Department of Primary Industries
Water

Rural floodplain management plans

Water Management Act 2000

Background document to the Floodplain Management Plan for the Barwon-Darling Valley Floodplain 2017

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Abbreviations

ABS	Australian Bureau of Statistics
AEP	Annual exceedance probability
AHIMS	Aboriginal Heritage Information Management System
ASDST	Aboriginal Sites Decision Support Tool
ATWG	Aboriginal Technical Working Group
AWIS	Aboriginal Water Initiative System
DEM	Digital Elevation Model
DPIW	NSW Department of Primary Industries, Water
Barwon-Darling Valley FMP	Floodplain Management Plan for the Barwon-Darling Valley Floodplain 2017
DVP	Depth-velocity product
EP&A Act	*Environmental Planning and Assessment Act* 1979
EY	Exceedances per year
FM	Flexible Mesh
FMP	floodplain management plan
FPWEC	First Peoples' Water Engagement Council
GVAP	Gross Value of Agricultural Production
HHIMS	Historic Heritage Information Management System
IPW	Infrastructure Protection Work
IQQM	Integrated Quantity and Quality Model
IRP	Interagency Regional Panel
IRSAD	Index of Relative Socio-economic Advantage and Disadvantage
LiDAR	Light Detection and Ranging
MDB	Murray-Darling Basin
MDBA	Murray-Darling Basin Authority
MZ A	Management Zone - Major discharge areas, defined floodways
MZ B	Management Zone - Flood storage and secondary flood discharge areas
MZ C	Management Zone - Flood fringe and flood protected developed areas
MZ CU	Management Zone - Urban areas
MZ D	Management Zone - Special protection areas
NBAN	Northern Murray-Darling Basin Aboriginal Nations
NSW	New South Wales
NSW DPI	NSW Department of Primary Industries
NVA 2003	*Native Vegetation Act 2003*
OEH	NSW Office of Environment and Heritage

PCT	Plant Community Type
SEIFA	Socio-economic Indexes for Areas
SF	Selection frequency
TAG	Technical Advisory Group
TSC Act	*Threatened Species Act 1995*
WA 1912	*Water Act 1912*
WMA 2000	*Water Management Act 2000*
WSP	Water Sharing Plan

Purpose

The purpose of this document is to inform local landholders and the wider community about how the rural floodplain management planning approach presented in the *Rural Floodplain Management Plans: Technical manual for plans developed under the Water Management Act 2000* (the Technical Manual) has been applied across the Barwon-Darling Valley Floodplain. This document should be read in conjunction with the Technical Manual and the *Floodplain Management Plan for the Barwon-Darling Valley Floodplain 2017* (Barwon-Darling Valley FMP).

The Barwon-Darling Valley Floodplain

This document relates to the area known as the Barwon-Darling Valley Floodplain, as shown in Figure 1. The upstream limit of the floodplain is at Mungindi on the Barwon River, at the New South Wales (NSW), Queensland border and the downstream limit is approximately 20 km downstream of Louth on the Darling River. The northern boundary and part of the southern boundary of the floodplain are confined to higher ground and include a limited extent of contributing influence streams. The remaining parts of the southern boundary are aligned to boundaries of other rural floodplain management plans (FMPs). The Barwon-Darling Valley Floodplain makes up 1.7 % of the Barwon-Darling catchment and one per cent of the Murray Darling Basin (MDB). The Barwon-Darling Valley Floodplain covers 1.1 million hectares.

The Barwon-Darling Valley Floodplain is characterised by low relief and elevation. Climatic conditions are extremely variable, including variable flow discharges with large areas of the catchment often subject to prolonged drought periods. High summer temperatures, averaging more than 33°C, are a feature of the floodplain, with extremes well above 40°C and Australia's second highest temperature of 52.8°C recorded at Bourke in 1877 (Thoms et al. 2004).

Major tributaries to the Barwon-Darling Valley Floodplain include the Macintyre, Gwydir, Namoi, Castlereagh, and Macquarie rivers. These systems enter the Barwon-Darling River upstream of the township of Bourke. Downstream of Bourke and further west, the Paroo and Warrego rivers contribute intermittent flows to the Darling River and can provide significant volumes during flood events, raising the duration of high flow events in the Barwon-Darling River (Cooney 1994).

For most of the time, 'low' flow conditions dominate the Darling River with major floods periodically interrupting these dry periods, however flows decrease downstream of Bourke due to the lack of contributions from tributaries and increased rates of evaporation (Thoms et al. 2004).

Although considered 'unregulated', the Barwon-Darling River is not technically free-flowing. It is regulated by a number of headwater storages on tributaries in both NSW and Queensland and by the Menindee Lakes Storage on the lower Darling River (437 km upstream from its confluence with the Murray). There are also numerous weirs along the entire length of the river, so that at low flows the river consists mostly of a series of weir-pools (Bowling & Baker 1996).

Tributary headwater dams and water extraction have subjected the Barwon-Darling River to significant impacts, with over one third of its average annual flow being diverted from the river or its tributaries (Thoms et al. 1996). The Darling River upstream from Menindee is greatly affected by headwater dams, low-level weirs and water extraction, both on upstream regulated and unregulated tributaries and on the Darling itself (Thoms et al. 2004). Flows in the system, have been modified by large-scale water extractions for irrigation.

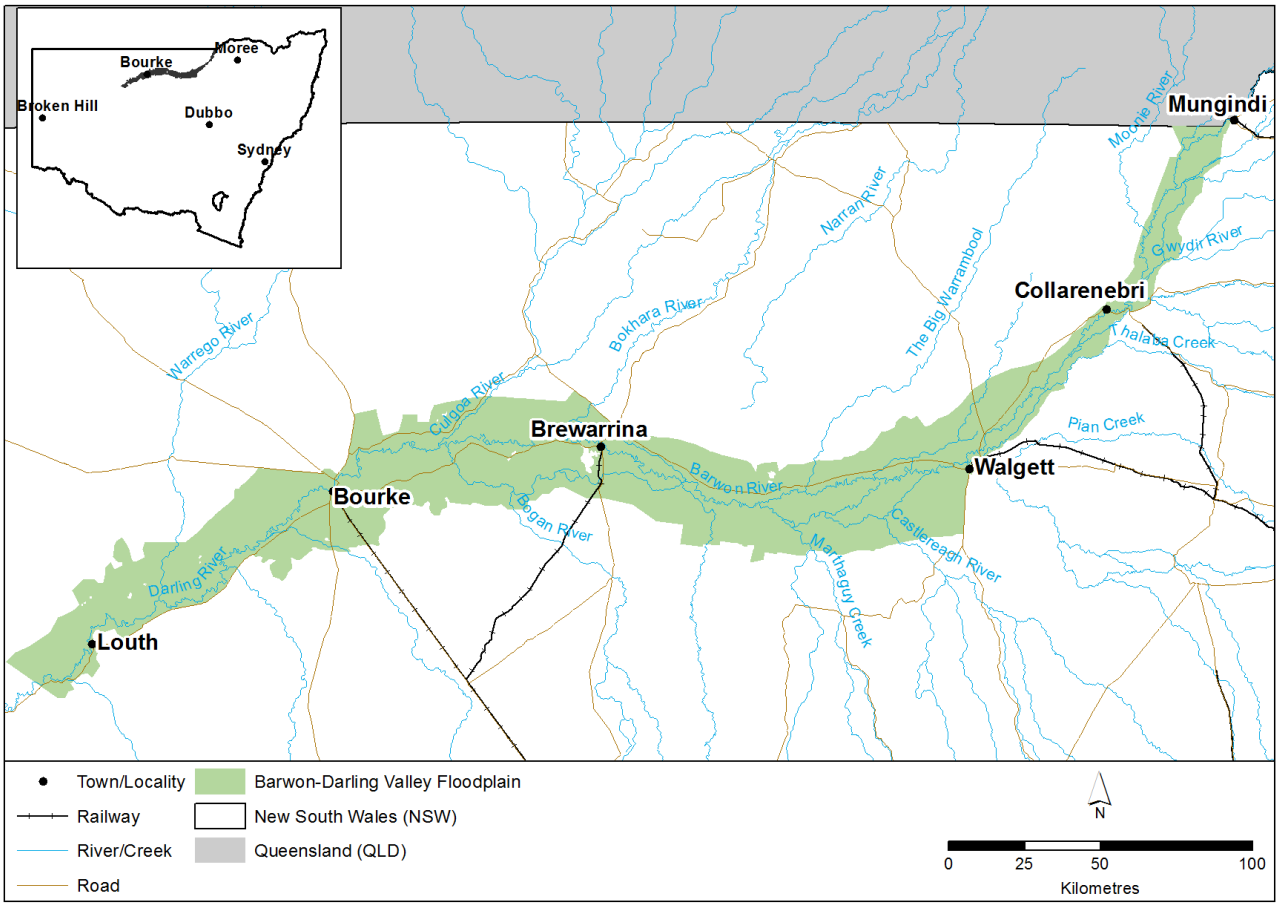

Figure 1: The Barwon-Darling Valley Floodplain

The Barwon-Darling Valley Floodplain has been influenced by the development of grazing, irrigated cropping, water extraction, road and rail infrastructure and some urbanisation. Over the past 100 years the Barwon-Darling River has experienced reduced water flows and quality due to water diversion, uncontrolled stock access, and polluted run-off from towns, salinity, sedimentation and blue-green algae (WCMA 2009). Still, the floodplain retains significant ecological values.

Characteristically, the floodplain has grey cracking clay soils, drainage lines of varying definition, riverine woodlands fringing the main watercourses and many wetlands including floodplain billabongs, anabranches and lagoons (Brennan et al. 2002). The floodplain supports a broad range of fauna.

The ecological significance of the Barwon-Darling Valley Floodplain includes:

- wetlands along the river and several deflation basin wetlands (geological depressions formed by erosion when soil is shifted by the wind);
- major waterbird breeding habitat sites at lakes and other wetlands along the floodplain which are watered at a variety of flows;
- the Barwon-Darling River channel and associated riparian habitats which support a wide variety of ecosystems and a number of fish species, including bony herring and golden perch;
- a diverse range of flora species including river red gum, black box, river cooba, coolibah and lignum;
- a range of fauna including species listed under the *Environment Protection and Biodiversity Conservation Act 1999* such as Murray cod, Latham's snipe, rainbow bee-eater and superb

parrot, and the NSW *Threatened Species Act 1995* (TSC Act) such as the blue-billed duck, the brolga and the grey falcon (CEWO 2013);

- part of the Lowland Darling River Aquatic Ecological Community (NSW DPI 2011) as the *Fisheries Management Act 1994* declares the main Barwon-Darling River from Mungindi to its junction with the Murray as endangered.

Many of the areas of ecological significance in the Barwon-Darling Valley Floodplain are linked with areas that are important to Aboriginal people. The floodplain has a rich Aboriginal heritage and contains many areas of Aboriginal importance, such as ceremonial sites, Dreamtime places and scarred or carved trees, some of which are sustained by periodic flooding. In recognition and respect for the traditional owners of the land the names of each Nation covered by the Barwon-Darling Valley FMP is documented for each floodplain reach. In the Barwon-Darling Valley Floodplain four reaches have been delineated to enable efficient hydraulic modelling (refer to Step 4). Each of these reaches have been named after the Aboriginal Nations who are the Traditional Owners of that land. A spatial representation of each reach is provided in Figure 7 and the following provides a textual description of each reach in the Barwon-Darling Valley Floodplain:

- **Gomeroi Reach**. This reach commences from the NSW/Queensland border in the vicinity of Mungindi in the north and extends downstream along the Barwon River and adjacent floodplain area to the junction of Dead Man's Creek and the Barwon River.
- **Euahlayi, Gomeroi and Wayilwan Reach.** This reach commences from the Gomeroi reach in the north and extends downstream along the Barwon River and adjacent floodplain to the area immediately downstream of the junction of the Big Warrambool and the Barwon River.
- **Ngemba, Wayilwan, Euahlayi and Baranbinja Reach.** This reach commences from the Euahlayi, Gomeroi and Wayilwan reach and extends downstream along the Barwon River and adjacent floodplain to the area immediately downstream of the junction of the Culgoa River, Barwon River and Bogan River, this area is also known as "Three ways".
- **Wangaaypuwan, Ngemba, Baranbinja and Gunu Reach.** This reach commences from the Ngemba, Wayilwan, Euahlayi and Baranbinja reach and extends downstream along the Darling River and adjacent floodplain to 'Weir 21' located downstream of Louth.

Agricultural production is a significant component of the Barwon-Darling floodplain economy. To enhance the agricultural productivity, works have been built on the floodplain to improve land used for grazing, dryland cropping and irrigated cropping. Typically, works such as levees, roads, banks and supply channels have been built to protect crops, stock and properties from flooding; provide on-farm access; and to manage irrigation, stock and domestic water. Works such as these, which affect the distribution or flow of floodwaters, are referred to as flood works. Approximately 45,700 ha (4 %) of floodplain area is protected by flood works in the Barwon-Darling Valley Floodplain.

In many instances, flood works have contributed positively to the agricultural productivity of land in Australia. However, flood works can cause major changes to flooding patterns, particularly when built in an uncoordinated manner.

For instance, flood works can cause flows to be redirected onto adjacent properties, or flood levels and velocities to be increased. These changes can result in crop losses, erosion, scour and flood damages, even in areas that are traditionally relatively flood-free. In some instances, flood works can influence flows many kilometres upstream and downstream beyond the original work location. Changes to flooding behaviour can also negatively impact floodplain ecosystems by blocking or redirecting flow away from flora and fauna that are dependent on flooding or towards species or cultural sites that are impacted by flooding.

The NSW Government has been responsible for rural floodplain management planning in the Barwon-Darling Valley Floodplain since the early 1980s. Previous floodplain management planning arrangements applied to a number of designated floodplains (Figure 2).

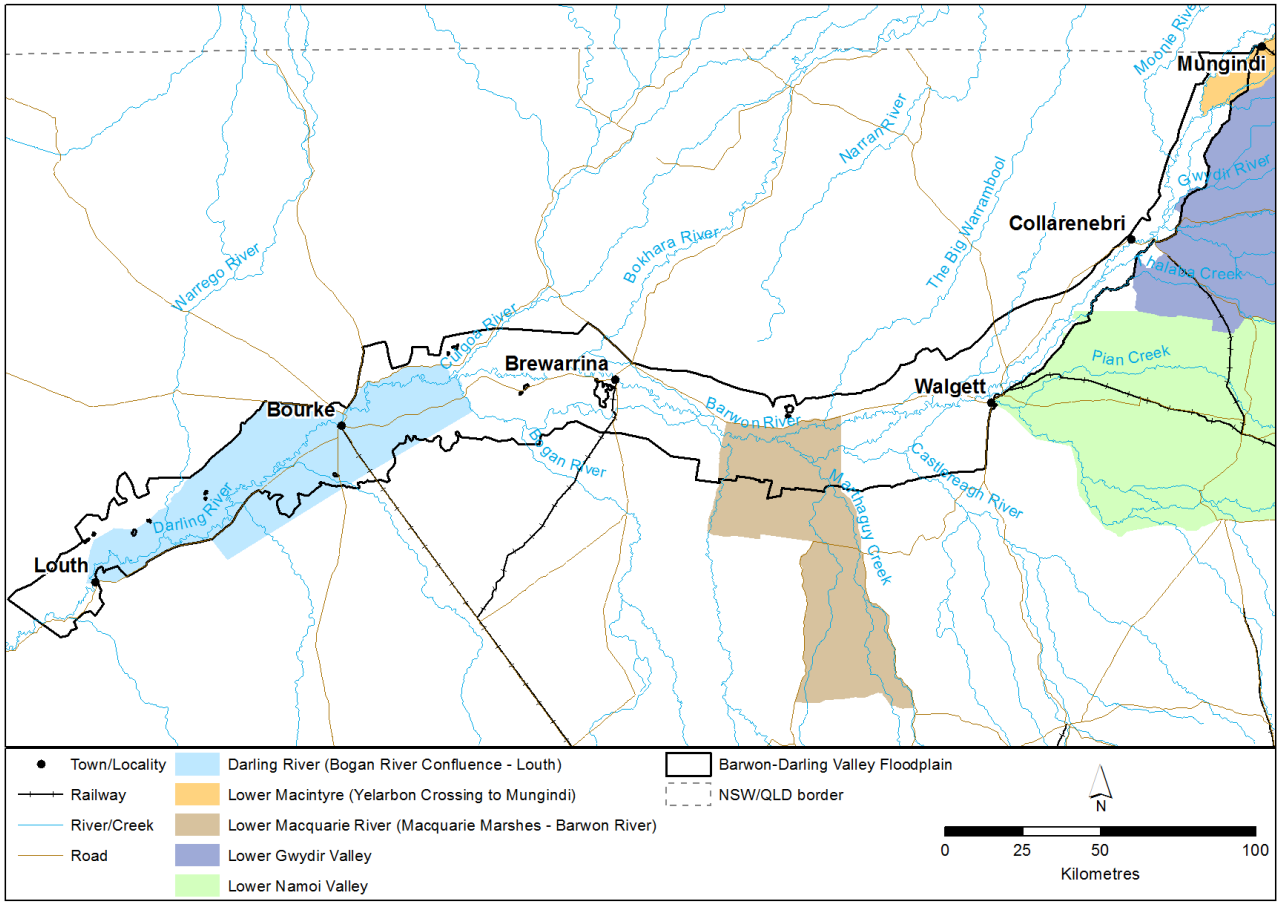

Figure 2: Floodplains designated under Part 8 of the *Water Act 1912*

The Barwon-Darling Valley FMP was prepared in accordance with the floodplain planning and environmental protection provisions of the *Water Management Act 2000* (WMA 2000). The FMP aims to coordinate flood-work development to protect flood behaviour while minimising flood risk to life and property. The Barwon-Darling Valley FMP provides management zones and rules to be used when determining flood-work development approvals for new flood works and amendments to existing flood works. Existing floodplain management arrangements that applied to the Barwon-Darling Valley Floodplain (Figure 2; Step 3) were reviewed and incorporated where relevant into the design of the management zones, rules and assessment criteria within the Barwon-Darling Valley FMP.

Flooding in the Barwon-Darling Valley Floodplain

The flooding regime in the Barwon-Darling Valley Floodplain is complex, as flood flows can arise from a number of sources. Flooding can originate from southern and central Queensland via the Culgoa, Birrie, Bokhara and Warrego rivers and from the Macintyre and Dumaresq rivers along the border between Queensland and NSW. Floodwaters can also originate from the north-western and central river valleys of NSW including the Gwydir, Namoi, Castlereagh, Macquarie and Bogan rivers. Floods can also arise from a combination of all the above sources.

The percentage of the total long-term flow from the six major flow contributors to the Barwon-Darling catchment is as follows (URS 2008):

- Macintyre (35 %)
- Gwydir River (10 %)
- Namoi River (25 %)
- Macquarie and Castlereagh rivers (5 %)
- Culgoa River system (20 %)
- local rainfall events and minor contributions from the Warrego and Paroo rivers (5 %).

The relative contributions of the tributaries have varied for the different historical flood events. The inflows from the southern tributaries are generally greater than those from the northern tributaries. In most floods, the largest inflow has been from the Namoi River; however, the largest inflow in the 1990 event was from the Bogan River.

Occasional relatively short periods of high flow result in the river overtopping its banks and inundating part or all the floodplain. Flood duration can range from a few hours to months with some areas of the floodplain, such as deep billabongs adjacent to the main channel, remaining inundated for several years.

Mungindi to Calmundi Weir

The floodwaters that flow downstream towards Mungindi originate from the Macintyre catchment, which is characterised by a complex drainage network straddling the NSW/Queensland border. These floodwaters inundate vast areas, and the length of time for floodwaters to reach Mungindi from Boggabilla is in the order of ten days. This timing may vary according to factors such as the location of rainfall on the Macintyre catchment and the vegetation cover (WRC 1981). The historical flood of April 1890 was the highest flood recorded at Mungindi, whilst the February 1976 and April 1988 were the second and third highest respectively.

Downstream of Mungindi, the overbank flows of Whalan Creek, the Boomi and Barwon rivers merge and flow in a south-westerly direction towards Collarenebri. Gil Gil Creek can influence flood behaviour south of Mungindi. Gil Gil Creek eventually joins the Boomi River downstream of Mungindi. The Little Weir River enters the Barwon River from the right bank, midway between Mungindi and the Boomi River confluence with the Barwon. Downstream of the Boomi River confluence, tributary inflows occur from the right bank via the Moonie River.

Between the Moonie River confluence and Walgett, complex and widespread flooding occurs on the left bank of the Barwon River, resulting from tributary flow from the Gwydir and Mehi rivers and Thalaba Creek.

Calmundi Weir to Namoi River Junction (DLWC 2001)

The Barwon-Darling Valley Floodplain near Calmundi Weir on the Barwon River is typically about 10 km wide, including the Thalaba Creek and Pagan Creek anabranches. Substantial inflows from the Lower Namoi Floodplain to the east occurred at two locations during the 1998 flood. The Barwon-Darling Valley Floodplain is generally separated by high ground to the east from Pian Creek which is an effluent watercourse of the Namoi River. Flows between the Barwon River and Pian Creek occur near “Eurie” and “College Green”. Around Walgett the floodplain is connected with the Namoi River.

Outflows from the Barwon River to the west occur in major floods, principally into Sparkes Warrambool which re-joins the Barwon River downstream of Walgett.

Namoi River Junction to Macquarie River Junction (DLWC 2001)

Extensive left (south) bank overflows occurred along the Namoi River upstream of Walgett in 1998. These overflows spread south of the town over a width of up to 20 km. The floodwaters were conveyed in a westerly direction through the Cumbadoon Warrambool system to reach the Castlereagh River.

Downstream of Walgett, left bank overflows of the Barwon River are conveyed via the effluent creek system of Euromlin, Wanourie and Womat Creeks to the Castlereagh River.

The Castlereagh River carries the Namoi River and Barwon River overflows, as well as run-off from its own catchment, to the Macquarie River which flows into the Barwon River just upstream of the "Miralwyn" development. There is also a flow path to the south of "Miralwyn" from the Macquarie River catchment to Marra Creek via Ginghet Swamp.

Right (north) bank overflows of the Barwon River may also be substantial but are generally less extensive than left bank overflows in this reach. Upstream overflows from Sparkes Warrambool re-enter the river and there are also inflows from the Big Warrambool.

Macquarie River Junction to Bogan River Junction (DLWC 2001)

Overflows of the right bank of the Barwon River occur into the Yambie Swamp area north of "Miralwyn".

There are major overflow systems from both the left and right banks of the Barwon River commencing about 10 km downstream of the Marra Creek junction. Overflows to the south are conveyed via Tarrion Creek to join the Bogan River about 30 km south-west of Brewarrina. Overflows to the north are conveyed via Cato Creek to join the Bokhara River about 10 km north of Brewarrina. There are extensive floodplains associated with the Tarrion Creek and Cato Creek flows as well as the Barwon River flows upstream and downstream of Brewarrina.

The interaction of Barwon River flows with Bokhara River and Culgoa River inflows from the north and Bogan River inflows from the south also leads to an extensive floodplain area.

Bogan River Junction to Warrego River Junction (DLWC 2001)

Extensive floodplain inundation occurred in this reach in 1998. The area east of Bourke was affected by flows in the Little Bogan River as well as by flows in the Darling River. The main flow path at Bourke was in the Darling River and the Big Billabong to the north of the town; however, there was also a substantial flow path to the south of the town. This path was also highly active in 1974 and 1976 when there were large flows from upstream in the Barwon-Darling River, as well as in 1990 when the major flow contribution was from the Bogan River.

Warrego River Junction to downstream of Louth (Weir 21) (SMEC 2012)

Flooding in this area is primarily confined to the right bank of the Darling River and during Darling River flood events some floodwaters cross the Warrego River in the area upstream of its confluence. While the floodplain in the Warrego confluence area is relatively wide, some isolated high spots exist on the right bank floodplain in this area.

Significant water features in the area adjacent to the Warrego confluence include the Ross Billabong (upstream of the confluence) and Talowa Billabong (downstream of the confluence).

The width of the floodplain during the 1974 flood in the area adjacent to Louth and in the area of Weir 21, downstream of Louth, was in the order of 10 km to 15 km wide.

Key changes to the natural flooding regime

The natural flooding regime of the Barwon-Darling Valley Floodplain has been altered over the years by the construction of weirs, flood works, town levees, and major roads/railways, along with vegetation clearing for farming and irrigation works. The modified/developed flood regimes of the main contributing valleys such as the Macintyre, Gwydir, Namoi, and Macquarie also influence the character of the existing Barwon-Darling flood regime. Works such as the ones mentioned above, along with associated water extraction, are the main types of development contributing to the overall changes in regime. This regulation of the system has altered the seasonal flow regime, reduced frequency and extent of flooding and reduced channel complexity.

The surface waters of the Barwon-Darling catchment show long-term variability, with water resource development also having the potential to change long-term flow variability. Thoms and Sheldon (2000) compared Integrated Quantity and Quality Model (IQQM) outputs of simulated 'reference' flows with simulated 1993/94 levels of development flows for the period 1963-96 for four NSW gauging stations at Mungindi, Walgett, Bourke and Wilcannia, and observed the following:

- water resource development has had a major impact on annual flows, with an average reduction of 33 per cent and 45 per cent in mean and median annual volumes of water respectively, with the biggest reduction seen at Walgett.
- low flows have increased but higher flows have decreased
- flow seasonality has also been altered with summer peaks being reduced by up to 56 per cent from irrigation diversions
- water resource development has also influenced the size of different flood events, for example, flows with more than two exceedances per year (EY) have experienced a significant reduction in size, and floods that occur every two years or more have also been reduced.

Demand for irrigation water from the Darling River has markedly reduced flows compared with those prior to settlement. Changes to the general level of river flows have resulted from increased extractions and irrigation development on tributaries, whilst low flows have been influenced by the local irrigation industry. This reduction in flows has major consequences for flood-dependent ecosystems as it results in increased time intervals between flood events and a reduction in flood duration (Kingsford 2000; Thoms et al. 2004; Jenkins & Boulton 2007).

Several local river health issues relating to the sharing of water between instream and consumptive uses have occurred in the Barwon-Darling in recent years. Declines in river health are the result of a number of factors, but changed river flows are important contributors to such declines. The Department of Land and Water Conservation (1998) listed the following environmental impacts associated with changed river flows in the Barwon-Darling:

- greater frequency of blue-green algal blooms
- riverbank instability, slumping and changes in channel form
- reduced fish breeding and migration opportunities
- decreased wetland inundation, and
- impacts on natural processes, including the decline in food production to support fish and bird populations.

Developing the plan

The Barwon-Darling Valley FMP was primarily developed by the NSW Department of Primary Industries, Water (DPIW) with technical support provided by the NSW Office of Environment and Heritage (OEH). The two agencies employed a ten-step process as outlined in the technical manual and Figure 3 below that involves collecting best-available data and analysis of existing floodplain management arrangements to inform hydraulic, ecological, cultural and socio-economic assessments. During the steps involving the collection of data and undertaking of technical assessments, the Barwon-Darling Technical Advisory Group (TAG) and Aboriginal Technical Working Group (ATWG) were engaged in consensus-based decision-making. The outputs from the assessments ensured that the steps used to determine the floodplain boundary, management zones and rules were supported by good science.

Consultation on the draft Barwon-Darling Valley FMP occurred in two stages: targeted consultation and public exhibition. The consultation stages align with DPIW internal policy originally developed for the making and review of water sharing plans under the WMA 2000. During these stages of

consultation community feedback was invited on the boundary, management zones, rules and assessment criteria in the FMP. Targeted consultation with stakeholder interest groups, including members of the Aboriginal community, occurred during October 2015 and February 2016, at Mungindi, Walgett, Brewarrina and Bourke. Public exhibition of the draft Barwon-Darling Valley FMP occurred from the 31 October 2016 to the 9 December 2016. Outcomes from targeted consultation and public exhibition are provided in this document in 'Consultation and review of the plan'.

An Interagency Regional Panel (IRP) was responsible for the review and whole-of-government endorsement of the draft Barwon-Darling Valley FMP. The IRP reviewed the draft plan prior to targeted consultation and public exhibition and post-public exhibition to review submissions. The IRP was also responsible for endorsement of the plan for commencement. Further details on the IRP review process are outlined in 'Consultation and review of the plan'.

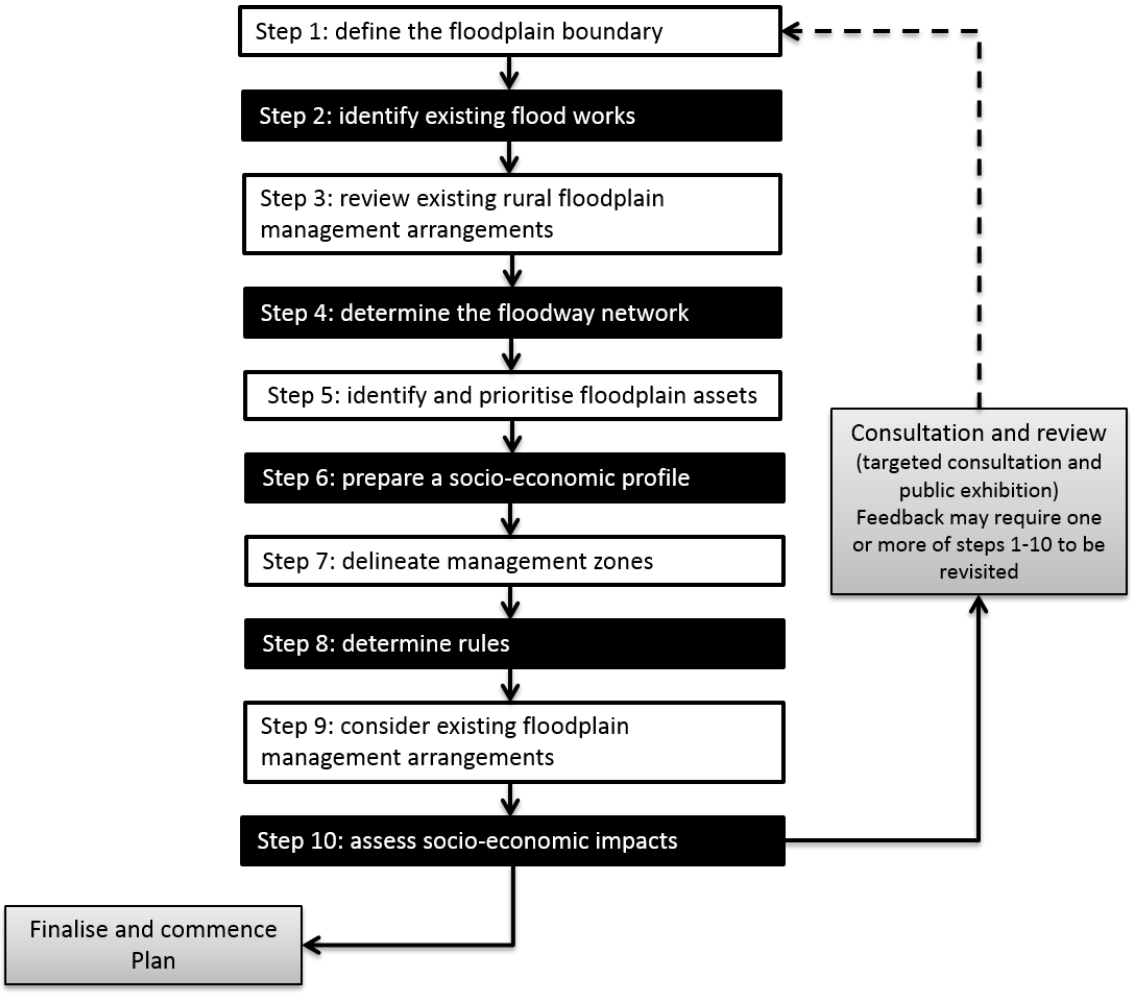

Figure 3: Ten steps used to develop rural floodplain management plans under the WMA 2000

Appendix 1 contains a detailed table of the ten steps including the input/process and output/outcome related to each step.

