Greater Hume Shire Council

Jindera Floodplain Risk Management Study and Plan

Final Report

March 2017

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Cover photograph: View south down Urana Street from Dight Street.

Preface

The NSW State Government's Flood Policy aims to provide solutions to existing flooding problems and ensure that new development within flood prone areas is compatible with the prevailing flood risk and does not create additional flooding problems in other areas.

Under the Policy, the management of flood liable land is the responsibility of local government. State government subsidises flood mitigation works to alleviate existing problems and provide specialist technical advice to assist councils in the discharge of their floodplain management responsibilities.

The Policy provides for technical and financial support by the State Government during the following four sequential stages:

- Flood Study – determines the nature and extent of the flooding problem
- Floodplain Risk Management Study – evaluates management options for the floodplain in respect of both existing and proposed development
- Floodplain Risk Management Plan – the formal plan adopted by Council for the management of the floodplain
- Plan Implementation – implementation of the various measures proposed by the Plan

This report documents the above second and third stages in the process (Floodplain Risk Management Study and Floodplain Risk Management Plan). It follows the completion of the Jindera Flood Study in 2015.

The Greater Hume Shire Council has prepared this document with financial assistance from the NSW and Commonwealth Governments through the Natural Disaster Resilience Program. This document does not necessarily represent the opinions of the NSW or Commonwealth Governments.

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Executive Summary

The Jindera Floodplain Risk Management Study and Plan was commissioned by the Greater Hume Shire Council.

The study has been carried out in accordance with the NSW Government's Floodplain Development Manual (2005). The primary objective of the NSW Government's Flood Prone Land Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce the risk of private and public losses resulting from floods.

The management of flood-prone land within urban areas remains the responsibility of local government. The NSW State Government provides funding to assist local councils with the development of floodplain risk management plans and their implementation.

The development of a Floodplain Risk Management Plan for Jindera follows the completion of the Jindera Flood Study in 2015. The Flood Study report (GHD, 2015) documents flooding conditions at Jindera based on an assessment of historical records and computer modelling using detailed terrain data for the floodplain.

Community Consultation

Community consultation activities are documented in Section 2 of this report.

The project has been overseen by Council's Floodplain Risk Management Committee. The Committee met regularly during the project to review progress and provide direction for future activities. Three local community representatives from Jindera served on this Committee.

The preceding 2015 Flood Study report was placed on public exhibition in draft form to provide an opportunity for submissions from the public. The draft form of this report was also placed on public exhibition during February 2017 prior to the report being finalised.

Flooding Conditions and Impacts at Jindera

Flooding conditions and impacts are summarised in Section 3 of this report. Details are documented within the Jindera Flood Study report (GHD, 2015).

The hydraulic modelling carried out as part of the 2015 Jindera Flood Study has enabled detailed flood mapping to be prepared for a range of floods. Events modelled consist of the 5, 10, 20, 50, 100 and 200 year ARI floods and an extreme event. Mapping prepared for each event defines the height, depth and extent of flooding.

As is typical for many small country towns within the NSW Riverina, during large flood events there is widespread shallow sheet flow inundation both within and outside the Jindera township. Depths of flooding outside the incised waterways and drains are generally less than 0.3 metre up to and including the 100 year ARI event. Consequently flooding conditions outside the incised waterway corridors are generally characteristic of Low Hazard conditions.

Due to the unconfined nature of flooding, flood heights typically only increase marginally with increasing severity (e.g. the 100 year ARI flood level is typically in the vicinity of 0.2 metre above the 5 year ARI flood level). Urana Street (Urana Road), Adams Street (Dights Forest Road) and numerous local roads and streets are subject to inundation. Roadway flooding at most of these locations will be to depths of less than 0.3 metre in a 100 year ARI event and for durations not expected to exceed 3 hours.

Flood damage analysis undertaken identified that there are an estimated 23 properties subject to above floor flooding in a 100 year ARI event. Nineteen of these properties are residential, with the remaining four industrial. The estimated average annual flood damage is $305,000 per annum. The average depth of above floor flooding is 0.07 metre. The maximum depth of above floor flooding is 0.26 metre.

Floodplain Management Options – Planning and Development Controls

Property modification mitigation measures are described in Section 5 of this report.

Integral to all floodplain risk management plans is the development of flood based planning and development controls. These are important for ensuring that future development occurs in a manner which is compatible with the flood risk. This includes excluding development from high risk areas and imposing appropriate controls (e.g. minimum floor levels) in low risk areas. The planning and development controls are linked to flood mapping prepared as part of the 2015 Flood Study and refined as part of this Floodplain Risk Management Study.

The proposed flood based planning and development controls for Jindera are documented in Appendix A. Figures A1, A2 and A3 in Appendix A are the maps which define the respective areas which are subject to these controls.

Most of the areas subject to inundation within Jindera have been designated as Flood Fringe (refer to Figure A2) and Low Hazard (refer to Figure A3). Development controls for these areas are primarily in the form of minimum floor level requirements.

In contrast, development controls for areas designated as Floodway and High Hazard are very restrictive with development largely excluded. Areas designated as Floodway and High Hazard are however generally limited to the waterway corridors as shown on Figures A2 and A3.

Floodplain Management Options – Flood Response Improvement Measures

Flood response improvement mitigation measures are described in Section 6 of this report.

Also integral to all floodplain risk management plans is an assessment of flood response modification measures. This can include improvements to the flood warning system and activities to increase the level of flood awareness in the local community.

Flood warning system improvements are not proposed given the small catchment size at Jindera which results in flooding very soon after the flood inducing rainfall. Telemetered rainfall and stream height gauges are more effective on larger catchments with sufficient time for residents to respond to gauge data.

The effectiveness of community awareness related measures is also limited by the short response times available. The following low cost measures are proposed:

- Provide flood information on Council's web site
- Inclusion of expanded flooding information on Section 149 certificates issued by Council
- Construction of a flood marker (e.g. in Pioneer Park)

The SES will prepare a Local Flood Plan for the Shire once all of the Floodplain Risk Management Plans have been completed. The Local Flood Plan will detail operations relating to flood preparedness, flood response measures and flood recovery measures.

It is important that flood data be collected in future large floods at Jindera. This includes recording peak flood heights and any instances of above floor flooding. The data will be most useful for assisting with any future updates of the Floodplain Risk Management Plan.

Floodplain Management Options – Flood Modification Measures

Flood modification mitigation measures are described in Section 7 of this report.

Modification measures were assessed at the four identified hotspots (areas containing clusters of buildings subject to 100 year ARI above floor flooding). Options assessed included retardation, enlarging existing waterways / drains, enlarged culverts and levees.

The preferred measures based on a consideration of their capital costs, resulting reduced future flood damage benefits, any adverse impacts on flooding, any adverse environmental effects and any adverse social effects are as follows:

- Hotspot 1 (Jindera Street). The proposed works involve multiple measures to address the targeted problems and offset any adverse impacts due to the mitigation measures. The works proposed consists of:
    - Extension of the Watson Street Drain works to Pioneer Drive, including works to prevent any eastern overflows down Pioneer Drive
    - Construction of a diversion channel from Pioneer Drive to the downstream side of Bungowannah Road
    - Vegetation management works within the Four Mile Creek corridor between Goulburn Street and Jindera Street
- Hotspot 2 (Four Mile Creek). The proposed works are the vegetation management works between Goulburn Street and Jindera Street consistent with the outcome for Hotspot 1. Further measures including a levee option and augmentation of the Urana Street culvert were found to be either ineffective or not practical
- Hotspot 3 (Molkentin Road). The proposed works involve enlarging the Pioneer Drive Drain from the west side of Urana Street through to the downstream side of Molkentin Road (refer to Figures 11 and 12). The preferred route option should be identified during detailed design. Any future development on the north side of Molkentin Road needs to make provision for the discharge of the 100 year ARI flow
- Hotpot 4 (Industrial Estate). The proposed works to address existing flooding risks involve extending the existing drain on the west side of the estate further south and then eastwards across the proposed extended boundary of the industrial estate (refer to Figure 13)

Floodplain Risk Management Plan

The Floodplain Risk Management Plan for Jindera is presented in Section 8 of this report. It summarises the adopted floodplain management measures. The adopted measure priorities, indicative capital costs and responsible implementation organisations are listed in Table 5.

Recommended floodplain management measures consist of:

- Implementation of the various land use planning and development control actions (e.g. incorporation of flood related controls into Council's LEP and DCP)
- Include expanded flooding information on Section 149 certificates issued by Council
- Preparation of a Local Flood Plan for the Greater Hume Shire
- Implementation of the other community awareness measures
- Implementation of the proposed flood modification measures

Council will be able to apply for funding assistance to implement the recommended floodplain management measures which do not form part of their core activities. Potential funding sources include the NSW State Government and Australian Commonwealth Government funding programmes for the implementation of flood risk mitigation measures and the SES for flood response improvement measures.

1. Introduction

Jindera is located on the south bank of the Four Mile Creek, approximately 15 km north of Albury. The town is affected by flooding from Four Mile Creek and a number of its tributary waterways aligned through the town.

The catchment draining to Jindera extends approximately 6 km south and 6 km west of the town as shown on Figure 1. Four Mile Creek, which is referred to as Bowna Creek downstream of Jindera, ultimately discharges into the Hume Dam, 13 km east of Jindera.

Greater Hume Shire Council commissioned GHD to prepare the Floodplain Risk Management Plan (FRMP) for Jindera in accordance with the NSW Government's Floodplain Development Manual (NSW Government, 2005).

The Jindera Flood Study was completed in 2015 (GHD, 2015). Flooding conditions outside the local waterways are characteristic of widespread shallow sheet inundation which affects parts of Jindera. A relatively small number of properties in these flood affected areas are at risk of above floor flooding.

The Jindera Floodplain Risk Management Study and Plan (FRMS&P) has been undertaken to provide the Greater Hume Shire Council and other stakeholders with a FRMP which clearly defines flooding risks at Jindera and identifies preferred options for implementation to reduce future flood risks and associated damages.

The Jindera FRMP will assist the Council and other government agencies to make appropriate decisions in relation to future land use planning.

The preparation of the FRMP has been overseen by Council's Jindera Floodplain Risk Management Committee. FRMPs are also currently being prepared for the other towns within the Greater Hume Shire (Henty, Holbrook, Culcairn and Walla Walla).

The FRMS is documented in Sections 4 to 7 of this report. The FRMS evaluates management options for the study area floodplain giving consideration to hydraulic, environmental, social and economic issues.

The FRMP is documented in Section 8 of this report. The FRMP outlines the adopted strategies to manage flood risk and flood management issues.

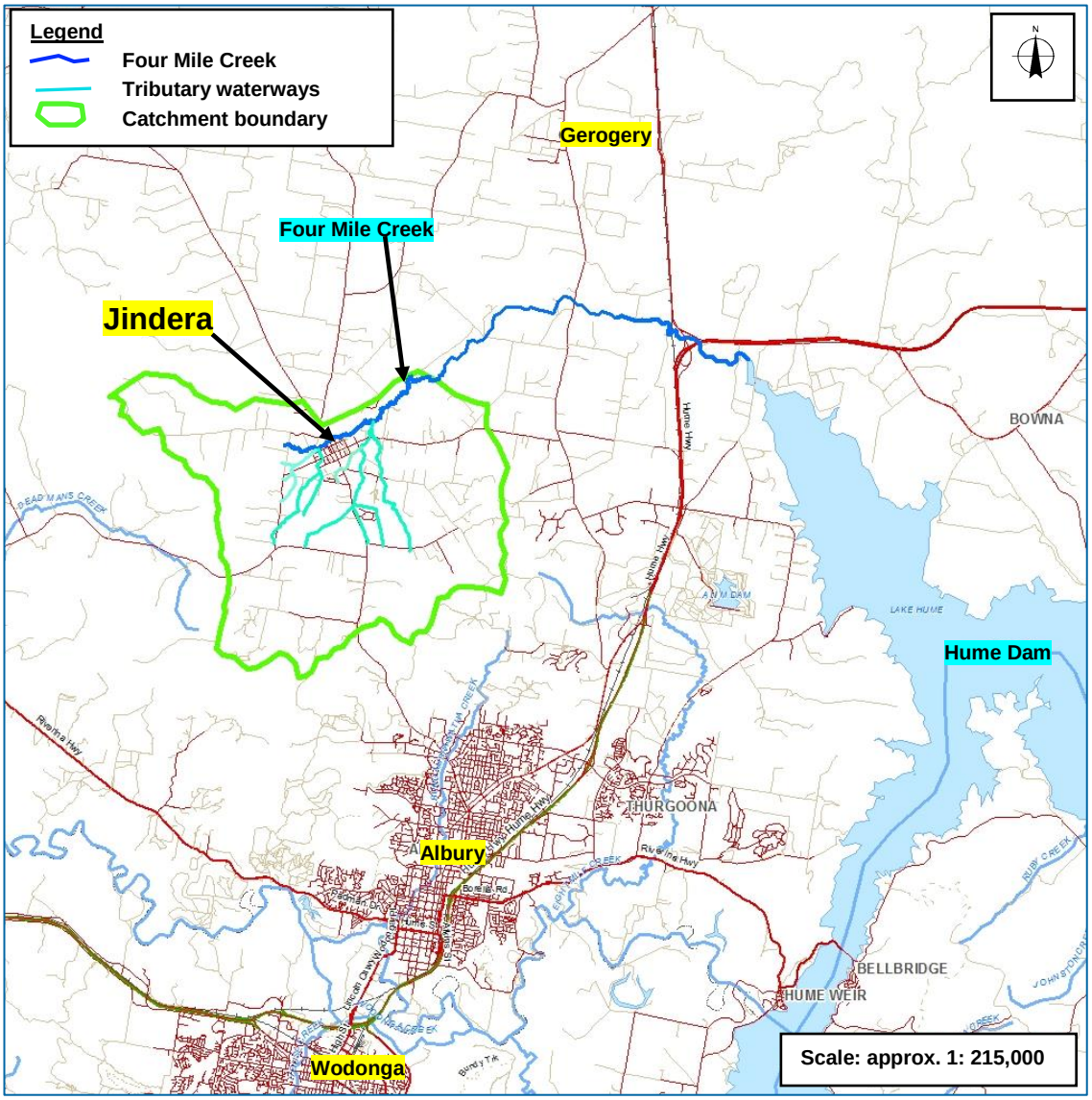


Figure 1 Jindera Locality Plan

2. Community Consultation

2.1 Overview

Community consultation forms an integral component of the floodplain management plan process. It is important that communities embrace ownership of the floodplain risk management plans and this requires their engagement during the preparation of the plans.

The objectives of the community consultation activities undertaken were as follows:

- To obtain any data held by the general public, local community groups or government agencies of relevance to the project
- To provide information to the community concerning the project including opportunities for the community to provide input into the development of the plan
- To seek feedback from the community on floodplain management issues and what views are held by the community in relation to flood mitigation options
- To seek feedback on the draft report documents produced including the Flood Study report and the FRMS&P report

2.2 Floodplain Risk Management Committee

Council established a Floodplain Risk Management Committee (FRMC) in 2014 to oversee the Jindera project. The ten person Committee consists of the following members:

- Three local community members
- Two Council staff representatives
- One Councillor
- Single representatives from OEH, SES, Department of Planning and Infrastructure and the BOM

Committee meetings took place in August 2014, October 2014, March 2015, July 2015, October 2015, February 2016 and October 2016.

2.3 Stage 1, 2 and 3 Community Consultation Activities

The following community consultation activities were undertaken during the Flood Study phase:

- Four meetings with the Floodplain Risk Management Committee (hereafter referred to as the Committee)
- Community Newsletter 1 distributed to all Jindera residents and businesses in September 2014
- Questionnaire distributed to all Jindera residents and businesses in September 2014.
- Community Forum meeting held at Jindera in September 2014 during the draft Flood Study report public exhibition period
- Public exhibition of the draft Flood Study report in August / September 2015

Further details are provided in the Flood Study report (GHD, 2015)

2.4 Stage 4

Council adopted the draft Jindera FRMS&P report at the December 2016 Council monthly meeting for the purpose of placing the draft report on public exhibition.

The draft Jindera FRMS&P report was subsequently placed on public exhibition during February 2017.

No public submissions on the draft Jindera FRMS&P report were received by Council. The Jindera FRMS&P report was subsequently finalised in March 2017.

3. Flood Study Summary

3.1 Background

Four Mile Creek is the main waterway aligned across the Jindera study area. The catchment area on the downstream urban fringe of Jindera is 50 km^2.

There are a series of tributary waterways aligned through Jindera which discharge into Four Mile Creek. These tributary waterways include the Watson Street Drain, Pioneer Drive Drain, Molkentin Middle and Molkentin East waterways as shown on Figure 2.

The tributary waterways at Jindera generally have limited incised channel capacity. In large floods, there is consequently substantial out of channel flooding. Due to the terrain, the out of channel flooding tends to be widespread and shallow. Four Mile Creek itself has a broad out of channel flood expanse on its south bank.

Notable recent flooding has occurred at Jindera in 2005, 2008, 2010, 2011 and 2012. Very few cases of above floor flooding have been confirmed in these recent floods. Due to the small catchment areas, the lag time between rainfall and peak flooding at Jindera is short, typically one hour or thereabouts. Flooding duration is similarly short, lasting for at most a few hours.

Flooding is typically associated with unpredictable short duration high intensity thunderstorm events. This combined with the very limited time elapsing between the rainfall and peak flooding limits the ability of those at risk to take actions to limit property contents damage.

3.2 Details

The Jindera Flood Study (GHD, 2015) identifies flooding conditions for a range of varying size flood events. The flood study consisted of the following stages:

- LiDAR terrain survey of Jindera township and the surrounds. Outputs from the survey included a 1m grid digital elevation model (DEM) of the ground surface
- Estimation of design flows for the local waterways including Four Mile Creek and its tributary watercourses, the Watson Street Drain and the Pioneer Drive Drain. Design flows were estimated using the XP-RAFTS hydrologic model
- Estimation of design flood levels, velocities and extents for a range of flood events using the TUFLOW two dimensional hydraulic model
- Preparation of hydraulic category and provisional flood hazard mapping
- Reporting including the flood map outputs

3.3 Key Outcomes

A streamflow gauge has been operating on Bowna Creek on the downstream side of the Gerogery Road since 1973. The data records for this station were however of limited use for the Jindera study given the substantially higher catchment area at the gauging station (280 km^2) in comparison to the catchment area at Jindera (approximately 50 km^2) and apparent discrepancies in the gauging station stage-discharge rating table.

Design flows for the study area waterways at Jindera are therefore largely based on the results of hydrologic modelling using the XP-RAFTS model. The adopted design flow is in good agreement with the flow predicted by the Regional Flood Frequency Estimation (RFFE) method. Given the relatively small contributing catchment areas at Jindera and the absence of reliable streamflow and rainfall data for calibration purposes, the adopted design flows are subject to fairly high levels of uncertainty as discussed in the Flood Study report (GHD, 2015).

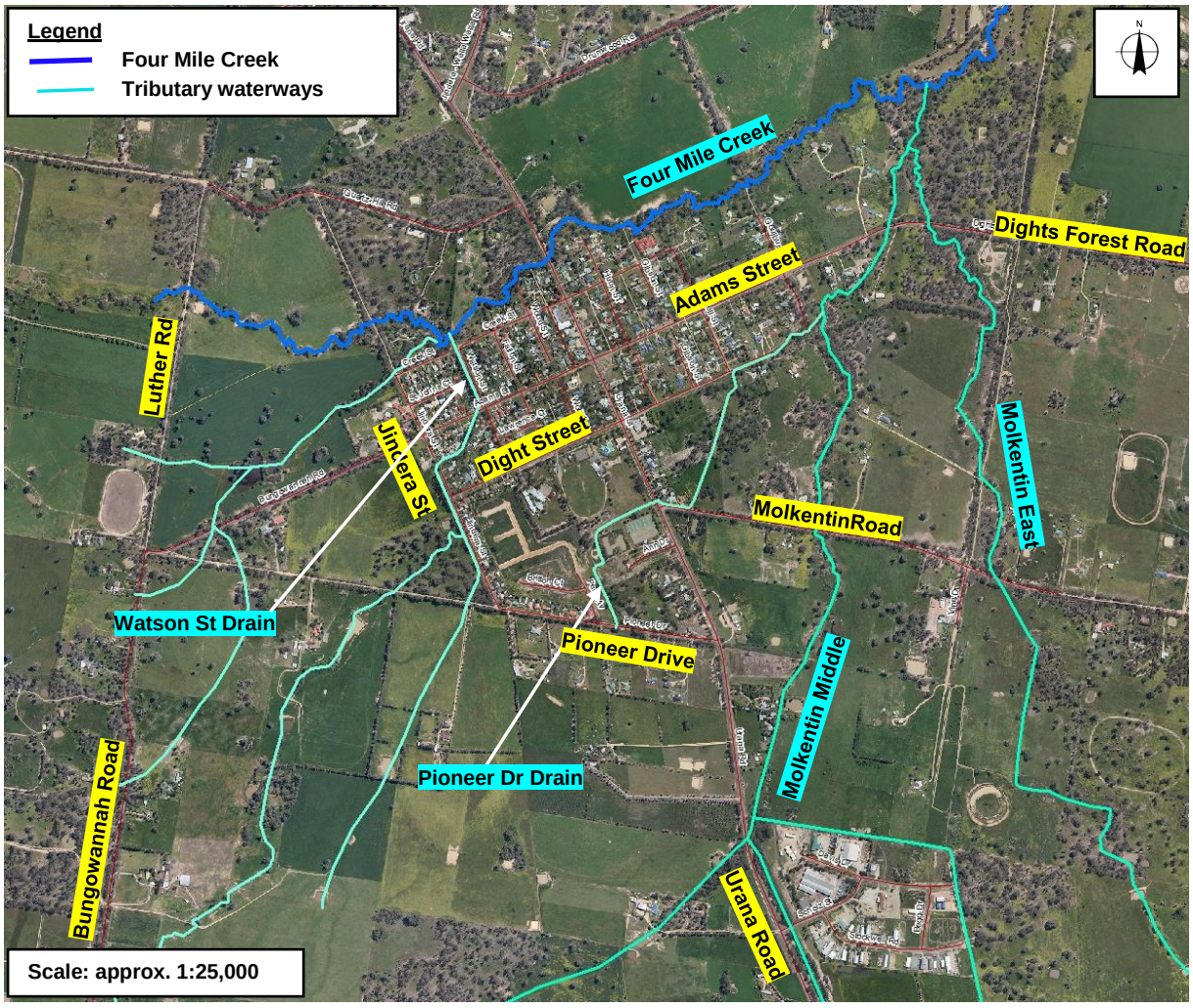


Figure 2 Study Area Waterways

Hydraulic modelling of the waterways within the Jindera study area was carried out using the full two dimensional TUFLOW hydraulic model. The study area floodplain was defined using a 4 metres grid with key features better defined using breaklines and cross sections. The terrain source used was the 2013 LiDAR aerial survey data obtained specifically for the study.

The TUFLOW model was calibrated using the limited recorded flood height data. The model was calibrated to achieve the optimum level of agreement between the available recorded flood heights and the modelled flood heights.

The following flood mapping is included in the 2015 Jindera Flood Study report:

- Design Flood Extent and Depth maps for the 5, 10, 20, 50, 100 and 200 year ARI events and an extreme flood event
- Provisional Flood Hazard mapping for the 20 and 100 year ARI design events
- Hydraulic Category mapping for the 20 and 100 year ARI design events

Notable features of flooding conditions derived from the modelling results are:

- In large flood events, there is widespread shallow sheet flow inundation both within and outside the Jindera township
- Depths of flooding outside the incised waterways and drains are generally less than 0.3 metre up to and including the 100 year ARI event. Consequently flooding conditions outside the incised waterway corridors are characteristic of Low Hazard based on hydraulic considerations only
- Due to the unconfined nature of flooding, flood heights typically only increase marginally with increasing severity (e.g. the 100 year ARI flood level is typically in the vicinity of 0.2 metre above the 5 year ARI flood level)
- Urana Street (Urana Road), Adams Street (Dights Forest Road) and numerous local roads and streets are subject to inundation. Most of these locations will be to depths of less than 0.3 metre in a 100 year ARI event and for durations not expected to exceed 3 hours

3.4 Hydraulic Category

The Floodplain Development Manual (NSW Government, 2005) defines the following three hydraulic categories:

- **Floodway** – are those parts of the floodplain where a significant volume of water flows during floods and if blocked or partially blocked, would result in a significant redistribution of flow
- **Flood Storage** – are those parts of the floodplain that are important for the temporary storage of floodwater during the passage of a flood
- **Flood Fringe** – are the remaining parts of the floodplain after floodway and flood storage areas have been defined

Planning and development controls vary for the above hydraulic categories. Development constraints are more restrictive for floodway areas.

The mapped hydraulic categories for a 100 year ARI event at Jindera are defined on Figure A2 in Appendix A.

3.5 Provisional Flood Hazard

The Floodplain Development Manual (NSW Government, 2005) defines the following two hazard categories:

- **High Hazard** – are those parts of the floodplain where there is possible danger to personal safety, evacuation by trucks would be difficult, able-bodied adults would have difficulty in wading to safety and there is potential for significant structural damage to buildings
- **Low Hazard** – are those parts of the floodplain where trucks could evacuate people and their possessions and able-bodied adults would have little difficulty in wading to safety

Provisional hazard mapping is included in the 2015 Jindera Flood Study report. The provisional hazard mapping reflects hydraulic conditions only (i.e. depth and velocity of floodwaters).

The provisional hazard mapping has been reviewed as part of this current FRMS. This is discussed in Section 5.4. Additional considerations in updating the provisional hydraulic category mapping include the rate of rise of floodwaters, duration of flooding, available flood warning time, level of flood awareness/readiness in the community and flood access and evacuation considerations. The amended flood hazard mapping is defined on Figure A3 in Appendix A.

3.6 Flooding Impacts

3.6.1 Overview

A floor level elevation survey of approximately 100 buildings located within the 100 year ARI flood affected area at Jindera was completed. The subsequent comparison with the modelled design flood levels enabled those buildings (i.e. houses or principle building on each property) which are subject to above floor flooding to be identified.

