



Floodplain Management Plan

Lachlan River (Jemalong Gap to Condobolin)

February 2012

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

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Cover photos (clockwise from main photo):

Lachlan River downstream of Jemalong Gap, August 1990 (Steve Hogg, NSW Department of Water Resources);
Goobang Creek and Lachlan River upstream of Condobolin, August 1990 (Steve Hogg, NSW Department of Water Resources);

River red gum woodland near Warroo Bridge (Paul Bendeich, OEH);

Goobang Creek (Paul Bendeich, OEH).

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Glossary

Term	Definition
Average recurrence interval (ARI)	The long-term average number of years between the occurrence of a flood as big as or larger than the selected event (e.g. floods with a discharge as great as, or greater than, the 100-year ARI event will occur on average once every 100 years).
Calibration	The process where parameter values within a computer model (e.g. hydraulic model) are progressively altered until the modelled output best matches the observed flooding behaviour.
Catchment	The area of land draining to a particular site.
Discharge (or flow)	The rate of flow measured in volume per unit of time (e.g. megalitres per day = ML/day).
Ecosystem	A biological system involving interactions between living organisms and their immediate physical, chemical and biological environment.
Flood dependent ecosystem	An ecosystem with important environmental or cultural features which rely on inundation by floodwaters to sustain essential ecological processes.
Floodplain	Any land which is so designated by an order in force under section 166 (1) of the <i>Water Act 1912</i> .
Floodplain management plan	The principal means of managing the risks associated with the use of the floodplain.
Flood storage area	Those areas of a floodplain which are important for the temporary storage of floodwaters during the passage of a flood.
Floodway areas	Those areas of a floodplain where a significant discharge of floodwater occurs during floods. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Flow rating table	Variation in flow versus water level at a particular location, determined from field measurements.
Flow hydrograph	A graph that shows how the discharge at any particular location changes with time during a flood.
Hydrologic/hydraulic computer models	A mathematical representation of the physical processes involved in generating runoff and streamflow. Models are typically computer software packages.
Gauged flow	The flow rate at a particular location, based on field measurements.
Observed flood data	Flood data that has been measured or recorded during or after a flood (e.g. flood height mark, velocity of floodwaters).
Peak discharge (or peak flow)	The maximum flow recorded during a flood event.
Stage	Equivalent to water level. Usually measured with reference to a specified height datum.
Stage hydrograph	A graph that shows how the flood level at a particular location changes with time during a flood.
Threatened species	Species of plants or animals listed as vulnerable or endangered in the schedules of the NSW <i>Threatened Species Conservation Act 1995</i> .

Abbreviations

ARI	Average recurrence interval
CMA	Catchment Management Authority
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i>
FDE	Flood dependent ecosystem
FMC	Lachlan River Jemalong Gap to Condobolin Floodplain Management Committee
FMP	Floodplain management plan
FRMS	Floodplain risk management study
FS	Flood study
LRRMC	Lachlan River Regulated River Management Committee
NOW	NSW Office of Water, Department of Primary Industries
OEH	Office of Environment and Heritage, Department of Premier and Cabinet
PVP	Property Vegetation Plan
WAMC	Water Administration Ministerial Corporation
WMA	<i>Water Management Act 2000</i>

Preface

Due to the enlargement of the Wyangala Dam, completed in 1971, the regulation of the Lachlan River has increased and irrigation activities on the Lachlan floodplain have intensified. This has led to a proliferation of earthworks on the floodplain, with larger areas being cultivated and sown with high-value crops. The net result is a situation in which flood patterns have been altered and the potential for crop loss and environmental impact has increased.

Floodplain development guidelines were prepared in 1978 (*Guidelines for Floodplain Development, Lachlan River Jemalong Gap to Condobolin*). To date, the 1978 Guidelines have served as the main reference for landholders undertaking development on the floodplain, including the construction of flood control works. However, these guidelines need to be replaced with a strategic plan that addresses current levels of development and is consistent with the needs of sustainable natural resource management.

The Jemalong Gap to Condobolin Floodplain Management Plan (FMP) was prepared by the Office of Environment and Heritage (OEH) within the Department of Premier and Cabinet, for the Water Administration Ministerial Corporation (WAMC) under Part 8 of the *Water Act 1912* and in accordance with the processes outlined in the NSW Government's Floodplain Development Manual (*NSW Government 2005*). The preparation of the FMP was overseen by the Lachlan River Jemalong Gap to Condobolin Floodplain Management Committee (FMC), which comprised representatives from the community, various stakeholder groups and government agencies. Funding for the project was provided by the Natural Disaster Mitigation Program with financial support from the State.

OEH prepares rural floodplain management plans that define requirements for managing floodwaters within floodplains. Approval of works and compliance functions under Part 8 of the *Water Act 1912* are the responsibility of the NSW Office of Water (NOW) within the Department of Primary Industries. The FMP is the first stage in developing an overall integrated scheme for the management of floodwaters on the Lachlan Valley floodplains.

Developing the FMP has progressed through three primary phases:

- preparation of a **Flood Study** – defining the nature and extent of flooding and flood-related issues (hydraulic, environmental and cultural) in technical terms (completed 2004),
- preparation of a **Floodplain Risk Management Study** – evaluating management options in consideration of social, environmental, and economic factors, in order to address existing and future flood risk and flood management issues (completed 2009), and
- preparing this **Floodplain Management Plan** – outlining strategies to manage flood risk and flood management issues and to support the natural functions of the floodplain environment.

The FMP allows for future floodplain management planning by providing for a coordinated and integrated network of floodways. The FMP floodway network has adequate hydraulic capacity and continuity to effectively convey floodwaters and support the floodplain environment during events with volumes up to and including the large floods that occurred in 1990. Once adopted, the FMP, including the FMP floodway network, will be the basis for determining whether flood control works (earthworks, embankments or levees) on the floodplain will be granted approval under Part 8 of the *Water Act 1912*. The plan also details the approval process and assessment criteria for proposed and existing works.

The FMP floodway network is designed to effectively convey floodwaters to flood dependent ecosystems (FDEs) within the FMP floodplain and downstream floodplains, including Lake Cowal. FDEs are areas that have important environmental 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. A high proportion of the existing river red gum and black box woodland has been captured within the FMP floodway network as well as an additional 630 hectares of FDEs that were excluded from the 1978 Guidelines floodway network. Where existing works affect flows to FDEs, the FMP outlines measures to enhance flood flow connectivity. In some cases, landholders may be eligible to receive funding from the Lachlan Catchment Management Authority (CMA) for removing or modifying works that result in an environmental benefit.

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

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

The performance of the FMP floodway network during floods will be assessed on the basis of information gathered during flood monitoring activities. This information will be measured against the FMP's objectives and the hydraulic, environmental, economic and social indicators that are outlined in the FMP.

Dense vegetation cover within the FMP floodway network may increase hydraulic roughness and reduce floodway efficiency. Under the *Native Vegetation Act 2003*, and other relevant legislation, there is a range of options for managing vegetation so that the FMP floodway network is maintained and operates as designed during floods.

It is expected that, in the future, the FMP will be adopted as a Minister's plan under the *Water Management Act 2000*. The FMP is required to be reviewed at five-yearly intervals in accordance with the *Water Management Act 2000*.

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

1 Introduction

1.1 Vision and objectives

The FMP has been prepared to provide strategic guidance to NSW government agencies and landholders in the management of floodwaters on the Lachlan River (Jemalong Gap to Condobolin) floodplain. The FMP will replace the 1978 Guidelines.

The vision for managing the Jemalong Gap to Condobolin floodplain is:

To manage the floodplain of the Lachlan River between Jemalong Gap and Condobolin township in an equitable and sustainable manner through careful use of parts of the floodplain for agricultural activities, while allowing for the floodplain's natural flood distribution and storage functions, and enhancing its environmental values.

The objectives linked to this vision for the FMP are:

- *To achieve a coordinated, balanced approach to floodplain management, taking into account hydraulic, environmental and economic considerations, and legislative requirements.*
- *To ensure the sustainable and equitable use of floodplain resources.*
- *To ensure that the current, accepted flow distribution to the north and south of the floodplain is retained.*

1.2 Overview of the Jemalong Gap to Condobolin floodplain

1.2.1 General overview

Between Jemalong Gap and Condobolin, the Lachlan River floodplain is relatively wide and flat and is interspersed with short ridges, gibber aggregations and sandhills. The location of the floodplain in relation to the Lachlan Valley catchment is shown in Figure 1.1. Figure 1.2 shows the Lachlan River Jemalong Gap to Condobolin FMP floodplain.

The Lachlan River Jemalong Gap to Condobolin floodplain to the north of the river extends to Goobang Creek, linked by Bumbergan Creek. To the south, it extends to Lake Cowal and further west to the Ulgutherie, Island, Bogandillon and Wallamundry creek systems. A continuous ridge between Manna and Bogandillon Mountains confines flood discharges northwards from Nerang Cowal via Manna and Bogandillon Creek, until close to Island Creek, and before flowing westward to Bogandillon Swamp.

The Jemalong Irrigation Limited Area of Operations, located south of the Lachlan River, occupies about 930 km² and overlaps a quarter of the FMP floodplain which is approximately 1,600 km² (see Figure 1.2). The remainder is primarily grazing pasture.

The floodplain beyond Bogandillon Swamp lies entirely to the south of Condobolin township and includes the complex network of billabongs within the Wallamundry, Wallaroi and Nerathong creek systems.

