Macquarie River (Narromine to Oxley Station) Floodplain Management Plan
Cover photos (clockwise from main photo):
Reddenville Break, August 1990 flood (Steve Hogg, NSW Department of Water and Energy)
Black box woodland, north-west of Warren (Paul Bendeich, DECC)
Channel near Crooked Creek, near Gin Gin (Paul Bendeich, DECC)
River Red Gum woodland near Gin Gin (Paul Bendeich, DECC)

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### Abbreviations

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<tbody>
<tr>
<td>AEP</td>
<td>Annual Exceedance Probability</td>
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<tr>
<td>ARI</td>
<td>Average Recurrence Interval</td>
</tr>
<tr>
<td>CMA</td>
<td>Catchment Management Authority</td>
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<tr>
<td>DECC</td>
<td>Department of Environment and Climate Change</td>
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<tr>
<td>DLWC</td>
<td>Department of Land and Water Conservation</td>
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<td>DNR</td>
<td>Department of Natural Resources</td>
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<td>DWE</td>
<td>Department of Water and Energy</td>
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<tr>
<td>EIA</td>
<td>Environmentally Important Area</td>
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<td>EMP</td>
<td>Macquarie Marshes Adaptive Environmental Management Plan</td>
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<td>FMC</td>
<td>Floodplain Management Committee</td>
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<td>FMP</td>
<td>Floodplain Management Plan</td>
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<td>FRMS</td>
<td>Floodplain Risk Management Study</td>
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<tr>
<td>HAC</td>
<td>Hydraulic Area of Concern</td>
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<tr>
<td>LGA</td>
<td>Local Government Area</td>
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<tr>
<td>MDBC</td>
<td>Murray Darling Basin Commission</td>
</tr>
<tr>
<td>R-HAC</td>
<td>Regional Hydraulic Area of Concern</td>
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<tr>
<td>PVP</td>
<td>Property Vegetation Plan</td>
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<td>SWMOP</td>
<td>State Water Management Outcomes Plan</td>
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<tr>
<td>WAMC</td>
<td>Water Administration Ministerial Corporation</td>
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<td>WMA</td>
<td><em>Water Management Act 2000</em></td>
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<td>WRC</td>
<td>Water Resources Commission</td>
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Preface

Since the completion of Burrendong Dam in 1965 and the transformation of the Macquarie River from carrying intermittent to regulated flows, the Macquarie floodplain has experienced considerable irrigation development. While the floodplain is a very successful farming and irrigation area, damaging floods over many years have resulted in the uncoordinated construction of crop protection works. In common with many other rural areas that have undergone irrigation development, the Macquarie floodplain is showing signs of stress related to alterations in flow patterns across the floodplain.

Floodplain development guidelines were prepared in 1978 (Guidelines for Floodplain Development, Macquarie River Narromine to Warren) and around 1982 (Guidelines for Floodplain Development, Warren to Oxley Station). Together these are known as the 1978/82 Guidelines. To date, these guidelines have served as the main reference for landholders undertaking floodplain development including the construction of flood control works. However, the 1978/82 Guidelines need to be replaced with a strategic plan that addresses current levels of development and is consistent with the needs of sustainable natural resource management.

The Macquarie River (Narromine to Oxley Station) Floodplain Management Plan (FMP) was prepared by the former Department of Natural Resources (DNR) for the Water Administration Ministerial Corporation (WAMC) under Part 8 of the Water Act 1912 and in accordance with the processes outlined in the NSW Government’s Floodplain Development Manual 2005. The preparation of the FMP was overseen by the Macquarie River Floodplain Management Committee (Macquarie River FMC), which comprised representatives from the community, various stakeholder groups and government agencies. Funding for the FMP was provided by the Commonwealth Natural Disaster Mitigation Programme with financial support by the state.

The Department of Environment and Climate Change (DECC) is responsible for preparing rural floodplain management plans that define requirements for the management of floodwaters within floodplains. Licensing of works and compliance functions under Part 8 of the Water Act 1912 are the responsibility of the Department of Water and Energy (DWE). The FMP is the first stage in developing an overall integrated scheme for the management of floodwaters in the lower Macquarie Valley.

Development of the FMP has progressed through three primary steps:

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

The FMP was publicly exhibited during October – December 2006 and submissions received were taken into account in the preparation of the final plan.

The FMP allows for future floodplain management planning by providing a coordinated and integrated network of floodways of adequate hydraulic capacity and continuity to effectively convey floodwaters and support the floodplain environment up to and including the largest flood on record, that of 1955. Once adopted, the FMP, including the FMP floodway network, will form the basis for determining whether flood control works (earthworks, embankments or levees) on the floodplain will be granted approval under Part 8 of the Water Act 1912. The plan also details the approval process and
assessment criteria for proposed and existing works. Flood control works located within floodways and outside delineated areas are assessed as non-complying works and are likely to be refused or require modification or removal.

The FMP floodway network is designed to effectively convey floodwaters to Environmentally Important Areas (EIAs) within the FMP floodplain and downstream to the Macquarie Marshes. EIAs are areas that have important environmental and/or cultural features that rely on flooding to sustain essential ecological processes. They include areas of flood dependent vegetation, wetlands and floodplain watercourses. A high proportion of the existing river red gum and black box woodland have been captured within the FMP floodway network as well as an additional 3,000 hectares of EIAs that were excluded from the 1978/82 Guidelines floodway network. Where existing works affect EIAs the FMP outlines measures to enhance flood flow connectivity. In some cases, landholders may be eligible to receive funding from the Central West Catchment Management Authority (CMA) for the removal or modification of works that result in an environmental benefit.

In finalising the FMP floodway network, some existing and proposed flood control works that result in floodways being subjected to encroachment or blockage, were identified as being Regional Hydraulic Areas of Concern (R-HACs). The FMP recommends remedial actions that affected landholders will need to take to ensure the flood control works comply with the FMP. The FMP also recommends floodwater drainage openings (bridges, culverts, siphons) for roadways located on public land.

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

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

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

Dense vegetation cover within the FMP floodway network may increase hydraulic roughness and reduce floodway efficiency. There is a range of options under the Native Vegetation Act 2003 and other relevant legislation to manage vegetation so that the FMP 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 in the future. The FMP is required to be reviewed at 5 yearly intervals in accordance with the Water Management Act 2000.

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

1.1 Vision and objectives

The FMP has been prepared to provide strategic guidance to NSW Government agencies and landholders involved in the management of floodwaters on the Macquarie River (Narromine to Oxley Station) floodplain. The overall vision for the FMP is as follows:

*To coordinate floodplain development to minimise flood risk to occupiers and users of the floodplain whilst addressing the environment, social and economic interest of the Macquarie River Valley.*

The objectives linked to the above vision statement for the FMP are as follows:

- To achieve a coordinated balanced approach to floodplain management taking into account hydraulic, environmental and economic considerations and legislative requirements;
- To ensure the sustainable and equitable use of floodplain resources;
- To reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible (NSW Flood Prone Land Policy objective);
- To coordinate floodplain development in order to minimise adverse changes to flood flow patterns;
- To increase the sustainable social, economic and ecological benefits of using the floodplain;
- To improve and maintain the diversity and well being of riverine and floodplain ecosystems that depend on flood inundation; and
- To take into account the cumulative impact on flooding behaviour of individual developments.

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

- Flood Study – completed by Sinclair Knight Merz in 2002, the study defines the nature and extent of flooding, including development of a hydraulic model of flood behaviour;
- Floodplain Risk Management Study – evaluates management options based on hydraulic modelling, analysis of the floodplain environment and social and economic considerations, to address existing and future floodplain management issues; and
- Floodplain Management Plan – adopts strategies to manage flood risk and to support the requirements of the floodplain environment.

The FMP has been prepared with the assistance of the Macquarie River FMC. The Macquarie River FMC has representatives from Warren and Narromine Shire councils, landholders, rural farm groups, and government agencies. The Central West CMA was also consulted during the preparation of the FMP.
Once adopted under the provisions of Part 8 of the Water Act 1912, the FMP must be considered by DWE when reviewing and determining approval applications for flood control works under the Act or the Water Management Act 2000 when this is applied.

1.2 FMP floodplain overview

1.2.1 General
The FMP floodplain extends from Narromine in the south to Oxley Station in the north. The Macquarie Marshes are located downstream of the FMP floodplain.

The location of the Macquarie Valley and the Macquarie Marshes are shown in Figure 1.1. The FMP floodplain and the names of the major waterways are shown in Figure 1.2. The FMP floodplain extends in the north to the southern boundary of Oxley Station. The eastern boundary generally follows Marthaguy Creek. The southern boundary of the FMP floodplain is at Narromine. On the western side the boundary is the Mitchell Highway.

The FMP floodplain falls within the local government areas of Warren and Narromine Shire Councils. The FMP floodplain is a highly productive agricultural region. Irrigated cotton and dryland wheat crops are the most important enterprises economically, while grazing of cattle and sheep occupies more area.

1.2.2 Flooding overview
The FMP floodplain drains a 26,000 square kilometre catchment area of the Macquarie River upstream of Narromine. The Macquarie River is a regulated river with two dams in its headwaters. Windamere Dam on the Cudgegong River has a relatively insignificant impact on flooding in the Macquarie River at and below Narromine. However, Burrendong Dam, which is on the Macquarie River just downstream of its confluence with the Cudgegong River, can be operated to have a significant mitigating effect on minor to medium sized floods within the FMP floodplain.

In common with all other major western flowing streams in New South Wales, the waterway area of the Macquarie River channel progressively decreases with distance downstream. With a reduced carrying capacity in the main channel, much of the flow of large floods in the Macquarie River leaves the river and flows through a multitude of cowals, swamps and natural depressions. Within the Macquarie River FMP, except for the Macquarie River and Ewenmar Creek, almost all of the waterways are effluent creeks (ie have no catchment).

Upstream of Narromine the floodplain of the Macquarie River is well defined and relatively narrow and hence flooding is confined and within river banks. A number of break-outs occur from the Macquarie River near Narromine, a significant one being at Webbs Siding.

In the reach from Narromine to Gin Gin considerable overbank flow occurs during major floods in the vicinity of Bugaboo Point and Rocky Point. The water escaping at Bugaboo Point moves on a wide front through highly developed irrigation areas to Buddah Lake and the balance passes into Trailgang Cowal. Overflows on the left bank of the Macquarie River are restricted to a relatively narrow floodplain because of the elevated nature of the area.

The Macquarie River floodplain below Gin Gin is considerably wider with medium size floods capable of initiating breakouts over both banks of the river.
Downstream of Warren, during small to moderate floods, floodwaters on the left bank of the Macquarie River are relatively confined to a moderately narrow strip as far down as Marebone Weir. Downstream of the weir the bulk of the floodwaters enter Middle and Marra Creeks. During small to moderate floods, the right bank floodwaters are confined to a relatively narrow strip between the Macquarie River and Five Mile Cowal as far as downstream of Drungalear Break where a large volume of water breaks to the northeast. In larger floods the Mumblebone and Marra Break operates on the west bank opposite Gillendoon and Drungalear forming major flows to the Marra Creek system.

Please refer to the Macquarie River (Narromine to Oxley Station) Flood Study (2002) and the Floodplain Risk Management Study reports for detailed information regarding the flooding characteristics of the Macquarie River floodplain.

1.2.3 Environmental overview

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 development of agriculture and associated flood control works has modified the floodplain environment by removing floodplain vegetation and altering river-floodplain connectivity. Despite these impacts, the floodplain retains important ecological values, including tracts of wooded riverine terrain and ecologically productive wetlands that support a range of floodplain fauna.

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

The Macquarie Marshes, located directly downstream of the FMP floodplain, is a large and complex system of wetlands that is unique in terms of its size (approximately 200,000 ha) and diversity. The significance of the Macquarie Marshes is internationally recognised with about 19,000 ha of the wetlands protected under the Ramsar Convention (Figure 1.1). The Marshes are an important breeding and refuge area for a variety of waterbirds including egrets, ibis, herons, spoonbills and cormorants. The ecological functions and habitats of the Marshes have been under increased stress in recent years due to the combined effects of river regulation and drought. The Marshes are inundated by flooding from the lower Macquarie River and its anabranches and effluents. The downstream delivery of floodwater volumes to the Macquarie Marshes, consistent with natural flow paths, has been a key consideration in the preparation of the FMP.
Figure 1.2 FMP Floodplain
2 Development of the FMP

2.1 Legislative and policy framework

The management of the FMP floodplain must be undertaken within the current legislative and policy framework. A brief summary of the primary pieces of relevant legislation and policy is presented below. The Macquarie River (Narromine to Oxley Station) Floodplain Risk Management Study (FRMS) report contains a more detailed overview of the legislation and policy framework for floodplain management.

2.1.1 Water Act 1912 and Water Management Act 2000

Development on floodplains in the western rural areas of NSW is managed through Part 8 of the Water Act 1912. Part 8 was gazetted in 1984 and makes provisions concerning ‘controlled works’ that affect, or are likely to affect, flooding and/or floodplain functions. Part 8 was amended in 1999 to allow for more strategic control of such works (hereafter known as 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 DWE’s ability to deal with unauthorised works.

