Gwydir Wetlands
Adaptive Environmental Management Plan

Synthesis of information projects and actions
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Synthesis of information projects and actions
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Summary

The extensive Gwydir Wetlands lie on the lower Gwydir River in north-western NSW. Just east of Moree, the Gwydir floodplain begins to broaden, forming an inland delta so wide it merges with the floodplains of the Barwon/Macintyre valley to the north and the Namoi valley to the south. As the river branches repeatedly and channels decrease in capacity, floodwaters from the upper catchment spill frequently onto the floodplain, creating a patchwork of flood-dependent wetlands. These provide habitat for waterbirds, fishes, frogs, reptiles and invertebrates.

The whole of the lower Gwydir floodplain is a wetland ecosystem, but at its heart is the complex of semi-permanent wetlands known as the Gingham and Lower Gwydir (Big Leather) watercourses. These wetlands are renowned for the huge flocks of waterbirds that congregate to breed when large floods flow down the river. The surrounding floodplain wetlands and woodlands, including the Mallowa Creek wetlands, are important feeding grounds for breeding waterbirds. Myall woodlands and woodland birds are also important elements of the floodplain ecology.

The Gamilaroi people were the first owners of the lands of the lower Gwydir valley. They retain strong cultural and spiritual ties to the Gwydir Wetlands despite being physically displaced by non-Aboriginal settlement and the policies of past colonial and state governments. Both archaeological evidence and oral histories provide information about Aboriginal occupation and use of the wetlands up to recent times.

The patterns of water flows that once sustained the wetlands have been profoundly altered since settlement by non-indigenous Australians. Even before the advent of large-scale river regulation, land holders changed the river to suit their needs by cutting or enlarging channels to re-direct flows. Extensive catchment clearing around the turn of the twentieth century created conditions that led to the formation of the Gwydir Raft, a mass of timber and sediment that clogs about 15 kilometres of the channel of the lower Gwydir River west of Moree.

The Raft effectively dams the river, creating the Gwydir Pool and redirecting flows towards the Gingham Watercourse. Construction of a weir and regulator at Tyreel has allowed some measure of control over the direction of flows, ensuring that the Lower Gwydir (Big Leather) Watercourse receives water for stock and domestic use, and environmental flows.

The completion of Copeton Dam in the 1970s – and the weirs and regulators subsequently constructed to control releases from the dam – has substantially affected the seasonality and distribution of river flows. Whereas previously water mainly flowed straight down the Gwydir River into the wetlands, much of the flow is now diverted into the Mehri River and Carole Creek systems to supply irrigators. Flows in these systems reach the Barwon River much more frequently than before river regulation, when most high flows and floods were dissipated in the Gingham and Big Leather watercourses.

Most of the floodplain is privately owned and used for agriculture. There have been dramatic changes in the last few decades as land holders have adapted to changing economic forces. While sheep and cattle grazing were once the dominant land uses, the major changes in water distribution and flooding from the late 1970s encouraged both the rapid development of irrigated agriculture and a switch from grazing of native pastures to improved pasture and dryland cropping. These changes have greatly reduced the former extent of wetland vegetation and floodplain woodlands.
Invasive exotic plants have also had a major impact on the wetlands. Water hyacinth, an aquatic weed, is firmly established in Gingham Watercourse. Control programs have aimed to limit the weed’s impact in the wetlands and prevent it from escaping downstream into the Barwon–Darling system. The initial outbreak of water hyacinth in the 1970s was regarded as so serious that measures were taken to drain the wetlands to kill the plants. While this approach reduced the extent of the infestation, it has had long-term consequences for the functioning of the wetlands.

Lippia is adapted to more terrestrial conditions on the floodplain but is quite tolerant of flooding. Current water and grazing regimes have allowed it to spread and displace native groundcover species, particularly water couch. Lippia is already widespread in the Murray–Darling Basin and remains difficult to control despite intensive research into eradication methods.

The Gwydir Wetlands Adaptive Environmental Management Plan (AEMP):

- describes the ecological assets and values of the Gwydir Wetlands and the values that the wetlands hold for Aboriginal people
- describes the ways in which the wetlands have changed since settlement by non-indigenous Australians
- provides maps and data showing changes in land use and vegetation cover from 1996–2008
- summarises what is currently known about the water needs of wetland plant communities and waterbirds
- explains how much water is held for environmental purposes and who controls it
- considers how much of the wetlands can be adequately watered under several scenarios of water availability
- explains ways in which management decisions will be made and the actions needed to restore and maintain critical ecological functions and habitats in the wetlands.

Water is the key to restoring the resilience of the wetlands. Ongoing development of river flow and flood models and decision support software will assist in maximising the benefits from the use of environmental water in the Gwydir Wetlands.
### Acronyms and abbreviations

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<th>Acronym</th>
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<tr>
<td>AEMP</td>
<td>adaptive environmental management plan</td>
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<tr>
<td>ARI</td>
<td>average recurrence interval</td>
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<td>AWD</td>
<td>available water determination</td>
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<td>BRG CMA</td>
<td>Border Rivers–Gwydir Catchment Management Authority</td>
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<td>CAMBA</td>
<td>China–Australia Migratory Bird Agreement</td>
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<td>CAP</td>
<td>catchment action plan</td>
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<td>CEWH</td>
<td>Commonwealth Environmental Water Holder</td>
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<td>CMA</td>
<td>catchment management authority</td>
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<td>CRC</td>
<td>cooperative research centre</td>
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<td>Department of Aboriginal Affairs</td>
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<td>DECCW</td>
<td>Department of Environment, Climate Change and Water</td>
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<td>DSEWPC</td>
<td>Department of Sustainability, Environment, Water, Population and Communities (formerly the Department of Environment, Water, Heritage and the Arts)</td>
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<td>Department of Infrastructure, Planning and Natural Resources</td>
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<td>ECA</td>
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<td>Environmental Contingency Allowance Operations and Advisory Committee</td>
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<td>EEC</td>
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<td>EPBC Act</td>
<td><em>Environment Protection and Biodiversity Conservation Act 1999</em> (Commonwealth)</td>
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<td>FM Act</td>
<td><em>Fisheries Management Act 1994</em></td>
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<td>Gwydir WSP</td>
<td><em>Water Sharing Plan for the Gwydir Regulated River Water Source</em></td>
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<td>I&amp;I NSW</td>
<td>Industry &amp; Investment NSW (formerly Department of Primary Industries)</td>
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<td>IMEF</td>
<td>Integrated Monitoring of Environmental Flows program</td>
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<td>JAMBA</td>
<td>Japan–Australia Migratory Bird Agreement</td>
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<td>LHPA</td>
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<td>LPMA</td>
<td>Land and Property Management Authority (NSW)</td>
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<td>LGA</td>
<td>local government area</td>
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<td>MDBA</td>
<td>Murray–Darling Basin Authority</td>
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<td>Abbreviation</td>
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<td>NOW</td>
<td>NSW Office of Water</td>
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<td>New South Wales Vegetation Classification and Assessment Database</td>
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<td>Rivers Environmental Restoration Program</td>
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<td>WSP</td>
<td>water sharing plan</td>
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1 Introduction

1.1 The purpose of the Gwydir Wetlands Adaptive Environmental Management Plan

The condition of the Gwydir Wetlands has been declining for many years. If this trend is not reversed, the wetlands will cease to exist as a large, diverse and complex ecosystem. The Gwydir Wetlands Adaptive Environmental Management Plan (AEMP) demonstrates that managers now possess much of the knowledge needed to begin restoring the wetlands’ ecological resilience.

The AEMP recommends various actions and strategies to improve the condition of the wetlands. It is a guide for adaptively managing a highly modified ecosystem to achieve realistic objectives. It is not a guide to returning the wetlands to a past condition or to managing them to maintain a fixed state.

1.2 The context for the AEMP

There are many important policies, Acts and programs that support and complement the AEMP at international, national, state and regional levels. Internationally, the Ramsar Convention (The Convention on Wetlands of International Importance, especially as Waterfowl Habitat) provides a global framework for the conservation and wise use of wetlands and their resources (Ramsar Convention 1987). In the Gwydir Wetlands, parts of four properties totalling 823 hectares are listed as a ‘wetland of international importance’ under the Ramsar Convention. When Ramsar listing occurred in 1999, most of the relevant land in these properties was privately-owned, although there was a small area of Crown land. One property, ‘Old Dromana’, has recently been purchased by the NSW Government, with funding provided by the Australian Government, and will be managed for conservation purposes.

In designating wetlands as Ramsar sites, countries agree to manage and monitor the listed sites with the aim of preventing adverse changes in their ecological character, which is described at the time of listing (Department of the Environment, Water, Heritage and the Arts 2009a).

Although there are separate management planning processes for Ramsar sites, one of the AEMP’s objectives is to consider the requirements of these internationally recognised wetlands.

The Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) gives legislative recognition to the Ramsar Convention under Australian law. It also provides for the national listing of threatened species and ecological communities. The EPBC Act gives the Australian Government certain powers to protect Ramsar sites, threatened species and endangered ecological communities.

Regarding the Murray–Darling Basin, the Commonwealth Water Act 2007 provides for the Murray Darling Basin Authority (MDBA) to develop a Basin Plan which will establish Sustainable Diversion Limits for each of the Basin’s water sources, including the Gwydir River. The Basin Plan will include an Environmental Watering Plan to coordinate the management of environmental water.

The Water Act also established the Commonwealth Environmental Water Holder (CEWH) to manage the Commonwealth’s environmental water holdings to protect or restore the environmental assets of the Basin to give effect to international agreements. The CEWH makes decisions after receiving advice from an Environmental Water Scientific Advisory Committee, as well as input from state governments and others, and must operate in accordance with the Basin Plan.
At state level, the *Water Sharing Plan for the Gwydir Regulated River Water Source* (Gwydir WSP) (NSW Government 2003) is a legal instrument made under the *Water Management Act 2000* that directs how the available water in Gwydir River is to be shared, including the provision of water for the environment.

Other NSW Acts that assist in protecting the wetlands include the:

- **Native Vegetation Act 2003** which signalled an end to broadscale clearing. This Act is important for conserving vegetation throughout the Gwydir floodplains, including the wetland vegetation described in this AEMP.
- **Threatened Species Conservation Act 1995** (TSC Act), which aims to protect threatened species, populations and ecological communities and their habitats in NSW.
- **Fisheries Management Act 1994** (FM Act), which applies to aquatic species, aiming to conserve threatened species, populations and ecological communities of fish and marine vegetation.

Regionally, the Border Rivers–Gwydir Catchment Action Plan (Border Rivers–Gwydir CAP) identifies broad catchment targets for natural resource management. Proposed actions in the AEMP complement these targets, and the Border Rivers–Gwydir Catchment Management Authority (BRG CMA) will help the Department of Environment, Climate Change and Water (DECCW) to annually review the implementation of the AEMP.

Floodplain management plans are an important tool for managing floodplains in NSW. The *Lower Gingham Watercourse Floodplain Management Plan* (Department of Natural Resources 2006) applies to the floodplains adjoining the western part of the Gingham Watercourse, and provides a statutory framework for managing floodplain structures that affect the distribution of floodwaters in that area.

The Gwydir Wetlands lie within the area of Moree Plains Shire Council, which is responsible for developing and implementing noxious weed control programs. The council’s most important role in relation to this plan is in assisting land holders to control infestations of water hyacinth.

The NSW and Australian governments funded the NSW Wetland Recovery Program (WRP) to halt the decline of the Gwydir Wetlands and Macquarie Marshes by restoring and protecting critical ecological functions and habitats. One component of the WRP is the development of this AEMP. The NSW RiverBank Program and the Rivers Environmental Restoration Program (RERP), funded by the NSW and Australian governments, are also supporting the restoration of the Gwydir Wetlands and Macquarie Marshes, as well as wetlands in the Lachlan and Murrumbidgee valleys and the Narran Lakes. These programs include significant resource planning, water and wetland purchases, research, infrastructure development and land management actions.

The AEMP is not a statutory document, and will need support from NSW and Australian governments, and local communities, for its implementation. DECCW is the lead government agency for implementing the AEMP. The Border Rivers–Gwydir Catchment Action Plan will take account of much of the information and many of the recommendations in the AEMP.
1.3 Gwydir River

Gwydir River is a large river system in the Murray–Darling Basin (Figure 1), with a catchment of about 26,000 square kilometres. The river begins west of Armidale and flows about 300 kilometres west where it begins to form a wide, flat floodplain that stretches to the Barwon River. West of Moree, the floodplain occupies the width of the valley, forming part of the Darling Riverine Plains. The northern and southern boundaries of the Gwydir catchment in this region are arbitrarily defined, as floodwaters occasionally flow to or from the adjoining Border Rivers (Barwon/Macintyre) and Namoi River catchments (Pietsch 2006).

Copeton Dam is the valley’s major water storage facility, with a capacity of 1,364,000 megalitres (Department of Water Resources nd). The main tributaries of Gwydir River downstream of Copeton Dam are Horton River, and Myall, Mosquito, Wariada, and MacIntyre creeks. Halls, Tycannah and Gurley creeks flow into Mehi River and Moomin Creek south-west of Moree.

Average rainfall in the Gwydir Valley ranges from 980 millimetres over the north-eastern margin to about 480 millimetres around the western extremity. There are two wet periods, from November–March and June–July, while the rest of the year is relatively dry (Water Resources Commission 1980).

Almost the entire runoff for the catchment is generated above Pallamallawa, with the western floodplains contributing almost no runoff due to low slopes, absorbent soils and a high evaporation rate. About 6% of the average flow at Pallamallawa is carried across the floodplain to Barwon River by the two largest distributaries, Mehi River and Carole-Gil Gill Creek (Pietsch 2006).

Pietsch (2006) provides a detailed description of the geomorphology and hydrology of the western part of the Gwydir Valley, which he calls the ‘Gwydir fan-plain’. The following details are taken mainly from that work, which makes extensive use of early survey plans and other historical records to evaluate changes in the river channels.

Within-channel flow across the Gwydir fan-plain is carried by Gwydir River and its three main effluent streams (streams that flow out of a major river): Mehi River, Moomin Creek and Carole Creek. Mehi River is the first to branch off from the south bank of Gwydir River, about 20 kilometres east of Moree. Carole Creek branches off from the north bank of Gwydir River about 25 kilometres further west. Moomin Creek diverges from Mehi River and takes a wide arc to the south before rejoining the river near Collarenebri.

In addition to in-channel flow, it is normal for water to flow through shallow depressions in the floodplain known as ‘watercourses’, such as the well-known Gingham and Big Leather watercourses. Survey plans of these features drawn in the early twentieth century depicted chains of ‘swamps’ (meaning wetlands without open water) that connected occasional waterholes, with only rare stretches of formed channels. Since that time, artificial channels have been cut along both watercourses. While these channels assisted the delivery of low-flow stock and domestic allocations, they reduced the watering of previously naturally irrigated prime wetland pastures (Pietsch 2006).

Of the main channels, Gwydir River has its bed at the lowest elevation and carries most of the coarse bedload sediment in the system (Pietsch 2006). Without the weirs that raise water levels at the off-takes to the Mehi River, Moomin Creek and Carole Creek, these streams would only commence to flow during high flows in Gwydir River (Pietsch 2006). The flow capacities of all these channels are reduced in the downstream direction. Although Gwydir River is the main stream, it has the greatest contraction in capacity, due in part to the natural diversion of high flows into effluent streams and watercourses.
Figure 1 Location of the Gwydir River catchment in the Murray–Darling Basin.
An important feature of the lower Gwydir River is the Raft, an accumulation of woody debris and silt that clogs the channel for over 15 kilometres. Pietsch (2006) and Blandford et al (1977) provide the most details on the origin and development of the Raft, although they contradict each other in some respects. However, the effect of the Raft on water distribution in the Gwydir Wetlands is not disputed.

The Raft began to develop in either the 1870s or the early 1900s. It commenced at a point about 7 kilometres above Brageen Crossing, from where it progressed upstream (Pietsch 2006). It is believed that the widespread clearing of trees in the upper catchment resulted in masses of logs and branches being carried downstream periodically by large floods. From 1946–1955, the Raft advanced upstream 3.6 kilometres. The 1971 flood caused it to grow by 365 metres in length, while the 1976 flood caused it to extend another 60 metres. Each growth phase caused changes in the hydrologic behaviour of this section of the floodplain (Blandford et al 1977).

Silt and other debris are trapped in the mass of woody debris, and the course of much of the former channel is now buried and largely obscured. The head of the Raft has stabilised about 20 kilometres west of Moree, where it partly dams Gwydir River, creating Gwydir Pool (Pietsch 2006).

The Raft is now over 15 kilometres long (Pietsch 2006). Its blocking effect has increased the proportion of flows entering Gingham Watercourse (Blandford et al 1977). This has created an overflow area at the eastern end of Gingham Watercourse, where about 2,000 hectares of mixed coolibah and river red gum forests and woodlands have developed since the 1950s (McCosker & Duggin 1993).

Figure 2 Gwydir River catchment.
The early activities of non-indigenous Australians had other important impacts on the distribution of flows across the floodplain. Pietsch (2006) describes several instances of channel works designed to redistribute natural river flows, including:

- A channel was cut to bypass the lower reaches of the Goonal Anabranch sometime after 1908, which was successful in increasing flows into the Big Leather Watercourse.
- Works undertaken between 1903 and 1936 reduced the height of the Mehi River off-take from about 3.4 metres above the bed of the Gwydir River to about 1.1 metres. This equates to a four-fold increase in flow duration, from less than 5% before cutting to more than 20% afterwards.
- A small, high-level channel was cut before the 1920s to create an off-take from Gwydir River to Carole Creek (previously there was no direct connection). The connecting channel was enlarged in the 1940s.
- A channel was cut in the 1890s from the northern end of Carole Creek, where it dissipated in a flood-out, to direct flows into Gil Gil Creek.
- The off-take of Moomin Creek from Mehi River was modified in the early twentieth century to increase flows down this creek.

