Draft Floodplain Management Plan

Warrah Creek

February 2011

This project was funded by the Natural Heritage Trust, the Namoi Catchment Management Authority and the NSW Government, with involvement by Evans and Peck Pty Ltd, the NSW Department of Environment, Climate Change and Water, the NSW Office of Water, Liverpool Plains Shire Council, local landholders and other relevant stakeholders.

The Warrah Creek Floodplain Management Plan project is indebted to the Warrah Creek Floodplain Management Committee, and the landholders who provided input and allowed access to private property. The cooperation received from landholders greatly assisted the collection of data and information on local land use and flooding history.

Cover photos (clockwise from main photo):
Pump Station and Yarramanbah creeks downstream of Round Island, July 1998 flood (Andrew Falkenmire, DECCW)
Constructed channel, Millers Creek floodplain downstream of Harrisons Plain Road (Robert Albert, NOW)
Yarramanbah Creek downstream of Round Island, July 1998 flood (Andrew Falkenmire, DECCW)
Constructed waterway, Millers Creek floodplain near Blackville Road (Robert Albert, NOW)

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Preface

The Warrah Creek catchment, located within the Upper Mooki River catchment system, has been identified as a stressed catchment. The uncoordinated development of works and land use in the catchment has led to the erosion and scouring of creeks, sediment deposition in the channels and floodplain, alterations in flow patterns on the floodplain and changes in the hydrologic patterns.

The NSW Government's *Flood Prone Land Policy* (see NSW Government 2005) aims to provide solutions to existing flooding problems as well as ensuring 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 this policy, the rural flood risk within New South Wales for those areas west of the Great Dividing Range is managed by the NSW Government. These management provisions are set out in Part 8 of the *Water Act 1912*, under which the Warrah Creek Floodplain Management Plan (FMP) has been prepared.

The Warrah Creek FMP has been prepared by the Department of Environment, Climate Change and Water (DECCW) for the Water Administration Ministerial Corporation (WAMC) under Part 8 of the Water Act and in accordance with the processes outlined in the *NSW Floodplain Development Manual* (NSW Government 2005) which supports the *NSW Flood Prone Land Policy*. The FMP was prepared in consultation with the Warrah Creek Floodplain Management Committee (FMC), which comprised representatives of the community, various stakeholder groups and government agencies. Funding for this project was provided by the Natural Heritage Trust (NHT), the Namoi Catchment Management Authority (CMA) and the NSW Government.

DECCW is responsible for preparing rural floodplain management plans that define requirements for managing floodwaters within floodplains. Approval of works and compliance functions under Part 8 of the Water Act are the responsibility of the NSW Office of Water (NOW), which has been established as an office within DECCW.

Development of the FMP has progressed through three phases:

- **flood study (FS)** – defines the nature and extent of flooding and flood-related issues (hydraulic, environmental and cultural) in technical terms
- **catchment management study (CMS)** – evaluates management options in consideration of social, environmental and economic factors, so as to address existing and future flood risk and flood management issues (Note: This phase is often referred to as a floodplain risk management study.)
- **floodplain management plan (FMP)** – outlines the strategies to manage flood risk and flood management issues and support the natural functions of the floodplain environment.

A five year average recurrence interval (ARI) design flood was adopted to identify and size flowpaths within the FMP floodplain. This approach will produce an equitable distribution of floodwater across the floodplain, and enable floodwater access to flood dependent ecosystems. It will also optimise the use of rural land for agricultural pursuits and give an acceptable level of flood risk for property and infrastructure.

Once adopted by DECCW, the FMP will be considered by NOW when determining applications for any works under Part 8 of the Water Act. Proposed works will be classified as either complying or non-complying, depending on whether the work complies with the assessment criteria specified in the FMP. Non-complying works must be advertised to seek objections and may be approved after a detailed investigation of the hydraulic, environmental, social and economic impacts of the proposal.

As part of the finalisation of the adopted FMP flowpath network, floodplain management issues associated with flood control works were investigated. The Warrah Creek FMP outlines the modifications that will need to be made to specified controlled works in order to comply with the FMP and ensure flood flow connectivity throughout the floodplain.

In line with requirements for sustainable natural resource management, care has been taken to ensure that the FMP addresses soil erosion and stabilisation issues and has a positive environmental impact on native vegetation and aquatic and terrestrial fauna on the floodplain.

The performance of the FMP flowpaths during floods will be monitored during flood events. The FMP will be assessed following major floods against three key performance indicators:

- Existing and proposed flood control works are constructed, maintained and modified in accordance with the FMP.
- The FMP flowpath network allows for the orderly passage of floodwaters during a range of floods.
- The FMP flowpath network allows for the delivery of floodwaters to support floodplain ecosystems.

The presence of dense vegetation cover within the FMP flowpath network may increase hydraulic roughness and reduce flow efficiency. There is a range of options under the *Native Vegetation Act 2003* and other relevant legislation to manage vegetation so that the FMP flowpath network is maintained and operates as designed during floods.

It is expected that the Warrah Creek FMP will be adopted as a Minister's plan under the *Water Management Act 2000* when the *Water Act 1912* is repealed. The FMP is required to be reviewed at five-yearly intervals in accordance with the Water Management Act. Triggers for review include significant flood events, changes to land use, impediments to implementation and changes to factors that influence decisions.

Climate change has the potential to result in many direct and indirect changes to floodplains, including to their hydrology and to the institutional framework in which floodplains are managed. Climate change has the potential to alter flood patterns as a result of changes in monthly average rainfall, rainfall distribution, rainfall intensity and flood frequency estimates. Changes to groundwater and soil moisture could further influence the magnitude and duration of floods. Any direct or indirect impacts of climate change on agriculture will have a strong flow-on effect on floodplain management, as most rural floodplain landowners are primary producers. Early adaptive responses will decrease longer-term vulnerability and economic costs. Therefore, as part of any plan review, particular attention will be given to exploring the adaptive capacity of rural FMPs to address climate change impacts on flood risk exposure, floodplain ecosystems and rural economies.

1 Introduction

1.1 Overview

The FMP was developed on the basis of a detailed technical analysis of flood flow and in accordance with the NSW Government's *Floodplain Development Manual* (2005). The FMP is the outcome of a floodplain management process that included input from affected stakeholders. In formulating the FMP a detailed evaluation of factors that affect, and are affected by, the use of flood prone land was undertaken. This included consideration of hydraulic, environmental, cultural and socio-economic factors.

The FMP has the following aims:

- Provide unobstructed flowpaths that will improve the current drainage of the floodplain system and allow for the orderly passage of flood flows.
- Balance the expressed requirements of landholders with the requirement to minimise the impact of floodplain development on natural flood flow patterns and ecological functions.

The FMP incorporates the key points and main outcomes of the Warrah Creek flood study (the FS; Hughes Trueman 2005) and the Warrah Creek catchment management study (the CMS; Evans and Peck 2007). The CMS deals with many issues, including legislative and policy matters and the floodplain environment, in substantial detail. The reader should refer to the CMS where background and/or greater detail are sought.

Once adopted under the provisions of Part 8 of the Water Act, the FMP must be considered by NOW when it reviews and determines approval applications for flood control works under the Act (or the *Water Management Act 2000* when it is applied).

1.2 Vision statement

The vision statement for the Warrah Creek FMP is:

> *to develop a rural floodplain management plan that will mitigate flooding, manage development, ensure that the functions of the floodplain are sustainable in all aspects and be compatible with the needs of the surrounding community.*

1.3 Objectives

The primary objectives for the Warrah Creek FMP are to:

- reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible
- coordinate any floodplain development in order to minimise adverse changes to flood flow patterns
- increase the sustainable social, economic and ecological benefits of using the floodplain
- improve and maintain the diversity and well being of native riverine and floodplain ecosystems that depend on flood inundation
- take into account the cumulative impact on flooding behaviour of individual developments.

1.4 The FMP floodplain

1.4.1 Overview

The Warrah Creek catchment, which has an area of approximately 1500 km^2, is within the Liverpool Plains and forms part of the Upper Mooki River catchment system. Warrah Creek flows into the Mooki River downstream of Pine Ridge, and the Mooki River eventually flows into the Namoi River near Gunnedah.

As indicated on **Figure 1**, the Warrah Creek catchment is bounded by the Great Dividing Range (Liverpool Range) to the south, Quirindi – Pine Ridge Road to the north, the Upper Mooki River catchment to the west and the Quirindi Creek catchment to the east. The major water courses within the catchment include Yarramanbah, Pump Station, McDonalds, Millers, Big Jacks, Little Jacks, Warrah and Borambil creeks.

The FMP floodplain includes land within the Warrah Creek catchment of less than 2% slope (see **Figure 1**). It occupies approximately 570 km^2, or 40% of the total catchment area. The FMP floodplain is located within the local government area (LGA) of Liverpool Plains Shire, adjacent to the rural townships of Murrurundi, Quirindi and Pine Ridge. The township of Willow Tree lies within the FMP area boundary but is excluded from the FMP.

The Warrah Creek CMS report (Evans and Peck 2007) includes a more detailed description of the FMP floodplain and the upper catchment and their associated catchment management issues.

1.4.2 Flooding, drainage, geomorphology and erosion

The complex underlying geomorphology of the Warrah Creek catchment together with human intervention to create significant drainage lines, have resulted in a very intricate pattern of flowpaths on the broad floodplain (see **Figure 2** in Appendix B).

In most cases the main streams in the catchment emanate from the Liverpool Range at the southern catchment border, and generally flow in a northerly direction. Beyond the foothills of the Liverpool Range these streams do not follow a defined route. Early European reports from the area describe large waterlogged areas with ill-defined drainage lines on the southern segment of the Liverpool Plains. This was due in part to the sharp change in gradient from range to plain that forced a sharp and discrete sorting of sediment, and also due to the sheer mass of sediment that levelled out the underlying topography and helped form the low gradient plains.

In geomorphic terms, the creek systems within the broader Warrah Creek catchment fall into four groups with different characteristics that relate to the soil landscape units and the channel gradients.

The four main drainage zones comprise:

- the western creeks (Yarramanbah and Pump Station creeks)
- the middle creeks (MacDonalds, Millers, Big Jacks and Little Jacks creeks)
- Warrah Creek, and
- Borambil Creek.

Prior to agricultural development the main streams in the western and middle part of the catchment (Yarramanbah, Pump Station, McDonalds, Millers, Big Jacks and Little Jacks creeks) had little definition at the point where they dispersed onto the broad floodplain (upstream of Harrisons Plain Road). From here the creeks gradually dispersed into a dendritic pattern of minor depressions. This drainage pattern still exists today for McDonalds, Millers and Little Jacks creeks; however, on Yarramanbah, Pump Station and Big Jacks creeks continuous channels now exist due to human intervention.

WARRAH CREEK FLOODPLAIN MANAGEMENT PLAN

Environment, Climate Change & Water

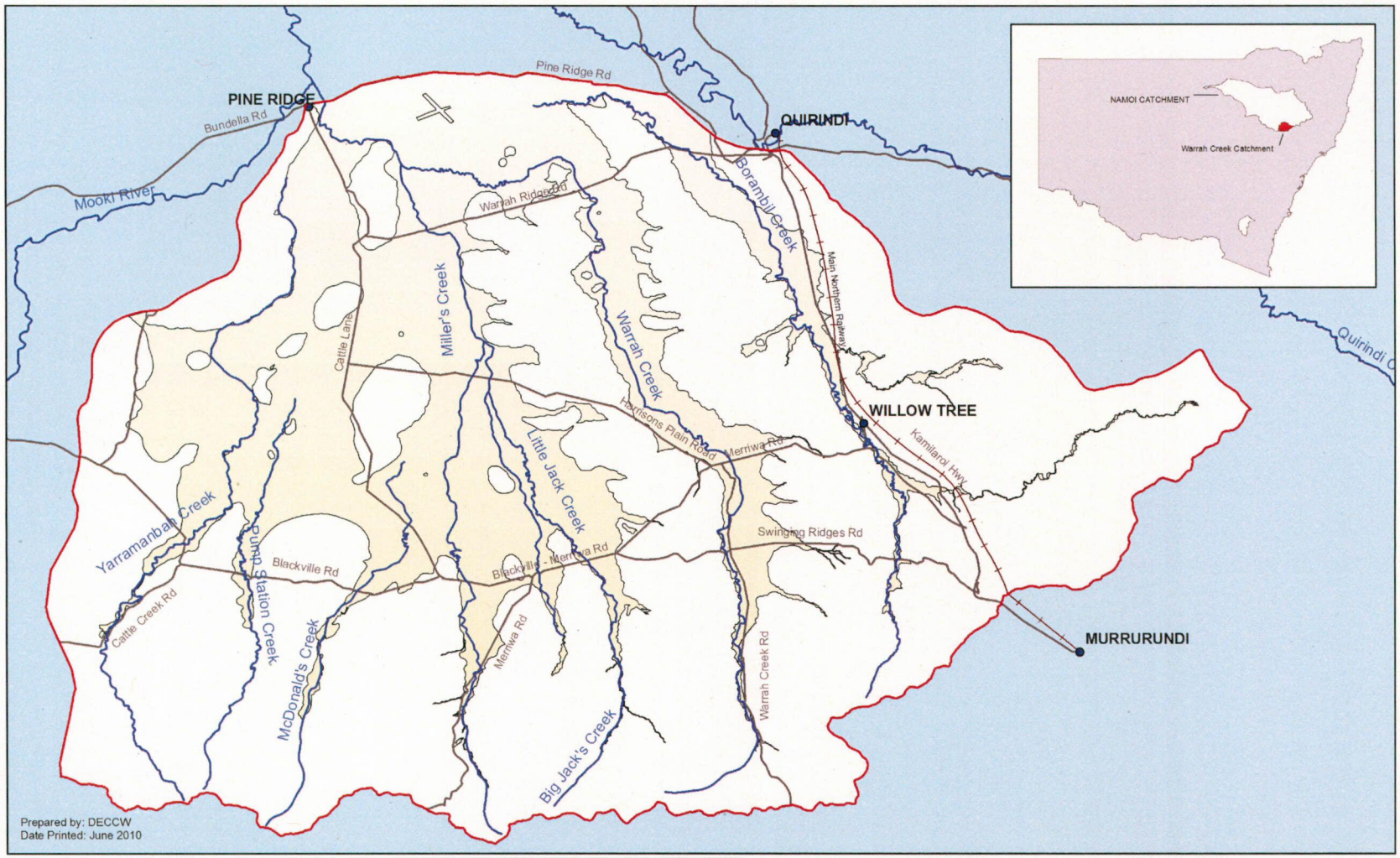

Figure 1: Warrah Creek FMP Floodplain

0 2.5 5 7.5 10 Kilometres

N

Legend

Warrah Creek Catchment
FMP Floodplain
Creeks
Railways
Roads

Warrah Creek has a relatively confined floodplain which provides little opportunity for flows to disperse into complex minor channels. The creek maintains a defined channel along its full course. Borambil Creek has significantly steeper gradients than the other creeks and maintains a defined channel to a point just north of Warrah Ridge Road where it disperses into a dendritic pattern on the broader floodplain.

A detailed description of the geomorphology of the four main drainage zones is contained in the Warrah Creek CMS (Evans and Peck 2007).

Significant erosion has occurred on the floodplain, with the worst erosion evident in the constructed drainage channels just north of the line of the Merriwa and Blackville roads, especially in the south-west sector of the catchment. The grade is still sufficient in this area to give some velocity and energy to headward erosion. The combination of fine, drainage-impeding sediment and a low but significant drainage slope produces just enough velocity during a flood to disturb the soil and create unstable drainage channels. In streams within this zone that retain some meandering form and where velocity is therefore lower, there is little or no headward and bank erosion.

There is little observable erosion once the streams, whether characterised by artificial or natural channels, proceed north around the barriers of the sandstone islands (Round Island) and adjacent ridges. This is apparently because velocity is substantially lower and because the regolith (the layer of loose rock particles that covers the bedrock) has built up to a greater depth, allowing water to infiltrate and disperse as groundwater.

1.4.3 Environmental summary

Floodplains play a fundamental ecological role by supplying organic matter and nutrients cycled during periods of flooding which in turn supports an extensive food base for fish and waterbird communities.

In common with many other rural areas, the Warrah Creek catchment has, in recent years, begun to show signs of stress indicated by:

- erosion and scouring of creeks
- sediment deposition in channels and on the floodplain
- alterations in flow patterns on the floodplain, and
- changes in the hydrologic patterns.

The Warrah Creek catchment has a long history of agricultural land use, with the current farming practices including the production of cereal crops (wheat and sorghum) on the lower slopes and plains, and sheep and cattle grazing on the upper slopes. As a result of the agricultural character of the Warrah Creek catchment, most of the floodplain has been cleared of native vegetation. The predominant vegetation consists of cereal crops, exotic and native grasslands with scattered isolated trees and stands of regenerating woodland present at several locations. Three vegetation communities have been recorded within the catchment, being Grassy White Box Woodlands, Riparian River Oak Forest and mixed grasslands (For more detail refer to Section 8.2 in this FMP and Section 2.4.2 in the Warrah Creek FS; Hughes Trueman 2005).

The Kamilaroi people inhabited the catchment prior to European settlement. Due to their nomadic, low impact existence, any traces left behind are extremely valuable as symbols of the spiritual and historical connection Aboriginal people have with the land. Much of the Aboriginal heritage has been lost since European settlement which makes remnant sites all the more important as tangible evidence of a prevailing age-old culture.

2 Development of the FMP

2.1 Legislative and policy framework

Management of the FMP floodplain must be undertaken within the current legislative and policy framework. A summary of relevant legislation and policy is presented below.

2.1.1 Water Act 1912 and Water Management Act 2000

Development on floodplains in the rural areas of New South Wales is managed through Part 8 of the *Water Act 1912*. Part 8 was gazetted in 1984 and makes provisions concerning 'controlled works' that affect, or are likely to affect, flooding and/or floodplain functions. Part 8 was amended in 1999 to allow for more strategic control of such works (hereafter known as flood control works) through the preparation of rural floodplain management plans, giving a streamlined and resource-efficient approval process. The amended Water Act provides for a broader consideration of issues in the approval of existing and proposed flood control works and strengthens NOW's ability to deal with unauthorised works.