Flood damages were estimated using the outcomes from the comparison of building floor levels with flood levels and flood damage data.

The main outcomes were:

- Damage for all floods up to the 10 year ARI event are almost entirely limited to external flood damage. There is only one property subject to above floor flooding in a 10 year ARI event
- Total flood damage in a 100 year ARI event is $2.9 million
- The average annual flood damage is $305,000 per annum
- There are 23 properties subject to above floor flooding in a 100 year ARI event. Nineteen of these properties are residential, with the remaining four industrial
- The average height of 100 year ARI above floor flooding is 0.07 metres
- The maximum height of 100 year ARI above floor flooding is 0.26 metre

Four hotspots were identified based on clusters of buildings subject to 100 year ARI above floor flooding. The four hotspots are:

- Hotspot 1 - Jindera Street Area
- Hotspot 2 - Four Mile Creek Area (Watson Street to Mitchell Street)
- Hotspot 3 - Molkentin Road Area
- Hotspot 4 - Industrial Estate Area

The damage estimates in Table 1 are a little lower than the damages reported in the Flood Study report (GHD, 2015) following a review of the estimation process (AAD given as $350,000/annum in the Flood Study report).

Table 1 Flood Damage Analysis

Flood ARI (years)	Number of properties potentially subject to above floor flooding		Estimated flood damage ($)
	Residential	Commercial / Industrial	
5	0	0	410,000
10	1	0	690,000
20	6	2	1,380,000
50	14	3	2,390,000
100	19	4	2,910,000
200	30	7	4,030,000
PMF	359 combined		24,800,000
			AAD – $305,000/annum

Note:

1. Above floor flooding numbers relates to the main building on each property.

3.6.2 Hotspot 1 – Jindera Street Area

A small number of residential properties in the Jindera Street / Dight Street intersection area are at risk of 100 year ARI above floor flooding.

Rural catchment runoff drains to the west side of Jindera Street. An informal levee and drain located within the Jindera Street road reserve directs flows to the Watson Street Drain entrance on the north side of 111 Jindera Street. The existing levee is overtopped in large flood events as occurred opposite Dight Street in the February 2011 flood.

Downstream of Jindera Street, the Watson Street drain was upgraded in 2013 / 2014. Under the upgraded drain conditions, there are no properties subject to 100 year ARI above floor flooding along the upgraded drain route. This includes a house close to the Adams Street / Watson Street intersection which is known to have flooded to above floor height in 2011 and 2005.

3.6.3 Hotspot 2 – Four Mile Creek Area

There are a small number of residential properties subject to 100 year ARI above floor flooding in the area bounded by Four Mile Creek, Watson Street, Adams Street and Mitchell Street.

Flooding in this area is associated with overbank flooding from Four Mile Creek, notably down Creek Street. Properties in Creek Street, Wood Street, Urana Street, Huon Street and Gibson Street are affected.

Flooding conditions within the affected area are relatively shallow in a 100 year ARI event (i.e. less than 0.3 metre deep).

The depth of 100 year ARI above floor flooding of those properties at risk does not exceed 0.12 metres. The threshold varies from 20 to 100 years ARI.

3.6.4 Hotspot 3 – Molkentin Road Area

There are a small number of residential properties in the vicinity of Molkentin Road which are subject to 100 year ARI above floor flooding due to overland flow from the large Molkentin Middle catchment to the south and to a lesser extent the Pioneer Drive Drain to the west.

The Pioneer Drive Drain is currently positioned within the Molkentin Road reserve east of the Urana Street intersection. Shallow sheet flooding occurs once the drain capacity is exceeded.

The depth of 100 year ARI above floor flooding for the affected properties does not exceed 0.17 metres. The threshold varies from 20 to 50 years ARI.

3.6.5 Hotspot 4 – Industrial Estate Area

There are a small number of properties within the Jindera industrial estate which are subject to 100 year ARI above floor flooding as a result of overland flow from the Molkentin Middle catchment to the south.

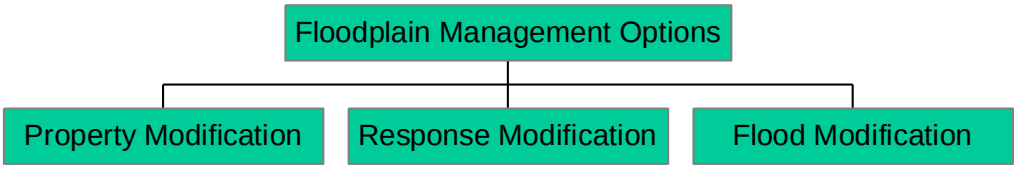
Flooding conditions at the industrial estate are again characteristics of shallow sheet flow inundation with depths generally less than 0.3 metre.

The maximum depth of 100 year ARI above floor flooding is 0.08 metres for the small number of properties at risk.

4. Floodplain Management Options – Preliminary Assessment

4.1 Overview of Types of Measures

As described in the Floodplain Management Manual (NSW Government, 2005), flood mitigation options can be categorised into the following three approaches:



Property modification measures are designed to avoid any future development within areas which have a high flood risk and to also reduce the damage inflicted on existing development by means of flood proofing. Property modification measures include:

- Land use planning including zonings and development control
- Voluntary house raising
- Flood proofing of buildings
- Improvements to flood access
- Voluntary purchase of high hazard properties

Response modification measures are designed to modify the response of the population at risk prior to, during and after a flood. Response modification measures include:

- Flood education and awareness
- Flood warning system establishment / improvements
- Flood response improvements
- Flood recovery improvements

Flood modification measures are designed to modify the behaviour of the flood itself by reducing flood levels or velocities or by excluding floodwaters from the area under threat. Flood modification measures include:

- Retarding basins
- Levees
- Waterway channel and structure modifications
- Bypass floodways
- Vegetation management and maintenance of creeks and culverts

The remainder of Section 4 documents the preliminary assessment of all of the above options in relation to their suitability for reducing flood impacts at Jindera.

The subsequent detailed assessments for Property Modification measures is provided in Section 5, Response Modification measures in Section 6 and Flood Modification measures in Section 7.

4.2 Property Modification Measures – Preliminary Assessment

4.2.1 Land Use Planning and Development Controls

Land use planning and development controls are an essential element in managing flood risk and the most effective way of ensuring future flood risk is managed appropriately. Planning not to develop land within high flood hazard or land that has the potential to impact flood behaviours in other areas represents an essential component of a floodplain risk management plan.

Land use planning controls can be achieved through zoning in the Local Environment Plan (LEP) and associated flood related controls incorporated into a Development Control Plan (DCP). Planning documents can be used as a floodplain management tool by controlling where development can occur and by specifying certain construction conditions (e.g. minimum floor levels).

The current land use zonings at Jindera are shown on Figure 3.

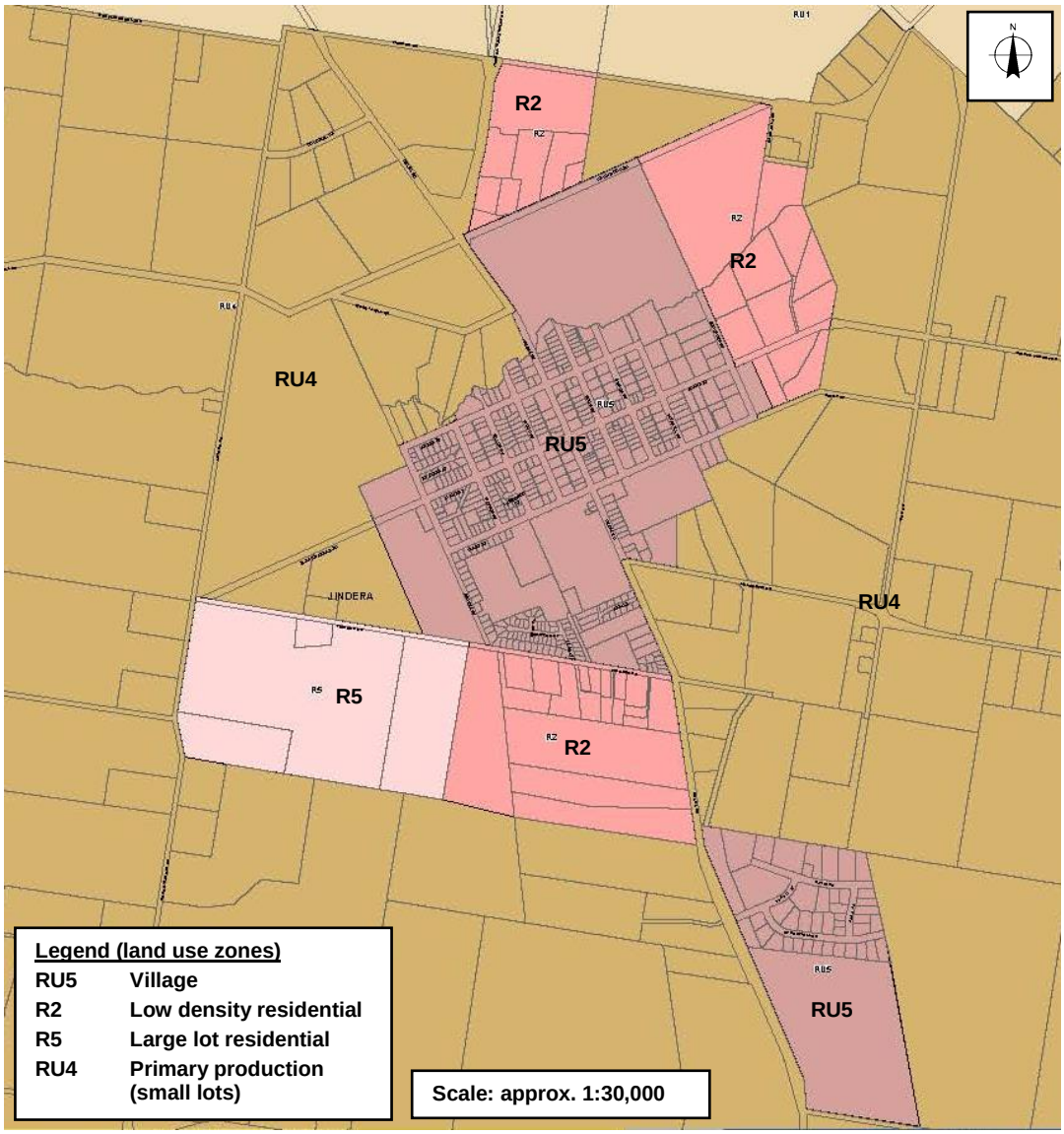


Figure 3 LEP Land Use Zonings at Jindera

The 2013 Greater Hume Local Environmental Plan (LEP) is the principal planning document which controls future development within the Shire. Clause 6.1A of the LEP relates to Flood Planning. The clause defines the Flood Planning Level as equal to the 100 year ARI flood level plus 0.5 metre freeboard.

The 2012 Greater Hume Development Control Plan (DCP) has a stand alone chapter on flood liable land (Section 8). This currently lists broad objectives and decision guidelines. Council is intending to expand this chapter of the DCP with the flood development controls forming part of the FRMPs for the towns within the shire, including Jindera, Culcairn, Holbrook, Henty and Walla Walla.

Integral to the development of flood based land use planning and development controls for Jindera is the:

- Basis for the Flood Planning Levels (FPLs)
- Delineation of the Flood Planning Area (FPA)

The above is documented in Section 5.

4.2.2 Voluntary House Raising

House raising is generally only implemented in low hazard and / or flood fringe areas. House raising involves lifting building floor levels above the flood planning level to avert damage to buildings, improve personal safety and reduce stress and post-flood trauma. House raising is often a potential solution to flooding in rural areas for isolated houses, particularly for dwellings constructed from fibro or timber positioned on stumps.

Consideration must be given to the type of house being raised, the level of hazard to be avoided, the duration of the flooding expected and social issues (access to balance of funding). An important consideration is that house raising will not mitigate flood risk entirely, since the effects of a flood of greater magnitude than the design flood (potentially up to the PMF) could still result in risk and damage.

All of the 23 buildings identified as subject to 100 year ARI above floor flooding are of concrete slab construction. Raising of the floor levels of any of these buildings is not therefore feasible.

No further detailed investigations associated with voluntary house raising are therefore recommended.

4.2.3 Voluntary House Purchase

Voluntary purchase involves the acquisition of flood affected properties, in particular those inundated in high hazard areas, and the subsequent demolition of the building on the acquired property.

Voluntary purchase is not considered suited to any of the flood affected properties at Jindera, given the low risks and infrequent nature of above floor flooding. The houses at most risk are located within Low Hazard areas.

No further detailed investigations associated with voluntary house purchase are therefore recommended.

4.2.4 Flood Proofing of Buildings

Flood proofing includes the following scenarios:

- Achieved through the design and construction of the building (i.e. water resistant building materials, electrics positioned above the water line)
- Temporary flood barriers. This involves the use of plastic sheeting and sand bags at points of water entry (e.g. doorways, vents)

The available flood warning time for occupants of individual properties to set up barriers at points of entry will typically be very short. This significantly reduces the practicality of flood proofing measures.

The potential use of flood proofing measures can be conveyed to the community as part of community awareness improvement measures.

No further detailed investigations into flood proofing options are recommended.

4.3 Flood Response Modification Measures

Response modification measures are reactions to flooding that reduce potential social, economic and environmental damages from flooding. While response modifications will reduce the risk to life and may reduce direct damages, they will not prevent flooding. Therefore, they will not address all the social impacts and damages associated with flooding.

4.3.1 Flood Warning Systems

Depending on warning time and resources available, flood warning systems and evacuation plans can be used to protect buildings, evacuate people, provide relief to evacuees and provide recovery assistance to those in flood affected areas.

The effectiveness of flood warning systems to aid flood response measures largely depends on the amount of flood warning time available. Flooding following rainfall on large catchments may not peak for days or even weeks following the flood inducing rainfall. Under these circumstances, flood warning systems are most effective.

The catchment area draining to Jindera is relatively small. Multiple waterways drain from the west and south into the town. The individual catchment areas of these waterways does not exceed 20 km^2. Peak flooding will generally be expected to occur within 15 minutes to 2 hours of the flood inducing rainfall. This leaves very little time for residents and flood response agencies to take actions to mitigate the resultant flooding impacts.

The nearest rainfall pluvio station to Jindera is located at the Bowna Creek streamflow gauging station located downstream of the Gerogery Road. Although this pluvio station is located only 9 km north east of Jindera, it is not necessarily a good indicator of rainfall within the catchment above Jindera.

Given the very limited amount of flood warning time available at Jindera, the expense associated with establishing and maintaining a pluvio station at the town or within the upstream catchment is not warranted. Similarly establishing and maintaining a stream height gauge upstream of or at Jindera will not provide worthwhile flood warning system benefits.

No further detailed investigations into flood warning system improvements are therefore recommended.

4.3.2 Public Awareness Measures

Increasing public awareness of flooding risks assists in increasing the readiness of the community to prepare for and respond to floods. Measures to increase flood awareness within the local community could include:

- The dissemination of a Flood Information Pack that could be sent to all owners, business operators and residents of potential flood impacted properties
- The dissemination of flood certificates on a regular basis which would inform each property owner of the flood situation at their particular property, flood data and advice
- Signage or flood markers in flood prone areas giving notification of potential and historic flood levels, for example within Pioneer Park adjacent to Four Mile Creek
- Providing a readily accessible flood information portal on Council's web site

Further investigations into potential ways to improve the level of flood awareness within the local community will form part of the detailed assessment of mitigation options (refer to Section 6).

4.4 Flood Modification Options

Flooding impacts at Jindera are from different sources of flooding as described in Section 3.5. The terrain and flooding conditions at the respective hotspots are similar, with short duration, shallow sheet flooding present. Flooding conditions are more characteristic of overland flow flooding rather than riverine flooding. This includes the overbank flooding from Four Mile Creek.

Flood modification measures are those that alter the flood conditions to reduce the flood hazard or change the flood behaviour. Flood modification is generally the only measures that will minimise both the social impacts and the risk to property and life.

An overview of flood modification options in relation to their potential application at Jindera is provided as follows.

4.4.1 Retarding Basins

Retarding or detention basins are temporary water storages which release flows at a controlled reduced rate in order to attenuate downstream peak flows and therefore flood levels.

Retarding basins tend to be used on smaller catchments such as local stormwater catchments as the amount of storage involved is able to be practically achieved. In larger catchments, the storage volume required to achieve worthwhile peak flow reductions becomes too large. An existing retarding basin is located on the Pioneer Drive Drain adjacent to the town tennis courts. The catchment area at the retarding basin is less than 1 km^2.

The flat terrain at Jindera also means that any storage volume needs to be formed through excavation. This is problematic given the need to gravity drain outflows without an excessively deep outfall drain.

4.4.2 Waterway Improvements

This category of works is aimed at improving the hydraulic conveyance capacity of the waterway in order to reduce out of channel flooding and lower flood levels. It can involve:

- Removing vegetation and sedimentation which may be reducing (choking) the hydraulic conveyance of the waterway
- Enlarging the incised waterway through either bed lowering or widening
- Providing a secondary channel which activates in flood events, providing additional conveyance (i.e. bypass floodway channel)

An example of waterway improvements is the recent modifications to the Watson Street Drain completed by Council in 2014.

In relation to the Jindera hotspots, waterway improvements will be central to the assessment of flood modification options.

4.4.3 Waterway Structure Improvements

Waterway structures typically represent a flow constriction which generates an energy loss (afflux) leading to higher upstream flood levels.

All of the roadway culvert structures within the Jindera study area are overtopped in a 100 year ARI flood. Many of these structures have little influence on flooding conditions in large floods, as they become drowned out.

In relation to the Jindera hotspots, waterway structure improvements will form part of the assessment of flood modification options.

4.4.4 Levees

The purpose of a levee is to mitigate flooding and associated economic and social consequences of flooding by preventing floodwaters from entering the area affected by flooding.

Whilst levees can be effective at reducing the impact of flooding, it is important to ensure that the flood risk for other areas outside the levee protected area is not significantly increased.

In relation to Jindera the following comments are made in regards to levees:

- Levees are required to incorporate a freeboard of typically 500 mm or more above the 100 year ARI flood level
- Although flooding depths at Jindera are generally less than 0.3 metres, the addition of the mandatory freeboard will result in a significant levee bank height
- Given the absence of above floor flooding impacts aside from one confirmed instance, there is likely to be low community support for levees at Jindera

Notwithstanding the above concerns, levees will remain under consideration as a potential flood modification measure to alleviate flooding impacts at the four hotspots.

The most notable existing levee bank at Jindera is the temporary bank located within the Jindera Street road reserve which assists to direct flows conveyed by the adjoining drain to the entrance of the Watson Street Drain. There are also earth bunds present within the drainage reserves adjoining the industrial estate which assist in confining overland flow to the reserves.

4.5 Summary and Recommendations

From the preceding discussion, the various options and their status are listed in Table 2.

The flood modification measures are likely to be based around waterway and waterway structure improvements.

The detailed assessment of flood modification options at each of the four hotspots is documented in Section 7.

Table 2 Preliminary Assessment of Flood Management Options

Option No.	Description	Recommended for further detailed assessment
1.	Define the basis for FPLs, FPA	**Yes**
2.	Develop draft Flood Policy for Jindera	**Yes**
3.	Voluntary house raising – not practical	**No**
4.	Voluntary house purchase – flood risks are too low	**No**
5.	Flood proofing of buildings. Only on an individual basis	**No**
7.	Improved flood warning system improvements	**No**
8.	Education and awareness measures	**Yes**
9.	Retardation - not generally suited	**No**
10.	Levee banks	**Yes**
11.	Waterway Improvements	**Yes**
12.	Waterway structure improvements	**Yes**

5. Property Modification Options - Detailed Assessment

5.1 LEP and DCP

Flood based planning and development controls aim to ensure that future development is compatible with the flood risk. To achieve this, Councils incorporate or link appropriate flood based planning and development controls to their Local Environmental Plans (LEPs) and Development Control Plans (DCPs).

The LEP guides land use and development through the zoning of land. Development is limited to complying land uses within each zone. Greater Hume Shire Council's LEP was adopted in 2012. The LEP includes a section on Flood Planning.

Greater Hume Shire Council adopted a DCP in 2013. The 2013 DCP lists objectives and broad decision guidelines in relation to flooding considerations.

5.2 Flood Planning Levels

5.2.1 Overview

The Flood Planning Level (FPL) is the combination of flood levels and freeboards selected for floodplain risk management purposes.

FPLs can vary depending on the intended application (e.g. minimum floor levels for development, minimum crest levels for levee banks). This section of the report relates to FPLs as they apply to future development. Different FPLs can apply to levees for example where levees are proposed as a flood modification measure.

The NSW Floodplain Development Manual states that in general the FPL for standard residential development is the 100 year ARI flood plus a freeboard of typically 0.5 metre.

The 100 year ARI flood is almost always adopted as the design flood for floodplain management purposes in NSW. The freeboard selected can however vary significantly depending on local flooding characteristics. Freeboard provides a factor of safety to provide protection against:

- Uncertainties in the estimation of flood levels
- Differences in water levels due to local factors
- Increases in flood level as a result of wave action
- Changes in rainfall patterns as a result of climate change

Individual FPLs can be specified for different types of development (e.g. residential, non-residential), for different flooding sources (e.g. riverine flooding, local overland flow) and for different locations (e.g. very broad floodplain reach, very confined floodplain reach). Selecting a higher FPL will reduce the risk of future flood impacts. It may also however result in a social and economic cost associated with the more restricted land use in flood prone areas.

Residential development tends to be viewed as warranting a higher FPL due to the increased exposure associated with habitable buildings including people being present at the time of flooding.

Commercial and industrial development can be less sensitive to flooding with property owners tending to be willing to take on a higher risk. Allowing commercial and industrial buildings to have reduced minimum floor levels whilst requiring flood proofing to the residential FPL is also an option.

Some types of especially vulnerable development (e.g. hospitals, critical infrastructure, senior's housing) can be assigned a higher freeboard than that for other development types.

5.2.2 100 Year ARI Flood Levels

The 100 year ARI flood levels at Jindera are those derived from modelling undertaken as part of the Flood Study (GHD, 2015).

The hydraulic model used for the Jindera modelling is a four metre grid two dimensional TUFLOW model. The appropriate flood level for a development site will require careful consideration given there will be a flood gradient across the site. The appropriate 100 year ARI flood level should be the highest flood level on the proposed building footprint.

5.2.3 Freeboard for Development FPLs

The freeboard is a factor of safety added to the design flood level. The individual factors which are taken into account when selecting an appropriate development control freeboard are described as follows with respect to flooding conditions at Jindera:

Uncertainties in the estimation of flood levels. The variation in design flood levels at Jindera with increasing flood ARI is relatively compressed. This is because local flooding conditions are typically characteristic of local overland flow with shallow sheet flow over a very broad area. This includes Four Mile Creek which although having an incised channel, results in broad shallow sheet inundation on the south side of the creek in large flood events. Given these flooding conditions, an allowance of 0.10 metre is considered appropriate.

Differences in water levels due to local factors. This factor accounts for afflux due to waterway blockages and other local disturbances not able to be taken into account by the hydraulic model. The afflux can increase as a result of blockages within waterway structures (e.g. culvert and bridge openings). All of the waterway roadway crossings at Jindera are subject to significant overflows in a 100 year ARI event. The 100 year ARI flood levels are not therefore particularly sensitive to the extent of any blockage present. The 0.10 metre allowance for 'uncertainties in the estimation of flood levels' is considered adequate to cater for any additional affects due to 'local factors'.

Wave action. Waves can be generated by wind and by trucks and other vehicles. An allowance of 0.10 metre is considered appropriate.

Climate Change. Climate change impacts, particularly for a very large catchment system such as the Murray River are subject to a high level of uncertainty. Possible changes in rainfall vary from small reductions to increases of up to 30% (DECC, 2007). Given the relative insensitivity of flood levels to increasing flow, an allowance of 0.10 metre is considered appropriate for accommodating potential climate change effects.

The above suggests that a cumulative freeboard of 0.3 metre may be appropriate (i.e. 0.10 metre for 'uncertainties in the estimation of flood levels', 0.10 metre for 'wave action' and 0.10 metre for 'climate change').

A 'rule of thumb' approach taken into account when considering what freeboard to adopt for the FPL is based on the height difference between the 100 and 500 year ARI flood levels. A height difference of say less than 0.3 metre adds support for the adoption of a freeboard of 0.3 metre. If the height difference is in excess of 0.3 metre, this suggests that a freeboard greater than 0.3 metre is advisable.

In the case of Jindera, the 500 year ARI flood levels for Four Mile Creek are typically 0.10 to 0.25 m above the 100 year ARI flood level. For flooding elsewhere (i.e. tributary drains and waterways) the 500 year ARI flood levels are typically 0.05 to 0.30 metres above the 100 year ARI flood levels.

On the basis of the above, the recommended approach is for the FPLs at Jindera to coincide with the 100 year ARI flood level plus 0.3 metre of freeboard.

5.3 Flood Planning Area

The flood planning area (FPA) is the area subject to flood related development controls. Properties falling within the FPA are also identified as such on Section 149 (2) certificates issued by Council.

A very large FPA can cause considerable angst within the local community. Shallow sheet flow inundation is not generally viewed in the same way as mainstream flooding as increases in flooding severity can result in only marginal increases in flood level. In these circumstances there is therefore little or no risk of above floor flooding providing that building floor levels are elevated above the highest adjoining ground level. Currently the Australian Standard for residential slabs and footings (AS 2870, 2011) requires the minimum height of the slab above the finished ground to be 150 mm with some exceptions.

Consequently the FPA has in some recent past studies been defined in alternative ways to avoid the FPA encompassing a very large area, much of which is subject to very shallow 100 year ARI flooding.

For mainstream flooding (i.e. waterways with significant incised channel capacity), the FPA is usually defined as the area below the FPL. For areas affected by local overland flow (i.e. flow on route to incised waterways), this approach can be problematic as it can lead to a very large FPA which can even in some circumstances encompass areas outside the PMF extent. This occurs in flat terrain areas where a freeboard of even 0.3 metre can result in a very large FPA.

