



Floodplain Management Plan

*Murrumbidgee River
Hay to Maude*

April 2014

Funding for the Murrumbidgee River Hay to Maude Floodplain Management Plan was provided by the Commonwealth Natural Disaster Mitigation Program with additional financial support from the NSW Government.

The Murrumbidgee River Hay to Maude floodplain management plan project is indebted to the Murrumbidgee River Floodplain Management Committee, Hay to Maude, 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):

Flooding following the peak of the May 1989 event, twin irrigation channels south of Murrumbidgee River (Allen Cox, Namcott Farms)

Black box woodland and canegrass, northern flood runner (Erin Askew, WMAwater)

Flooding following the peak of the May 1989 event, 'Pevensey' access road (Neil Benning, former NSW Department of Water Resources)

Sturt Highway crossing, Bungah Creek (Erin Askew, WMAwater)

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Published by:

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ISBN 978 1 74293 553 9
OEH 2014/0068
April 2014

Printed on recycled paper

Contents

Abbreviations	ii
Preface	iii
1 Introduction	1
1.1 Vision and objectives.....	1
1.2 Overview of the FMP floodplain.....	1
2 Development of the FMP	6
2.1 FMP process	6
2.2 Legislative and policy framework.....	6
2.3 Community consultation	11
2.4 Floodplain management principles.....	12
3 FMP floodway network	14
3.1 Purpose of the floodway network	14
3.2 Design flood.....	14
3.3 Hydraulic modelling	14
3.4 Floodway design.....	15
3.5 Floodway vegetation management.....	18
4 Required hydraulic and environmental improvement measures	20
5 Environmental impact	28
5.1 Overview.....	28
5.2 Catchment impacts.....	28
5.3 Projects being undertaken in the catchment	31
6 FMP implementation	32
6.1 Roles and responsibilities.....	32
6.2 Part 8 approval process for flood control works	32
6.3 Complying and non-complying works.....	35
6.4 Unauthorised works.....	37
6.5 Varying conditions of approved works.....	38
6.6 Roads and railways	38
6.7 Flood protection for high value infrastructure	38
6.8 Block banks	38
6.9 Possible funding sources for environmental works and public works.....	39
7 Monitoring and review	40
7.1 Performance indicators.....	40
7.2 Flood monitoring.....	40
7.3 Environmental monitoring.....	41
7.4 Floodplain management plan review.....	41
8 References	43

Appendices

Appendix A – Glossary	69
Appendix B – Flood/environmental monitoring guidelines	70
Appendix C – Details of improvement measures (Sites A to J).....	77
Appendix D – The importance of Aboriginal sites in the Australian landscape	99

Tables

Table 1: Hydraulic and environmental improvement measures.....	22
Table 2: Summary of FMP environmental impacts.....	29
Table 3: Projects being undertaken in the Murrumbidgee catchment	31
Table 4: Roles and responsibilities	32
Table 5: Complying works criteria.....	36
Table 6: Possible funding sources.....	39

Figures

Figure 1: FMP floodplain.....	3
Figures 2A to 2E: FMP floodway network	45
Figures 3A to 3E: FMP floodway network with flood dependent ecosystems	57
Figure B1: Flow and flood level monitoring sites.....	75
Figures C1 to C10: Details of improvement measures (Sites A to J).....	77

Abbreviations

AHIMS	Aboriginal Heritage Information Management System
AHD	Australian Height Datum
ALS	Airborne laser scanning (also known as LiDAR)
ARI	Average recurrence interval
CMA	Catchment Management Authority
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i>
FDE	Flood dependent ecosystem
FMP	Floodplain management plan
FRMS	Floodplain risk management study
IPA	Indigenous Protected Area
OEH	Office of Environment and Heritage, Department of Planning and Environment
PVP	Property Vegetation Plan
WMA	<i>Water Management Act 2000</i>

Preface

Following the construction of Burrinjuck and Blowering Dams and the transformation of the Murrumbidgee River from carrying intermittent to regulated flows, the Murrumbidgee floodplain has undergone substantial irrigation development. The floodplain between Hay and Maude is a successful grazing and irrigation area that also retains extensive floodplain ecosystems which support key ecological processes during floods. Crop protection works, irrigation channels and other earthworks (known as ‘flood control works’) have altered flow patterns on the floodplain. This development, if not coordinated, has the potential to create flooding problems and to impact on the connectivity of flood dependent ecosystems.

Floodplain development guidelines were prepared for the Murrumbidgee floodplain from Hay to Maude by the NSW Water Resources Commission in 1977 (the ‘1977 Guidelines’; WRC 1977) following a significant flood in 1974. To date, the 1977 Guidelines have served as the main reference for landholders undertaking floodplain development including the construction of flood control works. However, the Guidelines needed to be replaced with a strategic plan that addresses contemporary levels of development and is consistent with the needs of sustainable natural resource management. Preparation of this FMP has reviewed and expanded the 1977 Guidelines using current information and approaches to floodplain management.

The Murrumbidgee River Hay to Maude Floodplain Management Plan (the FMP) has been prepared by the Office of Environment and Heritage (OEH) within the Department of Planning and Environment, for the Water Administration Ministerial Corporation under Part 8 of the *Water Act 1912* and in accordance with the processes outlined in the *NSW Floodplain Development Manual* (NSW Government 2005). The preparation of the FMP has been overseen by the Murrumbidgee River Floodplain Management Committee, Hay to Maude, which comprised community representatives, stakeholder groups and government agencies. Funding for the FMP has been provided by the Commonwealth Natural Disaster Mitigation Program with additional financial support from the NSW Government.

OEH prepares rural floodplain management plans that define requirements for managing floodwaters within floodplains. The approval of flood control works and compliance functions under Part 8 of the Water Act is the responsibility of the NSW Office of Water within the Department of Primary Industries.

Development of the FMP 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 – outlining strategies to manage flood risk and flood management issues, and support the natural functions of the floodplain environment.

The FMP will allow for future floodplain management planning by providing a coordinated and integrated network of floodways, appropriately located and sufficiently sized to convey unimpeded floodwaters to support the floodplain environment and minimise flood risk. The FMP, including the FMP floodway network, will form the basis for determining whether

flood control works on the floodplain will be granted approval under Part 8 of the Water Act. The FMP also specifies the approval process and assessment criteria for proposed and existing works. Flood control works located within floodways are assessed as non-complying works and are likely to be refused or require modification or removal.

The FMP floodway network has been designed to effectively convey floodwaters to flood dependent ecosystems including river red gum and black box woodlands, lignum swamps, billabongs and flood runners within the FMP floodplain and to the downstream Lowbidgee floodplain wetlands. The FMP also specifies works modifications to resolve identified environmental connectivity and hydraulic issues associated with existing flood control works.

The performance of the FMP will be assessed against three key performance indicators, using information gathered during flood monitoring activities:

- existing flood control works are to be modified according to the FMP
- the FMP floodway network is to allow for the orderly passage of floodwaters, and
- the FMP floodway network is to allow for the connection of floodwaters to support flood dependent ecosystems.

Dense vegetation cover within the FMP 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.

It is expected that the FMP will 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 FMP will look at its capacity to address climate change impacts on flood risk, flood dependent ecosystems and rural economies.

1 Introduction

1.1 Vision and objectives

The Murrumbidgee River Hay to Maude Floodplain Management Plan (the FMP) has been prepared to provide strategic guidance to the NSW Government and landholders who are involved in the management of floodwaters on the Murrumbidgee River (Hay to Maude) floodplain.

The vision for the FMP is:

an environment where flood risk to occupiers and users of the floodplain is minimised and flood dependent ecosystems within the floodplain and on the downstream Lowbidgee floodplain are sustained by access to floodwaters.

The FMP has the following strategic objectives, linked to the above vision statement:

- *to achieve a coordinated, balanced approach to floodplain management taking into account hydraulic, environmental, social and economic considerations and legislative requirements*
- *to ensure the sustainable and equitable use of floodplain resources*
- *to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically methods wherever possible (NSW Flood Prone Land Policy objective)*
- *to coordinate floodplain development to minimise adverse changes to flow patterns*
- *to improve and maintain the diversity and well being of riverine and floodplain ecosystems that depend on flood inundation*
- *to take into account the cumulative impact on flooding behaviour of individual developments*
- *to provide flow paths to effectively support the downstream Lowbidgee floodplain wetlands, and*
- *to maintain areas of Aboriginal cultural significance that are flood dependent.*

1.2 Overview of the FMP floodplain

The specific area considered by this FMP is known as ‘the FMP floodplain’ and is shown on Figure 1. The FMP floodplain includes the reach and floodplain of the Murrumbidgee River between 11 km upstream of Hay and just downstream of Maude. It covers an area of approximately 1700 km², within the Hay Shire local government area.

Other significant waterways within the FMP floodplain providing connectivity between the Murrumbidgee River and the floodplain are Coonoon Creek, Eleven Mile Creek, Darcoola Creek, Sand Creek, Fiddlers Creek, Uara Creek (formerly known as Gum Creek), Black Creek and Budgee Creek, in addition to a number of unnamed flood runners. Figure 1 shows these waterways and the location of the FMP floodplain in the Murrumbidgee catchment.

1.2.1 Flooding characteristics

Flooding within the FMP floodplain is typified by high volume, long duration flooding, emanating from significant rainfall in the upper Murrumbidgee River catchment. The result is elevated river levels and large portions of the floodplain becoming flooded for up to months at a time. Within the FMP floodplain the Murrumbidgee River is generally well defined; however, as with a number of western flowing inland rivers, the capacity of the main channel reduces moving downstream, resulting in the distribution of floods across the wider floodplain. A number of flood runners are generated with some returning to the Murrumbidgee River and others continuing downstream as floodplain flow. The pattern of flood flow distribution is dependent on local topography and the size of the particular flood event. During the 1974 flood, which has an approximate average recurrence interval (ARI) of 40 years, flood flows were distributed from the river by four main flow paths, including:

- a flood runner which passed through the northern parts of the FMP floodplain and included Darcoola and Budgee Creek systems
- a flood runner which carried flows to the south of the river upstream of Hay and returned to the river just downstream of the town
- a breakout downstream of Hay Weir which carried flows along a runner to the north of the river in the vicinity of Coonoon Creek, and
- a breakout downstream of Hay Weir which carried flows through the southern FMP floodplain and included the Fiddlers Creek system.

