



NSW Government

DEPARTMENT OF NATURAL RESOURCES

Lachlan River

Hillston Floodplain Management Plan

Lake Brewster to Whealbah

October 2005



Cover Photograph:

Hillston - Roto Railway Crossing the Yangellawah Creek Floodplain - 30th August, 1990

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PREFACE

The following poem is reproduced from the book “Where the River Divides – History of Hillston and District”

HILLSTON’S RECORD FLOOD – 1956

By “Noega”

There’s a little town called Hillston
On the flooded Lachlan stands.
Its folks build banks by day and night
With help of many hands.
The floods round here are serious,
Yet the outside world don’t know;
The radio and the papers
Haven’t heard that this is so

Harry Biggar, who is eighty-odd,
Some big floods can recall,
Says this is far the worst he’s seen,
‘Tis the daddy of them all.
Joe Cashmere and his brother
Can remember, Oh! So well,
When the Lachlan it was flooded
And for twelve months never fell.

We seldom see the township,
The distance is too far,
If you dare to cross that water
Ten to one you’ll bog your car.
Some roads are back to normal
And some are not quite so;
A few belated Crusoes
Get out where they can row.

We made the trip into the town,
Our mileage it was doubled;
It wasn’t like old Hillston now,
The folks are all so troubled.
The old hands say, they’ve never seen
A flood like this before,
You go to bed to sleep the night,
Next morn it’s at your door.

No matter tho’ where e’er you look
There is water far and wide;
It’s sad to see sheep being drowned
Along the Railway side.
They are working hard to build high banks
It is the very devil,
We’re hoping now ’tis not in vain
When the water finds it’s level.

There is water from the tennis courts,
A good two mile they say;
It is the main road into town,
We must find another way
There’s one road left by “Poison-tank”
That still defies the water;
All this will make our rates go up,
Our hearts just turn to mortar.

The Police have taken things in hand,
Each person they compel
To give a hand where needed most
Otherwise you try the cell.
Yes, we’re clenching all efforts
Side by side in blinding rain,
We don’t give a “Tinkler’s Tadmum,”
There is much we can attain.

There’s the butcher and the baker
And two “Parsons” I can tell,
There’s men from every walk of life
Also the R.S.L.
The Farmer with his tractor
Is never know to lag,
And gangs of men in shovels bent
Dig sand to fill each bag.

There’s the Peters of “Burilda”
And those of “Bonnie Doone”,
With Cliff and Angus Rathmell,
Say, “It’s really none too soon.”
The Morans and the Shellys
With Kev-like and Harry Dagge
They leave their jobs behind them,
Not time to light a fag.

Bert Jackson and young Eric,
With their hands to tractor wheels,
Working many hours between them
With ne’er a thought for meals.
Our women-folk don’t lag behind
So they rob the pantry shelf,
When all our neighbours round us,
Go out each day to help.

The Fensoms at the “Four-mile”
Are worried one and all,
They’ve built high banks yet pleased they’d be
To see the Lachlan fall.
Frank Strong of “Currah”, and “Winton” too.
Indeed they have not tarried.
It’s hard to take, there’s no mistake
For folks who’ve just been married.

The western-end of Hillston
Is as bad as bad can be.
In the playground of the Convent school
There is water to the knee.
In Danny Pentland’s lovely home
The water flows inside
There are many others such as this,
‘Tis a fact you cannot hide.

Our Railway line is none too safe,
It’s got officials thinking
They’ve cut the line in a place or two
To save the rails from sinking.
So tragic it would be for all
Should our train just cease to run;
Its piercing whistle seems to say
“I’m here again, “but ‘tis no fun.

It won’t be long, ‘tis plain to see
Before our roads are taken,
With the surging waters rising fast
The old Town looks forsaken.
There is one thing we’ll remember,
Should we live four score and ten,
How the floods out-back just triumphed
Despite the efforts of our men.

There are lots of city dwellers
Say, “We do nought but moan,”
Whilst they spend their hours of leisure
By deep sea’s frothy foam.
Country folks have joys and sorrows,
(Quite right it seems to me),
But so often most one-sided
‘Tis their share of destiny.

If you mention out-back Hillston,
Why! They say with such surprise
“That place where crows fly backwards
Lest dust gets in their eyes?”
Still, its folk find joy in living
In this place of floods and drought.
It has many compensations
That the City cannot flout.

- Author: L. M. Busch

1 INTRODUCTION

1.1 Background

The Hillston Floodplain Management Plan Lake Brewster to Whealbah (FMP) has been prepared by the Department of Natural Resources (DNR) in conjunction with the local community. DNR has prepared the plan under Part 8 of the *Water Act 1912* on behalf of the Water Administration Ministerial Corporation. The Hillston Rural Floodplain Management Committee, comprising representatives of the community and stakeholder groups, has guided the preparation of the plan. Funding for the FMP was provided jointly by the State and Federal Governments, with Federal funding provided under the Natural Heritage Trust.

The FMP applies to the floodplains of the Lachlan River and Willandra Creek surrounding the town of Hillston as identified on Figure 1.1. The floodplains are regarded as prime agricultural land and support a very successful irrigation and dryland farming industry. They also have significant ecological values including extensive areas of wetlands and a diversity of native flora and fauna that benefit from periodic flooding. The expansion of irrigated cropping in recent times has led to concerns about the impacts of associated works on flood behaviour. Flood control works, such as levees, channels and roads, can alter floodwater distribution and can increase flood risk to floodplain occupiers and cause environmental problems by isolating flood-dependent ecosystems, such as wetlands, from flooding.

The FMP aims to coordinate the existing and future development of flood control works so that flood risk is minimised and the natural functions of the floodplain environment are sustained. It outlines specific modifications to existing flood control works based on hydraulic and environmental criteria and identifies a floodway network and flood fringe area for the planning of proposed works. Implementation of the FMP will provide the community with greater security against flood risk and allow for the sustainable management of flood-dependent ecosystems.

The required modifications to works identified in the FMP will restore the existing floodplain to one that is acceptable to the community in regard to the passage of flood flows and the ecology of the floodplain. The FMP also provides a process to allow the efficient assessment of new development in terms of the relevant legislation. Finally it provides a long - term strategy that encourages the reduction of less desirable development located in the defined floodway areas.

The FMP has been prepared in accordance with processes outlined in the NSW Government's *Floodplain Development Manual* (NSW Government 2005), which supports the *NSW Flood Prone Land Policy*. Development of the FMP has progressed through three (3) key stages:

- Flood Study – completed by the Department of Land and Water Conservation in 2001, the study defines the nature and extent of flooding, including development of a hydraulic model of flood behaviour;
- Floodplain Management Study – evaluates management options based on hydraulic modelling, analysis of the floodplain environment and social and economic considerations, to address existing and future floodplain management issues; and,
- Floodplain Management Plan – adopts community-owned strategies to manage flood risk and to support the requirements of the floodplain environment.

Extensive community consultation has been undertaken to improve understanding of flood behaviour, identify flooding issues and ensure that the plan is compatible with the community's expectations. The FMP forms a layer in the catchment planning process for the Lachlan Valley and has been prepared with consideration of natural resource legislation, policy and management plans relevant to floodplain management.

Once adopted under the provisions of Part 8 of the *Water Act 1912*, the FMP must be considered by DNR when reviewing and determining approval applications for flood control works under the Act or its forthcoming replacement the *Water Management Act 2000*.

A floodplain management plan for Hillston township has recently been completed by Carrathool Shire Council (Carrathool Shire Council 2005). It applies to the urban area of Hillston whereas the rural FMP covers the rural areas surrounding the town as described above. However, the two plans are closely related as they have both been developed from the same hydraulic model.



Brewster Weir, Ballyrogan (Inlet) Channel and Lake Brewster – 30th August 1990

1.2 Hillston FMP Area

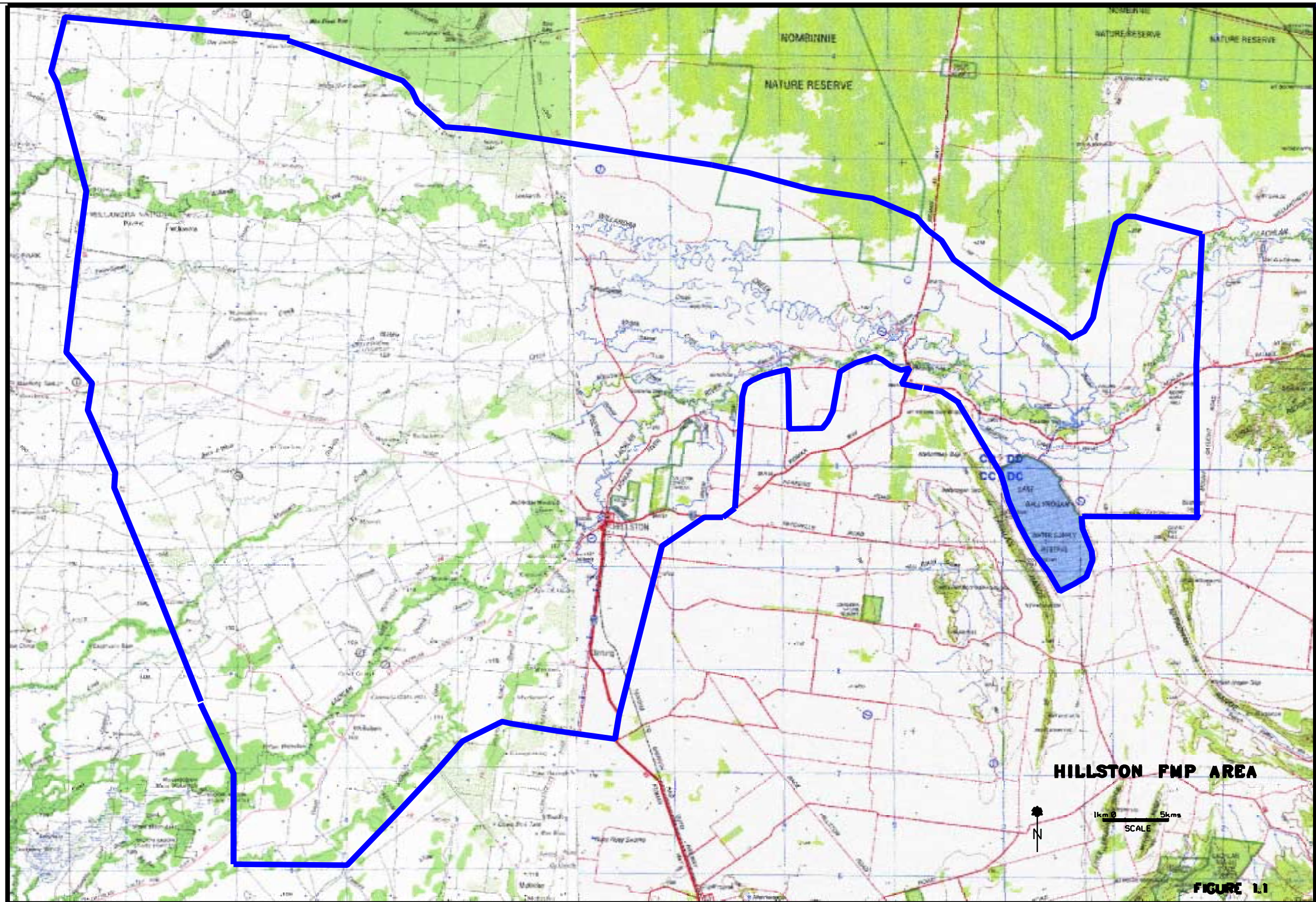
The FMP area extends along the Lachlan River floodplain from just upstream of the Carrathool / Lachlan Shire boundary to about 10 kilometres downstream of the Whealbah Bridge. The floodplain of Cabbage Garden Creek is also included in this area.

To the west, the FMP area extends to the Whealbah – Trida Road and includes the floodplains of Cogie, Conoble, Willandra, Yangellawah, Moolbong, Middle, Once-a-While, Umbrella and Merrowie Creeks.

Within the upstream and downstream limits, the boundaries of the FMP area have been defined to approximate the extent of flood liable land. Figure 1.1 shows the extent of the FMP area and relevant geographic details.



Kidman Way East of Hillston – 30th August, 1990



1.3 Objectives

The strategic objectives of the FMP are to:

- reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible (NSW Flood Prone Land Policy objective);
- coordinate 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; and,
- take into account the cumulative impact on flooding behaviour of individual developments.

1.4 Vision

The vision for the FMP is:

A floodplain managed for the social and economic interest of the community that contributes to a healthy and sustainable environment.

1.5 Legislation, Policy and Planning Overview

The management of the floodplain in the Hillston area must be undertaken within the current legislative and policy framework. A brief summary of the primary pieces of relevant legislation and policy is presented below. Refer to the *Hillston Floodplain Management Study Lake Brewster to Whealbah* (DNR 2005) for a detailed overview of the legislation and policy framework for floodplain management.

1.5.1 The Flood Prone Land Policy

The primary objective of the Government's *Flood Prone Land Policy* 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 using a merit approach. *Floodplain Development Manual* (NSW Government 2005) supports the policy and outlines a merit - based approach to floodplain management.

1.5.2 Water Act 1912 and Water Management Act 2000

DNR takes the lead role for floodplain management in the western rural areas of NSW through its administration of *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 through the preparation of FMPs and a more streamlined and resource efficient approval process. The amended *Water Act*

provides for a broader consideration of issues in the approval of existing and proposed “controlled works” and strengthens DNR’s ability to deal with unauthorised works.

At the time of preparing this FMP the State Government had initiated wide-ranging reform of water legislation, with the outcome being the new *Water Management Act 2000*. The Act consolidates most of the Acts previously covering water management in NSW and is being phased in gradually as various regulations are developed. It will eventually replace *Part 8 of the Water Act* and is likely to contain floodplain management provisions that relate closely to existing provisions under the amended *Water Act*.

1.5.3 Additional 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, wetlands, threatened species and fish habitat.

The *Environmental Planning and Assessment Act 1979* is of particular importance. In determining applications for flood control works, DNR 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 Act is not required as there is no relevant environmental planning instrument that applies to flood control works in the FMP area. Other relevant legislation includes:

- *Native Vegetation Conservation Act 1997* and *Native Vegetation Act 2003*
- *Fisheries Management Act 1994*
- *Threatened Species Conservation Act 1995*
- *National Parks and Wildlife Act 1974*
- *Rivers and Foreshores Improvement Act 1948*
- *The Forestry Act 1916*

In certain circumstances, where a flood control work is likely to impact on a matter of national environmental significance, such as a nationally listed threatened species or a listed migratory species, an approval may also be required under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*. These approvals are assessed by the Commonwealth Department of the Environment and Heritage.