Administrative orders published in April 2007 designated responsibilities under Part 8 of the Water Act 1912 as follows:

1. The Department of Environment and Climate Change (DECC) has the responsibility for preparing the rural floodplain management plans.

2. Licensing and compliance functions are the responsibility of the Department of Water and Energy (DWE).

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

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

(a) to apply the principles of ecologically sustainable development, and

(b) to protect, enhance and restore water sources, their associated ecosystems, ecological processes and biological diversity and their water quality, and

(c) to recognise and foster the significant social and economic benefits to the State that result from the sustainable and efficient use of water, including:

   (i) benefits to the environment, and
   (ii) benefits to urban communities, agriculture, fisheries, industry and recreation, and
   (iii) benefits to culture and heritage, and
(iv) benefits to the Aboriginal people in relation to their spiritual, social, customary and economic use of land and water,

(d) to recognise the role of the community, as a partner with government, in resolving issues relating to the management of water sources,

(e) to provide for the orderly, efficient and equitable sharing of water from water sources,

(f) to integrate the management of water sources with the management of other aspects of the environment, including the land, its soil, its native vegetation and its native fauna,

(g) to encourage the sharing of responsibility for the sustainable and efficient use of water between the Government and water users,

(h) to encourage best practice in the management and use of water.

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

(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, and

(b) the impacts of flood works on other water users should be avoided or minimised, and

(c) the existing and future risk to human life and property arising from occupation of floodplains must be minimised.

Core provisions – Water Management Act 2000

The Water Management Act 2000 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 following section lists these provisions and outlines how they have been addressed in the FMP.

(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 representing pre-development to existing flood regimes was analysed as part of the FRMS in order to calibrate the computer model and develop design floods. Identification of the natural flooding regime was approximated by the use of 1955 flood data which is highly indicative of pre-development conditions on the floodplain.

(b) The 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 8 of the FMP. Wetlands, other floodplain ecosystems and groundwater recharge areas (identified collectively as Environmentally Important Areas) have been specifically considered in the FMP in relation to flood connectivity. Detailed information on the environmental assessment is presented in the FRMS.

(c) The identification of existing flood works in the area and the way they are managed, their benefits in terms of the protection they give to life and property, and their ecological impacts, including cumulative impacts.
Identification of existing flood works was undertaken in detail in the FRMS and the impact of these works on flood behaviour was assessed in relation to flood risk and the flood connectivity of Environmentally Important Areas. Based on this assessment, the FMP specifies required modifications (Sections 5 and 6) to existing works to address identified hydraulic and environmental issues.

(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 4.2). The FMP is a strategic plan which identifies a network of coordinated floodways that need to be kept open for floods up to and including the design flood irrespective of whether there are flood protection works or not.

Additional provisions – Water Management Act

(a) Proposals for the construction of new flood works.

Section 3 of the FMP outlines the approval and determination process for new flood works. The FMP floodway network (Maps 1 to 7) will be used as the basis for determining applications for flood works.

(b) The modification or removal of existing flood works.

This is dealt with in Tables 5.1, 5.2 and 6.1 in the FMP.

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

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

These provisions are reflected in the floodplain management principles (Table 2.2) which formed the basis of decision-making in the preparation of the FMP and the design of the FMP floodway network.

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

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

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

Impacts of the FMP on water quality are assessed at a strategic level in Table 8.1.

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

Currently no matters have been prescribed by the regulations.
2.1.2 The Flood Prone Land Policy

The primary objective of the NSW Government’s Flood Prone Land Policy is to reduce the impacts of flooding on individual owners and occupiers of flood prone land, and to reduce private and public losses caused by flooding. A central tenet of the policy is that land use proposals for flood prone land be treated within the framework of a strategically generated floodplain risk management plan prepared using a merit-based approach. The Government’s Floodplain Development Manual (2005) supports the policy and outlines a merit-based approach to floodplain management.

2.1.3 Other floodplain management controls

There are several other legislative acts and policies that are relevant to floodplain management and the approval process for flood control works. The majority of these relate to floodplain environmental matters such as flora and fauna, wetlands, threatened species and fish habitat.

- **The Environmental Planning and Assessment Act 1979** – This Act is of particular importance. In determining applications for flood control works, DWE is required to assess the environmental impact of the works under Part 5 of this Act. Consideration of proposed works under Part 4 of the Act is not required as there is no relevant environmental planning instrument that applies to flood control works in the FMP floodplain.

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

- **Water Management Act 2000** – *The Rivers and Foreshores Improvement Act 1948*, which allowed for the carrying out of works to remove obstructions and to improve rivers and foreshores, has been repealed and replaced by provisions in the *Water Management Act 2000* for controlled activities. Under the Water Management Act, DWE 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 *Water Management Act 2000* would be required where earthworks are proposed in the bed of a watercourse or wetland or where material is being sourced from a watercourse to construct a flood control work.

Other relevant pieces of legislation include:

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

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

- **The Wetlands Management Policy 1996**
On 3 July 2008, the NSW Government announced the Floodplain Harvesting Policy that aims to bring floodplain harvesting activities into the statutory framework for water management for the first time. It is proposed that entitlements for floodplain harvesting be established in each valley in NSW that are within existing Water Sharing Plan limits and the Murray Darling Basin Cap. Eligible works will be assessed to determine whether they can be authorised to take floodplain water and if approved, a share of the total allowable floodplain harvesting volume will be issued under licence. DWE is leading a consultation process on the draft Policy with targeted stakeholders, including irrigators, floodplain graziers and environmentalists. It is intended that once a final policy is agreed, the data contained in this FMP, the FRMS and the Flood Study will support the implementation of the policy in the Macquarie valley.

2.1.4 Relevant State and Catchment Management Plans

The NSW State Plan, A New Direction for NSW (2006), outlines the goals, priorities and targets for the NSW Government to deliver better services and improved outcomes for the communities of NSW.

The State Plan priorities for the protection of the natural environment includes the provision of better outcomes for native vegetation, biodiversity, land, rivers, and coastal waterways (Priority E4). 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 provide long-term direction for investment in natural resources.

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

- **Macquarie Marshes Adaptive Environmental Management Plan** (due for release in 2009);
- **Macquarie Marshes Water Management Plan** 1986;
- **Water Sharing Plan for the Macquarie and Cudgegong Regulated Rivers Water Source** 2004;
- **Macquarie Marshes Land and Water Management Plan** 1997;
2.2 Community consultation

Community consultation formed an integral component in the development of the FMP. The immediate consultative committee was the Macquarie River FMC. The Macquarie River FMC included representatives from the Warren and Narromine Councils, landholders, rural farm groups, government agencies and environmental organisations.

In addition to regular Macquarie River FMC meetings, many meetings with landholders were held to assist with understanding flooding within the FMP floodplain. At the start of the Flood Study, a questionnaire and newsletter was sent out to residents within the FMP floodplain area requesting feedback from the community on a number of issues and topics including the effects of floods on property, the severity of flood damages, measures taken to control floods, the benefits of flooding and asking if there were any environmental issues of concern to the community. Approximately 80 responses were received and this information was analysed and presented in the Flood Study report. The Central West CMA was also consulted throughout the process of drafting the FMP.

In the FRMS phase, landholder focus groups were established for all areas within the floodplain to assist with specific issues.

A Review Panel composed of the convenors of the focus group meetings and former DNR agency staff, undertook a preliminary assessment of information supplied by each focus group to ensure consistency with the adopted floodplain management principles.

Table 2.1 is a summary of the meetings that have been held with the Macquarie River FMC and landholder focus groups during the Flood Study and FRMS Phase.

Table 2.1 Community consultation

<table>
<thead>
<tr>
<th>Meeting number</th>
<th>Main discussion points</th>
<th>Date</th>
</tr>
</thead>
</table>
| 1–8            | Macquarie River FMC meetings:  
  ▪ Project background, FMC role  
  ▪ Scoping study  
  ▪ DLWC brief for consultant  
  ▪ Legislative changes to Part 8 Water Act  
  ▪ Sinclair Knight Merz appointment as project consultant  
  ▪ Floodplain management principles  
  ▪ Floodplain modelling setup  
  ▪ 2000 flood monitoring  
  ▪ Environmental data collation  
  ▪ Discussion of Flood Study report | Between September 1999 and December 2001 |
| 9              | Macquarie River FMC meeting  
  ▪ Meeting to discuss the proposed work for floodplain Risk Management Study | 18 September 2002 |
| 10             | Macquarie River FMC meeting  
  ▪ Flooding in effluent creeks area  
  ▪ Environmental assessment criteria  
  ▪ Design flood considerations | 17 December 2002 |
<table>
<thead>
<tr>
<th>Meeting number</th>
<th>Main discussion points</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Focus group meeting</td>
<td>25 March 2003</td>
</tr>
<tr>
<td></td>
<td>2000 flood peaks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design flood considerations</td>
<td></td>
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<tr>
<td>12</td>
<td>Macquarie River FMC meeting</td>
<td>8 April 2003</td>
</tr>
<tr>
<td></td>
<td>Results of modelling design flood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hydraulic hot spots</td>
<td></td>
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<tr>
<td></td>
<td>Adoption of variable design standard</td>
<td></td>
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<tr>
<td></td>
<td>Vegetation management in the floodways</td>
<td></td>
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<tr>
<td></td>
<td>Interim development policy</td>
<td></td>
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<tr>
<td>13</td>
<td>Macquarie River FMC meeting</td>
<td>31 July 2003</td>
</tr>
<tr>
<td></td>
<td>Final results of design flood runs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Potential Hydraulic Hot Spots</td>
<td></td>
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<tr>
<td></td>
<td>Environmental assessment process</td>
<td></td>
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<tr>
<td></td>
<td>Vegetation management options</td>
<td></td>
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<tr>
<td>14</td>
<td>FMC meeting</td>
<td>27 April 2004</td>
</tr>
<tr>
<td></td>
<td>Accuracy of modelling</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environmental assessment process</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Copies of maps for FMC</td>
<td></td>
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<tr>
<td>15</td>
<td>Macquarie River FMC meeting</td>
<td>27 July 2004</td>
</tr>
<tr>
<td></td>
<td>Results of modelling hot spots</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Using Focus Group to modify floodways</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Focus group meeting</td>
<td>24 August 2004</td>
</tr>
<tr>
<td></td>
<td>Meetings with four groups of landowners representing different areas on the floodplain</td>
<td></td>
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<tr>
<td></td>
<td>Discussion of Potential Hydraulic Hot Spots and existing works</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Review panel meeting</td>
<td>15 December 2004</td>
</tr>
<tr>
<td></td>
<td>Effects of enlarging the Sandy Creek Regulator</td>
<td></td>
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<tr>
<td></td>
<td>Floodways in Buddah area</td>
<td></td>
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<tr>
<td></td>
<td>Marthaguy Irrigation area</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Potential Hydraulic Hot Spots 179 and 174</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>SKM and landholder meeting</td>
<td>15–16 February 2005</td>
</tr>
<tr>
<td></td>
<td>Meetings with individual landowners to discuss local floodway issues, floodway obstructions and historical flood behaviour</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Macquarie River FMC meeting</td>
<td>20 April 2005</td>
</tr>
<tr>
<td></td>
<td>Presentation of Potential Hydraulic Hot Spot maps</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Webbs Siding Breakout</td>
<td></td>
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<tr>
<td></td>
<td>Discussion of R-HACs</td>
<td></td>
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<tr>
<td></td>
<td>Results of field environmental assessment</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Focus group meeting</td>
<td>22 June 2005</td>
</tr>
<tr>
<td></td>
<td>Meeting with downstream of Warren Focus Group convenors to discuss actual and proposed locations of banks and Hydraulic Hot Spots</td>
<td></td>
</tr>
</tbody>
</table>
### 2.2.1 Stakeholder meetings

In addition to the formal Macquarie River FMC meetings and the focus group meetings, a number of technical meetings were held on-site with individual landholders and sometimes in conjunction with the focus groups. These typically involved a review of landholder proposed/existing floodways, inspection of hydraulically sensitive areas and banks, inspection of environmental sites and discussion of historical flood behaviour in the area.

In addition, former DNR staff carried out field assessment of Environmentally Important Areas and consulted with about 40 landholders to discuss site-specific flooding behaviour, ecological aspects and management options to restore flood connectivity.

### 2.2.2 Public exhibition

The FMP was put on public exhibition from 23 October 2006 to 1 December 2006 and 17 responses were received. The issues raised in the submissions have been addressed through amendments to the FMP, where possible.

All respondents received a reply addressing the issues raised.

### 2.3 Floodplain management principles

A set of floodplain management principles was adopted by the Macquarie River FMC at a committee meeting held on 21 June 2000.

