

Change in Flood Level (m)

- < -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.02
- No Impact
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- > 0.3
- No Longer Flooded
- Newly Flooded

This figure displays the change in peak flood level with implementation of this flood mitigation option. The warmer colours (yellow to red) indicate an increase in peak flood level and the cooler colours (shades of blue) indicate a decrease. The black areas are no longer flooded and the purple areas are areas that were previously not flooded but are now flooded due to the option's implementation.

0 125 250 500 750 Meters

0 0.5 1 2 3 4 Km

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FIGURE H11
FLOOD IMPACT 1% AEP
OPTION A7
INCREASED WALLACE STREET CULVERT CAPACITY

Raymond Street
Wallace Street
Hume Highway
Peel Street
Vine Street
Bruce Street
Spurr Street
Wallace Street
Wallace Street
Stirbeck Street
Frampton Street
Thorpe Street
Croft Street
Welton Street
Ross Street
Swift Street
Peel Street
Ross Street
Albury Street
Library Lane
Bowler Street
Yarra Street
King Street
Hume Street
Bowler Street
Bowler Street
Wilson Street
Hume Street
Hume Street
Young Street
Gundagai Street
Young Street
Hay Street
Jingellic

N

Culverts
Cadastre
Reporting Area

Change in Flood Level (m)

- < -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.02
- No Impact
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- > 0.3
- No Longer Flooded
- Newly Flooded

This figure displays the change in peak flood level with implementation of this flood mitigation option. The warmer colours (yellow to red) indicate an increase in peak flood level and the cooler colours (shades of blue) indicate a decrease. The black areas are no longer flooded and the purple areas are areas that were previously not flooded but are now flooded due to the option's implementation.

0 125 250 500 750
Meters

0 0.5 1 2 3 4
Km

J:\Jobs\114040\ARC\Arc_Maps\Holbrook\Report_Figures\Appendix_H\FigureH11_100Y_MR5.mxd

Appendix I

I. Appendix I: Mitigation Option Details

This section outlines indicative costs for the combined Option CL/BL and provides drawings to assist in detail design and investigation works.

Note all costs are indicative and are not guaranteed. Cost will vary with contractor prices, market forces and other factors. Detailed design will enable more accurate costs to be prepared.

The combined mitigation Option CL/BL is recommended for implementation at Holbrook as it provides a significant reduction in flood affected properties and significantly reduces risk by allowing evacuation of residents during Ten Mile Creek flooding (see Section 5.3.1.5).

Combined Option CL/BL

Preliminary concept design information of the combined Option CL/BL southern floodplain levee system is presented in Figure I 1. Features of this option include:

- 1,500 m Option CL embankment length;
- Typical Option CL embankment height of 1.15 m;
- 500 m Option BL embankment length;
- Typical Option BL embankment height of 1.15 m;
- Varying embankment level design level (see Figure I 1) with 0.75 m freeboard assumed;
- Embankment top width of 3 m;
- Embankment slopes at 1:4 ratio for both wet and dry sides;
- Design for the 1% AEP flood level;
- Culverts under the Bypass off-ramp constructed of a slab-linked box culvert system (5 x 3 m x 1.5 m RCBC);

Freeboard Assumption

Freeboard is incorporated into the final design height of the levee and is expressed as the incremental difference in height between the level of the flood the levee is designed to protect against, and the design crest level of the levee. Freeboard varies dependant on uncertainties in flood level estimates, wind and wave actions, storm surge, settlement, climate change etc. and therefore requirements can change significantly from levee to levee. Applying a stand freeboard allowance for a levee is considered simplistic, and in many instances, overly conservative (Reference 22).

Typical levee freeboards range from 0.5 m to 1 m in the region. For example the Main City Levee upgrade at Wagga Wagga will use a freeboard of 0.9 m (Reference 22). A full freeboard assessment is beyond the scope of the current study and will be undertaken as part of the detailed design. Accordingly, an estimated average freeboard allowance of 0.75 m has been assumed for all levees.

For modelling of design events greater than the design height of the levee, the freeboard has been incorporated into the modelling with the assumption that the levee will not fail until the levee is overtopped.

Freeboard Magnitude and Impact on Project Cost Estimates

The assigned levee freeboard will impact on the cost of construction of a levee. An increase in freeboard will not only affect the height of a levee but also the levee volume. In addition to this the levee width is also affected which impacts on easement purchase requirements. The larger the freeboard the greater the cost of the levee.

An estimate of the impact that assigned freeboard has on the cost of the Combined Option CL/BL is presented in Table I 1. Increasing and decreasing the freeboard varies the B/C ratio significantly.

Table I 1: Estimated Cost of Construction for Option CL/BL with Various Freeboards

Scenario	Freeboard (m)	Crest Width (m)	Estimated Cost	B/C Ratio
A	0.5	2	$ 1,100,000	1
B	0.75	3	$ 1,666,000	0.7
C	1	3	$ 1,932,000	0.6

The cost of a levee with a freeboard of 0.5 m and a crest width of 2 m was estimated (see Scenario A, Table I 1). This scenario has a benefit cost ratio of 1. As the freeboard increased (and the levee width), the estimated cost of the project also increased which caused a reduction in the B/C ratio. The selected design Scenario B has a B/C ratio of 0.7, however has an intangible benefit of providing a significant reduction in risk to life.

