



NSW Government

DEPARTMENT OF NATURAL RESOURCES

Draft Lachlan River Gooloogong to Jemalong Gap Floodplain Management Plan

February 2007

(Exhibition Document)



Cover Photo: Looking East along Cowra Road (25 April 1990)

Acknowledgments

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Contents

	Page
Preamble	v
1 Introduction	7
1.1 Background	7
1.2 Vision and Objectives	8
1.3 Draft FMP floodplain	8
1.4 Draft FMP Floodplain Overview	8
1.4.1 General.....	8
1.4.2 Flooding Overview	9
1.4.3 Environmental Overview	10
2 Development of the FMP	12
2.1 Legislative and policy framework	12
2.1.1 The Flood Prone Land Policy.....	12
2.1.2 Water Act 1912 and Water Management Act 2000	12
2.1.3 Additional Floodplain Management Controls.....	12
2.1.4 Relevant Management Plans.....	13
2.1.5 Community Consultation.....	13
2.1.6 Floodplain Management Principles	14
2.1.7 Adopted Design Flood	15
3 Plan Implementation	16
3.1 Part 8 Approval Process for Flood Control Works.....	16
3.1.1 General.....	16
3.1.2 Works that Require Approval	16
3.1.3 Applying for Approval.....	17
3.1.4 Determination Process	18
3.1.5 Possible Determinations	19
3.1.6 Complying Works	19
3.1.7 Non-complying Works.....	20
3.1.8 Unauthorised Works	21
3.1.9 Roads and Railways.....	22
4 Draft FMP Floodway Network	23
4.1 Floodway Network	23
4.2 Hydraulic Modelling	25
4.2.1 Design Flood Event Flow Distribution	25

4.3	Floodway Assessment Considerations	25
4.3.1	Hydraulic	25
4.3.2	Environmental.....	26
4.3.3	Social / Economic	26
5	Potential Hydraulic Restrictions – Recommended Actions	28
5.1	General	28
6	Environmental Assessment – Adopted Outcomes	35
6.1	Assessment Approach.....	35
6.2	Adopted Outcomes.....	36
7	Criteria for Assessing Works.....	37
7.1	Hydraulic Criteria for High Level Floodways	37
7.2	Criteria for Non-Complying Works	37
8	Strategic Environmental Assessment.....	38
8.1	Overview of Environmental Impact	38
8.2	State Water Management Outcomes Plan Target.....	40
8.3	Catchment Impacts.....	41
9	Monitoring and Review	42
9.1	Performance Indicators.....	42
9.2	Flood Monitoring.....	42
9.3	Environmental Monitoring	43
9.4	Plan Review	43
10	References	44
11	Appendices	45
11.1	Appendix A – Monitoring Activities.....	46
11.1.1	Potential Hydraulic Restrictions to Monitor.....	46
11.1.2	Flood Monitoring Guidelines for Landholders.....	46
11.1.3	Forbes Shire Council Monitoring Activities.....	51
11.1.4	DNR Monitoring Activities	52
11.2	Appendix B – Glossary and Abbreviations.....	54

Figures

	Page
Figure 1	Draft FMP Floodplain..... 8
Figure 2	Draft Lachlan River Gooloogong to Jemalong Gap Floodplain Management Plan – Floodway Network (5 sheets)..... 24
Figure 3	Flood Extent 22 August 1998 and Proposed Floodway Network (SWMOP Assessment) (2 Sheets: West and East)..... 41

Tables

	Page
Table 1	Recommended Actions for Areas with Potential Hydraulic Restrictions 29
Table 2	Potential EIAs assessed 36
Table 3	Summary of Environmental Impacts 38

Preamble

The Draft Lachlan River Gooloogong to Jemalong Gap Floodplain Management Plan (hereafter the draft FMP) has been prepared by the Water Administration Ministerial Corporation (hereafter WAMC) under Part 8 of the *Water Act 1912* and in accordance with the processes outlined in the NSW Government's Floodplain Development Manual (2005) which supports the NSW Flood Prone Land Policy. The preparation of the draft FMP was overseen by the Lachlan River Floodplain Management Committee Gooloogong to Jemalong Gap (hereafter FMC), which comprises representatives from the community, various stakeholder groups and government agencies. Funding for the draft FMP was provided by the Natural Disaster Mitigation Programme with Commonwealth and State financial support.

The Department of Natural Resources (hereafter DNR) acts on behalf of WAMC for all matters relating to Part 8 of the *Water Act 1912*. WAMC is the body who prepares, adopts and administers FMPs, as well as receives and determines Part 8 applications.

The Water Resources Commission, a precursor to the DNR, released the Guidelines for Floodplain Development Lachlan Valley Gooloogong to Jemalong Gap in 1979, (hereafter the 1979 Guidelines). The 1979 Guidelines were developed as a result of representations from the community concerned with the intensification of irrigation activities that had the potential to impact on flood flows. The area had experienced a number of floods in the 1970s.

The 1979 Guidelines have served as the main reference when reviewing earthwork development on the floodplain. The 1979 Guidelines are now outdated and required revision to be consistent with the needs of present day sustainable natural resource management.

Evolution of the draft FMP has progressed through three (3) primary stages:

- Flood Study – defines the nature and extent of flooding and flood-related issues (hydraulic, environmental, and cultural) in technical terms;
- Floodplain Risk Management Study – evaluates management options in consideration of social, environmental, and economic factors, in order to address existing and future flood risk and flood management issues; and
- Floodplain Management Plan – outlines strategies to manage flood risk and flood management issues, and support the natural functions of the floodplain environment.

Once adopted, the draft FMP will replace the 1979 Guidelines.

The Flood Study for the Gooloogong to Jemalong Gap floodplain (hereafter FS) (SKM 2003) was completed by Sinclair Knight Merz in 2003 with the Floodplain Risk Management Study (hereafter FRMS) (SKM 2007) being completed by Sinclair Knight Merz in 2007.



North Condobolin Road Upstream of Jemalong Gap (26 April 1990)

1 Introduction

1.1 BACKGROUND

The draft FMP applies to the floodplain of the Lachlan River from Gooloogong to Jemalong Gap and as identified on Figure 1. The town of Forbes lies within the floodplain. The floodplain supports sheep and cattle grazing, dryland farming and irrigated cropping. Wyangala Dam is the main regulatory structure in the Lachlan Valley, supplying water for irrigation, town, stock and domestic use. The dam operates a 'variable space' flood mitigation provision which can be operated for flood mitigation purposes. The dam also provides an environmental water allocation for seasonal watering downstream areas. Carcoar Dam regulates the Belubula River, a tributary that joins the Lachlan River just upstream of Gooloogong. This dam has little impact on flooding in the draft FMP floodplain.

There are a number of flood dependent ecosystems associated with the Lachlan River and its anabranches in the draft FMP floodplain. Native floodplain vegetation in these areas is generally dominated by River Red Gum and Black Box which lines the watercourses and forms scattered small woodlands on the floodplain.

The development of irrigation on the floodplain, particularly since completion of the enlargement of Wyangala in 1971, has led to concerns about the impacts of associated works on flood behaviour. Flood control works, such as levees, channels, roads and railways can alter floodwater distribution, increase flood risk to floodplain occupiers and cause environmental problems by isolating flood dependent ecosystems, such as wetlands, from flooding.

The draft 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 recommended actions for areas of potential hydraulic restrictions and identifies a floodway network for the planning of proposed works. Implementation of the draft FMP will provide the community with greater security against flood risk and allow for the sustainable management of flood-dependent ecosystems.

The recommended actions to works identified in the draft FMP will aid in restoring 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 draft FMP also provides a process to allow the efficient determination of flood control works in terms of the relevant legislation.