The most far reaching change in the Gwydir River system came with the construction of Copeton Dam, and the downstream weirs and regulators that allow much of the flows to be diverted into the Mehi River and Carole Creek systems.

Currently, river flows are managed by State Water according to the rules set out in the Gwydir WSP (NSW Government 2003). Within the regulated section, State Water supplies water ordered by licence holders. The regulated parts of the Gwydir Water Management Area include Gwydir River from Copeton Dam to the Raft, part of the lower Gwydir River (called Lower Gwydir Watercourse in this AEMP), Mehi River and Moomin Creek to the south, and Carole Creek and part of Gil Gil Creek to the north (Department of Infrastructure, Planning and Natural Resources 2004).

All other rivers and creeks that flow into the main river (tributaries) or flow from it (effluents) are unregulated rivers for the purposes of water supply management, and water availability is generally subject to natural river flows. Some of the effluents receive replenishment flows to satisfy the water requirements of domestic and stock water users.
1.4 Gwydir Wetlands

For the purpose of this AEMP, ‘wetland’ has the same meaning as the Ramsar Convention definition:

… areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.

(Ramsar Convention 1987)

Under this definition, virtually the entire Lower Gwydir floodplain (Figure 3) may be regarded as a wetland ecosystem. Gwydir Wetlands consist of a mosaic of wetland types, ranging from semi-permanent marshes and waterholes to floodplain woodlands only inundated by large floods (Australian Nature Conservation Agency 1996, Torrible et al 2008). Although these wetlands are highly modified by agricultural development and water management, they retain high ecological and cultural values, as described in the following sections.

The core wetland areas include waterholes and semi-permanent wetland vegetation typified by marsh club-rush (also known as sag) and water couch which is inundated frequently by overbank flooding from many small channels. River cooba and lignum shrublands are common in and around the margins of the core wetlands. Coolibah woodlands fringe the core wetland areas and form extensive woodlands on less frequently flooded parts of the floodplain (Keyte 1994, Bowen & Simpson 2010).

Figure 3  The Lower Gwydir floodplain, which is the region covered by this AEMP, showing key locations and features.
Gwydir Wetlands are known as a major centre for waterbird breeding in Australia (Morse 1922, McCosker 1996), and provide habitat for hundreds of animal and plant species. In 1921, part of the wetlands was proclaimed as a bird and wildlife sanctuary (Keyte 1994). The floodplain wetlands provide habitat for migratory birds listed under international agreements that Australia has made with Japan, China and the Republic of Korea (JAMBA, CAMBA and ROKAMBA respectively).

The values of the wetlands are now recognised at all levels of government in Australia, and internationally through the Ramsar Convention. The wetlands are included in the Directory of important wetlands in Australia (Australian Nature Conservation Agency 1996).

1.5 Ecological systems and processes

Ecosystems comprise both organisms and their non-living environments, and include humans if they are present (Barnhart 1986, Meffe et al 2002).

The Gwydir Wetlands ecosystem includes the plants, animals and places occurring there, and processes that form the wetlands such as flooding, drying and nutrient cycling. Managing the wetlands requires also considering the processes in the whole Gwydir catchment and the hydrology and geomorphology of the river and floodplain.

A river’s natural flow regime is driven by climate and runoff from the upstream catchment, and its main components are the size, frequency, duration, timing and rate of change of flows (Poff et al 1997, Puckridge et al 1998). This flow regime is the key driver of ecological systems in rivers and wetlands. High flows generate floods in Gwydir Wetlands, and the extent, frequency, duration and depth of flooding determine the distribution, type and vigour of wetland vegetation.

Like most other major rivers in the Murray–Darling Basin, Gwydir River is highly regulated (Mussared 1997, Young 2001). The resulting changes to the natural flow regime have severely affected the structure and functioning of the wetlands.

1.6 Aboriginal cultural values

Gwydir Wetlands are part of the traditional country of the Gamilaroi people. They provided an important and rich asset, complementing the resources of the plains and ranges. The specific places in the wetlands, and the plants and animals that the wetlands supported, were important in Aboriginal culture.

Aboriginal cultural values are related to the history of Aboriginal interaction with Gwydir Wetlands, and to the values, interests and aspirations of contemporary Aboriginal communities that have a custodial relationship with them. The Aboriginal ethos of ‘caring for Country’ can assist the sustainable management of wetlands through its emphasis on the connections between people and the natural world and the sense of responsibility to care for the natural world.

The three main elements of protecting and strengthening cultural values in Gwydir Wetlands are:

1. acknowledging Aboriginal connections to Country
2. protecting Country by maintaining the health of Gwydir Wetlands, protecting sites of Aboriginal cultural heritage, and protecting plants and animals that have cultural values
3. improving access for Aboriginal people to Country for cultural activities, facilitating working on Country, and increasing participation in managing the environment.
1.7 Economic systems

This section gives an overview of the economy of the Gwydir catchment (see Figure 2 for a map of the catchment) including a general description of key industry sectors. It should not be interpreted as a comparison of the relative economic value of these sectors in the Lower Gwydir floodplain because the available data apply to different areas.

The economy of the Gwydir catchment is highly reliant on agriculture, including cropping and livestock farming. The catchment has a number of small urban centres and rural settlements (Argent et al. 2007).

Consistent with regional areas across Australia, the catchment’s population has declined steadily over the past decade and youth out-migration has led to a higher rate of ageing of the population than is the average in NSW. Economic indicators show a stronger dependence on agriculture for employment, higher rates of unemployment and lower income levels than the state average (AgEconPlus 2007, Argent et al. 2007). However, these trends are not uniform across the catchment. The western catchment communities rely more on agriculture than the larger population centres in the east (Argent et al. 2007).

1.7.1 Agriculture and other industries

Total agricultural output for the Gwydir catchment was worth $755 million in 2005–06, which was 8.3% of the estimated value of NSW agricultural production. Crops accounted for 73% of the value of agricultural production, while livestock slaughtering and livestock products accounted for 22% and 5% respectively (Australian Bureau of Statistics 2010). Agriculture covers 83.1% of the land area of the catchment (Australian Bureau of Statistics et al. 2009, p. 131).

The agriculture, forestry and fishing sector is the largest employer in the Gwydir catchment. These rural industries accounted for 28.9% of total employment in 2006, declining from 32.1% in 1996. Other major sources of employment in 2006 were the retail trade sector (9.3%), education and training sector (8.5%), health care and social assistance sector (8.3%), public administration and safety sector (6.2%) and construction sector (5.7%) (Australian Bureau of Statistics 1996, 2006b).

1.7.2 The irrigation industry

Irrigated agriculture covers up to 5% of the area of the catchment (Australian Bureau of Statistics et al. 2009, p. 131) but contributes 30–40% of the total value of agricultural production depending on the conditions of the year. The gross value of irrigated agriculture in the Gwydir catchment in 2005–06 was approximately $154 million (Marsden Jacob Associates 2010).

Cotton is the dominant irrigated crop by area and value. The area of irrigated farming fluctuates annually, primarily in relation to water availability (Hassall & Associates 2007).

---

1. The statistics in this section are for the Guyra, Gwydir, Moree Plains and Uralla local government areas (LGAs). These areas are different to the official Gwydir catchment area because the LGA boundaries do not match the official catchment boundaries. These LGAs were selected in the AgEconPlus (2007) consultants’ report because more than half their areas were contained in the official Gwydir catchment boundaries.
1.7.3 Cotton production

Cotton production is highly concentrated in the catchment, with 95% of the area under production in 2005–06 located in the Moree Plains local government area (AgEconPlus 2007). In 2005–06, approximately 77,500 hectares were planted for cotton, of which approximately 90% was irrigated (Australian Cottongrower 2009). In 2005–06, the cotton crop had a value of approximately $162 million, with irrigated cotton accounting for approximately 95% of this value (Marsden Jacob Associates 2010, AgEconPlus 2007).

The irrigated cotton industry grew significantly during the 1980s and 1990s, but recent seasonal conditions and commodity prices have combined to lessen the momentum of that growth (Hassall & Associates 2007). Cotton planting fluctuates depending on seasonal conditions and availability of water. In 1998–99 and 2000–01 approximately 110,000 hectares were planted, although only approximately 30,000 hectares were planted in 2003–04 and 2008–09 (Australian Cottongrower 2009).

Cotton processing also contributes to the regional economy. Nine cotton gins operate in the Gwydir catchment, and each is reported to employ an average of 25 people in the cotton ginning season, which lasts three months each year (AgEconPlus 2007).

Cotton could be replaced with other crops if prices change significantly. To date, there is little evidence to suggest a long-term change in the cropping patterns in the catchment. The high variability of rainfall and river flows mean that annual crops such as cotton are likely to continue to be an important component of future cropping strategies (Hassall & Associates 2007).

Despite this, the recent dry period has exposed many irrigators to other cropping options at a time of low water availability and high prices for feed grains. This type of shift depends on many factors such as commodity prices, management expertise, and infrastructure and equipment exchangeability (Hassall & Associates 2007).

1.7.4 The grazing industry

Most agricultural land in the Gwydir catchment is used for livestock grazing. Livestock slaughtering and livestock products in the catchment were worth $233 million in 2005–06. Cattle and calves provided the largest contribution to livestock slaughtering ($142 million) followed by sheep and lambs ($20 million). Wool provided by far the largest contribution to livestock products ($34 million) (Australian Bureau of Statistics 2006a).

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2. This comprises the Guyra, Gwydir, Moree Plains and Uralla LGAs.
2 The ecological assets and values of the Gwydir Wetlands

The ecological assets and values described in this section have been identified through studies that have collated existing information and gathered new data about the flora and fauna of the Gwydir Wetlands. The results of these studies are reported in Bowen & Simpson 2010, Spencer 2010, Spencer et al 2010, Wilson et al 2009 and Torrible et al 2008.

The selected ecological assets that are listed below serve as indicators for the health of the whole ecosystem. When wetlands and waterbirds are flourishing, it is because ecological functions and processes are intact. To stabilise and eventually improve the condition of the wetlands under both existing and projected climatic conditions, the sensible base to work from is their existing condition. The studies will help to establish benchmarks from which future changes in condition of the wetlands can be monitored.

The animals, plants, and ecosystems described here also hold important Aboriginal cultural values, which are described in section 6.

The ecological assets and values defined in this AEMP are:

- **waterbirds and waterbird habitat** – the wetlands are renowned for large-scale waterbird breeding with many tens of thousands of birds breeding throughout the area
- **wetland vegetation** – the character of the wetlands derives from the presence of varied associations of water couch, marsh club-rush, lignum, river cooba, coolibah, black box and river red gum
- **species and communities of special significance** – these include the aquatic ecological community, fish, reptiles, frogs, woodland birds and myall woodland.

Water management is treated separately, in section 3. Water drives ecological processes of the wetlands, as well as supporting the agricultural and social systems of the Gwydir Valley.
2.1 Waterbirds and waterbird habitat

Gwydir Wetlands are recognised as a refuge for waterbirds in dry times, and for supporting some of the largest waterbird breeding colonies recorded in Australia. There have been 75 waterbird species recorded in Gwydir Wetlands – 65 species on the Ramsar-listed property ‘Old Dromana’ alone. They include species listed as threatened both in NSW and nationally, and species listed on the JAMBA, CAMBA and ROKAMBA migratory bird agreements (see table 1 for full names of these agreements) (Spencer 2010).

Table 1 Migratory bird species recorded in the Gwydir Wetlands listed under international agreements (from Spencer 2010).

Note: forktailed swift and white-throated needletail are species of swift that are not regarded as waterbirds.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Listed under JAMBA (J), CAMBA(C), ROKAMBA (R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian painted snipe</td>
<td>C</td>
</tr>
<tr>
<td>Caspian tern</td>
<td>C</td>
</tr>
<tr>
<td>Cattle egret</td>
<td>J C</td>
</tr>
<tr>
<td>Common greenshank</td>
<td>J C R</td>
</tr>
<tr>
<td>Common sandpiper</td>
<td>J C R</td>
</tr>
<tr>
<td>Common tern</td>
<td>J C R</td>
</tr>
<tr>
<td>Fork-tailed swift</td>
<td>J R</td>
</tr>
<tr>
<td>Glossy ibis</td>
<td>C</td>
</tr>
<tr>
<td>Great egret</td>
<td>J C</td>
</tr>
<tr>
<td>Latham’s snipe</td>
<td>J C R</td>
</tr>
<tr>
<td>Little curlew</td>
<td>J C R</td>
</tr>
<tr>
<td>Marsh sandpiper</td>
<td>J C R</td>
</tr>
<tr>
<td>Oriental plover</td>
<td>J R</td>
</tr>
<tr>
<td>Ruff</td>
<td>J C R</td>
</tr>
<tr>
<td>Sharp-tailed sandpiper</td>
<td>J C R</td>
</tr>
<tr>
<td>White-bellied sea-eagle</td>
<td>C</td>
</tr>
<tr>
<td>White-throated needletail</td>
<td>C R</td>
</tr>
<tr>
<td>White-winged black tern</td>
<td>J C R</td>
</tr>
</tbody>
</table>

JAMBA = Japan–Australia Migratory Bird Agreement
CAMBA = China–Australia Migratory Bird Agreement
ROKAMBA = Republic of Korea–Australia Migratory Bird Agreement
There is much available information about the required habitats, nesting materials and feeding areas of breeding waterbirds in the wetlands. Waterbird habitat includes preferred locations and vegetation for shelter and nest sites, the water needed to flood breeding sites and feeding areas, and the availability of preferred food items. Differences in flow size, timing and duration of flooding are known to encourage different-sized breeding events.

The key waterbird breeding habitats in Gwydir Wetlands are floodplain waterholes, in-channel lagoons and floodplain wetlands with sedgelands, stands of cumbungi, lignum, belah, coolibah and river red gum. Feeding habitats include floodplain waterholes, in-channel lagoons and floodplain areas with freshwater meadows, sedgelands and stands of cumbungi (Spencer et al. 2010).

Colonially nesting species are prominent among the waterbirds that breed in Gwydir Wetlands. Great egret, intermediate egret, little egret, Nankeen night heron, glossy ibis, Australian white ibis, straw-necked ibis, little pied cormorant and little black cormorant breed in the largest numbers. Records of major breeding events date back to the 1920s, when Gwydir Wetlands were thought to hold ‘the largest heronry in NSW’ with ‘hundreds of thousands of birds breeding there’ (Morse 1922).

Large-scale waterbird breeding in Gwydir Wetlands is an indicator that the ecological system is functioning well. To breed successfully, colonially nesting waterbirds need flooding of sufficient volume and duration to inundate colony sites and feeding areas for at least 4–5 months between August and April (Marchant & Higgins 1990, 1993). These flows are also critical for maintaining wetland vegetation, and for enabling aquatic invertebrates to complete their lifecycles (Jenkins & Wolfenden 2006). Although smaller flows do not generally support successful colonially nesting waterbird breeding, they do enable other flood-dependent waterbird species to breed (Marchant & Higgins 1990, Spencer 2010).
2.2 Wetland vegetation

Gwydir Wetlands provide important refuges for native plants and animals in a highly developed agricultural region (Bowen & Simpson 2010). The vegetation communities on the floodplains are very fragmented and poorly conserved in NSW. Some are listed as endangered ecological communities (EECs) under the TSC Act or threatened ecological communities under the EPBC Act (Benson et al 2006, Keith 2004, Keith et al 2009).

In addition to these legislative listings, vegetation communities in NSW are being systematically classified and their conservation status is being assessed under the New South Wales Vegetation Classification and Assessment Database Project (NSW VCA) being conducted by DECCW (Benson 2006). Descriptions of the communities found in the Western Plains region (which includes Gwydir Wetlands) have been published (Benson et al 2006).

Several studies have reported reductions in the extent and condition of both semi-permanent wetland and floodplain vegetation communities of Gwydir Wetlands since the regulation of Gwydir River in the 1970s. These changes have been attributed to reduced inundation of the floodplain which has reduced the productivity of floodplain pastures and encouraged changes in land use from grazing to cropping (Bennett & Green 1993, McCosker & Duggin 1993, Keyte 1994, Bowen & Simpson 2010).

Figure 4 Boundaries of vegetation maps for 1996, 2005 and 2008.
The condition of vegetation communities is a measure of the species composition and vigour of native plants compared to a reference condition, which is based either on sites which have not been significantly affected by human activities, or a hypothetical condition that would be expected in the absence of human-mediated stressors such as changes to water quantity and quality and fire regimes, physical habitat structure, grazing pressure and the impacts of weeds and pest animals.

Bowen and Simpson (2009) mapped the vegetation communities in Gwydir Wetlands in 2008, and used maps of vegetation in 1996 and 2005 by McCosker (1997, 2007) to measure changes in extent. Figure 4 shows the areas covered by these mapping projects, and Figures 5 and 6 show the changes between 1996 and 2008.

At higher elevations, the floodplain supports a variety of woodland and grassland communities classified as ‘dryland floodplain vegetation’ (e.g. poplar box and belah woodlands, native millet and windmill grass). These are shown on the maps but are not considered as assets, apart from the myall woodland described in section 2.3.6.

