



Floodplain Management Plan

*Edward and Niemur Rivers Stage 3
Moama–Moulamein Railway to Liewah and Mallan*

January 2011

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The Stage 3 floodplain management plan project is indebted to the Central Murray Floodplain Management Committee and the landholders who provided input and allowed access to private property. The cooperation received from landholders greatly assisted the collection of data and information on local land use and flooding history.

Cover photos (clockwise from main photo):

Niemur River and Murrain-Yarrein Creek confluence during October 1993 flood
(Steve Hogg, NSW Department of Water Resources)

Levee and black box woodland near Edward River (Jamie Kaye, Earth Tech)

Downstream reach of Niemur River during October 1993 flood
(Steve Hogg, NSW Department of Water Resources)

Black box wetland near Edward River (Jamie Kaye, Earth Tech)

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Abbreviations

AHD	Australian Height Datum
ALS	Airborne laser scanning (also known as LiDAR)
ARI	Average recurrence interval
CMA	Catchment Management Authority
CMFMC	Central Murray Floodplain Management Committee
DECCW	Department of Environment, Climate Change and Water NSW
DPI	NSW Department of Primary Industries
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i>
FDE	Flood dependent ecosystem
FMP	Floodplain management plan
FRMS	Floodplain risk management study
LiDAR	Light detection and ranging technology (also known as ALS)
LALC	Local Aboriginal Land Council
MIL	Murray Irrigation Limited
Murray REP2	Murray Regional Environmental Plan No. 2 (1994)
MWWG	Murray Wetlands Working Group
NOW	NSW Office of Water
NPWS	National Parks and Wildlife Service (DECCW)
PVP	Property Vegetation Plan
REP	Regional Environmental Plan
SMEC	Snowy Mountains Engineering Corporation
SPOT 5	Satellite Pour l'Observation de la Terre (Earth observation satellite)
WMA	<i>Water Management Act 2000</i>

Preface

The NSW Government's Flood Prone Land Policy aims to provide solutions to existing flooding problems and ensure that new development within flood prone areas is compatible with the prevailing flood risk and does not create additional flooding problems in other areas. Under the policy, the rural flood risk within New South Wales for those areas west of the Great Dividing Range is managed by the NSW Government. These management provisions are set out in Part 8 of the *Water Act 1912*, under which this Stage 3 floodplain management plan (Stage 3 FMP) is to be adopted and gazetted.

The Department of Environment, Climate Change and Water (DECCW) is responsible for preparing rural floodplain management plans that define requirements for managing floodwaters within floodplains. Approval of works and compliance functions under Part 8 of the *Water Act 1912* are the responsibility of the NSW Office of Water (NOW), which has been established as an office within DECCW.

The 'Stage 3 floodplain' referred to in this FMP is the floodplain of the Edward and Niemur Rivers between Moama–Moulamein railway, Liewah and Mallan.

Developing this FMP

Developing the management framework for the Stage 3 floodplain has progressed through three primary steps:

- preparation of a flood study – defining the nature and extent of flooding and flood-related issues (hydraulic, environmental, and cultural) in technical terms
- preparation of a floodplain risk management study (FRMS) – evaluating management options for the floodplain that consider the hydraulic, environmental, social and economic issues, and
- preparation of this floodplain management plan (the Stage 3 FMP) – outlining strategies to manage flood risk and flood management issues, and support the natural functions of the floodplain environment.

Separate FMPs have been prepared concurrently for the adjoining Stage 1 and Stage 2 floodplains (Edward and Wakool Rivers). The FMP for the downstream Stage 4 floodplain (Edward and Wakool Rivers) was completed in 2000 (DLWC) 2000.

All the investigations leading to the preparation of this Stage 3 FMP are documented in the Edward and Wakool Rivers Stages 1, 2 and 3 flood study report (SMEC 2004) and the Edward and Wakool Rivers Stages 1, 2 and 3 floodplain risk management study (FRMS) (Maunsell AECOM 2009).

The Stages 1, 2 and 3 FMPs were publicly exhibited from March to April 2010 and submissions received were taken into account in the preparation of the final plans.

Funding for the Stages 1, 2 and 3 FMPs was provided by the Commonwealth Natural Disaster Mitigation Program with financial support from the state.

Replacing the 1989 Guidelines

This Stage 3 FMP replaces the *Guidelines for Edward and Niemur Rivers Floodplain Development, Moama–Moulamein Railway to 'Liewah'* prepared in 1989 (the '1989 Guidelines'; WRC 1989). The 1989 Guidelines had served as the basis for floodplain management within the Stage 3 floodplain for the past 19 years. They had become outdated under current legislative requirements and natural resource management principles and needed to be revised; hence the preparation of this FMP.

Developing a floodway network

The Stage 3 FMP provides for future floodplain management by establishing a coordinated network of floodways (the Stage 3 floodway network) to effectively convey floodwaters and support the floodplain environment. The Stage 3 floodway network has been designed to convey floods of up to and including the 1975 flood magnitude, which is about a 20 year average recurrence interval (ARI) event.

The Stage 3 FMP, including the Stage 3 floodway network, forms 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. Works located within floodways are likely to be refused or will require modification or removal. The Stage 3 FMP also identifies a number of existing flood control works that require modification to address hydraulic and environmental issues.

Flood dependent ecosystems

The Stage 3 floodplain contains many ecosystems that rely on flooding to sustain essential ecological processes. Connecting floods to these ecosystems has been a key consideration in preparing the FMP. A high proportion of existing flood dependent ecosystems (FDEs) have been captured within the Stage 3 floodway network, thereby assuring their ongoing flood connectivity.

The development of infrastructure such as roads, channels and levees over many years has disconnected a number of wetlands and watercourses from flood access. These ecosystems have been individually assessed during preparation of the FMP to determine their environmental value and the practicality of restoring their flood connectivity.

Measuring the FMP's performance

The Stage 3 FMP will be assessed against two performance indicators:

- flood control works are to comply with the Stage 3 floodway network, and
- the Stage 3 floodway network is to perform adequately in floods.

Performance will be assessed using information gathered during flood monitoring activities and measured against the hydraulic, environmental and economic objectives outlined in the Stage 3 FMP.

Dense vegetation cover within the Stage 3 floodway network may increase hydraulic roughness and reduce floodway efficiency. Under the *Native Vegetation Act 2003* and other legislation there are several options for managing vegetation so the floodway network is maintained and operates as designed during floods.

Reviewing the FMP

It is expected that the Stage 3 FMP will, in the future, be adopted as a Minister's plan under the *Water Management Act 2000*. Under this Act, FMPs are required to be reviewed at five-yearly intervals. Triggers for review also include significant floods, changes to land use and changes to factors that influence decisions. Climate change has the potential to alter flood patterns due to changes in monthly average rainfall, the distribution of rainfall, rainfall intensity, soil moisture conditions and flood frequency estimates. Any direct or indirect impacts of climate change on agriculture will have a strong flow-on effect on floodplain management as most rural floodplain landowners are primary producers. Early adaptive responses will reduce longer-term vulnerability and economic costs. Therefore, any review of the Stage 3 FMP will look at the FMP's capacity to adapt to address climate change impacts on flood risk, flood dependent ecosystems and rural economies.

1 Introduction

1.1 Vision and objectives

This Stage 3 floodplain management plan (Stage 3 FMP) has been prepared to provide strategic guidance for the NSW Government agencies and landholders involved in managing floodwaters on the Edward and Niemur River (Moama–Moulamein railway to Liewah and Mallan) floodplain.

The vision for the Stage 3 FMP is:

to design a floodway network capable of transmitting the design flood volume, that minimises the social and economic impact of flooding, while maximising environmental watering within the floodplain where practically and economically possible.

The objectives linked to this vision statement 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.

The process leading to the preparation of the Stage 3 FMP began in 2000. The first step was a data collection and flood study, followed by a floodplain risk management study (FRMS). Extensive community consultation activities have taken place including focus group meetings, community workshops, distribution of newsletters and questionnaires, and on-site meetings with individual landholders to discuss specific issues. Consultation has also included meetings with representatives of Local Aboriginal Land Councils.

The Stage 3 FMP has been prepared with advice from the Central Murray Floodplain Management Committee (CMFMC). The CMFMC has 36 members including representatives of government agencies, landholder groups and individual landholders. The CMFMC is responsible for representing local community issues relating to flooding and assisting with the preparation of floodplain management plans in the Central Murray area.

FMPs have been prepared concurrently for the adjoining Stage 1 and Stage 2 floodplains. The FMP for the Stage 4 floodplain was completed in 2000 and gazetted in 2002. The FMP for the Tuppall and Bullatale Creek floodplains located upstream of Deniliquin was completed in 2004 (DIPNR 2004) and gazetted in 2006. Figure 1 shows the location of the Edward–Wakool floodplains (Stages 1, 2 and 3) within the NSW Murray catchment. Figure 2 shows the Central Murray system.

The Stage 3 FMP must be considered by NOW when reviewing and determining approval applications for flood control works under the *Water Act 1912* or the *Water Management Act 2000* when this is applied.

1.2 Overview of the Stage 3 floodplain

The Stage 3 floodplain is shown in Figure 3. It comprises that portion of the Central Murray floodplain located between the Moama–Moulamein railway (upstream limit) and Liewah (Edward River downstream limit) and Mallan (Niemur River downstream limit). The Stage 3 floodplain is located entirely within the Wakool Shire.

The terrain within the Stage 3 floodplain is very flat. Ground level elevations fall from approximately 71 m AHD at Moulamein to 64 m AHD at Liewah over a straight line distance of 38 km (an average straight line grade of 1 in 5400 for this reach of the Edward River). The Niemur River reach within the Stage 3 floodplain falls from 75 m AHD at the Moama–Moulamein railway to 68 m AHD upstream of Mallan (a straight line grade of 1 in 6400).

Land use within the Stage 3 floodplain is a mixture of cropping and livestock. Cropping is particularly sensitive to flooding, with inundation durations of a few days sufficient to kill most crops. The average farm size is in the vicinity of 1000 ha. Average annual rainfall is less than 400 mm, and river system flooding within the Stage 3 floodplain is independent of local rainfall.

Numerous levees have been erected within the Stage 3 floodplain since the late 1800s to confine flooding. An approval process for flood control works has been in place since around the 1930s; however, it was not until 1989 that detailed guidelines were prepared to help authorities control development on the floodplain.

Flooding characteristics – Central Murray system

The Edward, Niemur and Wakool River system is an anabranch of the Murray River. The Edward River offtake from the Murray River is located within the Barmah–Millewa Forest between Tocumwal and the Barmah Choke (see Figure 2).

The severity of flooding within the Stage 3 floodplain (see Figure 3) depends on flow conditions within the Edward River at Deniliquin. Flooding in the Edward River downstream of Moulamein also depends on inflows from Billabong Creek and Forest Creek.

Flooding in the Edward River at Deniliquin depends on:

- peak Murray River flow downstream of Tocumwal
- volume of floodwaters downstream of Tocumwal, and
- the water level in the Murray River downstream of the Barmah Choke, which largely depends on Goulburn River flooding behaviour.

The presence of the Barmah Choke contributes to a significant portion of Murray River flows being directed into the Central Murray system directly via the Edward River, and additionally via the Tuppal and Bullatale Creek systems in moderate and large flood events. The Murray River floodplain has an upper limiting flood flow discharge capacity of 30,000 to 35,000 ML/day at the Barmah Choke.

Flooding within the Billabong Creek and Forest Creek systems is independent of flooding conditions within the Murray River system. Consequently inflows from Billabong and Forest Creeks can be severe when flows in the Edward River upstream of Moulamein are quite minor, and vice versa.

Flooding characteristics – Stage 3 floodplain

See Figure 2. Key features of the Stage 3 floodplain system are:

- The Edward River floodway along the northern boundary of the Stage 3 floodplain. This reach has few levees. Flooding in this reach depends on inflows from Billabong and Forest Creeks in addition to the upstream Edward River flows.
- The Yarrein Creek floodway, generally located 2–5 km south of the Edward River floodway. The Yarrein Creek floodway has few levees, and a lack of floodwater in

recent years has been more of an issue than flooding induced problems. There is little or no interchange of flow from Yarrein Creek to the Edward River in minor and moderate floods. Yarrein Creek is connected to the Niemur River floodway via Gum Creek and additionally to the Murrain Yarrein Creek via Little Yarrein Creek.

- The Murrain Yarrein Creek floodway flows into the Niemur River floodway 10 km downstream of the Moama–Moulamein railway.
- The Niemur River floodway is up to 7 km wide and generally more than 2 km wide, with the exception of the extreme upstream and downstream reaches within the Stage 3 floodplain. It is predominantly lined with levees. Flows within the Niemur floodway split between the Niemur River and Cunninyeuk Creek floodway arms at the downstream end of the Stage 3 floodplain.

Flooding is particularly complex within the Niemur River floodway upstream of the Cunninyeuk Creek and Niemur River flow split. In this reach, multiple watercourses – including Buccaneit Creek, Pelham Creek, Burragorrima Creek, Ooronong Creek and Middle Creek – convey flows within the active parts of the floodplain around numerous areas protected by ring levees.

The ten largest floods on record, based on recorded heights and flows for the Edward River at Deniliquin, are listed in Table 1.1. The only notable flood to have occurred since 1993 was the October 1996 flood which peaked at 8.05 m at Deniliquin and 4.83 m at Moulamein.