Natural resource management policy that supported decision-making in the FMP included the *State Rivers and Estuaries Policy 1993*, which provides a framework for the sustainable use, conservation and management of rivers, the *Wetlands Management Policy 1996* and the *State Groundwater Dependent Ecosystems Policy 2002*.

1.5.4 Relevant Management Plans

Following recent natural resource reforms in NSW, catchment action plans that consolidate existing natural resource management plans and provide long-term direction for investment in natural resources, will be prepared. The Lachlan Catchment Management Authority will work with local

communities to prepare the Lachlan Catchment Action Plan. The FMP should be viewed as one component of the integrated planning process, with other linked components including -

- Lachlan Catchment Blueprint;
- Water Sharing Plan for the Lachlan Regulated River Water Source;
- State Water Management Outcomes Plan;
- Lower Lachlan Groundwater Sharing Plan; and
- Draft Western Riverina Regional Vegetation Management Plan.

1.6 Flooding Overview

Major flooding in the Hillston area generally arises from prolonged rainfall in the upper catchment and major flood releases from Wyangala Dam. The largest floods on record occurred in 1956 and 1990 when the Lachlan River at Hillston was above minor flood level for many months. Floods take a number of weeks to travel from Wyangala Dam to the Hillston area. For example, the peak of the August 1990 flood took some four weeks to reach Hillston from Wyangala Dam.

During larger floods a significant portion of total flows entering the FMP area are conveyed to the west via the major effluents of Willandra Creek, Yangellawah Creek, Middle Creek and Merrowie Creek and their floodplains. There is also a series of breakouts from the Lachlan River onto the floodplain. The most substantial of these are the outflows into Gum Swamp that activate flow paths to the east of Hillston and a breakout on the right bank opposite Hillston town that inundates a large area to the west. Downstream of Hillston, Cabbage Garden Creek is an important effluent of the Lachlan River in large flood events.

The larger floods can result in crop losses, damage to pastures and grasses from long inundation, damage to irrigation works, loss of fences and damage to private access roads. As well, inundation and damage to public roads and railways can result in the loss of vital transport links. The larger floods also threaten the security of Hillston town.

Floodplain development can impact on flooding by altering the flow distribution, blocking important flow paths, increasing flood levels, increasing flood flow velocities, and denying inundation of floodplain ecosystems. As well, extensive development of the floodplain has the potential to reduce the amount of floodplain storage area for a flood and result in more floodwater passing to the downstream areas.

Flood behaviour in the FMP area is dependent upon the volume of water in the flood wave, the length of time the flood is above the critical height, the rate of rise and fall of the flood, the vegetative cover and the development on the floodplain. Floods may reach similar heights at a river gauge, such as Hillston, but may behave differently on the floodplain remote from the gauge.

More detailed information on flooding is available in the Flood Study (Department of Land and Water Conservation 2001). The estimated 1990 flow distribution for the total study area is reproduced in Appendix A.

1.7 Environmental Overview

Flooding is a vital natural process that drives a pulse of ecological productivity. It replenishes the floodplain with water and releases organic carbon and nutrients on a large scale. This boosts invertebrate production, triggers breeding activity in waterbirds and fish, and initiates the growth and regeneration of floodplain vegetation. Floodplain inundation provides a key source of organic carbon and nutrients for river life in the lower Lachlan catchment.

The floodplain environment in the FMP area has been modified by agricultural development. Regulation of the river for agricultural water supply, through the operation of Wyangala and Carcoar Dams, has altered the frequency, magnitude and duration of floods. The environmental impacts of these changes are addressed within the *Water Sharing Plan for the Lachlan Regulated River Water Source (2003)*. Development has also altered the distribution and behaviour of floodwaters, removed large areas of floodplain vegetation (for broadacre cropping) and impacted on the hydrology and ecology of some wetlands. Despite these impacts, the floodplain area retains significant ecological values. The area also has important cultural values because of Aboriginal and European settlement.

There are approximately 85,000 hectares of wetlands in the FMP area. Flood flow paths to about 7,000 hectares of these wetlands are affected by existing flood control works. Native floodplain vegetation consists mainly of communities dominated by River Red Gum, Black Box, Lignum and Nitre Goosefoot. These species are dependent on flooding for their health and regeneration. The floodplain supports a diversity of native fauna including species that rely directly on flooding for maintenance of their life cycles (eg some species of waterbirds, invertebrates and fish) and species that rely on floodplain vegetation for food or habitat (eg honeyeaters). More detailed information on the floodplain environment is provided in the Floodplain Management Study.



Cabbage Garden Creek Offtake from the Lachlan River at “Cowl Cowl” – 30th August, 1990

1.8 Floodplain Management Principles

Management principles were developed and adopted to help guide the decision making process so that outcomes were consistent with the objectives of the FMP. The principles were applied to identify existing and potential flooding issues and to develop strategies to address them. These strategies related to the modification of existing works and the design of the FMP floodway network. A number of the principles related to the design of the FMP floodway network.

The committee adopted the following principles:

1. Defined floodways must possess adequate hydraulic capacity and continuity to enable the orderly passage of floodwaters through the floodplain;
2. Any system of defined floodways should conform as closely as is reasonable to the natural drainage pattern after taking into account the existing floodplain development;
3. Floodway areas should be equitably allocated, consistent with natural/historical flow paths;
4. Environmental issues related to the rural floodplain management plan need to be identified and investigated including developing strategies for flood dependent ecosystems;
5. The exit of floodwaters from defined floodways should be at rates and depths similar to those which would have been experienced under natural/historical conditions and should discharge as close as practicable to the location of natural/historical floodways;
6. Sufficient pondage must be retained on the developed floodplain so that the flood peak travel time is not unduly accelerated to downstream areas or its height increased;
7. Velocities of flood flow in defined floodways and through structures should be minimised and be of an order which would not cause erosion or increased siltation under various land uses;
8. There should be no detrimental impact from floodplain development on any individual landholder or community infrastructure including increases in peak flood levels and increased drainage times;
9. Floodplain development should not cause significant redistribution of floodwater.

The committee allowed for some scope to depart from the natural/historical drainage pattern, provided the community was in agreement and it was hydraulically and environmentally feasible.

2 PLAN IMPLEMENTATION

The FMP outlines modifications to existing flood control works and identifies a floodway network and flood fringe area to allow for the planning of future flood control works. Implementation of the FMP concerns identified modifications to existing flood control works, licensing of works and future property planning. Sheets 1 to 5 show the details of the FMP in map form.

Hydraulic and environmental issues associated with existing works have been identified and outcomes determined. The FMP has staged these modifications based on the nature of the issues and on economic and social considerations. It identifies priorities for the required works modifications and outlines emergency management measures to be implemented when a major flood is approaching. The FMP also identifies a timeframe for the licensing of existing flood control works not requiring modifications. The *Water Act 1912* requires that all flood control works (existing and proposed) within a designated floodplain need to be assessed for approval. There is scope for FMP requirements for flood control works to be incorporated into future property management plans that will be linked to the Lachlan Catchment Action Plan.

2.1 Staging of Plan Outcomes

The plan identifies broad implementation stages and, within this framework, priorities for specific outcomes for permanent works modifications:

Short term implementation

- High priority – within 2 years of FMP adoption - permanent works modifications that are important for the performance of the floodway network and have the potential to impact on flooding in Hillston Town; and,
- Medium priority – within 5 years of FMP adoption - other permanent works modifications that are important for the performance of the floodway network, licensing of existing flood control works.

All works modifications identified for short-term implementation are listed in Table 4.1

Emergency implementation

The FMP outlines emergency management measures for all works identified in the short-term implementation plan. These measures are to be implemented in the event that a flood is approaching and the permanent modifications required under the short-term plan are not completed. The emergency management measures also specify when temporary openings are to be made in existing works at the onset of a flood. The measures include specified openings in works, removal of works and, in some cases, monitoring to determine if emergency works are needed. DNR, the State Emergency Service and Carrathool Shire Council will coordinate the implementation of the emergency management measures. Emergency management measures are listed in Table 4.1.

2.2 Part 8 Approval Process for Flood Control Works

2.2.1 General

All activities associated with flood control works are administered under the relevant sections of Part 8 of the *Water Act 1912*. The Water Administration Ministerial Corporation (hereafter WAMC) is the body that prepares, adopts and administers FMPs, as well as receives and determines Part 8 applications. DNR acts on behalf of WAMC for all matters relating to Part 8 of the Water Act.

Once the Hillston FMP has been adopted, it is proposed to designate the land area of the FMP as a floodplain under the *Water Act 1912*. Once designated the following will apply:

- All flood control works will require an approval under Part 8 of the Act;
- All Part 8 applications for new and existing (unapproved) works within Hillston floodplain will be determined in accordance with the Hillston FMP and Part 8 of the Act; and,

In respect of any existing unauthorised works, a reasonable time will be allowed for the lodgment of an application under Part 8 of the Water Act. If, after a reasonable time period has elapsed, an application under Part 8 is not lodged for existing unauthorised works, the WAMC may serve a notice under Section 180D of the Water Act directing the occupier of the relevant land to do a number of things, such as: remove, modify, repair or restore the works. Unauthorised works are dealt with in more detail in Section 2.2.8 of the FMP.

2.2.2 Works that Require Approval

A work referred to as a flood control work is defined under *Part 8 of the Water Act 1912* as ‘controlled work’. A controlled work requires approval under the Act and is defined at Section 165A of the Act as:

- (a) an earthwork, embankment or levee that is situated, or proposed to be constructed, on land that:
 - (i) is, or forms part of, the bank of a river or lake, or
 - (ii) is within a floodplain, or
- (b) any work that is situated, or proposed to be constructed, on land that:
 - (i) is, or forms part of, the bank of a river or lake, or
 - (ii) is within a floodplain,

and that is declared by order of the Ministerial Corporation published in the Gazette to be a controlled work, or

- (c) an earthwork, embankment or levee, wherever situated or proposed to be constructed, that:
 - (i) affects or is reasonably likely to affect the flow of water to or from a river or lake, and
 - (ii) is used or is to be used for, or has the effect or likely effect of, preventing land from being flooded by water, or

- (d) any work, wherever situated or proposed to be constructed, that:
- (i) affects or is reasonably likely to affect the flow of water to or from a river or lake, and
 - (ii) is used or is to be used for, or has the effect or likely effect of, preventing land from being flooded by water, and
 - (iii) is declared by order of the Ministerial Corporation published in the Gazette to be a controlled work.

2.2.3 Applying for Approval

The following is an outline of the steps required by an applicant in applying for approval for a flood control work:

- Step 1** - Obtain an application form and discuss your proposal with neighbouring landholders.
- Step 2** - Contact a DNR Floodplain Licensing Officer to arrange a site inspection, discuss the application and get advice on the information required for the approval process.
- Step 3** - Gather supporting information as your application will require you to supply technical information.
- Step 4** - Fill in the application form. Complete additional information requirements on the form including the condition of the existing surrounding environment.
- Step 5** - Lodge the application with the supporting information and application fee at your local DNR office.

2.2.4 Determination Process

All applications under *Part 8 of the Water Act 1912* must proceed through a set process prior to DNR determining the application under Section 171 of the Act. This process includes (but is not limited to):

- **Section 166C of the Water Act 1912** - DNR 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 matter relating to the desirability or otherwise of a controlled work.
- **Part 5 of the *Environmental Planning and Assessment Act 1979*** – as there are no relevant environmental planning instruments relating to the FMP all proposals must undergo assessment under Part 5. DNR must take into account the following factors concerning the impact of the flood control works on the environment:
 - 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.
 - **Floodplain Management Plan** - DNR must consider the Hillston FMP and information contained within the Hillston FMP including principles, assessment criteria, and any recommendations.
-

- **Additional Information** - DNR must consider any investigation information that has been provided by the applicant.

2.2.5 Possible Determinations

DNR will inform the applicant at the earliest opportunity 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 licence. Under the *Water Act 1912*, 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, DNR is required to decide whether the works do or do not comply with the Hillston FMP.

2.2.6 Complying Works

Under Section 168B(2) of the *Water Act 1912*, a flood control work is assessed as a complying work if DNR is satisfied that the work complies with the FMP for the area in which the work is situated or proposed to be constructed. As such, complying flood control works are defined as:

- existing or proposed works located outside the limits of the floodway network as shown on Sheets 1 to 5;
- existing works that are satisfactory in their current state/condition as specified in Table 4.1;
- existing works to be modified in accordance with the required modifications as specified in Table 4.1; and,
- other existing works within the floodway network that are consistent with the hydraulic criteria as specified in Table 5.1 and the environmental value criteria in Table 5.2.

In some cases, a landholder may be required to provide the necessary technical details to demonstrate that the application is a complying work. Where an existing or proposed flood control work is complying, the application for approval will be determined by DNR without the need for advertising to canvass third party objections. Approvals for complying works are likely to be straightforward and expedient, depending on the required assessment of environmental impact.

2.2.7 Non-complying Works

Under Section 168B(3) of the *Water Act 1912*, a flood control work is assessed as a non-complying work if DNR is not satisfied that the work complies with the FMP for the area in which the work is situated or proposed to be constructed. As such, non-complying works are:

- works proposed to be located within the floodway network as shown on Sheets 1 to 5;
 - existing works that the landholder refuses to modify in accordance with the required modifications as specified in Table 4.1; and,
 - other existing works within the floodway network that are not consistent with the hydraulic criteria as specified in Table 5.1 and the environmental value criteria in Table 5.2.
-

Non-complying works may be considered for approval after a detailed investigation of hydraulic and environmental, impacts and consideration of social and economic issues (refer to Section 5). The cumulative impact of proposed works on flooding characteristics needs to be comprehensively addressed. It is important to understand that it is the applicant's responsibility to engage a suitably qualified consultant to undertake the investigation. DNR will provide the required assessment criteria for the consultant. Where the requested supporting information is not furnished, DNR can refuse to deal with the application.

Applications for non-complying works must be advertised and third party objections sought prior to the determination of the application. If an objection is received that cannot be resolved, compulsory mediation will be required. DNR 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 DNR grants an approval for an application and an objection has been made, DNR must notify the objector of its determination. The objector may appeal against the determination in the Land and Environment Court.

Any person applying for the approval of works may appeal to the Land and Environment Court against a determination by DNR to refuse to grant the approval or to grant the approval subject to conditions.

