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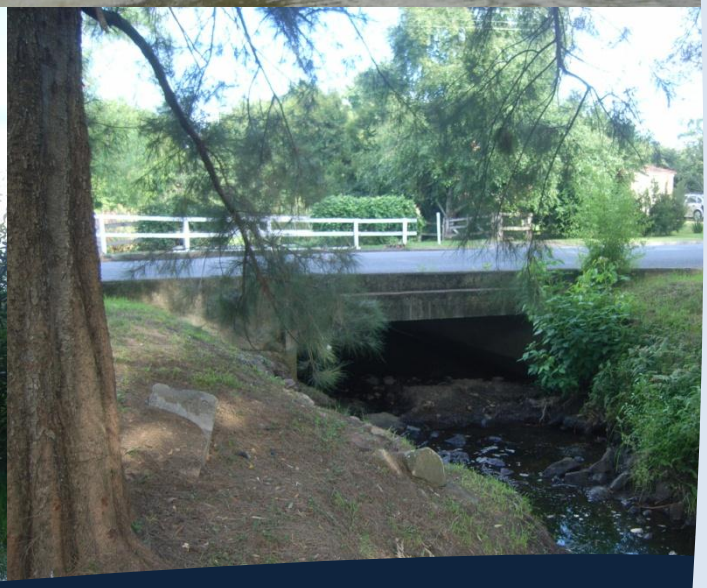

Broughton Creek Floodplain Risk Management Plan

W4858

Prepared for Shoalhaven City Council

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Foreword

The NSW Government Flood Prone Land Policy is directed towards providing solutions to existing flood problems in developed areas and ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood prone land is the responsibility of Local Government. The State Government subsidises flood management measures to alleviate existing flooding problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities. The Commonwealth Government also assists with the subsidy of floodplain management measures.

The Policy identifies the following floodplain management 'process' for the identification and management of flood risks:

1. Formation of a Committee	Established by a Local Government Body (Local Council) and includes community group representatives and State agency specialists.
2. Data Collection	The collection of data such as historical flood levels, rainfall records, land use, soil types etc.
3. Flood Study	Determines the nature and extent of the floodplain.
4. Floodplain Risk Management Study	Evaluates management options for the floodplain in respect of both existing and proposed development.
5. Floodplain Risk Management Plan	Involves formal adoption by Council of a management plan for the floodplain.
6. Implementation of the Plan	This may involve the construction of flood mitigation works (e.g. culvert amplification) to protect existing or future development. It may also involve the use of Environmental Planning Instruments to ensure new development is compatible with the flood hazard.

The process is iterative, and following the implementation of the plan, it is important that ongoing monitoring and evaluation is undertaken.

This Floodplain Risk Management Plan (Stage 5) has been prepared for Shoalhaven City Council by Cardno.

Executive Summary

Cardno were commissioned by Shoalhaven City Council to undertake the Floodplain Risk Management Study and Plan for the Broughton Creek catchment. This document forms the Floodplain Risk Management Plan, and should be read in conjunction with the Floodplain Risk Management Study (Cardno, 2012).

Flooding in the Broughton Creek catchment can pose a hazard to some residents and properties near creeks and overland flowpaths. The purpose of this study is to identify and examine options for the management of flooding and make recommendations for actions to be adopted as part of the Floodplain Risk Management Plan.

The Broughton Creek catchment area is approximately 518 km^2. Agricultural industry is the major land use within the catchment, with extensive areas utilised for dairy and beef cattle grazing in private pasture production. The township of Berry is the only urban area within the catchment.

In the past, flooding in the catchment has caused property damage and posed a hazard to residents. Significant flood events occurred in 2011, 2005, 2002, 1988 and 1974.

The flooding behaviour of the catchment was found to fall into three distinct groups:

- Flooding caused / governed by major creek flooding (such as Broughton Creek, Broughton Mill Creek and Bundewallah Creek)
- Flooding caused / governed by local creek flooding (such as Town Creek, and Hitchcocks Lane Creek)
- Flooding caused by backwater effects from the Shoalhaven River

Full details of the flood behaviour of the catchment can be sourced from the Broughton Creek Floodplain Risk Management Study (Cardno, 2012).

An assessment was undertaken on the number of properties to be affected under different frequency storm events and the appropriate economic damage for that event. The following table summarises these results.

Table i: Flood affected properties and damages under existing conditions

Flood Event	Properties with Over-floor flooding	Properties with Over-ground flooding	Flood Damage
50% AEP	0	4	$26,200
20% AEP	0	7	$39,300
10% AEP	2	15	$310,300
5% AEP	2	31	$606,100
2% AEP	4	40	$1,305,300
1% AEP	9	59	$2,290,600
PMF	50	118	$6,237,500
Average Annual Damage			$139,500

The Floodplain Risk Management Study investigated what could be done to reduce or manage the effects of flooding in the catchment, and recommended a mix of strategies to manage the risks of flooding.

Under the merits-based approach advocated in the NSW State Government's Floodplain Development Manual (NSW Government, 2005), and in consultation with the community, Council and state agency stakeholders, a number of potential options for the management of flooding were identified.

These options included:

- Flood modification measures
- Property modification measures
- Emergency response measures

An extensive list of options was assessed against a range of criteria (technical, economic, environmental and social). The assessment found, of the options investigated (including flood, property and emergency measures), the top three identified by the multi-criteria analysis were:

1. P 2 Building and Development Control Plans
2. P 1 LEP Update
3. FM 1.2 Town Creek Vegetation Clearing

Of the structural options assessed, the top options identified by the multi-criteria analysis were:

- FM1.2 Town Creek Vegetation Clearing
- FM 1.7 Town Creek Diversion

Property modification measures considered and recommended for the floodplain include:

- P1 Planning controls – LEP update
- P2 Building and development control plan
- P8 Flood proofing

Emergency response modifications for the floodplain include:

- EM 1 Information transfer to SES
- EM 2 Preparation of Local Flood Plans and update of DISPLAN
- EM 3 Flood warning system
- EM 4 Public awareness and education
- EM 5 Flood warning signs at critical locations

Data collection strategies proposed for the floodplain include:

- DC 1 Data collection following a flood event

The above listed flood, emergency and property modification measures ranked highly using a multi-criteria matrix assessment and have been selected for inclusion in the Draft Floodplain Risk Management Plan.