Community consultation in the form of community workshops, individual interviews and site inspections, was undertaken to improve understanding of flood behaviour, identify flooding issues to ensure that the draft FMP is compatible with the community's expectations. The draft 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 draft 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*.

Forbes Shire Council has recently revised the floodplain management plan for the Forbes Township. These revisions are reflected in the Forbes Shire Council, Development Control Plan No. 6: Managing our Flood Risks, 2002. It applies to the urban area of Forbes whereas this draft FMP covers the rural areas surrounding the town as described above.

1.2 VISION AND OBJECTIVES

The overall vision of the draft FMP is:

To coordinate floodplain development to minimise flood risk to occupiers and users of the floodplain whilst addressing the environmental, social and economic interests of the Lachlan River Valley.

However within this vision are a number of key objectives, as described below.

- embrace the Floodplain Management Principles adopted by the FMC;
- investigate strategic planning measures to restore the natural functions of the floodplain whilst minimising flood risk to private assets and public infrastructure;
- ensure that the community consultation process facilitates community ownership of the draft FMP; and,
- ensure compliance with State policies such as the Flood Prone Land Policy and State Rivers and Estuaries Policy, environmental legislation, relevant planning instruments and relevant resource management plans.

1.3 DRAFT FMP FLOODPLAIN

The draft FMP floodplain for the draft FMP incorporates the floodplain area covered by the 1979 Guidelines. It extends from Gooloogong in the east to Jemalong Gap in the Jemalong/Corridgery Range in the west. The extent of the draft FMP floodplain and the names of the major waterways are shown in **Figure 1**.

Figure 1 – Draft FMP Floodplain

1.4 DRAFT FMP FLOODPLAIN OVERVIEW

1.4.1 General

At Gooloogong, the Lachlan River commands a catchment of some 15,900 square kilometres. Wyangala Dam regulates flow from approximately half of the upstream catchment. However the major tributaries, Boorowa, Belubula Rivers, and Mandagery Creek join the Lachlan River below Wyangala Dam with Mandagery Creek joining the Lachlan River downstream of Gooloogong in the draft FMP floodplain.

While major floods arise from Lachlan River flows, the Belubula River and Mandagery Creek can provide relatively localised high flood levels however usually without enough flood volume to cause major flooding downstream alone. The smaller tributaries of Goonigal

Creek, Mulyandry Creek and Ooma Creek which join the draft FMP floodplain from the south are generally not large contributors to major floods.

Within the draft FMP floodplain area, north of the river, the Southern Cross break feeds Lake Forbes which passes through the town of Forbes. To the south the major anabranch of Bundaburrah Creek takes high level overflow to Bundaburrah Cowal (also known as Bundaburrah Swamp) before rejoining the Lachlan River at Jemalong Gap. At the lower end of the draft FMP floodplain Jemalong Gap provides a greatly reduced waterway area compared to the area downstream of Forbes. A major restriction to flood flows is the Forbes/Stockinbingal Railway which runs in a north – south direction across the draft FMP floodplain.

The majority of the draft FMP floodplain is located in Forbes Shire, except for the area of the northern side of the Lachlan River between Gooloogong and Mandagery Creek which is in Cabonne Shire and the village of Gooloogong, which lies in the Cowra Shire.

The existing Lachlan River designated floodplain under section 166(1) of Part 8 of the *Water Act 1912*, will be amended to conform to the draft FMP floodplain.

1.4.2 Flooding Overview

In recent years significant floods in the Lachlan River have occurred in 1952, 1974, 1976, 1990, and 1996. The 1952 flood is the highest on record at the Forbes Iron Bridge since measurements at the gauge commenced in 1891

At Gooloogong the spread of floodwater is generally confined to the river and adjacent river flats. However below Gooloogong the capacity of the main river channel progressively reduces with the consequence that significant overbank spillage occurs and floodwaters begin to spread over wide areas of the floodplain. Much of this water finds its way into natural depressions and billabongs which interconnect to form active flood runners.

On the northern side of the river the first major breakout downstream of Gooloogong occurs near the Mandagery Creek confluence. Floodwaters escaping the river through the breakout flow into a defined depression known as Nellie's Lagoon. Floodwaters from this lagoon rejoin the river near the important breakout known as the "Southern Cross".

The "Southern Cross" breakout, along with the higher level "12 Mile Break", is located approximately 17 kilometres upstream of Forbes. These breakouts feed a shallow depression which eventually flows into Lake Forbes within the town itself. All waters from these breakouts eventually pass through Forbes and have a major impact on the flooding of the town. The Lake Forbes floodwaters re-enter the Lachlan River west of the town.

From Forbes to Jemalong Gap, flooding to the north occurs mainly when three local billabongs overflow. These billabongs are associated with Bocobidgle Creek, Broad Creek, and Carrawabbity Creek. Floodwaters overflowing from these billabongs flow north west in a broad shallow sheet across the North Condobolin Road towards Gunning Gap. In the larger floods floodwaters can pass through Gunning Gap and join the Goobang Creek system.

The flood pattern on the south side is more complex with major breakouts commencing in the vicinity of Cumbijowa Forest. Floodwaters from the forest pass west via Joss's Lagoon and the Cowra Road, as well as south west to join Bundaburrah Creek. The major source of the

Bundaburrah Creek flow, however, is the Wandary Lane breakout, located about 8 kilometres upstream of Forbes. These flows pass into Half Moon Lagoon, across the Cowra Road at Duke's Crossing and into Bundaburrah Creek. The creek finally enters Bundaburrah Cowal before draining through Jemalong Creek into the Lachlan River at Jemalong Gap.

Below Forbes, floodwaters overflow from the river to the south at a number of locations and generally flow parallel to the river before draining to Bundaburrah Cowal.

Refer to the FS and FRMS reports for more detailed information regarding the flooding characteristics of the Lachlan River floodplain between Gooloogong and Jemalong Gap.

1.4.3 Environmental Overview

Floodplains have a key ecological role in providing organic matter and nutrients that are cycled during floods and support an extensive food base for fish and waterbirds. Within the broader floodplain however, there are a mosaic of environments ranging from terrestrial, that are seldom flooded, to aquatic environments that are permanently wet. In the draft FMP floodplain, land managed for agricultural production also forms part of this mosaic and clearly, the ecological value of floodplain land will vary according to flooding regime and land use impacts.

The Lachlan River and its distributaries in the draft FMP floodplain support a relatively intact corridor of wetlands including floodplain lakes and lagoons, River Red Gum forest and woodland, and associated lignum shrub lands. Outside the riparian zone, various box forest and woodland communities originally dominated the floodplain. These are now extensively cleared, with little of the indigenous Black Box, White Box, Yellow Box and Grey Box types present.

North of the river major wetlands include Nellie's Lagoon and Lake Forbes. Key wetlands south of the river include Tonambil Swamp, a large depression that is affected by backwater from the Lachlan River and overflow from Mulyandry Creek, Joss's Lagoon, Half Moon Lagoon, Bundaburrah Lagoon, and Bundaburrah Cowal.

The draft FMP floodplain supports a diversity of animals that are affected by flooding patterns. These include some species that depend directly on flooding for maintenance of their life cycles (eg waterbirds, invertebrates and native fish) and others that rely on floodplain plants and soils for food and habitat (eg honeyeaters).

The ecology of floodplain wetlands and watercourses is dependent on flooding. A key issue for the draft FMP has been to maintain flood connectivity to these ecosystems and to assess the merits of restoring flood access to ecosystems isolated by flood control works.

Another key issue for the draft FMP has been to ensure that fish passage is maintained and potentially enhanced along the watercourses such as effluents, anabranches and distributaries, which connect the river to the floodplain. These watercourses are used by those species with a migratory spawning response to floods such as Golden Perch and Silver Perch.

More detailed information on the floodplain environment is provided in the FS and the FRMS reports.