Table 1.1: Historical floods

Flood event	Edward River at Deniliquin		Edward River at Moulamein	
	Peak height (m)	Peak flow (ML/day)	Peak height (m)	Peak flow (ML/day)
1870	9.68	220,000	n/a	n/a
1917	9.63	210,000	n/a	n/a
1956	9.37	152,000	6.10	34,000
1975	9.04	116,000	5.55	19,000
1889	9.09	115,000	n/a	n/a
1931	8.99	109,000	6.00	30,000
1955	8.95	107,000	5.39	17,000
1993	8.48	83,000	5.28	15,000
1939	8.26	77,000	5.49	18,000
1981	8.21	76,000	5.53	19,000

Floodplain environment – Stage 3 floodplain

The Stage 3 floodplain contains large areas of ecologically productive wetlands and floodplain watercourses that rely on periodic flooding for their long-term sustenance. The flood dependent river red gum, black box and lignum are the dominant native plants on the floodplain. The floodplain supports a diversity of native fauna including species that depend on flooding for breeding success (such as fish and waterbirds) and species that use floodplain habitats (such as honeyeaters and bats).

The Stage 3 floodplain is culturally important due to Aboriginal and European settlement. Aboriginal people traditionally occupied the well-watered parts of the landscape where resources were plentiful. The Stage 3 floodplain covers the traditional nation of the Wamba Wamba. Aboriginal sites of particular relevance to the Stage 3 FMP include scarred trees that are flood dependent (river red gum and black box) and spiritually significant wetlands and watercourses. Listed sites of European heritage value have also been considered in the preparation of the Stage 3 FMP.

Figure 2: Central Murray system

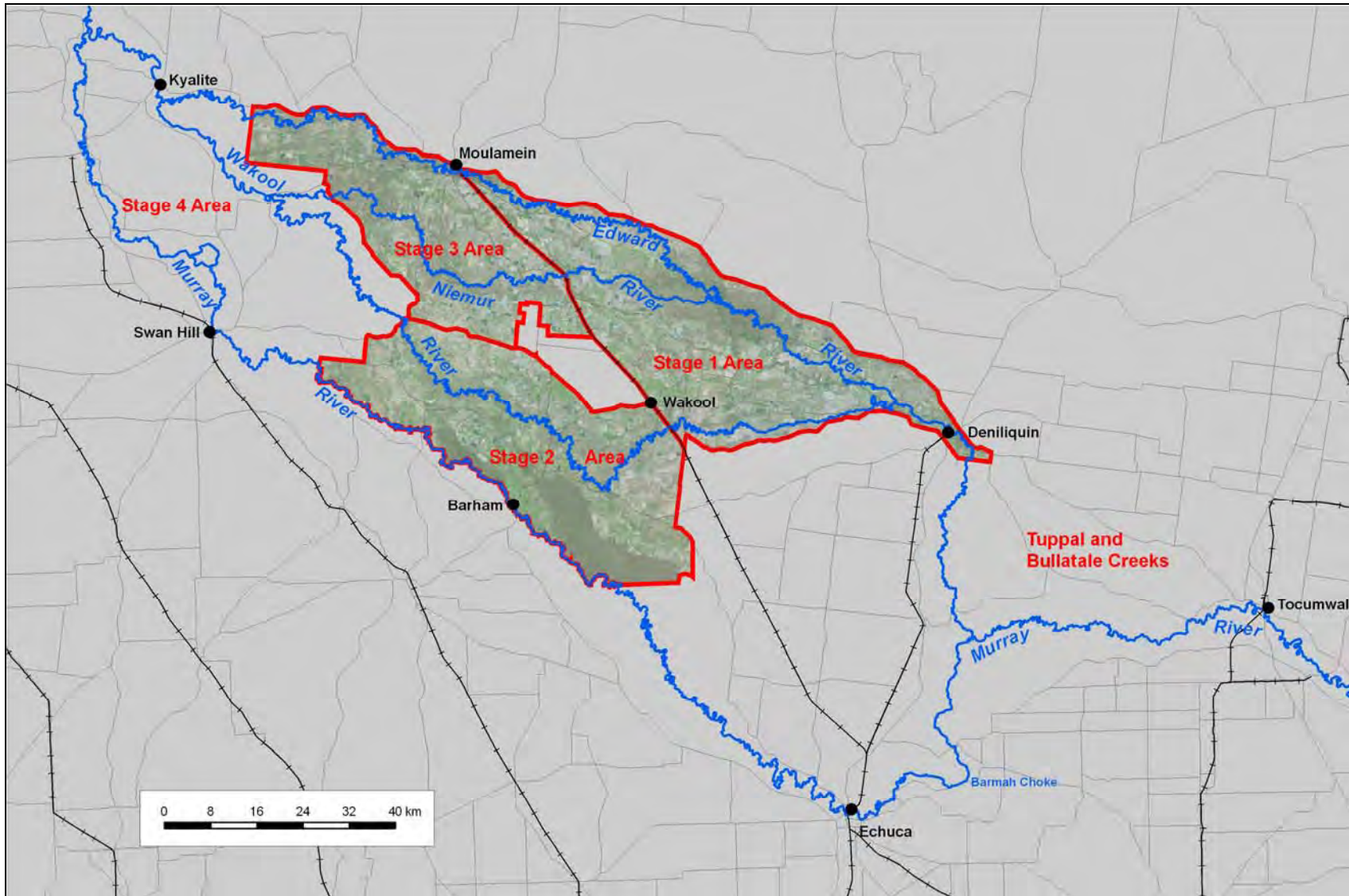
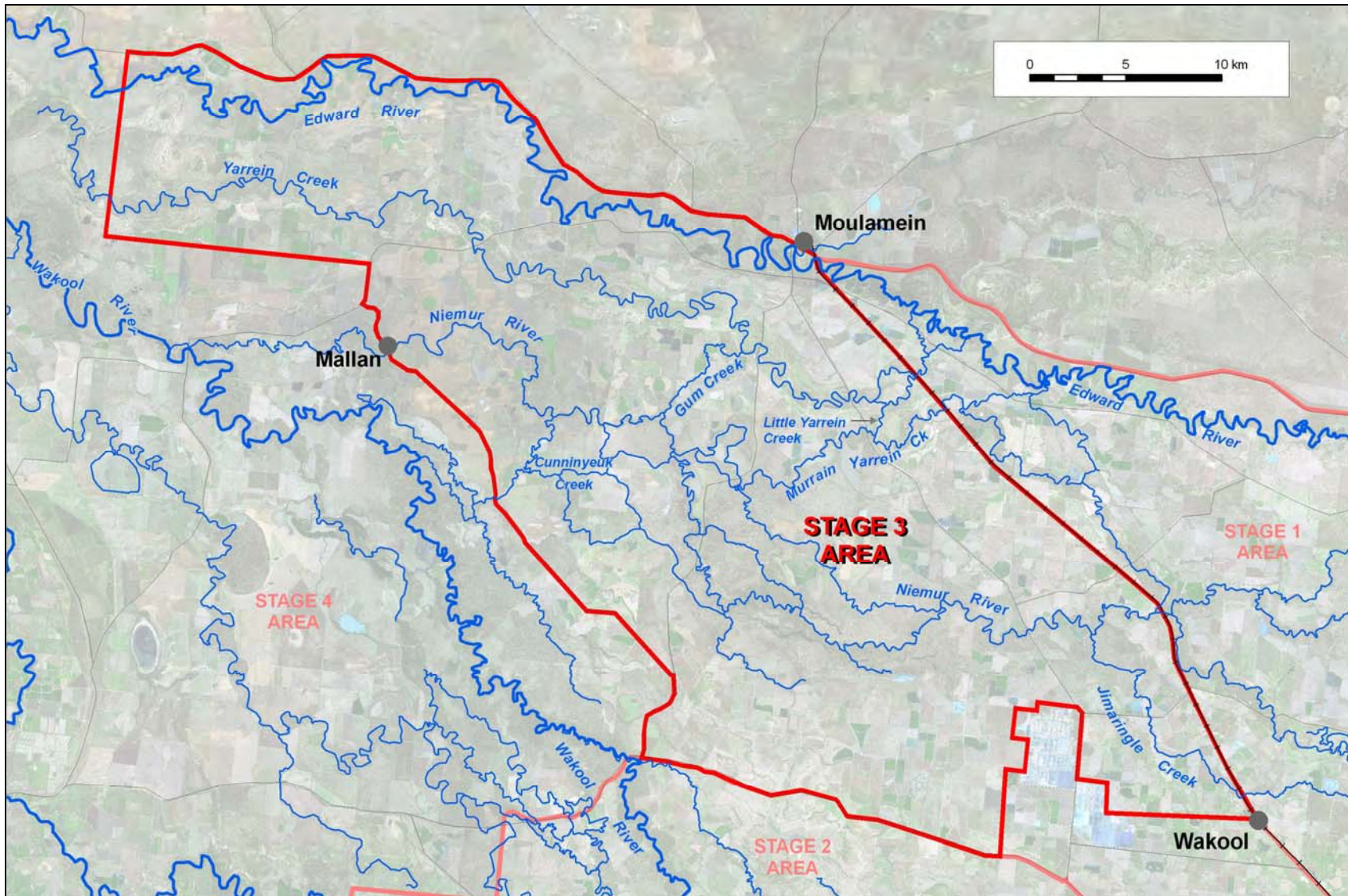


Figure 3: Stage 3 floodplain



2 Development of the Stage 3 FMP

2.1 Legislative and policy framework

Management of the Stage 3 floodplain must be undertaken within the current legislative and policy framework. This section provides an overview of relevant legislation and policy.

2.1.1 *Water Act 1912 and Water Management Act 2000*

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

The *Water Management Act 2000* (WMA) consolidates most of the Acts previously covering water management in New South Wales. The WMA is being phased in gradually as various regulations are developed. It will eventually replace Part 8 of the Water Act and is likely to contain floodplain management provisions that relate closely to existing provisions under the amended Water Act. Under the WMA's current transitional arrangements, existing FMPs under Part 8 of the Water Act may be deemed Minister's plans under the WMA.

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

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

-
- g) to encourage the sharing of responsibility for the sustainable and efficient use of water between the government and water users, and
 - h) to encourage best practice in the management and use of water.

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

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

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

Core provisions – Water Management Act

The WMA specifies core provisions that must be dealt with in a floodplain management plan made for a water management area and additional provisions that may be dealt with. These provisions have guided the preparation of the Stage 3 FMP. Table 2.1 summarises the provisions and lists references to additional background information within the FMP and supporting documents.

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 range of available flood data was analysed as part of the FRMS in order to calibrate the computer model and develop design floods. Section 3 describes the selection of the design flood and hydraulic modelling that supported design of the floodway network.

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

The ecological benefits of flooding in the area are outlined in Section 5. Detailed information on the environmental assessment is presented in the FRMS report (Maunsell AECOM, 2009).

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

Identification of existing flood works was undertaken in detail in the FRMS and the impact of these works on flood behaviour was assessed in relation to flood risk and the flood connectivity of environmentally important areas. Based on this assessment, the Stage 3 FMP specifies required modifications to existing works to address identified hydraulic and environmental issues (see Sections 4 and 5).

-
- d) The risk to life and property from the effects of flooding:

The FRMS undertook detailed risk analysis under different scenarios to investigate and finally adopt the design flood to be used for the hydraulic design of the Stage 3 floodway network (see Section 3.2). 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.

Additional provisions – Water Management Act

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

- a) Proposals for the construction of new flood works:

Section 7 outlines the approval and determination process for new flood works. This is also dealt with in Tables 4.1 and 5.1. The Stage 3 floodway network (see Figures 3.1 to 3.5) will be used as the basis for determining applications for flood works.

- b) Modification or removal of existing flood works:

This is dealt with in Tables 4.1 and 5.1.

- 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 (Table 2.2) which informed decision-making in the design of the Stage 3 floodway network (see Section 3) and in the hydraulic and environmental improvement measures in Tables 4.1 and 5.1.

- 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:

Sections 7 and 8 provide guidance on how to control activities associated with flood works.

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

Impacts of the Stage 3 FMP on water quality are assessed at a strategic level in Table 6.1.

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

The performance indicators and monitoring and review measures described in Section 8 are designed to assess the performance of the Stage 3 FMP in achieving its objectives.

- g) Such other matters as are prescribed by the regulations:

Currently no matters have been prescribed by the regulations.

Table 2.1: Provisions of the *Water Management Act 2000*

	Provision	Document reference
Core provisions	(a) the identification of the existing and natural flooding regimes in the area, in terms of the frequency, duration, nature and extent of flooding	February 2003 Compendium of Data report – Part A (all) May 2004 Flood study report – all April 2009 FRMS report – Section 5 Stage 3 FMP – Section 3
	(b) the identification of the ecological benefits of flooding in the area, with particular regard to wetlands and other floodplain ecosystems and groundwater recharge	February 2003 Compendium of Data report – Part B April 2009 FRMS report – Sections 2.2, 7 and Appendix C Stage 3 FMP – Section 5
	(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	April 2009 FRMS report – Section 6, Appendices A and B Stage 3 FMP – Sections 3 and 5
	(d) the risk to life and property from the effects of flooding	February 2003 Compendium of Data report – Part A, Appendix D April 2009 FRMS report – Section 5 Stage 3 FMP – Section 3
Additional provisions	(a) proposals for the construction of new flood works	April 2009 FRMS report – Sections 6 and 7 Stage 3 FMP – Section 7
	(b) the modification or removal of existing flood works	April 2009 FRMS report – Sections 6 and 7 Stage 3 FMP – Sections 4 and 5
	(c) restoration or rehabilitation of land, water sources or their dependent ecosystems	April 2009 FRMS report – Sections 6 and 7 Stage 3 FMP – Sections 2, 4 and 5
	(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	April 2009 FRMS report – Section 8 Stage 3 FMP – Sections 7 and 8
	(e) the preservation and enhancement of the quality of water in the water sources in the area during and after flooding	April 2009 FRMS report – Section 7.10 Stage 3 FMP – Section 6
	(f) other measures to give effect to the water management principles and the objects of this Act	Stage 3 FMP – Section 8
	(g) such other matters as are prescribed by the regulations	

Note: Full reference details for the above documents are given in Section 9.