Wetland vegetation in the study area is classified into two groups:

- **semi-permanent wetland vegetation** – communities that depend on frequent flooding to maintain their structural integrity and condition
- **floodplain wetland vegetation** – communities whose dominant overstorey species require flooding at some stage for regeneration, can tolerate prolonged flooding for several months and can survive dry periods lasting for several years.

### 2.2.1 Semi-permanent wetland vegetation

In Gwydir Wetlands, areas of semi-permanent wetland vegetation large enough to be mapped only occur in the Gingham and Lower Gwydir watercourses (see Figure 7). The total extent of these communities (water couch–spike rush, marsh club-rush and cumbungi) has declined by an estimated 76% since the regulation of Gwydir River in the 1970s (Bowen & Simpson 2010). Figures 5 and 6 and Table 2 show the changes from 1996–2008, which amount to a reduction of 51% in area over this period.

**Water couch grassland, water couch–spike rush meadows**

Extensive water couch grasslands have been previously mapped in Gwydir Wetlands (McCosker & Duggin 1993, Keyte 1994). Most no longer receive the flows they need, and have declined in area and condition or have disappeared entirely (Bowen & Simpson 2010).

Water couch generally needs to be flooded in spring or summer at least once a year to maintain vigorous growth and compete successfully with other species (Bennett & Green 1993, Roberts & Marston 2000). Flooding may continue for 4–6 months or longer, or can occur in separate, shorter events. Water couch can recover from a one- to three-year dry spell but cannot tolerate extended or frequently repeated dry periods. When water couch is dry, it does not tolerate grazing well, and when it is underwater, it does not tolerate persistent grazing. However, according to recent research, under suitable flow conditions, grazing can help maintain water couch’s dominance in grassy wetland communities (Wilson et al 2008, P Berney pers comm 2009).
Figure 5 Vegetation of the Gwydir Wetlands and floodplain 1996 (McCosker 1997).
The ecological assets and values of the Gwydir Wetlands

2008 Vegetation Map for the Gwydir Wetlands and Floodplain (Bowen & Simpson 2009)

Figure 6 Vegetation of the Gwydir Wetlands and floodplain 2008 (Bowen & Simpson 2010).
Figure 7 Changes in semi-permanent wetland vegetation in the Gwydir Wetlands 1996–2008 (Bowen & Simpson 2010).
Table 2  Change in extent of semi-permanent wetland vegetation, Gingham and Lower Gwydir watercourses, 1996–2008 (Bowen & Simpson 2010).

<table>
<thead>
<tr>
<th>Location</th>
<th>Vegetation community</th>
<th>1996</th>
<th>2005</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gingham Watercourse</td>
<td>Water couch–spike rush</td>
<td>9,393</td>
<td>5,298</td>
<td>3,485</td>
</tr>
<tr>
<td></td>
<td>Marsh club-rush</td>
<td></td>
<td></td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Cumbungi</td>
<td></td>
<td></td>
<td>257</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>9,393</td>
<td>5,298</td>
<td>3,753</td>
</tr>
<tr>
<td>Lower Gwydir Watercourse</td>
<td>Water couch–spike rush</td>
<td>4,254</td>
<td>2,726</td>
<td>2,816</td>
</tr>
<tr>
<td></td>
<td>Marsh club-rush</td>
<td>317</td>
<td>132</td>
<td>181</td>
</tr>
<tr>
<td></td>
<td>Common reed–marsh club-rush</td>
<td></td>
<td></td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Cumbungi–marsh club-rush</td>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Common reed</td>
<td>36</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>4,571</td>
<td>2,894</td>
<td>3,076</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>13,964</td>
<td>8,192</td>
<td>6,829</td>
</tr>
</tbody>
</table>

In 1996, approximately 13,600 hectares of water couch grassland were mapped in the Gingham and Lower Gwydir watercourses. By 2008, approximately 6,300 hectares remained. These communities can recover, given suitable flows and best practice land management.

Water couch is a prolific seeder, but the success of seed germination is limited, and it can regenerate more successfully from fragments or buried nodes (Middleton 1999). Loss of water couch from large areas might lead to its failure to recover quickly because regeneration depends on the presence of mature, healthy plants that have trailing stems. Water couch marsh is considered to be an endangered community (Benson 2006).

**Marsh club-rush**

Marsh club-rush occurs in three frequently flooded areas of the Gingham and Lower Gwydir watercourses. Under favourable conditions it grows as a dense stand to two metres tall (McCosker 1997). Keyte (1994) reported that decreased inflows had caused a contraction in the area of marsh club-rush from a reported 2,200 hectares in 1974 to less than 700 hectares in 1993. The area of marsh club-rush declined to 317 hectares in 1996 and 132 hectares in 2005. However, including 31 hectares co-dominant with common reed and cumbungi, the area had increased to 223 hectares in 2008. This community has been recently listed as critically endangered under the TSC Act.

The ecological requirements of marsh club-rush, (*Bolboschoenus fluitatilis*) are mostly unknown. However a closely related species, *Bolboschoenus medianus*, on the Murray River requires regular flooding (80–215 days a year) to a depth of less than 60 centimetres (Roberts...
Grazing appears to create openings for other mainly native species in marsh club-rush communities (P. Berney pers comm 2009). While this increases local species diversity, it can threaten the survival of the marsh club-rush ecological community.

### 2.2.2 Floodplain wetland vegetation

Lignum, river cooba, and coolibah are widespread in Gwydir Wetlands. Lignum and river cooba are present on the inner floodplain, on the margins of semi-permanent wetland. Coolibah occurs on the inner floodplain, in association with lignum, river cooba and river red gum, and extends to the outer floodplain where it coexists with black box.

Table 3 shows the changes in extent between 1996 and 2008 for all the floodplain wetland communities in the Gingham and Lower Gwydir floodplains, which amount to a decline in area of 37%.

Less information on the historical extent of vegetation communities is available for the Mehi, Mallowa and Moomin floodplains, although the remaining native vegetation on the floodplain is a small fraction of its original extent. Table 4 shows the changes in floodplain wetland vegetation in this area from 2005–2008.
Table 3  Change in extent of floodplain wetland vegetation, Gingham Watercourse and Lower Gwydir floodplains, 1996–2008 (Bowen & Simpson 2010).

<table>
<thead>
<tr>
<th>Location</th>
<th>Vegetation community</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1996</td>
<td>2005</td>
</tr>
<tr>
<td>Inner floodplain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>River cooba swamp–lignum shrubland</td>
<td>5,527</td>
<td>3,628</td>
</tr>
<tr>
<td>Coolibah–river red gum</td>
<td>3,653</td>
<td>3,543</td>
</tr>
<tr>
<td>Total (inner floodplain)</td>
<td>9,180</td>
<td>7,171</td>
</tr>
<tr>
<td>Outer floodplain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coolibah open woodland*</td>
<td>119,108</td>
<td>55,623</td>
</tr>
<tr>
<td>Coolibah–black box woodland</td>
<td>18,742</td>
<td>19,952</td>
</tr>
<tr>
<td>Total (outer floodplain)</td>
<td>137,850</td>
<td>75,575</td>
</tr>
<tr>
<td>Total</td>
<td>147,030</td>
<td>82,746</td>
</tr>
</tbody>
</table>


Table 4  Change in extent of floodplain wetland vegetation, Mehi, Mallow and Moomin floodplains, 1996–2008 (Bowen & Simpson 2010).

<table>
<thead>
<tr>
<th>Location</th>
<th>Vegetation community</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2005</td>
<td>2008</td>
</tr>
<tr>
<td>Inner floodplain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>River cooba–lignum association</td>
<td>456</td>
<td>393</td>
</tr>
<tr>
<td>Coolibah–river cooba–lignum association</td>
<td>not mapped</td>
<td>1,616</td>
</tr>
<tr>
<td>Coolibah–river red gum association</td>
<td>2,457</td>
<td>4,411</td>
</tr>
<tr>
<td>Total (inner floodplain)</td>
<td>2,913</td>
<td>6,420</td>
</tr>
<tr>
<td>Outer floodplain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coolibah open woodlands</td>
<td>24,893</td>
<td>19,956</td>
</tr>
<tr>
<td>Total</td>
<td>27,306</td>
<td>26,376</td>
</tr>
</tbody>
</table>

Lignum shrubland and river cooba

Lignum and river cooba provide valuable waterbird breeding habitat, especially for colonially nesting species. Lignum occurs throughout Gwydir Wetlands as an understorey plant but forms shrubland in only a few areas on Gingham Watercourse and Mallowa Creek. Lignum is considered to be vulnerable (Benson 2006). Little is known about the ecology of river cooba.

Lignum occurs in areas flooded at frequencies of once in 2–10 years for durations of 3–12 months. It responds rapidly to flooding by producing an abundance of shoots, leaves, flowers and seeds. Seeds ripen quickly, disperse on floodwaters and germinate under moist soil conditions. To maximise seed germination, seeds settle in moist, but not flooded, soil within approximately eight weeks of flower development (Chong & Walker 2005).

River cooba and lignum covered an area of 42,000 hectares in the Gingham Watercourse in 1985. By 1993, it was reported that little of this vegetation remained healthy (McCosker & Duggin 1993, Bowen & Simpson 2010). In 1996, 5,527 hectares were mapped in the Gingham...
and Lower Gwydir floodplains. By 2008, the area that remained in the two systems was 3,207 hectares, most of which is now infested with lippia. Less than 10% of the river cooba and lignum shrubland that grew in the Gingham and Lower Gwydir floodplains in the 1970s remains (Bowen & Simpson 2010).

Coolibah and black box woodlands

Coolibah is found along a gradient of decreasing flood frequency and duration, between the margins of semi-permanent wetlands and black box woodlands on the outer floodplain. Woodland communities with coolibah as a dominant species are a component of ‘Coolibah–Black Box Woodland of the northern riverine plains in the Darling Riverine Plains and Brigalow Belt South bioregions’, which is listed as an EEC under the TSC Act (Department of Environment, Climate Change and Water 2009). The determination of the NSW Scientific Committee states:

Coolibah–Black Box Woodland of the northern riverine plains in the Darling Riverine Plains and Brigalow Belt South bioregions is usually formed as a woodland or open woodland with a grassy ground layer. *Eucalyptus coolabah* (Coolibah) is typically the most common tree in this community, and it may occur with or without *Acacia stenophylla* (River Cooba), *Acacia salicina* (Cooba), *Casuarina cristata* (Belah), *Eremophila bignoniiflora* (Eurah), *Eucalyptus largiflorens* (Black Box), and *Eucalyptus populnea* subsp. *bimbil* (Bimble Box).

Department of Environment, Climate Change and Water 2009

![Coolibah woodland on ‘Old Dromana’ in March 2008 (Photo: Sharon Bowen).](image)
There are some vegetation communities in the Gwydir Wetlands that are listed in the NSW VCA and included under the above definition. These communities are coolibah woodlands (NSW VCA ID 40), black box woodlands (NSW VCA ID 37) and coolibah–river cooba–lignum woodlands (NSW VCA ID 39) (Benson 2006, Bowen & Simpson 2010). These communities have previously been included in various coolibah open woodland communities in earlier mapping of the Gwydir floodplain (McCosker et al 1993, McCosker 2007, Cox et al 2001).

Vegetation mapping recorded 150,000 hectares of coolibah open woodlands on the Gingham Watercourse floodplain in 1985 (McCosker et al 1993). They occur on fertile soils and have been cleared extensively for agricultural development, including irrigation and dryland cropping (McCosker 2007). In 1996, coolibah open woodlands were the most extensive vegetation communities on the Gwydir River floodplain but in the NSW northern wheat belt between 1985 and 2000, such woodlands were one of the most heavily cleared vegetation types (Cox et al 2001).

Coolibah open woodlands covered about 120,000 hectares on the Gingham and Lower Gwydir watercourses in 1996, decreasing to 52,000 hectares in 2008. Most of this reduction in area was caused by clearing (Bowen & Simpson 2010). All remaining coolibah woodland communities have high conservation value in the Gwydir valley.

Coolibah–black box woodlands are at the eastern extremity of their distribution on the Gwydir floodplain. In 2008, about 19,500 hectares of coolibah–black box woodland were mapped on the Gingham and Lower Gwydir floodplains (Bowen & Simpson 2010). On the western parts of these floodplains, grassy coolibah woodlands are present in a fragmented network of remnants and strips along travelling stock routes and road reserves. On the eastern floodplain, coolibah woodlands remain in larger remnants and merge with coolibah–river cooba–lignum and coolibah–river red gum communities along watercourses and more frequently inundated areas (Bowen & Simpson 2010). Lippia has invaded extensive areas of coolibah open woodlands along the Gingham and Lower Gwydir watercourses (McCosker 2007).

Knowledge of the ecological requirements of coolibah is limited. It is likely that coolibah requires wet soils or shallow flooding for regeneration (Roberts and Marston 2000) but it will die if inundated for too long. It is recommended that inundation of coolibah woodland lasts no longer than 6–8 months.

Coolibah–river red gum woodland and river red gum forest

These communities are relatively recent. It is thought that they established in the 1950s in response to the stabilisation of the Gwydir Raft (McCosker & Duggin 1993). Their condition is poor, as they are infested heavily by exotic species. African boxthorn forms impenetrable thickets in many areas. Ground cover is dominated by introduced species including lippia, prickly pear, and cobbler’s pegs. Noogoora burr grows in abundance after summer floods (McCosker 2007).

2.3 Species and communities of special significance

This category includes threatened species, EECs and species of conservation concern, including the aquatic ecological community, silver perch, reptiles, frogs, woodland birds and myall woodland.

Industry & Investment NSW (Fisheries) is developing priority action statements to recover threatened fish species, populations and communities.
2.3.1 The aquatic ecological community

The aquatic ecological community of the Gwydir Wetlands, which is part of the natural drainage system of the lowland catchment of the Darling River, is listed under the NSW FM Act as an EEC (NSW Government 2005). This community includes all the area’s native fish and aquatic invertebrates as well as the natural rivers, creeks, lagoons, billabongs, wetlands, lakes, tributaries and anabranches in which they live.

Photo 7 Watermilfoil (a native aquatic plant) in the Gingham Channel (Photo: Tracy Fulford).
The key threatening processes listed under the FM Act that may affect the Gwydir Wetlands aquatic ecological community are:

- the installation and operation of in-stream structures and other mechanisms that alter natural flow regimes of rivers and streams
- the removal of large woody debris
- the degradation of native riparian vegetation
- the introduction of fish to fresh waters within a river catchment outside their natural range.

2.3.2 Fish

During surveys conducted in 2007 and 2008, 11 species of native fish and three species of introduced fish were recorded in Gwydir Wetlands. The most common native species were Australian smelt, bony bream and Murray Darling rainbowfish, which are all small-bodied fish. The introduced species, carp, gambusia and goldfish, made up less than 10% of the total numbers of fish captured during these surveys (Spencer et al 2010).

Severe declines in some native species such as Murray cod, golden perch and eel-tailed catfish have been reported anecdotally since the 1970s, coinciding with river regulation and the invasion of carp (Copeland et al 2003, Siebentritt 1999). River regulation changes the flow conditions on which many native fish depend and, with other changes to the condition of the river, contributes to the degradation of native fish habitat. Changed flow patterns and degraded riparian zones increase bank erosion, turbidity and sedimentation in channels, filling pools and smothering habitats that include macrophytes, woody debris and gravel substrates (Murray–Darling Basin Commission 2003). Constant low flows reduce ecosystem productivity by removing the wetting and drying cues that trigger and sustain aquatic cycles (Poff et al 1997, Ward 1998). Other threats to native fish include increased contaminant runoff, removal of logs and debris from streams, competition with introduced species, and structures in the river that act as barriers to movement (Murray–Darling Basin Commission 2003, Spencer 2010).

Native fish often move long distances in the river to feed and spawn, and many depend on access to the floodplains. Levee banks, weirs and channelisation reduce connectivity between river channels and floodplain wetlands (Spencer 2010, Kelleway et al 2010). In the Gwydir Wetlands, significant barriers to fish movement include weirs, rock weirs, regulators and road crossings (Siebentritt 1999).

Larval and juvenile fish are directly extracted from the river when water is pumped for irrigation and town water supply. Collaborative research on this problem is being undertaken between Industry & Investment NSW, the Australian Cotton Cooperative Research Centre (CRC) and Murrumbidgee Irrigation (Department of Primary Industries 2005).

Releases of cold, poor-quality water from the bottom of Copeton Dam potentially affect aquatic habitat and native fish populations adversely for up to several hundred kilometres downstream (Lugg 1999) but ecological impacts have yet to be quantified (Preece 2004). Habitat degradation and control of introduced fish, especially carp, must be undertaken across whole river systems.

All native fish species in the Gwydir Wetlands and lower Gwydir River typically recruit during spring and early summer. Appropriate flows are needed for spawning, so eggs can be protected and larval and juvenile fish can survive. For most species, warmer temperatures are important during this period. Flow conditions must be suitable while fish larvae are growing and the summer irrigation flows that follow must not wash the larvae and their prey from
nursery habitats (Humphries et al 2002). Late-winter and spring floods enable adult fish to feed and grow before they spawn (Humphries et al 2002) and floodplain habitats to develop a rich supply of food for larval and juvenile fish (Gehrke et al 1995).