The *Water Management Act 2000* (WMA) consolidates most of the Acts previously covering water management in New South Wales and is being phased in gradually as water sharing plans are developed and commenced for particular water sources. The floodplain management provisions of that Act will eventually replace Part 8 of the Water Act. Under current transitional arrangements of the Act, existing FMPs under Part 8 of the Water Act may be deemed Minister's plans under the WMA.

As the regulation of flood control works will ultimately fall under the WMA, it is relevant to consider the objects and principles of that Act in the preparation of plans under Part 8 of the Water Act. The objects of the WMA are to provide for the sustainable and integrated management of the state's water sources for the benefit of both present and future generations and, in particular:

a) to apply the principles of ecologically sustainable development, and

b) to protect, enhance and restore water sources, their associated ecosystems, ecological processes and biological diversity and their water quality, and

c) to recognise and foster the significant social and economic benefits to the state that result from the sustainable and efficient use of water, including:

   i) benefits to the environment, and

   ii) benefits to urban communities, agriculture, fisheries, industry and recreation, and

   iii) benefits to culture and heritage, and

   iv) benefits to the Aboriginal people in relation to their spiritual, social, customary and economic use of land and water

d) to recognise the role of the community, as a partner with government, in resolving issues relating to the management of water sources

e) to provide for the orderly, efficient and equitable sharing of water from water sources

f) to integrate the management of water sources with the management of other aspects of the environment, including the land, its soil, its native vegetation and its native fauna

g) to encourage the sharing of responsibility for the sustainable and efficient use of water between the government and water users, and

h) to encourage best practice in the management and use of water.

In relation to floodplain management, the water management principles of the WMA are:

a) Floodplain management must avoid or minimise land degradation, including soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, decline of native vegetation or, where appropriate, salinity and, where possible, land must be rehabilitated.

b) The impacts of flood works on other water users should be avoided or minimised.

c) The existing and future risk to human life and property arising from occupation of floodplains must be minimised.

The repealed *Rivers and Foreshores Improvement Act 1948*, which allowed for the carrying out of works to remove obstructions and to improve rivers and foreshores, has been replaced by provisions in the WMA for controlled activities. Under the WMA, NOW requires approval for controlled activities which include the removal or deposition of material in the bed of a watercourse or wetland and on adjacent land, and other activities that affect the flow of water in a watercourse. Approval under the WMA would be required where earthworks are proposed in the bed of a watercourse or wetland or where material is being sourced from a watercourse to construct a flood control work.

Core provisions – Water Management Act

The WMA specifies core provisions that must be dealt with in a floodplain management plan made for a water management area and additional provisions that may be dealt with. These provisions have guided the preparation of the FMP. The following section lists these provisions and outlines how they have been addressed in the FMP.

a) Identification of the existing and natural flooding regimes in the area, in terms of the frequency, duration, nature and extent of flooding.

   A range of available flood data was analysed as part of the FS and CMS in order to calibrate the computer model and develop design floods. **Section 5** of this FMP describes the selection of the design flood and hydraulic modelling that supported the design and confirmation of the flowpath network.

b) Identification of the ecological benefits of flooding in the area, with particular regard to flood dependant and floodplain ecosystems and groundwater recharge.

   The ecological benefits of flooding in the area are outlined in **Section 8** of this FMP. Further detailed information on the environmental assessment is presented in Section 9 of the CMS.

c) Identification of existing flood works in the area and the way they are managed, their benefits in terms of the protection they give to life and property, and their ecological impacts, including cumulative impacts.

   Identification of existing flood works was undertaken in detail in the CMS, and the impact of these works on flood behaviour was assessed in relation to flood risk and the flood connectivity of flood dependant ecosystems. On the basis of this assessment, the FMP (**Section 6**) specifies modifications required to existing works to address identified hydraulic and environmental issues.

d) Identification of the risk to life and property from the effects of flooding.

The CMS undertook detailed risk analysis under different scenarios to investigate and finally adopt the design flood to be used for the hydraulic design and confirmation of flowpaths within the FMP floodplain (refer to **Section 5**). The FMP is a strategic plan that identifies a network of coordinated flowpaths that need to be kept open for floods up to, and including, the design flood, irrespective of whether there are flood protection works or not.

Additional provisions – Water Management Act

a) Proposals for the construction of new flood works.

Section 4.2 of this FMP outlines the approval and determination process for new flood works. The assessment criteria (**Section 7**) will be used as the basis for determining applications for flood works.

b) Modification or removal of existing flood works.

This is dealt with in **Section 6** in this FMP.

c) Restoration or rehabilitation of land, water sources or their dependent ecosystems, in particular in relation to the following:

i) the passage, flow and distribution of floodwater

ii) existing dominant floodways and exits from floodways

iii) rates of flow, floodwater levels and duration of inundation

iv) downstream water flows

v) natural flood regimes, including spatial and temporal variability.

These provisions are reflected in the floodplain management principles (**Section 3**) which formed the basis of decision-making in the preparation of this FMP, the design of flowpaths, and also in the required actions and recommendations (**Section 6**).

d) The control of activities that may affect or be affected by the frequency, duration, nature or extent of flooding within the water management area.

The FMP provides guidance on how to control activities associated with flood works (refer to **Section 6**).

e) The preservation and enhancement of the quality of water in the water sources in the area during and after flooding.

Impacts of the FMP on water quality are assessed at a strategic level in **Section 8**.

f) Other measures to give effect to the water management principles and the objects of the Act.

The performance indicators, monitoring and review measures described in **Section 9** are designed to assess the performance of the FMP in achieving its objectives.

g) Such other matters as are prescribed by the regulations.

Currently no matters have been prescribed by the regulations.

2.1.2 The Flood Prone Land Policy

The primary objective of the NSW Government's *Flood Prone Land Policy*, as defined in the *Floodplain Development Manual* (NSW Government 2005), is to reduce the impacts of flooding on individual owners and occupiers of flood prone land, and to reduce private and public losses caused by flooding. A central tenet of the policy is that land-use proposals for flood prone land be treated within the framework of a strategically generated floodplain risk management plan prepared by using a merit-based approach. The *Floodplain Development Manual* (NSW Government. 2005) supports the policy and outlines a merit-based approach to floodplain management.

2.1.3 Other floodplain management controls

There are several additional legislative acts and policies that are relevant to floodplain management and the approval process for flood control works. The majority of these relate to floodplain environmental matters such as flora and fauna, flood dependent ecosystems, threatened species and fish habitat.

Environmental Planning and Assessment Act 1979

The Environmental Planning and Assessment Act (EP&A Act) is of particular importance in determining applications for flood control works. NOW is required to assess the environmental impact of the works under Part 5 of this Act. Consideration of proposed works under Part 4 of the EP&A Act is not required.

Commonwealth Environment Protection and Biodiversity Conservation Act 1999

In certain circumstances, where a flood control work is likely to affect a matter or species of national environmental significance, such as a nationally listed threatened species or a listed migratory species, an approval may also be required under this Act. These approvals are assessed by the Commonwealth Department of the Environment, Water, Heritage and the Arts.

Other relevant legislation includes:

- *Native Vegetation Act 2003*
- *Native Vegetation Conservation Act 1997*
- *Fisheries Management Act 1994*
- *Threatened Species Conservation Act 1995*
- *National Parks and Wildlife Act 1974*
- *Forestry Act 1916.*

Natural resource management policies that supported decision-making in the FMP include:

- the NSW Wetlands Policy 2010
- the NSW State Groundwater Dependent Ecosystems Policy 2002.

Floodplain Harvesting Policy

The *NSW Floodplain Harvesting Policy*, once finalised, will bring floodplain harvesting activities into the statutory framework for water management. A draft of the policy was released for public exhibition in April 2010. It is proposed that entitlements for floodplain harvesting that are within existing water sharing plan limits and the Murray–Darling Basin Cap be established in each valley in New South Wales. Eligible works will be assessed to determine whether they can be authorised to take floodplain water. A process will be

undertaken to allocate floodplain harvesting licences which would be a share of the total allowable floodplain harvesting volume. The data contained in this FMP, the CMS and the FS will support the implementation of the policy in the Namoi Valley.

2.1.4 Relevant management plans

The *NSW State Plan, Investing in a Better Future* (NSW Government 2010), outlines the goals, priorities and targets for the NSW Government to deliver better services and improved outcomes for the communities of NSW.

The State Plan priorities for the protection of the natural environment include the provision of better outcomes for native vegetation, biodiversity, land, rivers, and coastal waterways. Paramount to realising such outcomes is the need to meet the NSW Government's statewide targets for natural resource management. The FMP will assist in meeting these targets by reducing the potential for soil erosion and scour and improving floodplain biodiversity. The FMP aims to reduce the impacts of flooding on rural communities and supports ecologically sustainable development using practical environmental solutions within a strategic planning framework. The State Plan also identifies a number of current activities that contribute to the improvement of the health of catchments, rivers and wetlands including the implementation of catchment action plans that provide long-term direction for investment in natural resources.

The Namoi Catchment Management Authority (CMA) worked with local communities to prepare the Namoi Catchment Action Plan which was adopted by the NSW Government in January 2007 (Namoi CMA 2007). The Catchment Action Plan outlines a number of natural resource management targets, some of which are directly relevant to outcomes and recommendations in the FMP. These include targets to improve riverine structural stability and the extent of native riverine vegetation, and to increase the area of land managed according to best management practice. The Warrah Creek FMP should be viewed as one component of the integrated planning process, with other components including:

- Water Sharing Plan for the Phillips Creek, Mooki River, Quirindi Creek and Warrah Creek Water Sources (amended 1 July 2004)
- Upper and Lower Namoi Groundwater Sharing Plan (announced 1 November 2006)
- Rivercare plans
- Liverpool Plains Catchment Strategic Action Plan
- Catchment Management Plan for Yarramanbah/Pump Station Creek Catchments.

2.2 Community consultation

An essential part of ensuring the successful progress and implementation of floodplain management plans is to provide an effective communication system to encourage community involvement and develop an FMP with local knowledge and ownership. Community consultation has been a key component in the preparation of this FMP.

The consultation process undertaken for the Warrah Creek FMP included extensive communication and meetings with the Warrah Creek Floodplain Management Committee, issuing stakeholder newsletters and direct consultation with landholders. The following sections summarise the consultation process undertaken. Further information relating to the consultation process, including meeting minutes and newsletters, is contained in Appendix B of the Warrah Creek CMS.

2.2.1 Warrah Creek Floodplain Management Committee (FMC)

The Warrah Creek FMC was formed in March 2002 and consisted of representatives from state government agencies, landholders, rural farm groups, Liverpool Plains Shire Council and community groups. Eight meetings were held throughout the duration of the studies and plan preparation to discuss and review options and develop criteria for the FMP.

The FMC has been the focal point of the community consultation process. Through the FMC and landholder interviews, the consultation strategy provided opportunities for the community to make informed decisions and provide input into the FMP.

Three working papers were produced and issued to the FMC. The working papers provided the FMC with information on the progress of the report and formed the basis of the discussions at the committee meetings. The working papers are included in the Warrah Creek CMS.

For further details on the consultation process refer to Section 3 in the CMS (Evans and Peck 2007).

3 Floodplain management principles

An FMP is designed to cater for flows, provide flood mitigation, encourage sustainability and maintain and enable flooding to flood dependent ecosystems. In consultation with the Warrah Creek FMC, a set of floodplain management principles consistent with these objectives was adopted for this plan.

The adopted principles were used as a guide for the purpose of making decisions when assessing management strategies and options for the FMP. The adopted floodplain management principles conform with the general matters for consideration with respect to flood control work approvals, set out in section 166C(1) of Part 8 of the *Water Act 1912*.

The principles adopted for the Warrah Creek FMP are listed below:

1. Flowpaths should conform as closely as is reasonable to the natural drainage pattern, after taking into account the existing floodplain development.
2. Earthworks should retain adequate hydraulic capacity and continuity on the catchment and floodplain to enable the orderly passage of floodwaters and be consistent with natural/historical flowpaths.
3. Floodplain development should not cause significant redistribution of floodwater.
4. Environmental issues, including strategies for maintaining any flood dependent ecosystems, need to be taken into account in developing the FMP.
5. The exit of floodwaters from flowpaths should be at rates and depths similar to those which would have been experienced under natural/historical conditions and should discharge as closely as possible to the natural/historical location.
6. Sufficient flood storage should be retained on the floodplain so that flood travel times are not accelerated to downstream areas or flood heights increased.
7. Flood velocities in channels and flowpaths and through structures should be minimised and not result in erosion or increased siltation under various land uses.
8. There should be no detrimental impact from floodplain development, including increases in peak flood levels and increased drainage times, on any individual landholder or community infrastructure.
9. Public and private roads and tracks should be constructed at existing natural ground level to avoid impacts on upstream flood levels and the concentration of flow through culverts or causeways.
10. Drains designed to remove ponded floodwater should be orientated at right angles to the direction of flood flow and should not promote the development of gullies.

These principles are reflected within the FMP through adopted assessment criteria and will be applied by NOW when considering Part 8 applications under the Water Act.

4 FMP implementation

4.1 Roles and responsibilities

The aspects of the Warrah Creek FMP relating to works on the FMP floodplain will be regulated under Part 8 of the *Water Act 1912*. Management of works on the FMP floodplain should be seen as one of a set of complementary strategies being developed within the region for natural resource management. It should be considered in conjunction with the broader components of catchment planning and recognising the natural resource links within the larger catchment (see **Section 6.4** for best management practices).

Successful implementation of the FMP depends largely on community ownership. Landholders should encourage one another to follow appropriate land use management practices and undertake the required modifications to existing flood control works (see **Section 6.3**). The roles and responsibilities of the relevant stakeholders in relation to the FMP implementation are listed in **Table 1**.

Table 1: Implementation roles and responsibilities

Stakeholder group/ relevant agency	Responsibilities
Warrah Creek FMC	• Provide local and specialist input to the preparation of the FMP.
NOW (DECCW providing technical advisory role)	• Oversee the implementation of the FMP by reviewing and determining applications for works on the FMP floodplain under Part 8 of the Water Act. • Oversee and provide technical assistance for proposed works within the floodplain system. • Undertake compliance investigation into alleged breaches of the Water Act/WMA. • Perform ongoing monitoring of future flood events and the performance of existing structures, and ensure maintenance requirements are implemented in accordance with approvals.
Local landholders	• Undertake the required modifications to existing flood control works (with the direction of NOW) and recommended land-use and creek management strategies. • Ensure that the legislation and policy controls are adhered to and that approval is obtained from NOW for upgrading and maintaining works. • Monitor future flood events and the performance of the flowpath network. • Manage the floodplain and catchment in accordance with recommended best management practices.
Local Landcare group	• Promote appropriate land-use management practices. • Undertake maintenance.
Landholder associations	• Fund and maintain existing and future works that benefit a group of landholders (similar to those schemes already in operation on Big Jacks Creek and Pump Station Creek).
Liverpool Plains Shire Council	• Undertake road level adjustments and causeway/culvert construction in accordance with the assessment criteria.

4.2 Part 8 approval process for flood control works

4.2.1 General

All proposed and existing flood control works within the FMP floodplain require approval under Part 8 of the *Water Act 1912*. The NSW Office of Water is responsible for all licensing and compliance functions under the Act. Where no approval exists, NOW may take compliance action(s) in accordance with the Act.

4.2.2 Works that require approval

Any works requiring approval under Part 8 of the Water Act are defined as 'controlled works'. These include:

- an earthwork, embankment or levee:
  - situated or proposed to be constructed on land that is, or forms part of the bank of a river or lake, or, is within a designated floodplain, or
  - wherever situated or proposed to be constructed, that affects or is reasonably likely to affect the flow of water to or from a river or lake, and is used or is to be used for, or has the effect or likely effect of, preventing land from being flooded
- any work:
  - that is situated or proposed to be constructed on land that is, or forms part of, the bank of a river or lake, or, is within a designated floodplain, and is declared to be a 'controlled work', or
  - wherever situated or proposed to be constructed, that affects or is reasonably likely to affect the flow of water to or from a river or lake, and is used or is to be used for, or has the effect or likely effect of, preventing land from being flooded, and is declared to be a 'controlled work'.

However, a 'controlled work' does not include any works declared not to be a controlled work, or a work in respect of which a licence or approval is in force under Part 2, 5, or 9 of the Water Act.

In this FMP, a 'controlled work' within the meaning of Part 8 is referred to as a 'flood control work'.

While controlled works include earthworks, embankments and levees, these works could also include access roads, farm storages, irrigation channels and dams. Landholders should therefore contact their local NOW office for clarification.

4.2.3 Applying for approval

To lodge an application for approval of flood control works, a Part 8 application form (**Appendix C**) must be completed and submitted to NOW. The following must accompany the application form:

- application fee (currently $182)
- a detailed locality plan showing the location of the works and providing full details of the proposal, including specifications of the dimensions and design of the works, and the construction materials
- supporting information that may help in the determination process (the applicant should get in touch with the nearest NOW office for details).

For non-complying works, a report on the hydraulic and environmental impacts, including an assessment against the hydraulic and environmental criteria outlined in **Section 7** of this FMP, must accompany the application.

It is important that all information requested by NOW be provided to allow proper consideration of the application. If requested information is not provided, NOW may refuse to deal with an application.