2.1.2 Other legislation

There are several other legislative acts and a planning instrument that are relevant to floodplain management and the approval process for flood control works:

- **Murray Regional Environmental Plan No. 2** (Murray REP2), which was gazetted in 1994, applies to riverine lands of the Murray River and its effluents (defined as the River Murray). Murray REP2 establishes the process for a consistent and coordinated approach to environmental planning and assessment along the River Murray. It requires development consent from the local council for the construction of 'flood control works'. Notwithstanding this, a number of existing levees and banks that have not been altered since construction may have existing use rights and may not require development consent. As well, the Murray Regional Organisation of Councils has advised that existing flood control works complying with the FMP (see Section 7.4) are considered an existing use and do not require development consent.

Murray REP2 requires development consent for wetland subdivision, wetland clearing, dredging, draining or filling and prohibits certain developments on flood liable land.

The Stage 3 floodway network does not define the extent of flood liable land. It has been designed to convey the 1975 flood taking into account environmental, social and economic needs. Flood liable land exists outside the boundaries of the floodway network and, due to the large scale of mapping, some isolated areas of high ground that are not flood liable occur within the floodway network. Councils, in determining flood liable land for approval purposes, should conduct specific site inspections and assess each case on its merits.

The draft Murray Regional Strategy, currently in preparation, will become the pre-eminent planning document for the region and replace Murray REP2. The draft strategy, once finalised, will guide land-use planning decisions of local government for the period to 2036 and will be reviewed every five years.

- **Environmental Planning and Assessment Act 1979** (EP&A Act) – This Act is of particular importance. Where development consent for flood control works is required, councils assess the environmental impact of proposals under Part 4 of the EP&A Act. Where development consent is not required, NOW is required to assess the environmental impact of applications for flood control works under Part 5 of the EP&A Act.
- **National Parks and Wildlife Act 1974** – Under this Act, a person must not destroy, deface, damage or desecrate, or cause or permit the destruction of an Aboriginal object or place. Applications for flood control works need to be assessed in accordance with this Act since the construction, modification and removal of flood control works has the potential to affect Aboriginal sites through direct disturbance or through off-site impacts, such as the blockage of flows to flood dependent scarred trees.
- **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 wetland of international importance listed under the Ramsar Convention, a nationally listed threatened species or a listed migratory species) an approval may be required under this Act. These approvals are assessed by the Australian Department of the Environment, Water, Heritage and the Arts.

Further legislation relevant to the Stage 3 FMP includes:

- *Native Vegetation Act 2003*
- *Native Vegetation Conservation Act 1997*
- *Fisheries Management Act 1994*
- *Threatened Species Conservation Act 1995*
- *Forestry Act 1916*.

2.1.3 Policy

There are several key government policies that supported decision-making in the FMP:

- **The Flood Prone Land Policy** – The NSW Government's *Flood Prone Land Policy* (see NSW Government 2005) aims to address existing flooding problems and ensure that new development within flood prone areas is compatible with the prevailing flood risk and does not create additional flooding problems in other areas. The *NSW Floodplain Development Manual* (NSW Government 2005) outlines how the social, economic and ecological attributes of flood prone areas need to be taken into account when floodplain management plans are being developed.
- **The Wetlands Policy** – This policy aims to provide for the protection, ecologically sustainable use and management of NSW wetlands. The *NSW Wetlands Policy* (DECCW 2010) defines wetlands as 'areas of land that are wet by surface water or groundwater, or both, for long enough periods that the plants and animals in them are adapted to, and depend on, moist conditions for at least part of their lifecycle'. The policy definition includes wetland sites which may contain water only temporarily. This is relevant to the Stage 1 floodplain where many wetland sites are subject to short periods of inundation followed by long periods of drying out.
- **The Floodplain Harvesting Policy** – 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 New South Wales 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. A process will be undertaken to allocate floodplain harvesting licences which would be a share of the total allowable floodplain harvesting volume. Once the policy is finalised (following public consultation), it is intended that the data contained in this FMP, the FRMS and the flood study will support the implementation of the policy in the Murray valley.

2.1.4 NSW State Plan

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

The State Plan priorities for the protection of the natural environment include the provision of better outcomes for native vegetation, biodiversity, land, rivers, and coastal waterways. Paramount to realising such outcomes is the need to meet the NSW Government's statewide targets for natural resource management. The Stage 3 FMP will assist in meeting these targets by improving floodplain biodiversity and increasing the likelihood of water reaching and supporting riverine ecosystems and important wetlands, by removing barriers to natural flooding regimes. The Stage 3 FMP aims to reduce the impacts of

flooding on rural communities and supports ecologically sustainable development using practical environmental solutions within a strategic planning framework. The State Plan also identifies a number of current activities that contribute to the improvement of the health of catchments, rivers and wetlands including the implementation of catchment action plans that consolidate existing natural resource management plans and provide long-term direction for investment in natural resources.

2.1.5 Other relevant management plans

The Stage 3 FMP is only part of the catchment and land-use planning picture. Following recent natural resource reforms in New South Wales, catchment action plans that consolidate existing natural resource management plans and provide long-term direction for investment in natural resources have been prepared. The Stage 3 FMP should be viewed as one component of the integrated planning process, with other linked components including:

- *Murray Catchment Action Plan 2006*
- Water Sharing Plan for the NSW Murray and Lower Darling Regulated Rivers Water Sources 2003
- The Living Murray Program 2002
- *The Living Murray Environmental Watering Plan* (issued annually)
- *Murray Wetlands Working Group Business Plan* (issued annually)
- *NSW Biodiversity Strategy 1996*
- *Wakool Land and Water Management Plan 1993*.

2.2 Community consultation

Community consultation has been a key component in the preparation of the Stage 3 FMP. Consultation occurred primarily through the CMFMC and a range of other activities that directly engaged community members.

2.2.1 Central Murray Floodplain Management Committee

The CMFMC has 36 members including representatives of government agencies and landholder groups, and individuals. It is a long-standing committee concerned with floodplain management issues in the Central Murray system between Tocumwal and Swan Hill and has assisted with preparing rural floodplain management plans in this area.

The composition of the CMFMC during preparation of the Stages 1, 2 and 3 FMPs was as follows:

- Department of Environment and Climate Change (now DECCW, 1 member)
- local government representatives for Murray Shire Council (2 members), Berrigan Shire Council (2 members), Conargo Shire Council (1 member), Deniliquin Council (1 member) and the Wakool Shire Council (2 members)
- government agencies including the NSW National Parks and Wildlife Service (now DECCW, 1 member), Roads and Traffic Authority (1 member), Murray–Darling Association (1 member), Murray–Darling Basin Commission (now Murray–Darling Basin Authority, 1 member), Forests NSW (1 member), NSW Department of Primary Industries (now Industry & Investment NSW), Fisheries (1 member), Agriculture (1 member), NSW Department of Planning (now Department of Planning and Local Government, 1 member)

-
- Victorian state government representatives from catchment management authorities (3 members), and
 - landholder groups and individual landholder representatives (16 members).

The CMFMC generally met at two-monthly intervals during the preparation of the Stages 1, 2 and 3 FMPs and was responsible for providing advice on milestone documents (e.g. Flood study report, FRMS report) and on assessment principles and criteria. All members were invited to attend meetings held during the preparation of the Stages 1, 2 and 3 FMPs. However, attendance at the meetings was generally limited to members with a significant interest in issues associated with the FMPs (i.e. primarily DECCW, local government representatives and landholders).

2.2.2 Other consultation activities

Other consultation activities undertaken included:

- focus group meetings held during the course of the flood study
- a questionnaire distributed to landholders at the commencement of the flood study
- community newsletter updates distributed to landholders during the flood study and the FRMS
- three rounds of community workshops held during the course of the FRMS to provide a forum for community discussion and input into the plan.

Each round of workshops consisted of separate meetings held at Deniliquin, Wakool and Moulamein. Issues impacting on the Stage 3 floodplain were the focus of the Moulamein meetings

- numerous on-site meetings with landholders to discuss floodplain management issues
- a number of meetings between NSW Government agency staff and Local Aboriginal Land Councils (LALCs) during the course of the flood study to provide information on the FMP and to seek input from Aboriginal communities.

These consisted of meetings with the Deniliquin LALC, Moama LALC and Wamba Wamba LALC. Matters discussed included Aboriginal representation on the CMFMC, access to the Aboriginal Heritage Information Management System and future involvement with implementation of the FMP.

2.2.3 Public exhibition

The Stages 1, 2 and 3 FMPs were publicly exhibited from 1 March 2010 to 9 April 2010 and ten submissions were received. The issues raised in the submissions have been addressed and, where appropriate, the Stage 3 FMP has been amended.

2.3 Floodplain management principles

A set of floodplain management principles was adopted by the CMFMC at a committee meeting held in March 2006.

The adopted principles were used as a guide for the purpose of making decisions when assessing management strategies and options during the FRMS. The adopted floodplain management principles are set out in Table 2.2 and 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.

The hydraulic category principles are targeted towards preserving the primary function of the floodway areas (to convey and store floodwaters). Most of the hydraulic principles are the same as those used when developing the 1989 Guidelines and those most recently used for the upstream Tuppal and Bullatale Creeks FMP. The major difference compared to the 1989 Guidelines is the addition of the environmental category principles. This is consistent with the requirement that floodplain management plans made under Part 8 of the Water Act must take into account the protection of the environment.

The social and economic principles take into account the potential impact of floodplain management strategies and options on agricultural operations, which in turn impact directly on social issues.

The legislative category principles reflect the need to comply with the current government policy relevant to the preparation of a floodplain management plan.

Table 2.2: Floodplain management principles

Principle category	Principle number	Principle description
Hydraulic principles	H1	Adopted floodways should conform as near as possible to the natural drainage pattern.
	H2	Flood levels and velocities should not be unduly increased, and where possible, maintained below the maximum recorded levels.
	H3	Floodwater velocities and depths should be as close as possible to the natural situation within adopted floodways.
	H4	Floodways should have adequate design capacity and be maintained free of restrictions.
	H5	Development on the floodplain should not cause significant redistribution of floodwater nor significant increases in flood levels and flood flow velocities.
	H6	Floodplain storage should be optimised by the inclusion of lakes, wetlands and the floodplain generally to minimise increases in downstream flooding.
	H7	The design capacity of the floodway should be based on flood hazard taking into account social, economic and environmental considerations.
	H8	The adopted floodway network design should consider controlled overtopping and include it in the modelling.
	H9	The design and drainage of local runoff within the protected areas remains the responsibility of the landholders.
Environmental principles	E1	Floods are a natural occurrence with many benefits. This should be promoted within the FMP and to the community at large.
	E2	Significant FDEs need to be identified and strategies developed to maintain a suitable balance of flooding to these areas.
	E3	Velocities in creeks and floodways should be minimised to reduce erosion wherever possible.
	E4	When designing floodways and flood storage areas consideration must be given to appropriate management of groundwater recharge areas.
Social and economic principles	S1	Floodwater should be fairly distributed.
	S2	Maximise the area of land that can be protected to predetermined flood level.
	S3	Information on flooding and the FMP should be made available to all landholders.
	S4	Minimise any adverse impacts on farms, other properties and public infrastructure.
	S5	The FMP should take account of existing works and retain works where possible to permit a reasonable economic use of the land.
	S6	Where an approved work needs to be adjusted all avenues should be explored to provide financial assistance.
Legislative principles	L1	The FMP should be consistent with government policy and legislation (<i>Floodplain Management Manual, Water Act 1912 (Part 8), Murray REP2, Water Management Act 2000, etc.</i>).
	L2	The management principles should have legislative backing.

3 Stage 3 floodway network

3.1 Purpose of the floodway network

The Stage 3 floodway network, shown in Figures 3.1 to 3.5 at the end of this report, provides the basis for determining applications for flood control works. The Stage 3 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.

All flood control works, including levees, channels and other works on the floodplain that can alter the behaviour of floodwaters, require approval from NOW under Part 8 of the Water Act. With regard to proposed flood control works, their location relative to the floodway network is a key factor in the approval process. Proposed flood control works located outside the floodway network are assessed as complying works and their approval is relatively straightforward. Proposed flood control works located inside the floodway network are assessed as non-complying works and require a detailed supporting investigation. In general, non-complying works are unlikely to be approved (further detail on the approval process is provided in Section 7).

Decisions relating to the delineation of floodway areas were largely guided by the floodplain management principles adopted by the CMFMC as listed in Table 2.2. The hydraulic, environmental, social, economic and legislative principles are all relevant to the delineation of the floodway areas.