Several species recorded in the Gwydir catchment are listed as threatened under the FM Act, including silver perch, olive perchlet, purple-spotted gudgeon, river snail and the Murray–Darling Basin population of eel tail catfish (Morris et al 2001). The Murray cod is listed as vulnerable under the EPBC Act. Of these species, only Murray cod has been collected in Gwydir Wetlands during recent sampling programs, in small numbers (Spencer et al 2010, Wilson et al 2009).

2.3.3 Reptiles

Information on reptiles in Gwydir Wetlands is limited (Torrible et al 2008). Caddy (2005) stated there were 20 reptile species on the Gingham floodplain, although no species names or references were presented. At least three turtle species (*Chelodina longicolis*, *C. expansa*, *Emydura macquarii*) are likely to occur in ephemeral and permanent pools and lagoons (Wilson and Swan 2003). However, no information on flow responses or flooding requirements that enable these species to thrive is available from this catchment (Wilson et al 2009).

The red-bellied black snake is not a threatened species, but it could be a useful indicator of the health of the wetlands. Keyte (1994) reported a decline in black snake numbers in the Lower Gwydir Wetlands, but the reasons are unknown. However, frogs are its main food (Cogger 1996), and changes in frog populations might be a factor.

2.3.4 Frogs

Frogs, including their tadpole stages, are periodically very abundant and play an important role in the food web of Gwydir Wetlands. The inspection of regurgitated food under egret nests showed that tadpoles and frogs are a major food source for egret nestlings (McCosker 1999b).

Wilson et al (2009) reviewed reports by McCosker (1999b, 2001) and Courtney (1997) on frog surveys in the Gwydir Wetlands during floods from 1995–96 to 2000–01. These surveys used frog calls to identify species and assess their relative abundance, which allow areas to be rapidly surveyed but do not provide quantitative data on abundance of adults, or any information on the numbers of tadpoles.

Wilson et al (2009) listed 14 species occurring in Gwydir Wetlands, of which the spotted marsh frog was the most abundant.

There is no information about the current status of frog populations or about ways in which flows might be better managed to ensure the survival of frog populations. Information is needed on
The ecological assets and values of the Gwydir Wetlands

2.3.5 Woodland birds

In south-eastern Australia, many woodland bird species that were once common are now declining. Of 20 woodland bird species whose numbers have declined significantly since the 1980s (Reid 1999), 19 are found in Gwydir Wetlands. Four species, the brown treecreeper, diamond firetail, hooded robin and grey-crowned babbler, are listed as vulnerable under the TSC Act.

According to research undertaken in the NSW central Murray catchment, woodland bird abundance and species richness were highest in woodlands that extended for more than 100 hectares and were less than a kilometre from other patches of woodland that had good canopy cover and tree health, and many different shrubs, ground covers, leaf litter and logs (Oliver & Parker 2006). The researchers also found that when they compared river red gum woodlands and forests with woodlands and forests of white cypress pine, black box, yellow box, grey box, buloke and myall (boree), the river red gum woodlands and forests had the highest total bird abundance and species richness.

The main reasons that woodland bird species decline are loss of habitat, fragmentation of woodland vegetation, and simplification or degradation of the remaining woodland vegetation (Reid 1999). In south-eastern Australia, large intact woodlands that contain native shrubs and groundcover plants are now extremely rare, especially on fertile soils. In Gwydir Wetlands, woodlands on fertile soils are still important habitat for woodland birds.

2.3.6 Myall woodland

Myall or weeping myall woodland is listed as an EEC under both the TSC Act and the EPBC Act (DECCW 2009, DEWHA 2009b). In NSW, only 14% of its original area remains (Benson 2006). Little is known about its ecological requirements. It occurs on the outer floodplain or higher ground in the wetlands. Recent surveys show that in 2008, 8,289 hectares of weeping myall woodland remained in the Gingham and Lower Gwydir watercourses, and 4,671 hectares in the Mehi–Mallowa–Moomin systems (Bowen & Simpson 2010).

2.4 Location and condition of assets in Gwydir Wetlands

This section provides more detail on the location and condition of the assets and values identified in the previous sections, and discusses some water management issues affecting them.

2.4.1 Gingham Watercourse (north)

The Gingham system supports river red gum forest and woodland, coolibah woodland, water couch grassland, lignum shrubland, river cooba, cumbungi, spike rush meadows and native floodplain grasslands. It contains relatively deep and protected open water lagoons, including Gingham Waterhole, Pear Paddock Lagoon and Boyanga Waterhole. It provides habitat for critically important breeding colony sites and feeding habitat for colonially nesting waterbirds, and supports many other waterbird species. Colonies of egret, heron, cormorant, spoonbill, ibis and darter are among the largest ever recorded in Australia. On ‘Tillaloo’ in 1998, McCosker and Johnson counted 800 glossy ibis nests in river cooba. The Gingham system provides habitat for the threatened species brolga, magpie goose, Australian painted snipe, Australasian bittern, blue-billed duck and black-necked stork, and species listed under JAMBA, CAMBA and ROKAMBA.

River red gum woodlands in the area of the Gwydir Raft are in fair to poor condition, and extensively colonised by weeds. Coolibah woodlands, and water couch and marsh club-rush communities throughout the system, are declining in condition and area. The river cooba–lignum community is an important habitat for many species, especially nesting waterbirds. Lignum occurs in many areas of Gingham Watercourse as an understorey plant and as shrublands in some
areas. Lignum shrubland on ‘Lynworth’ and ‘Yarrol’, the site of the main colonially nesting waterbird breeding colony in Gwydir Wetlands, is critical nesting habitat for straw-necked ibis. McCosker and Duggin (1993) used aerial photographs from 1958, 1967 and 1985 to determine the distribution of wetland and floodplain vegetation on Gingham Watercourse. They recorded 42,000 hectares of river cooba–lignum shrubland, 13,500 hectares of semi-permanent wetland vegetation (water couch, spike rush, tussock rush and common reed) and 150,000 hectares of coolibah open woodland.

By 1993, none of the 42,000 hectares of river cooba–lignum community were in good condition. Lignum shrubs were reduced to clumps and river cooba showed signs of extreme stress. Of the 13,500 hectares of semi-permanent wetland communities on Gingham Watercourse, 1,000 hectares were in a healthy condition, 7,000 hectares were weed infested and of low vigour and the remaining 5,500 hectares were extensively infested with terrestrial weeds (McCosker & Duggin 1993). Recent surveys show that 3,753 hectares of semi-permanent wetland and 2,190 hectares of river cooba–lignum remained on Gingham Watercourse in 2008 (Bowen & Simpson 2010).

The declining area and condition of wetland vegetation is the most significant ecological issue for Gingham Watercourse (McCosker & Duggin 1993, Keyte 1994, Bowen & Simpson 2010). Much of the vegetation is infested with lippia, and water hyacinth could cause major problems in the channels and waterholes if it is not adequately controlled.

2.4.2 Lower Gwydir Watercourse (central)

The Lower Gwydir Watercourse extends from the Gwydir Raft through a number of remnant semi-permanent wetland areas and waterholes. Before the 1970s, most floodwaters and flows terminated in the intermittent and semi-permanent wetlands of the Lower Gwydir Watercourse (also known as the Big Leather Watercourse) and large floods inundated wetlands, woodlands and grasslands to the west (Keyte 1994). Some of the water that historically reached the wetlands of the Lower Gwydir Watercourse is now diverted into the Lower Gwydir Channel (South Arm) for irrigation, stock and domestic use (McCosker 2001).

The Lower Gwydir Watercourse supports river red gum woodland, river cooba, water couch marsh, marsh club-rush and common reed. It contains open-water lagoons and provides important feeding habitat for colonially nesting species, especially ibis and spoonbill. Under suitable conditions it supports threatened species including brolga, magpie goose, Australian painted snipe, Australasian bittern, blue-billed duck and black-necked stork, as well as species that are listed under JAMBA, CAMBA and ROKAMBA. The Lower Gwydir Watercourse contains the ‘Big Leather’ section of the Gwydir Wetlands Ramsar site on the property ‘Old Dromana’.
Photo 13 Ramsar site at ‘Old Dromana’, Lower Gwydir Watercourse (Photo: Simon Hunter).

Photo 14 Marsh club-rush on ‘Old Dromana’ (Photo: Daryl Albertson).
Wandoona (Troy) Waterhole is the most westerly standing water body that receives natural flows. The properties ‘Wandoona’ and ‘Old Dromana’ are declared wildlife refuges under the National Parks and Wildlife Act 1974 (Keyte 1994).

Areas of semi-permanent wetland vegetation remain on ‘Old Dromana’ (both inside and outside the Ramsar site) and on ‘Belmont’, ‘Wandoona’, and ‘Gallimbarry’ (formerly ‘Retreat’). These properties also contain some small remnants of floodplain wetland and dryland vegetation communities including coolibah open woodland, weeping myall open woodland, belah and native grasslands.

Wandoona (Troy) Waterhole has been identified as one of the last lagoons in the Lower Gwydir Watercourse to dry out during extended periods of no inflow. It therefore provides a valuable refuge for waterbirds and other wetland-dependent animals. Birds observed include brolga, intermediate egret, Australian pelican, straw-necked ibis and plumed whistling duck, while 35 pairs of magpie geese were observed nesting in February 2000.

2.4.3 Mehi, Mallowa and Moomin system (south)

The southern parts of Gwydir Wetlands include the Mehi River corridor and floodplain south of Gwydir Highway and the floodplains of Mallowa and Moomin creeks. Mallowa Creek is a distributary stream of Mehi River. It begins approximately 50 kilometres downstream of Moree and flows through alluvial plains for approximately 40 kilometres until it joins Moomin Creek.
The Mehi–Mallowa–Moomin floodplain supports coolibah–river red gum woodland as a riverine corridor, coolibah woodland, river cooba and lignum shrubland, and associations of these species. Small areas of water couch are found in frequently flooded areas in these communities (Bowen & Simpson 2010). The floodplain supports threatened species including brolga, magpie goose, Australian painted snipe, Australasian bittern and blue-billed duck as well as species that are listed under JAMBA, CAMBA and ROKAMBA.

The flows of this system have been changed, especially since the widening and leveeing of the Mehi River, and construction of Copeton Dam and the Gundare and Mallowa Creek regulators. These regulators and their operation now cause most water to go down Mehi River and reduce flows to the Mallowa system (Wyllie 2009).

**Mallowa Creek**

River regulation and development have affected the natural flow regime in Mallowa Creek and its catchment. This has decreased the frequency and volume of overland flows running into Mallowa Creek and the Cookabunna Watercourse from Mehi River. Distribution of flows is now concentrated in the north, and flooding of the lower Mallowa Creek is less frequent and reduced in extent. A flow to land holders for domestic and stock use along the length of Mallowa Creek is controlled by the Mallowa Regulator at Gundare (Wyllie 2009).

The Mallowa floodplain historically supported coolibah woodland, floodplain wetlands dominated by river cooba and lignum, and wet meadows dominated by spike rush and water couch. River red gum woodland and river cooba–lignum shrubland occur along the banks of Mallowa Creek on the eastern side of the Mallowa floodplain (Torrible et al 2009). Remnant coolibah–river cooba–lignum communities on the properties ‘Derra’ and ‘Valletta’ in the eastern Mallowa system and ‘Baroona’ and ‘Currotha’ in the west are important habitats. ‘Valletta’ has frontage to Mehi River and Mallowa Creek, and is the largest area of wetland and
woodland in the Mehi–Mallowa–Moomin system. ‘Baroona’, ‘Currotha’, ‘Burragillo’ and ‘Box Ridge’ support the largest remaining areas of lignum and native grasslands in this system. The lower parts of this system are generally in poor condition.

Since river regulation, much of the water that has sustained this system has come from flows from streams from the south-east such as Tycannah Creek.

**Mehi River**

This system is extensively modified with only a very narrow riverine corridor of coolibah–river red gum. However, this corridor is generally in good condition.

Whittakers Lagoon is an isolated wetland on the Mehi River floodplain, located 18 kilometres west of Moree on a travelling stock route adjacent to the Gwydir Highway. DECCW has identified the lagoon as a priority for restoration, due to its value as a refuge and breeding site for waterbirds, and for its Aboriginal cultural values.

**Moomin Creek**

This is a highly cultivated system with only a very narrow strip of riparian vegetation along the creek. This area supports coolibah woodland, lignum, river cooba and water couch (Bowen & Simpson 2010). Although much of the remaining native vegetation is in poor condition, it has landscape value as a corridor.

The wetlands in the Mehi–Mallowa–Moomin systems are degraded from lack of suitable flows and clearing, although the upper parts of all these systems are still in reasonable condition.
2.5 Ecological outcomes

The desired ecological outcomes from managing Gwydir Wetlands are restoration and maintenance of critical ecological processes and functions, especially habitats. If these outcomes are to be achieved, the assets identified in this section of the AEMP will need to be restored where possible and subsequently maintained to the greatest possible extent to support a diversity of species, habitat types and ecosystems.

The general water requirements of the ecological components that contribute to the character and values of the wetlands are known. For a given area it is possible to give a reasonable assessment of the volume of water needed to maintain wetland functions and processes that support the assets identified in this AEMP. It is also possible to assess the area and location of wetland that can be maintained with an available volume of water. Water availability and its implications for the wetlands are discussed in section 3.
3 Water management

3.1 Flow regime and flooding in the Lower Gwydir Valley

Flows to Gwydir Wetlands are linked to rainfall and runoff in the upper catchment. Major flooding most commonly occurs during January and February, although the size and frequency of these floods is highly variable. Winter floods also occur but tend to be smaller than those in summer. Between flooding, the core wetlands are replenished by small flows generated from localised rain in the catchments of tributaries downstream of Copeton Dam (Keyte 1994).

Pallamallawa lies downstream of the major tributaries of Gwydir River and above the off-take of the first major distributary, Mehi River. It is the gauging point at which the highest flows in Gwydir River are recorded (CSIRO 2007). The channel capacity here is greater than the combined capacity of the four major streams forming the distributary system – Gwydir River, Mehi River, Moomin Creek and Carole Creek. Thus even small rises at Pallamallawa cause overbank flow downstream (Pietsch 2006).

The distribution of flows in the wetlands depends on the magnitude of river flows, but is strongly influenced by how much water is stored in the soil from previous flooding and local rainfall, described as ‘antecedent conditions’ (Johnson 2005). Prolonged, severe drought depletes stores of water in soil, which means that larger flows are then required to inundate the wetlands.

With the exception of isolated pockets of high ground associated with sand dunes and remnant palaeochannels, the whole of the lower Gwydir floodplain is prone to flooding, which may last for weeks or months during large floods. However, most floods spill along a particular floodway rather than inundating the entire plain (Pietsch 2006).

The flow regime of Gwydir River has been substantially altered since the construction of Copeton Dam and the weirs and regulators that allow water to be diverted into the Mehi/Moomin system and Carole Creek to supply irrigators along those streams. Regulation of the river system has caused significant reduction in moderate to high flows in the lower Gwydir. It has also contributed to an increase in the average period between large flows, and a reduction in the average volume of large flows (CSIRO 2007).

3.2 Inundation mapping

The gauge at Yarraman Bridge measures inflow to the wetlands of the Gingham and Lower Gwydir watercourses. Flooding in these wetlands starts to occur when river flows at Yarraman are between 5,000 and 10,000 megalitres per day, depending on the amount of extraction between the gauge and the wetlands and the antecedent conditions in the channels and wetlands. Flows smaller than 5,000 megalitres per day may wet low lying areas adjacent to the channels (Powell et al 2008).

There is no simple relationship between river flows at Yarraman and flooding patterns in the downstream wetlands. Two flows of the same magnitude may inundate different areas, and seasonal inundation patterns are irregular. Therefore, to gain an understanding of flooding patterns and ecological responses, inundation needs to be measured directly, and monitored over a long period.

Thomas et al (in press) studied inundation extent and frequency in Gwydir Wetlands from 1988 when the first Landsat imagery was available to 2009. The methodology investigated both the presence of surface water and the response of vegetation to watering, as measuring surface water alone underestimates the extent of flooding.
Maps of the extent of inundation were prepared for 32 floods using 56 Landsat Thematic Mapper images from 1988–2009. Mapping is affected by cloud cover, so not all floods were mapped, including the flood in 1998. Mapping demonstrated that maximum flood extent was closely related to the total inflow volume and the duration of inflow to the Gingham–Lower Gwydir system (Thomas et al in press).

Inundation frequency strongly influences the distribution of vegetation communities of dryland river floodplains. Potential wetland areas and flow paths were identified using an inundation frequency index. The index measures the relative probability of flooding and was calculated by dividing the number of times a location was inundated by the total number of inundation maps. An average recurrence interval (ARI) (i.e. the average number of years between floods) was calculated for each zone of inundation probability (Thomas et al in press) (Figure 8).

Figure 8 indicates distinct differences in flooding frequency across the floodplain. It clearly delineates core wetland areas, as well as off-river storages. In the Lower Gwydir–Gingham region, inundation zones with a relatively high likelihood of flooding, depicted in blue on the map, resulted from small, high-frequency flows (ARI equal to or less than 0.5). These flows inundated relatively small areas (about 9,000 hectares) with at least 20% of those areas representing off-river storages which also appear as dark blue shapes on the map. The core
wetland areas of the Lower Gwydir–Gingham region were inundated by larger, moderate-frequency flows (ARI of 1–4 years). These areas (coloured red, pink or purple on the map) either sustain or have previously sustained semi-permanent wetland vegetation, including marsh club-rush, water couch–spike rush grasslands, cumbungi and common reed; some floodplain wetland vegetation such as river cooba, lignum and river red gum; and some coolibah woodland.