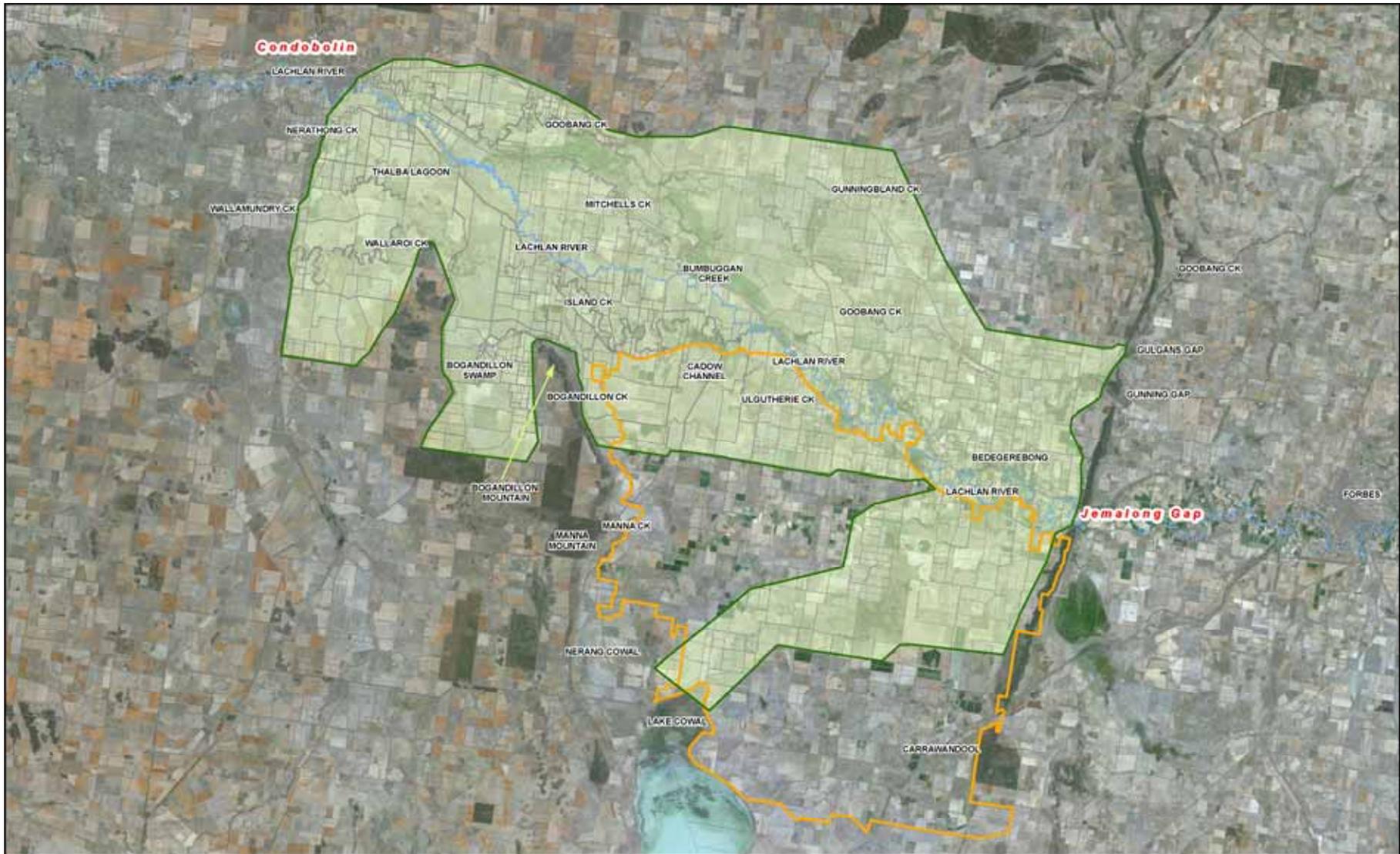


Image Source: 2000 Landsat Imagery



- Legend**
- Jemalong Irrigation District
 - Digital Cadastral Database
 - FMP Floodplain

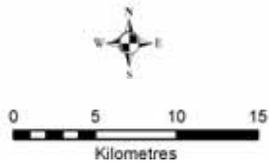


Figure 1.2
FMP Floodplain
 Lachlan River Jemalong Gap to
 Condobolin FMP

1.2.2 Flooding overview

Floods have been a common occurrence in the FMP floodplain and tend to cover vast areas of the floodplain for prolonged periods. As flood events pass through Jemalong Gap, part of the Lachlan River's flow splits to the north and south, leaving large parts of the Lachlan River itself unaffected. The flooding behaviour is summarised below.

Three flow paths exist, namely the Lachlan River itself, and the southern and northern systems each taking approximately 50% of the remaining flow.

The Lachlan River takes only about 15% of the total flow and is confined by a well-defined small channel and narrow floodplain of less than 3 km wide. Most of the flood flows separate from the main channel to the north and south by the time the flood has passed the major breakouts downstream of Jemalong Gap that are known locally as the 17-mile and 21-mile breakouts (see Figure 4.5).

The southern system is fed by outflows from the 17- and 21-mile breakouts that pass towards Lake Cowal. Flooding does not spread out as much as in the northern corridor. Overflow from Lake Cowal and Nerang Cowal discharges through Manna and Bogandillon Creek to Bogandillon Swamp and eventually to the creek system south of Condobolin.

The northern system extends to Goobang Creek, linked by Bumbergan Creek. The northern system is characterised by widespread flooding, with the bulk of flood flows located in the Goobang Creek floodplain and less flow in the Lachlan River main channel and its confined floodplain. The depressions and billabongs that fill during floods eventually channel water to Goobang Creek.

The volume of floodwaters in this reach of the Lachlan River can be swelled by inflows from Goobang and Gunningbland creeks catchment. Goobang Creek flows tend to pass into and through the floodplain well before Lachlan River peaks reach Jemalong Gap but can also coincide with peak Lachlan flows. Flood flows from the Goobang Creek catchment can also occur independently of floods in the Lachlan River.

For detailed information regarding the flooding characteristics of the FMP floodplain refer to the Lachlan River Jemalong Gap to Condobolin Rural Flood Study (FS) (Parsons Brinckerhoff 2004) and the Lachlan River Jemalong Gap to Condobolin Floodplain Risk management Study (FRMS) (Parsons Brinckerhoff 2009).

1.2.3 Environmental overview

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

The floodplain environment in the FMP floodplain has been modified by agricultural development. Regulation of the Lachlan River for agricultural water supply, through the operation of Wyangala Dam, and, to a lesser extent, Carcoar Dam, has altered the frequency, magnitude and duration of floods. Development has also altered the distribution and behaviour of floodwaters, removed large areas of floodplain vegetation (for broadacre cropping) and impacted on the hydrology and ecology of some wetlands. Despite these impacts, the floodplain retains significant ecological values. The floodplain also has important cultural values because of the Aboriginal and European history of the area.

The FMP floodplain contains extensive areas of wetlands and floodplain watercourses. Native floodplain vegetation consists mainly of communities dominated by river red gum, black box, lignum and river cooba. These species depend on flooding for their health and regeneration. The floodplain supports a diversity of native fauna including species that rely directly on flooding to maintain their life cycles (e.g. some species of waterbirds, invertebrates and fish) and species that rely on floodplain vegetation for food or habitat (e.g. honeyeaters). More detailed information on the floodplain environment is provided in the FRMS.

2 Developing the FMP

2.1 Legislative and policy framework

Management of the FMP floodplain must be undertaken within the current legislative and policy framework. This section of the FMP presents a brief summary of the primary pieces of relevant legislation and policy. Please refer to the FRMS report (Parsons Brinckerhoff 2009) for a detailed overview of the legislation and policy framework for floodplain management.

2.1.1 Water Act 1912 and Water Management Act 2000

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

At the time of preparing this FMP the NSW Government had initiated wide-ranging reform of water legislation, with the outcome being the *Water Management Act 2000* (WMA). The WMA consolidates most of the Acts previously covering water management in NSW. The WMA is being phased in gradually as Water Sharing Plans are developed and commenced for particular water sources. The floodplain management provisions of that Act will eventually replace Part 8 of the *Water Act 1912*. Under current transitional arrangements of the WMA, existing FMPs under Part 8 of the *Water Act 1912* may be deemed Minister's plans under the WMA.

As the regulation of flood control works will ultimately fall under the WMA, it is necessary to consider the objects and principles of that Act in the preparation of plans under Part 8 of the *Water Act 1912*.

Objects of the WMA

The objects of the WMA are to provide for the sustainable and integrated management of the water sources of NSW for the benefit of both present and future generations and, in particular:

- a) to apply the principles of ecologically sustainable development, and
- b) to protect, enhance and restore water sources, their associated ecosystems, ecological processes and biological diversity and their water quality, and
- c) to recognise and foster the significant social and economic benefits to the State that result from the sustainable and efficient use of water, including:
 - i) benefits to the environment, and
 - ii) benefits to urban communities, agriculture, fisheries, industry and recreation, and
 - iii) benefits to culture and heritage, and
 - iv) benefits to the Aboriginal people in relation to their spiritual, social, customary and economic use of land and water,
- d) to recognise the role of the community, as a partner with government, in resolving issues relating to the management of water sources,

- e) to provide for the orderly, efficient and equitable sharing of water from water sources,
- f) to integrate the management of water sources with the management of other aspects of the environment, including the land, its soil, its native vegetation and its native fauna,
- g) to encourage the sharing of responsibility for the sustainable and efficient use of water between the Government and water users,
- h) to encourage best practice in the management and use of water.

Floodplain management principles of the WMA

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

- a) floodplain management must avoid or minimise land degradation, including soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, decline of native vegetation or, where appropriate, salinity and, where possible, land must be rehabilitated,
- b) the impacts of flood works on other water users should be avoided or minimised, and
- c) the existing and future risk to human life and property arising from occupation of floodplains must be minimised.

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

2.1.2 Core provisions of the Water Management Act 2000

The WMA specifies the core provisions that must be dealt with in a floodplain management plan and additional provisions that may also be dealt with. These provisions have guided the preparation of the FMP.

The WMA core provisions, and how they have been addressed in this FMP, are:

- a) *identification of the existing and natural flooding regimes in the area, in terms of the frequency, duration, nature and extent of flooding,*

A detailed analysis of the flood data spanning numerous historical floods was carried out as part of the FRMS in order to calibrate the computer model and determine the design flood. Satellite imagery of the 1990 flood, which surcharged most of the existing development, provided a good understanding of the natural flood regimes and the extent of flooding.