Step 1: Define the floodplain boundary

The Barwon-Darling Valley FMP applies to the area defined as the Barwon-Darling Valley Floodplain. The Barwon-Darling Valley Floodplain covers 1.1 million hectares. When compared to the existing Part 8 designated floodplains, the overall increase of the floodplain area is significant, with the addition of approximately 765,400 ha (see Figure 2).

The boundary of the Barwon-Darling Valley Floodplain was delineated based on the consideration of the following:

- **Designated floodplains and floodplain development guidelines**

  Existing and potential floodplain developments in the Barwon-Darling Valley Floodplain were identified from the following existing floodplain areas designated under Part 8 of the WA 1912:

  - Bogan River Confluence to Louth designated floodplain, rural flood study (URS 2009)
  - Lower Macquarie designated floodplain
  - Lower Macintyre designated floodplain
  - Small sections of the Lower Gwydir and Lower Namoi designated floodplains
  - Little Bogan River to Yanda Creek floodplain guidelines (WRC 1986a), and
  - Darling River – Yanda Creek to Louth floodplain guidelines (WRC 1986b.

  The WA 1912 was repealed in 2015 and all existing designated floodplains under this Act transitioned across to the WMA.

- **Hydraulic effects of development**

  The floodplain was extended to include additional flood works that were outside the existing designated floodplain areas to meet the objectives of the Barwon-Darling Valley FMP and to assist with the coordination of all flood works across the extent of major flooding.

- **Cadastral and administrative relevance**

  Where appropriate, the floodplain was aligned with significant cadastral features (e.g. property, parish, county, LGA and State boundaries; roads and railways) to simplify administration and to provide clarity to water users.

- **Planning legacy (unregulated water sharing plans (WSPs))**

  Where appropriate, the boundary was aligned with unregulated WSP boundaries to ensure consistency with boundaries of water management plans under the WMA, ease of administration and increased clarity for water users.

- **Floodplain harvesting**

  The floodplain boundary included areas identified through the Floodplain Harvesting Project's expression of interest process for floodplain harvesting licences and potential floodplain harvesting structures. This ensures consistency with the NSW Floodplain Harvesting Policy (NSW DPI 2013), which only applies to floodplain harvesting activities on properties where all or part of that property lies within the designated floodplain.

- **Other FMP floodplain boundaries**

  The Barwon-Darling Valley Floodplain was aligned with FMP boundaries of the Border Rivers, Gwydir, Lower Namoi and Macquarie valleys to provide consistency with other water management plan boundaries under the WMA 2000.

- **Landscape features**

  Where appropriate, the boundary was aligned with significant landscape features, such as weirs, to assist ease of administration and to provide clarity for water users.

Step 2: Identify existing flood works

As of March 2017, approximately 45,900 ha (or 4 % of the total floodplain) is enclosed by flood works in the Barwon-Darling Valley Floodplain (Figure 4).

Individual works (linear features) and works not visible at a scale of 1:20 000 have not been mapped in the footprint areas shown in Figure 4. Mapped footprint areas may include:

- below-ground and above-ground supply channels
- infrastructure protection works
- levees
- private access roads
- storages
- stock refuge works, and
- other earthworks and embankments.

Limited height works were also included in the existing work footprint areas. Instream works are not identified as flood works but are generally identified as controlled activities under the WMA 2000. Supply channels and storages may be identified as water supply works and flood works.

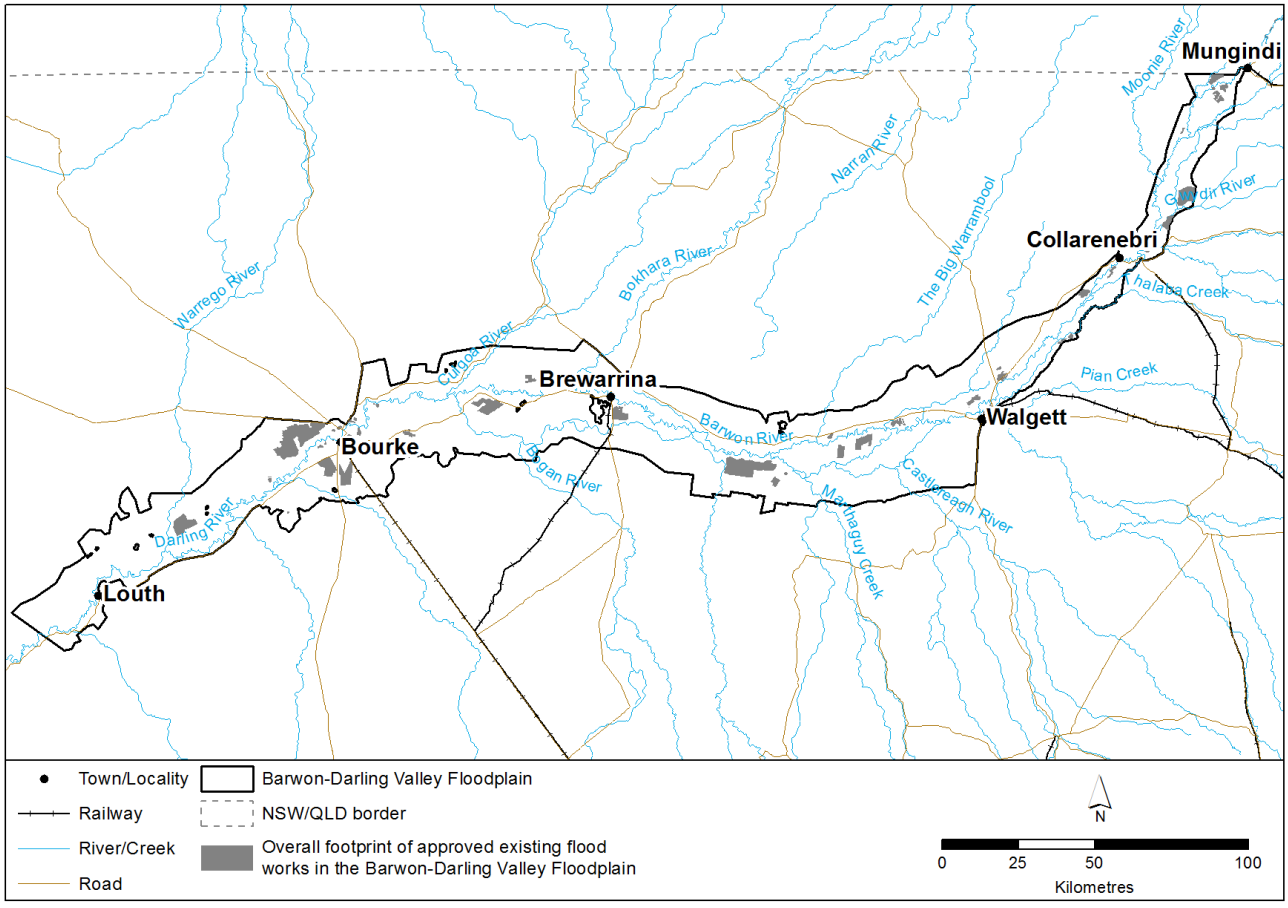

Figure 4: Overall footprint of constructed flood works

Step 3: Review existing rural floodplain management arrangements

Existing rural floodplain management arrangements in the Barwon-Darling Valley Floodplain consisted of floodplain development guidelines and supporting flood studies (Figure 5, Appendix 2). The following two guidelines were produced in the Barwon-Darling Valley Floodplain:

- Guidelines for Flood Plain Development Darling River Little Bogan confluence to Yanda Creek confluence (WRC 1986a)
- Guidelines for Flood Plain Development Darling River Yanda Creek confluence to Louth (WRC 1986b)

A very small portion of the downstream limits of the Lower Macintyre (Yelarbon Crossing to Mungindi) designated flood plain (1985) extends into the upstream limits of the Barwon-Darling Valley Floodplain, in the vicinity of Mungindi.

A number of supporting flood studies were developed in the Barwon-Darling Valley Floodplain to assist with flood work determinations. These studies include:

- Flood Study Report – Rural Flood Study Darling River Floodplain (Bogan River Confluence to Louth) (URS 2009)
- Compendium of Data - Rural Flood Study Darling River Floodplain (Bogan River Confluence to Louth) (URS 2008)

The following information in the guidelines and studies was reviewed to inform the development of the Barwon-Darling Valley FMP:

- flood management principles
- ecological and cultural heritage considerations
- floodway networks, hydraulic models and design flood events
- types of works considered for approval, and
- assessment process for flood-work applications, including any assessment criteria used.

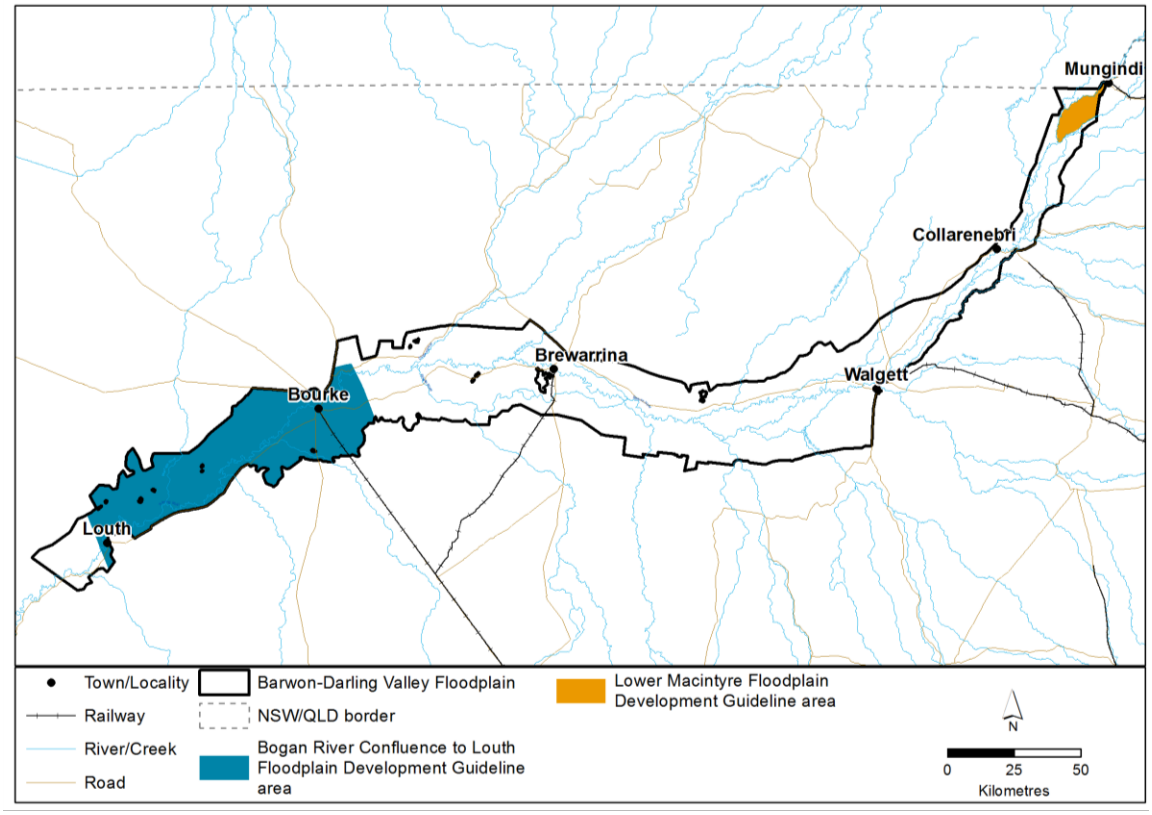

Figure 5: History of floodplain management in the Barwon-Darling Valley Floodplain

Step 4: Determine the floodway network

Step 4 involved selecting floods of different magnitudes (design floods) and constructing hydrologic and hydraulic models to simulate the movement of those floods through the river channels and floodplain. This modelling data as well as additional data, such as flood imagery, was used to map the floodway network.

The Barwon-Darling floodway network (Figure 6) is comprised of two hydraulic categories:

- floodways (324,200 ha or 30 % of the floodplain), which are areas where a significant discharge of floodwater occurs
- inundation extent (535,400 ha or 49 % of the floodplain), which includes areas of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood and for secondary flood discharge.

The remaining 235,900 ha or about 21 per cent of the floodplain was outside of the inundation extent of the large design flood and was therefore not included as part of the floodway network. About 45,900 ha of this area is not flooded because it is protected by flood works.

The floodway network was the hydraulic basis for determining the management zones, rules and assessment criteria of the Barwon-Darling Valley FMP. Refer to Appendix 3 for floodway network maps by floodplain reach.

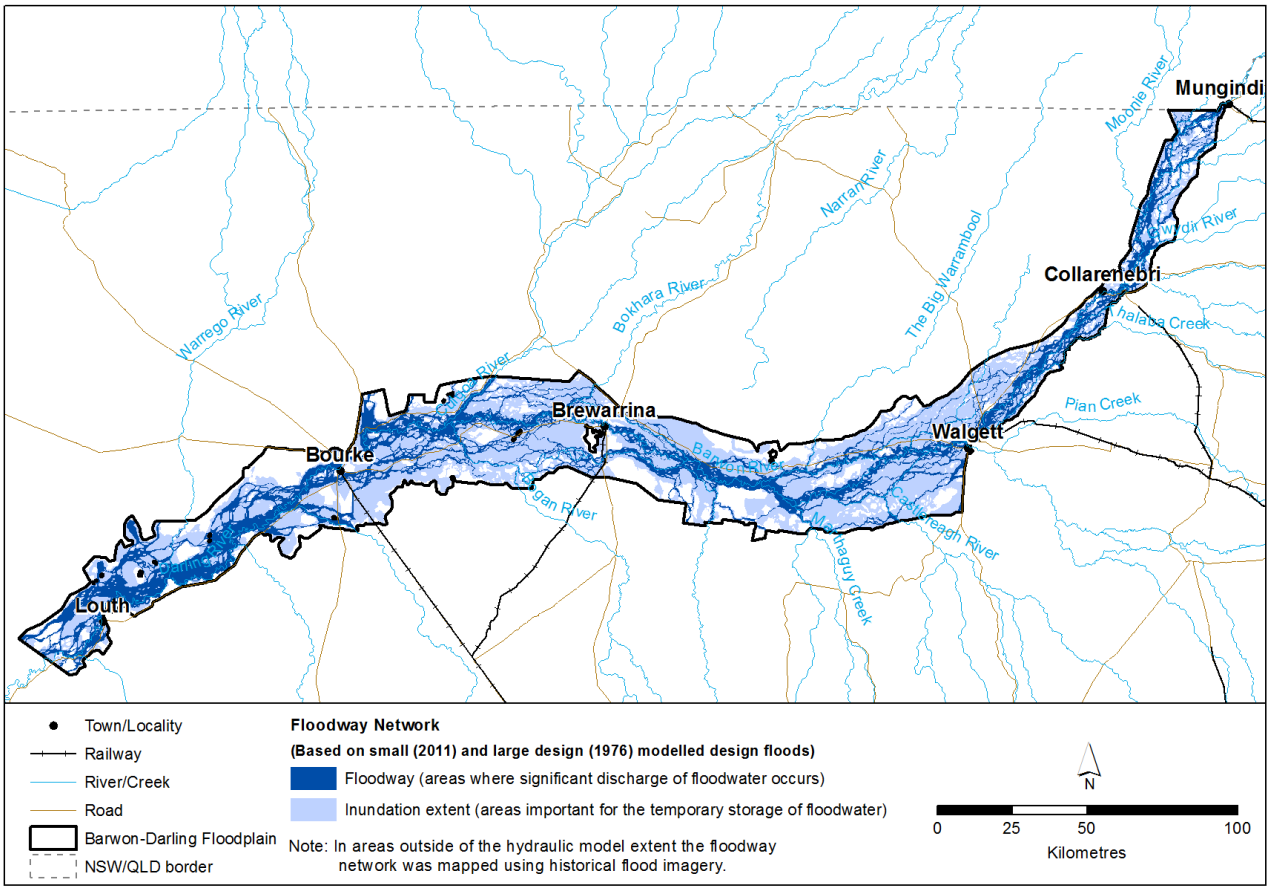

Figure 6: The Barwon-Darling floodway network

Design floods

A design flood is a flood of known magnitude or Annual Exceedance Probability (AEP) that can be modelled. A design flood forms the basis of the floodway network and this information is used as the hydraulic basis when developing the management zones. Selection of a design flood is based on an understanding of flood behaviour and associated flood risk. Multiple design floods may be selected to account for the social, economic and ecological consequences associated with floods of different magnitudes.

Two design floods were selected for the Barwon-Darling Valley FMP:

- large design flood – February 1976 (1.4 % AEP @ Walgett or 1.2 % AEP @ Bourke)
- small design flood – November 2011 (17 % AEP @ Walgett and Bourke).

A flood frequency analysis was undertaken to assist with the selection of the design floods (Table 1). The flood frequency analysis was used to determine the relationship between peak flood discharge at a location of interest and the likelihood that a flood event of that size or greater would occur (see Appendix 4 for more details on design floods and how the flood frequency analysis results were obtained).

Table 1: Annual exceedance probability for historic flood events at selected locations in the Barwon-Darling

Location (Gauging Station number)	Reason for gauging station selection	Flood event AEP (%)						
		1974	1976	1996	1998	2011	2012	2013
Barwon River at Mungindi (416001)	Long period of record, located at the top of the floodplain and top of Gomeroi Reach	4	1	6	4.5	14	25	13
Barwon River at Collarenebri (422003)	Located near the centre of Gomeroi Reach	10	7	6	3	13	1.7	25
Barwon River at Walgett (422001)	Long period of record, located near the centre of Euahlayi, Gomeroi and Wayilwan Reach	2.1	1.4	11	5.6	17	4.4	33
Barwon River at Brewarrina (422002)	Long period of record, located in the centre of Ngemba, Wayilwan, Euahlayi and Baranbinja Reach	3	2.9	14	5.6	20	6	50
Darling River at Bourke (425003)	Long period of record, located near the beginning of Wangaaypuwan, Ngemba, Baranbinja and Gunu Reach	1.1	1.15	20	3.6	17	2.9	50
Darling River at Louth (425004)	Located at Louth and near the downstream end of Wangaaypuwan, Ngemba, Baranbinja and Gunu Reach	2.6	2.3	25	5.6	20	9.1	50

The large design flood (February 1976) was used to delineate floodways with significant discharge and to determine the extent of the floodway network. The large design flood was selected because:

- it is a recent large flood and therefore likely to be in the collective memory of floodplain users
- it is representative of large floods in the Barwon-Darling Valley Floodplain, and
- there is a significant amount of information available for the event.

Other advantages of choosing the 1976 event for the large design flood are:

- streamlined modelling, by having the same flood throughout the whole Barwon-Darling Valley Floodplain
- same large design flood as used in the draft Border-Rivers Valley FMP, and
- similar flood magnitude as the large design flood (2012) adopted for the Gwydir Valley FMP.

The small design flood (December 2011) is a 14 % AEP flood event at the Mungindi gauge and 20 % AEP flood event at the Louth gauge. This smaller event was selected to ensure that critical flow paths to floodplain assets were identified in the floodway network and as a consideration during the technical assessment of flood work applications.

The small design flood was selected because it:

- approximated a 12 % AEP (1 in 8) event across the Barwon-Darling Valley Floodplain, which was selected in the Sustainable Rivers Audit as an indicator of river health associated with high overbank flows (see Davies et al. 2012), and
- will contribute to the protection of ecological assets and ecosystem functions in the Barwon-Darling Valley Floodplain that require environmental watering, according to the environmental objectives outlined in the Basin Plan's environmental watering plan and is consistent with the environmental objectives outlined in annual environmental water portfolio plans for the Northern Unregulated Rivers developed by the Commonwealth Environmental Water Office.

Hydrologic models

Hydrologic models simulate rainfall run-off on a catchment by converting storm rainfall to flow hydrographs. This is done using a procedure known as run-off routing, which subtracts losses, such as from soil infiltration, from the total rainfall. The rainfall excess is then routed through the catchment storage to produce flow hydrographs at specified locations (Laurenson et al. 2010).

The Barwon-Darling River can receive flood producing water from a number of tributaries, with larger floods occurring when several tributaries are in flood at the same time. The majority of the tributaries along the left bank of the Barwon River have been modelled up to large flood flows for their respective floodplain management plans (Border-Rivers, Gwydir, Namoi and Macquarie) and their flows into the Barwon-Darling are relatively well gauged. The other major tributaries are also gauged, including the Culgoa, Bokhara, Warrego, and Bogan rivers.

There are a number of other smaller ephemeral tributaries, such as the Yanda, Mulga, Ledknapper Creeks and the Big Warrambool that can contribute flow to the Barwon-Darling. However, the flow volume of these creeks is comparatively small and they are unlikely to have a significant impact on flood heights or flow distribution. Another important consideration is that these creeks drain local semi-arid catchments and flow from these creeks may fill and recede well before flood producing waters arrive from the larger, gauged tributaries for the same rainfall event.

For these reasons, no hydrological modelling was undertaken for the Barwon-Darling Valley Floodplain as the major inflows were derived from gauges, upstream modelling or from hydraulic modelling from adjoining FMP floodplains. Some calculations of potential flow were made (using the Rational Method) to ensure that the floodways from the ungauged tributaries are accounted for in the floodway network.

Hydraulic models

The Barwon-Darling Valley Floodplain was divided into four reaches for hydraulic modelling purposes (Figure 7). A MIKE 21 FM model was created for each of the four reaches. MIKE 21 FM is a 2-dimensional hydrodynamic model using MIKE 21 and Flexible Mesh (FM) bathymetry. The models utilise a range of elevation data sources including LiDAR data resampled to a 20 metre grid. A finer mesh resolution was used to represent all major water courses with a coarser mesh used to represent the floodplain. The crest level of major features such as roads and railway embankments were included in the model mesh.

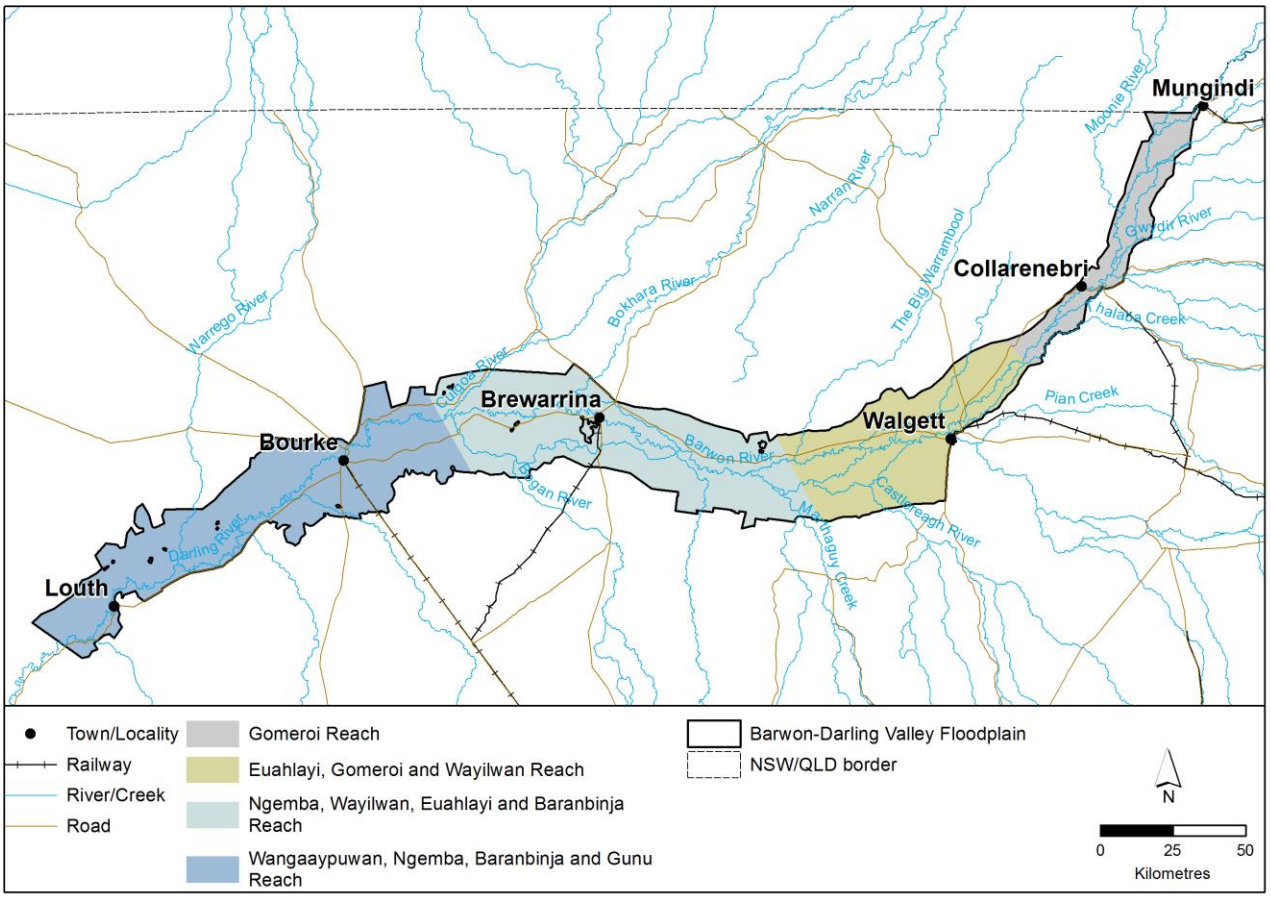

Figure 7: The four reaches of the Barwon-Darling Valley Floodplain

The hydraulic models used to develop the Barwon-Darling floodway network are outlined in Table 2. For information on hydraulic model networks, boundaries, structures, hydraulic parameters and model calibration, see Appendix 5.

Hydraulic model outputs used to develop the Barwon-Darling floodway network were:

- a depth-velocity product (DVP) map from the large design flood
- inundation extents of the small and large design floods.

These outputs were used to determine whether an area subjected to flooding was a floodway or an area important for floodplain pondage and the appropriate width of identified floodways. The location of flow paths in the models was determined using digital elevation models, flood aerial photography, satellite imagery, watercourse layers, flood marks and local knowledge.

The overall footprint of constructed works was identified in Step 2. For the purposes of hydraulic modelling, these floodplain areas enclosed by existing flood works that are not limited height works

were assumed to not be overtopped by floodwater and were excluded from the models' computational grid. Areas protected by limited height works (as indicated by licence files) were assumed to be overtopped by floodwater and were represented in the models as indicated by their licence files.

Table 2: Hydraulic models in each floodplain reach

Floodplain model	Model description
Gomeroi Reach (Mungindi to upstream of Tara)	A MIKE 21 FM model was built from Mungindi to upstream of Tara. The major tributary inflows within this reach include Gil Gil Creek, Barwon and Gwydir River. All protected areas including the township of Collarenebri were excluded from the mesh.
Euahlayi, Gomeroi and Wayilwan Reach (Upstream of Tara to Geera)	A MIKE 21 FM model was built from Tara to Geera. The major tributary inflows include Pian Creek, Barwon and Namoi rivers. All major protected areas were excluded from the mesh, including the township of Walgett.
Ngemba, Wayilwan, Euahlayi and Baranbinja Reach (Geera to Warraweena)	A MIKE 21 FM model was built from Geera to Warraweena. The major tributary inflows include the Bogan, Bokhara and Culgoa rivers. All major protected areas were excluded from the mesh, including the township of Brewarrina.
Wangaaypuwan, Ngemba, Baranbinja and Gunu Reach (Warraweena to downstream of Louth)	A MIKE 21 FM model was built from Warraweena to downstream of Louth. The major tributary inflows for this reach include the Warrego River, Mulga and Yanda creeks. All major protected areas were excluded from the mesh, including the township of Bourke.

Model calibration

Hydraulic models were calibrated using selected historic flood events that are around the design flood magnitude and that activate all likely flow paths. For further information on model calibration, see Appendix 5.

Hydraulic criteria for the floodway network

The small and large design floods provide the hydraulic basis for delineating the floodway network. Hydraulic criteria to develop the floodway network were determined through consultation with the TAG and local stakeholders. From this consultation, several hydraulic criteria options were developed. Each option proposed a target depth-velocity threshold that would be used to delineate floodways. An impact analysis of each option was also undertaken. The IRP used this information to adopt the option that provided the greatest hydraulic flood connectivity balanced with socio-economic considerations. The hydraulic criteria endorsed by the IRP and used to delineate the floodway network are described in Table 3. Once the thresholds were decided, applying the criteria in the spatial context remained a complex and iterative process requiring specialist input from practitioners with skills in interpreting flood data and floodplain geomorphology, and in understanding the importance of hydraulic controls and conveyance (Thomas & Golaszewski 2012).

Table 3: Summary of criteria used to delineate the hydraulic categories in the floodway network

Hydraulic category	Criteria
Floodways	• Areas that have a DVP of ≥ 0.3m^2/s for the large design flood (Feb 1976) • Areas that support tributary flows and outer floodplain floodways that have a DVP of ≥ 0.1m^2/s for the large design flood (Feb 1976) • Parts of the small design flood extent (Dec 2011) that ensure continuity of floodways
Inundation extent	• Flood extent of the small (Dec 2011) and large design flood (Feb 1976) • In areas outside the hydraulic model extent flood imagery from the 2012 flood event and NSW water count and water prevalence data (Fisher et al. 2016; Danaher & Collett 2006; Auscover Remote Sensing Data Facility 2016) derived from Landsat imagery.

Validation of the mapped floodway network was undertaken to ensure high level mapping accuracy. The following information was used to validate the floodway network:

- DVP maps for the large design flood (February 1976)
- discharge and velocity values along flow paths
- inundation extents for small (December 2011) and large (February 1976) design floods
- derived Landsat flood frequency and extent mapping products (Fisher et al. 2016; Danaher & Collett 2006; Auscover Remote Sensing Data Facility 2016)
- flood aerial photography and satellite imagery (see Appendix 6 for examples of flood imagery)
- spatial watercourse layers
- rural floodplain development guidelines
- local knowledge from floodplain communities, and floodplain and environmental managers, and
- existing flood-work development.

