



RURAL FLOODPLAIN MANAGEMENT PLANS

# Background document to the Floodplain Management Plan for the Border Rivers Valley Floodplain 2020

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*Water Management Act 2000*

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## Abbreviations

Abbreviation	Description
ABS	Australian Bureau of Statistics
ADS40	Airborne Digital Sensor
AEP	annual exceedance probability
AHD	Australian Height Datum
AHIMS	Aboriginal Heritage Information Management System
ASDST	Aboriginal Sites Decision Support Tool
ATWG	Aboriginal Technical Working Group
Barwon-Darling Valley FMP 2017	<i>Floodplain Management Plan for the Barwon-Darling Valley Floodplain 2017</i>
Border Rivers Valley FMP 2020	<i>Floodplain Management Plan for the Border Rivers Valley Floodplain 2020</i>
DEM	digital elevation model
DPI	NSW Department of Primary Industries
DVP	depth-velocity product
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i>
FMP	floodplain management plan
FPWEC	First Peoples' Water Engagement Council
FRMP	floodplain risk management plan
FRMS	floodplain risk management study
GVAP	gross value of agricultural production
Gwydir Valley FMP 2016	<i>Floodplain Management Plan for the Gwydir Valley Floodplain 2016</i>
HHIMS	Historic Heritage Information Management System
IPW	Infrastructure Protection Work
IRP	Interagency Regional Panel
IRSAD	Index of Relative Socio-economic Advantage and Disadvantage
LiDAR	light detection and ranging

Abbreviation	Description
LGA	local government area
Lower Namoi Valley FMP 2020	<i>Floodplain management plan for the Lower Namoi Valley Floodplain 2020</i>
MDB	Murray–Darling Basin
MDBA	Murray–Darling Basin Authority
ML	megalitres
MZ A	management zone A—major discharge areas and defined floodways
MZ B	management zone B—flood storage and secondary flood discharge
MZ C	management zone C—flood fringe and flood-protected developed areas
MZ CU	management zone CU—urban areas
MZ D	management zone D—special protection
NBAN	Northern Murray-Darling Basin Aboriginal Nations
NOW	(former) NSW Office of Water
NSW	New South Wales
OEH	NSW Office of Environment and Heritage
PCT	plant community type
Qld	Queensland
RAFTS	Runoff Analysis and Flow Training Simulator
Schedule 5	Schedule 5—Significant lagoons and wetlands—Water Sharing Plan for the NSW Border Rivers Unregulated and Alluvial Water Sources 2012
SEIFA	Socio-economic Indexes for Areas
TAG	Technical Advisory Group
Upper Namoi Valley FMP 2019	<i>Floodplain Management Plan for the Upper Namoi Valley Floodplain 2019</i>
WA 1912	<i>Water Act 1912</i>
WM Act	<i>Water Management Act 2000</i>
WR 2016	<i>Water Regulation 2016</i>

Abbreviation	Description
WRC	Water Resources Commission New South Wales
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 Border Rivers Valley Floodplain. This document should be read in conjunction with the Technical Manual and the *Floodplain Management Plan for the Border Rivers Valley Floodplain 2020* (Border Rivers Valley FMP 2020).

## The Border Rivers Valley Floodplain

This document pertains to the area known as the Border Rivers Valley Floodplain, as shown in Figure 1. The western boundary is at Mungindi on the Barwon River, at the New South Wales (NSW), Queensland (Qld) border which aligns with the boundary of the Barwon–Darling Valley FMP which commenced on 30 June 2017. The eastern boundary is aligned to significant cadastral features, such as roads, that best match the historical extent of flooding in the area. The northern boundary is aligned to the NSW, Qld border, and the southern boundary is aligned to the Gwydir Valley FMP, which commenced on 12 August 2016.

The Border Rivers Valley Floodplain is declared to be a floodplain under the *Water Management (General) Regulation 2018*. The Dictionary to the *Water Management Act 2000* provides that a *floodplain* means land declared by the regulations to be a floodplain.

The Border Rivers Valley Floodplain is within the NSW Border Rivers catchment (approximately 2.4 million ha) which forms the southern and NSW component of the greater Border Rivers catchment (Figure 2). The Border Rivers catchment (approximately 6.3 million ha) spans both southern Qld and northern NSW and comprises a major portion of the headwaters of the Barwon–Darling River system and the broader Murray–Darling Basin (MDB) (BRG CMA 2013).

The principal and mainly westward flowing streams within the Border Rivers catchment include:

- a) in Qld:
  - (i) Dumaresq River
  - (ii) Weir River,
- b) in NSW:
  - (i) Severn River
  - (ii) Macintyre River.

In Qld, the Dumaresq River is formed at the junction of the Severn River and Tenterfield Creek. The major tributaries of the Dumaresq include Pike Creek (on which Glenlyon Dam is constructed which first flows into the Severn then the Dumaresq), Mole River and Beardy Creek. Macintyre Brook is also a major tributary, joining the Dumaresq halfway between Texas and Boggabilla. The entire length of the Weir River flows through Qld in the northern part of the Border Rivers catchment. The Weir joins the Macintyre River 23 km upstream of Mungindi. Below the junction of the Weir and Macintyre River, the Macintyre is named the Barwon River.

In NSW, the headwaters of the Severn are in the Great Dividing Range between Emmaville and Ben Lomond, and it flows in a westerly direction to meet the Macintyre River. Pindari Dam is located on the Severn River. The Macintyre River flows generally in a north-westerly direction from its headwaters in the Great Dividing Range near Inverell and is joined by the Dumaresq River approximately 23 km upstream of Boggabilla. Whalan Creek and the Boomi River are major effluents of the Macintyre River. Downstream of its confluence with the Dumaresq River, the Macintyre River forms the Qld/NSW State border between Boggabilla and Mungindi.

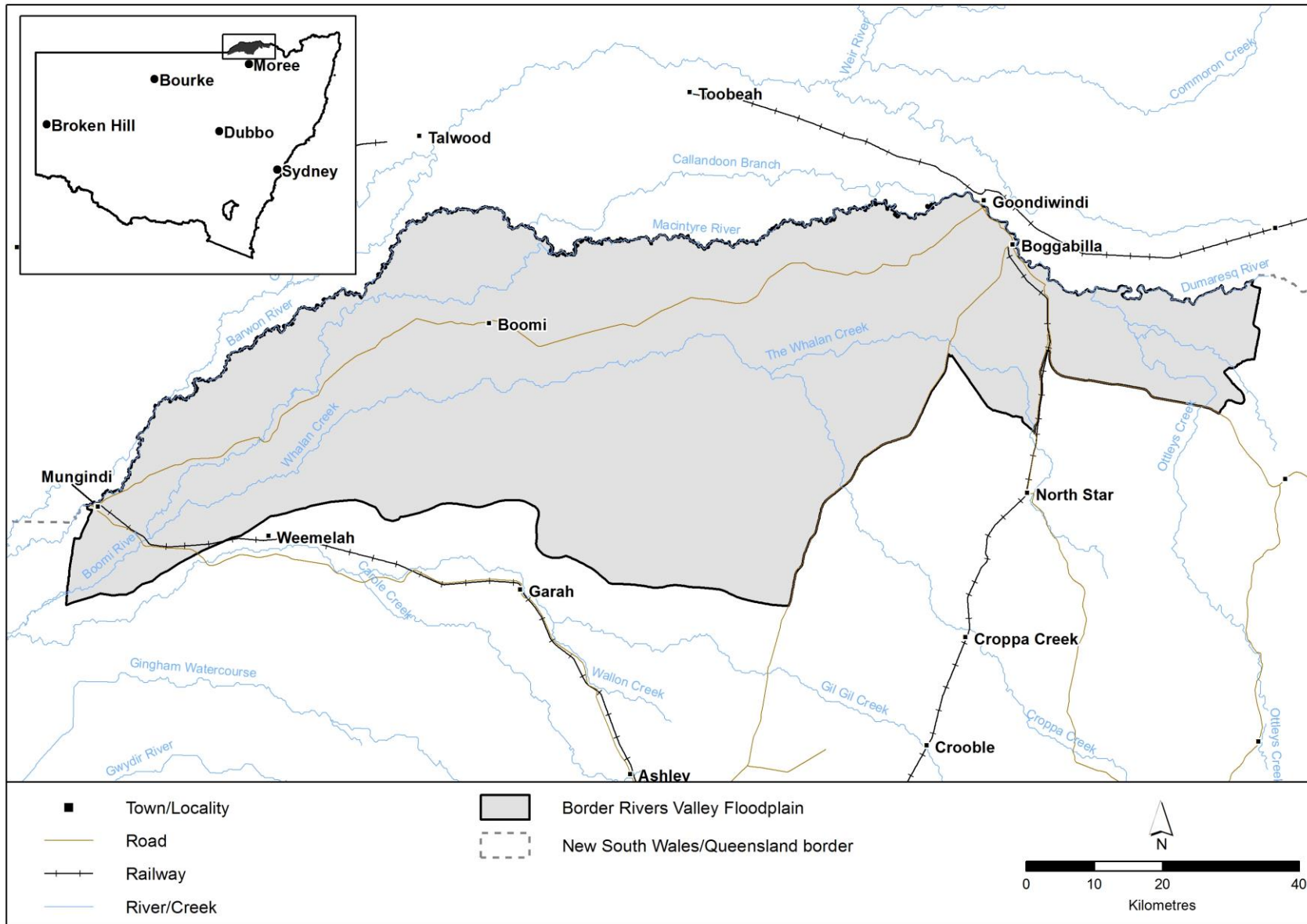


Figure 1: Overview of the Floodplain Management Plan for the Border Rivers Valley Floodplain 2020

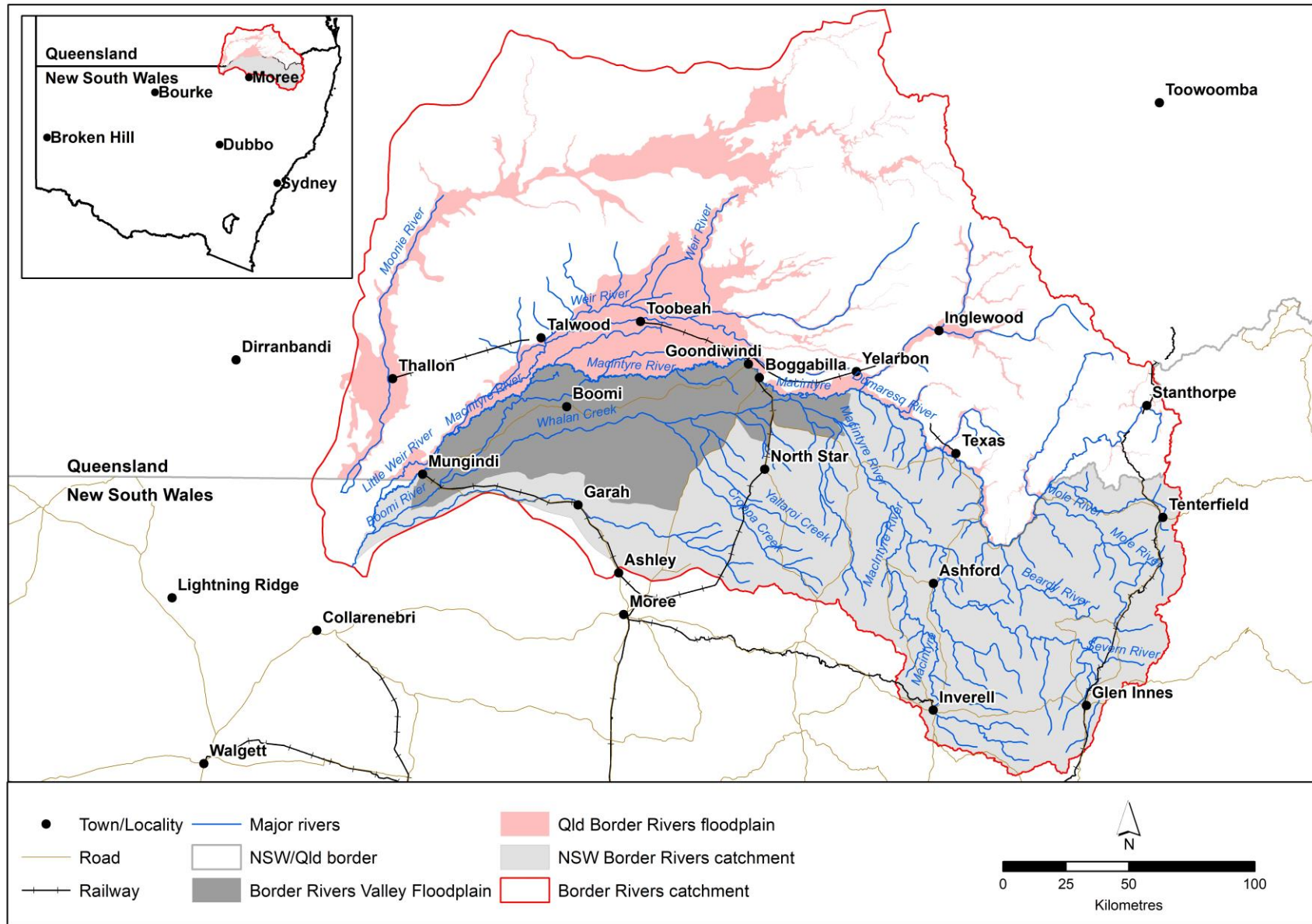


Figure 2: The Border Rivers Valley Floodplain and Border Rivers catchment



The western boundary of the floodplain boundary is downstream of the township of Mungindi where the Barwon–Darling Valley FMP 2017 commences.

In the lower Border Rivers catchment a number of effluent streams and lagoon systems convey a significant proportion of floodwaters away from the Macintyre River when certain river levels are reached. These include Whalan Creek (NSW), Callandoon and Dingo Creeks (Qld), Boomi River (NSW) and the Little Weir River (Qld). The only significant tributary downstream of Boggabilla is the Weir River.

From east to west, the topography of the NSW Border Rivers catchment varies markedly. The upper catchment of the Great Dividing Range, where the Macintyre River begins to flow, grades from steep terrain to undulating tablelands to rolling hills around Ashford (NSW) and Texas (Qld). Below Yetman, these hills merge into flat extensive floodplains in which the watercourse is well-incised. West and downstream of Boggabilla and Goondiwindi, the floodplain is characterised by wetland and lagoon complexes. These wetlands include the intermittently connected anabranches and billabongs, including the Morella Watercourse/ Boobera Lagoon/ Punbougol Lagoon wetland complex (NSW), listed in the Directory of Important Wetlands in Australia (DIWA) (Department of Sustainability Environment Water Population and Communities 2005), and the Rainbow, Intermittent and Serpentine lagoons (Qld). The location of these wetlands indicate old meander courses of the Macintyre River system (NSW Department of Water Resources 1988). The wetlands support a wide range of aquatic habitats, including wildlife breeding areas and drought refugia. Boobera Lagoon also holds profound cultural and spiritual significance to the Gamilaroi<sup>1</sup> Nation, the traditional owners of the Border Rivers Valley Floodplain, who believe that Boobera Lagoon is the resting place of Garriya, a spiritual creature also known as the rainbow serpent (Department of Sustainability Environment Water Population and Communities 2005). Boobera Lagoon is additionally recognised as an Aboriginal place under the *NSW National Parks and Wildlife Act 1974* (NPWS Act). The Border Rivers Valley Floodplain contains many cultural sites and values that are important to the local Aboriginal community.

The NSW Border Rivers catchment is regulated by major dams and other structures including weirs. A number of other structures are used to store and distribute water for irrigation and domestic uses such as town water supply. The major regulated rivers in the NSW Border Rivers catchment are the Macintyre, Severn (NSW) and Dumaresq Rivers in the south-east and east. Glenlyon Dam and Pindari Dam are the two major dams that regulate water supply in the Border Rivers catchment. Coolmunda Dam operated by the Qld Water Resources Commission (WRC) on the Macintyre Brook in Qld, provides water for irrigation along its length before it enters the Macintyre River system. Glenlyon Dam (storage capacity of 254,000 ML) on Pike Creek in Qld was constructed by the Dumaresq-Barwon Border Rivers Commission (BRC) to supply water to service irrigation, town water supply, stock and domestic water users on the Dumaresq, Macintyre and Barwon Rivers to Mungindi (SunWater 2011). Construction of Glenlyon Dam was completed in 1976 (SunWater 2011). The operation of the dam occurs on behalf of the BRC by the Qld WRC. Construction of Pindari Dam on the Severn River (NSW) (storage capacity of 312,000 ML) took place from 1967 to 1969, and was enlarged in 1995 (State Water 2013). Pindari Dam supplies regulated flows for irrigation, stock and domestic, town water supply and industrial purposes along the Severn (NSW) and Macintyre Rivers upstream of the Dumaresq River junction. Pindari Dam is operated in conjunction with Glenlyon Dam (State Water 2009). Following the completion of Glenlyon Dam in 1976, irrigation development expanded rapidly, particularly for cotton cultivation along the Macintyre and Barwon Rivers in both NSW and Qld (Department of Water Resources of New South Wales Technical Services Division 1988). Irrigation is the foundation for much of the economic activity in the region, with a large proportion of the output exported overseas (Department of Water Resources of New South Wales Technical Services Division 1988).

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<sup>1</sup> Also known as Kamilaroi, Gamilaraay and Gomeroi.

Both the Qld Border Rivers floodplain and the NSW Border Rivers Valley Floodplain are extensively developed with levee banks constructed to protect irrigated agriculture (mainly cotton) and urban centres from flood inundation, namely the town centres of Goondiwindi (Qld) and Mungindi (Qld and NSW). In addition to irrigated production, current land use activities in the NSW Border Rivers catchment include grazing, dryland farming, irrigated and intensive industries such as feedlots, forestry and recreation. Both surface and groundwater water sources are available for irrigation. While grazing is the dominant land use in the catchment, cotton is the dominant irrigated crop. Cotton is particularly important in the Border Rivers Valley Floodplain region between Boggabilla and Mungindi and has major economic importance for the NSW Border Rivers catchment (NSW Office of Water 2012).

Agricultural production is a significant component of the Border Rivers Valley Floodplain economy. To enhance 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, earthworks, banks and channels have been built to protect crops, land, stock and properties from flooding, provide on farm access, and to manage and store irrigation, stock and domestic water. Works such as these, which affect the distribution of floodwaters, are referred to as flood works. Approximately 60,000 ha of the floodplain area is enclosed by flood works in the Border Rivers Valley Floodplain.

In many instances, flood works have contributed positively to the agricultural productivity of land in the Border Rivers Valley Floodplain; however, when flood works are built in an uncoordinated way they can change traditional flood patterns.

For instance, flood works can cause flows to be redirected onto adjacent properties, or increase flood levels and/or velocities. 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 for 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.

Since the early 1980s, the NSW Government has been working to manage historic changes to flood flow patterns in the region as a result of floodplain development and to reduce any disadvantage that may be experienced by adjacent landowners. Sound management and planning is essential because even minor agricultural works can produce major diversions or concentrations of shallow flood flows. Planning has focused on areas with intensive irrigation development and areas where major flood events revealed changes to flooding behaviour caused by flood works.

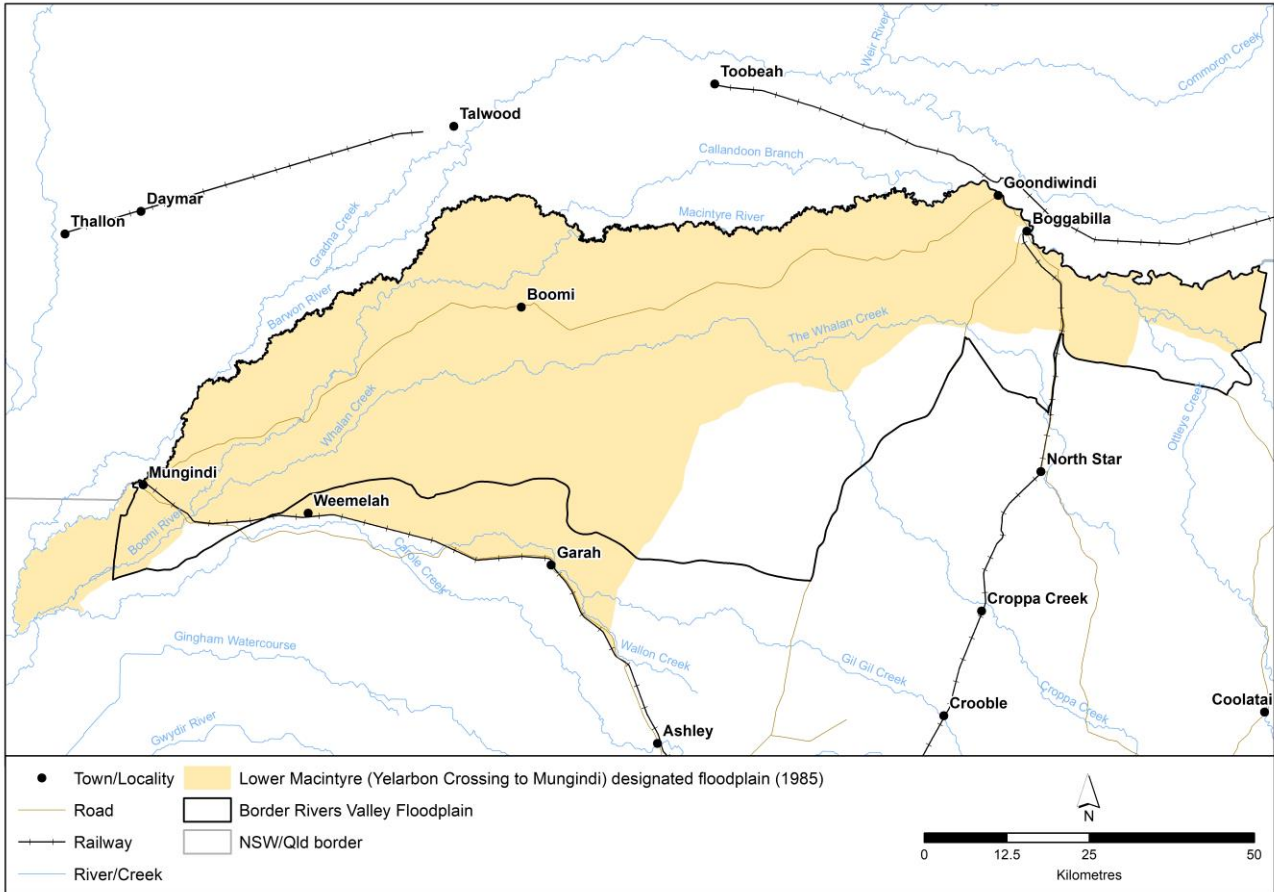
The Border Rivers Valley FMP 2020 has been prepared in accordance with the floodplain planning and environmental protection provisions of the *Water Management Act 2000* (WM Act). The floodplain captures the existing Lower Macintyre (Yelarbon Crossing to Mungindi) designated floodplain (July 31 1985) which was designated under Section 166 Part 8 of the *Water Act 1912* (WA 1912), and to which the NSW Macintyre Draft Interim Policy (2004) applies (Figure 3) (see Appendix 1 for further information on the NSW Macintyre Draft Interim Policy (2004)). Part 8 of the *Water Act 1912* has since been repealed and replaced by provisions in the WM Act.

Where relevant, existing floodplain management arrangements have been consolidated in the Border Rivers FMP, which applies floodplain management principles consistently across the extent of major flooding. The Border Rivers Valley FMP 2020 also gives consideration to existing floodplain management arrangements in Qld including legislation, policies, and non-statutory practices in the determination of management zones and rules. This was done to ensure that:

- a consistent approach to floodplain management is applied across the Border Rivers region that results in no unacceptable adverse flooding impacts to life or property in either the Qld or NSW component of the Border Rivers floodplain, and
- cross-border social, economic, ecological, and cultural equity is maintained.



Similar to current management measures, the new plan aims to coordinate flood work development to maintain flooding behaviour while minimising risk to life and property from the effects of flooding. The Border Rivers Valley FMP 2020 provides management zones and transparent rules to be used when determining flood work development approvals for new flood works and amendments to existing flood works.



**Figure 3: Floodplain designated under Part 8 of the WA 1912**

## Flooding behaviour

The flooding regime in the Border Rivers catchment is complex, as flood flows may initiate from a range of Qld watercourses (Dumaresq River, Macintyre Brook and Weir River) as well as NSW sources (Macintyre River, Severn River, Whalan Creek, Ottleys Creek and Croppa Creek) and local rainfall.

Flows from these sources ultimately converge in the vicinity of Mungindi and drain towards Collarenebri on the Barwon River. Several effluent streams branch off from the Macintyre between Boggabilla and Mungindi. These effluent streams convey a significant percentage of floodwaters and initiate flooding in otherwise dry regions. The main effluent stream systems include Whalan Creek, Callandoon and Dingo Creeks and the Boomi River. Flood volumes recorded at Boggabilla exceed those recorded downstream at Mungindi due to the numerous breakouts occurring from the main Macintyre channel downstream of Boggabilla and loss of water to floodplain storage. Flat-bed gradients which characterise the primary streams of the Border Rivers Valley Floodplain and the progressive decrease in channel capacity from Boggabilla to Mungindi facilitate these breakouts and overland flow (DLWC 1996).

Flooding characteristics vary extensively across the Border Rivers Valley Floodplain due to variations in geomorphology, hydrology, land use and river regulation across the NSW and Qld Border Rivers catchments.

## Downstream of Yetman to Goondiwindi

The eastern corners of the Border Rivers Valley Floodplain are defined by the Macintyre River (NSW) approximately 14 kilometres downstream of Yetman, and Keetah Bridge on the Dumaresq River which in this region forms the Qld and NSW State border. Flooding in the upper reaches of the Macintyre and Dumaresq is confined to a narrow floodplain with minimal overland flow. Major breakouts do not occur from either river until close to their junction about 20 kilometres upstream of Boggabilla, where major breakouts occur south into NSW (WRC 1981).

Whalan Creek is the first major effluent of the Macintyre River in NSW and thus contributes considerably to the nature of flooding in the Border Rivers Valley Floodplain. Whalan Creek breaks out from the Macintyre approximately 15 kilometres upstream of Boggabilla. Flooding in this region can be inflated by flows breaking out from Ottleys Creek which flows into the Macintyre upstream of the Whalan breakout. In addition to carrying a large volume of overbank flow from the Macintyre River, the Whalan also drains the catchments of Croppa, Tackinbri and Mobbindry Creeks. As a result of the input of different river systems, flooding behaviour in Whalan Creek varies extensively depending on the source or sources of floodwater. Whalan Creek has a well-defined channel on leaving the Macintyre River, however 10 kilometres downstream of the Newell Highway it begins to lose definition and at this location a major northward break occurs. These floodwaters combine with those from the Macintyre River that flow west across the Newell Highway between the Whalan offtake and Boggabilla via Maynes Lagoon and the ephemeral Morella Watercourse then westward into the Boobera Watercourse. These combined floodwaters rejoin the Macintyre River 30 to 40 kilometres downstream of Goondiwindi. Only a few kilometres further downstream the Macintyre again breaks its banks and major flood flows break south-west to the Boomi River.

The first major breakout from the Macintyre River into Qld occurs just upstream of Goondiwindi to Brigalow Creek, with large breakouts occurring immediately downstream of Goondiwindi to Callandoon Creek and Dingo Creek. Callandoon Creek has historically been a major breakout for flood flows from the Macintyre. The Callandoon Irrigation Scheme initiated in 1991 has played a role in stabilising the breakout level. Callandoon and Dingo Creeks commence flowing when the Macintyre River reaches approximately 2.75 and 3.0 metres on the Goondiwindi gauge respectively. Dingo Creek itself is also fed by breakouts from Callandoon Creek at between 3.5 and 4.5 metres on the Goondiwindi gauge (Sinclair Knight & Partners 1987). Dingo Creek conveys considerable flow away from the river during flood times. Approximately 60 kilometres west of Goondiwindi, Callandoon Creek rejoins the Macintyre River. One kilometre north of this confluence, Coomonga Creek breaks out of Callandoon Creek towards the west, rejoining the Macintyre downstream of the Boomi weir.

River and floodplain flows from Qld may rejoin the Macintyre near Boonanga Bridge just north of Boomi or just upstream of Mungindi before breaking out into Little Weir River.

## Goondiwindi to Boomi

Channel definition of the Whalan Creek is regained three to four kilometres downstream of Dolgelly Road. Tackinbri and Croppa Creeks which join the Whalan Creek about 12 kilometres west of the Newell Highway can convey large volumes of floodwater to the Whalan. In this reach of the Border Rivers Valley Floodplain, high topography between the Macintyre River and Whalan Creek generally separates flood flows and it is only in very large floods that floodwaters of the Macintyre River and Whalan Creek meet.

Approximately 20 to 25 kilometres due east of the Boomi township, floodwaters break from Whalan Creek in a north-west direction. Most of this flow crosses Boomi Road to join with Tarpaulin Creek floodwaters, which then generally flow due west to meet with the Boomi River. A high ridge

separates Whalan and Tarpaulin floodwaters which do not meet until approximately 20 kilometres due south-west of Boomi township.

## Boomi to Mungindi

Beyond the Boomi-Garah road crossing the Whalan Creek again loses definition and the water extends into a slow-moving sheet that flows westward towards Mungindi.

In addition to Whalan Creek, the Boomi River is also a major effluent of the Macintyre River, with the off-take approximately 65 kilometres downstream of Goondiwindi, a short distance upstream of where Callandoon Creek rejoins the Macintyre from the Qld side. Flowing roughly parallel to the Macintyre, the Boomi joins the Barwon (Macintyre) River downstream of Mungindi. Flooding from Boomi River is mainly directed towards the Macintyre, with the major carriers of floodwater being the Comillomori and Gnoura Gnoura Creeks just north of Boomi township. Gnoura Gnoura Creek is additionally fed by breakouts from the Macintyre River/Callandoon Creek confluence. The only major break to the south from the Boomi River is Goodlyama Creek, which leaves the Boomi near the “Kanowa” property and rejoins it on “Thorndale” about 15 kilometres downstream. The Weir River joins the Macintyre River between the Boomi Weir and the Kanowa Gauge. At this location there is a breakout from the Macintyre River towards the Weir River.

West of Boomi township, the floodplain is divided by numerous well-defined channels and depressions (including Boomangera, Crooked, Geary, Gravelly and Tundunna Creeks). In large floods, this section of the floodplain is inundated by a slow-moving sheet of floodwater. Near Mungindi, numerous breakouts occur on the Qld side and flow between the Barwon and Little Weir Rivers. Little Weir is an anabranch of the Barwon and begins to flow when the Barwon reaches 5.03 metres on the Mungindi gauge (Sinclair Knight & Partners 1987). The Little Weir River flows roughly parallel to the Barwon before heading west, south, then south-west, and crossing the Qld/NSW border. While breakouts that occur on the right bank of the Little Weir become floodplain storage, breakouts from the left bank typically join up with Barwon River floodwaters.

On the NSW side downstream of Mungindi, the overbank flows of Whalan Creek and the Boomi and Barwon Rivers merge and flow in a south-westerly direction towards Collarenebri.

## Key changes to the natural flooding regime

The Border Rivers Valley Floodplain has complex flooding characteristics which have been altered over the last 30 years due to significant changes in the floodplain which have impacted flood behaviour of the Macintyre River and its tributaries and effluents in certain areas. River regulation including the construction of Pindari and Glenlyon Dams, water extraction, land use changes including clearing for agriculture, water extraction, climate change and flood work development have caused changes to the nature, frequency, extent and duration of flooding in the Border Rivers Valley Floodplain. Current water resource development and river operations have decreased the average frequency of inundation of a range of billabongs in parts of the Border Rivers Valley Floodplain (Thoms et al. 2005).

The natural flooding regime of the Border Rivers Valley Floodplain was substantially modified by the construction of Glenlyon Dam (Pike Creek, Qld) in 1976, Pindari Dam (Severn River, NSW) from 1967 to 1969, and weirs and regulators that allow water to be managed for irrigation delivery and town water supply, as well as the installation of flood works for farming and irrigation purposes. Prior to the construction of these major storages, natural river flows were highest in summer and lowest towards the end of winter. Natural unregulated flows in the Border Rivers catchment display a large degree of variability. Flows downstream of both dams have been altered, mainly by decreasing low flow variability. The downstream average flow pattern is not as variable as those in the southern catchments of the Murray-Darling Basin, due to the demand for irrigation water peaking in summer/autumn (NSW Department of Water and Energy 2009).