The zones that have the lowest probability of inundation (coloured yellow, green or orange on the map), mainly due to their higher elevation (Keyte 1994), are flooded by large flows that occur infrequently (ARI of 5–6 or 10–20 years) but inundate large areas of the Lower Gwydir–Gingham floodplain (between 40,000 and 150,000 hectares). These zones comprise coolibah and coolibah–black box woodlands, native grasslands, myall–rosewood woodlands and cultivated land.

Areas that are located on ridges or behind large levee banks were not inundated even by relatively large flows. These areas are shown as white on the map.

### 3.3 Water sharing

The potential for irrigation development in the Gwydir Valley was recognised in the 1930s. In 1936, several dam sites were identified, but it was not until 1976 that Copeton Dam was completed. With a storage capacity of 1,364,000 megalitres, Copeton Dam is one of the largest dams in NSW (Jeffcoat 1996).

With the construction of diversionary weirs and other regulatory works downstream, the annual usable regulated flow was estimated at 345,000 megalitres, considered sufficient to supply some 50,000 hectares of irrigation after providing for stock and domestic use and transmission losses (Pigram 2007).

By 1979, irrigation licences had been issued for an area of 86,000 hectares, and the Water Resources Commission (WRC) placed an embargo on applications for irrigation licences on streams served by Copeton Dam (Keyte 1994). In 1981, the WRC introduced a volumetric water allocation scheme (Water Resources Commission nd) which converted area-based water allocation to a specified volume for each licence.

The Gwydir WSP provides the framework for sharing the available water in the regulated rivers of the Gwydir catchment. It estimates the essential annual water requirements as:

- 4,245 megalitres for domestic and stock access licences
- 3,836 megalitres for local water utility access licences.

For other access licences, the remaining available water is allocated in proportion to the number of shares held under each licence, in the following order of priority:

- 19,293 unit shares for regulated river (high security) access licences
- 509,500 unit shares for regulated river (general security) access licences
- 178,000 unit shares for regulated river (supplementary water) access licences (NSW Government 2003).

The Gwydir WSP also establishes an environmental contingency allowance (ECA) to be held in Copeton Dam. The ECA account is credited with up to 45,000 megalitres a year (in proportion to general security available water determinations), but may accumulate up to 90,000 megalitres by carrying over unused allocations from one water year to the next. All the accumulated allocations may be used in one year (Department of Infrastructure, Planning and Natural Resources 2004).
Environmental water rules in the Gwydir WSP also protect a specified proportion of natural inflows to the Gingham and Lower Gwydir wetlands (Department of Infrastructure, Planning and Natural Resources 2004). These rules require:

- flows into the wetlands (i.e. past Yarraman Bridge) to be at least equal to the sum of inflows from three unregulated streams – Horton River, Myall Creek and Halls Creek – up to 500 megalitres per day
- 50% of tributary flows above 500 megalitres per day to be protected for the environment.

The environment’s share of water has been increased by the purchase of access licences from willing sellers since the commencement of the Gwydir WSP. Both the NSW and Australian governments have purchased water entitlements in the Gwydir Valley.

Water can also be recovered for environmental purposes by water-savings projects. It is estimated that the completion of the Gingham pipeline will secure an additional 958 megalitres of high security entitlement for the environment.

### 3.4 Water availability

The Gwydir WSP contains rules for the allocation of the available regulated water, which is estimated based on inflows to Copeton Dam. An available water determination (AWD) is made at the start of the water year (1 July) for each licence category. In most years, unless severe drought conditions occur, local water utilities and domestic and stock licences receive an allocation equal to 100% of their entitlement, and high security licences receive 1 megalitre per unit share.

The allocations to general security licences vary from year to year (up to a maximum of 1 megalitre per share) depending on the water held in Copeton Dam. If the initial AWD is less than 1 megalitre per share for any licence category, water availability is reviewed monthly or whenever significant dam inflows occur and an additional AWD is made if warranted (Department of Infrastructure, Planning and Natural Resources 2004).

Gwydir WSP accounting rules allow up to 1.5 megalitres per general security share to be accumulated in a water account. These rules provide some flexibility for both irrigators and environmental water holders to match available water to production or environmental management needs.

Both the ECA and most environmental water licences receive the same proportional allocation as general security licences. Therefore, the AWD, along with any carry over from the previous year, determines the amount of water available for the environment in the form of a secure volume that can be ordered for delivery as required. However, in most years unregulated tributary inflows downstream of Copeton Dam provide the greater volume of flows to the wetlands.

Descriptions of water availability and use are often given as averages. For example, the long-term average annual flow in the Gwydir Regulated River Water Source is 875,400 megalitres a year, and long-term average annual extractions are 388,000 megalitres a year, which means that on a long-term basis approximately 56% of yearly flows in the river are protected to maintain environmental health (NSW Government 2003). However, long-term averages, especially in a highly variable system such as Gwydir River, can be misleading when managing at the shorter time scales relevant to agricultural systems and river and wetland ecosystems.
The variability of Gwydir River is demonstrated by the three indicators of water availability:
1. total system flows, calculated as surface water flow into storages and from tributaries downstream of Copeton Dam
2. extractive use of licensed surface water shares in the regulated river
3. flows to the wetlands at Yarraman gauge (Figure 9).

**Figure 9** Water flows and use in the Gwydir Valley (data provided by State Water).

*Note:* Extractive use includes licensed surface water extraction from the regulated river. It does not include extractions from unregulated tributaries, groundwater or other sources. Total system flows are greater than the combined total of extractions and flows to the wetlands because of operational losses and extensive floodplain and distributary system flows during high flows.

A large proportion of total flow occurs in relatively few years, and many years have extremely low flows. Extended periods of low flows highlight the risk of planning based on long-term averages. The wetlands experienced low inflows during the 11 years from 1984–85 to 1994–95. The eight years since 2001 have also been years of low inflows to the wetlands and during both these periods clearing and floodplain development have affected the area and condition of the wetlands.

Another indicator of water availability is the AWD for general security licences, which affects both extractive water users and available environmental water. Figure 10 shows the annual AWD since 1980, with averages calculated for decades as well as for the period from 2001–02 to 2008–09, which spans the recent dry period in terms of water allocations.
3.5 Climate variability, climate change and the Gwydir Valley

Modelling for the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Murray–Darling Basin Sustainable Yields Project indicates that the recent climate (1997–2006) was not statistically different to long-term average values (CSIRO 2007). It also indicates that future runoff in the Gwydir Valley is more likely to decrease than increase. Forecast scenarios for 2030, presented by CSIRO, range from extreme wet to extreme dry, with a mid-range ‘best estimate’, as follows:

- extreme wet – 34% increase in surface water availability, 20% increase in total diversions, and 33% increase in end-of-system flows
- extreme dry – 29% decrease in surface water availability, 25% decrease in total diversions, and 27% decrease in end-of-system flows
- best estimate – 10% decrease in surface water availability, 8% decrease in total diversions, and 6% decrease in end-of-system flows.

Flows to Gwydir Wetlands have been affected by water resource development, and may be affected further by climate change. Under the best estimate of the 2030 climate, the average annual flooding volume to the wetlands would fall by 20% relative to current conditions, to be less than half the pre-development event volume. This change would be likely to have additional effects on vegetation condition and structure and affect waterbird breeding (CSIRO 2007).

Regional climate change modelling and prediction by DECCW (2010) indicates that wetlands in north-west NSW, including Gwydir Wetlands, are at risk from increased temperatures, increased fire frequency and minor changes in the water regime. The report also notes that if there is less frequent flooding colonial nesting water bird breeding would lessen. Extended hot periods are likely to cause heat stress and death in birds.
3.6 Water requirements of ecological assets

Wetland plants and animals have different tolerances to environmental conditions. For example, each plant species requires a particular range of soil types, climate variables and water regimes. These individual differences, interacting with complex habitat patterns, create the high biodiversity found in wetlands.

A common approach to maintaining the biodiversity of wetland ecosystems is to mimic natural inundation as closely as possible. However, the situation in Gwydir Wetlands is complicated by the presence of two highly invasive exotic weeds: water hyacinth and lippia. Under these circumstances, wetland watering regimes must aim to minimise the impact of these weeds by reducing their growth and reproduction rate, thus giving the native wetland plants as much competitive advantage as possible.

The optimal watering regime will vary for different wetland management objectives. For example, livestock production can be maximised by providing short (10–30 days) annual flooding during late spring or summer (McCosker & Duggin 1993). Where lippia is established, flooding for longer than 30 days, and to a deeper level, may help native species to compete more successfully against this weed.

On the other hand, restoring natural vegetation communities and maintaining them in good condition requires the frequency and duration of flooding to be varied according to the characteristics of key plant species (McCosker & Duggin 1993). While not all species’ requirements are known, there is enough information to make informed decisions to guide watering strategies.

Based on the best available information (Bowen & Simpson 2010), environmental watering objectives may be set for two vegetation types:

- **water couch–spike rush** – inundate for at least 6 months of the year, at least 8 years in 10
- **lignum shrubland (associated with river cooba or coolibah)** – inundate for at least 3 months between September and March, at least 5 years in 10.

Marsh club-rush is also known to require frequent watering, but current knowledge is insufficient to set a specific objective. For other vegetation types such as coolabah—river red gum associations, setting of objectives for environmental water management is less relevant as flooding of these areas cannot be effectively managed with current delivery constraints.

Large-scale waterbird breeding depends on flooding of nesting sites for 4–5 months. Suitable conditions occur irregularly and depend on natural flooding, but the environmental water available at the time (ECA, licensed holdings and tributary inflows) can be used to maintain the desired extent and depth of floodwaters to give the chicks the best chance of survival.

3.7 Providing water to Gwydir Wetlands

Inflows from the unregulated tributaries are essential for maintaining the general health of Gwydir Wetlands. However, the environmental share of regulated water held in Copeton Dam, as ECA and environmental licences, can be used to achieve more specific management objectives, including:

- extending natural flooding to increase the chances of successful waterbird breeding
- maintaining refuges for aquatic organisms during droughts
- providing favourable conditions for native fish breeding and movement.

It is therefore important to make the most effective use of this limited resource.
The volume of water from regulated sources needed to inundate a specific area of the wetlands for a specific purpose depends on many factors, including the area of the wetland to be watered, the time of year, recent rainfall in the wetlands, the volume of unregulated flows, flow history and the desired duration and extent of flooding. The different frequencies of flooding required by different types of wetland vegetation add further complexity to calculations.

Several attempts have been made to calculate the volumes of water needed to maintain identified values, such as an area of semi-permanent wetland vegetation or breeding of colonially nesting waterbirds (Bennett & Green 1993, McCosker & Duggin 1993, McCosker 1994a, Keyte 1994, Rea 1994, Johnson 2001). The estimates varied depending on whether conditions were wet or dry, the season, and the area and duration of flooding.

Bennett and Green (1993) estimated that 100,000 megalitres for one month at Yarraman Bridge was needed to flood 20,000 hectares of semi-permanent wetland, amounting to about 5 megalitres per hectare. However, estimates did not deal with floods of longer duration. McCosker and Duggin (1993) and McCosker (1994a) estimated volumes needed to inundate 13,500 and 42,000 hectares for one to three months, proposing volumes of between 3.7 and 5.1 megalitres per hectare in cool, wet conditions, and 8.4 to 17.4 megalitres per hectare in hot, dry conditions. Keyte (1994) estimated that volumes of between 2 and 8 megalitres per hectare were needed to inundate 3,000 and 8,000 hectares for one month.

Johnson (2001) focussed on the volume of regulated general security water needed to be provided from Copeton Dam to flood 28,000 hectares of semi-permanent wetland, proposing 170,000 megalitres of regulated share, provided at 48% reliability, delivering an average of 81,600 megalitres a year. Assuming that about as much water again will be available from unregulated flows, this volume suggests about 4 megalitres per hectare to maintain 28,000 hectares of identified wetland, or 6 megalitres per hectare if twice as much unregulated flow as regulated flow occurs.

These estimates assume that some values are relatively stable, particularly the area of remaining wetland, and climate, weather and water availability. However, recent years have shown these factors to be highly variable, with direct effects on water requirements at specific times, and on the amount of water available for the environment.

### 3.8 Scenarios of water availability for the environment

Another way to consider the water needs of wetlands is to find out how much of the wetland can be restored, protected and maintained with a given volume of water. This approach estimates the amount of water required to maintain specific ecological values, calculates the volume of water likely to be available under different scenarios and estimates how many hectares of wetland can be maintained by a certain volume of water.

As at 30 June 2010, the total regulated environmental share available for use in the Gwydir Valley was equivalent to around 150,500 general security unit shares, consisting of 45,000 megalitres of ECA provided in the Gwydir WSP, over 17,000 unit shares of general security entitlement held by the NSW Government and over 88,500 unit shares of general security entitlement held by the Commonwealth Environmental Water Holder (CEWH). This amount did not include the 440 unit shares of NSW-held supplementary access entitlement and 19,000 unit shares of supplementary access entitlement held by the CEWH.

Four scenarios of water availability were selected to illustrate ways in which the approach described in the first paragraph of this section could be used (Table 5). The scenarios use AWDs for general security access licences and the environmental water allowance as an indicator of water availability, and are based on findings of the CSIRO Sustainable Yield Project (CSIRO 2007), long-term average conditions, and the history of allocations to general security licences.

The scenarios were chosen to reflect a range of likely water allocations. A scenario of 13.5% allocation is therefore included, as this was average allocation over the recent dry period from 2001–02 to 2008–09 (CSIRO 2007, State Water Corporation 2009).

The scenarios also take account of inflows from unregulated tributaries. A considerable volume of these flows are protected under the Gwydir WSP, so can be expected to reach the wetlands in most years. Table 5 includes three possibilities considered realistic for Gwydir Wetlands:

1. unregulated inflows equal to the volume of regulated environmental flow
2. twice as much unregulated as regulated flow
3. four times as much unregulated as regulated flow.

Table 5 Approximate area of wetland estimated to be supported under various scenarios for water availability, based on 150,500 megalitres of general security share.

<table>
<thead>
<tr>
<th>Percentage of AWD for general security and the environment</th>
<th>Volume per hectare required (megalitres)</th>
<th>Regulated environmental share (megalitres)</th>
<th>Hectares maintained with equal volume of unregulated flow</th>
<th>Hectares maintained with 2 x volume of unregulated flow</th>
<th>Hectares maintained with 4 x volume of unregulated flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>5</td>
<td>90,300</td>
<td>36,100</td>
<td>54,200</td>
<td>90,300</td>
</tr>
<tr>
<td>40</td>
<td>7</td>
<td>60,200</td>
<td>17,200</td>
<td>25,800</td>
<td>43,000</td>
</tr>
<tr>
<td>20</td>
<td>9</td>
<td>30,100</td>
<td>6,700</td>
<td>10,000</td>
<td>16,700</td>
</tr>
<tr>
<td>13.5</td>
<td>10</td>
<td>20,320</td>
<td>4,100</td>
<td>6,100</td>
<td>10,200</td>
</tr>
</tbody>
</table>

3.8.1 Scenario 1: 60% allocation to general security access licences and the environmental allowance

Under the relatively wet conditions represented by this scenario, the current regulated environmental share of 150,500 megalitres will provide about 90,300 megalitres of available regulated water.

Assuming about 5 megalitres per hectare is needed under these conditions, and that unregulated flows contribute equal, double or four times the regulated volume, it is possible that functions and habitats could be maintained in an area of between 36,100 and 90,300 hectares.
3.8.2 Scenario 2: 40% allocation to general security access licences and the environmental allowance

This scenario is close to the modelled historical average AWD for general security licences, under the rules of the Gwydir WSP. Under these conditions the current regulated environmental share of 150,500 megalitres will provide about 60,200 megalitres of available regulated water.

Assuming about 7 megalitres per hectare is needed under these conditions, and that there are contributions from unregulated flows of equal, double or four times this volume, it is possible that functions and habitats could be maintained in an area of between 17,200 and 43,000 hectares.

3.8.3 Scenario 3: 20% allocation to general security access licences and the environmental allowance

Under these conditions, the current regulated environmental share of 150,500 megalitres will provide about 30,100 megalitres of available regulated water.

Assuming about 9 megalitres per hectare is needed under these conditions, and that there are contributions from unregulated flows of equal, double or four times this volume, it is possible that functions and habitats could be maintained in an area of between 6,700 and 16,700 hectares.

3.8.4 Scenario 4: 13.5% allocation to general security access licences and the environmental allowance

Under the conditions prevailing between 2001–02 and 2008–09, with general security allocations averaging 13.5%, the current regulated environmental share of 150,500 megalitres would provide about 20,320 megalitres of environmental water.

Assuming about 10 megalitres per hectare is needed under these conditions, and that there are contributions from unregulated flows of equal, double or four times this volume, it is possible that functions and habitats could be maintained in an area of between 4,100 and 10,200 hectares.

3.9 Implications for managing environmental water

The above scenarios are based on the regulated environmental water share at the time of writing this AEMP. Additional water recovered under existing government initiatives will add to the environmental share and increase the area that can be maintained under each scenario. Greater volumes of unregulated flows would also increase the area of wetland that can be maintained.

The scenarios suggest that the remaining area of semi-permanent wetland in Gwydir Wetlands can be maintained during wetter than average periods with the current share of water for the environment. They also demonstrate the necessity of setting priorities for watering during drier periods.