- b) *the identification of the ecological benefits of flooding in the area, with particular regard to wetlands and other floodplain ecosystems and groundwater recharge,*

Ecological benefits of flooding on the FMP floodplain are outlined in Sections 6 and 7 of the FMP. Wetlands and other FDEs have been specifically considered in the FMP in relation to flood connectivity. Detailed information on the environmental assessment is provided in the FRMS (Parsons Brinckerhoff 2009).

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

Identification of existing flood works was undertaken in detail in the FRMS and the impact of these works on flood behaviour was assessed in relation to flood risk and the flood connectivity of FDEs. Based on this assessment, the FMP specifies environmental management measures (Section 6) to address identified environmental issues associated with existing flood works.

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

The FRMS included detailed risk analysis under different scenarios to investigate and finally adopt the design flood to be used for the hydraulic design of the FMP floodway network (Section 4.2). The FMP is a strategic plan which identifies a network of coordinated floodways that need to be kept open for floods up to and including the design flood, irrespective of whether there are flood protection works or not.

2.1.3 Additional provisions of the Water Management Act 2000

- a) *Proposals for the construction of new flood works.*

Section 3 of the FMP outlines the approval and determination process for new flood works. The FMP floodway network (Figures 4.5 to 4.8 in Appendix C) will be used as the basis for determining applications for flood works.

- b) *The modification or removal of existing flood works.*

This is dealt with in Table 6.1 in the FMP.

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

- i. the passage, flow and distribution of floodwater,*
- ii. existing dominant floodways and exits from floodways,*
- iii. rates of flow, floodwater levels and duration of inundation,*
- iv. downstream water flows,*
- v. natural flood regimes, including spatial and temporal variability.*

These provisions are reflected in the floodplain management principles (Section 2.3.1) which formed the basis of decision-making in the preparation of the FMP and the design of the FMP floodway network.

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

The FMP provides guidance on how to control activities associated with flood works (Section 3).

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

Impacts of the FMP on water quality are assessed at a strategic level in Table 7.1.

- f) *Such other matters as are prescribed by the regulations.*

Currently no other matters have been prescribed by the regulations.

2.1.4 The Flood Prone Land Policy

The primary objective of the NSW 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 a strategic, merit-based framework underpinned by a floodplain risk management plan. The NSW Government's *Floodplain Development Manual* (NSW Government 2005) supports this policy and outlines a merit-based approach to floodplain management.

2.1.5 Other floodplain management controls

There are several other 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** (EP&A Act) is of particular importance in this context. In determining applications for flood control works, NOW is required to assess the environmental impact of the works under Part 5 of this Act.
- **The Commonwealth Environment Protection and Biodiversity Conservation Act 1999**. 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 this Act. These approvals are assessed by the Australian Government Department of the Environment, Water, Heritage and the Arts.
- **Water Management Act 2000**. The *Rivers and Foreshores Improvement Act 1948*, which allowed for the carrying out of works to remove obstructions and to improve rivers and foreshores, has been repealed and replaced by provisions in the WMA for controlled activities. Under the WMA, NOW requires approval for controlled activities which include the removal or deposition of material in the bed of a watercourse or wetland and on adjacent land and other activities that affect the flow of water in a watercourse. Approval under the WMA would be required where earthworks are proposed in the bed of a watercourse or wetland or where material is being sourced from a watercourse to construct a flood control work.

Other relevant pieces of legislation include:

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

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

- **The Wetlands Policy 2010**,
- **The State Groundwater Dependent Ecosystems Policy 2002**,

- **Floodplain Harvesting Policy (Draft) 2008.** The NSW Government announced this draft policy on 3 July 2008 with the aim of bringing floodplain harvesting activities into the statutory framework for water management for the first time. It is proposed that entitlements for floodplain harvesting be established in each valley in NSW that are within existing Water Sharing Plan limits and the Murray Darling Basin Cap. Eligible works will be assessed to determine whether they can be authorised to take floodplain water, and, if approved, a share of the total allowable floodplain harvesting volume will be issued under licence. Once the policy is finalised (following public consultation), it is intended that the data contained in this FMP, the FRMS and the FS will support the implementation of the policy in the Lachlan Valley.

2.1.6 Relevant State and catchment management plans

NSW 2021: A Plan to Make NSW Number One (NSW Government 2011) is the new strategic plan for New South Wales, and outlines the goals, targets and actions for the NSW Government to deliver over the next ten years. NSW 2021 priority actions include working with Catchment Management Authorities and local community groups to protect and improve habitats on private lands.

There are a range of statewide targets for natural resources management in New South Wales which cover the themes of biodiversity, water, land and community. Catchment Management Authorities work with communities and government agencies to improve the condition of natural resources in their regions.

The Lachlan Catchment Management Authority (CMA) worked with local communities to prepare the Lachlan River Catchment Action Plan which was adopted by the NSW Government in January 2007 (Lachlan CMA 2006). The Catchment Action Plan outlines a number of natural resource management targets, several of which are directly relevant to outcomes in the FMP. These include the water target to maintain and improve the health of wetlands, the vegetation target to enhance native riparian vegetation identified as degraded, and the biodiversity target to maintain or enhance habitat features along all streams. The FMP should therefore be viewed as one component of an integrated catchment planning process that delivers catchment and State targets. Other relevant management plans that are linked to the FMP by also addressing catchment and State natural resource management targets include:

- Water Sharing Plan for the Regulated River Water Source – Lachlan River 2004, and the
- NSW Recovery Plan for Silver Perch 2005.

2.2 Community consultation

Community consultation has been an integral part of developing the FMP. The advisory committee responsible for overseeing the plan's preparation was the FMC. The FMC consists of 12 members including a mixture of representatives of local landholders, Jemalong Irrigation Limited, Lachlan and Forbes Shires, and OEH.

The FMC generally met on average at six-monthly intervals during the course of the plan's preparation and was responsible for providing advice on important documents (e.g. the FS and FRMS reports) and assessment principles and criteria.

Other consultation activities were also undertaken:

- On-site meetings and inspections relating to the environmental assessments were undertaken by OEH staff.

- A community information evening was held on 26 March 2002 at the Condobolin RSL. During the information evening, the study team was introduced to the community. The study team outlined the investigation process and project timeframe and provided an opportunity for people to contribute and register their interest.
- Public consultation questionnaires were sent out to all residences located within the flood-affected areas within the FMP floodplain.
- Returned questionnaires were followed up by telephone interviews and field visits where appropriate.

The FMP was publicly exhibited from 28 March 2011 to 13 May 2011 and two submissions were received. The matters raised in the submissions have been considered in finalising the FMP.

2.3 Floodplain management principles

A set of floodplain management principles was used as a guide for making decisions when assessing management strategies and options during the development of the FRMS. The floodplain management principles are set out below in Section 2.3.1. They 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 overall objective of the principles is to allow economic use of the land while ensuring that people and the environment are not unduly affected by redirected or changed flows. Further, the principles should ensure that, over time, the floodplain can function in as natural a way as possible.

2.3.1 Floodplain management principles

The floodplain management principles for the FMP floodplain are:

- Defined floodways must possess adequate hydraulic capacity and continuity to enable the orderly passage of floodwaters through the floodplain.
- Any system of defined floodways should conform as closely as is reasonable to the natural drainage pattern after taking into account the existing floodplain development.
- Floodway areas should be equitably allocated and be consistent with natural or historical flowpaths.
- Environmental issues related to the FMP plan need to be identified and investigated, including developing strategies for environmentally sensitive areas.
- The exit of floodwaters from defined floodways should be at rates and depths similar to those that would have been experienced under natural or historical conditions and floodwaters should discharge as close as practicable to the location of natural or historical floodways.
- Sufficient pondage must be retained on the developed floodplain so that peak flood travel time is not unduly accelerated to downstream areas nor is flood height or depth increased.
- Velocities of flood flow in defined floodways should be minimised and should not cause erosion or increased siltation under various land uses.
- There should be no detrimental impact from floodplain development on any landholders or community infrastructure, including increases in peak flood levels and increased drainage times.

- Floodplain development should not cause significant redistribution of floodwater.
- There might be scope to depart from the natural or historical drainage pattern, provided it is hydraulically and environmentally feasible and sustainable.

3 Implementing the FMP

The *Water Act 1912* requires that all flood control works (existing and proposed) within a designated floodplain need to be assessed for approval. Therefore, implementing the FMP involves undertaking the recommended environmental management measures set out in Section 6 of the FMP, with the approval of works and future property planning in line with the adopted floodway network. Figures 4.5 to 4.8 (see Appendix C) show the FMP floodway network and the locations of required environmental management measures.

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*. Flood control works situated or proposed to be constructed on land within the designated floodplain will be determined in accordance with the FMP and Part 8 of the Act. Once the FMP has been adopted, the designated floodplain will be amended to match the FMP floodplain.

3.1.2 Works that require approval

Works requiring approval under Part 8 of the Act are defined as a 'controlled work'. The following works are defined as controlled works requiring a Part 8 approval:

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

However, a 'controlled work' does not include any works declared not to be a controlled work, or a work in respect of which a licence or approval is in force under Parts 2, 5, or 9 of the *Water Act 1912*.

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

3.1.3 Applying for approval

To lodge an application for approval of flood control works, a Part 8 application form must be completed and submitted to NOW.

The following must accompany the application form:

- application fee (currently \$182),
- a detailed locality plan showing the location of the works and providing full details of the proposal including specifications of the dimensions and design of the works, and the construction materials,
- a detailed survey plan using Australian Height Datum (AHD) showing reduced levels relevant to established and or proposed works, and
- supporting information that may assist in the determination process (the applicant can get in touch with the nearest NOW office for details).

For non-complying works (see Section 3.1.7) in addition to the above, a report on the hydraulic and environmental impacts of the works, including an assessment against the hydraulic and environmental criteria outlined in Sections 5.1 and 5.2, must accompany the application form.

It is important that the applicant provides all the information requested by NOW so the application can be properly considered. If the requested information is not provided, NOW may refuse to deal with the application. For a detailed list of the required information refer to Appendix A.