The following sections provide more detail on how the hydraulic criteria for floodways and inundation extent were developed for the Barwon-Darling Valley Floodplain.

Floodways

Floodways were derived using the DVP from the large design flood, calculated by a series of hydraulic models. The models utilised inflows from gauges and overland flow from upstream modelling where available. The model bathymetry was determined using a range of elevation data sources including LiDAR, ADS40 and SRTM.

The expected velocity variation with depth for a large incised low-gradient floodplain channel across the Barwon-Darling Valley Floodplain was investigated to determine an appropriate threshold for identifying floodways (see Figure 8). A DVP of 0.1 m^2/s would require a depth of approximately 0.5 m which would have a velocity of approximately 0.23 m/s. As the Barwon-Darling River is a low-gradient floodplain characterised by depth rather than velocity that experiences high flow discharges and flood levels during large flood events, adoption of a DVP of equal to or greater than 0.1 m^2/s would result in majority of large sections of the floodplain that extend onto the alluvial plain being assigned as floodways. Rather, floodways were identified as any areas with a DVP of equal to or greater than 0.3 m^2/s (on average this threshold would equate to 0.85 m depth and 0.36 m/s velocity) for the large design flood (1976). This threshold captured major rivers and creeks and other flow paths where there is a significant flood water conveyance.

Floodways identified using the target DVP threshold were further refined by considering the DVP in tandem with flow velocity. In this way, the floodway network also included areas where:

- flow velocity was relatively higher than in other areas of the floodplain regardless of depth
- there was significant depth but relatively low velocity.

Floodways derived from the target DVP threshold were compared with the inundation extent of the small design flood. This comparison was undertaken to ensure that areas of the floodplain activated during small floods were identified as floodways, irrespective of whether they reached the selected DVP threshold. Such areas are also likely to be the first floodways activated during large flood events. For instance, Figure 9 shows that although the large design flood would activate both floodway A and B, only floodway B would be identified as a floodway using the DVP threshold. By considering the inundation extent of the small design flood, floodway A would be picked up in the floodway network as a floodway. Such floodways may be important for connecting flood-dependent ecological and cultural assets to floodwater during smaller floods.

The location and size of floodways is strongly reflected in the design of the management zones. Therefore, the socio-economic impacts of the selected DVP threshold were also a consideration (refer to Step 10 for further information).

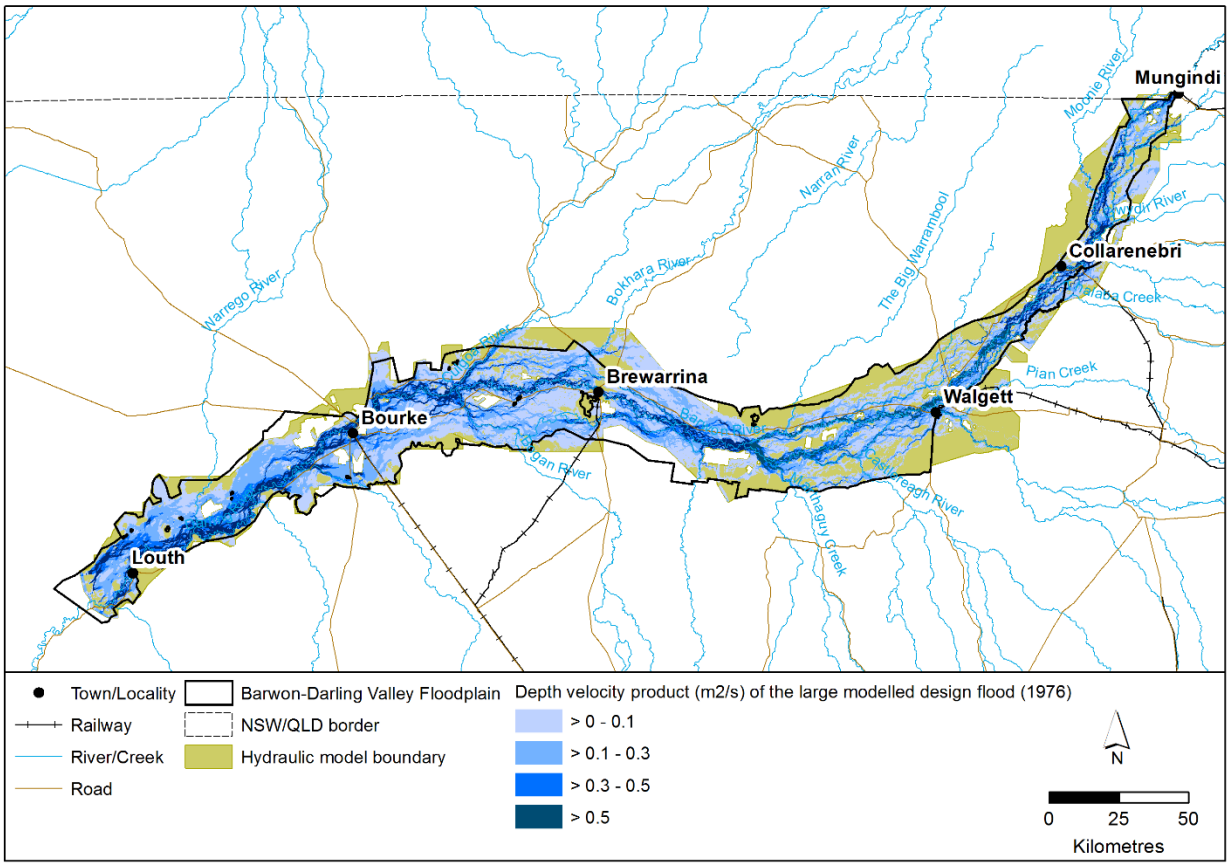

Figure 8: Depth-velocity product thresholds for the large modelled design flood (1976)

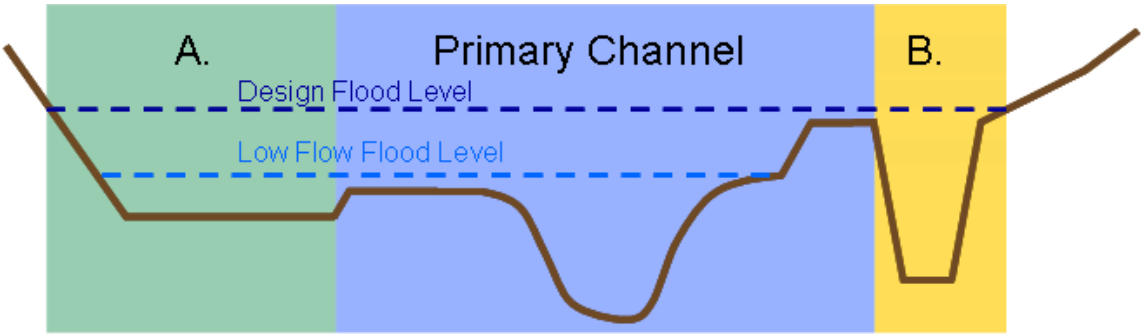

Figure 9: Identification of floodways using the depth-velocity threshold map versus inundation extent

Inundation extent

Hydraulic modelling produced the inundation extent of the large design flood across the floodplain. Where the flood extent was reliable, its outer limits were used to determine the extent of the floodway network; however, where topographic data was not sufficient to accurately map the extent of the flood, the limits to the floodway network were determined by using aerial and satellite flood imagery that was captured for the design event.

Areas within the extent of the design event are considered important for providing temporary pondage during large floods. Areas beyond the extent of the design flood may also be flood-prone, but would only become inundated during larger floods including extreme events, and would generally have low conveyance or pondage capacity.

Step 5: Identify and prioritise floodplain assets

Step 5 was undertaken to identify and prioritise the many unique and diverse ecological and cultural floodplain assets found in the Barwon-Darling Valley Floodplain to inform the design of the management zones and rules.

Ecological assets

During Step 5, ecological assets were:

- identified using best-available spatial data
- grouped using information on their optimum watering requirements
- prioritised to select the assets that best represent biodiversity on the floodplain.

Identifying ecological assets

The Barwon-Darling Valley FMP considered three types of ecological asset, including wetlands, other floodplain ecosystems and areas of groundwater recharge (see Figure 10). However, areas of groundwater recharge were not mapped due to data limitations.

Native vegetation mapping was predominantly used to identify wetlands and other floodplain ecosystems. Approximately 505,366 ha (or 46 % of the floodplain) was identified as native vegetation that is flood-dependent. A number of different regional vegetation maps and previous studies were utilised to identify semi-permanent wetlands, floodplain wetlands (flood-dependent shrubland wetlands), and other floodplain ecosystems, including flood-dependent forest/woodland (wetlands) and flood-dependent woodlands of the Barwon-Darling Valley Floodplain.

Each of the vegetation communities identified were collated into hydro-ecological functional groups. The following regional vegetation maps were used to create a composite vegetation map for the Barwon-Darling Valley Floodplain:

- The natural vegetation of north-western NSW (Pickard & Norris 1994)
- Pre-clearing and Existing Vegetation Mapping of the NE section of Bourke Shire (DIPNR 1998a)
- Existing Vegetation Mapping of Brewarrina Shire, Northern Floodplains, Far Western NSW (DIPNR 1998b)
- Existing Vegetation Mapping of the Western Division section of Walgett Shire, Northern Floodplains, Far Western NSW (DIPNR 1998c)
- Vegetation Mapping - Walgett Shire (East) North West NSW (Peasley & Walsh 1999)
- Composite Vegetation Map for the Border Rivers-Gwydir Catchment (Eco Logical Australia 2008)
- Gwydir Wetlands and Floodplain Vegetation Mapping (Bowen & Simpson 2009)
- Vegetation and Floristics of the Barwon Nature Reserve (Hunter 2010)
- Survey of Vegetation and Vegetation Condition of Toorale (Gowans et al. 2012)
- Survey and mapping of Darling Floodplain vegetation between Tilpa and Brewarrina (Shultz et al. 2014)
- Vegetation of the Condamine-Balonne floodplain systems of NSW Mapping and survey of plant community types (Eco Logical Australia 2015)
- State Vegetation Type Map: Border Rivers Gwydir-Namoi Regional Native Vegetation Mapping (OEH 2015; OEH 2017a)
- State Vegetation Type Map: Western NSW Plant Community Type draft version 0.1 (OEH 2017a, OEH 2017b).

In areas where existing vegetation mapping overlapped, the separate datasets were examined to select the coverage with superior representation of native vegetation patterns. Vegetation maps were ranked on reliability assessed using the following considerations:

- more recent studies were considered more reliable than older studies
- fine scale nature reserve studies were regarded as more reliable than coarse-scale studies
- studies with more intensive field sampling were regarded as more reliable than those that were based on sparse field sampling.

Maps with the highest assembly rank took precedence over those with lower ranks. Table 4 lists the existing regional vegetation maps and studies and the assembly rank used for the compilation of a seamless composite vegetation map for the Barwon-Darling Valley Floodplain.

In addition to native vegetation mapping, the location of semi-permanent wetlands in the Barwon-Darling Valley Floodplain were also identified from previous wetland studies including Brennan et al. (2002), Cooney (1994) and Hudson and Bacon (2009). Significant lagoons and wetlands in the Barwon-Darling Valley Floodplain were also identified from Schedule 4 - Significant identified lagoons and wetlands of the Water Sharing Plan for the Gwydir Unregulated and Alluvial Water Sources 2012 (see Ecological criteria: Table 10 for further information).

Table 4: Regional vegetation maps and studies and the assembly rules used for the compilation of a seamless composite vegetation map for the Barwon-Darling Valley Floodplain

Vegetation mapping dataset name (Reference)	NSW Vegetation Information System Number	Rank	Proportion of FMP area (%)	Area (ha)
Vegetation of the Condamine-Balonne floodplain systems of NSW Mapping and survey of plant community types (Eco Logical Australia 2015)	4453	1	15	161,000
Survey and mapping of Darling floodplain vegetation between Tilpa and Brewarrina (Schultz et al. 2014)	4186	1	27	295,082
The Border Rivers Gwydir and Namoi regional vegetation map version 2 (OEH 2015)	4204	1	14	150,216
Vegetation survey and mapping of Toorale National Park (Gowans et al. 2012)	4027	2	5	59,971
Vegetation and Floristics of the Barwon Nature Reserve (Hunter 2010)	-	3	1	7,377
Gwydir Wetlands and Floodplain Vegetation Mapping (Bowen & Simpson 2009)	3922	4	<1	13
Preclearing and Existing Vegetation Mapping of the NE section of Bourke Shire DIPNR 1998a and NFRPC (2004a)	1660	5	<1	1,456
Preclearing and Existing Vegetation Mapping of Brewarrina Shire, Northern Floodplains, Far Western NSW (DIPNR 1998b)	1658	6	14	150,435

Vegetation mapping dataset name (Reference)	NSW Vegetation Information System Number	Rank	Proportion of FMP area (%)	Area (ha)
Existing Vegetation Mapping of the Western Division section of Walgett Shire, Northern Floodplains, Far Western NSW (DIPNR 1998c; NFRPC 2004c)	1662	7	15	162,113
Vegetation Mapping - Walgett Shire – East, North West NSW (Peasley & Walsh 1999)	804	8	9	102,539
Composite Vegetation Map for the Border Rivers-Gwydir Catchment (Eco Logical Australia 2008)	3801	9	<1	45
The natural vegetation of North Western NSW (Pickard & Norris 1994)	825	10	<1	6,733

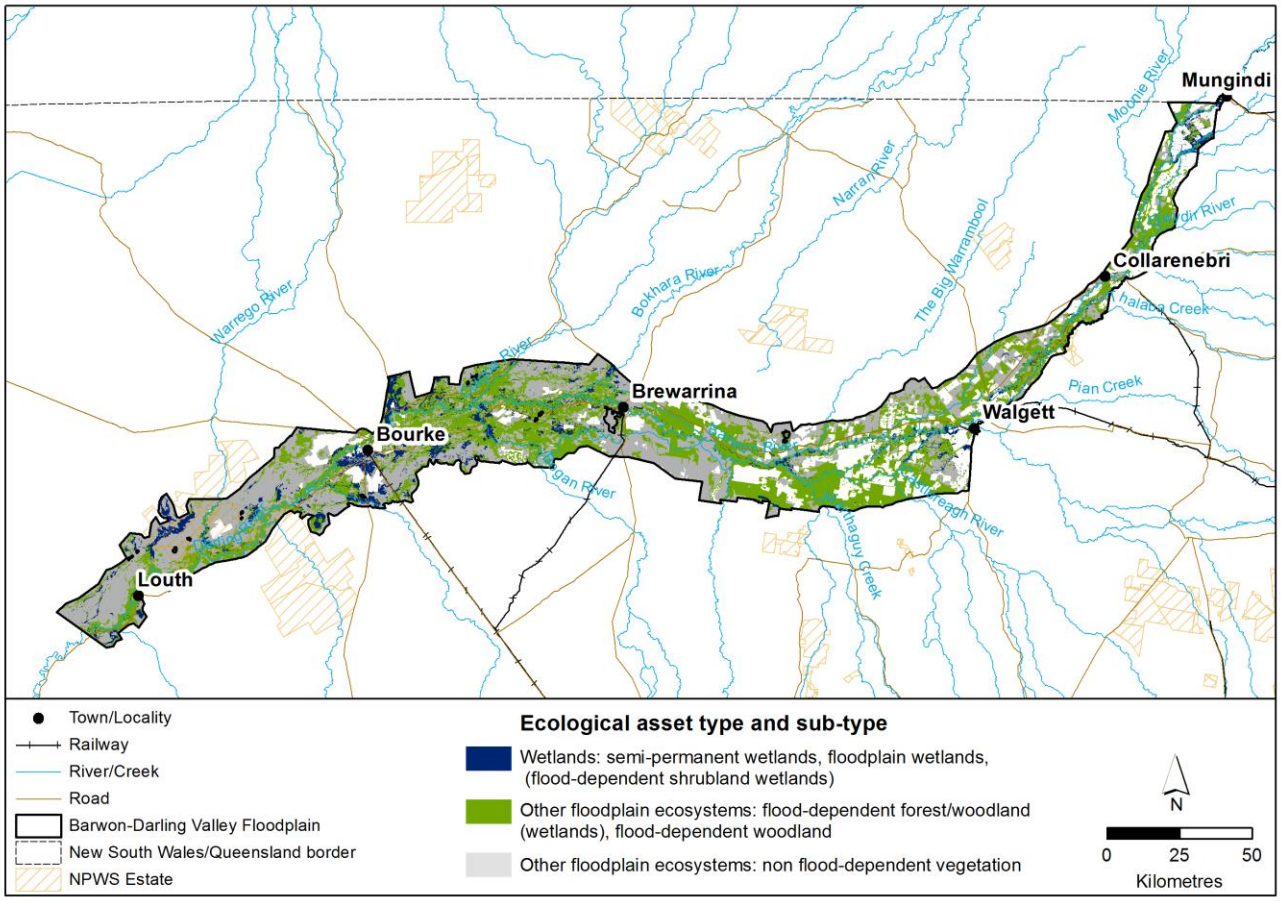

Figure 10: Ecological assets identified in the Barwon-Darling Valley Floodplain for the purposes of the Barwon-Darling Valley FMP

Ecological asset type – wetlands

The ecological asset, *wetlands*, is comprised of floodplain watercourses, semi-permanent wetlands and floodplain wetlands (see Figure 11).

Floodplain watercourses include:

- permanent flowing rivers and creeks[1], including those where the flow is modified by upstream dam(s), to the top of the natural bank regardless of whether the channel has been physically modified
- intermittent flowing rivers and creeks that retain water in a series of disconnected pools after flow ceases[1], including those where the flow is modified by upstream dam(s), to the top of the natural bank regardless of whether the channel has been physically modified
- flood channels or flood runners that run across or along floodplains during high-flow events[1]
- billabongs, lakes and lagoons that are fed by floodwater.

Semi-permanent wetlands require annual or a higher frequency of inundation to maintain structure and community composition. Semi-permanent wetlands contain the following vegetation communities (Plant Community Types (PCT)):

- Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains (PCT 53)
- Water Couch marsh grassland wetland of frequently flooded inland watercourses (PCT 204)
- Permanent and semi-permanent freshwater lakes wetland of the inland slopes and plains (PCT 238)
- Ephemeral herbaceous vegetation of the channels of major watercourses of western NSW (PCT 238a).

Floodplain wetland (flood-dependent shrubland wetland) requires flooding at intervals of one to five years (Roberts & Marston 2011; Rogers & Ralph 2011). Floodplain wetland contains the following vegetation communities:

- Canegrass swamp tall grassland wetland of drainage depressions, lakes and pans of the inland plains (PCT 24)
- Lignum shrubland wetland on floodplains and depressions of the Mulga Lands Bioregion, Channel Country Bioregion in the arid and semi-arid (hot) climate zones (PCT 25)
- Eurah shrubland of inland floodplains (PCT 115)
- Nitre Goosefoot shrubland wetland on clays of the inland floodplains (PCT 160)
- Golden Goosefoot shrubland wetland in swamps of the arid and semi-arid (hot summer) zones (PCT 161)
- River Coobah swamp wetland on the floodplains of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion (PCT 241)
- Lignum shrubland wetland on regularly flooded alluvial depressions in the Brigalow Belt South Bioregion and Darling Riverine Plains Bioregion (PCT 247).

Wetlands can provide habitat for flood-dependent fauna such as nesting waterbirds, fish, amphibians and turtles.

[1]These floodplain watercourses were picked up in the floodway network and were not re-identified in the ecological assessment.

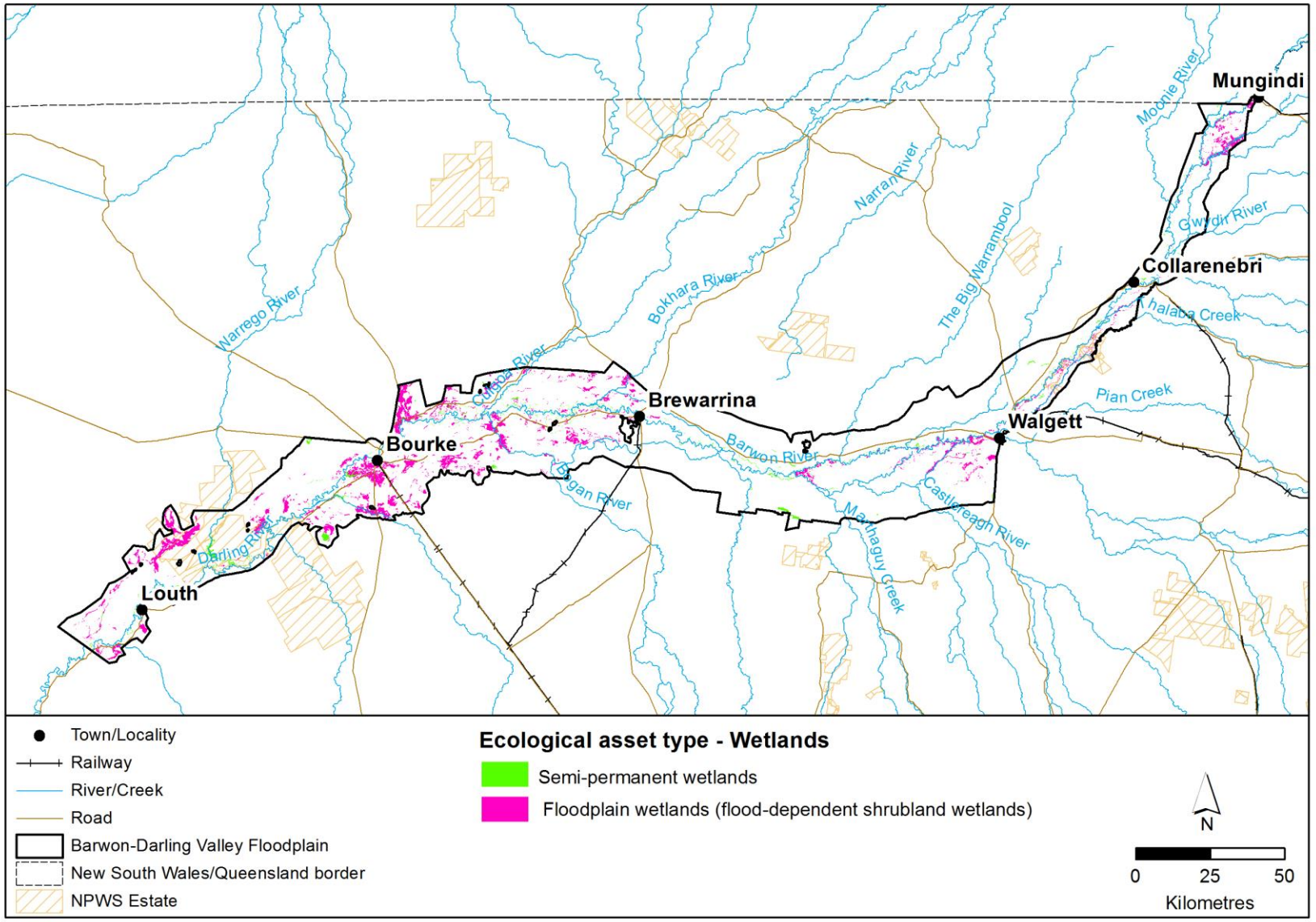

Figure 11: Location and type of wetlands identified as ecological assets.

Ecological asset type – other floodplain ecosystems

The ecological asset, *other floodplain ecosystems*, is comprised of flood-dependent forest/woodland (wetlands), flood-dependent woodlands and non-flood-dependent vegetation (see Figure 12). Flood-dependent forest/woodland (wetlands) requires flooding at intervals of between one and three years for forests or up to two to four years for woodlands (Roberts & Marston 2011). Flood-dependent forest/woodland (wetland) contains the following vegetation community:

- River Red Gum tall to very tall open forest / woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion (PCT 36).

Flood-dependent woodland requires flooding at least once every ten years (Roberts & Marston 2011). Flood-dependent woodland contains the following vegetation communities:

- Black Box woodland wetland on NSW central and northern floodplains including the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion (PCT 37)
- Black Box low woodland wetland lining ephemeral watercourses or fringing lakes and clay pans of semi-arid (hot) and arid zones (PCT 38)
- Coolibah - River Coobah - lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains Bioregion (PCT 39)
- Coolibah open woodland wetland with chenopod/grassy ground cover on grey and brown clay floodplains (PCT 40)
- Poplar Box - Coolibah floodplain woodland on light clay soil mainly in the Darling Riverine Plains Bioregion (PCT 87).

The flood-dependent forests and woodland may provide habitat for flood-dependent fauna including waterbirds and frogs.

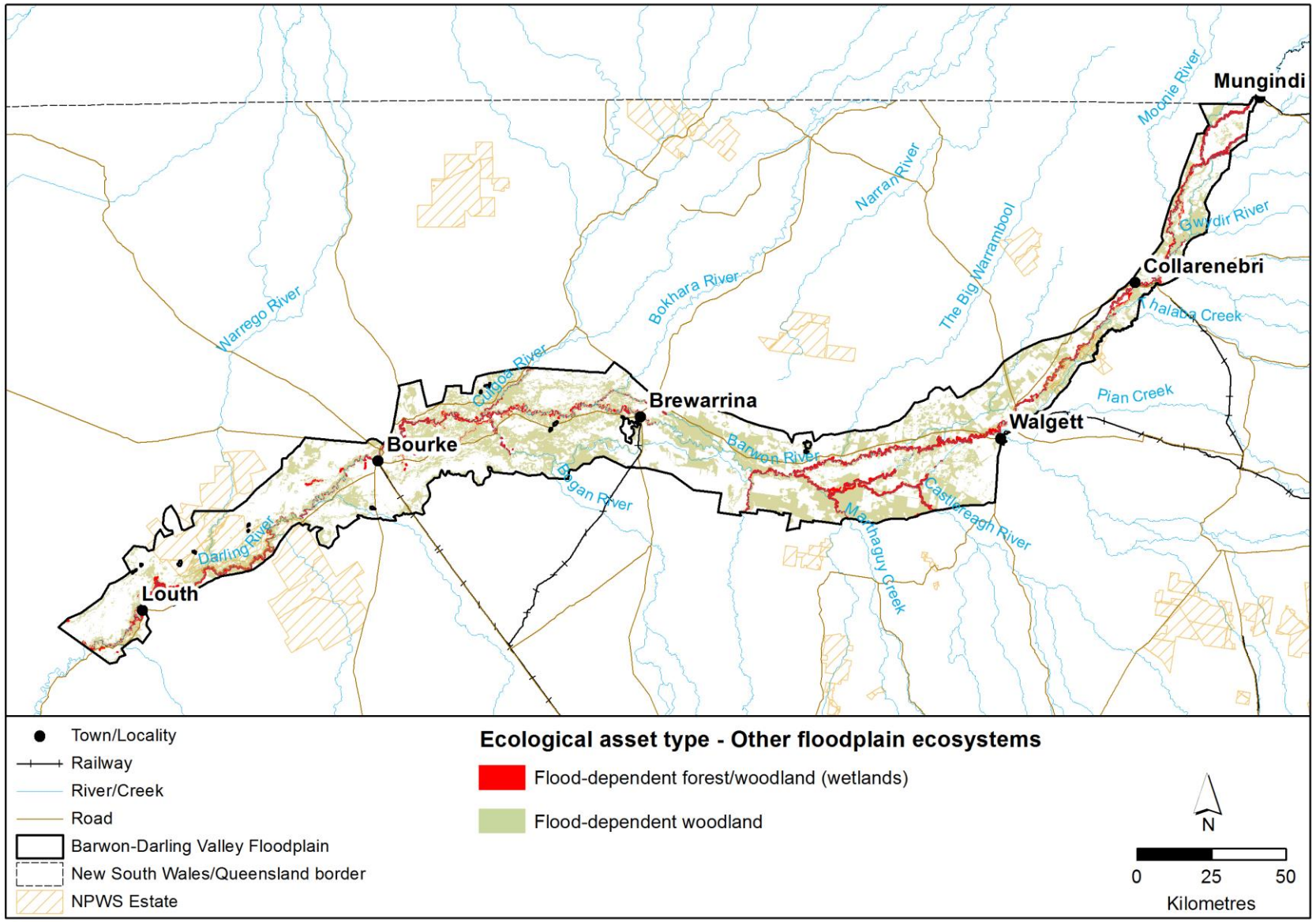

Figure 12: Location and type of other floodplain ecosystems identified as ecological assets

Ecological asset type – groundwater recharge

There is limited available spatial information related to the distribution of groundwater recharge areas in the Barwon-Darling Valley Floodplain.

CSIRO (2008) indicate that groundwater recharge depends on land use and soils, with groundwater levels showing a clear response to flood events. CSIRO (2008) document the following in relation to groundwater recharge in the Barwon-Darling:

- The Great Artesian Basin alluvial system is recharged by rainfall infiltration, flood recharge and throughflow from up-gradient sources in the east such as the Namoi region (although this throughflow is likely to be saline).
- Vertical leakage from flood inundation is a significant recharge mechanism for the Narrabri Formation near the junction of the Castlereagh and Barwon rivers.
- The Barwon-Darling River has a range of gaining and losing reaches dependent upon groundwater depth and varying hydraulic conductivity.

The Barwon-Darling Valley FMP will assist in maintaining flood-sourced groundwater recharge by protecting as natural a flood-flow distribution as practicable and maintaining core floodplain inundation. This will improve the likelihood and duration of natural groundwater recharge areas being subjected to natural flood inundation. If further information on flood-sourced groundwater recharge areas becomes available, the Barwon-Darling Valley FMP may need to be reviewed to ensure that they are adequately considered in the design of the management zones and rules.

Flood dependency of wetlands and other floodplain ecosystems

The distribution of vegetation communities in the Barwon-Darling Valley Floodplain may reflect the water regime (Casanova & Brock 2000; Porter & Kingsford 2007; Shultz et al. 2014). Vegetation in the immediate vicinity of the Darling River is in contrast to the drier environments of the surrounding plains, sand dunes and ridges (Westbrooke et al. 2004). The time-scales of flooding and the spatial extent of wet\dry ecotone may influence the types of plants that can germinate, grow and reproduce (Brock & Casonova 1997; Capon & Brock 2006). The recent studies of Gowans et al. (2012) and Shultz et al. (2014) provided some information about vegetation community watering requirements and implications of changed watering regimes on floodplain vegetation communities between Tilpa and Brewarrina.