Those options selected for inclusion in the Draft Plan are based upon both their likely benefit and the funding available from Council and the State Government.

The Plan outlines two implementation strategies, based on the Princes Highway diversion currently under assessment by RMS.

It is proposed to divert the Princes Highway around Berry, and RMS are investigating diversion options to both the north and south of Berry. As discussed in the Floodplain Risk Management Study, the northern diversion has opportunities to include flood mitigation works in its design and construction. The northern by-pass would also change the effectiveness of a number of proposed flood mitigation options.

In order to make the document as robust as possible, and able to effectively deal with the future development of the Broughton Creek catchment, two implementation plans have been prepared depending on the outcome of the Princes Highway diversion.

Based on the multi-criteria assessment of the options, the cost of implementing the Plan for the existing catchment, which would remain in effect if the southern by-pass was selected, would be an estimated capital cost of approximately $2,729,000 and an annual recurrent cost of approximately $17,200. An alternate plan has been prepared on the basis of the northern Princes Highway by-pass proceeding. This plan has an estimated capital cost $482,200 and an annual recurrent cost of approximately $12,200.

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Glossary

Annual Exceedance Probability (AEP)	Refers to the probability or risk of a flood of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded each year; it would occur quite often and would be relatively small. A 1%AEP flood has a low probability of occurrence or being exceeded each year; it would be fairly rare but it would be relatively large.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Recurrence Interval (ARI)	The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration. It is implicit in this definition that periods between exceedances are generally random
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Creek Rehabilitation	Rehabilitating the natural 'biophysical' (i.e. geomorphic and ecological) functions of the creek.
Design flood	A significant event to be considered in the design process; various works within the floodplain may have different design events. E.g. some roads may be designed to be overtopped in the 1 in 1 year or 100%AEP flood event.
Development	The erection of a building or the carrying out of work; or the use of land or of a building or work; or the subdivision of land.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Flash flooding	Flooding which is sudden and often unexpected because it is caused by sudden local heavy rainfall or rainfall in another area. Often defined as flooding which occurs within 6 hours of the rain which causes it.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.

Flood fringe	The remaining area of flood-prone land after floodway and flood storage areas have been defined.
Flood hazard	Potential risk to life and limb caused by flooding.
Flood-prone land	Land susceptible to inundation by the probable maximum flood (PMF) event, i.e. the maximum extent of flood liable land. Floodplain Risk Management Plans encompass all flood-prone land, rather than being restricted to land subject to designated flood events.
Floodplain	Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.
Floodplain management measures	The full range of techniques available to floodplain managers.
Floodplain management options	The measures which might be feasible for the management of a particular area.
Flood planning area	The area of land below the flood planning level and thus subject to flood related development controls.
Flood planning levels	Flood levels selected for planning purposes, as determined in floodplain management studies and incorporated in floodplain management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also take into account the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of land use and for different flood plains. The concept of FPLs supersedes the "Standard flood event" of the first edition of the Manual. As FPLs do not necessarily extend to the limits of flood prone land (as defined by the probable maximum flood), floodplain management plans may apply to flood prone land beyond the defined FPLs.
Flood storages	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often, but not always, aligned with naturally defined channels. Floodways are areas which, even if only partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels. Floodways are often, but not necessarily, areas of deeper flow or areas where higher velocities occur. As for flood storage areas, the extent and behaviour of floodways may change with flood severity. Areas that are benign for small floods may cater for much greater and more hazardous flows during larger floods. Hence, it is

	necessary to investigate a range of flood sizes before adopting a design flood event to define floodway areas.
Geographical Information Systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
High hazard	Flood conditions that pose a possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty wading to safety; potential for significant structural damage to buildings.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Low hazard	Flood conditions such that should it be necessary, people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty wading to safety.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of the principal watercourses in a catchment. Mainstream flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels.
Management plan	A document including, as appropriate, both written and diagrammatic information describing how a particular area of land is to be used and managed to achieve defined objectives. It may also include description and discussion of various issues, special features and values of the area, the specific management measures which are to apply and the means and timing by which the plan will be implemented.
Mathematical/computer models	The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff, pipe and overland stream flow.
NPER	National Professional Engineers Register. Maintained by Engineers Australia.
Overland Flow	The term overland flow is used interchangeably in this report with “flooding”.

Peak discharge	The maximum discharge occurring during a flood event.
Probable maximum flood	The flood calculated to be the maximum that is likely to occur.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a fuller explanation see Annual Exceedance Probability.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. For this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Stage	Equivalent to 'water level'. Both are measured with reference to a specified datum.
Stage hydrograph	A graph that shows how the water level changes with time. It must be referenced to a particular location and datum.
Stormwater flooding	Inundation by local runoff. Stormwater flooding can be caused by local runoff exceeding the capacity of an urban stormwater drainage system or by the backwater effects of mainstream flooding causing the urban stormwater drainage system to overflow.
Topography	A surface which defines the ground level of a chosen area.

* Terminology in this Glossary have been derived or adapted from the NSW Government *Floodplain Development Manual*, 2005, where available.