2.2.8 Unauthorised Works

Unauthorised controlled works include the following:

- Works without approval;
- Works that have been constructed in contravention of an approval; or,
- Works that have not been constructed in accordance with approval conditions.

Where unauthorised works are identified, DNR may direct that one or more of the following types of work are carried out by issuing a notice under Section 180D of the *Water Act, 1912*:

- (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.
- 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.

In the event of the occupier not complying with the served notice, DNR can carry out the work and recover the costs incurred in doing such work. DNR 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.

2.2.9 Roads and Railways

Roads and railways (and associated bridges, roadworks and railway works) vested in local government or State government transport agencies are prescribed works that do not require approval under Part 8 of the *Water Act 1912*. The forthcoming regulations of the *Water Management Act 2000* are also likely to exclude these works from approval requirements. Agencies constructing these works however, are required to assess their environmental impact under the *Environmental Planning and Assessment Act 1979*. However, in order to ensure coordination of road and rail structures in the FMP, recommended modifications to existing road and rail structures are included in Table 4.1



Hillston – Roto Railway in “Rivernook” – 30th August, 1990

3 FMP FLOODWAY NETWORK AND FLOOD FRINGE AREA

3.1 *Design Basis*

The 1990 flood was used as the design flood for determining the floodway network and flood fringe area on the floodplain. Flow estimates of the 1990 flood were used in assessing the modifications required to existing works.

Further to the hydraulic design of the floodways, the network was adjusted to include flood-dependent ecosystems, such as wetlands. This provides for continued flood access to these ecosystems so that the environmental benefits of flooding to these areas can be maintained.

It should be recognised that, due to the varied nature of floods, no two floods will behave exactly the same and, consequently, some local variation in the performance of the floodway network may occur. Whilst peak level readings at specific river gauges may be similar, the impacts of different densities of vegetation, differences in how long a flood stays up and differences in the rise and fall of a flood, can result in changes to flood behaviour on the floodplain.

Modelling of flood behaviour was undertaken using the best available processes but, as is the case in hydraulic modelling, it was limited by available data (ie flood levels, stream flow measurements, survey etc). As a result, some inaccuracies in absolute values will be inherent. As well, the modelling did not take into account increases in water level as a result of wave action.

The plan makes a number of recommendations for additional waterway area with an aim to providing an improved passage for a flood of the 1990 size. In some cases they aim to provide flood free access for a similar size flood. However, in the event of a flood similar in height to the 1990 flood occurring, it cannot be certain that the structure will behave exactly as planned. Hence it is important to monitor the works during floods. Larger floods may exceed the capacity of the recommended waterway areas.

Due to the low frequency of flooding the plan is not advocating a floodway/levee scheme that has been used in the past in other areas of the State to maximise areas of flood protected land. Rather, the plan is aiming to manage development, existing and new, on the floodplain in a manner that matches the social, environmental and economic needs of the community.

3.2 *Floodway Network*

The FMP floodway network that is shown on Sheets 1 to 5 will be used as the basis for determining future applications for flood control works. The floodway network represents a coordinated and integrated network of flood flow paths of adequate hydraulic capacity and continuity to effectively convey floodwaters and support the floodplain environment. The floodway, even if partially blocked, could cause a significant redistribution of flood flow or a significant increase in flood levels and thereby increase the flood risk to flood prone communities. As such, future applications to undertake flood control works in the floodway are assessed as non-complying works and are likely to be refused. However, if the applicant can demonstrate that the proposed works will meet relevant hydraulic and environmental criteria and will not result in any significant adverse environmental effects, then the works may be considered for approval. For example, proposed supply channels crossing floodway areas may need to be constructed below ground in order to meet approval requirements. Similarly, proposed access roads in floodway areas would need to be constructed at low levels.

Applications for flood control works outside the floodway limits will be assessed as complying works and, in general, will be readily approved with appropriate conditions if required. The assessment of these applications will need to take into account environmental impacts and cumulative impacts on the redistribution of floodwaters.

3.3 *Flood Fringe Area*

The FMP identifies the flood fringe area as the area between the delineated floodway and the extent of the 1990 flood and is shown by the blue wash area outside of the floodway limits. Development in the flood fringe would not in general cause a significant redistribution of design flood flows or a significant increase in flood levels. However, while applications for flood control works in this area will be assessed as complying works, the assessment will need to take into account any potential increase in flood hazard or flood damage to other properties bordering the floodway network. Adverse impacts could result, for example, if extensive works are proposed on one side of the floodway network and not the other.

Assessment of flood hazard will be largely qualitative taking into consideration existing works, the extent of proposed works and the potential for localised impacts on neighbouring properties. Such assessment would not need to go to the details of that for proposed works within the floodway where the impact on overall flood behaviour could be significant and therefore far reaching. It should be realised that floods larger than the 1990 flood would inundate areas outside of the flood fringe.

4 WORKS MODIFICATIONS

Table 4.1 lists the required modifications to existing flood control works determined by the FMP and the modifications to road and rail structures. The modifications are required for hydraulic and / or environmental (including fish passage) purposes as indicated. The table also lists emergency management measures in the event that a flood is approaching and the modifications have not been completed.

Implementation of the works modifications will restore the functions of the floodplain to levels acceptable to the community. The required modifications and their locations are shown on Sheets 1 to 5. Modifications listed in Table 4.1 indicate the minimum waterway needs for specified works. At a number of road sites the table states that existing structures be retained. However, if these structures are upgraded in future, it will be important to assess their impacts against the relevant design criteria as shown in Section 5.

It is important to remember that all proposed and existing flood control works within the Hillston floodplain will require approval under *Part 8 of the Water Act 1912*. Specific structural modifications to existing works outlined in Table 4.1 will be administered under the relevant sections of Part 8 of the Act. Where works are unauthorised, DNR may take the relevant action(s) under the Act. Please refer to Section 2 for further details regarding the approval of flood control works and administration of the Hillston FMP under *Part 8 of the Water Act 1912*.



“Rivernook” with Roto Railway crossing Roto Road in foreground

Table 4.1 Required Modifications to Existing Flood Control Works and Road and Rail Structures

The items are listed under the relevant sheet with reference to the property or location of the works:

SHEET 1								
(Willandra, Yangellawah, Moolbong, Middle and Merrowie Creeks Floodplains, Hillston/Roto Railway to Whealbah - Trida Road)								
Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
“MOUNT VIEW” and LOWLANDS ROAD								
“Mount View”	1.1	Supply channel	Channel prevents spread of flow to wetlands (E)	Provide minimum four temporary 20 metre openings in channel system	Temporary openings	Openings to be made before water passes Lowlands Road near “Mount View” homestead	N/A	Landholder
Lowlands Road	1.2, 1.3, 1.4, 1.5	Culverts	Inadequate waterway to allow sufficient water to the north (E)	Provide additional three 0.6 m pipe culverts, one additional 2 x 0.6 m pipe culvert and a 20 metre causeway	Install additional culverts and causeway	Monitor during floods to determine whether emergency openings are needed	Medium	Carrathool Shire Council
“WILLANDRA STATION”, “URALLA”, “VIETA”								
“Willandra Station”	1.6, 1.7, 1.8	Supply channel	Channel blocks floodplain flows (H,E)	Provide three 30 metre openings in stock supply channel. Opening across Yangellawah Creek to be permanent, other two are temporary	Install permanent opening across Yangellawah Creek	Openings to be made before water reaches the “Willandra Station”/ “Ballatherie” boundary	Medium	Landholder
	1.9, 1.10	Supply channel	Channel blocks floodplain flows (H,E)	Provide minimum two temporary 30 metre openings	Temporary openings	Openings to be made before water reaches the “Willandra Station”/ “Ballatherie” boundary	N/A	Landholder
	1.11	Supply channel syphon	Existing syphon appears adequate (H,E)	Retain existing syphon	N/A	N/A	N/A	Landholder
	1.12	Supply channel	Channel blocks floodplain flows (H,E)	Provide a minimum temporary 30 metre opening	Temporary openings	Openings to be made before water reaches the “Uralla”/ “Ballatherie” boundary	N/A	Landholder

SHEET 1**(Willandra, Yangellawah, Moolbong, Middle and Merrowie Creeks Floodplains, Hillston/Roto Railway to Whealbah - Trida Road)**

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
"Uralla"/ "Willandra Station"	1.13, 1.15	Supply channel	Channel blocks floodplain flows (H,E)	Provide minimum two temporary 30 metre openings	Temporary openings	Openings to be made before water reaches the "Uralla"/ "Ballatherie" boundary	N/A	Landholder
	1.14	Supply channel	Existing pipes for drainage (H,E)	Retain existing 2 x 0.7 metre pipes	N/A	N/A	N/A	Landholder
	1.16	Supply channel	Channel blocks floodplain flows (H,E)	Provide minimum temporary 200 metre opening	Temporary opening	Openings to be made before water reaches the "Uralla"/ "Ballatherie" boundary The opening widths for these sites are the widths shown on a condition of the bore license. The condition stated that the channel sections must be removed when a major flood reading is recorded at Brewster Weir. As it is not certain that floodwaters would reach the site for all major floods, the FMP has made the trigger point for the openings to be made closer to the site consistent with other trigger points in the area.	N/A	Landholder
	1.17	Supply channel	Channel blocks floodplain flows (H,E)	Provide minimum temporary 150 metre opening	Temporary opening		N/A	Landholder
	1.18	Supply channel	Channel blocks floodplain flows (H,E)	Provide minimum temporary 100 metre opening	Temporary opening		N/A	Landholder
	1.19	Supply channel	Channel blocks floodplain flows (H,E)	Provide minimum temporary 400 metre opening	Temporary opening		N/A	Landholder
"Vieta"	1.20	Supply channel across Middle Creek	Existing system of relifting channel across creek appears to provide adequate waterway area (H,E)	Retain existing relift system	N/A	N/A	N/A	Landholder

SHEET 1

(Willandra, Yangellawah, Moolbong, Middle and Merrowie Creeks Floodplains, Hillston/Roto Railway to Whealbah - Trida Road)

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
MOSSGIEL ROAD								
Mossgiel Road at Middle Creek	1.21	Two bridges	Existing bridges appear adequate (H)	Retain two existing bridges	N/A	N/A	N/A	Carrathool Shire Council
Mossgiel Road at Middle Creek overflow	1.22	Culverts	Existing culverts appear adequate (H)	Retain existing 2 x 0.45 metre pipe culverts	N/A	N/A	N/A	Carrathool Shire Council
Mossgiel Road at Once-a While Creek	1.23	Culvert	Some concern from local landholders that the culverts are inadequate (H)	Consider installing additional waterway area in the road, possibly in the form of a causeway	Council to consider installing causeway	Monitor during floods to determine whether emergency openings are needed	N/A	Carrathool Shire Council
Mossgiel Road at Umbrella Creek overflow	1.24	Bridge and culverts	Existing bridge and culverts appear adequate. Road has been raised since 1990. (H)	Retain existing bridge and culverts	N/A	Monitor road during floods to determine if existing waterway is adequate	N/A	Carrathool Shire Council
Mossgiel Road at Merrowie Creek overflow	1.25	Bridge	Existing bridge appears adequate (H)	Retain existing bridge	N/A	N/A	N/A	Carrathool Shire Council

SHEET 2**(Willandra and Yangellawah Creeks Floodplains – "Hunthawang" to Hillston/Roto Railway: Lachlan River Floodplain West of Hillston, East of Hillston)**

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
"HUNTHAWANG", "JOHNNELL", "YILGAH", "ROTO STATION", "GUNAGAI"								
"Hunthawang" at Middle Creek	2.1	Supply channel with syphon	Existing syphon appears adequate (H)	Retain existing 70 metre syphon	N/A	N/A	N/A	Landholder
	2.2	Access road/crossing	Creek crossing restricts high flow and road blocks high flow runner	Provide pipes and /or causeway in road across high flow runner	Install works	Provide opening in road before water reaches high flow runner	Medium	Landholder
"Hunthawang"	2.3	Supply channel to western irrigation area	Raised channel bank prevents water reaching wetland (E)	Remove 50 metre section of bank. Channel flow level is below ground level and removal of bank will not affect supply	Permanent opening	Remove before water reaches channel	Medium	Landholder
	2.4	Block banks along Middle Creek	Four block banks isolate meanders of Middle Creek (E,F)	Provide 10 metre openings in each of the four block banks	Permanent Openings	Provide openings before water reaches block banks.	Medium	Landholder
"Johnnell"	2.5	Levees	Existing levees may block some flow but it is expected to be only a small amount with little adverse impact (H)	Retain existing levees	N/A	N/A	N/A	Landholder
"Yilgah" at Yangellawah creek northern flow	2.6	Channel	Existing 10 metre syphon in channel is inadequate (H,E)	Provide a permanent opening (eg syphon) of minimum 160 metres in channel	Permanent opening	Opening to be made before water of the Yangellawah Creek northern flow reaches the "McGills"/ "Yilgah" boundary	Medium	Landholder
	2.7	Irrigation development in floodway	Above ground earthworks of the irrigation (eg head ditches, drains etc) that are within the floodway may restrict flows (H,E)	Above ground earthworks within floodway are to be realigned or removed to provide free passage of flow	Realign works or agree upon temporary removal of works	Remove above ground works before water of the Yangellawah Creek northern flow reaches the "McGills"/ Yilgah" boundary	N/A	Landholder
"Yilgah" at Yangellawah Creek	2.8	Channel spoil banks	Existing openings in spoil banks appear adequate (H,E)	Two openings of approximately 100 metres each have been provided in the spoil banks. More and/or larger openings would be desirable	N/A	N/A	N/A	Landholder

SHEET 2**(Willandra and Yangellawah Creeks Floodplains – "Hunthawang" to Hillston/Roto Railway: Lachlan River Floodplain West of Hillston, East of Hillston)**