In many cases, there is a trade-off between hydraulic concerns, environmental concerns and maximising the area that can be protected for agricultural purposes. Decisions ultimately have been made based on all of the relevant issues under consideration.

3.2 Design flood

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

The 1989 Guidelines floodway network was based on discharging 1956 event flows while retaining flood levels at or below the highest known recorded flood level where practical. The highest known flood level within the Stage 3 floodplain is generally the 1956 flood height. The 2004 flood study (SMEC 2004) attributes the 1956 flood at Moulamein as equivalent to a 100 year ARI event.

Three design flood options were considered in consultation with the CMFMC:

- adopting the 1956 flood (Option 1)
- adopting the 1975 flood (Option 2), or
- adopting different design floods for different parts of the system (Option 3).

Option 2, the 1975 flood event, was adopted as the design flood event. Landholders supported this approach during discussions at the community workshops.

The reasoning behind adopting the 1975 flood as the design flood is:

- It has a 15–20 year ARI within the Stage 3 floodplain which is considered appropriate for a rural floodway network.
- It is the highest Edward River peak flow experienced at Deniliquin since the 1956 flood and the third highest since the 1870 flood (after the 1917 and 1956 events).
- It represents a reasonable compromise between the 1956 major event (largest event in living memory) and more recent minor to moderate events in 1993 and 1996.

-
- Existing levee crest heights have commonly been fixed in relation to 1975 flood levels including the adjoining Victorian-side Murray River levee.
 - It will not give occupants of the floodplain the illusion that areas outside the levee system are totally exempt from flooding, which might be the case if the 1956 flood was adopted as the design flood.
 - More gauged flow data and flood level data is available for the 1975 flood in comparison to the 1956 and 1917 events, allowing for more reliable design discharges for the network and greater confidence in the hydraulic basis.

The Stage 3 floodway network has consequently been designed to discharge 1975 peak flows while maintaining flood levels and velocities compatible with those experienced in 1975. However, there are some reaches of the floodway network that have discharge capacity in excess of 1975 event flows.

The floodway network needs to be recognised as not providing any particular level of protection. It is not mandatory for landholders to either erect levees along the floodway boundary, or if they do decide to erect a levee, to erect it to a specified height. The floodway network simply ensures that if levees are erected along the floodway boundaries, the resultant confined flow is able to discharge without excessive flood heights or velocities being induced within the floodway.

The level of flood protection achieved depends on the height to which flood protection levees are constructed. The crest height for a privately funded or privately constructed levee is selected by the landholder, unless a particular levee or levee segment is subject to a height-limiting condition by the Stage 3 FMP. In some instances, the levee crest height chosen by the landholder may be lower than the resulting flood height if an event equivalent to the 1975 event occurs. The level of protection achieved in this instance would be.

3.3 Hydraulic modelling

Hydraulic modelling was undertaken to provide flood flow distributions within the Stage 3 floodplain. Modelling was undertaken using the MIKE 11 model. This model is able to simulate flooding in looped flow networks, providing two-dimensional simulation of flooding behaviour.

The MIKE 11 model was set up using cross-section data derived from previous surveys and new cross-sections obtained for the current study. The model provided a broadscale representation of the floodplain capable of simulating flow distributions within the study area.

The model was calibrated against recorded data from the 1956, 1975 and 1993 flood events. The model as calibrated to the 1993 event was then validated using data from the 1996 flood. The resultant model represents a 'current conditions' model (i.e. reflects conditions on the floodplain which take account of the numerous flood control works that have been erected over the past 100 years).

The 1975 event inflows were subsequently entered into the validated current conditions model to predict the design flow distributions. In overall terms, the model was able to predict flow distributions with a reasonable degree of confidence for use in the assessment of the floodway network discharge capacity.

The coarseness of the hydraulic model does not allow it to predict flood levels and velocities at point locations with a high degree of accuracy, so modelled flood levels should not be used for setting levee heights.

3.4 Design flood flow distribution

The design flood flow distributions derived from the hydraulic model are shown in Figure 4. The flow distributions reflect current floodplain conditions, with the gauged Edward River 1975 hydrograph input into the upstream end of the model at Deniliquin, and the gauged Billabong Creek hydrograph input into the model at Moulamein. Detailed descriptions of flooding behaviour are provided in the flood study report (SMEC 2004) and the FRMS report (Maunsell AECOM 2009).

The design flows were used to assess the hydraulic adequacy of the floodway network.

3.5 Floodway design considerations

Hydraulic considerations

Assessing the hydraulic issues associated with the 1989 Guidelines floodway network and flood control works incorporated the following:

- considering the floodplain management hydraulic principles (as set out in Table 2.2)
- considering the hydraulic adequacy and impacts of the floodway in varying flood events, but principally for the 1975 event design flow, derived from gauged data or the MIKE 11 predicted modelled flow (or both)
- using LiDAR (light detection and ranging technology) terrain data for establishing the presence and height of natural and constructed structures or features
- reviewing documentation relating to the design of the floodway network and recommendations for flood control works, and
- in some instances, holding on-site discussions and inspections with landholders regarding their views on the floodway network and flood control works issues.

Specific hydraulic assessment criteria were used to ensure a consistent approach to applying the floodplain management principles. These criteria were applied to determine the capacity of the floodway network and to determine management measures regarding existing flood control works located within the floodway network. The hydraulic assessment criteria were:

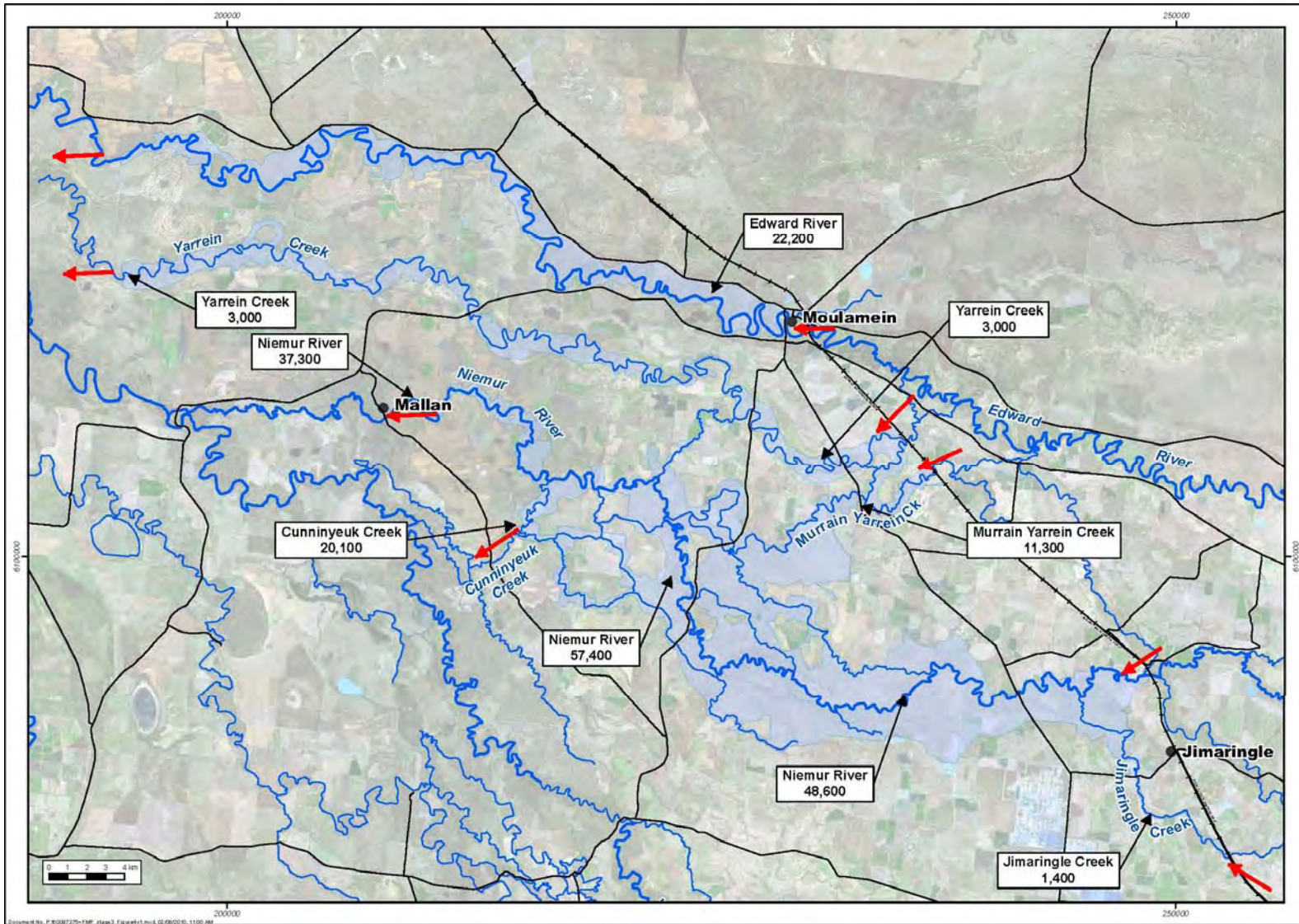
- Floodway capacity – Floodways should be established or retained if their closure has resulted, or would result, in a significant redistribution of peak flows for design flood flow conditions (i.e. more than a 5% redistribution of the design flood peak flows).
- Floodway velocities – To limit the potential for floodplain erosion, overbank floodway velocities should not exceed more than 0.8 m/s as a result of constrictions caused by flood control works for design flood flow conditions.
- Flood level – Flood control works should not lead to an increase in upstream flood level of more than 0.1 m encroaching onto an adjoining landholder's property for design flood flow conditions.

In general, these criteria were applied to flood control works which:

- are wholly or partly intruding into the floodway network, or
- were raised by landholders as being of concern.

In general, works complying with the 1989 Guidelines and any additional approval conditions were accepted. This is consistent with the management principle adopted to take into account existing works and retain them where possible to allow a reasonable economic use of land.

Figure 4: Floodway network – 1975 event design flows (ML/day)



Environmental considerations

Floodplain management plans made under Part 8 of the Water Act take into account principles relating to the protection of the environment and contain strategies to manage flood control works so that the natural functions of the floodplain are supported.

The 1989 Guidelines were prepared with less emphasis given to environmental considerations. Past construction of flood control works has, in some instances, led to the exclusion or restriction of floodwater access to FDEs, with subsequent environmental impacts. As well, a number of FDEs not affected by flood control works were not included in the 1989 Guidelines floodway network.

The environmental assessment for the Stage 3 FMP took into account the environmental principles in Table 2.2 and specifically focused on identifying and assessing FDEs on the floodplain. Satellite imagery and data from previous wetland surveys were used to identify FDEs outside the 1989 Guidelines floodway network and to assess their condition and flood access. Field work was undertaken on selected FDEs affected by existing flood control works using a set of assessment criteria developed in consultation with the CMFMC. The criteria were developed with the aim of identifying FDEs with significant environmental values and where the restoration of floodwater access would be practical after taking into account social and economic impacts. Based on the outcomes of the environmental assessment process, the 1989 Guidelines floodway network was adjusted at a number of sites to include FDEs.

Social and economic considerations

Social and economic considerations were an important factor when assessing the hydraulic and environmental issues associated with the 1989 Guidelines floodway network. The social and economic assessment principles set out in Table 2.2 were taken into account during the assessment process.

The decision to adopt the 1975 event as the design flood was in large part based on avoiding the significant adverse social and economic impacts associated with adopting a larger design flood. Additionally, the design flood is consistent with the level of protection against flooding generally sought by rural landholders (i.e. in the vicinity of 20 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 network area for hydraulic reasons associated with rare floods.

The assessment of existing flood control works has taken account of those approved works implemented in accordance with the 1989 Guidelines in order to minimise social and economic impacts on landholders.

Assessing environmental issues explicitly required that social and economic considerations were taken into account by applying the adopted practicality assessment criteria. The criteria encompassed factors including the cost of any recommended works, land use impacts and land-use compatibility. Where possible, field assessments were carried out in the company of landholders to ensure these considerations were adequately understood and taken into account in reaching decisions.

3.6 Adopted floodway network

The Stage 3 floodway network is shown in Figures 3.1 to 3.5 at the end of this report. The floodway network differs from the 1989 Guidelines network in some areas, in response to:

- existing flood control works considerations
- hydraulic considerations, and
- environmental considerations.

The availability of LiDAR terrain data has made it possible to make adjustments to floodway boundaries as follows:

- identifying the precise location of all flood control works present on the floodplain in 2001, and matching the floodway boundaries accordingly
- improving the floodway delineation adjacent to higher ground.

Similarly, in some locations the floodway boundaries have been adjusted to coincide with the perimeter of woodland areas using SPOT 5 satellite imagery (e.g. along the northern floodway boundary of the Edward River downstream of Moulamein).

In assessing potential changes to the floodway network, social and economic impacts on landholders and other stakeholders were taken into account as required by the floodplain management principles.

Landholders need to make their own assessment regarding the risk of flooding within floodway areas if they decide to use portions of the floodway network for cropping or other flood sensitive agricultural activities. Landholders also need to bear in mind that the erection of temporary flood control works within the floodway network in the event of impending flooding is not permitted.