Easement Requirements

The levee utilises Council owned land such as road easements where possible, however acquisition of easements on private land will also be required. The total area of land that will require acquisition is estimated to be 12,000 m² assuming a 0.75 m freeboard, which allows for the foot print of the levee plus 1.5 meters from the toe of the levee. The estimated price of land in the region is $15 per/m² (source: realestate.com).

Third Party Compensation

Increases in peak flood levels outside of the levee are less than 0.1 m in the vicinity of residential properties and are unlikely to adversely affect homes in this region. An investigation into floor level and flood affectation of properties outside of the levee indicates that increases of less than 0.1 m are expected due to construction of the Option CL/BL levee in both the 1% and 0.5% AEP events. Additionally, homes in this region will not be flooded over floor by either event with construction of this Option.

An estimate of $100,000 has been allowed for third party compensation for the property that is likely to experience an increase in flood levels proximate to their residence.

Combined Option CL/BL Estimated Costing

A summary of the estimated costings for the combined Options CL/BL is contained in Table D 1. All costs are not guaranteed. Costs will vary with contractor's prices, market forces and competitive bids from tenderers. It has been assumed that existing culverts will not be replaced, pre-cast standard size culverts will be used, coffer dams and dewatering will not be required and that works will be undertaken during a dry period.

Table D 1: Combined Option CL/BL Estimated Costing

Option CL/BL Combined

Foundation Preparation	UNIT	QUANTITY	2014 RATE RURAL NSW	COST (with factors)
remove top soil and vegetation	m^3	1,840	5	$ 9,200
compact foundation	m^2	18,969	3	$ 56,907
excavate foundation channel (core - assumed 10% of total)	m^3	1748	8	$ 13,984
lime stabilisation (core - assumed 10% of total)	m^3	1748	15	$ 26,220
Embankment Construction				
Material	m^3	17,480	8	$ 139,840
shaping of batter slopes	m^2	18,969	2.5	$ 47,423
Compaction	m^2	18,969	2.5	$ 47,423
Allowance to dispose of unsuitable material (10%)	m^3	1748	8	$ 13,984
Finishes				
top soil placement	m^2	18,969	8	$ 151,752
seeding	m^2	18,969	7	$ 132,783
Bypass Off-Ramp Culverts				
Wing Walls	-	4	1700	$ 6,800
3 x 3000 mm x 1500 mm RCBC (as part of a slab linked system)	m	90	1884.6	$ 169,614
2 x 3000 mm Concrete slab (as part of a slab linked system)	m	60	958.2	$ 57,492
Albury Street Traffic Control				
Traffic Control	weeks	1	1,450	$ 1,450

Construction Cost	**$874,871**

Easement and Adjoining Property Costs				
Easement Requirements	m^2	12,000	15	$ 180,000
Third party impact compensation	Total #	1		$ 100,000

**All costs are not guaranteed. Costs will vary with contractor's prices, market forces and competitive bids from tenderers.*

NOTES

Assumes that existing culverts will not be replaced.

Assumes pre-cast standard size culverts will be used.

Assumes coffer dams and dewatering will not be required and works will be undertaken during a dry period.

TOTAL PROJECT ESTIMATE	$ 1,666,000	
TOTAL PROJECT ESTIMATE	$ 1,665,795	*a+b+c+d+d*
Construction Cost (a)	$ 874,871	
Contingency (b)	$ 174,974	*20% of a*
Design (c)	$ 104,984	*10% of a+b*
Construction Management (d)	$ 125,981	*10% of a+b*
Project Management (e)	$ 104,984	*10% of a+b*

Appendix J

J. Appendix J: SES Flood Intelligence Draft Updates

Flood Intelligence Cards

Holbrook No. 3 (410187) Gauge

Notes:

- The precise location of the gauge was confirmed with the NSW Office of Water hydrographer. This longitude/latitude reported below reflects this location as extracted from the GIS system rather than the coordinates reported in the NoW site summary
- This will require revision if a levee to partly protect properties in South Holbrook is constructed

HOLBROOK NO. 3 GAUGE - STATION NUMBER: 410187
Thursday, 07 September 2017

Stream:	Ten Mile Creek			**Gauge Zero**:	268.86
Location:	Holbrook No. 3 gauge, 5.7km upstream from Albury Street Bridge (access via Jingellic Road)			**Datum Type**:	AHD
	Long: 147.3456	Lat: -35.7558	GDA94	**Owner**:	NoW
Minor:	**Moderate**:	**Major**:		**Levee Height**:	N/a
Design Flood Levels: *Culcairn, Henty and Holbrook Flood Studies* (WMAwater, 2013)					