Comparison of the features of the 1976 and 1996 floods reflects the alteration of the floodplain. While the historically larger flood event of 1976 was characterised by high rainfall intensity and longer rainfall duration and the smaller 1996 event by relatively low rainfall, the 1996 flood produced a similar gauge reading to that recorded at Goondiwindi gauge in 1976. Changes to the floodplain landscape that may have influenced this outcome include (Lawson and Treloar Pty Ltd 2000):

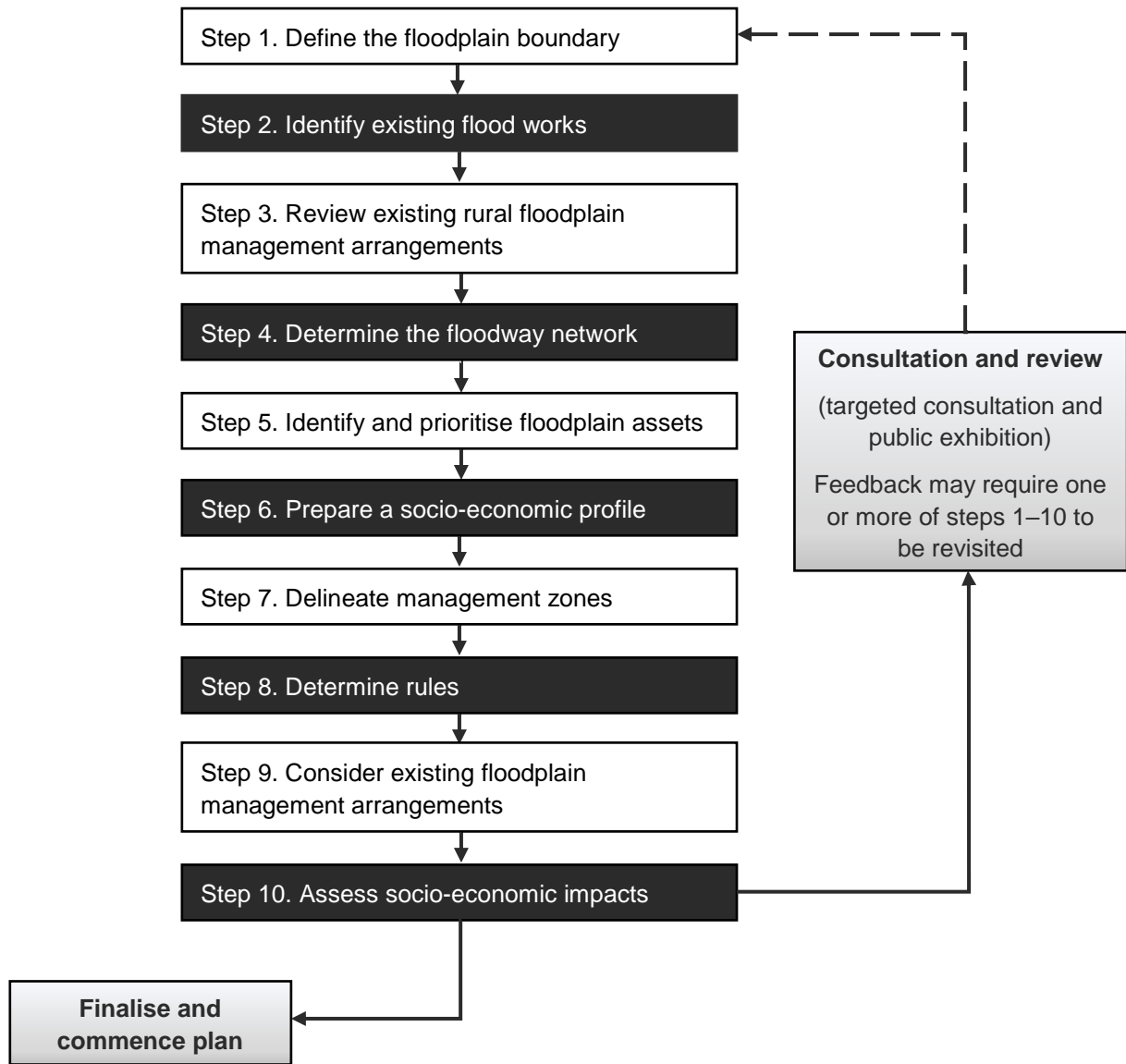
- alterations to roads, including the upgrade of the Newell Highway between Boggabilla and Goondiwindi, and the construction of the Goondiwindi bypass which crosses the Macintyre River, and
- changes in levee conditions including:
  - the extension of the eastern and western sides of Goondiwindi town levee,
  - the addition of rural or farm levees within NSW, and
  - the possibility of overtopping rural or farm levees (that is levees designed to overtop at certain discharge levels) not being able to overtop.

## Developing the plan

The Border Rivers Valley FMP 2020 was primarily developed by the Water group within the NSW Department of Planning, Industry and Environment (the department), with technical input provided by the department's Energy, Environment and Science group. The department employed a ten-step process as outlined in the technical manual and in the following sections (Figure 4). The process involves collecting best-available data and analysis of current 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 Border Rivers 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 Border Rivers Valley FMP 2020 occurred in two stages: targeted consultation and public exhibition. The consultation stages align with the department's internal policy originally developed for the making and review of water sharing plans (WSPs) under the WM Act. During targeted consultation and public exhibition, community feedback was invited on the boundary, management zones, rules and assessment criteria in the FMP. Targeted consultation with stakeholders, including members of the Aboriginal community, occurred at Goondiwindi and Mungindi in September 2016. Public exhibition of the Border Rivers Valley FMP 2020 occurred over 85 days from 15 December 2017 to 9 March 2018. 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 formal review and whole-of-government endorsement of the Border Rivers Valley FMP 2020. Facilitated by the department, the IRP reviewed the draft plan prior to targeted consultation and public exhibition. The IRP also reviewed all submissions received during public exhibition and was responsible for the endorsement of the final boundary, management zones, rules and assessment criteria prior to commencement. Further details on the IRP review process are outlined in 'Consultation and review of plan'.



**Figure 4: Ten steps used to develop rural floodplain management plans under the *Water Management Act 2000***

Appendix 2 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

Floodplains are essentially areas of land subject to inundation by flooding. The Border Rivers Valley Floodplain covers 558,440 hectares.

The boundary of the Border Rivers Valley Floodplain was defined to capture the floodplain areas inundated during flooding of major rivers and to include any flood works that may affect flooding.

Defining the Border Rivers Valley Floodplain boundary was based on the consideration of the following:

- **Designated floodplains and floodplain development guidelines**
  - Existing and potential floodplain developments in the Border Rivers Valley Floodplain were identified from the following existing floodplain areas designated under section 166 of Part 8 of the *Water Act 1912*:
    - The Lower Macintyre (Yelarbon Crossing to Mungindi) floodplain, which was designated as a floodplain on 31 July 1985
    - Floodplain development guidelines for the Macintyre River and Whalan Creek floodplains between Boggabilla and Mungindi (WRC 1981)
  - The existing Lower Macintyre (Yelarbon Crossing to Mungindi) designated floodplain was used as the basis for the Border Rivers Valley Floodplain to capture existing and potential floodplain developments within the floodplain.
  - Where appropriate, the floodplain was extended to include the floodplain development guidelines for the Macintyre River and Whalan Creek floodplains between Boggabilla and Mungindi (WRC 1981).
- **Hydraulic effects of development**
  - The floodplain was extended to include additional flood works located outside the existing designated floodplain area to meet the objectives of the Border Rivers Valley FMP 2020 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 (for example, state, property, parish, county and LGA boundaries, roads and railways) to simplify administration and to provide clarity to water users.
- **Planning legacy (unregulated WSPs)**
  - Where appropriate, the boundary was aligned with relevant unregulated WSP boundaries to ensure consistency with other boundaries for water management plans under the WM Act, ease of administration and increased clarity for water users.
- **Floodplain harvesting**
  - The floodplain boundary included areas identified through the Floodplain Harvesting Program's expression of interest process for floodplain harvesting licences and potential floodplain harvesting structures. This will ensure 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 Valley FMP floodplain boundaries**

- The Border Rivers Valley Floodplain was aligned with the boundaries of the Gwydir Valley FMP 2016 and the Barwon-Darling Valley FMP 2017 to provide consistency with other water management plan boundaries under the WM Act.
- **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.

The overall extent of boundary change when compared to the existing designated floodplain was the addition of approximately 113,840 hectares in some areas and the subtraction of approximately 62,990 hectares in other areas (Figure 3). Table 1 and Figure 5 and Figure 6 highlight the changes made to the existing floodplain to delineate the Border Rivers Valley Floodplain.

**Table 1: Changes made to the existing Part 8, WA 1912 Lower Macintyre floodplain when delineating the Border Rivers Valley Floodplain boundary**

No	Map points	Description of change	Alignment	Rationale/Evidence
1	A–B	Northern boundary expanded and contracted to align with NSW/Qld State border	NSW/Qld state border	The legal northern boundary for the Border Rivers FMP is the NSW/Qld state border, which is the centre of the Dumaresq, Macintyre and Barwon rivers.
2	B–C	Expansion of boundary to include Boggabilla township	Barwon-Darling Valley FMP 2017 and draft Lower Namoi and Upper Namoi Valley FMP boundaries	Departmental advice to include urban areas in FMPs.
3	C–D	Northern boundary expanded and contracted to align with NSW/Qld State border	NSW/Qld state border	The legal northern boundary for the Border Rivers FMP is the NSW/Qld state border, which is the centre of the Dumaresq, Macintyre and Barwon rivers.
4	D–E	Refinement of boundary to align with Keetah Rd, Tarwoona Rd, Holdfast Rd and Unnamed Rd.	Existing Lower Macintyre (Yelarbon to Mungindi) designated floodplain (1985).	Boundary brought into line with the LPI roads layer (roads centre line) D-E Keetah Rd, Tarwoona Rd, Holdfast Rd, Unnamed Rd which crosses the Macintyre River.
5	E–F	Expansion of boundary to align with Tucka Tucka Road	Floodplain development guidelines for Macintyre River and Whalan Creek floodplains between Boggabilla and Mungindi (WRC 1981).	Development in floodplain development guidelines which captured the existing and potential floodplain developments within the Lower Macintyre floodplain Flood works identified outside of the designated floodplain. Floodplain harvesting expressions of interest. Alignment with road
6	F–G	Expansion to align with Bruxner Highway and Oakhurst Rd	Floodplain development guidelines for Macintyre River and Whalan Creek floodplains between Boggabilla and Mungindi (WRC 1981).	Development in floodplain development guidelines which captured the existing and potential floodplain developments within the Lower Macintyre floodplain Flood works identified outside of the designated floodplain. Floodplain harvesting expressions of interest. Alignment with road.
7	G–H	Expansion to align with the southern extent of the guideline.	Existing Lower Macintyre (Yelarbon to Mungindi) designated floodplain (1985).	Basis determined for capturing existing and potential floodplain development in the Lower Macintyre Valley
8	H–I	Expansion to include guideline areas and align with roads	Floodplain development guidelines for Macintyre River and Whalan Creek floodplains between Boggabilla and Mungindi (WRC 1981).	To include southern guideline areas Alignment with roads (Newell Highway, Boggabilla Rd, Unnamed Rd.

No	Map points	Description of change	Alignment	Rationale/Evidence
10	I-J	Expansion to align with Newell Highway	Gwydir Valley FMP 2016 boundary Planning legacy (WSPs)	Consistency with existing plan boundaries
11	J-K	Contraction to align with the Gwydir FMP boundary	Gwydir Valley FMP 2016 boundary	Consistency with existing plan boundaries
12	K-L	Contraction to align with the Barwon-Darling Valley FMP 2017 boundary	Barwon-Darling Valley FMP 2017 boundary	Consistency with existing plan boundaries
13	L-A	Expansion to include Mungindi township	Barwon-Darling Valley FMP 2017 and draft Lower Namoi and Upper Namoi Valley FMP boundaries	Departmental advice to include urban areas in FMPs



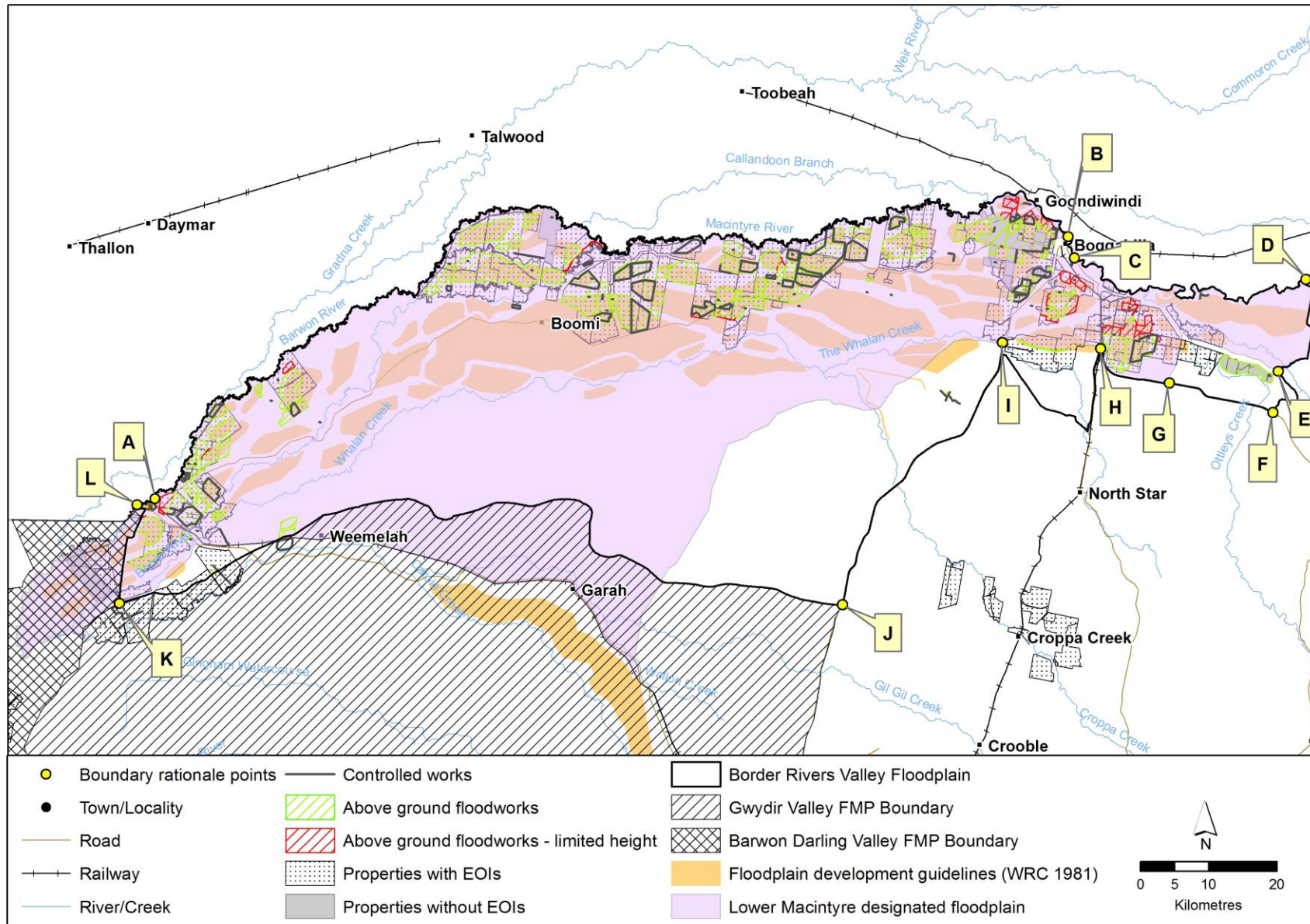


Figure 5: Changes made to the existing designated floodplain boundary when delineating the Border Rivers Valley Floodplain boundary

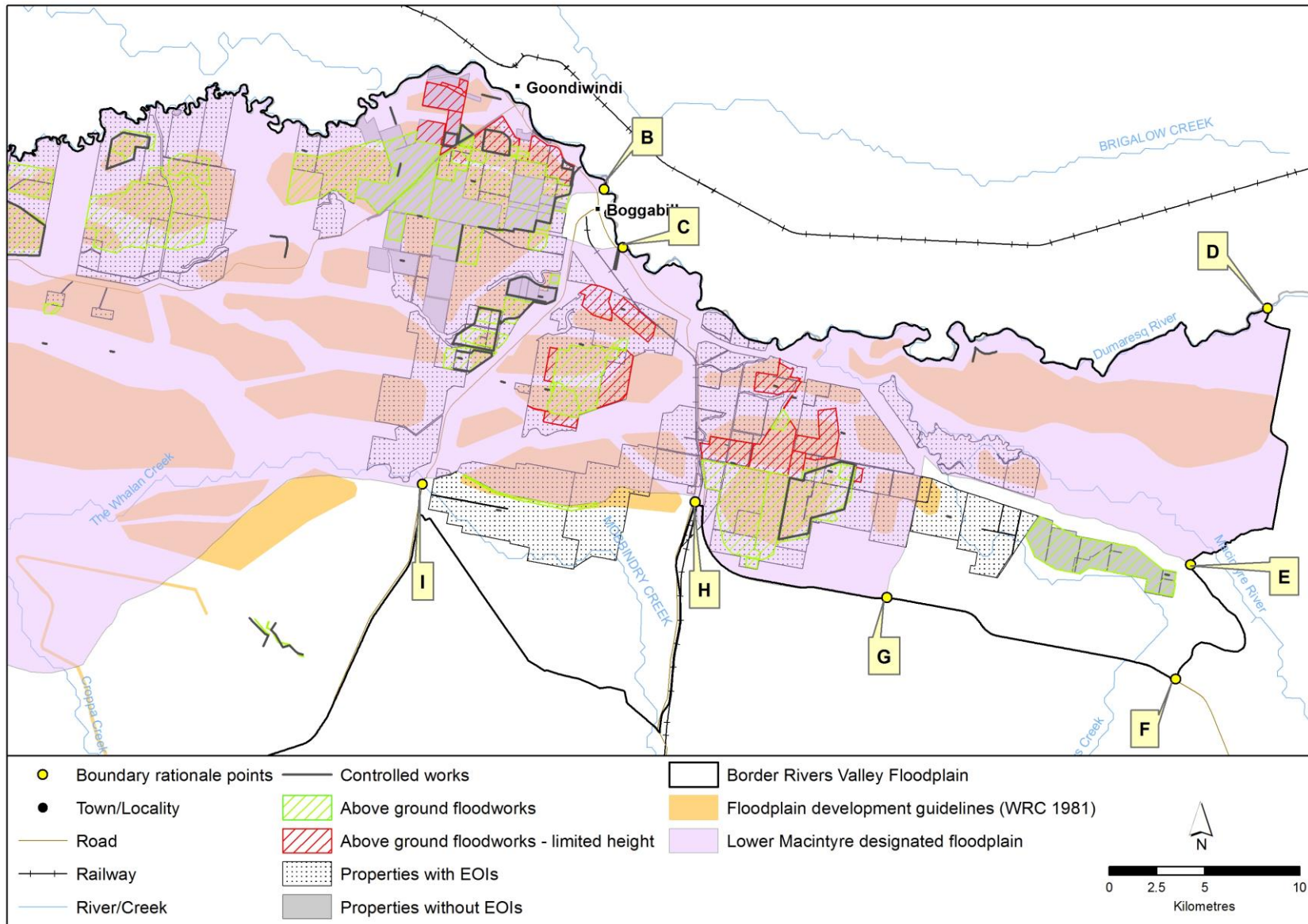


Figure 6: Changes made to the existing designated floodplain when delineating the Border Rivers Valley Floodplain boundary – eastern extent of the floodplain.



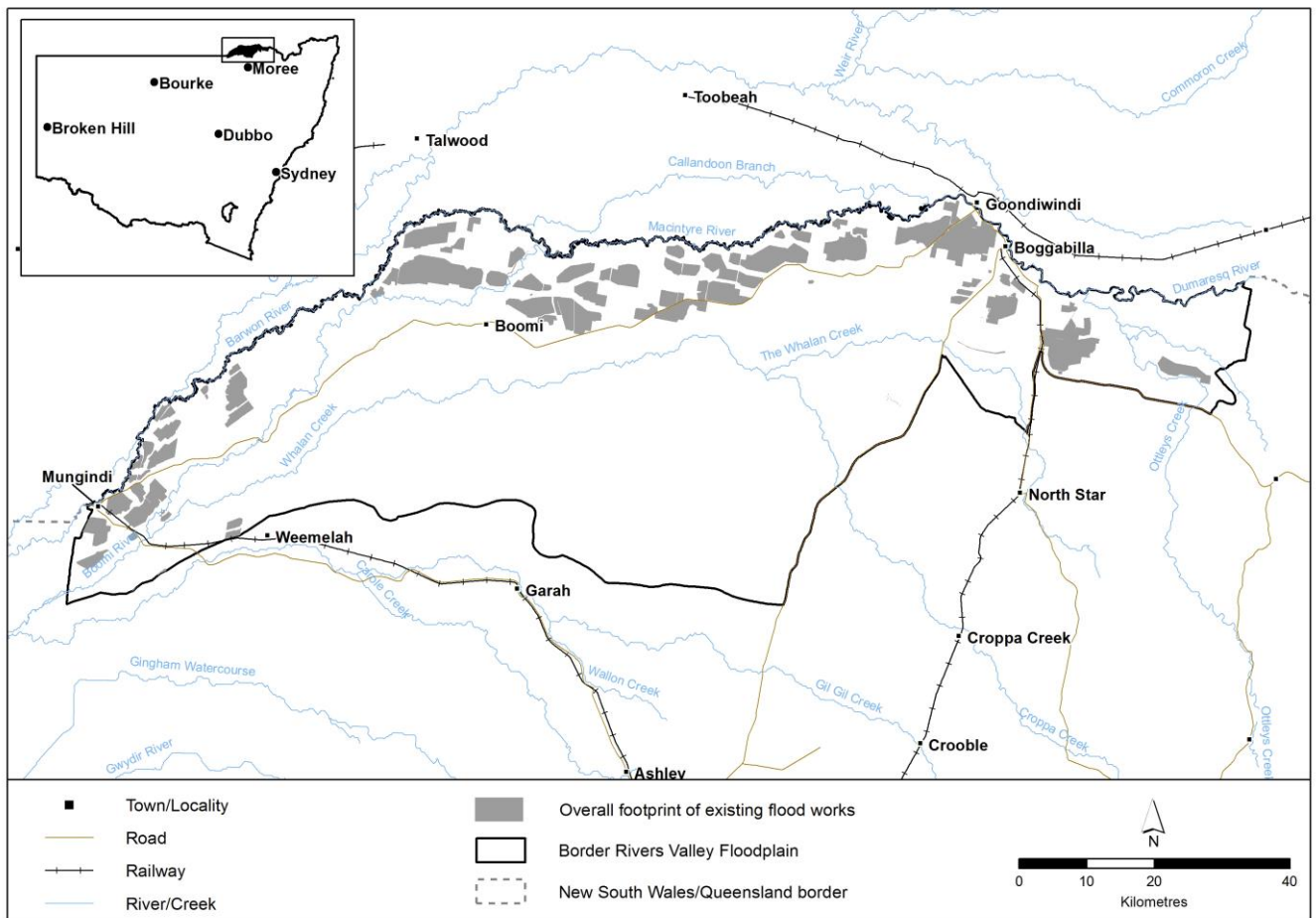
## Step 2: Identify existing flood works

As of June 2017, approximately 55,080 hectares (10%) of floodplain area was enclosed by flood works in the Border Rivers Valley Floodplain (Figure 7).

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 7 but may include:

- below-ground and above-ground supply channels
- infrastructure protection works (IPWs)
- 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 WM Act. Supply channels and storages may be identified as water supply works and flood works.



**Figure 7: Overall footprint of existing flood works in the Border Rivers Valley Floodplain**

## Step 3: Review existing rural floodplain management arrangements

Existing rural floodplain management arrangements were considered in the development of management zones and rules of the Border Rivers Valley FMP 2020. These arrangements pertain to the following areas:

- the NSW Border Rivers Valley Floodplain,
- the Qld Border Rivers floodplain, and
- the “Border Rivers region” where transboundary and interstate floodplain management arrangements apply.

### NSW Border Rivers Valley Floodplain

Existing NSW rural floodplain management arrangements in the NSW Border Rivers Valley Floodplain include (see Figure 8):

- Guidelines for Macintyre River and Whalan Creek Floodplain Development: Boggabilla to Mungindi (WRC 1981).
- *WA 1912*
  - Lower Macintyre (Yelarbon Crossing to Mungindi) designated floodplain (July 31 1985)
  - Floodplain management principles
  - Section 166C of Part 8 – Matters for general consideration
- *WM Act*, and
- *NSW Macintyre Valley Draft Interim Policy 2004*

### Qld Border Rivers Floodplain

Existing floodplain management arrangements by Qld State and local government authorities pertaining to the Qld Border Rivers floodplain that will be considered in the delineation of management zones, rules and assessment criteria for the Border Rivers Valley FMP 2020 include:

- Guidelines for Flood Plain Management of the Border Rivers – Yelarbon to Mungindi 1987
- *Waggamba Shire Council Local Law No. 26 (Levee Banks) 2004*
- *Queensland Water Act 2000* (Qld WA 2000), and the
- *Water Regulation 2016* (WR 2016) (Qld State framework for levee regulation).

### Border Rivers Region

The Interstate Levee Committee was established in the 1980s to coordinate the approach to levee construction in the Border Rivers region. It was composed of representatives from relevant NSW and Qld State agencies and Qld local councils. Due to the lack of recently constructed levees, this committee has not met since the late 1990s. Nevertheless, there is a history of cross-border cooperation and information exchange regarding floodplain management.

Intergovernmental legislation and policies that pertain to the Border Rivers region but were deemed to not have an impact on floodplain management include:

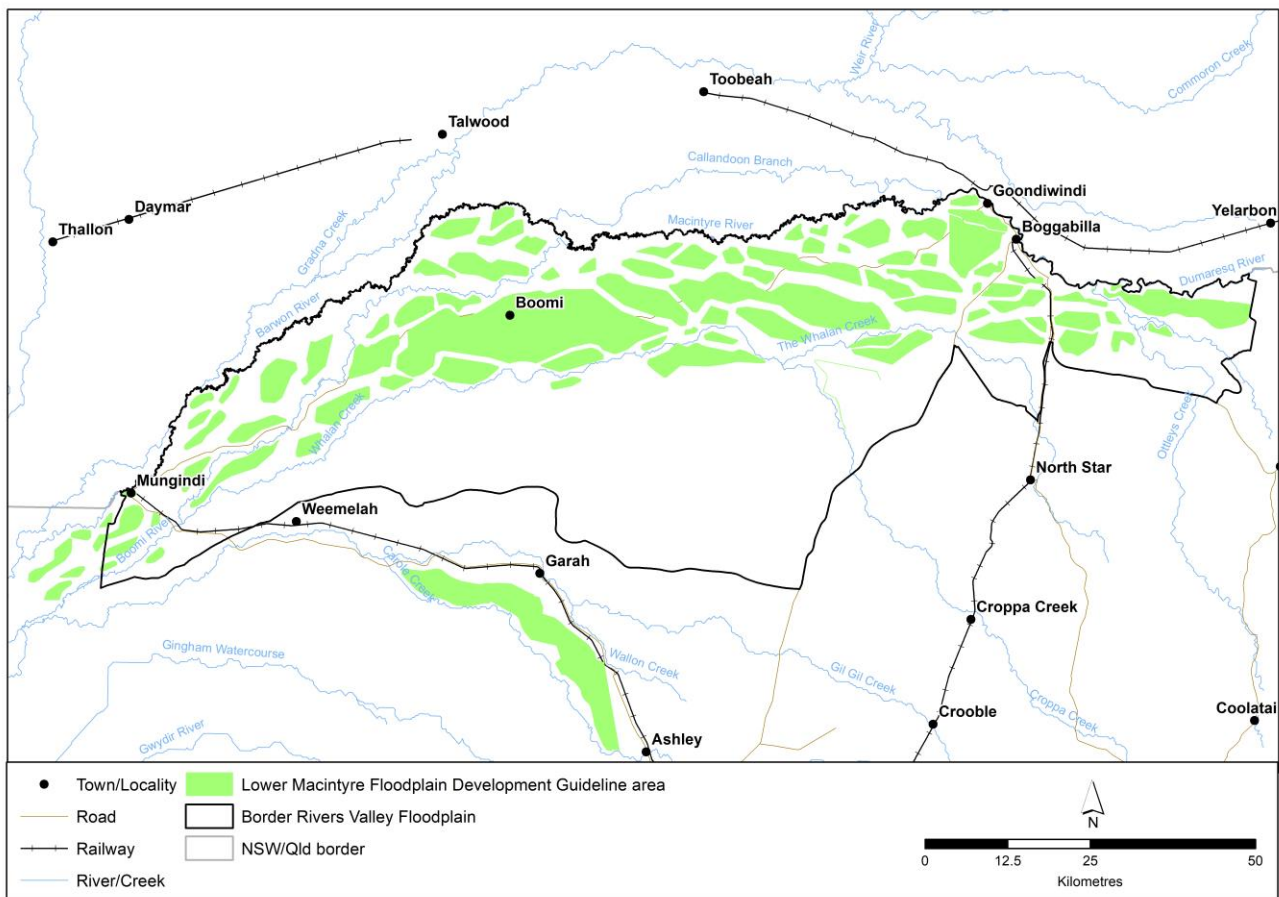
- *New South Wales–Queensland Border Rivers Act 1947 (and amending agreements) (NSW) and the New South Wales–Queensland Border Rivers Act 1946 (Qld)*, and

- *New South Wales–Queensland Border Rivers Intergovernmental Agreement 2008.*

A detailed history of floodplain management in the Border Rivers Valley Floodplain is outlined in Appendix 3.

Existing rural floodplain management arrangements in the Border Rivers Valley Floodplain were reviewed to determine their respective:

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



**Figure 8: Historical Floodplain Development Guideline areas in the Border Rivers Valley Floodplain**

## Step 4: Determine the floodway network

In step 4, hydraulic criteria were determined to map the floodway network. Design floods of different magnitudes were selected and hydraulic models were constructed to simulate the movement of these design floods through the river channels and floodplain. This modelling data, as well as additional information, such as flood imagery, was used to map the floodway network.

The Border Rivers floodway network (Figure 9) is comprised of two hydraulic categories:

- floodways (122,813 ha or 22% of the floodplain), which are areas where a significant discharge of floodwater occurs
- inundation extent (289,454 ha or 52% 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 146,178 hectares (about 26% of the floodplain) was outside the inundation extent of the large design flood and was therefore not included as part of the floodway network.

The floodway network was the hydraulic basis for determining the management zones, rules and assessment criteria of the Border Rivers Valley FMP 2020. Refer to Appendix 4 for more detailed maps of the floodway network. Further information on design floods and hydraulic criteria is provided below.