River Red Gum on the Floodplain Upstream of Forbes (October 2005)

2 Development of the FMP

2.1 LEGISLATIVE AND POLICY FRAMEWORK

The management of the draft FMP floodplain 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 FRMS for a detailed overview of the legislation and policy framework for floodplain management.

2.1.1 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. The Floodplain Development Manual (NSW Government 2005) supports the policy and outlines a merit - based approach to floodplain management.

2.1.2 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 draft FMP the State Government had initiated wide-ranging reform of water legislation, with the outcome being the *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*.

2.1.3 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 draft FMP floodplain. Other relevant legislation includes:

- *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*; and,
- *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 draft 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, the NSW Weirs Policy 1997 and the State Groundwater Dependent Ecosystems Policy 2002.

2.1.4 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, are being prepared. The Lachlan Catchment Management Authority is working with local communities to prepare the Lachlan Catchment Action Plan. The draft 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 Source; and,
- State Water Management Outcomes Plan (SWMOP);

2.1.5 Community Consultation

Community consultation formed an integral component in the development of the draft FMP. The FMC was the immediate consultative committee responsible for overseeing the plan's preparation. The FMC comprised representatives from landowners, rural farm groups, Forbes Shire Council and government agencies.

The FMC met at key milestones during the course of the plan's preparation and was responsible for signing off on important documents (e.g. FS report, FRMS report) and for adopting assessment principles and criteria.

Soon after commencement of the FS, a questionnaire and newsletter were sent out to all rural residents in the draft FMP floodplain. Some 113 responses were received to the questionnaire which was analysed and presented in the FS.

Two community workshops were held to both inform the participants about the FRMS and seek their input into the issues which they felt were important. Additionally meetings and/or site inspections were held with many key landowners in the valley.

2.1.6 Floodplain Management Principles

A set of ten floodplain management principles was developed and adopted by the FMC. These floodplain management principles were used as a guide for the purpose of making decisions when assessing management strategies and options during the development of the FRMS. The floodplain management principles conform with the general matters for consideration with respect to flood control work approvals set out in section 166C(1) of Part 8 of the Water Act 1912.

The principles relating to the hydraulic functions of the floodplain are similar to those used when developing the 1979 Guidelines. The major difference here is the addition of the environmental category principles. This is consistent with the requirement that floodplain management plans made under Part 8 of the Water Act must take into account the protection of the environment.

The FMC adopted the following principles:

1. Defined floodways and exits from floodways should be equitably distributed consistent with natural/historical flowpaths;
2. There may be scope to depart from the natural/historical drainage pattern, provided that the community agrees that the draft FMP is hydraulically and environmentally feasible and socially and economically acceptable to the community;
3. Defined floodways must possess adequate hydraulic capacity and continuity to enable the orderly passage of floodwaters through the floodplain;
4. Sufficient flood storage must be retained on the developed floodplain so that the flood wave is not significantly accelerated to downstream areas nor the flood height increased;
5. Velocities and depths of flood flow in defined floodways and exits from defined floodways should not cause significant erosion or increased siltation under various land uses, above what would otherwise be expected in a natural flood event;
6. There should not be any significant detrimental outcomes from the draft FMP. Any adverse outcomes from existing development in the floodplain should be identified and mitigation measures proposed;
7. There should be no significant detrimental impact from floodplain development on any individual landholder including downstream landholders or community infrastructure or environmental areas due to increases in peak flood levels, peak flows, total volumes and increased drainage times;

8. Floodplain development should not cause significant redistribution of floodwaters in terms of flow distribution, volumes or flow rates;
9. The draft FMP should aim to minimise detrimental impacts from future development and management activities on the floodplain on individual landholders, the environment and society; and,
10. Defined floodways should, wherever practicable, allow for the delivery of floodwaters to support floodplain ecosystems.

2.1.7 Adopted Design Flood

The overwhelming conclusion from modelling, discussions with landholders and from the floodplain management principles is that the floodway network should be designed for a medium size flood. The FMC agreed that the 15 year Average Recurrence Interval (ARI) flood be adopted as the design flood for the draft FMP.



Upstream of Jemalong Gap (26 April 1990)

3 Plan Implementation

The draft FMP outlines recommended actions for areas of potential hydraulic restrictions and identifies a floodway network to allow for the planning of future flood control works. Implementation of the draft FMP involves undertaking the recommendations, licensing of works and future property planning. The five sheets of Figure 2 show the details of the draft FMP floodway network and Table 1 (page 29) identifies the recommended actions for areas with potential hydraulic restrictions.

Once the draft FMP has been adopted, landholders affected by the draft FMP recommended actions will be approached individually by DNR to offer assistance in developing an agreed implementation program for their property. This will provide every affected landholder with a good understanding of the costs and timeframe to construct or modify flood control works on their property.

3.1 PART 8 APPROVAL PROCESS FOR FLOOD CONTROL WORKS

3.1.1 General

All activities associated with flood control works are administered under the relevant sections of Part 8 of the *Water Act 1912*. The 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 draft 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 (unauthorised) works within the draft FMP floodplain will be determined in accordance with the draft FMP and Part 8 of the Act.

In respect of any existing unauthorised works, a reasonable time will be allowed for the lodgement 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 3.1.8 of the draft FMP.

3.1.2 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.

3.1.3 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 Natural Resources Officer to 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.

3.1.4 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 draft 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 draft FMP and information contained within the draft FMP including principles, assessment criteria, and any recommendations.
 - **Additional Information** - DNR must consider any investigation information that has been provided by the applicant.

3.1.5 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 draft FMP.

3.1.6 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 (unauthorised) or proposed works located on the limits of the draft FMP 15 year ARI floodway network that do not exceed the height limitations specified on Figure 2 sheets 1 to 5; or,

- existing works to be modified in accordance with the results of the recommended actions of Table 1 (page 29); or,
- existing (unauthorised) or proposed works located outside the limits of the draft FMP 15 year ARI floodway network and the high level floodways* specified on Figure 2 sheets 1 to 5; or,
- existing (unauthorised) or proposed works located within the high level floodways specified on Figure 2 sheets 1 to 5 which meet the criteria stipulated in section 7.

*Note: It should be realised that with limited height restrictions for flood control works bordering the draft FMP 15 year ARI floodway network, floods larger than the 15 year ARI design flood will inundate areas outside of the floodway network. To manage these larger floods, high level floodways within the draft FMP floodplain have been identified on the basis of the 1990 flood satellite imagery and the 1979 Guidelines.

Development outside of the floodway limits (including the high level floodways) 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 generally be assessed as complying works, the assessment may need to take into account any potential increase in flood hazard or flood damage under flood conditions larger than the design flood. Adverse impacts could result, for example, if extensive works proposed near to the floodway network are substantially higher than the corresponding design level of the floodway network.

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 unprotected properties. Such assessment would not need to go to the details of that for works within the floodway unless the impact on overall flood behaviour could be significant and therefore far reaching.

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.

3.1.7 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:

- existing (unauthorised) or proposed works located within the draft 15 year ARI floodway network (excluding the high level floodways) as shown on Figure 2 sheets 1 to 5; or,
- existing (unauthorised) or proposed works located on the limits of the draft 15 year ARI floodway network that exceed the height limitations specified on Figure 2 sheets 1 to 5; or,
- existing works that are not modified in accordance with the results of the recommended actions of Table 1 (page 29); or,

- existing (unauthorised) or proposed works located within the high level floodways specified on Figure 2 sheets 1 to 5 which do not meet the criteria stipulated in Section 7.

Non-complying works may be considered for approval after a detailed investigation of hydraulic and environmental impacts. The cumulative impact of proposed works on flooding characteristics needs to be comprehensively addressed. Hydraulic impacts will be assessed against the criteria specified in Section 7. Environmental impacts will be assessed under Part 5 of the Environmental Planning and Assessment Act 1979. 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.