The flood dependency of ecological assets in the Barwon-Darling Valley Floodplain was a key consideration informing FMP management zone delineation which aims to protect the passage of flood water to ecological assets dependent on flooding to maintain their long-term persistence, structural integrity and community condition. Wetlands and other floodplain ecosystems were categorised into hydro-ecological functional groups according to the flooding requirements of the dominant or canopy species in the vegetation community to maintain their ecological character using information sourced from the reviews of Rogers and Ralph (2011) and Roberts and Marston (2011) which provide a synthesis of the best available knowledge (Table 5). It was assumed that floodplain watercourses would require water every year or more often to maintain their ecological character.

Table 5: Hydro-ecological functional groups that comprise wetlands and other floodplain ecosystems in the Barwon-Darling Valley Floodplain and their flooding frequency requirements (Source: Optimum watering requirements adapted from Roberts and Marston (2011) and Rogers and Ralph (2011))

Ecological asset	Description (hydro-ecological functional groups)	Vegetation/watercourse class	Ideal watering frequency
Wetlands	Floodplain watercourses	Drainage lines	Annual or near annual

		Lagoons Billabongs Waterholes Lakes	
	Semi-permanent wetland	Common reed Cumbungi Tussock rush Ribbed spikerush Water couch	Annual or near annual
	Floodplain wetland (Flood-dependent shrubland wetland)	Canegrass Eurah^ Golden goosefoot Lignum Nitre goosefoot^ River cooba	Every year to 1 in 5 years
Other floodplain ecosystems	Flood-dependent forest/woodland (wetland)	River red gum	1 in 3 to 1 in 5 years
	Flood-dependent woodland	Coolibah woodland Black box woodland	1 in <10 years

^ Nitre goosefoot (*Chenopodium nitrariaceum* (F. Muell.) F.Muell. ex Benth.) shrubland wetland grades into lignum communities in wetter sites where drainage is impaired. No specific watering requirements have been documented by Rogers and Ralph (2011) or Roberts and Marston (2011) for this floodplain shrubland vegetation community, however, is likely to require periodic flooding for maintenance and persistence (Shultz et al. 2014). Eurah (*Eremophila bignoniiflora* (Benth.) F.Muell.) generally occurs in periodically flooded areas of floodplains and drainage lines (Cunningham et al. 1981) chiefly in black box, and river red gum communities. No specific watering requirements have been documented by Rogers and Ralph (2011) or Roberts and Marston (2011). Watering requirements are likely to be similar to coolibah woodlands and protection of river flows and flooding regimes to these vegetation communities would benefit eurah seedling establishment (Shultz et al. 2014).

Prioritisation of ecological assets

Ecological assets were prioritised to select the assets that best represent biodiversity in the Barwon-Darling Valley Floodplain. High-priority assets were then considered in the design of the management zones to protect their flood connectivity. Ecological assets were predominantly prioritised by the Barwon-Darling TAG during workshops in September and November 2014.

Targets determined by the TAG were used to drive the selection of priority assets using the conservation planning decision-software, Marxan. This decision support tool assisted with identification and determination of areas of high conservation significance where floodplain connectivity should be secured (Ball & Possingham 2000; Possingham, Ball & Andelman 2000; Ball, Possingham & Watts 2009). Conservation targets are prescribed in Marxan to determine the amount of each feature the program is instructed to select. In conservation planning, variable targets are often prescribed for ecological surrogates based on ecological objectives to determine relative conservation priority (higher and lesser priority areas). In the Barwon-Darling Valley Floodplain, the TAG endorsed conservation targets of 100 per cent for each asset type to ensure their future persistence. As a result the Marxan analysis determined that all ecological assets were a high priority. Nevertheless, the prioritisation method was undertaken in full for completeness and to provide information on the relative conservation significance of fauna species and discrete wetlands identified in studies as determined by targets set by the TAG.

The prioritisation method involved:

- partitioning the floodplain into planning units (see Appendix 7)

- using local and expert knowledge to set targets for ecological surrogates (see Appendix 8)
- developing a spatial layer (constraint surface) that represents the ability to physically connect floodwater to ecological assets to constrain the selection of priority planning units (see Appendix 9)
- running Marxan to identify priority ecological assets and selection frequency scores.

Marxan analyses key ecological surrogates to represent biodiversity patterns and identifies floodplain areas which complement each other, producing an efficient, well-connected system that aims to ensure the future persistence of flood-dependent ecological assets. Ecological surrogates are spatially definable components of biodiversity patterns and may include mapped information such as vegetation, waterbird habitat and fish biodiversity hotspots.

Priority ecological assets

For the Barwon-Darling Valley Floodplain, the decision-support software was run using the targets prescribed by the TAG with one million iterations across 100 runs using a simulated annealing optimisation method[1] (Ball & Possingham 2000). This produced a map of priority planning units (Figure 13).

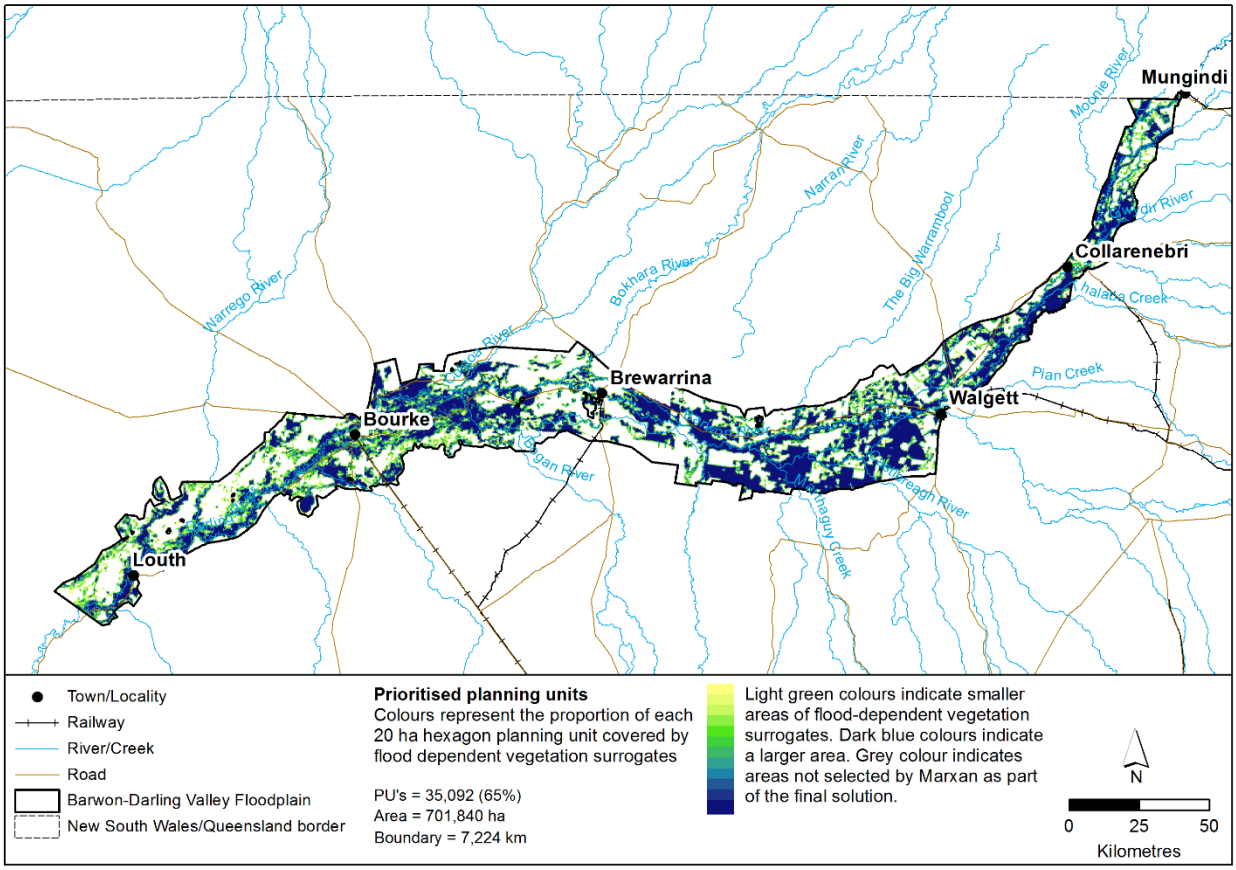

Figure 13: High-priority planning units selected in Marxan

Selection frequency score

Another output of the Marxan software runs is the selection frequency score (Figure 14). The number of times a planning unit was selected in each of the 100 runs was counted to measure the relative importance of planning units. The selection frequency score provides feedback on how likely a specific area is included in an efficient solution. When a planning unit is never

[1] a way of finding an optimal solution to a problem by comparing many possible solutions

selected it is attributed with a frequency score of 0, while those that are always selected have a selection frequency equal to the maximum number of runs of the Marxan software (e.g. the highest possible frequency score for a planning unit is 100, based on 100 runs). Areas with a high frequency score are consistently important in the solutions. They are highly irreplaceable and have fewer substitutes if conservation objectives are to be achieved efficiently.

The optimal set of planning units mapped from Marxan identified parts of the Barwon-Darling Valley Floodplain which are important for achieving a range of conservation targets and included parts of the floodplain which are essential for maintaining connected riparian ecosystems and protecting flood-dependent species and habitats. These focal areas of the floodplain were identified systematically at the landscape-scale using a variety of spatial ecological data which represent biodiversity patterns.

Additional information, including the distribution of mapped flood-dependent vegetation boundaries which represent the 'real' distribution of native vegetation species at discrete sites, hydraulic assessments and cultural heritage assets are also considered to guide demarcation of final floodplain management zones. In combination with the optimal set of planning units, these components formed part of the larger decision framework for determining the floodplain management zones in the Barwon-Darling Valley Floodplain.

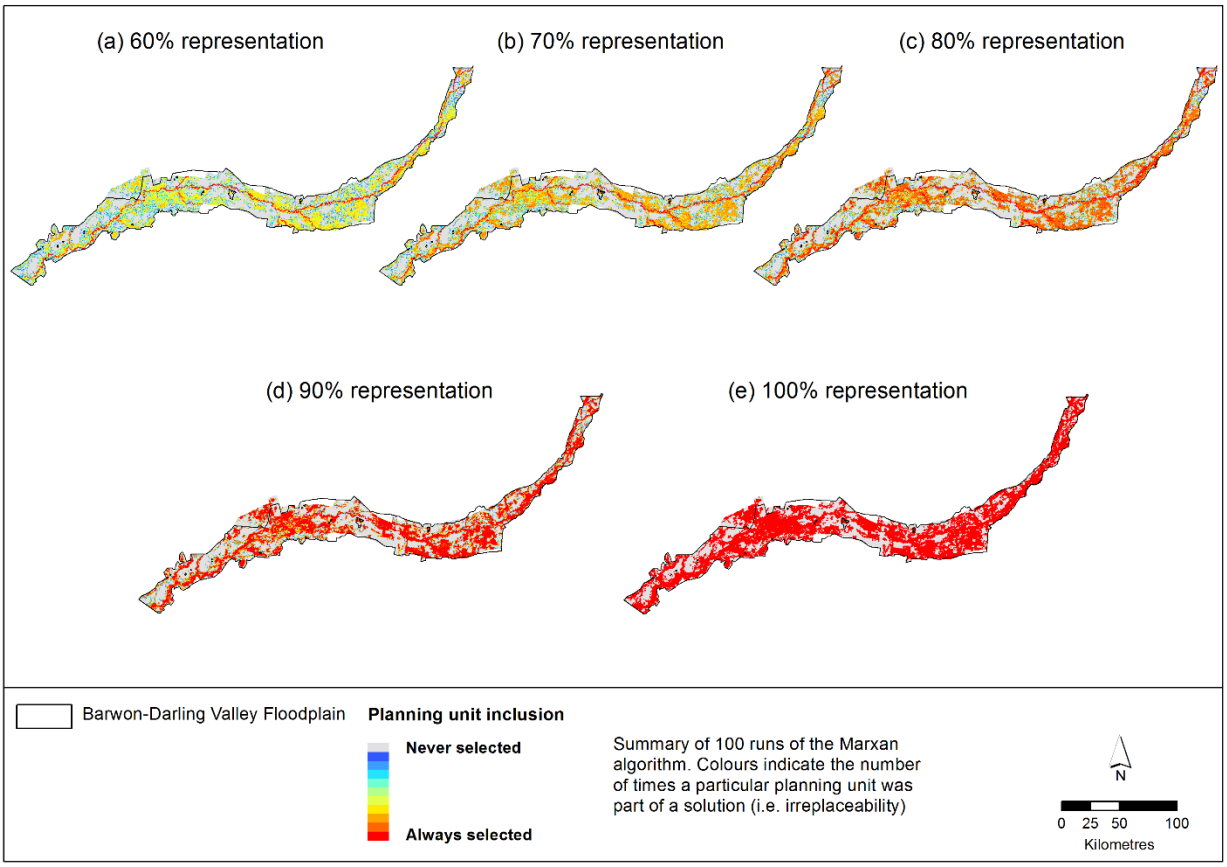

Figure 14: Relative priority (the selection frequency as an index of irreplaceability) of planning units (PU) based on the Marxan analysis (the sets of 100 Marxan runs) achieving a range of different representation targets for flood-dependent vegetation assets (60 %, 70 %, 80 %, 90 % and 100 %) for the Barwon-Darling Valley Floodplain

Cultural assets

The Barwon-Darling Valley Floodplain contains assets that have Aboriginal and cultural heritage value (cultural assets). The Barwon-Darling Valley FMP identified and prioritised two types of cultural assets:

- Aboriginal values - sites, objects, landscapes, resources and beliefs that are important to Aboriginal people as part of their continuing culture. Aboriginal values also include functions, services and features that benefit Aboriginal people that are listed in Commonwealth, state and local government databases.
- Heritage sites - cultural heritage objects and places as listed on Commonwealth, state and local government heritage registers.

In some cases, information about sensitive cultural assets are held by Elders and may not be listed in a Commonwealth, state or local database or register. To accommodate this information, flexibility has been integrated into the Barwon-Darling Valley FMP to accept Aboriginal values and heritage sites that are derived from 'any other source or database deemed relevant by the Minister'.

Cultural asset type – Aboriginal values

Aboriginal people have been living in the Murray-Darling Basin for at least 36,000 years, including living on lands surrounding the basin's rivers and lakes for at least 9,000 years based on archaeological evidence from middens (Blame & Hope 1990). Evidence of use of wetland areas based on the presence of hearths, middens, canoe scars, and stone tool-making sites, adds significantly to the heritage values Aboriginal people recognise on the floodplain (WCMA 2010). Aboriginal sites that may be found on the lunettes and banks of wetlands and in the vicinity of the Darling River and intersecting streams include:

- open or living sites (camp sites)
- scarred or carved trees (bark removed for tools/utensils or ceremonial markings)
- artefact scatters associated with living sites or hunting places
- rock art including painted, pecked or abraded surfaces
- manufacturing places (quarries, grinding grooves)
- sacred/ceremonial places including burial sites
- Dreamtime, story-telling and oral history places (WCMA 2010).

The Barwon-Darling Valley Floodplain contains many cultural sites and values that are important to the local Aboriginal community. Due to the sensitive nature of the data, specific Aboriginal values cannot be listed or mapped in published documents; however, Aboriginal values were generally found to include:

- wetlands and river channels, which were an important focus of settlement
- locations of Bora (initiation) ceremonies
- core semi-permanent wetlands with iconic plants (e.g. cumbungi and nardoo)
- riverine forests, woodland and grassland areas with iconic plants (e.g. river cooba, river red gum, coolibah, Mitchell grass and native millet)
- sites with scarred trees
- long-lasting waterholes of swamps in wetland areas that may have been a focus of settlement
- semi-permanent waterholes and channels on the floodplain that may have been a focus of settlement.

For the Barwon-Darling Valley FMP, Aboriginal values were identified at a regional scale by:

- reviewing previous studies that had investigated cultural values in the floodplain
- consulting with various NSW government agencies involved with landscape management within the valley (e.g. Local Land Services, National Parks and Wildlife Service, DPIW and OEH)
- targeted consultation with members of the Aboriginal community with knowledge of values connected with the floodplain
- consultation with the ATWG, that was comprised of Aboriginal people with cultural connection to the floodplain, and
- context setting using existing spatial information about the potential distribution of unidentified values using the Aboriginal Sites Decision Support Tool (ASDST) (Appendix 10).

Aboriginal values were also identified by reviewing the values recorded within the floodplain in the following databases:

- NSW Aboriginal Heritage Information Management System (AHIMS), which includes information on Aboriginal objects, Aboriginal Places and archaeological reports
- NSW Aboriginal Water Initiative System (AWIS)
- Murray Darling Basin Authority Aboriginal Submissions Database
- NSW State Heritage Register is accessed through the NSW State Heritage Inventory which includes:
    - Aboriginal Places
    - State Heritage Register
    - Interim Heritage Orders
    - State Agency Heritage Registers
    - heritage items in Local Environmental Plans
- Australian Heritage Database, also referred to as Commonwealth Heritage Register in the Barwon-Darling Valley FMP, which includes places in the:
    - World Heritage List
    - National Heritage List
    - Commonwealth Heritage List
    - Register of the National Estate.

Cultural flows

Aboriginal people view themselves as an inherent part of the river system. A holistic understanding of how water is connected to the land and rivers and the connection that Aboriginal people feel to river systems feeds a strong feeling of responsibility for the health of rivers and floodplains. The Murray Lower Darling Rivers Indigenous Nations and Northern Murray-Darling Basin Aboriginal Nations define cultural flows as:

"water entitlements that are legally and beneficially owned by the Indigenous Nations and are of a sufficient and adequate quantity and quality to improve the spiritual, cultural, environmental, social and economic conditions of those Indigenous Nations. This is our inherent right."

Cultural flows are being integrated into water planning and management.

Work is currently being undertaken by the National Cultural Flows Planning and Research Committee to improve our knowledge of cultural flows, including Indigenous water values and uses, and volumes of water that provide for those values and uses. Cultural flows may improve the health and wellbeing of Aboriginal people and empower Aboriginal communities to care for their country and undertake cultural activities.

This body of work was instigated by the Northern Basin Aboriginal Nations (NBAN). NBAN is an organisation that represents 22 First Nations in the Northern Murray Darling Basin in Natural Resource and Water Management. NBAN advises and advocates on behalf of Ancestral Owners. Its sister organisation, the Murray Lower Darling Rivers Indigenous Nations has produced a document called the *Echuca Declaration* from which the adoption of the term Cultural Flows came from. Both organisations ratified the meaning in 2011, providing the aforementioned consistent definition right across the whole MDB.

The Barwon-Darling Valley FMP does not address cultural water; however, cultural water will likely be a component of the WSPs being developed by DPIW, which will incorporate the Aboriginal cultural values identified in this study.

Aboriginal Water Initiative

The First Peoples' Water Engagement Council (FPWEC) was established to provide advice to the National Water Commission on national Indigenous water issues. The May 2012 advice set the overarching policy framework, including that there must be an Aboriginal water allocation in all water plans; that Aboriginal people are engaged in decision-making, planning and management; and that Aboriginal access to water for cultural and economic purposes is mandatory. The FPWEC also sought to establish and implement a National Aboriginal Water Strategy through the Council of Australian Governments. The FPWEC ended its tenure in 2012 and an Indigenous Water Advisory Council was formed to carry on with the initial work of the FPWEC at a national level.

An Aboriginal Water Initiative was established in June 2012 to better the involvement and representation of Aboriginal people in water planning and management in NSW. The initiative will allow DPIW to start monitoring the success of water sharing plans in meeting their statutory requirements for performance indicators specific to Aboriginal people, including providing water for Native Title rights.

The Aboriginal Water Initiative has established a database of cultural features which are water dependent. All cultural values and features identified in this study will be included in the Aboriginal Water Initiative System (AWIS), for follow-up investigations of their water requirements and the production of condition report cards by the Aboriginal Water Initiative team. The AWIS must be consulted as part of the flood work assessment process.

Cultural asset type – heritage sites

Heritage sites are cultural heritage objects and places as listed on Commonwealth, state and local government heritage registers. Some Aboriginal values may also be heritage sites and for the purposes of the Barwon-Darling Valley FMP, heritage sites were divided into historic heritage sites and Aboriginal heritage sites.

Commonwealth, state and local government heritage databases include:

- Australian Heritage Database
- Murray Darling Basin Authority Aboriginal Submissions Database
- NSW AWIS
- NSW AHIMS
- NSW Historic Heritage Information Management System (HHIMS)
- NSW State Heritage Inventory

Flood dependency of Aboriginal values and heritage sites

During the development of the Barwon-Darling Valley FMP, flood dependency of cultural assets was established so that consideration could be given to how changes to the flooding regime may impact the assets across the floodplain.

Flood dependency – Aboriginal values

Flood dependency of the Aboriginal values nominated by the Aboriginal community was determined through discussion with knowledge holders about the nature of the value, and how it is connected with floodwater. The places nominated as having significant Aboriginal value were all found to have a strong connection or dependency on flooding.

Flood-dependent Aboriginal values included sites that are not necessarily flood-dependent, but where the purpose or location of the site is flood-dependent; for instance, ceremonial locations connected with intact flood-dependent vegetation and camp sites near wetlands that may persist regardless of flooding, but may not be utilised until the landscape is flooded, and resources only abundant during flood events.

Flood dependency – historic heritage sites

Flood dependency was assessed by reviewing the heritage listing records to establish the nature of the heritage theme and value of the site and determine if this was dependent on, or connected with floodwater.

The following historical assets listed on the NSW Heritage inventory, were not identified as being flood-dependent but were considered in relation to potential flood impacts during the design of management zones in the Barwon-Darling Valley FMP:

- Bourke Weir Darling No 19A (Darling River, 20 miles below Bourke) is a 40 year old weir constructed as part of the Darling River Weir Scheme to provide domestic and stock requirements to the local Bourke region. The weir continues to service the needs of the local area which contributes to its value.
- Davidsons Lock and Weir (4 miles below Bourke by river) is a rare example of an important form of industrial technology. The Bourke Lock was the first to be built in Australia and the only one on the Darling River. Built in 1897, it was an attempt to make the river transport system more reliable, and was initiated by the river merchants. The weir still plays a vital role in the supply of water for irrigation. The remains of the lock are an important relic of the Lock and Weirs history and today is a tourist attraction.
- Barwon Bridge, Bridge Road (MR70), Brewarrina, is a significant technical accomplishment and was an important component of the historic river traffic of the Murray - Darling system. The Brewarrina bridge is the second oldest of four early movable bridges built across the Darling - Barwon River system. The bridge at Brewarrina which was furthest upstream is a tangible reminder of the penetration of the early river traffic.
- Brewarrina Weir Darling No 15 was constructed in 1968 to provide domestic and stock water requirements. The structure is a reinforced concrete weir situated on the Darling River on the outskirts of Brewarrina. The structure is slimline and clean in design. Its natural setting and pool contributes to the aesthetic appeal of the structure. The Weir is representative of a reinforced concrete weir constructed during the late 1960's in rural NSW to combat drought. The structure continues to be in use which contributes to its significance.
- Calmundi Weir is located on the Darling River, however the structure is assessed as having little heritage significance at this time as it fails to satisfy the relevant requirements of the NSW heritage criteria but has local value .

- Collarenebri Weir constructed in 1966 as part of the Drought Relief Programme introduced by Jack G. Beale, Minister for Conservation (from 1965). In addition, the local community uses the weir for fishing and recreation.
- Walgett Weir dates to an early period of development in water regulation in the area.
- Walgett Two-Mile Creek Underbridge is a rare example of a timber through truss from the post-Whitton era, built by the PWD railway construction branch in the early 20th century. It is a highly visible and accessible example of early 20th century bridge technology used as an economical solution in the development of a Pioneer line.

Flood dependency – Aboriginal heritage sites

The following Aboriginal site types occurring within the region were identified as having flood-dependent values associated with them:

- cultural modifications to living trees (e.g. coolamon scars) that are flood-dependent species
- fish traps
- ceremony and dreaming sites located within or surrounded by floodplain vegetation[1]
- resource gathering sites.

Prioritisation of Aboriginal heritage sites

High-priority Aboriginal heritage sites that are dependent on flooding are relatively rare in the floodplain and have high community importance. Each of these sites were considered in the design of the management zones to maintain condition of the site and to protect their flood connectivity. The type of Aboriginal heritage site including the process for identifying these high-priority cultural assets is outlined below.

Scarred trees

Scarred trees were investigated using AHIMS records and by inspecting the original site cards. Those scarred trees where it was clear that the tree was dead at the time of the recording, were excluded from the prioritisation. The location of each tree was also compared to 2009 SPOT imagery to ensure that there was a reasonable likelihood the tree still existed (some recordings were over 30 years old). As a result of the comparison with SPOT, some recordings were found to have locations recorded that were inconsistent with information in the original site card and were corrected when found.

Fish traps

There are several recordings of fish traps in the region. The largest and most significant of these is the one adjacent to Brewarrina, and listed as an Aboriginal place.

Ceremonial sites

A search of the AHIMS database identified thirty three ceremony sites recorded within the floodplain. Some of these have little physical remains on the landscape today but were well known in historic times. Others were recorded in detail by Etheridge (1918) in the early 20th century. One in particular contained a grove of over 80 trees with intricate designs carved into them.

[1] While it is recognised the ceremony site itself may not be flood-dependent, based on advice received from the ATWG, it was noted that many ceremonies were connected with the surrounding flood-dependent landscape, and were undertaken when many floodplain resources were abundant.

Resource gathering sites

The AHIMS data also identified 34 Aboriginal resource gathering sites. Some of these were known to have been used during historic times, while others have contemporary on-going use. Each of these sites involved plant or animal resources that were flood-dependent.

Aboriginal heritage sites vulnerable to the effect of erosion associated with the redistribution of flood flow or vulnerable to the direct impacts of the installation of new flood works or the modification of existing works are not dealt with in the design of the management zones. Therefore, these cultural assets were not prioritised but have been identified as sensitive Aboriginal heritage sites of high community importance. Where identified, these cultural assets will be an additional consideration during assessment of flood-work applications. The type of Aboriginal heritage sites that are classified as sensitive to disturbance are outlined below.

Aboriginal burials

There are 34 Aboriginal burials recorded within the floodplain, 27 of which occur adjacent to the main channel.

Aboriginal shell middens

There are 54 occurrences of Aboriginal shell middens in the floodplain, all of which occur downstream of Brewarrina. These resources were utilised during flood periods and are associated with lagoons filled during floods.

Earth-mound sites

There are several earth-mound sites recorded in the floodplain, all of which are adjacent to the main channel. These sites are closely associated with harvesting resources during flood periods.

Prioritisation of Aboriginal values

Targeted consultation was undertaken with members of the Aboriginal community throughout the region who have knowledge about flood-dependent Aboriginal values. Given available timeframes, this was not an exhaustive consultation process, and the incorporation of Aboriginal values into the FMP should be considered an on-going process.

Discussions were held in person with community members with printed maps that they could annotate. The maps were left with these people to give them a chance to consider the requirements of the plans, and follow-up discussions were held in the months following.

The consultation process identified a number of areas where the significance of Aboriginal values warranted an exclusion of further flood works. In some cases, this was because of the importance and sensitivity of important sites. In other cases, it concerned areas of relatively intact land that were rich with sites associated with living in the floodplain or where contemporary cultural activities are undertaken.

The areas were digitised and were used to inform the design of the management zones in the plan. The areas identified and their associated values will be stored in the AWIS database of flood-dependent Aboriginal values established by DPIW, and managed by the Aboriginal Water Initiative. The database will be drawn upon during the assessment of flood-work applications.

Step 6: Prepare a socio-economic profile

To develop options for future floodplain management, the floodplain area must be understood and the ability of the community to absorb change appreciated. A socio-economic profile of the Barwon-Darling Valley Floodplain was determined in this step to effectively consider the social and economic impact of development controls in the floodplain and flood risk to life and property from the effects of flooding. The socio-economic profile is detailed in Appendix 11 and a summary is provided below.

The profile is an assembly of existing key socio-economic data which provide a general picture of the catchment in terms of its socio-demographic and economic structures. Key socio-economic data that informs the baseline profile include:

- geographies that are relevant to the socio-economic discussion of water use on the floodplain
- demographic profiles
- employment by industry
- income statistics
- economic wellbeing indicators
- production statistics.

Information from this assessment is used in the socio-economic impact analysis of the proposed FMP, which is outlined in Step 10. The socio-economic impact analysis is undertaken in coordination with the development of management zones and rules for a valley and informs Steps 7, 8 and 9 of this process.

Study area geography

There are three geographies that are relevant to the socio-economic discussion of water use on the Barwon-Darling Valley Floodplain (see Table 6 for a description and Appendix 11 for maps showing the areas).

Table 6: Description of study area geographies used in socio-economic profile

Geography	Size (ha)	Description
Barwon-Darling floodplain economy	8,025,600	Includes the Barwon-Darling rural and urban floodplains as well as the adjacent areas in the catchments that engage with the economy of the region. Located between the regional centres of Moree, Dubbo and Broken Hill and the Queensland border. Most goods and services consumed in this area are sourced from Bourke, Brewarrina, Collarenebri, Lightning Ridge and Walgett, or other small townships in this area.
Barwon-Darling rural floodplain	4,777,900	This area includes the Barwon-Darling Valley Floodplain but also extends into the broader surrounding floodplain area. This area will be directly impacted by the Barwon-Darling Valley FMP. The community residents who live and work in this area are predominantly agricultural based, but the community does include people who live in small rural towns. There are limited community services and infrastructure in this area; most of the required farm inputs and human services are provided from the local towns and the regional centres.
Barwon-Darling urban floodplain	n/a	Incorporates the townships of Bourke, Brewarrina, Collarenebri and Walgett. Flood water management in urban areas of NSW is provided under the *Local Government Act* (1993). The communities that live in these towns are reliant upon the surrounding rural floodplain areas both as a source of employment and as a consumer of services.

Data sources

Demographic data for the Barwon-Darling floodplain economy, the Barwon-Darling rural floodplain, and the Barwon-Darling urban floodplain; on population including the Aboriginal community, on sex and age ratios; on household weekly incomes; and on labour participation rates and employment by industry sector; is drawn from the Australian Bureau of Statistics (ABS) Census of Population and Housing 2011 Statistical Area level 1 (SA1) data (ABS 2011a). The SA1 areas are the smallest unit for release of Census data. The SA1 boundaries combine to form the boundary of the Barwon-Darling floodplain economy and the urban floodplain areas. The Rural Floodplain area is defined as parts of 5 SA1 areas. Regional population trends for the Local Government Areas have been drawn from the ABS Regional Population Growth 2013 data (ABS 2013).

Information on the relative socio-economic advantage and disadvantage rankings for the LGA and SA1 areas is drawn from the ABS Census of Population and Housing 2011 Socio-economic Indexes for Areas (SEIFA) (ABS 2011b).

Agricultural production is a significant component of the Barwon-Darling floodplain economy. The ABS Agricultural Census 2011 (ABS 2011c) provides comprehensive data on both dry land and irrigated agricultural production at the Statistical Area level 2 (SA2). SA2 areas are a general-purpose medium sized area built from whole SA1s. The SA2 communities of the Barwon-Darling floodplain economy include parts of the SA2 regions of Bourke – Brewarrina, Walgett – Lightning Ridge and Moree Region.