The proposed FPA extent for Jindera is shown on Figure A1. It is based on:

- Four Mile Creek flood affected area – FPA coincides with the 500 year ARI extent. Four Mile Creek is more characteristic of mainstream flooding than the other local waterways at Jindera. The Four Mile Creek 500 year ARI flood levels are generally 0.15 to 0.25 metres above the 100 year ARI flood levels and represent a reasonable approximation of the flood extent coinciding with the 100 year ARI event plus the 0.3 metre freeboard adopted.
- All other local waterways and drains – FPA coincides with the trimmed 100 year ARI flood extent (depths less than 100 mm trimmed). Flooding conditions within these waterways and drains is more characteristic of local overland flow. Floor level control in those areas where there is flow less than 100 mm deep in a 100 year ARI event will be governed by the building code.

The limits of the FPA coverage shown on Figure A1 extends over the whole of the township of Jindera including all of the 2012 LEP urban land use zones (developed or undeveloped). The limits of the hydraulic model and the flood mapping produced (e.g. Figures A2 and A3) extends beyond the limits of the FPA defined coverage. Flood based development controls for these areas (e.g. the eastern-most area on Figure A1) will coincide with controls applicable to all rural areas in the Shire.

5.4 True Flood Hazard

Provisional flood hazard mapping is presented in the Flood Study report (GHD, 2015). The provisional hazard mapping is based on hydraulic conditions (i.e. depth and velocity of floodwaters) as determined using the Floodplain Development Manual (NSW Government, 2005).

The provisional flood hazard is reviewed during a FRMS, taking into account factors other than hydraulic conditions. Other factors taken into account include:

- Effective warning time. In regards to Jindera, there will generally be very little warning time available, typically less than 1 hour
- Flood readiness. Flooding impacts at Jindera in recent years have not generally been severe with a few exceptions. There have however been relatively frequent flood events since 2005 where road and grounds flooding has occurred. The level of community flood awareness probably varies from high for those exposed to recent minor flooding, to low for those with no exposure
- Rate of rise of floodwaters. The rate of rise of floodwater at Jindera will be relatively rapid.
- Duration of flooding. The duration of flooding at Jindera will normally be quite short, with flood levels remaining high for a few hours at most
- Evacuation access considerations. This is not a major consideration for Jindera given that there is insufficient warning time to initiate and complete a resident evacuation. Most streets will remain trafficable to heavy vehicles with flood depths not generally exceeding 0.4 metre

The final 100 year ARI flood hazard mapping is shown on Figure A3 in Appendix A.

The majority of the out of channel flooding remains designated as Low Hazard, unchanged from the provisional classification. Flooding conditions are characteristic of shallow sheet flow inundation. These conditions do not warrant a revision to High Hazard, notwithstanding the relatively short flood warning time available.

The High Hazard defined areas covering the waterway corridors have been adjusted in some places to provide improved connectivity along the waterway routes.

High Hazard designated areas are generally limited to the following:

- Four Mile Creek waterway corridor
- Watson Street Drain waterway corridor
- Waterway corridors for the two waterways which cross Molkentin Road on the east side of town

There are extensive Low Hazard designated areas. The development controls for these Low Hazard areas are not particularly restrictive, with minimum mandatory floor level requirements the main control requirement.

5.5 Local Flood Policy

A draft Local Flood Policy for Jindera is included in Appendix A.

The key aspects of the draft Local Flood Policy are:

- Flood related development controls detailed in the Local Flood Policy apply to the FPA as defined by Figure A1
- The minimum floor levels for new residential buildings are to be at the FPL (i.e. 0.3 metre above the 100 year ARI flood levels)
- Commercial and industrial development. At Council's discretion, the minimum floor level is to be at the FPL or the building is to be flood proofed to at least the FPL

Council's DCP should be updated to incorporate the Local Flood Policy including the FPA map, the Hazard Category map and the Hydraulic Category map. Flood based development controls are to apply to the FPA. The LEP will also require updating as it currently specifies FPLs based on 0.5 metre of freeboard.

6. Response Modification Options - Detailed Assessment

6.1 Flood Warning System

As discussed in Section 4.2, Jindera is located close to the head of a relatively small catchment. The lag time between any flood inducing rainfall and flooding at Jindera is very short. Flood warning system infrastructure such as telemetered stream height / flow measurement stations and rainfall pluviometer station will not be effective at reducing flood damages given the minimal warning time available.

Consequently there are no recommendations to install additional flood warning system infrastructure at or in the catchment above Jindera.

There are some elements of flood warning systems which would be beneficial, but more as a result of providing flood intelligence data which is useful for flood studies and floodplain risk management studies. This would include a rainfall pluviometer at Jindera (for continuously recording rainfall minute by minute) and a stream height gauge on Four Mile Creek.

There are costs associated with establishing and maintaining flood warning system stations. Councils are responsible for covering all ongoing maintenance costs associated with the stations. This typically amounts to $1,000 per annum for a pluviometer and $3,000 for a stream height station.

Flooding durations at Jindera will be very short. Flood levels will rise and fall typically within 30 minutes to 2 hours. There are therefore no lengthy ongoing flood response activities associated with the evacuation of those at risk or those affected. Only a relatively small number of houses are likely to be affected by above floor flooding (estimated 19 houses in a 100 year ARI event). Temporary accommodation needs for the relatively small number of persons affected is not therefore expected to be too onerous.

6.2 Emergency Management

6.2.1 Local Flood Plan

It is the role of the SES to develop a Local Flood Plan for vulnerable communities. The Local Flood Plan is a sub-plan of the Local Emergency Management Plan.

The Local Flood Plan details operations relating to flood preparedness measures, flood response measures and flood recovery measures.

Following the completion of the flood studies at Jindera, Culcairn, Holbrook, Henty and Walla Walla, the SES can proceed to prepare a Local Flood Plan for the Shire.

It is not envisaged that evacuation of residents from at risk areas would in general be able to take place at Jindera. There is too little flood warning time for this to be initiated and enacted.

Each flood at Jindera is likely to be different. This is because there are multiple local waterways impacting on different parts of the town. Local high intensity rainfall within the catchment draining into the Watson Street Drain and resultant flooding along the drain route will not necessarily coincide with flooding in other parts of the town which are affected by other waterways / drains. The random nature of rainfall areal variability combined with the small catchment sizes and short response times greatly limits any preparedness and response activities. Most of the operational activities covered by the Local Flood Plan in relation to

Jindera may therefore focus on recovery actions (clean-up, temporary accommodation for above floor affected residents etc).

In relation to potential temporary accommodation sites, notable properties which are at very low risk of flooding at Jindera include:

- Rural Fire Service (RFS) site in Urana Street
- Sportsground site in Dight Street which includes the swimming pool site
- St Johns Lutheran School at the corner of Adams Street and Jindera Street

The central business site at the corner of Urana Street and Creek Street is subject to very shallow (less than 0.1 metre) inundation in a 100 year ARI flood.

6.2.2 SES Flood Data

Given the short warning time available and the short duration of flooding, emergency response activities at Jindera are expected to be mainly focused on recovery related matters.

Most of the inundated affected areas at Jindera are characterised by relatively shallow sheet flow inundation up to and including a 200 year ARI event. Consequently, the flood affected areas at Jindera are expected to be characteristic of the following Emergency Response Planning (ERP) classifications:

- Areas with Overland Escape Routes – those areas which have access roads to flood free land crossing lower lying flood prone land
- Areas with Rising Road Access – those areas which have access roads rising steadily uphill and away from rising floodwaters

There is no existing stream height gauge at Jindera. The consequence of an imminent flood cannot be reliably predicted given the small catchment sizes. The flood inundation maps included in the Jindera Flood Study report identify the expected extent and depth of inundation for 5, 10, 20, 50, 100 and 200 year ARI events and the PMF assuming uniform rainfall conditions across the whole catchment draining to Jindera.

6.3 Flood Data

Comprehensive and up to date flood data is essential for effectively responding to flood events. With the completion of this FRMS&P, it is important that Council planning documents such as the DCP are updated to reflect the most up to date flooding information showing:

- Flood Planning Area (FPA) as the land inundated by the 100 year ARI flood plus the adopted freeboard
- Flood category maps defining the Floodway, Flood Storage and Flood Fringe areas
- Flood hazard maps defining the Low Hazard and High Hazard flood areas

It is important that flood data be collected both during and in the aftermath of future flood events. The data can be used for future investigations associated with the update of the Jindera FRMP. This is particularly important given the limited confirmed accounts of previous above floor flooding at Jindera. This may reflect the absence of above floor flooding or it may reflect the owner's reluctance to identify their houses as at risk of above floor flooding given the implications for the properties resale value.

Future data collection should focus on:

- Large floods (i.e. where above floor flooding results)
- Photographs if possible at or near the peak of flooding. Where possible, photographs to be date and time stamped
- Recording reliable peak flood levels and their subsequent survey to the AHD datum
- Details of any instances of above floor flooding

Council may consider preparing a flood data collection strategy to more formally define the data collection process (type data, how it is to be recorded, roles and responsibilities).

6.4 Education and Awareness Measures

An overview of possible measures to increase the level of flood awareness in the community at Jindera is provided in Section 4.2.2. Of the various measures available, the following are considered most suited to Jindera:

- With the completion of the flood study and FRMS&P for Jindera, Council has detailed flood data available. Section 149 Certificates issued by Council should include the relevant flood information known to Council which impacts on the subject property. This would typically include with the issue of 149 (2) certificates whether the property is within the FPA, the Hydraulic Category of the property and the Hazard Category of the property, and the subsequent flood based planning and development controls applicable to the property. Further detailed flood information could be provided if a Section 149 (5) is issued including frequency, level, depth and extent. This action is effectively a mandatory function that Council is required to perform as distinct from an optional activity
- Provide flood information on Council's web site including the Flood Study report, the FRMS&P report, Local Flood Plan, links to BOM and SES web sites and other flood warning and response information. It is easy to implement and maintain with minimal associated costs
- Construction of a flood marker. A site such as Pioneer Park adjoining the south side of Four Mile Creek would potentially be suited. If a marker was established, it would be beneficial to record the flood height at the marker in future floods and to record the peak height and date on a plaque attached to the marker

7. Flood Modification Options – Detailed Assessment

7.1 Hotspot 1 – Jindera Street Area

7.1.1 Description

The Watson Street drain was upgraded by Council in 2013 / 2014. The upgraded Watson Street Drain currently terminates at the Jindera Street road reserve (refer to Figures 4 and 5).

The 2013 / 14 improvements to the Watson Street drain involved enlarging the drain through deepening and widening and replacing the previous 0.9 m diameter low flow pipe and causeway arrangement at Adams Street with a three cell 2.1 m (wide) x 1.2 m (high) box culvert structure.

The 2013 / 14 Watson Street Drain works have significantly increased the discharge capacity of the drain. The upgraded culvert structure at Adams Street has a discharge capacity of 15 m^3/s. This compares to the combined capacity of the previous low flow culvert / causeway structure of 7 m^3/s. The discharge capacity of the section of drain between Adams Street and Jindera Street increased from 7 m^3/s to 15 m^3/s as a result of the 2013 / 14 upgrade works. The discharge capacity of the section of drain between Adams Street and Four Mile Creek increased from 13 m^3/s to 23 m^3/s as a result of the 2013 / 14 upgrade works.

An informal drain and earth bund is present on the west side of Jindera Street within the road reserve to the south of the Watson Street Drain. These works are understood to have been constructed following flooding in September 2005 and February 2008 to provide temporary protection to properties on the east side of Jindera Street.

Above floor flooding of four residential properties may potentially occur in the vicinity of the Jindera Street / Dight Street intersection. The flooding at this hotspot is characteristic of local overland flow. Flow depths are quite shallow. Of the properties which are subject to above floor flooding, the maximum 100 year ARI depth of above floor flooding is 0.26 metres.

The area on the west side of Jindera Street is undeveloped. It is zoned RU5 (Village). A woodland covers the triangle shaped area adjacent to Jindera Street and Pioneer Drive.

There are two waterways which discharge runoff from rural catchments south of Pioneer Drive. These waterways and other local features are shown on Figure 4.

7.1.2 Flood Modification Options

The mitigation options for addressing the overland flow flooding problem at the Jindera Street hotspot appear limited to (refer to Figure 4):

- Retardation. Varying size retarding basins on-line with the main waterway draining to Pioneer Drive were assessed as part of the 2009 study (GHD, 2009). The investigations undertaken using the XP-RAFTS hydrologic model found that peak 100 year ARI flow reductions able to be achieved through retardation are small (less than 5%) for basin volumes up to 50,000 m^3. Aside from this there are other practical concerns associated with the construction of a large basin on the upstream side of Jindera (e.g. most of the storage would need to be excavated given the flat terrain conditions and the spillway design requirements would be quite onerous given the need to comply with the 2000 ANCOLD guidelines. Retardation is therefore not considered to be feasible.

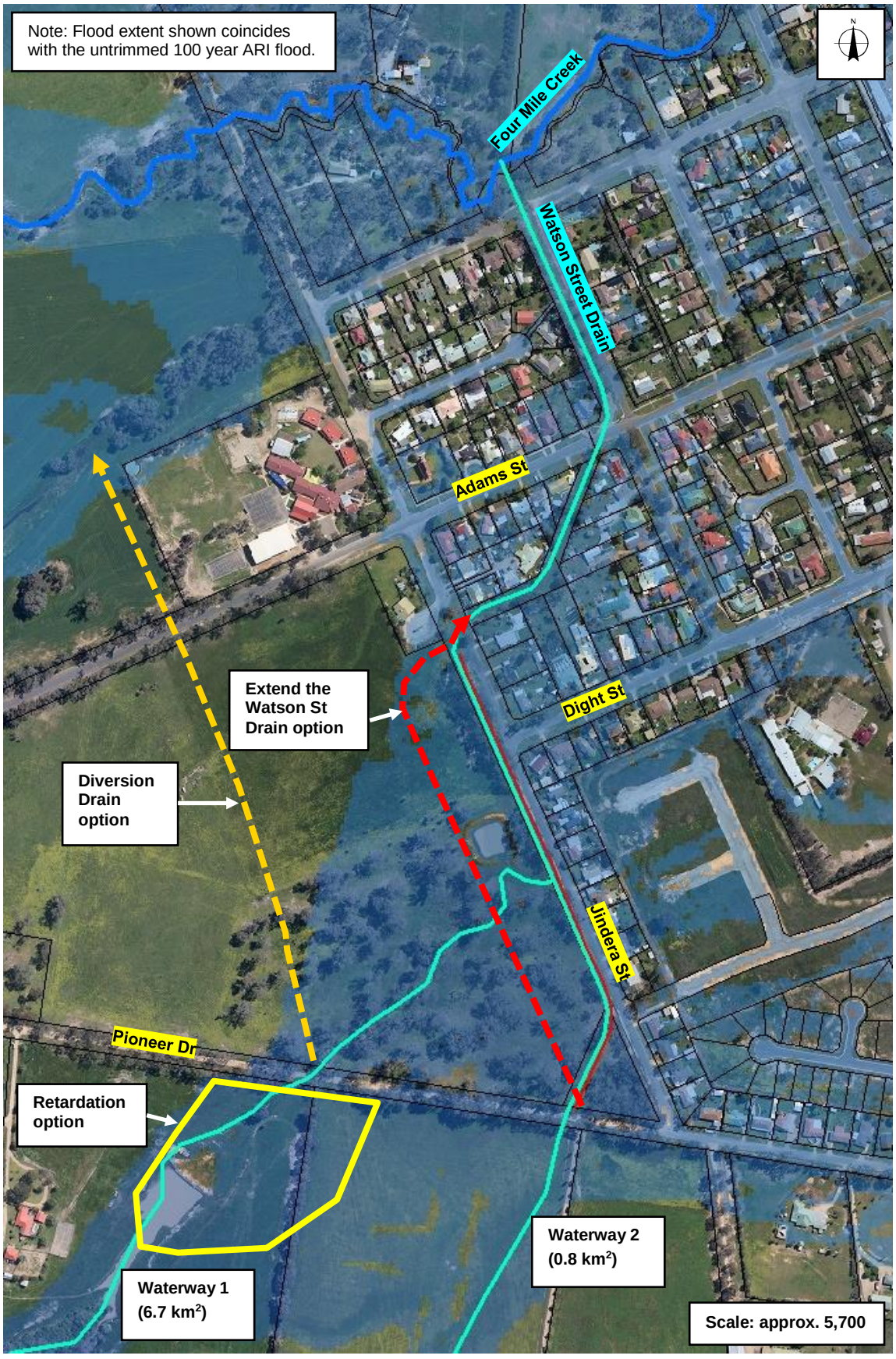


Figure 4 Hotspot 1 – Mitigation Options

Watson Street Drain – looking upstream towards the upstream limit of the 2013/14 upgrade works at Jindera Street.

Culvert headwall and drain downstream of Pioneer Drive constructed in 2010. Drain discharges runoff from Waterway 2 (refer Figure 4) to the open drain on the west side of Jindera Street.

Figure 5 Hotspot 1 – Photographs

- Extend the Watson Street Drain upstream to Pioneer Drive. This would consist of a new 540 metres open drain linking the existing Watson Street Drain at the footbridge opposite Jindera Street to the culvert crossing under Pioneer Drive, 100 metres west of the Jindera Street intersection.
- Diversion drain. This would consist of a 650 metres long diversion channel from the existing creek crossing at Pioneer Drive to a waterway on the north side of Adams Street on the west side of the St Johns Lutheran School.

7.1.3 Watson Street Drain Extension – 100 Year ARI Capacity

The Watson Street Drain extension was initially modelled based on the following (refer to Figure 6):

- Existing drain downstream of Jindera Street retained as is (i.e. as per post 2013 / 14 upgrade conditions). The capacity of the existing drain is approximately 23 m^3/s between Four Mile Creek and Adams Street, 15 m^3/s at the Adams Street culvert and 15 m^3/s between Adams Street and Jindera Street.
- Drain extension between Jindera Street and Pioneer Drive along the route shown on Figure 6 based on the current study 100 year ARI peak design flow of 23 m^3/s (design drain bed width 2.5 m, depth 1.4 m, batters 6:1, longitudinal grade 0.5%, no design freeboard provision).
- Formation of a road high point in Pioneer Drive on the east side of the Waterway 2 culvert crossing and construction of a low level berm on the south side of Pioneer Drive as an extension to the newly formed road high point. This prevents approximately 4 m^3/s discharging eastwards down Pioneer Drive as occurs under existing conditions in a 100 year ARI flood.
- Removal of the existing temporary works on the west side of the Jindera Street road reserve.

The model predicted change in 100 year ARI flood levels as a result of the proposed Watson Street Drain extension works is shown on Figure B1 in Appendix B.

The effect of the proposed works is to more efficiently funnel the incoming flow to the existing Watson Street Drain. This eliminates the existing above floor flooding impacts in the vicinity of Jindera Street.

There are however increases in peak flood level along the Watson Street Drain route and the Four Mile Creek route downstream of the Watson Street Drain entry point. This is due to both the increased efficiency of the upstream drainage system and the prevention of overflows discharging eastwards down Pioneer Drive.

The effect of the Watson Street drain extension works assessed in comparison to post 2013 / 14 upgrade conditions is an increase in flood damages due to the higher peak flows and flood levels downstream of Jindera Street, notwithstanding that the performance of the Watson Street Drain would remain significantly improved in comparison to pre 2013 conditions.

The increase in flood levels within the Watson Street Drain downstream of Jindera Street brought about by the upstream drain improvements could be mitigated through one or more of the following:

- Diversion of flows as per the diversion route option shown on Figure 4.
- A further upgrade of the Watson Street Drain capacity downstream of Jindera Street.
- Vegetation management works on Four Mile Creek.

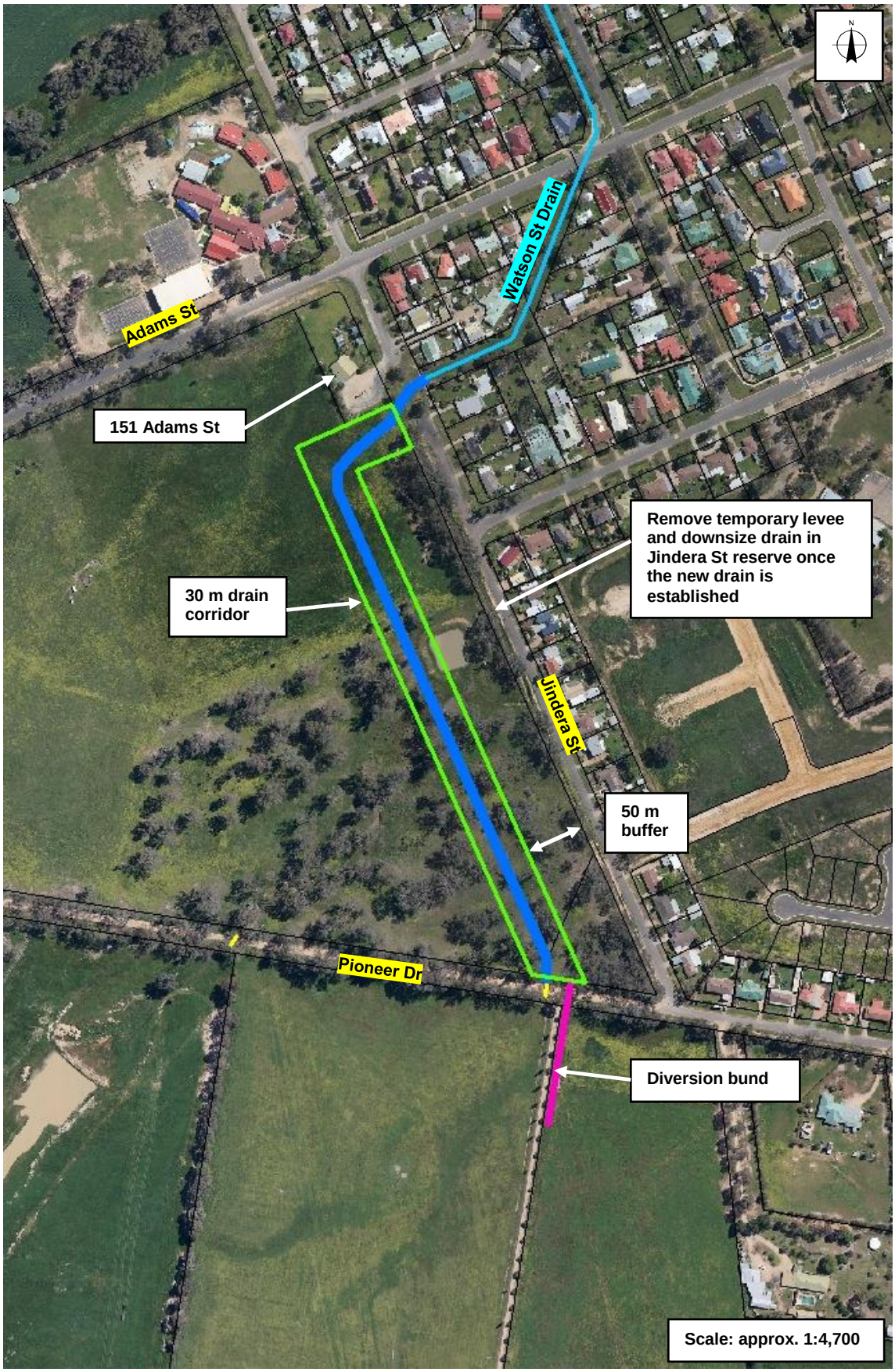


Figure 6 Hotspot 1 - Proposed Watson Street Drain Extension

7.1.4 Diversion Drain Option

Any diversion of flow away from its natural course can be problematic at it can exacerbate flooding impacts along the diverted flow path.

An assessment of preliminary design details for a potential diversion drain along the route shown in Figure 4 identified the following details:

- Route length 650 m.
- Indicative design flow 10 m^3/s (sufficient to reduce the 100 year ARI flow in the Watson Street Drain to less than its existing capacity.
- Drain longitudinal grade 0.5%, bed falls from 238.5 m AHD at the entry point to 235.25 m AHD at the downstream exit point).
- Design bed width 3.0 m, batters 3:1, design minimum depth 0.9 m, design depth with 0.3 m freeboard added 1.2 m.
- 100 year ARI velocities 1.3 m/s.
- Large culvert structure required at Bungowannah Road.

The diversion drain as a stand alone mitigation measure is not favoured for the following reasons:

- It cannot capture the flow currently spilling eastwards down the south side of Pioneer Drive into the adjoining catchment (Pioneer Drive Drain catchment).
- The diversion will lead to increases in flood levels in the receiving waterway down to as far as where the Watson Street Drain discharges into Four Mile Creek.

7.1.5 Combined Option – Watson Street Drain Extension & Diversion Drain

The Watson Street Drain Extension and the Diversion Drain were assessed in combination. The rationale for this combination was that the Diversion Drain would reduce the flow carried by the Watson Street Drain downstream of Jindera Street, thereby not exacerbating flooding either side of the existing drain as a result of the capture of the Pioneer Drive breakaway flow.

Hydraulic modelling undertaken identified that this option would be successful in preventing any increase in flooding along the existing Watson Street Drain route downstream of Jindera Street. This would eliminate the potential need for a further upgrade of the Watson Street Drain.

The residual problem with this option is however a marginal increase in flood levels along the Four Mile Creek route (refer to Figure B2 in Appendix B). This is due to the diversion itself, upstream of the Watson Street Drain junction, and the capture of the breakaway flow down Pioneer Drive.

Although the increases in the Four Mile Creek flood levels are generally small (0.01 to 0.03 metre), implementation of this option is not considered acceptable without additional measures to counter the effect of the increase in flow within Four Mile Creek.

7.1.6 Watson Street Drain extension and upgrade downstream Jindera St

A further upgrade of the existing Watson Street Drain downstream of Jindera Street would ideally involve achieving 100 year ARI capacity whilst retaining 0.3 m of freeboard. The previous upgrade in 2013/2014 was based on a lower design flow estimate, zero blockage of the Adams Street culvert structure and zero freeboard.