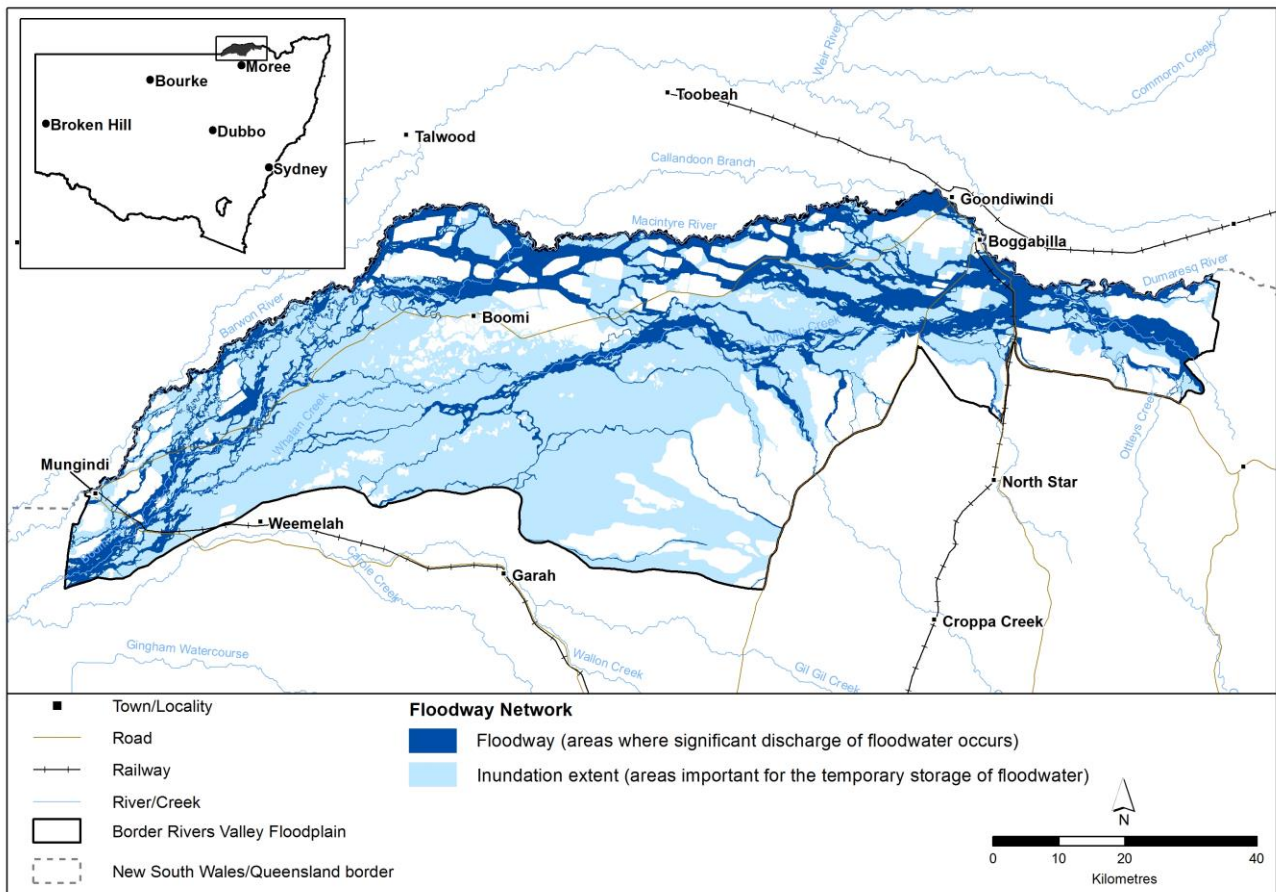


Figure 9: The Border Rivers Valley Floodplain floodway network

## 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.

**A flood frequency analysis was undertaken to assist with the selection of the design floods (**



Table 2). 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 5 for more details on design floods and how the flood frequency analysis results were obtained). This analysis uses available flow records, which may include records from when the flooding regime was relatively natural, as well as information that encompasses the existing flooding regimes.

Two design floods were selected for the Border Rivers Valley FMP 2020:

- large design flood – February 1976 (approximately 1% AEP @ Mungindi and 1.3% AEP @ Boggabilla), and
- small design flood – 13% AEP flood (equivalent to the January/February 2013 flood at Mungindi)

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 Border Rivers Valley Floodplain,
- there is a significant amount of information available for the event, and
- it is the large design flood event recommended to be used in hydraulic analyses of the impact of new or modifications to existing flood works in the Lower Macintyre designated floodplain by the *NSW Draft Interim Floodplain Management Policy – Macintyre Valley 2004*.

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

- it is the same large design flood used in the Barwon-Darling Valley FMP 2017, and
- it has a similar magnitude to the large design flood (2012) adopted for the Gwydir Valley FMP 2016.

The 13% AEP small design flood event was selected to ensure that critical flow paths to identified floodplain assets were identified and maintained in the floodway network and as a consideration during the technical assessment of flood work applications. The 13% AEP small design flood was equivalent to the January/February 2013 flood at Mungindi.



**Table 2: Annual exceedance probability (AEP) for historic flood events at selected locations in the Border Rivers**

Location (Gauging Station number)	Reason for gauging station selection	1890 Flood event AEP (%)	1976 Flood event AEP (%)	1996 Flood event AEP (%)	1998 Flood event AEP (%)	2000 Flood event AEP (%)	2001 Flood event AEP (%)	2011 Flood event AEP (%)	2013 Flood event AEP (%)
Dumaresq at Glenarbon weir (416040)	Measures inflows into the Border Rivers Valley Floodplain. Selected to compare with flows at 416012.	N/A	N/A	12	17	50	20	2.9	25
Macintyre at Holdfast – Yelarbon Crossing (416012)	Long period of record. Measures inflows into the Border Rivers Valley Floodplain	N/A	3.1	11	12	5.6	33	12	50
Macintyre at Boggabilla (416002)	Long period of record and located at the centre of the Valley	2.4	1.3	2.4	6.7	12	25	1.9	33
Macintyre at Terrewah (416047)	Located approximately halfway between Boggabilla and Mungindi	N/A	N/A	6.3	6.7	20	17	12	25
Macintyre at Kanowna (416048)	Located approximately halfway between Boggabilla and Mungindi	N/A	N/A	7.7	5.6	33	20	25	33
Barwon at Mungindi (416001)	Longest streamflow record in Border Rivers Valley Floodplain capturing major floods of 1890 and 1976.  Mungindi gauging station is located at the end of the system.	0.5	1	6	4.5	50	33	14	13

The 13% AEP flood was selected as the small design flood because it:

- approximated a 12% AEP (1 in 8) event, which was selected in the Sustainable Rivers Audit as an indicator of river health associated with high overbank flows (Davies et al. 2012),
- meets the site-specific ecological targets for in-channel environments in the Lower Border Rivers region identified by the Murray-Darling Basin Authority (MDBA) (MDBA 2012), including the surpassing of the MDBA (2012) requirement of a minimum discharge rate equal to or greater than 4,000 megalitres per day with flow duration of a minimum of 11 days. A flow duration of approximately 14 days was recorded at Mungindi gauging station during the 2013 flood event. The minimum discharge rate was exceeded during this period.
- will contribute to the protection of environmental assets and ecosystem functions in the Border Rivers region that require environmental watering, according to the environmental objectives outlined in the Basin Plan's environmental watering plan<sup>1</sup>. The annual identification of potential watering options in the Border Rivers region by the Commonwealth Environmental Water Office reflects these high-level environmental objectives.

## Modelling

### 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, Mein and Nathan 2010).

For the development of the Border Rivers Valley FMP 2020, the hydrological modelling assessment utilised the previously established Unified River Basin Simulator (URBS) and Runoff Analysis and Flow Training Simulator (RAFTS) models which formed part of the Lawson and Treloar *Border Rivers Floodplain Hydraulic Analysis* (1998). These models were originally developed by the Bureau of Meteorology for the Weir River and Macintyre Brook, but were extended across the broader Border Rivers Valley catchment to define flow conditions to the upstream extent of the hydraulic model.

The key hydrological sub-catchments providing the main inflows to the hydraulic model included:

- Dumaresq River,
- Macintyre River,
- Weir River,
- Macintyre Brook,
- Yarrill Creek,
- Commoron Creek,
- Ottleys Creek, and
- Croppa Creek.

Appendix 6 includes further detail on each of the sub-catchments.

The principal calibration events adopted for the development of the hydrological models were the February 1976 and January 1996 floods. Available data from established gauging stations was used

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<sup>1</sup> See <http://www.mdba.gov.au/what-we-do/environmental-water/ewp>

in the calibration process. The calibration largely focused on achieving a reasonable match between simulated and recorded water level hydrographs at the gauging stations.

The output of the model was a series of flow hydrographs at selected location such as the boundaries of the model. These hydrographs were used as inputs to the hydraulic model (see Appendix 6 for more details).

## Hydraulic models

Hydraulic modelling for the Border Rivers Valley Floodplain was undertaken using the two-dimensional (2D) software modelling package TUFLOW. TUFLOW has the capability to simulate the dynamic interaction of in-bank flows in open channels and overland flows through complex overland flow paths using a linked 2D/1D flood modelling approach. The channel and floodplain topography were defined using a high resolution digital elevation model (DEM) based on LiDAR data.

The TUFLOW 2D model covers an area of approximately 1.1 million hectares extending from approximately 50 kilometres upstream of Boggabilla to 40 kilometres downstream of Mungindi (Figure 10). It includes approximately 480,600 hectares (86%) of the Border Rivers Floodplain. The area of the Border Rivers Valley Floodplain that could be included in the model was largely determined by the availability of LiDAR data, which was used to define the channel and floodplain topography in the model. The model also includes approximately 498,000 hectares (45% of the total model area) in Qld to allow simulation of the complex interactions between the Qld and NSW parts of the Border Rivers floodplain.

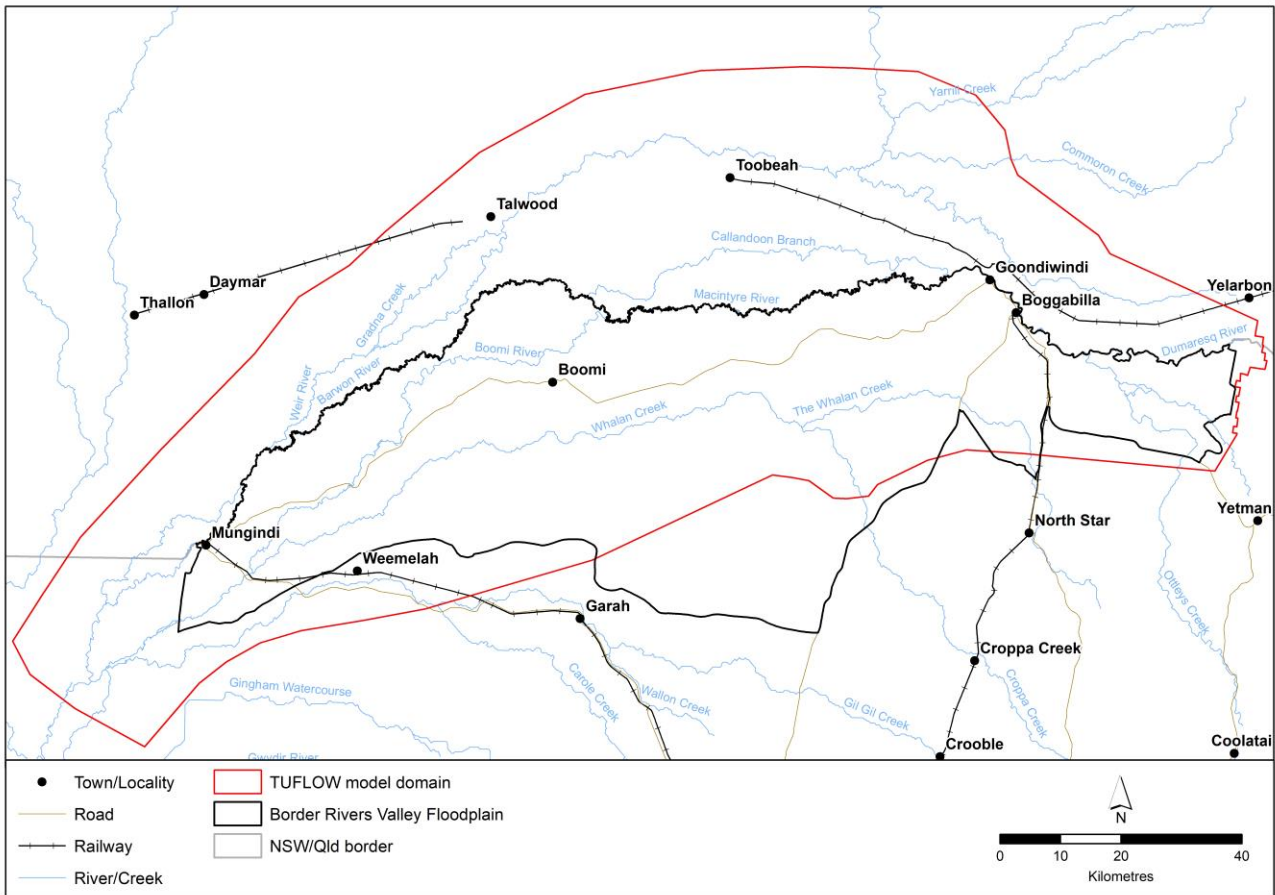
The hydraulic model outputs used to develop the Border Rivers floodway network were:

- 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 area important for floodplain pondage and the appropriate width of identified floodways. The location of flow paths in the models were determined using DEMs, 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.

For information on the hydraulic model networks, boundaries, structures, hydraulic parameters, and calibration, see Appendix 6.



**Figure 10: TUFLOW model boundary for the Border Rivers Valley Floodplain**

### Model calibration

The hydraulic model was calibrated using selected historic flood events that are around the design flood magnitude and that activate all likely flow paths. The models were calibrated against a range of data sources, which are listed in the Technical Manual. For further information on model calibration, see Appendix 6.

### Hydraulic criteria for the floodway network

There are no industry-specific procedures for identifying floodways or for defining their extent; however, the advancement of tools used to simulate flooding (such as two-dimensional modelling) and improved topographic data (such as LiDAR) allows practitioners to more rigorously interrogate flood characteristics (NSW Government 2005). Improvements to models and input data has enabled quantitative approaches for delineating floodways to be used such as DVP thresholds and extents of design floods. Nevertheless, there is no definitive flood modelling procedure that can be applied to automate the process of generating floodway extents and the methodology should involve iterative assessments (NSW Government 2005).

Through consultation with the TAG and with local stakeholders, criteria to interpret two-dimensional flood modelling outputs and develop the floodway network were determined, including deciding on appropriate DVP thresholds and use of the small design flood extent. 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 and the outcomes are described in detail below.

Once the thresholds were decided, applying the criteria 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 (NSW Government 2005).

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

Hydraulic category	Criteria
Floodways	<p>Areas that have a depth-velocity product (DVP) of greater than or equal to 0.3 m<sup>2</sup>/s for the large design flood (Feb 1976)</p> <p>Areas that support tributary flows and outer floodplain floodways that have a DVP of greater than or equal to 0.2 m<sup>2</sup>/s for the large design flood (Feb 1976)</p> <p>Parts of the 13% AEP small design flood extent that ensure continuity of floodways</p>
Inundation extent	<p>Areas not already defined as floodways that are within the extent of the large design flood (Feb 1976)</p> <p>Floodplain area enclosed by existing flood works that were designed to be overtopped by floodwater during moderate to large floods</p> <p>In areas outside the hydraulic model extent aerial imagery of flooding from the 1996 flood, Landsat 7 satellite imagery of flooding on 23 November 2000 and NSW water count and water prevalence data (Fisher et al. 2016; Danaher &amp; Collett 2006; Auscover Remote Sensing Data Facility 2016) derived from Landsat imagery.</p>
Areas outside floodway network	<p>Flood fringe areas outside the large design flood (Feb 1976) extent</p> <p>Floodplain area enclosed by existing flood works that were not designed to be overtopped by floodwater</p>

To ensure a high level of accuracy, the mapped floodway network was validated using:

- DVP maps for the large design flood (February 1976)
- discharge and velocity values along flow paths
- inundation extents for the small (13% AEP) 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 for the 1996 flood and satellite imagery (see Appendix 7 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 Border Rivers Valley Floodplain.

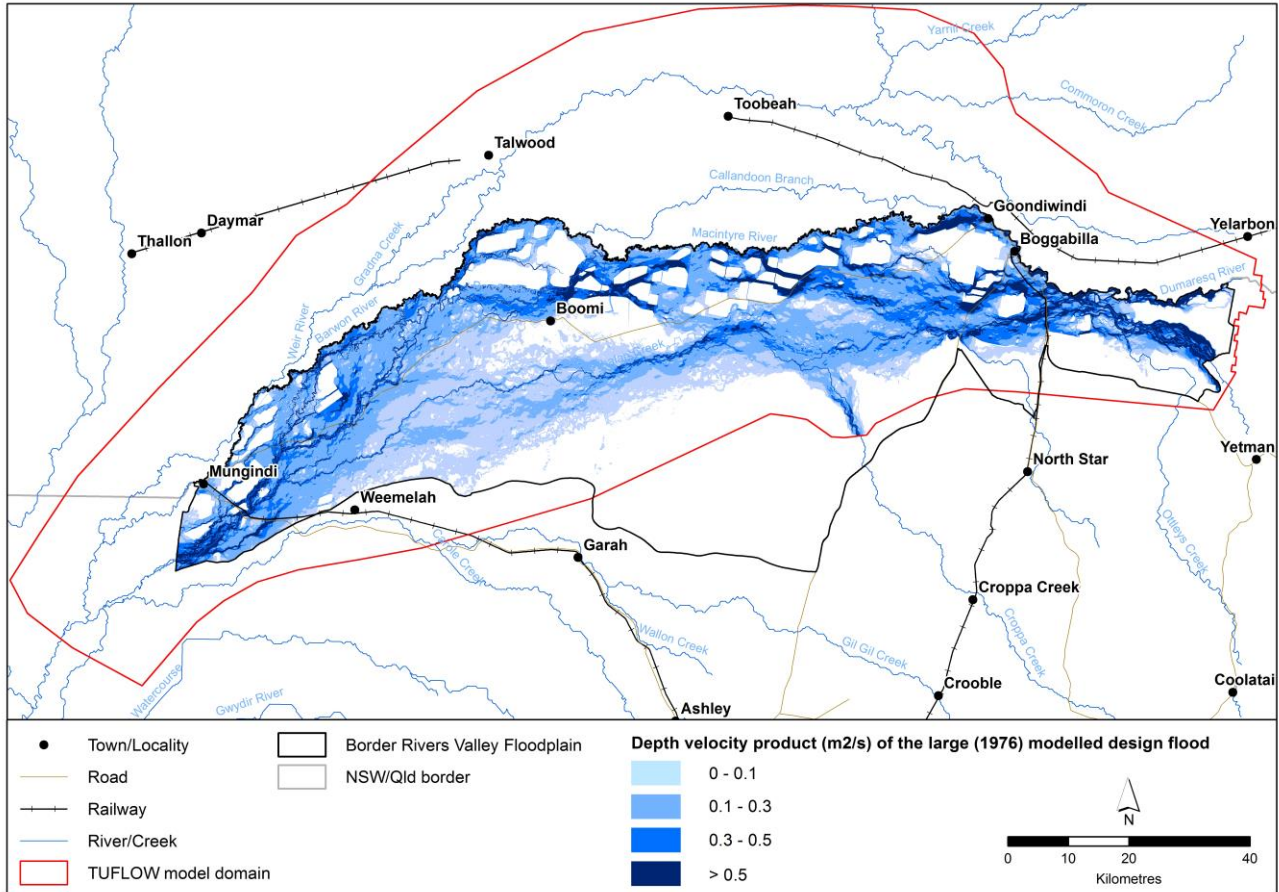
## Floodways

Hydraulic criteria were determined for floodways through consideration of existing floodplain management arrangements, hydraulic model outputs, feedback from targeted consultation, potential socio-economic impacts, and in discussion with the TAG. The criteria is described in detail below.

The velocity variation with depth for the Border Rivers Valley Floodplain was investigated to determine an appropriate threshold for identifying floodways. As the Border Rivers is a large flat floodplain, characterised by depth rather than velocity that experiences high flow discharges and flood levels during large floods, adoptions of a DVP threshold of greater than or equal to 0.1 m<sup>2</sup>/s (as was used in the Gwydir Valley FMP 2016) would result in the spatial extent of identified



floodways including large areas that may not be crucial for flood flows and may instead be acting primarily as floodplain pondage (Figure 11). As such, floodways were identified as any areas with a DVP of greater than or equal to 0.3 m<sup>2</sup>/s 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 (Figure 11).



**Figure 11: Depth velocity product thresholds for the large (1976) modelled design flood**

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

- flow velocity is relatively higher than other areas of the floodplain regardless of depth, and
- there is significant depth but relatively low velocity.

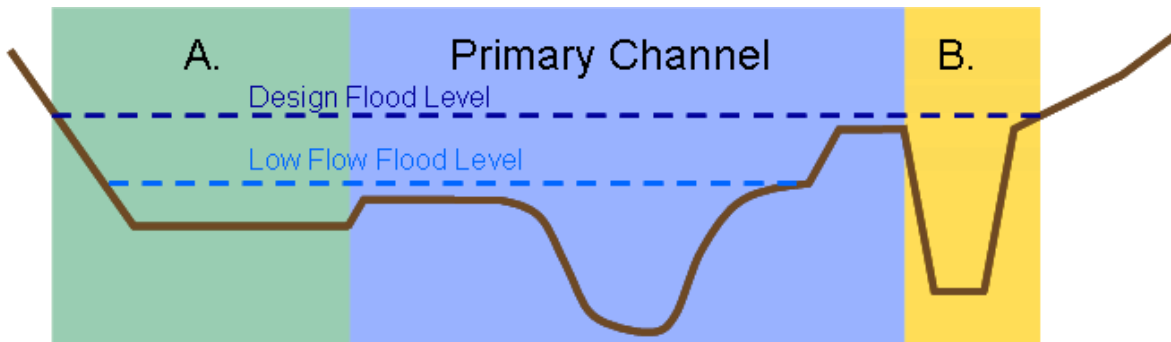
Floodways derived from the DVP thresholds were compared with the inundation extent of the small design flood. This comparison was undertaken to ensure that areas of the floodplain activated during small floods were identified as floodways regardless of whether they reached the DVP thresholds. Such areas are also likely to be the first floodways activated during large flood events. For instance, Figure 12 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.

Floodplain continuity was also provided for by incorporating areas that support tributary flows and outer floodplain floodways that have a DVP of greater than or equal to 0.2 m<sup>2</sup>/s.

To ensure that the floodways represent on-ground conditions, additional data was also used to guide the location of the floodways, including:

- flood aerial photography and satellite imagery from design floods (see Appendix 7),
- spatial watercourse layers, topographical mapping, ADS40 DEM and LiDAR,
- previous floodplain management arrangements, and
- local knowledge obtained from floodplain communities and floodplain/environmental managers

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



**Figure 12: 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 Border Rivers Valley Floodplain. Where the flood extent was reliable, its outer limits were used to determine the inundation extent; however, where topographic data was not sufficient to accurately map the extent of the flood, the limits to the inundation extent 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 floodplain assets found on the Border Rivers Valley Floodplain. This informed the design of the management zones, rules and assessment criteria in later steps.

### 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 Border Rivers Valley FMP 2020 considered three types of ecological asset, wetlands, other floodplain ecosystems, and areas of groundwater recharge (Figure 13); however, areas of groundwater recharge are not mapped due to data limitations.

For the Border Rivers Valley Floodplain, the State Vegetation Type Map: Border Rivers Gwydir-Namoi Regional Native Vegetation Mapping (OEH 2015; OEH 2017), a previous vegetation map, and several wetland studies were used to identify wetlands and other floodplain ecosystems. The Border Rivers Gwydir-Namoi Regional Native Vegetation Mapping dataset provided the most recent regional scale mapping of Plant Community Types (PCT) of the Border Rivers Valley Floodplain. Approximately 67,454 hectares (or 12% of the floodplain) was identified as native vegetation that is flood-dependent.

A composite map was created to identify semi-permanent wetlands using wetland vegetation components from the Border Rivers Gwydir-Namoi Regional Native Vegetation Mapping (OEH 2015; OEH 2017) and the Vegetation Mapping in the Border Rivers-Gwydir Catchment (Eco Logical Australia 2009). In addition to native vegetation mapping, the composite map integrated semi-permanent wetlands identified from several previous wetland studies including Hudson and Bacon (2009), Eco Logical Australia (2015), and NSW Land use data (OEH 2011a). The NSW Land use data components comprised wetland features including Floodplain swamp – billabongs (Marsh/wetland), Floodplain swamps (Marsh/wetland) and Swamps (Marsh/wetland) (OEH 2011a). Some natural waterbody features were also identified from the hydroarea polygon feature class in the NSW Digital Topographic Database.

Lagoons and wetlands were identified from Schedule 5 - Significant lagoons and wetlands - Water Sharing Plan for the NSW Border Rivers Unregulated and Alluvial Water Sources 2012 (Schedule 5) and were also included as part of the semi-permanent wetlands composite map. The spatial extent of wetlands identified and surveyed by Hudson and Bacon (2009) and the lagoons and wetlands from Schedule 5 were mapped by generating contours derived from LiDAR DEM in ArcGIS ArcMap 10.1 (ESRI 2012). Step 7 details the ecological criteria applied in the design of the management zones.

Each of the flood dependent vegetation communities identified from the regional vegetation maps were collated into hydro-ecological functional groups including semi-permanent wetlands, floodplain wetlands (flood-dependent shrubland wetlands), and other floodplain ecosystems, including flood-dependent forest/woodland (wetlands), and flood-dependent woodlands.



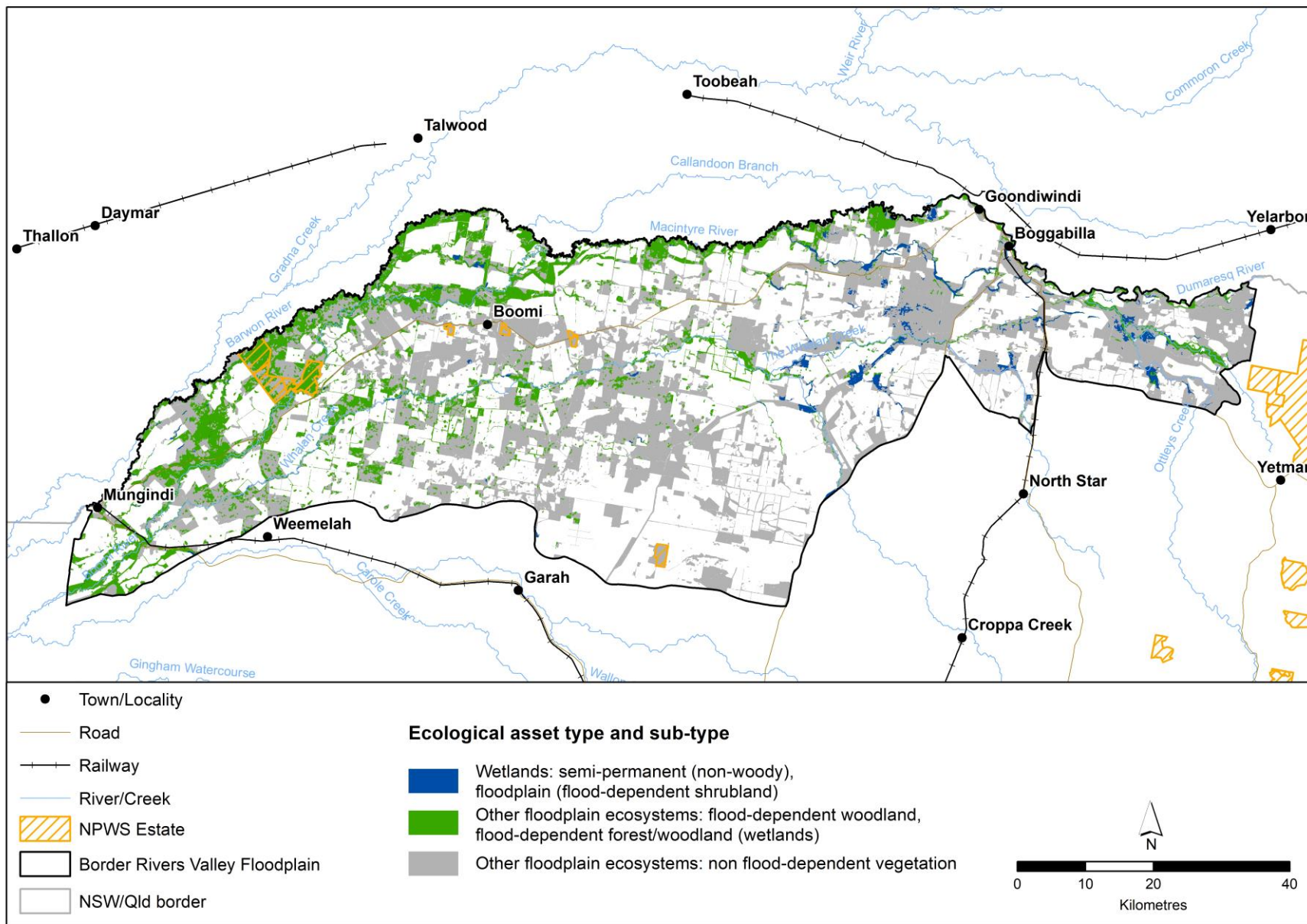


Figure 13: Ecological assets identified in the Border Rivers Valley Floodplain

## Ecological asset type—wetlands

The ecological asset, *wetlands*, is comprised of floodplain watercourses<sup>1</sup>, semi-permanent wetlands and floodplain wetlands (flood dependent shrubland wetland) (Figure 14).

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 (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)
- sedgeland – forbland wetland in depressions on valley flats of the NSW North-western Slopes (PCT 447).

Floodplain wetland (flood-dependent shrubland wetland) requires flooding at intervals of one to five years to maintain their structural integrity and community condition (Roberts and Marston 2011; Rogers and Ralph 2011). Floodplain wetland contains the following vegetation communities:

- 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.

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<sup>1</sup>These floodplain watercourses were picked up in the floodway network and were not re-identified in the ecological assessment.

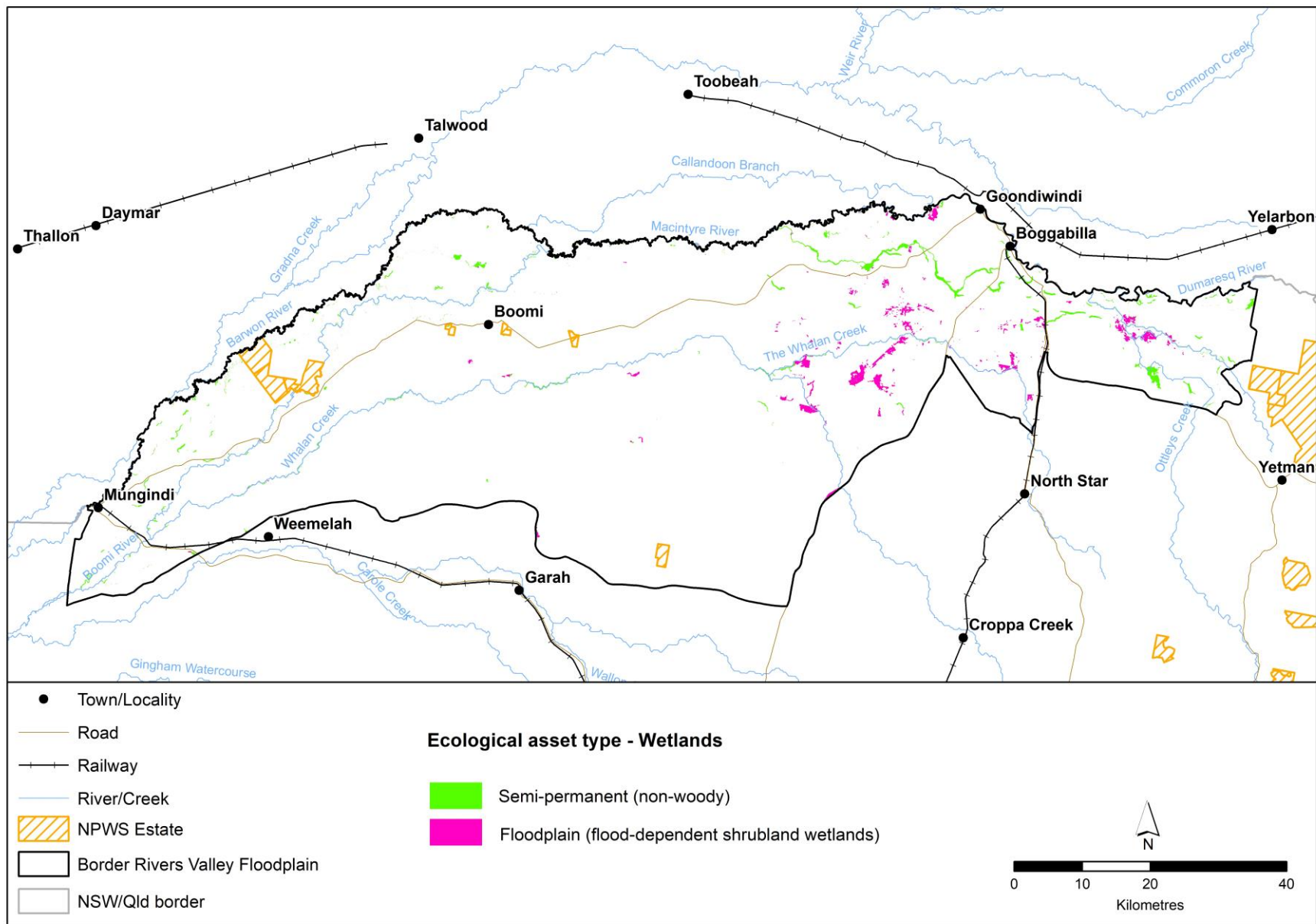


Figure 14: Location and type of wetlands identified as ecological assets

## 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 15).

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 and Marston 2011). Flood-dependent forest/woodland (wetlands) 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 and 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 (PCT37),
- coolabah - river coolabah - Lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains Bioregion (PCT 39),
- coolabah open woodland wetland with chenopod/grassy ground cover on grey and brown clay floodplains (PCT 40),
- poplar box – coolabah floodplain woodland on light clay soil mainly in the Darling Riverine Plains Bioregion (PCT 87), and
- carbeen +/- coolabah grassy woodland on floodplain clay loam soil on north-western NSW floodplains, mainly Darling Riverine Plain Bioregion (PCT 628).