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
"Yilgah" at Y-North Branch and railway	2.9	Spoil banks of tailwater drain	Banks will restrict passage of flow when additional openings are made in the railway embankment (H)	Remove banks to at least match railway openings	Remove before railway openings are installed	N/A	Medium	Landholder
"Yilgah" north of Middle Creek	2.10	Supply channel	Channel blocks floodplain flows (H)	Provide minimum temporary 20 metre opening	Temporary opening	Opening to be made before water reaches Roto Road	N/A	Landholder
"Yilgah" at Middle Creek	2.11	Supply channel with syphon	Existing syphon appears adequate (H)	Retain existing 70 metre syphon	N/A	N/A	N/A	Landholder
"Roto Station"	2.12	Levee	Existing levee has small breach to allow flow from Willandra Creek to Cogie Creek. (E)	Maintain opening in levee	N/A	N/A	N/A	Landholder
"Roto Station" at Cogie Creek	2.13	Two creek crossing	Crossings did not have pipes to pass low flows (H,E)	Provide minimum 1 x 0.9 metre diameter pipe in each crossing	Install pipes	Monitor during floods to determine if emergency works are needed	Low	Landholder
"Gunagai" at Yangellawah Creek northern flow	2.14	Stock supply channel	Channel blocks floodplain flows (H,E)	Provide minimum temporary 75 metre opening	Temporary opening	Opening to be made before water of the Yangellawah Creek northern flow reaches Roto Railway	N/A	Landholder
	2.15	Stock supply channel	Channel blocks floodplain flows (H,E)	Provide minimum temporary 35 metre opening	Temporary opening	Opening to be made before water of the Yangellawah Creek northern flow reaches Roto Railway	N/A	Landholder
"Gunagai" at Yangellawah Creek	2.16	Stock supply channel	Channel blocks floodplain flows (H,E)	Provide minimum temporary 20 metre opening	Temporary opening	Opening to be made before Yangellawah Creek water reaches Roto Railway	N/A	Landholder
	2.17	Stock supply channel	Channel blocks floodplain flows (H,E)	Across Yangellawah Creek provide a minimum 20 metre permanent opening	Install permanent opening	Opening to be made before Yangellawah Creek water reaches Roto Railway	Medium	Landholder

SHEET 2

(Willandra and Yangellawah Creeks Floodplains – "Hunthawang" to Hillston/Roto Railway: Lachlan River Floodplain West of Hillston, East of Hillston)

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
ROTO ROAD AND MOSSGIEL ROAD								
Roto Road at Yangellawah Creek	2.18	Culverts	Existing culverts appear adequate (H,E)	Retain existing culverts	N/A	N/A	N/A	Carrathool Shire Council
	2.19	Causeways	Existing causeways appears adequate (H,E)	Maintain existing causeways	N/A	N/A	N/A	Carrathool Shire Council
Roto Road at Yangellawah Creek northern flow.	2.20	Causeway	Inadequate waterway to pass design flow within plan's criteria (H,E)	Lower causeway to RL 121.45 metres AHD and widen to 325 metres (from 80 metres)	Modify causeway	Monitor during floods to determine if emergency works are needed	Medium	Carrathool Shire Council
Roto Road between "Talinga" and Middle Creek	2.37	Culverts	Existing culverts appear adequate (H,E)	Retain existing culverts	N/A	N/A	N/A	Carrathool Shire Council
Roto Road south of Middle Creek	2.38	Culvert	Existing culverts appear to hold up water (H,E)	Provide equivalent of an additional 6 x 2.1 metres x 0.3 metre box culverts	Install additional culverts	Monitor during floods to determine whether emergency openings are needed	Medium	Carrathool Shire Council
Roto Road north of Merrowie Creek	2.39	Culvert	Existing culverts appear to hold up water (H,E)	Provide an additional 0.6 metre pipe culvert	Install additional culvert	Monitor during floods to determine whether emergency openings are needed	Medium	Carrathool Shire Council
Roto Road at Merrowie Creek	2.40	Bridge and culverts	Existing bridge and culverts appear adequate (H,E)	Retain existing bridge and culvert	N/A	N/A	N/A	Carrathool Shire Council
Roto Road at Cogie Creek	2.21	Culvert	Inadequate waterway to allow sufficient flow west (E)	Provide an additional 0.9 metre pipe culvert	Install additional culvert	Monitor during floods to determine whether emergency openings are needed	Medium	Carrathool Shire Council
MR80-Mossgiel Road near Roto Road intersection	2.22	Culverts	Inadequate waterway area to pass design flow within plan's criteria (H,E,F)	Provide equivalent of an additional 11 x 1.22metre x 0.9 metre box culverts	Install additional culverts	Monitor during floods to determine if emergency works needed.	High	Carrathool Shire Council
MR80-Mossgiel Road near Golf Course	2.23	Culverts	Inadequate waterway area to pass design flow within plan's criteria (H,E,F)	Provide equivalent of an additional 3 x 0.9 metres pipe culverts	Install additional culverts	Monitor during floods to determine if emergency works needed.	High	Carrathool Shire Council

SHEET 2

(Willandra and Yangellawah Creeks Floodplains – "Hunthawang" to Hillston/Roto Railway: Lachlan River Floodplain West of Hillston, East of Hillston)

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
Roto Road at Middle Creek	2.41	Bridge	Existing Bridge appears adequate (H,E)	Retain existing bridge	N/A	N/A	N/A	Carrathool Shire Council
HILLSTON - ROTO RAILWAY								
Hillston - Roto Railway at Yangellawah Creek	2.24	Scour openings	Existing openings appear adequate but enlargement would be desirable (H,E)	Maintain existing openings as a minimum. (present openings total some 70 metres)	N/A	N/A	N/A	Rail Infrastructure Corporation
	2.25	Culvert	Existing culverts appear adequate (H,E)	Retain existing culverts. Includes bridge over Yangellawah Creek	N/A	N/A	N/A	Rail Infrastructure Corporation
Hillston - Roto Railway at Yangellawah Creek northern flow	2.26	Scour openings	Existing openings are inadequate to pass design flow within plan's criteria (H,E)	Provide additional minimum 57 metre opening in railway embankment (existing scour openings amount to approximately 76 metres minimum length). A larger opening would be desirable	Permanent opening	Opening to be made before water of the Yangellawah Creek northern flow reaches Roto Road	Medium	Rail Infrastructure Corporation
Hillston - Roto Railway at Middle Creek	2.42	Bridge	Existing Bridge appears adequate (H,E)	Retain existing bridge	N/A	N/A	N/A	Rail Infrastructure Corporation
Hillston - Roto Railway at Merowie Creek	2.43	Bridge	Existing Bridge appears adequate (H,E)	Retain existing bridge	N/A	N/A	N/A	Rail Infrastructure Corporation
Hillston - Roto Railway at "Rivernook"	2.27	Railway embankment	Existing openings cannot pass design flood within plan's criteria (H,E,F)	Provide additional minimum 60 metre opening	Permanent opening	Opening to be made before floodwater reaches channel of 2.1	High	Rail Infrastructure Corporation
"MERROWIE" AND "RIVERNOOK"								
"Merrowie"	2.28	Supply channel	Channel prevents floodwaters entering right bank floodplain (H,E,F)	Provide minimum 20 metre opening	Permanent opening	Opening to be made before floodwater reaches channel	High	Landholder

SHEET 2**(Willandra and Yangellawah Creeks Floodplains – "Hunthawang" to Hillston/Roto Railway: Lachlan River Floodplain West of Hillston, East of Hillston)**

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
"Rivernook"	2.29	Levee adjacent to River	Present realigned levee provides adequate waterway area (H,E,F)	Maintain existing levee alignment	N/A	N/A	N/A	Landholder
	2.30	Floodway constriction near development	Constriction restricts flow (H,E,F)	Provide minimum 20 metre opening	Permanent opening	Opening to be made before floodwater reaches channel of 2.28	High	Landholder
Julies Channel	2.31	Supply channel	Channel restricts flow (H,E,F)	Remove channel	Permanent removal	Substantial removal of channel – a minimum opening of 40 metres- before floodwaters reach railway	High	Landholder
"MOORA FARM", "WYOLA", "ROSEMONT"								
"Moora Farm"	2.32	Levee	Levee constructed according to community agreement (H)	Maintain at existing alignment and level	N/A	N/A	N/A	Landholder
"Wyola"	2.33	Floodway downstream of 'Big Bend' Causeway	Spread of floodwaters onto irrigation area below road causeway (H)	Provide 100 metre wide floodway to contain spread of water	Construct floodway if desired by landholder	Construct floodway before flows reach 'Big Bend' for major floods.	N/A	Landholder
	2.44	Floodway between vineyard and irrigation area	Spread of floodwaters into vineyard and irrigation areas (H)	Provide levees for protection leaving a minimum 50 metre wide floodway	Construct floodway if desired by landholder	Construct floodway before flows reach 'Big Bend' for major floods.	N/A	Landholder
"Rosemont"	2.34	Supply channel	Channel blocks floodplain flows (H,E)	Provide minimum temporary 50 metre opening	Temporary opening	Opening to be made before water passes Lachlan River Road at 'Big Bend'	N/A	Landholder to consider making opening permanent

SHEET 2**(Willandra and Yangellawah Creeks Floodplains –"Hunthawang" to Hillston/Roto Railway: Lachlan River Floodplain West of Hillston, East of Hillston)**

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
LACHLAN RIVER ROAD								
Lachlan River Road at 'Big Bend'	2.35	Causeway and training works	Small floods may cause nuisance flooding that can be managed by preventing flow onto farming land (H)	Maintain causeway. Provide training works in road reserve to link with floodway in "Wyola". Construct levee around culvert opening 50 mm below minimum causeway level.	Complete works	Construct levee around culvert opening before flows reach 'Big Bend' for up to moderate flood level. Construct training works before flows reach 'Big Bend' for major floods.	Medium	Carrathool Shire Council
Lachlan River Road at Gum Swamp	2.36	Culverts	Present culverts appear adequate (H)	Retain existing culverts	N/A	Monitor during floods to determine if emergency works needed.	N/A	Carrathool Shire Council

SHEET 3**(Lachlan River and Willandra Creek Floodplains - Carrathool/Lachlan Shire Boundary to “Hunthawang”)**

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
LACHLAN VALLEY WAY NEAR LAKE BREWSTER – Road is being upgraded and sealed								
Mountain Creek Offtake	3.1	Culverts and/or causeway	Road improvement not to restrict flood flows excessively (H,E,F)	Provide bridge or culvert structure. Details yet to be assessed	Construct works when funding available	Monitor during floods to determine if emergency works needed.	High	Lachlan Shire Council
East of “Merri Merrigal” house	3.2	Causeway	Restricted access during small to medium floods (H)	Raise causeway and install culvert	Works constructed	N/A	N/A	Carrathool Shire Council
“Merri Merrigal” House	3.3	Causeway	Causeway is ineffective due to levees upstream and downstream (H)	Remove causeway	Works constructed	N/A	N/A	Carrathool Shire Council
Horseshoe Lagoon	3.4	Causeway and culvert	Road recently realigned with culvert and causeway installed in consultation with local landholder (H,E,F)	Maintain existing works	Works constructed	N/A	N/A	Carrathool Shire Council
Near sand hill upstream of Ballyrogan Channel	3.5	Road	Provision of adequate waterway area for flood flows past road (H,E,F)	Realign road, provide culvert structure and enhanced table drain to connect upstream runners. yet to be designed	Construct works when funding available	Monitor during floods to determine if emergency works needed.	Medium	Carrathool Shire Council
S-Bend east of Mountain Creek	3.6	Road	Dangerous road alignment. need to provide adequate waterway area (H)	Realign and provide culvert(s) Yet to be designed	Construct works when funding available	Monitor during floods to determine if emergency works needed.	Medium	Carrathool Shire Council
Immediately east of Mountain Creek Bridge	3.7	Causeway	Road improvement not to restrict flood flows excessively (H)	Yet to be assessed	Construct works when funding available	N/A	Medium	Carrathool Shire Council

SHEET 3**(Lachlan River and Willandra Creek Floodplains - Carrathool/Lachlan Shire Boundary to “Hunthawang”)**

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
LACHLAN RIVER ROAD								
Lachlan River Road at “Hunthawang”	3.8	Culverts and Causeways	Existing culverts and causeways appear adequate (H,E,F)	Retain existing culverts and causeways	N/A	N/A	N/A	Carrathool Shire Council
BREWSTER WEIR AREA								
Brewster Weir	3.9	Bywash embankment	Embankment may impact on flood distribution around Brewster Weir	Temporary removal in significantly large floods	Temporary removal	If flood is large enough to remove embankment before flood arrives.	N/A	State Water
Ballyrogan Channel at Mountain Creek	3.10	Culverts	Channel restricts floodplain flows (H,F)	Yet to be assessed	N/A	If flood is large enough, consider lowering embankments of Ballyrogan Channel to allow flow across the channel. This work should be done before water passes Lachlan Valley Way at the Mountain Creek offtake.	Medium	State Water
Lake Brewster	3.11	Flood inlet and outlet embankments	Late removal creates sudden flows (H)	Temporary removal in significantly large floods	Temporary removal	If flood is large enough to warrant opening of flood inlet and outlet to Lake Brewster, remove before water passes Lachlan Valley Way at the Mountain Creek offtake.	N/A	State Water
“MOUNTAIN CREEK”								
“Mountain Creek” at channel offtake near river	3.12	Supply channel	Channel blocks flows and was breached in 1990 (H)	Provide a minimum 20 metre opening in channel	Temporary opening	Opening to be made before water reaches channel	N/A	Landholder
“Mountain Creek” at channel syphon	3.13	Syphon in supply channel	Existing syphon appears adequate (H,E,F)	Retain existing 67 metre syphon	N/A	N/A	N/A	Landholder

SHEET 3**(Lachlan River and Willandra Creek Floodplains - Carrathool/Lachlan Shire Boundary to “Hunthawang”)**

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
“Mountain Creek” at creek crossing	3.14	Mountain Creek access crossing	Existing pipe in crossing is not favourable for fish passage and may be hydraulically inadequate (H,F)	Provide more fish friendly structure if Ballyrogan Channel culverts are suitably modified	Install new structure when required	Monitor during floods to assess impact of crossing hydraulically and environmentally	Low	Landholder
“Mountain Creek” where creek joins outlet channel	3.15	Block bank on Mountain Creek	Block bank restricts flow and fish passage (H,F)	To be assessed if modifications made to Ballyrogan Channel	N/A	Monitor during floods to assess impact of block bank hydraulically and environmentally	Low	Landholder
EUABALONG ROAD								
Euabalong Road at “Tarcoola”	3.16	Culvert and causeways	Existing culverts and causeways appear adequate (H,E)	Retain existing culverts and causeways	N/A	N/A	N/A	Carrathool Shire Council
Euabalong Road at “Kindra Park”	3.17	Culvert	Inadequate waterway to allow sufficient water to spread to wetland (E)	Provide additional 0.45 metre pipe culvert	Install works	Monitor during floods to determine if emergency opening is required	Medium	Carrathool Shire Council
Euabalong Road at “Stobhall”	3.18	Culvert	Existing culvert appears adequate (E)	Retain existing 0.45 metre pipe culvert	N/A	N/A	N/A	Carrathool Shire Council
Euabalong Road at Willandra Creek and overflow	3.19	Bridge, culverts and causeways	Existing waterway area in road appears adequate (H)	Retain existing bridges, culverts and causeways.	N/A	N/A	N/A	Carrathool Shire Council