The adopted principles were used as a guide for the purpose of making decisions when assessing management strategies and options during the FRMS phase.
adopted floodplain management principles are provided in Table 2.2 and reflect the general matters for consideration with respect to flood control work approvals set out in section 166C of Part 8 of the *Water Act 1912* (Section 3.2.4).

Table 2.2  Floodplain management principles

<table>
<thead>
<tr>
<th>Principle category</th>
<th>Principle number</th>
<th>Principle description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location of floodways</strong></td>
<td>1</td>
<td>Defined floodways and exits from floodways should be equitably distributed consistent with natural/historical flowpaths.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>There may be scope to depart from the natural/historical drainage pattern, provided that the community agrees that the Plan is hydraulically and environmentally feasible and acceptable to the community.</td>
</tr>
<tr>
<td><strong>Hydraulic design of floodways</strong></td>
<td>3</td>
<td>Defined floodways must possess adequate hydraulic capacity and continuity to enable the orderly passage of floodwaters through the floodplain.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Sufficient flood storage must be retained on the developed floodplain so that flood wave is not significantly accelerated to downstream areas nor flood height increased.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Velocities and depths of flood flow in defined floodways and exits from defined floodways should not cause significant erosion or increased siltation under various land uses.</td>
</tr>
<tr>
<td><strong>Required outcomes</strong></td>
<td>6</td>
<td>There should not be any significant detrimental impact from the FMP. Any adverse hydraulic or environmental outcomes from existing development in the floodplain should be identified and mitigation measures proposed.</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>There should be no significant detrimental impact from floodplain development on any individual landholder including downstream landholders or community infrastructure or environmental areas due to increases in peak flood levels peak flows, total volumes and increased drainage times.</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Floodplain development should not cause significant redistribution of floodwaters in terms of flow distribution, volumes or flow rates.</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>The FMP should aim to minimise detrimental impacts from future development and management activities on the floodplain on individual landholders, the environment and society.</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Defined floodways should, wherever practicable, allow for the delivery of floodwaters to support floodplain ecosystems.</td>
</tr>
</tbody>
</table>
3 Plan implementation

The FMP outlines modifications to existing (unapproved) and proposed flood control works and identifies a floodway network to allow for future property planning. Maps 1 to 7 show the details of the FMP floodway network and Tables 5.1 and 6.1 identify the required modifications. Table 5.2 details recommended modifications for works on public land.

3.1 Staging of plan outcomes

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

- **High**: The recommended actions are vital in order to ensure adequate performance of the floodway system. The responsible party will initiate consultation and action within 6 months and have the works completed within 18 months from the gazettal of the FMP.
- **Medium**: These measures are important for hydraulic and/or environmental reasons. The responsible party will initiate consultation and action within 12 months and have the works completed within 3 years of gazettal.
- **On-going**: These issues or measures may require further investigation or need to be monitored by DECC and relevant stakeholders during flood events.

3.2 Part 8 approval process for flood control works

3.2.1 General

All activities associated with flood control works are administered under the relevant sections of Part 8 of the *Water Act 1912*. Administrative orders published in April 2007 designated responsibility for preparing FMPs to DECC and for licensing of works and compliance functions to DWE.

Once the FMP has been adopted, it is proposed to designate the land area of the FMP as a floodplain under the *Water Act 1912*. All flood control works situated or proposed to be constructed on land within the designated floodplain will be determined in accordance with FMP and Part 8 of the Act.

3.2.2 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’;
- 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’ (Refer glossary).

3.2.3 Applying for approval
To lodge an application for approval of flood control works, a Part 8 application form (Appendix D) must be completed and submitted to DWE.

The following must accompany the application form:
- Application fee (currently $182);
- A detailed locality plan showing the location of the works and providing full details of the proposal including specifications of the dimensions and design of the works, and the construction materials;
- A detailed survey plan adopting Australian Height Datum (AHD) showing reduced levels relevant to established and or proposed works;
- Supporting information that may assist in the determination process (Applicant to get in touch with the nearest DWE office for details).

For non-complying works, in addition to the above, a report on the hydraulic and environmental impacts of the works, including an assessment against the environmental and hydraulic criteria outlined in section 7.0, must accompany the application form.

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

3.2.4. Determination process
All applications under Part 8 of the Water Act 1912, including works considered to be complying with the FMP, must proceed through a set process prior to DWE determining the application under Section 171 of the Act. This process includes (but is not limited to):

- Section 166C of the Water Act 1912 – DWE must have regard to the matters 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 matter relating to the desirability or otherwise of a controlled work.

- **Part 5 of the *Environmental Planning and Assessment Act 1979* –** as there are no relevant environmental planning instruments relating to the FMP all proposals must undergo assessment under Part 5. DWE must take into account the following factors concerning the impact of the flood control works on the environment:
  - any environmental impact on a community;
  - any transformation of a locality;
  - any environmental impact on the ecosystems of the locality;
  - any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality;
  - any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations;
  - any impact on the habitat of protected fauna (within the meaning of the *National Parks and Wildlife Act 1974*);
  - any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air;
  - any long-term effects on the environment;
  - any degradation of the quality of the environment;
  - any risk to the safety of the environment;
  - any reduction in the range of beneficial uses of the environment;
  - any pollution of the environment;
  - any environmental problems associated with the disposal of waste;
  - any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply;
  - any cumulative environmental effect with other existing or likely future activities.

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

- **Other management plans** – DWE 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** – DWE will liaise with the Culture and Heritage Division of DECC to assess Aboriginal heritage issues associated with individual applications. Applications will be assessed in accordance with the *National Parks and Wildlife Act 1974* and against the cultural heritage section of the Macquarie Marshes Adaptive Environmental Management Plan.

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

### 3.2.5 Possible determinations

DWE 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 licence. Under the *Water Act 1912*, there are three (3) possible determinations: approval of the application, approval of the application subject to conditions, or refusal of the application.

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

### 3.2.6 Complying works

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

- existing (unapproved) and proposed works located outside the FMP floodway network and within hatched areas shown on Maps 1 to 7; or
- upstream of Warren, existing (unapproved) and proposed works located on the boundaries of the hatched areas shown on Maps 1 to 7 that do not exceed specified height limitations (as shown on Maps 1 to 7); or
- existing (unapproved) or proposed works to be modified in accordance with the required hydraulic modifications as specified in Table 5.1; or
- existing (unapproved) or proposed works to be modified in accordance with the required environmental modifications as specified in Table 6.1.

A landholder will be required to provide the necessary supporting information to demonstrate that the application is a complying work. Where an existing (unapproved) or proposed flood control work is complying, the application for approval will be determined by DWE without the need for advertising to canvass third party objections. While the majority of approvals for complying works are likely to be straightforward and expedient, they will not be automatically approved and will be subject to the determination process outlined in section 3.2.4, including assessment against the matters raised in Section 166C of the *Water Act 1912* and Part 5 of the *Environmental Planning and Assessment Act 1979* (Section 3.2.4).

The hydraulic capacity of the FMP floodway network is based on the two largest floods on record, those of 1955 and 1990 (see Section 4.0 for more detail). Floodway widths upstream of Warren are designed to cater for floods similar to 1990 due to loss of floodplain storage to development. However, by specifying height limitations, for flood control works upstream of Warren, floods larger than 1990...
would inundate the hatched areas shown on Maps 1 to 7 located outside the draft FMP floodway network. Therefore, while applications for flood control works in these areas will be assessed as complying works, the assessment may need to take into account any potential reduction in floodplain storage for floods greater than the 1990 design flood.

3.2.7 Non-complying works
Under Section 168B(3) of the *Water Act 1912*, a flood control work is assessed as a non-complying work if DWE is not satisfied that the work complies with the floodplain management plan for the area in which the work is situated or proposed to be constructed, or, the flood control work is situated or proposed to be constructed in an area that is not the subject of a floodplain management plan. For the FMP, non-complying flood control works are defined as:

- existing (unapproved) and proposed works located on all non-hatched areas shown on Maps 1 to 7 including all identified floodways constituting the draft FMP floodway network; or
- upstream of Warren, existing (unapproved) and proposed works located on the boundaries of the hatched areas shown on Maps 1 to 7 that exceed specified height limitations (as shown on Maps 1 to 7); or
- existing (unapproved) or proposed works that are not modified in accordance with the required hydraulic modifications as specified in Table 5.1; or
- existing (unapproved) or proposed works that are not modified in accordance with the required environmental modifications as specified in Table 6.1.

Non-complying works may be considered for approval after a detailed investigation of hydraulic and environmental impacts. The cumulative impact of existing (unapproved) or proposed works on flooding characteristics needs to be comprehensively addressed in the application. Hydraulic impacts will be assessed against the criteria specified in Section 7.0. Environmental impacts will be assessed under Part 5 of the *Environmental Planning and Assessment Act 1979* and against the criteria specified in Section 7.0. It is important to understand that it is the landholder’s responsibility to provide the necessary technical details to support an application. Where the requested supporting information is not furnished, DWE can refuse to deal with the application.

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

3.2.8 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, DWE may direct that one or more of the following types of work are carried out by issuing a notice under Section 180D of the Water Act 1912:

- (a) Work to remove, modify, repair or restore the controlled work or to render the work ineffectual.
- (b) Work to repair any damage caused by the controlled work (including any damage caused to any specified land, river, lake, structure or vegetation, or to the environment).
- (c) Work to ensure that any specified land, structure, river, lake or vegetation, or the environment, will not be damaged or adversely affected, or further damaged or further adversely affected, by the controlled work.
- 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, DWE can carry out the work and recover the costs incurred in doing such work. DWE is not required to give any prior notice of its decision to exercise these powers. The occupier can appeal such action to the Land and Environment Court.

3.2.9 Flood protection for high value infrastructure

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

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

3.2.10 Floodplain harvesting works

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

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

3.2.11 Roads and railways

Roads and railways (and associated bridges, culverts and roadworks) vested in local government or State government transport agencies are declared by order as non-controlled works under section 165(2)(a) of the Water Act 1912. Agencies constructing these works however, are required to assess their environmental impact under the Environmental Planning and Assessment Act 1979.
3.2.12 Possible funding sources for environmental works and public works

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

**Table 3.1 Funding sources**

<table>
<thead>
<tr>
<th>Source</th>
<th>Fund manager</th>
<th>Eligible works</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commonwealth and State assisted Natural Disaster Mitigation Program</td>
<td>State Emergency Management Committee (at State level)</td>
<td>Mainly flood mitigation works (public)</td>
</tr>
<tr>
<td>State Assisted Floodplain Management Program</td>
<td>Department of Environment and Climate Change</td>
<td>Local government floodplain management related studies and works (public)</td>
</tr>
<tr>
<td>Various Incentive Funds</td>
<td>Central West Catchment Management Authority</td>
<td>On-farm works with natural resource management outcomes consistent with targets in the Central West Catchment Action Plan</td>
</tr>
<tr>
<td>• Caring For Country</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Conservation farming incentive funding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Native vegetation incentive program</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4 FMP floodway network

4.1 General
The FMP floodway network shown on Maps 1 to 7 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. Obstructions to floodways, even if partial, could cause a significant redistribution of flood flow or a significant increase in flood levels. This could increase the flood risk to flood prone communities and affect the flooding regime to wetlands and related ecosystems. As such, applications to undertake flood control works located in all non-hatched areas shown on Maps 1 to 7 including all identified floodways constituting the FMP floodway network will be assessed as non-complying works and will likely be refused. However, if the applicant can demonstrate that the proposed works will meet the relevant hydraulic and environmental assessment criteria (see Section 7.0) and will meet the requirements of Section 166C of the Water Act 1912 and Part 5 of the Environmental Planning and Assessment Act 1979, then the works may be considered for approval. For example, proposed supply channels crossing floodways may need to be constructed below ground in order to meet approval requirements. Similarly, proposed access roads in floodways would need to be constructed at low levels and with adequate floodwater drainage openings.

The FMP floodway network also identifies hatched areas where flood control works that do not have the capacity to block, impede or divert environmental water will be assessed as complying works and, in general, will be readily approved with appropriate conditions if required (such as limitations on levee and bank heights). All proposals must also undergo assessment under Part 5 of the Environmental Planning and Assessment Act 1979 to take into account any environmental impacts including cumulative impacts with other existing or likely future activities.

Decisions relating to the delineation of the FMP floodway network were largely driven by the Floodplain Management Principles adopted by the Macquarie River FMC and listed in Table 2.2.

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

4.2 Design flood
The design flood is the event to be used for the hydraulic design of the floodway network. A floodway network needs to be designed for an agreed design flood in much the same way as a bridge needs to be designed for a certain load. If a design flood is not adopted then this can lead to an inequitable distribution of floodwaters and an increase in the flood risk to neighbouring and downstream properties.

The 1978/82 Guidelines floodway network design was based on the 1955 historical flood which for most of the floodplain is the largest flood on record. An assessment was carried out to determine whether this flood was still appropriate using a detailed hydraulic computer model that addressed the following considerations:

- complex inter-connected channel networks;
• attenuation of floods by floodplain storage;
• changes in land use on the floodplain;
• assessment of cumulative impacts;
• transparency in calculations;
• readily available tool for quantifying the impacts of floodplain development.