3.1.8 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*:

- Work to remove, modify, repair or restore the controlled work or to render the work ineffectual.
- 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).
- 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.

3.1.9 Roads and Railways

Roads and railways (and associated bridges, roadworks and railway works) vested in local government or State government transport agencies are declared by order as non-controlled works under section 165(2)(a) of the Water Act 1912. 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 draft FMP, recommended actions for existing and proposed road and railway structures are included in Table 1 (page 29).



Railway at Grawlin Plains (4 August 1990)

4 Draft FMP Floodway Network

4.1 FLOODWAY NETWORK

The central element of the draft FMP is the floodway network. 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 delineation of the floodway areas provides the basis by which future applications to undertake flood control works are assessed under Part 8 of the *Water Act 1912* in order to ensure that the primary function of the floodway network (to convey and store floodwaters) is not compromised.

Flood control works in floodway areas are generally not permitted. If however the applicant can demonstrate that the proposed works do not result in any significant adverse impacts on flooding behaviour and/or flood dependent ecosystems, then the works may be approved. The assessment of these applications will also need to take into account environmental impacts and cumulative impacts on the redistribution of floodwaters.

Please refer to Section 3 for further details regarding approval of flood control works and administration of the draft FMP under Part 8 of the *Water Act 1912*.

Decisions relating to the delineation of the floodway network were largely driven by the floodplain management principles adopted by the FMC as listed in Section 2.1.6. The hydraulic, environmental, social and economic, and legislative principles are all relevant to the delineation of the floodway network.

In many cases, the respective management principle categories conflict with each other (e.g. a trade off between hydraulic concerns, environmental concerns and maximising the area that can be protected for agricultural purposes). Decisions ultimately have been made based on a balanced viewpoint taking into account all of the relevant issues under considerations.

The floodway network is shown on the 5 sheets of Figure 2. The floodway network differs in some areas in comparison to the 1979 Guidelines network. These differences have arisen in response to:

- Existing flood control works considerations;
- Hydraulic considerations; and,
- Environmental considerations.



Southern Cross Break (14 August 1990)

Figure 2 sheet 1 of 5

Figure 2 sheet 2 of 5

Figure 2 sheet 3 of 5

Figure 2 sheet 4 of 5

Figure 2 sheet 5 of 5

4.2 HYDRAULIC MODELLING

The computer model selected in preparing the draft FMP is the Danish Hydraulic Institute's MIKE-11 model. The modelling system allows flow to be modelled in one-dimensional flowpaths which can be linked in a network to represent quasi two-dimensional flow behaviour experienced on floodplains. It has the ability to model structures, weirs and floodplain storages. The model has been extensively used in flood studies in Australia for the last 10 years.

In the FS, extensive hydraulic modelling was undertaken to define flood behaviour for historical and existing conditions and to develop a model that could be used for future investigations and assessment of options.

For the draft FMP the model was run to simulate selected historic flooding conditions to provide estimates of flood levels, flows and velocity for different floodway networks and flood sizes. The results were used to assist in determining the design flood and provide estimates of parameters to allow setting of levee crest heights for the adopted design flood. The FRMS report provides more detail information regarding this hydraulic modelling of the floodplain.

4.2.1 Design Flood Event Flow Distribution

A critical aspect of the draft FMP is the flow distribution throughout the floodway network. The hydraulic model provides an estimated flow distribution which was used for the assessment of the hydraulic adequacy of the floodway network. It can also be used for assessing the impacts of proposed floodplain development. Details of the flow distribution derived from the hydraulic model for the adopted 15 year ARI design event is shown in the FRMS report. These design flows were used for the assessment of the hydraulic adequacy of the floodway network

4.3 FLOODWAY ASSESSMENT CONSIDERATIONS

Analysis of the floodway network involved identifying potential hydraulic and environmental areas of concern then assessing these in terms of whether their impact of flooding is acceptable. If not modifications were recommended to make them acceptable. The following summarises this process.

4.3.1 Hydraulic

The assessment of hydraulic issues associated with the review of the floodway network and flood control works involved the following tasks:

- Consideration of the adopted floodplain management principles (refer Section 2.1.6).
- The hydraulic adequacy and impacts of the floodway in varying flood events, but most notably the adopted flow conditions for the design event.
- The use of the hydraulic model to assist in quantifying the hydraulic impacts of different options/scenarios and existing flood control works. The application of the model was focused on those flood control works which:

- Are wholly or partly intruding into the floodway system.
- Were raised by landholders at the community workshops or through returned questionnaires as being of concern.

In general, works complying with the 1979 Guidelines and any additional approval conditions were accepted. This is consistent with the management principle adopted to condone as many existing works as possible.

- On-site discussions and inspections with landholders regarding their views on the floodway network and flood control works issues.

4.3.2 Environmental

Floodplain management plans must take into account principles relating to the protection of the environment. In particular, floodplain management plans must contain strategies to manage flood control works so that the natural functions of the floodplain environment are supported.

The review of the floodway network included an assessment of issues associated with the present status of flood access to flood dependent ecosystem areas. The environmental assessment was undertaken taking into account the environmental principles given in Section 2.1.6. The 1979 Guidelines and associated floodway network were prepared with less emphasis given to environmental considerations.

An important consideration has been to include Environmentally Important Areas (EIAs), including vegetation, wetlands and watercourses that depend on flooding, within the floodway network where appropriate. Where such ecosystems were located outside the 1979 Guidelines floodway and are not affected by existing works, the floodway was adjusted to include them. This has meant that in some areas the floodways are wider than would otherwise be required based on hydraulic assessment.

Where EIAs were affected by existing works, a set of assessment criteria adopted by the FMC were applied. The criteria were developed with the objective of identifying those ecosystems possessing moderate or high environmental values and for which the restoration of floodwater access was practical after taking into account social and economic impacts.

4.3.3 Social / Economic

Social and economic considerations were an ever present factor when assessing the hydraulic and environmental related floodway issues. The impact of decisions on farm operations in relation to the layout and extent of the floodway was discussed at length with landholders during the various community consultation activities, notably the three rounds of community workshops and at numerous on-site meetings with individual landholders.

The decision to adopt the 15 year ARI event was in large part based on avoiding significant adverse social and economic impacts associated with the adoption of a larger design flood. It was also consistent with the level of protection generally sought by rural landholders for protection against flooding. It is also generally seen to represent an appropriate balance between achieving an acceptable flood risk and not unnecessarily tying up an excessively large floodway area for hydraulic reasons associated with rare floods.

The appraisal of environmental assessment issues explicitly required social and economic considerations to be taken into account through the adopted practicality assessment criteria. The criteria encompassed factors including the cost of any recommended works, land use impacts and land use compatibility. Field assessments where possible were carried out in the company of landholders to ensure these considerations were adequately understood and taken into account in reaching decisions.



Bundaburrah Creek at Dog and Duck Crossing (25 August 1990)

5 Potential Hydraulic Restrictions – Recommended Actions

5.1 GENERAL

In order to finalise the draft FMP floodway network, identified areas with potential hydraulic restrictions needed to be investigated. These areas included existing flood control works that were identified during the consultation phase as possibly resulting in flooding problems. The recommended actions for potential hydraulic restrictions are given in Table 1 (page 29) and the locations of the potential hydraulic restrictions identified are shown on the five sheets of Figure 2. In order to minimise social and economic impacts licensed flood control works consistent with the 1979 Guidelines were generally condoned.

It is important to remember that all proposed and existing flood control works within the draft FMP floodplain require approval under Part 8 of the *Water Act 1912*. Where no approval exists, DNR may take the relevant action(s) under the Act.