SHEET 3**(Lachlan River and Willandra Creek Floodplains - Carrathool/Lachlan Shire Boundary to “Hunthawang”)**

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
“RED LAGOON”, “STOBHALL”, “BILLABOURIE”, “ALDINGA”								
“Red Lagoon”	3.20	Supply channel	Channel blocks floodplain flow (H)	Provide a minimum temporary 20 metre opening and set channel as low as possible	Temporary opening	Opening to be made before water reaches channel	N/A	Landholder
“Stobhall”	3.21	Supply channel along river	Floodway is blocked by supply channel preventing spread of water to lagoon (E)	Provide gated 0.6 metre pipe through channel	Install pipe	Monitor during floods to determine if emergency opening is required	Medium	Landholder
	3.22	Supply channel at Euabalong Road	Channel blocks flow path preventing spread of water to lagoon (E)	Provide 0.6 metre pipe through channel	Install pipe	Monitor during floods to determine if emergency opening is required	Medium	Landholder
	3.23	Area immediately downstream of where supply channel crosses Euabalong Road	Existing road table drain requires modifications to improve passage of flow. (E)	Provide training works in the form of a drain and/or low levee downstream of channel to direct flows to natural channel that passes under ‘Stobhall’ entrance road.	Construct works as appropriate	Monitor during floods to determine if emergency opening is required	Medium	Landholder/ Carrathool Shire Council
“Billabourie”	3.24	Supply channel at Stobhall/ Billabourie boundary	Existing culvert through channel is blocked (E)	Remove plug in culvert	Clean out culvert	Monitor during floods to determine if emergency opening is required	Medium	Landholder
“Aldinga”	3.25	Supply channel	Channel blocks floodplain flow (H)	Provide a minimum temporary 20 metre opening and set channel as low as possible	Temporary opening	Opening to be made before water reaches channel	N/A	Landholder
	3.26	Levee	Prevents flow heading north. Washed out and overtopped in 1990 (H,E,F)	Levee has holes in it. Remove remaining sections	Remove levee	Levee to be removed before water reaches levee	High	Landholder

SHEET 3

(Lachlan River and Willandra Creek Floodplains - Carrathool/Lachlan Shire Boundary to “Hunthawang”)

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
“SCRUBBY”, “WAABALONG”, “URANAWAY”, “VALROONA”, “TOCABIL”								
“Scrubby”	3.27	Supply channel	Channel prevents spread of water to wetland (E)	Provide a minimum temporary 20 metre opening in channel	Temporary opening	Provide openings before water reaches channel.	N/A	Landholder
“Waabalong”	3.28	Supply channel	Channel prevents spread of water to wetland (E)	Provide gated 0.6 metre pipe through channel	Install pipe and operate gate to provide controlled flooding to wetland	Monitor during floods to determine if emergency opening is required	Medium	Landholder
“Uranaway”	3.29	Supply channel	Floodway is blocked by supply channel preventing spread of water to wetlands (H,E,F)	Provide a minimum temporary 20 metre opening in channel	Temporary opening	Provide openings before water reaches channel.	N/A	Landholder
“Valroona”	3.30	Supply channel	Floodway is blocked by supply channel preventing spread of water to wetlands (H,E,F)	Remove channel across floodway	Provide permanent opening	Provide openings before water reaches channel.	Medium	Landholder
“Tocabil”	3.31	Supply channel downstream of Kidman Way	Floodway is blocked by supply channel preventing spread of water to wetlands (H,E,F)	Provide a minimum temporary 20 metre opening in channel	Temporary opening	Provide openings before water reaches Kidman Way.	N/A	Landholder is considering permanent work
	3.32	Supply channel	Floodway is blocked by supply channel preventing spread of water to wetlands (H,E,F)	Provide a minimum temporary 20 metre opening in channel	Temporary opening	Provide openings before water reaches Kidman Way.	N/A	Landholder is considering other works
	3.33	Disused supply channel from Lachlan River	Channel blocks flow (H)	Provide a minimum 50 metre opening	Provide permanent opening	Provide openings before water reaches channel.	Low	Landholder

SHEET 3**(Lachlan River and Willandra Creek Floodplains - Carrathool/Lachlan Shire Boundary to “Hunthawang”)**

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
KIDMAN WAY								
Kidman Way north of Lachlan River to “Valroona”	3.34	Bridges, culverts, and causeways	Existing waterway area in road appears adequate (H,E,F)	Retain existing bridges, culverts and causeways.	N/A	N/A	N/A	Roads and Traffic Authority

SHEET 4

(Lachlan River Floodplain – “Cowl Cowl to “Gunbar Station”; Merrowie Creek Floodplain; Cabbage Garden Creek)

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
“WYADRA”, “GUNBAR STATION”								
“Wyadra”	4.1	Supply channel	Works prevent flows reaching wetlands in “Woorilla” (E)	Provide 2 x 0.9 metre pipes through supply channel	Install works	Monitor during floods to determine whether emergency openings are needed	Medium	Landholder
	4.2	Irrigation works	Works prevent flows reaching wetlands in “Woorilla” (E)	Provide drainage capacity along the lateral move supply channel to allow water to reach wetlands in “Woorilla”	Install works	Monitor during floods to determine whether emergency openings are needed	Medium	Landholder
“Gunbar”	4.3	Stock supply channel near Lachlan River	Channel prevents spread of flow to wetlands (E)	Provide 0.6 metre pipe through channel. Pipe may be gated to give controlled flooding	Install works	Monitor during floods to determine whether emergency openings are needed	Medium	Landholder
	4.4	Stock supply channel at Cabbage Garden Creek	Existing syphon appears adequate (H,E,F)	Retain existing 30 metre syphon	N/A	N/A	N/A	Landholder
WHEALBAH (CROWS NEST) ROAD								
Whealbah Road at Cabbage Garden Creek	4.5	Culverts	Water overtopped road in 1990 impacting on access (H,E,F)	Provide additional culverts if flood free access for low frequency floods is desired. Size yet to be determined	Install additional culverts as required	Monitor during floods to determine whether emergency openings are needed	N/A	Carrathool Shire Council
WHEALBAH - TRIDA ROAD								
Whealbah - Trida Road	4.6	Culverts	Existing culverts appear adequate (H,E)	Retain existing culverts (1 x 0.9 metre pipe and 1 x 0.6 metre pipe)	N/A	N/A	N/A	Carrathool Shire Council

SHEET 4

(Lachlan River Floodplain – “Cowl Cowl to “Gunbar Station”; Merrowie Creek Floodplain; Cabbage Garden Creek)

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
“TALLAWANTA”, “WOORILLA”								
“Tallawanta” – “Woorilla”	4.7	Cut drain	“Tallawanta” Irrigation works prevent flow reaching woodland downstream of Whealbah – Trida Road (E)	Provide cut drain upstream of the Whealbah –Trida Road to culvert(s) to allow watering of woodland	Details of drain alignment to be finalised. Install when finalised	Monitor during floods to determine whether emergency works are needed	Low	Landholder (“Tallawanta”)

SHEET 5**(Lachlan River Floodplain - West of Hillston , East of Hillston; Cabbage Garden Creek)**

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
“MYALLA”, “HAZELWOOD”, “BRAYVILLE”, “BROOKLYN”								
“Myalla”	5.1	Supply channel near Merungle Road	Channel prevents flow reaching culverts in Merungle Road (H,E,F)	Provide minimum temporary 15 metre opening	Temporary opening	Opening to be made before water passes Roto Road	N/A	Landholder to consider making opening permanent
	5.2	Supply channel	Channel blocks floodplain flows (H,E,F)	Provide minimum 40 metre opening	Permanent opening	Opening to be made before floodwaters reach Roto Road	High	Landholder
“Hazelwood”	5.3	Supply channel	Channel blocks floodplain flows (H)	Provide equivalent 2 x 1.2 metre diameter pipe culverts	Install culverts	Provide temporary opening before water passes Merungle Road	Medium	Landholder
	5.4	Channel	Channel blocks floodplain flows (H,E,F)	Provide minimum 35 metre opening	Permanent opening	Opening to be made before floodwaters reach Roto Road	High	Landholder
	5.5	Channel	Channels blocks floodplain flows (H,E,F)	Provide minimum 45 metre opening	Permanent opening	Opening to be made before floodwaters reach Roto Road	High	Landholder
	5.6	Two channels	Both channels prevent inundation of wetlands (E)	Provide 0.9 metre pipe through both channels	Install pipes	Monitor during floods to determine if emergency works needed.	Medium	Landholder
	5.35	Access Road	Existing road formation appears adequate. (H,E,F)	Retain existing road height	N/A	N/A	N/A	Landholder
“Brayville”	5.7	Supply channel	Channel blocks floodplain flows (H,E)	Provide pipe(s) through proposed channel to allow water to reach downstream wetland	Install pipes	Monitor during floods to determine if emergency works needed.	N/A	Landholder
	5.8	Supply channel	Channel prevents inundation of wetland (E)	Provide 0.45 metre gated pipe through channel	Install pipe	Monitor during floods to determine if emergency works needed.	Medium	Landholder
“Brooklyn”	5.9	Supply channel	Channel blocks floodplain flows (H,E)	Provide equivalent 1 x 1.2 metre diameter pipe culvert	Install culvert	Provide temporary opening when water reached channel	Medium	Landholder

SHEET 5**(Lachlan River Floodplain - West of Hillston , East of Hillston; Cabbage Garden Creek)**

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
KIDMAN WAY								
Kidman Way at 'High Bank'	5.10	Culverts	Inadequate waterway area to pass design flow within plan's criteria (H)	Provide equivalent of an additional 6 x 1.2 metre pipe culverts	Install additional culverts	Monitor during floods to determine if emergency works needed.	High	Roads and Traffic Authority
Kidman Way at 'Rosemont' bend	5.35	Culverts	Ponding upstream of the road and enhanced watering of wetlands downstream (H,E)	Provide equivalent of an additional 2 x 0.45 metre pipe culverts	Install additional culverts	Monitor during floods to determine if emergency works needed.	Medium	Roads and Traffic Authority
Kidman Way East of Sewage Treatment Plant	5.11	Culverts	Inadequate waterway area to pass design flow within plan's criteria (H)	Provide equivalent of an additional 13 x 0.9 metre pipe culverts	Install additional culverts	Monitor during floods to determine if emergency works needed.	High	Roads and Traffic Authority
Kidman Way West of Sewage Treatment Plant	5.12	Culverts and causeway	Inadequate waterway area to pass design flow within plan's criteria (H,E)	Provide equivalent of an additional 2 x 0.83 metre pipe culvert Retain causeway	Install additional culvert	Monitor during floods to determine if emergency works needed.	High	Roads and Traffic Authority
Clifton Channel near Kidman Way	5.13	Culvert	Present culvert appears adequate (H)	Maintain existing 1.2 metre pipe culvert	N/A	N/A	N/A	Carrathool Shire Council and Landholders
Kidman Way 2km south of Hillston	5.14	Culverts and causeway	Inadequate waterway area to pass design flow within plan's criteria (H,E)	Provide equivalent of an additional 1 x 1.8 metre x 0.3 metre box culverts Retain causeway	Install additional culverts	Monitor during floods to determine if emergency works needed.	Medium	Roads and Traffic Authority
Kidman Way 5km south of Hillston	5.15	Culverts and causeway	Existing culverts and causeway appear adequate (H,E)	Maintain existing culverts Retain causeway	N/A	N/A	N/A	Roads and Traffic Authority
Kidman Way near "Mt Erin"	5.16	Culverts and causeway	Additional waterway in the form of culverts and a causeway has been installed since the 1990 flood. However this may not provide flood free access for the design flood.	If flood free access for the design flood is required, provide equivalent of an additional 10 x 2.1 metre x 0.5 5 metre box culverts. (More detailed analysis may show a lesser waterway area will be sufficient.)	Install additional culverts – if required by community	Monitor during floods to determine if emergency works needed.	N/A	Roads and Traffic Authority

SHEET 5**(Lachlan River Floodplain - West of Hillston , East of Hillston; Cabbage Garden Creek)**

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
			(H,E)	Retain causeway				
“REDBANK CITRUS”, “INVERARY”, ”THE OASIS”, ”WOODLANDS”, “CURRAH”, “KARALEE”								
“Redbank Citrus”	5.17	Supply channel	Channel blocks floodplain flows (H,E)	Provide minimum temporary 50 metre opening	Temporary opening	Opening to be made before water passes Kidman way at ‘High Bank’	N/A	Landholder to consider making opening permanent
“Inverary”	5.18	Supply channel	Channel blocks floodplain flows (H,E)	Provide minimum temporary 40 metre opening	Temporary opening	Opening to be made before water passes Kidman Way at ‘High Bank’	N/A	Landholder
“The Oasis”	5.19	Supply channel	Channel blocks floodplain flows (H,E)	Provide minimum temporary 30 metre opening	Temporary opening	Opening to be made before water passes Jardines Road	N/A	Landholder
“Woodlands”	5.20	Supply channel and access road near Kidman Way	Channel and road block drain along Kidman Way (H)	Provide a minimum temporary 5 metre opening in channel and access road	Temporary opening	Openings to be made before water reaches Griffith –Hillston railway	N/A	Landholder
“Currah”	5.21	Supply channel	Channel blocks floodplain flows (H,E)	Provide minimum temporary 30 metre opening	Temporary opening	Opening to be made before water reaches channel	N/A	Landholder
	5.22	Levee if constructed	Levee would prevents inundation of wetland (H,E)	Provide gated 0.6 metre pipe through levee	Install pipe if levee constructed	If levee constructed monitor during floods to determine if emergency works needed	N/A	Landholder
“Karalee”	5.23	Two supply channels	Channels blocks floodplain flows (H,E)	Provide minimum temporary 30 metre opening in both channels	Temporary opening	Opening to be made before water passes Railway and Kidman Way	N/A	Landholder

SHEET 5**(Lachlan River Floodplain - West of Hillston , East of Hillston; Cabbage Garden Creek)**