Details in regards to the section of drain between Adams Street and Jindera Street are as follows:

- Existing 200 m length drain is located within 15 m wide reserve initially upstream of Adams Street which broadens to 18 m in width as it approaches Jindera Street.
- Existing drain – depth 1.2 m, grade 0.65%, base width 2.0 m, batters 5:1, capacity 15 m^3/s flowing full (zero freeboard)
- 100 year ARI peak design flow 23 m^3/s, design freeboard 0.3 m.
- It would be possible to lower the drain bed by up to 0.5 m. A possible drain section to achieve 0.3 m freeboard assuming a drain depth of 1.7 m is a base width of 3.0 m and batter slopes of 3.5:1 (i.e. too steep for ride on mowing).

In regards to the Adams Street culvert structure, the following details are relevant:

- Existing culverts consist of a three cell 2.1 x 1.2 m box culvert structure, 50 m in length, capacity assuming zero blockage is 15 m^3/s.
- 100 year ARI peak design flow 23 m^3/s, design freeboard 0.3 m at upstream end of culvert.
- With two same size additional culvert cells added, the upgraded structure can pass the 100 year ARI flow whilst limiting the upstream flood level to that required to achieve 0.3 m freeboard, whilst sustaining 10% blockage.
- The practicality of providing an additional same size cell either side of the existing box culverts is questionable given the space limitations.

In regards to the section of drain between Adams Street and the Four Mile Creek outlet, the following details are provided:

- Existing 230 m length drain is located within the 30 m wide Watson Street road reserve.
- Existing drain – minimum depth 1.4 m, grade 0.33%, base width 2.0 m, batters no steeper than 4:1 on road side and 3:1 on opposite side, capacity 23 m^3/s flowing full (zero freeboard)
- To increase the capacity in order to achieve 0.3 m of freeboard, without deepening the drain, will require steepening of the road side batter to 3:1 and widening the base to 7 metres.
- The practicality of the above is questionable given it is not desirable to have to steepen the batter adjacent to the roadway for road safety reasons.

In summary the major reservations associated with the above drain upgrade works are the need to use steeper batters than is desirable both downstream and upstream of Adams Street, and the difficulty in providing two same size culvert cells at Adams Street due to the limited space available.

7.1.7 Watson Street Drain Extension, Diversion Drain & Four Mile Creek Vegetation Works

The rationale for this composite option was for the vegetation management works along the Four Mile Creek waterway corridor to offset the effect of the diversion drain and the capture of the Pioneer Drive breakaway flow.

The vegetation management works would be in the form of:

- Removal of any moderate to dense stands of exotic vegetation in the vicinity of the creek corridor.
- Removal of low value native vegetation such as regrowth.
- Removal of any overly large or dense debris which is substantially blocking the waterway corridor.

The above measures were represented within the model by reducing the main channel corridor Mannings roughness down from 0.06 to 0.05.

The hydraulic modelling results for this combined option showed that the vegetation management works generally offset the small increases in Four Mile Creek flood levels which resulted from the capture of the breakaway flow down Pioneer Drive (refer to Figure B3 in Appendix B).

A further consideration in relation to vegetation management works along the Four Mile Creek corridor is bush fire risk mitigation. The Four Mile Creek corridor is within a Strategic Fire Advantage Zone as identified by the Hume Zone Bush Fire Risk Management Plan (Hume Zone Bush Fire Risk Management Committee, 2015). Vegetation management works to mitigate bush fire risks may give cause for more extensive works than that outlined above.

7.1.8 Environmental and Social Impacts

The Watson Street Drain extension is located within a woodland area. Issues associated with the inevitable tree loss impacts if the drain is extended to Pioneer Drive require assessment prior to detailed design.

The Diversion Drain option will also require the loss of some native trees, notably at the Pioneer Drive end of the drain, and where the drain crosses Bungowannah Road.

The vegetation management works along the Four Mile Creek corridor will require careful planning to ensure only exotic vegetation or low value native vegetation is targeted. Any vegetation management plan should have input from the NSW Department Local Land Services (LLS).

The proposed Watson Street Drain extension and the Diversion Drain works are located just outside the outer urban fringe of Jindera. The closest developed property is a pre-school located at 151 Adams Street. Depending on detailed design, the Watson Street Drain extension may occupy a small area at the south eastern corner of this property.

7.1.9 Economic Assessment

The economic assessment results for Hotspot 1 are summarised in Table 3.

Indicative cost estimates for the Hotspot 1 mitigation options are provided in Table C1 (Watson Street Drain Extension), Table C2 (Diversion Drain) and Table C5 (Vegetation Management Works).

The cost estimates are based on the concept designs, with where possible quantity estimates and unit rates applied based on past experience with similar works. Cost estimates for any

measures which are adopted and proceed to implementation should be updated following detailed design.

The property database was used to estimate the flood damages under post works conditions. The TUFLOW hydraulic modelling derived design flood levels at each of the buildings within the property database were used to compute the post works estimated flood damages, similar to how the existing flood damages were estimated during the 2015 Flood Study.

The change in flood damages represents the difference between the post works damage estimates and the existing conditions estimates.

Implementation of the Watson Street Drain and Diversion Drain works reduces the AAD by $32,000. The benefit cost ratio is 0.32.

Implementation of the Watson Street Drain, Diversion Drain and Four Mile Creek vegetation management works reduces the AAD by $44,000. The benefit cost ratio is 0.37.

7.1.10 Conclusion

The only acceptable option is the composite option which comprises:

- Extending the Watson Street Drain to Pioneer Drive and berm works on the south side of Pioneer Drive to capture the current breakaway flows.
- Diversion Drain from Pioneer Drive along an alignment which crosses Bungowannah Road as shown on Figure 4.
- Vegetation management works along the Four Mile Creek corridor extending from Goulburn Street through to Jindera Street.

The above does not require any changes to the existing Watson Street Drain downstream of Jindera Street.

Table 3 Hotspot 1 – Economic Assessment of Flood Modification Options

Mitigation Option	Extend Watson Street Drain and construct the Diversion Drain	Extend Watson Street Drain, Diversion Drain & Four Mile Creek Vegetation Management Works
Existing conditions AAD ($/annum)	305,000	305,000
Existing conditions – number of buildings at Hotspot 1 subject to 100 year ARI above floor flooding	4	4
Post mitigation works reduced AAD ($/annum)	273,000	261,000
Post mitigation – number of buildings at Hotspot 1 subject to 100 year ARI above floor flooding	0	0
Reduced AAD post mitigation ($/annum)	32,000	44,000
Present value of future benefits ($)	339,000	466,000
Capital cost of mitigation works ($)	950,000	1,130,000
Future maintenance costs ($/annum)	9,500	11,300
Present value of future maintenance costs ($)	100,000	120,000
Present value of total costs (capital plus maintenance)	1,050,000	1,250,000
Benefit / Cost ratio	0.32	0.37

Notes:

1. Capital cost estimate breakdowns are given in Appendix C.
2. Future annual average maintenance costs assumed to be 1% of the capital costs.
3. Present values of future flood reduction benefits and levee maintenance costs assume a discount rate of 7% and a design life of 20 years.

7.2 Hotspot 2 – Four Mile Creek Area

7.2.1 Description

There are 11 residential properties potentially subject to above floor flooding on the south side of Four Mile Creek in the area between Watson Street and Gibson Street (refer to Figure 7).

The depth of above ground flooding affecting this area is generally less than 0.35 metre in a 100 year ARI flood. The maximum depth of above floor 100 year ARI flooding is only 0.12 metre. In excess of a 20 year ARI flood or greater is required to initiate above floor flooding.

There is only a very gentle fall towards Four Mile Creek in this area. The fall along Urana Street from Adams Street to just south of Four Mile Creek is only 0.5 metre. Extensive shallow inundation of this area subsequently occurs in large floods.

Notable Four Mile Creek break-out flow occurs between Watson Street and Fallon Street. These flows discharge eastwards down Creek Street, spreading out onto the intersecting roads and residential properties.

7.2.2 Flood Modification Options

Flood modification options to reduce flooding impacts for this area are listed as follows (refer to Figure 7):

- Increase the discharge capacity of the Urana Street Four Mile Creek culvert structure
- Vegetation management along the Four Mile Creek waterway corridor (i.e. to achieve a reduction in the effective Mannings roughness value)
- Levee protection

Option 1 - Upgrade Four Mile Creek Culvert Structure at Urana Street

The existing Four Mile Creek culvert structure at Urana Street consists of a three cell 2.7 m (wide) x 2.4 m (high) box culverts. The road is overtopped close to the culvert structure in a 10 year ARI flood event. The depth of 100 year ARI overflows at the culvert crossing is approximately 0.3 metres.

Road overflows down Creek Street and across Urana Street will occur in a 5 year ARI flood. The road level at the Creek Street intersection (231.50 m AHD) is marginally lower than the road low point at the Four Mile Creek intersection (231.55 m AHD).

Modelling of this option assumed a doubling of this the existing three cell culvert structure. The resultant modelled change in 100 year ARI water level (afflux) comparing post culvert upgrade conditions with existing conditions is shown on Figure B4 in Appendix B. The impact of a doubling of the culvert capacity is to:

- Locally lower 100 year ARI flood levels by up to 0.06 metre
- Produce a very localised small increase in the 100 year ARI flood level on the immediate downstream side of the culvert
- Nine of the eleven properties subject to above floor 100 year ARI flooding remain so under post culvert upgrade conditions

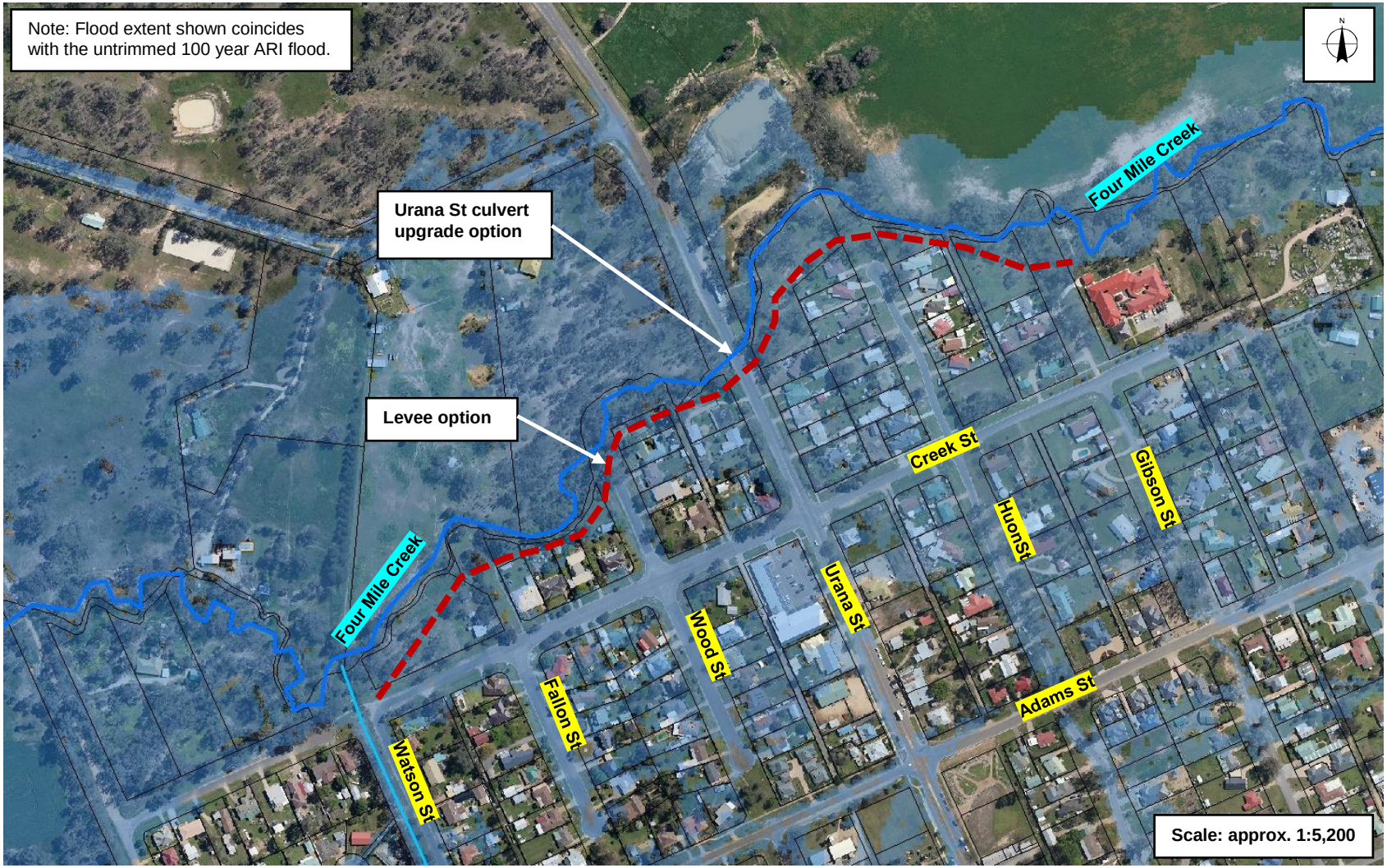


Figure 7 Hotspot 2 – Flood Mitigation Options

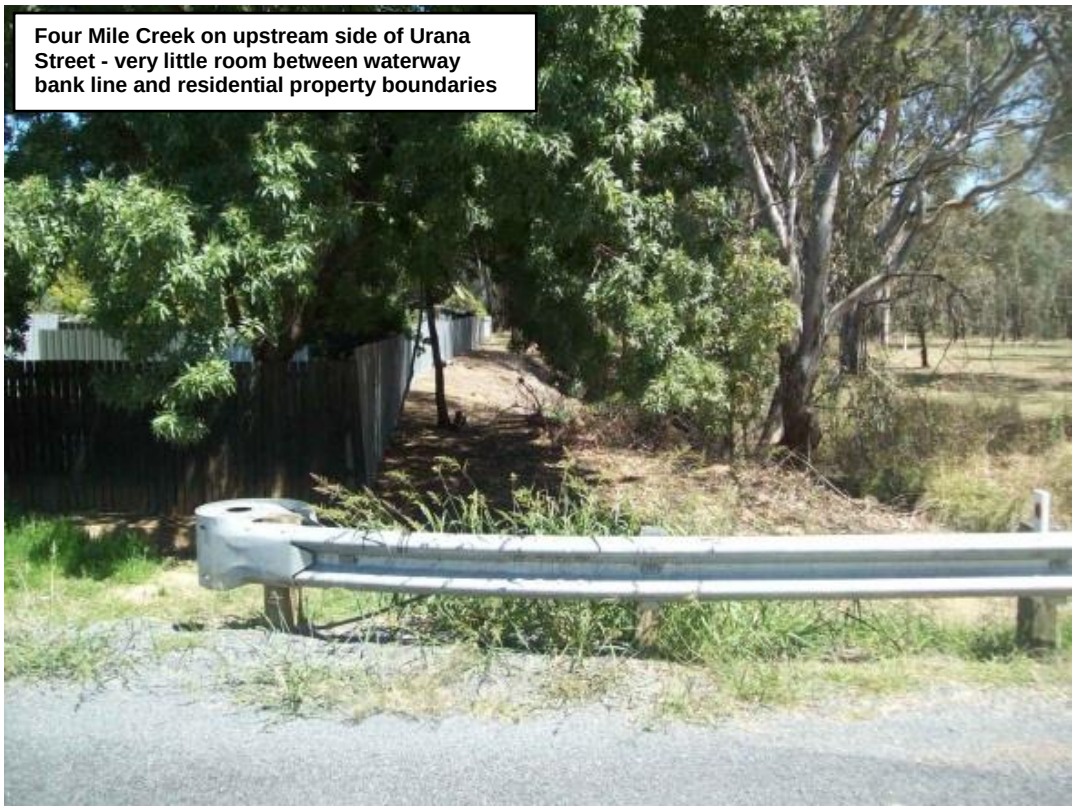


Figure 8 Hotspot 2 – Four Mile Creek Photographs

Option 2 - Four Mile Creek – Vegetation Management / Thinning

A few local reaches of Four Mile Creek have extensive exotic vegetation present (refer to Figure 8). The hydraulic model was used to quantify the impact of lowering the Manning roughness values as an indication of what would result if the vegetation density conditions (tree, shrub and debris density) were reduced. This was represented within the hydraulic model by lowering the Mannings waterway roughness from 0.06 to 0.04.

The modelled impact of the reduced main channel and overbank Manning roughness values is shown on Figure B5 in Appendix B.

The modelled impact of the vegetation measures result in:

- Average reduction of 0.04 metre at the eleven properties identified as potentially subject to 100 year ARI above floor flooding
- Seven of the eleven properties subject to above floor 100 year ARI flooding remain so under post vegetation clearing conditions

The preceding section looking at mitigation options for Hotspot 1 concluded that vegetation management measures along the Four Mile Creek waterway corridor would assist in offsetting the effect of the Watson Street Drain extension and Diversion Drain works.

It is stressed that any vegetation management measures should exclude any broad scale native vegetation. Only low value native vegetation removal such as regrowth would be acceptable for removal.

Option 3 – Four Mile Creek Levee

A levee bank along the alignment shown on Figure 7 was modelled. The potential levee bank is 870 metres long. The ground level along the route varies from 0.0 to 0.6 m below the 100 year ARI flood level.

The modelled impact of the levee on flooding conditions is shown on Figure B6 in Appendix B. The modelling indicates that:

- Above floor flooding is prevented at all 11 properties which are subject to 100 year ARI above floor flooding under existing conditions
- Flood levels within the adjoining section of Four Mile Creek will increase by more than 0.1 metre as a result of the levee. At least one house is located within the area where flood levels increase

The use of levee banks for mitigation flooding impacts on the south side of Four Mile Creek is considered problematic for the following reasons:

- Much of the levee route upstream of Urana Road is very confined with very little room to positon the levee (refer to Figure 8). A vertical wall levee will therefore be necessary in these space confined areas
- At Urana Street, the levee will require either a temporary structure or the road will need to be raised appreciably. A temporary structure is not advisable given the very limited flood warning time. Raising of the road will require major roadworks.
- Although the 100 year ARI depth of flooding adjoining the levee route would generally not exceed 0.6 metre, the addition of 500 mm of design freeboard would result in a levee which is relatively high compared to the flat terrain conditions and visually intrusive. Given this, the levee is likely to be strongly opposed by some residents
- The 100 year ARI flood level increases typically in the order of 0.10 metre on the north side of the creek are a concern

- Potential for flooding due to local runoff being trapped on the dry side of the levee

7.2.3 Economic Assessment

The economic assessment results for Hotspot 2 are summarised in Table 4.

Indicative cost estimates for the options under consideration are provided in Table C3 (Urana Street culvert upgrade), Table C4 (Four Mile Creek vegetation management) and Table C5 (Four Mile Creek levee).

Option 1 (Jindera Street Four Mile Creek culvert upgrade) achieves a reduction of only $6,000 in the AAD and consequently has a benefit cost ratio of only 0.17.

Option 2 (Four Mile Creek vegetation thinning) achieves a reduction in the AAD of $24,000. This results in a benefit cost ratio of 1.00.

Option 3 (Four Mile Creek levee) achieves a reduction in the AAD of $35,000. This results in a benefit cost ratio of 0.50. This is considered an upper bound benefit cost ratio outcome, given that segments of the levee are likely to be required to be constructed as vertical walls due to space restrictions, resulting in higher capital costs.

7.2.4 Discussion

The 11 properties which have been assessed as subject to 100 year ARI above floor flooding from Four Mile Creek are not severely affected. The maximum depth of 100 year ARI above floor flooding for these 11 properties is only 0.12 metre.

The hydraulic modelling indicates that in excess of a 20 year ARI flood is required to initiate above floor flooding. No known above floor flooding has occurred within the area on the south side of Four Mile Creek during recent flood events, although this is not surprising given these events are thought to have been less severe than 20 years ARI.

The Urana Street culvert augmentation option is not effective and can be discarded.

A Four Mile Creek levee bank extending over the 870 m route shown on Figure 7 is considered to have too many negative aspects and is therefore not nominated as a preferred measure.

Future impacts in large Four Mile Creek floods should be recorded, particularly any instances of above floor flooding. If above floor flooding does occur, mitigation options could be revisited with more certainty in relation to the actual risk. Whilst the modelling predicts potential above floor flooding of 11 properties in a 100 year ARI flood, there is considerable uncertainty in relation to actual flooding conditions given the limited recorded flood data available for model calibration.

7.2.5 Conclusions

Limited vegetation management is nominated as a preferred measure for Hotspot 2. The vegetation management works will assist to offset any negative effects associated with the Hotspot 1 works (i.e. Watson Street Drain Extension and Diversion Drain) as discussed in the preceding Section 7.1.

Table 4 Hotspot 2 – Economic Assessment of Flood Modification Options

Mitigation Option	Option 1 - Double Urana Street culvert capacity	Option 2 - Vegetation management along creek corridor	Option 3 - 870 m Levee
Existing conditions AAD ($/annum)	305,000	305,000	305,000
Existing conditions – number of buildings at Hotspot 2 subject to 100 year ARI above floor flooding	11	11	11
Post mitigation works reduced AAD ($/annum)	299,000	281,000	270,000
Post mitigation – number of buildings at Hotspot 2 subject to 100 year ARI above floor flooding	9	7	0
Reduced AAD post mitigation ($/annum)	6,000	24,000	35,000
Present value of future benefits ($)	63,000	254,000	371,000
Capital cost of mitigation works ($)	360,000	200,000	670,000
Future maintenance costs ($/annum)	-	5,000	6,700
Present value of future maintenance costs ($)	-	53,000	71,000
Present value of total costs (capital plus maintenance)	360,000	253,000	741,000
Benefit / Cost ratio	0.17	1.00	0.50

Notes:

1. Capital cost estimate breakdowns are given in Appendix C.
2. Future annual average maintenance costs assumed to be 1% of the capital costs.
3. Present values of future flood reduction benefits and levee maintenance costs assume a discount rate of 7% and a design life of 20 years.

7.3 Hotspot 3 - Molkentin Road

7.3.1 Description

Hotspot 3 is shown on Figures 9 and 10. The Pioneer Drive Drain currently discharges under the Urana Road adjacent to the Molkentin Road intersection into a roadside drain. This roadside drain discharges eastwards down Molkentin Road to the south west corner of a vacant 2 hectare RU5 (Village) zoned lot, from where there is no downstream formal drain or confined drain route.

The roadside drain at the corner of Urana Street and Molkentin Road has limited discharge capacity. There are three driveway culverts within this short section of drain. Drain overflows result in flooding impacts on the adjoining properties.

Widespread shallow inundation occurs either side of the Molkentin Middle waterway both south and north of Molkentin Road. The road culvert structure consists of a three cell 2.4 x 1.2 m box culvert. The modelled 100 year ARI afflux is 0.4 metres. There is no above floor flooding on the upstream side of the Molkentin Road (rural land use properties).

Road overflows occur predominantly on the west side approach to the culvert structure. The road low point is located opposite 41 Molkentin Road, 70 metres west of the culvert structure.

Two issues have been assessed at Hotspot 3. The first issue involves flooding impacts associated with the Pioneer Drive Drain in the vicinity of Urana Street. The second issue is flooding impacts associated with the Molkentin Middle waterway in the vicinity of Molkentin Road.

7.3.2 Pioneer Drive Drain – Flood Modification Options

There is no adequate formal drain present to discharge flows from the Pioneer Drive Drain at Urana Street to the Molkentin Middle receiving waterway. Flows in this drain will tend to increase as the catchment is progressively developed, notwithstanding that a retarding basin is located 150 metres upstream of the Urana Road which will limit peak flow increases.

The objective is therefore to identify the preferred option for upgrading the Pioneer Driver Drain, commencing at the upstream side of Urana Street.

Flood modification options consist of:

- Upgrading the drain along the existing roadside route within the Molkentin Road reserve. This is not a viable option as there is insufficient room to adequately enlarge the drain. Multiple driveway crossings along the drain route present additional difficulties.
- Route aligned through east side Urana Street residential properties. All of the residential lots on the east side of Urana Street (141, 145 and 147) have been developed. There are no vacant lots or open space reserve present on which to site a potential drain route. A new drain route through the residential properties is not considered acceptable.
- South side Molkentin Road route. There is no development on the south side of Molkentin Road on its approach to Urana Street. The property is zoned RU1 (Primary Production). It would be possible to locate a realigned Pioneer Drive Drain down the south side of Molkentin Road, before crossing to the north side at some point. Insufficient fall is present to continue the drain through to the waterway, 550 metres east of the Urana Street intersection.

Corner Urana Street and Molkentin Road – February 2008 flood

View across Urana Street down Molkentin Road. Pioneer Drive Drain on north (left) side of Molkentin Road.

Figure 9 Hotspot 3 – Molkentin Road Photographs

Possible drain upgrade arrangements are shown on Figures 11 and 12. It includes the possible future realignment of Molkentin Road as it approaches Urana Street (Option 3). This allows a new drain to be positioned between the realigned Molkentin Road and a retained laneway for provision of access to the three properties on the north side (147 Urana Street, 8 Molkentin Road and Lot 2 Molkentin Road).

Preliminary design drain details for the upgrade of the drain are as follows:

- Design discharge capacity at Urana Street – 3.5 m^3/s
- Preliminary proposed Urana Street Culvert structure – four cell 1.2 x 0.45 m box culvert or equivalent
- Design discharge capacity at Molkentin Road – 5.0 m^3/s
- Preliminary proposed Molkentin Road culvert structure – six cell 1.2 x 0.45 m box culvert or equivalent

The currently undeveloped properties on the downstream side of the proposed Molkentin Road culvert structure are zoned Village (RU5) and as such may be subject to future residential subdivision development. Provision for the discharge of the design flow through these properties is required to be maintained and should form a condition of any subdivision approval.

7.3.3 Hydraulic Modelling

The Option 1 alignment option (refer to Figure 11) was modelled. The change in 100 year ARI flood levels as a result of this option assessed in isolation is shown on Figure B7 in Appendix B. The option will mitigate the flood impacts on properties, notably the three properties closest to the Urana Street / Molkentin Road intersection.