With regard to the issues outlined in Table 1 (page 29), please note the following:

- Specific structural modifications to existing flood control works will be administered under the relevant sections of Part 8;
- Minor modifications to existing approved flood control works will be administered through modifying the Part 8 approval conditions under Section 176A of the *Water Act 1912*; and
- With regard to unauthorised flood control works, directions for remedial work(s) may be used as a means of encouraging landholders to bring the subject work(s) within the *Water Act 1912* by lodging an application for approval that is complying (refer to Section 3.2.6) with the FMP. It is envisaged that the approval process for complying works will be more expedient including development consent from the local council (where applicable).

Refer to Section 3 for further details regarding approval of flood control works and administration of the draft FMP under *Part 8 of the Water Act 1912*.

Table 1 Recommended Actions for Areas with Potential Hydraulic Restrictions

Ref No.	Figure 2 Sheet	Property /Landholder	Description	Recommended Actions	Action by whom	Priority ¹
1	2	Jack Francis	Landowner has applied to DNR to extend previously approved low-level protection. This proposed extension is not supported by the adopted floodway alignment.	<ul style="list-style-type: none"> Landowner to provide supporting information on hydraulic and environmental grounds for proposed extensions to approved low-level protection. 	Landowner	Medium
2	1	'River-sleigh', David Josephs, Manager	The area close to the river, shown as possibly irrigated on the satellite image is not irrigated. It consists of existing mature River Red Gums and other vegetation. It is used for grazing but has no levees or other impediment. Further review of the satellite image, shows that the area does not appear as bright red as other irrigated areas. The area may also have seemed irrigated due to vegetation growth after a small flood that had occurred a few months earlier.	<ul style="list-style-type: none"> No action required. 	NA	NA
3	1	Claude Robinson	Property not inspected but owner says all levees are in accordance with 1979 Guidelines. Probable that the area shown as irrigated over the Lachlan River floodway is natural riparian vegetation. Area to the south west of the Ref No, does now have bank protection in accordance with the option detailed in the 1979 Guidelines. The Guidelines require that the banks be "low level". Works are licensed with low level condition and floodway width of 65 metres.	<ul style="list-style-type: none"> No action required. 	NA	NA
4	2	Oakley Holdings	High level floodway based on 1990 SPOT image. The 1979 Guideline levees only dashed as potential floodway on Guidelines, 'subject to agreement with landowners'. Floodway probably currently blocked with banks. Owner does not think that a floodway is required. Currently any flooding would simply flow around the banked areas.	<ul style="list-style-type: none"> Monitor the need for an actual floodway during future floods. 	DNR / landowner	On-going
5	1	David Brett	a) Vegetation shown close to the road is natural and does not block the floodway.	<ul style="list-style-type: none"> No action required. 	NA	NA

Draft Lachlan River Gooloogong to Jemalong Gap Floodplain Management Plan

Ref No.	Figure 2 Sheet	Property /Landholder	Description	Recommended Actions	Action by whom	Priority ¹
			<p>b) However landowners believe that flooding has become much worse in their area than previously. They say that replacement of the causeway at Parsons Creek with a culvert (4m wide and 3.5m high) and raising of the road have resulted in a bottleneck forcing more floodwaters to remain on the south side of the Lachlan Valley Way.</p> <p>c) The Lachlan Valley Way is frequently crossed by channel siphons supplying water to the south of the road at both Ref No 5 and 8. These siphons are quite narrow, less than 50 metres which is much less than the design width of the floodway of about 200-300 metres.</p>	<ul style="list-style-type: none"> Hydraulic modelling shows that additional waterway area is desirable, either as a culvert or causeway to the east of the existing culvert. An additional waterway area of 42 m² under the existing vertical alignment of the road is desirable to handle the design flow. Monitor Area during future floods. 	<p>Forbes Shire Council</p> <p>DNR</p>	<p>Medium</p> <p>On-going</p>
6	1	John Cole	Likely that the vegetation is natural and that the area is not irrigated.	<ul style="list-style-type: none"> No action required. 	NA	NA
7	1	Trevor Smith	The owner advises that the area is not irrigated and that the vegetation is natural near to the creek.	<ul style="list-style-type: none"> No action required. 	NA	NA
8	1	David Brett	As for Ref No. 5 a), b) and c)	<ul style="list-style-type: none"> Refer to Ref No. 5. 	Refer to Ref No. 5	Refer to Ref No. 5
9	1	Norm Redfern	<p>Vegetation is related to irrigated crops but area not protected with levees. Some of the vegetation shown on the satellite image is in the 'seepage' area and is not irrigated.</p> <p>However the owner and adjacent landowners have a major problem with landowner to the north in Broad Creek (Ref No. 12).</p>	<ul style="list-style-type: none"> No action required. Refer to Ref No. 12. 	<p>NA</p> <p>Refer to Ref No. 12</p>	<p>NA</p> <p>Refer to Ref No. 12</p>
10	1	Peter Cowhan	Not inspected but probably natural vegetation along the creek line.	<ul style="list-style-type: none"> Carry out an inspection of the property and assess whether there are any banks blocking the floodway and if so if they would be overtopped in a design flood. 	DNR	Medium
11	1	Greg Dunn	Likely that the vegetation is natural and that the area is not	<ul style="list-style-type: none"> No action required. 	NA	NA

Draft Lachlan River Gooloogong to Jemalong Gap Floodplain Management Plan

Ref No.	Figure 2 Sheet	Property /Landholder	Description	Recommended Actions	Action by whom	Priority ¹
			irrigated. There are no banks present.			
12	1	Trevor Smith	Banks in this area were the subject of Land Board Hearing involving previous owner Philip Adams. Adjacent landowners interviewed said that floodwaters could not escape to the north and instead would flow west and flood their land. Review of the area indicates that some of the required remedial works have been carried out on the property, but banks remain which may hinder the free passage of floods, up to and including the design flood, to the north.	<ul style="list-style-type: none"> Remaining banks subject to the decision of the Land Board be modified in consultation with DNR and in accordance with agreed outcomes. 	Landowner	High
13	1	Graham Thornton	Likely that the vegetation is natural and that the area is not irrigated.	<ul style="list-style-type: none"> No action required. 	NA	NA
14	2	RTA, Newell Highway	The Newell Highway, south from Forbes, crosses a number of floodways including Bundaburrah Creek and Ooma Creek. The highway is generally at about natural ground level and so does not cause a restriction to floodwaters. However in a number of locations the road is elevated for approaches to bridges and crossing depressions. Detailed topographic plans were not available but it is likely that at these locations the road forms a minor restriction, particularly for minor floods.	<ul style="list-style-type: none"> RTA to assess flood impacts of any likely maintenance or upgrading of the Newell Highway in consultation with DNR. Any proposed upgrade should meet DNR adopted assessment criteria. 	RTA	On-going
15	2	Michael Green	Not contacted, but area inspected. Some irrigation and banks may be hindering flow.	<ul style="list-style-type: none"> Carry out an inspection of the property and assess whether there are any banks that may block floodwaters. Monitor area during future floods. 	DNR DNR / Landowner	High On-going
16	2	David Betland	Owner's orchard was severely flooded in 1990, He believes that there are major problems with flood flow distribution in his area. His orchard is within the Guidelines and is not blocking the floodway. Vegetation shown close to the road is the natural road easement vegetation.	<ul style="list-style-type: none"> Monitor area during future floods. 	DNR / Landowner	On-going
17	2	Michael Green	As for Ref No. 15	Actions as for Ref No. 15.	Refer to Ref	Refer to