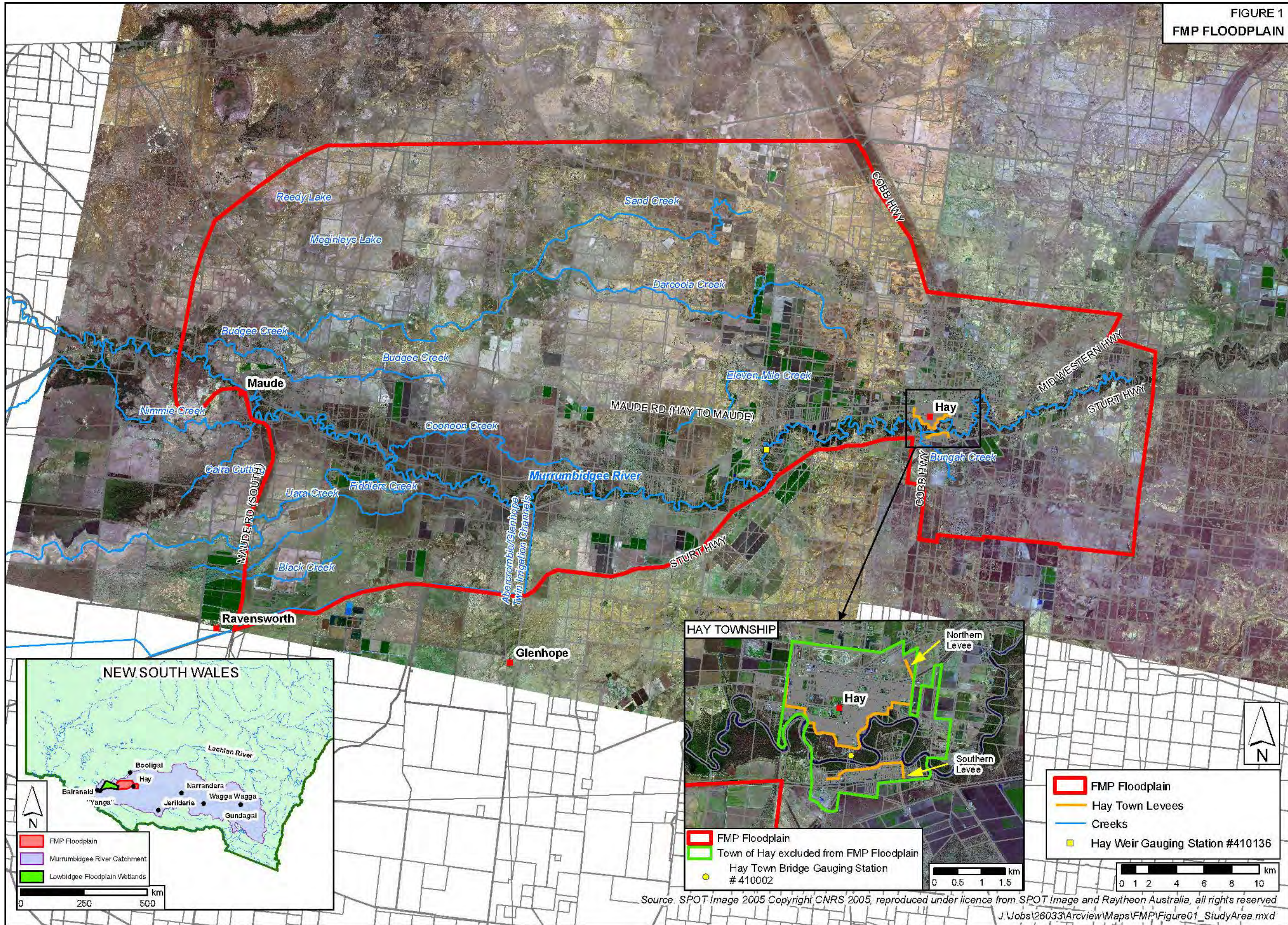
The Murrumbidgee River has a long history of recorded floods and a number of major flood events have occurred on the FMP floodplain within living memory. The most significant of these floods occurred in 1956 and 1974 with peak flows at Hay estimated to be 82,500 ML/day and 69,900 ML/day respectively. It is important to note that since the 1956 flood, significant changes have taken place within the FMP floodplain and in the vicinity of Hay. As a result of these and other changes, the behaviour of the river is likely to be different from that experienced in past floods. For example, the 1974 peak height recorded at the Hay Town Bridge gauge was higher than the 1956 flood peak even though the peak flow in 1974 was 20% lower than that in 1956. Since the decommissioning of the Hay Town Bridge gauge in 1982, major floods have occurred in 1984, 1989, 1990, 1991 and 1993.

1.2.2 Floodplain environment

Flooding is a vital natural process that drives pulses of ecological productivity. Floodplains have a key ecological role in providing organic matter and nutrients that are cycled during floods and support an extensive food base for fish and waterbirds. Within the broader floodplain however, there is a mosaic of environments ranging from terrestrial, that are seldom flooded, to aquatic environments that are permanently wet.

The environment within the FMP floodplain has been modified by the development of agriculture and associated flood control works. This has resulted in the removal of floodplain vegetation and the reduction of flood connectivity. Despite these impacts, the FMP floodplain retains important ecological values. It contains extensive areas of flood dependent ecosystems (FDEs) that rely on temporary or permanent inundation by floodwaters to sustain essential ecological processes. These include wetlands, floodplain vegetation, watercourses, and Aboriginal sites that depend on flooding. Native remnant vegetation is mainly dominated by communities of river red gum along the Murrumbidgee River corridor and black box woodlands and lignum and nitre goosefoot swamps along the flood flow paths away from the river. These species are flood dependent and rely on frequent inundation for general health and regeneration.

FIGURE 1
FMP FLOODPLAIN



The FMP floodplain also supports a diversity of native animals 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). Three threatened fauna species (blue-billed duck, bush stone-curlew, southern bell frog) and a threatened plant (slender Darling pea) have been observed in wetland habitats on the FMP floodplain. Native fish benefit from the floodplain habitat, utilising food resources generated during floods and undertaking breeding opportunities. Golden perch and silver perch (a threatened species), recorded within the FMP floodplain, both undertake migration and spawn on the floodplain in response to flooding.

The FMP floodplain has a rich Aboriginal heritage as it was once part of a major Aboriginal trade route and provided abundant food resources to support the indigenous occupants. It lies within the traditional nations of the Nari Nari and Wiradjuri. A diverse range of Aboriginal sites including artefacts, hearths, burial sites, earth mounds and scarred trees has been recorded within the FMP floodplain. Further information on the significance of Aboriginal sites in the landscape is included in Appendix D. Aboriginal occupation on the floodplain was generally concentrated at water sources and decreased markedly with distance away from water (Pardoe and Martin 2001). Sites of particular relevance to the FMP include scarred trees that are flood dependent (river red gums and black box) and spiritually significant wetlands and watercourses. The Nari Nari Tribal Council has indicated that floodplain and wetland vegetation on the FMP floodplain is critical to their culture as it can provide traditional food and medicine or be used in important ceremonies.

The Lowbidgee floodplain, located directly downstream of the FMP floodplain (see Figure 1) is a large wetland system (about 200,000 ha) with important areas of lignum that support waterbird breeding following flooding, and large areas of river red gum woodland. The significance of the Lowbidgee floodplain is nationally recognised by its listing in the *Directory of Important Wetlands in Australia* (Environment Australia 2001). The downstream delivery of floodwater volumes to the Lowbidgee floodplain wetlands, consistent with natural flow paths, has been a key consideration in the preparation of the FMP.

2 Development of the FMP

2.1 FMP process

The FMP has been prepared in accordance with the NSW Government's *Flood Prone Land Policy* (see NSW Government 2005), and has been developed through three key stages:

- **Flood study** – a technical assessment of the nature and extent of flooding and flood related issues. The *Murrumbidgee River Floodplain – Hay to Maude – Phase A: flood study and data collection* (WMAwater 2008) was completed in January 2008.
- **Floodplain risk management study** – evaluates management options for the floodplain giving consideration to hydraulic, environmental, social and economic issues. The *Murrumbidgee River Floodplain – Hay to Maude – Phase B: floodplain risk management study* (WMAwater 2009) built upon the work undertaken in the flood study and included the development of management options for the sustainable development of the floodplain.
- **Floodplain management plan** – outlines strategies to manage flood risk and flood management issues.

The process has been guided by a Floodplain Management Committee comprising representatives of the community and stakeholder groups (see Section 2.3.1).

The FMP replaces the *Guidelines for Floodplain Development – Murrumbidgee River Hay to Maude 1977* (the '1977 Guidelines'; WRC 1977). The 1977 Guidelines have provided the basis for floodplain development to date and required revision to be consistent with current natural resource management policies.

2.2 Legislative and policy framework

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

2.2.1 *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 the Office of Water's ability to deal with unauthorised works.

At the time of preparing this FMP the NSW Government had initiated wide-ranging reform of water legislation, with the outcome being the *Water Management Act 2000* (WMA). The WMA consolidates most of the previous Acts covering water management in New South Wales. The WMA is being phased in gradually as water sharing plans are developed and commenced for particular water sources. The floodplain management provisions of that Act will eventually replace Part 8 of the *Water Act 1912*. Under 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, the Office of Water requires approval for controlled activities which include the removal or deposition of material in the bed of a watercourse or wetland and on adjacent land, and other activities that affect the flow of water in a watercourse. Approval under the WMA would be required where earthworks are proposed in the bed of a watercourse or wetland or where material is being sourced from a watercourse to construct a flood control work.

Core provisions – Water Management Act

The WMA specifies core provisions that must be dealt with in a floodplain management plan made for a water management area and additional provisions that may be dealt with. These provisions have guided the preparation of the FMP. The 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 (WMAwater 2009). Section 3 of the FMP 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 of the FMP. Detailed information on the environmental assessment is presented in the FRMS (WMAwater 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 (WMAwater 2009). Based on this assessment, the FMP specifies required modifications to existing works to address identified hydraulic and environmental issues (Section 4).

- 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 FMP floodway network (Section 3.2 of the FMP). 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 6 outlines the approval and determination process for new flood works. The FMP floodway network (Figures 2A to 2E) 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 Table 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 (Section 2.4) which informed decision-making in the design of the FMP floodway network and in the hydraulic and environmental improvement measures in Table 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 6 and 7 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 FMP on water quality are assessed at a strategic level in Table 2.

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 7 are designed to assess the performance of the FMP in achieving its objectives.

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

Currently no matters have been prescribed by the regulations.

2.2.2 Other legislation

There are several other legislative acts relevant to floodplain management and the approval process for flood control works.