Abbreviations

AAD	Average Annual Damage
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
AHIS	Aboriginal Heritage Information Services
ARI	Average Recurrence Intervals
BoM	Bureau of Meteorology
DCP	Development Control Plan
DECCW	Department of Environment, Climate Change & Water (now Office of Environment & Heritage)
DISPLAN	Local Disaster Plan
DHI	Danish Hydraulics Institute
EPI	Environmental Planning Instrument
EP&A	Environmental Planning and Assessment Act
ESD	Ecologically Sustainable Development
FPL	Flood Planning Levels
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
GIS	Geographic Information System
GSDM	Generalised Short Duration Method
ha	Hectare
HAT	Highest Astronomical Tide
IEAust	Institution of Engineers, Australia (now referred to as Engineers Australia)

IFD	Intensity Frequency Duration
km	Kilometres
km^2	Square kilometres
LAT	Lowest Astronomical Tide
LEP	Local Environment Plan
LGA	Local Government Area
LIC	Land Information Centre
m	Metre
m^2	Square metre
m^3	Cubic Metre
mAHD	Metres to Australian Height Datum
MHWL	Mean High Water Level
MHWN	Mean High Water Neaps
MHWS	Mean High Water Spring
MIKE11	MIKE11 Proprietary Software Package
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Spring
mm	Millimetre
m/s	Metres per second
MSL	Mean Sea Level
NPV	Net Present Value
NPWS	National Parks and Wildlife Service (within the Department of Environment and Conservation)

NSW	New South Wales
OEH	Office of Environment & Heritage
POEO	Protection of the Environment Operations Act
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
REP	Regional Environmental Plan
RMS	Roads and Maritime Services
RNE	Register of the National Estate
RL	Reduced Level
RTA	Roads and Traffic Authority (Now RMS)
SEPP	State Environmental Planning Policy
SES	State Emergency Service

1 Introduction

A Floodplain Risk Management Study (FRMS) and Floodplain Risk Management Plan (FRMP) for the Broughton Creek catchment has been prepared by Cardno for Shoalhaven City Council. The Study identifies and examines options for the management of flooding within the Broughton Creek catchment floodplain. This Plan takes the recommendations from the Study and incorporates them into a plan of implementation. Both studies have been prepared in accordance with the NSW Government *Floodplain Development Manual* (2005).

A locality plan is included as **Figure 1.1**. The key components of the study are shown in **Figure 1.2**.

1.1 Study Context

The Floodplain Management process progresses through 6 stages, in an iterative process:

1. Formation of a Floodplain Management Committee
2. Data Collection
3. Flood Study
4. Floodplain Risk Management Study
5. **Floodplain Risk Management Plan**
6. Implementation of the Floodplain Risk Management Plan

This report addresses Stage 5.

Stages 2 through 4 were addressed in the *Broughton Creek Floodplain Risk Management Study* (Cardno, 2012).

1.2 Study Objectives

The overall objective of the Floodplain Risk Management Study and Plan is to devise a strategy that addresses the existing, future and continuing issues in the Broughton Creek catchment in accordance with the NSW Government's Flood Policy, as detailed in the NSW *Floodplain Development Manual* (NSW Government, 2005).

Objectives of the Broughton Creek Floodplain Risk Management Study and Plan are to:

- Describe an appropriate mix of measures that addresses existing, future and continuing flood risks
- To protect and where possible enhance the creek and floodplain environment.
- To be consistent with the objectives of relevant State policies, in particular, the Government's Flood Prone Lands and State Rivers and Estuaries Policies, and to satisfy the objectives and requirements of the Environmental Planning and Assessment Act, 1979.
- To integrate the floodplain risk management plan with the local emergency management plan (flood plan), other relevant catchment management plans, Council's existing corporate, business and strategic plans, existing and proposed environmental planning instruments and policies, and to meet Council's obligations under the Local Government Act, 1993.
- To have the support of the local community.
- To ensure actions arising out of the management plan are sustainable in social, environmental, ecological and economic terms, including the timely adaptation to climate change impacts as they manifest.
- To establish a program for implementation that should include priorities, staging, responsibilities, funding mechanism, constraints and monitoring.

1.3 Study Methodology

The Floodplain Risk Management Plan report details the recommended actions to be implemented based on the assessment detailed in the Floodplain Risk Management Study report.

2 Existing Flood Behaviour

The following provides an overview of the existing flooding behaviour within the Broughton Creek catchment. A more detailed assessment can be found in the Floodplain Risk Management Study (Cardno, 2012).

2.1 Background

The Broughton Creek catchment area is approximately 518 km^2. Agricultural industry is the major land use within the catchment, with extensive areas utilised for dairy and beef cattle grazing in private pasture production. The township of Berry is the only urban area within the catchment.

The area downstream of Berry is flat and swampy and is generally below the level of the natural Broughton Creek levees. This floodplain has an elevation generally between 1mAHD and 2mAHD. Tidal influence extends approximately 12km upstream of the Broughton Creek and Shoalhaven River confluence to the vicinity of the Coolangatta Road Bridge (SMEC, 2008).

The main tributaries to Broughton Creek, upstream of the Coolangatta Road Bridge include Broughton Mill Creek, Bundewallah Creek, Connollys Creek and an unnamed watercourse locally know as Town Creek. Other tributaries include Anderson Lane Creek, Anderson Lane Tributary, Hitchcock's Lane Creek and Hitchcock's Lane Tributary.

The lower reaches of the Broughton Creek catchment, downstream of the Coolangatta Road bridge, forms part of the Shoalhaven River floodplain, and as such has previously been considered in the Lower Shoalhaven River Floodplain Risk Management Study and Plan (WMA, 2002) and subsequent Climate Change Review (WMAwater, 2011).

2.2 Revision of Flood Study

.A flood study was previously undertaken that identified the flood behaviour in the study area (SMEC, 2008). An update has subsequently been undertaken in this study as part of the Floodplain Risk Management Study (Cardno, 2012) to improve the definition of the flood behaviour in the Berry Township, and in the areas immediately adjacent to the township.

Information from the updated flood study was applied to assess potential flood management measures as detailed in the Floodplain Risk Management Report.

2.3 Flood behaviour

Peak flood depths modelled in the study area are shown in **Figure 2.1** and **Figure 2.2** for the 5% AEP event and the 1% AEP event respectively. A full presentation and discussion on the existing flood behaviour is in the Floodplain Risk Management Study Report.