Downstream of the proposed upgrade works, there are some small increases in the 100 year ARI flood level as shown on Figure B7. This is due to the increased efficiency of the drainage system. The modelled 100 year ARI flood level increase is 0.02 m at the Dight Street ,/ Mitchell Street intersection.

7.3.4 Environmental Impacts

Environmental impacts associated with the expected loss of any trees should be assessed prior to detailed design and taken into account when selecting the preferred drain route.

The property on the south side of Molkentin Road is a rural land use property. A farm dam is located in close proximity to the Molkentin Road reserve.

Figure 10 Hotspot 3 - Pioneer Drive Drain – Existing Conditions

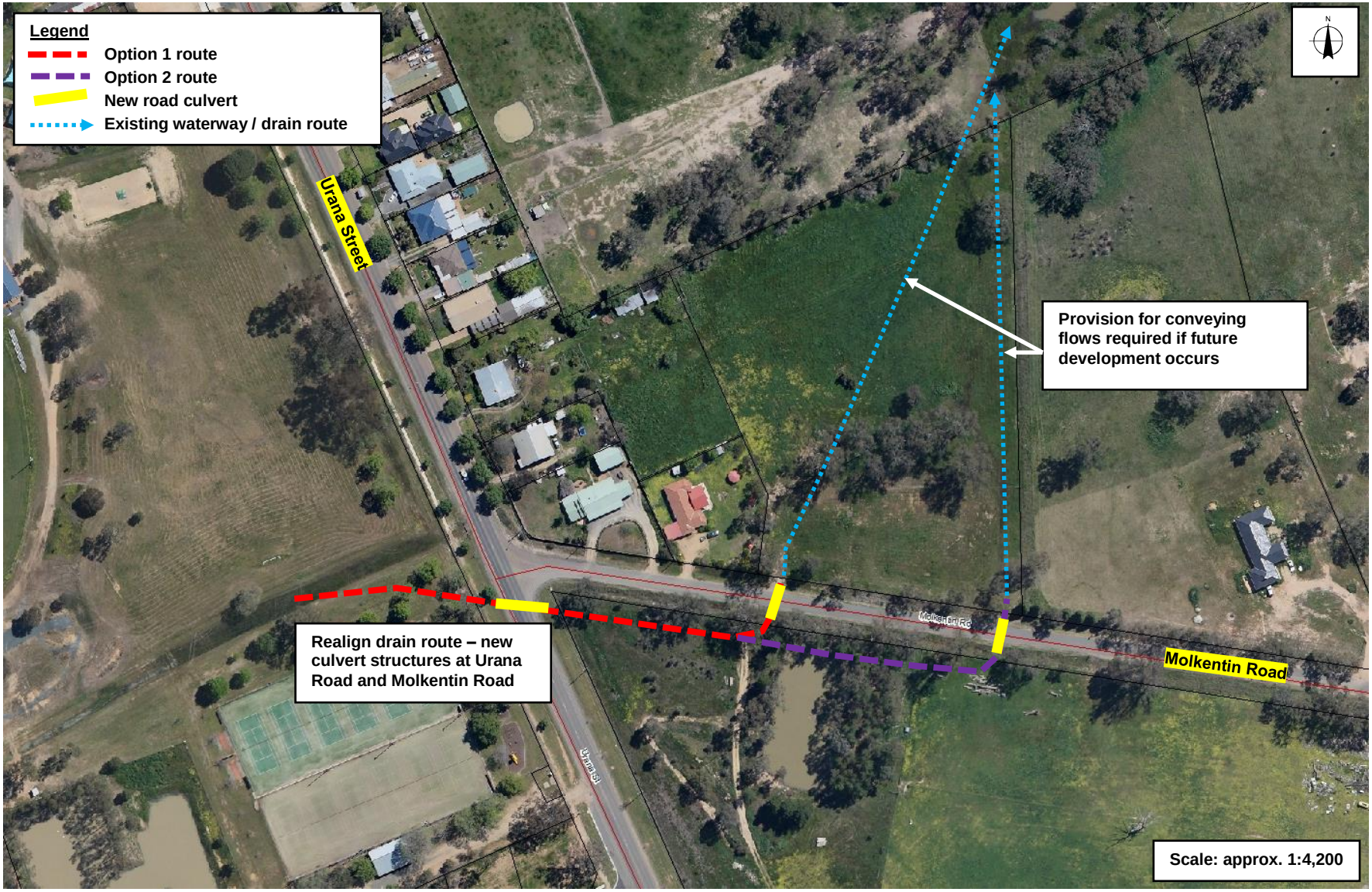


Figure 11 Hotspot 3 - Pioneer Drive Drain – Drain Upgrade Route Options 1 and 2

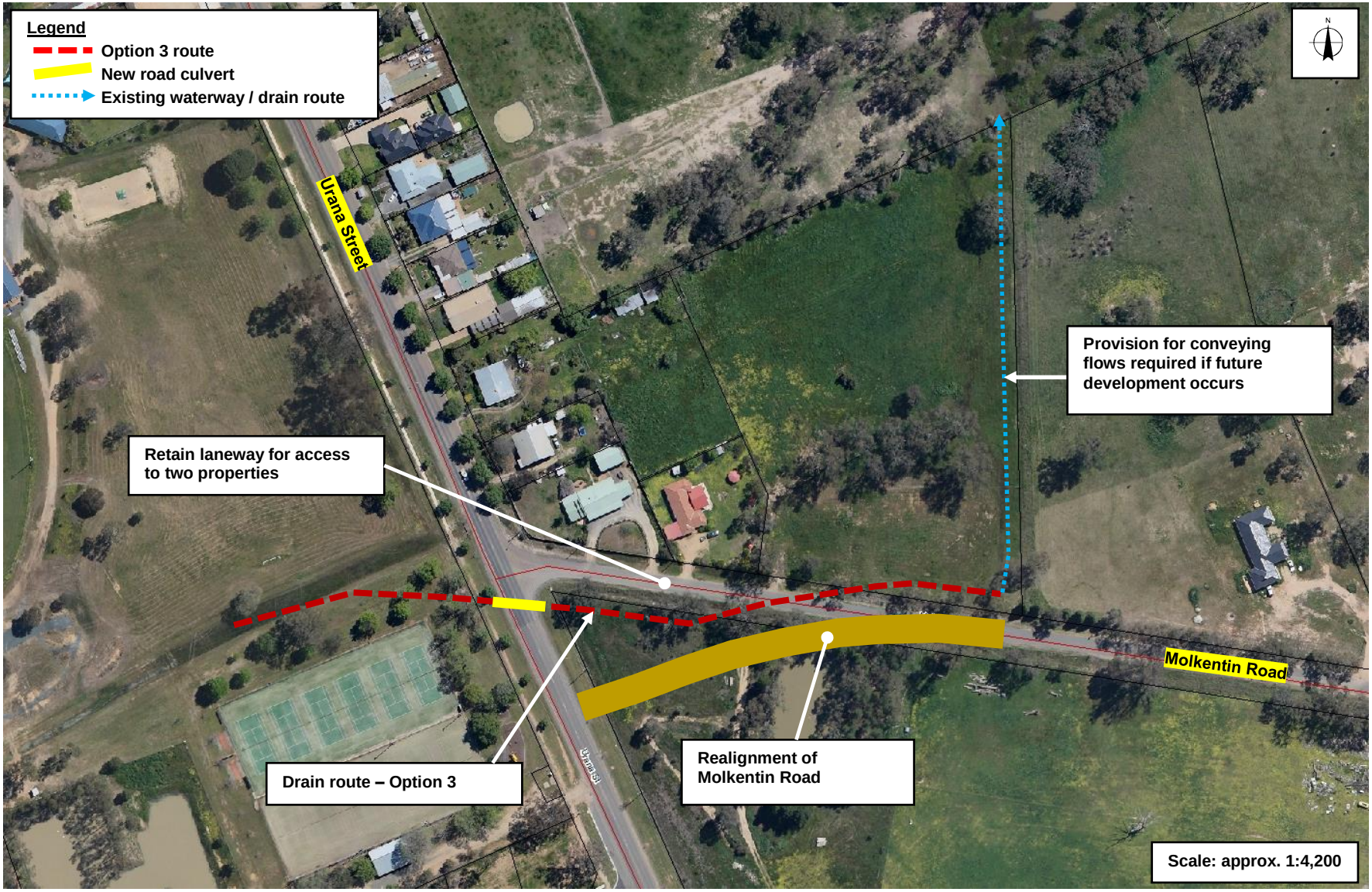


Figure 12 Hotspot 3 - Pioneer Drive Drain – Drain Upgrade Route Option 3

7.3.5 Middle Molkentin Waterway – Flood Modification Options

Existing culvert and flooding conditions at the Molkentin Road, Middle Molkentin waterway crossing are as follows (refer to Figure 10):

- Existing culvert structure – three cell 2.4 x 1.2 m box culverts
- Overtopping threshold – approximately a 10 year ARI flood event
- Depth 100 year ARI road overflows – approximately 0.3 metres
- 100 year ARI afflux – approximately 0.4 metre on the immediate upstream side of the culvert structure

As for much of Jindera, there is broad shallow sheet flooding on either side of the Middle Molkentin waterway both upstream and downstream of Molkentin Road. This is typical of natural waterways where only smaller floods are confined to within the incised waterway.

An upgrade of the existing culvert structure and possible raising of the Molkentin Road is not favoured for the following reasons:

- The limited in-channel capacity of the upstream and downstream incised waterway (i.e. a larger culvert is not compatible with the size of the existing incised waterway)
- There are two houses on the upstream side of the Molkentin Road. Road raising to divert overland flow away from houses on the downstream side of the road has the potential to increase flood levels on the upstream side of the road. None of the houses on the upstream side of the road are thought to be at risk of 100 year ARI above floor flooding
- The discharge capacity of the existing road culvert (equivalent to 10 year ARI design flow) is quite reasonable given the road is a local access road

Flooding conditions are characteristic of shallow sheet flow on either side of the creek. Although modelling has indicated that two houses on the downstream side of the road may be at risk of above floor flooding, the depth of 100 year ARI above ground flooding for this area is less than 0.3 metre. Under these conditions, it is difficult to predict whether flood levels will peak marginally above or marginally below floor level given local influences not represented within the model (e.g. landscaped grounds around the house perimeters).

Given the above considerations, no flood modification options are proposed for Molkentin Road in the vicinity of the Middle Molkentin waterway crossing. Impacts should be monitored in future floods and if the actual impacts are high (i.e. above floor flooding is experienced), the need for flood modification measures could be revisited.

7.3.6 Economic Assessment

The economic assessment results for Hotspot 3 are summarised in Table 5.

The works at Hotspot 3 (extension of the Pioneer Drive Drain from Jindera Street to the downstream side of Molkentin Road) achieve a reduction in the AAD of $5,000 and consequently has a relatively low benefit cost ratio of 0.13.

7.3.7 Conclusions

Works at the intersection of Urana Street and Molkentin Road are required to provide an adequate level of drainage service. Although the benefit cost ratio of the preferred works is low (0.13), the works are necessary in order to achieve an adequate level of service and could be described as necessary stormwater drainage infrastructure works. The final arrangement selected for the drainage upgrade at this location can be worked out during detailed design.

Table 5 Hotspots 3 and 4 – Economic Assessment

	Pioneer Drive Drain Works – Hotspot 3	Industrial Estate Works – Hotspot 4
Existing conditions AAD ($/annum)	305,000	305,000
Existing conditions – number of buildings at hotspot subject to 100 year ARI above floor flooding	1	4
Post mitigation works reduced AAD ($/annum)	300,000	295,000
Post mitigation – number of buildings at hotspot which remain subject to 100 year ARI above floor flooding	0	0
Reduced AAD post mitigation ($/annum)	5,000	10,000
Present value of future benefits ($)	53,000	102,000
Capital cost of mitigation works ($)	370,000	180,000
Future maintenance costs ($/annum)	3,700	1,800
Present value of future maintenance costs ($)	39,000	19,000
Present value of total costs (capital plus maintenance)	409,000	199,000
Benefit / Cost ratio	0.13	0.51

Notes:

1. Capital cost estimate breakdowns are given in Appendix C.
2. Future annual average maintenance costs assumed to be 1% of the capital costs.
3. Present values of future flood reduction benefits and levee maintenance costs assume a discount rate of 7% and a design life of 20 years.

7.4 Hotspot 4 – Industrial Estate

7.4.1 Description of Flooding and Drainage Conditions

The industrial estate is shown on Figures 13 and 14. Runoff from the south currently drains partly through the estate as shallow sheet overland flow.

The floor levels of some of the existing industrial estate buildings are only marginally above the ground level. Shallow sheet flow under these circumstance is sufficient to potentially cause above floor flooding. There are four properties identified as potentially subject to above floor flooding within the industrial estate. The depth of 100 year ARI above floor flooding at the four properties varies from 0.02 to 0.08 metre.

Council is currently intending to proceed with development of the next stage of the Industrial Estate on the adjoining south side property as follows (refer to Figure 13):

- Northern third of property to be developed as industrial
- Southern two thirds of property to be developed as Large Lot Residential

Existing and proposed drains in the vicinity of the Industrial Estate are shown on Figure 13.

The existing east side drain (Drain 2) adjoining the estate extends upstream to Hawthorn Road. There is no existing culvert at the Hawthorn Road end. Drain 2 is located on 20 metre wide reserve. The indicative capacity of the drain is 5 m^3/s.

The existing west side drain (Drain 1) is located on 50 metre wide reserve between the industrial estate and Urana Road. Drain 1 opposite the industrial estate consists of two earth bunds positioned between 25 and 40 metres apart. A similar bund floodway system is present on the east side of the Urana Road reserve, extending for 2 km south of the industrial estate. The bund system appears to be a remnant rural drainage system set up many decades ago.

Drain 1 directs overland flow to a waterway junction at the north west corner of the industrial estate. There is no extension of Drain 1 upstream of the industrial estate. A small culvert structure (0.9 x 0.3 m box culvert) is located under Hawthorn Road close to the Urana Road intersection. The capacity of the existing drain varies markedly from a minimum of 4 m^3/s at the Scholz Street crossing to in excess of 15 m^3/s towards the northern end of the industrial estate.

There is also extensive overland flow capacity within the 60 metre wide Urana Road reserve adjoining the existing and proposed industrial estate, particularly on the east side of the road. A significant portion of runoff from the upstream catchment is likely to spill into the Urana Road reserve, discharging northwards parallel to flows retained within the bunded system on the east side of the road reserve.

Design plans for the Industrial Estate extension prepared by SJE Consulting show the extension of Drain 1 on 50 m wide drainage reserve adjoining the western and southern boundaries of the proposed extended industrial estate (refer to Figure 13). The proposed Drain 1 extension involves the formation of 'swale drains' (i.e. broad shallow excavated open drains with the drain depth varying from 0.4 to 1.0 m).

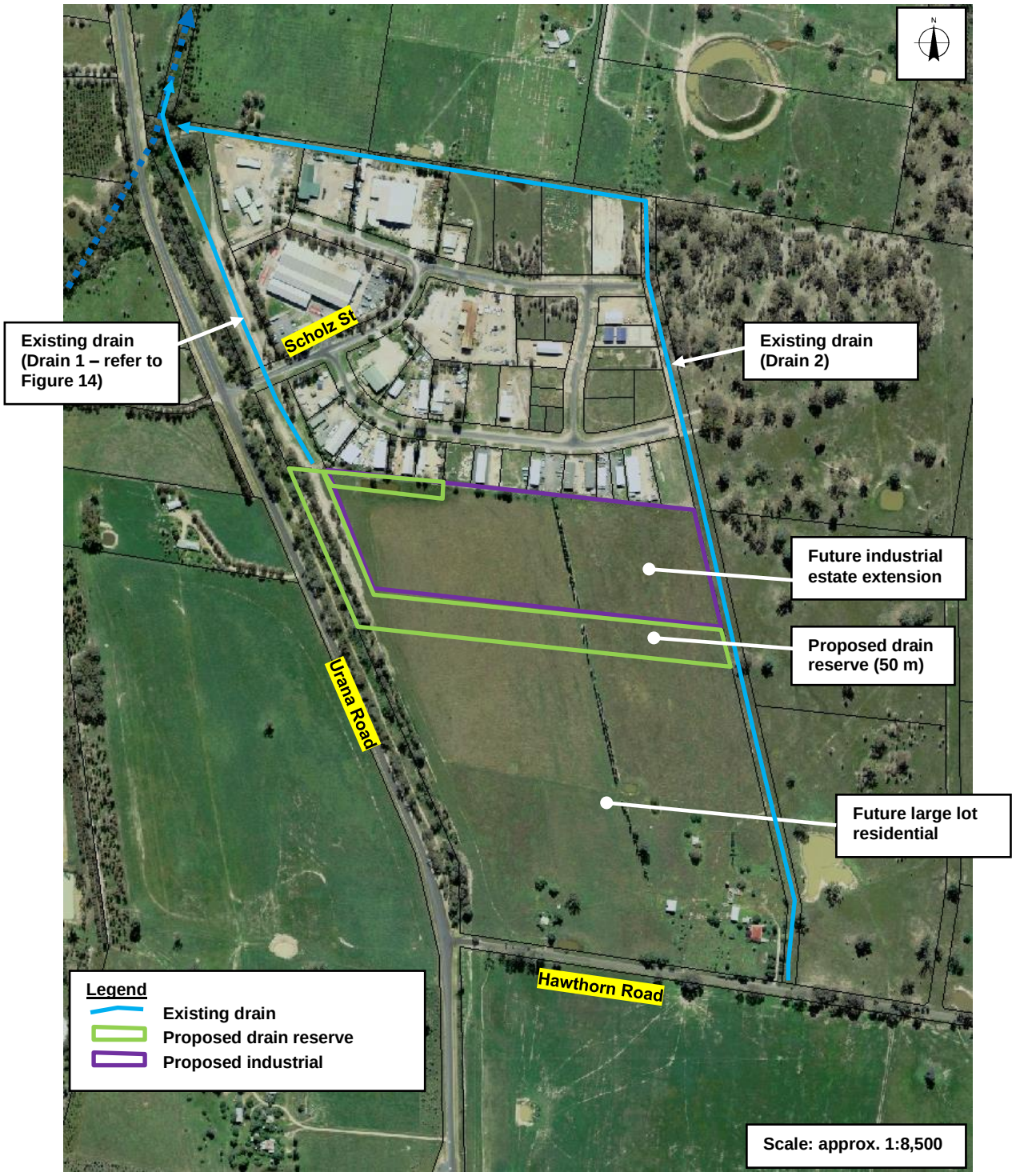


Figure 13 Hotspot 4 – Industrial Estate

Figure 14 Hotspot 4 – Industrial Estate Photographs

7.4.2 Flood Modification Options – Industrial Estate

The proposed Industrial Estate extension drainage works (i.e. Swales 1 and 2 as per the SJE Consulting September 2015 preliminary design drawings) will adequately mitigate the flooding impacts within the existing industrial estate. Further drainage works to the south (e.g. at Hawthorn Road) are therefore only required to service future development on the north side of Hawthorn Road.

It is difficult to define the amount of runoff which is actually draining to the existing drain on the west side of the Industrial Estate (refer to Drain 1 on Figure 15). The total catchment area could be as high as 550 hectares. It appears likely that a significant portion of the runoff is however discharging down the 50 metre wide Urana Road reserve which has significant capacity to convey flows without impacting on the road itself.

The Drain 1 culvert at Scholz Street is a low flow culvert only (1.2 m (wide) x 0.3 m (high) box culvert). Once its capacity is exceeded, the road will be overtopped between two raised road high points approximately 40 metres apart. Flows will be confined to the drain until the eastern side road low point is overtopped at a drain flow of approximately 4 m^3/s.

The performance of Drain 1 should be monitored by Council. If future flood events generate overflows into the Industrial Estate at Scholz Street, then an upgrade of the culvert and roadway vertical alignment at the drain crossing should be considered. The flood modelling undertaken as part of the current study indicates that this is not presently required.

The economic assessment results for Hotspot 4 are summarised in Table 5. The works at Hotspot 4 (extension of Drain 1 as per the SJE drawing Swales 1 and 2) achieve a reduction in the AAD of $10,000 and a benefit cost ratio of 0.51.

7.4.3 Drainage Infrastructure – Future Development to South of Industrial Estate

The areas on the north side of Hawthorn Road are likely to be progressively developed as low density residential.

There are no significant incised natural drainage lines through this area. Drain 2 (refer to Figure 13) was constructed to intercept overland flow and direct it down the east side of the Industrial Estate.

In the longer term, Council could give consideration to the following drainage infrastructure works:

- Drain 1 extension to Hawthorn Road. A continuation of the drainage reserve a further 400 metres south to Hawthorn Road
- New cross drainage culvert structures under Hawthorn Road at Drains 1 and 2
- Raising of Hawthorn Road as part of a future road upgrade to direct overland flow to the two proposed culvert crossings. This will reduce the frequency and severity of overland flow through rural residential properties on the north side of Hawthorn Road (e.g. Range View Drive)

The design approach to the above requires careful consideration. Adopting a 100 year ARI design capacity is arguably not appropriate for the following reasons:

- The drain capacity will be far larger than the downstream drain / waterway capacity.
- A significant amount of flow can be conveyed within the Urana Road reserve in large flood events

Given the above, it is recommended that the future Hawthorn Road drain improvements be designed to discharge the 5 year ARI design flow. The 50 metres wide Drain 1 reserve allows for further enlarging of the drain in the future, if required.

It is important that appropriate minimum floor level controls are imposed on future residential development to safeguard against above floor flooding. The area north of Hawthorn Road is characteristic of shallow sheet flooding, similar to much of the area at and surrounding Jindera. Providing new dwellings are constructed with floor levels a minimum of 300 mm above the adjoining finished landscape level, the risk of above floor flooding is minimal.

Preliminary design details for the drainage works are as follows:

Drain 1

- Catchment area 415 hectares at Hawthorn Road, 100 year ARI design flow 16 m^3/s, 5 year ARI design flow 5 m^3/s
- 5 year ARI capacity drain details – longitudinal grade 1.0%, 5.0 m bed width, 8:1 batters, minimum depth 0.5 m excluding freeboard, drain top width 13 metres
- Hawthorn Road 5 year ARI capacity culvert – 4 No. 1.2 m (wide) x 0.6 m (high) box culverts or equivalent. The road is currently raised only marginally above the natural ground level

Drain 2

- Catchment area 80 hectares at Hawthorn Road, indicative 100 year ARI design flow 5 m^3/s, 5 year ARI design flow 2 m^3/s
- Retain existing drain
- Hawthorn Road 5 year ARI capacity culvert – 3 No. 1.2 m (wide) x 0.45 m (high) box culverts or equivalent

The above works are not flood mitigation measures (i.e. measures to alleviate flooding impacts on existing development). They are drainage infrastructure works to service future development.

7.4.4 Economic Assessment

The economic assessment results for Hotspot 4 are summarised in Table 5.

The works at Hotspot 4 (extension of Drain 1 as per the SJE drawing Swales 1 and 2) achieve a reduction in the AAD of $10,000 and a benefit cost ratio of 0.51.

7.4.5 Conclusions

The proposed Drain 1 extension works shown on Figure 15 are necessary stormwater drainage infrastructure works associated with the next stage of the industrial estate development. Council is committed to implementing these works.

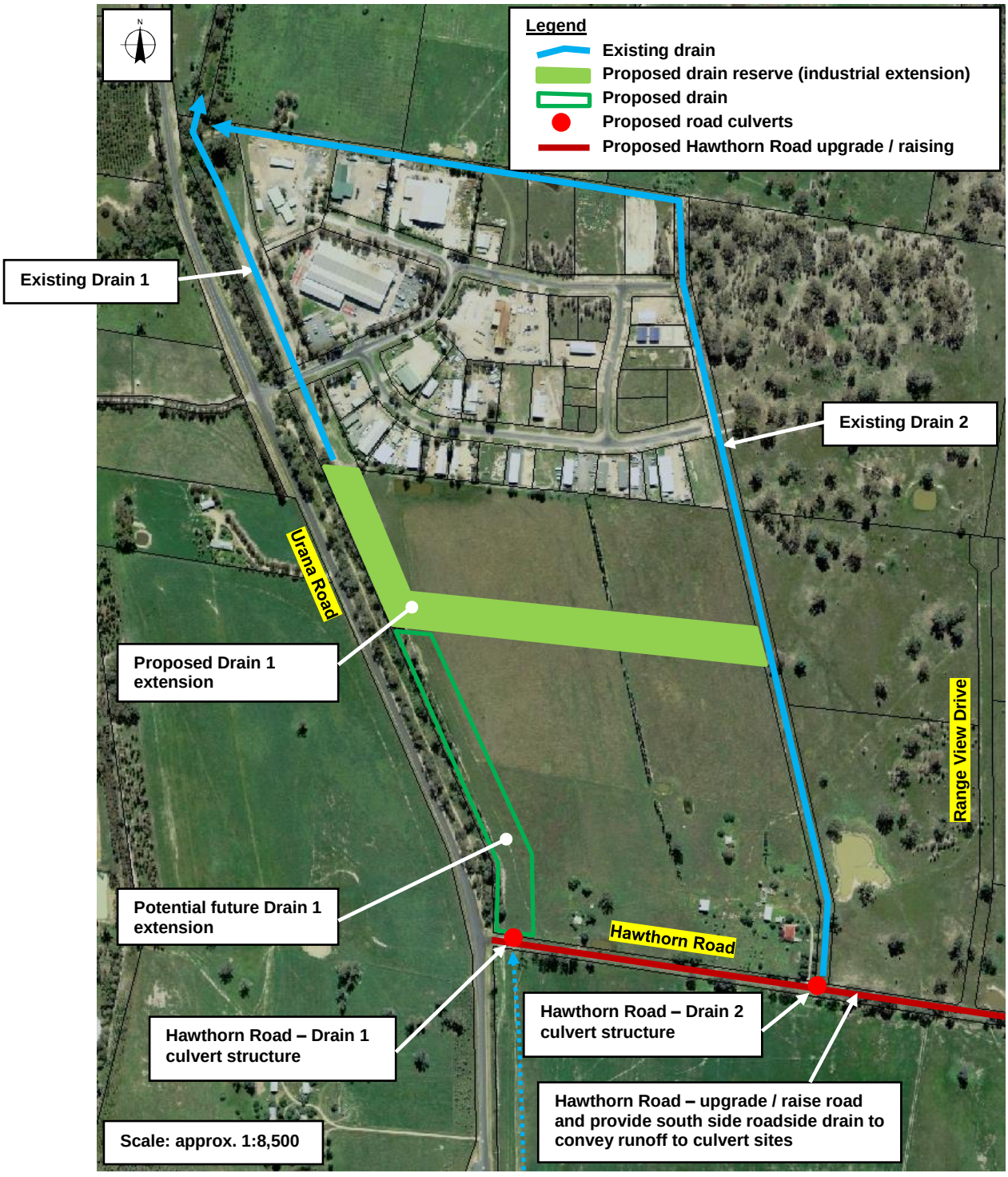


Figure 15 Hotspot 4 – Proposed Flood Mitigation and Drainage Improvement

8. Floodplain Risk Management Plan

8.1 Overview

This Floodplain Risk Management Plan (FRMP) applies to the Jindera township and adjoining area as defined by Figure A1.