4.2.4 Determination process

All applications for works under Part 8 of the Water Act, including works considered to be complying with the FMP, must proceed through a set process before NOW (on behalf of the WAMC) determines the application under section 171 of the Water Act. This process includes (but is not limited to):

- **Section 166C of the *Water Act 1912*** – NOW must have regard to the matters for general consideration outlined in section 166C including (but not limited to):
  - the contents of any relevant FMP or any other relevant government policy
  - the need to maintain the natural flood regimes in wetlands and related ecosystems and the preservation of any habitat animals (including fish) or plants that benefit from periodic flooding
  - the effect or likely effect on water flows in downstream river sections
  - any geographical features, or other matters of Aboriginal interest that may be affected by a controlled work
  - the effect or likely effect of a controlled work on the passage, flow and distribution of flood waters
  - the effect or likely effect of a controlled work on existing dominant floodways or exits from floodways, rates of flow, flood water levels and the duration of inundation
  - the protection of the environment, and
  - any other matters relating to the desirability or otherwise of a controlled work.
- **Part 5 of the *Environmental Planning and Assessment Act 1979*** – all applications must undergo assessment under Part 5 of the EP&A Act. The factors to be considered include the following:
  - any environmental impact on a community
  - any transformation of a locality
  - any environmental impact on the ecosystems of the locality
  - any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality
  - any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations
  - any impact on the habitat of protected fauna (within the meaning of the *National Parks and Wildlife Act 1974*)

- any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air
- any long-term effects on the environment
- any degradation of the quality of the environment
- any risk to the safety of the environment
- any reduction in the range of beneficial uses of the environment
- any pollution of the environment
- any environmental problems associated with the disposal of waste
- any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply
- any cumulative environmental effect with other existing or likely future activities.

- Part 5 of the EP&A Act also requires that the effect of a proposed activity on threatened species, populations or ecological communities, or their habitats must be considered.
- **Floodplain management plan** – NOW must consider the FMP and information contained within the FMP including principles, assessment criteria and any recommendations.
- **Other management plans** – NOW must have regard to the contents of any other management plan or policy, including those dealing with the delivery of environmental water as specified under section 8 of the WMA.
- **Aboriginal heritage assessment** – NOW will liaise with DECCW Environment Protection and Regulation Group (North West) and if required DECCW Country, Culture and Heritage Division (North West) to assess Aboriginal heritage issues associated with individual applications. Applications will be assessed in accordance with the *National Parks and Wildlife Act 1974*.
- **Additional information** – NOW must consider any additional information that has been provided by the applicant.

4.2.5 Possible determinations

NOW will inform the applicant as soon as practicable of the determination of an application for a flood control work. The general terms of approval should be comprehensive enough to cover all of the constraints (terms and conditions) that may be applied to the relevant Part 8 approval. Under the Water Act there are three (3) possible determinations:

- approval of the application
- approval of the application subject to conditions, or
- refusal of the application.

In certain circumstances there may be a right of appeal to the Land and Environment Court in respect of a determination under the Water Act. Before making a determination in respect of an application for flood control works, NOW is required to decide whether the works do or do not comply with the FMP.

4.3 Complying and non-complying works

4.3.1 Complying works

Under section 168B(2) of the Water Act, a flood control work is to be assessed as complying work if NOW is satisfied that the work complies with the FMP for the area in which the work is situated or proposed to be constructed. Within the FMP floodplain complying flood control works are defined as:

- proposed or existing (unapproved) works that are consistent with the assessment criteria in **Section 7**
- existing (unapproved) works to be modified in accordance with the required modifications, as specified in **Table 3.**

An applicant will be required to provide the necessary supporting information to demonstrate that their application is a complying work. If an existing (unapproved) or proposed flood control work is complying, the application for approval will be determined by NOW without the need for advertising to canvass third-party objections. Applications for approvals for complying works will be subject to the determination process outlined in **Section 4.2.4**, including assessment against the matters raised in section 166C of the Water Act and Part 5 of the EP&A Act.

4.3.2 Non-complying works

Under section 168B (3) of the Water Act, a flood control work is to be assessed as a non-complying work if NOW is not satisfied that the work complies with the FMP for the area in which the work is situated or proposed to be constructed, or if the work is situated or proposed to be constructed in an area that is not the subject of a floodplain management plan. For the FMP floodplain, non-complying flood control works are defined as:

- proposed or existing(unapproved) works that are not consistent with the assessment criteria in **Section 7**
- existing (unapproved) works that are not modified in accordance with the required modifications, as specified in **Table 3**.

Non-complying works may be considered for approval after a detailed investigation of hydraulic, environmental and socio-economic impacts. The cumulative impact of the proposal on flooding characteristics will need to be comprehensively addressed in the application. Hydraulic impacts will be assessed against the criteria specified in **Section 7**. Environmental impacts will be assessed under Part 5 of the EP&A Act and against the criteria specified in **Section 7**. Socio-economic impacts will be assessed against the criteria specified in **Section 7**. It is important to understand that it is the applicant's responsibility to provide the necessary technical details to support an application. Where the requested supporting information is not provided, NOW can refuse to deal with the application.

Applications for non-complying works must be advertised and third-party objections sought before the determination of the application. If an objection is received that cannot be resolved, compulsory mediation will be required. NOW may request additional supporting information from the party who lodged the objection, with failure to do so possibly resulting in the objection being rejected. If NOW grants an approval for an application and an objection has been made, NOW must notify the objector of its determination. The objector may appeal against the determination in the Land and Environment Court.

4.4 Unauthorised works

The amended Water Act strengthened NOW's ability to deal with unauthorised works. Unauthorised controlled works include the following:

- works where there is no approval in force
- works that have been constructed otherwise than in accordance with an approval that is in force, and
- works that have not been constructed in accordance with the conditions of an approval.

It is an offence to construct a controlled work otherwise than in accordance with an approval that is in force, or to fail to comply with the conditions of an approval.

Where unauthorised works are identified, NOW may direct that one or more of the following types of work be carried out by issuing a notice under section 180D of the Water Act:

a) work to remove, modify, repair or restore the controlled work or to render the work ineffectual

b) work to repair any damage caused by the controlled work (including any damage caused to any specified land, river, lake, structure or vegetation, or to the environment)

c) works to ensure that any specified land, structure, river, lake or vegetation, or the environment, will not be damaged or adversely affected, or further damaged or further adversely affected, by the controlled work

d) Without limiting (a) to (c) above, work to correct or restore any alteration caused by the controlled work to the flow of water into or from, or the quantity of water contained in, any specified river or lake.

It is an offence to fail to comply with a direction.

In the event of the occupier not complying with the served notice, NOW can carry out the work and recover the costs incurred in doing such work. NOW is not required to give any prior notice of its decision to exercise these powers. The occupier can appeal such action to the Land and Environment Court.

4.5 Varying conditions of approved works

If there is a need to vary the conditions of an already approved work, under section 176A of the Water Act, NOW:

- must notify the affected person of its intention to vary the conditions
- must give that person a reasonable opportunity to make written submissions to the Ministerial Corporation with respect to the condition concerned, and
- must have regard to any submission that is made.

In this regard the holder of the approval would be consulted regarding any variations considered necessary.

4.6 Floodplain harvesting works

Floodwaters play a vital role in replenishing the floodplain and wetland environment and are an important water source for many NSW irrigators.

The NSW Government is developing the Floodplain Harvesting Policy to ensure that floodplain harvesting is appropriately licensed, is sustainable for the long-term and will meet the requirements under the Murray–Darling Basin Ministerial Council Cap and the National Water Initiative. This initiative requires New South Wales to establish a framework for managing activities that have the potential to intercept significant volumes of water.

4.7 Roads and railways

Roads and railways (and associated bridges, culverts and roadworks) vested in local government or state government agencies are declared as non-controlled works under section 165(2)(a) of the Water Act and are not subject to approval under the Act However, the agencies constructing these works are still required to assess the works' environmental impact under the EP&A Act. For works undertaken on regional roads and state and national highways, the roads authority follows the public consultation procedure set out in section 29 of the *Roads Act 1993.*

Any constructed farm roads or tracks on the floodplain are 'controlled works' for the purposes of Part 8 of the Water Act and require approval in the same manner as proposed levees or drains.

For work undertaken on shire roads, a simplified informal procedure is usually adopted whereby the council's superintendent approaches landholders to discuss matters that may affect their interests, and their suggestions and objections are considered, as appropriate.

Prior to undertaking any work on public roads, the local council should consider the aim of achieving and maintaining natural flood flow distribution. Council needs to consider potential impacts of roadworks for the full range of floods, for the entire floodplain system. Although not bound by the requirements of Part 8 of the Water Act, the local council should consult DECCW and consider the FMP for the area in which any roadworks are proposed.

4.8 Flood protection for high value infrastructure

Landholders can protect from flooding those parts of their property that contain high value infrastructure such as houses, workshops and sheds. If such works are constructed solely for the protection of high value infrastructure, Part 8 approval will not be required. However, if such works are integrated into a much larger area of protection incorporating earthworks or levee banks that also protect arable land, then the infrastructure protection works will need to be assessed as a Part 8 determination process for flood control works on a property.

5 FMP flowpath network

5.1 General

The inherent floodplain geomorphology and the impact of human intervention have resulted in a very complex drainage pattern on the floodplains within the Warrah Creek catchment. **Figure 2** (Appendix B) shows pre-development flowpaths as well as the current flowpaths that carry concentrated flow and overland flow. Concentrated flowpaths carry flood flows in defined channels including existing creeks, whereas overland flowpaths convey floodwaters across a wider expanse of floodplain with little or no defined channels present. The pre-development flowpaths indicate the extent of change from the natural drainage pattern.

5.2 Hydraulic assessment overview

Implementation of floodplain management measures requires a detailed understanding and knowledge of flooding behaviour within the FMP floodplain. To supplement available information on historical flood events, computer-based hydraulic models can be used to simulate flooding behaviour. Information derived from hydraulic modelling includes flood flow distribution, flood levels, and flood flow velocities within the floodplain.

Hydraulic models are used to assess the impact on flood behaviour of structural management options and any proposed flood control works.

The Warrah Creek flowpath network was hydraulically modelled using a fully dynamic, networked one-dimensional hydraulic model known as the Danish Hydraulic Institute's MIKE 11 model. MIKE 11 is a commercially available engineering package specifically designed for unsteady flow computation, particularly in river and floodplain systems. The software program has built in functions for handling hydraulic structures such as culverts and weirs.

For more detailed information regarding the hydraulic modelling of the Warrah Creek floodplain system, including input data and calibration methods, refer to Section 6 of the Warrah Creek FS.

5.3 The FMP flowpath network and design flood event

The FMP flowpath network has been designed to maintain the natural flood distribution, as far as practicable, and to protect the structural stability of the floodplain. The concentrated and overland flowpaths that form the FMP flowpath network provide a coordinated flow network to effectively convey floodwaters for the adopted design flood flow and support the floodplain environment. The FMP flowpath network is a key consideration in the assessment criteria (see **Section 7**) used to assess applications for flood control works under Part 8 of the Water Act.

The design flood is the event used for the hydraulic design of the FMP flowpath network. It is applied to determine the magnitude of the event and the dispersion of water across the floodplain. The design event adopted for the FMP floodplain was the five year average recurrence interval (ARI) event, which is similar to the 1992 flood event within the catchment.

The selection and adoption of the design flood was aimed at producing an equitable distribution of floodwater across the floodplain that enables floodwater access to flood

dependent ecosystems, optimises the use of rural land for agricultural pursuits and gives an acceptable level of flood risk for property and infrastructure.

Figure 3 (Appendix B) shows the peak flood discharges for the five year ARI design flood event.

5.4 Modelling procedure

The MIKE 11 modelling for the Warrah Creek FMP involved three distinct phases:

- **'Existing conditions' modelling** – the Warrah Creek FS documents the hydrologic and hydraulic characteristics of the Warrah Creek catchment upstream of Pine Ridge Road. Four historic floods covering the range of primary interest to landholders (7–21 years ARI) were modelled using catchment conditions existing in 2004. The modelling was undertaken to establish and quantify the impact of a range of floods for the present floodplain conditions.
- **'Proposed conditions' modelling** – modelling of the floodplain system with management options that address various hydraulic and environmental issues. The issues identified include channel stability, entry/exit of floodwaters in/out of channels, roads and culverts, drainage of remnant/ponded floodwaters, catchment land use, debris loads, fence lines, and water quality. The modelling process employed the design flood and calculated flood discharges and flood gradients at many locations to aid in assessing the impact on flood levels and velocities for the numerous proposed management options.
- **'Large event' modelling** – floodplain behaviour was assessed with the 1955 flood and existing catchment conditions. This flood was a 75–100 year ARI event across the catchment, and provided useful input to the decision-making process on the impact of an extreme flood and where this may cause stress within the catchment in terms of flood behaviour, erosion and impacts on infrastructure.

The models are suited to predicting the changes in flood behaviour due to existing or proposed floodplain development and to assist in the assessment of the various management options considered. The management issues were treated collectively to determine the impact on surrounding areas and the cumulative impact.

5.5 Maintenance of flowpaths

To ensure the integrity of flow distribution, flowpaths and buffer zones may require ongoing maintenance. Siltation and growth of dense vegetation will reduce the operational efficiency and channel capacity of flowpaths, and this in turn will increase flood flow breakouts.

There is a range of measures available under the *Native Vegetation Act 2003* and certain provisions of the *Native Vegetation Conservation Act 1997* that may allow thinning of vegetation in flowpaths within the FMP floodplain. Any person proposing to undertake vegetation clearing to maintain flowpaths should contact the Namoi CMA in the first instance. The method of thinning should be one that minimises soil disturbance and reduces damage to non-target species. It is equally important that flowpaths be maintained and regularly inspected for damage, with identified problems promptly fixed. Such maintenance could include slashing and desilting.

6 Floodplain management issues, actions and recommendations

6.1 General

The Warrah Creek CMS (Evans and Peck 2007) identified flood risk issues associated with flood control works on the FMP floodplain. These issues have been developed and carefully considered in the preparation of this FMP in relation to the floodplain management principles (**Section 3**) and hydraulic, environmental, social and economic impacts. A set of key actions to be implemented as part of the FMP, including modifications to existing flood control works, has been identified. These actions are listed in **Table 2** below.

It is important to remember that all existing and proposed flood control works within the FMP floodplain require approval under Part 8 of the Water Act. Where no approval exists, NOW may take compliance action(s) in accordance with the Act. Please refer to **Section 4.2.3** for details on applying for approval.

The Warrah Creek CMS also identified a number of catchment management issues relating to flooding. These included channel stability, soil erosion, flood debris and water quality issues. The CMS recommended a range of land-use management practices to address these issues and these are shown in **Table 2** below. The implementation of these practices will support the objectives of the FMP.

6.2 Staging of FMP outcomes

The implementation of actions under this FMP has been prioritised and a staged approach recommended, as shown in **Table 2**.

Table 2: FMP priority actions

Priority	Interpretation
High	The required actions are vital to ensure adequate performance of the FMP flowpath network. The responsible party is required to initiate consultation and action within 6 months of gazettal of this plan and have the works completed within 18 months of gazettal.
Medium	These measures are important for hydraulic and/or environmental reasons. The responsible party is required to initiate consultation and action within 12 months of gazettal of this plan and have the works completed within 3 years of gazettal
Landholder discretion	It has been determined that these proposed works/issues will not have a significant impact on surrounding properties and landholders can therefore lodge a Part 8 application to implement the recommendation in consultation with NOW. Note: Construction should not be undertaken until the Part 8 application is approved.
Ongoing	These issues or measures may require further investigation or need to be monitored by DECCW and relevant stakeholders during flood events.

6.3 Existing flood control works requiring modification

Table 3 lists flood control works that have been assessed as requiring modification. With the exception of the work on 'Kelso', which requires a controlled activity approval under the WMA, the works require approval under Part 8 of the Water Act. Refer to **Section 4.2.3** for information on applying for approval. Refer to **Figures 4–9** for details on the location of the works.

Table 3: Existing flood control works where modifications are required

Map ref.	Property	Issues	Required modification and recommendations	Responsibility	Priority
PSC1 Fig. 4	'Windy Station'	Straightened and scoured residual flow drain (Pump Station Creek) on 'Windy Station'. Originally 0. 6 m deep x 6–8 m wide, now the flow drain is 4–5 m deep and up to 30 m wide, due to confined flows and creek-bed lowering in conjunction with unauthorised creek works upstream.	• Needs to be stabilised and vegetation allowed to grow, especially reed beds. Bed control structure needs to be constructed to reduce depth and allow for overland flow. Works have been implemented in two critical locations in conjunction with Namoi CMA. • DECCW, Landcare, CMA and other support groups should work with landholders in an attempt to minimise the erosion and scouring	Landholder Namoi CMA (support) DECCW	High
PSC2 Fig. 4		Uneven flow distribution around Round Island.	• Local landholders have agreed to aim for a 50/50 split in the design flow around Round Island. Residual flow drains to be constructed to achieve this flow distribution.	Landholder	Medium
MDC1 Fig. 5	'Alkoomie'	Levee located on right bank downstream of Cattle Lane has created an incised channel.	• Levee has been constructed at a location where sub-surface flow should effluent onto the floodplain. The bank has restricted the flow spreading ability and concentrated the flow to the neighbouring property. • Further investigation is required for this issue.	Landholder	Medium
MDC2 Fig. 6	'Silso'	Constructed residual drain (M^{c}Donalds Creek) between Harrisons Plain Road and Warrah Creek junction has been constructed too deeply.	• Bed control structure needs to be constructed to reduce depth of the channel.	Landholder Namoi CMA (support)	Medium
MLC1 Fig. 6	'Ameroo'	Levee constructed on right bank has restricted the ability of flows to spread across the area and slow down.	• Original flow pattern prior to the construction of the bank needs to be established and the bank either removed or modified to allow water to spread. • Further investigation into this issue is required.	Landholder	Medium

Map ref.	Property	Issues	Required modification and recommendations	Responsibility	Priority
BJC1 Fig. 7	'Warrah Ridge'	Constructed channel between Harrisons Plain Road and Warrah Creek Junction. Constructed by Soil Conservation Service in 1990 to allow water in and out.	• Needs to comply with plan requirements for channel stabilisation by controlling stock grazing to allow for revegetation to occur.	Landholder	Ongoing
WC1 Fig. 8	'Warrah Hall'	Channel shaping and levee at 'Warrah Hall' undertaken by community. Of particular concern is a head-cut below this area that has the potential to change the course of the creek.	• Levee height to be limited to 1.5 m. • The bank near this area also requires stabilisation.	Landholder	Medium
BC1 Fig. 9	'Kelso'	Loss of meanders and bed lowering near 'Kelso' on the Quirindi side of Willow Tree. New channel suffering significant erosion.	Controlled Activity (WMA): • Lodge a controlled activity approval (NOW) form. • Significant effect on flood flows. Requires remediation consistent with land-use management practices for channel stability. • River bed requires control structures to allow for sediment accumulation.	Landholder	Medium

6.4 Land-use management practices

A range of remedial land-use management practices to address issues within Warrah Creek catchment has been identified in the CMS report (Evans and Peck 2007). These practices, which are listed in **Table 5** opposite, are recommended to support the objectives of the FMP and to improve catchment health. The recommended practices are consistent with management targets contained in the Namoi Catchment Action Plan (Namoi CMA 2007) and landholders are encouraged to contact the Namoi CMA for advice and assistance in implementing the practices. The CMA has a range of incentive funding programs available for on-ground works, and activities and training that aim to improve the natural resources of the catchment.