2.4 Damage Analysis

A flood damage assessment for the existing catchment conditions and several flood management options has been completed and is detailed in the Broughton Creek Floodplain Risk Management Study.

The results from the damage analysis are shown in **Table 2.1**. Based on the analysis described in the Floodplain Risk Management Study, the average annual damage for the Broughton Creek floodplain under existing conditions is $139,500.

Table 2.1: Flood Damage Analysis Summary

Event / Property Type	Properties with overfloor flooding	Average Overfloor Flooding Depth (m)	Maximum Overfloor Flooding Depth (m)	Properties with overground flooding	Total Damage ($ May 2011)
PMF					
Residential	43	0.63	2.67	109	$ 3,793,100
Commercial	4	1.74	2.55	8	$ 2,190,400
Industrial	3	1.22	3.03	1	$ 254,000
PMF Total	50			118	$ 6,237,500
1% AEP					
Residential	6	0.51	0.65	54	$ 937,000
Commercial	2	1.00	1.01	3	$ 1,192,900
Industrial	1	0.40	0.36	2	$ 160,700
100 Year ARI Total	9			59	$ 2,290,600
2% AEP					
Residential	2	0.13	0.54	36	$ 548,000
Commercial	2	0.47	0.79	3	$ 757,200
Industrial	0			1	$ -
50 Year ARI Total	4			40	$ 1,305,300
5% AEP					
Residential	1	0.45	0.45	27	$ 289,100
Commercial	1	0.51	0.51	3	$ 317,000
Industrial	0			1	$ -
20 Year ARI Total	2			31	$ 606,100

Event / Property Type	Properties with overfloor flooding	Average Overfloor Flooding Depth (m)	Maximum Overfloor Flooding Depth (m)	Properties with overground flooding	Total Damage ($ May 2011)
10% AEP					
Residential	1	0.38	0.38	13	$ 135,700
Commercial	1	0.25	0.25	2	$ 174,600
Industrial	0			0	$ -
10 Year ARI Total	2			15	$ 310,300
20% AEP					
Residential	0			6	$ 39,300
Commercial	0			1	$ -
Industrial	0			0	$ -
5 Year ARI Total	0			7	$ 39,300
50%AEP					
Residential	0			4	$ 26,200
Commercial	0			0	$ -
Industrial	0			0	$ -
2 Year ARI Total	0			4	$ 26,200

3 Floodplain Risk Management Options

Flood risk can be categorised as existing, future or residual risk:

- **Existing Flood Risk** – existing buildings and developments on flood prone land. Such buildings and developments by virtue of their presence and location are exposed to an 'existing' risk of flooding
- **Future Flood Risk** – buildings and developments that may be built on flood prone land. Such buildings and developments would be exposed to a flood risk when they are built
- **Residual Flood Risk** – buildings and development that would be at risk if a flood were to exceed management measures already in place. Unless a floodplain management measure is designed to withstand the PMF, it will be exceeded by a sufficiently large event at some time in the future.

Measures available for the management of flood risk can be characterised according to the way in which the risk is managed. As a result, there are three broad types of measures for the management of flooding that have been addressed:

- Flood modification options – for the existing risk
- Property modification options – for the future risk
- Emergency modification options – for the residual risk

A range of options were considered as part of the floodplain risk management plan. These are discussed in detail in the Floodplain Risk Management Study, and are summarised below.

3.1 Flood Modification Measures

Flood modification measures are structural options aimed at preventing, avoiding or reducing the likelihood of flood risks.

The options are discussed in detail in the Floodplain Risk Management Study, and are summarised in **Table 3.1**.

3.2 Property Modification Options

A number of property modification options were identified for consideration in the Broughton Creek floodplain, and these are summarised in **Table 3.2**. Additional options were also assessed, but they were found not to be suitable for the Broughton Creek catchment.

3.3 Emergency Response Modification Options

A number of emergency response modification options are suitable for consideration within the Broughton Creek floodplain. These are summarised below in **Table 3.3**.

3.4 Data Collection

In addition to the options discussed above, a data collection strategy is also proposed. This would involve the collection of relevant data such as survey of flood marks and records of property flooding, following a flood event. This data could then be analysed to develop further information about flooding behaviour in the catchment.

Table 3.1: Structural Modification Options

Option ID	Option	Option Outline
Drainage Augmentation / Upgrade		
FM 1.1 *	Town Creek Culvert Upgrade	Increase culvert sizes along Town Creek to improve efficiency of the channel
FM 1.2 *	Town Creek Vegetation Management	Remove foreign weed species and dense vegetation from the channel and vegetate with native species. Removal of debris, and culvert blockages.
FM 1.3 *	Railway Culvert Upgrade	Increase culvert capacity to convey a greater flow volume to reduce water building up upstream of the railway line
FM 1.4 *	Railway Bridge Upgrade	Increase bridge capacity to convey a greater flow volume to reduce water building up upstream of the railway line
FM 1.5 *	Woodhill Mountain Rd, Bundewallah Creek Bridge Upgrade	Increase the bridge capacity to convey a greater flow volume to reduce water overtopping the upstream banks and short-circuiting to Broughton Mill Creek through the Berry Township
FM 1.6 *	North St Diversion Swale	Construction of a swale along the northern side of North Street to intercept the North Street flowpath and direct it to Bundewallah Creek.