Three historical floods were used for calibrating the hydraulic model. These were the 1955, 1990 and 2000 floods. A full description of the model formulation and calibration is provided in the Flood Study Report (2002). As can be seen in Table 4.1, the 1955 flood had a peak flow of 501,100 ML/day at Narromine and an estimated average recurrence interval (ARI) of about 200 years. The next biggest flood was the flood of 1990 flood which had a peak flow of 179,500 ML/day and an ARI of about 65 years.

### Table 4.1 Assigned AEPs and ARIs of selected historic floods

<table>
<thead>
<tr>
<th>Historic flood event</th>
<th>Narromine peak flow (ML/day)</th>
<th>Assigned annual Exceedance Probability (AEP)</th>
<th>Assigned Average Recurrence Interval (ARI) (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1955</td>
<td>501,100</td>
<td>0.5%</td>
<td>200 years</td>
</tr>
<tr>
<td>1990</td>
<td>179,500</td>
<td>1.5 %</td>
<td>65 years</td>
</tr>
<tr>
<td>1971</td>
<td>158,000</td>
<td>4.5 %</td>
<td>20 years</td>
</tr>
<tr>
<td>2000</td>
<td>99,300</td>
<td>7.5 %</td>
<td>15 years</td>
</tr>
<tr>
<td>1998</td>
<td>92,300</td>
<td>10.0 %</td>
<td>10 years</td>
</tr>
<tr>
<td>1976</td>
<td>67,200</td>
<td>19.0 %</td>
<td>5 years</td>
</tr>
</tbody>
</table>

Both the 1955 and 1990 inflow hydrographs at Narromine were tested in the hydraulic model to assess the consequences of the cumulative impact of building a floodway network in its entirety. With the construction of roads, levees, supply channels and banks, the available storage volume on the floodplain has decreased. As more floodways and levees are constructed, the less floodplain storage will be available and the higher the flood levels will become. Consequently to determine an appropriate design flood, it is necessary to assume that all floodways have been constructed and all developed land bordering the floodways have banks or levees that provide flood protection. In some areas, such as the left bank upstream of Gin Gin, this is almost the case already. By examining the modelling results, and appraising flood level rises, flow re-distributions and velocity increases against the requirements of the adopted floodplain management principles, an assessment can then be made as to which flood to adopt as the design flood.

The hydraulic model was modified to assess the effects of combining a variety of development scenarios with a fully constructed floodway network. The various model configurations are discussed in detail in the FRMS. In summary, all model configurations tested included the flow paths identified in the 1978/82 Guidelines floodway network but with individual variations to cover the following development scenarios:

- existing levees and restrictions included
- selective widening of floodways
- levee height restrictions
The results of the modelling are detailed in the FRMS. The conclusions drawn from the results of the modelling were as follows:

- Even if all floodways are kept fully open, upstream of Warren, the loss of storage when the floodplain is fully developed means that for a very large flood (1955), the flood rises are unacceptable and additional flood storage on the floodplain is required.
- Using wider floodways would not result in a significant reduction in flood levels.

The results were discussed with landholder focus groups upstream of Warren and the Macquarie River FMC. It was concluded that upstream of Warren, the floodway network could not be designed to carry the 1955 flood without significant socio-economic impacts. As a result of this finding the Macquarie River FMC adopted a dual design flood standard with the 1990 flood as the design standard upstream of Warren and the 1955 flood as the design standard downstream of Warren.

This means that upstream of Warren, flood control works bordering floodways need to have their crest levels limited to the 1990 design flood level so that in the event of a 1955 size flood, banks can be overtopped and the flood storage on the floodplain can be maintained. The Macquarie River FMC also agreed that due to available flood storage no height restrictions were required downstream of Warren. For the dual Design Standard to be effective, the floodways need to be free of obstructions.

### 4.2.1 Webbs Siding outflows

In the 1955 flood in the Macquarie River, floodwaters left the Macquarie River catchment at a number of points by crossing over the Narromine to Nyngan Road (Mitchell Highway) and either flowing through culverts or overtopping the railway line which runs parallel to the road.

In this flood, one of the largest outflows occurred at Webbs Siding just upstream of Narromine where the railway line was overtopped and washed out. Since then the railway line has been rebuilt at a slightly higher level and would now not be washed out and would be overtopped only very slightly in a 1955 size flood.

The Macquarie River FMC requested information on the impact of the closure of Webbs Siding outflows on the FMP floodway network. The hydraulic model was used to examine the differences in levels and flows with and without the railway line at Webbs Siding being lowered.

The benefit of lowering or increasing the capacity through the railway line at Webbs Siding is strongest at the upstream end of the FMP floodway network and could provide benefit for floodplain management in Narromine.

The advantages of increasing the capacity of Webbs Siding include:

- reduced flood levels in the Narromine area and downstream in the Macquarie floodplain in times of a 1955 size flood; and
- diversion of flows into the Bogan River system.

The disadvantages of lowering or increasing the capacity through the railway line include:

- potential floodwater damage to landholders downstream of Webbs Siding;
- cost of reconstructing the railway or building the culverts; and
• benefit of lowering/enlarging Webbs Siding only occurs with a very rare flood of the magnitude of the 1955 flood. It would have no benefit for a 1990 type flood.

On the basis of the modelling done to date and the identification of the relative merit of undertaking work at this location, it has been determined that these actions are not a priority at this time.

4.2.2 Beleringar/Sandy Creek regulator

Water from the regulator enters a man made channel which is about 900 metres long before joining Beleringar (Sandy) Creek. Sandy Creek crosses the Mitchell Highway and enters the Bogan River system downstream of Nevertire.

Some landholders consider they receive a disproportionate share of floodwaters from the Macquarie River when the river is in flood and flows out through breaks such as Reddenville Break. They argue that it would be beneficial if more water was able to exit the Macquarie River by enlarging the Beleringar regulator and so a review was undertaken to determine the impact of increasing the flow in Sandy Creek.

The review found that an enlarged regulator and channel could take about 20,000 ML/day for the design flood and reduce flood levels in the Macquarie River at Warren by 0.3 metres. However, there would be increased flood levels in the Sandy Creek system. Additionally, any increase in capacity would have the effect of reducing flow to the Macquarie Marshes.

Given the results of the review and potential impacts on the Macquarie Marshes, it has been determined to not increase the capacity of the regulator at this time.

4.3 Regional Hydraulic Areas of Concern

4.3.1 General

Over the course of many years, landholders have developed areas for farming and particularly for irrigated crops. Some of these areas have levee banks to protect the fields from flooding. Generally floodways have been kept open in accordance with the 1978/82 Guidelines but some floodways have been subjected to encroachment or blockage. These areas, referred to as Hydraulic Areas of Concern (HACs), were defined as:

• Point restrictions within the 1978/82 Guidelines floodway due to earthworks such as banks, supply channels, roads, reservoirs; and

• Realignment of the 1978/82 Guidelines floodway due to landholder modifications to accommodate development.

HACs were identified from the following sources:

• advice from the Macquarie River FMC, landholder focus groups and ground inspections;

• hydraulic modelling;

• remote sensing using satellite images, aerial photography; and

A NSW Agriculture irrigation survey completed in 1996 was used as a guide for the extent of irrigation.

About 200 HACs were identified during the course of the initial Flood Study (2002) from the above listed sources. The identification of HACs and the modelling of hydraulic restrictions using the hydraulic computer model are discussed in detail in the FRMS report.

4.3.2 Determining Regional Hydraulic Areas of Concern

A more integrated approach to resolving HACs was required given the large number of individual sites identified during the FRMS phase. Consequently it was decided to identify those HACs which individually or collectively had a regional significance and required an integrated solution to finalise floodway design. These HACs were defined as Regional Hydraulic Areas of Concern (R-HACs) and were identified based on the following factors:

- at least three landholders involved; or
- at least two high priority HACs in the area; or
- at least 10 HACs in the area; or
- affected floodways carry at least 10,000 ML/day; or
- at least 1,000 ha in size.

The above factors resulted in 13 R-HACs being identified that required integrated solutions. In addition to the R-HACs identified, a number of residual HACs were assessed with only minor localised impacts and were resolved by discussion between neighbours facilitated by landholder focus groups.

4.3.3 Criteria for assessing Regional Hydraulic Areas of Concern

In order to resolve R-HACs and to finalise the hydraulic aspects of the draft FMP floodway network design the following assessment criteria were adopted:

- If the R-HAC caused a flood rise of greater than 200 mm in the Macquarie River or 300 mm in the floodplain, under design flood conditions, when compared to the 1978/82 Guidelines, then this would require appropriate measures to rectify the problem;
- If the R-HAC caused a flow redistribution, under design flood conditions, of greater than 10% then this would require appropriate measures to rectify the problem;
- If the flood rise or flow redistribution was below the above criteria, there would be no required action for the landholder to undertake.

The required modifications to R-HACs are listed in Table 5.1.

4.4 Maintaining flood connectivity to Environmentally Important Areas

Environmental assessment in the design of the FMP floodway network was focussed on the requirements of Environmentally Important Areas (EIAs) which were defined as areas with important environmental and/or cultural features that rely on inundation by floodwaters to sustain essential ecological processes. EIAs include areas of flood dependent vegetation, wetlands, floodplain watercourses, groundwater recharge areas and Aboriginal sites.
Most of the EIAs within the FMP floodplain are not isolated by existing works and are connected to the flooding regime. While most of these EIAs were included in the 1978/82 Guidelines floodway, some with existing flood access were located outside the floodway. These EIAs have been specifically assessed during the design of the draft FMP floodway network. As a result, the draft FMP floodway network includes a number of sections where the 1978/82 Guidelines floodway has been adjusted to incorporate EIAs that were previously excluded. This has meant that in some areas the floodways are wider than would otherwise be required based on hydraulic factors. Further detail on the environmental approach taken in the preparation of the FMP is presented in Section 6.0.

4.5 Floodway alignment design standard

4.5.1 Floodway alignment design standard (upstream of Warren)
The resulting FMP floodway network meets the following design standard upstream of Warren:

- FMP floodway network alignments including floodway widths are generally based on the 1978 Guidelines but include modifications to R-HACs (Section 4.3) and environmental adjustments (Section 4.4);
- The design flood standard adopted is the 1990 historical flood event;
- Crest levels of flood control works located on the boundaries of hatched areas upstream of Warren and shown on Maps 1 to 7 are to be limited to the 1990 design flood levels (as shown on Maps 1 to 7). A linear interpolation of the adjoining upstream and downstream design flood levels can be made to determine the appropriate levee and bank heights.

4.5.2 Floodway alignment design standard (downstream of Warren)
The resulting FMP floodway network meets the following design standard downstream of Warren:

- FMP floodway network alignments including floodway widths are generally based on the 1982 Guidelines but include modifications to R-HACs (Section 4.3) and environmental adjustments (Section 4.4);
- The design flood standard adopted is the 1955 historical flood event;
- Flood control works located on the boundaries of the hatched areas downstream of Warren and shown on Maps 5 to 7 are not subject to height limits.

4.6 Flood flow distribution

A simplified schematic flow distribution for the FMP floodway network under 1955, 1990 and 2000 floods are shown in Figures 4.1 to 4.3. Flows shown in Figures 4.1 to 4.3 are peak flows simulated by the hydraulic model. For comparison purposes, distribution of peak flood flows for the ‘natural’ floodplain and a floodway network with no modifications to R-HACs (Section 4.3) are also shown. The ‘natural’ floodplain was approximated by conditions in 1955 when the floodplain was relatively free of obstruction by works. Further details on peak flows simulated by the hydraulic model can be seen in the FRMS report.

Appendix C includes bar charts showing trends in peak flows for the floodplain conditions modelled.
4.7 Floodway vegetation management

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

There is a range of measures available under the *Native Vegetation Act 2003* and certain provisions of the *Native Vegetation Conservation Act 1997* that may allow thinning of vegetation in the FMP floodway network.

4.7.1 Native Vegetation Act 2003

Measures that may be suitable for managing native vegetation under the *Native Vegetation Act 2003* include clearing of regrowth and Property Vegetation Plans (PVPs). Landholders proposing to thin vegetation in floodways are advised to contact the Central West CMA in the first instance.

*Regrowth*

Regrowth, which is permitted to be cleared, includes vegetation that has regrown since 1990 on previously cleared land. It does not include protected regrowth (including vegetation within 20 metres 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 Central West CMA.

*Continuing Use PVPs*

Continuing Use PVPs provide long term certainty for ongoing farming practices. They cover a number of provisions for managing native vegetation including identification of regrowth (as above), the continuation of 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 for the continuation of existing cultivation, grazing or rotational farming practices. Landholders proposing to prepare Continuing Use PVPs should seek advice from the Central West CMA.