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



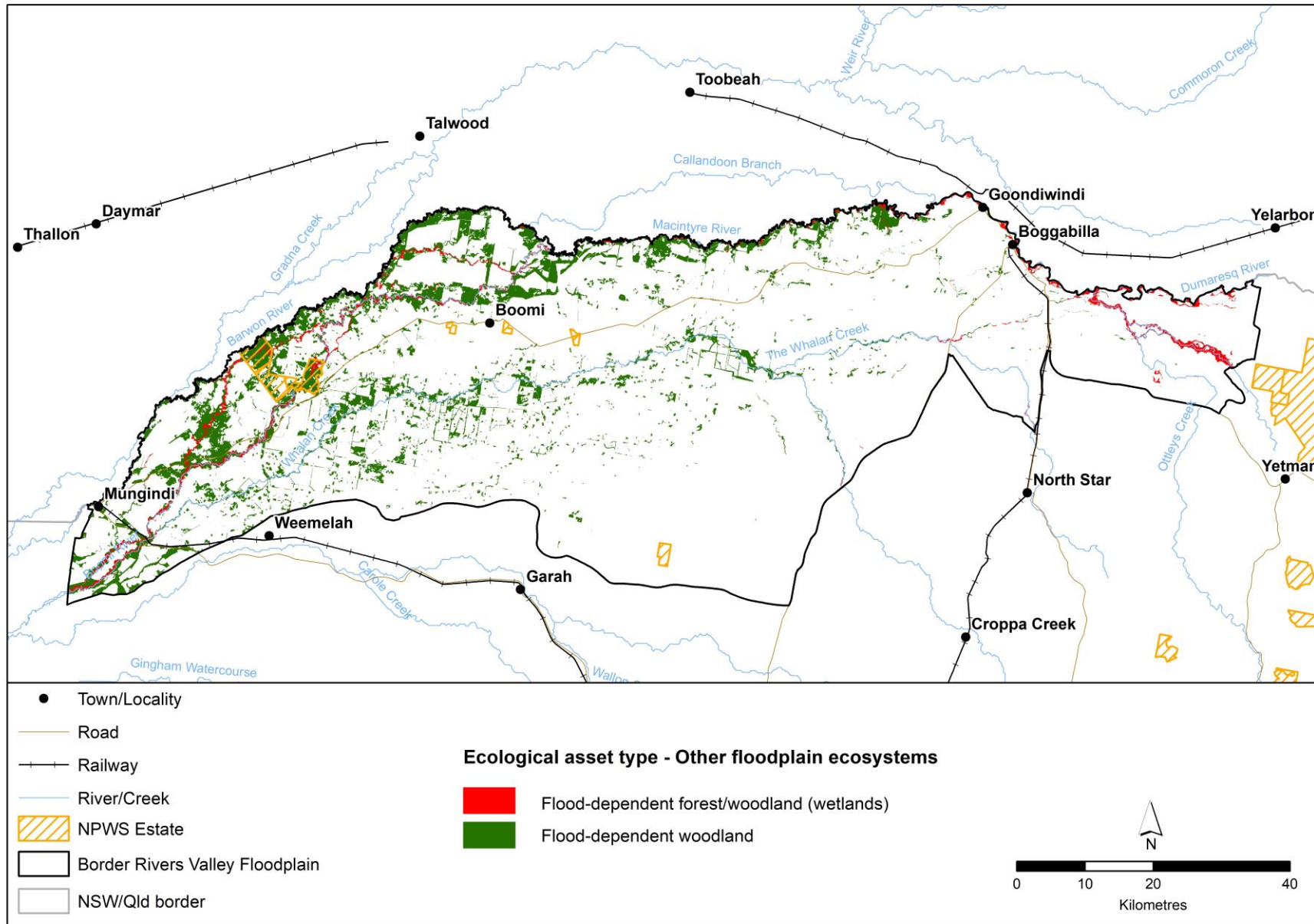


Figure 15: Location and type of other floodplain ecosystems identified as ecological assets



## Ecological asset type—groundwater recharge

Groundwater recharge areas are sites where water from a flood event leaks through the soil profile into underlying aquifers. In general, flooding is an important source of groundwater recharge on floodplains and changes to flood connectivity may impact on groundwater storage.

CSIRO (2007) indicate that groundwater recharge depends on land use and soils, with groundwater levels showing a clear response to flood events.

There are limited studies relating to the recharge of groundwater by floodwaters in the Border Rivers Valley Floodplain, however it is acknowledged that all groundwater sources are considered to be highly connected to surface water (NSW Office of Water 2012). Together with recharge from rainfall and side slope runoff, leakage of surface water occurs from the following alluvial groundwater sources:

- regulated Dumaresq River in NEW Upstream Keetah Bridge Alluvium
- Macintyre River
- Ottleys Creek
- Downstream Keetah Alluviums (NSW Office of Water 2012)

The Border Rivers Valley FMP 2020 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 floodwater recharge areas being subjected to natural flood inundation.

If further information on flood-sourced groundwater recharge areas becomes available, the Border Rivers Valley FMP 2020 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 flood dependency of ecological assets in the Border Rivers 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 surface water requirements of the dominant or canopy species in a floodplain vegetation community to maintain their ecological character using information sourced from the reviews of Roberts and Marston (2011) and Rogers and Ralph (2011) which provide a synthesis of the best available knowledge of surface water requirements of common floodplain plants (Table 4). It was assumed that floodplain watercourses would require water every year or more often to maintain their ecological character.

The distribution of vegetation communities in the Border Rivers Valley Floodplain may reflect the flooding regime. Floodplain vegetation communities of the Border Rivers Valley Floodplain have varying degrees of flood dependence and the riverine habitats experience natural patterns of wetting and drying from floods of different magnitude and duration. The riverine vegetation of the Border Rivers Valley Floodplain is distributed laterally across the floodplain in response to over-bank flooding (Roberts et al. 2016, Casanova and Brock 2000).

Plant communities of billabongs in floodplain river ecosystems such as the Border Rivers Valley Floodplain rely on surface water flow connectivity to aid germination and recolonise habitats when conditions are suitable (Reid et al. 2016). Semi-permanent wetland vegetation communities in the Border Rivers Valley Floodplain are connected with major watercourse channels by over-bank flooding and vegetation composition and condition reflect differences in flood frequency, timing and duration. These 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 and Casanova 1997, Capon and Brock 2006, Roberts et al. 2016).

Thoms et al. (2005) provide an analysis of commence-to-fill and connectivity of anabranches and billabongs for part of the Border Rivers Valley Floodplain. Inundation and connectivity of anabranches and billabongs from overbank flooding from main river channels is important for maintaining vegetation condition and for the provision of dissolved organic carbon and other nutrients to aquatic systems (Thoms et al. 2005). In the absence of large-scale flooding, semi-permanent wetland vegetation communities occurring on low lying flats or previous ox-bow depressions, such as water couch and sedgeland communities, may contract and species composition may switch to more terrestrial species (Capon 2016, Roberts and Marston 2011).

Riverine vegetation such as river red gum along with low level wetlands including waterholes and billabongs align the major watercourses and anabranches of the Border Rivers Floodplain including the Barwon, Boomi, Macintyre and Dumaresq River's and the Boomangera, Budelah, Croppa, Doondoona, Goodlayamma and Gnoura Gnoura Creeks. These frequently flooded habitats are in contrast to infrequently flooded habitat which occurs further from the main watercourse channels on the floodplain at higher elevations where coolibah and black box woodland communities occur. The vegetation communities in outer floodplain habitats are highly fragmented from clearing, with some isolated stands of original native vegetation communities occurring in patches surrounded by agricultural land.

**Table 4: Hydro-ecological functional groups that comprise wetlands and other floodplain ecosystems in the Border Rivers Valley Floodplain and their flooding frequency requirements.**

HEF <sup>1</sup> group	Vegetation/watercourse class	Ideal watering frequency
Floodplain watercourses	Drainage lines, lagoons, billabongs, waterholes, lakes	Annual or near annual
Semi-permanent wetland	Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains (PCT 53)	Annual or near annual
Semi-permanent wetland	Water Couch marsh grassland wetland of frequently flooded inland watercourses (PCT 204)	Annual or near annual
Semi-permanent wetland	Sedgeland - forbland wetland in depressions on valley flats of the NSW North-western Slopes (PCT 447)	Annual or near annual
Floodplain wetlands (Flood-dependent shrubland wetlands)	River oobah swamp wetland on the floodplains of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion (PCT 241)	Every year to 1 in 5 years
Floodplain wetlands (Flood-dependent shrubland wetlands)	Lignum shrubland wetland on regularly flooded alluvial depressions in the Brigalow Belt South Bioregion and Darling Riverine Plains Bioregion (PCT 247)	Every year to 1 in 5 years
Flood-dependent forest/woodland (wetlands)	River Red Gum tall to very tall open forest / woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion (PCT 36)	1 in 3 to 1 in 5 years
Flood-dependent woodland	Black Box woodland wetland on NSW central and northern floodplains including the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion.(PCT 37)	1 in <10 years
Flood-dependent woodland	Coolabah - River Coobah - Lignum woodland wetland of frequently flooded floodplains mainly in the Darling Riverine Plains Bioregion (PCT 39)	1 in <10 years
Flood-dependent woodland	Coolibah open woodland wetland with chenopod/grassy ground cover on grey and brown clay floodplains (PCT 40)	1 in <10 years

HEF <sup>1</sup> group	Vegetation/watercourse class	Ideal watering frequency
Flood-dependent woodland	Poplar Box - Coolibah floodplain woodland on light clay soil mainly in the Darling Riverine Plains Bioregion (PCT 87)	1 in <10 years
Flood-dependent woodland	Carbeen +/- Coolabah grassy woodland on floodplain clay loam soil on north-western NSW floodplains, mainly Darling Riverine Plain Bioregion (PCT 628)	1 in <10 years

(Source: Optimum watering requirements adapted from Roberts and Marston 2011 and Rogers and Ralph 2011)

<sup>1</sup>HEF—Hydro-ecological functional; PCT—plant community type; RVC—regional vegetation communities

## Prioritisation of ecological assets

Ecological assets were prioritised to select the assets that best represent biodiversity in the Border Rivers 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 Border Rivers TAG during a meeting in February 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 the identification and determination of areas of high conservation significance where floodplain connectivity should be secured (Ball and Possingham 2000; Possingham, Ball and Andelman 2000; Ball, Possingham and 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 Border Rivers Valley Floodplain, the TAG endorsed conservation targets of 100% for most asset types to ensure their future persistence. The exception was the flood dependent shrubland class Eurah shrubland of inland floodplains (PCT 115) for which the TAG endorsed a conservation target of 80%. 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 8)
- using local and expert knowledge to set targets for ecological surrogates (see Appendix 9)
- 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 10)
- running Marxan to identify priority ecological assets and selection frequency scores.

Marxan analyses key ecological surrogates to represent biodiversity patterns and identifies floodplain areas that 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 Border Rivers 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<sup>1</sup> (Ball and Possingham 2000). The best solution from the 100 runs was chosen to identify the high-priority planning units. The best solution is the minimum set solution or the optimum planning unit portfolio. It is selected because it has the minimum amount of planning units that will achieve the conservation targets at the least cost (Figure 16).

Fifty-five percent of the planning units ( $n=6188$ ) were identified as high priority for conservation in the Border Rivers Valley Floodplain (Figure 16).

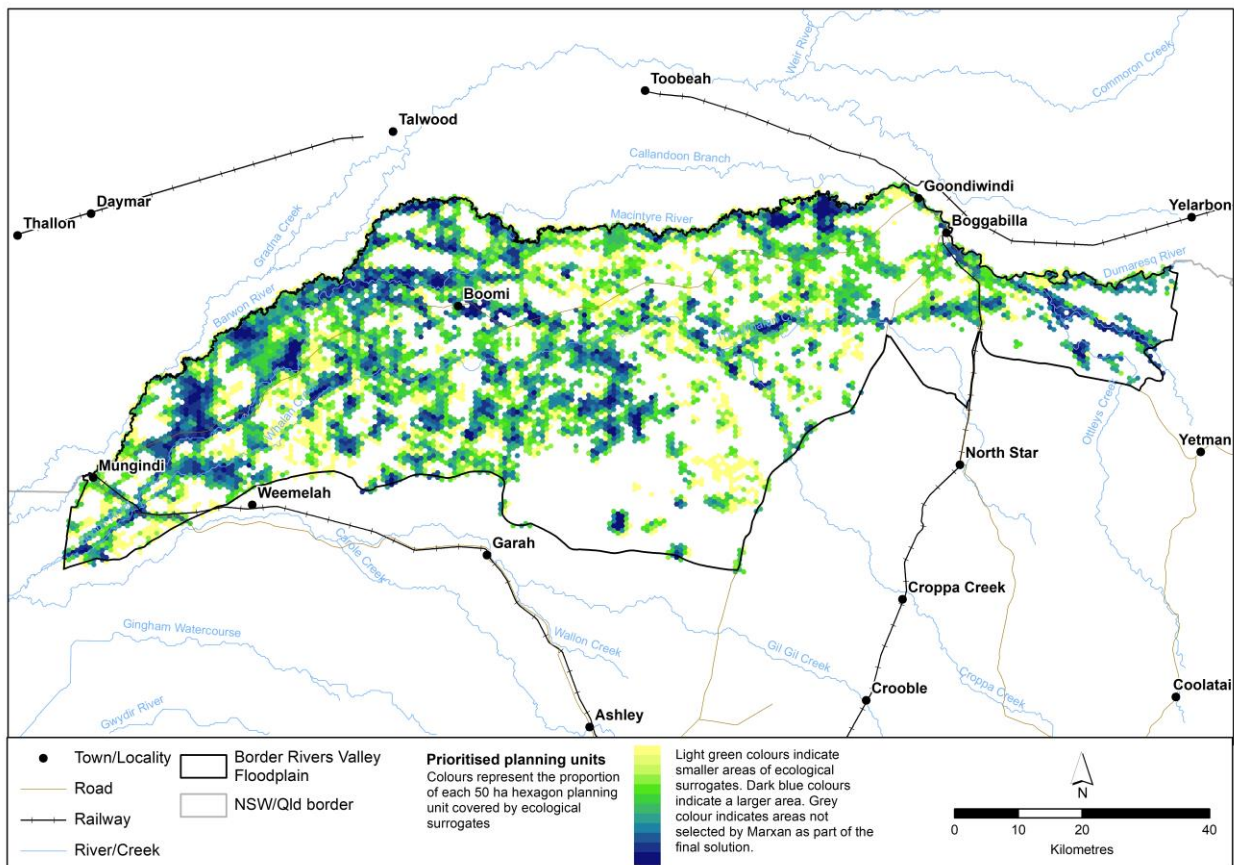
The optimal set of planning units mapped from Marxan identified parts of the Border Rivers Valley Floodplain which are important for achieving a range of conservation targets and included parts of the floodplain which are essential for maintaining connected riparian ecosystems and protecting flood-dependent 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 current spatial extent 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 Border Rivers Valley Floodplain.

The high-priority ecological assets form part of the larger decision framework for the final determination of the management zones in Step 7.

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<sup>1</sup> a way of finding an optimal solution to a problem by comparing many possible solutions



**Figure 16: High-priority planning units selected in Marxa in the Border Rivers Valley Floodplain**

## Cultural assets

The Border Rivers Valley Floodplain contains assets that have Aboriginal and cultural heritage values (cultural assets). The Border Rivers Valley FMP 2020 identified and prioritised two types of cultural assets:

- **Aboriginal cultural values**—sites, objects, landscapes, resources and beliefs that are important to Aboriginal people as part of their continuing culture. Aboriginal cultural values also include functions, services and features that benefit Aboriginal people that are listed in Commonwealth, state and local government databases.
- **heritage sites**—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 Border Rivers Valley FMP 2020 to accept Aboriginal cultural values and heritage sites that are derived from ‘any other source that, in the minister’s opinion, is relevant’.

### Cultural asset type—Aboriginal cultural values

Aboriginal people view themselves as an inherent part of the river system. The Gamilaroi people are the traditional owners of the Border Rivers Valley Floodplain. It is acknowledged that the Bigumbul people play an integral role in the management of the Qld Border Rivers floodplain. Ceremony between the two Nations may have been conducted on both sides of the state border as a show of unity, common belief systems and shared country.



The Border Rivers 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 cultural values cannot be listed or mapped in published documents; however, Aboriginal cultural values were generally found to include:

- wetlands and river channels that were an important focus of settlement, and are also places of spiritual and specifically Dreaming significance for example, Boobera Lagoon
- locations of Bora (initiation) ceremonies
- core semi-permanent wetlands with iconic plants (for example, cumbungi and nardoo)
- riverine forests, woodland and grassland areas with iconic plants (for example, river cooba, river red gum, coolabah, 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 Border Rivers Valley FMP 2020, Aboriginal cultural values were identified at a regional scale by:

- reviewing previous studies that have investigated cultural values in the floodplain
- consulting with various NSW government agencies involved with landscape management within the Valley (for example, North West Local Land Services, National Parks and Wildlife Service, the department's Water Group and Environment, Energy and Science Group)
- consulting with various Qld government agencies regarding their knowledge of Aboriginal cultural values near the Macintyre River where the Macintyre forms the NSW/Qld State border
- reviewing the values recorded in the Aboriginal Heritage Information Management System (AHIMS)
- targeted consultation with members of the Aboriginal community with knowledge of values connected with the floodplain
- consultation with the Border Rivers ATWG, that is comprised of Aboriginal people with cultural connection to the floodplain
- context-setting using existing spatial information about the potential distribution of unidentified values using the Aboriginal Sites Decision Support Tool (ASDST) (Ridges 2010) (Appendix 12).
- Aboriginal cultural values were also identified by reviewing the values recorded within the floodplain in the following databases:
  - NSW Aboriginal Heritage Information Management System (AHIMS) (see [www.environment.nsw.gov.au/topics/aboriginal-cultural-heritage/protect-and-manage/aboriginal-heritage-information-management-system](http://www.environment.nsw.gov.au/topics/aboriginal-cultural-heritage/protect-and-manage/aboriginal-heritage-information-management-system)), which includes:
    - information on Aboriginal objects
    - information about Aboriginal Places
    - archaeological reports
  - NSW Aboriginal Water Initiative System (AWIS) (no longer actively used; see Appendix 11 for more details)
  - Murray–Darling Basin Authority Aboriginal Submissions Database

- NSW State Heritage Inventory (see [www.heritage.nsw.gov.au/search-for-heritage/search-for-nsw-heritage/](http://www.heritage.nsw.gov.au/search-for-heritage/search-for-nsw-heritage/)), which includes:
  - declared Aboriginal Places
  - items listed on the State Heritage Register
  - listed Interim Heritage Orders
  - items on State Agency Heritage Registers
  - items listed of local heritage significance on a local council's Local Environmental Plan.
- Australian Heritage Database (see [www.environment.gov.au/heritage/publications/australian-heritage-database/](http://www.environment.gov.au/heritage/publications/australian-heritage-database/)), which includes places in the:
  - World Heritage List
  - National Heritage List
  - Commonwealth Heritage List
  - Register of the National Estate.

## 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 cultural values may also be heritage sites and for the purposes of the Border Rivers Valley FMP 2020, heritage sites were divided into historic heritage sites and Aboriginal heritage sites.

Commonwealth, state and local government heritage sources include:

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

## Flood dependency of Aboriginal cultural values and heritage sites

During the development of the Border Rivers Valley FMP 2020, the 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 cultural values**

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

Flood-dependent Aboriginal cultural values included sites that are not necessarily flood-dependent, but the purpose or location of the site is flood-dependent. Examples include, ceremonial locations connected with intact flood-dependent vegetation, 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. Wherever possible, the nature of these cultural relationships was considered in the design of the management zones.

## **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 value was dependent on, or connected with floodwater. In the Border Rivers Valley Floodplain, none of the identified historic assets that were reviewed were found to have flood-dependent values.

## **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 (for example, coolamon scars) that are flood-dependent species
- fish traps
- ceremony and Dreaming sites located within or surrounded by floodplain vegetation<sup>1</sup>
- Aboriginal resource gathering sites.

## **Prioritisation of Aboriginal heritage sites**

The flood dependence of Aboriginal heritage sites 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 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 current 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 no records of existing fish traps within the study region. The possibility of fish traps being used was noted by the ATWG.

### **Ceremonial sites**

A search of the AHIMS database identified several ceremony sites recorded within the floodplain. Some of these have little physical remains on the landscape but were well known in historic times.

### **Gathering sites**

The AHIMS data identified one Aboriginal resource gathering site with contemporary on-going use. Although it was within the floodplain, it was not associated with flood-dependent vegetation.

### **Burial sites**

The AHIMS database holds six records of Aboriginal burials within the Border Rivers Valley Floodplain, several of which occur within areas mapped as flood dependent vegetation.

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<sup>1</sup> 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.

## Midden sites

Within mapped flood-dependent vegetation, there were also records of Aboriginal shell middens. These resources were utilised during flood periods and are associated with lagoons filled during floods.

## Prioritisation of Aboriginal values

Targeted consultation was undertaken with members of the Aboriginal community throughout the region who have knowledge about flood-dependent Aboriginal cultural values. Given available time frames this was not an exhaustive consultation process, and the incorporation of Aboriginal cultural values into the plan should be considered an ongoing process.

Discussions were held in person with community members with printed maps that they could annotate. The maps were left with the community members 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 cultural values warranted an exclusion of further flood works. In some cases, this was because of the importance and sensitivity of the site. In other cases, it concerned areas of relatively intact land believed to be 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 Aboriginal cultural values were added to AHIMS. This database will be used 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 must be appreciated. A socio-economic profile of the Border Rivers 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 13 and a summary is provided below.

Developing the profile, or 'snapshot', involves documenting the biophysical, social, and economic conditions of the valley. This provides a general picture of the catchment in terms of its socio-demographic and economic structures. The key socio-economic data that informs the baseline profile includes:

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

Information from this assessment is used in the socio-economic impact analysis of the plan, 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 Border Rivers Valley Floodplain. The three areas are:

- the Border Rivers Floodplain Economy,
- the Border Rivers Rural Floodplain, and
- the Border Rivers Urban Floodplain.

The Border Rivers Floodplain Economy area (2,418,380 ha) includes the Border Rivers Rural and Urban Floodplains, and the adjacent areas in the Barwon-Darling and Gwydir catchments and the Qld component of the Border Rivers catchment that engage with the economy of the region (Figure 17). Most goods and services consumed in the Border Rivers Floodplain Economy area are sourced from the regional centre of Goondiwindi or the small townships in the area.

The Border Rivers Rural Floodplain (727,712 ha) incorporates the area of the Border Rivers Valley Floodplain bounded by the Barwon-Darling Valley Floodplain in the west, the Gwydir Valley Floodplain in the south, the Barwon and Macintyre River in the north and the slopes of the NSW Border Rivers catchment in the east (Figure 18). The community residents who live and work in this area are predominantly agricultural-based, but the community also includes 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 regional centre.

The Border Rivers Urban Floodplain incorporates the regional centre of Goondiwindi, and the townships of Boggabilla and Mungindi. In these areas flood works are managed under the Local



Government Act 1993. The communities that live in these towns are reliant upon the surrounding rural floodplain areas both as sources of employment and as consumers of services.

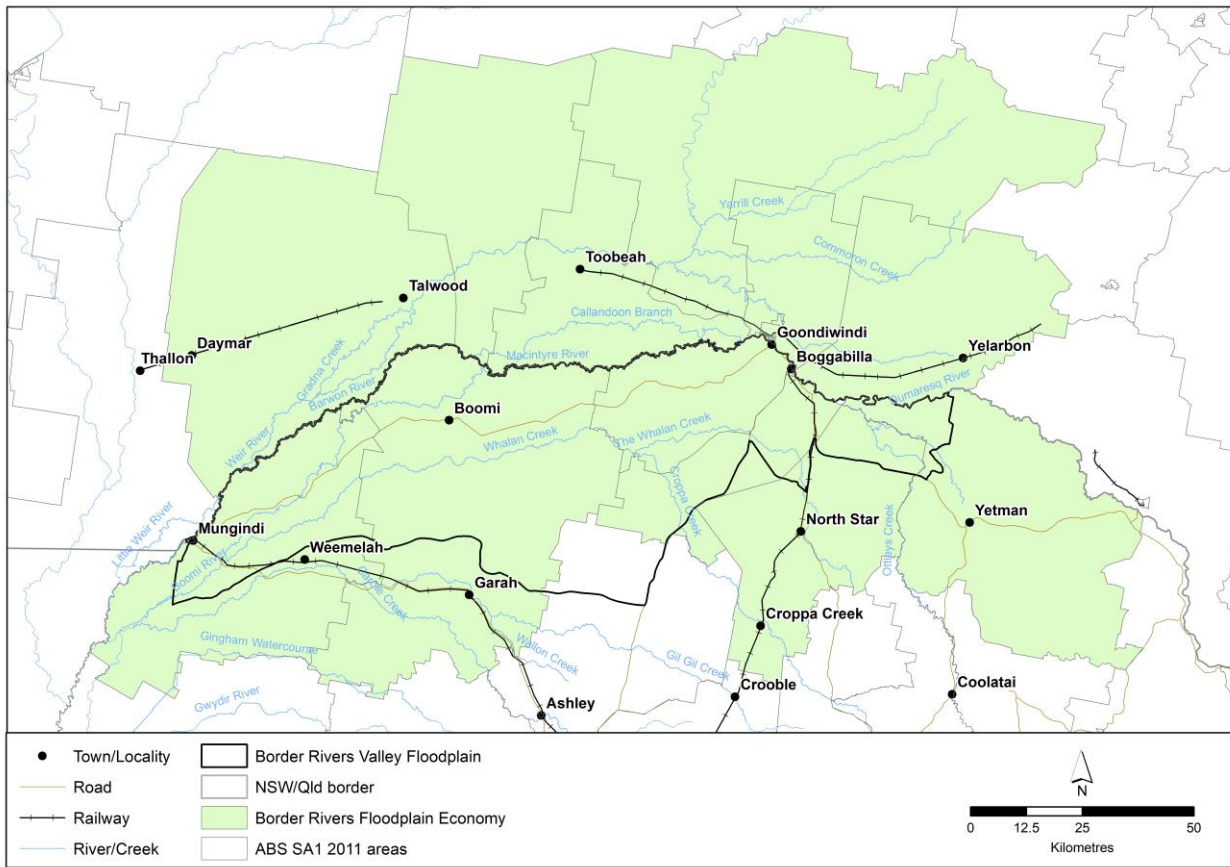
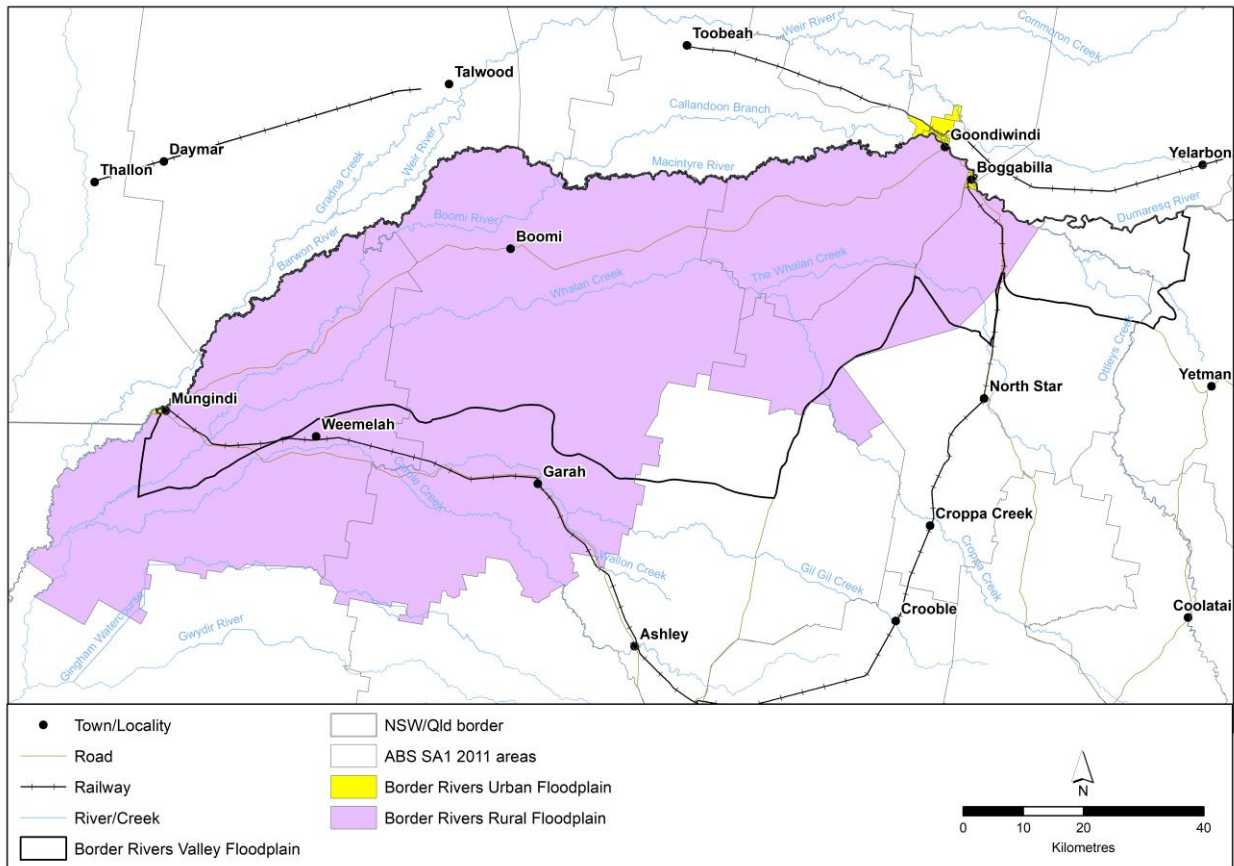


Figure 17: Border Rivers Valley Floodplain and Border Rivers Floodplain Economy area



**Figure 18: Border Rivers Valley Floodplain and Border Rivers Rural and Urban Floodplain areas**

## Data sources

Demographic data for the Border Rivers Floodplain economy, the Border Rivers Rural floodplain, and the Border Rivers 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 closely align with the boundary of the Border Rivers Floodplain Economy area and of the Rural and Urban Floodplain areas. Regional population trends for the Moree Plains (A) and Inverell (A) 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 Border Rivers Floodplain Economy. The ABS Agricultural Census 2011 (ABS 2011c) provides comprehensive data on both dryland 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 Border Rivers Floodplain Economy include the Moree Region and Inverell Region-East.

## Demographic profiles

Demographic information is provided in Table 5 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 5: 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)
Border Rivers Floodplain Economy <sup>1</sup>	11,080	64	11	101	59
Border Rivers Rural Floodplain	1,100	n/a	5	119	45
Border Rivers Urban Floodplain	7,130	n/a	15	94	70
State average	n/a	n/a	2.5	97	52

The age by sex distribution of the Border Rivers Floodplain economy and the Border Rivers Rural and Urban floodplain communities reveals an under representation in the 10 to 40 age groups, as compared to the under 10 and over 40 age groups and as compared to the NSW population. This under representation is demonstrated to a greater extent in the Rural Floodplain.