FM1.7*	Town Creek Diversion	Construction of a diversion channel to divert Town Creek flows north of North Street to Bundewallah Creek. Channel will be sized to convey 1% AEP flows.
Levee Banks		
FM 2.1 *****	Berry RSL / Prince Alfred Street Levee 5% AEP level	Construction of a levee bank along the boundary of the Bowling Club site, as well as a section along the Princes Highway and behind properties on Prince Alfred Street.
FM 2.2 *****	Berry RSL / Prince Alfred Street Levee 1% AEP level	Construction of a levee bank along the boundary of the Bowling Club site, as well as a section along the Princes Highway and behind properties on Prince Alfred Street.
FM 2.3	Town Creek Flood Walls 5% AEP level	Construction of flood walls / levee banks to prevent the overflow of Town Creek in events up to the 5% AEP event
FM 2.4	Town Creek Flood Wall 1% AEP level	Construction of flood walls / levee banks to prevent the overflow of Town Creek in events up to the 1% AEP event
Detention Basins		
FM 3.1 *****	Town Creek upstream detention	Construction of a detention basin upstream of North Street on the North Street flowpath to detain upstream flows up to the 1% AEP event, and reduce outflow to the 20% AEP volumes
Rural Property Options		
FM 4.1	Stock Mounds	Creation of raised mounds that would provide a dry / shallow depth region for the storage of stock and machinery during flood events

*** Indicates options that were assessed with the hydraulic model**

Table 3.2: Flood Mitigation Options

Option ID	Name	Option Description
P1	LEP Update	Only minor changes required, and can be incorporated into Councils LEP revision
P2	Building and Development Controls	A number of updates are recommended to Councils building and development controls
P8	Flood Proofing	Incorporating structural and other procedures in order to reduce or eliminate the risk to life and property. This can also include temporary flood protection measures such as flood barriers.

Table 3.3: Emergency Response Modification Options

Option ID	Name	Option Description
EM 1	Information transfer to SES	Transfer of findings from the floodplain risk management study and plan to the SES
EM 2	Preparation of Local Flood Plans and update of DISPLAN	Preparation of a local flood plan for Berry and its surrounding areas, and update the Shoalhaven DISPLAN document with specific information for Berry and its surrounding areas.
EM 3	Flood warning system	The critical durations for the lower Broughton Creek catchment may mean the implementation of a flood warning system is feasible. This should be investigated in conjunction with the wider Shoalhaven River catchment area
EM 4	Public awareness and education	Improvement of flood awareness in the community to reduce the overall flood risk
EM 5	Flood warning signs at critical locations	Flood warning signs placed at public locations where high hazard flooding is experienced.

4 Findings of the Floodplain Risk Management Study

The options identified in the Floodplain Risk Management Study were assessed using a multi-criteria matrix, which incorporated a benefit / cost analysis for the structural options which can be quantitatively assessed. The matrix is attached in **Appendix A**. The multi-criteria matrix utilises a triple bottom line approach to assess the options on their economic, environmental and social suitability.

The Plan consists of a mixture of:

- Flood modification options
- Property modification options
- Emergency modification options

Triple bottom line and economic benefit / cost ratio analysis provide direction in the selection of various options. However, the final selection of options needs to consider other factors relevant to the wider community. For the purposes of selecting a list of options for the Plan, the following criteria have been adopted:

- Overall ranking in the multi-criteria matrix
- Benefits to the wider community, as opposed to localised benefits

The flood management options recommended in the plan, and their implementation is discussed in the following chapter.

5 Implementation Program

The implementation program essentially forms the action list for this Plan.

The benefit of following this sequence is that gradual improvement of the floodplain occurs, as the funds become available for implementation of these options.

Further steps in the floodplain management process from this point forwards are:

1. Floodplain Management Committee to consider and adopt recommendations of this Plan
2. Council to consider the Floodplain Management Committee's recommendations
3. Council to adopt the Plan and submit an application for funding assistance to OEH and other agencies as appropriate
4. As funds become available from OEH, other state government agencies and / or Council's own resources, implement the measures in accordance with the established priorities.

This plan should be regarded as a dynamic instrument requiring review and modification over time. The catalysts for change could include new flood events and experiences, legislative change, alterations in the availability of funding and reviews of Council planning policies. In any event, a review every five years is warranted to ensure the ongoing relevance of the Plan.

Two plans have been included in this document. The first is based on the existing catchment conditions. The second takes into account the possibility of the construction of a northern diversion of the Princes Highway.

The Roads and Maritime Services (RMS) is investigating a diversion of the Princes Highway around Berry. It is investigating both a northern and southern diversion option. Should the southern option be selected, the first plan in this document would still be applicable. If however, the northern option is selected, there is a potential for including some level of flood mitigation within the design. This would impact the effectiveness and suitability of the proposed structural mitigation options. The opportunities for flood mitigation associated with the northern option are discussed in the Floodplain Risk Management Study (Cardno, 2012).

In order to make the document as robust as possible, and able to effectively deal with the future development of the Broughton Creek catchment, two implementation plans have been prepared depending on the outcome of the Princes Highway diversion.

It should be noted that an attempt has been made to keep the first steps in both plans similar, in order to allow some time for the highway option to be resolved without impacting on the implementation of the plan.

The action list for the existing catchment, which will remain applicable under the southern Princes Highway Diversion, is shown in **Table 5.1**. The action list for the northern Princes Highway diversion scenario is shown in **Table 5.2**.

The options selected for the plan are based on the ranking of the multi-criteria analysis. For the existing catchment plan, the options selected represent a capital outlay of approximately $2,729,000.

For the northern Princes Highway by-pass plan, the options selected represent a capital outlay of approximately $482,200.

There a few important points to note in regards to the plan:

- The Town Creek Detention and Diversion options are mutually exclusive. The Diversion has been included in the Plan as it is more effective at mitigating flooding impacts. If it does not prove feasible, the detention will provide improvements in the same region, of a smaller magnitude, and will reduce the cost of the plan by $627,500.
- Options for augmenting railway structures have not been included in the plan due to their low performance in the multi-criteria assessment, and their significant capital cost. The works however, do provide a benefit to the railway by reducing overtopping frequency. As such, the cost of implementing this option may be provided by Rail Corp, which would increase the feasibility of these options, and allow their inclusion in the plan.