Environmental watering strategies must attempt to match the duration and frequency of wetland inundation to the ecological requirements of wetland vegetation communities and target fauna. Long flows that are too infrequent and frequent flows that are too short are both ineffective in maintaining wetland vegetation. Available water should not be distributed over too large an area, as this would lead to continuing decline of the wetlands.
More accurate estimates are needed of the volumes required to provide suitable flow regimes in different parts of the wetlands under a range of climatic conditions. Digital elevation and hydrodynamic models being developed will assist environmental flow managers to narrow the range of volumes required for different climate sequences.

Small flows to specific areas of the wetlands can be managed under dry conditions, although for some areas this may require new or modified infrastructure. Determining priorities for wetland areas on both public and private land will involve considering the ecological importance of each area and its importance for the character of Gwydir Wetlands, legislative status, proximity to water supply and ease of delivery, and likelihood of achieving ecological outcomes and objectives.

Land management (e.g. grazing regimes, weed control) in different areas will have a bearing on the ecological benefits achieved by watering and is likely to be an important consideration in developing watering priorities, especially in a drying climate.

Under the scenarios outlined above, floodplain wetland vegetation, except for some areas on the fringes of semi-permanent wetlands, will rarely receive managed flows from allocated shares. In most cases, inundation of these communities will rely on unregulated flows.

3.10 Structures for managing water in Gwydir Wetlands

Structures including banks, weirs, regulators and diversion channels in Gwydir Wetlands are used for flood protection, erosion control and water supply. An important task for government agencies and land holders is to clarify the role, effectiveness and status of the structures in the wetlands and determine their effects on flows.

Three initiatives will contribute to this outcome:
1. the Gingham pipeline and restoration project
2. the licensing of floodplain harvesting activities
3. the development of a valley-wide floodplain management plan for the lower Gwydir valley.

3.11 Measurement of water extraction

The measurement of water extractions, including the reliability of meters, has been a matter of concern since the introduction of volumetric allocations (Minister for Water Resources 1986, Armstead & Johnson 1993). Measurement of all water extractions, including regulated river allocations, groundwater use, unregulated flows, and floodplain harvesting, must be as accurate and reliable as possible. A draft national metering standard framework has been developed, and aims to provide an acceptable level of confidence whereby non-urban metering across Australia has a maximum permissible error limit, in the field, of plus or minus 5%. Each state will develop a metering implementation plan.

The Australian Government has made an in-principle agreement to provide up to $90 million to NSW under its Water for the Future program, subject to due diligence assessment, to replace existing customer-owned meters on regulated rivers. Meters will be owned by State Water and larger meters may be connected by telemetry.
4 Aquatic habitat management and restoration

Possible reasons for the decline in native fish in Gwydir River, as in other highly regulated rivers, include reduced water quality, flow alteration, the introduction of pest species, over-fishing and barriers to movement (Murray–Darling Basin Commission 2003). There is also concern about fish mortality due to downstream passage through weirs and extraction via pumps or other irrigation infrastructure (Department of Primary Industries 2005, 2007). The quality of aquatic habitat is critical for maintaining the diversity of aquatic plants and animals. Refuge pools that rarely dry out enable native fish to survive through dry periods and subsequently recolonise other areas. Aquatic habitat and aquatic ecosystems are often degraded by channelisation, the removal of woody debris to improve the efficiency of water delivery, and degradation of riparian vegetation (Murray–Darling Basin Commission 2003).

4.1 Water quality

Water quality is an important factor in the suitability of aquatic habitat for fish and other aquatic organisms (Spencer et al 2010). The National Water Quality Management Strategy (NWQMS) includes policies, a process and guidelines for improving water quality in Australia’s waterways. The Australian and New Zealand guidelines for fresh and marine water quality (ANZECC & ARMCANZ 2000) are the key water quality guidelines.

The NSW Government has endorsed the community’s environmental values for water, known as ‘water quality objectives’ (WQOs). WQOs were developed for each catchment in NSW in line with the national guidelines. Those for Gwydir River may be found at www.environment.nsw.gov.au/ieo/Gwydir. The WQO for protecting aquatic ecosystems is particularly relevant to this AEMP and should help guide management decisions.

The catchment action plan (CAP) developed by the Border Rivers–Gwydir Catchment Management Authority (BRG CMA) contains six water-related management targets. These aim to maintain or improve water quality in all sub-catchments, reduce streambank erosion in priority locations, improve riparian vegetation in priority locations, maintain or improve native aquatic biodiversity in priority locations, reduce river salinity, and maintain or improve the condition of priority wetlands including Gwydir Wetlands. The management actions that BRG CMA is implementing to achieve these targets will improve water quality and therefore the health of aquatic habitats in Gwydir Wetlands.

The Australian Government’s Murray–Darling Basin Plan will include a water quality and salinity management plan that will set water quality and salinity objectives and targets for the basin’s water resources. The water quality and salinity management plan will refer to the NWQMS, and targets set in the plan will be reviewed every five years (Murray–Darling Basin Authority 2008).

Monitoring in the Gwydir catchment has revealed a general improvement in water quality (Mawhinney 2005). Between 1991 and 2004, the amount of pesticides found in waterways decreased significantly, which may be attributed to restrictions on their use and best management practices (Mawhinney 2005, Wilson 2009).

Pesticides are still occasionally detected in the Gwydir catchment such as the widely used herbicide, atrazine, although levels are typically well below the national guideline levels (Mawhinney 2005, Wilson 2009). Any high concentrations of pesticides would be addressed through legislation such as the Pesticides Act 1999 and the Protection of the Environment Operations Act 1997.
Wilson et al (2009) found high nutrient and turbidity levels in waterways of Gwydir Wetlands. While flow releases for environmental purposes appeared to reduce nutrient concentrations through dilution, total nutrient and sediment loads increased due to higher discharges. Spencer et al (2010) recommended revegetation of riparian areas and restriction of stock access to waterways as strategies to improve water quality.

Water in large dams tends to form layers of different temperatures, with the bottom layer up to 15 degrees Celsius cooler than the surface layer. Cold water pollution affects water quality for town water supplies, damages aquatic communities downstream of the dam and may eliminate native fish populations if temperature thresholds to initiate breeding are not reached. The effects of cold water releases from Copeton Dam have been recorded more than 250 kilometres downstream of the dam (McCosker et al 1999). The NSW Government identified Copeton Dam as one of the dams in NSW likely to cause severe cold water pollution (Preece 2004) and has adopted a strategy to address pollution impacts from large dams over time.

State Water will address the issue of cold water pollution under the terms of the Gwydir Water Supply Work Approval issued by the NSW Office of Water. The work approval requires State Water to ‘develop options, including a preferred option, for the mitigation of cold water pollution from Copeton Dam for consideration and approval by the Minister by July 2012’. No specific actions regarding cold water pollution are proposed in this AEMP.

4.2 Impacts of instream structures and extraction on fish

Native fish may travel long distances to find food and complete their life cycles. Structures such as dams, weirs, culverts and river crossings form barriers that prevent fish moving through the river (Murray–Darling Basin Commission 2003). Fish attempting to migrate upstream may become easy prey for birds as they gather downstream of barriers.

Fish larvae are usually poor swimmers, and travel with currents. Weirs cause injury or death of larval golden perch and Murray cod, as well as small-bodied native species as they move downstream (Baumgartner et al 2006, 2009).

The weirs are of two designs:
1. overshot, whereby the water passes over a crest

2. undershot, whereby the water passes under a gate.

Fish can be injured as they pass over the crest and fall to the bottom of the weir, or by turbulence and pressure changes as water passes under the gate. Tareelaroi Weir is an example of an undershot design that is known to cause the highest mortality among larval and juvenile fish (Department of Primary Industries 2007).
Fish can also be captured by infrastructure used to extract water from rivers. Most irrigation occurs during the warmer months and coincides with spawning and migration, and there is evidence that many fish are being extracted from rivers through channels or pumps (Baumgartner et al 2007). Even if the fish are not injured, it is unlikely they would be able to return to the river as used irrigation water is not permitted to be returned to waterways. Industry & Investment NSW (Fisheries), the Australian Cotton CRC and Murrumbidgee Irrigation are undertaking collaborative research into this problem (DPI 2005).

4.3 Degradation of riparian zone and in-stream habitat

Industry & Investment NSW is the lead agency for statewide programs aimed at restoring aquatic habitat and the riparian zone of river systems. Healthy riparian vegetation is important for river health because of its role in stabilising river banks and reducing water temperature fluctuations by shading, and as a source of large woody debris (as fish habitat) and fine organic matter which is the base of aquatic food chains.

One ongoing project involving the University of New England and the BRG CMA involves identifying important fish refuge areas in inland river systems. Waterholes and lagoons which retain water through long dry periods allow local fish populations to survive and recolonise other aquatic habitats when conditions improve.
5 Land management

Land capability investigations carried out during the 1960s indicated that the areas most suitable for irrigated agriculture in the Gwydir Valley were in the vicinity of Moree and west in Gwydir Wetlands. Irrigation in this area increased rapidly after the completion of Copeton Dam in 1976. However, flooding of the wetlands was an impediment to irrigation development, and ‘could render the land both inaccessible and unproductive for several months at a time’ (Department of Water Resources nd). Several flood management schemes were developed for the wetlands to prevent flooding of irrigation land.

Clearing, cultivation, grazing, fire, and obstruction of floodways by diversion banks and channels fragmented the wetlands, leaving narrow corridors of vegetation along flow lines and disconnected vegetation remnants.

5.1 Clearing

The vegetation communities most affected by clearing in Gwydir Wetlands are river cooba and lignum shrublands and coolibah and black box woodlands. Semi-permanent wetlands have also been lost because inundation is less frequent and large areas have been infested by lippia. These are challenging issues for farmers working to progress agricultural productivity on their lands. DECCW and BRG CMA are undertaking vegetation awareness campaigns and incentive programs to begin restoring parts of the wetlands.

Research undertaken for this AEMP found the extent of native vegetation in Gwydir Wetlands and on the floodplain between 1996 and 2008 had been reduced due to clearing (Bowen & Simpson 2010). On the Gingham and Lower Gwydir floodplains, native vegetation had been reduced by more than 75,000 hectares, declining from 61% in 1996 to 38% in 2008 of the total land area. The communities most heavily cleared included coolibah–black box woodlands, weeping myall open woodland and native grasslands.

In 2008, about 71,000 hectares of coolibah–black box remained in the Gingham and Lower Gwydir area, which is 28% of the estimated 250,000 hectares that occurred prior to regulation of the Gwydir River in the 1970s. The area of weeping myall open woodland had been reduced by 33% from about 12,400 hectares in 1996 to about 8,300 hectares in 2008 (Bowen & Simpson 2010).

In the mapped section of the southern Gwydir Wetlands (Mehi–Mallowa–Moomin creeks and their floodplains) about 76,000 hectares or 64% of the total land area of native vegetation was cleared by 2008. Most clearing had been of floodplain woodland communities, primarily coolibah–black box woodland (coolibah open woodland, coolibah–river cooba–lignum) and weeping myall open woodland. In the Mehi–Mallowa–Moomin systems, about 21,000 hectares of coolibah–black box woodland (consisting of about 19,500 hectares of coolibah open woodland and 1,500 hectares of coolibah–river cooba–lignum open woodlands) remained in 2008. Areas formerly supporting semi-permanent and inner floodplain wetland communities, primarily water couch grasslands and river cooba–lignum shrublands, had been cleared.

Between 1996 and 2008, the area of semi-permanent wetland communities in the Gingham and Lower Gwydir watercourses declined by 51%, from about 14,000 to 6,800 hectares. Water couch grassland and marsh club-rush communities declined in area and condition between 1996 and 2008. In 2008, only 9% of the 1974 area of marsh club-rush remained and less than 10% of these remnants were contained in the Gwydir Wetlands Ramsar Site.
In the southern Gwydir Wetlands (Mehi, Mallowa and Moomin floodplains), about 6,400 hectares of semi-permanent and floodplain wetland communities, or 5% of the floodplain area, remained in 2008. These areas exist as narrow riverine corridors and as small fragmented floodplain channel remnants, particularly in the western half of the Moomin Creek floodplain and the eastern part of the Mallowa floodplain. These isolated remnants remain under threat from insufficient inundation, colonisation by terrestrial and exotic species such as lippia, and clearing (Bowen & Simpson 2010).

In the Gwydir floodplain most clearing of native vegetation before 2005 was concentrated in the fertile western alluvial plains. In 2005–08, proportionally more clearing occurred in areas of non-woody semi-permanent and floodplain vegetation habitat in the lower lying areas of the floodplain (Figure 11). Reduced flooding has caused degradation of semi-permanent and floodplain wetlands and led to the clearing of semi-permanent wetland communities for cropping and management of exotic species such as lippia and water hyacinth (Bowen & Simpson 2010).

**Figure 11** Clearing of the floodplain of the Gwydir River below Moree: 1996–2008 (Bowen & Simpson 2010).
5.2 Grazing

Flows to Gwydir Wetlands have always been variable. However, there has been a major alteration to wetland hydrology since river regulation, and the recent dry period is as severe as any drought on record. Under these conditions, managing the effects of grazing on wetlands has become more important (Holmes et al 2009). Researchers from the University of New England investigated the effects of grazing on five aspects of wetland condition: vegetation composition, the soil seedbank, soil chemistry, water quality and aquatic invertebrates (Wilson et al 2008).

Long-term grazing exclusion plots established in 1994 were used to assess the effects of grazing by both domestic stock and native herbivores on four different wetland plant communities. Results indicated the major cause of vegetation change was flow regime and that grazing had a relatively small impact (Wilson et al 2008). Grazing by cattle was important in maintaining the dominance of water couch in grassy wetland communities. In contrast, grazing disturbance created openings for other, mainly native species in a marsh club-rush wetland. Although grazing increased species diversity at the site, that is not necessarily a desirable outcome for this community. At drier sites where inundation was less frequent, grazing showed only minor detectable impacts on community composition (Wilson et al 2008). Inundation at these sites was the factor most capable of causing changes in condition (Wilson et al 2008).

To best determine the ways in which grazing affects a wetland, the system’s resilience needs to be studied. A species-rich and abundant seedbank is vital for a wetland plant community to cope with variable environmental conditions and inundation patterns. The soil seedbank study from the wetlands demonstrated that the seedbank was abundant and diverse, with a broad range of wetland and terrestrial species. Species richness in the seedbank was significantly higher in plots where cattle (but not native herbivores) were excluded.

These findings indicate that plant communities are showing considerable resilience to the disturbance caused by grazing of domestic stock and other herbivores. The benefits of grazing need to be balanced with the needs of plant species to reach maturity and set seed, and thrive in the long-term (Wilson et al 2008).

If grazing is reduced, more species can complete their lifecycle and contribute seed to the seedbank. To facilitate this, programs that provide an incentive for land holders to fence wetland paddocks into smaller units should be considered. Smaller paddocks provide the opportunity to protect sections of the wetland, especially during periods following inundation, allow plants to set seed, and help maintain the diversity of wetland plant communities (Wilson et al 2008).

In general, stocking rates in Gwydir Wetlands have been low compared to other parts of the Murray–Darling Basin due to prevailing drought conditions and the invasive species lippia, which has reduced the carrying capacity of many parts of the floodplain by up to 50%, especially where the water is shallow (Wilson et al 2008). This reduction in stocking rate has probably contributed to a reduction in the impact of grazing on many wetland sites (Wilson et al 2008).

Industry & Investment NSW, in conjunction with the University of New England, has developed grazing guidelines for Gwydir Wetlands and Macquarie Marshes. Scientific knowledge was reviewed and graziers in Gwydir Wetlands and Macquarie Marshes contributed specific issues and management practices. The guidelines advise on managing grazing in the wetlands to protect the system and provide for sustainable grazing enterprises (Holmes et al 2009).
5.3 Weeds and pest animals

5.3.1 Weeds

The Gwydir Wetlands are a highly disturbed system and are infested with many weeds (McCosker 1999a, 1999b, Bowen & Simpson 2010). These include lippia, water hyacinth, African boxthorn, prickly pear, noogoora burr, Bathurst burr, variegated thistle, cobbler's pegs and wild turnip (Bowen & Simpson 2010). Some areas are dominated by mimosa bush, black roly-poly and soft roly-poly (Bowen & Simpson 2010). The species that cause the most concern are lippia and water hyacinth.

Lippia

Lippia (Phyla canescens) is widespread in riparian and wetland areas of the Murray–Darling Basin, infesting about 5,300,000 hectares, and degrading agricultural land and natural ecosystems (McCosker 1994b, 1999a, Crawford 2008). Most of the wetland and floodplain vegetation communities in the Gwydir Wetlands are infested with lippia (Bowen & Simpson 2010). Lippia can germinate in a wide range of conditions, grow quickly, flower early, produce many seeds, reproduce vegetatively and compete strongly with native species. It can produce a dense mat of growth, spread rapidly, remain dormant when moisture is low, and survive prolonged inundation.

Research in the Gwydir Wetlands showed that water couch grew more prolifically than lippia under flooding, and that lippia was less able to tolerate deeper water. When covered with 20 centimetres of water, lippia plants remained alive but produced very little new growth (Wilson et al 2008). Wetlands susceptible to infestation by lippia should be flooded regularly and for long enough to allow native wetland plants to compete (McCosker 1994b, 1999a, 1999b, 2001; Crawford 2008).

Some lippia infestations can be managed by herbicides, but these practices encourage perennial pastures, clearing, cultivating and cropping. To control lippia and increase the productivity of pastures, land holders are sowing existing native pastures with introduced perennial species such as bambatsi panic. This may result in substantial alteration to some wetland areas. If areas of dense lippia continue to expand, the replacement of native pastures with introduced species may become increasingly common (Wilson et al 2008).