- ***Environmental Planning and Assessment Act 1979*** (EP&A Act) – This Act is of particular importance. In determining applications for flood control works, the Office of Water is required to assess the environmental impact of the works under Part 5 of the Act. Consideration of proposed works under Part 4 of the Act is not required as there is no relevant planning instrument that applies to flood control works in the FMP floodplain.
- ***National Parks and Wildlife Act 1974*** – Part 6 of this Act aims to conserve, protect and manage Aboriginal objects and places in New South Wales. It is an offence under the Act to 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 the 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. There are no Ramsar-listed wetlands within the FMP floodplain.

Further legislation relevant to the FMP includes:

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

2.2.3 Policy

There are two key state 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 FMP floodplain, where many wetland sites are subject to short periods of inundation followed by long periods of drying out.

2.2.4 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 state-wide targets for natural resource management. The 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 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.

2.2.5 Other relevant management plans

The FMP is only part of the catchment and land-use planning picture and should be viewed as a component of the integrated planning process, with other linked components including:

-
- *Murrumbidgee Catchment Action Plan 2013*
 - *Water Sharing Plan for the Murrumbidgee Regulated Rivers Water Sources 2003*
 - *NSW Biodiversity Strategy 1996*
 - *Lower Murrumbidgee Floodplain Natural Resource Management Plan 2009*
 - *Toogimbie Indigenous Protected Area Plan of Management 2004–2008*
 - *Hay Local Environmental Plan 1998*, and
 - Lowbidgee Water Management Plan (in preparation).

2.3 Community consultation

The development of the FMP provides the local community with a resource that can be utilised for issues relating to the floodplain including flood risk management, future development, works remediation and environmental management. For this reason, community consultation plays a vital role in the FMP process. The local community in the FMP floodplain has been a source of valuable flooding information and has raised many issues and suggestions in relation to the overall management of the floodplain.

2.3.1 Floodplain management committee

The Murrumbidgee River Floodplain Management Committee, Hay to Maude ('the Committee') was formed in line with the principles and policies of the *NSW Floodplain Development Manual* (NSW Government 2005) and comprises numerous stakeholders, including local landholders and state and local government representatives. The Committee was formed at the commencement of the FMP process, and its key role was to provide advice for the preparation of the FMP. The Committee endorsed a set of principles to guide decision-making in the FMP and criteria against which both existing and future flood control works will be assessed. The Committee has also provided essential information on the history of flooding, potential floodplain management issues and has acted as a vital link to the local community. Landholders on the Committee actively represented their floodplain constituents at meetings and relayed up-to-date information to them during the preparation of the FMP. This consultation process was facilitated by the distribution of landholders on the FMP floodplain, since each landholding is substantial and there are only a relatively small number of landholders.

Committee meetings were held on a regular basis throughout the preparation of the FMP. A number of areas with environmental and hydraulic issues were identified as 'hot spots' during the flood study phase. The Committee provided historical information to confirm these, in addition to suggesting other areas for further assessment in the floodplain risk management study (FRMS).

In February 2008, a field inspection of the key sites identified as hot spots was undertaken by the Committee. This inspection provided the Committee with a good understanding of the areas of interest and the floodplain as a whole.

2.3.2 Other consultation activities

Other consultation activities undertaken included:

- telephone consultation with landholders regarding flooding issues and information undertaken during the preparation of the FRMS
- targeted consultation with landholders regarding environmental areas of interest carried out during environmental field inspections in February 2008

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- targeted consultation with landholders regarding areas of interest on the FMP floodplain undertaken during the Committee's field inspection of key sites in February 2008
 - consultation with a representative of the Nari Nari Tribal Council regarding matters of Aboriginal interest on the FMP floodplain and the management of 'Toogimbie' Indigenous Protected Area.

The FMP was publicly exhibited from August 1 to September 23 2011 and three submissions were received. The matters raised in the submissions have been considered in finalising the FMP.

2.4 Floodplain management principles

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

The guiding principles are:

- Defined floodways must possess adequate hydraulic capacity and continuity to enable the orderly passage of floodwaters through the floodplain.
- Any system of defined floodways should conform as closely as is reasonable to the natural drainage pattern after taking into account the existing floodplain development.
- Floodway areas should be equitably allocated (between adjacent landholders) and consistent with natural/historical flow paths.
- Environmental issues related to the FMP need to be identified and investigated including developing strategies for flood dependent ecosystems such as wetlands, riparian vegetation, any other environmentally sensitive areas, and consider impacts on adjacent downstream areas.
- The exit of floodwaters from defined floodways should be at rates and depths similar to those that would have been experienced under natural/historical conditions and should discharge as closely as practicable to the location of natural/historical floodways.
- Sufficient pondage must be retained on the developed floodplain so that the flood peak travel time is not unduly accelerated to downstream users or its height increased.
- Velocities of flood flow in defined floodways should be minimised and be of an order which would not cause erosion or increased siltation under various land uses.
- There should be no detrimental impact from floodplain development on any individual landholder or community infrastructure including increases in peak flood levels and increased drainage times.
- Floodplain development should not cause significant redistribution of floodwater.
- Socio-economic issues relating to floodplain management need to be identified and investigated. This includes considering both tangible damages (financial in nature and can be readily measured in monetary terms) and intangible damages (includes increased levels of emotional stress, physical illness and disruption to daily life).

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- Should the community agree, there may be scope to depart from the natural/historical drainage pattern, provided it is hydraulically and environmentally feasible.
 - Floodplain management should encourage sustainable (social, economic and ecological) management of all natural resources on the floodplain. It should balance the various interests to ensure compatible and ecologically sustainable use of this important resource.
 - The FMP should balance the implications of actions by one generation for another, such that the environment of one generation does not unreasonably gain or suffer from the development decisions or activities of another.
 - The FMP should formally adopt community-owned strategies to provide a plan of management for the floodplain to be implemented by the stakeholders.

3 FMP floodway network

3.1 Purpose of the floodway network

One of the key outcomes of this FMP has been the development of a floodway network (the FMP floodway network) for the management of floodwaters. The FMP floodway network is shown on Figures 2A to 2E (at the end of the report) and will be used as the basis for determining applications for flood control works. The FMP floodway network represents a coordinated and integrated network of flood flow paths of adequate hydraulic capacity and continuity to effectively convey floodwaters and support the floodplain environment.

All flood control works, including levees, channels and other earthworks on the FMP floodplain that can alter the behaviour of floodwaters, require approval from the Office of Water under Part 8 of the Water Act. With regard to proposed flood control works, their location relative to the FMP floodway network is a key factor in the approval process. Proposed flood control works located outside the FMP floodway network are assessed as complying works and their approval is relatively straightforward. Proposed flood control works located inside the FMP floodway network, and exceeding acceptable impacts as defined by the complying works criteria (Table 5), are assessed as non-complying works. In general, non-complying works are unlikely to be approved (further detail on the approval process is provided in Section 6).

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 construction of temporary flood control works within the FMP floodway network in the event of impending flooding is not permitted.

3.2 Design flood

The design flood is the event to be used for the hydraulic design of the FMP floodway network. The selection and adoption of the design flood is aimed at producing an equitable distribution of floodwater across the floodplain that enables floodwater access to flood dependent ecosystems, optimises the use of rural land for agricultural pursuits and gives an acceptable level of flood risk for property and infrastructure.

Following the investigation of significant historical floods in conjunction with hydraulic modelling undertaken in the flood study (WMAwater 2008), the Committee agreed that the 1974 flood flow should be adopted as the required capacity of the design floodway network on the FMP floodplain. The 1974 event has approximately a 40 year average recurrence interval (ARI) while the 1956 event has approximately a 100 year ARI. The 1956 event was a larger event (in terms of flood volume) and extended further across the floodplain than the 1974 event. However, the adopted 1974 event was also recent enough that the flow behaviour during the event was well remembered by the community, and it was the event adopted for the 1977 Guidelines.

It was therefore agreed by the Committee that the 1974 event would be adopted as the design event against which changes to flood behaviour will be measured.

3.3 Hydraulic modelling

The flood study developed a computer hydraulic model of the floodplain based on the TUFLOW software package (BMT WBM 2010). Specifically, the model incorporated a combination of one-dimensional and two-dimensional flow elements, with the purpose of replicating real time flooding on the floodplain with an acceptable degree of accuracy.

Data inputs included recorded (gauged) hydrograph data, Airborne Laser Scanning (ALS) survey, and field survey data collected specifically for the flood study. The flood study investigation also included details on the history of flooding, collection of relevant data, hydrological assessment and a flood frequency (probability) analysis.

The TUFLOW hydraulic model was established for the reach of the Murrumbidgee River within the FMP floodplain. ALS survey in addition to field survey was used to define the topography of the river, floodplain and key control features. A digital elevation model (DEM) of the existing (2006) floodplain topography was developed. A DEM grid resolution of 40 m was selected as it gave sufficient definition of the floodplain topography while still allowing computational efficiency. The Murrumbidgee River and other significant waterways where conveyance was not sufficiently defined within the 40 m grid resolution were defined using cross section data within the one-dimensional component of TUFLOW. The TUFLOW model was calibrated against the 1974 historical event and verified against the 1956, 1975 and 1989 historical events.

The TUFLOW model results agreed well with recorded in-bank flow estimates and generally agreed with documented flood extents. Generally floodplain development (typically flood control works) could be attributed as the cause where model results differed from documented evidence.

The flow, velocity and flood level results used in the hydraulic assessment were derived from the results presented in the flood study (WMAwater 2008). These results have also been used to identify significant flow paths. For further discussion of both the hydrologic and hydraulic modelling undertaken for the FMP floodplain, in addition to full details of the TUFLOW model results, refer to the flood study (WMAwater 2008).

March 2012 flood

In March 2012, a flood of similar magnitude to the 1974 design flood occurred in the FMP floodplain. OEH coordinated monitoring of the flood including flow gauging and aerial imagery. The Office of Water carried out flow gauging at monitoring sites identified in the FMP, tracking the flood peak from Hay to Maude. Aerial imagery was captured over the Hay area at the flood peak on 19 March and over the lower floodplain on 24 and 28 March. The flood peaked at Maude on 26 March.

Due to the similarity between the March 2012 flood and the 1974 design flood, and the relatively large amount of information gathered, validation of the TUFLOW model was undertaken. Observed flood extents were compared to modelled extents for the 2012 event. In general, flood extent over the FMP floodplain was reproduced well by the model. Modelling of the March 2012 flood also confirmed the improvement measures listed in Table 1 of the FMP.

3.4 Floodway design

The FMP floodway network has been appropriately located and sized to convey unimpeded floodwaters to support flood dependent ecosystems, minimise flood risk and coordinate existing and future flood control works. The network represents, as closely as possible under current floodplain topography, the natural flow paths across the floodplain and will be used as a basis for determining future applications for flood control works as well as identifying modifications required to existing works.