5.1 Key Stakeholders

As a part of the implementation of the Plan and the detailed design phase of some of the options, liaison should be undertaken with key stakeholders. These stakeholders should include, but are not limited to:

- Private residents

  In particular, those affected by proposed works
- Community groups
- Shoalhaven Water

  Particularly with regard to any impacts on their assets within the catchment

- State Rail Authority / Rail Corp

  Options involving the augmentation of railway structures would require close liaison with the organisation to ensure an optimal design

- RMS

  Continued consultation regarding the Princes Highway by-pass, and further consultation regarding options that impact on any RMS roads in the study area

- SES

  Particularly with regards to the emergency management options. Generally, the SES should also be kept informed of changes to the flood behaviour resulting from any of the implemented option

- OEH

  As it is likely that funding would be sourced from OEH for a number of the options, they should be consulted as a part of the design process

Table 5.1: Floodplain Risk Management Measures Recommended for Inclusion in the Broughton Creek Risk Management Plan – Existing Catchment Conditions & Southern Princes Highway Diversion Scenario

ID	Description	Estimated Capital Cost	Estimated Recurring Cost	Funding Sources / Responsibility	Priority for Implementation
EM1	Information transfer to the SES	$3,000	$0	Council / SES	High
EM4	Public awareness and education	$20,000	$2,000	Council	High
DC1	Data collection following a flood event	$5,000	$3,000	Council	High
P2	Building and Development Controls	$15,000	$1,000	Council / SES	High
P1	LEP Update	$5,000	$1,000	Council	High
P8	Flood Proofing Guidelines	$15,000	$1,000	Council / SES	High
FM 1.2	Town Creek Vegetation Clearing	$371,700	$500	Council / OEH	High
EM2	Preparation of Local Flood Plans and update of DISPLAN	$30,000	$2,000	Council / SES	Medium
EM5	Flood warning signs	$5,000	$200	Council / SES	Medium
FM 1.7	Town Creek Diversion	$1,400,000	$2,500	Council / OEH	Medium
FM 4.1	Stock Mounds	$2,500	$0	Council	Medium
EM3	Flood warning system	$10,000	$1,500	Council / OEH	Low
FM 1.6	North St Diversion Swale	$846,800	$2,500	Council / OEH	Low
Total Cost of Implementing the Plan		**$2,729,000**	**$17,200**		

Table 5.2: Floodplain Risk Management Measures Recommended for Inclusions in the Broughton Creek Risk Management Plan – Northern Princes Highway Diversion Scenario

ID	Description	Estimated Capital Cost	Estimated Recurring Cost	Funding Sources / Responsibility	Priority for Implementation
EM1	Information transfer to the SES	$3,000	$0	Council / SES	High
EM4	Public awareness and education	$20,000	$2,000	Council	High
DC1	Data collection following a flood event	$5,000	$3,000	Council	High
P2	Building and Development Controls	$15,000	$1,000	Council / SES	High
P1	LEP Update	$5,000	$1,000	Council	High
P8	Flood Proofing Guidelines	$15,000	$1,000	Council / SES	High
FM 1.2	Town Creek Vegetation Clearing	$371,700	$500	Council / OEH	High
EM2	Preparation of Local Flood Plans and update of DISPLAN	$30,000	$2,000	Council / SES	Medium
EM5	Flood warning signs	$5,000	$200	Council / SES	Medium
FM 4.1	Stock Mounds	$2,500	$0	Council	Medium
EM3	Flood warning system	$10,000	$1,500	Council / OEH	Low
Total Cost of Implementing the Plan		**$482,200**	**$12,200**		

6 Recommendations and Conclusions

This report presents the findings of the Floodplain Risk Management Plan for Broughton Creek. The investigations and consultations undertaken as part of the Floodplain Risk Management Study identified a number of issues for the floodplain. Based on these issues, a series of floodplain management measures were developed, and have been recommended in this Floodplain Risk Management Plan.

The assessment of management options provided in the Floodplain Risk Management Study facilitates the identification of the most beneficial options (in terms of hydraulics, economics, environmental and social issues).

7 Qualifications

This report has been prepared by Cardno for Shoalhaven City Council and as such should not be used by a third party without proper reference.

The investigation and modelling procedures adopted for this study follow industry standards and considerable care has been applied to the preparation of the results. However, model set-up and calibration depends on the quality of data available. The flow regime and the flow control structures are complicated and can only be represented by schematised model layouts.

Hence there will be a level of uncertainty in the results and this should be borne in mind in their application.

The report relies on the accuracy of the survey data and pit and pipe data provided by Council.

Study results should not be used for purposes other than those for which they were prepared.