*Invasive Native Scrub PVPs*

Invasive Native Scrub PVPs may be appropriate for the clearing of native vegetation in floodways in cases where river red gum, river cooba or black wattle has regenerated densely following natural or artificial disturbance and the regeneration results in a change of structure and/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.

4.7.2 Clause 28 policy

The *Native Vegetation Regulation 2005* enables the preparation of a Clause 28 policy to allow for minor clearing that has minimal short term impact and provides for 'long term improvement in the condition of native vegetation'. A draft Clause 28 Policy for the thinning of floodway vegetation in the Macquarie FMP floodplain was
prepared by the Central West CMA in 2007. The draft policy outlined processes to allow thinning of river red gum, river cooba and black wattle in specified areas of the FMP floodway network to benchmarks that would maintain hydraulic efficiency.

It has been determined that the Clause 28 policy is not an appropriate mechanism for thinning vegetation in the FMP floodway network as it cannot demonstrate that it provides for ‘long term improvement in the condition of native vegetation’. Additionally, as clearing applications would need to be assessed against the draft Clause 28 policy through a PVP process, it is considered to be more appropriate to use PVPs that are specifically suited to individual clearing issues, such as those outlined above.

4.7.3 Native Vegetation Conservation Act 1997

Certain provisions of the Native Vegetation Conservation Act 1997 that regulate the removal of exotic vegetation and dead timber on State Protected Land, including land within 20 metres of the bed or bank of a prescribed stream, remain in effect. Applications for the removal of such vegetation may require approval from DECC. 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 (Department of Natural Resources 2006).

4.7.4 Removal of vegetation on waterfront land

The removal of vegetation on ‘waterfront land’ is a controlled activity under the Water Management Act 2000. Waterfront land includes the bed of any watercourse and land within 40 metres of its high bank and the bed of any wetland and land within 40 metres of its shore. Under the Act, controlled activities require approval from DWE. However, the Water Management Regulation 2004 exempts activities that comprise nothing more than the removal of vegetation provided that they are lawful under other legislation. Notwithstanding this, landholders may still seek approval for the removal of vegetation as a controlled activity under the Water Management Act and if approval is granted, the clearing would be exempt from the requirements of the Native Vegetation Act 2003. This ensures that only one approval for clearing native vegetation on ‘waterfront land’ is required. Clearing approved under the Water Management Act would also be exempt from the requirements of the Native Vegetation Conservation Act 1997, if applicable (Section 4.7.3).

4.7.5 Recommended floodway vegetation management approach

From the range of available vegetation management measures, two options, regrowth clearing and Invasive Native Scrub PVPs, are considered to be the most appropriate for thinning in floodways to improve hydraulic efficiency. Regrowth (as defined under the Native Vegetation Act 2003) can be cleared without a permit using the full range of clearing methods but cannot be cleared within 20 metres of the bank of a watercourse. Invasive Native Scrub PVPs allow clearing to densities that are suitable for floodway maintenance and can be used throughout the FMP floodway network (including in riparian areas).

Vegetation thinning is most critical in narrow sections of the FMP floodway network, less than 500 metres wide, where increased densities can lead to the redistribution of flood flows and increased flood levels. In these areas, the Central West CMA may use a minor variation to Invasive Native Scrub PVPs for floodway maintenance so scale clearing provided there is minimal disturbance to soil and groundcover and environmental outcomes are maintained or improved.
Community awareness of the need to manage vegetation in critical sections of the FMP floodway network is important; particularly as properties change ownership and land use changes occur over time. Suitable maintenance measures need to be adopted to limit the density of vegetation cover to appropriate benchmarks. The hydraulic design of the FMP floodway network, including design flood levels, is based on adopting the vegetation cover for the 2000 historical flood event. Property owners are encouraged to seek advice from the Central West CMA as to the most suitable land use management options within floodways. The Central West CMA will assist in promoting community awareness of vegetation maintenance needs in critical sections of the FMP floodway network through its role in providing community education and training in vegetation management.

The clearing of invasive native scrub in floodways may lead to improved biodiversity due to reduced competition or increased opportunity for structural and floristic diversity. In such cases, funding through the Central West Catchment Action Plan may be available to support the cost of activities associated with the management of the vegetation (such as fencing and controlled grazing) but is not available for the cost of clearing.
5 Required hydraulic modifications

5.1 General

In order to finalise the FMP floodway network, identified floodplain management issues needed to be investigated and resolved. These issues included existing and proposed flood control works that were identified during the consultation phase as being within a R-HAC (see Section 4.5) and which needed an integrated solution. The required modifications to existing and proposed flood control works, including priority timeframes, are given in Table 5.1 and also include basic hydraulic design information to assist in meeting the required assessment criteria (see Section 7.0).

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 1912. Where no approval exists, DWE may take compliance action(s) in accordance with the Act.

With regard to the actions outlined in Table 5.1:

- Landholders should contact DWE in the first instance to obtain all necessary design information where action is required to modify existing works;
- It is important the regional design flow distribution (as shown on Figures 4.1 and 4.2) and flood levels (as shown on maps 1 to 7) are not compromised and any proposed development needs to meet the assessment criteria (Section 7) for FMP compliance;
- Specific structural modifications to existing works will be administered under the relevant sections of Part 8;
- Minor modifications to existing approved works identified to be necessary will be administered through modifying the Part 8 approval conditions under Section 176A of the Water Act 1912;
- 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 (section 3.2.8);
- Landholders proposing new works as outlined in Table 5.1 are required to lodge a Part 8 application for approval prior to any construction activities. The identified structural requirements should be incorporated into the engineering design of the work(s) and where necessary will be included as approval conditions under Section 176A of the Water Act 1912.

Please refer to Section 3 for further details regarding approval of flood control works and administration of the FMP under Part 8 of the Water Act 1912.
5.2 Works on public land

There are a number of locations where causeways would be beneficial across roadways within the FMP floodplain. Causeways and other floodwater drainage openings (siphons and pipes) are located on public land and are associated with non-controlled works (see Section 3.2.11). However, in order to ensure coordination of works located in the FMP floodplain, these recommended floodwater drainage openings are included in Table 5.2 and may be eligible for public funding.
Table 5.1 Required modifications to existing and proposed flood control works

<table>
<thead>
<tr>
<th>Map Ref.</th>
<th>R-HAC Ref.</th>
<th>Location/Property</th>
<th>Issue</th>
<th>Required actions*</th>
<th>Responsibility</th>
<th>Priority</th>
</tr>
</thead>
</table>
| Map 1 and 2 | A | Bugaboo Point area | The Bugaboo Point area is an important left bank breakout for floodwaters during major floods. For the 1990 design flood, 25% of the Macquarie River peak flow breaks away and flows westward to join Trangie Cowal and thereafter Beleringar/Sandy Creek thereby providing a natural relief valve for downstream flooding. The existing flood control banks through ‘Buddah’ are narrow. Modelling has shown that if the 1990 design flood is confined within these banks flood levels will raise by more than 0.5 metres and flood flows will be restricted causing a flow redistribution of more than 10% when compared to modelling results for the 1978/82 Guidelines. For further details see Figure A-1 in Appendix A. This restriction, if not managed properly, will reduce peak flow away from the Macquarie River at Bugaboo Point. Major floodways to the west are also partially blocked, restricting flow through the Buddah Lakes area and into the Trangie Cowal. | An integrated scheme of floodways is required in this area to safely carry the 1990 design flood from Bugaboo Point through ‘Buddah’, Buddah Lakes and around Trangie. Such a scheme, shown in Figure A-1, includes the following salient features:  
- Lowering or restricting the height of existing banks A and B on the main floodway through ‘Buddah’ to 1.00 metre below the 1990 design flood level or widening the floodway width to the widths shown in Figure A-1;  
- Removing existing banks C and E that block the floodway as shown in Figure A-1;  
- Limiting the height of existing bank D across Trangie Cowal as shown in Figure A-1;  
- In general, any banks, supply channels or any other form of obstruction across floodways should be removed. | Landholders | High |
<table>
<thead>
<tr>
<th>Map Ref.</th>
<th>R-HAC Ref.</th>
<th>Location/Property</th>
<th>Issue</th>
<th>Required actions*</th>
<th>Responsibility</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Map 2</td>
<td>B</td>
<td>Gin-Gin/Mullah</td>
<td>Existing flood banks and a reservoir have reduced the width of a floodway on ‘Mullah’ property compared to the 1978/82 Guidelines. For further details see Figure A-2 in Appendix A. Modelling shows the existing works do not affect design flood levels or discharges from the Macquarie River but increase flood levels locally near the restrictions up to a maximum of 0.5 metres when compared to modelling results for the 1978/82 Guidelines.</td>
<td>No action required at present to increase the width of the floodway as the impacts are localised and landholders understand and accept the risks. Floodway behaviour to be monitored in the next major flood and if there are any problems with excessive flood rise or scour then remedial action may be required.</td>
<td>Landholder/DECC</td>
<td>On-going</td>
</tr>
<tr>
<td>Map 2</td>
<td>C</td>
<td>‘Miegunyah’</td>
<td>The major floodway from the Macquarie River to Ban Ban Creek is about 900 metres wide at its narrowest point. For further details see Figure A-3 in Appendix A. The landholder has proposed to construct flood banks that will partially block two floodways. The floodways will provide only 450 metres width for the southern floodway and 100 metres minimum width for the northern floodway. These restrictions will raise design flood levels in the area.</td>
<td>Any Part 8 application for proposed banks in this area will need to demonstrate sufficient capacity to carry the floodway design flow as shown in Figure A-3 without raising design flood levels in the area, and meet the assessment criteria (Section 7) for FMP compliance. For FMP compliance a minimum width of 600 metres is required for the southern floodway and 300 metres for the northern floodway as shown in Figure A-3.</td>
<td>Landholder</td>
<td>On-going</td>
</tr>
<tr>
<td>Map Ref.</td>
<td>R-HAC Ref.</td>
<td>Location/Property</td>
<td>Issue</td>
<td>Required actions*</td>
<td>Responsibility</td>
<td>Priority</td>
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</tbody>
</table>
| Map 3   | D          | `Toucan`/Beleringar Creek and Channel floodways | Two important floodways running through `Toucan` allow floodwaters from Ban Ban Creek/Macquarie River to join Beleringar (Sandy) Creek thereby providing a natural relief valve for downstream flooding.  
  The southern floodway conveys floodwaters from Ban Ban Creek to Beleringar Creek. The southern floodway is partially blocked by a siphon and stockpile of cotton waste. For further details see Figure A-4 in Appendix A.  
  The northern floodway conveys floodwaters from the Macquarie River to Beleringar Creek.  
  The landholder has proposed to completely block both the southern and the northern floodways with banks designated as `A`, `B` and `C` as shown in Figure A-4.  
  Modelling has shown that the 1990 design flood level will increase up to 0.4 metres when compared to modelling results for the 1978/82 Guidelines if the proposed works are approved. The proposed works will impact on flooding on the right bank floodplain of the Macquarie River. | The supply channel needs to be lowered to ground level as shown in Figure A-4. The stockpile of cotton waste also needs to be removed.  
  Proposed flood banks `A`, `B` and `C` in Figure A-4 are not to be constructed.                                                                 | Landholder       | High      |
<table>
<thead>
<tr>
<th>Map Ref.</th>
<th>R-HAC Ref.</th>
<th>Location/Property</th>
<th>Issue</th>
<th>Required actions*</th>
<th>Responsibility</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Map 4</td>
<td>E</td>
<td>Greenhide Area</td>
<td>The two existing floodways removing water from Greenhide Swamp (‘Wambianna’) have generally been built in accordance with the 1978/82 Floodway Guidelines. For further details see Figure A-5 in Appendix A. However the efficiency of the floodways is reduced due to: • A siphon across the floodways which is partially above ground; • The upstream end of the southern floodway has two sharp bends. The restrictions cause increased flood levels at the upstream end on ‘Wambianna’ property.</td>
<td>The siphon should be lowered to natural surface over the full width of the floodway. Both floodways A and B in Figure A-5 should be clear of any obstructions and a minimum width of 110 metres maintained over their full length. The entrance to the southern floodway should be straightened and any other obstruction removed as shown in Figure A-5.</td>
<td>Landholders</td>
<td>High</td>
</tr>
<tr>
<td>Map 6</td>
<td>F</td>
<td>‘Ardoch’/Nellyvale area</td>
<td>During the consultation process, landowners have proposed three development areas, shown on Figure A-6 in Appendix A. Currently there are no banks in these areas. The proposed development areas will partially restrict the floodways on both sides of the Macquarie River. Modelling shows that the design flood level will increase more than 0.2 metres in the Macquarie River when compared to modelling results for the 1978/82 Guidelines.</td>
<td>Any Part 8 application for proposed banks in the three areas shown in Figure A-6 will need to demonstrate sufficient capacity to carry the design flow on each side of the Macquarie River without any change in design flood levels in the area, and meet the assessment criteria (Section 7) for FMP compliance.</td>
<td>Landholders</td>
<td>On-going</td>
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<tr>
<td>Map Ref.</td>
<td>R-HAC Ref.</td>
<td>Location/ Property</td>
<td>Issue</td>
<td>Required actions*</td>
<td>Responsibility</td>
<td>Priority</td>
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<tr>
<td>Map 6 G</td>
<td>Marebone Creek</td>
<td>The landholder has proposed a modification to the floodway in the 1978/82 Guidelines adjacent to Marebone Creek in order to incorporate existing banks. For further details see Figure A-7 in Appendix A. On the basis of modelling results, it was concluded that the change of alignment of the floodway would not have a significant effect on design flood levels or design flow distribution.</td>
<td>The alignment proposed by the landholder for the floodway was adopted in the floodway network as shown in Figure A-7. The existing bank following the alignment of the floodway network will be considered as a complying work for the purpose of a Part 8 approval. However it is recommended that the area be monitored during major floods.</td>
<td>Landholder/ DECC</td>
<td>On-going</td>
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<tr>
<td>Map 7 H</td>
<td>Gradgery Lane</td>
<td>Land development in this area has restricted floodway capacity when compared to the 1978/82 Guidelines. The constructed floodways are shown in more detail on Figure A-8 in Appendix A. There are three floodways in the area crossing Gradgery lane, designated as Floodways A, B and C in Figure A-8. Modelling showed a significant (greater than 10%) redistribution of flow due to the restricted widths of the existing floodways. An increment in design flood level rise of 0.3 metres is estimated under the design conditions when compared to modelling results for the 1978/82 Guidelines.</td>
<td>Following site visits and model analysis, it was found that floodway B needs to have a minimum width of 500 metres and to closely follow the alignment shown in Figure A-8. The floodway is to be free from any obstructions. An existing secondary floodway, Floodway C as shown in Figure A-8 needs to have its entrance straightened and a minimum width of 100 metres maintained.</td>
<td>Landholder</td>
<td>High</td>
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<td>Map Ref.</td>
<td>R-HAC Ref.</td>
<td>Location/Property</td>
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<tr>
<td>Map 7</td>
<td>I</td>
<td>‘Buttabone’</td>
<td>Development on ‘Buttabone’ has effectively blocked Middle Creek. For further details see Figure A-9 in Appendix A. This has had the effect of seriously redistributing flows and raising flood levels in Marra Creek and Bulgeraga Creek. Modelling has shown that the 1955 flood level has increased by up to 0.8 metres when compared to the 1978/82 Guidelines.</td>
<td>A floodway with a minimum width of 200 metres needs to be incorporated into the existing development by removing or modifying existing banks. The floodway is to generally follow the alignment of Middle Creek as shown on Figure A-9. Alternatively, the landholder is to provide a scheme to increase the floodway capacity for Middle Creek and meet the assessment criteria (Section 7) for FMP compliance.</td>
<td>Landholder</td>
<td>High</td>
</tr>
<tr>
<td>Map 6</td>
<td>J</td>
<td>‘Bellevue’</td>
<td>Figure A-10 in Appendix A shows existing development adjacent to Five Mile Cowal. An existing irrigation supply channel (Tenandra Channel) and a flood bank have closed the floodway provided in the 1978/82 Guidelines (Floodway B). An extremely narrow floodway (Floodway A) exists adjacent to the reservoir shown on Figure A-10. Development without a floodway effectively diverts water breaking out of Five Mile Cowal and has the potential to increase flood levels in the area.</td>
<td>The effectiveness of the floodway to convey the Five Mile Cowal overflow will need to be monitored in the next major flood and if there are any problems with excessive flood rise or scour, then remedial action may be required.</td>
<td>Landholder/ DECC</td>
<td>On-going</td>
</tr>
<tr>
<td>Map Ref.</td>
<td>R-HAC Ref.</td>
<td>Location/Property</td>
<td>Issue</td>
<td>Required actions*</td>
<td>Responsibility</td>
<td>Priority</td>
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<tr>
<td>Map 6</td>
<td>K</td>
<td>Five Mile Cowal</td>
<td>Development on ‘Drungalear’ property within the 1978/82 Guidelines floodways has reduced the width of Five Mile Cowal floodway in the vicinity of Pig Island. For further details see Figure A-11 in Appendix A. Insufficient floodway capacity will increase flood levels and has the potential to cause erosion or overtopping of the bank of Marthaguy channel. An analysis of the topographic data, aerial photography and design flows from the computer model shows that there is still sufficient floodway width available across and around Pig Island. However it is important that the floodway is not restricted further by development.</td>
<td><strong>Figure A-11</strong> shows the required location and width of the floodway around the Pig Island area. Flood behaviour is to be monitored in the next major flood, including the areas upstream (RHAC-L) which have a direct bearing on the passage of floodwaters in the vicinity of the Marthaguy channel (RHAC-K). If there are any problems with excessive flood rise or scour near the junction of Five Mile Cowal with the Macquarie River and Marthaguy channel, then remedial action may be required.</td>
<td>Landholder/DECC</td>
<td>On-going</td>
</tr>
<tr>
<td>Map 2</td>
<td>L</td>
<td>Five Mile Cowal, approximately 5 km upstream of junction with Macquarie River</td>
<td>Existing banks and a reservoir have restricted the floodway linking Five Mile Cowal to the Macquarie River and may not provide adequate bypass capacity during major floods. This floodway has a direct bearing on the passage of floodwaters in the vicinity of the Marthaguy channel (RHAC-K). For further details see Figure A-12 in Appendix A.</td>
<td>Floodway performance is to be monitored in the next major flood. If there are any problems with excessive flood rise or scour in the floodway or downstream near the junction of Five Mile Cowal with the Macquarie River and Marthaguy channel, then remedial action may be required.</td>
<td>Landholder/DECC</td>
<td>On-going</td>
</tr>
<tr>
<td>Map Ref.</td>
<td>R-HAC Ref.</td>
<td>Location/Property</td>
<td>Issue</td>
<td>Required actions*</td>
<td>Responsibility</td>
<td>Priority</td>
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<tr>
<td>Map 7</td>
<td>M</td>
<td>Near ‘Twenty Stone’</td>
<td>Existing development on ‘Twenty-Stone’ has reduced the width of floodways between the Macquarie River and Marra Creek to approximately 25 metres. For further details see Figure A-13 in Appendix A. This is the only floodway over a distance of 4 kilometres on the left bank of the Macquarie River. If there is insufficient capacity in the floodway, then flood levels in the Macquarie River will rise to unacceptable levels.</td>
<td>A floodway with a minimum width of 110 metres needs to be incorporated into the existing development by enlarging the existing 25 metre wide floodway and removing or modifying existing banks. The floodway is to follow the alignment as shown on Figure A-13.</td>
<td>Landholder</td>
<td>High</td>
</tr>
</tbody>
</table>