3.1.4 Determination process

All applications under Part 8 of the *Water Act 1912*, including works considered to be complying with the FMP, must proceed through a set process before NOW determines the application under section 171 of the Act. This process includes (but is not limited to):

Section 166C of the *Water Act 1912* – NOW must have regard to the matters for general consideration outlined in section 166C, including (but not limited to):

- the contents of any relevant FMP or any other relevant government policy,
- the need to maintain the natural flood regimes in wetlands and related ecosystems and the preservation of any habitat animals (including fish) or plants that benefit from periodic flooding,
- the effect or likely effect on water flows in downstream river sections,
- any geographical features, or other matters of Aboriginal interest that may be affected by a controlled work,
- the effect or likely effect of a controlled work on the passage, flow and distribution of flood waters,
- the effect or likely effect of a controlled work on existing dominant floodways or exits from floodways, rates of flow, flood water levels and the duration of inundation,
- the protection of the environment, and
- any other matter relating to the desirability or otherwise of a controlled work.

Part 5 of the *Environmental Planning and Assessment Act 1979* – As there are no relevant environmental planning instruments relating to the FMP, all proposals must undergo assessment under Part 5 of the EP&A Act. NOW 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 definition of ‘fauna’ from 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, and
- any cumulative environmental effect with other existing or likely future activities.

Floodplain management plan – NOW must have regard to the contents of any relevant floodplain management plan before determining an application for an approval.

Other management plans – NOW must have regard to the contents of any other management plan or policy including those dealing with the delivery of environmental water as specified under section 8 of the WMA.

Aboriginal heritage assessment – NOW will liaise with OEH Environment Protection and Regulation Group, Landscape and Aboriginal Heritage Protection (North West) and if required OEH Country, Culture and Heritage Division (North West) , to assess Aboriginal heritage issues associated with individual applications. Applications will be assessed in accordance with the *National Parks and Wildlife Act 1974*.

Additional information – NOW must consider any relevant supporting information that has been provided by the applicant.

3.1.5 Possible determinations

NOW must inform the applicant as soon as practicable of the determination of an application for a flood control work. The general terms of approval should be comprehensive enough to

cover all of the constraints (terms and conditions) that may be applied to the relevant Part 8 approval. Under the *Water Act 1912*, there are three 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 to a determination under the *Water Act 1912*. Before making a determination in respect of an application for flood control works, NOW is required to decide whether the works do or do not comply with the FMP.

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 NOW is satisfied that the work complies with the floodplain management plan for the area in which the work is situated or proposed to be constructed. For the FMP, complying flood control works are defined as:

- existing (unapproved) or proposed works located outside the limits of the FMP floodway network as shown on Figures 4.5 to 4.8 (Appendix C), or
- existing (unapproved) or proposed works located on the limits of the FMP floodway network that do not exceed the height limits specified on Figures 4.5 to 4.8 (Appendix C), or
- existing (unapproved) works that are to be modified in accordance with the measures in Table 6.1 of the FMP.

Development outside of the limits of the FMP floodway network would not generally 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 the 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 an assessment would not need to go into the details required for works within the floodway, unless the impact on overall flood behaviour could be significant and therefore far-reaching.

A landholder will be required to provide the necessary supporting information to demonstrate that the application is a complying work. Where an existing (unapproved) or proposed flood control work is complying, the application for approval will be determined by NOW without the need for advertising to canvass third party objections. While the majority of approvals for complying works are likely to be straightforward and expedient, they will not be automatically approved and will be subject to the determination process outlined in Section 3.1.4, including assessment against the matters raised in section 166C of the *Water Act 1912* and Part 5 of the EP&A Act.

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 NOW is not satisfied that the work complies with the floodplain management plan for the area in which the work is situated or proposed to be constructed, or, the flood control work is situated or proposed to be constructed in an area that is not the

subject of a floodplain management plan. For the FMP, non-complying flood control works are defined as:

- existing (unapproved) or proposed works located within the FMP floodway network as shown on Figures 4.5 to 4.8 (Appendix C), or
- existing (unapproved) or proposed works located on the limits of the FMP floodway network that exceed the height limitations specified on Figures 4.5 to 4.8 (Appendix C), or
- existing (unapproved) works that are not modified in accordance with measures stipulated in Table 6.1 of the FMP.

Non-complying works may be considered for approval after a detailed investigation of hydraulic and environmental impacts. The cumulative impact of existing (unapproved) or proposed works on flooding characteristics needs to be comprehensively addressed in the application. Hydraulic impacts will be assessed against the criteria specified in Section 5.1. Environmental impacts will be assessed under Part 5 of the EP&A Act and against the criterion specified in Section 5.2 of the FMP. It is the applicant's responsibility to provide the necessary technical details to support an application. Where the requested supporting information is not provided, NOW can reject the application.

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

3.1.8 Unauthorised works

Unauthorised controlled works include:

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

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

- a) work to remove, modify, repair or restore the controlled work, or to render the work ineffectual,
- b) work to repair any damage caused by the controlled work (including any damage caused to any specified land, river, lake, structure or vegetation, or to the environment),
- c) work 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, and
- d) without limiting (a) to (c) above, work to correct or restore any alteration caused by the controlled work to the flow of water into or from, or the quantity of water contained in, any specified river or lake.

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

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

3.1.9 Varying conditions of approved works

If there is a need to vary the conditions of an already approved work, under section 176A of the *Water Act 1912*, NOW:

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

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

3.1.10 Flood protection for high-value infrastructure

Landholders can flood-protect those parts of their property that contain high-value infrastructure such as houses, workshops, sheds and pumps. Where such works are constructed solely for the direct protection of high-value infrastructure, no Part 8 approval will be required.

However, where such works are integrated into a much larger area of protection incorporating earthworks or levee banks that also protect arable land, then the infrastructure protection may need to be assessed as a Part 8 determination process for flood control works on a property.

3.1.11 Floodplain harvesting works

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

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

3.1.12 Roads and railways

Roads and railways (and associated bridges, roadworks and railway works) vested in local or State government transport agencies are declared by order as non-controlled works under section 165(2) (a) of the *Water Act 1912*. However, agencies constructing these works are required to assess their environmental impact under the EP&A Act.

3.1.13 Block banks

Block banks, which are earthworks situated within waterways, require either of the following types of authorisation, depending on their intended purpose:

- controlled activities approval under the WMA (for vehicle crossings),
- water supply work approval under the WMA (where water supply works are constructed on streams listed in a Water Sharing Plan), or
- licensing under Part 2 of the *Water Act 1912* (where water supply works are constructed on streams not listed in a Water Sharing Plan).

Authorisation is subject to endorsement by the NSW Department of Primary Industries under the requirements of the *Fisheries Management Act 1994*.

3.1.14 Possible funding sources for environmental works and public works

There are potential funding sources available for both private and public works as listed in Table 3.1. The funds are competitive and generally any application has to demonstrate how proposed works are consistent with a plan or policy and will produce a natural resource outcome and not just a private benefit.

Table 3.1 Funding sources

Source	Fund manager	Eligible works
Australian Government and State-assisted Natural Disaster Mitigation Program	State Emergency Management Committee (at State level)	Mainly flood mitigation works (public)
State-assisted Floodplain Management Program	OEH	Local government studies and works (public) related to floodplain management
Various incentive funds: <ul style="list-style-type: none"> • Caring for Country • Conservation farming incentive funding • Native vegetation incentive programs. 	Lachlan CMA	On-farm works with natural resource management outcomes consistent with targets in the Lachlan Catchment Action Plan

4 FMP floodway network

4.1 General

The central element of the FMP is the floodway network. The FMP 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. Partially blocking the floodway could cause a significant redistribution of flood flow or a significant increase in flood levels and thereby increase the flood risk to flood prone communities. The delineation of 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.

Applications to undertake flood control works located within the identified floodways constituting the FMP floodway network will be assessed as non-complying works and will likely be refused. However, if the applicant can demonstrate that the proposed works will meet the relevant hydraulic and environmental assessment criteria (Sections 5.1 and 5.2 of the FMP) and will meet the requirements of section 166C of the *Water Act 1912* and Part 5 of the EP&A Act, then the works may be considered for approval.

The FMP floodway network also identifies areas (outside the FMP floodway network) where flood control works will be assessed as complying works and, in general, will be readily approved with appropriate conditions if required (such as limitations on levee and bank heights). All proposals must also undergo assessment under Part 5 of the EP&A Act to take into account any environmental impacts including cumulative impacts with other existing or likely future activities.

Decisions relating to the delineation of the FMP floodway network were largely driven by the floodplain management principles adopted by the FMC (listed in Section 2.3.1 of the FMP). The hydraulic, environmental, social, economic and legislative principles are all relevant to the delineation of the floodway network.

In many cases, the respective categories of management principles 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 have ultimately been made based on a balanced viewpoint taking into account all of the relevant issues under consideration.

The FMP floodway network is based on the 1978 Guidelines network and with modifications in response to:

- existing flood control work considerations (i.e. levees),
- environmental considerations, or
- hydraulic modelling considerations.

4.2 Floodway network design

4.2.1 Design flood

The 'design flood' is the event used for the hydraulic design of the floodway network.

The adopted design flood for the FMP is the 1990 historical flood event and is identified as a 25-year average recurrence interval (ARI) event. This flood event was selected because it is a relatively recent event that people can recall and is well-recorded. It is also similar in magnitude to the 1974 flood event used to develop the 1978 Guidelines.

However, the design flood should not be confused with the level of protection achieved against flooding. The level of protection achieved depends on the height to which flood protection levees are constructed. The crest height for a privately funded or constructed levee is selected by the individual landholder. In some instances, the levee crest height is restricted to a maximum level as defined by the FMP floodway network. The level of protection achieved in this instance is governed by the need to allow larger floods to surcharge the floodway network in a controlled manner. Further information on design crest levels is set out in Section 5.1.3.

4.2.2 Goobang Creek inflows

Goobang Creek arises north-east of Parkes and flows westward through Gulgans Gap, officially known as Culgans Gap, joining the Lachlan River at Condobolin. Its catchment can generate significant inflows but these usually do not coincide with the peak of the Lachlan River.