6.4.1 Riparian buffer zones

Riparian vegetation provides multiple benefits for improving water quality, reducing land degradation (soil) and salinity, and increasing terrestrial and aquatic biodiversity. It is known to support a greater diversity of plants and animals than does non-riparian vegetation due to its wide range of habitats and food types, its proximity to water, its microclimate and its ability to provide refuge. Many native plants and animals are found only, or mainly, in riparian lands. These areas are therefore essential to these animals for all or part of their life cycles.

Careful management and protection of riparian land is essential. The Native Vegetation Regulation 2005 defines minimum riparian buffer distances to maintain or improve environmental outcomes for water quality. It is recommended that these buffer distances be used as a guide for establishing and maintaining riparian vegetation as outlined in the land-use management practices in **Table 5**. The buffer distances that apply to the FMP floodplain are shown in **Table 4**.

Table 4: Definition of riparian buffer distances

Location	Size of stream or wetland			
	Minor watercourses, flood runners and effluents	Minor creeks and lagoons	Minor rivers, minor wetlands and major creeks	Major rivers and important wetlands
Western Slopes & Plains	20 m	40 m	60 m	100 m

Source: Native Vegetation Regulation 2005, Environmental Outcomes Assessment Methodology

Refer to the Environmental Outcomes Assessment Methodology – Native Vegetation Regulation 2005 for the definitions and sizes of stream and wetlands. DECCW's Major Rivers Database (DECCW 2009) lists prescribed streams in New South Wales for determining riparian buffer widths.

For streams, riparian buffer distances are measured on both sides of the stream from the top of the bank if this is defined, otherwise from the centre of the stream. If a stream has more than one bank on either side, the bank closest to the main channel should be used, to protect vegetation on and within the stream banks. For wetlands, riparian buffer distances are measured on all sides from the wetland limit. If a wetland has more than one bank, the bank closest to the wetland area should be used.

Landholders will benefit from maintaining adequate riparian buffer zones in terms of improving water quality and minimising land degradation and restoration expenses. For more information on riparian buffer zones contact the Catchment Coordinators at the Namoi CMA office.

Table 5: Recommended land-use management practices

Issues/concerns	Recommendations
Channel stability • Channel stability is a significant problem in the FMP floodplain particularly along a number of main drainage lines immediately downstream of the Blackville – Merriwa Road (see **Figure 10** in Appendix B), that have eroded significantly. • Gullying is a problem in steeper areas, where previously discontinuous gullies have joined up and deliver water more quickly to creeks. • Scouring and enlargement (in width and depth) of channels that were originally constructed as 'first and last' drains is a problem, particularly in the mid-catchment. • Some channels that are now considered part of the creek system started as minor drains. • Costs associated with the maintenance of creek banks are increasing. For more detail refer to Section 6.1 in the CMS.	• Substantial engineering works may be required to ensure that the channels remain stable in the design flood. Vegetative stabilisation of channel banks is often difficult because of the climate and cracking soils. As a general rule, no further channel construction or realignment should be undertaken other than for the purposes of channel stabilisation. • Give priority to any 'nick points' that represent the progressive upstream movement of the bed lowering process. Bed stabilisation at these locations will help stop the consequential channel widening process. • At other selected locations, stabilise the banks at a selected control point to ensure any subsequent bed control is not outflanked by erosion of the banks. Where feasible, slight narrowing of the channel can be combined with stabilisation of a section of the bank. • Stabilise and incrementally raise the bed to reduce the hydraulic capacity of the channel. • Revegetate with permanent vegetation, a riparian zone of the desired width, from 20–100 m (refer to **Section 6.4.1**) each side of the channel, particularly at inflow and outflow points. • Avoid farming and grazing of gullies and depressions. Refer to Section 6.1.3 of the CMS for more detail.
Entry and exit of floodwater in and out of channels • The creation of new gullies is an issue, particularly where floodwater drains back into the main channel in a concentrated manner. For more detail refer to Section 6.2 in the CMS.	• Create buffer zones of permanent dense grass, of the desired width between 20 and 100 m depending on size of stream (refer to **Section 6.4.1**), at breakout points to ensure water exits channel in an orderly manner and to minimise scour. • Plant appropriate tree species for bank stabilisation (minimum riparian zone width of 20 m). • Disperse concentrated inflows before entering channel and provide protection of the channel bank at the entry point. • Construct structural works to reinforce banks at locations where concentrated flow cannot be dispersed or where the gully head needs to be stabilised away from the bank. • On steeper country, dam gullies and direct flow around dam. Protect land onto which the flow is directed with permanent grass cover. Refer to Section 6.2.3 of the CMS for more detail.

Issues/concerns	Recommendations
Catchment land use and farming practices • The changes in land use in the catchment have been reflected in the changes in flood behaviour. • The changes from grazing to cropping have increased the likelihood of floodwaters becoming faster and more channelised, tending to travel along fence lines or between fields. • Land-use changes are tending to increase the speed at which water moves down the catchment. This has the potential to increase flood heights in the downstream lower gradient floodplain areas and where channel capacity is limited, causing greater damage and reducing flood warning time.	• Continue to encourage the use of minimum/zero till and downhill farming, or technology that is appropriate to the conditions, in particular: – Farming practices on grazing land in the upper catchment should focus on increasing groundcover, rotation grazing, tree cover, riparian buffer widths, and stock management in riparian zone. – Farming practices on cropping land on slopes should focus on zero/minimum tillage, stubble retention, maintenance of banks and waterways. – Farming practices for cropping land on the floodplain should focus on zero/minimum tillage, stubble retention, response cropping and minimum width of grassed buffer from channel bank. • Increase groundcover appropriate to the conditions. • Undertake opportunity cropping for the efficient utilisation of soil profiles (avoid a long fallow period and utilise seasonal conditions). • Ensure best management practices are used to control stormwater. • Avoid farming and grazing of gullies and depressions. • Improve stream management practices to reduce bed lowering, bank erosion and siltation. • Maximise water-use efficiency. • Encourage management practices that reduce the mobility/size of stubble.
Debris loads • The increase in production of crops in the early 1970s (when the cultivation of summer crops began) has increased the amount of potential debris on the floodplain. • Significant quantities of debris are washed down the floodplain during floods, causing damage to infrastructure and requiring clearing after the floodwaters recede. For more detail refer to Section 6.6 in the CMS	• Undertake conservation farming practices for cultivated areas, including reduced or zero tillage, stubble retention and well-designed erosion control works. • Implement maintenance of buffer zones along creeks and drainage lines (see **Section 6.4.1**). • Identify and encourage management practices that reduce the mobility/size of stubble.
Fence lines • Fences lines that run at an angle across the floodplain have the potential to divert flow and initiate scouring. • Fence lines that run at right angles to the flow of water (once blocked) will lead to a weak spot where gully formation is initiated. For more detail refer to Section 6.7 in the CMS.	• Maintain fence lines to prevent build up of vegetation and soil. • Remove non-essential fences from the floodplain. • Replace netting fences with wire fences where possible.

Issues/concerns	Recommendations
Contour banks For more detail refer to Section 6.8 in the CMS.	• Individually assess contour banks prior to any construction, modification or removal. • Increase awareness of individual landholders regarding the implications of any alteration to contour banks on their land.
Water quality • Farming practices have the potential to introduce a range of pollutants into the surface water. • Suspended sediment levels in floodwaters are high due to eroding channel banks and sheet erosion from cultivated areas.	• Establish, vegetate and maintain riparian buffer zones (Refer to **Section 6.4.1**). • Encourage responsible farming practices with respect to chemicals (e.g. drift zones). • Establish and encourage erosion control measures in all areas. • Increase permanent vegetation cover with locally occurring native species, especially around environmentally sensitive and erosion risk areas. • Preserve remnant vegetation (including dead trees and fallen timber) and remove competitive weeds. • Exclude or limit stock from remnant vegetation and wetland areas to maintain and protect vegetation structure and diversity of habitat, as well as reduce soil compaction. • Minimise chemical use and undertake chemical activities (storing, loading and mixing) within controlled/bunded areas. • Undertake nutrient balance calculations so as to apply only as much fertiliser as the crop requires, and limit or avoid the use of residual chemicals when cropping flood flowpath areas. • Continue to encourage the use of minimum/zero till and downhill farming, or technology that is appropriate to the conditions. • Encourage or increase groundcover appropriate to the conditions.
Salinity • Salinity impacts are rising due to increased recharge to some aquifers. • Increased diffuse recharge occurs where crop water use is less than the amount of rainfall infiltrating into the soil on alluvial plains and colluvial slopes. • Increased direct recharge from runoff where erosion gullies or watercourses intersect aquifers on colluvial slopes.	• Reduce localised recharge into alluvial/colluvial aquifers from gullies and streams by: – reducing runoff from land above the colluvium – controlling soil erosion and gully development in the colluvium and increasing plant water use on land above the colluvium with the following vegetation management: o maintaining existing tree cover and re-establishing to 40% where less o ensuring well managed pasture on the remaining land (can be agroforestry), and o ensuring groundcover is at least 70% – increasing crop water use which may have incremental benefits for reducing diffuse recharge into aquifers but will also reduce surface runoff and the frequency of flooding. • Use earthworks to prevent gully formation and rehabilitate existing gullies.

7 Assessment criteria for flood control works

7.1 Overview

In order to apply the floodplain management principles, assessment criteria were developed and adopted in consultation with the FMC. These include hydraulic, environmental and socio-economic criteria. The criteria were used as a tool to assess management options and support the decision-making process by balancing flood risk and socio-economic and environmental factors, ensuring that all relevant issues were considered. The adopted assessment criteria were based on the five-year ARI design flood event (see **Section 5.3**), however larger events may need to be considered.

NOW will apply the adopted assessment criteria in assessing applications for the approval of flood control works. Applications will be assessed against the matters raised in section 166C of the Water Act (see **Section 4.2.4**), Part 5 of the EP&A Act, and the assessment criteria. Flood control works in the FMP floodplain can include levees, channels, private roads and access tracks, drains, contour banks (constructed waterways) and other earthworks.

7.2 Hydraulic assessment criteria

7.2.1 General hydraulic criteria

- **Hydraulic capacity** – Works on the floodplain should not reduce the hydraulic capacity or continuity of the FMP flowpath network (concentrated and overland flowpaths as defined on **Figure 3** in Appendix B) and should not significantly alter the flow distribution between the channel and floodplain. Proposed works should ensure the orderly passage of floodwaters through the floodplain.
- **Pondage and flow duration** – Works on the floodplain should not cause any significant loss in flood storage volume or significantly impact on pondage duration or cause flood peak travel time to unduly accelerate to downstream areas.
- **Flow velocities** – Works should not significantly increase velocities within the FMP flowpath network (concentrated and overland flowpaths as defined on **Figure 3** in Appendix B). Velocities should not significantly increase erosion and siltation under various land uses.
- **Cumulative effects** – Works should not result in significant cumulative effects when assessed in relation to similar development along the FMP flowpaths (concentrated or overland flowpaths).

7.2.2 Specific hydraulic criteria

- **Location of works** – Works should not be constructed across FMP flowpaths (concentrated and overland flowpaths as defined on **Figure 3** in Appendix B).
- **Design flood levels** – Bank heights should be set so as to limit flood level increase to no more than 100 mm in the five-year ARI design event and allow overtopping in floods greater than the five-year ARI design event.
- **Flow velocities** – Velocities should not exceed the maximum/limiting flow velocities allowable for the specified design event (five-year ARI for the FMP flowpath network) shown in **Table 6**.

Table 6: Maximum permissible flow velocities

Ground condition	Maximum permissible velocity (m/s)*
Bare soil	0. 4
Crop	0. 6
Native tussocky grass	0. 8

* Values based on soil classification of medium to heavy clay, highly pedal with moderate dispersability (NSW Soil Conservation Service 1982).

- **Drains** – Drains are incised structures that may be used to return runoff and remnant floodwaters to the FMP flowpath network. Some drains constructed in the past have subsequently eroded into large gullies. Accordingly, any future drains will need to be carefully designed, constructed and regularly maintained. The following criteria are proposed to limit the erosion of drainage channels:
  - Drains should be designed to convey the runoff from the one-year ARI rainfall only.
  - Drains should be orientated at approximately right angles (90°) to the direction of flood flow.
  - Drains should have a longitudinal slope less than 1 in 500.
  - Drains should be a maximum 300 mm below natural ground.
  - Drains should preferably comprise a wide, shallow cross section.
  - Drain cross section and slope should be designed for a non-scouring velocity during the recession after a flood (refer to **Table 6**). For this analysis a flood level of 0.5 m at the upstream end of the drain and bankfull level at the discharge point should be assumed.
  - Drains should discharge to a natural depression, and not directly to the main watercourse.
  - Where drainage directly to a creek or channel is unavoidable a drop structure must be provided.
- **Private roads and access tracks** – Private roads and access tracks can act as levees and can cause significant diversion of flow, increases in flood levels and waterlogging of areas which are unable to drain. The following criteria relating to proposed roads and access tracks are designed to prevent this occurring and include:
  - The construction of roads/access tracks at ground level is preferred. It is assumed that roads and access tracks will be constructed across the direction of flow.
  - Where the road/track is elevated more than 100 mm above natural surface, causeways are to be provided at natural surface level (minimum 20 m wide causeway per 100 m of road/track) to allow flood waters to escape and to prevent areas from becoming waterlogged.

Note: The height criteria for roads and access tracks is set at 100 mm (compared to bank heights which can be greater than 300 mm – refer to Section 7.3.2 of the Warrah Creek CMS) because roads are generally aligned across the direction of flow whereas banks are generally aligned parallel to the flow, resulting in roads having a greater impact on flood behaviour.

7.2.3 Hydraulic assessment procedure

Landholders applying for the approval of flood control works will be required to undertake the following procedure to assess the hydraulic impacts of the proposed works:

- Identify the location of the proposed works in relation to the relevant FMP flowpath(s) (concentrated and/or overland flowpath) from **Figure 3** (Appendix B).
- Identify the appropriate five-year ARI design flow width and slope from **Figure 3** (Appendix B).
- Obtain survey of land surface cross sections (at right angles to the flow direction). Depending on the watercourse extent and location of tributaries, obtain a minimum of five cross sections as follows:
  - at the centre of the proposed works
  - at the upstream and downstream end of the proposed works, and
  - at the upstream and downstream property boundaries.

  An hydraulic model suitable for modelling backwater effects (e.g. HEC-RAS) will need to be set up based on the surveyed cross sections and the five-year ARI design flows. The model should be configured for existing conditions and conditions with the works in place. Flood levels and velocities for both cases should be calculated. Bank height and minimum set back distance should be varied until the variation in flood level does not exceed 100 mm (between existing conditions and with works in place). The banks should overtop in floods greater than the five-year ARI design flood. Suitably qualified professionals should be engaged to undertake survey and hydraulic modelling.
- Assess the cumulative impact of similar works extending upstream and downstream of the proposed works.
- The model data and results should be supplied to NOW as part of the application for assessment.

Cumulative effects – The cumulative effect of flood control works should be considered as if similar new works were to be constructed in the vicinity or other existing works were to be developed to the same extent. For a bank, this would mean assessing the impacts on flood levels and velocities, assuming the proposed bank were extended for the same length in any upstream and downstream direction. The 'acceptable assessment procedure' using the HEC-RAS analysis approach would be suitable to make this assessment.

7.3 Environmental assessment criteria

Soil condition and structure:

- Flood control works should not impose negative impacts on soil structure or condition by increasing the potential for scour and erosion or blocking flow to significant areas of floodplain soils.
- Permanent grass should be established between banks and associated channels.

Fish passage:

- Flood control works should not significantly block or restrict the free passage and migration of fish within the floodplain environment.

Cultural sites:

- Flood control works should not block or restrict the delivery of flood flows to any Aboriginal sites that rely on flooding regimes (such as scarred trees) or increase the potential for erosion or scour that may impact on Aboriginal sites.

Flood dependent ecosystems:

- Flood control works should not block or restrict floodwater access to flood dependent ecosystems (including wetlands and watercourses that rely on flooding to support plant and animal communities in them).

Flora and fauna:

- Flood control works should not fragment or isolate stands of the endangered Grassy White Box Woodlands identified on **Figure 10** (Appendix B). Any works proposed within this vegetation require:
  - additional botanical surveys targeting the presence and distribution of this community and any associated threatened flora
  - targeted surveys for potentially occurring threatened fauna species to identify the diversity of threatened species present, their reliance upon those habitats present and their likely tolerance to any of the floodplain works proposed
  - targeted surveys during seasonal and climatic conditions that are suitable for the detection of flora and fauna species. Where possible, the surveys should be conducted during the late spring – early summer months.
- Flood control works should not fragment or isolate stands of low to moderately disturbed Riparian River Oak Forest identified on **Figure 10** (Appendix B). Any works proposed within this vegetation require:
  - additional botanical surveys targeting the presence and distribution of this community and any associated threatened flora.