3.7 Floodway vegetation management

3.7.1 Floodway efficiency

The primary function of the floodway network is to convey and store floodwater. A major factor which has the potential to reduce the floodway network's ability to convey floodwaters efficiently is the likelihood of the density of vegetation within floodways increasing over time. An increase in the vegetation density increases the resistance to flow, often referred to as hydraulic 'roughness'.

Parts of the Stage 3 FMP floodway network are particularly sensitive to increases in hydraulic roughness. Increased vegetation density in these areas could cause significant redistribution of flood flows or increases in flood levels, or both. These impacts will be most apparent for smaller floods and become less pronounced with increasing flood magnitude. The more sensitive areas of the Stage 3 FMP floodway network, where it will be particularly important to monitor increases in vegetation density, are:

- Niemur River floodway extending from the Moama–Moulamein railway to the Jimaringle Creek entry point
- Niemur River floodway extending from opposite the Gum Creek entry point to the downstream boundary of the Stage 3 floodplain. This includes the Cunninyeuk Creek, Buccaneit Creek and Pelham Creek floodway arms.

There are several measures available under current legislation that may be suitable for managing vegetation in these hydraulically sensitive floodway areas. Management actions should be carried out as required in consultation with the Murray Catchment Management Authority (CMA).

3.7.2 Native Vegetation Act 2003

The *Native Vegetation Act 2003* includes measures that may allow thinning of vegetation in the Stage 3 floodway network. These include clearing of regrowth and Property Vegetation Plans (PVPs). Landholders proposing to thin vegetation in floodways are advised to contact the Murray CMA in the first instance.

Regrowth

Regrowth 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 Murray CMA.

Continuing Use PVPs

Continuing Use PVPs provide long-term certainty for farming practices. They include 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 Murray CMA.

Invasive Native Scrub PVPs

Invasive Native Scrub PVPs may be appropriate for clearing native vegetation in floodways where listed species, including black box and river red gum, have regenerated densely following natural or artificial disturbance, and the regeneration results in a change of structure or composition of 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 predetermined 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.

3.7.3 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 DECCW. 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).

3.7.4 Removal of vegetation on waterfront land

'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.

The removal of vegetation on waterfront land is a controlled activity under the WMA and requires 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 to remove vegetation as a controlled activity under the WMA, 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 is required for clearing native vegetation on waterfront land. Clearing approved under the WMA would also be exempt from the requirements of the *Native Vegetation Conservation Act 1997*, if applicable (see Section 3.7.3).

4 Required hydraulic improvements

In developing the Stage 3 floodway network various hydraulic issues have been addressed. This has resulted in a range of hydraulic improvement measures, including modifications to flood control works, roadway drainage structures and monitoring requirements.

Investigations undertaken during the FRMS identified the flood control works that will require modifications. The modifications will generally involve removing the flood control work from the floodway. However, in some instances it may be possible to retain part of the flood control work in question. This is consistent with the principle of minimising social and economic impacts.

The required hydraulic improvement measures are set out in Table 4.1.

It is important to remember that all proposed and existing flood control works within the Stage 3 floodplain require approval under Part 8 of the Water Act, and where applicable, development consent from the local council under Murray REP2. Where no approval exists, NOW may take the relevant actions under the Act.

Flood control works in floodway areas are generally not permitted. However, if the applicant can demonstrate the proposed works do not result in any significant adverse impacts on flooding behaviour or FDEs, the works may be approved.

With regard to the measures outlined in Table 4.1, 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.
- Modifications to existing (approved) flood control works will be administered through modifying the Part 8 approval conditions under section 176A of the Water Act. See Section 7.7 for further information on the procedure for varying the conditions of an approved work.
- With regard to unapproved works, occupiers who have not already lodged an application for approval will need to do so. An application that is for a non-complying controlled work will require advertising. Objections to the granting of an approval for a non-complying work may be made. Applications for complying controlled works do not require advertising.
- Directions for remedial work(s) 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 7.6).
- Some of the structural modifications listed in Table 4.1 are for works located on public roads. These works are prescribed works under Part 8 of the Water Act and are assessed by government agencies under the EP&A Act.

Section 7 has further details regarding approval of flood control works and administration of the Stage 3 FMP under Part 8 of the Water Act.

Staging

Priorities for implementing the required changes to flood control works are set out in Table 4.1. The priorities and their timeframes are:

- **High priority** – within two years of adopting the Stage 3 FMP. These measures are considered very important in relation to the performance of the floodway network and as a consequence should be implemented quickly.
- **Medium priority** – within five years of adopting the Stage 3 FMP. These measures will achieve important hydraulic objectives.
- **Further investigation** – these issues have not been fully resolved and require further investigation or are subject to review pending ongoing monitoring of the floodway network performance.

Funding

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. Landholders may be eligible to receive funding from the Murray CMA for removing or modifying works where this results in an environmental benefit.

Section 7.12 has further information on possible funding sources.

Table 4.1: Hydraulic improvement measures

Issue	Description of issue	Required actions	Priority	Responsibility
3.1	Refer to map sheet 2 of 5. Yarrein Creek – raised farm access track is blocking the Yarrein Creek channel. The bank is close to the full height of the channel.	Lower the track/bank to the bed of Yarrein Creek.	High	Landholder
3.2	Refer to map sheet 2 of 5. Little Yarrein Creek – existing culvert structure at Goreys Road is under capacity and will impact on flow distributions in downstream floodways.	Upgrade Goreys Road Little Yarrein Creek structure to the design floodway capacity.	Medium	Wakool Shire
3.3	Refer to map sheet 2 of 5. Murrain Yarrein Creek – redundant road embankment intrudes into the floodway immediately downstream of the Little Yarrein Creek offtake.	Remove the redundant road embankment.	Medium	Landholder / Wakool Shire
3.4	Refer to map sheet 1 of 5. Niemur River – approved levee intrudes into the south side of the floodway a short distance downstream of the Moama–Moulamein railway line.	Realign the floodway boundary consistent with licensed levee alignment.	High	DECCW
3.5	Refer to map sheet 1 of 5. Jimaringle Creek – existing levee alignments result in a restricted levee opening width of 60 m. Given design flow uncertainty the final status of the floodway alignment is subject to monitoring – an interim measure to widen the floodway is also required.	Realign the floodway boundaries to retain a 100 m minimum opening width. All levees to be subject to future monitoring outcomes.	High	DECCW / NOW
3.6	Refer to map sheet 1 of 5. Niemur River – multiple flood control works are intruding into the Niemur River floodway upstream and downstream of the Barham–Moulamein road.	Remove the identified flood control works from within the floodway.	Medium	NOW / Landholders
3.7	Refer to map sheet 3 of 5. Burragorrima Creek – unapproved levee extends across the majority of this watercourse, restricting levee opening width to 40 m.	This needs to be further assessed on-site in consultation with the landholder. Required modifications will depend on the outcome of this assessment.	Further investigation	NOW / Landholder
3.8	Refer to map sheet 3 of 5. Niemur River – unapproved levees are located within the floodway. This effectively forms a large ring levee enclosing a light density floodplain woodland.	Remove levee segments from within the floodway.	Medium	Landholder
3.9	Refer to map sheet 3 of 5. Ooronong Creek – levee on the east side of Ooronong Creek is isolating a woodland area. The area protected by the levee has been cleared and developed.	Realign the floodway boundary consistent with the licensed levee alignment.	High	DECCW

Issue	Description of issue	Required actions	Priority	Responsibility
3.10	Refer to map sheet 3 of 5. Pelham Creek – levee reduces flood storage. The majority of the area protected by the levee has been developed, except for a woodland area at the northern protected end.	Install a regulator structure (900 mm diameter or equivalent) in northern section of levee adjacent to woodland.	Medium	Landholder
3.11	Refer to map sheet 3 of 5. Pelham Creek – unapproved levee on the north side of the creek intrudes 400 m into the floodway, resulting in a minimum opening width of 100 m.	Remove the levee intrusion from the floodway.	High	Landholder
3.12	Refer to map sheet 3 of 5. Pelham Creek – unapproved levee on the west side of the creek intrudes 300 m into the floodway, resulting in a minimum opening width of 70 m.	Remove the levee intrusion from the floodway.	High	Landholder
3.13	Refer to map sheet 3 of 5. Unapproved levees intrude into the Niemur River floodway south of the river. The floodway narrows through this reach due to natural constriction on the north side of the river.	Remove the levee intrusions from the floodway.	High	Landholder
3.14	Refer to map sheet 4 of 5. Niemur River – unapproved levees intrude into the floodway on both sides of the river, reducing the unimpeded active flow width to 200 m.	Remove the levee intrusions from the floodway.	High	Landholder

Note: Refer to the map sheets (Figures 3.1 to 3.5 at the end of this report) for the locations of these issues.

5 Environmental assessment

5.1 Overview

Flooding is a vital natural process that sustains 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 Murray catchment.

The floodplain environment in the Stage 3 floodplain has been modified by agricultural development. Regulation of the Murray River for agricultural water supply, through the operation of Hume and Dartmouth Dams, has altered the frequency, magnitude and duration of floods. The environmental impacts of these changes are addressed in the NSW Regulation: Water Sharing Plan for the NSW Murray – Lower Darling Regulated Rivers Water Sources 2003. Development has also altered the distribution and behaviour of floodwaters, removed large areas of floodplain vegetation (for broadacre cropping) and impacted on the hydrology and ecology of some wetlands. Despite these impacts, the floodplain retains significant ecological values. The floodplain also has important cultural values because of the Aboriginal and European history of the area.

The Stage 3 floodplain contains extensive areas of wetlands and floodplain watercourses that are referred to as flood dependent ecosystems (FDEs). Native floodplain vegetation consists mainly of communities dominated by river red gum, black box and lignum. 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 *Compendium of Data* report (SMEC 2003) and the FRMS (Maunsell AECOM 2009).

The environmental assessment focused on issues associated with the status of floodwater access to FDEs. The FDEs are areas supporting plant and animal communities that are adapted to wetting and drying and depend on flooding to remain healthy. This approach recognised that these areas of the floodplain have higher ecological value and should have special consideration in the decision-making process.

The 1989 Guidelines did not place a high degree of emphasis on the needs of FDEs. Consequently, flood control works undertaken in the past have, in some instances, excluded or restricted floodwater access to FDEs. Other sites, although retaining floodwater access to date, are situated outside the 1989 Guidelines floodway network. These FDEs, if kept outside the Stage 3 FMP floodway network, could potentially be isolated by flood control works in the future.

Environmental assessment activities were therefore orientated towards:

- identifying higher value FDEs affected or potentially affected by flood control works, and
- subsequently identifying FDEs suitable for having flood access restored or preserved.

FDEs located within the existing floodway network and known not to be affected by flood control works were not subject to assessment. These sites remain within the Stage 3 floodway network, thereby ensuring that future floodwater access to these sites is maintained.

5.2 Assessment process and criteria

FDEs considered for assessment were selected after reviewing all relevant available data including past surveys by Pressey (1986), the NSW Murray Wetlands Working Group (MWWG 2006), SMEC (2003), and satellite imagery.

The assessment process involved:

- a preliminary desktop assessment of 105 FDEs identified as being located outside the 1989 Guidelines floodway network
- field-based environmental value assessment of 20 selected FDEs arising from the preliminary desktop assessment
- desktop environmental value assessment of a further 11 FDEs which were inspected and documented as part of the flood study work, and
- field-based assessment of the practicality of restoring flood access to 11 selected FDEs arising from the desktop and field-based environmental value assessments.

Criteria for assessing FDEs were developed in consultation with the CMFMC. The adopted assessment criteria were applied in the following two-stage process:

- **Step 1 – Environmental value assessment** – assessment of the environmental values of FDEs affected by existing or potential flood control works. Factors taken into account included the site size, ecological condition and vegetation biodiversity, uniqueness within the region, cultural and historical significance, hydrology, hydrological connectivity and threatened features.
- **Step 2 – Practicality assessment** – assessment of the practicality of restoring flood access to areas of moderate or high environmental value, taking into account social and economic factors. The factors considered included the cost of works involved in restoring flood access, complexity of ownership, land-use compatibility, land-use impacts and demonstration value.

Where possible, assessments were carried out on-site in the company of the landholder. A small number of sites, where the landholder refused access for field inspections, were subsequently assessed using a desktop study of available data.

The required modifications to flood control works affecting FDEs were determined based on the outcomes of the environmental assessment process. Additionally, the 1989 Guidelines floodway network was adjusted to include the FDEs not affected by existing works. Further information on the environmental assessment approach is included in the FRMS report (Maunsell AECOM 2009).

5.3 Required environmental improvements

Environmental improvement measures, including required modifications to flood control works affecting FDEs, maintenance of specified drainage structures and adjustments to the 1989 Guidelines floodway network boundaries, are set out in Table 5.1.

The improvement measures fall into two categories:

1. works that will restore floodwater access to sites that currently have either restricted or no access to floodwaters due to flood control works (six sites)
2. adjustments to the floodway boundaries to encompass sites previously located outside the floodway network, to ensure that future access for floodwaters to these sites is maintained (five sites).

With regard to the measures set out in Table 5.1, 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.
- Specific structural modifications to existing (unapproved) flood control works will be administered under the relevant sections of Part 8 of the Water Act.
- Modifications to existing (approved) flood control works will be administered through modifying the Part 8 approval conditions under section 176A of the Water Act.
- With regard to unapproved works, occupiers who have not already lodged an application for approval will need to do so. An application that is for a non-complying controlled work will require advertising. Objections to the granting of an approval for a non-complying work may be made. Applications for complying controlled works do not require advertising.
- Directions for remedial work(s) 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 7.6).