During the design of the FMP floodway network it became apparent that there were key differences in flow behaviour and potential flood impacts associated with the design flood across the floodplain. As expected, it was found that flood dependent ecosystems (FDEs) are distributed within the inundation limits of the 1974 design flood. However, it was also found that FDEs are distributed on outer parts of the floodplain beyond the modelled 1974

flood inundation limit, where they are subject to flooding from larger floods and local runoff. As a result of these findings, the FMP floodway network was divided into three zones with two defined by key hydraulic aspects of the design flood and the third by flow paths connecting FDEs on the outer floodplain. This delineation allowed for the development of suitable zone-specific hydraulic and environmental criteria to be used during the assessment process for flood control works located within the FMP floodway network (Section 6).

The three zones of the FMP floodway network consist of:

- **Zone A – major discharge areas for the design flood.** This zone defines flood flow path areas where there is significant discharge of floodwaters for the 1974 design flood. These areas, if partially blocked by uncoordinated development, can cause significant impact on the redistribution of flood flows, flood levels and flood connectivity to FDEs. Zone A also represents areas of high discharge for flood flows larger than the design flood across the floodplain.
- **Zone B – flood storage and minor discharge areas for the design flood.** This zone represents areas of temporary flood storage and lower discharge for the passage of the design flood which, if significantly restricted by works, would reduce natural flood attenuation. The zone extends from the Zone A boundary to the modelled 1974 flood inundation limit (the modelled inundation limit assumes implementation of the improvement measures to existing works in Table 1). Zone B is also important for maintaining flow connectivity to FDEs.
- **Zone C – flow paths connecting flood dependent ecosystems affected by roads (non-controlled works) or subject to high level flooding and/or local runoff.** This zone is important for protecting flow paths to FDEs affected by public roads and for maintaining flow connectivity to FDEs on the outer floodplain beyond the modelled 1974 flood inundation limit.

Zone C may be subject to change following the implementation of improvement measures to public road sites specified in Table 1. Public roads are declared as non-controlled works under Part 8 of the Water Act (Section 6.7). Altered flood behaviour resulting from improvement measures to public roads may warrant a revised assessment of floodway zones in downstream areas to account for changed hydraulic conditions. Such an assessment would normally be carried out as part of a scheduled review of the FMP (Section 7.4).

Details on the design of the FMP floodway network are outlined below. Decisions relating to the delineation of the FMP floodway network were largely guided by the floodplain management principles adopted by the Committee (Section 2.4).

The FMP floodway network differs from the 1977 Guidelines floodway network in a number of areas, in response to:

- specific consideration of flood dependent ecosystems
- location of existing flood control works
- consideration of 1956 modelled flood flows, and
- improved delineation of floodplain features due to the use of detailed ALS survey and ortho-imagery data.

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.

3.4.1 Hydraulic assessment

The potential for flood control works (and other works) to impact on the distribution, attenuation and velocity of floodwaters is a contentious issue among landholders on the floodplain. Changes to flood behaviour across the floodplain can potentially result in significant damage. Increases in velocity can damage valuable irrigation infrastructure and increases in the extent of inundation can result in the loss of crops. To properly analyse the situation and determine the impacts, clear determination was required of the natural flow paths conveying floodwater across the FMP floodplain. Following this determination, the location of hydraulically significant flood flow paths under the existing floodplain topography could more easily be determined.

The FMP floodplain has a distributary nature, particularly downstream of Hay Weir, and this complicates the hydraulic analysis. The TUFLOW model results for the historical events (1956 and 1974) were used to determine the significance of each flow path. This was achieved by an analysis of the volume of flow down each individual flow path and the velocity and depth at which the floodwater was conveyed for each of the events.

The 1974 design event flow distribution, as defined by the hydraulic (TUFLOW) model results (assuming 2006 floodplain conditions), was used as the basis for determining the significance and location of each flow path. In order to determine the minimum width of each flow path a constant velocity of 0.5 m/s and constant depth of 0.5 m was considered appropriate. A visual comparison of the flow paths to historical flood photography was then undertaken and the widths of the flow paths were expanded in some areas. The resulting flow paths defined the major discharge areas of the FMP floodway network, known as Zone A.

Hydraulic (TUFLOW) modelling was carried out to show the extent of the 1974 flood with hydraulic improvement measures to existing flood control works in place (Table 1). This flood extent was used as the basis for Zone B of the FMP floodway network.

3.4.2 Environmental assessment

The 1977 Guidelines did not specifically examine the flood connectivity needs of flood dependent ecosystems (FDEs). Consequently, flood control works have been constructed that isolate some FDEs from flooding. Other FDEs, while currently retaining flood access, are located beyond the 1977 Guidelines floodway network and should they remain beyond the FMP floodway network, could potentially be isolated by flood control works in the future.

As part of the design process for the floodway network, an assessment of the location and flood connectivity status of FDEs on the FMP floodplain was undertaken so that the FDEs could be considered for inclusion in the floodway network. The assessment analysed available floodplain vegetation mapping (Horner *et al.* 2002), Aboriginal site data from the NSW Aboriginal Heritage Information Management System (AHIMS), satellite imagery and threatened species recordings. As well, an assessment of flood connectivity was carried out using ALS orthophoto imagery to determine FDEs that were affected by flood control works.

FDEs with existing flood access that were not already included in Zone A of the FMP floodway network (Section 3.4.1) were incorporated into Zones B and C. Zone C of the FMP floodway network contains FDEs, including stands of black box and canegrass, that experience flooding from events higher than the 1974 design flood (as confirmed from modelling) or from local runoff.

FDEs affected by existing flood control works were assessed through a separate process that was oriented 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.

A total of five FDE sites with flood connectivity restricted by flood control works were identified within the FMP floodplain. Field work was undertaken on these FDEs using a set of assessment criteria developed in consultation with the Committee. 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. The adopted assessment criteria were applied in the following process:

- **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 habitat value, uniqueness within the region, cultural and historical significance, hydrology, hydrological connectivity and special features.
- **Practicality assessment** – assessment of the practicality of restoring flood access to FDEs 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.

Required modifications to reconnect FDEs affected by existing flood control works were determined based on the outcomes of the environmental assessment process and are specified in Table 1. FDEs identified for reconnection of flood access were incorporated into the FMP floodway network.

Further details on the environmental assessment process including the environmental criteria and assessment results are presented in the FRMS report (WMAwater 2009).

3.5 Floodway vegetation management

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 potential for the density of vegetation within floodways to increase over time. An increase in the vegetation density increases the resistance to flow, often referred to as hydraulic 'roughness'.

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

3.5.1 Native Vegetation Act 2003

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

Invasive Native Scrub PVPs

Invasive Native Scrub PVPs may be appropriate for clearing native vegetation in floodways in cases where listed species, including black box and river red gum, have regenerated densely following natural or artificial disturbance, and the regeneration 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 pre-determined benchmarks for particular vegetation types. Thinning benchmarks for floodplain vegetation types specify a higher density than is allowable under Invasive Native Scrub PVPs. Consequently, Thinning PVPs may be too restrictive to improve hydraulic efficiency.

3.5.2 Native Vegetation Conservation Act 1997

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

3.5.3 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 the Office of Water. However, the Water Management Regulation 2004 exempts activities that comprise nothing more than removing vegetation, provided they are lawful under other legislation.

Notwithstanding this, landholders may still seek approval for removing vegetation as a controlled activity under the 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 (Section 3.5.2).

4 Required hydraulic and environmental improvement measures

A number of floodplain management issues have been identified and assessed as part of the FRMS (WMAwater 2009). These have included existing flood control works that have been identified, through community consultation and further investigation, to be affecting flood flows or an identified flood dependent ecosystem. The improvement measures to be implemented as part of the FMP are detailed in Table 1 and annotated on Figures 2A to 2E. The improvement measures are for both hydraulic and environmental purposes with a number of works modifications providing a benefit to both.

It is important to remember that all proposed and existing flood control works within the FMP floodplain require approval under Part 8 of the Water Act. Where no approval exists, the Office of Water may take the relevant compliance actions under the Act.

Flood control works in floodway areas are generally not permitted. However, if the applicant can demonstrate that 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 1, please note the following:

- Landholders should contact the Office of Water 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 6.5 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 6.4).
- Some of the structural modifications listed in Table 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 6 has further details regarding the approval of flood control works and administration of the FMP under Part 8 of the Water Act.

Staging

Each measure has been assigned a priority, defined as follows:

- **High** – within two years of adoption of the FMP. These measures are essential to ensure adequate performance of the FMP floodway network. The responsible parties will initiate the action within 12 months and complete it within two years of the FMP adoption.

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- **Medium** – within five years of adoption of the FMP. These measures are still essential to ensure the adequate performance of the FMP floodway network, but with reduced urgency. The responsible parties will initiate the action within three years and complete it within five years of the FMP adoption.
 - **Non-controlled works** – these measures apply to roadworks vested in local government or NSW transport agencies that are not controlled works under Part 8 of the Water Act. Implementation of the measures is recommended when future upgrades of the specific roads are undertaken.
 - **Ongoing** – these measures require that specified works are maintained and that monitoring by OEH and relevant stakeholders is carried out during floods.

Table 1 lists the priorities and responsible parties for each improvement measure.

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 Murrumbidgee CMA for removing or modifying works where this results in an environmental benefit. Section 6.10 has further information on possible funding sources.