The inflows from Goobang Creek for a 30-year ARI event were estimated using a RORB¹ model of the local catchment. These flows were then used in the MIKE 11 model (see 4.2.3 below) of the Lachlan River, with the Goobang Creek flows timed to pass into the floodplain before the peak of the Lachlan River arrives at Jemalong Gap. The parameters adopted from this modelling were the larger of the 30-year ARI design flows for Goobang Creek and 1990 flows for the Lachlan River.

4.2.3 Hydraulic modelling

Designing the floodway network involved the following tasks:

- reviewing the 1978 Guidelines,
- using a hydraulic model to quantifying the hydraulic adequacy and impacts of the floodway network under varying flood events, but most notably the adopted flow conditions for the 1990 design flood event, and
- considering the adopted floodplain management principles (set out in Section 2.3.1 of the FMP).

Assessment of the hydraulic performance of the floodway network under design flood conditions requires a detailed understanding and knowledge of flooding behaviour. To supplement available information on historical flood events, computer-based hydraulic models can be used to simulate flooding behaviour and assess the impact on flood behaviour of floodway alignment options and any existing or proposed flood control works.

The hydraulic modelling of the FMP floodway network was undertaken using a fully dynamic, one-dimensional hydraulic model known as the Danish Hydraulic Institute's MIKE 11 model. MIKE 11 is a commercially available software package specifically designed for open channel flow computation, particularly river and floodplain systems.

¹ The RORB program is a runoff routing computer program suitable for modelling the hydrologic response from catchments.

The MIKE 11 modelling involved the simulation of the hydraulic behaviour of the existing 1978 Guidelines floodway network using 1952, 1974 and 1990 historical flood conditions. The modelling was undertaken to check the performance of the existing floodway network design using more updated analysis methods and more recent flooding data. The modelling results included water velocities, flow distributions and water surface levels and these were examined in detail in order to quantify the locations of any 'weaknesses' in the design of the floodway network and to assist in changing the network's design parameters.

For detailed information regarding the hydraulic modelling of the FMP floodplain, including input data and calibration methods, refer to the FS and FRMS reports (Parsons Brinckerhoff 2004, 2009).

The adopted 1990 design flood event flow distributions, derived from the hydraulic model, are shown in Figures 4.1 to 4.4 (Appendix C).

4.2.4 Environmental considerations

Environmental considerations in the review of the FMP floodway network focused on the requirements of identified FDEs. Most of the FDEs within the FMP floodplain are not isolated by existing works and are connected to the flooding regime. While the majority of these FDEs were included in the 1978 Guidelines floodway network, some with existing flood access were located outside the floodways. These FDEs have been specifically addressed, and as a result, the FMP floodway network includes a number of sections where the 1978 Guidelines floodway has been adjusted to incorporate FDEs that were previously excluded. This has meant that, in some areas, the floodways are wider than would otherwise be required based on hydraulic factors. Further detail about the environmental approach taken is presented in Section 6 of the FMP.

4.2.5 Groundwater recharge

Groundwater recharge during floods was also considered when designing the floodway network. Although detailed knowledge of groundwater recharge behaviour during floods in the FMP floodplain was not available, major recharge of the shallow aquifer was known to occur in the 1974 and 1990 floods through natural flood runners. The floodway network design incorporated all existing active watercourses thus allowing for ongoing groundwater recharge.

The Jemalong Land and Water Management Plan (Jemalong Land and Water Management Plan Working Group 2001) has identified groundwater accession during floods as a contributing factor towards high water tables in the Jemalong Irrigation Limited Area of Operations. The group has flagged the construction of a series of levees to reduce groundwater accessions. However, details of the location of these levees are subject to soil mapping and are not available at present.

Future levee applications would be assessed in relation to the FMP under Part 8 of the *Water Act 1912* and Part 5 of the EP&A Act as outlined in Section 3.1.4. Impacts on groundwater storage would be specifically considered as part of this assessment.

4.2.6 Social and economic considerations

Social and economic considerations were an ever-present factor when assessing the floodway's hydraulic and environmental issues. The decision to adopt the 1990 historical flood event was largely 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 (i.e. 25 years ARI). 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.

4.3 Floodway vegetation management

Dense vegetation cover within the FMP floodway network may increase hydraulic roughness and reduce efficiency. In some areas of the FMP floodway network, increases in vegetation density could have the effect of blockages and cause redistribution of flood flows or increases in flood levels.

There is a range of measures available under current legislation that may be suitable for thinning vegetation in the FMP floodway network.

4.3.1 Native Vegetation Act 2003

Measures available under the *Native Vegetation Act 2003* include clearing of regrowth and Property Vegetation Plans (PVPs). Landholders proposing to thin vegetation in floodways are advised to contact the Lachlan CMA in the first instance.

Regrowth

Regrowth, which is permitted to be cleared, includes vegetation that has regrown since 1990 on previously cleared land. It does not include protected regrowth (including vegetation within 20 m of the bank of a watercourse) or vegetation that has regrown after clearing caused by a natural event such as fire or flood. Landholders unsure about the status of regrowth on their properties should seek advice from the Lachlan CMA.

Continuing Use PVPs

Continuing Use PVPs provide long-term certainty for ongoing farming practices. They cover a number of provisions for managing native vegetation including identifying regrowth (as above), continuing existing agricultural practices, and, in exceptional circumstances, changing the regrowth date. PVPs that change the regrowth date allow landholders to alter the starting date for regrowth so they can continue existing cultivation, grazing or rotational farming practices. Landholders proposing to prepare Continuing Use PVPs should seek advice from the Lachlan CMA.

Invasive Native Scrub PVPs

Invasive Native Scrub PVPs may be appropriate for clearing native vegetation in floodways in cases where listed species, including black box and river red gum, have regenerated densely following natural or artificial disturbance and the regeneration has resulted in a change of structure or composition within the vegetation community. Invasive Native Scrub PVPs have thinning rules that are suitable for clearing to improve hydraulic efficiency.

Thinning PVPs

Thinning PVPs allow the removal of individual trees and shrubs to pre-determined benchmarks for particular vegetation types. Thinning benchmarks for floodplain vegetation types specify a higher density than is allowable under Invasive Native Scrub PVPs. Consequently, Thinning PVPs may be too restrictive to improve hydraulic efficiency.

4.3.2 Native Vegetation Conservation Act 1997

Certain provisions of the *Native Vegetation Conservation Act 1997* that regulate the removal of exotic vegetation and dead timber on State Protected Land, including land within 20 m of the bed or bank of a prescribed stream, remain in effect. Applications for removing such vegetation may require approval from OEH. Clearing dead trees and exotic trees will not require approval if the clearing is carried out in accordance with the *Guideline for the Clearing of Exotic Trees and Dead Native Trees on State Protected Land* (NSW Government 2006).

4.3.3 Removal of Vegetation on Waterfront Land

The removal of vegetation on 'waterfront land' is a controlled activity under the *Water Management Act 2000*. Waterfront land includes the bed of any watercourse and land within 40 m of its high bank, and the bed of any wetland and land within 40 m of its shore. Under the Act, controlled activities require approval from NOW. However, the Water Management Regulation 2004 exempts activities that comprise nothing more than removing vegetation provided they are lawful under other legislation. Notwithstanding this, landholders may still seek approval for removing vegetation as a controlled activity under the *Water Management Act 2000*, and, if approval is granted, the clearing would be exempt from the requirements of the *Native Vegetation Act 2003*. This ensures that only one approval for clearing native vegetation on 'waterfront land' is required. Clearing approved under the *Water Management Act 2000* would also be exempt from the requirements of the *Native Vegetation Conservation Act 1997*, if applicable (Section 4.3.2).

4.4 Floodway network

The floodway network, incorporating the design levels, is shown on Figures 4.5 to 4.8 (Appendix C).

5 Assessing non-complying works

Landholders applying for approval of non-complying works will need to engage a suitably qualified consultant to investigate the hydraulic and environmental impact of the works. To be compatible with the FMP floodway network design, applications will be assessed against the matters raised in section 166C of the *Water Act 1912* (see Section 3.1.4 of the FMP) and the following hydraulic and environmental measures.

5.1 Hydraulic management measures

5.1.1 Floodway network zones

The predicted peak flow rate distributions, together with the peak flow velocities, indicate four hydraulically independent floodway network zones within the FMP floodplain, namely:

- Zone A Lachlan River floodplain between Jemalong Gap and Bedgerebong including the 17- and 21-mile breakouts,
- Zone B 17- and 21-mile breakout flow paths immediately out of the Lachlan River which do not impact on upstream flood levels in the Lachlan River, and the floodway to Lake Cowal,
- Zone C Goobang Creek and associated creeks and floodplain located downstream of Zone A and Zone B and within the northern floodplain,
- Zone D Lachlan River and the floodplain downstream of Zone A and Zone B; i.e. southern breakouts and Lachlan River within the southern floodplain.

The four identified floodway network zones (shown in Figure 5.1, Appendix C) have different potentials for generating adverse hydraulic impacts, as follows:

- Zone A** **Very high significance.** The flood flow distribution for the balance of the downstream floodplain is established at this location. That is, very small flood level changes could produce significant flood flow redistribution between the southern and northern major flow paths. The hydraulic sensitivity to overall floodplain dynamics is demonstrated by hydraulic model flood flow rate simulations which show that the 17- and 21-mile breakouts can allow significant additional flow to be directed south with modest flood level increases on the Lachlan River. New works within this section of the floodway network are not desirable.
- Zone B** **High significance.** This zone has a well-established floodway levee network. Consequently, the flow redistribution and flood level increases have already been created. Hence, to avoid incremental impacts in the unlikely event that levee banks are moved or works are proposed within the floodway network, the hydraulic criteria should allow no further impacts.
- Zone C** **Medium significance.** This zone is less developed than Zone B, with fewer existing levee banks. Works proposed within the floodway network could be considered because the potential impacts are less significant than those of Zones A and B.
- Zone D** **Medium significance.** This zone is less developed than Zone C, with levees along some creeks. Proposed works within the floodway network could be considered provided flow paths are maintained.