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
	5.24	Levee	Levee prevents inundation of wetland (E)	Provide temporary 0.45 metre gated pipe through levee	Temporary opening	Install pipe or equivalent opening before water reaches “Karalee” supply channel	N/A	Landholder
JARDINES ROAD, NORWOOD LANE, PETERS ROAD								
Jardines Road	5.25	Causeway	Existing causeway appears adequate (H)	Maintain existing causeway	N/A	N/A	N/A	Carrathool Shire Council
Norwood Lane	5.26	Drains	Drainage linked to urban flood plan (H)	Provide drains as recommended in urban flood plan	N/A	N/A	High	Carrathool Shire Council
Peters Road	5.27	Culverts	Existing culverts appear adequate (H)	Maintain existing culverts	N/A	N/A	N/A	Carrathool Shire Council
RANKIN SPRINGS ROAD								
Rankin Springs Road	5.28	Culverts	Existing culverts appear adequate (H)	Maintain existing culverts Linked to urban plan	N/A	N/A	N/A	Carrathool Shire Council
Rankin Springs Road near Norwood Lane	5.29	Culverts and causeway	Existing culverts and causeway appear adequate (H)	Maintain existing culverts Retain causeway Linked to urban plan	N/A	N/A	N/A	Carrathool Shire Council
GRIFFITH – HILLSTON RAILWAY								
Railway 2km south of Hillston	5.30	Culverts	Inadequate waterway area to pass design flow within plan’s criteria (H,E)	Provide equivalent of an additional 2 x 0.6 metre diameter pipe culverts	Install additional culverts	Monitor during floods to determine if emergency works needed.	Medium	Rail Infrastructure Corporation

SHEET 5

(Lachlan River Floodplain - West of Hillston , East of Hillston; Cabbage Garden Creek)

Property/ Location	Sheet Ref	Works Requiring Modification	Concern(s)	Required Modification	Short Term Action	Emergency Action if Short Term Action not Completed	Priority	Responsibility
Railway 5km south of Hillston	5.31	Culverts	Inadequate waterway area to pass design flow within plan's criteria (H,E)	Provide equivalent of an additional 3 x 1.9 metre x 0.65 metre box culverts	Install additional culverts	Monitor during floods to determine if emergency works needed.	Medium	Rail Infrastructure Corporation
Railway	5.32	Viaduct in "Currah"	Existing viaduct appears adequate (H)	Maintain existing opening	N/A	N/A	N/A	Rail Infrastructure Corporation
MERUNGLE ROAD								
Merungle Road	5.33	Culverts	Inadequate waterway area to pass design flow within plan's criteria (H,E)	Provide equivalent of an additional 1 x 1.2m diameter pipe culvert	Install additional culvert	Monitor during floods to determine if emergency works needed.	High	Carrathool Shire Council
LACHLAN VALLEY WAY								
Lachlan Valley Way at Cabbage Garden Creek	5.34	Bridge	Existing bridge appears adequate (H,E,F)	Maintain existing bridge	N/A	N/A	N/A	Carrathool Shire Council

In the "Concern(s)" column a code of H, E and/or F is indicated. This code indicates whether the main concerns are:

H –Hydraulic issue being an impact on flow distribution, flood levels or flow velocity;

E – Ecosystem access being an issue of wetlands having been denied flooding due to works; and/or,

F – Fish passage requirement according to the adopted fish passage classification

5 ASSESSING NON – COMPLYING WORKS

Landholders applying for approval of non-complying works will need to engage a suitably qualified consultant to investigate the hydraulic and environmental impact of the works. DNR will provide the required assessment criteria for the consultant. Applications will be assessed against, among other things, hydraulic and environmental criteria adopted by the committee in determining outcomes in the *Hillston Floodplain Management Study Lake Brewster to Whealbah* (DNR 2005). As well, the environmental impacts of the works applications will need to be assessed under Part 5 of the *Environmental Planning and Assessment Act 1979*. Assessment under Part 4 of this Act is not required as there is currently no relevant environmental planning instrument applying to flood control works in the FMP area.

5.1 Hydraulic Criteria

The hydraulic criteria adopted to assess existing works during preparation of the *Hillston Floodplain Management Study Lake Brewster to Whealbah* (DNR 2005) will be applied to assess applications for non-complying works. These criteria were also used in the design of the floodway network where hydraulic modelling was undertaken. The criteria consider the maximum allowable afflux (afflux can be defined as the increase in the upstream flood level created by the obstruction to flow of the structure), the maximum allowable velocities, and what is acceptable in terms of the impact on flood flow distribution.

Design Flood

The 1990 flood, which was adopted by the committee as the design flood, is used as the basis for determining hydraulic impact. This flood was selected as it was:

- a large flood of 60 to 70 year Average Recurrence Interval (ARI) close to the 100 year ARI flood or otherwise termed the 1% Annual Exceedance Probability (AEP) flood. The 1% AEP flood is an accepted common design flood; and,
- relatively recent so that people could remember the flooding behaviour.

Hydraulic Criteria

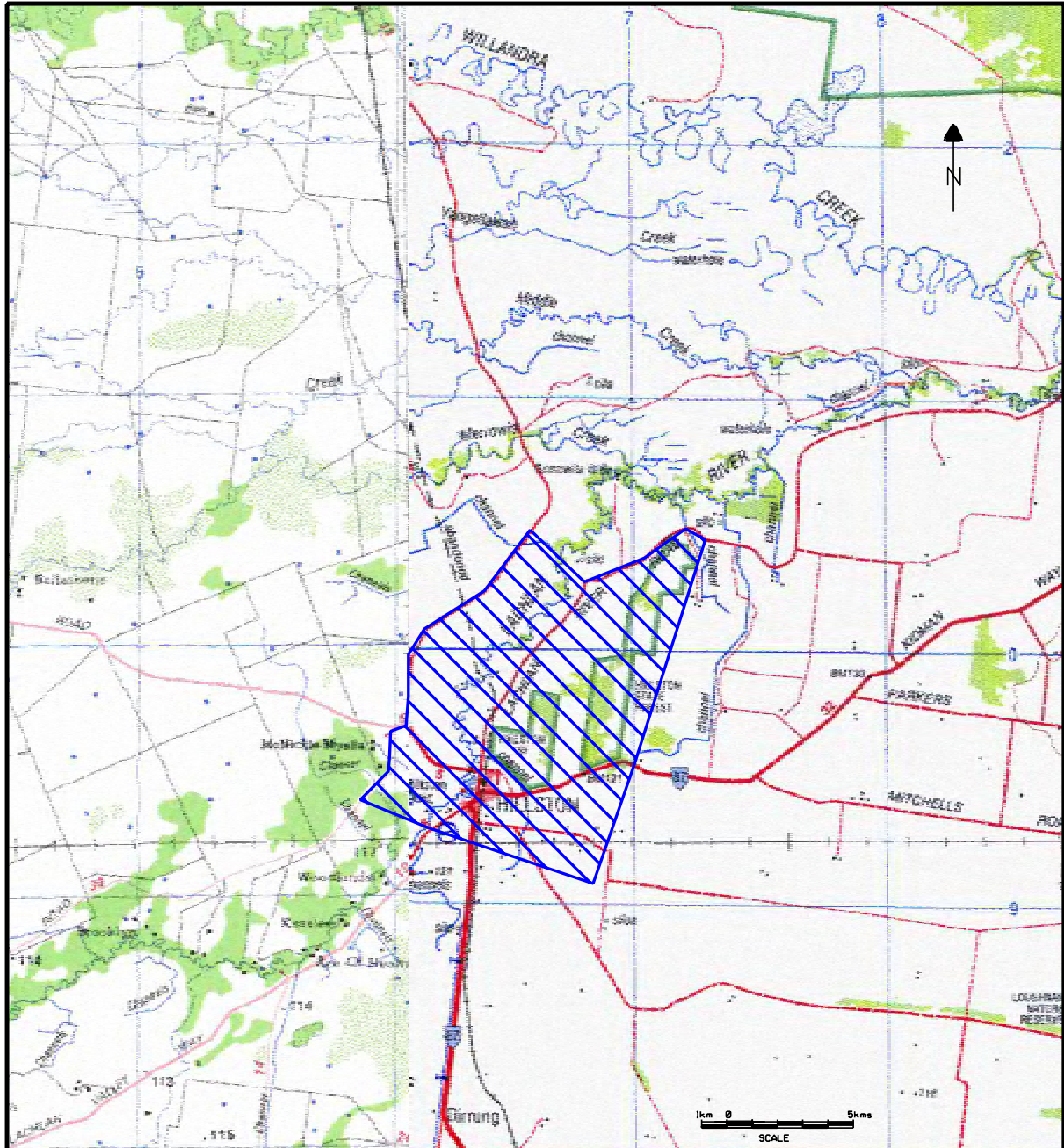
Applicants will need to demonstrate the impact of their works in relation to the hydraulic criteria, as adopted by the committee. The criteria differ based on the location of works on the floodplain. Proposed works situated in the modelled areas close to Hillston will need to meet tighter criteria of afflux and flow distribution than works proposed in other parts of the floodplain. Table 5.1 summarises the hydraulic criteria. The areas referred to in Table 5.1 are shown on Figure 5.1

Table 5.1 Adopted Hydraulic Criteria

Area	Maximum Afflux* (metres)	Maximum Velocity** (metres/second)	Flow Distribution
West of Hillston Branch: from “Rivernook” to Twynam (“Hazelwood”) property downstream of Roto Road	0.1	0.7 on the floodplain and through syphon/channel openings 1.0 for culverts and causeways	No flow increase at Hillston
East of Hillston Branch: from Lachlan River Road to about 1 km south of Jardines Road	0.1	0.7 on the floodplain and through syphon/channel openings 1.0 for culverts and causeways	No flow increase at Hillston
Other areas	0.15 – 0.2	0.7 on the floodplain and through syphon/channel openings 1.0 for culverts and causeways	Local community acceptance

*The lower afflux was adopted near town to ensure there is minimum adverse impact on Hillston

**Velocity criteria are set to minimise the chance of scour occurring. Higher velocity can be accepted through culverts and over road causeways as scour protection can be provided relatively easily on the downstream side.



Areas of Differing Hydraulic Criteria

FIGURE 5.1

Area	Maximum Afflux (metres)	Maximum Velocity (metres/second)	Flow Distribution
<p>Shaded Area:</p> <p>West of Hillston Branch: from "Rivernook" to "Hazelwood" ;</p> <p>East of Hillston Branch: from Lachlan River to "Inverary"</p>	0.1	<p>0.7 on the floodplain and through syphon/channel openings</p> <p>1.0 for culverts and causeways</p>	No flow increase at Hillston
Other Areas	0.15 - 0.2	<p>0.7 on the floodplain and through syphon/channel openings</p> <p>1.0 for culverts and causeways</p>	Local community acceptance

5.2 Environmental Criteria

Environmental assessment criteria were developed in consultation with the committee to help determine outcomes for flood dependent ecosystems affected by existing private works. Two sets of criteria were developed, one to assess the environmental value of an area and another to assess the practicality of modifying works to restore flood flow access. Applicants with non-complying works affecting a flood dependent ecosystem will need to address the environmental value criteria (in addition to the need to address environmental impact under Part 5 of the EPA Act).

The environmental value criteria are shown in Table 5.2.

Table 5.2 Environmental Value Assessment Criteria

Factor	Criteria	Score
Size (wetland, floodplain vegetation) [Watercourses are measured in width x length for area]	<ul style="list-style-type: none"> Greater than 50 ha 10-50 ha Less than 10 ha 	<ul style="list-style-type: none"> High Moderate Low
Ecological condition / Habitat value	<ul style="list-style-type: none"> Sound ecological condition / habitat value based on current impacts Poor ecological condition / habitat value 	<ul style="list-style-type: none"> High / Moderate Low
Representativeness of ecosystem type	<ul style="list-style-type: none"> Good example of an ecosystem type that is not common on the floodplain Good example of an ecosystem type that is relatively common on the floodplain Poor example of ecosystem type 	<ul style="list-style-type: none"> High Moderate Low
Cultural / historical significance	<ul style="list-style-type: none"> Known significance based on Aboriginal sites, mythological values Likely significance based on regional evidence No known / likely significance 	<ul style="list-style-type: none"> High Moderate Low
Rehabilitation potential	<ul style="list-style-type: none"> Sound rehabilitation potential based on ease of restoring aquatic flora and fauna / floodplain vegetation Poor rehabilitation potential 	<ul style="list-style-type: none"> High / Moderate Low
Hydrology	<ul style="list-style-type: none"> Ecosystem would wet up under a range of flood events Ecosystem would wet up in large floods (>20yr ARI) only 	<ul style="list-style-type: none"> High Low
Hydrological connectivity	<ul style="list-style-type: none"> Watercourse connects with wetlands or other watercourses Watercourse does not connect with wetlands or other watercourses 	<ul style="list-style-type: none"> High Low
Special Features	<ul style="list-style-type: none"> Sites which are part of complexes or have listed species or have high habitat diversity If these features don't exist, then no score is given 	<ul style="list-style-type: none"> High

Consultants engaged by applicants will need to score any flood dependent ecosystem affected by proposed works against the individual criteria and supply adequate information to support these scores. Scores for individual criteria will be rated using the points systems shown below in Table 5.3 and then averaged to provide an overall score of high, moderate or low as per Table 5.3.

Table 5.3 Scores for Rating Assessment Criteria

Score	Points (Individual Criteria)	Points (Overall Average)
High	5	4 – 5
Moderate	3	2 – 4
Low	1	< 2

Non-complying works adversely affecting flood dependent ecosystems assessed with moderate or high environmental value will not be approved. Works affecting ecosystems of low environmental value may be approved subject to any further assessment that may be necessary to satisfy Part 5 of the *Environmental Planning and Assessment Act 1979*. The following criteria based on the requirements of the Act would need to be investigated:

- Fish Passage - *flood control works should not significantly block or restrict the free passage of fish within the floodplain environment.* Fish passage impacts will be considered relative to the fish habitat and flood frequency classifications for the watercourses and flow paths on the floodplain as shown on Sheets 1 to 5 and described in the Floodplain Management Study.
- Flora and fauna – *flood control works should not impose adverse impacts on habitat for plants or animals that benefit from periodic flooding and / or on the habitat of threatened species.*
- Aboriginal sites – *flood control works should not destroy or damage any Aboriginal site or relic and/or should not block or restrict the delivery of flood flows to scarred or carved trees that rely on flooding regimes.*
- Groundwater recharge – *flood control works should not block or restrict flood flow to identified groundwater recharge areas.*
- Soils – *flood control works should not impose significant negative impacts on soil structure or condition.* For example, works should not increase the potential for scour and erosion.