Demographic profiles

Demographic information is provided in Table 7 and includes information on the population, percentage of the population living in towns, percentage of the community who are Aboriginal, gender ratio and the dependency ratio for each geography and the state average.

Table 7: Demographic information per socio-economic geography

Geography	Population	Percentage living in towns	Aboriginal community (%)	Gender ratio (men to women)	Dependency ratio (proportion of the population not working vs working)
Barwon-Darling floodplain economy[1]	10,690	72	34.5	110	59[2]
Barwon-Darling rural floodplain	1, 800[3]	n/a	15.6	119	53[2]
Barwon-Darling urban floodplain	5, 150	n/a	49.3	98	57[2]
State average	n/a	n/a	2.5	97	52

[1] The information about population is based on ABS collection district (CD) boundaries that do not match the boundary of the Barwon-Darling Valley Floodplain economic areas (rural and urban floodplains). Therefore the total of the Barwon-Darling rural and urban populations do not equal the overall Barwon-Darling floodplain economy.

[2] may be overstated.

[3] based on 3.8 people per 100 km^2 based on the ABS Census 2011

The age by sex distribution of the Barwon-Darling floodplain economy and the Barwon-Darling rural floodplain community reveals an under representation in the 15 to 45 age groups, as compared to the under 15 and over 45 age groups of the NSW population.

Employment by industry

Employment in the Barwon-Darling floodplain economy is predominantly within the agricultural, forestry and fishing sector, with 23.5 per cent of employment (920 persons, with this number including employment in a large agricultural area that is not on the rural floodplain). In contrast, the NSW state agriculture sector engages 2.2 per cent of the workforce. The next most significant employment sectors are health care and social assistance, education and training and public administration and safety, with 13.8 per cent, 12.7 per cent, and 11.6 per cent of employment respectively. Employment in the Barwon-Darling rural floodplain is dominated by the agriculture, forestry and fishing sector, with 55.4 per cent of the workforce or 510 persons, working in the agricultural industry. In contrast, employment in the Barwon-Darling urban floodplain is dominated by the service sectors of public administration and safety, health care and social assistance, and education and training.

Income

The proportion of low income households in the Barwon-Darling floodplain economy, Barwon-Darling rural floodplain and Barwon-Darling urban floodplain was 38 per cent, 22 per cent and 29 per cent respectively, compared with the NSW state proportion of 23 per cent. The medium income households' proportion of 53 per cent for the Barwon-Darling floodplain economy, 60 per cent for the Barwon-Darling rural floodplain and 60 per cent for the Barwon-Darling urban floodplain, are close to the NSW proportion of 56 per cent. The proportion of high income households within these three areas (9 %, 18 % and 10 %) are each lower than the NSW state proportion of 21 per cent.

Economic wellbeing indicators

The Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) ranks areas in terms of relative socio-economic advantage and disadvantage, using 25 variables. An area with a high score on this index has a relatively high incidence of advantage.

The IRSAD scores for key regions are (see Appendix 11):

- Local Government Area of Bourke (A) is in the 3rd decile
- Moree Plains (A) is in the 2nd decile
- Local Government Areas of Brewarrina (A) and Walgett (A) are in the 1st decile of NSW, demonstrating distinct relative disadvantage at a large scale
- The Barwon-Darling rural floodplain area is generally within deciles 4 to 7, indicating that they are neither advantaged nor disadvantaged, or are relatively marginally advantaged, excepting the SA1 surrounding Brewarrina (decile 1) which is substantially disadvantaged
- The index scores for the smaller SA1 areas representing the townships are all within deciles 1 to 3 indicating that they are relatively disadvantaged, excepting one SA1 on the south of Bourke (decile 4) and two SA1s on the East of Walgett (decile 4 and 6).

Production

Agricultural production is the significant economic activity of the region's economy, occupying 86 per cent of the farm holdings in the Barwon-Darling Valley Floodplain. The Gross Value of Agricultural Production (GVAP) in 2010-2011 in the Barwon-Darling Valley Floodplain, using a farm holding area of 946,200 ha, is estimated to be $122 million or 1.1 per cent of total NSW GVAP. The gross value of broadacre cropping, estimated at $105 million, constitutes 86 per cent of the GVAP of the Barwon-Darling Valley Floodplain production using 138,800 ha or 15 per cent

of the area. The highest value producing individual broadacre crops are wheat yielding $36 million and cotton yielding $55 million or 30 per cent and 45 per cent of the total Barwon-Darling Valley Floodplain GVAP, respectively. Livestock and livestock products yield $15 million, accounting for 12 per cent of GVAP while using 85 per cent of the area.

There was an estimated total of 18,200 ha of irrigated land in the Barwon-Darling Valley Floodplain in 2010-2011. This area of irrigated land constitutes approximately 1.6 per cent of the Barwon-Darling Valley Floodplain farm holding area. It is estimated that 92,000 ML of water was extracted for agricultural irrigation across the regions in 2010-2011. The majority of the irrigation water used in 2010-2011 was applied to cotton, using 84,500 ML or 92 per cent, at an estimated average rate of 5.6 ML/ha.

Step 7: Delineate management zones

In Step 7, the nature and location of the management zones in the Barwon-Darling Valley Floodplain was determined using hydraulic, ecological and cultural criteria as well as criteria to ensure the plan reflects existing floodplain management arrangements. This approach considered the impact of existing and future development on flooding in rivers and floodplains; the flood risk to life and property; the flood connectivity of floodplain assets and the social and economic impacts of restricting flood-work development.

The above approach resulted in five management zones for the Barwon-Darling Valley FMP.

Description of management zones

The Barwon-Darling Valley FMP contains five management zones (MZ):

- MZ A – Major discharge areas, defined floodways (337,700 ha or 31 % of the floodplain)
- MZ B – Flood storage and secondary flood discharge areas (516,400 ha or 47 % of the floodplain)
- MZ C – Flood fringe and flood protected developed areas (234,500 ha or 21 % of the floodplain)
- MZ CU – Urban areas managed by local council (1400 ha or < 1 % of the floodplain)
- MZ D – Special protection areas (5500 ha or < 1 % of the floodplain)

A map of the management zones is shown in Figure 15 and a summary description is provided below. More detailed maps are provided in Appendix 12.

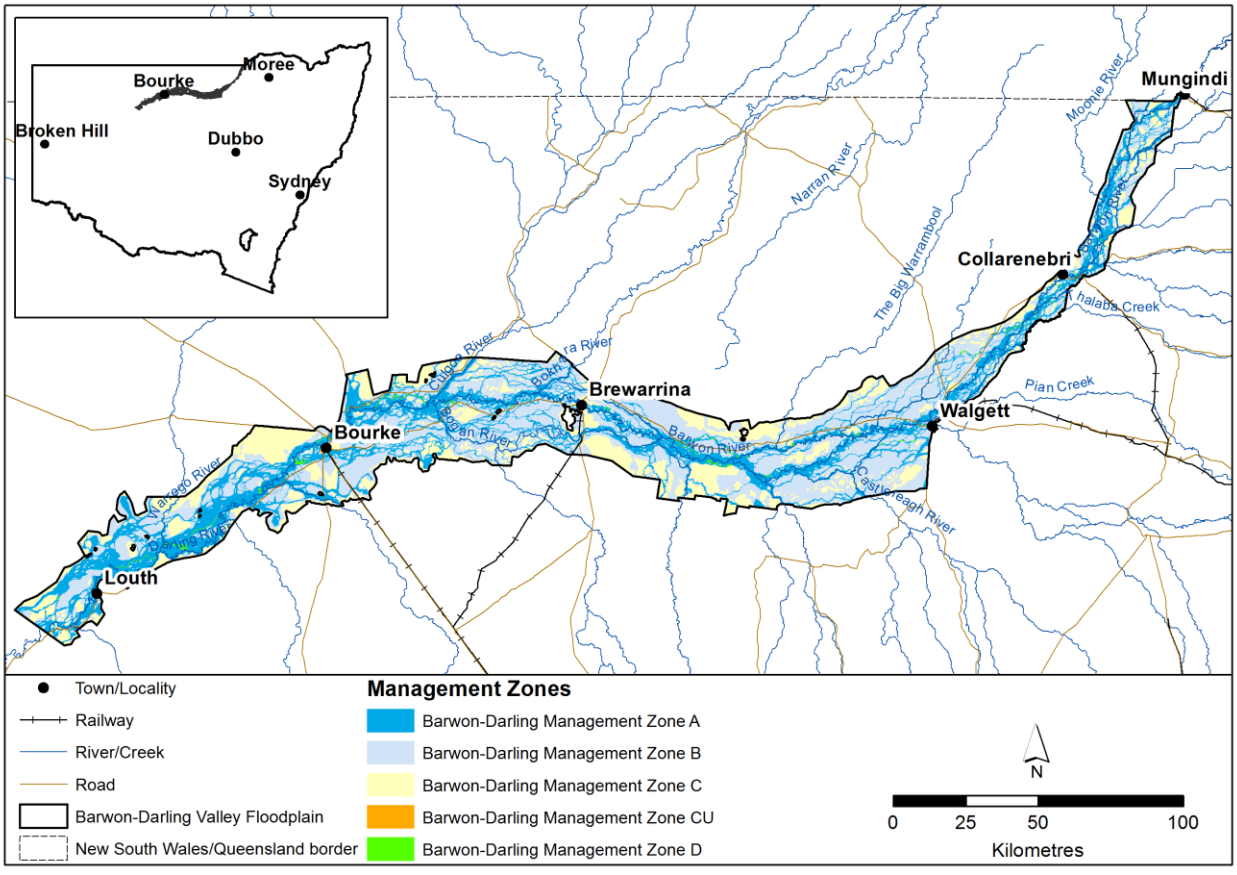

Figure 15: Map of the management zones in the Barwon-Darling Valley Floodplain

Management Zone A – major flood discharge areas and defined floodways

MZ A covers 337,700 ha or 31 per cent of the floodplain. It includes defined floodways with channels or banks that include major drainage lines and other areas where a significant discharge of floodwater occurs during all flood events. These areas are generally characterised by relatively high flood flow velocity and high depth-velocity thresholds (see Table 3 for further information).

MZ A includes areas where uncoordinated flood-work development may have a high adverse impact on flood behaviour. It was designed to ensure a reduction in the risk to life and property by limiting flood-work development to prevent flood flow redistribution, increased flood velocities and flood levels. MZ A was designed to ensure there is continuity of flow and flow paths and assist in maintaining the overall flow distribution on the floodplain.

MZ A is also important for the conveyance of floodwater to highly flood dependent ecological and cultural assets. MZ A includes the extent of semi-permanent wetland and key fish passage areas to ensure connectivity to these significant assets. MZ A was also designed to provide flood connectivity to floodplain wetland (flood-dependent shrubland wetlands) and flood-dependent forest/woodland (wetlands).

MZ A includes the extent of Aboriginal values that are highly flood-dependent. Certain trees that have been modified by Aboriginal people have also been included in MZ A. Such trees must be scarred or carved trees, found to be living, in close proximity to floodways and require relatively frequent flooding to maintain their ecological character.

Where the Barwon-Darling adjoins another FMP, floodways in the Barwon-Darling have been aligned to ensure floodway continuity and protection between floodplains. Adjoining floodplains include: Border Rivers, Gwydir, Lower Namoi and Macquarie.

Management Zone B – flood storage and discharge areas for design floods

MZ B covers 516,400 ha or 47 per cent of the floodplain. It includes areas that are important for the conveyance of floodwater during large flood events and for the temporary pondage of floodwaters during the passage of a flood. The outer boundary is defined by the modelled inundation extent of the large design flood (1976).

MZ B included ecological assets that have a moderate level of flood dependency. MZ B may include areas of floodplain wetland (flood-dependent shrubland wetlands), flood-dependent forest/woodland (wetlands) which were not captured entirely within MZ A and areas of flood-dependent woodlands. MZ B also includes cultural assets such as modified trees that are likely to only be flood connected during moderate and large floods.

MZ B is important for the conveyance of floodwater to floodplain assets during larger flood events. This zone includes areas where coordinating flood-work development is important to manage the cumulative and local impact of works on flood behaviour.

Management Zone C – flood fringe areas and existing developed areas

MZ C covers 234,500 ha or 21 per cent of the floodplain. It contains flood fringe and flood protected developed areas. This zone includes areas protected by flood works that are unlimited height and are not overtopped by water during moderate to large floods.

Ecological assets that are highly flood-dependent were not recommended for inclusion in MZ C. However, ecological assets that occur in this zone may include areas of floodplain wetland (flood-dependent shrubland wetlands), flood-dependent forest/woodland (wetlands) and flood-dependent woodlands occurring adjacent to floodplain watercourses in flood fringe areas. Some of these assets may occur in developed areas which are potentially disconnected from flooding. All flood-dependent ecological assets in this management zone are to be considered during the assessment of flood work applications.

MZ C also includes some cultural assets such as scarred trees. Generally, these trees are species that require infrequent flooding or the record of the tree could not be verified. All cultural asset records in this management zone are to be considered during the assessment of flood work applications.

Management Zone CU – Urban areas managed by Local Council (hereafter MZ CU)

MZ CU covers 1400 ha which is less than one per cent of the floodplain. It captures urban areas that are covered by either a flood study, flood risk management study, flood risk management plan or that are protected by flood mitigation works such as town levees.

It includes parts of Walgett, Brewarrina, Bourke, Collarenebri and Louth that are urban areas where flood risk is managed by local councils through flood risk management plans and studies developed in accordance with the *Floodplain Development Manual* (NSW Government 2005).

Management Zone D – special protection areas

MZ D covers 5500 ha or less than one per cent of the floodplain. It is a special protection zone for areas of ecological and/or cultural significance. These areas are subject to very frequent inundation and have high ecological and/or cultural value. There are 58 MZ D areas as listed in Appendix 13.

Image 1. *An example of a MZ D area of the Barwon-Darling Valley FMP. Big Billabong, Bourke. (S.Hunter, OEH, Feb 2016)*

Hydraulic criteria

Management zones were initially established based on hydraulic criteria, which were developed from information on flood behaviour contained in the floodway network and the flood fringe (i.e. areas outside of the floodway network) (Table 3 and Figure 6). The following three hydraulic categories were the basis of MZ A, B and C:

- floodways are the hydraulic basis for MZ A (316,770 ha)

- inundation extent of the large design flood is the hydraulic basis for MZ B (516,300 ha)
- flood fringe is the hydraulic basis for MZ C (234, 500 ha)

MZ CU and MZ D do not have a hydraulic basis.

Ecological criteria

Management Zones A and B

Floodplain water flows are crucial to maintain the structure and function and long-term survival of flood-dependent ecological assets. Flood-work development has the potential to change the passage of floodwater which can have adverse impacts on flood-dependent ecological assets. To minimise the likelihood of this occurrence, ecological criteria were developed to ensure flood connectivity will be maintained to wetlands, watercourses and floodplain ecosystems and areas of groundwater recharge. The criteria outline the optimum watering requirements for each asset as well as the recommended management zone that aligns with these requirements (Table 8).

Ecological criteria were finalised in discussion with TAG members and local experts. In addition to the criteria in Table 8, key fish habitat areas for silver perch (*Bidyanus Bidyanus*), olive perchlet (*Ambassis agassizii*), eel tailed catfish (*Tandanus tandanus*) and purple spotted gudgeon (*Mogurnda adspersa*) were also considered as ecological criteria. Key fish habitat data was identified from the NSW Fish Community Status and Threatened Fish Species Data (Aquatic Biodiversity Value Mapping Project – NSW DPI 2016) and was recommended for inclusion in MZ A. However, no management zone refinements were required as all indicative threatened species distributions identified by NSW DPI 2016 were included in MZ A.

Table 8: Ecological criteria, including management zone recommendation for each asset type

Asset	Hydro-ecological functional group	Ideal frequency of watering	Management Zone recommendation
Wetland	Watercourses (including billabongs, waterholes, lakes and anabranches)	Annual or near annual	MZ A
	Semi-permanent wetland	Annual or near annual	MZ A (entire mapped area)
	Floodplain wetland (flood-dependent shrubland wetlands)	Every year to 1 in 5 years	MZ A (mapped area at least has a hydraulic connection through asset)
Other floodplain ecosystems	Flood-dependent forest/woodland (wetlands)	1 in 3 to 1 in 5 years	MZ A (mapped area at least has a hydraulic connection through asset)
	Flood-dependent woodland	1 in <10 years	MZ B
Areas of groundwater recharge	Likely recharge		MZ A or B*

*Due to limited groundwater recharge information, no modification of management zones could be undertaken.

The management zone recommendations, outlined in Table 8, were initially used to determine if ecological assets were captured in the recommended management zone. Prior to application of ecological criteria, approximately 86 per cent of semi-permanent wetland, 60 per cent of floodplain wetland (flood-dependent shrubland wetlands) and 97 per cent of flood-dependent forest/woodland (wetlands) were found to occur in hydraulic floodways (Table 9).

The high proportion of inner floodplain semi-permanent wetlands was expected as these communities tend to occur within channels or depressions in close proximity to floodways (MZ A) and depend on frequent flooding to survive and maintain their condition. Similarly, ecological assets such as flood-dependent forest – river red gum (*Eucalyptus camaldulensis*) are inner floodplain vegetation communities predominately found along or adjacent to the banks of watercourses and primary channels, such as the consistent patterns of vegetation identified by Shultz et al. (2014) and Eco Logical Australia 2015 including the presence of River Red Gum tall open forest (PCT 36) occurring along the Darling, Little Bogan and Bogan rivers and the majority of this vegetation community were identified as already having connection to floodways (MZ A).

Outer floodplain vegetation, such as flood-dependent woodlands – coolibah and black box (*Eucalyptus largiflorens*) woodlands were found to extend from the inner floodplains (36 %) across the landscape into MZ B (52 %), which are parts of the floodplain that experience a wide range of inundation frequency and duration (Table 9). These communities also extend into MZ C (12 %) which may reflect inundation frequency greater than the large design flood and/or that these communities may be located within existing flood-work development. Most of flood-dependent woodland occurred in MZ A and MZ B (88 %) prior to the application of ecological criteria in areas with variable flooding regimes. Only minor refinements were made to management zones where this asset type occurred adjacent to ecological asset types recommended for MZ A.

Where ecological assets were not captured in the recommended management zone (see Tables 8 and 9) refinements were made to MZ A and MZ B to incorporate assets based on optimum watering requirements. Refinements were made using interpretation of LiDAR DEM, hydraulic modelling, and water count and water prevalence data.

Overall, approximately 20,900 ha were added to MZ A after application of ecological criteria. The proportion of semi-permanent wetland within MZ A or MZ D increased from 86 to 98 per cent. Connecting almost 100 per cent of semi-permanent wetland to floodways will help to protect flood connectivity to these assets and to conserve these significant ecological areas in to the future.

The objective of the ecological criteria for floodplain wetland and flood-dependent forest/woodland (wetlands) was to connect the assets to floodways (not to wholly incorporate them into the zones). The proportion of flood-dependent forest/woodland (wetlands) and floodplain wetland mapped as their recommended management zone was very high (97 %) and moderately high (60 %), respectively before application of the ecological criteria (Table 9). Minor changes were made to the zones to connect additional isolated assets in these sub-group categories.

Where a management zone could not be amended to connect recommended asset types (i.e. could not be hydraulically justified), these assets will be protected through application of the management zone rules and assessment criteria (Step 8) as part of the flood work assessment process.

Table 9: Proportion of ecological assets mapped for each zone before and after ecological criteria. The green cells indicates the management zones recommended for each type of asset.

Asset	*Before (%)			After (%)			
	A	B	C	A	D	B	C/CU
WETLANDS							
Semi-permanent wetland	86	13	1	66	32	1	1
^Floodplain wetland (flood-dependent shrubland wetlands)	60	38	2	66	1	31	2
OTHER FLOODPLAIN ECOSYSTEMS							
^Flood-dependent forest/woodland (wetlands)	97	3		97	1	2	
^Flood-dependent woodland	36	52	12	37	1	50	12

*Figures based on the floodway network only. In this scenario there is no MZ CU or D in the hydraulic floodway network. MZ C was determined using areas outside of the floodway network.

^Ecological criteria required a connection to go through these vegetation communities rather than the entire spatial extent of the vegetation community be incorporated as the recommended zone

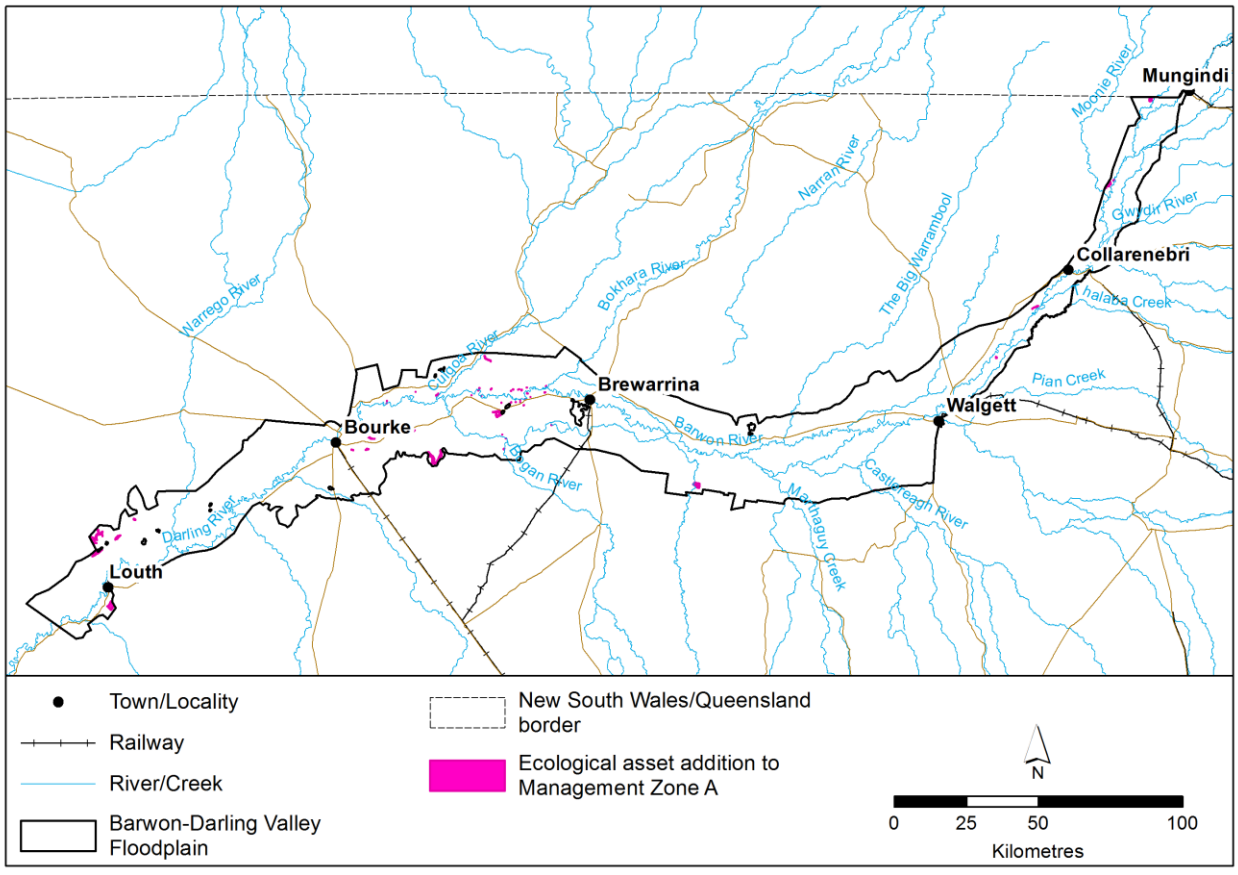

Figure 16: Refinements to Management Zone A based on ecological criteria

Management Zone D

MZ D was based on floodplain assets of special value that have high flood dependency, high ecological or cultural value. These assets may also have been identified as features susceptible to conversion or loss of flood connectivity due to flood-work development. Forty nine floodplain assets were recommended to become MZ D based on ecological criteria (Figure 17). After application of MZ D criteria 32 per cent of mapped semi-permanent wetland areas was included in MZ D (Table 9). An overview of the ecological significance of each MZ D asset is provided in Table 10. A detailed description of MZ D assets is provided in Appendix 13.

Criteria to classify an ecological asset as MZ D included that the asset:

- had been identified in previous studies as having a high degree of floodwater dependency, habitat complexity and/or a history of supporting a diversity or abundance of waterbird, native fish or frog populations and/or
- has the functional capacity to act as an aquatic drought refuge and/or
- has been mapped, recognised in or protected by a local, state, or commonwealth environmental policy and/or
- has been reviewed by a technical expert panel and/or
- is susceptible to conversion or loss of flood connectivity due to flood-work development and/or
- is listed as a significant lagoon or wetland in a WSP.

Table 10: List of floodplain assets classified as Management Zone D, based on ecological significance

Ecological significance	MZ D ecological asset
Recognised in commonwealth environmental policy (MDBA 2010)	Briery Anabranch, Briery Water, Broadsheet Lagoon on Wombat Creek, Canary Lagoon, Horseshoe Lagoon (A) and (B), Kier Lagoon, Ross Billabong, Ryan's Lagoon on Mulga Creek, Talowla Billabong, The Big Billabong, and Warraweena Lagoon
Functional capacity to act as waterbird feeding and breeding habitat	Ngemba Old Mission Billabong Polygonum Swamp, Ross Billabong, Ryan's Lagoon on Mulga Creek, and Warraweena Lagoon
Listed as a significant lagoon or wetland in Schedule 4 of the WSP for the Gwydir Unregulated and Alluvial Water Sources 2012	Unnamed lagoons 1 - 9
Functional capacity to act as an aquatic drought refuge	All of the above MZ D ecological assets and: Butti Lagoon, Collymongle Lagoon, Duck Egg Swamp, Eight Mile Lagoon, Elephant Waterhole, Euromlin Lagoon, First Lagoon, Fish Holes Lagoons, Gidgin Lagoon, Half Moon Lagoon, Herding Yard Lagoon, Louth Waterhole, Orange Tree Lagoon, Piano Creek Lagoons, Second Lagoon, Sparkes Warrambool, Toothia Billabong, Turee Lake, Ulah Lagoon, Walgett Lagoon, Waterholes at Big Waterhole Creek, Weerabilla Lagoon, Wigelroy Lagoon, Yambacuna Lagoon, Yambie Lagoon, and Yambie Swamps

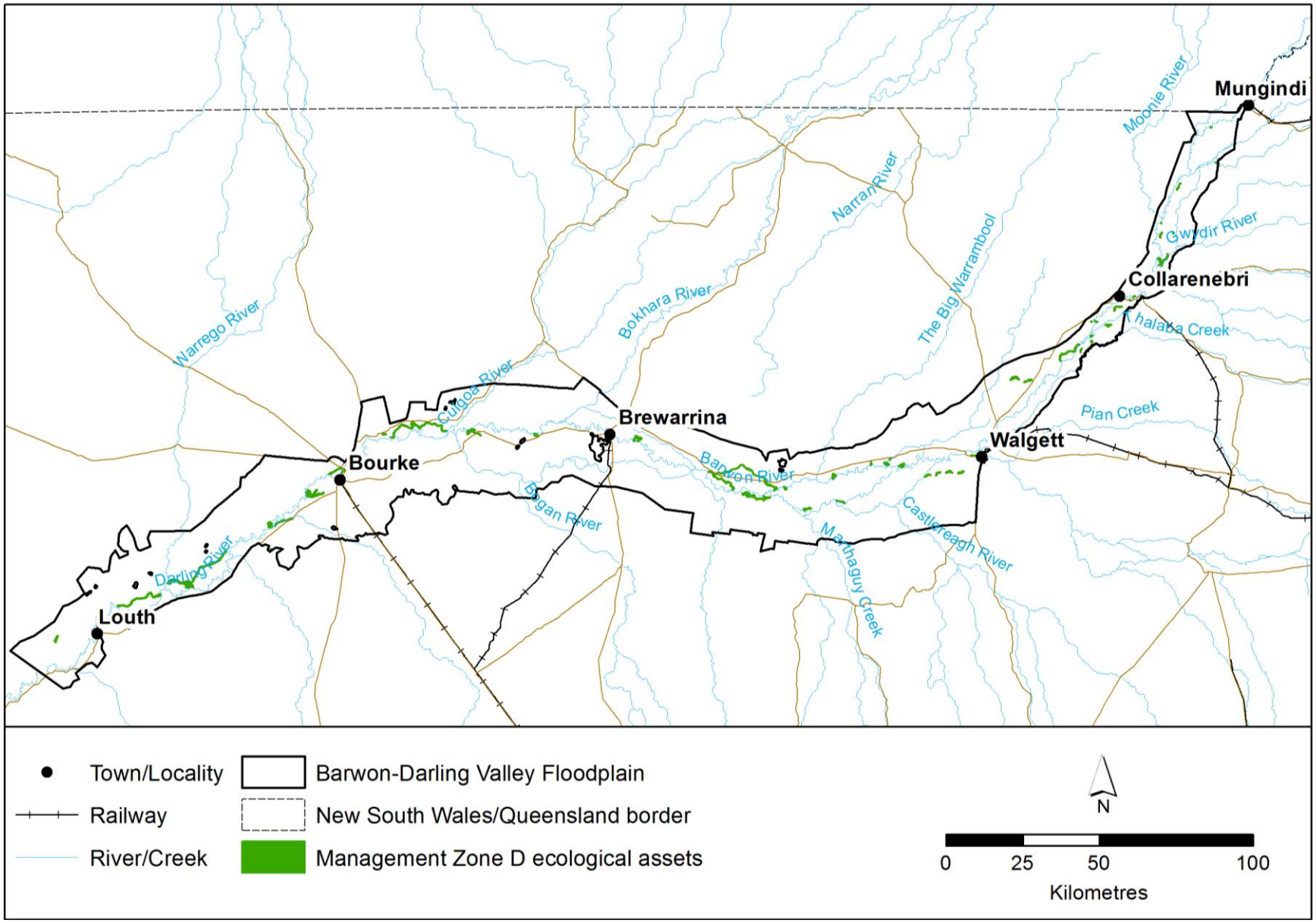

Figure 17: Location of Management Zone D ecological assets in the Barwon-Darling Valley Floodplain

Cultural criteria

Cultural criteria was developed to ensure that flood-dependent Aboriginal heritage sites and values are not impacted by flood behaviour changes caused by flood-work development. Historic heritage sites that are not flood dependent were not included as part of the cultural criteria for management zone delineation (Table 10).