5.1.2 Quantitative hydraulic criteria

Table 5.1 provides quantitative hydraulic criteria for assessing applications for non-complying works. These criteria apply under all flows up to the design flow conditions for the four floodway network zones.

Table 5.1: Quantitative hydraulic criteria

Zone	Maximum afflux (m)	Maximum velocity (m/s)*	Flow redistribution
A	0	< 1 m/s Nil increase	Nil
B	0	< 0.5 m/s	Nil
C	< 0.15	< 0.5 m/s	< 20% locally and nil to Lachlan River
D	< 0.25	< 1 m/s within banks < 0.5 m/s in floodplain	< 20% locally

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

In zones C and D, if the local rise in flood levels is accepted for new works, then the adopted design flood levels may need adjustment, and the nearby works may be able to be raised to accommodate such increases. The works proposed to be undertaken on the boundary of zones will be assessed based on their merits and taking into account the criteria requirements for each zone. The floodway network and the zones' hydraulic criteria are the key tools for managing the FMP floodplain.

5.1.3 Design levels for flood control works

In keeping with the approach taken in the 1978 Guidelines, design flood levels are specified in Figures 4.5 to 4.8 (Appendix C). The levels indicate the allowable maximum heights for works in these areas. Where existing authorised works exceed the allowable maximum heights each work will be assessed on its own merits at the time of renewing the approval.

5.2 Environmental criterion

Existing or proposed non-complying works located in all identified floodways constituting the FMP floodway network as shown on Figures 4.5 to 4.8 (Appendix C) will need to meet the following environmental assessment criterion:

- Do not block, impede or divert the flooding regimes in flood dependent ecosystems within the FMP floodway network.

As well, the environmental impacts of works applications will need to be assessed under Part 5 of the EP&A Act.

6 Environmental assessment of the FMP

6.1 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. However, within the broader floodplain there is a mosaic of environments ranging from terrestrial environments, that are seldom flooded, to aquatic environments that are permanently wet. In the FMP floodplain, land managed for agricultural production also forms part of this mosaic. Clearly, the ecological value of floodplain land will vary according to flooding regime and land use impacts.

The FMP's environmental considerations focus on maintaining or restoring flood connectivity to those parts of the floodplain that are of higher environmental value and support a high proportion of the ecological functions that occur during floods. These are known as flood dependent ecosystems (FDEs) and are defined as areas that have important environmental or cultural features that rely on inundation by floodwaters to sustain essential ecological processes. They include areas of flood dependent vegetation (predominantly river red gum and black box communities), wetlands and floodplain watercourses.

6.2 Assessment approach

The environmental assessment approach was based on identifying FDEs and assessing their flood connectivity. FDEs not affected by existing works were included in the FMP floodway network while those that were blocked or restricted from flooding by works were assessed using a set of environmental assessment criteria that were adopted by the Committee.

FDEs were initially identified from a desktop analysis of vegetation mapping, aerial flood photography and non-flood satellite imagery. This information was further analysed using the 1978 Guidelines floodway network to indicate FDEs that could be potentially isolated from flooding. Ground truthing of the FDEs isolated or potentially isolated from flooding was then undertaken to determine their ecological and flood connectivity status.

Environmental criteria were applied to determine the environmental value of FDEs affected by works and the practicality of modifying the works to reconnect them to the flooding regime. This was done to ensure that the FMP's environmental management measures to reconnect FDEs to flooding were warranted based on ecological factors and had a practical basis. The criteria were applied in two stages:

1 Environmental value assessment

Factors taken into account were:

- site size,
- ecological condition and habitat value,
- representativeness of ecosystem type,
- cultural or historical significance, or both,
- rehabilitation potential,
- hydrology and hydrological connectivity, and
- any special features.

2 Practicality assessment

Factors taken into account were:

- complexity of ownership,
- land-use compatibility,
- land-use impacts, and
- demonstration value.

Cost estimates and practicality issues, based on landholder advice, were also considered as a key part of the assessment process.

A total of 34 potential FDEs located outside the 1978 Guidelines floodway network were assessed with the following outcomes:

- 13 did not contain flood dependent vegetation and were not classified as FDEs,
- 15 were not affected by existing works and were included in the FMP floodway network,
- 1 received inflows from local runoff, and
- 5 were affected by existing works and assessed with environmental value and practicality criteria to determine environmental management measures.

The potential FDE sites assessed individually were a small subset of the FDEs in the FMP floodplain. Many of the FDEs in the FMP floodplain were included within the 1978 Guidelines floodway network and are connected to the flooding regime. Figures 6.1 to 6.4 (Appendix C) show wetland vegetation mapping (prepared by the Department of Water Resources in 1989) in relation to the FMP floodway network. This mapping contains some inaccuracies, including mapped vegetation that has been cleared since the preparation date, but provides an indication of the extent of FDEs in the FMP floodplain.

Detailed information on the environmental assessment, including criteria application, is provided in the FRMS report (Parsons Brinckerhoff 2009).

6.3 Environmental management measures

Proposed environmental management measures include works modifications that can restore flood connectivity to five FDEs (covering up to 100 ha) affected by existing works. In a number of cases where existing works are authorised, environmental works modifications have been proposed for consideration when approvals are assessed for renewal. Environmental management measures are listed below in Table 6.1 (for unapproved works) and 6.2 (for licensed or approved works) and their locations are shown in Figures 4.5 to 4.8 (Appendix C).

With regard to the measures outlined in Tables 6.1 and 6.2, please note the following:

- Landholders should contact NOW in the first instance to obtain all necessary design information where action is required to modify works.
- Modifications to existing *unapproved* flood control works will be administered under the relevant sections of Part 8 of the *Water Act 1912*.
- 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*. See Section 3.1.9 for further information on the procedure for varying the conditions of an approved work.

- With regard to unapproved works, directions for remedial work may be used to direct the occupier to carry out specified work in a specified manner and within a specified time. The types of work that may be directed include work to remove, modify, repair or restore the controlled work or to render the work ineffectual (see Section 3.1.8).
- Section 3 of the FMP has further details regarding approval of flood control works and administration of the FMP under Part 8 of the *Water Act 1912*.

Table 6.1: Environmental management measures for unapproved works

FDE number*	Property	Description	Required measure	Responsibility
E1	Crown land	A levee constructed from the spoil of the Jemalong Irrigation supply channel blocks flood flows to the woodland.	Install a series of gaps in the existing levee. Construction of a bordering levee along the adjoining property boundary is required to prevent flooding to the east of the woodland area.	NOW / Landholder
E23	'Lemnos'	A levee used for stock access blocks inflows to the lagoon during small and moderate floods (large floods outflank the structure).	Install a 0.6 m gated pipe in the levee to allow controlled flooding into the lagoon during small to moderate floods.	NOW / Landholder

* FDE numbers listed are a subset of a larger set of potential FDEs assessed – refer to the FRMS for further information.

Table 6.2: Environmental management measures for licensed or approved works

FDE number*	Property	Description	Required measure	Responsibility
E10	'Sidbury'	An approved levee blocks flows from Goobang Creek from entering the lagoon. The levee allows on-farm access during floods.	When renewal of the approval is assessed, consider options to modify existing works to allow controlled flooding of the lagoon. Options include installing gaps in the existing levee and elevating the access road with a gated box culvert.	NOW / Landholder
		An approved levee adjacent to Goobang Creek blocks inflows to the river red gum/yellow box woodland.	When renewal of the approval is assessed, consider installing gaps in the existing levee and constructing a levee to border the woodland.	NOW / Landholder
E25	'Borambil Park'	An approved levee blocks flows to a runner leading to a lignum depression.	When renewal of the approval is assessed, consider installing a 0.45 m gated pipe in the levee.	NOW / Landholder

Table 6.2 continued

FDE number*	Property	Description	Required measure	Responsibility
E33	'Bogandillon'/ 'Grassmere'	A licensed (Part 2 Water Act) block bank in Manna Creek (constructed for stock water use) near the inflow to Bogandillon Swamp restricts flow connectivity to the swamp. An adjacent constructed bywash channel is unstable and has been eroded.	When the licence is renewed, consider lowering the existing bed works in Manna Creek by 0.6 m and infilling the bywash channel.	NOW / Landholder

* FDE numbers listed are a subset of a larger set of potential FDEs assessed – refer to the FRMS for further information.

6.4 Funding issues

Removal or modification of works incurs direct costs such as earthmoving and pipe installation, and can have indirect costs such as building additional flood control works to protect developed land. In some cases, landholders may be eligible to receive funding from the Lachlan CMA for the removal or modification of works that result in an environmental benefit.

Refer to Section 3.1.14 for information on possible funding sources.

6.5 Floodway adjustments

The 1978 Guidelines floodway was adjusted to include 15 FDEs (covering 630 ha). These FDEs were located outside the 1978 floodway network but were not affected by existing works. The locations of these FDEs are shown in Figures 6.1 to 6.4 (Appendix C) which also display the FMP floodway network and mapped wetland vegetation. Including these FDEs within the floodway network will maintain their flood connectivity in the future because approval for new works in the floodway will not be likely and would only be granted following a detailed impact assessment. More information on the FDEs that were included in the floodway is provided in the FRMS report (Parsons Brinckerhoff 2009).

7 Environmental impacts of the FMP

7.1 Overview

Implementing the FMP will ensure flood flow access to the floodplain area within the FMP floodway network, including an area of about 630 ha of FDEs previously excluded from the 1978 Guidelines floodway. The FMP floodway network has been sized to convey the 1990 flood which has an ARI of about 25 years on the 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 FDEs. Because of these design requirements, the FMP floodway network includes a high proportion of existing FDEs. Figures 6.1 to 6.4 (Appendix C) indicate the extent of FDEs on the floodplain. Future flood connectivity to these ecosystems is reasonably assured since approval for future works within the floodway is unlikely and would only be granted following a detailed impact assessment, including the requirements of the EP&A Act.

The environmental impacts of the FMP have been assessed at a strategic level by considering the impacts on the individual components of the floodplain environment. These impacts are summarised in Table 7.1 below.