It is important to remember that all proposed and existing flood control works within the Stage 3 floodplain require approval under Part 8 of the Water Act, and, where applicable, development consent from the local council under Murray REP2. Where no approval exists, NOW may take the relevant actions under the Act.

Section 7 has further details regarding approval of flood control works and administration of the Stage 3 FMP under Part 8 of the Water Act.

Staging

Priorities for implementing the required modifications to flood control works are the same as those set out earlier (i.e. high priority – implement within two years; medium priority – implement within five years; further investigation – further investigations or consultation will be required to reach an outcome).

Funding

Removal or modification of works incurs direct costs such as earthmoving and regulator installation, and can have indirect costs such as building additional flood control works to protect developed land. Landholders may be eligible to receive funding from the Murray CMA for removing or modifying works where this results in an environmental benefit.

Section 7.12 has further information on possible funding sources.

Table 5.1: Environmental improvement measures

Note: MWWG is the Murray Wetlands Working Group.

MWWG no.	Description of issue	Required actions	Priority	Responsibility
2590	Refer to map sheet 5 of 5. Twelve Mile Creek connected to the north side of Edward River.	Maintain the existing Balranald Road culvert providing backwater flood access to the portion of the site north of the road.	High	Wakool Shire
2683	Refer to map sheet 4 of 5. Berambong Creek – high level anabranch of the Edward River.	Remove the banks blocking the creek at two separate locations.	Medium	Landholder
2712	Refer to map sheet 4 of 5. Watercourse site connected to MWWG 2683.	Maintain the existing Balranald Road culvert providing flood access to part of this site.	High	Wakool Shire
2757	Refer to map sheet 4 of 5. Depression connecting to Edward River, divided by Swan Hill Road.	Install a culvert under Swan Hill Road (minimum 900 mm diameter or equivalent). Works are to coincide with other roadworks when they next occur.	Medium	Wakool Shire
2763	Refer to map sheet 4 of 5. Depression site with flood access depending on Swan Hill Road culvert.	Maintain the existing Swan Hill Road culvert providing flood access to this site.	High	Wakool Shire
2768	Refer to map sheet 4 of 5. Depression site with flood access restricted by Swan Hill Road.	Install a culvert under Swan Hill Road (minimum waterway area 0.6 m ²). Works are to coincide with other roadworks when they next occur.	Medium	Wakool Shire
2773	Refer to map sheet 4 of 5. Depression site with flood access restricted by Swan Hill Road.	Same culvert providing floodwater access to MWWG 2768 will provide floodwater access to MWWG 2773.	Medium	Wakool Shire
2785	Refer to map sheet 4 of 5. Depression on the south side of Yarrein Creek.	Clear the siphon under Mallan Branch canal and install a culvert structure at Pine Point Road.	Medium	Murray Irrigation (MIL) / Wakool Shire
2832	Refer to map sheet 4 of 5. Billabong and adjoining area of floodplain vegetation outside the Yarrein Creek floodway defined in the 1989 Guidelines.	Realign the floodway boundary to encompass this site. No physical works required.	High	DECCW

MWWG no.	Description of issue	Required actions	Priority	Responsibility
2987	Refer to map sheet 2 of 5. Lake Agnes – large deflation basin. Flood access is supplied by an existing regulator structure.	Maintain the existing regulator supplying flood access to this site.	High	Landholder
3636	Refer to map sheet 5 of 5. Lagoon with fringing vegetation outside the Yarrein Creek floodway defined in the 1989 Guidelines.	Realign the floodway boundary to encompass this site. No physical works required.	High	DECCW
East 3640	Refer to map sheet 4 of 5. Large woodland site located west of Mortons Swamp.	Install a regulator structure (900 mm diameter or equivalent) to cater for inflows and outflows to the target woodland area.	High	NOW / Landholder
5175	Refer to map sheet 2 of 5. Part of the Bigantic Creek system.	Maintain the existing Craigiemans Road culvert providing flood access to this site.	High	Wakool Shire
5241	Refer to map sheet 1 of 5. Lagoon with fringing vegetation outside the Niemur River floodway defined in the 1989 Guidelines.	Realign the floodway boundary to encompass this site. No physical works required.	High	DECCW
5343	Refer to map sheet 1 of 5. Billabong and adjoining area of floodplain vegetation outside the Niemur floodway defined in the 1989 Guidelines.	Realign the floodway boundary to encompass this site. No physical works required.	High	DECCW
8629	Refer to map sheet 3 of 5. Depression and fringing woodland between Niemur River and Ooronong Creek – outside the 1989 Guidelines floodway network.	Realign the floodway boundary to encompass this site. No physical works required.	High	DECCW

Note 1: Refer to the map sheets (Figures 3.1 to 3.5 at the end of this report) for the locations of these FDEs.

Note 2: Further details on the assessment of FDEs are in Appendix C of the Edward–Wakool FRMS report (Maunsell AECOM 2009).

6 Environmental impact

6.1 Overview

Implementation of the Stage 3 FMP will reasonably assure flood flow access to a floodplain area of at least 285 km² (i.e. the total floodway area within the Stage 3 floodplain) including an area of 1.4 km² of FDEs previously excluded from the 1989 Guidelines floodway network. As well, environmental outcomes from the Stage 3 FMP include restoring flood access to 1.1 km² of FDEs previously affected by flood control works.

The floodway network has been sized to convey the 1975 flood which has an equivalent ARI of about 15 to 20 years within the Stage 3 floodplain. In line with the principles adopted by the CMFMC, the Stage 3 floodway network has been designed to conform as closely as reasonably possible to the natural drainage pattern and to allow for the delivery of floodwaters to support floodplain ecosystems. Because of these design criteria, the floodway network includes a high proportion of existing floodplain ecosystems. Future flood connectivity to these ecosystems is reasonably assured since approval for future works within the floodway is unlikely, and would only be granted following a detailed assessment of impacts, including the requirements of the EP&A Act.

A number of the measures proposed to achieve hydraulic objectives (Table 4.1) will also result in environmental benefits. Of particular note are:

- Issue 3.1 – will improve floodwater access to the downstream section of Yarrein Creek.
- Issue 3.6 – will improve floodwater access to MWWG 5343 and other woodland areas currently affected by existing levees.
- Issue 3.8 – will improve floodwater access to MWWG 3227 and adjoining woodland areas.
- Issue 3.10 – will improve floodwater access to a woodland area.
- Issue 3.14 – will improve floodwater access to woodland areas on both sides of the Niemur River.

The impacts of the environmental management measures proposed for inclusion in the Stage 3 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 6.1.

Table 6.1: Summary of Stage 3 FMP environmental impacts

Feature	Stage 3 FMP impacts
Wetlands	<p>There are a total of 360 wetlands identified by Pressey (1986) and MWWG (2006) located within the Stage 3 floodplain. Of these, 260 are located within the Stage 3 floodway network. Future flood access to these 260 FDEs is therefore reasonably assured.</p> <p>Implementation of the Stage 3 FMP will restore flood access to six FDEs located outside the Stage 3 floodway network. This will be achieved by installing regulator structures that will give flood flows access to the targeted areas in a controlled manner, or by modifying levees (e.g. removing or realigning them).</p> <p>Approximately 90 FDEs remain outside the Stage 3 FMP floodway network. Some of these sites have been isolated from floodwaters for many decades and have been substantially modified for agricultural purposes, hence retaining limited environmental value. In other instances, sites receive water from local runoff inflows, irrigation-allocated water supplied voluntarily by landholders, or assigned environmental flows resulting in a favourable hydrologic regime. In some cases the economic and social impacts that would arise from restoring flood access to FDEs was the reason why sites will remain disconnected.</p>
Floodplain vegetation	<p>The total floodway network area within the Stage 3 floodplain is 285 km². The previous floodway network (defined by the 1989 Guidelines) has been adjusted to include five wetland or woodland area sites, comprising a total area of 1.4 km². A further 1.1 km² will have floodwater access restored to floodplain woodland areas that are currently isolated, through modifications to flood control works.</p> <p>The Stage 3 floodway network will allow for ongoing flood connectivity and the sustenance and regeneration of floodplain vegetation in the long term. Some sections of the floodway network are very broad and contain areas which experience a range of flooding characteristics. This supports the retention of a mixture of river red gum, black box and grey box woodlands.</p> <p>Two threatened plant species, a spear grass (<i>Austrostipa wakoolica</i>) and the slender Darling pea (<i>Swainsona murrayana</i>) are known to occur in floodplain woodland habitats of the Edward–Wakool region. Both species are expected to benefit from the Stage 3 FMP as it will allow ongoing flood connectivity and help to maintain or restore the condition of these woodlands.</p>
Aquatic fauna	<p>The Stage 3 floodway network will be instrumental in ensuring improved flood connectivity between the rivers, creeks, floodplain watercourses and wetlands in the Stage 3 floodplain. This connectivity is vital in maintaining the habitat value of the floodplain as a food source for aquatic invertebrates and fish and as a breeding ground for migratory fish, including golden perch and silver perch, the second of which is a threatened species. Additionally this is expected to benefit four other threatened fish species and the threatened river snail which may also inhabit the Stage 3 floodplain and the aquatic ecological community of the Lower Murray catchment (which is listed as an endangered community).</p> <p>An expansive floodway has been retained along the Niemur River route. This and other floodways contain extensive spawning habitat areas.</p>
Terrestrial fauna	<p>The Stage 3 FMP will benefit terrestrial fauna species relying directly on flooding (e.g. waterbirds) and those using floodplain habitats by restoring or maintaining flood connectivity to FDEs.</p> <p>A total of 28 threatened fauna species, including 22 bird species, one frog species and five mammal species are known to occur within or in the vicinity of the Stage 3 floodplain. Many of the bird species are waterbirds, some of which have a strong dependence on flooding for breeding success. These species will be expected to benefit from the retention and enhancement of the 285 km² floodway network.</p>

Feature	Stage 3 FMP impacts
Soils	<p>The 285 km² within the floodway network will continue to receive the benefits that come from experiencing flooding, in the form of moisture recharge, deposited organic carbon and deposited nutrients. This, in turn, leads to other processes (e.g. flora germination) which are beneficial for soil properties (e.g. wind erosion being negated, organic matter ultimately returned to the soil).</p> <p>The floodway network will have a further positive affect on soils by ensuring that velocities and the associated scour risk are not unduly increased.</p>
Groundwater	<p>The floodway network will ensure that floodwater will be able to inundate a large area and therefore continue to recharge the watertable.</p> <p>Notwithstanding the large floodway network area (285 km²), the extent of inundation is less in comparison to what would occur in the absence of flood control works. The amount of recharge will therefore be similarly diminished. Given the problems with high watertable levels in the latter part of the 1900s, this is not necessarily an adverse outcome.</p>
Water quality	<p>The Stage 3 FMP will not have a significant impact on water quality within the Stage 3 waterways. The plan will reduce the potential for floodplain erosion to occur and thereby limit the quantity of eroded sediment deposited into waterways. Inundation of cropped areas is also less likely, thereby reducing the potential for surplus agricultural chemicals to be mobilised and deposited into waterways.</p>
Aboriginal heritage	<p>Information on the location of recorded Aboriginal sites on the Stage 3 floodplain has been obtained from the Aboriginal Heritage Information Management System. It is highly likely that additional sites of significance exist (undiscovered) within the floodplain. The floodplain contains a diversity of sites including scarred trees, campsites, middens and burial sites. Sites of particular relevance to the Stage 3 FMP include scarred river red gum and black box trees, wetlands and watercourses of spiritual importance (flood dependent) and on-ground sites that are subject to erosion by floods.</p> <p>Recorded Aboriginal sites that are flood dependent are largely contained within FDEs that are within the Stage 3 floodway network and ongoing floodwater access to these sites is reasonably assured. Two scarred trees lie outside the Stage 3 floodway network in areas where flood connectivity has been highly modified over a period of decades by transport and agricultural development. Restoring flood access to these sites was not considered to be practical due to the extent of development.</p> <p>Flood damage to on-ground Aboriginal sites (such as burial sites) may occur naturally; however, the Stage 3 floodway network has been designed to minimise flood velocities and, accordingly, would help to minimise erosion damage to these sites during floods.</p>
European heritage	<p>The only listed European heritage site in the vicinity of the Stage 3 floodplain is the courthouse and footbridge site at Moulamein. Implementation of the Stage 3 FMP is unlikely to impact on this or any other historical sites present.</p>

6.2 Upstream and downstream impacts

The catchment upstream of the Stage 3 floodplain initially consists of the Stage 1 floodplain between Deniliquin and the Moama–Moulamein railway (see Figure 1). An FMP for this area has been prepared concurrently with the Stage 3 FMP. Further upstream between Deniliquin and the Murray River is the area which includes the Tuppal and Bullatale Creek effluent streams. An FMP for this area was completed in 2004 using similar floodplain management principles to those adopted for the Stage 3 FMP (DIPNR 2004).

It is expected that the Stage 1 FMP and the Tuppal and Bullatale Creeks FMP should be compatible with the Stage 3 FMP given that they have been prepared using the same or very similar floodplain management principles. The design flood approach is identical for the Stage 1, the Stage 3 and the Tuppal and Bullatale Creek floodplains.