Water hyacinth

Water hyacinth (Eichhornia crassipes) is a declared Class 2 noxious weed. A native of South America, it has been described as the world’s worst aquatic weed due to its ability to rapidly cover whole waterways. It has been in Australia since the 1890s and is now distributed along the east coast from Kiama to Cape York Peninsula (Burton et al 2010). In the Gwydir region, water hyacinth was first confirmed in the Gingham Watercourse in 1955 and major floods in the 1970s caused it to spread over a wide area. By 1976, over 7,000 hectares were infested (SPCC 1981).
Water hyacinth can be spread by high flows that break up infestations and carry whole plants to new areas, or by seeds carried in water or mud (Burton et al 2010). The plant has a number of growth forms and can adapt to widely different growing conditions, which makes it very difficult to eradicate (SPCC 1978).

In 1976, an inter-departmental project team was established to conduct an integrated water hyacinth control program, including researching the ecology of species in Gwydir Wetlands (McCosker & Duggin 1993). It became apparent that the soil seedbank was the key to reducing the extent of the infestation.

The management strategy relied on manipulating the hydrology of the wetland. Natural off-takes from Gwydir Pool were blocked with banks to prevent flows and minor floods from entering the Gingham Watercourse, which was cleared of obstructions to a width of 50 metres to help drain the weed-infested areas. During the control period, flows were diverted down Mehi River to dry out the Gingham Watercourse. After the main infestation was controlled by desiccation, the watercourse was periodically flooded to promote germination of the seedbank. Young plants were killed before they could flower with herbicides or by re-drying the area. The program reduced the infestation to a manageable area that is now regularly monitored and treated as necessary.

Despite these efforts, water hyacinth remains a major threat to the wetlands and the risk of spread into the Barwon River and beyond remains an important consideration (Torrible et al 2008).

### 5.3.2 Feral animals

Pest species in Gwydir Wetlands include pigs, foxes and alien species of fish. Livestock health and pest authorities and land holders have long-standing control programs for pigs and foxes.

Gwydir Wetlands are a known ‘hotspot’ for breeding carp (Gilligan et al 2008), and ongoing control measures are required. The *NSW draft control plan for the noxious fish carp (Cyprinus carpio)* was released for public comment in November 2009 (Industry & Investment NSW 2009). Submissions received have been included in the revised plan where appropriate, and the *NSW control plan for the noxious fish carp (Cyprinus carpio)* was released in December 2010. The final plan describes the most up-to-date information about the biology and impacts of this species and outlines what is being done – or should be done – to stop further spread of carp, control the size of carp populations, better understand the species and increase the understanding and involvement of the community.
6 Aboriginal cultural values of Gwydir Wetlands

6.1 Introduction

Gwydir Wetlands lie within the traditional country of the Gamilaroi people. Gamilaroi country covers a large area of north-western NSW, including most of the length of Gwydir River. Aboriginal cultural values relate to the deep history of Aboriginal interaction with the wetlands, and the values, interests and aspirations of contemporary Gamilaroi and other Aboriginal communities who have custodial relationships to the wetlands. These communities have a connectedness to the landscape and a sense of responsibility to care for this important part of their Country.

However, over the past two centuries non-Aboriginal settlement has made it increasingly difficult, if not impossible, for Aboriginal people to exercise custodial duties. Enhancing Aboriginal cultural values involves strengthening the relationships of Aboriginal communities with Gwydir Wetlands.

There is strong alignment between protecting the cultural and natural values of the wetlands. However, there are significant differences as well, including differences in emphasis for on-ground protection. For instance, the land in Gwydir Wetlands is an important part of the Aboriginal cultural landscape, containing culturally important vegetation communities and a range of important cultural heritage sites. These areas are a priority for conservation.

6.2 History of Aboriginal settlement and occupation of Gwydir Wetlands

6.2.1 Traditional settlement of Gwydir Wetlands

For Aboriginal people, the wetlands, riverine forests, grasslands and elevated sandy ridges of the Lower Gwydir floodplain were rich assets to complement the vast swathe of Country on the plains and ranges.

The wetland landscape was at the centre of Aboriginal culture and spirituality. Aboriginal people were connected to the natural world through totem and kinship relationships, which established relationships of mutual care and responsibility. The landscape, particular places in the landscape, and specific plants and animals, were all animated through events in the Dreamtime. The creation spirits still inhabited the landscape, often resting in large waterholes or in the form of animals.

Bora (initiation) ceremonies occurred to the west of the core semi-permanent wetland areas, with an iconic Bora site at Collymungle. The ecologically rich and reliable wetland environments provided the reliable setting and quantity of resources capable of sustaining Bora ceremonies (Bowdler 2005). The wetlands landscape was a ‘nourishing terrain’ for Gamilaroi as the traditional owners, and other groups who had relationships with this place (Rose 1996).

During flood times, the people living on the wetlands would have eaten the abundant waterbirds and their eggs. When not in flood, the large river channels and semi-permanent areas of water would also have been a major feature of the cultural landscape, providing water and associated resources. Food, tools, shelter and medicinal items were harvested from plant and animal resources. These plants and animals provided a cultural and material contribution to the social and ceremonial aspects of Aboriginal life in the region. Aboriginal
Aboriginal cultural values of Gwydir Wetlands people adapted and developed sophisticated technologies to live in the wetland environment, including nets and fish traps and processing of cumbungi.

A key aspect of living in Gwydir Wetlands would have been movement between the ‘red country’ (thin elevated ridges that run sinuously through the wetlands and floodplain) and ‘black country’ (floodplain and wetlands). During floods, the black country was uninhabitable but, as the flood waters dried up, people would move back to the main river channels and core wetland areas (Witter 1999). Today, elevated red ridges are the dominant location for stone artefact sites. The black soil floodplains, with self-mulching alluvial soils and periodic floods, provide poor conditions for preserving stone artefacts and far fewer traces of Aboriginal occupation have been identified there (Biosis Research 2008).

Core semi-permanent wetland areas provided the important, and iconic, wetland plants including cumbungi (bulrush) and nardoo. The riverine forests, woodland and grasslands would have provided other important plants including river cooba, river red gum, coolibah, Mitchell grass and native millet. Scarred trees located in the wetlands today, typically coolibah trees, indicate the use of floodplain trees for implements (such as coolamons) and shelter. These scarred trees have added importance because few of the actual wooden implements have survived. Many surviving mill stones indicate the importance of grasses and seeds in the wetlands (Biosis Research 2008).

The elevated ridges also provided important resources. Some of the important plants include wilga, bumble/wild orange, belah, leopardwood, quinine bush, nepine, quandong and western boobialla. Today, the elevated ridges are a key area for plants with cultural values.

After over 200 years of non-Aboriginal settlement, most of the country has been radically changed, which explains the Aboriginal concern for those remnants which survive in a relatively natural condition.

6.2.2 Post-contact history

Colonisation of Gwydir Wetlands from the 1830s caused radical changes for Aboriginal people in the Gamilaroi country and more broadly across western NSW. Aboriginal people were usurped from their lands and their social, cultural and spiritual ways of being were severely disrupted.
However, Aboriginal people were not dispossessed (Goodall 1996, 2001, Hope 2004). In the colonial situation, Aboriginal people maintained a connection to the area. While physical ‘openings’ into the landscape were constrained, Aboriginal people used a range of strategies to maintain connections with the wetlands under greatly changed circumstances (Byrne & Nugent 2004).

Throughout the nineteenth century and into the early twentieth century, Aboriginal people were valued workers in pastoral properties in the region, working on stations including ‘Tyrel’, ‘Noonah’, ‘Goonal’, ‘Combadello’ and ‘Gingham’. Aboriginal people lived in communal camps at pastoral stations, at camps on riverbanks and on reserves created by the Aboriginal Protection Board. Up to the late 1890s, Aboriginal people continued to conduct ceremonial activities in the region.

The 1930s marked a radical increase in the supervision of Gamilaroi and other Aboriginal people living in the wetlands area. In the 1930s the Aboriginal Protection Board, as part of a policy of segregation, began concentrating Aboriginal people onto a small number of Board-run reserves, including the reserve at Brewarrina (Goodall 1996, Hope 2004). As this forced removal from Country happened relatively recently, older people still remember it.

To escape the control of the Protection Board and seek education for their children, Aboriginal people moved from the wetlands to informal camps outside towns across the region. By the 1950s, there were few Aboriginal families living permanently on properties in the wetlands area. However, many Aboriginal people based in surrounding towns continued to work in the wetlands as shearsers, stock workers and fencers.

By the late 1950s a pattern of limited physical access to the wetlands was in place and this has continued until today. Significant Aboriginal communities live in the towns surrounding the wetlands: Moree, Mungindi, Collarenebri and Walgett. Few Aboriginal people live in the wetlands area.

In this situation, physical access to the wetlands depended on good relationships with private land holders. As the amount of work on properties decreased, these relationships were more difficult to maintain. Many Aboriginal people report that in trying to gain access to favoured areas of the wetlands, for fishing or just for visiting places, they faced fences and locked gates. The ecological decline in the wetlands since the 1970s has been experienced as another form of loss, because the Country itself is rapidly declining.

Restriction of physical access has led to a loss of detailed knowledge of areas of Country. However, Aboriginal people have sustained detailed knowledge of some areas of Country which they continued to access, such as the area surrounding reserves in which they lived, places they accessed through work, or riverbanks which they visited. Land continued to be at the centre of culture, identity and spirituality for Aboriginal people in the region (Goodall 2001).

Since the 1970s, Aboriginal rights relating to land have been reasserted and Aboriginal people have become increasingly confident about accessing land, protecting cultural heritage sites and managing the environment. The practice of environmental management has also slowly changed, with incremental increases in the involvement of Aboriginal people in conservation and environmental management issues creating new ‘openings’ into the landscape of Gwydir Wetlands.
6.3 Values, interests and aspirations of contemporary Aboriginal communities

The issues below were documented in community consultation activities conducted in 2007–08, including workshops held in the Gwydir Wetlands area. This section also draws on oral history interviews with key community members (Waters Consulting 2008).

6.3.1 Gamilaroi traditional descendants – key priorities

The Gamilaroi people, as traditional owners of Country, have a special role in planning for Country. Gamilaroi traditional descendents have identified the following key priorities for the Gwydir Wetlands:

1. cultural flows to Country
2. access to Country to conduct cultural activities
3. inclusion in management of Country
4. training and working for Country
5. cultural continuity and heritage protection on Country

As first people, Gamilaroi have inherent rights in Country. Gamilaroi people, along with other Aboriginal people, have never given up sovereignty over or connection to their lands and water. Gamilaroi people have a particular interest in re-engaging with Country to enhance their spiritual connection to Country, and to revive their cultural practices.

Many Aboriginal communities have strong associations with Gwydir River through their ancestors’ ceremonial and cultural practices. Gamilaroi people have a holistic view of land management and aspire to be involved in all aspects of cultural, environmental, economic and social management processes. Gamilaroi people hold a vision for a healthy, living river system with natural flows and cycles, shared with other Aboriginal peoples of the Gwydir and Barwon–Darling Rivers. Today, Gamilaroi descendants and other Aboriginal people wish to become equal participants in the protection and regeneration of the ecology of Gwydir Wetlands, and in the protection of Aboriginal culture and heritage. In addition, the Gamilaroi community wants to ensure a sustainable economic base for all Gamilaroi people for present and future generations.

Although the Gamilaroi have a special position as descendents of the traditional people of the area, other Aboriginal communities also have important associations with Gwydir Wetlands, including:

- traditional owner groups from upstream and downstream of Gwydir Wetlands
- traditional owner groups who gathered on Gamilaroi Country for ceremonial purposes
- Aboriginal people with historic connections to the wetlands, particularly through working in the pastoral and agricultural industries
- Aboriginal people who currently reside on Gamilaroi Country.

It is important that all these groups are also recognised in planning for Country.
6.3.2 Values, interests and priorities – Gamilaroi and other Aboriginal people

During the community consultations, the following values, interests and priorities arose.

**Recognising custodianship**
An overarching issue was acknowledging and strengthening Aboriginal custodianship. Contemporary custodianship could be recognised by maintaining place names and renaming places with Aboriginal place names, by welcoming people to Country at the beginning of events, and by increasing Aboriginal people’s participation in managing the environment.

**Protecting Country**
During the consultations, specific aspects of Country were acknowledged as being particularly important to the Aboriginal community and in need of conservation and protection. The priorities were:

- to restore core wetlands
- to protect other areas and ecosystems – riverine forests, woodlands and grasslands, elevated sandy ridges
- to protect cultural heritage sites, ceremonial and dreaming sites, scarred trees, campsites and places where people lived and worked
- to take a holistic approach to managing Country
- to establish conservation reserves in the Gwydir wetlands.

**Undertaking activities on Country**
Aboriginal people described the following activities they wanted to undertake on Country:

- having access to Country to conduct cultural activities
- having work, training and economic opportunities on Country
- being involved in managing Country, especially in managing environmental water
- establishing conservation reserves in the region and forming partnerships with DECCW in managing these reserves
- establishing an Aboriginal cultural flow of water.

6.4 Identifying and protecting Aboriginal cultural values

6.4.1 Protecting Country

Aboriginal cultural values and ecological health
The Aboriginal cultural values of the wetlands are strongly associated with their overall ecological health. Protecting the natural values of wetlands enhances their cultural values. However, there are differences of emphasis. For instance, Aboriginal communities have a strong interest in protecting wetland plants with iconic cultural values such as nardoo, cumbungi, river cooba, coolibah and river red gum. Along with the core semi-permanent wetland areas, other ecosystems and vegetation communities in the Gwydir Wetlands are highly significant in terms of Aboriginal cultural values. Riverine forests, woodlands and grassland, and the elevated ridge country (often called ‘red country’) all support significant plants and animals with cultural values and are important for the preservation of cultural heritage sites.
Aboriginal cultural values and the management of environmental water: a cultural flow of water

Water is a key factor in sustaining wetland plants and animals with cultural values, and for sustaining the health of the landscape in general. There is strong community aspiration for a dedicated cultural allocation of water for the Gwydir Wetlands. Cultural flows are allocations of water controlled by Aboriginal people to improve the spiritual, cultural, environmental, social and economic conditions of Country (Morgan et al 2004). A cultural allocation of water is a way for Aboriginal community members to enact their custodial responsibilities for Gwydir Wetlands and to protect the health of the environment. The primary focus of these flows would be providing water for plants, animals, sites, and the broader landscape that depend on water. Cultural flows could be used in conjunction with environmental flows in many circumstances.

Bringing about broader recognition of Aboriginal cultural values in managing environmental water involves other steps, including having Aboriginal representatives on committees that manage environmental flows and including Aboriginal cultural values as criteria in managing environmental water.

Aboriginal cultural heritage sites

More than 160 sites have been recorded in the Gwydir Wetlands area (Biosis Research 2008). These places are important indicators of the long history of Aboriginal peoples’ interaction with the Gwydir Wetlands; they indicate how Aboriginal people adapted to and used the resources these wetlands provided.

Cultural heritage sites in the Gwydir Wetlands include:
- carved trees
- burials in soft sediment
- a large number of scarred trees
- flaked stone and ground stone assemblages
- stone artefacts (Biosis Research 2008).

Cultural heritage sites occur predominantly on the red ridge country and are most common near water sources. They face a range of threats including land clearing, tramping and erosion from stock, and vegetation die back from lack of water. Cultural heritage sites occur across private land, travelling stock reserves and wildlife refuges.

6.4.2. Cultural activities on Country

Access to Country for cultural purposes

Access to Country is a key contributor to cultural renewal, creating opportunities for Aboriginal people to reconnect with their Country, carry out cultural practices and pass on knowledge. Restoring access to Country addresses the long history of exclusion from the wetlands.

Activities that Aboriginal communities want to conduct on Country include:
- conducting family camps, back to Country camps and camps for conducting cultural practices
- undertaking education and cultural awareness activities
- collecting bush foods and wild resources – including sedges and reeds for weaving
- conducting men’s and women’s specific activities and specific activities for young people.
Access to Country can be facilitated through negotiating access to private land and establishing public conservation reserves in Gwydir Wetlands.

**Working on Country: increased employment, training and economic opportunities on the wetlands**

Employment and training in conservation and natural resource management activities are important ways for Aboriginal people to restore connections to Country. (For the benefits of working on Country programs in northern Australia, see Altman & Whitehead 2003, Garnett & Stilhole 2007.) Aboriginal people in Gwydir Wetlands could be employed to work on conservation projects, DECCW programs or natural resource and environmental management activities on private land supported by CMA projects. In the longer term, there may be opportunities for Aboriginal-owned businesses or Aboriginal contractors to undertake work in conservation, natural resource and environmental management activities.

6.4.3 Participation in management of the wetlands

It is important that environmental management agencies engage with Aboriginal communities early in the process, and on an ongoing basis, so Aboriginal people have the best opportunities to be involved in environmental management of Gwydir Wetlands. Aboriginal communities would then be involved in decisions that affect them and be able to enact their custodial responsibilities to Country (DAA 2003, DECC 2006, 2007).

In the context of Gwydir Wetlands, a natural area with strong cultural values, it is important that Aboriginal communities participate in overall environmental management of the wetlands as well as management of cultural heritage. A key forum for participation of Aboriginal communities is the Environmental Contingency Allowance Operations and Advisory Committee (ECAOAC).