Table 7.1: Summary of environmental impacts

Factor	Impact
Soils	<ul style="list-style-type: none"> Flood connectivity will benefit soil condition and structure within the floodway area and undeveloped areas of the floodplain. Floods will provide sediment, soil moisture recharge and nutrient release in these areas.
FDEs (wetlands and watercourses)	<ul style="list-style-type: none"> All FDEs 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 reasonably assured. An additional 100 ha of FDEs lie outside the FMP floodway network and are affected by existing works. Environmental management measures (Tables 6.1 and 6.2) will potentially restore or enhance flood access to these FDEs.
Floodplain vegetation	<ul style="list-style-type: none"> A high proportion of existing flood dependent vegetation, consisting mainly of river red gum and black box woodland, is contained within the FMP floodway network – including an additional 630 ha of FDEs (Figures 6.1 to 6.4*, Appendix C). 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 impact assessment. The potential enhancement of flood flow connectivity to about 100 ha of FDEs affected by existing works is expected to benefit the health and regeneration of floodplain vegetation in these areas. One threatened plant species, Wakool speargrass (<i>Austrostipa wakoolica</i>), has been recorded and six others may potentially occur. Wakool speargrass, winged peppergrass (<i>Lepidium monoplocoides</i>) and austral pillwort (<i>Pilularia novaehollandiae</i>) are confined to floodplain habitats and would be expected to benefit from proposed measures to enhance flood flow access to FDEs. The remaining species do not tend to colonise wetland plant associations and are unlikely to be impacted by the proposed floodplain management measures.

Table 7.1 continued

Factor	Impact
Fauna	<ul style="list-style-type: none"> • By enhancing or maintaining flood connectivity to floodplain ecosystems, the proposed floodplain management measures will benefit terrestrial fauna species relying directly on flooding (e.g. waterbirds) and those utilising floodplain habitats. • Up to 34 threatened fauna species may potentially occur in the FMP area based on known habitat preferences. Of these, four species (magpie goose, freckled duck, Australasian bittern and brolga) directly depend on flooding to maintain their life cycles. Implementing the proposed floodplain management measures will maintain flood flow access to habitat in the floodplain ecosystems currently connected to the flooding regime. The potential enhancement of flood access to an additional 100 ha of FDEs may allow for the expansion of suitable habitat for threatened fauna species on the FMP floodplain.
Aquatic fauna	<ul style="list-style-type: none"> • The FMP floodway network and management measures to potentially restore access to additional floodplain areas (including up to 100 ha of FDEs) will be integral in ensuring ongoing flood connectivity between the river, floodplain watercourses and wetlands. This connectivity is vital in maintaining the habitat value of the FMP floodplain as a food source for aquatic invertebrates and fish and as a breeding ground for migratory fish including golden perch and silver perch, which is a threatened species. • This is expected to benefit the aquatic ecological community of the lowland Lachlan River catchment (listed as an endangered ecological community) including Murray cod, a nationally listed threatened species recorded on the FMP floodplain, and other listed threatened species which potentially inhabit the FMP floodplain.
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 because 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 regime will allow for a continuation of flood dilution and flushing of salt in wetlands and floodplain watercourses. The potential reconnection of flood flows to an additional area of up to 100 ha of FDEs is expected to enhance these processes in these ecosystems.
Groundwater	<ul style="list-style-type: none"> • Detailed information on groundwater recharge behaviour over the FMP floodplain during floods is not available. However, major recharge of the shallow aquifer occurred in the 1990 flood through natural flood runners. All existing active watercourses are included in the proposed floodway network thus allowing for ongoing groundwater recharge during floods. Recharge from the shallow aquifer to deeper aquifers occurs through pressure-driven leakage and is a long-term process. • The Jemalong Land and Water Management Plan (LWMP) (2001) identifies groundwater accession during floods as a factor contributing to high water tables and salinity issues in the Jemalong district. The LWMP has flagged the construction of a series of levees in the floodways below the 17- and 21-mile breakouts to reduce groundwater accessions. At this stage, mapping is planned to identify areas of lighter soil that potentially would be isolated from flooding by levees. The LWMP predicts that about 300 ha of the floodway area (under 2%) would be isolated from flooding. When further details become available, the proposal will need to be assessed in relation to the FMP.

Table 7.1 continued

Factor	Impact
Aboriginal heritage	<ul style="list-style-type: none"> • Information on the location of recorded Aboriginal sites on the FMP floodplain has been obtained from the Aboriginal Heritage Information Management System. Aboriginal site types of greatest relevance to the FMP are likely to include scarred river red gum or black box trees, wetlands and watercourses of spiritual importance (flood dependent) and burial sites (subject to erosion impacts). Recorded Aboriginal sites that are flood dependent are largely contained within FDEs that lie within the FMP floodway network and ongoing flood access to these sites is reasonably assured. Four recorded scarred or carved trees are situated outside the FMP floodway network in relatively clear areas which did not receive general flooding in the 1990 flood. • Other Aboriginal sites (not recorded) that are flood dependent are expected to be largely contained within FDEs. The FMP floodway network includes all FDEs with existing connectivity to the flooding regime and a high proportion of all FDEs on the floodplain (as indicated by Figures 6.1 to 6.4). Ongoing flood access to unrecorded Aboriginal sites that are flood dependent is therefore reasonably assured. Additionally, environmental management measures (Tables 6.1 and 6.2) that will potentially reconnect up to 100 ha of FDEs currently affected by works will benefit the longevity of any flood dependent Aboriginal sites in those FDEs. • Flood damage to on-ground Aboriginal sites (such as burial sites) may occur naturally. However, the FMP floodway network has been designed to minimise flood velocities, and, accordingly, would be expected to reduce the risk of erosion damage to these sites during floods.
European heritage	<ul style="list-style-type: none"> • Listed historical sites include the Fitzgerald Family Graves (1879), marking a family drowning tragedy at Island Creek, the Cadow Homestead Cemetery (1860) just south of the Lachlan River, the Hodges Family Cemetery (late 1800s) and the Spring Grove Cemetery (1887) near the Lachlan at Bedgerebong. These sites are located on higher ground and are not likely to be flooded. Implementing the proposed floodplain management measures is unlikely to significantly impact on other historical sites because potential erosion damage from flooding will be minimised.

* Mapped wetland vegetation on Figures 6.1 to 6.4 lying outside the FMP floodway network includes FDEs identified with environmental measures, some areas that have been cleared since the mapping preparation date and some incorrectly identified areas on higher ground.

7.2 Catchment impacts

The catchment directly upstream of Jemalong Gap includes the broad floodplain of the Lachlan River and Bundaburrah Creek west of Forbes. This area contains important wetlands, such as Jemalong Swamp, and is included in the Gooloogong to Jemalong Gap Floodplain Management Plan that is currently in preparation. The principles guiding decision-making in that FMP are consistent with those in this FMP and consequently measures in both FMPs are expected to provide compatible outcomes.

The floodway network just downstream of Jemalong Gap drains to Lake Cowal – a significant wetland supporting a high diversity of waterbirds and native fish when flooded. Overflows from Lake Cowal drain to the smaller Nerang Cowal then into Manna Creek, Bogandillon Swamp and Wallamundry Creek. Impacts of the 1978 Guidelines floodway network on flows to Lake Cowal were assessed by the Department of Water Resources (1992) following concerns from lake landholders that levees along the floodway were restricting floodplain

storage and delivering increased flows into the lake. The study assessed the significance of denied flood storage during small and large floods. It found that, for smaller floods reaching the lake, the volume of denied storage was considered to be insignificant. To assess the impact of the floodway on larger floods, the 1990 flood was analysed. The study found that the volume of flood storage denied in 1990 was less than 0.5% of the total volume of outflow from the Lachlan River into the Lake Cowal floodway, and would have little or no impact on flood levels in the lake.

The Lake Cowal floodway levees are designed to overtop during floods larger than the 1974 flood (slightly higher than the 1990 flood) and the temporary storage provided when floodwaters are retained behind the levees would reduce peak flow and volume into the lake. This reduction would vary according to the size of the flood but is not expected to impact on the ecology of the lake, since the lake would fill prior to the overtopping of the levee system. Floodwaters overtopping the floodway levees would drain westward into Manna Creek and Bogandillon Swamp.

At the western end of the FMP floodplain, the floodway network drains to the Lachlan River, Nerathong Creek and Wallaroi Creek floodplains downstream of Condobolin. The 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 and historical conditions. The FMP floodway network will preserve flood flow paths and allow for future delivery of the flood regime to downstream ecosystems.

8 Monitoring and review

8.1 Performance indicators

The performance of the FMP will be assessed against three performance indicators:

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

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

Hydraulic indicators

- Improved passage of flood waters through the FMP floodplain,
- Structures performing to the agreed hydraulic criteria.

Environmental indicators

- Improved fish passage,
- Improved habitat for plants and animals that utilise floodplains,
- Increased flood connectivity to wetlands,
- Structures performing to the agreed environmental criteria.

Economic indicator

- Less flood damage.

Social indicator

- Clarity for the community in actions carried out during a flood.

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

8.2 Flood monitoring

Monitoring of hydraulic flood behaviour will identify any problem areas and whether any modifications or upgrades are required. Depending on the size of the flood, monitoring will range from simple observation to measuring of flows and levels followed by additional hydraulic analyses. The larger floods, nearing the design flood levels, should be monitored in more detail. In particular, as the hydraulic modelling has a significant degree of reliance upon flow estimates, especially peak flows, it will be important to collect data to verify these estimates. Appendix B lists critical areas for gauging flood flows in the larger floods.

OEH will lead the planning and implementation of monitoring programs and will seek input from NOW, Forbes and Lachlan Shire Councils and landholders. The following activities are recommended:

- OEH should undertake aerial photography, collection of satellite imagery and surveys,
- NOW should undertake stream gaugings and flow measurements, and
- where safe to do so, OEH, Forbes and Lachlan Shire Councils 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. Councils should provide an estimate of flood damage to public roads and infrastructure.

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

8.3 Environmental monitoring

Environmental monitoring during and after floods will determine whether the 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.