Downstream of the Stage 3 floodplain is the lower end of the Edward–Niemur–Wakool system referred to as the Stage 4 floodplain. The design flood adopted by the Stages 1, 2 and 3 FMPs is different to that adopted for the Stage 4 floodplain. Notwithstanding this, the retention of a floodway network encompassing almost all of the natural drainage system will ensure that floodwaters are delivered to the downstream Stage 4 floodplain at rates and depths similar to those which have occurred historically. Flow regulation further up the Murray catchment (e.g. Lake Hume, Dartmouth Dam) will continue to impact on non-flood and smaller flood flow regime characteristics.

The retention of the floodway network within the Stage 3 floodplain will ensure that the downstream Stage 4 floodplain continues to receive the ecological benefits that flooding brings. The retention of all of the Werai Forest within the upstream Stage 1 floodway network ensures that the volume of flood storage available is not significantly reduced, thereby eliminating the potential for higher induced flood peaks within the downstream Stage 3 and Stage 4 floodplains.

6.3 Environmental watering of FDEs

DECCW (on behalf of the former Murray Wetlands Working Group) manages an adaptive environmental water allocation, generated from water efficiency savings, to water target wetlands in the NSW Murray catchment. The proportion of the allocation diverted to wetlands varies from year to year and depends on river flow conditions and specific conditions at possible target wetlands.

Landholders on the Stage 3 floodplain with wetlands that remain isolated from floodwaters due to existing works may apply to DECCW for delivery of environmental water. Irrigation infrastructure may be used to deliver these flows.

6.4 Acid sulfate soils

With the extended drought in recent years, acid sulfate soils have become an increasing issue in the Murray catchment. The drying out of waterlogged soils has exposed sulfidic sediments built up during long periods of inundation. When exposed to air, chemical reactions may occur that lead to the generation of sulfuric acid. When these sulfuric sediments are rewetted there is a risk that significant amounts of acid and associated heavy metals may be released downstream, potentially impacting on the environment, livestock and agriculture as well as domestic uses.

Acid sulfate soils in the Central Murray area are mostly limited to watercourses and wetlands that have been permanently wet from regulated flows or irrigation return water and have dried out in recent times. The Stage 3 floodplain contains a number of these areas, including reaches of the Niemur River and Yarrein Creek. While the rewetting of affected soils by rainfall or streamflows can mobilise acid and metals and impact on larger areas, this impact will diminish during higher volume floods due to dilution effects. The Stage 3 floodway network will allow for the effective conveyance of floodwaters through the floodplain and facilitate the flushing of acid sulfate soils.

The Murray–Darling Basin Authority is coordinating an assessment of the risk of acid sulfate soils in key wetlands in the Murray–Darling Basin which will be used to determine suitable management options.

7 Implementation

7.1 Roles and responsibilities

Implementation of the Stage 3 FMP will be regulated under Part 8 of the *Water Act 1912*. NOW is currently responsible for implementing FMPs within rural New South Wales west of the Great Dividing Range. DECCW provides a technical advisory role in regard to this implementation.

The successful implementation of the Stage 3 FMP will largely depend on stakeholders fulfilling their responsibilities as set out in Table 7.1.

Table 7.1: Implementation roles and responsibilities

Stakeholder	Role or responsibility
NOW / DECCW (DECCW providing technical advisory role)	Arrange for implementation of FMP measures including changes to existing flood control works and restoring floodwater access to specified FDEs. Provide technical advice and support to landholders where appropriate. Assess applications for new flood control works and continue to approve existing flood control works. Monitor floodway performance, floodway conditions and flood data collection.
Murray CMA	Provide funding support, as available, for implementing approved modifications to flood control works to allow flood connectivity to be restored to FDEs, where consistent with Murray Catchment Action Plan targets for biodiversity, land and water.
Landholders	Undertake, under the direction of NOW, the required modifications to existing flood control works. Seek approval from NOW for any unapproved and future proposed flood control works, and construct works in accordance with approval conditions. Monitor floodway performance, floodway conditions and flood data collection.
Local government (Wakool Shire Council)	Maintain hydraulic capacity at waterway structures (e.g. bridges, culverts, causeways). Implement the FMP recommendations relating to council assets (e.g. new waterway structures or modifications to existing structures).
Murray Irrigation Limited	Maintain hydraulic capacity at floodway network waterway structures.

7.2 Application procedures for flood control works

7.2.1 General

Development consent from the local council under Murray REP2 and approval from NOW under Part 8 of the *Water Act* is required for flood control works (i.e. works that could affect the distribution of floodwaters on the floodplain).

As a first step in obtaining approval for an existing flood control work, landholders should enquire at the local council office to find out whether development consent is required under Murray REP2. A number of established banks, levees and works that have not been altered since construction may have existing use rights and may not require development consent. Additionally, the Murray Regional Organisation of Councils advised in 2007 that all existing flood control works complying with the FMP (see Section 7.4) are considered an existing use and do not require development consent. However, these works will still require approval from NOW under Part 8 of the *Water Act*.

7.2.2 How to apply for approval

For works without existing use rights – council development consent is required:

- A development application is made at the local council office for consent under Murray REP2.
- An application is then lodged with the local NOW office for approval under Part 8 of the Water Act (see Section 7.3).

For works with existing use rights – council development consent is not required:

- An application is lodged with the local NOW office for approval under Part 8 of the Water Act (see Section 7.3).

What happens when development consent is required

When consent is required, a development application is lodged with the local council which is the consent authority for flood control works under Murray REP2. Council is required to refer the development application to NOW before consent is granted. NOW advises council of its general terms of approval. 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. If NOW decides it cannot issue general terms of approval then the local council must refuse development consent.

The development application for a flood control work is advertised in the local newspaper and any submissions are assessed by the local council or by its Floodplain Management Committee. Council's assessment procedure is under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), and requires a broad environmental assessment of the works described in the development application. Appeals against the council's development consent or refusal are heard in the Land and Environment Court.

Following the granting of consent, an application is lodged with NOW for the issue of an approval under Part 8 of the Water Act (see Section 7.3).

What happens when development consent is not required

When development consent is not required, an application is made directly to NOW for approval under Part 8 of the Water Act (see Section 7.3). If the application complies with the Stage 3 FMP and meets NOW environmental requirements under Part 5 of the EP&A Act, NOW will issue an approval. However, if the application does not comply with the Stage 3 FMP it must be advertised in a local newspaper and in the Government Gazette. If objections result following advertising, NOW will arrange a compulsory mediation session with the purpose of resolving the objections.

NOW determines an application by granting an approval or by refusing the approval. Appeals against NOW's determination are heard in the Land and Environment Court.

7.3 Part 8 approval process for flood control works

7.3.1 General

All activities associated with flood control works are administered under the relevant sections of Part 8 of the Water Act.

Once the FMP has been adopted, it is proposed to designate the land area of the FMP as a floodplain under the Water Act. All flood control works situated on 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.

7.3.2 Works that require approval

Works requiring approval under Part 8 of the Water 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', or
 - wherever situated or proposed to be constructed, that affects or is reasonably likely to affect the flow of water to or from a river or lake, and is used or is to be used for, or has the effect or likely effect of, preventing land from being flooded, and is declared to be a 'controlled work'.

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

In the Stage 3 FMP, a 'controlled work' within the meaning of Part 8 is referred to as a 'flood control work'.

7.3.3 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, and
- supporting information that may help in the determination process (the applicant should get in touch with the nearest NOW office for details).

For non-complying works, a report on the hydraulic and environmental impacts of the proposal will be required.

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

7.3.4 Determination process

All applications under Part 8 of the Water Act, 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** – 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** – all proposals must undergo assessment under Part 5 of the EP&A Act except where development consent under Murray REP2 is required (see Section 7.2). The factors to be considered include, but are not limited to:
 - any environmental impact on a community
 - any transformation of a locality
 - any environmental impact on the ecosystems of a locality
 - any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality
 - any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations
 - any impact on the habitat of protected fauna (within the meaning of the *National Parks and Wildlife Act 1974*)
 - any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air
 - any long-term effects on the environment
 - any degradation of the quality of the environment
 - any risk to the safety of the environment
 - any reduction in the range of beneficial uses of the environment
 - any pollution of the environment
 - any environmental problems associated with the disposal of waste
 - any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply, and
 - any cumulative environmental effect with other existing or likely future activities.

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- **Floodplain management plans** – 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 Water Management Act.
 - **Aboriginal heritage assessment** – NOW will liaise with DECCW Environment Protection and Regulation Group, Landscape and Aboriginal Heritage Protection (South) and if required DECCW Country, Culture and Heritage Division (Far West), to assess Aboriginal heritage issues associated with individual applications. Applications will be assessed in accordance with the National Parks and Wildlife Act.
 - **Additional information** – NOW must consider any investigation information that has been provided by the applicant.

7.3.5 Possible determinations

NOW must inform the applicant as soon as practicable of the determination of an application for a flood control work. Where development consent under Murray REP2 is required, NOW will advise council of its general terms of approval (see Section 7.2).

The general terms of approval should be comprehensive enough to cover all of the constraints (terms and conditions) that may be applied to the relevant Part 8 approval. Under the Water Act, there are three possible determinations: approval of the application, approval of the application subject to conditions, or refusal of the application.

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

7.4 Complying and non-complying works

Complying work

Under section 168B(2) of the Water Act, a flood control work is to be 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.

Within the Stage 3 floodplain, complying flood control works are defined as:

- existing (unapproved) and proposed works that are located outside the Stage 3 floodway network as shown in Figures 3.1 to 3.5 of the Stage 3 FMP, or
- existing (unapproved) and proposed works that are to be modified in accordance with the required modifications specified in Table 4.1 and Table 5.1 of the Stage 3 FMP.

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 7.3, including assessment against the matters raised in section 166C of the Water Act and Part 5 of the EP&A Act (see Section 7.3).

Non-complying work

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

Within the Stage 3 floodplain, non-complying flood control works are defined as:

- existing (unapproved) and proposed works that are located within the Stage 3 floodway network as shown in Figures 3.1 to 3.5 of the Stage 3 FMP, or
- existing (unapproved) and proposed works that are not modified in accordance with the required modifications specified in Table 4.1 and Table 5.1 of the Stage 3 FMP.

7.5 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. Applications will be assessed against the matters raised in section 166C of the Water Act (see Section 7.3) and the following environmental and hydraulic assessment criteria.

7.5.1 Environmental assessment criteria

Existing or proposed non-complying works located within the Stage 3 floodway network (as shown on Figures 3.1 to 3.5) will need to meet the following environmental assessment criteria:

- The works do not block, impede or divert the flooding regimes in flood dependent ecosystems within the Stage 3 floodway network.
- The works do not impede the delivery of environmental water to ecological assets specified under *The Living Murray Environmental Watering Plan* (issued annually) or the *Murray Wetlands Working Group Business Plan* (issued annually).

In addition, the environmental impacts of works will be assessed under Part 5 of the EP&A Act (see Section 7.3).

7.5.2 Hydraulic assessment criteria

Existing or proposed non-complying works located within the Stage 3 floodway network (as shown in Figures 3.1 to 3.5) will need to meet the following hydraulic assessment criteria:

- The works do not cause any redistribution of the design flood (1975) peak floodway flows (as shown in Figure 4).
- The works do not cause any significant redistribution of floodway flows smaller than the design flood floodway flows (i.e. no more than a 5 per cent redistribution of the unimpeded floodway flow distribution for floods smaller than the design flood).
- The works do not cause any significant increase in Stage 3 floodway network velocities for all flood flows up to and including the design flood floodway flows. Velocities should be of an order that is below the threshold of erosion for the potential land usage.
- The works do not cause a significant increase in upstream water levels for all floodway flows up to and including the design flood floodway flow conditions (i.e. increases must not exceed 0.1 m encroaching onto an adjoining landholder's property).

(See Section 3.2 for information about the design flood.)

It is the landholder's responsibility to provide the necessary technical details to support an application. Where the requested supporting information is not provided, NOW can refuse to deal with the application.

Applications for non-complying works must be advertised and third party objections sought before the 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.

7.6 Unauthorised works

Unauthorised controlled works include the following:

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

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

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

- a) work to remove, modify, repair or restore the controlled work or to render the work ineffectual,
- b) work to repair any damage caused by the controlled work (including any damage caused to any specified land, river, lake, structure or vegetation, or to the environment),
- c) 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,
- 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 to the Land and Environment Court.

7.7 Varying conditions of approved works

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

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

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

7.8 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 New South Wales to establish a framework for managing activities that have the potential to intercept significant volumes of water.

7.9 Roads and railways

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

7.10 Flood protection for high-value infrastructure

Landholders can protect from flooding those parts of their property that contain high-value infrastructure such as houses, workshops and sheds. Where such works are constructed solely for the protection of high-value infrastructure, Part 8 approval will not 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, the infrastructure protection works will need to be assessed as a Part 8 determination process for flood control works on a property.

7.11 Block banks

There are a number of block banks (in-stream earthworks) present within the waterways in the Stage 3 floodplain, mostly in the form of low level embankments constructed for vehicle crossing purposes. These low level banks have not been individually identified by the Stage 3 FMP. Depending on their intended purpose, block banks require one of the following types of authorisation:

- controlled activities approval under the Water Management Act (for vehicle crossings)
- water supply work approval under the Water Management Act (where water supply works are constructed on streams listed in a water sharing plan), or
- licensing under Part 2 of the Water Act (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*.