* General hydraulic design information is provided on figures in Appendix A

**Priorities:**  
*High:* The recommended actions are vital in order to ensure adequate performance of the floodway system. The responsible party will initiate consultation and action within 6 months and have the works completed within 18 months.

*On-going:* These issues or measures may require further investigation or need to be monitored by DECC and relevant stakeholders during the floods.
### Table 5.2 Recommended actions for works on public land

<table>
<thead>
<tr>
<th>Map Ref.</th>
<th>Ref. No*</th>
<th>Location/Property</th>
<th>Issue</th>
<th>Recommended actions</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Map 1</td>
<td>P1</td>
<td>Near Buddah Station</td>
<td>The existing siphon across the Narromine to Gin Gin Road is only about 50 metres wide and reduces the effectiveness of the floodway in this area</td>
<td>Need to widen the siphon across the Narromine to Gin Gin Road. Recommend siphon width of 100 metres with 2 x 1000 mm diameter pipes.</td>
<td>Shire Council</td>
</tr>
<tr>
<td>Map 2</td>
<td>P2</td>
<td>Near Bridge over Macquarie River at Gin Gin.</td>
<td>The floodway on left bank of the Macquarie River at Gin Gin is partially blocked by raised road embankments on the Warren to Gin Gin Road and spoil dumps associated with a quarry and supply channel. This floodway is the start of Mullah Creek and is an important floodway.</td>
<td>Floodway behaviour to be monitored in the next major flood and if there are any problems with excessive flood rise or scour then remedial action such as removing the spoil dumps may be required.</td>
<td>Shire Council</td>
</tr>
<tr>
<td>Map 3</td>
<td>P3</td>
<td>Toucan Channel</td>
<td>Siphon for supply channel (private work) across the Warren to Gin Gin Road (Elengerah Road) is too short and restricts a major flood route.</td>
<td>Need to widen the siphon. Recommend siphon width of 100 metres with 2 x 1000 mm diameter pipes.</td>
<td>Landholder/ Shire Council</td>
</tr>
<tr>
<td>Map 5</td>
<td>P4</td>
<td>Along Carinda Road</td>
<td>Need to improve the ability for floodwaters to cross the Warren to Carinda Road in a safe and efficient manner. These floodways will also assist with improving flood access to important areas of vegetation.</td>
<td>Need to provide additional causeways across the road: Chainage 6 km (from Warren) concrete causeway 300 metres long; Chainage 13 km (from Warren) concrete causeway 300 metres long; Chainage 16 km (from Warren) concrete causeway 300 metres long. Warren Shire to consult with local landholders regarding causeway construction.</td>
<td>Shire Council</td>
</tr>
<tr>
<td>Map Ref.</td>
<td>Ref. No*</td>
<td>Location/Property</td>
<td>Issue</td>
<td>Recommended actions</td>
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<tr>
<td>Map 6</td>
<td>P5</td>
<td>Near ‘Buttabone’</td>
<td>‘Buttabone’ supply channel restricts flows over Carinda Road causeway.</td>
<td>Supply channel (including Old Carinda Road) needs to be lowered to ground level.</td>
<td>Landholder/ Shire Council</td>
</tr>
<tr>
<td>Map 6</td>
<td>P6</td>
<td>Near ‘Buttabone’</td>
<td>Floodway takes overflow from Marra Creek. The only culvert is a 1.8 m diameter pipe under the road. In times of large floods the road is overtopped.</td>
<td>Causeway required: Warren Shire to consult with landholders regarding construction.</td>
<td>Shire Council</td>
</tr>
<tr>
<td>Map 6</td>
<td>P7</td>
<td>Near ‘Buttabone’</td>
<td>Carinda Road impedes flows upstream of Marra channel.</td>
<td>Causeway required: Warren Shire to consult with local landholders regarding construction.</td>
<td>Shire Council</td>
</tr>
<tr>
<td>Map 7</td>
<td>P8</td>
<td>Near Mount Harris</td>
<td>Mt Harris Road near Gradgery Lane impedes floodwater flows from the east side of the road to the west.</td>
<td>200 metre long concrete causeway required.</td>
<td>Shire Council</td>
</tr>
</tbody>
</table>

* Works prefixed with a P may be eligible for public funding. All lengths of siphons and causeways are subject to review at the time of detail design.
6 Environmental assessment

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

EIAs were initially identified from a desktop analysis of available mapping which included composite mapping of floodplain vegetation (Department of Land and Water Conservation 1996, Murray Darling Basin Commission 2001, National Parks and Wildlife Service 1999). This mapping was then analysed using hydraulic information and flood photography to determine EIAs that were connected to the flooding regime and those that were isolated by existing works. The floodway layer from the 1978/82 Guidelines was overlain on the environmental mapping to indicate EIAs that could potentially be isolated by future development. Ground truthing of EIAs isolated or potentially isolated from flooding was then undertaken to determine the environmental value of the EIAs identified and to check their flood connectivity.

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

The practicality of reconnecting EIAs was assessed during field inspections based on details of existing works, economic considerations and discussions with landholders.

A total of 37 EIAs were inspected. At 12 additional sites, landholders were not willing to permit access and environmental inspections were not undertaken. A desktop environmental assessment was carried out for these sites using aerial flood photography, satellite imagery, available vegetation mapping and information on existing works and land use. A further site, which is affected by the Tenandra Channel, was identified for subsequent assessment and was also not inspected. The channel is jointly owned by a group of private irrigators and because of the nature of this ownership, it is expected that ongoing consultation will be required to carry out this assessment and to determine an agreed floodplain management measure.

Detailed information on the environmental assessment, including the environmental criteria used to determine environmental value of the EIA is presented in the FRMS report.

6.2 Adopted outcomes
Adopted outcomes for EIAs were influenced by the presence of existing works. For EIAs not affected by existing works, the adopted outcome was to maintain flood connectivity by including them in the FMP floodway network. EIAs affected by existing works and assessed as having moderate or high environmental value were considered further in relation to the practicality of modifying the works to restore
flood connectivity and outcomes were determined. At sites where landholders were not willing to allow field inspections, management measures adopted for inclusion in the FMP have been based on available environmental information and discussions with the landholders. Adopted environmental measures for existing works are shown in Table 6.1. Figures 6.1 to 6.7 show the composite mapping of floodplain vegetation in relation to the FMP floodway network. They also highlight EIAs previously excluded from the 1978/82 Guidelines floodway that are now included in the FMP floodway network.