Cultural criteria were based on flood dependency of Aboriginal values and heritage sites determined in step 5. Cultural criteria were finalised in discussion with TAG members and local Aboriginal heritage experts. Three criteria were used to refine MZ A (where there was hydraulic justification) to incorporate cultural assets:

1. Aboriginal values (excluding scarred/carved trees) that are highly flood-dependent if they:
    - are listed on the DPIW AWIS database, or
    - are listed on the NSW AHIMS, or
    - were identified during direct community consultation with the local Aboriginal community
2. scarred/carved tree locations where the trees are:
    - living flood-dependent vegetation that generally requires flooding at least every five years to maintain their ecological character and cultural value
    - within 100 m of hydraulic MZ A
3. Heritage sites that are flood dependent and are cultural heritage objects and places as listed on Commonwealth, state and local government heritage registers.

Overall, approximately 600 ha were added to MZ A based on cultural criteria. These additions were to better connect scarred/carved trees to hydraulic floodways. More extensive changes based on cultural criteria were not required due to the high correlation of the management zones with the identified assets. Modifications were not made to MZ B, MZ C or MZ CU using cultural criteria.

To ensure management zone refinements represent on-ground conditions the above criteria were field validated against expert recommendations and to account for data accuracy and confidence. Where hydraulic justification could not be made to amend the management zones, application of management rules and assessment criteria through the flood work assessment process will to protect flood connectivity to the assets in Step 8.

In addition to the refinements to MZ A, cultural criteria was also developed to include floodplain assets in MZ D. Eleven floodplain assets were recommended for inclusion in MZ D based on cultural criteria. Criteria to classify a cultural asset as MZ D included that the asset was a location or landscape feature with a high degree of:

- flood water dependency such as swamps, marshes, lagoons, billabongs, rocky bars or warrumbools that are strongly dependent on the passage of floodwater
- cultural significance to the Aboriginal community, including spiritual, archaeological or resource use-values and are listed on a heritage register or scientific publication or
- cultural significance recognised by several senior knowledge holders in the Aboriginal community.

Due to cultural sensitivities surrounding MZ D cultural assets, Table 11 includes a description of the criteria that each asset has met to qualify as a MZ D asset and Appendix 13 provides a detailed description of each asset.

Table 11: List of floodplain assets classified as Management Zone D, based on cultural criteria

MZ D cultural asset	Cultural significance
Brewarrina Fish Traps	Culturally significant to the Aboriginal community including spiritual, archaeological or resource use-values (Maclean et al. 2012). Listed on the National Heritage List (2005)
Bundabina Falls	Area linked with flooding and is recognised for its cultural significance by several senior knowledge holders in the Aboriginal community. Identified as an important cultural area in Hudson and Bacon (2009).
Butti Lagoon	Area recognised for its cultural significance by several senior knowledge holders in the Aboriginal community. Functional capacity to act as an aquatic drought refuge (as per ecological criteria) Identified as an important cultural area in Hudson and Bacon (2009).
Cemetery Billabong	
Comilaroy Billabong 1	
Eurool Wetland	
Gil Gil Creek Waterhole	
Meeki Creek Billabong	
Ngemba Old Mission Billabong	Listed as an Aboriginal Protected Area recognised for both its ecological and cultural features (Maclean et al. 2012). Functional capacity to act as an aquatic drought refuge and waterbird feeding and breeding habitat (as per ecological criteria)
Two (2) Mile Creek Lagoon	Area recognised for its cultural significance by several senior knowledge holders in the Aboriginal community. Functional capacity to act as an aquatic drought refuge (as per ecological criteria) Identified as an important cultural area in Hudson and Bacon (2009).
Wali Billabong	

Non-flood dependent cultural assets

Cultural assets vulnerable to the effect of erosion associated with the redistribution of flood flow or vulnerable to the direct impacts of the installation of new flood works or the modification of existing works are not dealt with in the design of the management zones. Where identified, these cultural assets will be an additional consideration during the assessment of a flood work application.

Review of existing floodplain management arrangements

The purpose of this stage was to review the draft management zones, derived from the hydraulic, ecological and cultural criteria above, to reflect existing floodplain management arrangements. All management zones were reviewed for consistency with existing floodplain management studies and guidelines. This included review and consideration of identified floodway areas within the following existing guidelines in developing and refining the boundaries of MZ A:

- Guidelines for Flood Plain Development Darling River Little Bogan confluence to Yanda Creek confluence (WRC 1986a)
- Guidelines for Flood Plain Development Darling River Yanda Creek confluence to Louth (WRC 1986b)

New criteria were developed at the scale of the FMP, guidelines and approved flood works. A new criterion was also developed to account for urban areas where flood works generally do not require approval under State-wide exemptions to the WMA 2000 but are not exempt on landholdings greater than 0.2 ha.

Four criteria to reflect existing floodplain management arrangements were developed:

1. amendments to make MZ A and MZ B congruent with neighbouring floodways in the Gwydir Valley FMP 2016, draft Lower Namoi Valley FMP and draft Macquarie Valley FMP
2. inclusion of floodways in existing guideline areas, where possible, into MZ A
3. inclusion in MZ C areas of the floodplain enclosed by existing approved flood works that are not designed to be overtopped during flooding
4. zoning floodplain areas that are included within existing urban flood studies, flood risk management studies or floodplain risk management plans as MZ CU:
    - Bourke (~ 650 ha)
    - Brewarrina (~ 100 ha)
    - Collarenebri (~ 100 ha)
    - Louth (~ 50 ha)
    - Walgett (~ 500 ha)

Overall, the majority of MZ A aligned with existing floodways in the guidelines. In areas where existing and proposed floodplain management arrangements could not be aligned, as outlined in Step 9, the changes reflect improvements in floodplain knowledge and flood behaviour, improvements in spatial knowledge of existing flood-work development and a more consistent approach to floodplain management across the floodplain.

Summary of management zone criteria

The overall configuration of management zones in the Barwon-Darling Valley Floodplain was based on four categories of management zone criteria:

- hydraulic criteria
- ecological criteria
- cultural criteria
- criteria to reflect existing floodplain management arrangements.

Management zones A, B and C were predominately based on hydraulic criteria. Around 20 per cent of MZ C was based on existing approved flood works as part of criteria to better reflect existing floodplain management arrangements. One hundred per cent of MZ CU was based on towns managed by local councils identified as part of the criteria to better reflect existing floodplain management arrangements. All of MZ D was based on ecological and cultural assets identified using ecological and cultural criteria (Figure 18).

Figure 19 outlines the percentage that each management zone occupies in the Barwon-Darling Valley Floodplain. MZ B is the largest zone, occupying 47 per cent of the total floodplain area. MZ CU and MZ D were the smallest zones both occupying less than one per cent of the total floodplain area.

A summary of the criteria for delineating management zones is provided in Table 12.

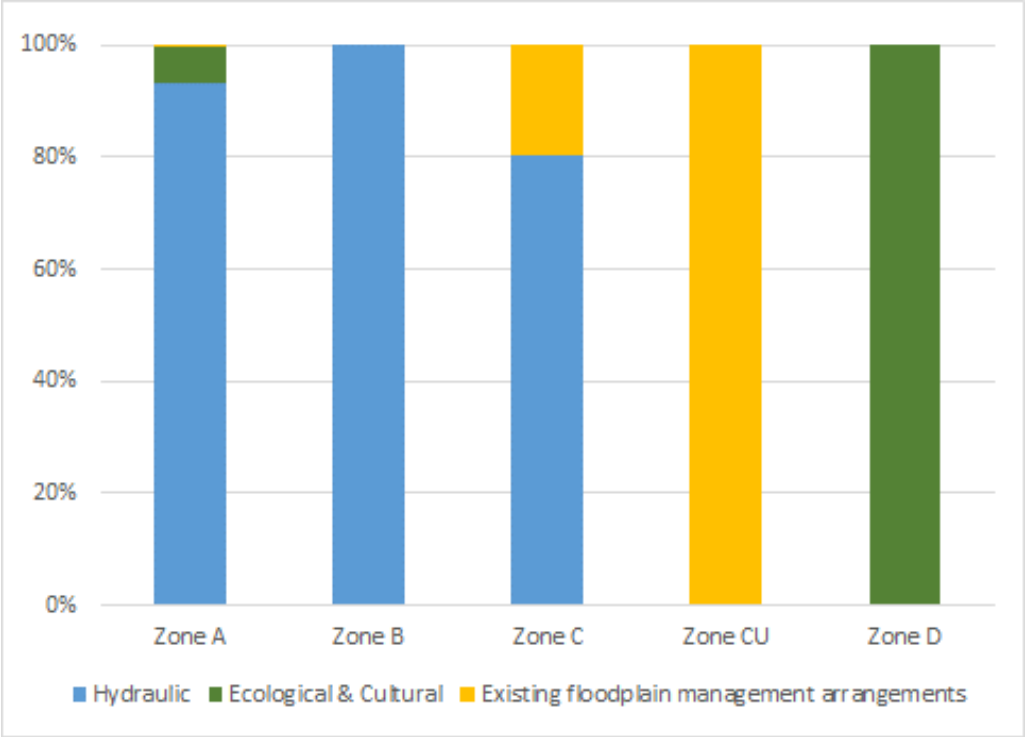

Figure 18: Percentage contribution of the four types of criteria (hydraulic, ecological, cultural, existing arrangements) to each management zone

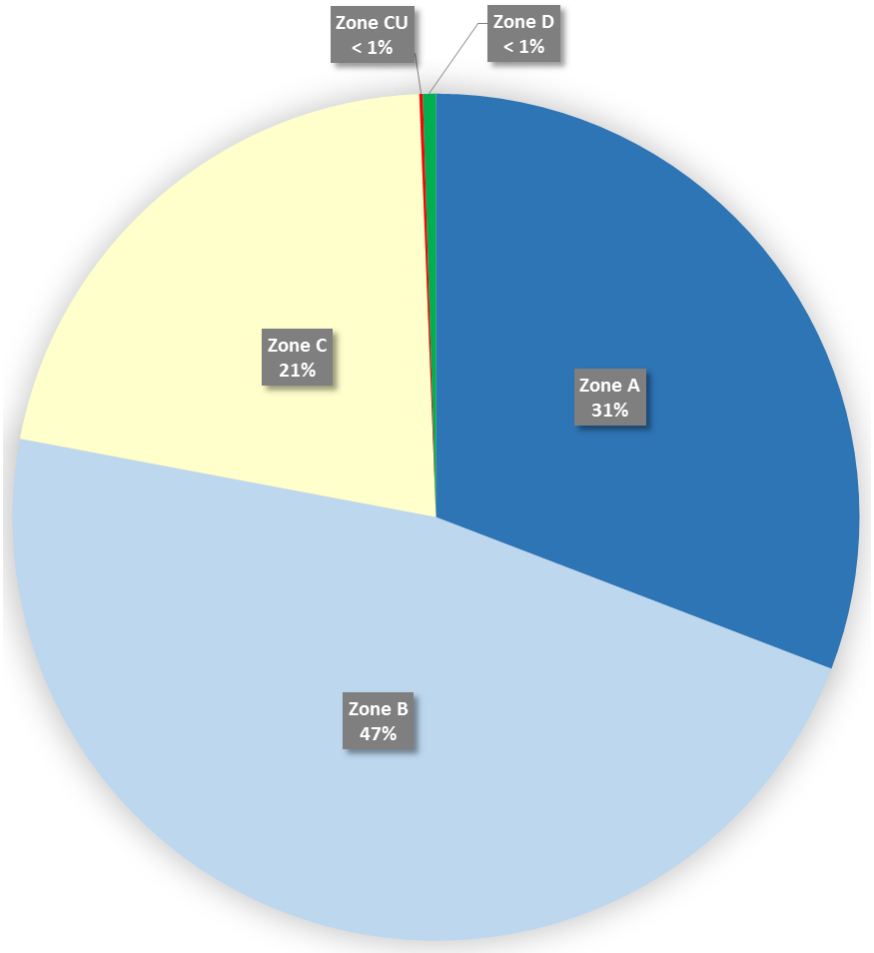

Figure 19: Proportion of the floodplain mapped as each of the five types of management zones

Table 12: Compilation of management zone criteria

MANAGEMENT ZONE A

Hydraulic criteria
MZ A includes major discharge areas that have a DVP of greater than or equal to 0.3 m^2/s for the large design flood (1976).

Floodplain connectivity was provided for by incorporating:
- parts of the small design flood extent (2011) and/or
- floodplain areas that support tributary flows and outer floodplain floodways that have a DVP of greater than or equal to 0.10 m^2/s for the large design flood (1976).

Ecological criteria
MZ A includes, where there is hydraulic justification:
- semi-permanent wetland
- connections to/through floodplain wetland (flood-dependent shrubland wetlands) and flood-dependent forest/woodland (wetlands)
- tracts of floodplain land within low-lying areas bordering a watercourse that contain floodplain wetland (flood-dependent shrubland wetland) or flood-dependent forest/woodland (wetlands)
- key fish passage areas identified using NSW Fish Community Status and Threatened Fish Species Data - Aquatic Biodiversity Value Mapping Project (NSW DPI 2016)

Cultural criteria
MZ A includes, where there is hydraulic justification:
- floodplain areas with Aboriginal values that are highly flood-dependent that were identified during direct community consultation with the local Aboriginal community and/or are listed on the AWIS and AHIMS databases
- locations for scarred/carved trees that are living flood-dependent vegetation that generally require frequent flooding to maintain their ecological character and cultural value
- locations for heritage sites that are flood dependent and are cultural heritage objects and places as listed on Commonwealth, state and local government heritage registers.

Existing floodplain management arrangements criteria
Existing floodplain development guidelines prepared to support assessment for applications under Part 8 WA 1912 were reviewed and minor changes were made to MZ A to incorporate this historical flood behaviour information. MZ A was made congruent with the MZ A of the bordering Gwydir, draft Border Rivers, draft Macquarie and draft Lower Namoi Valley FMPs.

MANAGEMENT ZONE B

Hydraulic criteria
MZ B includes the inundation extent of the small and large design floods and any areas protected by existing flood works that are overtopped by the large design flood.

Ecological criteria
MZ B includes, where there is a hydraulic justification, flood-dependent woodland and to a lesser degree flood-dependent forest/woodland (wetlands) where there was no hydraulic justification for inclusion in MZ A.

Cultural criteria
MZ B includes, where there is hydraulic justification, locations for scarred/carved trees that are living and located within flood-dependent woodland.

Existing floodplain management arrangements criteria
MZ B was made congruent with MZ B of the bordering Gwydir, draft Macquarie and draft Lower Namoi Valley FMPs. MZ B includes some area of the floodplain that are enclosed by existing flood works that are designed to be overtopped during moderate to large floods.

MANAGEMENT ZONE C

Hydraulic criteria
MZ C includes flood fringe areas of the floodplain that are outside the large design flood and areas enclosed by existing flood works that are not designed to be overtopped during flooding.

Ecological criteria
The basis of MZ C was not ecological. However, some ecological assets that have been enclosed by existing approved flood works are located in MZ C.

Cultural criteria
The basis of MZ C was not cultural. However, some cultural assets that have been enclosed by existing approved flood works are located in MZ C.

Existing floodplain management arrangements criteria
Existing flood-work development identified in floodplain management guidelines were incorporated into MZ C.

MANAGEMENT ZONE CU

Hydraulic criteria
The basis for MZ CU was not hydraulic.

Ecological criteria
The basis of MZ CU was not ecological.

Cultural criteria
The basis of MZ CU was not cultural.

Existing floodplain management arrangements criteria
MZ CU includes floodplain areas that are included within existing urban flood studies, flood risk management studies, or flood risk management plans or that are protected by flood mitigation works such as town levees.

MANAGEMENT ZONE D

Hydraulic criteria
The basis for MZ D was not hydraulic.

Ecological criteria
MZ D includes assets that are a location of landscape feature, such as a swamp, marsh, lagoon, anabranch or billabong with a high degree of floodwater dependency, and:

- a high degree of habitat complexity
- a history of supporting a diversity or abundance or waterbird, native fish or frog populations
- the functional capacity to act as an aquatic drought refuge
- is susceptible to conversion or loss of flood connectivity due to flood-work
- recognition in, or protected by a local, state or commonwealth environmental policy.

Cultural criteria
MZ D includes areas that have a high degree of floodwater dependency, such as swamps, marshes, lagoons, billabongs, rocky bars or warrambools and have significance to the Aboriginal community, including spiritual, archaeological or resource use-values. These areas were listed on a heritage register or were a place that was recognized for its cultural significance by several senior knowledge holders in the Aboriginal community.

Existing floodplain management arrangements criteria
MZ D was reviewed for consistency with existing plans, however, the basis for MZ D did not include existing floodplain management planning arrangements

Modifying a management zone

The Barwon-Darling Valley FMP (Part 10 Amendment of this Plan) provides opportunity for landholders to seek to modify a management zone.

Amendments may be made to modify the area to which the plan applies or any management zone using any of the following information, or supporting information as determined by the Minister:

- an aerial photograph or equivalent satellite image showing flood inundation at the property scale of either the small design flood or the large design flood
- oblique photos showing flood inundation of either the small design flood or the large design flood that contain verifiable land marks
- oblique photos of flood survey marks that can be verified for either the small design flood or the large design flood.

Note that a hydraulic study which provides velocity and depth information for the large design flood may be used to support this information.

Step 8: Determine rules

The management zones and rules (including assessment criteria) together provide the legal framework to assess flood work applications. Step 8 was undertaken to develop specific rules to define the type, nature and construction of flood works that can occur in each management zone. The rules vary between management zones to reflect differences in flood behaviour and the floodplain environment. Step 8 was also undertaken to develop rules to license or modify existing licences for eligible existing flood works in MZ A and MZ D.

The rules can be split into four general types, including those that:

- specify the physical nature of flood works
- specify advertising triggers
- are assessment criteria to determine the acceptable impacts of flood works
- relate to existing flood structures and works in MZ A and MZ D.

The rules provided in Step 8 should be considered in conjunction with the state-wide exemptions, which are detailed at the end of this section.

Authorised flood works

The types of flood works that can be applied for in each management zone (authorised flood works) are determined by considering the optimal balance between hydraulic, ecological, cultural and socio-economic considerations on the floodplain. Rules relating to the physical nature of flood works are used to specify the types of authorised flood works. This approach ensures clarity on authorised flood works and will enable a streamlined assessment process. Where rules are not specified in a management zone all flood works are authorised via application. These flood works are categorised as other (non-specified) flood works. Nine types of flood works were identified for the Barwon-Darling Valley Floodplain:

- enhancement works to provide a positive outcome for an ecological or cultural asset that is mapped, recognised in or protected by the FMP, or a local, State or Commonwealth environmental policy or legislation. Enhancement works include three sub-categories:
    - Aboriginal value
    - ecological, and
    - heritage site
- infrastructure protection works – to minimise risk to life and property
- limited height flood protection works that are less than or equal to 80 cm in height – generally used for crop and land protection against smaller floods
- private access roads – to ensure landholders have basic provisions to access property
- stock refuges – to account for animal welfare and to minimise a landholder's potential to lose stock to floodwaters
- supply channels – to ensure supply channels reach water sources so landholders can access water rights
- other (non-specified) flood works that are generally used for crop and land protection against larger floods.

Authorised flood works by management zone

In MZ A and MZ D there is a high risk that flood works may impact on flooding behaviour. To minimise this risk, restrictions were placed on the types of flood works that could be applied for in these two management zones. The restrictions on authorised flood works were made to be considerate of landholder needs and decisions were checked against:

- works likely to be approved under existing floodplain management planning arrangements (Step 9 and Step 10: phase 1)
- targeted consultation with the community, regional departmental officers and the interagency regional panel

The rules that specify the types of authorised flood works in each management zone are outlined in Table 13.

Table 13: Rules for authorised works by management zone

MANAGEMENT ZONE A
• Aboriginal value enhancement work • ecological enhancement work • heritage site enhancement work • access road • infrastructure protection work • stock refuge • supply channel below the natural ground surface
MANAGEMENT ZONE D
• Aboriginal value enhancement works • ecological enhancement works • heritage site enhancement works
MANAGEMENT ZONE B, C and CU
All types of flood works are authorised.

The rules that specify the physical nature of authorised flood works in MZ A and MZ D are described in detail below.

Aboriginal value enhancement works

In MZ A and MZ D, an Aboriginal value enhancement work must provide positive outcomes for an Aboriginal value asset that is listed on one of the following databases:

- NSW AHIMS
- NSW AWIS
- Murray Darling Basin Authority Aboriginal Submissions Database
- NSW State Heritage Inventory
- Australian Heritage Database (also referred as Commonwealth Heritage Register)
- Any other source or database deemed relevant by the Minister.

Justification for specifications

An Aboriginal value enhancement work is a new type of work that enables the protection of locations or landscape features that have Aboriginal value. These types of works are authorised in MZ A and MZ D areas as they will provide a positive outcome for locations or landscapes that

contain Aboriginal values. This rule is consistent with the objects of the WMA 2000, clause 3(c)(iii) and (iv), which ensure that culture and benefits to Aboriginal people in relation to their spiritual and customary use of land and water are recognised and incorporated into sustainable water resource management. As Aboriginal values are linked with ecological assets this rule is also consistent with the WMA 2000 additional provision 30(c) which allows for an FMP to deal with the restoration or rehabilitation of land, water sources or their dependent ecosystems.

Access roads

In MZ A access roads must be:

- no more than 50 cm in height above the natural surface level at any location, or
- a primary access road* no more than 100 cm in height above the natural surface level at any location,

and

- constructed in such a way as to allow for the adequate passage of floodwater and to adequately prevent the diversion of floodwater from natural flow paths, and
- constructed so that the borrow associated with the construction and maintenance of the access road is located on the downstream side of the road and is of no greater depth than 50 cm below the natural surface level.

**primary access road: a road providing access from a public road to a permanently occupied fixed dwelling via a direct route.*

Justification for specifications

Initially, it was recommended that access roads be no higher than 30 cm in MZ A. However, during targeted consultation in October 2015 landholders raised concerns that the nature of flooding in the Barwon-Darling Valley Floodplain is characterised by deeper longer lasting floods and 30 cm high access roads would be inundated or washed out during flood events preventing access to properties. As a result, authorised access road height has been increased to 50 cm and for primary access roads, roads can be authorised up to 100 cm in height in MZ A.

The causeway requirements are to allow unimpeded flood flow during small flood events. The causeways also allow for connectivity that is important for fish passage. The requirements for causeways are modelled on the Gwydir Valley FMP 2016 (NOW 2014), which were originally adopted from the Lower Gingham Watercourse FMP (DNR 2006). Causeways are included to ensure that access roads will not block or divert flood flows, which are important for flood-dependent ecological and cultural assets.

Rules relating to borrow pits were developed for the Gwydir Valley FMP 2016 and represent existing best practice principles. The positioning of the borrow pit on the downstream side and limiting the depth to 50 cm was selected to facilitate the passage of floodwater, prevent diversion of floodwater, minimise soil erosion and reduce disruption to access by maintaining the stability of the roadway.

Ecological enhancement works

In MZ A and MZ D, ecological enhancement works must provide a positive outcome for an ecological asset that is mapped, recognised in or protected by this Plan, or a local, State or Commonwealth environmental policy or legislation.

Justification for specifications

An ecological enhancement work is a new type of work that provides a positive outcome for the environment. These types of works are authorised in MZ A and MZ D areas as they will provide

a positive outcome for the environment, consistent with the WMA 2000 additional provision 30(c) which allows for an FMP to deal with the restoration or rehabilitation of land, water sources or their dependent ecosystems, in particular in relation to the following:

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

Heritage site enhancement works

In MZ A and MZ D, a heritage site enhancement work must provide a positive outcome for a heritage site asset that is listed in one of the following databases:

- NSW AHIMS
- NSW AWIS
- Murray Darling Basin Authority Aboriginal Submissions Database
- NSW State Heritage Register
- Historic Heritage Information Management System
- Australian Heritage Database (also referred as Commonwealth Heritage Register)
- Any other source or database deemed relevant by the Minister.

Justification for specifications

A heritage site enhancement work is a new type of work that enables the protection of Aboriginal or heritage locations in the floodplain that have recognised significance. These types of works are authorised in MZ A and MZ D areas as they will provide positive outcomes to flood-dependent heritage sites. This rule is consistent with the objects of the WMA 2000, clause 3(c)(iii) and (iv), which ensure that culture and heritage, and benefits to Aboriginal people in relation to their spiritual and customary use of land and water are recognised and incorporated into sustainable water resource management. As some heritage sites are linked with ecological assets this rule is also consistent with the WMA 2000 additional provision 30(c) which allows for an FMP to deal with the restoration or rehabilitation of land, water sources or their dependent ecosystems.

Infrastructure protection works (IPW)

In MZ A, IPWs must:

(1) on landholdings less than or equal to 20 ha, be no more than 10 % of the total area of the landholding

OR

(2) on landholdings greater than 20 ha, be no more than the greater of the following:

- 2 ha, or
- 1 % of the size of the landholding.

AND

(3) on all landholdings, not block more than 5 % of the width of MZ A at the location of the works.

Justification for specifications

IPWs are important flood works that provide for the protection of life and property from the effects of flooding. The thresholds selected for the works ensure that flood behaviour is not significantly affected by a work of this nature.

The size or area of an IPW is dependent on the total size of the landholding where the work is being built. This is to cater for the practicality of larger properties being likely to have more infrastructure servicing their land.

On properties no larger than 20 ha, IPWs can cover an area that is up to 10 per cent of the area of the property. For example, if a property is 10 ha, proposed IPWs can cover an area that is no more than 1 ha. This rule is consistent with the Gwydir Valley FMP 2016.

On properties larger than 20 ha, IPWs can be whichever is the larger of the following two options (1) either 2 ha in size or (2) one per cent of the total area of the property. For example, if a property is 25 ha the proposed IPW can be no more than 2 ha in size. Whereas, if a property is 300 ha in size, the proposed IPW can be no more than 3 ha in size. This rule is consistent with the Gwydir Valley FMP 2016.

The rule requiring IPWs to not block more than five per cent of the width of MZ A at the location of the works was referenced from the Gwydir Valley FMP 2016 and was used in interim working policies adopted by DPIW prior to this. This rule provides greater certainty to landholders wishing to construct an IPW by specifying a threshold for how much of MZ A can be blocked.

Stock refuges

In MZ A, stock refuge must be no more than:

- 10 ha in area in any single location, and
- 5 % of the total area of the landholding, and
- 5 % of the width of MZ A measured at the location of the works.

Justification for specifications

To avoid flood flow redistribution impacts, stock refuges are regulated and subjected to an assessment process. The thresholds are consistent with those used in the Gwydir Valley FMP 2016 (NOW 2014).

Supply channels

In MZ A, supply channels must be:

- below the natural ground surface level, and
- constructed in such a way as to allow for the adequate passage of floodwater and to adequately prevent the diversion of floodwater from natural flow paths, and
- constructed and maintained so that the spoil is
    - windrowed parallel to the direction of flow such that is does not block more than 5 % of the width of MZ A at the location of the work,

  OR

    - is levelled to a no more than 10 cm in height above the natural surface level at any location.

Justification for specifications

Ensuring that supply channels are below the natural ground surface level reduces the potential for the work to affect the distribution or flow of floodwater during flood events. However, it is still a requirement to construct the supply channel in a way that facilitates adequate passage of floodwater and that also prevents floodwater diversion. This is because, during small floods, a supply channel could potentially capture and divert flow from its natural flow path. It may be required that a siphon or gate be put in place at the low point(s) of the supply channel to enable timely floodwater passage and/or drainage on the floodplain. Construction of siphons or equivalent structures will enable floods to pass through or under these works. It is also possible that the spoil from the construction and maintenance of a supply channel will act as an above-ground flood work. To minimise the chance of spoil influencing flood flow, it is required to windrow the spoil to the specifications in the rules or to ensure it is levelled to no more than 10 cm in height. It is also required that the encroachment of spoil into active discharge areas is limited to minimise any impacts on flooding.

In the majority of the Barwon-Darling Valley Floodplain, below-ground supply channels were typically licensed under Part 2 of the WA 1912 rather than a flood work or controlled work approval. To ensure consistency with the Gwydir Valley FMP 2016 (NOW 2014), below-ground supply channels were added as a category of flood work because of their potential to impact on flooding behaviour. The regulation of this type of work as a flood work better ensures flood connectivity during small flood events.

Advertising requirements

The Barwon-Darling Valley FMP does not require advertising for works deemed to be minor in nature. Advertising requirements were determined by considering the level of impact flood works would likely have on flood behaviour, floodplain connectivity and on neighbouring properties.

The types of flood works that can be applied for in MZ A and MZ D are minor in nature and therefore flood-work applications in these management zones do not need to be advertised.

There are no restrictions on the types of flood works that can be applied for in MZ B. However, because this management zone is a major flood storage and secondary flood discharge area there is a reasonable risk that some flood works will impact on flood behaviour and floodplain connectivity. To address this issue, the rules for this management zone divide flood-work applications into:

- specified flood-work applications that do not require advertising,

- non-specified flood-work applications that do require advertising

In MZ B, a flood work does not require advertising if it is:

- no more than 80 cm in height
- used as a stock refuge and is no more than 5 % of the total area of the landholding, and no more than 10 ha in size in any single location
- used to protect infrastructure and the area enclosed by the flood work accounts for no more than 1 % of the total area of the landholding

In MZ C there are no restrictions on the types of authorised flood works. As MZ C includes flood fringe and existing developed areas flood-work applications do not require advertising as there is a low risk that flood works will impact third parties. However, in some instances, such as removal of an existing flood work that has the potential to have significant flood redistribution impacts, the Minister may request a flood-work application to be advertised.

In MZ CU there are no restrictions on the types of authorised flood works. The majority of flood works likely to be applied for in MZ CU will be exempt from requiring a flood work approval under the WMA 2000 (see 'Exemptions to flood work approvals'). For those works that are not exempt, flood-work applications will be assessed under MZ C assessment criteria. This means that such flood-work applications do not need to be advertised unless requested by the Minister.

Assessment criteria

Assessment criteria relating to the acceptable impacts of flood works have been designed to consider the potential for a flood work to have:

- ecological and cultural impacts
- social (drainage) impacts
- local hydraulic impacts
- cumulative hydraulic impacts.

The above categories of impacts are considered in the assessment criteria in different ways depending on the management zone that a flood-work application is made for (Table 14).

Table 14: Categories of impacts that flood-work applications must be assessed against in each management zone

Assessment criteria		MZ A	MZ B	MZ C/CU	MZ D
Ecological and cultural impacts	Flood connectivity to ecological assets	☑	☑	☑	☑
	Flood connectivity to facilitate fish passage	☑	☑	☑	☑
	Flood connectivity to Aboriginal values	☑	☑	☑	☑
	Flood connectivity to heritage sites	☑	☑	☑	☑
	Heritage site impacts	☑	☑	☑	☑
Social (drainage) impacts	Drainage impacts	☑	☑	☑	☑

Local hydraulic impacts	Redistribution	N/A	☑#	^	N/A
	Flood levels	N/A	☑#	^	N/A
	Velocity	N/A	☑#	^	N/A
Cumulative hydraulic impacts	Redistribution	☑	☑#	^	☑

^ Assessment criteria are discretionary

Assessment criteria are discretionary for minor works that do not require advertising. For flood works that require advertising, all assessment criteria are mandatory.