7.4 Socio-economic assessment criteria

- **Disruption to daily life** – Unless previously agreed among all affected landholders, flood control works should not result in significant disruption to the daily life of surrounding landholders (e.g. property access).
- **Maintenance costs** – Landholder agreements such as those that currently exist for the maintenance of works on Pump Station and Big Jacks creeks should be considered in other locations where channel stabilisation works would benefit more than one landholder.
- **Infrastructure damage** – Flood control works should not cause a detrimental impact (e.g. increases in peak flood levels, velocities and drainage times) on any individual landholder or community infrastructure.
- **Equity** – All current landholders should be allowed a reasonable area of flood protection, depending on the flood pattern across their property.

8 Environmental assessment

8.1 Overview

A number of the floodplain management principles and assessment criteria adopted in the FMP promote a system of flowpaths that conforms as closely as possible to the natural drainage pattern of the floodplain. Hence, the Warrah Creek FMP provides a flowpath network that approximates the natural flood flow distribution. This allows for the orderly passage of flood flows through the system, enables the structural stability of streams and maintains core inundation of the floodplain.

The following sections outline the expected impacts of the FMP on the floodplain environment. Refer to the CMS (Section 5 and Appendices C & D) for more detail on the environmental assessment.

8.2 Environmental impacts

Implementing the FMP will have a positive impact on the floodplain environment principally by reducing soil erosion and scour and reasonably assuring the long term structural stability of streams on the floodplain. The FMP also includes a range of measures and recommendations that will benefit floodplain vegetation, fauna and fish habitat, water quality and the protection of Aboriginal heritage sites. **Table 7** summarises the expected impacts of the Warrah Creek FMP on components of the floodplain environment.

Table 7: Summary of Warrah Creek FMP environmental impacts

Component	Expected impact
Soils	Floodplain soils benefit from flooding through increased moisture, sediment and nutrients. Soils regain their porosity and structure through a wetting and drying cycle. Four soil landscape units have been identified within the FMP floodplain, consisting of: • Phillips Creek alluvial soil landscape – confined to a narrow strip along the upper reaches of the creek channels and characterised by basaltic boulders and gravel within and adjacent to the creek channel • Windy Creek transferral soil landscape – found at the change in slope from the steep hills to the low gradient floodplain • Conadilly alluvial soil landscape unit – typical of the broad, level floodplain, with local relief less than 3 m that is characteristic of the Liverpool Plains • Borambil Creek alluvial soil landscape. The dominant soil landscape includes highly pedal, black cracking clays which are prone to erosion. Modifications to existing flood control works identified in the FMP will alleviate existing soil erosion issues. The FMP flowpath network has been designed to enable the orderly passage of the five-year ARI design flood flow through the system, reducing the potential for scour and erosion. Additionally hydraulic and environmental criteria identified in the FMP for use in the assessment process for flood control works, specifically address soil erosion and scour issues as well as the beneficial inundation of floodplain soils. Floods larger than the five-year ARI design event could result in localised erosion and scour due to the overtopping of flood control works.

Component	Expected impact
Flora	Within the FMP floodplain three key native vegetation communities have been recorded: • **Grassy White Box Woodland** has a very limited distribution (adjacent to Swing Road, Borambil Creek Road and Borambil Creek – see **Figure 10** in Appendix B). This community is listed as an endangered ecological community under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and NSW *Threatened Species Conservation Act 1995*. Although not classified as a flood dependent ecosystem, environmental criteria identified in the FMP for use in the assessment process for flood control works, require that works do not isolate or fragment this community • **Riparian River Oak Forests** occur adjacent to existing flowpaths within the FMP floodplain and vary in quality from highly to lightly disturbed. This vegetation community has been identified as being of regional conservation concern. The river oak community is dependent on maintenance of flows and includes the flood dependent river red gum (*Eucalyptus camaldulensis*). It also provides the important function of reducing the sedimentation of drainage lines, erosion of creek banks and provides important habitat for native species. Environmental criteria identified in the FMP require that flood control works being assessed for approval do not isolate or fragment low to moderately disturbed stands of Riparian River Oak Forest (see **Figure 10** in Appendix B) or isolate or restrict flows to flood dependent ecosystems which may include this community. Recommended land-use management practices in the FMP support the revegetation of riparian zones in areas where this community is highly disturbed. • **Mixed grasslands** dominate the majority of the FMP floodplain (see **Figure 10** in Appendix B). This community is heavily modified and was rated in the CMS as having low conservation value and low recovery potential due to the lack of native vegetation. The FMP does not identify specific criteria for this vegetation in the assessment process for flood control works.
Flood dependent ecosystems	Flood dependent ecosystems include floodplain wetlands and watercourses that rely on flooding to support plant and animal communities in them. Three potential wetland areas were identified within the FMP floodplain through reference to topographic mapping. Two of these sites were field inspected during the preparation of the FMP and identified as cleared farming land under cultivation. The third site was assessed from satellite imagery and was also identified as cleared farming land. While naturally occurring wetlands may have originally been located at these sites, it is considered that the sites have been highly modified by human activities and retain minimal wetland value. Implementation of any works associated with the FMP will be subject to meeting environmental assessment criteria including the maintenance of floodwater access to any flood dependent ecosystems.
Fauna	The Warrah Creek catchment lies within the Liverpool Plains (Part B) Namoi CMA sub-region. Within this region there are 48 fauna species listed under the NSW *Threatened Species Conservation Act 1995* and 13 threatened fauna species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 2000*. For more detail on listed species, populations and communities refer to the CMS. A fauna survey undertaken during the Warrah Creek CMS found that the remnant woodlands and better developed stands of riparian vegetation provide a habitat structure suitable for some of the threatened fauna species previously recorded or potentially occurring within the FMP floodplain. Those species most likely to occur within these habitats would be hollow dependent animals, such as the insectivorous bats and several of the birds (both local and migratory). Environmental criteria identified in the FMP require that flood control works being assessed for approval do not isolate or fragment remnant Grassy White Box Woodland or low to moderately disturbed Riparian River Oak Forest. The FMP also identifies assessment criteria to maintain floodwater access to flood dependent ecosystems which may include areas of riparian vegetation. As a result, implementation of the FMP is expected to have a positive impact in protecting fauna habitat in the FMP floodplain. Additionally, land-use management practices recommended in the FMP to support the revegetation of riparian zones where this community is highly disturbed are expected to enhance fauna habitat in these areas over the long term.

Component	Expected impact
Fish	Within the Liverpool Plains (Part B) Namoi CMA sub-region, three threatened fish species, an endangered population and an endangered ecological community consisting of the 'Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River' are listed under the *Fisheries Management Act 1994*. No threatened fish species have been recorded within the FMP floodplain. The aquatic environments within the FMP floodplain vary in condition and habitat value for native fish. Drainage lines supporting permanent water and riparian and aquatic vegetation have a relative high habitat value compared to the ephemeral creeks lined by exotic vegetation. During floods lower parts of the FMP floodplain where water may reside for longer periods would be expected to provide resources for aquatic invertebrates and fish inhabiting the floodplain. Works modifications identified in the FMP will enhance the structural stability of flowpaths and will be expected to benefit fish habitat. Criteria identified in the FMP for the assessment of flood control works approvals will protect fish habitat by requiring that fish passage within the floodplain is not significantly restricted, the flowpath network is not impeded and floodwater access to flood dependent ecosystems is maintained. Additionally, recommended land-use management practices in the FMP to support the revegetation of riparian zones where this community is highly disturbed are expected to enhance fish habitat by providing improved food resources and shelter along drainage lines.
Water quality	The FMP will allow the orderly passage of flood flow through the FMP floodplain, which will minimise flow velocity and concentration and subsequently reduce the potential for scour and erosion. This will subsequently minimise sedimentation and water turbidity, thereby improving water quality.
Groundwater	Increased groundwater recharge from rainfall infiltration-crop water use imbalances and from erosion gullies and watercourses intersecting aquifers has been identified as an issue leading to increased salinity in the catchment. Modifications to existing flood control works identified in the FMP will alleviate existing soil erosion issues and would be expected to reduce aquifer recharge in some areas. Land-use management practices recommended in the FMP include measures to restrict recharge and if implemented would be expected to reduce salinity impacts. The FMP flowpath network has been designed to enable the orderly passage of the five-year ARI design flood flow through the system, reducing the potential for scour and erosion. As well, hydraulic and environmental criteria identified for use in the assessment process for flood control works, specifically address soil erosion and scour issues. These factors, by minimising ongoing erosion including the development of erosion gullies, are expected to restrict groundwater recharge from these sources and help to mitigate catchment salinity.
Indigenous heritage	Information on the location of recorded Aboriginal sites in the catchment has been obtained from the Aboriginal Heritage Information Management System. Recorded sites occurring within the FMP floodplain include scarred trees, artefacts and grinding grooves. Flood damage to on-ground Aboriginal sites (such as artefacts) may occur naturally however the FMP flowpath network has been designed to minimise flood flow velocities and accordingly, would be expected to reduce the risk of erosion damage to these sites during floods. Criteria identified in the FMP for the assessment of flood control works approvals will protect Aboriginal sites by requiring that the delivery of flood flows to sites that rely on flooding regimes (such as scarred trees) is not restricted and that the potential for erosion or scour that may impact on sites is not increased. As well, the criteria require that floodwater access to any flood dependent ecosystems (which may contain Aboriginal sites) is maintained.
Non-indigenous heritage	Non-indigenous settlement of the Liverpool Plains did not commence until around 1830. Many structures and monuments from those early years were impermanent and have been lost to the ravages of time and weather. Liverpool Plains Shire Council maintains a list of properties of historical significance. In general, implementation of the FMP is expected to minimise potential erosion damage from flooding and is not likely to significantly impact on historical properties in the FMP floodplain.

8.3 Downstream floodplains

Downstream of the FMP floodplain Warrah Creek joins the Mooki River which then flows to the north-west joining the Namoi River near Gunnedah. The Mooki River floodplain has been highly modified for cultivation and retains relatively little floodplain habitat. It is anticipated that the implementation of the Warrah Creek FMP will have a positive influence on downstream floodplain environments as a result of more natural and orderly flood flow distribution and the removal of significant barriers to flood flow. The downstream boundaries of the FMP floodplain will be largely open and as such promote the free passage of flood flow to downstream floodplains. This will assist in maintaining remnant downstream productivity and biodiversity. The implementation of the FMP will result in better control of flow velocity and concentration, minimisation of soil erosion and improved flow distribution. This will have a positive influence on the hydrological regime and flooding characteristics of downstream floodplains.

9 Monitoring and review

9.1 Performance indicators

Following major floods, the performance of the FMP will be assessed against three sets of performance indicators, namely:

1. Existing and proposed flood control works are constructed, modified and maintained according to the FMP.
2. Flowpaths within the FMP floodplain allow for the orderly passage of flood waters during a range of floods.
3. Flowpaths within the FMP floodplain allow for the delivery of floodwaters to support floodplain ecosystems.

The performance of the flowpaths within the FMP floodplain will be assessed from information gathered during flood monitoring activities. This information will be measured against the FMP's objectives and the following indicators:

Hydraulic:

- improved passage of flood waters through the FMP floodplain
- controlled works performing to the agreed hydraulic criteria

Environmental:

- improved fish passage
- improved habitat for plants and animals that utilise floodplains
- increased flood connectivity to flood dependent ecosystems
- controlled works performing to the agreed environmental criteria

Economic:

- reduced flood damage

Social:

- reduced inundation period
- less disruption to community infrastructure (roads, railways and essential services)
- increase in flood awareness within the community.

There are a number of data sources that can be used to report on the performance indicators such as flood monitoring, auditing of flood control works and results from flora and fauna surveys. The following monitoring program is proposed to assist in the performance assessment of the FMP.

9.2 Flood monitoring

Any surface water management scheme requires monitoring in mainstream flood and local catchment flow events to assess performance efficiency, identify problem areas and identify whether any modifications or upgrades are required. An effective monitoring program will require input from both DECCW and landholders. Depending on the size of the flood, monitoring will range from simple observation to measuring of flows and levels, followed by additional hydraulic analyses. The larger floods, nearing (and exceeding) the

design flood levels, should be monitored in more detail. In particular, as the hydraulic modelling has a significant degree of reliance upon flow estimates, and especially peak flows, it will be important to collect data to verify these estimates.

DECCW will lead the planning and implementation of monitoring programs and will seek input from NOW, Liverpool Plains Shire Council and landholders. The following activities are recommended:

- DECCW/NOW to undertake aerial photography, collection of survey and satellite imagery, collation of environmental data
- NOW to undertake stream gaugings and flow measurements at predetermined locations
- Where safe to do so, DECCW, NOW, Liverpool Plains Shire Council and landholders to observe the performance of relevant parts of the FMP floodplain, including marking high flood levels, estimating flow velocities and taking photographs.

9.3 Environmental monitoring

Environmental monitoring during and after floods would determine whether the required environmental works modifications are working properly and help to assess the ecological impacts of local flooding. Environmental data would consist mainly of observations, with supporting photography wherever possible. The scale of flooding would influence the extent of data collected.

DECCW should collate environmental data from Liverpool Plains Shire Council, landholders and other agencies. Council and landholders would observe their areas of the floodplain, noting:

- the performance of environmental works modifications during floods
- flood dependent ecosystems inundation
- the presence of waterbirds and fish, and
- regeneration of floodplain vegetation.

Refer to **Appendix D** for detailed advisory notes on flood monitoring.

9.4 FMP review

FMPs adopted as Minister's plans under the WMA are required to be reviewed at five-yearly intervals in order to determine whether their provisions adequately implement the water management principles of the Act. In addition to this requirement, it is recommended that the FMP be reviewed after the occurrence of a five-year ARI flood event. This process would include reconvening the FMC in order to obtain the opinions of the various interest groups on the flood event and the performance efficiency of flowpaths within the FMP floodplain.

Any direct and indirect impacts of climate change on agriculture will also have a strong flow-on effect on floodplain management, as most rural floodplain landholders are primary producers. Some landholders may respond to the impacts of climate change by undertaking reafforestation activities and creating carbon sinks. Early adaptive responses will decrease longer term vulnerability and economic costs. Therefore, as part of any FMP review, particular attention will be given to exploring the adaptive capacity of rural FMPs to address the possible impact of climate change on flood risk exposure, floodplain ecosystems and rural economies.

10 References

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NSW Government (2005), *NSW Floodplain Development Manual: the management of flood liable land*, NSW Department of Infrastructure, Planning and Natural Resources, Sydney. This document incorporates the *NSW Flood Prone Land Policy*.

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Appendix A – Glossary and abbreviations

Glossary

Term	Definition
average recurrence interval	The long-term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20-year average recurrence interval flood event will occur on average once every 20 years.
Australian Height Datum	A common national reference plane, relative to which survey heights are given. It is approximately at mean sea level.
calibration	The process by which a computer model (hydrologic or hydraulic) is adjusted so that it best represents the real world situation that the model is intended to simulate.
catchment	The area draining to a site. It always relates to a particular site, and may include the catchments of tributary streams as well as the main stream.
colluvium	Soil and debris that accumulates at the base of a slope through gravity.
controlled activity	Under the *Water Management Act 2000*, a controlled activity means: • the erection of a building or the carrying out of a work (within the meaning of the *Environmental Planning and Assessment Act 1979*), or • the removal of material (whether or not extractive material) or vegetation from land, whether by way of excavation or otherwise, or • the deposition of material (whether or not extractive material) on land, whether by way of landfill operations or otherwise, or • the carrying out of any other activity that affects the quantity or flow of water in a water source within 40 m of 'waterfront land'.
dendritic	Tree-like branching of streams.
designated floodplain	Any land which is so designated by an order in force under section 166 (1) of the *Water Act 1912*.
development	The erection of a building or the carrying out of work on land; or the use of land or a building or a 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 velocity, which is a measure of the speed of water rather than how much is moving.
discharge hydrograph	A graph which shows how the discharge changes over time at a specific location.
ecosystem	A biological system involving interaction between living organisms and their immediate physical, chemical and biological environment.
flood	Relatively high stream flow when water overtops the natural or artificial banks of a stream and spreads over adjoining land.
flood control works	Works such as levees, roads and channels that can affect the distribution of floodwaters on the floodplain. These are known as 'controlled works' under the *Water Act 1912* (refer to Section 4.2.2 of the FMP).
flood dependent ecosystem	An ecosystem that depends on periodic flooding to support essential ecological processes.
flood gradient	Slope of the water surface profile at a particular time.
flood liable land	Land susceptible to flooding by the probable maximum flood event.
floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, or in other words land that is liable to flooding.
floodplain harvesting	The collection, extraction or impoundment of water flowing across floodplains.

Term	Definition
flood prone land	See 'flood liable land'.
FMP floodplain	Within this FMP, land with less than 2% slope that is a 'designated floodplain' under the *Water Act 1912*.
FMP flowpath network	A coordinated network of flowpaths consisting of concentrated and overland flowpaths defined to convey the adopted design flood flow. Impacts on the flowpath network are specifically considered as part of the approval process for flood control works.
habitat	The type of environment in which a plant or animal lives; including physical and chemical interactions.
HEC-RAS	Computer software designed by the US Army Corps of Engineers to perform one-dimensional hydraulic calculations for natural and constructed channels.
hydraulics	In the context of this FMP, the study of water flow in waterways, particularly the evaluation of flow characteristics such as stage and velocity.
hydrograph	A graph which shows how either the discharge or the stage changes with time at a particular location.
hydrology	The term given to the study of the rainfall and runoff process.
MIKE 11	A computer software model designed by the Danish Hydraulic Institute to perform dynamic one-dimensional hydraulic calculations.
peak discharge	The maximum discharge occurring during a flood event.
precipitation	The general term for the release of water from the atmosphere. It can be in the form of rain, hail, sleet, snow, dew or frost.
probable maximum flood	The largest flood that could conceivably occur at a particular location, usually estimated from the probable maximum precipitation.
probable maximum precipitation	The greatest depth of precipitation considered to be possible from consideration of meteorological processes, applying to a particular location, time of year, storm duration and size of storm area.
probability	A statistical measure of the likelihood, or expected frequency of occurrence, of an event.
riparian	The interface between land and a flowing surface water body, typically characterised by water-dependent vegetation and often subject to flooding; has a significant role in soil conservation, biodiversity and water quality.
runoff	The amount of precipitation which ends up as streamflow, after allowing for losses such as evaporation and infiltration.
stage	Equivalent to 'water level' or 'flood level'; both are measured with reference to a specified datum.
sub-catchment	A subdivision of a catchment; it has all the features of a catchment defined above.
steady flow	Describes the type of flow that occurs when discharge and depth are constant, that is, they do not vary with time.
unsteady flow	Describes the type of flow that occurs when discharge and depth vary with time. This is the typical behaviour of a flood wave as it moves down a catchment.
water surface profile	A graph showing the flood stage along a watercourse at a particular time.
waterfront land	The bed of any river, together with any land lying between the bed of the river and a line drawn parallel to, and the prescribed distance inland of (40 m), the highest bank of the river.
wetland	An area of land that is wet by surface water or groundwater, or both, for long enough periods that the plants and animals in it are adapted to and depend on moist conditions for at least part of their lifecycle.