6.3 Funding issues

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

Refer to Section 3.2.12 for information on possible funding sources.
### Table 6.1 Required environmental measures

<table>
<thead>
<tr>
<th>MapRef.</th>
<th>EIA No</th>
<th>Property/Landholder</th>
<th>Description</th>
<th>Required action</th>
<th>Responsibility</th>
<th>Priority</th>
</tr>
</thead>
</table>
| Map 4   | 11     | ‘Yeronah’           | Reach of floodplain watercourse linking Greenhide Ck and Birchalls Plain Ck blocked by two banks and used for storage of tailwater and storm surge from adjacent irrigation. | 1. Remove upstream bank  
2. Lower crest level of downstream bank by 0.5 metres                                                                                           | Landholder                      | Medium  |
| Map 5   | 16     | Nevertire Road      | Box culvert under Nevertire Rd on floodplain cowal allows connectivity to Gunningbar Ck during large floods but is located about 50 metres west of cowal channel and undersized in comparison to upstream railway culverts. | When the road is upgraded in this area install additional box culvert in line with cowal channel and match capacity of railway culvert. Monitor future floods and further assess performance. | Warren Shire Council          | Medium  |
| Map 5   | 20     | ‘Yanganbil’         | An area containing wheat crop interspersed with river red gum woodland is partly protected from flooding by existing levees that are consistent with the FMP floodway network. Landholder proposes to construct a levee along Macquarie River edge of the floodway to further protect cropping. | If levee constructed along Macquarie River edge of floodway:  
1. Provide gated 0.6 metre pipes in existing levee and new section of levee as indicated  
2. Operate gated pipes during floods to allow controlled flooding of woodland areas | Landholder                      | Medium  |
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<thead>
<tr>
<th>MapRef.</th>
<th>EIA No</th>
<th>Property/Landholder</th>
<th>Description</th>
<th>Required action</th>
<th>Responsibility</th>
<th>Priority</th>
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<tbody>
<tr>
<td>Map 5</td>
<td>21</td>
<td>Carinda Rd (Burlong Ck)</td>
<td>Carinda Rd crosses a billabong that is likely to connect the Macquarie River to Burlong Ck. The road has a 0.6 metre pipe culvert and a small causeway (which would operate in larger floods). The roadworks may impede the passage of smaller floods along the billabong and retard fish passage.</td>
<td>Monitor flood flow behaviour to determine if existing roadworks impede passage of smaller floods. Install larger box culvert as required.</td>
<td>Warren Shire Council/DECC</td>
<td>On-going</td>
</tr>
<tr>
<td>Map 6</td>
<td>25</td>
<td>‘Mumblebone’</td>
<td>Access road across anabranch that connects Macquarie River outflows to Crooked Ck is at bank height with two pipe openings that are unsuitable for fish passage.</td>
<td>Install 2 metre x 0.9 metre open box culvert in existing bank.</td>
<td>Landholder</td>
<td>Medium</td>
</tr>
<tr>
<td>Map 6</td>
<td>32</td>
<td>‘Kainga’</td>
<td>Two open (1.1 metre) pipes under the Marthaguy channel pass flood flows to an open wetland and river red gum woodland. Pipes may be undersized to allow adequate filling of these areas.</td>
<td>DECC to monitor during floods to determine if existing pipes allow adequate filling of wetlands. Landholder to upgrade pipe openings as required and maintain pipes in silt-free condition.</td>
<td>Landholder/DECC</td>
<td>On-going</td>
</tr>
<tr>
<td>Map 7</td>
<td>39</td>
<td>‘Mundoole’</td>
<td>A system of open-ended levees that is used to spread floodwater has adequate openings to allow for flows to pass to downstream ecosystems. Gate in pipe on downstream levee has potential to affect flows to watercourse and adjacent woodland downstream.</td>
<td>Remove gate from pipe in downstream levee.</td>
<td>Landholder</td>
<td>Medium</td>
</tr>
<tr>
<td>MapRef.</td>
<td>EIA No</td>
<td>Property/Landholder</td>
<td>Description</td>
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<td>Map 7</td>
<td>40</td>
<td>‘Mt Foster’</td>
<td>Levee affecting flood inflows to mapped river red gum woodland. Not inspected.</td>
<td>Options for controlled flooding of woodland to be assessed</td>
<td>Landholder/DWE</td>
<td>Medium</td>
</tr>
<tr>
<td>Map 7</td>
<td>43</td>
<td>‘Kiameron’</td>
<td>Levee affecting flood inflows to mapped river red gum woodland. Not inspected.</td>
<td>Install 0.6 m gated pipe in levee subject to environmental assessment. Operate gate during floods to allow controlled flooding of woodland.</td>
<td>Landholder/DWE</td>
<td>Medium</td>
</tr>
<tr>
<td>Map 7</td>
<td>47</td>
<td>‘Bibbiejibbery’</td>
<td>0.45 metre gated pipe in levee is located 500 metres from river red gum woodland and may not allow adequate watering.</td>
<td>DECC to monitor during floods to determine if existing pipe allows adequate filling of wetland. Landholder to upgrade pipe opening as required and maintain pipe in silt-free condition.</td>
<td>Landholder/DECC</td>
<td>On-going</td>
</tr>
<tr>
<td>Map 5</td>
<td>50</td>
<td>‘Argyle’</td>
<td>Tenandra Channel affecting flood outflows from Five Mile Cowal into Eight Mile Cowal. Not assessed.</td>
<td>DWE and DECC to check existing opening in channel and recommend action if required.</td>
<td>DWE/DECC</td>
<td>Medium</td>
</tr>
</tbody>
</table>

**Priorities:**

*Medium:* These measures are important for hydraulic and/or environmental reasons. The responsible party will initiate consultation and action within 12 months and have the works completed within 3 years.

*On-going:* These issues or measures may require further investigation or need to be monitored by DECC and relevant stakeholders during floods.

**Note:** Further details on the EIAs and required measures are provided in Appendix H of the Macquarie FRMS report.
7 Assessing non-complying works

Landholders applying for approval of non-complying works will need to engage a suitably qualified consultant to investigate the hydraulic and environmental impact of the works. Applications will be assessed against the matters raised in Section 166C of the Water Act 1912 (Section 3.2.4) and the following environmental and hydraulic criteria to be compatible with the FMP floodway network design.

7.1 Environmental assessment criteria

Existing or proposed non-complying works located in all non-hatched areas shown on Maps 1 to 7 including all identified floodways constituting the FMP floodway network; will need to meet the following environmental assessment criteria:

- Are consistent with actions specified in the Macquarie Marshes Adaptive Environmental Management Plan (Section 8.2) relating to the delivery of environmental water to identified ecological assets in the Macquarie Marshes;

- Do not block, impede or divert the natural flooding regimes in wetlands and related ecosystems, or in habitats benefiting from periodic flooding, located in all non-hatched areas shown on Maps 1 to 7 including all identified floodways constituting the FMP floodway network.

As well, the environmental impacts of the works applications will be assessed under Part 5 of the Environmental Planning and Assessment Act 1979 (Section 3.2.4).

7.2 Hydraulic assessment (upstream of Warren)

Existing or proposed non-complying works located in all non-hatched areas upstream of Warren and shown on Maps 1 to 7 including all identified floodways constituting the FMP floodway network will need to meet the following hydraulic assessment criteria:

- Do not cause any significant increase in water levels for all floodway flows up to and including the adopted 1990 design flow conditions (ie increases not to exceed 100 mm on neighbours boundaries and not to cause rises that create flood levels that exceed the 1990 Design Flood Levels as shown on Maps 1 to 7);

- Do not cause any significant redistribution of floodway flows (i.e. more than a 10% redistribution of the unimpeded floodway flow distribution for all floods up to and including the adopted 1990 Design Peak Floodway Flows as shown in Figures 4.1 to 4.3);

- Do not cause any significant increase in floodway velocities for all flood flows up to and including the 1990 Design Peak Floodway Flow conditions. Velocities should be of an order that is below the threshold of erosion for the potential land usage.
7.3 Hydraulic assessment (downstream of Warren)

Existing or proposed non-complying works located in all non-hatched areas downstream of Warren as shown on Maps 5 to 7 including all identified floodways constituting the FMP floodway network will need to meet the following hydraulic assessment criteria:

- Do not cause any significant increase in water levels for all floods up to and including the adopted 1955 design flow conditions (ie increases not to exceed 100 mm on neighbours boundaries and not to cause rises that create flood levels that exceed the 1955 design flood levels as shown on Maps 5 to 7);

- Do not cause any significant redistribution of floodway flood flows (i.e. more than a 10% redistribution of the unimpeded floodway flow distribution for all floods up to and including the adopted 1955 design peak floodway flows as shown in Figures 4.1 to 4.3);

- Do not cause any significant increase in floodway velocities for all floods up to and including the 1955 design peak floodway flow conditions. Velocities should be of an order that is below the threshold of erosion for the potential land usage.
8 Overview of environmental Impact

Implementation of the FMP environmental management measures will ensure flood flow access to an area of about 3,000 hectares of EIAs previously excluded from the 1978/82 Guidelines floodway. The FMP floodway network is designed to convey major floods – upstream of Warren the 1990 flood (Average Recurrence Interval [ARI] of 60-70 years) and downstream the 1955 flood (200 year ARI). Also, in line with principles adopted by the Macquarie River FMC, it is designed to conform as closely as reasonably possible to the natural drainage pattern and to allow for the delivery of floodwaters to support floodplain ecosystems. Because of these design factors, the FMP floodway network will include a high proportion of existing floodplain ecosystems (EIAs). Future flood connectivity to these ecosystems is reasonably assured since approval of future works within the FMP floodway network will be unlikely and will only be granted if a detailed assessment of the impact of the work found that there will be no significant environmental impact.

The impacts of the environmental 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 8.1 below.

Table 8.1 Summary of environmental Impacts

<table>
<thead>
<tr>
<th>Factor</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soils</td>
<td>Flood connectivity will benefit soil condition and structure within the floodway area and undeveloped areas of the floodplain. Floods will provide sediment, soil moisture recharge and nutrient release in these areas.</td>
</tr>
<tr>
<td>EIAs (wetlands and watercourses)</td>
<td>All EIAs with existing connection to the flooding regime are contained within the revised floodway network. Since new works in the floodway will require a detailed assessment of impact (including impacts on wetlands) long-term maintenance of flood flow connectivity to these wetlands is reasonably assured.</td>
</tr>
<tr>
<td></td>
<td>Proposed modifications (Table 6.1) will restore or enhance flood access to about 150 ha of EIAs currently affected by flood control works, subject to further environmental assessment in three cases. Performance monitoring of existing pipe openings connecting a further 180 ha of wetlands is proposed so that remedial action can be carried out as required.</td>
</tr>
<tr>
<td></td>
<td>Existing works affecting about 70 ha of EIAs will be retained without modification. The affected areas were assessed as having low environmental value or moderate environmental value but low practicality for modification due to the extent of development affecting their flood connectivity.</td>
</tr>
<tr>
<td>Factor</td>
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</table>
| Floodplain vegetation        | • A high proportion of existing flood dependent vegetation, consisting mainly of river red gum and black box woodland, is contained within the FMP floodway network – including an additional 3000 ha of EIAs (Figures 6.1 to 6.7). This will maintain flood connectivity and vegetation health since approval for future works within the floodway will be unlikely and would only be granted if a detailed assessment of the impact of the work found that there would be no significant environmental impact.  
  • Enhancement of flood flow connectivity to about 150 ha of EIAs affected by existing works is expected to benefit the health and regeneration of floodplain vegetation in these areas.  
  • Continued disconnection of 70 ha of EIAs from flood flows due to retention of existing works will restrict regeneration of floodplain vegetation in these areas. Existing vegetation mainly consists of river red gum woodland that is watered periodically by local runoff.  
  • One threatened plant species, red darling pea (*Swainsona plagiotropis*) has been recorded and two others (*Swainsona murrayana* and *Lepidium hyssopifolium*) may potentially occur. The two *Swainsona* species may depend on floodplain inundation for breeding, dispersal or recolonisation and would be expected to benefit from proposed measures to enhance flood flow access to EIAs. *Lepidium hyssopifolium* does not tend to colonise wetland plant associations and is unlikely to be impacted by the proposed floodplain management measures. |
| Fauna                        | • Proposed floodplain management measures will benefit terrestrial fauna species relying directly on flooding (eg waterbirds) and those utilising floodplain habitats by enhancing or maintaining flood connectivity to floodplain ecosystems.  
  • Twenty six threatened fauna species have been recorded in the study area and a further five species may potentially occur. Five of the recorded species (black-necked stork, magpie goose, freckled duck, Australasian bittern and brolga) have a direct dependence on flooding to maintain their life cycles. Implementation of the proposed floodplain management measures will maintain flood flow access to habitat in floodplain ecosystems currently connected to the flooding regime. Enhancement of flood access to an additional 150 ha of EIAs is likely to allow for the expansion of suitable habitat for threatened fauna species in the study area. |
<table>
<thead>
<tr>
<th>Factor</th>
<th>Impact</th>
</tr>
</thead>
</table>
| Aquatic fauna | • Maintenance of flood flow access to wetlands currently connected to the flooding regime and restoration of access to additional floodplain areas (including about 150 ha of EIAs) currently affected by works is likely to enhance invertebrate production and fish habitat. Modifications to works on anabranches of Greenhide Creek and Crooked Creek and Eight Mile Cowal (EIA No 50) (subject to further assessment) are expected to directly improve fish passage and habitat.  
  • Two watercourse reaches, an arm of Five Mile Cowal and Bulgeraga Creek remain blocked from flood flows. Both reaches are relatively short and alternative fish passage to the downstream reaches of these streams is available. The Five Mile Cowal reach is a terminal reach that does not drain to a potential fish refuge.  
  • One threatened species, silver perch (*Bidyanus bidyanus*) has been recorded in the study area. Silver perch depends on access to the floodplain for spawning and is expected to benefit from enhanced flood connectivity between the river and the floodplain provided through the FMP floodway network. An additional threatened species, the river snail (*Nothopala sublineata*) is expected to occur and is also likely to benefit from increased floodplain access. |
| Water quality | • Risk of surplus nutrient and pesticide transport through inundation of cropped areas or through excessive scour or erosion will be restricted as the FMP floodway network has been designed to limit flood velocities and to minimise the flood risk to complying agricultural development.  
  • Proposed measures to maintain flood flow access to existing wetlands connected to the flooding regime and to enhance flows to an additional 150 ha of EIAs affected by works will allow for a continuation or improvement of flood dilution and flushing of salt in wetlands during floods. Salt accretion within the 70 ha of EIAs that remain blocked from flood flows may result in the long term however this impact is likely to be offset by local runoff. |
| Groundwater | • Most groundwater recharge in the study area occurs through the bed of the Macquarie River during high inbank flows. Recharge on the floodplain is confined to paleochannels (floodplain watercourses) and is a relatively slow process. All existing watercourses with the exception of Five Mile Cowal and Bulgeraga Creek are included in the FMP floodway network thus allowing for recharge during floods. The affected reaches are of relatively minor lengths that are not likely to impact on the quantity of groundwater accession during floods. |
8.1 Catchment impacts