Table 1: Hydraulic and environmental improvement measures

Location	Issue area ^^	Management issue	Improvement measures	Priority	Responsibility
Eleven Mile Creek area	A For location refer to Figure 2B.	<p>Hydraulic: Flood flows obstructed by various works including Maude Road, private access roads and irrigation channels.</p> <p>Environmental: Flood flow connectivity to flood dependent ecosystem FDE 1 (refer to Figures 3B & 3D), which includes the Eleven Mile Creek watercourse and extensive stands of black box woodland, restricted.</p>	<p>Note: For Issue area A refer to Figure C1 for details on location and impact of the improvement measures described below.</p>		
			<p>A1 – Investigate installation of 2 x 1.8 m (w) x 0.9 m (h) or equivalent capacity culverts as part of future Maude Road upgrade in this area.</p>	Non-controlled works**	Council
			<p>Note: Due to the uncertainty of implementing improvement measure A1 in the short term, FDE 1 to be considered as a priority area for environmental watering using existing infrastructure.</p>		
			<p>A2 – Provide drainage channel immediately downstream of Maude Road (approximately 800 m length) to connect to existing natural flow path. Channel to have 14 m² flow conveyance area at the 1974 design flood level of 85.7 m AHD.</p>	Subject to implementation of A1	Landholder
			<p>A3 – Provide 16 m² flow conveyance area through channel at the 1974 design flood level of 87.6 m AHD (syphon required). Implementation of this measure can be achieved with a 10 m wide opening in the channel at the average design flood depth of 1.0 m but is not limited to this option. ##</p>	High	Landholder
			<p>A4 – Provide 8 m² flow conveyance area through channel at the 1974 design flood level of 86.6 m AHD (syphon required). Implementation of this measure can be achieved with a 10 m wide opening in the channel at the average design flood depth of 0.6 m but is not limited to this option. ##</p>	High	Landholder
			<p>A5 – Provide 1 x 0.6 m diameter culvert under access road.</p>	Medium	Landholder
<p>A6 – Provide 10 m² flow conveyance area through channel at the 1974 design flood level of 85.5 m AHD (syphon required). Implementation of this measure can be achieved with a 10 m wide opening in the channel at the average design flood depth of 0.8 m but is not limited to this option. ##</p>	High	Landholder			

Location	Issue area ^^	Management issue	Improvement measures	Priority	Responsibility
'Newmarket' Property	B For location refer to <i>Figure 2A</i> .		Note: For Issue area B refer to <i>Figure C2</i> for details on location and impact of the improvement measures described below.		
		Hydraulic: Potential flood flow restriction due to limited opening through irrigation channel.	B1 – Maintain the existing channel opening to ensure a minimum flow conveyance area of 55 m ² at the 1974 design flood level of 79.9 m AHD. Implementation of this measure can be achieved by maintaining a minimum 15 m wide opening in the channel at the average design flood depth of 1.7 m but is not limited to this option. ## Monitor during future floods (refer to Appendix B for monitoring guidelines). (Note: The channel beyond the opening overtops for a distance of approximately 80 m in the design flood.)	Ongoing	Landholder, OEH Landholder/OEH/Office of Water
'Lang's Crossing'	C For location refer to <i>Figure 2E</i> .		Note: For Issue area C refer to <i>Figure C3</i> for details on location and impact of the improvement measures described below.		
		Hydraulic: Flood flows obstructed as a result of Sturt Highway and various irrigation infrastructure and flood control works.	C1 – Investigate installation of larger causeway with 150 m ² flow conveyance area at the 1974 design flood level of 91.8 m AHD as part of future Sturt Highway upgrade in this area. C2 – Investigate installation of larger causeway with 550 m ² flow conveyance area at the 1974 design flood level of 92.5 m AHD as part of future Sturt Highway upgrade in this area.	Non-controlled works**	RTA
		Environmental: Flood flow connectivity to flood dependent ecosystem FDE 2 (refer to <i>Figure 3E</i>), which includes extensive stands of black box woodland, restricted.	Note: Due to the uncertainty of implementing improvement measures C1 and C2 in the short term, FDE 2 to be considered as a priority area for environmental watering using existing infrastructure.		
			C3 – Provide flood flow connectivity and improved drainage by lowering part of embankment perpendicular to flow to a maximum height of 300 mm over a distance equivalent to the causeway width for measure C1.	Subject to implementation of C1 & C2	Landholder
			C4 – Provide flood flow connectivity and improved drainage by lowering part of embankment perpendicular to flow to a maximum of 300 mm over a distance equivalent to the causeway width for measure C2.	Subject to implementation of C1 & C2	Landholder
			C5 – Maintain flood flow connectivity / drainage (existing and future works) at critical locations identified on <i>Figure C3</i> . Monitor during future floods (refer to Appendix B for monitoring guidelines).	Ongoing	Landholder OEH/Office of Water (monitoring)

Location	Issue area ^{^^}	Management issue	Improvement measures	Priority	Responsibility
Northern Flood Runner	D For location refer to <i>Figure 2D</i> .		Note: For Issue area D refer to Figure C4 for details on location and impact of the improvement measures described below.		
		<p>Hydraulic: Flood flow obstructed as a result of the Mid Western Highway and various flood control works.</p> <p>Environmental: Flood flow connectivity to flood dependent ecosystem FDE 3 (refer to <i>Figures 3C & 3D</i>), which includes floodplain watercourses with riparian black box and associated cane grass stands, restricted.</p>	<p>D1 – Investigate installation of a coordinated program of flood flow connectivity / drainage works including a causeway through the Mid Western Highway and associated works along the Northern Flood Runner as part of future highway upgrade in this area. (Note: Pending the outcome of future investigation it is likely that some of the required works will be classified as controlled works and subject to the provisions of Part 8 of the Water Act.)</p> <p>Note: Due to the uncertainty of implementing improvement measure D1 in the short term, FDE 3 (the Northern Flood Runner) to be considered as a priority area for environmental watering using existing infrastructure.</p>	Non-controlled works**	RTA Council OEH
<p>START OF COORDINATED WORKS PROGRAM FOR SOUTHERN FLOODPLAIN DOWNSTREAM OF ‘PEVENSEY’ ACCESS ROAD. Hydraulic and environmental improvement measures (Issue areas E, F, G, H & I) are to be implemented as part of the coordinated works program for the southern floodplain downstream of ‘Pevensy’ access road.</p>					
‘Pevensy’ property continued...	E For location refer to <i>Figure 2B</i> .		Note: For Issue area E refer to Figure C5 for details on location and impact of the improvement measures described below.		
		<p>Hydraulic: Flood flows obstructed by ‘Pevensy’ access road.</p> <p>Environmental: Flood flow connectivity to flood dependent ecosystem FDE 4 (refer to <i>Figure 3B</i>), which includes a black box woodland, restricted.</p>	<p>E1 – Provide 200 m (w) causeway, 1 m below average road level (equivalent flow conveyance area of 170 m² at the 1974 design flood level of 85.4 m AHD).</p>	Non-controlled work**	Council Landholder (Council responsible for part of road requiring causeway)

Location	Issue area ^^	Management issue	Improvement measures	Priority	Responsibility
'Pevensey' property, cont.	E, cont.	<p>Hydraulic: Potential flood flow restriction due to limited opening through irrigation channel.</p> <p>Environmental: Flood flow connectivity to flood dependent ecosystem FDE 5 (refer to <i>Figure 3A</i>), which includes reaches of Uara and Fiddlers Creeks and associated lignum communities, restricted.</p>	<p>E2 – Maintain the existing channel opening width to ensure a minimum flow conveyance area of 40 m² at the 1974 design flood level of 85.1 m AHD. Implementation of this measure can be achieved by maintaining a minimum 45 m wide opening in the channel at the average design flood depth of 1.0 m but is not limited to this option. ##</p> <p>Monitor during future floods (refer to Appendix B for monitoring guidelines).</p>	Ongoing	<p>Landholder</p> <p>Landholder/ OEH/Office of Water</p>
Twin Irrigation Channels ('Abercrombie' and 'Glenhope')	<p>F For location refer to <i>Figure 2A</i>.</p>		<p>Note: For Issue area F refer to Figure C6 for details on location and impact of the improvement measures described below.</p>		
		<p>Hydraulic: Flood flows restricted due to inadequate opening through irrigation channel.</p> <p>Environmental: Flood flow connectivity to flood dependent ecosystem FDE 5 (refer to <i>Figure 3A</i>) restricted.</p>	<p>F1 – Provide 110 m² flow conveyance area at the 1974 design flood level of 82.5 m AHD through both 'Abercrombie' and 'Glenhope' channels (larger syphons required). Implementation of this measure can be achieved with a 75 m wide opening in the channel at the average design flood depth of 1.5 m but is not limited to this option. ##</p>	Medium	Landholder
'Toogimbie' property continued...	<p>G For location refer to <i>Figure 2A</i>.</p>		<p>Note: For Issue area G refer to Figure C7 for details on location and impact of the improvement measures described below.</p>		
		<p>Hydraulic: Potential flood flow restriction due to limited opening through irrigation channel.</p> <p>Environmental: Flood flow connectivity to flood dependent ecosystem FDE 5 (refer to <i>Figure 3A</i>) restricted.</p>	<p>G1 – Maintain existing channel opening to ensure a minimum flow conveyance area of 80 m² at the 1974 design flood level of 81.9 m AHD. Implementation of this measure can be achieved by maintaining a minimum 20 m wide opening in the road at the average design flood depth of 3.8 m but is not limited to this option. ##</p> <p>Monitor during future floods (refer to Appendix B for monitoring guidelines).</p>	Ongoing	<p>Landholder</p> <p>Landholder/ OEH/Office of Water</p>

Location	Issue area ^^	Management issue	Improvement measures	Priority	Responsibility
'Toogimbie' property, cont.	G, cont.	<p>Hydraulic: Flood flows restricted due to inadequate opening through access road.</p> <p>Environmental: Flood flow connectivity to flood dependent ecosystem FDE 5 (refer to <i>Figure 3A</i>) restricted.</p>	G2 – Provide 80 m ² flow conveyance area through abandoned access road at the 1974 design flood level of 81.9 m AHD. Implementation of this measure can be achieved with a 20 m wide opening in the road at the average design flood depth of 3.8 m but is not limited to this option. ##	Medium	Landholder
		<p>Hydraulic: Flood flows restricted due to inadequate opening through irrigation channel.</p> <p>Environmental: Flood flow connectivity to flood dependent ecosystem FDE 5 (refer to <i>Figure 3A</i>) restricted.</p>	G3 – Provide 170 m ² flow conveyance area through the channel at the 1974 design flood level of 81.7 m AHD (syphon required). Implementation of this measure can be achieved with a 75 m wide opening in the channel at the average design flood depth of 2.3 m but is not limited to this option. ##	Medium	Landholder
'Paterson' property	H For location refer to <i>Figure 2A</i> .		Note: For Issue area H refer to Figure C8 for details on location and impact of the improvement measures described below.		
		<p>Hydraulic: Flood flows restricted due to inadequate openings through irrigation channel.</p> <p>Environmental: Flood flow connectivity to flood dependent ecosystem FDE 5 (refer to <i>Figure 3A</i>) restricted.</p>	<p>H1 – Provide 60 m² flow conveyance area through northern section of channel at the 1974 design flood level of 80.5 m AHD (larger syphon required). Implementation of this measure can be achieved with a 55 m wide opening in the channel at the average design flood depth of 1.1 m but is not limited to this option. ##</p> <p>H2 – Provide 30 m² flow conveyance area through southern section of channel at the 1974 design flood level of 80.5 m AHD (larger syphon required). Implementation of this measure can be achieved with a 25 m wide opening in the channel at the average design flood depth of 1.1 m but is not limited to this option. ##</p>	Medium	Landholder