Draft Lachlan River Gooloogong to Jemalong Gap Floodplain Management Plan

Ref No.	Figure 2 Sheet	Property /Landholder	Description	Recommended Actions	Action by whom	Priority ¹
					No. 15	Ref No. 15
18	4	State Rail	<p>The railway line through Forbes crosses Bundaburrah Creek at this location. The owner of the adjacent property says that the viaduct across the floodplain is not long enough and in a major flood, there is about 0.5 metres afflux between the upstream and downstream sides.</p> <p>However it is unlikely that State Rail would be willing to upgrade the viaduct. The benefit of the restriction is that floodwaters are held on the upstream side of the viaduct and therefore reduce flooding downstream.</p>	<ul style="list-style-type: none"> ▪ State Rail to consult with DNR on: <ul style="list-style-type: none"> - Any plans to upgrade the viaduct; - Any proposed upgrade should meet DNR adopted assessment criteria. 	State Rail	On-going
19	4	Quinton Moxey (formerly Michael Simshauser)	Met with owner, but property not inspected. Owner maintains that all floodways are open and works are in accordance with the Guidelines. Area is irrigated.	<ul style="list-style-type: none"> ▪ Carry out an inspection of the property and assess whether there are any banks blocking the floodway and if so if they would be overtopped in a design flood. 	DNR	Medium
20	3	Kosta Frangos	Owner not available but area inspected from the road. Seems to be some restrictions due to supply channels and banks. Important breakout from the left bank of the Lachlan and a feeder floodway to Bundaburrah Creek.	<ul style="list-style-type: none"> ▪ Carry out an inspection of the property and assess whether there are any banks and if so if they would be overtopped in a design flood. 	DNR	High
21	4	Quinton Moxey (formerly Michael Simshauser)	As for Ref No. 19.	<ul style="list-style-type: none"> ▪ Action as for Ref No. 19. 	Refer to Ref No. 19	Refer to Ref No. 19
22	3	Southern Cross Landowners	<p>Very important breakout to the north which comes back into Forbes through the golf course and Lake Forbes. Any change to ground levels or road level in this area has major implications on flow distribution in the Lachlan River, the Southern Cross Floodway, the 12 Mile Break and the flow to Bundaburrah Creek.</p> <p>There has been a history of disputes involving Land Board Hearings over many years. Very complex issues relating to levees in the Southern Cross area and flow distribution. Need to</p>	<p>A detailed hydraulic modelling was undertaken for Southern Cross breakout and 12 Mile Break. Modelling results indicated the following:</p> <ul style="list-style-type: none"> ▪ Southern Cross breakout flows first when a flood occurs but the 12 Mile Break carries more water in the larger event; ▪ Importance of both Southern Cross breakout and the 12 Mile Break are more 		

Ref No.	Figure 2 Sheet	Property /Landholder	Description	Recommended Actions	Action by whom	Priority ¹
			provide detailed modelling and advice in this area.	<p>pronounced for flood events larger than the design flood;</p> <ul style="list-style-type: none"> ▪ Construction of any new banks and/or raising of existing banks (including Eugowra Road) in the vicinity of Southern Cross breakout and the 12 Mile Break would change flow distribution between Lachlan River and Bundaburrah Creek; ▪ Existing unauthorised works on the floodplain on the north and southern banks of the Lachlan River downstream of Southern Cross breakout between "Ulmarra" and "Sandhills" would have no significant impact on the regional flood flow distribution for the design flood. The works would however, have localised impacts for the design flood. <p>On the basis of the above the following are recommended:</p> <ul style="list-style-type: none"> ▪ Maintain high level floodway for the 12 Mile Break. ▪ Monitor area during future floods. 	Landowners/ Forbes Shire Council DNR	Ongoing Ongoing
23	4	Neil Merchant	Vegetation that seems to block the floodway is natural and the floodway is open. Banks constructed on the Guideline alignment.	<ul style="list-style-type: none"> ▪ No action required. 	NA	NA
24	4	Ian Alley	Potential blockage of floodway. Not inspected.	<ul style="list-style-type: none"> ▪ Carry out an inspection of the property and assess whether there are any banks blocking the floodway and if so whether they would be overtopped in a design flood. 	DNR	High
25	4	Frank Donohoe	Potential blockage of floodway. Not inspected.	<ul style="list-style-type: none"> ▪ Carry out an inspection of the property and assess whether there are any banks blocking the floodway and if so whether 	DNR	High

Ref No.	Figure 2 Sheet	Property /Landholder	Description	Recommended Actions	Action by whom	Priority ¹
				they would be overtopped in a design flood.		
26	4	Junemar Nominees P/L	Potential blockage of floodway. Not inspected.	<ul style="list-style-type: none"> Carry out an inspection of the property and assess whether there are any banks blocking the floodway and if so whether they would be overtopped in a design flood. 	DNR	High

Key

- **High Priority** -. These measures are considered very important in relation to the performance of the floodway system and should as a consequence be implemented in the shorter term.
- **Medium Priority** –These measures are desirable for hydraulic and/or environmental reasons.
- **On-going** – these issues may require further investigation or have not been fully resolved and therefore may need further investigation

6 Environmental Assessment – Adopted Outcomes

6.1 ASSESSMENT APPROACH

Flood control works undertaken in the past have in some instances resulted in the exclusion or restriction of floodwater access to flood dependent ecosystem areas. Other sites, although retaining floodwater access to date, have been located outside the floodway areas for the 1979 Guidelines and as such could be isolated by flood control works in the future.

The environmental assessment approach taken in preparing the draft FMP focussed on those parts of the floodplain of higher environmental value that support a high proportion of the ecological functions that occur during floods. These areas were identified as Environmentally Important Areas (EIAs) and are defined as areas that have important environmental and/or cultural features that rely on inundation by floodwaters to sustain essential ecological processes. They include areas of flood dependent vegetation, wetlands and floodplain watercourses.

EIAs were initially identified from a desktop analysis of available mapping and then analysed using hydraulic information and flood photography to determine those that were connected to the flooding regime and those that were isolated by existing works. The floodway layer from the 1979 guidelines was overlain on the environmental mapping to indicate EIAs that could potentially be isolated by future development. Ground truthing of EIAs isolated or potentially isolated from flooding was then undertaken to determine the environmental value of the EIAs identified and to check their flood connectivity. A total of 16 sites were inspected. The locations of these sites are shown on the five sheets of Figure 2.

Environmental criteria, adopted by the FMC, were applied to determine the environmental value of EIAs affected by works. This was done to ensure that management actions in the draft FMP to reconnect EIAs to flooding were warranted (based on ecological factors) and targeted those works affecting ecosystems of moderate or higher environmental value. The criteria assigned an environmental value score to the EIAs based on size, ecological condition, habitat value, uniqueness, cultural significance, rehabilitation potential, vegetation connectivity and special features.

A second set of criteria for determining the practicality of reconnecting EIAs affected by works to flood flows was considered by the FMC. The FMC decided that these criteria should be applied if, following consultation with landholders, funding is sought for any environmental works proposed. Consultation with landholders during the assessment process included discussions on the practicality of restoring flood access.

Further information on the environmental assessments for the 16 sites inspected is provided in the FRMS report.

EIAs located within the floodway network for the 1979 Guidelines and known not to be affected by flood control works were not subject to detailed assessment. All of these sites have been retained within the draft FMP floodway network, thereby ensuring that future floodwater access to these ecosystems is maintained.

6.2 ADOPTED OUTCOMES

Adopted outcomes for EIAs assessed were influenced by the presence of existing works:

- Adjustments to the 1979 Guidelines floodway boundaries to encompass EIAs not affected by works but previously located outside the floodway network so that future access for floodwaters to these sites is maintained (11 sites).
- No action as EIAs affected by works were assessed as having low environmental value (4 sites).
- No action as EIA affected by works was assessed as having moderate environmental value but restoration of flooding not considered to be a practical option due to economic and social impact (1 site).