## Employment by industry

Employment in the Border Rivers Floodplain economy area (NSW and Qld) is predominantly within the Agricultural sector, accounting for 32% of total employment. The next highest employment sector is Retail trade accounting for 10% of total employment. Employment in the Rural Floodplain is dominated by the Agriculture sector, with 68% of the workforce. Employment in the Urban Floodplain is reasonably evenly distributed across sectors. The Retail trade sector is the most significant employer, with 14% of the workforce, followed by Agriculture, which comprises 12% of the workforce (ABS 2011b).

## Income

The proportion of low income households in the Border Rivers Floodplain economy, Border Rivers Rural floodplain, and Border Rivers Urban floodplain were 22%, 17%, and 23% respectively, compared with the NSW State proportion of 23%. The medium income proportions of 67% in the Border Rivers Floodplain economy, of 70% in the Border Rivers Rural floodplain, and of 66% in the Border Rivers Urban floodplain, are all higher than the NSW State proportion of 56%. The proportions of high-income households across all three areas (11%, 14%, and 11% respectively) are notably lower than the NSW state proportion of 21%.

## Economic wellbeing indicators

The ABS 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 Local Government areas of Moree Plains (A) and Inverell (A) are in the 2nd decile, indicating significant relative disadvantage. The five rural floodplain ABS Statistical Area level 1 (SA1) areas have scores in the 5th to 7th deciles indicating that they are neutral or relatively advantaged, excepting the upstream SA1 in the 3<sup>rd</sup> decile that is relatively disadvantaged.

## Production

Agriculture is the significant economic activity of the region's economy, occupying 94% of the farm holding area within the Border Rivers Valley Floodplain. The estimated Gross Value of Agricultural Production (GVAP) of 2010-2011 is \$233.7 million or 2.0% of total NSW State GVAP, using 438,130 hectares. Broadacre cropping produces \$221.6 million or 95% of the total FMP area GVAP, using 247,000 hectares or 56% of the area. Livestock and livestock products account for 5.2% of the GVAP while using most of the remaining 44% of the area. The highest value producing individual broadacre crops are cotton-yielding \$117.9 million or 50% and wheat-yielding \$55.1 million or 24% of the total GVAP in the Border Rivers Valley Floodplain.

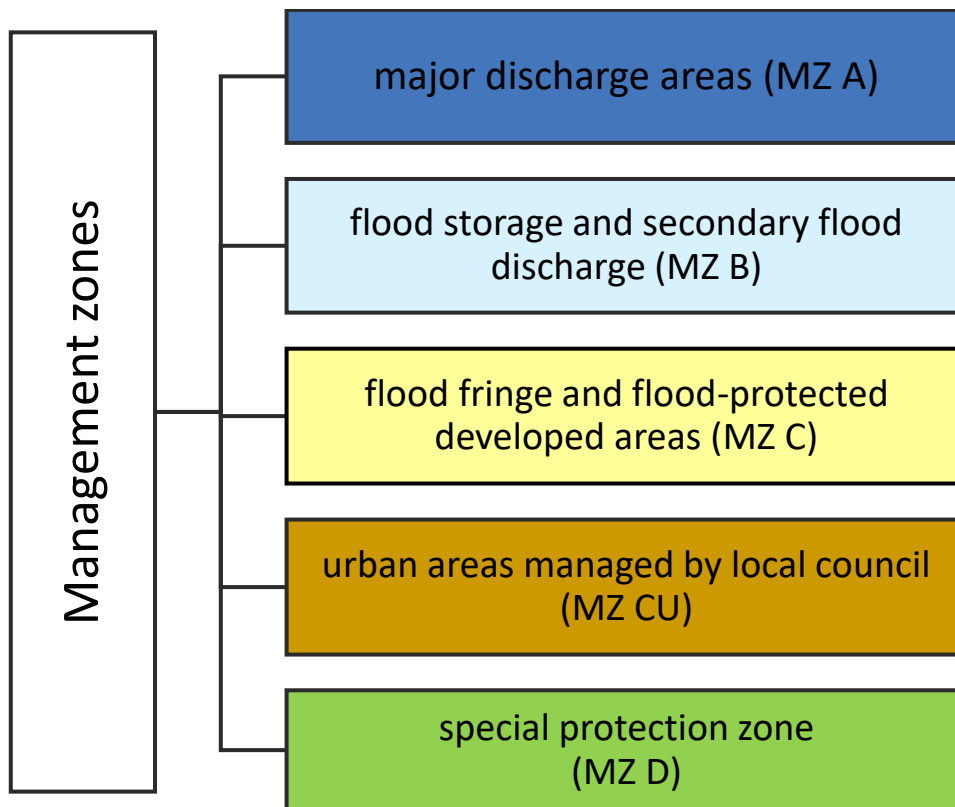
The total irrigated land within the Border Rivers Valley Floodplain in 2010-2011 is estimated at 19,300 hectares which constitutes approximately 2.6% of farm holding area. The total water extracted for agricultural irrigation across the Inverell Region-East and the Moree Region in 2010-11 is estimated at 110,900 megalitres. The majority of irrigation water used is applied to cotton (using 18,200 ha or 94% of the estimated irrigated area in the Border Rivers Valley Floodplain in 2010-2011).

## Step 7: Delineate management zones

In Step 7, the nature and location of the management zones for the Border Rivers Valley Floodplain was determined using hydraulic, ecological, and cultural criteria as well as criteria to ensure the plan reflects current floodplain management arrangements.

The Border Rivers Valley FMP 2020 contains five different management zones:

- Management Zone A (MZ A) – Major discharge areas, defined floodways (124,359 ha or 23% of the floodplain)
- Management Zone B (MZ B) – Flood storage and secondary flood discharge (285,755 ha or 51% of the floodplain)
- Management Zone C (MZ C) – Flood fringe and flood protected development areas (145,590 ha or 26% of the floodplain)
- Management Zone CU (MZ CU) – Urban areas managed by local council (600 ha or <1% of the floodplain)
- Management Zone D (MZ D) – Special environmental and cultural protection (2,153 ha or <1% of the floodplain)



**Figure 19. Finger diagram of management zones in the Border Rivers Valley FMP 2020**

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.

Part 10 'Amendment of this Plan' in the Border Rivers Valley FMP 2020 provides the opportunity to modify the management zones in response to improvements in knowledge and technology. More information about modifying the management zones is provided at the end of this step. The Border Rivers Valley Floodplain management zones are displayed in more a detailed series of maps in Appendix 14.



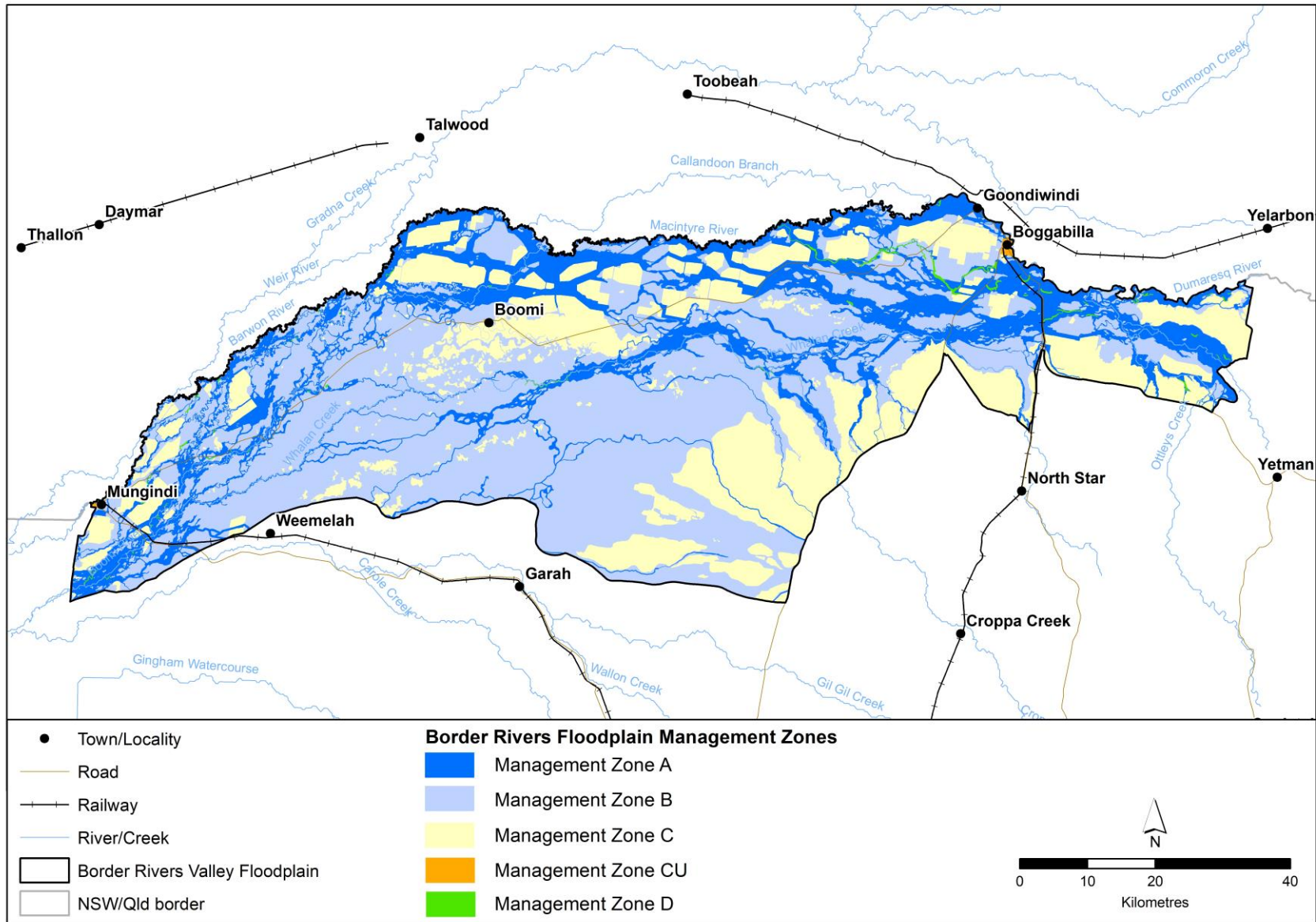


Figure 20: Overview of the management zones in the Border Rivers Valley Floodplain

## Description of management zones

### Management Zone A – major discharge areas, defined floodways (MZ A)

MZ A covers 124,359 hectares or 23% of the floodplain. It includes defined floodways with 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.

MZ A includes floodways that have a depth-velocity threshold of greater than or equal to 0.3 m<sup>2</sup>/s for the large design flood (1976).

Floodplain connectivity is provided for in MZ A by incorporating:

- floodplain areas that have a DVP of greater than or equal to 0.2 m<sup>2</sup>/s for the large design flood (1976), and
- the 13% AEP small design flood extent (equivalent to the January/February 2013 flood at Mungindi)

MZ A includes areas where uncoordinated flood work development may have a high adverse impact on flood behaviour. It was designated to ensure a reduction in the risk to life and property by limiting flood work developments to prevent flood flow redistribution, and 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 important for the conveyance of floodwater to highly flood dependent ecological and cultural assets. MZ A includes the extent of semi-permanent wetlands 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 a high proportion of the extent of Aboriginal cultural values that are highly flood dependent. Certain trees that have been modified by Aboriginal people have also been included in MZ A. Modified trees were incorporated into Management Zone AD if the trees are living scarred or carved trees and found in close proximity to floodways.

Where the Border Rivers FMP joins another FMP, such as the Gwydir Valley FMP 2016 and the Barwon-Darling Valley FMP 2017, floodways in the Border Rivers have been aligned where appropriate to ensure floodway continuity and protection between floodplains.

### Management Zone B – flood storage and discharge areas for design floods (MZ B)

MZ B covers 285,755 hectares or 51% 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.

MZ B is defined as areas not already identified as MZ A that are within the modelled inundation extent of the large design flood (1976).

MZ B also includes areas protected by existing Part 8, WA 1912 approved flood works that are overtopped during moderate to large floods.

MZ B includes ecological assets that have a moderate level of flood dependency. MZ B may include areas of floodplain wetland (flood-dependent shrubland wetland), 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 also includes cultural assets

such as living scarred/carved 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 impacts of works on flood behaviour.

### Management Zone C – flood fringe areas and existing developed areas (MZ C)

MZ C covers 145,590 hectares or 26% of the floodplain. It contains flood fringe and flood protected developed areas. This zone includes areas that are outside the extent of the large design flood (1976) and/or are enclosed by existing Part 8, WA 1912 approved flood works that are not designed to be overtopped during moderate to large floods.

Ecological assets that are highly flood-dependent were not recommended for inclusion in MZ C. However, ecological assets still occur in MZ C and are likely to include those that may tolerate infrequent flooding. 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 to ensure that the proposed flood work can be constructed to maintain adequate flood connectivity to ecological assets and to facilitate fish passage.

MZ C also includes some cultural assets such as scarred trees; however, cultural assets were not specifically assigned to MZ C. Generally these trees are species that require infrequent flooding or the record of the tree could not be verified. Any cultural assets that are recorded in MZ C will still be required to be considered during the assessment of flood work applications.

The rules and assessment criteria of MZ C are less restrictive than other management zones as MZ C includes areas where flood work development is unlikely to have a significant effect on flood behaviour. Nevertheless, flood works still require an assessment and approval to protect the health of the floodplain environment.

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

MZ CU covers 600 hectares or less than 1% of the floodplain. It captures urban areas that are within existing urban flood studies, flood risk management studies and/or floodplain risk management plans, or that are protected by flood mitigation works such as town levees.

MZ CU includes parts of Boggabilla, Boomi and Mungindi 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 environmental and cultural protection areas (MZ D)

MZ D covers 2,153 hectares or less than 1% of the floodplain. It is a special protection zone for areas of ecological and/or cultural significance. MZ D includes floodplain assets that are highly flood dependent with high ecological value and/or high cultural value as determined from consultation with the Aboriginal community (Figure 21). There are 64 MZ D areas within the Border Rivers Valley Floodplain, as listed in Appendix 15.





**Figure 21: Boobera Lagoon - An example of a Management Zone D asset in the Border Rivers Valley Floodplain (G. Pezzimenti, OEH (Feb 2013))**

## Hydraulic criteria

Draft management zones were initially established based on hydraulic criteria, which were developed from information on flood behaviour contained in the floodway network and flood fringe (that is areas outside of the floodway network) (Table 3 and Figure 9). The following three hydraulic categories were the basis of MZ A, B, and C:

- floodways are the hydraulic basis for MZ A
- inundation extent up to the large design flood is the hydraulic basis for MZ B
- flood fringe (that is areas outside the floodway network) is the hydraulic basis for MZ C

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

## Ecological criteria

### Management Zones A, B, and C

Floodplain water flows are crucial to maintain the structure, 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, 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 6).

The ecological criteria were finalised in discussion with TAG members and local experts. In addition to the criteria listed in Table 6, key fish passage areas for Silver Perch (*Bidyanus bidyanus*), Purple Spotted Gudgeon (*Mogurnda adspersa*), Olive Perchlet (*Ambassis agassizii*),

and Eel tailed Catfish (*Tandanus tandanus*) were also considered as ecological criteria. Key fish habitat data was identified using 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.

No adjustments to the management zones were made on the basis of groundwater recharge due to the lack of information and the unreliable nature of data available.

Where a management zone could not be amended to connect recommended asset types (that is 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 6: Management zone recommendations for ecological asset types**

Ecological Asset	Hydro-ecological functional group	Ideal frequency of watering	Management zone recommendation
Wetland	Semi-permanent wetland	Annual or near annual	MZ A (entire mapped area)
Wetland	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)
Other floodplain ecosystems	Flood-dependent woodland	1 in <10 years	MZ B or C
Areas of groundwater recharge	Likely recharge		MZ A or B*

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

## Ecological refinements to Management Zone A

The management zone recommendations outlined in Table 6 were initially used to determine if ecological assets were captured in the recommended management zone. Prior to application of ecological criteria, approximately 38% of semi-permanent wetland, 55% of floodplain wetland (flood-dependent shrubland wetlands) and 93% of flood-dependent forest/woodland (wetlands) were found to occur in hydraulic floodways. Following the application of the ecological criteria approximately 45% of semi-permanent wetland was allocated to MZ D and 50% was protected within MZ A (Figure 22). This included protection within MZ D of the full spatial extent of the nationally significant wetland Morella Watercourse, Boobera and Pungboulal Lagoon's and the entire spatial extent of wetlands that had Aboriginal cultural values associated with them identified and surveyed by Hudson and Bacon (2009) and the significant lagoons and wetlands from Schedule 5. Connecting 95% of semi-permanent wetland to floodways will help to protect flood connectivity to these assets and to conserve these significant ecological areas in the future.

Refinements were made to MZ A ensure that flood connectivity is maintained and protected to 65% of flood-dependent shrubland wetlands, including River coobah swamp wetland on the floodplains of the Darling riverine plains bioregion and Brigalow Belt South Bioregion - PCT 241 and Lignum shrubland wetland on regularly flooded alluvial depressions in the Brigalow Belt South bioregion and Darling riverine plains bioregion - PCT 247. Refinements to MZ A were made using interpretation of LiDAR DEM, hydraulic modelling, 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.

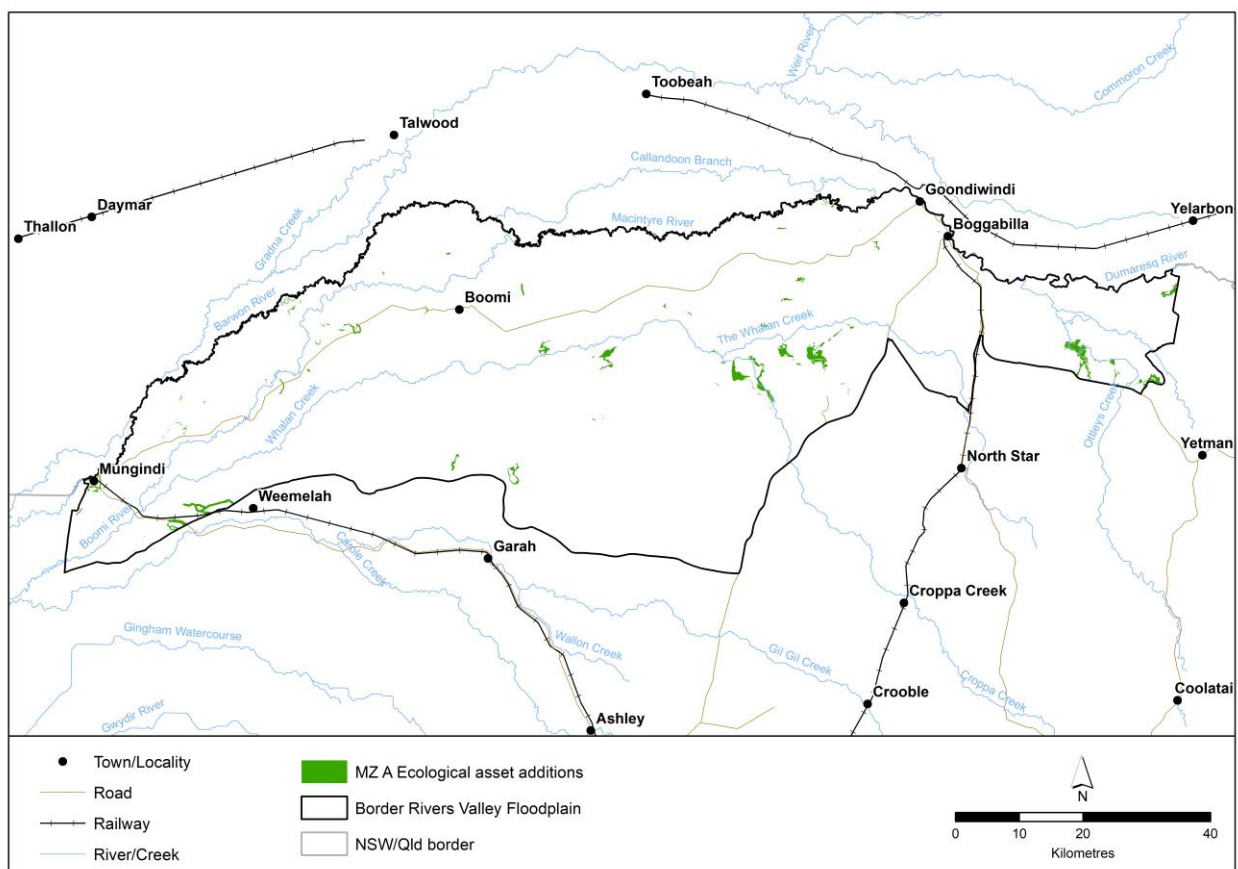
Prior to the application of the ecological criteria approximately 93% of the flood-dependent forest/woodland (wetlands) were found to be in major flood discharge areas (hydraulically defined floodways) and in areas beside channels or on lowland floodplain areas which are flooded by overbank flows beyond the hydraulically defined floodways in MZ B and MZ C (7%).



This was expected as riparian corridors of River Red Gum tall to very tall open forest / woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion – PCT 36 align the channels of the major watercourses of the Border Rivers floodplain including the Barwon, Boomi, Macintyre and Dumaresq River's and the Boomangera, Budelah, Croppa, Doondoona, Goodlayamma and Gnoura Gnoura Creeks.

Only minor refinements were made to management zones for flood-dependent forest/woodland (wetlands) as the objective of the ecological criteria for this vegetation community was to ensure that riparian corridors of river red gum were connected to floodways (not to incorporate the entire spatial extent of the vegetation community into MZ A).

Flood-dependent woodlands, including coolabah (*Eucalyptus coolabah*) and black box (*Eucalyptus largiflorans*) communities were found to extent from lowland frequently flooded habitat (MZ A; 50%) to higher elevation floodplain locations distant from the main channels that are more infrequently flooded (MZ B and MZ C; 50%). Only minor refinements were made to MZ A where this asset type occurred adjacent to other ecological asset types recommended for MZ A.



**Figure 22: Refinements to Management Zone A based on ecological criteria**

## Ecological refinements to 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. Sixty-four floodplain assets were recommended to become MZ D based on ecological criteria (Figure 23). An overview of the ecological significance of each MZ D asset is provided in **Error! Reference source not found.**, and a detailed description the assets is provided in Appendix 15.

Criteria to classify an ecological asset as MZ D included assets that are a location or landscape feature, such as a swamp, marsh, lagoon, anabranch or billabong with a high degree of floodwater dependency, and may also have:

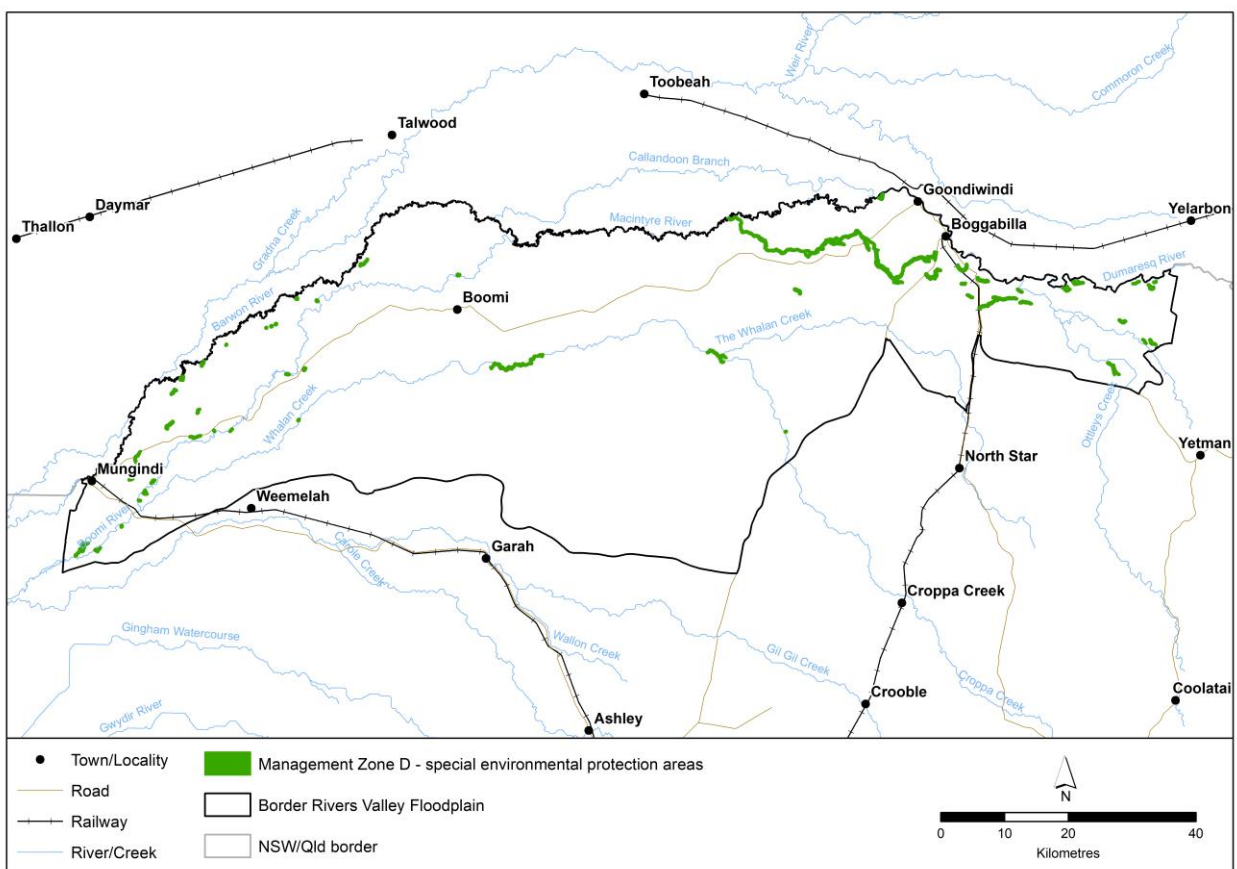
- a high degree of habitat complexity, or
- a history of supporting a diversity or abundance of waterbird, native fish or frog populations, or
- the functional capacity to act as an aquatic drought refuge, or
- have been identified as a named feature on Land and Property Information – SIX Maps/Topographic Map, or
- recognition in or protection by a local, state, or Commonwealth environmental policy and/or legislation.

**Table 7. List of floodplain assets classified as Management Zone D, based on ecological significance**

Ecological significance	MZ D ecological asset
Recognised in or protected by a local, state, or Commonwealth environmental policy	Morella Watercourse, Boobera Lagoon, Pungbougall Lagoon (Directory of Important Wetlands in Australia)  Boobera Watercourse, Gooroo Lagoon, Poopoopirby Lagoon (MDBA 2010)
Functional capacity to act as waterbird feeding and breeding habitat	All listed MZ D ecological assets may support waterbird feeding and breeding habitat when conditions are suitable.
Listed as a significant lagoon or wetland in Schedule 5 - Significant lagoons and wetlands - Water Sharing Plan for the NSW Border Rivers Unregulated and Alluvial Water Sources 2012.	Barden Lagoon, Boobera Lagoon, Mundine waterhole, Carwell Lagoon, Gobbooyallana Lagoon (Turkey Lagoon), Gooroo Lagoon, Malgarai Lagoon, Maynes Lagoon (Yarrangooran Lagoon), Morella Lagoon, Morella Watercourse, Poopoopirby Lagoon, Polidoroi Lagoon, Telephone Lagoon, Unnamed Lagoon (Barden), Unnamed Lagoon (Bengalla A), Unnamed Lagoon (Bengalla B), Unnamed Lagoon (Bengalla C), Unnamed Lagoon (Boroo), Unnamed Lagoon (Dindierna), Unnamed Lagoon (Hamilton), Unnamed Lagoon (Narrawal A), Unnamed Lagoon (Narrawal B), Unnamed Lagoon (Tulloona), Unnamed Lagoon (Turrawah A), Unnamed Lagoon (Turrawah B), Unnamed Lagoon (Turrawah C) Unnamed Lagoon (Umbri A), Unnamed Lagoon (Umbri B), Unnamed Lagoon (Werrina A), Unnamed Lagoon (Werrina B), Unnamed Lagoon (Werrina C), Unnamed Lagoon (Werrina D), Unnamed Lagoon (Werrina E), Unnamed Lagoon (Winslow), Unnamed Lagoon - Gravelly Creek, Unnamed Lagoon - Myall Park, Unnamed Lagoon - Spring Creek, Unnamed Lagoon's 1 to 7

Ecological significance	MZ D ecological asset
Functional capacity to act as an aquatic drought refuge	Boomi River Billabong, Boomangera Waterhole, Unnamed Lagoon (Boomangera Creek), Bora Waterhole, Bora Wetland, Bumble Waterhole, Coolibah Lagoon, Curraweena Waterhole, Doondoona Waterhole, Goony Waterhole, La Mascotte Billabong, Malgarai Overflow, Marakai Wetland, Niggettes Creek Waterhole, Toomelah Lagoon, Thorndale Lake, Wombyanna Lagoon, Woolinna and Cobbanthanna Waterholes and Significant lagoon or wetlands in Schedule 5 - Significant lagoons and wetlands - Water Sharing Plan for the NSW Border Rivers Unregulated and Alluvial Water Sources 2012 and Morella Watercourse, Boobera Lagoon, Mundine waterhole, Pungbougai Lagoon's

Note: ecological assets may appear in the table more than once if they satisfy multiple MZD criteria.



**Figure 23: Location of Management Zone D special environmental protection areas in the Border Rivers Valley Floodplain**

## Cultural criteria

Cultural criteria were 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 8).

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 cultural criteria were used to refine MZ A (where there was hydraulic justification) to incorporate cultural assets:

- Aboriginal values (excluding scarred/carved trees) that are highly flood-dependent if they:
  - were identified by the department's Aboriginal Water Initiative, or
  - are listed on the NSW AHIMS, or
  - were identified during direct community consultation with the local Aboriginal community
- 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 Management Zone A
  - within 100 m to 500 m of hydraulic Management Zone A and the site card has been evaluated
- Heritage sites that are flood-dependent and are cultural heritage objects and places as listed on Commonwealth, state and local government heritage registers.

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

**Table 8. Cultural criteria to include cultural assets in recommended management zones**

Asset	Type	Description	Management zone recommendation	Criteria for management zone inclusion
Aboriginal cultural values	Scarred trees	Living/flood-dependent vegetation	Variable – refer to vegetation	Include area in recommended MZ if within 100 m
Aboriginal cultural values	Places identified by the community	Some flood-dependent, others linked to flooding.	MZ D	Include whole of mapped area in MZ D
Heritage sites	Bridges	Not flood-dependent	n/a	n/a
	Weirs	Not flood-dependent	n/a	n/a
	Locks	Not flood-dependent	n/a	n/a

Cultural criteria also required that where there was hydraulic justification, MZ B be modified to include scarred/carved tree locations where the trees are living flood dependent woodland (to be consistent with ecological criteria).

In addition to the refinements to MZ A and MZ B, cultural criteria was also developed to include floodplain assets in MZ D. To be classified as MZ D, the criteria required that the cultural asset be a location or landscape feature with a high degree of:

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

Due to cultural sensitivities surrounding MZ D cultural assets, a map of the cultural refinements made to management zones is not provided. However, a detailed description of all MZ D assets is provided in Appendix 15.

### **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 current works are not dealt with in the design of the management zones. Where identified, these cultural assets will be an additional consideration when assessing flood work applications.

## **Criteria to better reflect current floodplain management arrangements**

The purpose of this stage was to amend management zones to better reflect current floodplain management arrangement. All management zones were reviewed for consistency with the following existing floodplain management studies and guidelines:

- Lower Macintyre (Yelarbon to Mungindi) designated floodplain (July 31 1985)
- WA 1912 Section 166C of Part 8 – Matters for general consideration
- WM Act, and
- NSW Macintyre Valley Draft Interim Policy 2004.
- Local Government policies and plans (NSW)
- The following Qld State and local Government legislation and policies were also considered:
- Guidelines for Flood Plain Management of the Border Rivers – Yelarbon to Mungindi 1987
- Waggamba Shire Council Local Law No. 26 (Levee Banks) 2004
- Qld WA 2000, and the
- WR 2016

Eight criteria were developed to better reflect current floodplain management arrangements:

1. Amendments to make MZ A congruent with neighbouring floodways in the Gwydir Valley FMP 2016 and the Barwon–Darling Valley FMP 2017.
2. Amendments to make MZ A consistent with *Guidelines for Macintyre River and Whalan Creek Flood Plain Development Boggabilla to Mungindi. Water Resources Commission – New South Wales 1981*
3. Amendments to make MZ A floodways more consistent with current mapped floodways and existing approved development. Where current floodways differ to approved flood work developments, consistency with the approved development was a priority. Proposed floodways were not made to be more restrictive than existing floodways.
4. MZ A was also amended to include areas of the floodplain that are enclosed by existing Part 8, WA 1912 approved flood works that are designed to be overtopped during moderate to large floods.
5. Amendments to relax the DVP threshold for MZ A in current guideline areas to greater than or equal to 0.4 m<sup>2</sup>/s for the large design flood in areas outside the guidelines' floodway networks. This increased the area of MZ B.