6 LONG TERM STRATEGY

The proposed works modifications identified in the FMP will address key hydraulic and environmental issues on the floodplain. While they will improve floodplain functions significantly, flood behaviour could be further improved by the relocation or removal of other existing above ground works and irrigation areas from the floodway. It is not seen as necessary that such development should be removed in the short term. However, in the long term, as farming practices change and if opportunities arise, it is recommended that such development be relocated away from the floodway areas thereby improving flood passage and floodplain ecology.

Examples of alternative land use practices that would enable works to be relocated from the floodway include:

- transfer of irrigation water from floodway areas to less flood - prone and more water efficient areas. The works in the floodway could then be removed and the floodway area used for activities such as grazing which do not require above ground works; and,
- replacement of above ground channels leading from river pumps with underground piping. This would lessen irrigation water transmission losses and remove flow restrictions near the river. While the initial costs may be high, valuable future water savings would be expected.

Some areas within the floodway network have pasture developments using “check bank” irrigation. While not completely desirable, such works, (as those in the Willanthery area), are generally overtopped by floodwaters and do not impact greatly on flood flows. These works have existed for some time and have undergone a number of floods without major concern. However the larger main supply channels may have the potential to impact adversely on flood flows and under the long - term strategy these would preferably be replaced by underground piping.

In summary the long - term strategy should:

- discourage future above ground works in the defined floodway; and,
- promote relocation of existing development (eg irrigation areas) within the floodway to less flood liable areas.

7 ENVIRONMENTAL WATERING RECOMMENDATION

Four flood dependent ecosystems rated in the FMP as having moderate environmental value but with a low practicality rating (for modifying barrier works) have the potential to be watered through existing irrigation supply channels during floods. The ecosystems are Black Box woodlands located on “Ace of Hearts” and “Woodlands” and part of a floodplain watercourse on “Riverview” (Sheet 5). Details of these ecosystems including required volumes for watering and associated flooding frequencies are shown in Table 7.1. The FMP recommends that possibilities for watering these ecosystems during floods of appropriate magnitude are actively pursued within the framework of the *Water Sharing Plan for the Lachlan Regulated River Water Source (2003)* and the *Water Management Act 2000*.

Table 7.1 Ecosystems Recommended for Watering through Irrigation Infrastructure

Property	Ecosystem	Area (ha)	Approximate required Volume (ML)	Flood Frequency
“Ace of Hearts”	Woodland	80	240	Low*
“Riverview”	Watercourse	50	150	Moderate**
“Woodlands” (north)	Woodland	15	45	Low*
“Woodlands” (south)	Woodland	20	60	Low*

*Low - watered during a large flood such as 1990 (60-70yr ARI)

**Moderate – watered during a moderate flood such as 1974 (10 – 15yr ARI)

8 STRATEGIC ENVIRONMENTAL ASSESSMENT

8.1 Overview of Environmental Impact

Implementation of the FMP will ensure flood flow access to a floodplain area of up to 170,000 ha within the floodway network, including an area of about 10,000 ha previously affected by flood control works. The floodway network has been designed to convey a flood of similar magnitude to the 1990 flood (60 – 70 year ARI) and, in line with the principles of the FMP, conforms as closely as reasonably possible to the natural drainage pattern. Future works in the floodway will only be permitted if an impact assessment shows that they meet hydraulic and environmental criteria (Section 5) and the requirements of the *Environmental Planning and Assessment Act 1979*. Sheet 6 shows flood dependent ecosystems, incorporating wetlands, watercourses and groundwater recharge areas, in relation to the floodway network.

The FMP will allow for potential agricultural development outside the floodway network but this will be limited by the required assessment of cumulative impact of proposed works on flow redistribution in the flood fringe area and required environmental clearances. Consequently, wholesale development of the flood fringe area is not expected to occur. There may be some decline in the ecological benefits of flooding in this area due to future development, however this impact is not expected to be significant.

The impacts of the FMP have been assessed at a strategic level by considering the impacts on the individual components of the floodplain environment. These impacts are summarised in Table 8.1 below.

Table 8.1 Summary of Environmental Impacts

Factor	Impact
Soils	<ul style="list-style-type: none"> Flood connectivity will benefit soil condition and structure within the floodway area and undeveloped areas of the flood fringe and FMP area. Floods will provide sediment, soil moisture recharge and nutrient release in these areas. Soils adapted to more frequent flooding are contained within the floodway network. The FMP will maintain ecological benefits to soils in the floodway by allowing for ongoing flood connectivity.
Wetlands	<ul style="list-style-type: none"> Wetlands currently connected to the flooding regime (78,000 ha) are contained within the FMP floodway network (Sheet 6). Maintenance of flood flow connectivity to these wetlands is ensured, subject to any new works in the floodway meeting environmental criteria. FMP will restore flood access to about 6,000 ha of wetlands currently affected by flood control works (Sheet 6). This will restore and maintain the ecological processes sustained by flooding in wetlands. Additionally, modifications identified (at Lachlan Valley Way) will restore flood connectivity to Mountain Creek and its associated wetlands. However these are subject to funding availability and are yet to be assessed in detail. About 500ha of wetlands affected by existing works are not included in the floodway network (Sheet 6) because they were assessed as having low environmental value or low practicality for modification. Alternative means of delivering floodwater to four wetlands with low practicality (165 ha) through irrigation infrastructure are recommended in the FMP.

Factor	Impact
Floodplain Vegetation	<ul style="list-style-type: none"> Existing stands of flood dependent vegetation (predominantly River Red Gum and Black Box woodlands) identified within wetlands and, with the exception of 500 ha of wetlands listed above, are incorporated into the floodway network. The FMP will allow for ongoing flood connectivity and the sustenance and regeneration of floodplain vegetation in the long term. It will restore flood connectivity to about 10,000 ha of floodplain (including 6,000 ha of wetlands) currently affected by flood control works and enhance restoration of floodplain vegetation in this area. One threatened plant species, Slender Darling Pea (<i>Swainsonia murrayana</i>) has been recorded and four others may potentially occur. None of the species is restricted to floodplain habitats but four, including Slender Darling Pea, are found in Black Box woodlands and expected to benefit as the FMP will help to maintain or restore the condition of these woodlands.
Fauna	<ul style="list-style-type: none"> FMP will benefit terrestrial fauna species relying directly on flooding (eg waterbirds) and those utilising floodplain habitats by restoring or maintaining flood connectivity to floodplain ecosystems. 14 threatened fauna species have been recorded and a further 15 species may potentially occur. These species are expected to benefit from the restoration and maintenance of ecological processes sustained by ongoing flood connectivity through the FMP.
Aquatic Fauna	<ul style="list-style-type: none"> Maintenance of flood flow access to wetlands currently connected to the flooding regime and restoration of access to about 10,000 ha of floodplain (including 6,000 ha of wetlands) currently affected by works will enhance invertebrate production and fish habitat. Fish passage has been a key consideration in determining modifications to existing works and in the design of the floodway network. A fish habitat classification scheme based on the hydrology, stream morphology and stream connectivity of flood flow paths across the floodplain was taken into account and is shown on Sheets 1 to 5 in relation to the floodway network. One threatened species, Silver Perch is expected to occur. This species depends on access to the floodplain for spawning and is expected to benefit from enhanced flood connectivity between the river and the floodplain provided through the FMP floodway network.
Water Quality	Risk of surplus nutrient and pesticide transport through inundation of cropped areas or through excessive scour or erosion will be restricted as the floodway network has been designed to limit flood velocities and to minimise the flood risk to complying agricultural development
Groundwater	Areas of groundwater recharge with the greatest response to flooding are incorporated in the mapping of flood dependent ecosystems (Sheet 6) and are included in the FMP floodway network. Implementation will allow for flood connectivity to these areas to be maintained in the long term.
Aboriginal Heritage	Recorded Aboriginal sites that benefit from flooding include scarred and carved Black Box trees, other unrecorded sites likely to occur in floodplain woodlands. These are incorporated in flood dependent ecosystems mapping and included in the floodway network. Assessment of wetlands affected by existing works has included consideration of Aboriginal heritage value.
European Heritage	Known historical sites are located on high ground and not likely to be flooded. Implementation of the FMP not likely to significantly impact on other historical sites as potential erosion damage from flooding will be minimised.

8.2 State Water Management Outcomes Plan Target

The State Water Management Outcomes Plan (SWMOP) outlines an action target for 11 key rural NSW floodplains, including the Hillston area, for which floodplain management plans are being prepared. This specifies that action is taken to (re)connect at least 60% of the natural 1 in 5 year flooded area to the river by:

- mapping the major flood paths and flood dependent ecosystems; and
- identifying the significant barriers to flooding and commencing action to deal with the priority barriers.

The 1998 flood at Hillston had an AEP of about 20% (5 year ARI). The extent of this flood at its peak at Hillston on 23rd October 1998 is shown on Sheet 7 with the FMP floodway superimposed. While the extent of the 1998 flood does not exactly replicate the natural 1 in 5 year flooded area because of the presence of on-ground works, it is highly indicative and the best available approximation. As shown on Sheet 7, the 1998 flood extent is contained within the FMP floodway network, which also includes the major flood paths and flood dependent ecosystems on the floodplain. The FMP has identified significant barriers within the floodway network, specified actions to deal with these and set out a process to allow the floodway network to be unimpeded by future works. In summary, the FMP will exceed the SWMOP target for the Hillston floodplain of (re)connecting at least 60% of the natural 1 in 5 year flooded area to the river.

8.3 Catchment Impacts

The Lachlan floodplain directly upstream of the FMP area is relatively confined with little wetland development. Implementation of the FMP is not expected to impact on this area. Downstream of the FMP area, the floodplain is expansive and there are a number of wetlands of national importance on Merrimajeel and Muggabah Creeks (Booligal Swamp, Lake Merrimajeel, Murrumbidgee Swamp), Merrowie Creek (Tarwong Lakes) and the Lachlan River (Great Cumbung Swamp). The FMP floodway network is based on the natural drainage pattern and the exit of floodwaters from the floodways is expected to be at rates and depths similar to those that would have been experienced under natural / historical conditions. The FMP floodway network will preserve flood flow paths and allow for future delivery of the flood regime to downstream ecosystems.

9 MONITORING AND REVIEW

9.1 Performance Indicators

Two sets of performance indicators are proposed. The first is that existing works are modified according to the FMP, the second that the floodplain performs adequately in a flood. These indicators will be closely linked with the FMP objectives.

The process of approval of flood control works will provide a measure of works that abide by the FMP and works that are not approved will need to be removed. An audit of works should be carried out after the majority of approvals are completed.

The performance of the floodplain during floods would be assessed from information gathered during flood monitoring activities. This information should be measured against the FMP's objectives. In particular the following should be considered with comparison made to historical flood events:

Hydraulic:

- improved passage of flood waters through the FMP area;
- structures performing to the agreed hydraulic criteria;

Environmental:

- improved fish passage;
- improved habitat for plants and animals that utilise floodplains;
- increased flood connectivity to wetlands

Economic:

- lesser flood damage

Social:

- improved access during floods;
- clarity for the community in actions carried out during a flood

In order to assess the performance of the FMP against these indicators, a monitoring program as outlined below is proposed.

9.2 Flood Monitoring

Monitoring of hydraulic flood behaviour would identify any problem areas and whether any modifications or upgrades are required. Depending on the size of flood, monitoring would range from simple observation to measuring of flows and levels followed by additional hydraulic analyses.

For the smaller, more frequent floods, monitoring should be limited to observations of critical areas (or 'hot spots'). A list of these areas and what to look for is included in Appendix B. The larger floods, nearing the 1990 design flood levels, should be monitored in more detail. In particular, as the hydraulic modelling has a significant degree of reliance upon flow estimates, especially peak flows, it will be important to collect data to verify these estimates. Appendix B also lists critical areas to monitor in the larger floods.

Floods in the Hillston area usually have a relatively long lead - in time. Hence there is time to plan a monitoring program. An effective monitoring program will require input from DNR, Carrathool Shire Council and landholders. The following is recommended:

- DNR should undertake aerial photography, collection of satellite imagery, survey, stream gaugings and flow measurements; and,
- where safe to do so, Carrathool Shire Council and landholders should observe the performance of their part of the floodway network, including marking high flood levels, estimating flow velocities and taking photographs.

Following floods, landholders should estimate flood damage including crop and fencing losses and damage to private roads. Council should provide an estimate of flood damage to public roads and infrastructure.

Refer to Appendix B for detailed advisory notes on flood monitoring.

9.3 Environmental Monitoring

Environmental monitoring during and after floods would determine whether required environmental works modifications are working properly and help to assess the ecological impacts of local flooding. Environmental data would mainly consist of observations with supporting photography wherever possible. The scale of flooding would influence the extent of data collected. For example, in a flood of 1990 proportions, observations of wetland inundation, waterbirds and fish would be extensive in comparison to a relatively small flood.

DNR should undertake the collation of environmental data from Carrathool Shire Council, landholders and other agencies. Council and landholders would observe their areas of the floodplain noting:

- performance of environmental works modifications during floods,
- wetland inundation,
- waterbirds and fish presence; and
- regeneration of floodplain vegetation.

Appendix B includes detailed advisory notes on environmental monitoring and specifies sites where the performance of environmental modifications should be monitored during floods.

9.4 Plan Review

Floodplain management plans adopted as Minister's plans under the *Water Management Act 2000* are required to be reviewed at 5 yearly intervals to determine whether their provisions adequately implement the water management principles of the Act.

10 REFERENCES

Carrathool Shire Council (2005) *Hillston Floodplain Risk Management Study – Final Study Report and Floodplain Risk Management Plan*.

Department of Natural Resources (2005) *Hillston Floodplain Management Study, Lake Brewster to Whealbah*

Department of Land and Water Conservation (2001) *Lachlan River Floodplain Management Study – Lake Brewster to Whealbah Final Report on Flood Study*.

Lachlan Regulated River Management Committee (2003) *Water Sharing Plan for the Lachlan Regulated River Water Source*.

NSW Government (2005) *Floodplain Development Manual: the management of flood liable land*.