The Macquarie floodplain directly upstream of the FMP floodplain is relatively confined with little wetland development. Implementation of proposed floodplain management measures is not expected to impact on this area.

Within the FMP floodplain, a series of effluent creeks carry flows out of the river into the Bogan–Barwon catchment. These creeks include Sandy Creek, Gunningbar Creek, Crooked Creek, Marra Creek and the Middle Creek floodway. Flows at the downstream end of the FMP floodplain pass into the Macquarie Marshes via the Macquarie River, Bulgeraga Creek, Back Swamp floodway and Gum Cowal floodway. Flood inflows are vital to ecosystem health both in the Marshes and the Bogan catchment and significant changes in natural flow distribution due to floodplain management measures would impact on ecosystem values.

As an indication of potential impacts, hydraulic modelling was used to determine the changes to outflow volume distribution from the FMP floodplain under alternative floodway networks.

Chart 8.1 compares simulated outflow volumes from the FMP floodway network, ‘natural’ floodplain conditions and a floodway network with no modifications to R-HACs. These results were based on modelled flood volume distributions shown in Figures 8.1 to 8.3 for the 1955, 1990 and 2000 floods. ‘Natural’ floodplain conditions were approximated by the floodplain conditions in 1955 when the floodplain was relatively free of obstruction by works. Volumes were considered to be the most meaningful parameter to compare since they can be related to the physical requirements for filling wetlands.

Chart 8.1 shows that for the three floods analysed there is a net trend towards some increase in flow volume reaching the Marshes, when comparing the alternative floodway networks to that under natural conditions. For the FMP floodway network, this approximates to an additional outflow volume to the Marshes of 7 to 9% of the total inflow volume. Modelling results show a corresponding net loss in total outflow volumes reaching the Bogan–Barwon systems for all floods assessed. Bar charts showing a comparison of flood volume distribution on the left bank floodplain and the right bank floodplain at Gin Gin and at Warren are also shown in Appendix C.
The expansion of the irrigation industry has resulted in the original 1978/82 Guidelines floodway network being modified by works with floodways being subject to encroachment or blockage. The FMP floodway network has removed specific obstructions in R-HACs thereby providing a more natural distribution of outflow volume when compared to the floodway network with no modifications to R-HACs.

It should be stated that modelling results will tend to overstate the impacts of the FMP floodway network since, in reality, land management practice will vary throughout the floodplain and not all landholders will choose to construct levees.

The net increase in outflow volume to the Marshes can also be attributed to the closure of the Webbs Siding outflow at Narromine. This outflow point through the railway embankment was blocked when the rail level was raised. Consequently any flow that previously left the system at Narromine is now retained. Approximately 50% of this additional flow leaves the system via Sandy Creek at Warren while the remaining 50% adds to the outflow volume reaching the Marshes. This flow behaviour would only occur during extreme floods such as the 1955 flood (200 year ARI).

For floods similar in magnitude to the design events (1990 and 1955), Burrendong Dam operating rules are also likely to have an impact on outflow distributions to the Bogan–Barwon and inflows to the Marshes. This is because the emphasis on flood mitigation for Dubbo City will mean that the magnitude of the larger design flows, which provide the largest percentage of flow diversion, will be attenuated. The result will be that flood flow peaks will be reduced. This in turn will mean that less flow would be diverted away from the FMP floodplain.
Chart 8.1 – Comparison of modelled outflow volumes

** Floodway Network with no modifications to R-HACs
8.2 Macquarie Marshes Adaptive Environmental Management Plan

The Macquarie Marshes Adaptive Environmental Management Plan (EMP) is being developed by DECC under the Wetland Recovery Program. The EMP aims to guide government and community projects to restore critical ecological functions and habitats in the Macquarie Marshes. The FMP is expected to contribute towards a number of actions identified in the EMP that will be required to improve the management of the Macquarie Marshes. These actions target land and water management and increased knowledge of the system. Outcomes from the EMP will be considered as part of the assessment criteria for non-complying works in the FMP (Section 7.0). The outcomes will also need to be addressed as part of the normal five year review process.

8.3 Projects being undertaken in the catchment

There are a number of natural resource management related projects being undertaken throughout the Macquarie catchment, which will contribute towards the environmental values of the floodplain and complement outcomes from the FMP. Table 8.2 lists most of these projects and the relevant organisations managing the projects.

Table 8.2 Projects being undertaken in the Macquarie catchment

<table>
<thead>
<tr>
<th>Project</th>
<th>Project manager</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetland Recovery Program</td>
<td>DECC, DWE, DPI, Central West CMA, Gwydir CMA and Australian Government</td>
</tr>
<tr>
<td>Willow Removal – Macquarie River</td>
<td>Central West CMA</td>
</tr>
<tr>
<td>Ecological Characterisation of the Catchment</td>
<td>DECC</td>
</tr>
<tr>
<td>Environmental Management Plan</td>
<td>DECC and Central West CMA</td>
</tr>
<tr>
<td>Management and Control of Lippia in Wetlands and Riparian Zones</td>
<td>DECC</td>
</tr>
<tr>
<td>Review Potential Water Savings in the Macquarie River</td>
<td>Central West CMA</td>
</tr>
<tr>
<td>Community Based Salinity Stream Sampling</td>
<td>Central West CMA and Australian Government</td>
</tr>
<tr>
<td>Environmental History Evaluation and Community Perceptions</td>
<td>Central West CMA and Australian Government</td>
</tr>
<tr>
<td>Climate Change and Catchment Management in the Central West</td>
<td>CMA and Australian National University</td>
</tr>
<tr>
<td>Riverbank and Rivers Environmental Restoration Program</td>
<td>DECC and Australian Government</td>
</tr>
<tr>
<td>Project</td>
<td>Project manager</td>
</tr>
<tr>
<td>---------</td>
<td>----------------</td>
</tr>
<tr>
<td>Digital Model Suitability for Mapping and Hydrological Modelling of the Macquarie Marshes</td>
<td>DECC</td>
</tr>
</tbody>
</table>

Various Incentive Programs  
- Grazing management training  
- Soil management training  
- Farm planning  
- Native grasslands and grazing management  
- Remnant vegetation  
- Revegetation  
- Riparian vegetation  
- Innovations in vegetation and biodiversity  
- Property vegetation planning  
- Environmental water trust  

Water for the Future | Australian Government |

Landholders are encouraged to consult with the Central West CMA for advice on land management best practice and how to adhere to it. The CMA is currently preparing guidelines for best practice which will be a valuable tool in maintaining and enhancing the environmental values of the floodplain.
9 Monitoring and review

9.1 Performance indicators

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

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

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

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

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

Economic:
- Lesser flood damage.

Social:
- Improved access during floods;
- Clarity for the community in actions carried out during a flood.

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

9.2 Flood monitoring

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

Floods within the FMP floodplain area usually have a relatively long lead-in time which allows for the planning and preparation of monitoring programs. DECC will lead the planning and implementation of monitoring programs and will seek input
from DWE, Narromine and Warren Shire Councils and landholders. The following activities are recommended:

DECC to undertake aerial photography, collection of satellite imagery and survey;

- DWE to undertake stream gaugings and flow measurements; and,
- Where safe to do so, DECC, DWE, Narromine and Warren Shire Councils and landholders to observe the performance of their part of the floodway network, including marking high flood levels, estimating flow velocities and taking photographs.

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

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

9.3 Environmental monitoring

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

DECC should undertake the collation of environmental data from Narromine and Warren Shire Councils, landholders and other agencies. Council and landholders would observe their areas of the floodplain noting:

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

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

9.4 Plan review

Floodplain management plans adopted as Minister’s plans under the *Water Management Act 2000* are required to be reviewed at five yearly intervals to determine whether their provisions are being given effect.

If new flood data comes to light following a major flood the FMP may need to be reviewed and updated earlier than the statutory five year review. Triggers for review can also include changes to land use, impediments to implementation, and changes to factors that influence decisions. Climate change has the potential to result in many direct and indirect incremental changes to floodplains including their hydrology and the institutional framework in which floodplains are managed. Climate change has the potential to alter flood patterns due to changes in monthly average rainfall, the distribution of rainfall, rainfall intensity and flood frequency estimates. Changes to groundwater and soil moisture levels could further influence the magnitude and duration of floods.
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 reafforestation activities and creating carbon sinks. Early adaptive responses will decrease longer term vulnerability and economic costs. Therefore, as part of any plan review, particular attention will be given to exploring the adaptive capacity of rural FMPs to address climate change impact on flood risk exposure, floodplain ecosystems (eg: wetlands) and rural economies.
References


Department of Primary Industries (2005) *NSW Recovery Plan for Silver Perch*.


Sinclair Knight Merz (2008 final in print) *Macquarie River Floodplain Risk Management Study (Narromine to Oxley Station) – Floodplain Risk Management Study Report*, prepared for Department of Natural Resources and Macquarie River Floodplain Management Committee.


Glossary

anabranch: a channel of a river or creek that leaves the main channel and re-enters downstream.

Annual Exceedance Probability (AEP): the chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage.

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.

ecosystem: a biological system involving interaction between living organisms and their immediate physical, chemical and biological environment.

effluent stream: a stream that leaves a watercourse and does not return to it.

Environmentally Important Area (EIA): an area with important environmental and/or cultural features that relies on inundation by floodwaters to sustain essential ecological processes. EIAs include areas of flood dependent vegetation, wetlands, floodplain watercourses, groundwater recharge areas and Aboriginal sites.

flood control works: these are known as ‘controlled works’ in section 165A of the Water Act 1912.

flood dependent ecosystem: an ecosystem that depends on periodic flooding to support essential ecological processes.

floodplain: any land which is so designated by an order in force under section 166(1) of the Water Act 1912.

floodway network: the area of floodplain required for the unobstructed and orderly passage of a flood of given magnitude.

habitat: the type of environment in which a plant or animal lives, including physical and chemical conditions.

hydraulics: the study of water flow in relation to watercourses and the land surface; in particular the assessment of water level and velocity.

hydrology: the study of the rainfall and runoff process; in particular, the assessment of peak flows and flow volumes.
invertebrates  animals without backbones, including zooplankton, worms, insects, shellfish, crabs, shrimps and snails.

microinvertebrates  invertebrates that cannot be seen with the naked eye.

Ramsar Convention  a convention (signed in Ramsar, Iran in 1971) 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.

threatened species  species of plant or animals listed as vulnerable or endangered on the schedules of the *NSW Threatened Species Conservation Act 1995*.

wetland  an area that is wet for a long enough period such that the plants and animals living in it are adapted to, and often dependent on, living in wet conditions for at least part of their life cycle.