Location	Issue area ^{^^}	Management issue	Improvement measures	Priority	Responsibility
'Ravensworth' property	I For location refer to Figure 2A.		Note: For Issue area I refer to Figure C9 for details on location and impact of the improvement measures described below.		
		Hydraulic: Potential flood flow restriction due to limited opening through northern part of irrigation channel. Environmental: Flood flow connectivity to flood dependent ecosystem FDE 5 (refer to Figure 3A) restricted.	I1 – Maintain existing channel opening width to ensure a minimum flow conveyance area of 35 m ² at the 1974 design flood level of 78.5 m AHD. Implementation of this measure can be achieved by maintaining a minimum 30 m wide opening in the channel at the average design flood depth of 1.4 m but is not limited to this option. ## Monitor during future floods (refer to Appendix B for monitoring guidelines).	Ongoing	Landholder Landholder/ OEH/Office of Water
		Hydraulic: Flood flows restricted due to inadequate floodway openings through southern section of irrigation channel. Environmental (Figure 3A): Flood flow connectivity to flood dependent ecosystem FDE 5 (refer to Figure 3A) restricted.	I2 – Provide 50 m ² flow conveyance area through southern section of channel at the 1974 design flood level of 78.5 m AHD (larger syphon required). Implementation of this measure can be achieved with a 30 m wide opening in the channel at the average design flood depth of 1.7 m but is not limited to this option. ##	Medium	Landholder
END OF COORDINATED WORKS PROGRAM FOR SOUTHERN FLOODPLAIN DOWNSTREAM OF 'PEVENSEY' ACCESS ROAD					
Budgee Creek	J For location refer to Figure 2C.		Note: For Issue area J refer to Figure C10 for details on location and impact of the improvement measures described below.		
		Environmental: Frequent flood flows to flood dependent ecosystem FDE 6 (refer to Figures 3A & 3C), which includes the Budgee Creek watercourse with adjacent river red gum and black box stands, restricted by in-stream embankments.	J1 – Monitor impact of in-stream embankments on flow distribution and fish passage during floods up to the 20 year ARI event (refer to Appendix B for monitoring guidelines).	Ongoing	Landholder, OEH

^{^^} Some issue areas have issues at multiple sites – for example issue area A has six issue sites (A1, A2, A3, A4, A5 and A6).

^{**} Roads and railways (and associated bridges, culverts and roadworks) vested in local government or NSW Government transport agencies are not controlled works under Part 8 of the Water Act. Implementation of non-controlled works measures is recommended when upgrades of the specific roads are undertaken.

^{##} The flow conveyance area has a trapezoidal shape (not rectangular) due to side batters. Hence, the actual flow conveyance area is larger than the simple multiplication of nominal channel opening width (measured between the toe of batters) and average design flood depth. Also, at some locations the design flood depth shown in Table 1 is quite high due to the presence of a depression(s) immediately upstream of the opening – this applies particularly to Improvement Measures G1, G2 and G3. These design depths do not affect the width of required opening shown in Table 1 (width measured between the toe of batters).

5 Environmental impact

5.1 Overview

Implementation of the FMP will reasonably assure flood flow access to flood dependent ecosystems (FDEs) within the FMP floodway network. The FMP 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 FDEs. It has been sized to include the major discharge areas (Zone A) and the flood storage and minor discharge areas (Zone B) for the 1974 design flood, and also to include the flow paths connecting FDEs that are affected by public roads or subject to high level flooding or local runoff (Zone C). The approval of any flood control work within Zones A, B and C of the FMP floodway network is subject to maintaining access to FDEs in the floodway network for flood regimes and the delivery of environmental water.

The FMP floodway network includes all FDEs with existing flood access and those with identified environmental improvement measures to restore flood access (Table 1). Implementation of the environmental improvement measures will water additional areas of black box woodland and lignum during a flood of similar magnitude to the 1974 design flood. Figures 3A to 3E (at the end of the report) show the FMP floodway network in relation to flood dependent ecosystems including mapped floodplain vegetation (Horner *et al.* 2002) and the Toogimbie Indigenous Protected Area (IPA).

The impacts of the FMP floodway network and the environmental improvement measures 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 2.

5.2 Catchment impacts

The Murrumbidgee floodplain immediately upstream of the FMP floodplain is relatively narrow with fewer floodplain distributary channels and wetlands. Implementation of the FMP is not expected to impact on this area. Downstream of the FMP floodplain, the floodplain is expansive and includes significant expanses of wetlands including the nationally important Lowbidgee floodplain wetland system (Environment Australia 2001) which supports widespread waterbird breeding following flooding. The FMP floodway network closely follows the natural drainage pattern and the exit of floodwaters from the floodways is expected to be at rates and depths that would have been experienced under natural and historical conditions. The FMP floodway network will preserve flood flow paths and allow for the future delivery of the flood regime to sustain downstream ecosystems.

Environmental improvement measures identified for the southern floodplain downstream of 'Pevensey' access road (Table 1) will increase volumes transferred through this area by approximately 20% during design flood flows. This increased volume is expected to provide substantial support to lignum communities along Fiddlers and Uara Creeks within the FMP floodplain and to downstream ecosystems on the Lowbidgee floodplain.

Table 2: Summary of FMP environmental impacts

Feature	FMP impacts
Flood dependent ecosystems	<p>Existing flood dependent vegetation, consisting mainly of river red gum, black box, lignum and nitre goosefoot communities (Figures 3A to 3E), is contained within the FMP floodway network with the exception of a small number of black box trees. As approval for proposed works in the FMP floodway network is subject to maintaining flood access to FDEs, flood connectivity to existing flood dependent vegetation is reasonably assured.</p> <p>Environmental improvement measures identified in the FMP will restore flood access to 2 FDEs including about 50 ha of black box woodland (FDE 4) and enhance flood volumes watering lignum communities extending along Fiddlers and Uara Creeks (FDE 5). The FMP identifies modifications to the Mid Western Highway, Sturt Highway and Maude Road to be considered as part of any future road upgrades so that flood flows can be restored to FDE 1 (Eleven Mile Creek), FDE 2 (south of Lang's Crossing) and FDE 3 (the Northern Flood Runner) respectively. Should these and other associated measures proceed, an additional 10 km² of black box (FDE 1), 5 km² of black box (FDE 2) and an extensive reach of Darcoola Creek and associated flood runners (FDE 3) would be inundated and sustained during design flood flow conditions. However, given that the works modifications are unlikely to be implemented in the immediate future, the FMP has recommended that the FDEs are given priority for environmental watering using existing irrigation infrastructure.</p> <p>Budgee Creek (FDE 6) contains a series of in-stream structures which pond water and are overtopped by floods larger than about 20 year ARI. The structures have resulted in a range of environmental effects. Increased inundation has benefited black box away from the creek and created drought refuge habitat. Conversely, river red gums adjacent to the creek have become waterlogged. Structures along Budgee Creek would be overtopped in design flood conditions with little impact on environmental watering. However, as flow behaviour in more frequent floods is not well known (e.g. outflanking of structures), the FMP has recommended that the performance of the in-stream structures is monitored during frequent flood events.</p>
Terrestrial flora	<p>Two threatened plant species, the Mossgiel daisy (<i>Brachycome papillosa</i>) and the slender Darling pea (<i>Swainsona murrayana</i>) have been recorded in FDEs within or near the FMP floodplain. Both species are expected to benefit from the FMP as it will allow ongoing flood connectivity and help to maintain or restore the condition of FDEs.</p>
Aquatic fauna	<p>The FMP floodway network will be instrumental in ensuring improved flood connectivity between the rivers, creeks, floodplain watercourses and wetlands in the FMP 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 latter being a threatened species. Additionally, this is expected to benefit the threatened Macquarie perch which occurs within the FMP floodplain and the endangered aquatic ecological community of the Lower Murray catchment (which includes the Murrumbidgee River downstream of Burrinjuck Dam).</p> <p>In-stream structures along Budgee Creek (FDE 6) may impact on fish passage during floods smaller than 20 year ARI. The FMP recommends monitoring of flow behaviour along the creek during frequent floods so that fish passage impacts can be identified and addressed.</p>
Terrestrial fauna	<p>The FMP will benefit terrestrial fauna species relying directly on flooding (e.g. waterbirds) and those using floodplain habitats, by maintaining or restoring flood connectivity to FDEs.</p> <p>Five threatened fauna species, including three bird, one frog and one mammal species have been recorded within or near the FMP floodplain. Two of the species, the blue-billed duck and southern bell frog, have a strong dependence on flooding for breeding success. Implementation of the FMP will benefit these species by maintaining flood flow access to habitat in FDEs currently connected to the flooding regime. Enhancement of flood access to additional areas of black box woodland and lignum communities is likely to allow for the expansion of suitable habitat for threatened species in the FMP floodplain.</p>

Feature	FMP impacts
Soils	<p>The extensive land area 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 negated, organic matter ultimately returned to soil).</p> <p>The FMP floodway network will have a further positive effect on soils by ensuring that velocities and the associated scour risk are not unduly increased during floods.</p>
Groundwater	<p>The FMP floodway network covers an extensive area and represents, as closely as possible, the natural flow paths across the floodplain. While flood inundation patterns will differ to what would occur in the absence of flood control works, it is expected that groundwater recharge during floods would not be significantly different to that under natural conditions.</p>
Water quality	<p>The FMP will not have a significant impact on water quality within the floodplain watercourses. The FMP floodway network has been designed to limit flood velocities and will thereby reduce the potential for floodplain erosion and restrict the quantity of eroded sediment material 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 watercourses.</p>
Aboriginal heritage	<p>Information on the location of recorded Aboriginal sites on the FMP floodplain has been obtained from the Aboriginal Heritage Information Management System. The floodplain contains a diversity of sites including scarred trees, hearths, artefacts, earth mounds and burial sites (see Appendix D for further information). Sites of particular relevance to the FMP floodplain include scarred river red gum or 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 contained within FDEs that are within the FMP floodway network. Consequently, ongoing flood access, enhancing the longevity of these sites, is reasonably assured. Flood damage to on-ground Aboriginal sites (such as burial sites) may occur naturally. However, the FMP floodway network has been designed to minimise flood velocities, and, accordingly, would help to minimise erosion damage to these sites during floods.</p> <p>Other Aboriginal sites exist (undiscovered) within the floodplain. A predictive landscape model of the likelihood of site occurrence (Pardoe and Martin 2001) indicates that Aboriginal sites are concentrated near the Murrumbidgee River and decrease in frequency away from the river to a distance of about 10 km. A high percentage of sites that are flood dependent are likely to be contained within FDEs that are connected to flood flows within the FMP floodway network. Any sites located within FDEs 1, 2 and 3 may remain isolated from flood access pending future road modifications. The FMP recommends that these FDEs are given priority for environmental watering through existing irrigation infrastructure.</p> <p>The Toogimbie Indigenous Protected Area (IPA), an area of 5000 ha containing a variety of FDEs including extensive areas of lignum swamp, is managed by the Nari Nari Tribal Council to promote biodiversity and cultural resource conservation. Wetland vegetation within the IPA is included within the FMP floodway network (Figure 3A) and consequently ongoing floodwater access to support management objectives is reasonably assured.</p>
European heritage	<p>There are no listed European heritage sites within the FMP floodplain. Implementation of the FMP is not likely to impact adversely on sites of historical value because potential erosion damage from flooding will be minimised.</p>

5.3 Projects being undertaken in the catchment

There are a number of natural resource management related projects being undertaken throughout the Murrumbidgee catchment, which will contribute towards the environmental values of the floodplain and complement outcomes from the FMP. Table 3 lists most of these projects and the organisations managing them.