6. Areas of the floodplain that are enclosed by existing Part 8, WA 1912 approved flood works that are designed to be overtopped during moderate to large floods were also included in MZ B.
7. Areas of the floodplain that are enclosed by existing Part 8, WA 1912 approved works that are not designed to be overtopped during flooding were included in MZ C
8. Floodplain areas that are included within existing urban Flood Studies, Flood Risk Management Studies, and/or Flood Risk Management Plans were included in MZ CU. In the Border Rivers Valley FMP 2020, the following towns were included in MZ CU:
  - Boggabilla,
  - Mungindi, and
  - Boomi.

The basis for MZ D does not include consideration of existing floodplain management arrangements.

## Modifying the management zones

Part 10 of the Border Rivers Valley FMP 2020 (Amendment of this Plan) is the mechanism by which modifications may be made to the management zones.

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 landmarks
- 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.

## Summary of management zone criteria

The configuration of management zones in the Border Rivers Valley Floodplain was based on four categories of management zone criteria:

- Hydraulic criteria,
- Ecological criteria,
- Cultural criteria, and
- Criteria to better reflect current floodplain management arrangements.

Management zones A, B and C were predominantly based on hydraulic criteria. Around 40% of MZ C was based on existing approved flood works as part of criteria to better reflect existing floodplain management arrangements. All of MZ CU was based on towns managed by local councils identified as part of the criteria to better reflect current floodplain management arrangements. All of MZ D was based on ecological and cultural assets identified using ecological and cultural criteria.

The breakdown of each category's contribution to each management zone is provided in Figure 24.

Figure 25 outlines the percentage that each management zone occupies in the Border Rivers Valley Floodplain. As it can be seen from this figure MZ B is the largest zone, occupying 52% of the total floodplain area. MZ CU and MZ D were the smallest zones both occupying less than 1% of the total floodplain area.

A summary of the criteria for delineating management zones is provided in Table 9. Criteria for Management Zone A

Criteria	Description
Hydraulic	<p>MZ A includes major discharge areas that have a DVP of greater than or equal to 0.3 m<sup>2</sup>/s for the large design flood (1976).</p> <p>Floodplain connectivity was provided for by incorporating:</p> <ul style="list-style-type: none"> <li>The 13% AEP small design flood extent and/or</li> <li>floodplain areas that have a DVP of greater than or equal to 0.2 m<sup>2</sup>/s for the large design flood (1976).</li> </ul> <p>To ensure that conditions on the ground are adequately represented, the above criteria were road tested against the following additional data:</p> <ul style="list-style-type: none"> <li>flood aerial photography and satellite imagery from design floods</li> <li>spatial watercourse layers, topographical mapping, ADS40 DEM and LiDAR</li> <li>previous floodplain management plans and development guidelines</li> <li>local knowledge obtained from floodplain communities and floodplain/environmental managers.</li> </ul>
Ecological criteria	<p>MZ A includes, where there is hydraulic justification:</p> <ul style="list-style-type: none"> <li>semi-permanent wetland</li> <li>floodplain watercourses including wetland - floodplain swamps - billabongs</li> <li>connections to/through floodplain wetland (flood-dependent shrubland wetlands) and flood-dependent forest/woodland (wetlands)</li> <li>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)</li> <li>key fish passage areas identified using NSW Fish Community Status and Threatened Fish Species Data - Aquatic Biodiversity Value Mapping Project (NSW DPI 2016)</li> </ul>
Cultural criteria	<p>MZ A includes, where there is hydraulic justification:</p> <ul style="list-style-type: none"> <li>floodplain areas with Aboriginal cultural values that are highly flood-dependent that were identified during direct community consultation with the local Aboriginal community and/or are listed on the: <ul style="list-style-type: none"> <li>Aboriginal Water Initiative System (AWIS) database (now inactive)</li> <li>Aboriginal Heritage Information Management System (AHIMS)</li> </ul> </li> <li>locations for scarred/carved trees that are living flood-dependent vegetation that generally require flooding at least every five years to maintain their ecological character and cultural value</li> <li>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.</li> </ul>
Existing floodplain management arrangements criteria	<p>MZ A was made congruent with the MZ A of the bordering Gwydir Valley FMP 2016 and the Barwon-Darling Valley FMP 2017. MZ A was also reviewed for consistency with existing FMPs and Floodplain Development Guidelines. During the review, MZ A floodways were matched to historical floodways. If the historical floodways were inconsistent with current flood work development, the floodways were designed to match current development conditions. Importantly, MZ A was not made to be more restrictive than the historic floodways.</p>

**Table 10. Criteria for Management Zone B**

Criteria	Description
Hydraulic criteria	<p>MZ B includes flood storage areas of the floodplain that are</p> <ul style="list-style-type: none"> <li>not already identified as MZ A and</li> <li>included within the extent of the large design flood (1976) or are</li> <li>enclosed by existing Part 8, WA 1912 approved flood works that are designed to be overtopped during moderate to large floods.</li> </ul> <p>To ensure that conditions on the ground are adequately represented, the above criteria were road tested against the following additional data:</p> <ul style="list-style-type: none"> <li>flood aerial photography and satellite imagery from design floods</li> <li>spatial watercourse layers, topographical mapping, ADS40 DEM and LiDAR</li> <li>previous floodplain management plans and development guidelines</li> <li>local knowledge obtained from floodplain communities and floodplain/environmental managers.</li> </ul>
Ecological criteria	MZ B includes, where there is a hydraulic justification, ecological assets identified as high priority flood-dependent woodland that generally tolerate less frequent flooding than those recommended for MZ A to maintain their ecological character.
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	<p>MZ B includes areas that were initially mapped as MZ A (based on hydraulic criteria) where the DVP was less than 0.4 m<sup>2</sup>/s for the large design flood. These areas also had to be outside of the original floodway networks described in the floodplain development guidelines. Before being made MZ B, these areas were checked for consistency with current flood work development levels in the floodplain.</p> <p>MZ B may include areas of the floodplain that are enclosed by existing Part 8, WA 1912 approved flood works that are designed to be overtopped during moderate to large floods.</p>

**Table 11. Criteria for Management Zone C (189,700 ha)**

Criteria	Description
Hydraulic criteria	<p>MZ C includes flood fringe areas of the floodplain that are outside the large design flood and/or are enclosed by existing flood works that are not designed to be overtopped during flooding.</p> <p>To ensure that conditions on the ground are adequately represented, the above criteria were road tested against the following additional data:</p> <ul style="list-style-type: none"> <li>flood aerial photography and satellite imagery from design floods</li> <li>spatial watercourse layers, topographical mapping, ADS40 DEM and LiDAR</li> <li>previous floodplain management plans and development guidelines</li> <li>local knowledge obtained from floodplain communities and floodplain/environmental managers.</li> </ul>
Ecological criteria	The basis of Management Zone C was not ecological
Cultural criteria	The basis of Management Zone C was not cultural.
Existing floodplain management arrangements criteria	<p>Management Zone C was reviewed for consistency with existing plans.</p> <p>Management Zone C includes areas of the floodplain that are enclosed by existing Part 8 approved flood works that are not designed to be overtopped during flooding.</p>

**Table 12. Criteria for Management Zone CU**

Criteria	Description
Hydraulic criteria	The basis of Management Zone CU was not hydraulic.

Criteria	Description
Ecological criteria	The basis of Management Zone CU was not ecological. If any assets fall within Management Zone CU, ecological asset mapping will be provided to the relevant local government authority for consideration in land-use planning and assessment of development applications.
Cultural criteria	The basis of Management Zone CU was not cultural. If any assets fall within Management Zone CU, the relevant local government authority will be notified and provided with relevant contact details.
Existing floodplain management arrangements criteria	Management Zone CU was mapped as floodplain areas that are included within existing urban flood studies, floodplain risk management studies, or floodplain risk management plans or that are protected by flood mitigation works such as town levees.

Table 13. Criteria for Management Zone D

Criteria	Description
Hydraulic criteria	The basis for Management Zone 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: <ul style="list-style-type: none"> <li>• a high degree of habitat complexity</li> <li>• a history of supporting a diversity or abundance of waterbird, native fish or frog populations</li> <li>• the functional capacity to act as an aquatic drought refuge</li> <li>• identified as a named feature on Land and Property Information – SIX Maps/Topographic Map, or</li> <li>• recognition in, or protected by a local, state or Commonwealth environmental policy.</li> </ul>
Cultural criteria	MZ D includes areas of the floodplain that are a location or landscape feature that has a high degree of: <ul style="list-style-type: none"> <li>• floodwater dependency such as swamps, marshes, lagoons, billabongs, or rocky bars that are strongly dependent on the passage of floodwater</li> <li>• cultural significance to the Aboriginal community including spiritual, archaeological or resource use-values and are listing on a heritage register or are a place that is recognized for its cultural significance by several senior knowledge holders in the Aboriginal community.</li> </ul>
Existing floodplain management arrangements criteria (0 ha)	Management Zone D was reviewed for consistency with existing plans. However, the basis for Management Zone D did not include existing floodplain management planning arrangements.

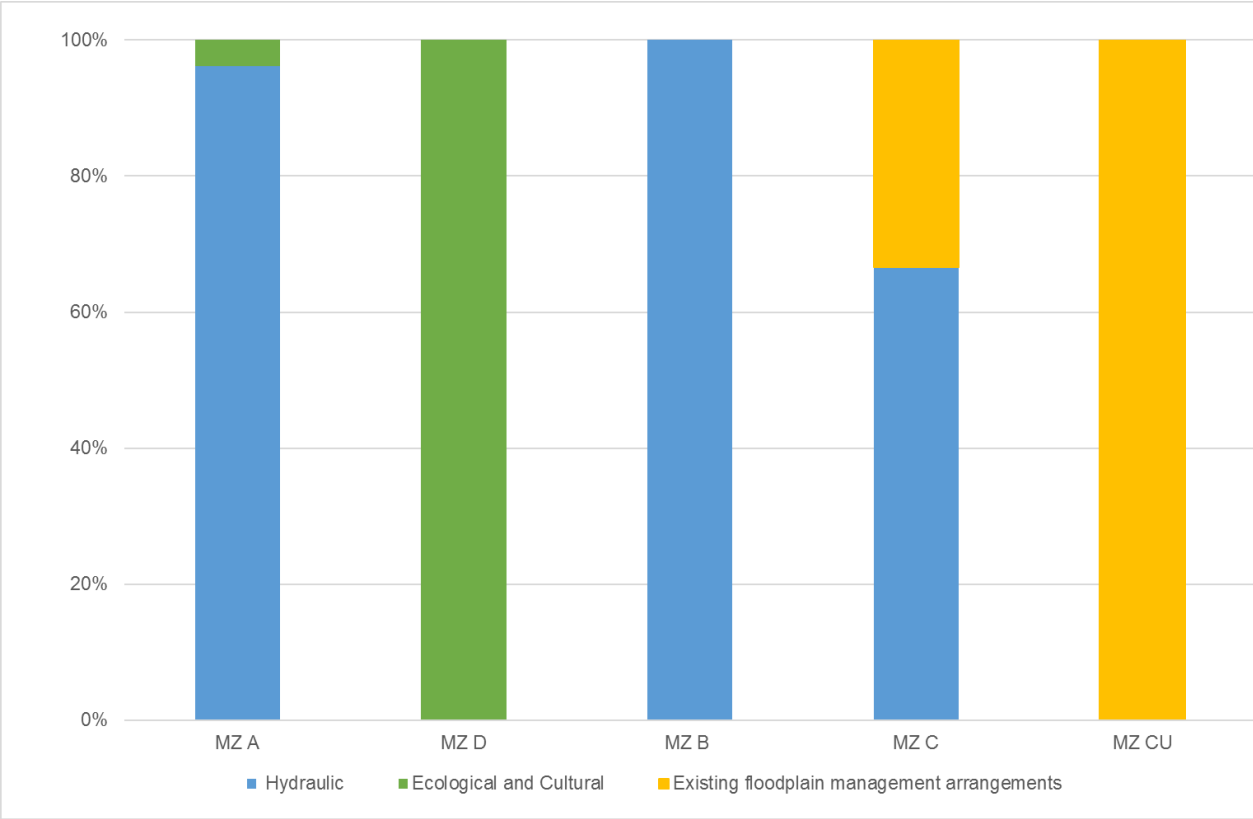


Figure 24: Percentage breakdown of criteria used to delineate each management zone



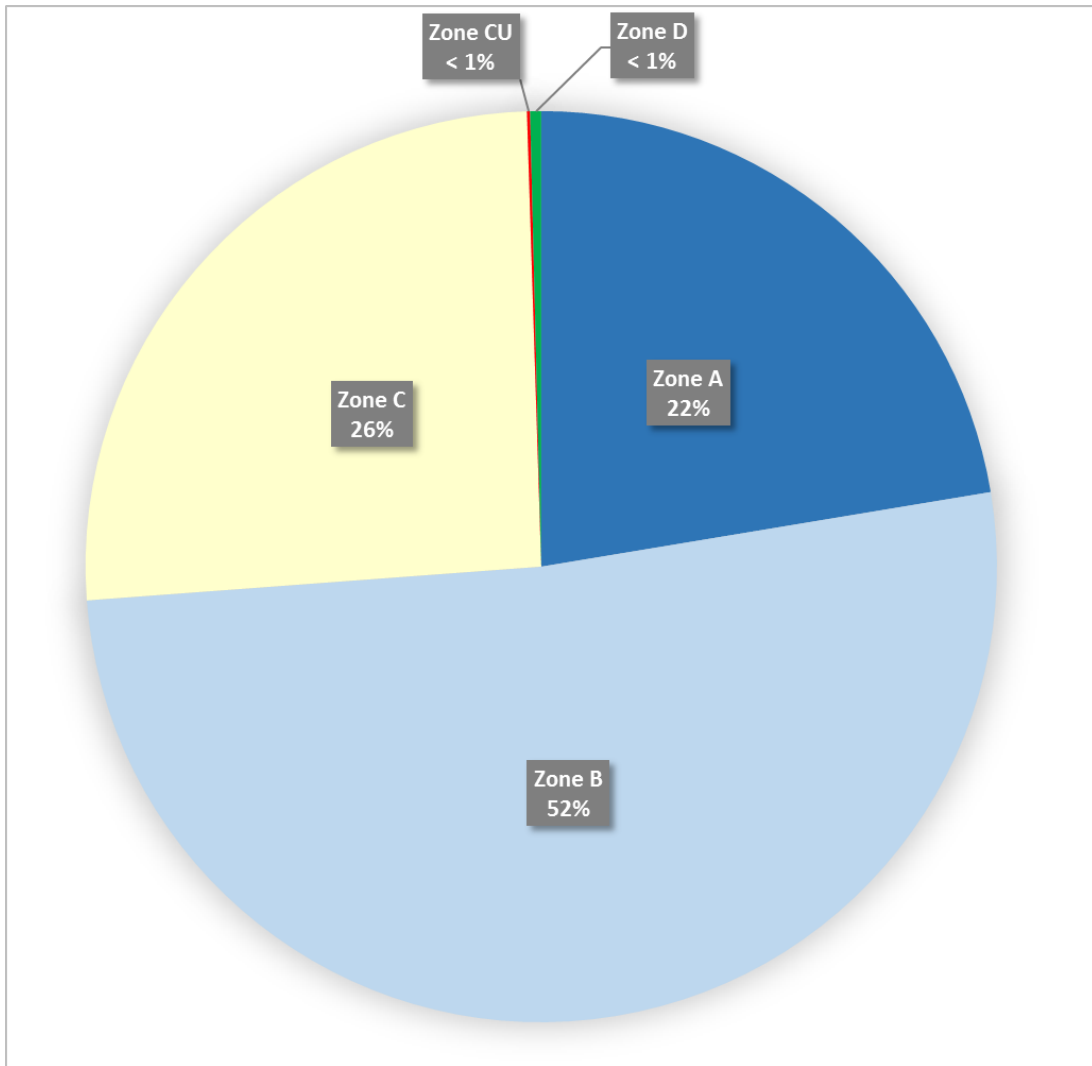


Figure 25: Percentage of each management zone in the Border Rivers Valley Floodplain

Table 9. Criteria for Management Zone A

Criteria	Description
Hydraulic	<p>MZ A includes major discharge areas that have a DVP of greater than or equal to 0.3 m<sup>2</sup>/s for the large design flood (1976).</p> <p>Floodplain connectivity was provided for by incorporating:</p> <ul style="list-style-type: none"> <li>The 13% AEP small design flood extent and/or</li> <li>floodplain areas that have a DVP of greater than or equal to 0.2 m<sup>2</sup>/s for the large design flood (1976).</li> </ul> <p>To ensure that conditions on the ground are adequately represented, the above criteria were road tested against the following additional data:</p> <ul style="list-style-type: none"> <li>flood aerial photography and satellite imagery from design floods</li> <li>spatial watercourse layers, topographical mapping, ADS40 DEM and LiDAR</li> <li>previous floodplain management plans and development guidelines</li> <li>local knowledge obtained from floodplain communities and floodplain/environmental managers.</li> </ul>
Ecological criteria	<p>MZ A includes, where there is hydraulic justification:</p> <ul style="list-style-type: none"> <li>semi-permanent wetland</li> <li>floodplain watercourses including wetland - floodplain swamps - billabongs</li> <li>connections to/through floodplain wetland (flood-dependent shrubland wetlands) and flood-dependent forest/woodland (wetlands)</li> <li>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)</li> </ul>

Criteria	Description
	<ul style="list-style-type: none"> <li>key fish passage areas identified using NSW Fish Community Status and Threatened Fish Species Data - Aquatic Biodiversity Value Mapping Project (NSW DPI 2016)</li> </ul>
Cultural criteria	<p>MZ A includes, where there is hydraulic justification:</p> <ul style="list-style-type: none"> <li>floodplain areas with Aboriginal cultural values that are highly flood-dependent that were identified during direct community consultation with the local Aboriginal community and/or are listed on the: <ul style="list-style-type: none"> <li>Aboriginal Water Initiative System (AWIS) database (now inactive)</li> <li>Aboriginal Heritage Information Management System (AHIMS)</li> </ul> </li> <li>locations for scarred/carved trees that are living flood-dependent vegetation that generally require flooding at least every five years to maintain their ecological character and cultural value</li> <li>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.</li> </ul>
Existing floodplain management arrangements criteria	<p>MZ A was made congruent with the MZ A of the bordering Gwydir Valley FMP 2016 and the Barwon-Darling Valley FMP 2017. MZ A was also reviewed for consistency with existing FMPs and Floodplain Development Guidelines. During the review, MZ A floodways were matched to historical floodways. If the historical floodways were inconsistent with current flood work development, the floodways were designed to match current development conditions. Importantly, MZ A was not made to be more restrictive than the historic floodways.</p>

Table 10. Criteria for Management Zone B

Criteria	Description
Hydraulic criteria	<p>MZ B includes flood storage areas of the floodplain that are</p> <ul style="list-style-type: none"> <li>not already identified as MZ A and</li> <li>included within the extent of the large design flood (1976) or are</li> <li>enclosed by existing Part 8, WA 1912 approved flood works that are designed to be overtopped during moderate to large floods.</li> </ul> <p>To ensure that conditions on the ground are adequately represented, the above criteria were road tested against the following additional data:</p> <ul style="list-style-type: none"> <li>flood aerial photography and satellite imagery from design floods</li> <li>spatial watercourse layers, topographical mapping, ADS40 DEM and LiDAR</li> <li>previous floodplain management plans and development guidelines</li> <li>local knowledge obtained from floodplain communities and floodplain/environmental managers.</li> </ul>
Ecological criteria	<p>MZ B includes, where there is a hydraulic justification, ecological assets identified as high priority flood-dependent woodland that generally tolerate less frequent flooding than those recommended for MZ A to maintain their ecological character.</p>
Cultural criteria	<p>MZ B includes, where there is hydraulic justification, locations for scarred/carved trees that are living and located within flood-dependent woodland.</p>
Existing floodplain management arrangements criteria	<p>MZ B includes areas that were initially mapped as MZ A (based on hydraulic criteria) where the DVP was less than 0.4 m<sup>2</sup>/s for the large design flood. These areas also had to be outside of the original floodway networks described in the floodplain development guidelines. Before being made MZ B, these areas were checked for consistency with current flood work development levels in the floodplain.</p> <p>MZ B may include areas of the floodplain that are enclosed by existing Part 8, WA 1912 approved flood works that are designed to be overtopped during moderate to large floods.</p>

Table 11. Criteria for Management Zone C (189,700 ha)

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

Criteria	Description
	To ensure that conditions on the ground are adequately represented, the above criteria were road tested against the following additional data: <ul style="list-style-type: none"> <li>• flood aerial photography and satellite imagery from design floods</li> <li>• spatial watercourse layers, topographical mapping, ADS40 DEM and LiDAR</li> <li>• previous floodplain management plans and development guidelines</li> <li>• local knowledge obtained from floodplain communities and floodplain/environmental managers.</li> </ul>
Ecological criteria	The basis of Management Zone C was not ecological
Cultural criteria	The basis of Management Zone C was not cultural.
Existing floodplain management arrangements criteria	Management Zone C was reviewed for consistency with existing plans. Management Zone C includes areas of the floodplain that are enclosed by existing Part 8 approved flood works that are not designed to be overtopped during flooding.

**Table 12. Criteria for Management Zone CU**

Criteria	Description
Hydraulic criteria	The basis of Management Zone CU was not hydraulic.
Ecological criteria	The basis of Management Zone CU was not ecological. If any assets fall within Management Zone CU, ecological asset mapping will be provided to the relevant local government authority for consideration in land-use planning and assessment of development applications.
Cultural criteria	The basis of Management Zone CU was not cultural. If any assets fall within Management Zone CU, the relevant local government authority will be notified and provided with relevant contact details.
Existing floodplain management arrangements criteria	Management Zone CU was mapped as floodplain areas that are included within existing urban flood studies, floodplain risk management studies, or floodplain risk management plans or that are protected by flood mitigation works such as town levees.

**Table 13. Criteria for Management Zone D**

Criteria	Description
Hydraulic criteria	The basis for Management Zone 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: <ul style="list-style-type: none"> <li>• a high degree of habitat complexity</li> <li>• a history of supporting a diversity or abundance of waterbird, native fish or frog populations</li> <li>• the functional capacity to act as an aquatic drought refuge</li> <li>• identified as a named feature on Land and Property Information – SIX Maps/Topographic Map, or</li> <li>• recognition in, or protected by a local, state or Commonwealth environmental policy.</li> </ul>
Cultural criteria	MZ D includes areas of the floodplain that are a location or landscape feature that has a high degree of: <ul style="list-style-type: none"> <li>• floodwater dependency such as swamps, marshes, lagoons, billabongs, or rocky bars that are strongly dependent on the passage of floodwater</li> <li>• cultural significance to the Aboriginal community including spiritual, archaeological or resource use-values and are listing on a heritage register or are a place that is recognized for its cultural significance by several senior knowledge holders in the Aboriginal community.</li> </ul>

Criteria	Description
Existing floodplain management arrangements criteria (0 ha)	Management Zone D was reviewed for consistency with existing plans. However, the basis for Management Zone D did not include existing floodplain management planning arrangements.

## 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 flooding behaviour and the floodplain environment. Step 8 was also undertaken to develop rules to license or modify existing licenses for eligible existing flood works in MZ A and MZ D.

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

- specify the physical nature of permissible 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 Border Rivers Valley FMP 2020 is supported by assessment guidelines to assist with assessing flood work applications using the rules.

The rules in Step 8 should be considered in conjunction with the state-wide exemptions as set out in the Water Management (General) Regulation 2018 (see 'Exemptions to flood work approvals' below for further information).

## Permissible flood works

Permissible flood works are works for which an application for an approval will be accepted. Applications for permissible flood works must still go through the assessment process to receive an approval. Applications for non-permissible flood works will not be approved.

The types of flood works that can be applied for in each management zone (permissible 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 permissible flood works and are easy to interpret and do not require technical assessment.

### Types of flood works

The following types of flood works are present in the Border Rivers Valley Floodplain:

- (a) infrastructure protection works—to minimise risk to life and property
- (b) private access roads—to ensure landholders have basic provisions to access property
- (c) supply channels—to ensure supply channels reach water sources so landholders can access water rights
- (d) stock refuges—to account for animal welfare and to minimise a landholder's potential to lose stock to floodwaters
- (e) ecological, Aboriginal cultural value and heritage site enhancement works—to provide a positive outcome for an ecological or cultural asset that is listed in any of the sources identified in the plan
- (f) levees
- (g) storages
- (h) other earthworks and embankments.

### Permissible 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 interagency officers.

The rules specify that the types of permissible flood works in MZ A are:

- access roads
- supply channels
- infrastructure protection works
- stock refuges
- ecological enhancement works
- Aboriginal cultural value enhancement works
- heritage site enhancement works.

The rules specify that Aboriginal cultural value, ecological and heritage-site enhancement works are the only type of permissible flood works in MZ D.

In Management Zone B, Management Zone C and Management Zone CU all types of flood works are permissible.

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

## Specific requirements for permissible flood works

### Access roads

In Management Zone A, the granting or amending of a flood work approval for an access road is only permitted if, in the minister's opinion, all of the following apply:

(a) the height of the access road at any point of the road is no more than:

(i) 15 cm above the natural surface level if it is not a primary access road, or

**Note.** *Natural surface level* is the average undisturbed surface level in the immediate vicinity of a flood work. A *primary access road* is a road providing access from a public road to a permanently occupied fixed dwelling via a direct route.

(ii) 50 cm above the natural surface level if it is a primary access road,

(b) the access road is constructed:

(i) with causeways that:

(A) are no higher than the natural surface level, and

(B) are located at low points of the floodway, and

(C) occur at least once every 200 metres, and

(D) total at least 10% of the total length of the access road that is in the Border Rivers Management Zone A, and

**Note.** This applies to access roads that span a single property or multiple properties.

(ii) with any borrow associated with the construction and maintenance of the access road located on the downstream side of the access road and no deeper than 15 cm below the natural surface level.

## Justification for specifications

Access road rules in MZ A allow for floodplain access with minimal impact on flood behaviour by limiting access road height to 15 centimetres. However, the rules also allow for larger, 50 centimetre primary access roads to improve reliability of road access to a permanently occupied fixed dwelling during small to medium floods. This additional rule acknowledges the demand for the use of primary access roads during times of flood is of higher priority than the demand for the use of general access roads. Fifty centimetres is an appropriate compromise between providing reliable access and providing for the adequate passage of floodwater and local drainage during small to medium floods.

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 the 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 current best practice principles. The positioning of the borrow pit on the downstream side and limiting the depth to 15 centimetres 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.

## Supply channels

In Management Zone A, the granting or amending of a flood work approval for a supply channel is only permitted if, in the minister's opinion, all of the following apply:

- (a) the height of the supply channel is below the natural surface level,
- (b) the supply channel is constructed to ensure:
  - (i) the adequate passage of floodwater and prevention of diversion of floodwater from natural flow paths, and

**Note.** The minister may require that a structure be put in place at a low point of the supply channel to meet the requirements of this subparagraph.

the spoil associated with the construction and maintenance of the supply channel:

- (A) forms a windrow parallel to the direction of flow so that it does not block more than 5% of the width of the Border Rivers Management Zone A, as measured at the location of the supply channel and perpendicular to the flood flow direction, or

**Note.** Width is measured perpendicular to flood flow direction.

- (B) is levelled to a height of 10 cm or less above the natural surface level at any point of the spoil.

**Note.** **Spoil** refers to waste material (such as dirt or soil) that is produced during the construction or modification of a flood work. **Windrow** refers to a row or line of cut vegetation or other material.

## Justification for specifications

Ensuring that supply channels are below the natural ground 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 centimetres 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 Border Rivers Valley Floodplain, only the point of access and not the location of supply channels had to be licensed under Part 2 of the WA 1912. During preparation of the Gwydir Valley FMP 2016, it was proposed to assess below ground supply channels as a flood work because of their potential to impact on flooding behaviour. The regulation of this type of work better ensures flood connectivity during small floods.

## Stock refuges

In Management Zone A, the granting or amending of a flood work approval for a stock refuge is only permitted if, in the minister's opinion, all of the following apply:

- (a) the area of the stock refuge is 10 ha or less and no other stock refuge is in that area,

**Note.** *Stock refuge* refers to a flood work is for the purpose of protecting stock in times of flooding.

- (b) the total area of stock refuges on the landholding on which the stock refuge is located is no more than 5% of the total area of the landholding,
- (c) the stock refuge blocks 5% or less of the width of the Border Rivers Management Zone A, as measured at the location of the stock refuge and perpendicular to the flood flow direction.

**Note.** For example if the Border Rivers Management Zone A is 200 m in width, the stock refuge must not extend more than 10m into the Border Rivers Management Zone A.

## Justification for specifications

Stock refuges are an important consideration for the protection of life and property from the effects of flooding. It is important to have a safe place for stock to take refuge during times of flood. For this reason, there are no height restrictions on stock refuges so that a landholder can ensure stock are not overcome by flood waters. However, to ensure that flooding behaviour is not significantly affected, there are limitations on the size and location of the work.

An individual stock refuge can be no more than 10ha, and the total area of stock refuges can take up no more than 5% of the total area of the landholding. For example, if a landholding is 400 hectares, the applicant is entitled to apply for 20 hectares of stock refuge. In line with the rules, the 20 hectares would have to be divided into at least two parcels each with a maximum of 10 hectares in area. These refuges would also have to be located so as not to take up more than 5% of the width of MZ A. For instance, if a floodway is 200 metres wide, a stock refuge must not extend more than 10 metres into the floodway.

The thresholds are consistent with those used in the Gwydir Valley FMP 2016 (NOW 2014) and the Barwon-Darling Valley FMP 2017 (NSW DPIW 2017).

## Infrastructure protections works

In Management Zone A, the granting or amending of a flood work approval for an infrastructure protection work is only permitted if, in the minister's opinion, the following apply:

- (a) the infrastructure protection work is on a landholding:
  - (i) where 20 ha or less of the landholding is in the Border Rivers Management Zone A and 10% or less of the total area of the landholding is enclosed by the work, or

**Note.** For example, if a landholding is 10ha in area, the infrastructure protection work must enclose no

more than 1ha.

- (ii) where more than 20 ha of the landholding is in the Border Rivers Management Zone A and no more than 2 ha or 1% (whichever is greater) of the total area of the landholding is enclosed by the work,

**Note.** For example, if a property is 25 ha in area, the area enclosed by infrastructure protection works must not exceed 2 ha in area. Alternatively, if a property is 300 ha in area, the area enclosed by infrastructure protection works must not exceed 3 ha in area.

- (b) the infrastructure protection work blocks 5% or less of the width of the Border Rivers Management Zone A, as measured at the location of the infrastructure protection work and perpendicular to the flood flow direction.

### Justification for specifications

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

IPWs can be built to different sizes depending on the total area 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 not larger than 20 hectares, IPWs can cover an area that is up to 10% of the area of the property. For example, if a property is 10 hectares, proposed IPWs can cover an area that is no more than one hectare. This rule is consistent with the Gwydir Valley FMP 2016 and the Upper Namoi Valley FMP 2019.

On properties larger than 20 hectares, IPWs can be whichever is the larger of the following two options either (1) two hectares in size or (2) 1% of the total areas of the property. For example, if a property is 25 hectares the proposed IPW can be no more than two hectares in size. Whereas, if a property is 300 hectares in size, the proposed IPW can be no more than three hectares in size. This rule is consistent with the Gwydir Valley FMP 2016 and the Upper Namoi Valley FMP 2019.

The rule requiring IPWs to not block more than 5% 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 the department 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.