7.12 Possible funding sources for environmental works and public works

Funding may be available for both private and public works as listed in Tables 4.1 and 5.1. The funds are competitive and generally any application has to demonstrate how proposed works are consistent with a plan or policy and produce a natural resource outcome and not just a private benefit. Table 7.2 lists details of possible funding sources for works modifications.

Table 7.2: Possible funding sources

Source	Fund manager	Eligible works
Commonwealth and State-assisted Natural Disaster Mitigation Program	Emergency Management NSW (at state level)	Mainly flood mitigation works (public)
State Assisted Floodplain Management Program	DECCW	Studies and public works related to local government floodplain management
Various incentive funds: <ul style="list-style-type: none"> • Caring for our Country • conservation farming incentive funding • native vegetation incentive program 	Murray CMA	On-farm works with natural resource management outcomes consistent with targets in the Murray Catchment Action Plan

8 Monitoring, maintenance and review

8.1 Performance indicators

Performance indicators will be used to assess whether the Stage 3 FMP has achieved its objectives. The performance indicators are:

- Performance indicator 1 – Flood control works are to comply with the Stage 3 floodway network.
- Performance indicator 2 – The floodway network is to perform adequately in flood events.

The approval process for flood control works will provide a measure of the number of flood control works that are constructed, modified and maintained according to the Stage 3 FMP.

The performance of the Stage 3 floodway network during future floods will be assessed using information gathered during flood monitoring activities.

When assessing the FMP's performance the following objectives should be taken into account:

Hydraulic:

- improved conveyance of floodwaters through the Stage 3 floodway network
- increased volume of flood storage available within the Stage 3 floodway network
- floodplain hydraulic structures able to adequately discharge the design flood flow

Environmental:

- improved floodwater connectivity to FDEs
- improved floodplain connectivity for fish passage
- floodplain environmental structures performing adequately

Economic:

- reduced flood damage.

In order to assess the FMP's performance, a monitoring program will be undertaken as outlined below.

8.2 Flood monitoring

DECCW will lead the preparation and implementation of monitoring programs during major flood events. Input will be sought from NOW, local councils, MIL and landholders on an as-needs basis. Monitoring activities include flow gauging, aerial and ground photography and observations and recordings of the hydrologic, hydraulic and environmental aspects of flooding. Observations and measurements recorded will help to identify whether the floodway network is performing adequately. Future improvements or refinements to the floodway network can be identified as a result.

Monitoring and collection of hydraulic data in future floods should encompass the following activities:

-
- stream gaugings across the system, with priority given to the following sites:
 - Cunninyeuk Creek floodway in the vicinity of Cunninyeuk Road
 - Niemur River floodway in the vicinity of Cunninyeuk Road
 - Yarrein Creek (the precise location can vary to suit access and minimise gauging complexity)
 - observations of the direction of flow paths and estimates of flow velocities
 - recording of flood data at infrastructure crossings (e.g. roads, supply channels)
 - in significant floods, recording the peak flood heights and times, particularly in the vicinity of causeways, bridges, culverts, siphons and other notable floodplain features.

In relation to these monitoring activities, NOW is responsible for flood event stream gaugings. NOW and DECCW will provide input into the other activities with support from landholders, councils and MIL (Appendix B has further details).

8.3 Environmental monitoring

Environmental monitoring during and after floods will determine whether the required environmental improvement measures (Table 5.1) are working properly, and help to assess the ecological impacts of local flooding. DECCW will coordinate this monitoring with input sought from NOW, local councils, MIL and landholders.

Throughout the Stage 3 floodplain, environmental monitoring information will consist mainly of observations with supporting photography wherever possible. The scale of flooding will influence the extent of data collected during and following each flood event.

For example, in a flood of 1975 proportions, observations of wetland inundation would be extensive in comparison to a relatively small flood. Monitoring information would include:

- performance of works modifications (e.g. installed regulators, levee bank realignments or openings)
- inundation of FDEs (e.g. duration, extent, depth)
- presence of waterbird and fish species, and
- regeneration of floodplain vegetation.

Guidelines for monitoring activities are set out in Appendix B. Specific guidelines are included for landholder, council and NOW/DECCW monitoring activities.

8.4 Levee design, construction and maintenance issues

The construction of flood protection measures within the Edward–Wakool system has been, and will remain, a voluntary scheme. This means there is no obligation on the part of landholders to erect levees for flood protection.

Furthermore, the height which landholders choose to construct private levees is generally of their own choosing. In some instances, levee approvals have been issued which limit the maximum height to which a levee can be constructed. However, there are no minimum height requirements in accordance with the voluntary nature of the scheme.

The local community has expressed concern about voluntary levee construction limiting flood protection. Joint levee schemes that protect multiple properties require that all landholders along the levee route participate so that flood protection is viable. However, the construction and maintenance of flood control works for the protection of private rural properties remains voluntary and participation in such schemes cannot be enforced.

The use of sound construction techniques is critical to the structural adequacy of levee banks. Key aspects of construction include the suitability of the material used, foundation conditions and the level of compaction achieved. Landholders should seek relevant engineering advice on levee construction.

In relation to ongoing maintenance of levees, landholders should carry out inspections annually and shortly after major significant events. Inspections should check for any visible damage, including crest erosion, batter erosion or slumping, tree growth (regrowth should be removed from the vicinity of levees) and animal burrows (burrows should be dug out and filled with compacted soil).

8.5 Regulators

Regulators (gated flow structures) are proposed at a number of sites to allow for controlled flooding of FDEs. The operation of these regulators will be specified as a condition of the Water Management Act 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 if landholders or managers are absent at the onset of a flood. Contingency plans to provide an alternative means of gate operation will need to be prepared to address this issue.

Maintenance of regulators to ensure they remain in sound operating condition will be essential for maintaining flood connectivity to FDEs. Waterway structures are prone to siltation and should be checked periodically to optimise their operation, particularly after floods or heavy rain.

8.6 Reviewing the FMP

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

Accordingly, the Stage 3 FMP will be subject to scheduled reviews at five-yearly intervals. The occurrence of a major flood may warrant an unscheduled review of the Stage 3 FMP, particularly if issues arise in relation to the adequacy of the floodway network's performance during flood events. 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 ecology and the institutional framework in which they are managed. Climate change is expected 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.

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

9 References

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Appendix A – Glossary

Term	Definition
Average recurrence interval (ARI)	The long-term average number of years between the occurrence of a flood as big or larger than the selected event (e.g. floods with a discharge as great or greater than the 100 year ARI event will occur on average once every 100 years)
Catchment	The area of land draining to a particular site
Discharge (or flow)	The rate of flow measured in terms of volume per unit time (e.g. megalitres per day – ML/day)
Flood dependent ecosystems (FDEs)	Areas supporting plants and animal communities that are adapted to wetting (flooding) and drying and depend on flooding to remain healthy
Floodplain	Any land which is so designated by an order in force under section 166 (1) of the <i>Water Act 1912</i>
Flood risk	Potential for damage to property or people due to flooding
Flood storage area	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood
Floodway network	A network of flow paths across the floodplain where a significant discharge of floodwaters occurs during floods
Gauged flow	Flow rate at a particular location determined based on field measurements
Hydraulics	The study of water flow in waterways
Hydrologic / hydraulic computer models	The mathematical representation of the physical processes involved in runoff generation and streamflow
Hydrology	The study of the rainfall and runoff process
Peak discharge (or peak flow)	The maximum flow recorded during a flood event
Ramsar Convention	A convention on wetlands of international importance that aims to halt the worldwide loss of wetlands and to conserve, through wise use and management, those that remain
SPOT 5 satellite imagery	High-resolution photographic imagery captured by the SPOT 5 satellite (launched in 2002)
Water sharing plan	A legal document prepared under the <i>Water Management Act 2000</i> that establishes rules for sharing water between the environmental needs of a river or aquifer and water users, and also between different types of water users

Appendix B – Flood/environmental monitoring guidelines

B1 Specific flow and flood level monitoring sites

There are several specific locations within the Stage 3 floodway network where data on flow and flood level, collected for future floods, will enable an improved understanding of the hydraulic performance of the whole floodway network. These specific locations – to be treated as a priority for obtaining flow and flood level data in future floods – are as follows:

- Cunninyeuk Creek floodway in the vicinity of Cunninyeuk Road
- Niemur River floodway in the vicinity of Cunninyeuk Road
- Yarrein Creek (the precise location can vary to suit access and minimise gauging difficulty).

B2 Flood monitoring guidelines for landholders

The following advisory notes specify monitoring activities that can be undertaken by landholders. Data collected will help in future reviews of the Stage 3 FMP, which will most likely be undertaken at five-yearly intervals or after major flooding events. If appropriate, changes to the Stage 3 floodway network may be an outcome of the review process.

Flood event data

Landholders are encouraged to collect the following information during significant floods:

- Mark or peg the location of the maximum flood height. Suitable locations may include the sides of trees, fence posts, building walls. Use a nail or some other marking technique that will not easily be lost.
- Note the location of the outer fringe of the flood extent at the time of the flood peak (e.g. relative to a permanent object such as a tree or fence line).
- Note the time of the flood peak.
- Note any apparent significant obstructions which are visible obstructing the passage of floodwaters, and if possible, estimate and note the difference in water level between the upstream and downstream side of the obstruction.
- Take photographs or videos of the flood, particularly at locations of interest (e.g. causeways, bridges, weirs, levees, flood breakout points, obstructions). Record the time and date each photograph or video was taken.
- Observe the direction of flow paths.
- Where possible estimate the velocity of flow. This can be done by timing the movement of small floating debris carried by the flow over an approximate known distance.

Flood damage data

Flood damage data is useful for assessing the effectiveness of the floodway network. Landholders are encouraged to record damages incurred as a result of floods:

- Note the location, area and estimated value of crops damaged or destroyed.
- Note the extent and estimated value of damage to farm infrastructure and equipment (e.g. fencing, tracks, machinery, etc.).
- Note the location of any significant erosion and silt deposition, either in-stream or on the broader floodplain.

Environmental data

Environmental data can be collected at any time coinciding with observations of interest:

- Note the performance of flow regulators in allowing floodwater connectivity into FDEs during the course of floods (e.g. the period of time flow was discharged through a regulator into an FDE, the period of time flow returned through the regulator as the flood receded, the period of time floodwater was present within the FDE).
- Photograph and note flood characteristics within FDEs (e.g. duration, depth, extent of inundation).
- Photograph vegetation at the same location over time to allow for the extent of regeneration to be quantified by comparing the photographs.
- Note, and where possible photograph, the presence of any observed unusual fauna species (fish, birds, etc.).

Landholders could use the questionnaire overleaf to record flood data.

B3 *Flood monitoring guidelines for councils*

Council's focus in relation to flood monitoring should be on the performance of road structures (e.g. bridges, culverts, causeways). Council is encouraged to collect the following data during a flood to help identify the hydraulic performance of road structures:

- Note the following:
 - time when flow starts and finishes
 - water levels at both the upstream and downstream sides of the structure (this allows the head difference (afflux) to be quantified)
 - the depth of flow over the road (e.g. at causeways)
 - the flow velocity through or across the structure
 - the direction of flow through the structure, noting the time of observation, and
 - the quantity of debris accumulated affecting flow through the structure.
- Photograph the structure during the flood.

In the aftermath of a flood, council is encouraged to document the following data to assess the extent of disruption and flood damage to roads:

- Note the location and extent of damage to the road infrastructure, including pavement damage, road embankment cuts or erosion, silt deposition on road surfaces, damage to bridges or culverts.
- Where applicable, note the period that the road remained closed during the flood.

B4 *Flood monitoring guidelines for DECCW and NOW*

DECCW will undertake the following flood monitoring activities with input from NOW as required:

- Obtain NOW gauged flow data and flood heights at points of interest within the Stage 3 floodway network (the priority sites are specified in Section B1).
- Organise or obtain flood photography and satellite imagery during the course of significant flood events where this is considered advantageous.
- Organise any necessary survey to be undertaken in the aftermath of floods (e.g. for flood heights recorded by landholders, councils or MIL).

-
- Consult with stakeholders (e.g. landholders, emergency response groups, councils) in the aftermath of significant floods to ascertain their views in relation to the management of response activities during floods and the performance of the floodway network. Where appropriate, conduct follow-up field inspections or investigations to view identified problem areas or flood damaged sites.
 - Obtain and collate relevant environmental data that is collected on an ongoing basis by government agencies and interest groups (e.g. data from the Sustainable Rivers Audit led by the Murray–Darling Basin Authority and the Integrated Monitoring of Environmental Flows led by NOW).

Flood monitoring questionnaire

Flood event data

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 _____

Direction of flow (floodplain flow paths) – provide location and time: _____

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

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

Compare with previous floods – larger / smaller, etc.: _____

Flood damage data

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

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

Road/track 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 are required to reconnect wetlands,
is the regulator or levee opening of adequate capacity or size? Yes / No

If no, what are your observations: _____

Did floodwater reach the wetland? Yes / No

Was floodwater backed up upstream of the opening? Yes / No

Appendix C – Stage 3 floodway network maps

Figure 3.0: Key map

Figure 3.1: Sheet 1 of 5

Figure 3.2: Sheet 2 of 5

Figure 3.3: Sheet 3 of 5

Figure 3.4: Sheet 4 of 5

Figure 3.5: Sheet 5 of 5