Table 3: Projects being undertaken in the Murrumbidgee catchment

Project	Project manager
Riverbank and Rivers Environmental Restoration Program	OEH and Australian Government
Lower Murrumbidgee Floodplain Natural Resource Management Plan	Murrumbidgee CMA
Water Management Plan for the Lower Murrumbidgee	Office of Water
Hydrodynamic modelling of Yanga National Park and Lower Murrumbidgee floodplain	OEH
Various incentive programs: <ul style="list-style-type: none">• Wetland Refugia Project• riparian revegetation• Murray Mouth to Mountains Climate Change corridors• Murrumbidgee Eco Tender II• grazing management incentive program• property vegetation planning• Community Group Natural Resource Management grants• Land and Natural Resource Management training• The River Restoration project• Targeted Salinity and Water Quality project	Murrumbidgee CMA
Water for the Future	Australian Government

Landholders are encouraged to consult with the Murrumbidgee CMA for advice on land management best practice and how to adhere to it.

6 FMP implementation

6.1 Roles and responsibilities

Implementation of the FMP will be regulated under Part 8 of the *Water Act 1912*. The Office of Water is currently responsible for the implementation of FMPs within rural New South Wales west of the Great Dividing Range. OEH provides a technical advisory role in regards to implementation.

The successful implementation of the FMP will largely depend on stakeholders fulfilling their roles and responsibilities as set out in Table 4.

Table 4: Roles and responsibilities

Stakeholder	Role/responsibility
Office of Water to lead OEH to provide a 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. Process and determine applications for the approval of flood control works. Monitor floodway performance, floodway conditions and flood data collection.
Murrumbidgee 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 Murrumbidgee Catchment Action Plan targets.
Landholders	Undertake, under the direction of the Office of Water, the required modifications to existing flood control works. Seek approval from the Office of Water 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 (refer to Appendix B for monitoring guidelines).
Hay Shire Council	Ensure that implementation of FMP improvement measures to specified roads is considered when road upgrades in these areas are proposed.
RTA	Ensure that implementation of FMP improvement measures to specified roads is considered when road upgrades in these areas are proposed.

6.2 Part 8 approval process for flood control works

6.2.1 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.

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

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

6.2.3 Applying for approval

To lodge an application for approval of flood control works, a Part 8 application form must be completed and submitted to the Office of Water. 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 Office of Water 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 the Office of Water be provided, in order to allow proper consideration of the application. If the requested information is not provided, the Office of Water can refuse to deal with the application.

6.2.4 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 the Office of Water determines the application under section 171 of the Act. This process includes (but is not limited to):

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

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- any pollution of the environment
 - any environmental problems associated with the disposal of waste
 - any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply
 - any cumulative environmental effect with other existing or likely future activities.

Part 5 of the EP&A Act also requires that the effect of a proposed activity on threatened species, populations or ecological communities, or their habitats must be considered.

- **Floodplain management plans** – The Office of Water must have regard to the contents of any relevant floodplain management plan before determining an application for an approval.
- **Other management plans** – The Office of Water 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 2000*.
- **Aboriginal heritage assessment** – The Office of Water will liaise with OEH Environment Protection and Regulation Group, Landscape and Aboriginal Heritage Protection (South) and if required OEH's Country, Culture and Heritage Division, Far West region, to assess Aboriginal heritage issues associated with individual applications. Applications will be assessed in accordance with the *National Parks and Wildlife Act 1974*.
- **Additional information** – The Office of Water must consider any investigation information that has been provided by the applicant.

6.2.5 Possible determinations

The Office of Water must inform the applicant as soon as practicable of the determination of an application for a flood control work. The general terms of approval should be comprehensive enough to cover all of the constraints (terms and conditions) that may be applied to the relevant Part 8 approval. Under the Water Act, 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, the Office of Water is required to decide whether the works do or do not comply with the FMP.

6.3 Complying and non-complying works

6.3.1 Complying works

Under section 168B(2) of the Water Act, a flood control work is to be assessed as a complying work if the Office of Water 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 FMP floodplain, complying flood control works are defined as:

- existing (unapproved) and proposed works that are located outside Zones A, B or C of the FMP floodway network (Figures 2A to 2E), or that meet the criteria for complying works (Table 5)
- existing (unapproved) works that are to be modified in accordance with the hydraulic or environmental improvement measures in Table 1 of the FMP.

Table 5: Complying works criteria

Zone A – major discharge areas for the 1974 design flood	
Obstruction of floodways	<ul style="list-style-type: none"> • maximum 10% obstruction of floodway width (works other than irrigation channels)
Flood level impact (under design flood conditions)	<ul style="list-style-type: none"> • maximum increase in flood levels of 200 mm at irrigation channel openings (syphons) • maximum increase in flood levels of 100 mm on adjacent properties (all works) • no significant effect on floodplain drainage times on adjacent properties • no impact (maximum increase of 10 mm in flood level) on high value infrastructure (such as a residence or equipment shed)
Redistribution of flows (under design flood conditions)	<ul style="list-style-type: none"> • maximum flow redistribution of 10% when assessing cumulative impacts across the floodplain and 5% when assessing localised impacts onto adjacent properties
Velocity in floodways (under design flood conditions)	<ul style="list-style-type: none"> • maximum increase of 50% up to a maximum of 0.5 m/sec • no increase in velocity in areas where the velocity is already higher than 0.5 m/sec
Environment	<ul style="list-style-type: none"> • no blocking, impeding or diverting of the flooding regimes in FDEs within the FMP floodway network (Figures 3A–3E) • no impeding the delivery of environmental water to ecological assets specified under the Lowbidgee Water Management Plan (in preparation)
Zone B – flood storage and minor discharge areas for the 1974 design flood	
For works >300 mm: Redistribution/flood level impact (under design flood conditions)	<ul style="list-style-type: none"> • maximum flow redistribution of 10% when assessing cumulative impacts across the floodplain and 5% when assessing localised impacts onto adjacent properties • maximum increase in flood levels of 100 mm on adjacent properties (all works) • no impact (maximum increase of 10 mm in flood level) on high value infrastructure (such as a residence or equipment shed)
Environment (all works including works <300 mm)	<ul style="list-style-type: none"> • no blocking, impeding or diverting of the flooding regimes in FDEs within the FMP floodway network (Figures 3A–3E) • no impeding the delivery of environmental water to ecological assets specified under the Lowbidgee Water Management Plan (in preparation)
Zone C – flow paths connecting FDEs affected by roads (non-controlled works) or subject to high level flooding and/or local runoff	
Environment	<ul style="list-style-type: none"> • no blocking, impeding or diverting of the flooding regimes in FDEs within the FMP floodway network (Figures 3A–3E) • no impeding the delivery of environmental water to ecological assets specified under the Lowbidgee Water Management Plan (in preparation)

A landholder will be required to provide the necessary supporting information to demonstrate that the application is a complying work. In some cases this may require engaging a consultant. Where an existing (unapproved) or proposed flood control work is complying, the application for approval will be determined by the Office of Water 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 6.2.4, including assessment against the matters raised in section 166C of the Water Act and Part 5 of the EP&A Act.

6.3.2 Non-complying works

Under section 168B(3) of the Water Act, a flood control work is to be assessed as a non-complying work if the Office of Water 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 FMP floodplain, non-complying flood control works are defined as:

- existing (unapproved) and proposed works that are located within Zones A, B or C of the FMP floodway network (Figures 2A to 2E) and do not meet the criteria for complying works (Table 5)
- existing (unapproved) works that are not modified in accordance with the hydraulic or environmental improvement measures in Table 1 of the FMP.

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. The Office of Water 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 the Office of Water grants an approval for an application and an objection has been made, the Office of Water must notify the objector of its determination. The objector may appeal against the determination in the Land and Environment Court.

6.4 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, the Office of Water 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)

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- 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, the Office of Water can carry out the work and recover the costs incurred in doing such work. The Office of Water 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.

6.5 Varying conditions of approved works

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

- 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.

6.6 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. Table 1 identifies certain improvement measures for non-controlled works within the FMP floodplain to ensure the coordination of work across the floodplain.

6.7 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, then the infrastructure protection works will need to be assessed as a Part 8 determination process for flood control works on a property.

6.8 Block banks

There are a number of block banks (in-stream earthworks) present within the waterways in the FMP 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 FMP. Depending on their intended purpose, block banks require either of the following types of authorisation:

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

Authorisation is subject to endorsement by Industry and Investment NSW under the requirements of the *Fisheries Management Act 1994*.

6.9 Possible funding sources for environmental works and public works

Funding may be available for both private and public works as listed in Table 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 6 lists possible funding sources for private and public works.

Table 6: Possible funding sources

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

7 Monitoring and review

7.1 Performance indicators

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

1. Flood control works are to be constructed or modified according to the FMP.
2. The FMP floodway network is to allow for the orderly passage of flood waters.
3. The FMP floodway network is to allow for the connection of floodwaters to support flood dependent ecosystems.

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 FMP.

The performance of the FMP 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 FMP floodway network
- increased volume of flood storage available within the FMP 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

Social:

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

7.2 Flood monitoring

Monitoring of flood behaviour will help to identify whether the FMP floodway network and identified hydraulic improvement measures are performing adequately. Future improvements or refinements to the floodway network can be identified as a result. Depending on the size of the flood, monitoring would range from simple observation to measuring of flows and levels followed by additional hydraulic analysis.

For smaller more frequent events, monitoring should be limited to observations of areas with identified floodplain management issues as shown in Appendix C (Figures C1 to C10). The larger floods, nearing or exceeding the magnitude of the 1974 design flood event, should be monitored in more detail. In particular, as the computer hydraulic modelling has relied upon a combination of gauged and estimated flows, it will be important to collect data to verify these values used. Key locations for monitoring during a flood event are provided in Appendix B (Figure B1).