### Ecological enhancement work

In Management Zone A and Management Zone D, the granting or amending of a flood work approval for an ecological enhancement work is only permitted if, in the minister's opinion, the work is for the purpose of providing a positive outcome for a flood-dependent ecological asset or any other ecological asset specified in local, state or Commonwealth environmental plans, policy or legislation, including any of the following:

- (a) *Basin Plan 2012* (Cwlth),
- (b) *Biodiversity Conservation Act 2016*,
- (c) *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth),
- (d) the long-term watering plan for the Namoi water resource plan area under the *Basin Plan 2012* (Cwlth),
- (e) *National Parks and Wildlife Act 1974*,
- (f) *Fisheries Management Act 1994*,

- (g) NSW Wetland Policy 2010,
- (h) Fisheries NSW *Policy and Guidelines for Fish Habitat Conservation and Management* (2013 update),
- (i) any other source that, in the minister's opinion, is relevant.

### **Justification for specifications**

An ecological enhancement work is an important new type of work that is constructed only to benefit flood-dependent ecological assets, or any other ecological asset specified in local, state or Commonwealth environmental plans, policy or legislation.

These types of works are permissible in sensitive Management Zone A and Management Zone D areas as they will provide a positive outcome for the environment. This rule is consistent with the WM Act 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.

### **Aboriginal cultural value enhancement works**

In Management Zone A and Management Zone D, the granting or amending of a flood work approval for an Aboriginal cultural value enhancement work is only permitted if, in the minister's opinion, the work is for the purpose of providing a positive outcome for a flood-dependent Aboriginal cultural value or any other Aboriginal cultural value listed in any of the following:

- (a) Aboriginal Heritage Information Management System,
- (b) Murray–Darling Basin Authority Aboriginal Submissions Database,
- (c) NSW State Heritage Register,
- (d) Commonwealth Heritage List,
- (e) any other source that, in the minister's opinion, is relevant.

### **Justification for specifications**

An Aboriginal cultural value enhancement work is an important new type of work that is constructed only to benefit Aboriginal cultural values that are listed in the Aboriginal Heritage Information Management System (AHIMS), Murray–Darling Basin Authority Aboriginal Submissions Database, NSW State Heritage Register or Commonwealth Heritage Register, or any other source that, in the minister's opinion, is relevant.

These types of works are authorised in Management Zone AD and Management Zone D as they will provide a positive outcome for, locations or landscapes that contain Aboriginal cultural values and cultural areas. This rule is consistent with the objects of the WM Act, 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 often linked with ecological assets this rule is also consistent with the WM Act additional provision 30(c) which allows for an FMP to deal with the restoration or rehabilitation of land, water sources or their dependent ecosystems.

### **Heritage site enhancement works**

In Management Zone A and Management Zone D, the granting or amending of a flood work



approval for a heritage site enhancement work is only permitted if, in the minister's opinion, the work is for the purpose of providing a positive outcome for a heritage site that is a flood-dependent heritage site or any other heritage site that is listed in any of the following:

- (a) Aboriginal Heritage Information Management System,
- (b) Murray–Darling Basin Authority Aboriginal Submissions Database,
- (c) NSW State Heritage Register,
- (d) NSW State Heritage Inventory,
- (e) Historic Heritage Information Management System,
- (f) Commonwealth Heritage List,
- (g) any other source, that in the minister's opinion, is relevant.

### **Justification for specifications**

Heritage site enhancement work is an important new type of work that is constructed only to benefit heritage site assets that are listed in the Aboriginal Heritage Information Management System (AHIMS), Murray–Darling Basin Authority Aboriginal Submissions Database, NSW State Heritage Register, NSW State Heritage Inventory, Historic Heritage Information Management System, Commonwealth Heritage List or any other source, that in the minister's opinion, is relevant.

A heritage site enhancement work enables the protection of Aboriginal or heritage locations in the floodplain that have recognised significance. These types of works are authorised in Management Zone AD and Management Zone D areas as they will provide positive outcomes to heritage sites. This rule is consistent with the objects of the WM Act, 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 WM Act additional provision 30(c) which allows for an FMP to deal with the restoration or rehabilitation of land, water sources or their dependent ecosystems.

### **Undetermined flood work applications in Management Zone A**

A transitional provision has been included in the Border Rivers Valley FMP 2020 that applies to applications for flood work approvals that:

- were lodged prior to 31 December 2019, and
- are for works that are located or proposed to be located in Management Zones A or D (including applications to amend an existing approval), and
- were yet to be assessed and determined at the time of commencement of the FMP.

For these applications, the transitional provision allows for the assessment to be undertaken against the comprehensive and comparatively less restrictive assessment criteria specified for Management Zone B, subject to the application being advertised.

All other applications, including those applications for flood works located or proposed to be located in other management zones or those applications lodged after the 31 December 2019 will be assessed against the relevant rules and assessment criteria in the commenced Border Rivers Valley FMP 2020.

Once all of the outstanding applications have been assessed and determined, the transitional provision will no longer be used.

### **Justification for the transitional provision**

At the time of commencement of the Border Rivers Valley FMP 2020, there were significant delays in the assessment of applications lodged for flood work approvals in the Border Rivers

Valley Floodplain. These delays were a result of a change in focus by WaterNSW during the recent drought to applications for works that relate to critical water needs. The department identified a potential disadvantage faced by some applicants as a result of these delays. Specifically, in areas where the rules have become more restrictive with the commencement of the FMP.

A transitional provision has been included in the Border Rivers Valley FMP 2020 to mitigate any disadvantage applicants may face as a result of significant delays in the assessment of the flood work applications while ensuring that a comprehensive set of assessment criteria is applied to the application. The latter providing for the long-term protection of the floodplain, environmental assets, cultural values and flood flow paths.

Prior to commencement of the FMP, there were significant delays in assessing applications for flood work approvals in the Border Rivers Valley Floodplain. These delays were the result of WaterNSW focusing on applications for works relating to critical water needs during the recent drought.

There was a potential for some applicants to face disadvantage as a result of these delays, specifically in areas where the rules have become more restrictive with the start of the FMP.

This is because the rules and assessment criteria of an FMP in force **when the application is determined** that apply. This is clarified by section 95(3) of the *Water Management Act 2000*, which prevents an approval being granted if it contravenes the provisions in a relevant management plan.

This transitional provision also ensures that a comprehensive set of assessment criteria applies, and applications are advertised. This results in the long-term protection of the floodplain, environmental assets, cultural values and flood flow paths, which contributes to the protection of life and property from the effects of flooding.

## Advertising requirements

The Border Rivers Valley FMP 2020 does not require advertising for works deemed to be minor in nature in most management zones. Advertising requirements were determined by considering the level of impact flood works would likely have on flood behaviour, floodplain connectivity and on neighbouring properties.

For the purposes of clause 26 (1) (c) of the *Water Management (General) Regulation 2018*, an application for a new or amended flood work approval for a flood work in Management Zone B must be advertised if, in the minister's opinion, any of the following applies:

- (a) the flood work is greater than 40 cm above the natural surface level at any location,
- (b) the flood work is a stock refuge:
  - (i) with an area that is greater than 10 ha and no other stock refuge is within that area, and
  - (ii) on a landholding of which the total area of stock refuges is greater than 5% of the total area of the landholding,
- (c) the flood work is an infrastructure protection work with an area that is greater than 1% of the total area of the landholding on which it is located.

## Justification for specifications

Advertising gives interested parties the opportunity to comment on a flood work application and for that comment to be considered during the assessment process.

Flood work applications do not need to be advertised in Management Zone A or Management Zone D (unless specified by the transitional provision). This is because works in these zones are

minor in nature and the cost of advertising is likely to outweigh any potential benefits gained from advertising.

Management Zone B includes areas of flood storage and secondary flood discharge. As all works are authorised works in this zone there is an increased likelihood that some flood works applied for will impact on flood behaviour and floodplain connectivity. Although the suite of assessment criteria in the Border Rivers Valley FMP 2020 mitigates this risk, it was considered prudent to advertise works that may have an increased risk of impacting flood behaviour. As a result, all flood works in Management Zone B must be advertised except for those that are minor in nature. Works that are minor in nature are defined in the rules to include works less than 40 cm in height, stock refuges and infrastructure protection works.

Flood works in Management Zone C do not need to be advertised. This is because in Management Zone C there is a low risk that flood works will impact third parties in the flood fringe and existing developed areas.

Flood works in Management Zone CU will be assessed under the assessment criteria for Management Zone C and do not need to be advertised. The majority of flood works likely to be applied for in Management Zone CU will be exempt from requiring a flood work approval under the WM Act (see 'Exemptions to flood work approvals').

## 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, Aboriginal cultural value, and heritage site 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 to be approved by management zone**

Assessment criteria	Type	MZ A	MZ B	MZ C/CU	MZ D
Ecological and cultural impacts	Flood connectivity to ecological assets (including fish passage)	✓	✓	✓	✓
Ecological and cultural impacts	Flood connectivity to Aboriginal cultural values	✓	✓	✓	✓
Ecological and cultural impacts	Heritage site impacts	✓	✓	✓	✓
Social (drainage) impacts	Drainage impacts	✓	✓	✓	✓
Local hydraulic impacts	Redistribution	N/A	✓ <sup>#</sup>	^	N/A
Local hydraulic impacts	Flood levels	N/A	✓ <sup>#</sup>	^	N/A
Local hydraulic impacts	Velocity	N/A	✓ <sup>#</sup>	^	N/A
Cumulative hydraulic impacts	Redistribution	✓	✓ <sup>#</sup>	^	✓

^ Assessment criteria are discretionary

<sup>#</sup> 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 Border Rivers Valley FMP 2020) 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 Border Rivers Valley FMP 2020. More information on each of the four assessment criteria categories is found below.

## 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.

In all management zones, a flood work must, in the minister's opinion:

- (a) maintain adequate flood connectivity to the following under a range of flood scenarios including, at a minimum, scenarios for the large design flood and small design flood:
  - (i) flood-dependent ecological assets,
  - (ii) facilitation of fish passage, and
- (b) maintain adequate flood connectivity to the following under a range of flood scenarios including, at a minimum, scenarios for the large design flood and small design flood:
  - (i) flood-dependent Aboriginal cultural values,
  - (ii) flood-dependent heritage sites, and

not be constructed or modified if the construction or modification is likely to 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 designated 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 cultural values, and heritage sites. This assessment criteria ensures that flood works will not block any 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 and Harris 2000; Humphries, Serafini and King 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 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 current 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 and the Barwon-Darling Valley FMP 2017.

## 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 will also be checked 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.

There may be instances where the flood work proposal triggers the need for the applicant or the assessing officer to seek advice, permits or to notify external agencies of a flood work application. Referrals will be an integral part of meeting these assessment criteria due to the overlap of the assessment requirements of the WM Act and other legislation relevant to flood work approvals, including the *Environmental Planning and Assessment Act 1979*, the *Fisheries Management Act 1994*, the *National Parks and Wildlife Act 1974* and the *Biodiversity Conservation Act 2016*.

Referrals will improve the assessment of flood work applications against the assessment criteria by strengthening links with other agencies or groups that have a responsibility or function to contribute to the assessment of the impacts under related legislation.

In some cases, additional detailed ecological and cultural assessments may be required to support a flood work application.

If an application is required to be supported by a flood study, there will be specific requirements that the applicant (or consultant on behalf of the applicant) will be required to address to demonstrate that flood connectivity is adequately maintained to flood-dependent ecological and cultural assets.

## Social (drainage) impacts

### Description of the criterion

In all management zones, a flood work must, in the minister's opinion, maintain adequate drainage on landholdings (including adjacent landholdings) that may be affected by the proposed flood work.

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

### 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 previous floodplain management arrangements. There are also equivalent assessment criteria in the Gwydir Valley FMP 2016, the Barwon–Darling Valley FMP 2017 and the Upper Namoi Valley FMP 2019.



## How will the criterion be applied?

The flood work applicant will need to demonstrate that flood water will not remain in the local area for an excessively long time compared to existing floodplain conditions. Consideration will also need to be given to avoiding peak travel time being unduly accelerated to downstream users.

Assessment of this criterion will involve giving key consideration to pondage times, peak travel time downstream and soil types that may influence permeability (that is potential waterlogging of land). A range of spatial datasets will be used to assist with this assessment, including contours, slope, soils information as well as site observation data.

If a flood study is available, information from the study will be used during the assessment. Assessment will also consider additional data such as floodplain asset datasets to ensure that changes to drainage do not have a significant effect on flood connectivity to sensitive wetland areas. 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 landholdings and other landholdings that may be affected by the proposed flood work.

The use of the assessment criteria to assess applications for minor works (that is those that do not require advertising) in Management Zone B is discretionary. The use of the assessment criteria to assess applications for all types of flood works in Management Zones C and CU is also discretionary. For flood work applications that require advertising in Management Zone B, the assessment criteria are mandatory.

In Management Zone B, applications for flood works that require advertising (that is are not minor) must not, in the minister's opinion, be likely to:

- (a) redistribute the peak flood flow by greater than 5% on adjacent landholdings and other landholdings that may be affected by the proposed flood work when compared to the peak flood flow under existing development conditions for a range of flood scenarios including, at a minimum, a scenario for the large design flood, or
- (b) increase flood levels by greater than 20 cm on adjacent landholdings and other landholdings that may be affected by the proposed flood work when compared to flood levels under pre-development and existing development conditions for a range of flood scenarios, including at a minimum, a scenario for the relevant large design flood, or
- (c) increase flow velocity by more than 50% on the landholding, adjacent landholdings and other landholdings that may be affected by the proposed flood work when compared to flow velocity under pre-development and existing development conditions for a range of flood scenarios, including at a minimum, a scenario for the relevant large design flood, unless:
  - (i) increases greater than 50% are in isolated areas on the landholding and the landholder mitigates the impact of the flood wave so that the average impact across the landholding does not exceed 50%, and

- (ii) increases in flow velocity do not exceed 50% at the boundary of the landholding, or
- (d) increase flood levels resulting in impacts on high-value infrastructure when compared to flood levels under pre-development and existing development conditions for a range of flood scenarios, including at a minimum, a scenario for the relevant large design flood, or
- (e) increase flow velocity by an amount that, in the minister's opinion, is likely to have more than a minimal impact on soil erodibility on the landholding, adjacent landholdings and other landholdings that may be affected by the proposed flood work, taking into account the ground cover on those landholdings.

**Note.** *Pre-development conditions* and *existing development conditions* are defined in the plan Dictionary.

In Management Zones C and CU, the minister may require flood work applications to demonstrate that they adhere to the hydraulic assessment criteria described above for Management Zone B. The flood scenarios used to assess these applications 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 flood behaviour, 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 the Macintyre floodplain policy (internal department policy) and the Gwydir Valley FMP 2016 and Barwon-Darling Valley FMP 2017. Criteria were also developed through consideration of the draft Lower Namoi, and Upper Namoi Valley FMPs.

### **How will the criteria be assessed?**

Assessment against the hydraulic local impacts criteria will occur when an application is required to be supported by a flood study. In most cases, a flood study will be required to report on and be supported by hydraulic modelling. A flood study will only be accepted if the assessing officer considers that it meets appropriate reporting requirements, document standards and technical standards for hydraulic modelling. The results of the flood study must clearly demonstrate that the thresholds for the hydraulic local impacts assessment criteria are not exceeded.

Typically, the criteria will be assessed by comparing key modelled hydraulic parameters (flood flow distribution, flood levels and flow velocity) for proposed development conditions against flood study results for pre-development and/or existing development conditions, under relevant flood scenarios (such as the large design flood). Incremental changes brought by the various stages of floodplain development over time (as represented by the various modelled floodplain conditions) will need to be reported in the flood study for subsequent consideration in any final assessment of whether nominated criteria thresholds are exceeded.

For the purposes of assessing a flood work application, the following definitions apply:

- pre-development conditions—refers to natural flooding regimes and is derived from running a model of the floodplain without flood work development on the landholding under application

- existing development conditions—refers to the level of development at the commencement of the plan
- proposed development conditions—derived from running a model with the floodplain, the existing development conditions and the proposed flood work.
- In regard to assessing flow velocity impacts, soil erodibility will be assessed by ensuring that maximum permissible velocities relevant to the Border Rivers Valley Floodplain are not exceeded. This assessment criterion provides flexibility to consider ground cover when assessing the potential impact of a flood work on soil erodibility. It is likely that soil types will be a consideration—for instance, maximum permissible velocities may be relaxed for applicants who can prove that the soil type is not highly erodible.

## 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 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 that may be affected by the flood work and the floodplain environment. No specific thresholds apply. All flood works in MZ AD and MZ D must be assessed against this criterion.

When considering the cumulative impacts of a proposal on the floodplain environment, consideration will be given to those impacts that are likely to combine with each other or with impacts of other activities to produce a beneficial or adverse effect. Impacts should be considered in terms of:

- the relationship of the activity to other proposals or developments in the area
- synergistic effects of individual developments when considered in combination
- any known environmental stresses in the affected area and the likely contribution of the proposed activity to increasing or decreasing those stresses.

In MZ B, MZ C and MZ CU, the intent of the cumulative hydraulic impact assessment criteria is to limit the redistribution of flood flows across the floodplain to acceptable thresholds. Flood flow distributions are quantified at given peak discharge calculation locations (see Appendix 16 or the *Peak Flood Flow Distribution (1976) Map* in the plan).

The use of this assessment criteria to assess applications for minor works (that is those that do not require advertising) in MZ B is discretionary. For flood work applications that require advertising in MZ B, these criteria are mandatory. Flood work applications assessed against these criteria will be done so by comparing to redistribution under existing development conditions to proposed conditions.

The use of these criteria to assess applications for all types of flood works in MZ C and CU is discretionary. If required by the minister, a flood work application in MZ C or CU must also be assessed against this criterion, which will typically be using floods larger than the design flood such as the 1% AEP flood.

Peak flood flow distribution was selected to measure cumulative impacts because distribution of flood waters is an important flood parameter and any significant changes to distribution may signify changes to other flood parameters such as velocity and depth.

### Why are cumulative hydraulic impacts considered?

Current estimates are that the footprint of developed areas (areas protected by flood works) makes up approximately 11% of the Border Rivers 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 Border Rivers Valley Floodplain.

Further redistribution may have consequences from socio-economic, hydraulic, ecological and cultural perspectives. Therefore, the cumulative impact of current and future works must be assessed to ensure that the current 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 current 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 1976 large design flood event.

Some redistribution has likely occurred due to existing flood works, and that 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 a uniform threshold has been set across the entire floodplain.

### **How will the criteria be assessed?**

Typically, assessment against hydraulic cumulative impacts assessment criteria will differ depending on if the application is required to be supported by a flood study or not.

Where a flood study is not required, the applicant must demonstrate that the proposed flood work has considered cumulative impacts of the proposal and other existing works by considering development in the surrounding area. Consideration may need to be given to if existing development is concentrated on one side of the floodplain or if there is any existing blockage to floodways or smaller flow paths important for flood connectivity to flood-dependent assets. It should be noted that the rules for MZ A and MZ D alleviate the potential for cumulative impacts in these zones.

Where a flood study is required, the applicant (or consultant on behalf of the applicant) will be required to report on changes to peak flood flow distribution at specific locations by comparing proposed development conditions against existing development conditions.

## **Existing flood works**

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 Border Rivers Valley FMP 2020 restricts the types of authorised flood works.

The inclusion of these rules allows acceptance of applications for existing works that do not comply with the rules for MZ A and MZ D.

The rules for granting approval to an existing flood work are outlined below and are consistent with the rules in the Gwydir Valley FMP 2016, the Barwon–Darling Valley FMP 2017 and the Upper Namoi Valley FMP 2019

### **Rules for existing unlicensed flood works**

The granting of a flood work approval for a flood work in MZ A or MZ D that was constructed at any time before the commencement of the plan and does not comply with the rules for MZ A or MZ D is only permitted if, in the minister's opinion, all of the following criteria are met:

- (a) the flood work is an access road, a stock refuge, an infrastructure protection work, a supply channel,
- (b) as at the date of application, the flood work is not the subject of a previously refused application, for any of the following:
  - (i) an approval for a controlled work under Part 8 of the *Water Act 1912*, or
  - (ii) a flood work approval under the *Water Management Act 2000*.
- (c) the flood work satisfies the assessment criteria for MZ A and MZ D, including the completion of a cumulative impact assessment of the flood work.

### Amending an existing flood work approval

The amending of a flood work approval for a flood work in MZ A or MZ D that was constructed at any time before the commencement of the plan and does not comply with the rules for the relevant management zone is only permitted if, in the minister's opinion, all of the following criteria are met:

- (a) any proposed modification to the flood work will reduce the impact of the flood work on flow patterns (including distribution of flows, drainage, depth or velocity) in the relevant management zone
- (b) the flood work satisfies the assessment criteria for MZ A and MZ D, including the completion of a cumulative impact assessment of the flood work.

### Exemptions to flood work approvals

An approval is required to construct or use a flood work under section 91D(1) of the WM Act. However, flood works that satisfy the exemption criteria outlined in the Water Management (General) Regulation 2018, do not require an approval. State-wide exemptions are for works or types of works which are considered low risk or are necessary for public safety, or which are more appropriately overseen by another government body such as a local council.

For further information on state-wide exemptions, refer to the Water Management (General) Regulation 2018.



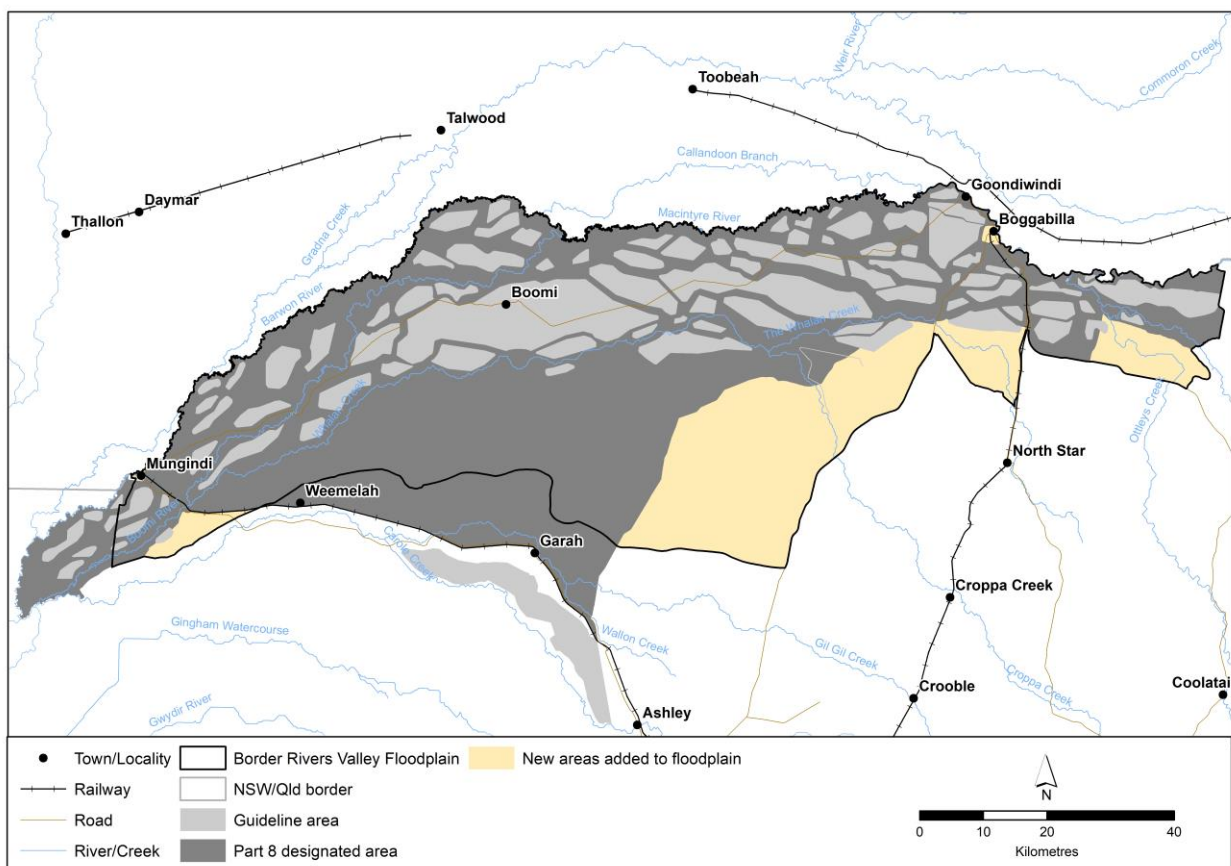
## Step 9: Consider existing floodplain management arrangements

Consideration of existing floodplain management arrangements was integrated throughout the planning process as 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 Border Rivers Valley FMP 2020.

The existing floodplain management arrangements referred to below and in Figure 26, are areas in the Border Rivers Valley Floodplain that are:

- covered by the Guidelines for Macintyre River and Whalan Creek Floodplain Development: Boggabilla to Mungindi (WRC 1981) (hereafter, guideline area)
- part of the existing Lower Macintyre (Yelarbon Crossing to Mungindi) designated floodplain (July 31 1985) which was designated under Section 166 Part 8 of the WA 1912) (hereafter, designated areas)
- new areas added to the proposed floodplain (hereafter, new floodplain areas).

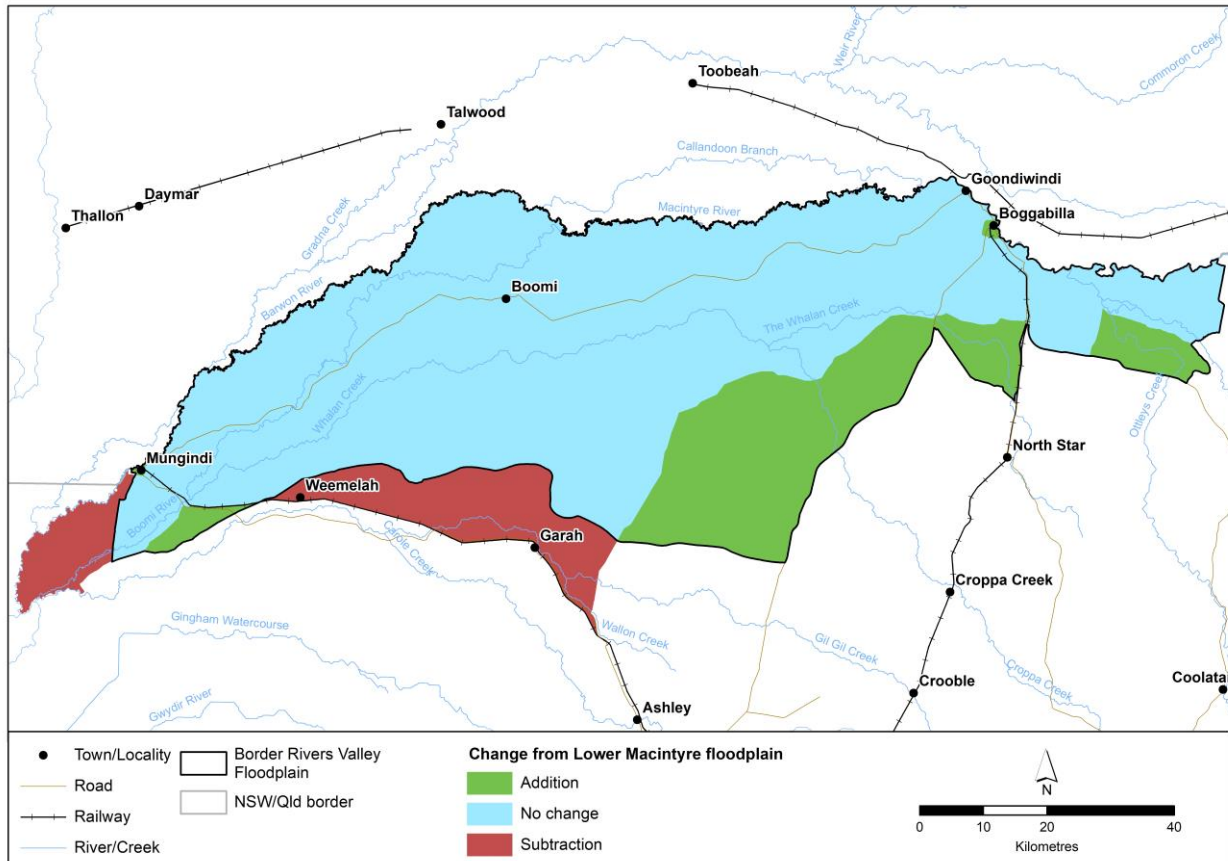
As there were no statutory FMPs in the Border Rivers Valley Floodplain prior to the Border Rivers Valley FMP 2020, the introduction of the floodplain boundary, management zones and rules including assessment criteria, and the improved consideration of ecological and cultural floodplain assets will result 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 Border Rivers Valley FMP 2020 ensures that floodplain management is aligned with the WM Act.



**Figure 26: Existing floodplain management arrangements in the Border Rivers Valley FMP 2020 area**

## Floodplain boundary

The existing Lower Macintyre floodplain (Yelarbon Crossing to Mungindi) designated under section 166 Part 8 of the WA 1912 on July 31 1985 was a primary consideration when delineating the Border Rivers Valley Floodplain boundary. When compared to the existing designated floodplain, the overall extent of boundary change is a net gain of approximately 51,000 hectares (Figure 27). The rationale for the changes are detailed in Step 1.



**Figure 27: Change in the floodplain boundary when comparing the floodplain made under Part 8 of the WA 1912 with the Border Rivers Valley Floodplain to be made under the WM Act**

## Management zones

The Border Rivers Valley FMP 2020 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 in the guidelines 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 management zones to determine the level of change.

As described in Step 7, the Border Rivers Valley Floodplain has five different management zones based on hydraulic, ecological and cultural criteria, and criteria to better reflect existing floodplain management arrangements. The proposed management zones in the Border Rivers 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 WM Act places on protecting the floodplain environment.

The areas outside the floodways 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 Border Rivers Valley FMP 2020.
- 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 hectares, approval under the WM Act is required.

MZ D is a new type of management zone in the Border Rivers Valley Floodplain. It was created to provide additional protection to 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 Border Rivers Valley FMP 2020. These changes are described below.

### Change to authorised flood works

There has been no change in MZ B, MZ C, and MZ CU. Under the guideline area, designated areas, and the Border Rivers Valley FMP 2020, a landholder could apply for any type of flood work to be built in areas that are equivalent to MZ B, MZ C, and MZ CU.

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

### Management zone A

Under current management practices, a landholder can apply for any type of flood work to be built in areas that correspond to proposed MZ A areas. The Border Rivers Valley FMP 2020 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 Border Rivers Valley FMP 2020 would be unlikely to be approved. This is because areas corresponding to MZ A (floodway network areas) needed to satisfy strict assessment criteria before being approved. By limiting applications to certain authorised works in the Border Rivers Valley FMP 2020, landholders save time and money by applying only for those works likely to be approved.

### Management zone D

Under current management practices, a landholder can apply for any type of flood work to be built in areas that correspond to proposed MZ D areas. The Border Rivers Valley FMP 2020 only limits flood work applications in MZ D to Aboriginal value, ecological value and heritage site enhancement works. By limiting applications to certain authorised works in the Border Rivers

Valley FMP 2020, 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 the proposed 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 Border Rivers Valley FMP 2020 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 Border Rivers Valley Floodplain, including designated areas and the Guideline area. This was because there was no sufficient information available to determine the scale of flood behaviour impacts from proposed flood work developments. However, as the Border Rivers Valley FMP 2020 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 Border Rivers Valley FMP 2020 is less restrictive in areas covered by designated areas, the Guideline area and new areas added to the floodplain, where advertising is required.

The following outlines advertising requirements for each management zone in the Border Rivers Valley FMP 2020:

- *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 unlikely to impact flooding patterns.
- *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 (Aboriginal value, ecological 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 included in the Border Rivers Valley FMP 2020 and how they compare to existing floodplain management arrangements is provided in Table 15. The assessment criteria for heritage site impacts is new and will be a major change in all areas of the Border Rivers Valley Floodplain. For all other assessment criteria there are similar provisions in at least one of the existing floodplain management arrangements.

Part 8 of the WA 1912 includes provisions with equivalent principles to the draft assessment criteria for flood connectivity to ecological and cultural assets and to facilitate fish passage. As



such, these criteria represent a minor change for the entire Border Rivers Valley Floodplain (Table 15).

For all local and cumulative hydraulic impact assessment criteria the change is minor within the area of the NSW Macintyre Valley Draft Interim Policy 2004, which only applies to the Lower Macintyre designated floodplain, because the policy includes provisions equivalent to the proposed assessment criteria in the Border Rivers Valley FMP 2020 (Table 15).