OEH should collate environmental data from Forbes and Lachlan Shire Councils, landholders and other agencies. Council and landholders could observe their areas of the floodplain, noting:

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

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

8.4 Operational issues

Effective implementation of the proposed floodplain management measures requires that a number of operational issues be addressed. These issues are discussed below.

8.4.1 Gated pipe operation

Gated pipes through banks are proposed at some sites to allow controlled flooding of FDEs. The operation of these gates will be specified as a condition of the approvals for the associated flood control works. The gates would be opened when a suitable threshold of flooding has been reached and would remain open until the FDE has been filled. Logistical problems may arise when landholders or managers are absent at the onset of a flood. Contingency plans to provide alternative means of gate operation will need to be prepared to address this issue.

8.4.2 Maintenance of works

Maintaining proposed and existing works in sound condition will be essential for maintaining flood connectivity to FDEs. Pipe works and culverts are prone to siltation and should be checked periodically, particularly following floods or heavy local rain, to optimise their operation.

8.5 Model review

The flood model developed for the Lachlan River Jemalong Gap to Condobolin floodplain is a tool to help manage the floodplain in accordance with the FMP. The model may require updating as the floodways develop and as new data becomes available. The appropriate frequency of any updates depends on the extent of changes and may be affected by results derived from the ongoing monitoring of the flood plain.

8.6 Plan review

Floodplain management plans adopted as Minister's plans under the WMA are required to be reviewed at five-yearly intervals to determine whether their provisions are being put into effect.

If new flood data comes to light following a major flood, the FMP may need to be reviewed and updated earlier than the statutory five-year review. Triggers for review can also include changes to land use, impediments to implementation, and changes to factors that influence decisions. Climate change has the potential to result in many direct and indirect incremental changes to floodplains including their hydrology and the institutional framework in which floodplains are managed. Climate change has the potential to alter flood patterns due to changes in monthly average rainfall, the distribution of rainfall, rainfall intensity and flood frequency estimates. Changes to groundwater and soil moisture levels could further influence the magnitude and duration of floods.

9 References

- Department of Environment and Heritage (1999) *Commonwealth Environmental Protection and Biodiversity Conservation Act*
- Department of Land and Water Conservation (2001) *Mid-Lachlan Region Vegetation Mapping. Native Vegetation Resource Package for the Mid-Lachlan Region*
- Department of Land and Water Conservation (1997) *NSW Weirs Policy*
- Department of Land and Water Conservation (2002) *State Groundwater Dependent Ecosystems Policy*
- Department of Natural Resources (1993) *State Rivers and Estuaries Policy*
- Department of Primary Industries (2005) *NSW Recovery Plan for Silver Perch*
- Department of Primary Industries, Water and Environment (1996) *Wetlands Management Policy*
- Department of Water Resources (1992) *Lachlan River to Lake Cowal Floodway Scheme – Impact on Lake Cowal*
- Department of Water Resources (1993) *Forbes Flood Study Report*
- Jemalong Land and Water Management Plan Working Group (2001) *Jemalong Land and Water Management Plan*
- Lachlan Catchment Management Authority (2006) *Lachlan Catchment Action Plan 2006–2016*.
- Murray Wetlands Working Group (2002) *Wetlands Watch: A Field Guide for Monitoring Wetlands in the Southern Section of the Murray–Darling Basin*
- NSW Government (2004) *Water Sharing Plan for the Regulated River Source – Lachlan River*
- NSW Government (2005) *Floodplain Development Manual*
- NSW Government (2006) *Guideline for the Clearing of Exotic Trees and Dead Native Trees on State Protected Land*,
www.environment.nsw.gov.au/resources/vegetation/splguideline.pdf
- NSW Government (2011) *NSW 2021: A Plan to Make NSW Number One*, NSW Government, Sydney.
- Parsons Brinckerhoff (2004) *Lachlan River (Jemalong Gap to Condobolin), Lachlan, NSW – Rural Flood Study* (the FS referred to throughout this FMP)
- Parsons Brinckerhoff (2009) *Lachlan River Jemalong Gap to Condobolin Floodplain Risk Management Study* (the FRMS referred to throughout this FMP)
- Water Resources Commission (1978) *Guidelines for Floodplain Development Lachlan River Jemalong Gap to Condobolin*.

Appendix A – Information that must accompany the Part 8 application form

1 Proposal plan

In order for an application to be assessed, a plan providing full details of the proposal must accompany the application.

The plan should show the following:

- Property boundaries: Clearly delineate the external boundary of the entire property, as well as any internal boundaries (portions, closed roads etc.). The correct cadastral description should be shown for each parcel of land within the property i.e. Lot and Deposited Plan (DP) number, Portion, Parish and County.
- Adjoining properties: Show name of property and owners name.
- Location of all existing and proposed infrastructure:
 - floodways,
 - channels,
 - levees,
 - storages,
 - head ditches,
 - tail return drains,
 - pumps.
- Dimensions to be shown include the height of structures, particularly the heights of perimeter structures relative to the adjacent natural surface. It is important to show the full development, and not simply a line enclosing the area of the proposed development.
- General topographic features:
 - watercourses, rivers, creeks,
 - lakes and wetlands,
 - location of and description of native vegetation communities.
- Other infrastructure:
 - roads,
 - buildings,
 - railways,
 - services – powerlines etc.
- The following information should also be shown:
 - property name,
 - applicant name/s,
 - scale,
 - north point,
 - date.
- Reference datum:
 - Vertical: Australian Height Datum (AHD),
 - Horizontal: Australian Map Grid (AMG).

The plan should be A4 or A3 size to enable ease of copying. If larger plans are needed to show detail, please provide A3 copies as well. If colour plans are submitted, please provide five copies.

To provide a plan to the required standards, you will normally require the services of a registered surveyor.

2 Guidelines for assessment where a flood work proposal does not comply with an existing floodplain management plan

The applicant will be responsible for demonstrating that a proposed work will not have a significant or adverse affect on the redistribution of floodwaters. A consultant should be engaged for this purpose. A flood study from a consulting engineer is required to support a flood work proposal.

The following guidelines are provided to ensure that sufficient information is obtained to enable NOW to make a full assessment of the application:

- (1) Include relevant historical flood data (depending on applicability and availability):
 - flood photography (oblique, vertical, ground),
 - remote sensing imagery (satellite imagery of historical flood events)
<http://www.auslig.gov.au/acres/>,
 - flood marks levelled to Australian Height Datum (AHD),
 - topographic surveys (DTM, cross-sections etc. used to support hydraulic analyses),
 - field measurements of flood flows taken during floods,
 - flood references in historical or private journals (description of local flood behaviour).
- (2) Include mapped local flow paths and an estimate of flow distributions for at least the adopted design flood magnitude (this would require some sort of calibrated computer modelling approach) under natural, present and proposed conditions.
- (3) Include hydraulic analysis results quantifying impacts attributed to the proposal (the method used will need to include hydraulic analysis to estimate afflux – increase in upstream flood levels, estimate of potential flood flow redistributions, and velocity and erosion potential).
- (4) Include a conclusion or summary describing the effect of the proposal including any changes to the FMP floodway network (refer to Section 4) and a comparison assessment with the adopted quantitative hydraulic criteria (refer to Section 5.1).
- (5) Ensure that neighbouring landholders have been consulted and their concerns (if any) noted and addressed.
- (6) Identify all other existing works in the vicinity of the proposal and their possible impacts on flooding:
 - Consider cumulative effects – if similar works are to be constructed in the vicinity or others were to develop to the same extent.
 - Consider the effect of statutory and local authorities' infrastructures on flooding and drainage within the study area.

- (7) Consider the environmental impact of the proposed development, such as potential barriers to river and floodplain connectivity that could affect the wellbeing of FDEs such as wetlands, river red gum forests etc.

Note:

The above list is not exhaustive. Include any other information considered to be relevant. Further information may be necessary, depending upon the nature of the development.

Appendix B – Monitoring activities template and guidelines

Flood monitoring guidelines for landholders

The following advisory notes specify monitoring activities that should be undertaken by landholders, Forbes and Lachlan Shire Councils, OEH and NOW. The collected monitoring data will assist the FMP review process at the required five-yearly intervals and after major flooding events. If necessary, modifications to the FMP could be recommended based on the findings of the review process.

a) Hydrologic and hydraulic data

Flood event characteristics

- 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).
- Compare the flooding with other flood events experienced.

Data near streamflow gauging stations

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

Floodplain data

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

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

b) Flood damage

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

Farm loss incurred

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

Road damage

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

Erosion and siltation

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

c) Environmental data

Wetland data

- Monitor the performance of works modifications specified in Tables 6.1 and 6.2 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 in the wetland at different times.
- Note and photograph the condition and variety of wetland plant species over time.

Floodplain vegetation (black box, river red gum, lignum) data

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

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 10s, 50s or 100s.
- 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*.

d) Aerial and ground photography

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

Photograph:

- areas flooded and areas not flooded,
- areas of active flow and backwater,
- main flow paths,
- known earthworks such as levees, banks, channels,
- known problem areas,
- roads and railways,
- environmental information, as outlined in (c) above,
- time and date each photograph was taken.

Monitoring questionnaire

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

Landholder monitoring questionnaire

Hydrologic and hydraulic data

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

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

Duration of inundation _____ hours/days

Depth of inundation _____ metres at location _____

Flow velocity estimates _____ metres per second at location _____

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

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

Compare with previous floods – larger/smaller, etc.

Flood damage

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

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

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

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

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

Environmental data

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).

Where works modifications have been carried out to reconnect wetlands:

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.

Council monitoring activities

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

Road structures

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

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

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

OEH monitoring activities

OEH's role in monitoring includes the following activities:

Flood photography

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

Survey data

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

Consultation activities

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

Flow data

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

Environmental data

Fish and aquatic invertebrates

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

Vegetation

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

Additional data

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

Appendix C – Figures

Figures 4.1 to 4.4	1990 flood model results (flows and velocities)
Figures 4.5 to 4.8	FMP floodway network
Figure 5.1	FMP floodway network zones
Figures 6.1 to 6.4	FMP floodway network and mapped wetland vegetation

The above figures are available as separate downloads for this web version of the document.