Abbreviations

Abbreviation	Definition
AHD	Australian Height Datum
ARI	Average recurrence interval
CMA	Catchment Management Authority
CMS	(Warrah Creek) Catchment management study
DECCW	Department of Environment, Climate Change and Water
DIPNR	Department of Infrastructure, Planning and Natural Resources
D/S	Downstream
DWR	Department of Water Resources
EP&A Act	*Environmental Planning and Assessment Act 1979*
FMC	(Warrah Creek) Floodplain Management Committee
FMP	(Warrah Creek) Floodplain Management Plan
FRMS	Floodplain risk management study
FS	Flood study
HEC-RAS	Hydrologic Engineering Center's Rivers Analysis System
LGA	Local government area
NHT	Natural Heritage Trust
NOW	NSW Office of Water (part of DECCW)
U/S	Upstream
WAMC	Water Administration Ministerial Corporation
WMA	*Water Management Act 2000*

Appendix B – Figures 2 to 10

WARRAH CREEK FLOODPLAIN MANAGEMENT PLAN

NSW GOVERNMENT Environment, Climate Change & Water

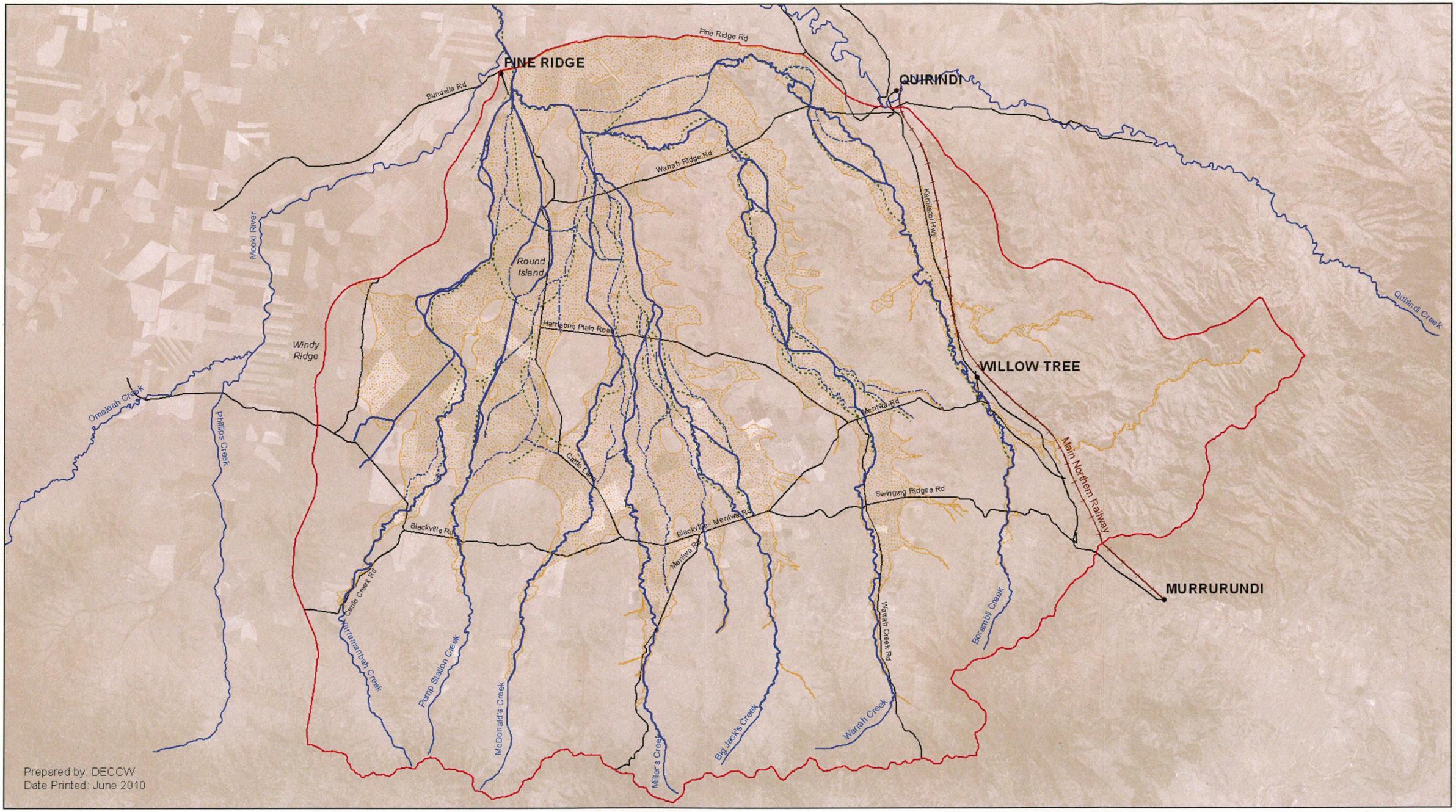

Figure 2: Warrah Creek FMP Pre-Development and Current Drainage Pattern

0 2 4 6 8 10
Kilometres

N

Legend

- Creeks
- Concentrated Flowpaths
- Overland Flowpaths
- Pre-Development Flowpaths
- FMP floodplain
- Warrah Creek Catchment
- Towns
- Railways
- Roads

Environment, Climate Change & Water

PINE RIDGE
QUIRINDI
WILLOW TREE
Pine Ridge Rd
Bundella Rd
Harrisons Plain Road
Merriwa Rd
Blackville Rd
Blackville - Merriwa Rd
Swinging Ridges Rd
Cattle Lane
Borambil Creek
Kamilaroi Hwy
Main Northern Railway
Warrah Creek
Wapan Creek Rd
Pump Station Creek
McDonald's Creek
Miller's Creek
Little Jack Creek
Bowdens Creek
Yarramanbah Creek
Cattle Creek Rd

Q is 5 yr ARI discharge in m3/s
S is channel slope in m/m

Prepared by: DECCW
Date Printed: June 2010

Figure 3: Warrah Creek FMP Flowpath Network, Design Flood Discharges and Channel Slopes

0 1 2 3 4 5
Kilometres

N

Legend

- Concentrated Flowpaths
- Overland Flowpaths
- FMP Floodplain
- Warrah Creek Catchment
- Railways
- Roads
- Towns

WARRAH CREEK FLOODPLAIN MANAGEMENT PLAN

Environment, Climate Change & Water

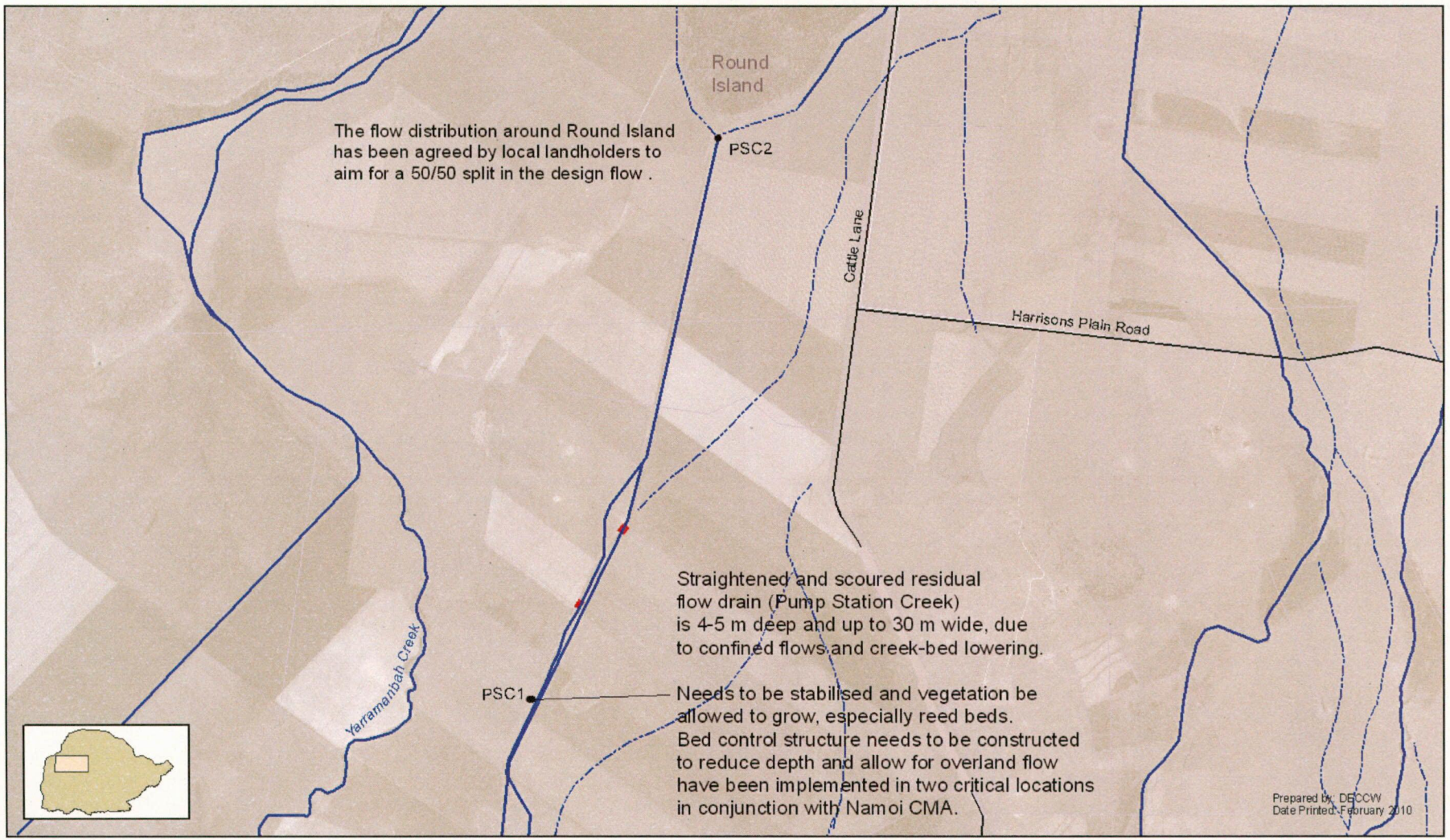

Figure 4: Location of Pump Station Creek Issues PSC1

WARRAH CREEK FLOODPLAIN MANAGEMENT PLAN

Environment, Climate Change & Water

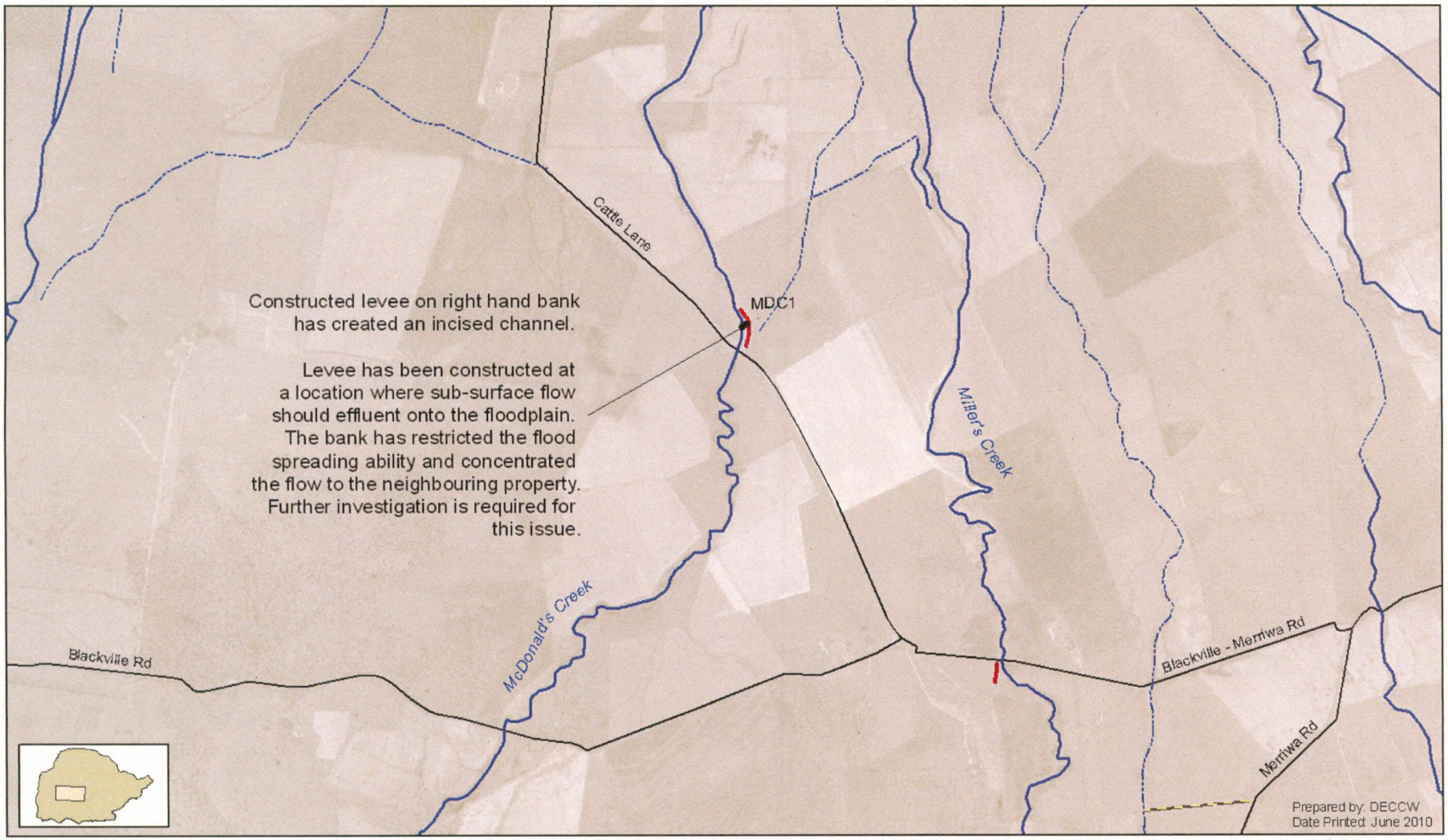

Figure 5: Location of McDonald's Creek Issue MDC1

WARRAH CREEK FLOODPLAIN MANAGEMENT PLAN

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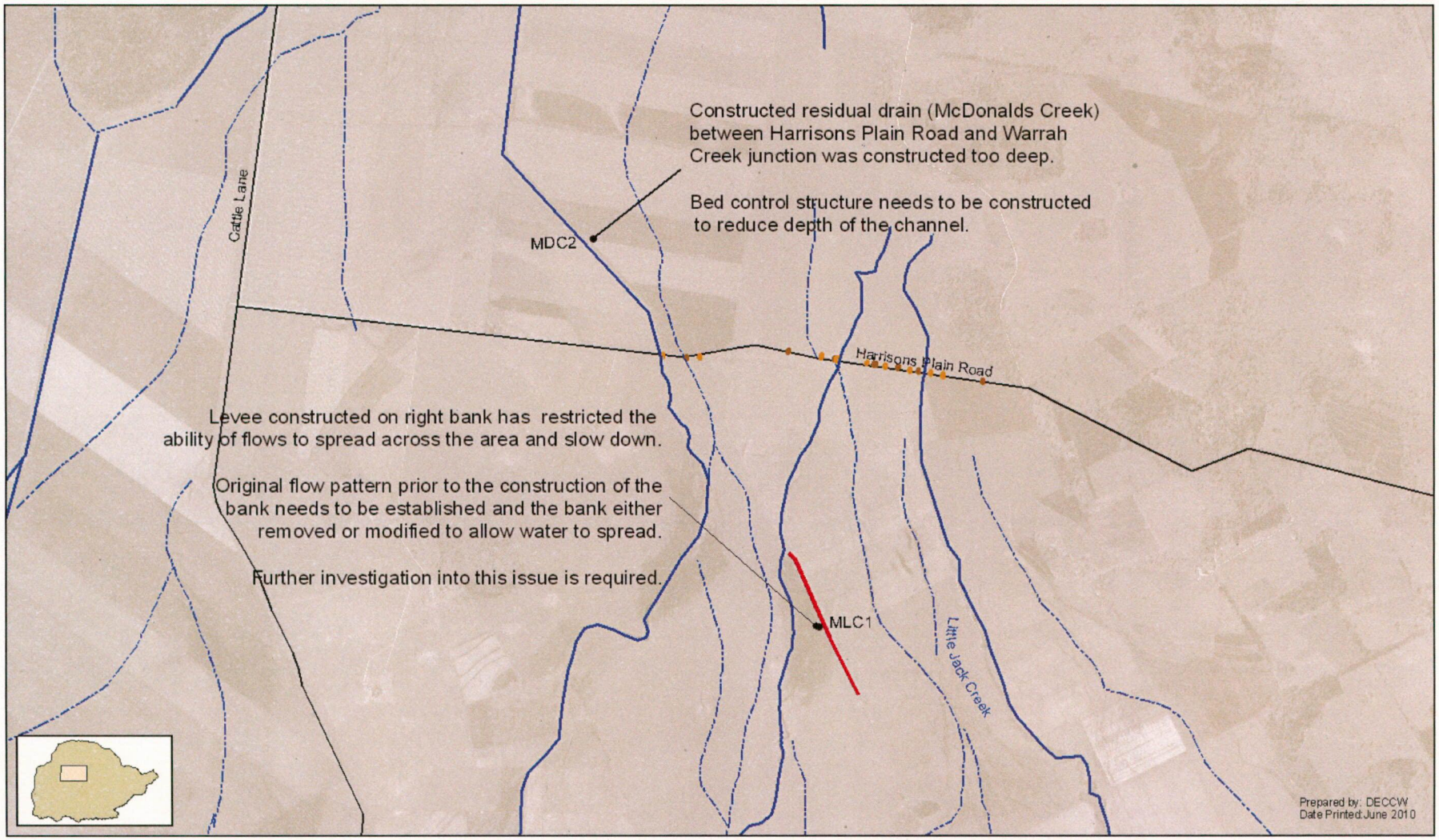