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Figures

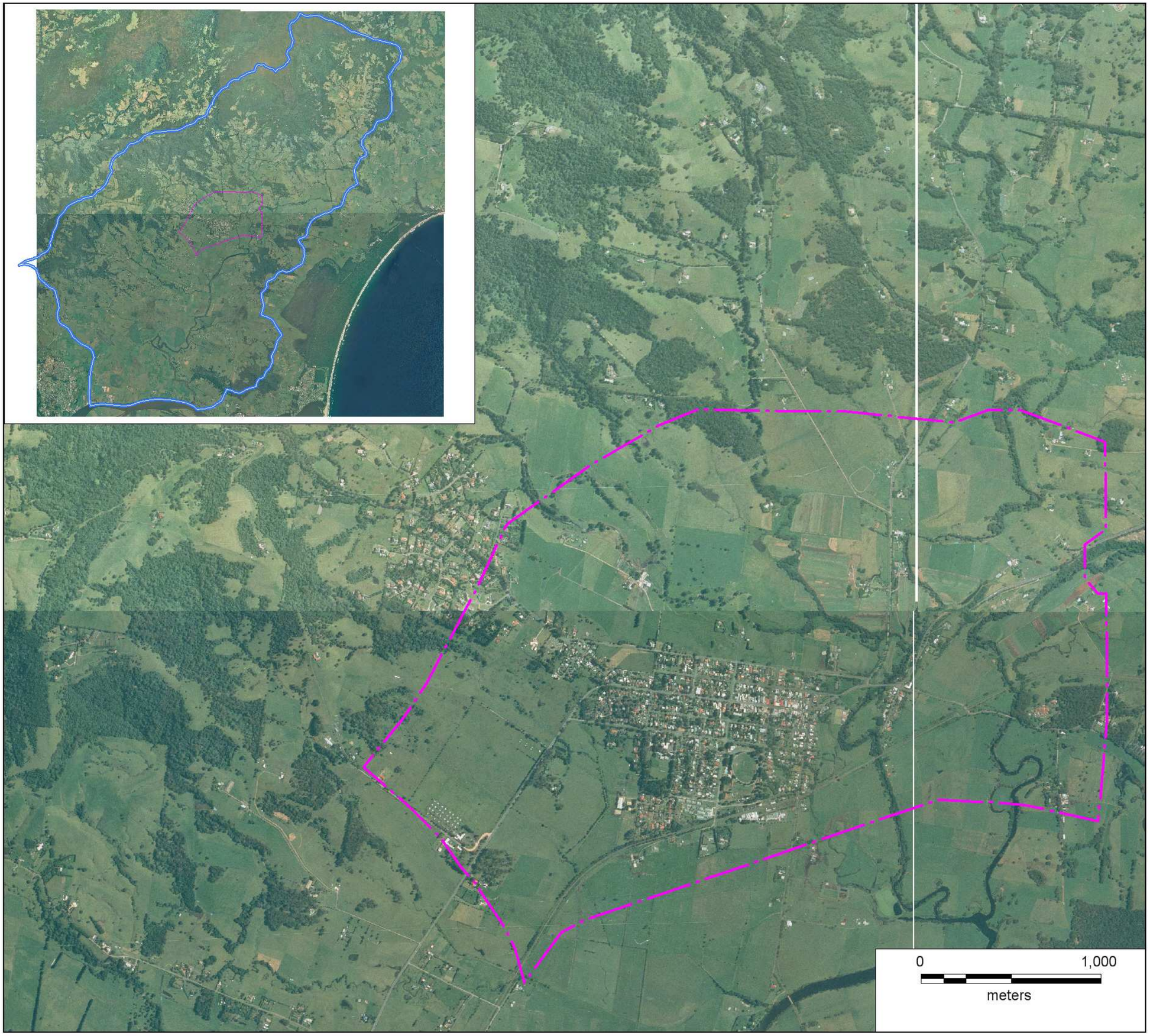


FIGURE 1.1

CATCHMENT AND STUDY AREA

Berry FRMSP

Model Extent

Broughton Creek Catchment Area

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd
Date: 04 April 2012
Coordinate System: Zone 56/1 ISG
GIS MAP REF:
W4858_04_Figure_1-1_Catchment_Area.mxd 02