Table 2 below specifies the observed ecosystem type and the outcomes determined for the EIAs assessed.

Table 2 Potential EIAs assessed

EIA No.	Observed ecosystem	Draft FMP outcome
1	River Red Gum woodland	Floodway adjustment
2	River Red Gum woodland	Floodway adjustment
3	River Red Gum woodland	Floodway adjustment
4	Shallow cropped depression	No action
5	River Red Gum woodland	Floodway adjustment
6	Shallow cropped depression	No action
7	River Red Gum woodland	Floodway adjustment
8	Flood runners with scattered Yellow Box & River Red Gum	Floodway adjustment
9	River Red Gum depression	Floodway adjustment
10	Shallow cropped wetland	Floodway adjustment
11	Cropped wetland	No action
12	Cropped depression	No action
13	River Red Gum woodland / open wetland	Floodway adjustment
14	River Red Gum woodland	Floodway adjustment
15	Irrigated area	No action
16	Shallow cropped depression / farm dams	No action

The ecosystems assessed are not the complete set of EIAs in the draft FMP floodplain. The majority of EIAs were included within the 1979 Guidelines floodway network and are connected to flooding. These EIAs are incorporated into the draft FMP floodway network thus ensuring their ongoing flood connectivity.

7 Criteria for Assessing Works

7.1 HYDRAULIC CRITERIA FOR HIGH LEVEL FLOODWAYS

The following hydraulic criteria will apply to the existing (unauthorised) or proposed works located within the high level floodways:

- do not cause an increase of greater than 100mm in flood levels for floods larger than the 15 year ARI design flood
- do not cause any significant redistribution of peak flood flows for floods larger than the 15 year ARI design flood (i.e. more than a 5% redistribution of flow)
- do not cause any significant increase in floodway velocities. Velocities should be of an order that is below the threshold of erosion and siltation for the potential land usage.

To assist in such assessment in the high level floodways the modelled flood parameters for the 1974 historical flood are presented in the FRMS. This flood has an ARI estimated at about 50 years.

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 draft FMP floodplain.

7.2 CRITERIA FOR 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. Applications will be assessed against, among other things, the hydraulic criteria adopted by the committee in determining outcomes in the FRMS. 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 draft FMP floodplain.

Existing or proposed non-complying works will need to meet the following hydraulic assessment criteria:

- do not cause any increase in the **15 year ARI Design Flood Levels (as shown on five sheets of Figure 2)**;
- do not cause any significant redistribution of peak flood flows for 15 year ARI (i.e. more than a 5% redistribution of the **adopted 15 year ARI Design Peak Floodway Flows (refer to FRMS)**);
- do not cause any significant increase in floodway velocities under **15 year ARI Design Peak Floodway Flow (refer to FRMS)** conditions. Velocities should be of an order that is below the threshold of erosion and siltation for the potential land usage.

8 Strategic Environmental Assessment

8.1 OVERVIEW OF ENVIRONMENTAL IMPACT

Implementation of environmental management measures proposed for inclusion in the draft FMP will ensure flood flow access to the floodplain area within the proposed floodway network, including an area of about 1000 hectares of EIAs previously excluded from the 1979 Guidelines floodway. The floodway network is designed to convey a flood with an ARI of 15 years in the draft FMP floodplain. As well, in line with principles adopted by the Committee, it has been designed to conform as closely as reasonably possible to the natural drainage pattern and to allow for the delivery of floodwaters to support floodplain ecosystems. Because of these design criteria, the floodway network includes a high proportion of existing floodplain ecosystems. Future flood connectivity to these ecosystems is ensured since approval for future works within the floodway will be unlikely and would only be granted following a detailed assessment of impact including the requirements of the *Environmental Planning and Assessment Act (1979)*.

Although the draft FMP will allow for potential development outside the floodway network subject to environmental clearances, advice from some graziers in the draft FMP floodplain indicates that widespread construction of levees is not a likely proposition under current farming practice. As a result, while future development may cause some reduction in flood connectivity outside the floodway and reduce the ecological benefits of flooding in this area the impact is not expected to be significant based on current projections.

The impacts of the draft 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 3 below.

Table 3 Summary of Environmental Impacts

Factor	Impact
Soils	Flood connectivity will benefit soil condition and structure within the floodway area and undeveloped areas of the floodplain. Floods will provide sediment, soil moisture recharge and nutrient release in these areas.
EIAs (wetlands & watercourses)	<ul style="list-style-type: none"> All EIAs with existing connection to the flooding regime are contained within the revised floodway network. Since new works in the floodway will require a detailed assessment of impact (including impacts on wetlands) long – term maintenance of flood flow connectivity to these wetlands is ensured. Existing works affecting five EIAs assessed (about 320 ha) will be retained without modification. These areas have been highly modified for agriculture. Four of the sites (about 100 ha) were assessed as having low environmental value. The 200 ha section of Bundaburrah Swamp assessed had a moderate environmental value but was considered to have low practicality for modifying the associated levee banks due to major economic impacts. Overall impact of retaining existing works at these EIAs is not significant.

Factor	Impact
Floodplain Vegetation	<ul style="list-style-type: none"> Existing flood dependent vegetation, consisting mainly of River Red Gum and Black Box is contained within the revised floodway (with the exception of a small number of individual trees). This vegetation includes an additional 1000 ha of EIAs previously outside the floodway. This will maintain flood connectivity and vegetation health since approval for future works within the floodway will be unlikely and would only be granted following a detailed assessment of impact. Continued disconnection of the five EIAs affected by existing works will have a negligible impact on native vegetation as the areas are, with the exception of a small number of trees, currently cleared. Four threatened plant species associated with floodplain environments are known or predicted to occur in the draft FMP floodplain. These include Wakool Speargrass (<i>Austrostipa wakoolica</i>), Winged Peppergrass (<i>Lepidium monoplocoides</i>), Austral Pillwort (<i>Pilularia novaehollandiae</i>) and Spikerush (<i>Eleocharis obicis</i>). These species would be expected to benefit from proposed measures to maintain connectivity to EIAs with existing connection to the flooding regime.
Fauna	<ul style="list-style-type: none"> Proposed floodplain management measures will benefit terrestrial fauna species relying directly on flooding (eg waterbirds) and those utilising floodplain habitats by enhancing or maintaining flood connectivity to floodplain ecosystems. Up to 34 threatened fauna species may potentially occur in the draft FMP floodplain based on known habitat preferences. Of these, four species (Magpie Goose, Freckled Duck, Australasian Bittern and Brolga) have a direct dependence on flooding to maintain their life cycles. Implementation of the proposed floodplain management measures will maintain flood flow access to habitat in EIAs currently connected to the flooding regime.
Aquatic Fauna	<ul style="list-style-type: none"> Long term maintenance of flood flow access to wetlands currently connected to the flooding regime is expected to sustain invertebrate production and fish habitat. No threatened fish species have been recorded in the draft FMP floodplain. However, based on known habitat preferences, a number of listed species, including Silver Perch (<i>Bidyanus bidyanus</i>) which depends on access to the floodplain for successful reproduction, is likely to occur. Silver Perch is expected to benefit from enhanced flood connectivity between the river and the floodplain provided through the proposed floodway network.
Water Quality	<ul style="list-style-type: none"> 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. Proposed measures to maintain flood flow access to existing wetlands connected to the flooding will allow for a continuation or improvement of flood dilution and flushing of any salt that may accumulate in wetlands and floodplain watercourses. There may be some risk of salt accretion in the 320 ha of EIAs that remain blocked from flood flows however each of these sites receives local runoff that would tend to offset this impact.