Class	Height	Consequences
		Note: This gauge could provide limited warning of flooding downstream at Holbrook. However, Holbrook is considered beyond this gauge's reference area, with significant tributaries joining between this gauge and the town. For this reason, few consequences are described here.
	2.00	5 year ARI flood.
	2.03	5 February 2011 Peak height. No adverse consequences reported.
	2.27	10 year ARI flood.
	2.32	9 December 2010 Peak height. No adverse consequences reported.
	2.50	11 February 2011 Peak height. No adverse consequences reported.
	2.71	19 February 2011 Peak height. Hay Street partly inundated and closed.
	2.81	20 year ARI flood. The Flood Study suggests that flows would begin to spill out to affect Macinnes and Bardwell Streets, though this was not observed in the March 2012 flood, which suggests that the design flood heights extracted from the model for this gauge may be understated.
	2.95	4 March 2012 Peak height. Ten Mile Creek Gardens flooded including Miniature Railway station. Hay Street flooded plus eastern side of Albury Street near Pottery Museum. No houses or businesses flooded over floor. (Note, although some yards were flooded in properties in Macinnes Street and Bardwell Street, this water is believed to have originated from a flowpath to the south and not from break outs from Ten Mile Creek – see Flood Study p.58).
	3.17	50 year ARI flood.
	3.49	100 year ARI flood.
	3.78	200 year ARI flood.
	3.89	15 October 2010 Peak height. Refer to property register in Bewsher Consulting (2012) report for detailed listing of consequences. 25+ houses and 10+ businesses or public sector buildings inundated including two motels. Macinnes Street, Bardwell Street, Murray Street, Hay Street, Nolan Street, Byng Street, Albury Street (Hume Highway), Nyhan Street, Young Street all affected.
	7.21	PMF peak height.

Holbrook Manual Gauge

Note:

- This will require revision if a levee to partly protect properties in South Holbrook is constructed

HOLBROOK (ALBURY STREET BRIDGE) GAUGE - STATION NUMBER: TBC
Thursday, 07 September 2017

Stream:	Ten Mile Creek			**Gauge Zero**:	257.13
Location:	Manual gauge on downstream pylon of Albury Street (Hume Highway) Bridge, Holbrook			**Datum Type**:	AHD
	Long: 147.3124	Lat: -35.7256	GDA94	**Owner**:	GHSC
Minor:	**Moderate**:	**Major**:		**Levee Height**:	N/a
Design Flood Levels: *Culcairn, Henty and Holbrook Flood Studies* (WMAwater, 2013)					

Class	Height	Consequences
	1.5	17 February 2011. Peak height. Miniature railway tracks and walkway under Albury Street Bridge (both sides) inundated – up to the grate behind the Shire Hall.
	2.1	5 February 2011 Peak height. No adverse consequences reported.
	2.3	11 February 2011 Peak height. No adverse consequences reported.
	2.37	5 year ARI flood. Largely contained within channel. Ten Mile Creek Gardens partly flooded. No houses flooded over floor.
	2.64	10 year ARI flood. Ten Mile Creek Gardens flooded. Water reaches Hay Street. No houses flooded over floor.
	2.65	4 March 2012 Peak height. Ten Mile Creek Gardens flooded including Miniature Railway station. Hay Street flooded plus eastern side of Albury Street near Pottery Museum. No houses or businesses flooded over floor. (Note, although some yards were flooded in properties in Macinnes Street and Bardwell Street, this water is believed to have originated from a flowpath to the south and not from break outs from Ten Mile Creek – see Flood Study p.58).
	3.07	20 year ARI flood. Floodwater surcharges creek upstream of Macinnes Street, inundating some properties in Macinnes, Bardwell, Albury and Nyhan Streets. Hay Street flooded. About 5-10 houses flooded over floor.
	3.22	50 year ARI flood. Extensive though relatively shallow flooding in South Holbrook, including much of Albury Street. Some houses along Jingellic Road between Pound Lane and Young Street surrounded by floodwater. About 20 houses flooded over floor.
	3.34	100 year ARI flood. Extensive though low hydraulic hazard flooding in South Holbrook, with ever shrinking 'islands'. Road to caravan park flooded. Electricity substation on Jingellic Road begins to be flooded. About 30 houses flooded over floor.
	3.43	200 year ARI flood. Extensive flooding in South Holbrook with about half of caravan park under water. Electricity substation on Jingellic Road half flooded. About 40 houses and 10 non-residential buildings flooded over floor.
	3.5	15 October 2010 Peak height. Refer to property register in Bewsher Consulting (2012) report for detailed listing of consequences. 25+ houses and 10+ businesses or public sector buildings flooded over floor including two motels. Macinnes Street, Bardwell Street, Murray Street, Hay Street, Nolan Street, Byng Street, Albury Street (Hume Highway), Nyhan Street, Young Street all affected.
	5.45	PMF peak height. Extensive areas of high hydraulic hazard flooding including all of South Holbrook plus several properties east of Holbrook (in Jingellic Road, Malabar Road, Pound Lane, Young Street) and much of 'central' Holbrook (south of about Hume Street, west of about Welton Street and Bond Street). About 350 houses and 60 non-residential buildings flooded over floor.