Outside of the Lower Macintyre designated floodplain Part 8 of the WA 1912 is the only existing floodplain management arrangement. The change is considered moderate where there is an existing Part 8 provision with equivalent principles or similar intent, but a threshold has been introduced with the Border Rivers Valley FMP 2020 assessment criteria (Table 15). The change is considered major if there is no equivalent provision (Table 15).

**Table 15: Summary of assessment criteria for the Border Rivers Valley FMP 2020 and in existing floodplain management arrangements**

Assessment criteria category	Assessment Criteria	Zone	Similar provisions in Floodplain development guidelines^	Similar provisions in Part 8 of the WA 1912	Similar provisions in NSW Macintyre Draft Interim Policy (2004)	Change
Ecological and cultural impacts	Flood connectivity to ecological assets and to facilitate fish passage	All	✗	✓	✓	Minor
Ecological and cultural impacts	Flood connectivity to cultural assets	All	✗	✓	✓	Minor
Ecological and cultural impacts	Heritage site impacts	All	✗	✗	✗	Major
Social (drainage) impacts	Drainage impacts	All	✓	✓	✓	Minor
Local hydraulic impacts	Redistribution	MZ B, C & CU	✓	✓	✓	Minor in designated floodplain Moderate elsewhere*
Local hydraulic impacts	Flood level increase	MZ B, C & CU	✓	✓	✓	Nil in designated floodplain Moderate elsewhere*
Local hydraulic impacts	Flood level impact on high value infrastructure	MZ B, C & CU	✓	✓	✓	Minor in designated floodplain Moderate elsewhere*
Local hydraulic impacts	Velocity increase	MZ B, C & CU	✓	✓	✓	Minor in designated floodplain Moderate elsewhere*
Local hydraulic impacts	Velocity impact on soil erodibility	MZ B, C & CU	✗	✗	✓	Minor in designated floodplain Major elsewhere



Assessment criteria category	Assessment Criteria	Zone	Similar provisions in Floodplain development guidelines <sup>^</sup>	Similar provisions in Part 8 of the WA 1912	Similar provisions in NSW Macintyre Draft Interim Policy (2004)	Change
Cumulative hydraulic impacts	Redistribution	MZ A & D	✘	✘	✔	Minor in designated floodplain Major elsewhere
Cumulative hydraulic impacts	Redistribution	MZ B, C & CU	✔	✔	✔	Minor in designated floodplain Moderate elsewhere*

<sup>^</sup> Refers to the Floodplain development guidelines for Macintyre River and Whalan Creek floodplains between Boggabilla and Mungindi (WRC 1981)

\* Moderate change where a threshold has been introduced but the assessment criterion is true to the intent of the previous provisions.

## Existing flood works and structures

The Border Rivers Valley FMP includes rules which enable the Minister to accept applications for a limited range of existing unapproved flood works (specifically access roads, infrastructure protection works, stock refuges or supply channels) that do not comply with the rules for Management Zone A or Management Zone D. For an approval to be granted these existing works must satisfy the assessment criteria for the relevant management zone.

For approved flood works that do not comply with the rules of Management Zone A and Management Zone D, the plan allows for the amendment of these works so long as the modification will reduce their impact on flow patterns. Under previous floodplain management arrangements, the modification of such works that would result in an increased impact would unlikely have been approved, so this is not likely to represent any change from the previous 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 Border Rivers Valley FMP 2020 to determine the negative socio-economic impact of the proposed plan. Phase one assessment was undertaken prior to community consultation. Phase two is optional and only triggered if the Phase one assessment identified significant socio-economic impacts and/or socio-economic concerns are 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 has been and is being applied to the development and revision of water sharing plans in NSW.

### Purpose

The objective of this assessment was the enumeration of the negative effects of the implementation of the Border Rivers Valley FMP 2020 quantified in 2011 dollars. Because benefits of the draft 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, reducing erosion and reducing 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 1 assessment

The first phase is the preliminary assessment that was undertaken prior to community consultation. This phase adopted the following sequential analysis:

- document the effect of change between the base case the Border Rivers Valley FMP 2020 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 impacts of the Border Rivers Valley FMP 2020 construct was quantifiable in 2011 dollars,
- prepare a sensitivity analysis of the assessment.

Each stage of the Phase 1 analysis is described in more detail in the following sections.

#### Changes between the base case and the Border Rivers Valley FMP 2020 construct

The base case is the socio-economic condition of the floodplain if the Border Rivers Valley FMP 2020 had not been prepared. The base case is the condition where the following assumptions are made over the next ten years (the period of the Border Rivers Valley FMP 2020):

- flood work approvals will continue under the floodplain management provisions of the WM Act,
- a greater area of floodplain will be covered by new FMPs in due course,
- floodplain guidelines may be revised or upgraded to a FMP as better data and modelling becomes 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 WM Act in the Border Rivers Valley Floodplain.

The impact of the Border Rivers Valley FMP 2020 was assessed for the whole floodplain (558,600 ha). Depending on the location of affected land, there may be areas that are anticipated to be relatively heavily impacted by the proposals.

A summary of the rules under the base case and the Border Rivers Valley FMP 2020 is presented in Table 16.

**Table 16: Summary of rule changes between the Base Case and the Border Rivers Valley FMP 2020**

Base Case	Border Rivers FMP
Flood works across the whole floodplain require application for a WM Act 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 WM Act.
<p><b>Floodway network</b></p> <p>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<sup>1</sup> 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.</p>	<p><b>MZ A</b> provides for flood work approvals by application that is one of the following:</p> <ul style="list-style-type: none"> <li>• an access road up to 15 cm above natural surface level, or</li> <li>• a primary access road up to 50 cm above natural surface level, or</li> <li>• a supply channel below the natural surface level, or</li> <li>• stock refuge, or</li> <li>• an infrastructure protection work, or</li> <li>• ecological, Aboriginal value, and heritage site enhancement works, or</li> <li>• existing works – licensed and unlicensed.</li> </ul> <p>Applications do not require advertising.</p> <p><b>MZ D</b> provides for a prohibition of Flood Work approvals except for:</p> <ul style="list-style-type: none"> <li>• ecological, Aboriginal value, and heritage site enhancement works, or</li> <li>• existing works – licensed and unlicensed</li> </ul>

<sup>1</sup>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 WM Act and are consistent with the rules and assessment criteria in the draft Border Rivers Valley FMP.

Base Case	Border Rivers FMP
<p><b>Non-floodway network area</b></p> <p>As there are no existing FMPs in the Border Rivers Valley Floodplain, the applicant is required to provide a floodplain engineers report identifying that the hydraulic parameters<sup>1</sup> are not exceeded. All applications are deemed to be non-complying and require advertising and objections are to be considered before possible approval.</p>	<p><b>MZ B</b> provides that Flood Work approvals or modifications by application does not require advertising if it is one of the following:</p> <ul style="list-style-type: none"> <li>• no more than 40 cm in height above the natural surface level, or</li> <li>• stock refuge, or</li> <li>• infrastructure protection works.</li> </ul> <p>All other flood works require advertising. The application <b>must not</b> be approved if it exceeds the assessment criteria defined in the Plan. State wide exemptions apply in this zone. See the departmental website for the list of exemptions.</p> <p><b>MZ C</b> 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 zone. See the departmental website for the list of exemptions.</p> <p><b>MZ CU</b> provides for urban area where flood management is provided by local government.</p>

## Impact of rule changes

### Management Zone A

MZ A floodways in the Border Rivers Valley FMP 2020 are initially defined by hydraulic criteria, including the DVP from the flood modelling.

It is expected that flood work approvals in areas defined by hydraulic criteria are not likely to be substantially negatively affected by the Border Rivers Valley FMP 2020.

In addition to the hydraulic floodways, MZ A in the Border Rivers Valley FMP 2020 includes areas that are important for flood connectivity to significant flood-dependent vegetation and flood-dependent cultural assets. These are known as ecological or cultural amendments to MZ A. Land included as ecological or cultural amendments to MZ A will be subject to significant change under the Border Rivers Valley FMP 2020. If the Border Rivers Valley FMP 2020 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 zones, 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 15 centimetres above surface level,
- primary access roads up to 50 centimetres above surface level,
- stock refuge,
- IPWs,
- supply channels below natural surface level,
- ecological, Aboriginal value, and heritage site enhancement works, and
- existing works – licensed and unlicensed (see Table 16 for rule changes).

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 Border Rivers Valley FMP 2020.

## 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. The Border Rivers Valley FMP 2020 has reduced advertising requirements through the specification of minor works in MZ B. Minor works such as limited height works, stock refuge, and IPWs subject to size conditions, can be approved without advertising. This change is expected to provide 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 Border Rivers Valley FMP 2020.

## 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 in the base case across the Border Rivers Valley Floodplain will not require advertising under the Border Rivers Valley FMP 2020.

Flood work approvals in this area may be marginally positively affected by the Border Rivers Valley FMP 2020.

## Management Zone CU

This 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 these areas.

## Management Zone D

MZ D is a special ecological and cultural protection zone. This zone includes ecological or cultural areas that are highly significant. The inclusion of this zone in the Border Rivers Valley FMP 2020 is to ensure that flood connectivity to these assets is maintained and protected. All the assets included in this management zone are associated with water bodies. Ecological, Aboriginal cultural 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 WM Act. 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 zone are not likely to be substantially negatively affected by the Border Rivers Valley FMP 2020.

## Summary of negative impacts

Considering the changes from the base case to the Border Rivers Valley FMP 2020, the negative impacts identified is the lost access by landholders to all but limited applications in the ecological assets connector and cultural significance to MZ A. The details of the impact are presented in Table 17.

### Table 17: Impacts of the Border Rivers Valley FMP 2020



Measure	Outcome
Total area (ha)	3,653
Possible land use	Cropping (Wheat as representative)
Impact	Lost access to complying works other than: Aboriginal value enhancement works, heritage site enhancement works, stock refuge, supply channels and existing works.
Who is impacted	Landholder
Quantifiable (\$)	Yes
Data sources	GIS—area; ABS—Wheat \$ GVAP
Scale : extent and intensity*	<b>Plan:</b> Negative, Low
Scale : extent and intensity*	<b>Regional:</b> Negative, Low
Scale : extent and intensity*	<b>Local:</b> Negative, Low
Scale : extent and intensity*	<b>Owner:</b> Negative, Medium
Likelihood and duration*	<b>Plan:</b> Low, Permanent
Likelihood and duration*	<b>Regional:</b> Low, Permanent
Likelihood and duration*	<b>Local:</b> Low, Permanent
Likelihood and duration*	<b>Owner:</b> Medium, Permanent

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

## Impacted areas

Ecological and cultural amendments are part of MZ A because they are adjacent, in close proximity to, or connect with the hydraulic floodway network and therefore connect ecological and/or cultural assets to flood waters. The total area of land defined as ecological or cultural amendments to MZ A is estimated to be 5,364 hectares (0.96% of the total floodplain area) (Table 18)<sup>1</sup>.

**Table 18: Land capability of areas that are Management Zone A (ecological and cultural)**

Land capability	Area (ha)	Proportion of total area (%)
Nature reserve	6	0.1
Other – unsuitable for agriculture and pastoral production	6	0.1
Suitable for grazing with no cultivation	214	4.0
Suitable for grazing with occasional cultivation	1,485	27.7
Suitable for regular cultivation	3,653	68.1
<b>Total</b>	<b>5,364</b>	<b>100.0</b>

Of the impacted area, land suitable for regular cultivation is more likely to receive applications for flood works due to the value of protecting crops, which cannot be moved. In contrast, land for grazing is not assumed to receive applications for flood works as livestock can be protected by moving them to higher ground. Moving livestock is assumed to be a lower cost alternative to building flood works.

On the land defined as ecological or cultural amendments to MZ A, 3,653 ha (two thirds of the total of 5,364 ha of MZ A) would have been suitable for regular cultivation. This assessment was

<sup>1</sup> The final area of ecological or cultural amendments to MZ A may vary marginally from those used in this report as the zone mapping continues to be refined.

based on Land Capability data<sup>1</sup>. It is acknowledged that, depending on the property size, affected areas may have a large impact on option value for individual landholders.

Regulations for flood work approvals in MZ A apply to the construction of flood works and do not prevent cultivation or grazing on the land<sup>2</sup>. Actual development of these areas may be limited by other legislation including the *Biodiversity Conservation Act 2016*). Notwithstanding the Biodiversity Conservation Act 2016, 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, it was assumed that in the base case, all of the area defined as ecological or cultural amendments to MZ A and with a land capability suitable for regular cultivation would be cropped<sup>3</sup>. This provides an upper estimate of the gross value of production that might be lost (or foregone revenue) with the introduction of the Border Rivers Valley FMP 2020.

## Estimated values of economic impacts

The economic impact of the Border Rivers Valley FMP 2020 on landholders with land zoned as ecological or cultural amendments to MZ A is estimated as lost revenue. The assumptions used in the central scenario are intentionally conservative. While they may not be completely reflective of reality, they remain feasible and serve the purpose of clearly and fairly identifying negative socio-economic impacts.

Areas zoned as ecological or cultural amendments to MZ A are likely to be exposed to frequent flooding due to their proximity to watercourses. As flood works that protect crops cannot be constructed in MZ A, it is assumed that the outcome of these events is detrimental to crop production and has a one in four chance of causing total crop failure in any year<sup>4</sup>. To place this assumption into context, the 13% AEP small design flood, which would not inundate the entire affected area, has approximately a one in eight chance of occurring in any year.

This is a conservative assumption of the impact of flooding. This is because it assumes flooding occurs more often than the small design flood, it inundates an area larger than the small design flood, and because it does not consider the positive impacts of flooding. For landholders, flooding can potentially improve soil fertility, improve sub-soil moisture and improve water storage levels.

To simplify the analysis and because it is unrelated to the change in management practices, it is assumed that other risks to crop production do not exist. In reality, crop yields and outputs are sensitive to a host of other risks such as pests and disease, extreme rainfall and temperature, as well as changes in inputs.

The analysis also assumes that the loss is total annual gross value of production. In reality, production costs are saved if the crop does not reach maturity. At the very least, production costs saved is the cost of crop harvest but may also include fertilised and chemical applications.

Cropping in the Border Rivers includes a variety of crop types and rotation sequences. The largest area of crop growth is wheat (89,419 ha compared to 51,699 ha of other cereals and 35,596 ha of cotton – Macintyre Agriculture ABS 2011) and as a consequence, the potential use of the area suitable for regular cultivation is assumed to be wheat. Since 2011, the crop mix may have changed. The sensitivity of the analysis to crop and other changes is tested in the sensitivity analysis.

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<sup>1</sup> Land capability mapping was developed for broad scale application and may not be applicable to small scale portions of the landscape. Land capability classification was developed by the Soil Conservation Service that identifies the suitability of land for cultivation or cropping.

<sup>2</sup> The development of these areas for cultivation may otherwise be limited by other legislation including the Biodiversity Conservation Act 2016 and Controlled Activities under the Water Management Act 2000. Notwithstanding the Biodiversity Conservation Act 2016, it is expected that it would not be practical for a large proportion of this land to be developed for reliable cultivation.

<sup>3</sup> In the absence of information on the proportion of the area that could practically be developed for reliable cultivation.

<sup>4</sup> Some of these flood events are beneficial to the crop or pasture and some are detrimental, depending on the timing (relative to crop and pasture growth cycle), depth, duration and speed of the floodwater.

The potential revenue of land affected by the FMP with complete flood protection in the Border Rivers is \$2.25 million per year (3,653 ha of land multiplied by the gross value of wheat per hectare (\$616))<sup>1</sup>. Without flood protection works, this land is estimated to produce \$2.09 million per year (if one in four crops were lost, production would be equivalent to 75% of total potential revenue (\$2.25 million)). This implies a potential cost of approximately \$563,000 per year on average in foregone revenue of \$154 per hectare (\$563,000 divided by 3,653 ha). This equates to 0.24% of the total value of agricultural revenue in the Border Rivers Valley FMP 2020 area (GVAP of \$233.7 million). While small in aggregate, the localised impact of the changes could be felt more intensely by individual landholders.

### Sensitivity analysis

The analysis is sensitive to the assumed frequency of crop failure, the cropping area within the areas of flood-dependent vegetation and cultural significance to MZ A, the assumed crop mix, and the impact on individual property owners. The sensitivity analysis was undertaken by varying one of the assumptions in the central scenario.

The loss due to the inability to construct flood works to protect crops from flooding is estimated to result from flood-related crop failure one in every four years. If the rate of crop failure due to flooding was to increase to one crop failure every two years, the estimated impact would rise to \$1.13 million or 0.48% of the Border Rivers Valley FMP 2020 GVAP. Conversely, if the rate of additional crop failure due to flooding was to decrease to one crop failure in eight years, the estimated impact would be reduced to \$0.28 million or 0.12% of the Border Rivers Valley FMP 2020 GVAP.

The impact of the Border Rivers FMP will also depend on what the affected land could have been used for. Much of the area earlier assumed 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 crops other than wheat are planted, the impact of the Border Rivers FMP would also change. Assuming a crop mix that is representative of the average crop mix across the Border Rivers Valley Floodplain, the impact would rise to \$3.6 million or 1.5% of the Border Rivers FMP GVAP. This mix contains 20% wheat, 12% other cereals, 8% cotton, 10% legumes, and 2% oilseed (Table 19).

**Table 19: Land Use in the draft Border Rivers FMP**

Broadacre crop	Share of land use in the Border Rivers Valley FMP 2020 (%)
Wheat	20.4
Other cereals	11.8
Cotton	8.1
Legumes	9.5
Oilseeds	1.8

Source: ABS Census (2011)

The increase in estimated costs in dollar terms is due to the higher price of crops such as cotton compared to wheat; however, farmers are likely to choose which crop to plant not solely based on potential revenue. Instead, the decision of what to plant likely reflects broader consideration of the suitability of their land, the available alternatives (including livestock production) and a consideration of profits (which includes associated costs).

<sup>1</sup> The gross value of 'wheat for grain' produced in the Border Rivers FMP area was \$616 ha. This estimate was prepared using 2011 ABS census data – total GVAP of \$55.1 million divided by 89,419 ha of production.

Changes in a cropping mix are likely to occur across the whole floodplain and not just in MZ A ecological and cultural amendments. This is because farmers respond to the same price signals from year to year. As a result, any change in crop mix is unlikely to significantly affect the size of the impact from the Border Rivers Valley FMP 2020 as it will be captured both in a change in crop mix to the impact area (the numerator) and a change in crop mix to the entire Border Rivers Valley Floodplain (the denominator).

If climate change forecasts are considered and there is a 5-10% increase in annual mean precipitation in the Border Rivers Valley Floodplain<sup>1</sup> and this additional rainfall results in a corresponding increase in wheat yield, then the estimated impact of the draft Border River Valley FMP would increase to \$0.75 million or 0.32% of the Border Rivers Valley FMP 2020 GVAP.

Many landholders will not be impacted by the Border Rivers Valley FMP 2020. 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 ecological or cultural amendments to MZ A would probably have discounted land value due to a higher likelihood of being flooded.

## Summary

Considering the changes from the Base Case to the proposed Border Rivers FMP, the following key negative impacts were identified:

- lost opportunities to get approval in the area of ecological asset connector and cultural significance in Zone A for works other than limited infrastructure protection works, access roads and below ground supply channels,

The negative impact of the Border Rivers FMP is estimated to be a small reduction of 0.29% of the total GVAP for the Border Rivers floodplain area and therefore no further investigation is currently proposed.

Community consultation of the Border Rivers Valley FMP 2020 occurred as part of targeted consultation and for public exhibition. Any potential socio-economic impacts and/or options identified by the community were included in the socio-economic impact analysis where appropriate.

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.

## Phase 2: detailed analysis

The methodology used in this analysis requires that a detailed analysis (Phase 2) be conducted, if the preliminary analysis in Phase 1 indicates that there would be significant socio-economic impact as a result of the proposed FMP. Considering that the estimated impact of the proposed Border Rivers FMP rules (estimated to be a reduction of 0.24% of the total GVAP for the Border Rivers floodplain area) is of low significance for the regional economy, no further investigation is currently proposed. In addition, there was no other major issue raised during the public exhibition period that warrants further detailed assessment.

## Role of socio-economics in plan development

This impact assessment concludes that there is a limited negative socio-economic impact from the Border Rivers Valley FMP 2020 and therefore no further investigation was undertaken.

Socio-economic advice has influenced the development of the Border Rivers Valley FMP 2020 management zones, rules, and assessment criteria. Key consideration was given to achieve a

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<sup>1</sup> OEH estimate of the change in annual mean precipitation 1990 – 2009 to 2020 - 2039

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 (step 3)
- ensuring socio-economic impacts were included in the criteria for reasonable consistency with previous floodplain management arrangements (step 9)
- incorporating, wherever possible, areas with approved existing flood work development into MZ C (step 4 and 7)
- 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 (step 8)
- the requirement to advertise proposed flood works provides local landholders with an opportunity to comment on any impact that a proposed flood work could have in causing or exacerbate 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 (step 8).



## Consultation and review of the plan

The department's Water Group was responsible for the review and consultation process throughout the development of the Border Rivers Valley FMP 2020. The Environment, Energy and Science Group contributed technical expertise and local experience to the review and consultation process. All stakeholders and interested parties had an opportunity to review and provide comment on the Border Rivers Valley FMP 2020 at key stages throughout the development of the FMP.

### 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 Border Rivers Valley FMP 2020, and collection, review, and incorporation of feedback from formal submissions to finalise the FMP for ministerial approval and commencement.
- **post-public exhibition consultation:** targeted consultation to collect feedback from affected landholders in response to updates to the management zones following public exhibition and incorporation of feedback to finalise the FMP for ministerial approval and commencement.

Consultation with Aboriginal stakeholders was undertaken using the approach outlined in Appendix 17 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 2011b).

### 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 the department's Water Group, the department's Environment, Energy and Science group, NSW Department of Primary Industries (agriculture and fisheries interests) and Local Land Services.

The TAG was engaged throughout the FMP development process through a combination of email correspondence and face-to-face meetings. The TAG officially met four times from February 2013 to August 2014 to identify and establish:

- the floodplain boundary
- draft management zones and rules
- cultural and ecological assessments 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 Border Rivers Valley FMP 2020.

### **Aboriginal Technical Working Group (ATWG)**

The ATWG was created as a consultative group to advise the development of FMPs on:

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

The ATWG was comprised of state and regional cultural heritage experts. Workshops were held with the ATWG to:

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

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

### **Aboriginal community**

The local Aboriginal communities were engaged by a departmental Aboriginal Natural Resources Officer through informal meetings. The aim of these informal discussions 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 these activities, the department's Environment, Energy and Science group collected spatial information on cultural assets that are dependent on flooding. These were later analysed as part of Step 5 to be factored into the management construct. These cultural assets were discussed with the Aboriginal community during targeted consultation to obtain further feedback.

### **Targeted consultation**

Targeted consultation was an opportunity to 'road test' the Border Rivers Valley FMP 2020 boundary, management zones, and rules. Targeted consultation was undertaken with stakeholders at Goondiwindi and Mungindi in September 2016.

The objectives of targeted consultation were to:

- provide background to key stakeholders as to why and how the FMPs are being developed, what management zones and rules are proposed in the Border Rivers Valley FMP 2020, and how stakeholders could provide feedback, and
- 'road test' the Border Rivers Valley FMP 2020 boundary, management zones, and rules.

Targeted consultation involved the following key stakeholder groups and individuals within the Border Rivers 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, 62% related specifically to the Border Rivers Valley FMP 2020 boundary, management zones, rules, and assessment criteria.

No changes were made to the boundary, management zones, rules, or assessment criteria as a result of feedback received from targeted consultation.

## Public exhibition

The Border Rivers Valley FMP 2020 was on public exhibition from 15 December 2017 to 9 March 2018. Over this period, 12 stakeholder events were held, with 55 participants, and 15 submissions were received, from which 65 items of inquiry were collated.

The objectives of this consultation were to provide background information to stakeholders on:

- why the FMP is being developed
- how the FMP has been developed to date
- what rules and assessment criteria are proposed in the various areas
- how to make a formal submission.

The public exhibition of the plan was advertised in the *North West Magazine*, *Goondiwindi Argus* and the *Moree Champion* during the week commencing Monday 2 October 2017, and on the NSW Government HaveYourSay website. The department posted 480 letters to flood work approval holders, landholders who submitted floodplain harvesting registrations of interest (ROIs) and landholders whose properties intersected MZ A and MZ D of the Draft Border Rivers Valley FMP 2020, notifying them of the exhibition period.

Display packages containing information about the draft plan were available for inspection throughout the exhibition period from locations in Goondiwindi, Boomi, Mungindi and Boggabilla.

The department hosted information appointments and briefing sessions for stakeholders at Goondiwindi (4 events), Boomi (2 events), Mungindi (3 events), Boggabilla and Inverell during the exhibition period to view the draft management zones at individual property scale at locations within the Border Rivers Valley FMP 2020 area.

A suite of products was developed to support stakeholders in understanding the Draft Border Rivers Valley FMP 2020, and this information was available to stakeholders in hard copy from each display location (4), by post or email upon request, and for download from the department's website (Table 20).

**Table 20. Upper Namoi Valley FMP: public exhibition display products**

Document name	Description
Report cards for each management zone of the Draft Border Rivers Valley FMP 2020	A summary of the draft rules and key factors developed for each management zone of the Draft Border Rivers Valley FMP 2020
Map of the Draft Border Rivers Valley FMP 2020	A colour map illustrating the floodplain boundary and management zones contained within the Draft Border Rivers Valley FMP 2020
Draft rural floodplain management plans: technical manual	A general description of the method employed for development of floodplain management plans across rural New South Wales

Document name	Description
Rural floodplain management plans: Background document to the Draft Floodplain Management Plan for the order Rivers Valley Floodplain 2017	A description of how the method presented in the technical manual has been applied across the Draft Border Rivers Valley Floodplain and should be read in conjunction with the technical manual
Draft Floodplain Management Plan for the Border Rivers Valley Floodplain 2017	The legal document that includes all of the rules and requirements in a statutory format
Floodplain management under the <i>Water Management Act 2000</i> : A guide to the changes	A guide to the transition of floodplain management planning from the <i>Water Act 1912</i> to the <i>Water Management Act 2000</i> in NSW
An overview of floodplain management plans under the <i>Water Management Act 2000</i>	A general, plain English explanation of the key provisions of floodplain management plans. The overview is a summary that should be read in conjunction with the Draft Border Rivers Valley FMP 2020
Submission form for public exhibition	A template that stakeholders can use to provide comments on the Draft Border Rivers Valley FMP 2020 during public exhibition

Submissions were accepted in writing, electronically and by post.

In addition to the targeted consultation and public exhibition processes, the preparation of the Border Rivers Valley FMP 2020 was supported by the implementation of two additional consultation processes:

- ground-truthing (field validation)
- post-public exhibition consultation.

The purpose of the ground-truthing process, including one property visit with a landholder during public exhibition, was to gain a practical understanding of flood behaviour on the ground.

On 12 April 2019, the department wrote to 158 landholders whose properties were affected by the proposed property-scale changes and sought their feedback.

The department has written to all stakeholders who provided a submission to public exhibition (15) and also those who responded to post-public exhibition consultation (28), describing the updates that have been made to the plan in response to the feedback received and providing a copy of the final draft of the management zones map for information.

## Review

### Interagency Regional Panel

The Interagency Regional Panel (IRP) was established to review the boundary, management zones and rules contained in the Border Rivers Valley FMP 2020. The IRP consisted of one representative each from the following groups within the Department of Planning Industry and Environment:

- the Energy, Environment and Science Group to cover environmental interests
- the Water Group to cover water management interests
- the Department of Primary Industries to cover agriculture and fisheries interests.

Representatives from Local Land Services, Water NSW, the Natural Resources Access Regulator and the department's 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 achieve the objectives of the WM Act
- provide information and analysis
- bring a balanced approach to the development of the FMP: economic, social, environmental and cultural considerations.

The IRP provides whole-of-government oversight and review of the development of the Border Rivers Valley FMP 2020 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 Border Rivers Valley FMP 2020 in June 2016 and supported its release for targeted consultation.

### **Prior to public exhibition**

The IRP reviewed the Draft Border Rivers Valley FMP 2020 and feedback from targeted consultation in July 2017.

The IRP supported the decision to make no changes to the boundary, management zones, rules, and assessment criteria as a result of feedback received from targeted consultation.

The IRP also provided key considerations for the implementation of the Border Rivers Valley FMP 2020. 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 reconvened after public exhibition to:

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

A total of 15 submissions were received in response to the public exhibition of the Draft Border Rivers Valley FMP 2020. From the 15 submissions received, 61 items of inquiry (IOI) were identified and collated.

The feedback received during public exhibition was considered by the IRP prior to finalising the FMP. Changes supported by the IRP are reflected in the finalised products in this report and the Border Rivers Valley FMP 2020 plan order.

On 27 March 2019, the IRP approved changes to the rules and numerous property-scale changes to the management zones for the Draft Border Rivers Valley FMP 2020 in response to the review processes for feedback received to public exhibition.

On 25 June 2019, the IRP reviewed the feedback received to post-public exhibition consultation and approved changes to the plan in response to the feedback received to post-public exhibition consultation.



On 22 May 2020, the IRP approved the inclusion of a transitional provision for dealing with outstanding flood work applications for flood works that are located or proposed to be located in Management Zones AD, AID and D, that were lodged with WaterNSW prior to 31 December 2019.

## Plan finalisation and commencement

After endorsement by the IRP in June 2019, the Border Rivers Valley FMP 2020 was submitted to the Minister for Water, Property and Housing for in-principle approval and then to the Minister for the Environment to seek concurrence. The Border Rivers Valley FMP was then returned to the Minister for Water, Property and Housing for final approval. The Border Rivers Valley FMP commenced on 11 September 2020. Copies of the FMP can be obtained from the NSW Legislation website.

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## Glossary

**Aboriginal cultural 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) (now inactive), Murray Darling Basin Authority Aboriginal Submissions Database, NSW State Heritage Register or Commonwealth Heritage Register.

**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. For example, if a peak flood discharge of 500 ML/d has an AEP of 5%, it means there is a 5% chance (that is a one-in-20 chance) of a 500 ML/d or larger events occurring 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 (for example, 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 for the improvement, conservation and protection of ecological assets and is not for an agricultural purpose.

**ecological values (aka ecological surrogates)** are surrogates for biodiversity that are used to prioritise the ecological assets and included fauna 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.

**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-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 connectivity** refers to the unimpeded passage of floodwater through the floodplain, and is important for in-stream aquatic processes and biota and the conservation of natural riverine systems.

**flood flow direction** means the direction in which a flood flows for the relevant area as depicted on the Peak Flood Flow Distribution (1976) Map.

**Flood Risk Management Plan** 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** provides preferred options relating to flood risk and provides the information necessary for adequate forward planning of flood prone land.

**flood work** 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 Border Rivers Valley FMP 2020.

**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),
- (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 sites** are cultural heritage objects and places as listed on Commonwealth, state and local government heritage registers.

**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) (now inactive), Murray Darling Basin Authority Aboriginal Submissions Database, NSW State Heritage Register, NSW State Heritage Inventory, Historic Heritage Information Management Systems or Commonwealth Heritage Register.

**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.

**MIKE** is a suite of water modelling software developed by DHI Group. Further information about the software packages used to develop the hydraulic models for the Border Rivers Valley Floodplain is available in Appendix 6.

**natural surface level** is the average undisturbed surface level in the immediate vicinity.

**peak discharge calculation location** is a section of the floodplain where flow is calculated for the purpose of assessing the change in flow behaviour due to proposed flood works.

**permissible flood work** is a type of flood work that can be applied for in a particular management zone. Applications for permissible flood works are still required to go through assessment in order to receive an approval.

**pre-development conditions** refers to natural flooding regimes.

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

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

**spoil** refers to waste material (such as dirt or soil) that is produced during the construction or modification of a flood work.

**SPOT** is a commercial high-resolution optical imaging Earth observation satellite system operating from space.

**stock refuge** refers to a flood work that is for the purpose of protecting stock in times of flooding.

**wetland** refers to areas of land that are wet by surface water or groundwater, or both, for long enough periods that the plants and animals in them have adapted to, and depend on, moist conditions for at least part of their lifecycle. They include areas that are inundated cyclically, intermittently or permanently with fresh, brackish or saline water, which is generally still or slow moving except in distributary channels. Examples of wetlands include lakes, lagoons, rivers, floodplains, swamps, billabongs and marshes.

**windrow** refers to a row or line of material.