Assessment criteria relating to the acceptable impacts of flood works follow a merit-based assessment approach and require technical assessment to interpret and apply. Flood-work applications may require supporting information to assist with interpretation during the determination. Flood events (known as 'flood scenarios' in the Barwon-Darling Valley FMP) are considered when applying the assessment criteria. The types of flood scenarios depend on the management zone and the type of assessment criteria as outlined in the Barwon-Darling Valley FMP. More information on each of the four assessment criteria categories is found below. The blue boxes provide a plain English version of the assessment criteria found in the Barwon-Darling Valley FMP.

Ecological and cultural impacts

Description of the criteria

The ecological and cultural impacts assessment criteria are designed to ensure that flood connectivity to ecological and cultural assets is considered when determining a flood-work approval. Criteria were also developed to ensure that areas of cultural heritage significance are not disturbed during construction of flood works.

Flood connectivity to assets

In all management zones, a flood work must be constructed to maintain adequate flood connectivity to:

- ecological assets
- facilitate fish passage
- Aboriginal values
- heritage sites

Such flood connectivity must be maintained under a range of flood scenarios, including at a minimum, scenarios for the relevant small and large design floods.

Heritage site impacts

In all management zones, the construction of a flood work must not disturb the ground surface of a heritage site or cause more than minimal erosion to a heritage site.

Why are ecological and cultural impacts considered?

Potential ecological and cultural impacts were considered to ensure that flood-dependent assets are not harmed by changes to flood connectivity caused by flood works. This assessment criteria was considered because the management zones were designed at a strategic scale. It is therefore needed to have assessment criteria to account for the complex network of flow paths at the property scale that may have been missed in the management zone map. Many of these

smaller flow paths are important for maintaining the ecological or cultural character of flood-dependent ecological assets, Aboriginal values and heritage sites. This assessment criteria ensures that flood works will not block these critical flow paths.

TAG and agency experts determined that fish habitat on the floodplain is a significant asset that requires additional protection measures. Regulatory structures and flow alteration have contributed to a significant decline in the abundance and distribution of native fish in the Murray-Darling Basin (Cadwallader 1978; Horwitz 1999; Thorncraft & Harris 2000; Humphries et al. 2002). Therefore, flood connectivity that facilitates fish passage is addressed in the assessment criteria.

Consultation with the ATWG and agency experts identified that some heritage sites are at risk from being impacted during the construction of a flood work or as a result of erosion from changes to flood behaviour caused by a flood work. Sites that may be potentially impacted by flood-work development were identified in the FMP and will be considered as part of the flood work application assessment process. If a flood work is proposed in the vicinity of such a site, the *National Parks and Wildlife Act 1974* will be triggered and a due diligence assessment will be required to be undertaken to ensure the sites are not impacted by the proposal.

How were the criteria determined?

The criteria were determined by considering existing floodplain management arrangements and after discussions with the TAG and the ATWG. These assessment criteria have also been adopted in the Gwydir Valley FMP 2016 (NOW 2014).

How will the criteria be applied?

Ecological and cultural impacts assessment criteria will be assessed using spatial floodplain asset datasets and site observation data. State and Commonwealth heritage registers to identify any heritage sites within the local area of a flood-work application. Flow paths across a range of flood scenarios may be considered to ensure flood connectivity is maintained to ecological and cultural assets. In some cases additional detailed ecological and cultural assessments may be required to support a flood-work application.

Social (drainage) impacts

Description of the criterion

The drainage impacts assessment criterion was designed to ensure that local drainage on neighbouring properties is maintained.

> In all management zones, a flood work must maintain adequate drainage on adjacent landholdings and other landholdings that may be affected by the proposed flood work.

Why are drainage impacts considered?

Drainage impacts are considered because the management zones were designed on a strategic scale that may not account for a flood work impacting on local drainage in such a way as to cause a significant disruption to the daily life of surrounding landholders. For instance, changes to local drainage may cause considerable local issues, nuisance or conflict, or property access may be disrupted.

How was the criterion determined?

The criterion was determined by considering existing floodplain management arrangements. This assessment criterion was also adopted in the Gwydir Valley FMP 2016 (NOW 2014) and the proposed Border Rivers and Lower Namoi Valley FMPs.

How will the criterion be applied?

The drainage impacts assessment criterion will be assessed using topographical maps, flood photography and site observation data. Local topography will be considered to minimise the likelihood of new flood works changing local drainage lines in a disruptive manner. Local flooding patterns across a range of floods may also be considered, including the small and large design floods.

Local hydraulic impacts

Description of the criteria

The local hydraulic impacts assessment criteria were designed to ensure that within the local area, a flood-work application has a minimal impact (thresholds apply) on:

- redistribution of peak flood flow
- flood levels
- flow velocity.

The 'local' area is generally defined as the adjacent landholding and other landholdings that may be affected by the proposed flood work.

The use of the local hydraulic assessment criteria to assess applications for works that do not require advertising in MZ B is discretionary. Local hydraulic assessment criteria is also discretionary for all types of flood works in MZ C and MZ CU. For flood-work applications that require advertising in MZ B, assessment against the local hydraulic assessment criteria are mandatory.

In MZ B, applications for flood works that require advertising must demonstrate that the work is unlikely to:

- redistribute the peak flood flow by more than 5 % in the local area when compared to the peak flood flow under existing development conditions for a range of flood scenarios including, at minimum, the large design flood
- increase flood levels by more than 20 cm in the local area when compared to flood levels under pre-development and existing development conditions for a range of flood scenarios including, at minimum, the large design flood
- increase flow velocity by more than 50 % on the landholding under application or in the local area when compared to flow velocity under pre-development and existing development conditions for a range of flood scenarios including, at a minimum, the large design flood, unless:
    - increases of more than 50 % are in isolated areas where the landholder mitigates the impact of the flood wave so that the average impact across the landholding under application is no greater than 50 %, and
    - flow velocity is not increased by more than 50 % at the boundary of the landholding under application
- increase flood levels such that they impact high value infrastructure when compared to flood levels under pre-development and existing development conditions for a range of flood scenarios including the large design flood.
- increase flow velocity by an amount (determined by the Minister) that is likely to have more than minimum impact on soil erodibility, taking into account the ground cover, on the landholding under application or in the local area.

In MZ C (and for non-exempt works in MZ CU), applications for flood works may be required to demonstrate that they comply with the assessment criteria specified above for MZ B. The flood scenarios used to assess the application are not prescriptive and may be determined by the Minister.

Why are local hydraulic impacts considered?

Local hydraulic impacts assessment criteria were developed to ensure that flood-work applications do not significantly change key hydraulic parameters in the local area and in some instances, on the landholding under application. To best assess impacts on local hydrology, each relevant flood-work application must be assessed on a case-by-case basis. This assessment will reduce the likelihood that flood works will impact on flood behaviour, including the potential to redistribute peak flood flows, increase the flood risk and inundation extents by raising flood levels, and increase the potential for erosion and siltation by increasing flood flow velocities.

How were the criteria determined?

The criteria were determined by considering Macintyre floodplain policy (internal DPIW policy) and the Gwydir Valley FMP 2016 (NOW 2014). Criteria were also developed through consideration of the proposed Border Rivers, Lower Namoi and Upper Namoi Valley FMPs.

How will the criteria be assessed?

Hydraulic local impacts assessment criteria will be assessed by comparing:

- pre-development conditions (refers to the floodplain without flood-work development)
- existing conditions (refers to the floodplain and level of flood-work development at the time that the Barwon-Darling Valley FMP was made)
- proposed conditions (the proposed work and existing conditions combined).

Specifically:

- flood flow redistribution is to be assessed by comparing proposed conditions with existing conditions and must not exceed the allowable threshold
- flood level increases are to be assessed by comparing pre-development conditions with existing and then proposed conditions and summing the impacts to make sure the allowable threshold is not exceeded
- flow velocity increases are to be assessed by comparing pre-development conditions with existing and proposed conditions to make sure the allowable threshold is not exceeded.

Cumulative hydraulic impacts

Description of the criteria

Cumulative hydraulic impact assessment criteria differ between the management zones. MZ A and MZ D share the same criteria and MZ B, MZ C and MZ CU have similar assessment criteria relating to cumulative hydraulic impacts.

In MZ B, MZ C and MZ CU, the cumulative hydraulic impact assessment criteria limits the redistribution of flood flow across the floodplain. The large design flood is to be used for the assessment, and redistribution is to be limited to less than or equal to five per cent of the peak flow in this event at any of the Peak Discharge Calculation Points as defined by the Minister (see Appendix 14). All flood-work applications received for MZ B must be assessed against this criterion when compared to redistribution under existing development conditions. If required by the Minister, a flood-work application in MZ C or MZ CU must also be assessed against this

criterion, which will typically be using floods larger than the design flood such as the 1 in 100 AEP flood. The use of this assessment criteria to assess applications that do not require advertising in MZ B and for all types of flood works in MZ C and MZ CU is discretionary. For flood work applications that require advertising in MZ B, cumulative assessment criteria are mandatory.

In MZ A and MZ D, the cumulative hydraulic impact assessment criteria is in place to ensure that the potential cumulative impacts of works in these management zones are assessed in conjunction with existing works on the property where the work is to be located. All flood works in MZ A and MZ D must be assessed against this criterion.

In MZ A and MZ D, the Minister must consider the cumulative effect that the proposed flood work and other existing works on the landholding may have on adjacent landholdings, other landholdings and the floodplain environment.

And,

In MZ B, applications for flood works that require advertising must demonstrate that the work is unlikely to redistribute the peak flood flow by more than 5 % at any of the Peak Discharge Calculation Points, as defined by the Minister, when compared to redistribution under existing development conditions for a range of flood scenarios including, at minimum, the relevant large design flood.

In MZ C and for non-exempt works in MZ CU, flood-work applications may be required to demonstrate that they comply with the assessment criterion specified above for MZ B. The flood scenarios used to assess the application are not prescriptive and may be determined by the Minister.

Why are cumulative hydraulic impacts considered?

Current estimates are that the footprint of developed areas (hereafter *developed areas*) makes up approximately 45,900 ha (4 %) of the Barwon-Darling Valley Floodplain (Step 2). Typically the developed areas are protected by levees, which will only overtop in extreme floods and so are likely to impact on flooding behaviour in small and large floods.

The hydraulic models developed as part of Step 4 were used to estimate the redistribution of floodwater that may have occurred due to the existing level of development. Existing flood-work development has been found to have altered the flow distribution between major branches of the Barwon-Darling Valley Floodplain.

Further redistribution may have consequences from socio-economic, hydraulic, ecological and cultural perspectives. Therefore, the cumulative impact of existing and future works must be assessed to ensure that the existing flood flow distribution is maintained.

How were the thresholds for the criteria determined?

The thresholds for the hydraulic cumulative impacts have been determined by comparing the modelling results from the existing floodplain conditions with a pre-development modelling scenario, where all flood works had been removed from the model bathymetry.

The two scenarios were compared at cross-sections at key locations within the floodplain. The basis for the assessment was the peak flood flow for the large design flood event.

Some redistribution has likely occurred due to existing flood works, and this redistribution is likely to be variable across the floodplain; however, limitations with representing the pre-development floodplain preclude a quantitative analysis of the redistribution within the sub-floodplain areas. Therefore uniform thresholds have been set across the floodplain.

How will the criteria be assessed?

For MZ B, MZ C, and MZ CU, the hydraulic cumulative impacts will be assessed by comparing the peak flow distribution (for the large design event) of the December 2016 level of development to the existing level of development in addition to the proposed works. For MZ C and MZ CU, the hydraulic cumulative impacts may also need to be assessed against the 1 in 100 AEP flood.

For MZ A and MZ D, where minor works only are permitted, cumulative assessments of proposed flood works will be considered in relation to other existing works on a landholding, other landholdings and the floodplain environment.

Existing flood works and structures

Rules to either license eligible existing flood structures or to modify the licences of eligible existing flood works were required in MZ A or MZ D where the Barwon-Darling Valley FMP restricts the types of authorised flood works. The rules for granting approval to an existing flood structure are outlined below.

Approval may be granted for an existing unlicensed work that does not comply with the rules for MZ A or MZ D if all of the following criteria are met:

- the flood structure was constructed as at the date of commencement of this Plan, and
- the flood structure is for an access road, an infrastructure protection work, a stock refuge or a supply channel, and
- as at the date of application, the flood structure is not the subject of:
    - an undetermined controlled work application under Part 8 of the *Water Act 1912,* or
    - a previously refused Part 8 application under the *Water Act 1912*, or
    - an undetermined flood work application under the *Water Management Act 2000*, or
    - a previously refused flood work application under the *Water Management Act 2000*.

The rules for amending the flood work approval of an existing licensed flood work are outlined below.

An amendment to an **existing *licensed* work** in MZ A and MZ D may be granted for a flood work that does not comply with the rules for MZ A or MZ D if all of the following criteria are met:

- the flood work was constructed as at the date of commencement of this Plan, and
- the proposed modification to the flood work will reduce the impact of the work on flow patterns (distribution of flows, drainage, depth or velocity) in MZ A or MZ D.

In either scenario, to be granted a flood work approval, the work must be assessed against the assessment criteria outlined in MZ A and MZ D, whichever is applicable.

Exemptions to flood work approvals

During Step 8, consideration is given to works that are exempt from requiring a flood work approval as set out in the *Water Management (General) Regulation 2011* (such works are hereafter referred to as *state-wide* exemptions).

In the Barwon-Darling Valley FMP area, state-wide exemptions apply (Table 15).

Table 15: State-wide exemptions under the Water Management (General) Amendment (Flood Work Approvals) Regulation 2011

State-wide exemptions under *Water Management (General) Regulation 2011*	Where does this exemption apply?
Works constructed by or under the direction of the State Emergency Service	All management zones
Works constructed by a local council within a managed designated high flood risk area under a development authorisation granted by the council	Management zones B, C and CU
Works constructed by a person (other than a local council) within a managed designated high flood risk area, on a total landholding area of no more than 0.2 ha, under a development authorisation granted by the council	Management zones B, C and CU
Ring embankments around homes and farm infrastructure, protecting not more than 2 ha in area and not more 10 % of the total property area	Management zones B, C and CU
Public roads and railways	All management zones
Earthworks less than 150 mm above natural surface level including farm tracks and check banks	Management zones B, C and CU

Step 9: Consider existing floodplain management arrangements

Consideration of existing floodplain management arrangements was integrated throughout the planning process outlined in this document. Step 9 reports on how these arrangements were considered, including the occurrence of change between existing rural floodplain management arrangements and the Barwon-Darling Valley FMP.

The existing floodplain management arrangements referred to below and in Figure 20, are areas in the Barwon-Darling Valley floodplain that are:

- covered by floodplain guidelines (*hereafte*r, guideline area)
- part of the original Part 8 designated floodplain (designated under section 166 of the WA 1912) (*hereafte*r, designated areas)
- new areas added to the floodplain (*hereafter*, new floodplain areas).

As there were no statutory FMPs in the Barwon-Darling Valley Floodplain prior to the Barwon-Darling Valley FMP, the introduction of the floodplain boundary, management zones and rules including assessment criteria, and the improved consideration of ecological and cultural floodplain assets will result in changes to existing management practices. These changes reflect improvements in our understanding of the floodplain, improvements in the management of flood-work development, and a more consistent approach to floodplain management across the floodplain. The Barwon-Darling Valley FMP has ensured that floodplain management is aligned with the WMA 2000.

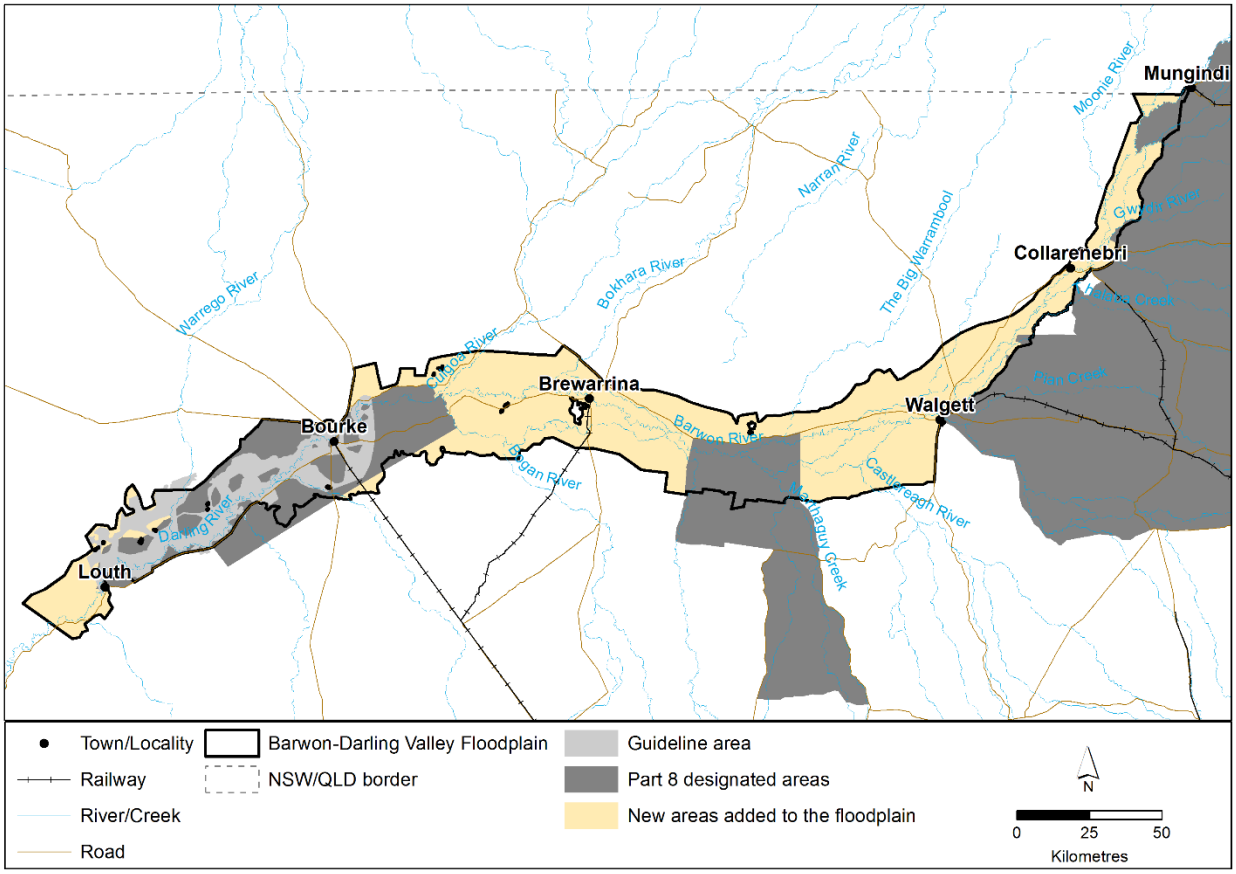

Figure 20: Existing floodplain management arrangements in the Barwon-Darling Valley FMP area

Floodplain boundary

Designated floodplain areas were a primary consideration when delineating the Barwon-Darling Valley Floodplain boundary. The floodplain was partially aligned with the Bogan River Confluence to Louth designated floodplain; Lower Namoi designated floodplain; and the Lower Gwydir designated floodplain (Figure 20). When compared to the existing designated floodplains, the overall extent of boundary change is significant, with the addition of 765,400 ha. The rationale for all the boundary changes is detailed in Step 1.

Management zones

The Barwon-Darling Valley FMP introduces the use of management zones in floodplain management. Current floodplain management arrangements include floodways in the guideline area which are used, through the application process, to guide the location and nature of flood-work development. The floodways were designed to remain unobstructed. Areas outside of the floodways in the guideline area were identified as being suitable for flood-work development. Existing floodways in the guideline area were compared against the management zones to determine the level of change.

As described in Step 7, the Barwon-Darling Valley Floodplain has five different management zones based on hydraulic, ecological and cultural criteria and criteria to better reflect existing management arrangements. The hydraulic criteria were based on the floodway network.

The management zones in the Barwon-Darling Valley Floodplain differ from existing floodplain management arrangements as a result of:

- extension of the floodplain boundary to capture areas of major flooding
- improved ecological and cultural data across a greater floodplain area

- strategic consideration of flood connectivity throughout the entire floodplain
- significantly more accurate hydraulic data (supported by new LiDAR) available from using the latest modelling techniques with new hydraulic models being developed and existing models being updated.

Floodways identified in the existing guideline area are equivalent in principle to the hydraulic criteria used to develop MZ A. However, the data used to develop MZ A is more sophisticated and better represents flooding behaviour. Another difference is that ecological and cultural assets were considered in the design of MZ A. Ecological and cultural assets were incorporated into the management zones to reflect the greater emphasis that the WMA 2000 places on protecting the floodplain environment.

The areas outside the floodway in the guideline area are equivalent in principle to the hydraulic criteria used to develop MZ B and MZ C.

Key differences are that:

- the non-floodway network areas under the guidelines also contain flood fringe and developed areas that form MZ C in the Barwon-Darling Valley FMP
- ecological and cultural assets were identified and prioritised and considered in the design of MZ B (see Step 7).

MZ CU was designed to include urban areas that are covered by a flood study, flood risk management study, or flood risk management plan or that are protected by flood mitigation works such as town levees. Flood works are typically assessed by local council under the *Environmental Planning and Assessment Act 1979* in these areas however on landholdings greater than 0.2 ha approval under the WMA 2000 is required.

MZ D is a new type of management zone in the Barwon-Darling Valley Floodplain. It was created to provide additional protection to special ecological and cultural assets, with regards to the potential for flood works to affect flood connectivity.

Rules (including assessment criteria)

Change has occurred between management practices in the guideline area and designated areas and the rules of the Barwon-Darling Valley FMP. These changes are described below.

Change to authorised flood works

Change has not occurred in MZ B, MZ C or MZ CU. Under the guideline area, designated areas and the Barwon-Darling Valley FMP a landholder could apply for any type of flood work to be built in areas that are equivalent to MZ B, MZ C or MZ CU.

Change has occurred in MZ A and MZ D and is outlined below.

Management zone A

Prior to commencement of the Barwon-Darling Valley FMP, a landholder could apply for any type of flood work to be built in areas that corresponded to MZ A areas. The Barwon-Darling Valley FMP only allows flood-work applications in MZ A for five different types of authorised works. Under existing assessment practices, works other than those authorised in the Barwon-Darling Valley FMP would be unlikely to be approved. This is because areas corresponding to MZ A (floodway network areas) needed to satisfy stringent assessment criteria before being approved. By limiting applications to certain authorised works in the Barwon-Darling Valley FMP, landholders save time and money by applying only for those works likely to be approved.

Management zone D

Prior to commencement of the Barwon-Darling Valley FMP), a landholder could apply for any type of flood work to be built in areas that corresponded to MZ D areas. The Barwon-Darling

Valley FMP limits flood-work applications in MZ D to Aboriginal value, ecological and heritage site enhancement works. By limiting applications to certain authorised works in the Barwon-Darling Valley FMP, landholders save time and money by applying only for those works likely to be approved.

Changes to advertising requirements

Advertising flood works gives interested parties the opportunity to comment on a flood-work application and for that comment to be considered during the assessment. The intention of advertising rules is that if a flood work is minor or is in an area of the floodplain where the potential for the flood work to impact on flood behaviour is minimal, then it should not need to be advertised.

Advertising requirements have been updated in the Barwon-Darling Valley FMP to reflect changes made to the types of flood works that will be considered for approval. Some of the rules have advertising requirements depending on the management zone in which the flood work is proposed to be developed as well as the purpose, nature and construction of the work. These factors relate directly to the potential of the work to cause or exacerbate flooding problems. Therefore, advertising requirements reflect the level of impact that flood works are likely to have on flood behaviour, floodplain connectivity and neighbouring properties.

Under existing floodplain management arrangements, advertising was required in all areas of the Barwon-Darling Valley Floodplain, including designated areas and the guideline area. This was because there was not sufficient information available to determine the scale of flood behaviour impacts from proposed flood-work developments. However, as the Barwon-Darling Valley FMP incorporates sophisticated hydraulic, ecological and cultural information, advertising requirements have been refined and are linked to certain management zones and the nature of flood works. In this way, the Barwon-Darling Valley FMP is less restrictive in areas covered by designated areas, the guideline area and new floodplain areas, where advertising is required. The following outlines advertising requirements for each management zone in the Barwon-Darling Valley FMP:

- *MZ A:* flood-work applications do not require advertising. This is because the types of flood works that can be applied for are minor in nature and are unlikely to impact flood behaviour.
- *MZ B:* flood-work applications that are minor in nature do not require advertising unless requested by the Minister. All other flood-work applications require advertising because of the potential for the work to impact on flood behaviour, floodplain connectivity and neighbouring properties.
- *MZ C and CU:* flood-work applications do not require advertising, unless specified by the Minister, as it is unlikely that a flood work in this area would impact on flood behaviour, floodplain connectivity or neighbouring properties.
- *MZ D:* flood-work applications do not require advertising, as the only allowed works (ecological Aboriginal value and heritage site enhancement works) must result in a positive outcome for the environment and satisfy rigorous assessment criteria.

Changes in assessment criteria

A summary of the types of assessment criteria considered in existing floodplain management arrangements is provided in Table 16. These assessment criteria have been incorporated into the Barwon-Darling Valley FMP. Assessment criteria that have been explicitly addressed in the rules are highlighted in green. To varying degrees, all existing assessment criteria have been considered in the development of the management zones and rules of the Barwon-Darling Valley FMP.

Table 16: Summary of assessment criteria in existing floodplain management arrangements in the Barwon-Darling Valley Floodplain

Criteria highlighted in green have been explicitly incorporated into the Barwon-Darling Valley FMP as assessment criteria. All the assessment criteria were considered during the development of the management zones.

Historical	Socio-economic	Ecological & Cultural	Flooding
Existing floodplain guidelines	Disruption to daily life (relates to local drainage)	Wetland connectivity	Natural flooding characteristics
Concerns and objections	Health impact	Floodplain flora and fauna	Hydraulic capacity
	Cost of the works	Soil condition and structure	Pondage and flow duration
	Infrastructure damage	Fish passage	Redistribution
	Equity	Cultural sites	Flow velocities
	Land use and restrictions	Groundwater recharge	

Existing flood works and structures

Under existing management practices (prior to enactment of the Barwon-Darling Valley FMP), in parts of the Barwon-Darling Valley Floodplain that were not covered by a designated area or guideline area, floodplain structures or works may not have required an approval under Part 8 of the WA 1912. These works may now be considered a flood work under the Barwon-Darling Valley FMP. The rules in the Barwon-Darling Valley FMP enable existing works that do not meet the specifications to be an authorised work to be licensed, so long as they meet certain criteria. This enables landholders to apply for a flood work approval under the WMA 2000 for those types of works that did not necessarily require a controlled work approval under the WA 1912.

For licensed works that do not comply with the rules of MZ A and MZ D, the Barwon-Darling Valley FMP allows modification of these works to reduce their impact on flow patterns. Under existing management arrangements, modification of such works that would result in an increased impact would not be approved, so this is not likely to represent any change from the existing arrangements.

Step 10: Assess socio-economic impacts

Step 10 is split into two phases and examines the extent of change between the base case (floodplain without reform) and the Barwon-Darling Valley FMP to determine the potential negative socio-economic impacts of the plan. Phase one assessment was undertaken prior to community consultation whereas Phase two assessment was optional and only triggered if Phase one assessment identified significant socio-economic impacts and/or socio-economic concerns were raised during public exhibition.

The assessment approach was based on the *Socio-economic Assessment Guidelines for River, Groundwater and Water Management Committees* prepared by the Independent Advisory Committee for Socio Economic Assessment (IACSEA 1998). This approach is being applied to the development and revision of WSPs in NSW.

The focus of this assessment was the enumeration of the negative effects of the implementation of the proposed FMP that will be quantified in 2011 dollars. Because benefits of the proposed FMP are not enumerated it was not a Benefit Cost Analysis. There are significant benefits from the implementation of the FMP that were expected to outweigh the negative impacts. Some of the benefit categories include; minimising impacts of flooding due to constructed flood works, reduced erosion and reduced sediment deposition, and ecological and cultural benefits. Benefit value types include use, existence and bequest values.

The detail of the methodology used in this analysis is included in the *Rural Floodplain Management Plans: Technical manual for plans developed under the Water Management Act 2000.*

Phase one assessment

Phase one assessment was undertaken prior to community consultation. This phase adopted the following sequential analyses:

- documenting the effect of change between the base case and the Barwon-Darling Valley FMP construct on different sectors of the community across the whole floodplain
- assess the extent, likelihood, intensity and timing of the effects and document these in a socio-economic impact table
- provide a breakdown of the land capability of the floodplain and identify where the impact of the proposed Barwon-Darling Valley FMP construct was quantifiable in 2011 dollars
- prepare a sensitivity analysis of the assessment

Each stage of the Phase one analysis is provided in more detailed in the following sections.

Comparing Base Case and Plan rules

The base case is the socio-economic condition of the floodplain if the Barwon-Darling Valley FMP was not developed. The base case is the condition where the following assumptions are made over the next ten years (the period of the Barwon-Darling Valley FMP):

- flood work approvals will continue under the floodplain management provisions of the WMA 2000
- a greater area of floodplain will be covered by new FMPs in due course
- floodplain guidelines may be revised or upgraded to an FMP as better data and modelling become available
- more emphasis will be put on environmental issues associated with flood work approvals as the community increases their general awareness of environmental issues
- flood works will continue to be approved in areas outside the floodway networks identified in FMPs and guidelines

- the approval rate of flood works within the floodway networks identified in FMPs and guidelines will decline as cumulative impacts approach acceptable limits.

Note, there were no existing FMPs prepared under Part 8 provisions of the WA 1912 or floodplain management provisions of the WMA 2000 in the Barwon-Darling Valley Floodplain.

The impact of the Barwon-Darling Valley FMP was assessed for the whole floodplain (1.1 million ha). Depending on the location of affected land, there may be areas that were anticipated to be relatively heavily impacted by the proposals.

A summary of the rules under the Base Case is presented in Table 17.