Jindera is located on the south side of Four Mile Creek. A number of tributary waterways and drains discharge northwards through the town area and into Four Mile Creek within the Jindera FRMP area.

Jindera has been affected by flooding most recently in 2005, 2008, 2010, 2011 and 2012. Very few cases of above floor flooding have been confirmed in these recent floods. Due to the small catchment areas, the lag time between rainfall and peak flooding at Jindera is short, typically 30 minutes to one hour. Flooding duration is similarly short, lasted for at most a few hours.

Flooding conditions are typically characteristic of broad shallow sheet flow, which can spread out over large areas. This is typical for small towns with relatively flat terrain where waterways and drains typically confine low and minor flood flows only.

Flood modelling undertaken as part of the Jindera Flood Study (GHD, 2015) has identified that there are an estimated 23 buildings at risk of 100 year ARI above floor flooding. The maximum depth of above floor 100 year ARI flooding is 0.26 metres. The average depth of above floor 100 year ARI flooding is 0.07 metres.

Flooding impacts are therefore likely to be confined to property damage, with depths and velocities through developed properties not high enough to create the risk of serious injury or, worse case, loss of life.

The average annual flood damage at Jindera is estimated to be $305,000 per annum.

Flood mitigation measures which can be used to reduce flooding impacts are:

- **Property modification measures** which are designed to avoid future development within areas which have a high flood risk or to reduce damages by flood proofing existing development
- **Response modification measures** which are designed to modify the response of the population at risk prior to, during and after a flood
- **Flood modification measures** which are designed to modify flooding conditions by lowering flow rates, flood levels or velocities and excluding floodwaters from protected areas

Almost all of the 23 properties identified as at the highest risk of above floor flooding are clustered in four areas referred to within this report as hotspots. Mitigation options to alleviate flooding impacts at each hotspot were assessed with respect to their effectiveness (reduced future flood damage compared to their cost) and any adverse hydraulic, environmental and social impacts.

The recommended measures are a mixture of property modification, response modification and flood modification measures.

8.2 Recommended Mitigation Measures

The recommended floodplain management plan measures are listed in Table 6. The recommended measures have assigned priorities based on a subjective assessment of the costs and benefits.

8.2.1 Property Modification Measures

Implementing appropriate land use planning and development controls is an integral component of all floodplain risk management plans. In relation to Jindera, the following measures are recommended:

- Adoption of development control Flood Planning Levels (FPLs) based on the 100 year ARI flood level plus 0.3 metre of freeboard
- Adoption of a Flood Planning Area (FPA) as defined on Figure A1 of Appendix A
- Update of the Greater Hume Shire LEP such that it is consistent with the proposed Local Flood Policy for Jindera
- Update of the Greater Hume Shire DCP to incorporate the Local Flood Policy planning and development controls for Jindera (refer to Appendix A)

Although the FPA covers a significant size area, the associated flood based development controls are not particularly restrictive unless the site in question is located within a Floodway (refer to Figure A2) and / or a High Hazard (refer to Figure A3) defined area. The Floodway and High Hazard areas are primarily restricted to the waterway corridors (e.g. Four Mile Creek and its tributary waterways).

Most of the FPA area is designated as Flood Fringe and Low Hazard. The main development control applied to these areas is minimum floor levels. The minimum floor level for new residential development must be at or above the FPL (100 year ARI flood level plus 0.3 metre).

8.2.2 Response Modification Measures

The catchment draining to Jindera is relatively small. Installing telemetered rainfall and streamflow gauges is therefore not proposed given the very limited flood warning time available to respond to an imminent flood.

Subsequent to the completion of the FRMPs within the Shire, a Local Flood Plan (LFP) for the Greater Hume Shire should be prepared by the SES. The LFP will detail operations relating to flood preparedness measures, flood response measures and flood recovery measures.

The following community awareness measures are recommended:

- Establishment of a flood information facility on Council's web site where flood response information (e.g. Local Flood Plan), detailed flood information (e.g. reports and maps from this project) and other useful information relating to flooding can be accessed by the community
- Inclusion of expanded flooding information on Section 149 certificates issued by Council
- Construction of a flood marker at a suitable prominent location within parkland adjoining Four Mile Creek (e.g. Pioneer Park)

It is important that flood data be collected both during and in the aftermath of future flood events. The data can be used for future investigations associated with the update of the Jindera FRMP. Future data collection should focus on:

- Large floods (i.e. where flooding leads to inundation of low lying developed properties)
- Photographs if possible at or near the peak of flooding
- Recording reliable peak flood levels and their subsequent survey to the AHD datum
- Details of any instances of above floor flooding

Flood Modification Measures

Flood modification measures to alleviate flooding risks to those properties with the greatest risk of above floor flooding were assessed as part of the FRMS. The assessment focused on four identified hotspots (i.e. areas containing clusters of buildings at risk of above floor flooding in a 100 year ARI flood).

Council will be responsible for the implementation of the flood modification measures subject to its own funding constraints. Some funding may be available through the NSW Government's Floodplain Risk Management Program.

Watson Street Drain (Hotspot 1)

Council recently completed an upgrade of the Watson Street Main Drain between Four Mile Creek and Jindera Street in 2013 / 2014. This resulted in the discharge capacity of the previous drain being more than doubled.

The 2013 / 2014 works have significantly alleviated flooding risks along the Watson Street Drain route downstream of Jindera Street. Flooding problems remain however including four houses subject to above floor flooding in Jindera Street, the need to replace the existing temporary drain and levee works in Jindera Street and the problems caused by overflows down Pioneer Drive eastwards into the Pioneer Drive Drain catchment.

Various mitigation option assessments are documented in Section 7.1 of this report. This includes extending the Watson Street Drain from its current upstream limit at Jindera Street a further 540 metres to Pioneer Drive in combination with berm works to prevent overflows down the southern side of Pioneer Drive. Although this option eliminates the problems present at Hotspot 1, it does result in an increase in flows and flood levels within the existing downstream Watson Street Drain and Four Mile Creek. This is due to the capture of the Pioneer Drive overflows and the increased drainage efficiency associated with the drain extension.

The Watson Street Drain extension cannot therefore be nominated for implementation without other measures to offset the effect of the works downstream of Jindera Street. The following additional works are therefore proposed to achieve this:

- Construction of a 650 metres diversion drain from Pioneer Drive to the waterway on the north side of Bungowannah Road as shown on Figure 4.
- Vegetation management works along Four Mile Creek (i.e. removal of exotic vegetation and low value native vegetation).

The benefit cost ratio of the above combined works is 0.37 (Table 3). The works will however provide additional benefits in the form of potentially allowing the development of properties fronting onto the west side of Jindera Street.

8.2.3 Hotspot 2

Three options were assessed for mitigating flood impacts on the south side of Four Mile Creek between Watson Street and Mitchell Street.

Option 1 involves an upgrade of the Jindera Street Four Mile Creek culvert crossing. Hydraulic modelling has confirmed that this option would be ineffective.

Option 3 involves an 870 m levee on the south side of Four Mile Creek. Problems associated with this option include insufficient space for an earth levee at some locations, adverse aesthetic / visual impacts taking into account the crest will need to be a minimum of 0.5 metre above the 100 year ARI flood level, practical difficulties associated with the levee crossing at Urana Street and increases in flood levels on the north side of the creek due to the obstruction effect of the levee. Option 3 was consequently not recommended due to these reservations.

Option 2 involves the removal of high density vegetation along the creek corridor route. This is not a high cost measure and despite the flood mitigation benefits being modest (reduction in the AAD of $24,000), the option achieves a benefit cost ratio of 1.00. Option 2 would however need to be largely constrained to the removal of exotic vegetation and low value native vegetation (e.g. small regrowth). The removal of high value native vegetation is not environmentally acceptable.

Given the above and the outcome of the mitigation option assessment for Hotspot 1, the recommendation for Hotspot 2 is as follows:

- Survey of vegetation conditions along the creek corridor between Goulburn Street and Jindera Street, focusing on identifying exotic vegetation, low value native vegetation and excessive channel debris present suitable for potential removal
- Council to subsequently undertake discussions with residents in relation to the removal of exotic vegetation or at least a reduction in density, particularly within and close to the Four Mile Creek channel.
- Vegetation removal works to follow

A further consideration in relation to vegetation management works along the Four Mile Creek corridor is bush fire risk mitigation. The Four Mile Creek corridor is within a Strategic Fire Advantage Zone as identified by the Hume Zone Bush Fire Risk Management Plan (Hume Zone Bush Fire Risk Management Committee, 2015). Vegetation management works to mitigate bush fire risks may give cause for more extensive works than that proposed solely for flood mitigation purposes.

8.2.4 Hotspot 3

The existing drainage system in the vicinity of the Urana Street and Molkentin Road intersection does not provide an adequate level of service, particularly given the ongoing development which is occurring within the upstream catchment.

There are a number of alternative arrangements by which an upgrade of the main drain at this location could be completed (refer to Figures 11 and 12).

The upgrade of the existing drain between the upstream side of Urana Street and the downstream side of the Molkentin Road is included within the FRMP. The section of drain in question forms part of the Pioneer Drive Drain. The works will alleviate flooding impacts for those properties in the immediate vicinity.

The benefit cost ratio for the works is not high however and less than that likely to be required to attract State and Commonwealth Government funding.

8.2.5 Hotspot 4

Drainage improvement works on the south side of the Industrial Estate will alleviate flooding impacts on the existing industrial properties and also allow for the next stage of the Industrial Estate expansion to proceed. The proposed works are shown on Figure 13.

The drainage system to the south of the Industrial estate is quite complex, particularly the interaction between overland flow conveyed within the Urana Road reserve and the flow carried by the drain reserve between the Industrial Estate and Urana Road. The discharge capacity of the drain within the drainage reserve can be upgraded in the future if conditions in future floods confirm a need for this.

Table 6 Recommended Floodplain Management Plan Measures

Measure Description	Priority	Indicative Capital Cost ($)	Funding Sources
Property Modification Measures			
- Endorse land use planning approach outlined in Plan	High	Nil	Council
- Refine & incorporate flood planning and development controls into LEP & DCP	High	Nil	Council
Response Modification Measures			
- Include expanded flooding information on S149 certificates	High	Ongoing	Council
- Develop and maintain flood information on Council's web site	High	5,000	Council / OEH / SES
- Prepare a Local Flood Plan	Moderate	10,000	SES
- Data collection and documentation in future floods	Moderate	Ongoing	Council / OEH / SES
- Construct flood marker adjacent to Four Mile Creek in Pioneer Park	Low	10,000	Council
Flood Modification Measures			
- Industrial Estate Drain Extension	High	180,000	Council
- Four Mile Creek – vegetation management works	High	180,000	Council / OEH
- Pioneer Drive Drain Works at Urana Street & Molkentin Road	Medium	370,000	Council
- Watson Street Drain Extension	Medium	420,000	Council / OEH
- Diversion Channel – Pioneer Drive to downstream side of Bungowannah Rd	Medium	530,000	Council / OEH

Note:

1. Costs are indicative only and should be reviewed following any further design or investigation activities.

8.3 Implementation/Funding

There are a number of possible funding sources that could be considered by Council to assist with the implementation of the Floodplain Risk Management Plan. Potential funding sources include:

- Council contributed funds
- NSW State Government and Australian Commonwealth Government funding programmes for the implementation of flood risk mitigation measures
- SES for flood response improvement measures

The majority of NSW State Government financial assistance is likely to come via the NSW Government Floodplain Management Program (the Program). The Program is administered by OEH. Applications under the most recent round of funding within this Program were also eligible for funding assistance under the jointly funded NSW and Commonwealth Government's Natural Disaster Resilience Program.

Funding for vegetation management works could be sourced via the NSW Environmental Trust through OEH. The Environmental Trust offers a range of grant programs that rehabilitate or regenerate the environment. Funding for vegetation management works could also be available through the NSW LLS.

Additional funding for vegetation management works could also be sourced through bush fire mitigation funding or assistance for those vegetation management works which are consistent with the Hume Zone Bush Fire Risk Management Plan (Hume Zone Bush Fire Risk Management Committee, 2015).

The adopted flood modification measures in Table 6 generally have relatively low benefit cost ratios. This reduces the likelihood of Council securing State and Commonwealth funding assistance. Some of these flood modification measures provide additional benefits by potentially allowing for the development of land currently subject to flooding. Developer contribution assistance may therefore provide a further funding source.

Funding under the Program is not available for assistance with measures associated with the applicant's core activities. This would include implementing land use planning and building development controls for example which is a core local government task. Eligible measures include implementing structural mitigation works, flood warning systems, evacuation management, voluntary house raising and voluntary purchase. Applicants are required to provide a certain level of funds for every $1 of grant funding. Funding of investigation and design activities is available. Funding for maintenance activities is generally not available.

9. Acknowledgements

The 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.

The project has been completed with the assistance of the Greater Hume Shire Council's Jindera Floodplain Risk Management Committee, Council's staff, Office of Environment of Heritage's staff, NSW SES staff and the other government agency and local residents who have had involvement in the project. The assistance which has been provided is very much appreciated by Council.

10. Abbreviations and Glossary

10.1 Abbreviations

AAD	Average annual damage
AEP	Annual exceedance probability
AHD	Australian height datum
ARI	Average recurrence interval
BOM	Bureau of Meteorology
DEM	Digital elevation model
EMPLAN	Emergency Management Plan
LEP	Local Environmental Plan
LLS	Local Land Services
FDM	Floodplain Development Manual (2005)
FPA	Flood planning area
FPL	Flood planning level
FRMS	Floodplain Risk Management Study
FRMP	Floodplain Risk Management Plan
OEH	Office of Environment and Heritage
PMF	Probable maximum flood
SES	State Emergency Service

10.2 Glossary

Annual Exceedance Probability (AEP) - AEP (measured as a percentage) is a term used to describe flood size. AEP is the long-term probability between floods of a certain magnitude. For example, a 1% AEP flood is a flood that occurs on average once every 100 years. It is also referred to as the '100 year ARI flood' or '1 in 100 year flood'.

0.2% AEP sometimes referred to as the 500 year ARI event

0.5% AEP sometimes referred to as the 200 year ARI event

1% AEP sometimes referred to as the 100 year ARI event

2% AEP sometimes referred to as the 50 year ARI event

5% AEP sometimes referred to as the 20 year ARI event

10% AEP sometimes referred to as the 10 year ARI event

20% AEP sometimes referred to as the 5 year ARI event

50% AEP sometimes referred to as the 2 year ARI event

Afflux - The increase in flood level upstream of a constriction of flood flows. A road culvert, a pipe or a narrowing of the stream channel could cause the constriction.

Australian Height Datum (AHD) - A common national plane of level approximately equivalent to the height above sea level. All flood levels; floor levels and ground levels in this study have been provided in metres AHD.

Average annual damage (AAD) - Average annual damage is the average flood damage per year that would occur in a nominated development situation over a long period of time.

Average recurrence interval (ARI) - ARI (measured in years) is a term used to describe flood size. It is a means of describing how likely a flood is to occur in a given year. For example, a 100-year ARI flood is a flood that occurs or is exceeded on average once every 100 years.

Catchment - The land draining through the main stream, as well as tributary streams.

Development Control Plan (DCP) - A DCP is a plan prepared in accordance with Section 72 of the *Environmental Planning and Assessment Act, 1979* that provides detailed guidelines for the assessment of development applications.

Design flood level - A flood with a nominated probability or average recurrence interval, for example the 100 year ARI flood is commonly used throughout NSW.

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

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.

Extreme flood - An estimate of the probable maximum flood (PMF), which is the largest flood likely to occur.

Flood - A relatively high stream flow that 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 - An appreciation of the likely effects of flooding and knowledge of the relevant flood warning, response and evacuation procedures.

Flood Fringe - The remaining area of land affected by flooding, after floodway and flood storage areas have been defined. Development in flood fringe areas would not have any significant effect on the pattern of flood flows and / or flood levels.'

Flood hazard - The potential for damage to property or risk to persons during a flood. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.

Flood level - The height of the flood described either as a depth of water above a particular location (e.g. 1m above a floor, yard or road) or as a depth of water related to a standard level such as Australian Height Datum (e.g. the flood level was 77.5 m AHD). Terms also used include flood stage and water level.

Flood liable land - Land susceptible to flooding up to the Probable Maximum Flood (PMF). Also called flood prone land. Note that the term flood liable land now covers the whole of the floodplain, not just that part below the flood planning level, as indicated in the superseded Floodplain Development Manual (NSW Government, 2005).

Flood Planning Levels (FPLs) - The combination of flood levels and freeboards selected for planning purposes, as determined in floodplain management studies and incorporated in floodplain management plans. The concept of flood planning levels supersedes the designated flood or the flood standard used in earlier studies.

Flood Prone Land - Land susceptible to flooding up to the Probable Maximum Flood (PMF). Also called flood liable land.

Flood Storage - Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. If the capacity of a flood storage area is substantially reduced by, for example, the construction of levees or by landfill, flood levels in nearby areas may rise and the peak discharge downstream may be increased. Substantial reduction of the capacity of a flood storage area can also cause a significant redistribution of flood flows.

Flood Study - A study that investigates flood behaviour, including identification of flood extents, flood levels and flood velocities for a range of flood sizes.

Floodplain - The area of land that is subject to inundation by floods up to and including the Probable Maximum Flood event, that is, flood prone land or flood liable land.

Floodplain Risk Management Study – Studies carried out in accordance with the Floodplain Development Manual and which assess options for minimising the danger to life and property during floods.

Floodplain Risk Management Plan - The outcome of a Floodplain Management Risk Study.

Floodway - Those areas of the floodplain where a significant discharge of water occurs during floods. Floodways are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.

Freeboard - A factor of safety expressed as the height above the design flood level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such as wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as “greenhouse” and climate change.

High Flood Hazard - For a particular size flood, there would be a possible danger to personal safety, able-bodied adults would have difficulty wading to safety, evacuation by trucks would be difficult and there would be a potential for significant structural damage to buildings.

Hydraulics Term - given to the study of water flow in waterways, in particular, the evaluation of flow parameters such as water level and velocity.

Hydrology Term - given to the study of the rainfall and runoff process; in particular, the evaluation of peak discharges, flow volumes and the derivation of hydrographs (graphs that show how the discharge or stage/flood level at any particular location varies with time during a flood).

Local catchments - Local catchments are river sub-catchments that feed river tributaries, creeks, and watercourses and channelised or piped drainage systems.

Local Environmental Plan (LEP) – A Local Environmental Plan is a plan prepared in accordance with the *Environmental Planning and Assessment Act*, 1979, that defines zones, permissible uses within those zones and specifies development standards and other special matters for consideration with regard to the use or development of land.

Local overland flooding - Local overland flooding is inundation by local runoff within the local catchment.

Local runoff - local runoff from the local catchment is categorised as either major drainage or local drainage in the NSW Floodplain Development Manual (2005).

Low flood hazard - For a particular size flood, able-bodied adults would generally have little difficulty wading and trucks could be used to evacuate people and their possessions should it be necessary.

Flows or discharges - It is the rate of flow of water measured in terms of volume per unit time.

Flood Planning Area – the area of land below the FPL and thus subject to flood related development controls.

Flood Planning Levels – Are the combination of flood levels and freeboards selected for floodplain risk management purposes and incorporated into floodplain risk management plans.

OEH (formerly DECCW, DECC, DNR, DLWC, DIPNR) - Office of Environment and Heritage. Covers a range of conservation and natural resources science and programs, including native vegetation, biodiversity and environmental water recovery to provide an integrated approach to natural resource management. The NSW State Government Office provides funding and support for flood studies.

Overland flow path - The path that floodwaters can follow if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads. Floodwaters travelling along overland flow paths, often referred to as 'overland flows', may or may not re-enter the main channel from which they left — they may be diverted to another watercourse.

Peak discharge - The maximum flow or discharge during a flood.

Probable Maximum Flood (PMF) - The largest flood likely to ever occur. The PMF defines the extent of flood prone land or flood liable land, that is, the floodplain.

Risk - Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.

Runoff - the amount of rainfall that ends up as flow in a stream, also known as rainfall excess.

SES - State Emergency Service of New South Wales

Stage–damage curve - A relationship between different water depths and the predicted flood damage at that depth.

Velocity - the term used to describe the speed of floodwaters, usually in m/s (metres per second). 10km/h = 2.7m/s.

Water surface profile - A graph showing the height of the flood (flood stage, water level or flood level) at any given location along a watercourse at a particular time.

11. References

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Appendices

Appendix A – Draft Local Flood Policy

Draft Local Flood Policy

Figure A1 – Flood Planning Area

Figure A2 – Hydraulic Category Plan

Figure A3 – Hazard Category Plan

Draft Local Flood Policy

1. Land to which these Development Controls Apply

The development controls in this Local Flood Policy apply to the Flood Planning Area at Jindera as defined by Figure A1.

2. Objectives

The floodplain development controls are intended to:

- Guide the development of flood prone land, applying balanced strategies to economically, socially and environmentally manage the potential flood risk to life and property
- Ensure that sufficient land is set aside to convey and/or store floodwaters and to protect and enhance the riparian zone
- Ensure that development, when considered both individually and in the context of cumulative development trends, will not cause unreasonable adverse flooding impacts in other locations

3. Definitions

Floodway	Those parts of the floodplain where a significant discharge of water occurs during floods. 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 the passage of a flood.
Flood Fringe	The remaining area of land affected by flooding, after floodway and flood storage areas have been defined.
Low Flood Hazard	Those parts of the floodplain where able bodied adults would generally have little difficulty wading and trucks could evacuate people and their possessions should it be necessary.
High Flood Hazard	Those parts of the floodplain where there would be a possible danger to personal safety, able bodied adults would have difficulty wading to safety, evacuation by trucks would be difficult and there would be potential for significant structure damage to buildings.
Flood Planning Area (FPA)	Represents the area below the FPL and thus subject to flood related development controls.
Flood Planning Levels (FPLs)	Is the combination of flood levels and freeboards selected for floodplain risk management purposes.
Flood Prone Land	Land susceptible to flooding by the Probable Maximum Flood event. Flood prone land is synonymous with flood liable land.
Freeboard	Refers to a designated height above the design flood which is stipulated to incorporate a suitable factor of safety into development.

4. Site Classifications

- Flood Planning Area means land as defined by the attached Figure A1. The FPA for the Four Mile Creek flood affected area coincides with the 500 year ARI event. The FPA for all other waterways and drains coincides with the trimmed 100 year ARI extent (i.e. areas where the flood depth is less than 100 mm not included within the FPA).
- Flood Planning Levels coincide with the 100 year ARI flood level plus 0.3 metre as determined by this FRMS&P.
- Floodway, Flood Storage and Flood Fringe Areas means land as defined by the attached Figure A2.
- Low Hazard and High Hazard Areas means land as defined by the attached Figure A3.

5. General - Development within the Flood Planning Area

General Development Standards applicable to the Flood Planning Area are as follows:

a) All development within the Flood Planning Area requires the consent of Council.

b) All development shall be generally assessed in accordance with the latest edition of the NSW Floodplain Development Manual as issued by the NSW Government.

c) Development will not be permitted unless Council is satisfied that the proposed development will not increase the flood hazard rating or likely flood damage to any other property.

6. Development within Floodway Areas

Development Standards applicable to Floodway Areas are as follows.

High Hazard Floodway Areas

Development within High Hazard Floodway areas is generally discouraged. Council may consider granting permission to minor developments including extensions provided the requirements for Low Hazard Floodway areas can be met.

Low Hazard Floodway Areas

a) No alteration in ground levels by more than 100 mm will be permitted, whether by excavation or filling, without the submission of a hydraulic study and prior development consent.

b) The erection of any new habitable structure on land within Floodway Areas will only be permitted if the land is outside the High Hazard area and supported by a hydraulic study demonstrating that the works will have no adverse flooding effect on any other property.

c) Extensions. Extensions of up to 60 m^2 to dwellings are permissible. The floor level of the extension is to be as high as practical without requiring modification to the existing roof line.

d) Fencing. Fences of a continuous (impermeable) design, such as metal cladding, shall not be permissible. Post and rail fences will be permitted providing they are designed to permit the unimpeded flow of floodwater.

7. Development within Flood Storage Areas and Flood Fringe Areas

Development Standards applicable to Flood Storage Areas and Flood Fringe Areas are as follows.

High Hazard Flood Storage and Flood Fringe Areas

The same requirements as those listed under Low Hazard Floodway Areas apply.

Low Hazard Flood Storage and Flood Fringe Areas

a) Development consent is required to be obtained prior to any work or building activity being carried out within the Flood Planning Area. A hydraulic study may be required to be submitted with any Development Application at the discretion of Council.

b) The minimum floor level of any new residential building is to be at the FPL (i.e. 0.3 metres above the 100 year ARI flood level).

c) Commercial and industrial development. At Council's discretion, the minimum floor level is to be at the FPL or the building is to be flood proofed to at least the FPL.

d) Extensions to existing residential buildings.

   i. Where the area of the extension is less than 50% of the existing floor area, the floor level of the extension may be constructed to the same level as the existing floor level.

   ii. Where the extension is greater than 50% of the existing floor area, the minimum floor level of the extension is to be at the FPL.

e) Extensions to existing non-residential buildings. Extensions to existing non-residential buildings may be constructed at the same level as the existing building. At Council's discretion, the complete building is to be flood proofed to the FPL.

f) Carports and open sheds. Carports and open sheds may be constructed at existing ground levels. They must be constructed from flood compatible materials.

g) Fencing. Fencing of a continuous design (e.g. metal cladding) shall be permissible.