Figure 6: Location of McDonald's and Millers Creek Issues MLC1 & MDC2

0 0.5 1 1.5 2
Kilometres

N

Legend

Concentrated Flowpaths
Overland Flowpaths
Levees
Causeways
Pipes
Roads

WARRAH CREEK FLOODPLAIN MANAGEMENT PLAN

Environment, Climate Change & Water

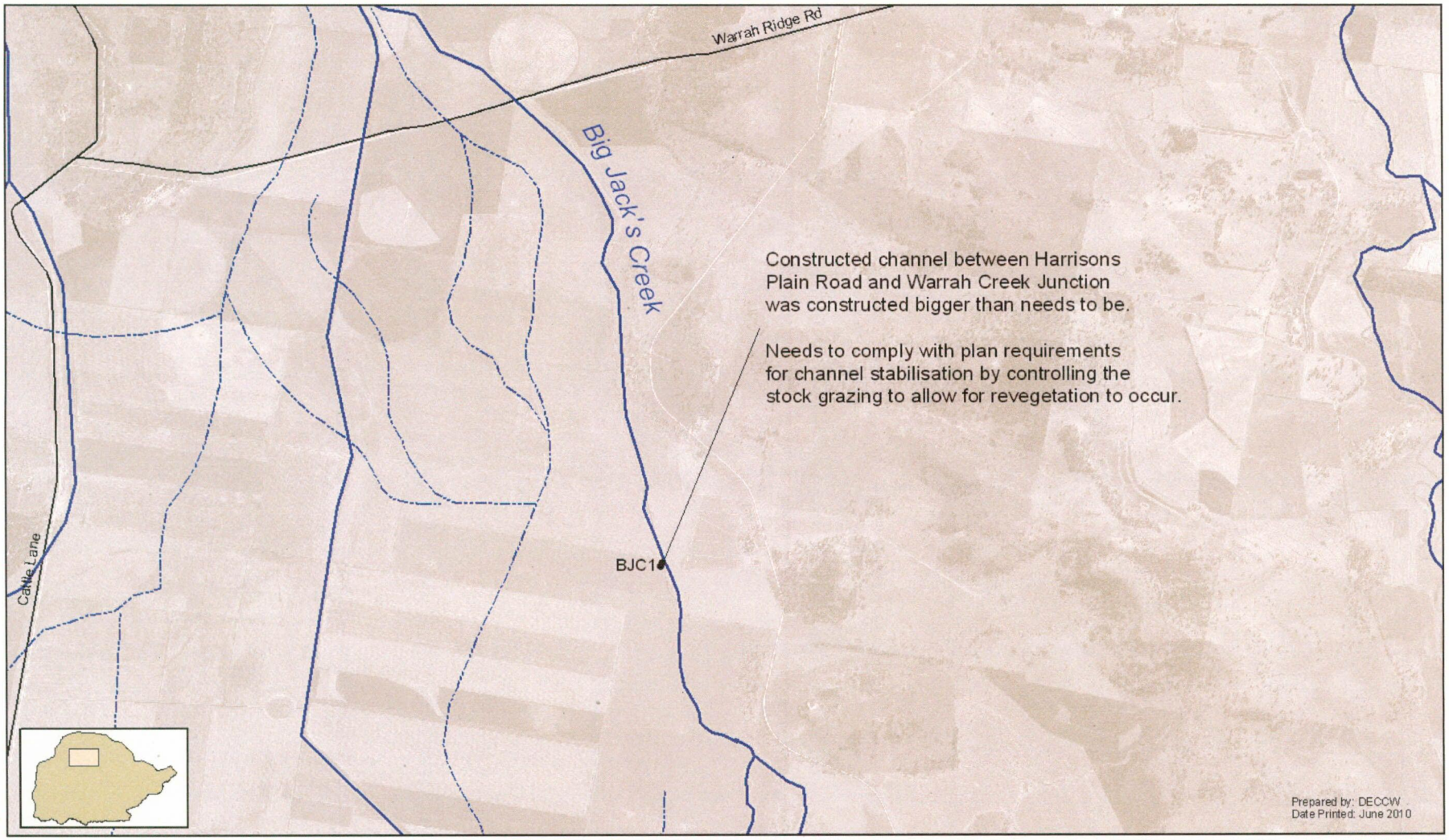

Figure 7: Location of Big Jack's Creek Issue BJC1

WARRAH CREEK FLOODPLAIN MANAGEMENT PLAN

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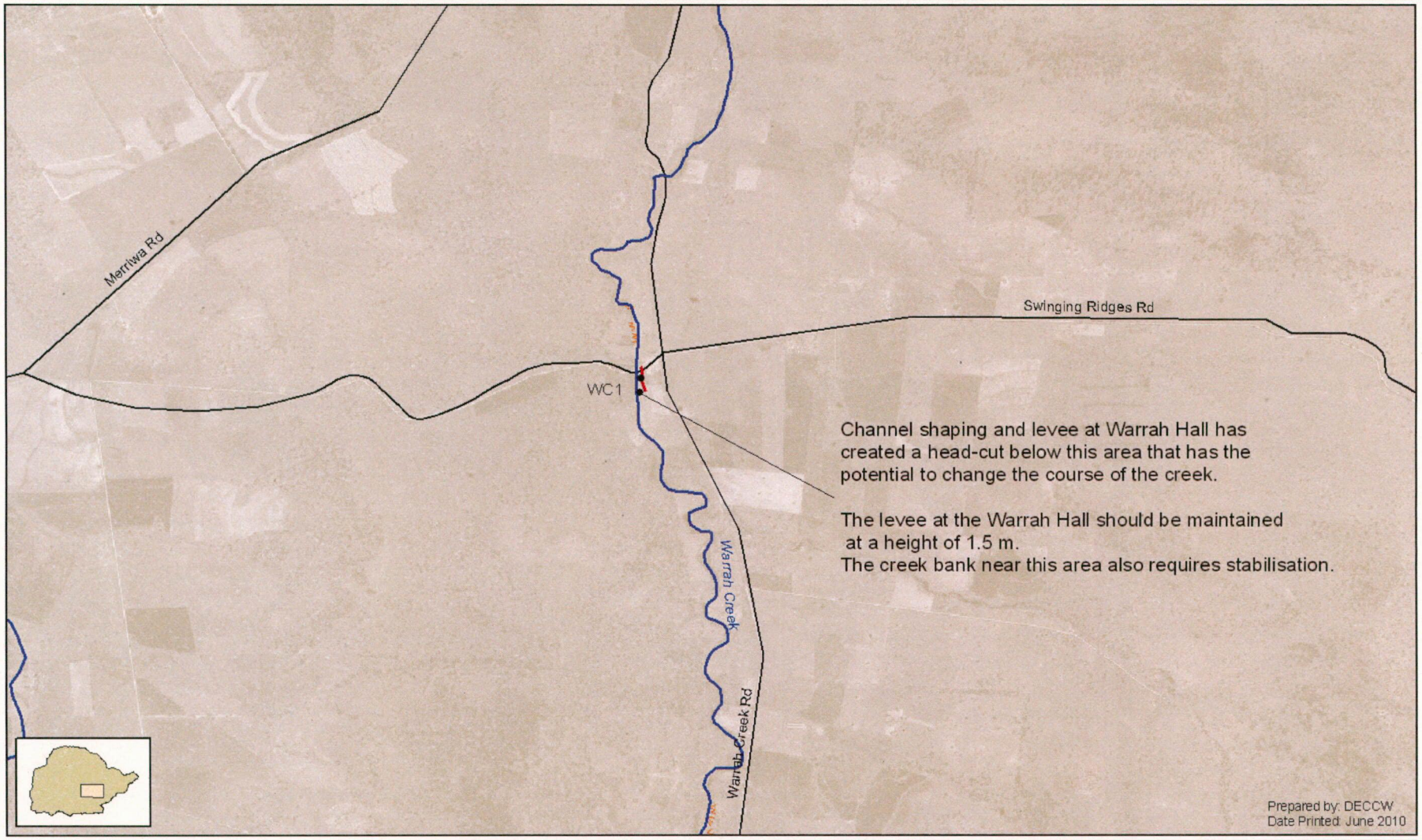


Figure 8: Location of Warrah Creek Issues WC1

WARRAH CREEK FLOODPLAIN MANAGEMENT PLAN

Environment, Climate Change & Water

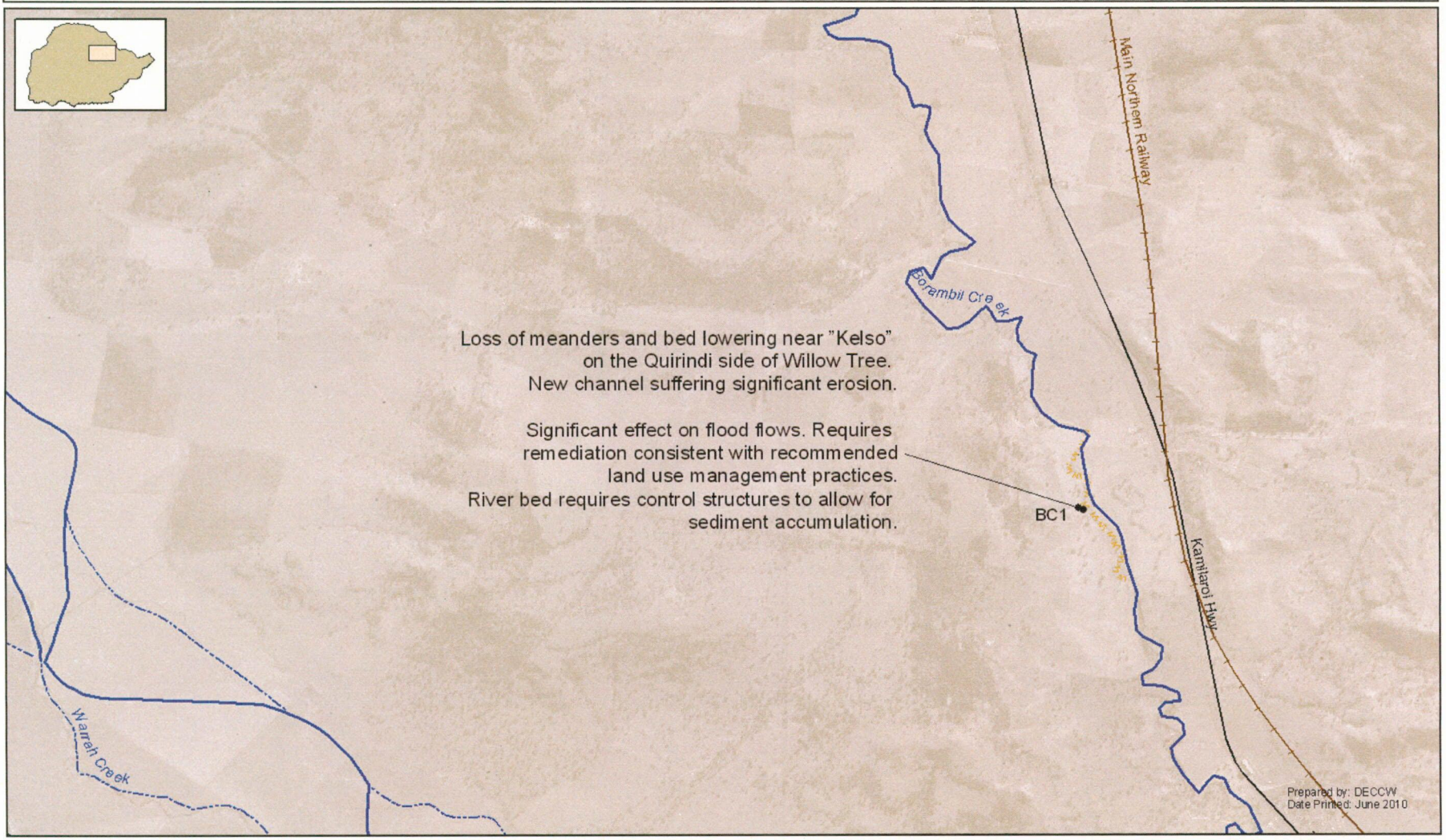


Figure 9 : Location of Borambil Creek Issue BC1

0 0.5 1 1.5 2 Kilometres

N

Legend

- Concentrated Flowpaths
- Overland Flowpaths
- Controlled Activity
- Roads
- Railways

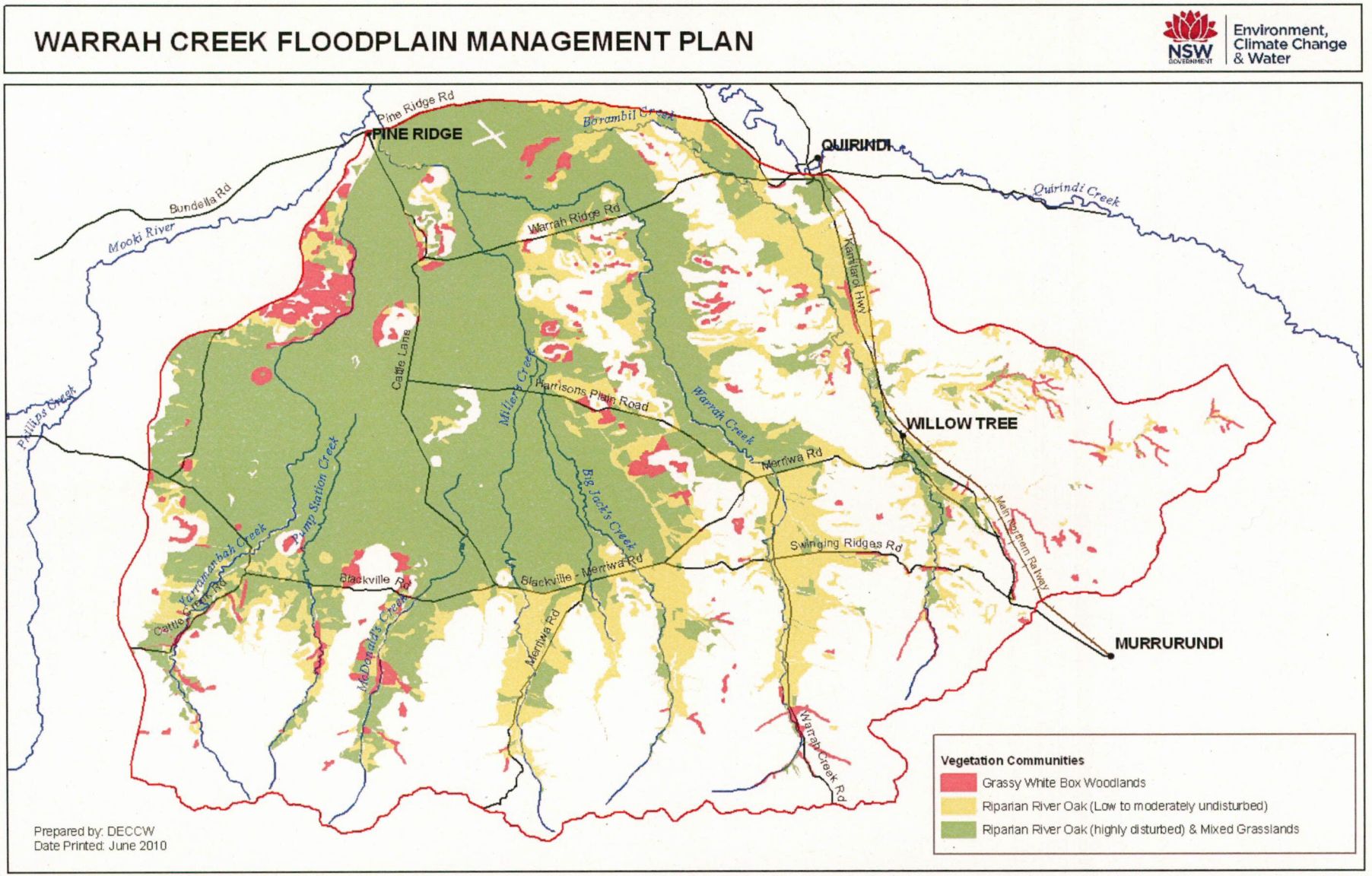


Figure 10: Location of Key Vegetation Communities - FMP Floodplain

Appendix C – Part 8 Water Act and WMA controlled activity application forms

Application under section 167(1)(a) of Part 8 of the *Water Act 1912* for approval of a controlled work:

- application form
- notes to the application form

Application for a controlled activity approval under Part 3, Chapter 3 of the *Water Management Act 2000* for works on waterfront land:

- checklist of items to accompany an application
- application form

APPLICATION UNDER SECTION 167 (1) (a) OF PART 8 OF THE WATER ACT FOR APPROVAL OF A CONTROLLED WORK

NSW GOVERNMENT | Environment, Climate Change & Water

WHEN COMPLETING PLEASE READ NOTES ON THE REVERSE SIDE

NAME(S) OF APPLICANT(S) *(See Note 1)	SURNAME	GIVEN NAME(S)	
ADDRESS FOR SERVICE OF NOTICES		Postcode	Telephone
PROPERTY ADDRESS		Postcode	Telephone
LOCATION OF WORK (See Note 2)	LOT/PLAN/PORTION NUMBER(S)	PARISH	COUNTY
RIVER/LAKE/ FLOODPLAIN (See Note 3)			
DESCRIPTION OF NATURE AND PURPOSE OF THE WORK (See Note 4)		(please ✓) Existing ☐ Proposed ☐	
RIGHT OF OCCUPANCY OF THE LAND ON WHICH THE WORK IS LOCATED (See Note 5)	(Please ✓) FREEHOLD ☐ LEASEHOLD ☐ PERMISSIVE OCCUPANCY ☐ OTHER (please describe)	Per. Occ. No. where applicable	

*I/we declare – (a) that the whole of the work is situated/proposed to be constructed * on the abovementioned land and

(b) that I am/we are * the occupier(s) of the whole of that land

*I/we enclose – (a) a plan of the abovementioned land indicating the boundaries of the land and the site of the work and

(b) the prescribed fee of $182 (See note 6)

Delete whichever is inapplicable

SIGNATURE(S) OF APPLICANT(S) ..... Date : / /

.....