Factor	Impact
Groundwater	Major recharge of the upper aquifer (the Cowra Formation) occurs when larger floods (as in 1990) inundate the floodplain. Although detailed information on groundwater accession behaviour on the floodplain is not available, recharge is known to occur through ephemeral flood runners, particularly those containing sandy/alluvial layers. All existing floodplain watercourses are included in the proposed floodway network thus allowing for ongoing groundwater recharge during floods. Recharge from the upper aquifer to the deeper aquifer (the Lachlan Formation) occurs through pressure-driven leakage and is a long-term process.
Aboriginal Heritage	Information on the location of recorded Aboriginal sites in the draft FMP floodplain has not been available but based on information from other catchments, it is likely that the lifestyles of the Wiradjuri people who inhabited the region were focussed on the more well-watered parts of the landscape. Potential sites that would benefit from flooding are likely to include scarred and carved River Red Gum or Black Box trees and wetlands and watercourses that may be of spiritual importance. These are incorporated within EIAs and, with the exception of the five EIAs (about 320 ha) that remain blocked from flood flows, are connected to flood flows. Assessment of EIAs affected by existing works (Appendix A) has included a broad consideration of Aboriginal heritage value and based on this, significant impacts on Aboriginal heritage due to continued isolation from flooding are not expected.
European Heritage	One historical site, a Lone Grave on “Wongajong”, has been listed on the Register of the National Estate. The grave is located on higher ground above the northern bank of Bundaburrah Creek and is not likely to be flooded.

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 Gooloogong to Jemalong Gap floodplain, 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 ARI 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 Forbes approximated a 5 year ARI event. SPOT imagery taken on 22nd August 1998 is shown on the two sheets of Figure 3 with the draft FMP floodway network superimposed. The image was captured between two similar peaks in August 1998 at Forbes (11 and 27 August). While the extent of the 1998 flood shown on the image 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 figure 3, the 1998 flood extent is contained within the draft FMP floodway network, which also includes the major flood paths and flood dependent ecosystems on the floodplain. The draft 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 draft FMP will exceed the SWMOP target for the Gooloogong to Jemalong Gap floodplain of (re)connecting at least 60% of the natural 1 in 5 year ARI flooded area to the river.

Figure 3 Sheet 1 of 2

Figure 3 Sheet 2 of 2

8.3 CATCHMENT IMPACTS

The Belubula River and two smaller tributaries, Kangaroooby Creek and Pipeclay Creek join the Lachlan floodplain directly upstream of Gooloogong. There are a number of floodplain wetlands in this area, notably Goodwin's Swamp that is associated with Pipe Clay Creek. The proposed floodway network in the draft FMP floodplain will maintain corridors throughout the floodplain for the free passage of floods and is not likely to adversely affect the hydrology of the tributaries or floodplain wetlands upstream.

Downstream of Jemalong Gap, the floodplain broadens and includes significant natural resources. This area, which contains numerous wetlands (including Lake Cowal) and supports a high diversity of waterbirds and native fish when flooded, is included in the Jemalong Gap to Condobolin Floodplain Management Plan that is currently in preparation. Principles guiding decision-making in that FMP are consistent with those in the draft FMP and consequently measures in both FMPs are expected to provide compatible outcomes.

The draft FMP floodway network is based on the natural drainage pattern and the exit of floodwaters from the floodway network is expected to be at rates and depths similar to those that would have been experienced under natural/historical conditions. The floodway network will preserve flood flow paths and allow for future delivery of the flood regime to downstream ecosystems.



Bundaburrah Cowal (26 April 1990)

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 draft FMP, the second that the floodplain performs adequately in a flood. These indicators will be closely linked with the draft FMP objectives.

The process of approval of flood control works will provide a measure of works that abide by the draft 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 objectives of the draft FMP. In particular the following should be considered with comparison made to historical flood events:

Hydraulic:

- improved passage of flood waters through the draft FMP floodplain; and,
- structures performing to the agreed hydraulic criteria.

Environmental:

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

Economic:

- lesser flood damage.

Social:

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

In order to assess the performance of the draft 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.

A list of potential hydraulic restrictions to be monitored is included in Appendix A. For the larger floods, nearing the design flood levels, monitoring should be undertaken 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. An effective monitoring program will require input from DNR, Forbes 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, Forbes 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 A 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 Forbes 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 A 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

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

Sinclair Knight Merz (2003) *Lachlan River Floodplain Management Study (Gooloogong to Jemalong Gap), Data Collection and Flood Study, Phase A Final Report*.

Sinclair Knight Merz (2007) *Lachlan River Floodplain Risk Management Study (Gooloogong to Jemalong Gap)*.

Water Resources Commission (1979) *Guidelines for Floodplain Development Lachlan Valley Gooloogong to Jemalong Gap*.

11 Appendices

Appendix A – Monitoring Activities

Appendix B – Glossary and Abbreviations

11.1 APPENDIX A – MONITORING ACTIVITIES

11.1.1 Potential Hydraulic Restrictions to Monitor

Reference	Where to Monitor	What to Monitor
Figure 2 Sheet 2 – Ref No. 4	Oakley Holdings	Monitor the need for an actual floodway during future floods – refer to Table 1 (page 29) for details.
Figure 2 Sheet 1 – Ref No.5, 8	Lachlan Valley Way	Monitor Area during future floods – refer to Table 1 (page 29) for details.
Figure 2 Sheet 2 – Ref No. 15, 17	Michael Green	Monitor Area during future floods – refer to Table 1 (page 29) for details.
Figure 2 Sheet 2 – Ref No. 16	David Betland	Monitor Area during future floods – refer to Table 1 (page 29) for details.
Figure 2 Sheet 3 – Ref No. 22	Southern Cross Breakout	Monitor Area during future floods – refer to Table 1 (page 29) for details.

11.1.2 Flood Monitoring Guidelines for Landholders

The following advisory notes specify monitoring activities that should be undertaken by landholders, Forbes 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, gulying 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 landuse 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 2 (page 36) 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>Where works modifications are required to reconnect wetlands:</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.

11.1.3 Forbes Shire 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 Forbes town. With regard to the road structures, those that are of significance 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; and,
- 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.

11.1.4 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 for the draft FMP floodplain 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 draft FMP floodplain; 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 draft FMP floodplain. 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.

11.2 APPENDIX B – GLOSSARY AND ABBREVIATIONS

GLOSSARY

<i>anabranch</i>	a channel of a river or creek that leaves the main channel and re-enters downstream.
<i>average recurrence interval</i>	the long term average number of years between the occurrence of a flood as big as, or larger than, the selected event.
<i>draft FMP floodplain</i>	designated floodplain under section 166(1) of Part 8 of the <i>Water Act 1912</i>
<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>environmentally important area</i>	areas that have important environmental and/or cultural features that rely on inundation by floodwaters to sustain essential ecological processes
<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>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.

hydraulics	the study of water flow in relation to watercourses and the land surface; in particular the assessment of water level and velocity.
hydrology	the study of the rainfall and runoff process; in particular, the assessment of peak flows and flow volumes.
invertebrates	animals without backbones, including zooplankton, worms, insects, shellfish, crabs, shrimps and snails.
probable maximum flood	the largest flood that could conceivably occur at a particular location.
riparian	The interface between land and a flowing surface water body. It is typically characterized by water-dependent vegetation and is often subject to flooding. The riparian zone has a significant role in soil conservation, biodiversity and water quality.
threatened species	species of plant or animals listed as vulnerable or endangered on the schedules of the NSW Threatened Species Conservation Act.
wetland	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

ARI	Average Recurrence Interval
DNR	Department of Natural Resources
EIA	Environmentally Important Area
FMP	Floodplain Management Plan
FMC	Lachlan River Floodplain Management Committee, Gooloogong to Jemalong
FRMS	Floodplain Risk Management Study
FS	Flood Study
SWMOP	State Water Management Outcomes Plan
WAMC	Water Administration Ministerial Corporation