11 APPENDICES

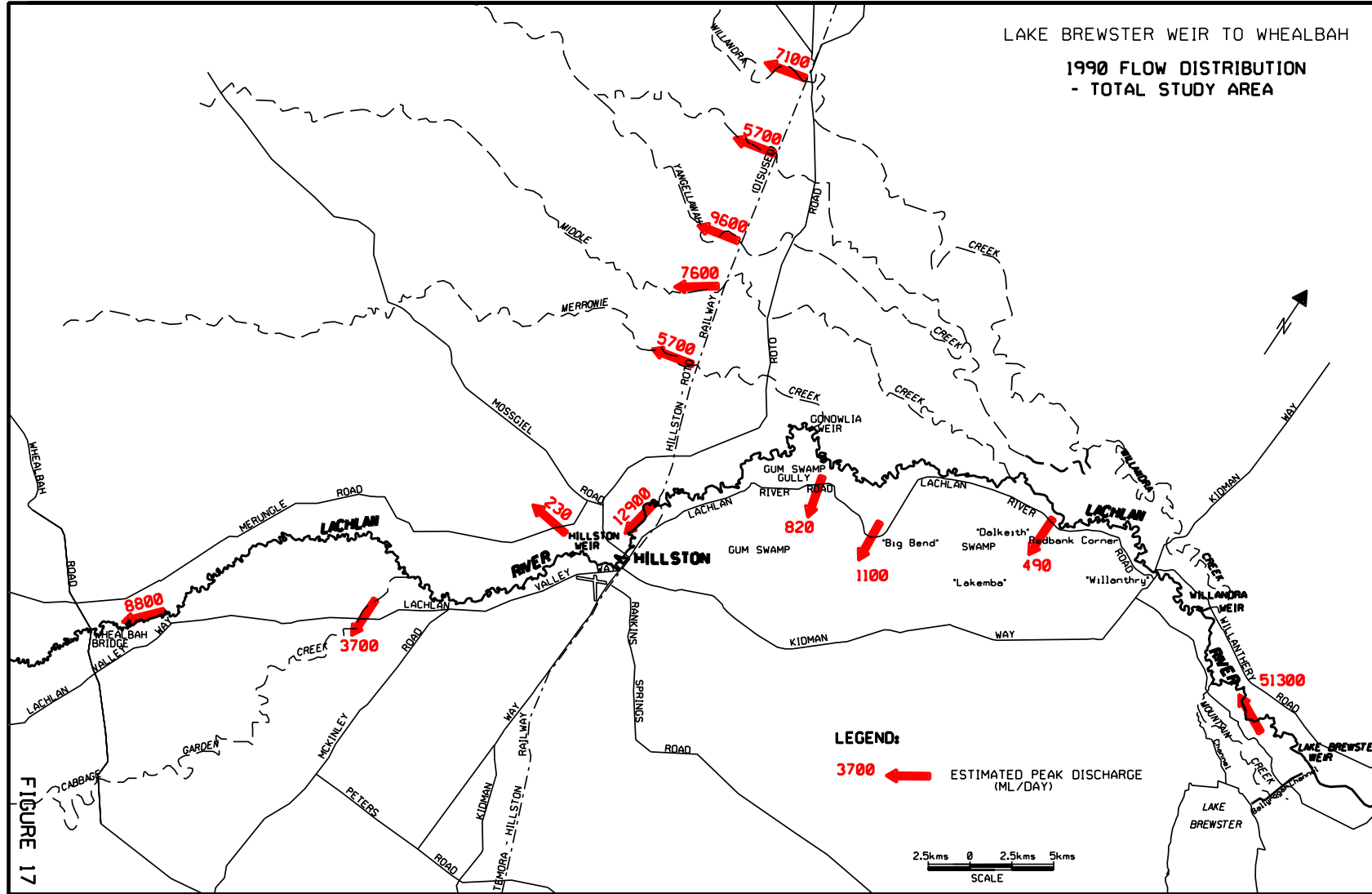
Appendix A – Estimated 1990 Flow Distribution

Appendix B – Monitoring Activities

Appendix C – Glossary and Abbreviations

11.1 APPENDIX A – Estimated 1990 Flow Distribution

Reproduced from the Flood Study Figure 17, “Lake Brewster Weir to Whealbah, 1990 Flow Distribution – Total Study Area”



11.2 APPENDIX B – Monitoring Activities

In addition to the activities listed below, a number of existing works requiring modification will need to be monitored if the modifications have not been carried out at the onset of a flood. These works are specified in Table 4.1 of the FMP. Monitoring would determine if emergency works are required.

1) Critical Hydraulic Areas (“Hot Spots”) to Monitor

(Listed from the upstream end of the study area)

Area	When to Monitor	Where to Monitor	What to Monitor
Lachlan Valley Way at Mountain Creek near Carrathool/Lachlan Shire boundary	Major floods	Culverts for Mountain Creek	Head difference; Flow Rates; Velocities
Brewster Weir	All floods	Block bank on bywash Weir	Flow behaviour; Head difference; Velocities
Ballyrogan Channel	Major floods	Culverts for Mountain Creek	Head difference; Flow Rates; Velocities
Lake Brewster	Major floods	Flood inlet and outlet embankments	Flow behaviour
“Tocabil”	Moderate floods	Irrigation channel downstream of Kidman Way	Flow behaviour, Drainage of water on recession
Lachlan River Road at ‘Big Bend’	All floods	Rennie’s Bank, road culvert and causeway, “Wyola” floodway	Flow behaviour, Head difference, Velocities
“Hunthawang”	All floods	Middle Creek crossing and culverts	Flow behaviour, Head difference, Velocities
Lachlan River Road at Gum Swamp	All floods	Culverts	Head difference; Flow Rates; Velocities
“Rosemont” Channel	Moderate flood	Irrigation channel	Flow behaviour, Head difference, Velocities
Kidman Way east of Hillston	Moderate floods	Culverts and causeways from Hillston to “Rosemont”	Flow behaviour, Head difference, Velocities
Clifton’s Channel at Kidman Way	Moderate floods	Pipe in channel	Flow behaviour, Head difference, Velocities
East of Hillston	Moderate floods	Irrigation development and channels, roads	Flow behaviour particularly with regard to the impact on the town levee; Head difference,

Area	When to Monitor	Where to Monitor	What to Monitor
			Velocities
Kidman Way and railway south of Hillston	Major floods	Culverts and causeways	Flow behaviour, Head difference, Velocities
West of Hillston – “Rivernook” to “Myalla”	All floods	Irrigation development and channels, roads	Flow behaviour particularly with regard to the impact on the town levee; Head difference, Velocities
Roto Road and Hillston - Roto Railway	Moderate floods	Culverts, causeways and openings for Yangellawah Creek floodplain flows	Flow behaviour, Head difference, Velocities
“Yilgah”	Moderate floods	Floodways and irrigation development	Flow behaviour, Head difference, Velocities
“Uralla” and “Willandra Station”	Major floods	Channels	Flow behaviour, Head difference, Velocities

2) Flood Monitoring Guidelines for Landholders

The following advisory notes specify monitoring activities that should be undertaken by landholders, Carrathool Shire Council and DNR. The collected monitoring data will assist the FMP review process at the required 5 yearly intervals and after major flooding events. If found necessary, modifications to the FMP can be recommended based on the findings of the review process.

(a) HYDROLOGIC AND HYDRAULIC DATA

Flood event characteristics, including -

- Note rainfall depths from private rain gauges throughout the storm event in order 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); and
- Compare the flooding with other flood events experienced.

Data near streamflow gauging stations, including -

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

Floodplain data including –

- Where possible peg flood peaks across the floodplain (eg. 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 kilometre;
- Note any obstructions to the passage of flood flow (eg. roads, levees, banks), and where possible obtain estimated difference in water levels upstream and downstream of the obstruction; and
- Take photographs illustrating flow paths, 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 floodways.

Data along roads and at causeways/floodways, including –

- 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; and
- 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 damages –

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

Erosion and siltation –

- Symptoms of stream bed lowering include vertical headcuts in stream bed, extensive bank erosion on both side of stream, headcuts in tributary streams and gullies, exposed gravel and/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, gullyng 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 (eg. clearing), overflows from perched streams, and/or flow concentration due to floodplain development; and

- Causes of floodplain siltation include hill-slope erosion and/or reduced capacity of the main channel (bridge crossings, excessive vegetation/regrowth, influx of sediment), which result in instream sediment being deposited onto the floodplain.

(c) ENVIRONMENTAL DATA

Wetland data, including –

- Monitor the performance of works modifications specified in Table 4.1 to reconnect wetlands to flood flows. Note whether flood flows are reaching the wetland and whether openings in existing works are of adequate size;
- Note and photograph any changes to the flooding and drying patterns of the wetland;
- Note how long the wetland holds water after a flood event;
- Measure and note how deep the water is at different times in the wetland; and
- Note and photograph the condition and variety of wetland plant species over time.

Floodplain vegetation (Black Box, River Red Gum, Lignum) data, including –

- Note and photograph the extent of floodplain vegetation regeneration over time; and
- Note and photograph the extent of flood inundation in the vicinity of floodplain vegetation.

Waterbird and fish observations –

- At key sites, such as wetlands, note the abundance and diversity of waterbird species. The easiest method is to group the waterbirds into ducks, grebes, cormorants, etc. and count by 10's, 50's or 100's; and
- At key sites, such as wetlands and waterways, note the abundance and diversity of fish species. Dip-netting is the simplest way to monitor small fish in wetlands.

For more information on monitoring wetlands, waterbirds and fish refer to the NSW Murray Wetlands Working Group (2002) document titled *Wetlands Watch – A Field Guide for Monitoring Wetlands in the Southern Section of the Murray-Darling Basin*.

The following questionnaire could be filled out by landholders as a means of collating information regarding the characteristics of a flood event, as well as flood damage. Additional sheets could be used.

LANDHOLDER MONITORING QUESTIONNAIRE
Hydrologic and Hydraulic Data
Rainfall depths & duration (private rain gauges).....millimetres at 9:00am each day Inundation limits – sketch on a map areas inundated, flow paths, & 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 & extent Fence loss – Yes/No – If yes describe location & extent Road damage – Yes/No – If yes describe type, location & extent Erosion – Yes/No – If yes describe type, location & extent Siltation – Yes/No – If yes describe location & extent
Environmental Data
Duration of flooding in wetland.....days Depth of flooding in wetland.....metres at location..... Note numbers and types of waterbirds if present Note presence of native fish in floodwaters Note extent of regeneration of floodplain vegetation (following floods)
<p><i>Where works modifications are required to reconnect wetlands:</i></p> Is the opening of adequate size? Did floodwater reach the wetland? Was floodwater backed up upstream of the opening? Note level of floodwater through works modifications.

(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;
- The main flow paths;

- Known earthworks such as levees, banks, channels;
- Known problem areas;
- Roads and railways;
- Environmental information, as outlined in (c) above, and;
- Time and date each photograph was taken.

3) Carrathool Council Monitoring Activities

These activities are similar to those listed for landholders above but in relation to council works. In particular the performance of road structures should be carefully assessed as well as the impact of all floodplain development on Hillston town. With regard to the road structures, those that are of significant importance (eg the ‘High Bank’ on the Kidman Way) should be monitored over the duration of the flood. Less crucial structures could be observed at peak levels and at overtopping levels for causeways.

For road structures the following data should be collected:

- the head difference across the structure at peak and critical levels;
- depth of flow over causeways
- estimate the flow velocity through or across the structure;
- whether the structure gets affected by debris;
- photographs of the structure in flood;
- time when flow commences and finishes.

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

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

4) DNR Monitoring Activities

DNR’s role in monitoring includes the following activities:

Flood photography, including –

- Undertake and obtain on-ground photography of flood event;
- If thought necessary, undertake oblique aerial photography of flood event;
- If found necessary, organise vertical aerial photography of flood event; and
- Obtain available satellite imagery the study area under flood.

Obtain survey data, including –

- Collate existing survey data undertaken or organised by DNR, landholders, or local councils; and,
- If found 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, including –

- 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 floodway network;
- If thought necessary, reconvene the FMC in order to source their opinion on the flood event, the performance of the FMP floodway network, and any identified issues; and,
- Undertake field investigations after flood events to view identified problem areas.

Obtain flow data, including –

- Obtain flood heights and discharge records from gauging stations within the vicinity of the study area; and,
- If necessary, obtain rainfall data from the Bureau of Meteorology and DNR records.

Collate environmental data, including –

Fish and aquatic invertebrates -

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

Vegetation –

- Based on obtained flood photography and field investigations, assess change(s) 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.

Review Floodplain Management Plan

- Review hydraulic models with new data; and,
- Identify modifications to plan.

11.3 APPENDIX C – Glossary and Abbreviations

GLOSSARY

<i>anabran</i>	a channel of a river or creek that leaves the main channel and re-enters downstream.
<i>Annual Exceedance Probability (AEP)</i>	the chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage.
<i>Average Recurrence Interval (ARI)</i>	the long term average number of years between the occurrence of a flood as big as, or larger than, the selected event.
<i>ecosystem</i>	a biological system involving interaction between living organisms and their immediate physical, chemical and biological environment.
<i>effluent stream</i>	a stream that leaves a watercourse and does not return to it.
<i>flood control works</i>	works such as levees, roads and channels that can affect the distribution of floodwaters on the floodplain. These are known as “controlled works” in the <i>Water Act 1912</i> .
<i>flood dependent ecosystem</i>	an ecosystem that depends on periodic flooding to support essential ecological processes.
<i>flood fringe area</i>	the floodplain area between the limit of the floodway and the extent of the 1990 flood.
<i>floodplain</i>	an area of land which is subject to inundation by floods up to and including the probable maximum flood.
<i>floodway network</i>	the area of floodplain required for the unobstructed and orderly passage of a flood of given magnitude.
<i>habitat</i>	the type of environment in which a plant or animal lives, including physical and chemical conditions.
<i>hydraulics</i>	the study of water flow in relation to watercourses and the land surface; in particular the assessment of water level and velocity.
<i>hydrology</i>	the study of the rainfall and runoff process; in particular, the assessment of peak flows and flow volumes.
<i>invertebrates</i>	animals without backbones, including zooplankton, worms, insects, shellfish, crabs, shrimps and snails.
<i>microinvertebrates</i>	invertebrates that cannot be seen with the naked eye.
<i>Probable Maximum Flood (PMF)</i>	the largest flood that could conceivably occur at a particular location.

<i>threatened species</i>	species of plant or animals listed as vulnerable or endangered on the schedules of the NSW Threatened Species Conservation Act.
<i>wetland</i>	an area that is wet for a long enough period such that the plants and animals living in it are adapted to, and often dependent on, living in wet conditions for at least part of their life cycle.

ABBREVIATIONS

AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
DNR	Department of Natural Resources
DLWC	Department of Land and Water Conservation
FMP	Floodplain Management Plan
PMF	Probable Maximum Flood
SWMOP	State Water Management Outcomes Plan
WAMC	Water Administration Ministerial Corporation