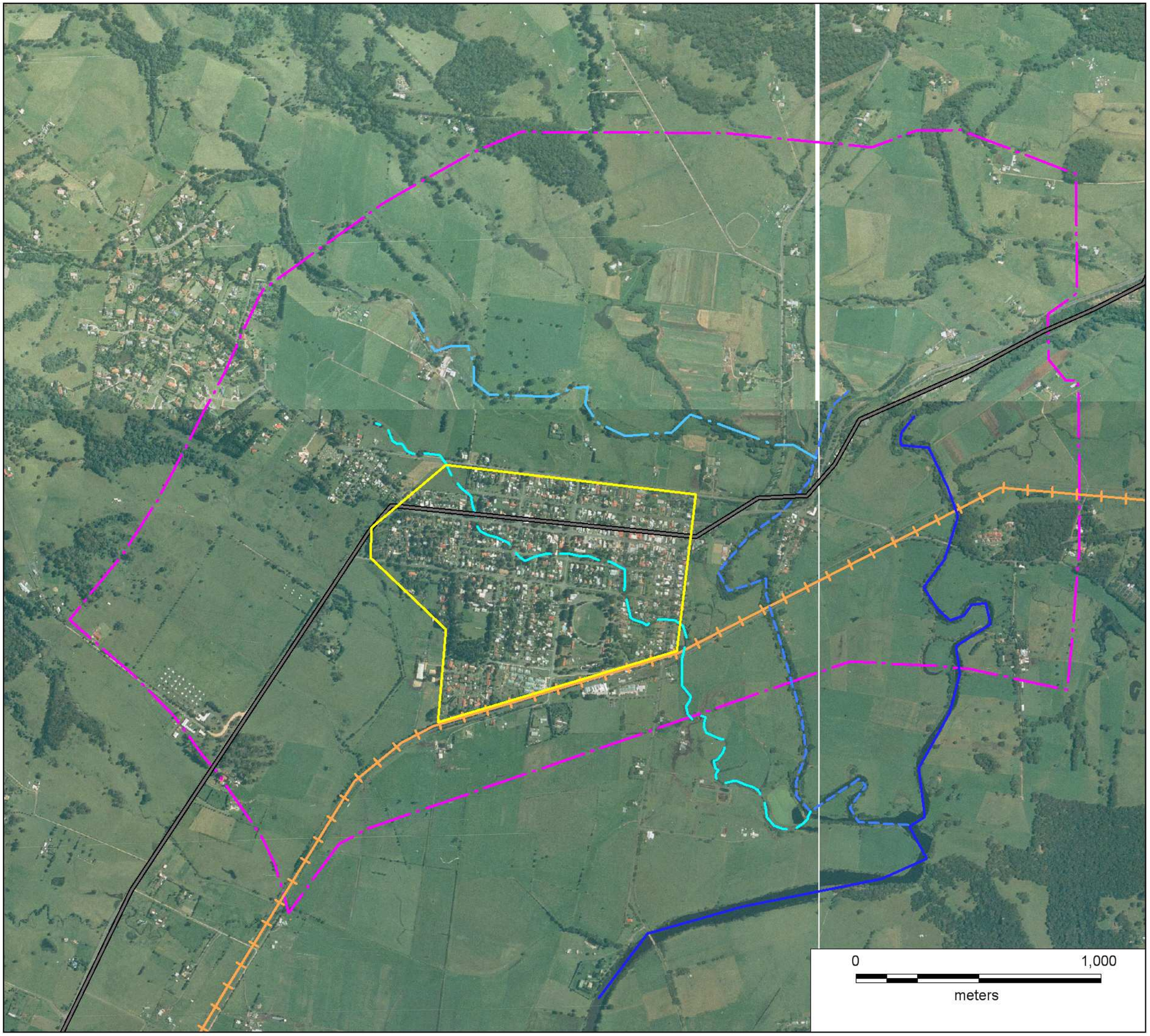


FIGURE 1.2

STUDY AREA FEATURES

Berry FRMSP

- Model Extent
- Berry Township
- Princes Highway
- Railway Line
- Broughton Creek
- Broughton Mill Creek
- Bundewallah Creek
- Town Creek

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd
Date: 04 April 2012
Coordinate System: Zone 56/1 ISG
GIS MAP REF:
W4858_04_Figure_4-2_Study_Area_Features.mxd 02

FIGURE 2.1

5% AEP
PEAK FLOOD DEPTH

Berry FRMSP

Depth (metres)

- 0.15 - 0.30
- 0.30 - 0.50
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- > 3.0

N

0 500.0

meters

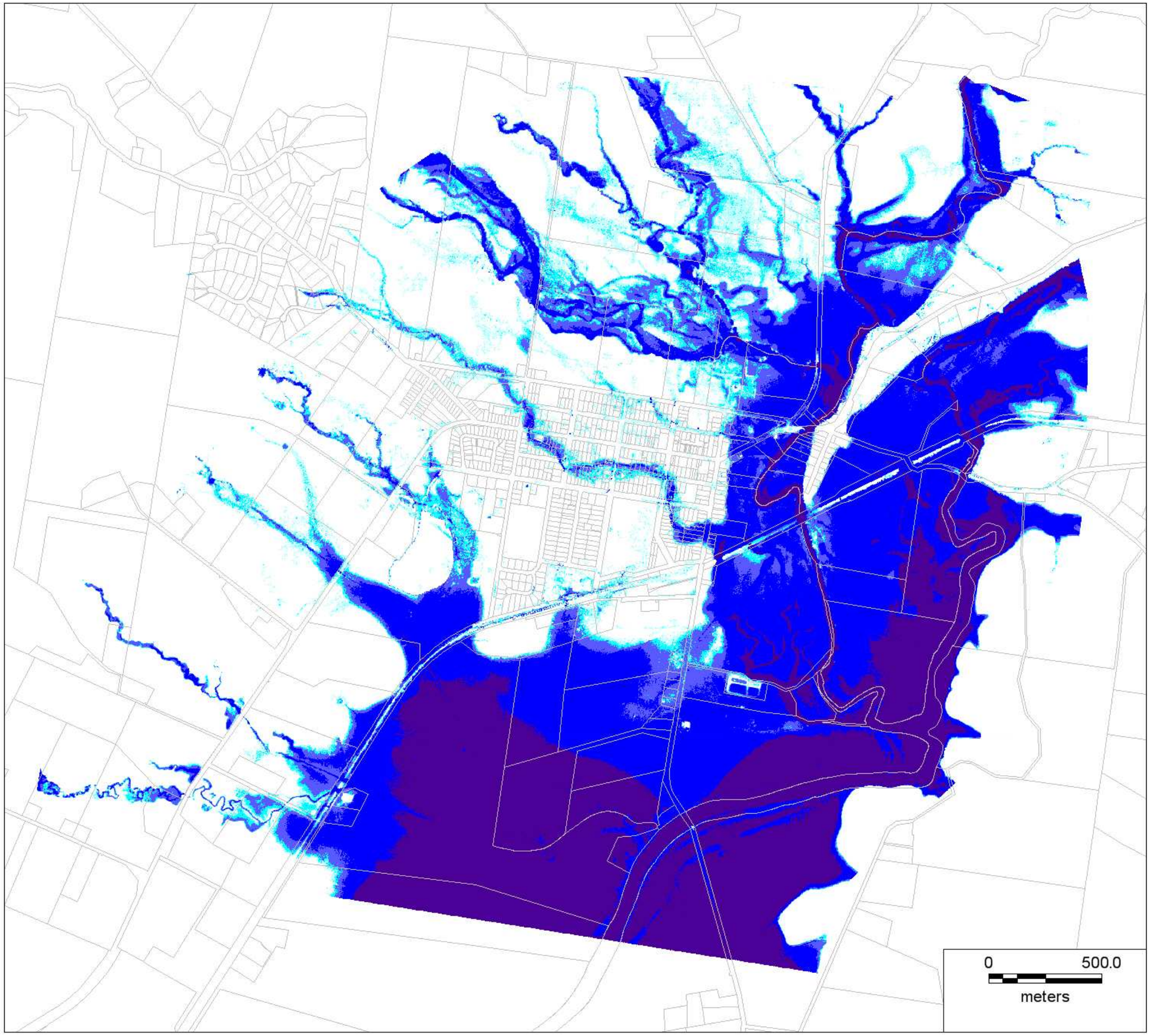
Cardno

Map Produced by Cardno NSW/ACT Pty Ltd
Date: 8 September 2011
Coordinate System: Zone 56/1 ISG
GIS MAP REF:
W4858_01_Figure_7-8_2yr_Depth.mxd 02

FIGURE 2.2

1% AEP PEAK FLOOD DEPTH

Berry FRMSP



Depth (metres)

- 0.15 - 0.30
- 0.30 - 0.50
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- > 3.0

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd
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