Floods within the FMP floodplain typically have a relatively long lead-in time (often a number of weeks) which allows for the planning and preparation of monitoring programs. OEH will lead the planning and implementation of monitoring programs and will seek input from the Office of Water, Hay Shire Council and landholders. The following activities are recommended:

- OEH to undertake aerial photography, collection of satellite imagery and survey
- Office of Water to undertake stream gauging and flow measurements, and
- where safe to do so, OEH, the Office of Water, Hay Shire Council and landholders to observe the performance of their part of the floodway network, including marking high flood levels, estimating flow velocities, observing the direction of flow paths and taking photographs.

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

7.3 Environmental monitoring

Environmental monitoring during and after floods will determine whether identified environmental improvement measures are working effectively and help assess the ecological impacts of local flooding. Environmental data would mainly consist of direct observations with supporting photography wherever possible. The scale of flooding would again influence the extent of data collected. For example, in a flood of the magnitude of the 1974 design flood event, observations of wetland inundation, waterbirds and fish would be extensive in comparison to a relatively small flood.

OEH will coordinate the environmental monitoring with input from Hay Shire Council, the Office of Water and landholders. Monitoring information would include:

- performance of environmental improvement measures during floods
- inundation of FDEs (e.g. duration, extent, depth)
- presence of waterbirds 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 Office of Water/OEH monitoring activities.

7.4 Floodplain management plan review

FMPs adopted under the WMA must be reviewed every five years to determine whether their provisions adequately implement the water management principles of the Act.

Accordingly, the FMP will be subject to scheduled reviews at five-yearly intervals. The occurrence of a major flood may warrant an unscheduled review of the 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.

8 References

BMT WMB (2010), *TUFLOW flood and tide simulation software*, BMT WMB Pty Ltd, Brisbane, viewed November 2010, www.tuflow.com/index.htm.

Department of Environment, Climate Change and Water (2010), *NSW Wetlands Policy*, Department of Environment, Climate Change and Water NSW, Sydney.

Environment Australia (2001), *A Directory of Important Wetlands in Australia, Third edition*, Environment Australia, Canberra.

Horner, G, McNellie, M, Nott, TA, Vanzella, B, Schliebs, M, Kordas, GS, Turner, B and Hudspith, TJ (2002), *Native vegetation of the Dry Lake, Oxley, Hay, One Tree, Moggumbill and Gunbar 1:100 000 map sheets*, Native vegetation map report series, NSW Department of Land and Water Conservation, Sydney.

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

New South Wales Government (2006), *Guideline for the Clearing of Exotic Trees and Dead Native Trees on State Protected Land*, NSW Department of Natural Resources, available from www.environment.nsw.gov.au/vegetation/stateland.htm

New South Wales Government (2010), *NSW State Plan – Investing in a Better Future*, NSW Government.

Pardoe, C and Martin, S (2001), *Murrumbidgee Province Aboriginal Cultural Heritage Study*, unpublished report to the NSW National Parks and Wildlife Service and Aboriginal communities of the region.

WMAwater (2008), *Murrumbidgee River Floodplain – Hay to Maude – Phase A – flood study and data collection*, WMAwater, Sydney.

WMAwater (2009), *Murrumbidgee River Floodplain – Hay to Maude – Phase B – floodplain risk management study*, WMAwater, Sydney.

Water Resources Commission (1977), *Guidelines for floodplain development Murrumbidgee River – Hay to Maude*, Water Resources Commission, Sydney.

Maps of the FMP floodway network

Figure 2A

Figure 2B

Figure 2C

Figure 2D

Figure 2E

Maps of the FMP floodway network with flood dependent ecosystems

Figure 3A

Figure 3B

Figure 3C

Figure 3D

Figure 3E

Appendix A – Glossary

Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
average recurrence interval (ARI)	The long-term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
discharge	The rate of flow of water measured in terms of volume per unit time, for example cubic metres per second (m ³ /s). Discharge is different to the speed or velocity of flow, which is a measure of how fast the water is moving, for example metres per second (m/s).
flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse.
flood dependent ecosystems (FDEs)	Ecosystems that rely on temporary or permanent inundation by floodwaters to sustain essential ecological processes. They include wetlands and/or floodplain vegetation, watercourses, and Aboriginal sites that depend on flooding.
floodplain	Any land that is so designated by an order in force under section 166 (1) of the <i>Water Act 1912</i> .
floodway network	The area of the floodplain required for the unobstructed and orderly passage of floods and the delivery of floodwaters to sustain flood dependent ecosystems.
hydraulics	The study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	The study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
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.
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 a number of specific locations within the FMP floodplain where future flow and flood level data collection will enable a better understanding of the hydraulic performance of the design floodway network, and provide a basis for future improvements. Specific locations within the FMP floodplain to be treated as a priority for obtaining flow and flood level data are shown on Figure B1.

B2 Flood monitoring guidelines for landholders

The following provides a set of advisory notes for landholders when undertaking flood monitoring activities. Collection of data not only assists in an improved understanding of the hydraulic performance of the design floodway network but also assists in the FMP review process.

Flood event data

Where it is safe to do so, landholders are encouraged to collect the following data 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 peak of the flood on their property.
- Note any apparent significant obstructions to 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 and record the time and date each photograph or video was taken.
- Observe the direction of flow paths.
- Where possible estimate the velocity of flow. A simple way to achieve this is to measure the travel time of a floating object over a measurable distance.

Flood damage data

Flood damage data is useful in assessing the effectiveness of the design floodway network. Landholders are encouraged to record damage incurred as a result of the flood event:

- 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. Provided it is safe to do so, landholders are encouraged to record the following:

- Note the performance of improvement measures specified in Table 1 in allowing floodwater connectivity into FDEs during the course of floods.
- 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 fauna species (fish, birds, etc.).

Landholders could use the questionnaire overleaf to record flood data.

B3 Flood monitoring guidelines for Hay Shire Council

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 assist in identifying 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 and its effect on 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 / erosion, silt deposition on road surface, damage to bridges / culverts.
- Where applicable, note the period that the road remains closed during the flood.

B4 Flood monitoring guidelines for OEH/Office of Water

OEH will undertake the following flood monitoring activities with input from the Office of Water as required:

- Obtain Office of Water gauged flow data and flood heights at points of interest within the FMP floodway network (the priority sites are specified in Figure 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).
 - 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.
 - Oversee the necessary scheduled revisions of the FMP and initiate any unscheduled revisions that may be warranted in the aftermath of flood events.
 - 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 the Office of Water).

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 FDE: _____ days

Depth of flooding in FDE: _____ 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 improvement measures to reconnect FDEs are in place, is the work modification of adequate capacity or size? Yes / No

If no, what are your observations: _____

Did floodwater reach the FDE? Yes / No

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

Appendix C – Details of improvement measures (Sites A to J)

- Figure C1 Details of improvement measures at site A - Eleven Mile Creek area
- Figure C2 Details of improvement measures at site B – ‘Newmarket’ Irrigation Channel
- Figure C3 Details of improvement measures at site C – Lang’s Crossing (‘Kerringal Escape’)
- Figure C4 Details of improvement measures at site D – ‘Birriwa Escape’ (Northern Flood Runner)
- Figure C5 Details of improvement measures at site E – ‘Pevensey’ Access Road (coordinated works program for the southern floodplain downstream of ‘Pevensey’ access road)
- Figure C6 Details of improvement measures at site F – Twin Irrigation Channels (coordinated works program for the southern floodplain downstream of ‘Pevensey’ access road)
- Figure C7 Details of improvement measures at site G – ‘Toogimbie’ Irrigation Channel and Access Road (coordinated works program for the southern floodplain downstream of ‘Pevensey’ access road)
- Figure C8 Details of improvement measures at site H – ‘Paterson’ Irrigation Channel (coordinated works program for the southern floodplain downstream of ‘Pevensey’ access road)
- Figure C9 Details of improvement measures at site I – ‘Ravensworth’ Irrigation Infrastructure (coordinated works program for the southern floodplain downstream of ‘Pevensey’ access road)
- Figure C10 Details of improvement measures at site J – Budgee Creek area

Appendix D – The importance of Aboriginal sites in the Australian landscape

Indigenous peoples have lived in this country for more than 65,000 years. Places with physical evidence of this occupation are known as Aboriginal sites. Such sites have the remains of prehistoric and historic occupation, and are of contemporary significance to the indigenous community.

Traditional and contemporary practices of the indigenous peoples focus on waterways, including their tributaries and associated wetlands, as sources of food, medicines and raw material. Indigenous people used and managed the natural resources in a manner that enabled them to survive.

Traditional practices did not just involve physically managing the environment, but were intertwined with religious beliefs and ceremonies, law and lore, as well as song and dance. Ceremonial places and areas were created by ancestral beings from the Dreamtime, who visited, lived or performed some act or activity, thereby creating some of the prominent natural features of the environment. These are therefore considered places of high significance.

The land and natural resource management methods and practices used were sophisticated and obviously sustainable. Some of these practices included:

- the use of a fire regime, a major tool for clearing the undergrowth in the riverine forests, allowed for new growth, encouraged grazing by fauna and thereby increased their reproduction, and enabled the germination of much of the native vegetation
- distribution of herbal medicine and other seeds during harvesting (non-tilling seeding)
- the placing of restrictions or taboos on the taking of threatened or diminished species, including the taking of more than was needed for that day, as well as the rule to always leave viable material for regeneration
- construction of weirs that allowed small fish to escape, and stone traps that allowed for selective harvesting of fish, for future breeding purposes.

Wetlands and floodplains remain extremely important for the survival of traditional foods, such as fish and crustaceans, water fowl and other fauna, herbal and medicinal plant resources. Other natural resources include raw materials for tools, utensils and building.

All Aboriginal sites are significant in some way. Some sites are sacred, some are secret, and some are important for other reasons. One reason sites are significant is that they can contain information that is important not only on a local level, but on regional, national and global levels, and are important in terms of understanding past changes in our environment. This type of information can be accessed through archaeological studies and can reveal such information as:

- the availability of natural resources for survival
- trade routes and movement through the country
- environmental changes over periods of time
- climatic changes
- the history of exploitation of native fauna and flora, including extinct fauna and flora
- dietary changes
- regional changes in natural resources, such as changes in water flow and availability, which can also suggest changes in native grasses and other flora

A site at Mungo, for instance, contains some of the earliest evidence of ceremonial burial, therefore suggesting a religion being practiced more than 40,000 years ago. A site near Brewarrina in New South Wales, contains the earliest evidence of grain being ground into flour for bread making (35,000 years ago).