8. Development Application Requirements

A development application lodged for development within the Flood Planning Area is to be accompanied by:

a) Existing ground levels of the subject site certified by a registered surveyor.

b) Floodway and / or High Hazard Areas only:

   a. A report from an accredited Consulting Engineer detailing any adverse effects of the proposed development on potential flood damages to the subject property and any other property as a result of the development.

   b. An evacuation plan for the development accompanied by evidence that the local division of the SES has been consulted in the formulation of the plan.

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6,022,000 6,021,000 6,020,000 6,019,000

JINDERA-WALLA WALLA ROAD
DRUMWOOD ROAD
URANA ROAD
QUARTZ HILL ROAD
FOUR MILE CREEK
FOUR MILE CREEK
GIBSON STREET
GOULBURN STREET
CLYNN ROSS CIRCUIT
DIGHTS FOREST ROAD
JINDERA STREET
WOOD STREET
CREEK STREET
HUON STREET
MITCHELL STREET
ADAMS STREET
LUTHER ROAD
ST JOHNS COURT
WATSON STREET
LAWRENCE COURT
FALLON STREET
DIGHT STREET
URANA STREET
VINE DRIVE
ANN DRIVE
BRITTON COURT
PIONEER DRIVE
PECH AVENUE
MOLKENTIN ROAD
FUNK ROAD
BUNGOWANNAH ROAD
URANA ROAD
DAVIS DRIVE
SCHOLZ STREET
STOCKWELL ROAD
BEGG DRIVE

488,000 489,000 490,000 491,000 492,000 493,000

Paper Size A3

0 125 250 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Area Subject to 100 Year ARI Flooding
- Flood Planning Area (FPA) Boundary
- Hydraulic Modelling Extent
- HydroLine
- Cadastre

Greater Hume Shire Council
Jindera Floodplain Risk Management Study

Job Number	31-31790
Revision	C
Date	6 Mar 2017

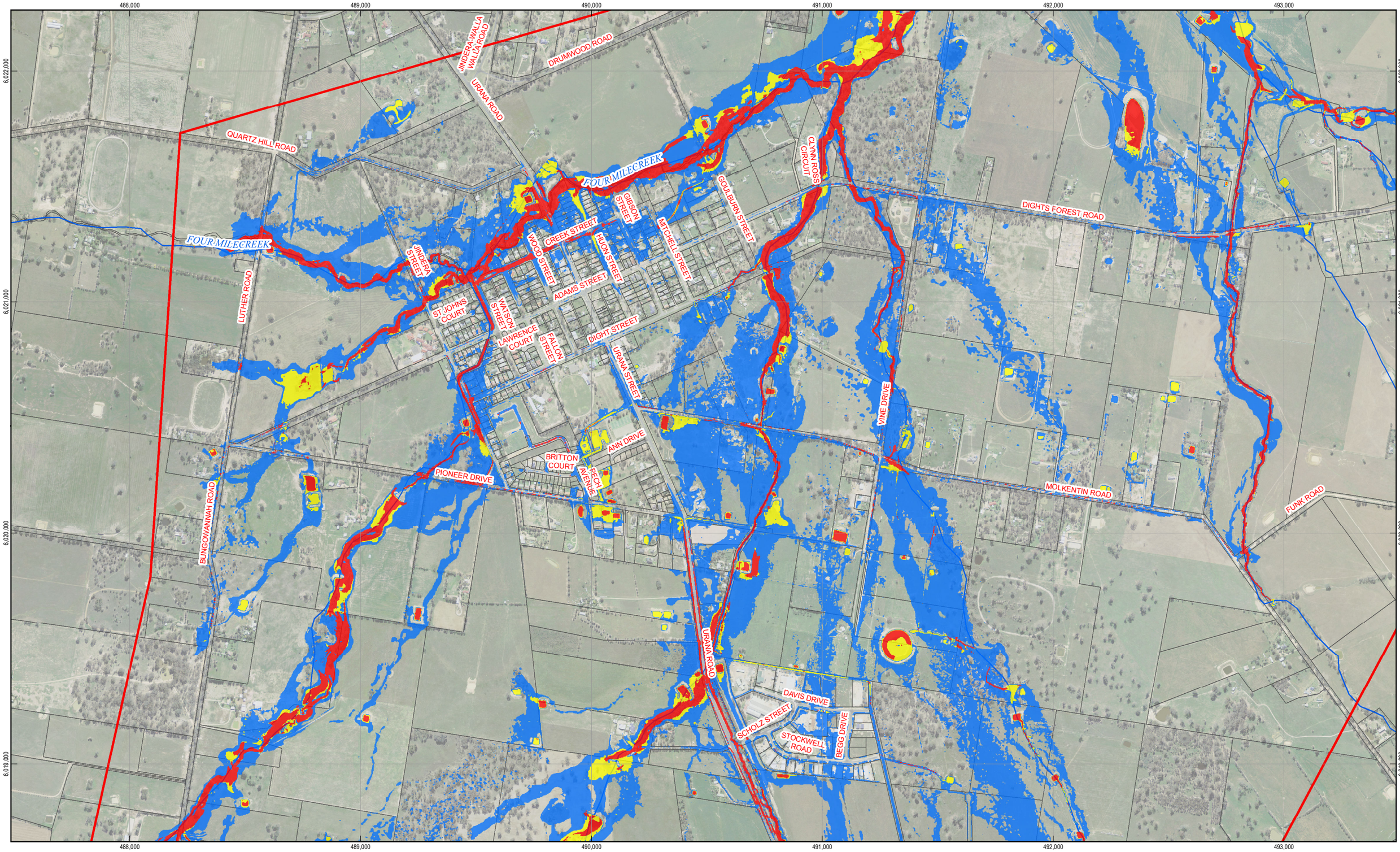
Flood Planning Area

Figure A1

G:\31\31790\GIS\Maps\Deliverables\31_31790_Jindera_FRMP_Fig_A1_100yr_Flood_Planning_Area_Rev_C.mxd

Data source: Flood modelling data, GHD 2014, Imagery, Greater Hume Shire council, 2010. Created by:sldouglas

180 Lonsdale Street Melbourne VIC 3000 Australia **T** 61 3 8687 8000 **F** 61 3 8687 8111 **E** melmail@ghd.com **W** www.ghd.com



Paper Size A3

0 125 250 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Flood Fringe
- Flood Storage
- Floodway
- Hydraulic Modelling Extent
- HydroLine
- Cadastre

Greater Hume Shire Council
Jindera Floodplain Risk Management Study

Job Number 31-31790
Revision A
Date 6 Mar 2017

100 Year ARI Flood Event Hydraulic Category

Figure A2

G:\31\31790\GIS\Maps\Deliverables\31_31790_Jindera_FRMP_Fig_A2_100yr_Hydraulic_Category_Rev_A.mxd

Data source: Flood modelling data, GHD 2014, Imagery, Greater Hume Shire council, 2010. Created by:sldouglas

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488,000 489,000 490,000 491,000 492,000 493,000

6,022,000 6,021,000 6,020,000 6,019,000

JINDERA-WALLA WALLA ROAD
DRUMWOOD ROAD
URANA ROAD
QUARTZ HILL ROAD
FOUR MILE CREEK
GIBSON STREET
GOULBURN STREET
CLYNN ROSS CIRCUIT
DIGHTS FOREST ROAD
CREEK STREET
WOOD STREET
HUON STREET
MITCHELL STREET
JINDERA STREET
ADAMS STREET
LUTHER ROAD
ST JOHNS COURT
WATSON STREET
LAWRENCE COURT
FALLON STREET
DIGHT STREET
URANA STREET
VINE DRIVE
ANN DRIVE
BRITTON COURT
PECH AVENUE
PIONEER DRIVE
MOLKENTIN ROAD
FUNK ROAD
BUNGOWANNAH ROAD
URANA ROAD
DAVIS DRIVE
SCHOLZ STREET
STOCKWELL ROAD
BEGG DRIVE

Paper Size A3

0 125 250 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Low Hazard
- High Hazard
- Hydraulic Modelling Extent
- HydroLine
- Cadastre

Greater Hume Shire Council
Jindera Floodplain Risk Management Study

Job Number 31-31790
Revision A
Date 6 Mar 2017

100 Year ARI Flood Event Hazard Category

Figure A3

G:\31\31790\GIS\Maps\Deliverables\31_31790_Jindera_FRMP_Fig_A3_100yr_Hydraulic_Hazard_Rev_A.mxd

Data source: Flood modelling data, GHD 2014, Imagery, Greater Hume Shire council, 2010. Created by:sldouglas

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Appendix B – Flood Modification Modelling Results

The figures in Appendix B show the change in 100 year ARI flood level (afflux) associated with the particular mitigation option modelled.

Figure B1 – Hotspot 1 – Watson St Drain Extension

Figure B2 – Hotspot 1 – Watson St Drain Extension plus Diversion Channel

Figure B3 – Hotspot 1 – Watson St Drain Extension plus Diversion Channel plus Four Mile Creek Vegetation Management Works

Figure B4 – Hotspot 2 – Option 1 - Upgrade Four Mile Creek Culvert at Urana Street

Figure B5 – Hotspot 2 – Option 2 – Four Mile Creek Vegetation Management

Figure B6 – Hotspot 2 – Option 3 - Four Mile Creek Levee

Figure B7 – Hotspot 3 – Upgrade Pioneer Drive Drain downstream of Urana Street

Figure B8 – Hotspot 4 – Drainage Works on south side Industrial Estate

Paper Size A3

0 50 100 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Cadastre
TUFLOW model boundary

hs1_aff
Change in flood level
Decrease more than 0.1m
Decrease 0.01-0.1m
Change less than 0.01m
Increase 0.01-0.1 m
Increase more than 0.1m

Greater Hume Shire Council
Jindera Floodplain Risk Management Study

Hotspot 1
Watson Street Drain Extension
Change in 100 Year Flood Level (3 hr)

Figure B1

Job Number	31-31790
Revision	B
Date	6 Mar 2017

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Data source: Flood modelling data, GHD 2104. Imagery, Greater Hume Shire Council, 2010. Created by:mlmedwellsquier

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Paper Size A3

0 25 50 100

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Cadastre
- TUFLOW model boundary

aff_hs1_divc

Change in flood level

- Decrease more than 0.1m
- Decrease 0.01-0.1m
- Change less than 0.01m
- Increase 0.01-0.1 m
- Increase more than 0.1m
- Was Wet Now Dry
- Was Dry Now Wet

Greater Hume Shire Council
Jindera Floodplain Risk Management Study

Hotspot 1
Watson Street Drain Extension & Diversion Channel
Change in 100 Year Flood Level

Figure B2

Job Number	31-31790
Revision	B
Date	6 Mar 2017

G:\31\31790\GIS\Maps\Working\3131790_Jindera_Mitigation.mxd

Data source: Flood modelling data, GHD 2104. Imagery, Greater Hume Shire Council, 2010. Created by:sng

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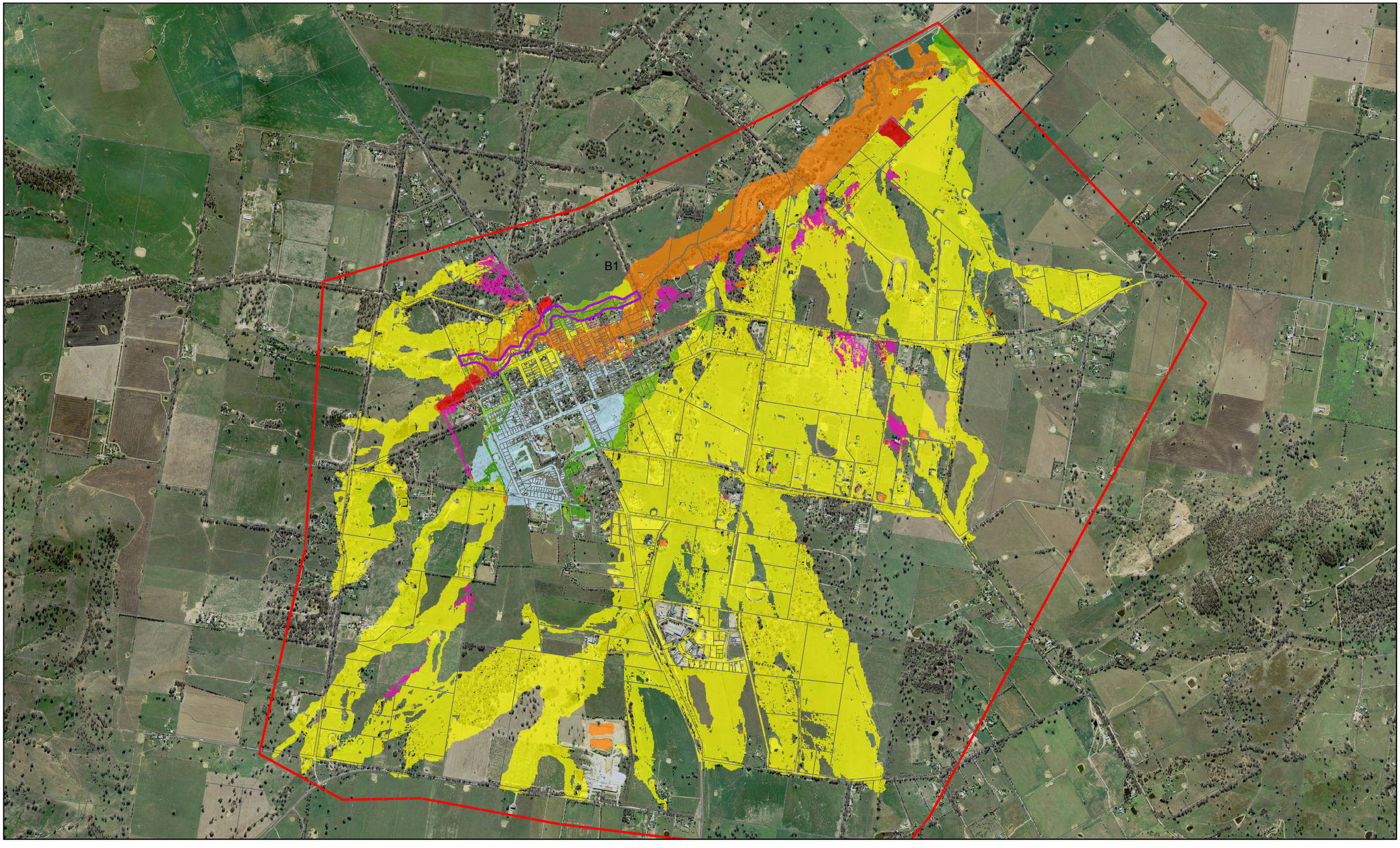

Paper Size A3

0 2500
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Cadastre
- TUFLOW model boundary
- Four Mile Ck Works

aff_100yr_180min_hs1_divc_4mc.flt
Change in flood level

- Decrease more than 0.1m
- Decrease 0.01-0.1m
- Change less than 0.01m
- Increase 0.01-0.1 m
- Increase more than 0.1m
- Was Wet Now Dry
- Was Dry Now Wet

Greater Hume Shire Council
Jindera Floodplain Risk Management Study

Hotspot 1
Watson St Drain Extension plus Diversion Channel plus Four Mile Creek Vegetation Works Figure B3

Job Number	31-31790
Revision	B
Date	6 Mar 2017

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Data source: Flood modelling data, GHD 2104. Imagery, Greater Hume Shire Council, 2010. Created by:sng

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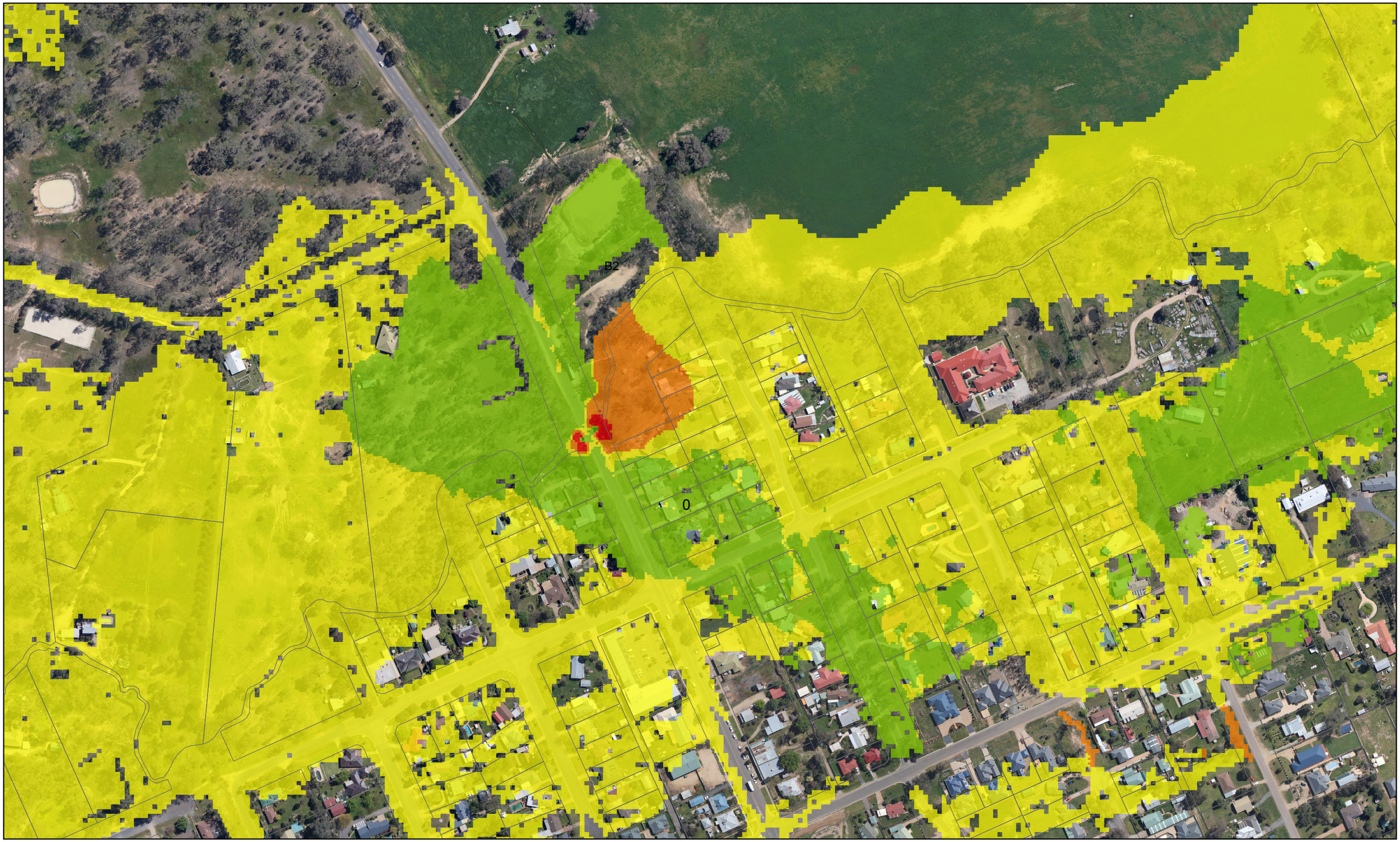

Paper Size A3

0 25 50 100

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Cadastre
TUFLOW model boundary

Aff_HS2_Opt1
Change in flood level (m)
Decrease more than 0.1m
Decrease 0.01-0.1m
Change less than 0.01m
Increase 0.01-0.1 m
Increase more than 0.1m

GHD

Greater Hume Shire Council
Jindera Floodplain Risk Management Study
Hotspot 2
Option 1 Upgrade Four Mile Creek Culvert at Urana
Change in 100 Year Flood Level

Job Number 31-31790
Revision B
Date 6 Mar 2017

Figure B4

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Data source: Flood modelling data, GHD 2104. Imagery, Greater Hume Shire Council, 2010. Created by:mlmedwellsquier

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Paper Size A3

0 25 50 100

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Cadastre
TUFLOW model boundary

Aff_HS2_Opt2

Change in flood level (m)

Decrease more than 0.1m
Decrease 0.01-0.1m
Change less than 0.01m
Increase 0.01-0.1 m
Increase more than 0.1m

Greater Hume Shire Council
Jindera Floodplain Risk Management Study

Hotspot 2
Option 2 Four Mile Creek Vegetation Management
Change in 100 Year Flood Level

Figure B5

Job Number	31-31790
Revision	B
Date	6 Mar 2017

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Data source: Flood modelling data, GHD 2104. Imagery, Greater Hume Shire Council, 2010. Created by:mlmedwellsquier

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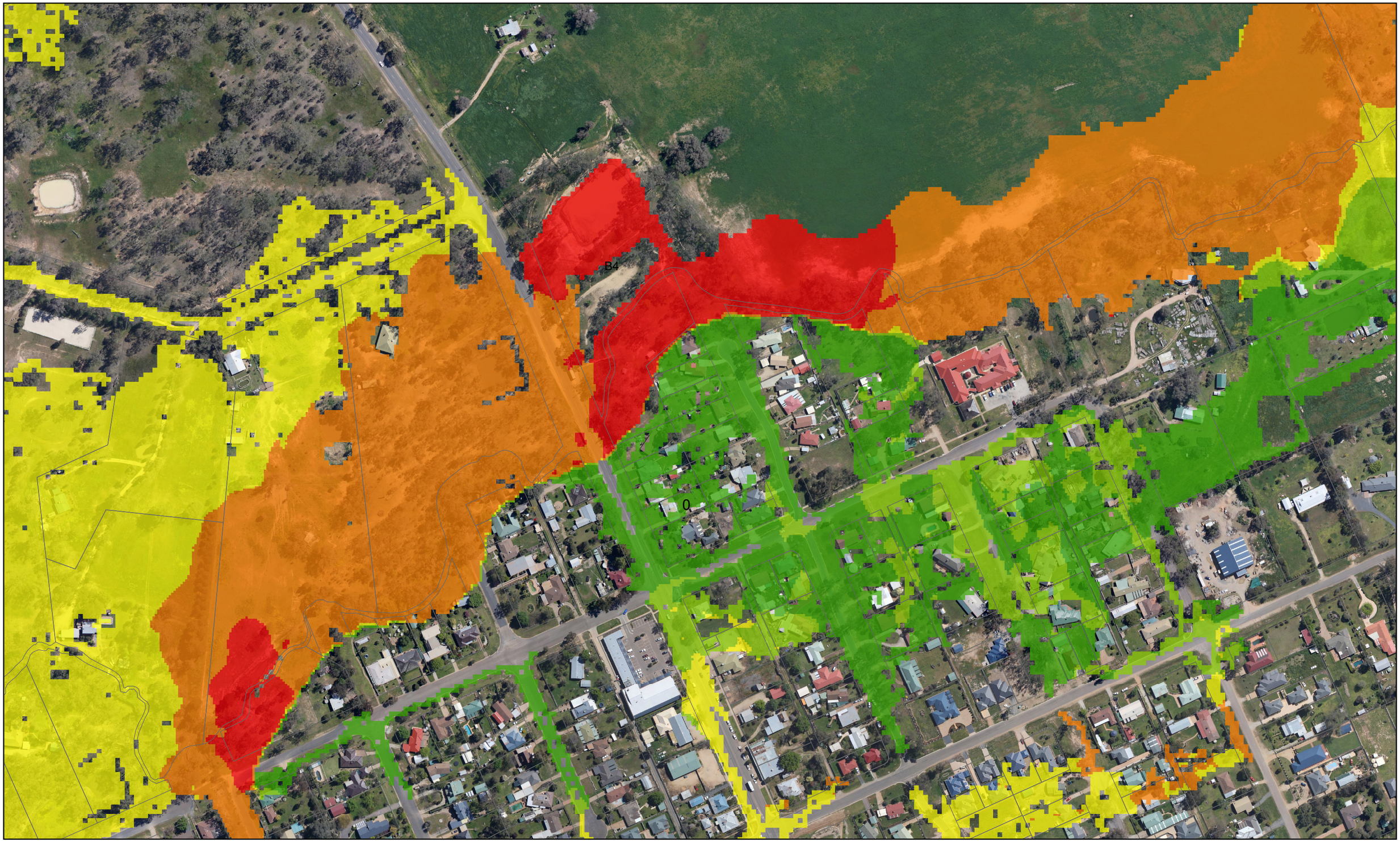

Paper Size A3

0 25 50 100

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Cadastre
- TUFLOW model boundary

Aff_HS2_Opt3

Change in flood level (m)

- Decrease more than 0.1m
- Decrease 0.01-0.1m
- Change less than 0.01m
- Increase 0.01-0.1 m
- Increase more than 0.1m

Greater Hume Shire Council
Jindera Floodplain Risk Management Study

Hotspot 2
Option 3 Four Mile Creek Levee
Change in 100 Year Flood Level

Job Number	31-31790
Revision	B
Date	6 Mar 2017

Figure B6

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Data source: Flood modelling data, GHD 2104. Imagery, Greater Hume Shire Council, 2010. Created by:mlmedwellsquier