Table 17: Summary of rule changes between the Base Case and the Barwon-Darling Valley FMP

Base case	Barwon-Darling Valley FMP construct
Flood works across the whole floodplain require application for a WMA 2000 flood work approval under similar criteria to Part 8 of the WA 1912.	Flood works in the designated flood plain management area are subject to the FMP and require application for a flood work approval under WMA 2000.
Floodway network In an identified floodway in a guideline area or a suspected unidentified floodway in a non-guideline area, the applicant is required to provide a floodplain engineers report identifying that the hydraulic parameters[1] are not exceeded. All applications are deemed to be non-complying and require advertising and objections are to be considered before possible approval. Flood-work applications are unlikely to be approved in floodway networks. There are no existing FMPs in the Barwon-Darling Valley Floodplain. All flood-work applications must be advertised.	**MZ A** provides for flood work approvals by application that is one of the following: • an access road up to 30 cm above natural surface level, or • a supply channel below the natural surface level, or • stock refuge, or • an infrastructure protection work, or • ecological, Aboriginal value and heritage site enhancement works, or • existing works – licensed and unlicensed. Applications do not require advertising. Note: assessment was undertaken prior to proposal to increase road height in February 2016. Initial road height of 30 cm would have a greater socio-economic impact than increased road height allowances of 50 cm for 'all other roads' and 1 m for 'primary access roads'. See Step 8: Determine Rules for more information on the access road rule
	MZ D provides for a prohibition of flood work approvals except for: • ecological, Aboriginal Value and heritage site enhancement works, or • existing works – licensed and unlicensed
Areas outside the floodway network As there are no existing FMPs in the Barwon-Darling Valley Floodplain, the applicant is required to provide a floodplain engineers report identifying that the hydraulic parameters[1] are not exceeded. All applications are deemed to be non-complying and require advertising and objections are to be considered before possible approval.	**MZ B** provides that flood work approvals or modifications by application does not require advertising if it is one of the following: • no more than 50 cm in height above the natural surface level, or • stock refuge, or • infrastructure protection works. All other flood works require advertising. The application **must not** be approved if it exceeds the

Base case	Barwon-Darling Valley FMP construct
	assessment criteria defined in the Plan. State-wide exemptions apply in this management zone. See DPIW website for the list of exemptions. Note: assessment was undertaken prior to proposal to increase advertising height to 80 cm in February 2016. Initial advertising height of 50 cm would have a greater socio-economic impact than the increased advertising height of 80 cm.
	MZ C provides for flood work approvals by application if they meet the assessment criteria. The application does not require advertising. State-wide exemptions apply in this management zone. See DPIW website for the list of exemptions.

[1]Hydraulic parameters are based on hydraulic criteria defined under Part 8 of the WA 1912 that have been transferred to flood work assessments under the WMA 2000 and are consistent with the rules and assessment criteria in the proposed Barwon-Darling Valley FMP.

Impact of rule changes

Management Zone A

MZ A floodways in the Barwon-Darling Valley FMP are initially defined by hydraulic criteria, including the DVP from the flood modelling.

Under existing management practices (prior to enactment of the Barwon-Darling Valley FMP) in the Barwon-Darling Valley Floodplain all flood-work applications would require advertising and detailed technical assessment prior to authorisation. It is also unlikely in floodway areas in the Base Case scenario that any works other than those permissible in MZ A would have been approved. It is expected that flood work approvals in this area are not likely to be substantially negatively affected by the Barwon-Darling Valley FMP.

MZ A in the Barwon-Darling Valley FMP includes areas in addition to the hydraulic floodways that are important for flood connectivity to significant flood-dependent vegetation and flood-dependent cultural assets. These areas are known as ecological or cultural amendments to MZ A. Land included as the ecological or cultural amendment to MZ A will be subject to significant change under the Barwon-Darling Valley FMP. If the Barwon-Darling Valley FMP had not been developed (the Base Case), it is likely that flood work proposals in these areas would have been assessed in general accordance with the rules in the adjacent management zone, usually MZ B. However, with the addition of ecological and cultural assets to MZ A, these areas are now subject to MZ A rules that provide for only:

- approved access roads up to 30 cm above surface level
- stock refuge
- infrastructure protection works
- supply channels below the natural surface level
- ecological, Aboriginal value and heritage site enhancement works
- existing works – licensed and unlicensed

This will incur costs to landholders in the form of lost option value on this land compared with the Base Case. It is expected that flood work approvals in these areas may be significantly negatively affected by the Barwon-Darling Valley FMP.

Management Zone B

Floodplain land that is outside MZ D and MZ A, but is within the large design flood area will become the flood storage and secondary flood discharge, MZ B.

Under the Base Case scenario all flood-work applications would require advertising. However, the Barwon-Darling Valley FMP has reduced advertising requirements through the specification of minor works in MZ B. Minor works such as limited height flood works, stock refuge and infrastructure protection works subject to size conditions, can be approved without advertising. This change is expected to provide additional benefits to landholders and streamline the assessment process. Flood works in excess of the size limits in MZ B will require advertising which is the same requirement as the Base Case.

Specification of the types of works that require advertising will not incur any additional costs to landholders. Furthermore, where a flood-work application satisfies the criteria for a minor work there will be a reduction in application processing time as applications will not be subject to third party objections.

It is expected that flood work approvals in this category may be positively affected by the Barwon-Darling Valley FMP.

Management Zone C

Areas above the design flood or afforded protection by approved works will be in MZ C. Flood-work applications in MZ C may be required to meet assessment criteria but will not require advertising. This is a positive change from the Base Case, whereby flood-work applications that required advertising across the Barwon-Darling Valley Floodplain will not require advertising under the Barwon-Darling Valley FMP. Flood work approvals in this category may be marginally positively affected by the Barwon-Darling Valley FMP.

Management Zone CU

This management zone includes the areas managed by Local Council. The hydraulic, ecological or cultural criteria are not applicable in these areas.

It is expected that there will not be any substantially negative impacts in this area.

Management Zone D

MZ D is a special ecological and cultural protection zone. This MZ includes ecological or cultural areas that are highly significant. The inclusion of this MZ in the Barwon-Darling Valley FMP is to ensure that flood connectivity to these assets are maintained and protected. All the assets included in this management zone are associated with water bodies. Ecological, Aboriginal values and heritage site enhancement works and existing works - unlicensed and licensed flood works are permitted in this management zone. Any proposed work would also require a controlled activity approval under the WMA 2000. It is unlikely that such a controlled activity approval would be given in the Base Case.

It is expected that flood work approvals in this management zone are not likely to be substantially negatively affected by the Barwon-Darling Valley FMP.

Summary of negative impacts

Considering the changes from the Base Case to the Barwon-Darling Valley FMP the negative impacts identified is the lost access by landholders to all but limited applications in the ecological asset connector and cultural significance to MZ A. The details of the impacts are presented in Table 18.

Table 18: Impact table of the Barwon-Darling Valley FMP

	Ecological asset connector and area of Cultural Significance
Total area (ha)	3 387 (east of Brewarrina)

		Ecological asset connector and area of Cultural Significance
Possible land use		Cropping
Representative land use		Wheat
Impact		Lost access to complying works other than: Infrastructure protection works, access roads, and supply channels below the natural surface level.
Who is impacted		Landholder
Quantifiable ($)		Yes
Data sources		GIS – area; ABS - Wheat $ GVAP
Scale : extent and intensity*	**Plan**	Negative, Low
	Regional	
	Local	
	Owner	Negative, Medium
Likelihood and duration*	**Plan**	Low, Permanent
	Regional	
	Local	
	Owner	

*Impact: assess each factor with the other three factors held constant. Magnitude: Low, Medium, High.

Impacted area

The total area of ecological and cultural refinements to MZ A (flood-dependent vegetation) from outside the modelled hydraulic floodway networks is estimated to be 22,787 ha. However, this whole area is not impacted by the Barwon-Darling Valley FMP as not all of the area is suitable for dryland cropping. Based on local governmental knowledge it is assumed that the eastern side of the Barwon-Darling Valley FMP area starting from halfway through the Brewarrina Shire is suitable for dryland cropping. It is estimated that 3,387 ha, 15 per cent of the total area of ecological asset connector and cultural significance in MZ A, is in that region.

This area is adjacent, in close proximity to or connects with the hydraulic floodway network. This amounts to about 0.3 per cent of the total floodplain area. It is acknowledged that, depending on the property size, these areas may have a large impact on option value for individual landowners.

The Barwon-Darling Valley FMP rules regulate only the construction of flood works and do not regulate land use such as cultivation or grazing of the land. Actual development of these areas may be limited by other legislation including the *Native Vegetation Act 2003* (NVA 2003).

Notwithstanding the NVA 2003, it is expected that it would not be practical for a large proportion of this land to be developed for reliable cultivation. However, in the absence of any information on the proportion of the area that could practically be developed for reliable cultivation, we assumed that all of this area, 3,387 ha, could be developed for cultivation in order to estimate the annual gross value associated with the ‘option value’, knowing that it will result in an estimate of the maximum impact.

Estimated value of economic impacts

The financial impact of the restrictions imposed on the area of flood-dependent vegetation and of cultural significance in MZ A can be estimated using data on the area of land suitable for regular dryland cropping and the Gross Value of Agricultural Production (GVAP). This land in the Barwon-Darling Valley Floodplain may be used for many summer or winter crops in various

rotation sequences. The most widely recognised crop type and cropping sequence is continuous wheat production. The potential use of the area suitable for regular cultivation (3,387 ha) is assumed to be continuous wheat production.

The estimated gross value and area of 'wheat for grain' produced in the Barwon-Darling Valley Floodplain was $541 GVAP/ha . These estimates were prepared as part of the Socio-economic profile of the Barwon-Darling Valley Floodplain and are based on Australian Bureau of Statistics data for 2011.The GVAP loss due to the prevention of the capacity to construct flood protection banks in this area under the proposed FMP will be compared to the total GVAP for the Barwon-Darling Valley FMP to identify the level of significance.

The area of flood-dependent vegetation and cultural significance in MZ A is largely adjacent to or flowing to watercourses and is therefore likely to be exposed to frequent flooding. Some of these flood events are beneficial to the crop or pasture and some are devastating depending on the timing (relative to crop and pasture growth cycle), depth, duration and speed of the floodwater. As flood works to protect crops cannot be constructed in MZ A, it is assumed that the outcome of these events is an additional one crop failure in four years.

On average, the gross value of wheat production from the 3,387 ha of cropping land could potentially produce $1.83 million per year in the Base Case with flood protection. Without flood work protection under the FMP this area would potentially produce $1.37 million per year from cropping - a reduction of $0.46 million (a result of an additional 1 in 4 crop failure). The upper limit of the net impact of the implementation of the Barwon-Darling Valley FMP on the area of private cropping due to flood-dependent vegetation and cultural significance within MZ A is estimated to be a reduction of $0.46 million. This is very small, 0.49 per cent of the total GVAP for the Barwon-Darling Valley Floodplain of $94 million.

Sensitivity analysis

This analysis is sensitive to the assumed frequency of crop failure, the cropping area within the area of flood-dependent vegetation and cultural significance to MZ A and the impact on individual property owners.

The loss due to the inability to construct flood works to protect these areas from flooding is an estimated additional one crop failure in four years. If the rate of additional crop failure due to flooding was to increase to one crop failure in two years, the estimated impact would rise to $0.92 million or 0.98 per cent of regional GVAP. Conversely, if the rate of additional crop failure due to flooding was to decrease to one crop failure in six years, the estimated impact would be reduced to $0.31 million or 0.33 per cent of regional GVAP.

The estimated impact is expected to be an over estimate due to much of the 3,387 ha, identified in the analysis as holding potential for continuous wheat production, is currently used for grazing because it floods too often to be cropped reliably. In such cases the farmer's assessment has been that the higher cost of cropping and the risk of loss are greater than the more reliable pasture grazing option of lower cost and smaller gain. If the area was reduced by one half to 1,694 ha, due to incorrect classification as suitable for regular cropping or inability to crop due to other restrictions such as the NVA 2003, the estimated impact would be reduced to $0.23 million or 0.24 per cent of regional GVAP.

Many landholders will not be impacted by the FMP; however, there may be some individual farm level impacts that could be more significant depending on the proportion of their land that is affected. A counter balancing item is that the area of flood-dependent vegetation and cultural significance in MZ A would probably have a discounted land value due to flooding frequency.

Phase two assessment

A second socio-economic assessment was not required as the Phase one analysis found that the estimated impact of the proposed Barwon-Darling Valley FMP rules (as outlined above) is of

low significance for the regional economy. Based on this result it was decided not to proceed with the Phase two assessment. This decision was also supported by the following mitigating factors:

- community feedback on potential socio-economic impacts received during targeted consultation was considered and incorporated into the draft Barwon-Darling Valley FMP. Based on community feedback:
  - the area of MZ A was reduced (4.5 % reduction in MZ A – based on comparison between Phase one assessment MZ A and finalised MZ A)
  - the rules for access roads in MZ A were relaxed (Table 17); and
  - the advertising height threshold in MZ B was relaxed (Table 17).

  As these changes occurred post Phase one socio-economic impact analysis, the impact on GVAP will be less than the Phase one impact assessment findings
- the community had another opportunity to provide feedback on potential socio-economic impacts of the draft management zones and rules for the draft Barwon-Darling Valley FMP during public exhibition. However, no major socio-economic impact issues were raised during the public exhibition period.

Summary

Considering the changes from the Base Case to the Barwon-Darling Valley FMP, the following key negative impacts were identified:

- lost opportunities to get approval in the area of flood-dependent vegetation and cultural significance in MZ A for works other than limited infrastructure protection works, access roads, stock refuges and supply channels below the natural surface level.

The impact of the Barwon-Darling Valley FMP is estimated to be a small reduction of 0.49 per cent of the total GVAP for the Barwon-Darling Valley Floodplain. This impact is further mitigated with the reduction in MZ A and relaxation of the access road rule in MZ A and advertising height rule in MZ B post Phase one assessment. Due to the estimated small GVAP impact and post Phase one refinements Phase two assessment was not required.

The GVAP estimate is the upper limit economic impact considering that it is unlikely that all of the area of flood-dependent vegetation and cultural significance within MZ A (eastern side of the Barwon-Darling Valley FMP area starting from halfway through Brewarrina Shire) suitable for regular cultivation will be cropped.

Many landholders will not be impacted by these estimated costs. However, there may be some individual farm level impacts that are more significant depending on where the land is situated in the landscape.

Role of socio-economics in plan development

This impact assessment concludes that there is a limited negative socio-economic impact from the Barwon-Darling Valley FMP. Socio-economic advice has influenced the development of the Barwon-Darling Valley FMP management zones, rules and assessment criteria. Key consideration was given to achieve a balance at each stage between flood behaviour and the environment, social and economic outcomes. Some examples include:

- categorising the types of flood works enabled consideration of important information on the socio-economic benefits of flood works along with the level of risk that a flood work type would significantly impact on flood behaviour,
- ensuring socio-economic impacts were included in the criteria for ‘reasonable consistency’ with previous floodplain management arrangements,

- incorporating, wherever possible, areas with approved existing flood-work development into MZ C,
- weighing up the socio-economic impacts of development controls against the potential for different types of flood works to impact on flooding behaviour. The restrictions on the types of flood works that could be applied for were made to minimise the risk that flood works would impact flooding behaviour whilst being sympathetic to landholder needs. These decisions were checked against the works likely to be approved under existing floodplain management planning arrangements and discussions held during targeted consultation with the community and interagency officers,
- the requirement to advertise proposed works provides local landholders with an opportunity to comment on any impact that a proposed flood work could have in causing or exacerbating flooding depth, duration or flow rate problems on their land,
- the non-advertising of proposed minor flood works enables landholders to construct approved flood works of a more minor nature without advertising their proposed works, which will save both money and time.

Consultation and review of the plan

DPIW was responsible for the review and consultation processes throughout the development of the Barwon-Darling Valley FMP. OEH contributed technical expertise and local experience to the review and consultation processes. All stakeholders and interested parties had an opportunity to review and provide comment on the Barwon-Darling Valley FMP at key stages throughout plan development.

Consultation process

Consultation activities involved:

- technical assessment: consultation of regional and scientific experts to collect relevant data/knowledge, provide technical input and review the FMP planning approach and criteria for delineating management zones and rules
- targeted consultation: engagement of targeted community groups for feedback on the proposed boundary, management zones and rules
- public exhibition: formal public exhibition of the Barwon-Darling Valley FMP, and collection, review and incorporation of feedback from formal submissions to finalise the FMP for Ministerial approval and commencement.

Consultation with Aboriginal stakeholders was undertaken using the approach outlined in Appendix 15 to be in line with:

- Aboriginal People, the Environment and Conservation (APEC) principles (DEC 2006)
- an Aboriginal Community Engagement Framework for DECC (2007)
- working to protect Aboriginal cultural heritage (OEH 2011).

Technical assessment

Technical Advisory Group (TAG)

The TAG was responsible for providing expert knowledge and technical advice to the project team to help facilitate the development of the FMP. The TAG was composed of NSW Government agencies and other key agencies involved in water management in NSW, including DPIW, OEH, DPI Agriculture, Local Land Services and DPI Fisheries.

The TAG was engaged throughout the FMP development process through a combination of email correspondence and face-to-face meetings. The TAG officially met five times from July 2013 to June 2015 to identify and establish:

- the floodplain boundary
- draft management zones and rules
- ecological and cultural assets that are dependent on flooding
- watering requirements of flood-dependent assets
- cultural and ecological assessments and targets
- design floods and hydraulic modelling parameters
- socio-economic considerations.

Information provided by the TAG was incorporated into the development of the Barwon-Darling Valley FMP.

Aboriginal Technical Working Group (ATWG)

The ATWG was created as a consultative group to provide strategic advice on the:

- type, scope and integration of flood-dependent Aboriginal values into the FMPs
- identification and prioritisation of cultural assets that require protection under the FMPs
- key contacts/knowledge holders in the Aboriginal community for consultation
- cultural knowledge on the history of flooding.

The ATWG was comprised of state and regional cultural heritage experts. It was designed to have flexible membership in order to adapt to the moving focus of plan development in different valleys. A number of workshops were held with the ATWG to:

- define and identify Aboriginal values that are dependent on flooding
- identify watering requirements of Aboriginal values and other floodplain assets that have Aboriginal value
- identify and document significance of Aboriginal values and other floodplain assets that have Aboriginal value
- develop a community consultation process for identification of Aboriginal values in data gap areas
- review management zones, rules and assessment criteria.

Information provided by the ATWG was incorporated into the development of the FMP and is outlined in Steps 5, 7 and 8.

Aboriginal community

Local Aboriginal communities were engaged by an OEH Aboriginal Natural Resource Officer through informal meetings. The aim of these meetings with Aboriginal stakeholders was to identify issues of concern in the valley and to introduce the objectives of the FMP in the context of the issues raised. During this engagement, OEH collected spatial information on cultural assets dependent on flooding. These were later analysed as part of Step 5 and were factored into the management construct. These cultural assets were discussed with the community during targeted consultation and public exhibition to obtain further feedback. Refer to Steps 5, 7 and 8 for further information on how Aboriginal values from consultation were incorporated into the FMP.

Targeted consultation

Targeted consultation was an opportunity to ‘road test’ the proposed Barwon-Darling Valley FMP boundary, management zones and rules. Targeted consultation was undertaken with stakeholders at Mungindi, Walgett, Brewarrina and Bourke in October 2015 and February 2016.

The objectives of targeted consultation were to:

- provide background to key stakeholders as to why and how FMPs are being developed, what management zones and rules were proposed in the Barwon-Darling Valley FMP and how stakeholders could provide feedback, and
- ‘road test’ the proposed Barwon-Darling Valley plan boundary, management zones and rules.

Targeted consultation involved the following key stakeholder groups and individuals within the Barwon-Darling Valley Floodplain:

- graziers, dryland and irrigation landholders and organisations
- Aboriginal community representatives
- environmental representatives
- local and state government representatives

- local agronomists and consultants.

As a proportion of the total items of inquiry received, 28 per cent collectively related specifically to the Barwon-Darling Valley FMP boundary, management zones, rules and assessment criteria.

The suggestions in Table 19 were reviewed and incorporated as recommendations for consideration by the IRP following feedback from targeted consultation.

Table 19: Changes recommended for consideration by the IRP as a result of feedback received during targeted consultation.

No.	Rule/assessment criteria proposed at targeted consultation	Change to rule/assessment criteria as a result of feedback	Justification
1.	That access roads must be constructed at a height ≤30 cm above the natural surface level	To allow, through application, access roads: • up to 50 cm above the natural surface level or • up to 100 cm above the natural surface level as long as the access road is a primary access road and • has appropriate causeways and borrow treatment.	Landholders raised concerns that the nature of flooding in the Barwon-Darling Valley Floodplain is characterised by deeper longer lasting floods and 30 cm high access roads would be inundated or washed out during flood events preventing access to properties.

Public exhibition

The draft Barwon-Darling Valley FMP was on public exhibition from Monday 31 October 2016 to Friday 9 December 2016. The objectives of this consultation can be grouped into two categories:

- provide background to stakeholders on:
  - why the FMP is being developed
  - how the FMP has been developed to date
  - what rules are proposed in the various areas
  - how to make a formal submission.
- seek feedback on the management construct to:
  - incorporate local knowledge on historical flooding in data poor areas, which may help to refine management zones,
  - identify additional ecological and cultural assets for inclusion in the FMP,
  - review and validate existing flood-work development zoned as MZ C

The draft Barwon-Darling Valley FMP was available on the DPIW website and was displayed at regional locations within the FMP area. Only written submissions, submitted electronically or by post were accepted.

Public exhibition consultation, mainly in the form of individual appointments, was held at Bourke, Brewarrina and Walgett during the public exhibition period.

A total of eight submissions were received in response to exhibition of the draft Barwon-Darling Valley FMP. From the eight submissions received, 47 items of inquiry (IOI) were identified. Twenty-three per cent of IOI received were in relation to the draft management zones, 23 per cent in relation to the draft rules, 11 per cent in relation to the draft assessment criteria, and 43 per cent were related to other interests. There was no feedback in relation to the draft boundary. All feedback received during public exhibition was presented and considered by the IRP in March 2017. A summary of the changes supported by the IRP are outlined in Table 20. Changes

supported by the IRP are reflected in the finalised products in this report and the Barwon-Darling Valley FMP Plan Order.

Table 20: Summary of changes to the management construct supported by the IRP for the Barwon-Darling Valley FMP as a result of feedback received during public exhibition.

Feedback category	Feedback summary	Recommendation
Management zones	Thin MZ A in specific areas	Thin existing MZ A in specified areas in support of feedback but retain overall management zone to maintain flood connectivity.
	Change the zoning of specific areas to include areas of existing flood-word development covered by Part 8 Water Act 1912 approvals	Where there is an approved Part 8 controlled work approval include the approved Part 8 area in MZ C.
Rules	For Aboriginal Value and heritage site improvement works the databases listed in the FMP may not contain all cultural assets. It was advised additional wording be added to the plan order to capture cultural asset information that may be contained in other sources or databases not listed in the FMP at the time of public exhibition.	Modify the wording in the FMP (plan order) in parts: • Part 5 - Division 3 – S21 and S22 • Part 8 - Division 2 – S38 (9) and (10) • Part 8 - Division 6 – S45 (2) and (3) to include 'any other source and/or database deemed relevant by the Minister'.
Other	During consultation with the Ngembah community members at Brewarrina the issue of recognition in the FMP was raised. It was suggested by the Ngembah community members that the floodplain reaches in the FMP should be named after the Nations that represent that land out of recognition and respect to the Traditional Owners of the land.	Modify the floodplain reach descriptions in the FMP (plan order) to include the Aboriginal Nations who are the Traditional Owners of each floodplain reach. A description of the Aboriginal Nations by floodplain reach is outlined in The Barwon-Darling Valley Floodplain section of this report

Review

Interagency Regional Panel

The IRP was established to review the boundary, management zones and rules contained in the draft Barwon-Darling Valley FMP. The IRP consisted of one representative from OEH to cover environmental interests and two representatives from the Department of Primary Industries: one from DPI Water and another DPI representative covering agricultural, fisheries and water management interests.

Representatives from Local Land Services, Water NSW and the Department of Trade and Investment (Economics Branch) also attended meetings (as observers) to provide advice on relevant matters within their area of expertise.

The key responsibilities of the IRP were to:

- ensure that proposed management rules achieved the objectives of the WMA 2000
- provide information and analysis
- bring a balanced approach to the development of the FMP: economic, social, environmental and cultural considerations.

The IRP provided whole-of-government oversight and review of the development of the Barwon-Darling Valley FMP and met at key stages throughout the FMP development:

- prior to targeted consultation
- prior to public exhibition

- prior to finalisation and commencement.

Prior to targeted consultation

The IRP reviewed the draft Barwon-Darling Valley FMP in September 2015 and supported its release for targeted consultation.

Prior to public exhibition

The IRP reviewed the draft Barwon-Darling Valley FMP and feedback from targeted consultation in March 2016.

The IRP recommended that:

- rule specifications for access roads in MZ A be increased to ≤ 50 cm in height with associated causeway requirements and additional provisions be included for primary access roads to ≤ 100 cm in height with associated causeway requirements
- rule specifications for advertising height trigger thresholds in MZ B be increased to 80 cm in height.

The IRP also provided key considerations for the implementation of the Barwon-Darling Valley FMP. These considerations will be incorporated into assessment guidelines and used by licensing staff when assessing flood work applications.

Prior to finalisation and commencement

The IRP was reconvened after public exhibition to:

- consider stakeholder feedback
- recommend changes to the draft boundary, management zones and rules based on feedback from public exhibition
- review and endorse final boundary, management zones and rules prior to FMP commencement.

A summary of the changes to the Barwon-Darling Valley FMP endorsed by the IRP are outlined in Table 20. The IRP supported the finalisation of the boundary, management zones, rules and assessment criteria for the Barwon-Darling Valley FMP in March 2017.

Plan finalisation and commencement

After endorsement by the IRP in March 2017, the Barwon-Darling Valley FMP was submitted to the Minister for Regional Water for approval and then to the Minister for the Environment to seek concurrence prior to commencement. The Barwon-Darling Valley FMP was commenced on 30 June 2017. Copies of the FMP can be obtained from the NSW Legislation website.

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Glossary

Aboriginal values are sites, objects, landscapes, resources and beliefs that are important to Aboriginal people as part of their continuing culture.

Aboriginal value enhancement work is a flood work that is constructed only to benefit Aboriginal value assets that are listed in the Aboriginal Heritage Information Management System (AHIMS), Aboriginal Water Initiative System (AWIS), Murray Darling Basin Authority Aboriginal Submissions Database, NSW State Heritage Register or Commonwealth Heritage Register or any other source and/or database deemed relevant by the Minister.

Annual Exceedance Probability is the chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage (%) or a likelihood of 1 flood in x years. For example, a flood with an AEP of 5% means there is a 5% chance that a flood of the same size or larger will occur in any one year.

borrow is an area of land where material is excavated or removed to construct a flood work at another location. The removal of material from this area results in a depression or 'hole' in the ground.

connectivity refers to the unimpeded passage of floodwater through the floodplain. Connectivity is important for instream aquatic processes and biota and the conservation of natural riverine systems.

cultural asset is an object, place or value that is important for people to maintain their connections, beliefs, customs, behaviours and social interaction.

depth-velocity product is a hydraulic model output that can be used to indicate areas of a floodplain where a significant discharge of water occurs during floods; that is, areas where flow velocity and/or water depth are relatively high.

design flood is a flood of known magnitude or annual exceedance probability (AEP), that can be modelled. A design flood is selected to design floodway networks which are used to define management zones for the planning and assessment of the management of flood works on floodplains. The selection is based on an understanding of flood behaviour and associated flood risk. Multiple design floods may be selected to account for the social, economic and ecological consequences associated with floods of different magnitudes.

discharge (or flow) is the rate of flow measured in volume per unit of time (e.g. megalitres per day = ML/day).

ecological assets are a wetland or other floodplain ecosystem, including watercourses that depend on flooding to maintain their ecological character. Areas where groundwater reserves are recharged by floodwaters are also considered to be ecological assets. Ecological assets are spatially explicit and are set in the floodplain landscape.

ecological enhancement work is a flood work that is constructed only to benefit ecological assets that are recognised in or protected by a local, state or Commonwealth environmental policy and/or legislation.

ecological values are surrogates for biodiversity that are used to prioritize the ecological assets and include fauna species and fauna habitat, vegetation communities and areas of conservation significance.

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

Exceedances per Year **(EY)** is the expected number of times in a year that the event will occur or be exceeded.

existing development conditions refers to the level of development at the commencement of this Plan.

fish passage refers to connectivity that facilitates the movement of native fish species between upstream and downstream habitats (longitudinal connectivity) and adjacent riparian and floodplain areas (lateral connectivity). Areas that are important for fish passage include rivers, creeks and flood flow paths.

Flood Risk Management Plan (FRMP) identifies and determines options in consideration of social, ecological and economic factors relating to flood risk and the management of flood prone land.

Flood Risk Management Study (FRMS) provides preferred options relating to flood risk and provides the information necessary for adequate forward planning of flood prone land.

flood study (FS) is a comprehensive technical investigation of flood behaviour and defines the nature of flood risk.

flood-dependent assets refers to assets that have been identified in the plan as having important ecological or cultural features which rely on inundation by floodwaters to sustain essential processes.

flood structure refers to any existing floodplain feature (such as a barrage, causeway, cutting or embankment) without a flood work approval for which a flood work approval is now required, from the commencement of the Barwon-Darling Valley FMP.

flood study is a comprehensive technical investigation of flood behaviour and defines the nature of flood risk.

flooding regime refers to the frequency, duration, nature and extent of flooding.

floodplain watercourses include:

(a) permanent flowing rivers and creeks, including those where the flow is modified by upstream dam(s), and

(b) intermittent flowing rivers and creeks that retain water in a series of disconnected pools after flow ceases including those where the flow is modified by upstream dam(s), to the top of the natural bank regardless of whether the channel has been physically modified, and

(c) flood channels or flood runners that run across or along floodplains during high flow events.

floodways are areas where a significant discharge of floodwater occurs during small and large design floods.

groundwater recharge areas are areas where water from a flood event leaks through the soil profile into the underlying aquifers.

heritage site enhancement work is a flood work that is constructed only to benefit heritage site assets that are listed in the Aboriginal Heritage Information Management System (AHIMS), Aboriginal Water Initiative System (AWIS), Murray Darling Basin Authority Aboriginal Submissions Database, NSW State Heritage Register, NSW State Heritage Inventory, Historic Heritage Information Management Systems, Commonwealth Heritage Register or any other source and/or database deemed relevant by the Minister.

heritage sites are cultural heritage objects and places as listed on Commonwealth, State and local government heritage registers or any other source and/or database deemed relevant by the Minister.

high value infrastructure includes but is not limited to houses/dwellings, infrastructure protection works, town levees, stockyards, sheds and pump sites. It does not include farm levee banks, irrigation development and fences.

infrastructure protection works are flood works that are for the protection of houses, stock yards and other major infrastructure, such as machinery sheds.

management zones are areas in the floodplain that have specific rules to define the purpose, nature and construction of flood works that can occur in those areas.

natural flooding regime refers to how flood waters moved over the floodplain before development (i.e. flood works and major storage dams), landuse changes and climate change.

natural surface level is the average undisturbed surface level in the immediate vicinity of a flood work.

primary access road is a road providing access from a public road to a permanently occupied fixed dwelling via a direct route.

pre-development conditions refers to the natural flooding regimes.

recharge means the addition of water, usually by infiltration, to an aquifer.

windrow refers to a row or line of cut vegetation or other material.