DEPARTMENTAL USE ONLY

☐ FEE ☐ PLAN ☐ DETAILS LICENCE NUMBER .....

NOTES:

NOTES

Note 1 : APPLICANT'S NAME(S)

The application must show the FULL NAMES of ALL persons who are, or propose to be for the purpose of constructing the work, in occupation of ALL the lands and properties on which the work is, or proposed to be located.

Note 2 : LOCATION OF WORK

The location of the work should be described by reference to the County / Parish / Portion(s) in which the work is situated or, if these details are not known or are inapplicable, in some other manner sufficient to identify its location, this information may be available from your local Council. If this information cannot be obtained please provide any other plan or title references to the land and ensure that the PLAN TO ACCOMPANY THIS APPLICATION clearly depicts property boundaries and the location of the work thereon.

Note 3 : RIVER / LAKE / FLOODPLAIN

If the work is to be located near, on, or within the banks of a named lake, river or watercourse, please provide its name. If the work is on a flood plain of a particular river valley please provide the name of that river valley.

Note 4 : DESCRIPTION OF WORK

Describe the nature, materials to be used, and purpose of the work, for example:

- an earthen levee, for preventing inundation of land ...
- an earthen access road; with concrete piped culverts; from residence to main road ...
- an earthen block dam; with wing walls for conservation of water ...
- earth fill building pad ...
- irrigation supply channel; with inverted siphons ...

If separate structures are proposed the Department may require that separate applications be lodged.

A controlled work, for which Approval is required is any structure which may affect the passage, distribution or height of flood water.

Note 5 : OCCUPATION

Indicate the nature of the right of occupancy at present held over the land on which the work is or proposed to be located. If the right of occupancy is yet to be obtained describe the type of occupancy right being sought.

Note 6 : FEE

This application MUST be accompanied by the prescribed fee. If you withdraw this application, prior to it having been determined (Approved or Refused) by the Department, the Department may retain part of the fee, as is deemed appropriate, to partly or wholly offset the expenses incurred dealing with the application.

NSW Government
Department of Water & Energy

Application for a controlled activity approval under Part 3, Chapter 3 of the *Water Management Act 2000* for works on waterfront land

Checklist of items that must accompany this application

Have you included the following information in your application? Your application may be rejected or delayed if the following information is not supplied. Please note that within this document, all references to the Department means the Department of Water and Energy.

- ☐ Completed application form including land owner's signature
- ☐ Clear description of all proposed works
- ☐ Environmental information, assessment or report
- ☐ Confirmation from local council that works are approved or that no approval is required
- ☐ Any extra information as required in Sections G and H of the application
- ☐ Required fee (as advised by the Department)
- ☐ Required Security (Bond or Bank Guarantee)
- ☐ Copy of property title certificate and a map CLEARLY showing the boundary of all tenures pertaining to the land in question
- ☐ Topographic map and/or aerial photo showing where works are to occur
- ☐ A sketch, plan or diagram depicting the proposed works – to scale where possible
- ☐ If relevant, evidence that you have conferred with Department of Primary Industries regarding the proposal
- ☐ If relevant, impact assessment regarding threatened aquatic species - in accordance with the *Threatened Species Conservation Act 1995*

If development was assessed by the Department under the 'Integrated Development Assessment Process' of the *Environmental Planning and Assessment Act 1979* and General Terms of Approval (GTA), were issued then please only submit the following information:

- ☐ Completed Sections A to F of the application form
- ☐ Copy of the proposed works plan approved or stamped by the Consent Authority
- ☐ Required fee
- ☐ All information requested in the General Terms of Approval (GTA)

Please forward completed application form to your local Department of Water and Energy office

Application for controlled activity approval

Reference No. (use EA/ERM number, if known))	Office Use Only	File No.

SECTION A: Applicant's details Please use BLOCK letters if filling out by hand

Title (Mr, Mrs, Ms)	Surname	Given name(s)
Company name (if applicable)		
Postal address		
Town	State	Postcode
Phone	Alternate phone	
Fax	Email	
Is Applicant the approval holder and property owner? ☐ Yes ☐ No		

SECTION B: Property owner's details if different from Applicant

1. Title (Mr, Mrs, Ms)	Surname	Given name(s)
Postal address		
Town	State	Postcode
Phone	Alternate phone	
2. Title (Mr, Mrs, Ms)	Surname	Given name(s)
Postal address		
Town	State	Postcode
Phone	Alternate phone	

OWNER'S CONSENT: As owner(s) of the property described above, I/We have no objections to the 'controlled activity' occurring on my/our property as described in this application and as shown on the attached plans. I/We understand that I/We will be responsible for all 'controlled activities' on my/our land and for any measures required to protect a water source under Part 1 of Chapter 7 of the *Water Management Act 2000*.

Signature	Date	Signature	Date

SECTION C: Details of property on which proposed controlled activity will occur

NOTE: Ownership and cadastral details of properties on both sides of watercourse and the consent/s of all property owners must be provided together with a photocopy of the location of the property marked on a topographic map (or equivalent)

Name of watercourse (if known)			
Lot	DP	Portion	Parish
Lot	DP	Portion	Parish
Lot	DP	Portion	Parish
Lot	DP	Portion	Parish
Local Council		DA No. (if applicable)	
If space provided is insufficient to record property details, please attach additional information.			
Property address			
Town		State	Postcode

SECTION D: Details of controlled activity to be undertaken

DESCRIBE the 'controlled activity' proposed, including stages, site rehabilitation and erosion prevention. Please attach additional pages or a report if necessary. A guide to the information required for assessment should be obtained from the Department.		
WHERE do you propose to undertake the controlled activity? Tick box(es)		
On waterfront lands adjacent to....	On the banks of...	In the bed of...
☐ an intermittent watercourse	☐ a perennial watercourse	☐ a lake
☐ an artificially improved watercourse	☐ a realigned watercourse	☐ a wetland
☐ a drainage channel	☐ an abandoned stream channel	☐ a weir pool
☐ Other (please specify)		
IF EXTRACTING		
☐ bar on inside of bend	☐ mid-channels bar or bend	☐ bar along bank on straight section
☐ Other (please specify)		
ESTIMATED TOTAL COST to complete all works within, or likely to affect waterfront land or their associated riparian corridors		$
Approximate commencement date		
Approximate completion date		
FOR APPLICANTS CARRYING OUT EXCAVATION		
What is estimated **maximum depth of excavation** below natural surface?		metres
What machines do you propose to use?		
FOR APPLICANTS CARRYING OUT EXTRACTION What type of material do you intend to excavate?		
☐ Soil ☐ Sand or gravel ☐ Quarry rock ☐ Other (please specify)		
FOR ONGOING EXTRACTION What is the estimated annual removal rate, in cubic metres per year?		m^3 per year

SECTION E: Application fee

Please confirm the fee amount with the relevant Departmental officer prior to finalising payment. Cheques or money orders should be payable to the Department of Water and Energy.	
Fee enclosed	$

SECTION F: Declaration and application

I/We, the undersigned, apply for an approval described above for the nature and purpose specified in the application. I/We state that the information provided for the purpose of this application is accurate and true.		
For applications made by individuals		
Name	Signature	Date
Name	Signature	Date
For applications made by companies		
Name of company	Position held	
Name of company representative	Signature	Date
Witnessed by (Name)	Signature	Date

Please note that it is an offence to provide misleading or incorrect information. This approval (should it be granted) may be cancelled or suspended if you are convicted of an offence under the *Water Management Act 2000*.

Submit your completed form to your local Departmental office. Enclose a cheque or money order for the application fee.

Privacy Note: The personal information you provide in this form will be treated in accordance with the *Privacy and Personal Information Protection Act 1998*, under which you have rights of access and correction. Your personal information will be used for assessing and processing your application and may be disclosed to public authorities and other parties as required.

NB: *The Water Management Act 2000* requires that some details of your application appear in a public application register. Should your application be approved, details of the approval will also appear in a public approval register.

Appendix D – Flood monitoring guidelines

The following advisory notes specify monitoring activities that should be undertaken by landholders, Liverpool Plains Shire Council, DECCW and NOW. The collected monitoring data will assist the FMP review process at the required five-yearly intervals and after major flooding events.

Flood monitoring guidelines for landholders

a) Hydrologic and hydraulic data

Flood event characteristics

- Note rainfall depths from private rain gauges throughout the storm event to obtain total depth and temporal pattern.
- Note the start and finish times of flooding, as well as when the flood peak arrived.
- Note the duration of the flood peak (how long the peak lasted prior to receding).
- Compare the flooding with other flood events experienced.

Data near streamflow gauging stations

- Note peak water levels from staff gauges (the average of a number of readings should be taken).
- Take photographs illustrating flood extent and flow pattern.

Floodplain data

- Where possible peg flood peaks across the floodplain (e.g. flood marks or debris on strainer posts, trees, farm sheds or dwellings).
- Note the extent and width of the flooding.
- Estimate surface flow velocities (usually expressed in metres per second) and where possible, note flow pattern. Velocities can be estimated by timing the movement of floating debris over an approximated length of travel.
- Where possible measure flood water slope by pegging water levels over a length of 1 km.
- Note any obstructions to the passage of flood flow (e.g. roads, levees, banks), and where possible obtain estimated difference in water levels upstream and downstream of the obstruction.
- Take photographs illustrating flowpaths, flooded areas and dry areas, and flow near obstructions.

Note: Select floodplain monitoring sites that are near hydraulic controls such as roads, levees, major overbank flow breakouts and at defined flowpaths.

Data along roads and at causeways

- Where flooded – estimate flow velocities and flow width over the road, as well as the difference in water levels upstream and downstream of the road.
- Where dry – estimate the height out of water.

b) *Flood damage*

After a flood event, information is normally sought to assist in determining the nature and cause of any flood damage. Notes and sketches provided by landholders can aid this process.

Farm loss incurred

- Note the location of any damage and estimate the loss of crops and fencing.

Road damage

- Note the location and extent of pavement damage and silt over roads.
- Where possible estimate the length of road cuts.

c) *Environmental data*

Erosion and siltation

- Symptoms of stream bed lowering include vertical headcuts in the stream bed, extensive bank erosion on both sides of the stream, headcuts in tributary streams and gullies, exposed gravel or rock beds, exposed pipe capping on bridge piers, and undermining of causeways.
- Causes of stream bank erosion include flood flows and abrupt changes in channel alignment, gullying where overland flow enters streams, bed lowering, and obstructions to stream flow such as weirs or low level crossings.
- Causes of floodplain erosion include unsustainable land-use practices (e.g. clearing), overflows from perched streams, or flow concentration due to floodplain development.
- Causes of floodplain siltation include hill-slope erosion or reduced capacity of the main channel (bridge crossings, excessive vegetation or regrowth, influx of sediment), which result in in-stream sediment being deposited onto the floodplain.

Floodplain vegetation

- Note and photograph the extent of floodplain vegetation regeneration over time.
- Note and photograph the extent of flood inundation in the vicinity of floodplain vegetation (Riparian River Oak Forest).

Waterbird and fish observations

- Note the abundance and diversity of waterbird species.
- Note the abundance and diversity of fish species.

d) *Aerial and ground photography*

Photographs (to be taken between identifiable points on a map):

- areas flooded and areas not flooded
- areas of active flow and backwater
- flowpaths
- known earthworks such as levees, banks, drains and channels
- known problem areas

- roads and railways
- environmental information, as outlined in (c) above
- time and date each photograph was taken.

e) Monitoring questionnaire

The questionnaire overleaf could be filled out by landholders as a means of recording and collating information regarding the characteristics of a flood event, as well as flood damage. Use extra pages if required.

Landholder monitoring questionnaire

Hydrologic and hydraulic data

Rainfall depths and duration (private rain gauges) _____ millimetres at 9:00 am each day

Inundation limits: sketch on a map areas inundated, flowpaths and areas of backwater.

Duration of inundation _____ hours/days

Depth of inundation _____ metres at location _____

Flow velocity estimates _____ metres per second at location _____

Flood marks: provide location and description, mark levels upstream and downstream of structures (channels, roads, culverts, etc.)

Identify any flow obstructions – banks, channels, roads, etc.

Compare with previous floods – larger/smaller, etc.

Flood damage

Crop loss: Yes / No – If yes describe location and extent _____

_____

Fence loss: Yes / No – If yes describe location and extent _____

_____

Road damage: Yes / No – If yes describe type, location and extent _____

_____

Erosion: Yes / No – If yes describe type, location and extent _____

_____

Siltation: Yes / No – If yes describe location and extent _____

_____

Environmental data

Note numbers and types of waterbirds if present.

Note presence of native fish in floodwaters.

Note extent of regeneration of floodplain vegetation (following floods).

Council monitoring activities

These activities are similar to those listed above for landholders, but they relate to council works. In particular the performance of road structures should be carefully assessed. With regard to the road structures, those that are significant should be monitored over the duration of the flood. Less crucial structures could be observed at peak levels and at overtopping levels for causeways.

Road structures

- Note the head difference across the structure at peak and critical levels.
- Note the depth of flow over causeways.
- Estimate the flow velocity through or across the structure.
- Note whether the structure is affected by debris.
- Note the time when flow commences and finishes.
- Photograph the structure in flood.

Following floods, council should assess flood damage to roads and infrastructure:

- Note the location and extent of pavement damage and silt over roads.
- Estimate the length of road cuts where possible.
- Note damage to other infrastructure such as culverts or bridges.

DECCW monitoring activities

DECCW's role in monitoring includes the following activities:

Flood photography

- Undertake and obtain on-ground photography of the flood event.
- If necessary, undertake oblique aerial photography of the flood event.
- If necessary, organise vertical aerial photography of the flood event.
- Obtain available satellite imagery of the FMP floodplain under flood.

Survey data

- Collate existing survey data undertaken or organised by DECCW, landholders, or local councils.
- If necessary, obtain additional survey data, particularly in the vicinity of new flood control works (storages, levees, channels, etc.) and structures (bridges, culverts, weirs).

Consultation activities

- Undertake consultation activities with stakeholder groups (landholders, government agencies, local councils and other interest groups) to source their opinion on the flood event and the performance efficiency of the FMP flowpath network.
- Undertake field investigations after flood events to view identified problem areas.

Flow data

- Obtain flood heights and discharge records from gauging stations in the vicinity of the FMP floodplain.
- If necessary, obtain rainfall data from the Bureau of Meteorology and NOW records.

Environmental data

Fish and aquatic invertebrates

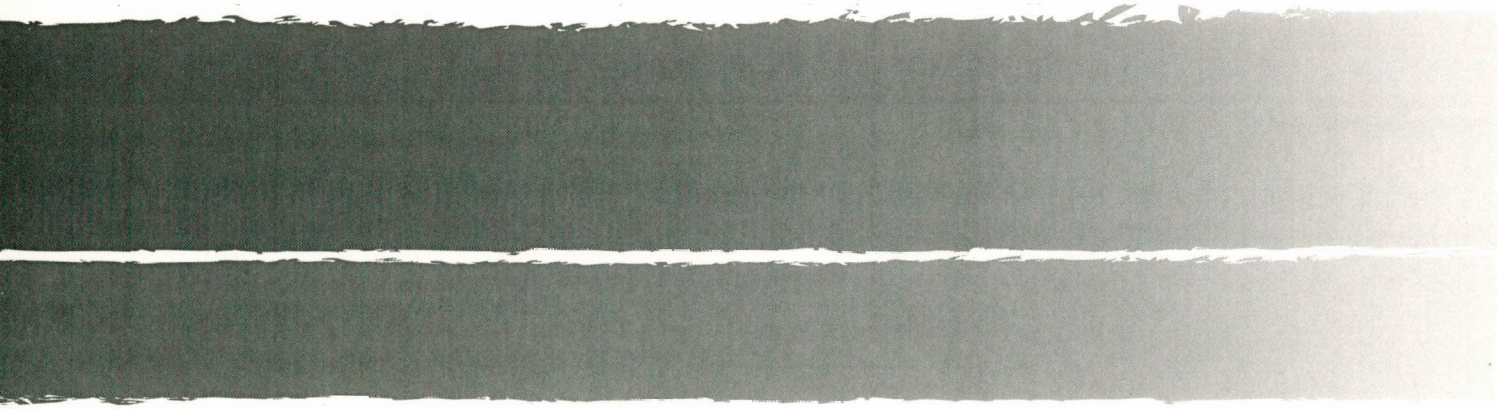
- Obtain information regarding fish abundance and diversity within the vicinity of the FMP floodplain. This data can be sourced from Industry and Investment NSW (Fisheries) offices that undertake sampling on a regular basis.
- Obtain information regarding the abundance and diversity of macroinvertebrates within the vicinity of the FMP floodplain. This data can be sourced from the program titled AusRivAS (Australian River Assessment System) that generates health assessments for river sites based on the presence of macroinvertebrates.

Vegetation

- Based on flood photography and field investigations, assess changes in floodplain vegetation following flood events.

Additional data

- Approach government agencies in order to source any relevant environmental data gathered by them in response to a flood event. This may include data in relation to fish, water quality, floodplain vegetation, waterbird observations and wetlands.



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