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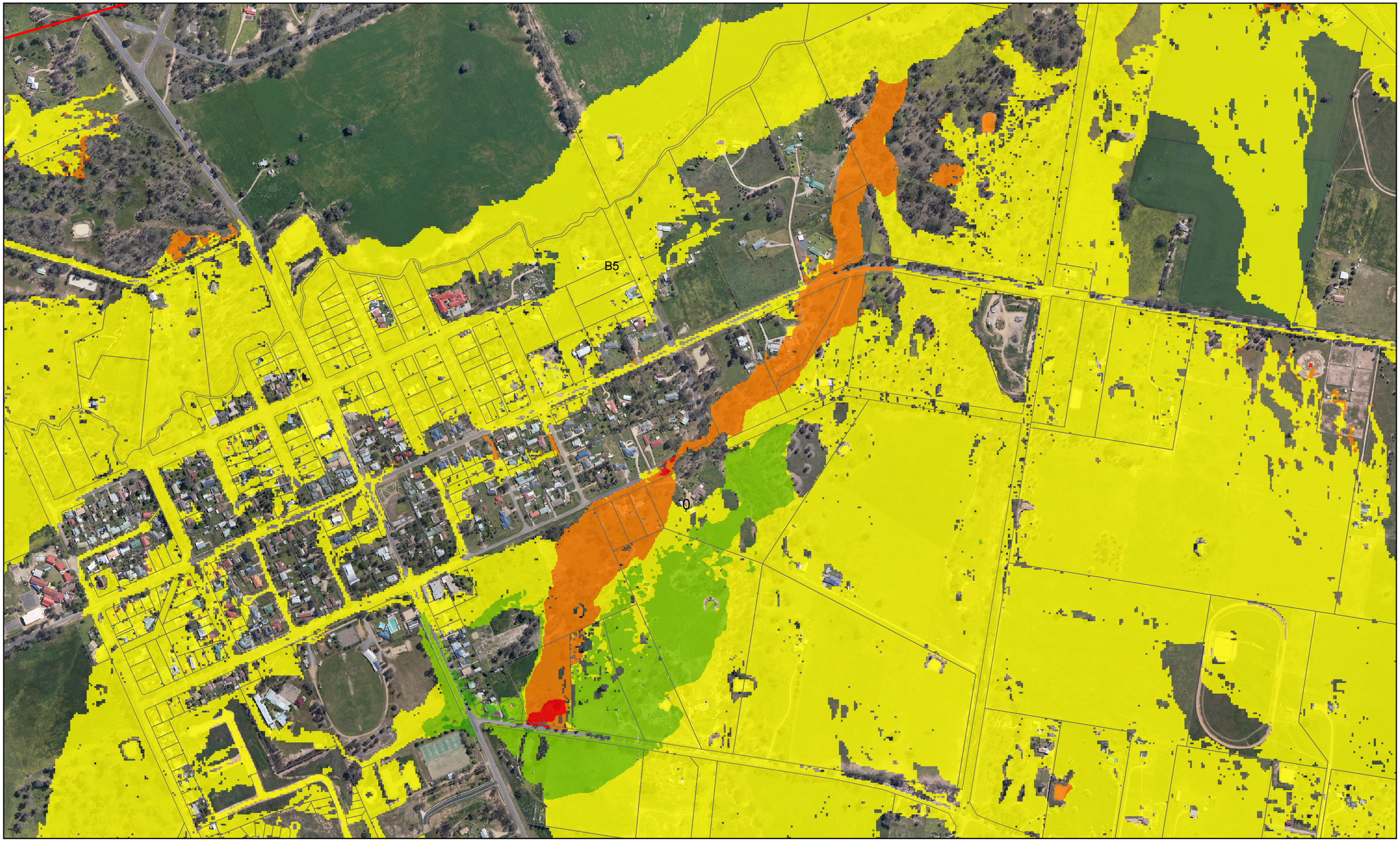

Paper Size A3

0 50 100 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Cadastre
TUFLOW model boundary

aff_hs3
Change in flood level
Decrease more than 0.1m
Decrease 0.01-0.1m
Change less than 0.01m
Increase 0.01-0.1 m
Increase more than 0.1m

GHD

Greater Hume Shire Council
Jindera Floodplain Risk Management Study

Hotspot 3
Upgrade Pioneer Drive Drain downstream Urana St
Change in 100 Year Flood Level

Figure B7

Job Number	31-31790
Revision	B
Date	6 Mar 2017

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Data source: Flood modelling data, GHD 2104. Imagery, Greater Hume Shire Council, 2010. Created by:mlmedwellsquier

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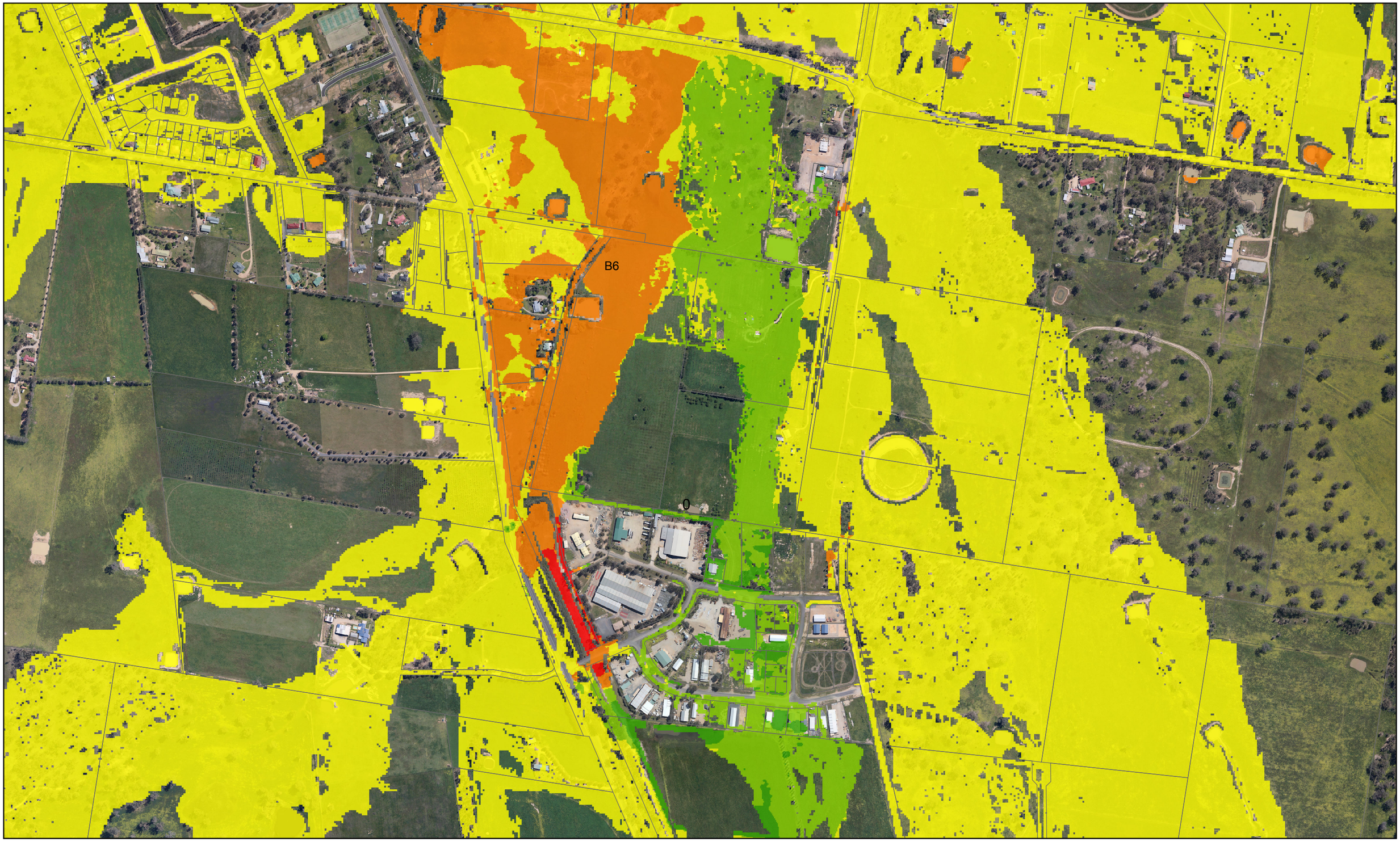

Paper Size A3

0 50 100 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Cadastre
TUFLOW model boundary

aff_hs4
Change in flood level
Decrease more than 0.1m
Decrease 0.01-0.1m
Change less than 0.01m
Increase 0.01-0.1 m
Increase more than 0.1m

GHD

Greater Hume Shire Council
Jindera Floodplain Risk Management Study

Hotspot 4
Drainage Works on south side Industrial Estate
Change in 100 Year Flood Level

Figure B8

Job Number	31-31790
Revision	B
Date	6 Mar 2017

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Data source: Flood modelling data, GHD 2104. Imagery, Greater Hume Shire Council, 2010. Created by:mlmedwellsquier

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Appendix C – Flood Modification Measures – Costs Estimates

Table C1 - Cost Estimate Hotspot 1 - Watson Street Drain Extension

TO: Greater Hume Shire Council **Date** 4-Oct-16

FROM: GHD Pty Ltd **Revision No.** 0

WORKS: Watson St Drain extension - Jindera St to Pioneer Drive **Job No.** 3131790

Element		Quantity	Unit	Rate (ex GST)	Amount	Contingency (%)	Contingency	Revised Fee
Preliminaries								
	Site survey - setout		Item	$10,000	$10,000	20%	$2,000	$12,000
	Project Management Costs		Item	$15,000	$15,000	20%	$3,000	$18,000
	Contractors Establishment		Item	$5,000	$5,000	20%	$1,000	$6,000
	Contractors Foreman Supervision	240	hrs	$90	$21,600	20%	$4,320	$25,920
	Contractors Engineer Supervision	120	hrs	$140	$16,800	20%	$3,360	$20,160
	Sediment and erosion control		Item	$10,000	$10,000	20%	$2,000	$12,000
	Environmental approvals		item	$30,000	$30,000	20%	$6,000	$36,000
	Land acquisition	1.65	ha	$5,000	$8,250	20%	$1,650	$9,900
	Traffic Control		item	$10,000	$10,000	20%	$2,000	$12,000
	Sub Total P				**$126,650**		**$25,330**	**$151,980**
Topsoil Strip & Stockpile								
	Strip area under channel and bund and stockpile	1650	m^3	$5	$8,250	20%	$1,650.0	$9,900.0
	Sub Total TS & S				**$8,250**		**$1,650**	**$9,900**
Berm and channel construction								
	excavation of channel and construction of berm - cut	7800	m^3	$10	$78,000	20%	$15,600	$93,600
	excavation of channel and construction of berm - fill	1500	m^3	$10	$15,000	20%	$3,000	$18,000
	spread topsoil	1650	m^3	$5	$8,250	20%	$1,650	$9,900
	seed reserve	1.65	ha	$3,200	$5,280	20%	$1,056	$6,336
	Berm at Pioneer Drive	Item			$50,000	20%	$10,000	$60,000
	Sub Total B&CC				**$156,530**		**$31,306**	**$187,836**
	COMBINED SUB-TOTALS ...				**$291,430**		**$58,286**	**$349,716**
	Design	**10**	%					**$34,972**
	Total excluding GST							**$384,688**
	GST ...	**10**	%					**$38,469**
	TOTAL incl GST ...							**$423,156**

Table C2- Cost Estimate Hotspot 1 - Diversion Channel via Bungowannah Road

TO: Greater Hume Shire Council **Date** 4-Oct-16

FROM: GHD Pty Ltd **Revision No.** 0

WORKS: **650 m Diversion Channel: Pioneer Dr - Bungowannah Rd** **Job No.** 3131790

Element		Quantity	Unit	Rate (ex GST)	Amount	Contingency (%)	Contingency	Revised Fee
Preliminaries								
	Site survey - setout		Item	$5,000	$10,000	20%	$2,000	$12,000
	Project Management Costs		Item	$15,000	$15,000	20%	$3,000	$18,000
	Contractors Establishment		Item	$5,000	$5,000	20%	$1,000	$6,000
	Contractors Foreman Supervision	240	hrs	$90	$21,600	20%	$4,320	$25,920
	Contractors Engineer Supervision	120	hrs	$140	$16,800	20%	$3,360	$20,160
	Sediment and erosion control		Item	$10,000	$5,000	20%	$1,000	$6,000
	Environmental approvals		item	$10,000	$10,000	20%	$2,000	$12,000
	Easement acquisition	1.3	Item	$10,000	$13,000	20%	$2,600	$15,600
	Traffic Control		item	$10,000	$5,000	20%	$1,000	$6,000
	Sub Total P				**$101,400**		**$20,280**	**$121,680**
Formation of open channel - earthworks								
	Strip area under channel and bund and stockpile	1950	m^3	$5	$9,750	20%	1,950	11,700
	Excavation and formation of open channel	10400	m3	$10	$104,000	20%	20,800	124,800
	spread topsoil	1950	m3	$10	$19,500	20%	3,900	23,400
	seed reserve	1.3	ha	$3,200	$4,160	20%	832	4,992
	Sub Total TS & S				**$9,750**		**$1,950**	**$164,892**
Culvert structure (Bungowannah Road)								
	Supply and deliver 1500 x900 BCs	69	m	$700	$48,300	20%	9,660	57,960
	Supply headwalls	2	Item	$5,000	$10,000	20%	2,000	12,000
	Base slab	130	m2	$60	$7,800	20%	1,560	9,360
	Excavator	120	hrs	$160	$19,200	20%	3,840	23,040
	Truck plus 4 man crew	120	hrs	$260	$31,200	20%	6,240	37,440
	Pavement over new culverts	100	m3	$60	$6,000	20%	1,200	7,200
	seal	250	m2	$15	$3,750	20%	750	4,500
	Sub Total B&CC				**$126,250**		**$25,250**	**$151,500**
	COMBINED SUB-TOTALS ...				**$237,400**		**$47,480**	**$438,072**
	Design	**10**	%					**43,807**
	Total excluding GST							**481,879**
	GST ...	**10**	%					**48,188**
	TOTAL incl GST ...							**$530,067**

Table C3 - Cost Estimate Hotspot 2 - Urana Street Culvert Upgrade

TO: Greater Hume Shire Council **Date** 4-Oct-16

FROM: GHD Pty Ltd **Revision No.** 0

WORKS: **Urana Rd Culvert Upgrade** **Job No.** 3131790

Element		Quantity	Unit	Rate (ex GST)	Amount	Contingency (%)	Contingency	Revised Fee
Preliminaries								
	Site survey - setout		Item	$5,000	$5,000	20%	$1,000	$6,000
	Compaction tests during construction		Item	$0	$0	20%	$0	$0
	Project Management Costs		Item	$5,000	$5,000	20%	$1,000	$6,000
	Contractors Establishment		Item	$3,000	$3,000	20%	$600	$3,600
	Contractors Foreman Supervision	160	hrs	$90	$14,400	20%	$2,880	$17,280
	Contractors Engineer Supervision	80	hrs	$140	$11,200	20%	$2,240	$13,440
	Sediment and erosion control		Item	$5,000	$5,000	20%	$1,000	$6,000
	Traffic Control		item	$15,000	$15,000	20%	$3,000	$18,000
	Sub Total P				**$58,600**		**$11,720**	**$70,320**
Culvert Works								
	supply and deliver new culverts 3 cell 2700 x 2400 RCBC	36	m	$2,400	$86,400	20%	$17,280	$103,680
	supply new headwalls	2	each	$10,000	$20,000	20%	$4,000	$24,000
	excavation for new culvert crossing adjacent to existing		Item	$5,000	$5,000	20%	$1,000	$6,000
	300mm DGS 20 base underneath base slab. Supply place and compact	50	m^3	$60	$3,000	20%	$600	$3,600
	Cast-in-situ base slabs for culverts 300mm thick	40	m3	$350	$14,000	20%	$2,800	$16,800
	Excavator	60	hr	$160	$9,600	20%	$1,920	$11,520
	Crane for placement of culverts	40	hr	$200	$8,000	20%	$1,600	$9,600
	Truck + 4 man crew; form up and pour slabs	24	hrs	$260	$6,240	20%	$1,248	$7,488
	Truck + 4 man crew; RCBC placement	80	hrs	$260	$20,800	20%	$4,160	$24,960
	Pavement over culverts- DGS20 - supply place and compact	200	m3	$60	$12,000	20%	$2,400	$14,400
	2 coat spray seal wearing course 14/7	350	m2	$15	$5,250	20%	$1,050	$6,300
	Sub Total AC				**$190,290**		**$38,058**	**$228,348**
	COMBINED SUB-TOTALS ...				**$248,890**		**$49,778**	**$298,668**
	Detailed design	**10**	%					**$29,867**
	Total excluding GST							**$328,535**
	GST ...	**10**	%					**$32,853.48**
	TOTAL incl GST ...							**$361,388**

Table C4 - Cost Estimate Hotspot 2 - Four Mile Creek Vegetation Management

TO: Greater Hume Shire Council **Date** 4-Oct-16

FROM: GHD Pty Ltd **Revision No.** 0

WORKS: **Four Mile Creek - Vegetation Management** **Job No.** 3131790

Element		Quantity	Unit	Rate (ex GST)	Amount	Contingency (%)	Contingency	Revised Fee
Preliminaries								
	Vegetation site survey		Item	$15,000	$25,000	20%	$5,000	$30,000
	Compaction tests during construction		Item	$15,000	$0	20%	$0	$0
	Project Management Costs		Item	$15,000	$10,000	20%	$2,000	$12,000
	Contractors Establishment		Item	$10,000	$5,000	20%	$1,000	$6,000
	Contractors Foreman Supervision	120	hrs	$90	$10,800	20%	$2,160	$12,960
	Contractors Engineer Supervision	60	hrs	$140	$8,400	20%	$1,680	$10,080
	Sediment and erosion control		item	$10,000	$10,000	20%	$2,000	$12,000
	Easement acquisition		item	$20,000	$0	20%	$0	$0
	Traffic Control		item	$10,000	$5,000	20%	$1,000	$6,000
	Environmental approvals		item	$15,000	$10,000	20%	$2,000	$12,000
	Sub Total P				**$84,200**		**$16,840**	**$101,040**
Tree and shrub removal								
	Full removal from site	2000	m	$20	$40,000	20%	$8,000	$48,000
	Sub Total TS & S				**$40,000**		**$8,000**	**$48,000**
Other items								
		2.9	m	$3,200	$0	20%	$0	$0
			Item	$50,000	$0	20%	$0	$0
		0	hr	$260	$0	20%	$0	$0
		0	hr	$160	$0	20%	$0	$0
		0	m^2	$30	$0	20%	$0	$0
	Sub Total IP				**$0**		**$0**	**$0**
	Construction Total ...				**$124,200**		**$24,840**	**$149,040**
	Detailed Design (& pre works landholder consultation)	**10**	%					**$14,904**
	Total excluding GST							**$163,944**
	GST ...	**10**	%					**$16,394.40**
	Total incl GST ...							**$180,338**

Table C5 - Cost Estimate Hotspot 2 - Four Mile Creek Levee

TO: Greater Hume Shire Council **Date** 4-Oct-16

FROM: GHD Pty Ltd **Revision No.** 0

WORKS: **Four Mile Creek Levee Option (500 mm freeboard assumed)** **Job No.** 3131790

Element		Quantity	Unit	Rate (ex GST)	Amount	Contingency (%)	Contingency	Revised Fee
Preliminaries								
	Site survey		Item	$15,000	$15,000	20%	$3,000	$18,000
	Compaction tests during construction		Item	$15,000	$15,000	20%	$3,000	$18,000
	Project Management Costs		Item	$15,000	$15,000	20%	$3,000	$18,000
	Contractors Establishment		Item	$10,000	$10,000	20%	$2,000	$12,000
	Contractors Foreman Supervision	480	hrs	$90	$43,200	20%	$8,640	$51,840
	Contractors Engineer Supervision	240	hrs	$140	$33,600	20%	$6,720	$40,320
	Sediment and erosion control		item	$10,000	$10,000	20%	$2,000	$12,000
	Easement acquisition		item	$20,000	$50,000	20%	$10,000	$60,000
	Traffic Control		item	$10,000	$10,000	20%	$2,000	$12,000
	Environmental approvals		item	$15,000	$15,000	20%	$3,000	$18,000
	Sub Total P				**$216,800**		**$43,360**	**$260,160**
Topsoil Strip & Stockpile								
	Strip area under levee and stockpile	2000	m3	$10	$20,000	20%	$4,000	$24,000
	Sub Total TS & S				**$20,000**		**$4,000**	**$24,000**
Earthworks								
	Supply & tranport fill material to site	3600	m^3	$20	$72,000	20%	$14,400	$86,400
	Placement and compaction of materials for Levee	3600	m^3	$10	$36,000	20%	$7,200	$43,200
	Supply, transport to site & spread topsoil (0.05 m deep)	1500	m^3	$30	$45,000	20%	$9,000	$54,000
	Seed levee area	2.9	ha	$3,200	$9,280	20%	$1,856	$11,136
	Sub Total E				**$162,280**		**$32,456**	**$194,736**
Other items								
	Reinstate disturbed areas following construction	2.9	m	$3,200	$9,280	20%	$1,856	$11,136
	Local drainage works provisional allowance		Item	$50,000	$50,000	20%	$10,000	$60,000
		0	hr	$260	$0	20%	$0	$0
		0	hr	$160	$0	20%	$0	$0
		0	m^2	$30	$0	20%	$0	$0
	Sub Total IP				**$59,280**		**$11,856**	**$71,136**
	Construction Total ...				**$458,360**		**$91,672**	**$550,032**
	Detailed Design	**10**	%					**$55,003**
	Total excluding GST							**$605,035**
	GST ...	**10**	%					**$60,503.52**
	Total incl GST ...							**$665,539**

Table C6 - Cost Estimate Hotspot 3 - Pioneer Drive Drain Extension

TO: Greater Hume Shire Council **Date** 4-Oct-16

FROM: GHD Pty Ltd **Revision No.** 0

WORKS: **Pionneer Drive Drain extension - Urana Street to downstream side of Molkentin Road** **Job No.** 3131790

Element		Quantity	Unit	Rate (ex GST)	Amount	Contingency (%)	Contingency	Revised Fee
Preliminaries								
	Site survey - setout		Item	$5,000	$10,000	20%	$2,000	$12,000
	Project Management Costs		Item	$15,000	$15,000	20%	$3,000	$18,000
	Contractors Establishment		Item	$5,000	$5,000	20%	$1,000	$6,000
	Contractors Foreman Supervision	240	hrs	$90	$21,600	20%	$4,320	$25,920
	Contractors Engineer Supervision	120	hrs	$140	$16,800	20%	$3,360	$20,160
	Sediment and erosion control		Item	$10,000	$5,000	20%	$1,000	$6,000
	Environmental approvals		item	$20,000	$10,000	20%	$2,000	$12,000
	Land acquisition	0.5	Item	$10,000	$5,000	20%	$1,000	$6,000
	Traffic Control		item	$10,000	$5,000	20%	$1,000	$6,000
	Sub Total P				**$93,400**		**$18,680**	**$112,080**
Formation of open channel - earthworks								
	Strip area under channel and bund and stockpile	400	m^3	$5	$2,000	20%	400	2,400
	Excavation and formation of open channel	1300	m3	$10	$13,000	20%	2,600	15,600
	spread topsoil	400	m3	$10	$4,000	20%	800	4,800
	seed reserve	0.3	ha	$3,200	$960	20%	192	1,152
	Sub Total TS & S				**$2,000**		**$400**	**$23,952**
Culvert structures (Urana Street and Molkentin Road)								
	Supply and deliver 1200 x450 BCs	160	m3	$420	$67,200	20%	13,440	80,640
	Supply headwalls	4	Item	$3,000	$12,000	20%	2,400	14,400
	Base slab	45	m^3	$60	$2,700	20%	540	3,240
	Excavator	120	hrs	$160	$19,200	20%	3,840	23,040
	Truck plus 4 man crew	120	hrs	$260	$31,200	20%	6,240	37,440
	Pavement over new culverts	100	m3	$60	$6,000	20%	1,200	7,200
	seal	250	m2	$15	$3,750	20%	750	4,500
	Sub Total B&CC				**$142,050**		**$28,410**	**$170,460**
	COMBINED SUB-TOTALS ...				**$237,450**		**$47,490**	**$306,492**
	Design	**10**	%					**30,649**
	Total excluding GST							**337,141**
	GST ...	**10**	%					**33,714**
	TOTAL incl GST ...							**$370,855**

Table C7 - Cost Estimate Hotspot 4 - Industrial Estate Drain Extension Works

TO: Greater Hume Shire Council **Date** 4-Oct-16

FROM: GHD Pty Ltd **Revision No.** 0

WORKS: **Drain 1 extension (Swale 1 and Swale 2 as per SJE Consulting design drawings)** **Job No.** 3131790

Element		Quantity	Unit	Rate (ex GST)	Amount	Contingency (%)	Contingency	Revised Fee
Preliminaries								
	Site survey - setout		Item	$5,000	$10,000	20%	$2,000	$12,000
	Project Management Costs		Item	$5,000	$5,000	20%	$1,000	$6,000
	Contractors Establishment		Item	$5,000	$5,000	20%	$1,000	$6,000
	Contractors Foreman Supervision	240	hrs	$60	$14,400	20%	$2,880	$17,280
	Contractors Engineer Supervision	120	hrs	$120	$14,400	20%	$2,880	$17,280
	Sediment and erosion control		Item	$5,000	$5,000	20%	$1,000	$6,000
	Environmental approvals		item	$5,000	$10,000	20%	$2,000	$12,000
	Land acquisition	0	Item	$10,000	$0	20%	$0	$0
	Traffic Control		item	$5,000	$5,000	20%	$1,000	$6,000
	Sub Total P				**$68,800**		**$13,760**	**$82,560**
Formation of open channel - earthworks								
	Strip area under channel and bund and stockpile	170	m^3	$5	$850	20%	$170.0	$1,020.0
	Excavation and formation of open channel	5000	m3	$10	$50,000	20%	$10,000.0	$60,000.0
	spread topsoil	170	m3	$10	$1,700	20%	$340.0	$2,040.0
	seed reserve	1.7	ha	$3,200	$5,440	20%	$1,088.0	$6,528.0
	Sub Total TS & S				**$850**		**$170**	**$69,588**
		0	m2	$15	$0	20%	$0.0	$0.0
	Sub Total B&CC				**$0**		**$0**	**$0**
	COMBINED SUB-TOTALS ...				**$69,650**		**$13,930**	**$152,148**
	Design	**10**	%					**15,214.80**
	Total excluding GST							**167,362.80**
	GST ...	**10**	%					**$15,214.80**
	TOTAL incl GST ...							**$182,578**

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