There are other important ways for Aboriginal communities to be involved. The formation of an Aboriginal community reference group would be a key avenue for increasing engagement in environmental management, especially in managing environmental water. This would be a forum for Aboriginal communities to develop and advocate perspectives on environmental management in the wetlands. Agencies or the BRG CMA could support the reference group by providing resources to meet on Country a number of times a year.

Given that Aboriginal peoples’ involvement in environmental management forums is relatively new, it is important that management agencies provide ongoing support and training for Aboriginal community representatives. To assist Aboriginal representatives on these forums, cultural awareness training should be available for non-Aboriginal committee members.
Implementing the AEMP

Action is needed to arrest the decline of the Gwydir Wetlands and ensure their ecological functions and processes are maintained. It is clear from the many plans and reports prepared for the wetlands since the early 1990s, and reviewed for this AEMP, that stakeholders are aware of many actions needed to restore, maintain and protect the wetlands.

Activities are being carried out or planned under existing funding programs, policies or legislation. DECCW is responsible for managing environmental water allocations established under water sharing plans (WSPs) and water access licences held by the NSW Government for an environmental purpose. The Environmental Contingency Allowance Operations and Advisory Committee (ECAOAC), established under the Gwydir WSP, advises DECCW on managing this water and helps DECCW prepare an annual watering plan. The NSW Office of Water (NOW) is responsible for developing and implementing WSPs and for water licensing, including enforcement and compliance. The Basin Plan will establish ‘sustainable diversion limits’ for water sources in the basin and future WSPs will need to comply with these limits.

Under the Water Act 2007 (Commonwealth), the independent CEWH determines the use of the Commonwealth’s environmental water holdings. In the Murray–Darling Basin, the holdings are managed in accordance with the Basin Plan to protect or restore environmental assets. Priority given to watering actions by the CEWH is based on an assessment of environmental benefits against publicly available criteria and after receiving advice from the Environmental Water Scientific Advisory Committee, as well as input from state governments and other stakeholders. The criteria are available at www.environment.gov.au/water/policy-programs/cewh.

Governments, through the Murray–Darling Basin Reform Intergovernmental Agreement signed in 2008, have agreed to cooperate on environmental water management. In early 2009, DECCW and CEWH signed a memorandum of understanding to ensure close cooperation on Australian Government and state environmental water planning and management.

7.1 Determining priorities for delivering water

Tables 6–8 set out objectives for the duration and frequency of inundation to maintain the values of semi-permanent and floodplain wetlands in Gwydir Wetlands. The Murray-Darling Basin Plan will also indicate the environmental watering requirements for important wetlands across the basin, including Gwydir Wetlands.

This AEMP does not prescribe the priorities for watering the environmental assets described in section 2. It is not possible to anticipate every event that could influence the future condition of the wetlands and priorities for environmental watering. The determination of priorities for delivering water is most appropriately undertaken on an annual basis with an understanding of the current condition of and threats to assets and values. Over longer time scales, these priorities will be influenced by the scale of water recovery achieved in the medium term and the capacity of the wetlands to recover from the recent dry sequence of years.

Prioritising the delivery of environmental water to specific assets and for specific objectives will be undertaken annually with input and advice from the Gwydir ECAOAC and will include:

- considering the ecological assets, values and water needs described in this AEMP
- agreeing on the condition of the wetlands and appropriate management responses (DECCW, BRG CMA and ECAOAC)
- considering the amount of water available under a range of likely climate scenarios (DECCW, ECAOAC)
• determining priority areas for water delivery to sustain the assets, values and character of the wetlands (DECCW, BRG CMA, ECAOAC and affected stakeholders) in the context of the above point
• identifying flow paths and means of delivering water to identified areas (DECCW and ECAOAC).

Information to be considered in this process includes:
• the ecological, social and cultural assets and values that may be threatened as a result of recent and expected climatic conditions
• the location, character and significance of wetland systems, including their complexity and diversity; when possible, management will support the complexity and diversity of the larger system as well as the complexity and diversity of specific assets or areas
• legislative and policy responsibilities
• the nature of land and water management activities within or along flow paths to ecological assets, including the number and role of banks, channels, regulators and other structures; management practices; and formal management agreements
• the likelihood that identified management activities will lead to achievement of land and water management objectives
• the capacity to deliver water to different areas, including existing or potential works for directing, holding or otherwise managing water.

7.2 Delivering and managing water in Gwydir Wetlands

Extensive public and private works have been built throughout the wetlands to manage water; to direct, control, harvest and store flows; and to control channel erosion. Although many of these works are essential for managing the wetlands, others are of limited or of no benefit. Some works will have to be modified or removed to protect assets, and in some cases, new works may be needed.

An environmental allocation has existed in the Gwydir Valley and has been actively delivered to the Gwydir Wetlands since 1995. Many members of the Gwydir community have considerable expertise in managing environmental flows and will contribute to operational plans either at a site scale or on a broader wetland scale.

7.3 Cooperation and community participation in management

The centrepiece of community participation in management of environmental flows in the river and wetlands is the Gwydir ECAOAC, which has developed a high degree of skill in water management. The members include representatives of DECCW, NOW, State Water, I&I NSW, Gwydir Valley Irrigators Association, Gingham Watercourse Association, Lower Gwydir Watercourse Association, BRG CMA, the Aboriginal community, conservation interests (World Wildlife Fund) and scientific expertise. The Australian Government Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) has observer status on the ECAOAC.

Effective communication will be an essential part of community participation. Credible, trusted knowledge will not be developed without strong links and communication between relevant stakeholders. A communication plan will be developed for actions that either affect or potentially affect people and sectors.
Effective community participation in management of the Gwydir Wetlands will rely on addressing five key challenges:

1. Ensuring effective representation by creating an explicit statement of roles, responsibilities and expectations and providing leadership and support so roles can be undertaken effectively.

2. Designing workable and useful processes.

3. Including scientific, expert and local knowledge in decision-making.

Photo 24 Environmental watering of semi-permanent wetland vegetation will support native plants such as watermilfoil. Photo: Tracy Fulford.
4. Developing a common understanding of the system and the challenges that it faces.
5. Evaluating whether decisions are effective and whether they achieve management objectives (Scholz & Stiftel 2005).

7.4 Research, monitoring, evaluation and reporting

To manage the wetlands adaptively, different sources and types of information are needed including the knowledge of landholders and Aboriginal people. Community ownership of scientific research will be more likely if people are involved in the conception, implementation and completion of research projects. Information is sometimes not available, and sometimes science cannot answer the questions that managers and policy makers ask. Strong links and effective communication between researchers, managers and policy makers must be developed and fostered. A research plan will be developed as part of implementing the AEMP.

Monitoring, evaluating and reporting on the effectiveness of policies and management actions are essential for learning and adaptive management. The NSW Wetlands Monitoring, Evaluation and Reporting Rapid Assessment is an example of a system which can be used to report on wetland condition. However, more comprehensive monitoring will be necessary to evaluate management in the Gwydir Wetlands. Water delivery must be monitored to ensure that it reaches identified assets, and the distribution of water in the assets must be measured. Gauges are already in place for monitoring and measurement in most areas, but some additional measuring points may need to be installed. Satellite mapping of inundation is also an effective way of measuring inundated areas.

NOW has been implementing the Integrated Monitoring of Environmental Flows (IMEF) program for long-term monitoring of WSPs across the state since 1998. In Gwydir Wetlands, IMEF has focused on researching and monitoring the ecological responses to flows in the wetlands and the Gwydir River channel.

The environmental water provisions in the Gwydir WSP are expected to increase the inundation of benches and riparian zones in the river reach downstream of Copeton Dam and within the network of effluent channels occurring on the floodplains. The many small wetland systems which occur in and adjacent to these channels should also benefit from the improved water regime.

Lagoons and floodplain wetlands are expected to be replenished more frequently and for longer times, resulting in the creation and maintenance of wetland habitat for a wide range of plant and animal species. Specific monitoring of ECA releases from Copeton Dam, which target Ramsar sites among other key environmental assets, is also undertaken to inform short-term flow management requirements.

Several wetland sites in the Gingham and Lower Gwydir watercourses have been assessed to determine the linkages between river flows and the ecological response of aquatic vegetation and aquatic macroinvertebrates. Studies have also investigated the transfer of dissolved organic carbon to and from the floodplain and the relationship between flows and native fish recruitment.

A review of the Gwydir WSP’s effectiveness will consider the economic and social elements of WSP objectives. To this end, key indicators for monitoring the irrigation sector have been identified and a survey was conducted in 2006 to establish baseline information for ongoing assessment. It is expected that outcomes of the IMEF program will also inform the ongoing development and review of the AEMP.
Implementing the AEMP

The effectiveness of management should be assessed against objectives related to restoration of critical ecological functions and habitats. The effectiveness of environmental flow management in meeting the objectives will be of special interest, particularly in relation to:

- changes in the extent of semi-permanent wetland vegetation
- the proportion of healthy and stressed semi-permanent wetland vegetation
- the diversity and density of aquatic invertebrates
- the diversity and density of waterbird species.

Scientific research and monitoring activities should also be evaluated, including the extent to which their findings are used to inform management actions.

DECCW is developing a decision support system (DSS) to improve its capacity to optimise the use of environmental flows for wetlands. The DSS will enable DECCW to compare scenarios relating to the volume and timing of water delivered to meet ecological outcomes, to guide decisions about the use of environmental water. The DSS is based on integrated ecosystem response and hydrological models.

### 7.5 Projects and actions to deliver the AEMP

For Gwydir Wetlands to have a sustainable future, communities and government must establish a shared view of the condition of the wetlands, ways in which wetland condition is changing, why it is changing, and suitable management and research responses.

A range of actions to restore and protect the ecological assets described in section 2 of this plan are outlined in Tables 9 to 14 covering water management, aquatic habitat management and restoration, land management, application of scientific knowledge to management and policy, Aboriginal cultural values and adaptive management.

Some actions already under way include:

- developing guidelines for managing breeding of colonially nesting waterbirds
- modifying weirs and other barriers to improve conditions for native fish
- piping the Gingham stock and domestic channel
- undertaking environmental restoration of the Gingham Channel
- improving irrigation efficiency and purchasing water from willing sellers to return water to the environment
- applying guidelines for grazing management to ensure the best outcomes from environmental water management
- establishing processes for ensuring that community members participate effectively in river and wetland management.

DECCW and the BRG CMA will coordinate the implementation of these actions, including progressing further feasibility assessments where necessary, in the context of the ongoing review and implementation of the AEMP. An annual review of the implementation of the AEMP by DECCW and the BRG CMA will seek to ensure that other agencies, interest groups and individuals are involved in resourcing and progressing relevant actions.

DSEWPC, Industry & Investment NSW (I&I NSW), NSW Office of Water, State Water, Aboriginal communities, Land & Property Management Authority and Gwydir Wetlands land holders will be critical participants in this implementation process.
### Table 6  Gingham Watercourse wetland vegetation watering objectives.

<table>
<thead>
<tr>
<th>Vegetation community and watering objective</th>
<th>Location</th>
<th>Area (hectares) in 2008</th>
<th>Tenure</th>
<th>Current vegetation condition</th>
<th>Environmental water delivery potential</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>River red gum woodland</strong>&lt;br&gt;Objective not set as watering needs likely to be met by flows to other assets</td>
<td>Riverine corridors near the Gwydir Raft</td>
<td>253 total for Gingham and Lower Gwydir watercourses</td>
<td>Private</td>
<td>Fair to poor: infested with many exotic species</td>
<td>Good</td>
</tr>
<tr>
<td><strong>Coolibah–river red gum</strong>&lt;br&gt;Objective not set as watering needs likely to be met by flows to other assets</td>
<td>Riverine corridors near the Gwydir Raft, extending west along the Gwydir River</td>
<td>3,259 total for Gingham and Lower Gwydir watercourses</td>
<td>Private</td>
<td>Fair to poor: infested with many exotic species</td>
<td>Good</td>
</tr>
</tbody>
</table>
Table 6 (continued)  Gingham Watercourse wetland vegetation watering objectives.

<table>
<thead>
<tr>
<th>Vegetation community and watering objective</th>
<th>Location</th>
<th>Area (hectares) in 2008</th>
<th>Tenure</th>
<th>Current vegetation condition</th>
<th>Environmental water delivery potential</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Marsh club-rush, very tall sedgeland</strong>&lt;br&gt;Objective not set as current knowledge is insufficient to determine an optimal watering regime</td>
<td>‘Bunnor’</td>
<td>11</td>
<td>Private</td>
<td>Seasonal: ranges from good to poor – heavily grazed in November 2009</td>
<td>Good</td>
</tr>
</tbody>
</table>
Table 7  Lower Gwydir Watercourse wetland vegetation watering objectives.

<table>
<thead>
<tr>
<th>Vegetation community and watering objective</th>
<th>Location</th>
<th>Area (hectares) in 2008</th>
<th>Tenure</th>
<th>Current vegetation condition</th>
<th>Environmental water delivery potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coolibah woodland</td>
<td>‘Old Dromana’, ‘Gallimbarray’ (Retreat), ‘Te Mona’, and properties to the east</td>
<td>51,652 total coolibah woodland in Gingham and Lower Gwydir watercourses: (about 33,572 hectares located in Lower Gwydir) (73,230 total coolibah–black box woodland in Gingham and Lower Gwydir watercourses)</td>
<td>Private/public</td>
<td>Some good, some areas closest to watercourses infested with lippia</td>
<td>Good</td>
</tr>
<tr>
<td>Marsh club-rush, very tall sedgeland</td>
<td>‘Old Dromana’, ‘Belmont’, ‘Gallimbarray’ (Retreat), ‘Wandoona’</td>
<td>197</td>
<td>Private/public</td>
<td>Seasonal: some good, some fair</td>
<td>Good</td>
</tr>
</tbody>
</table>
Table 8  Mehi, Mallowa, Moomin system wetland vegetation watering objectives.

<table>
<thead>
<tr>
<th>Vegetation community and watering objective</th>
<th>Location</th>
<th>Area (hectares) in 2008</th>
<th>Tenure</th>
<th>Current vegetation condition</th>
<th>Environmental water delivery potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coolibah–river red gum association</td>
<td>Riverine corridors along Mehi and Mallowa</td>
<td>4,411</td>
<td>Private</td>
<td>Fair to good</td>
<td>Good – possibly accessing groundwater from streams</td>
</tr>
<tr>
<td>Objective not set as watering needs likely to be met by flows to other assets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective not set as flooding required for regeneration is likely to be uncontrolled</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provide water to inundate for at least three months between September and March, at least 5 years in 10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provide water to inundate for at least three months between September and March, at least 5 years in 10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Implementing the AEMP
### Table 9  Water management.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Management action</th>
<th>Responsibility</th>
<th>Mechanism</th>
<th>Timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flow regime, including flow size, frequency, duration and timing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Consider further water purchases for the environment</td>
<td>DECCW, DSEWPC</td>
<td>NSW RiverBank; Australian Government Water for the Future; Restoring the</td>
<td>2011, 2018</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Balance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increase water efficiency through upgrading irrigation and water delivery systems and improving metering</td>
<td>State Water, DSEWPC, irrigation industry, BRG CMA, DECCW</td>
<td>Australian Government Water for the Future; Sustainable Rural Water Use and Infrastructure program</td>
<td>2018</td>
</tr>
<tr>
<td></td>
<td>Gingham Watercourse pipeline and restoration project</td>
<td>DECCW, NOW</td>
<td>WRP and RERP</td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>Assess modification of Tyreel Weir to improve capacity to control flow distribution downstream</td>
<td>DECCW, State Water</td>
<td>To be determined</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Works to ensure water for Mallowa Creek:</td>
<td>DECCW, NOW</td>
<td>Stage 1 funded by RERP; Stages 2 and 3 to be determined</td>
<td>Stage 1 completed 2009</td>
</tr>
<tr>
<td></td>
<td>Stage 1 – survey and environmental assessments</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Stage 2 – Audit of structures</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Stage 3 – Modify structures as necessary to ensure reliable delivery of environmental water</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Clarify the role, effect and status of water management structures in the wetlands</td>
<td>NOW, with support from DECCW, DSEWPC, I&amp;I NSW (Fisheries), BRG CMA</td>
<td>Healthy Floodplains Project (Water for the Future – subject to due diligence assessment)</td>
<td>2010–14</td>
</tr>
<tr>
<td></td>
<td>License and measure all floodplain harvesting extractions</td>
<td>NOW, DECCW</td>
<td>Healthy Floodplains Project (Water for the Future – subject to due diligence assessment)</td>
<td>2010–14</td>
</tr>
<tr>
<td></td>
<td>95% of extraction under non-floodplain harvesting water access licences to be metered</td>
<td>State Water, NOW</td>
<td>Murray–Darling Basin Metering Project (Water for the Future – subject to due diligence assessment)</td>
<td>2010–14</td>
</tr>
<tr>
<td>Issue</td>
<td>Management action</td>
<td>Responsibility</td>
<td>Mechanism</td>
<td>Timeline</td>
</tr>
<tr>
<td>---------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Water quality</td>
<td>Apply the <em>Protection of the Environment Operations Act 1997</em> to regulate polluting activities</td>
<td>DECCW</td>
<td>Legislative responsibility</td>
<td>Ongoing</td>
</tr>
<tr>
<td></td>
<td>Implement BRG CMA Catchment Action Plan targets</td>
<td>BRG CMA</td>
<td>Legislative responsibility</td>
<td>Ongoing</td>
</tr>
</tbody>
</table>
| Impacts of in-stream structures and extraction on fish             | Install fishways on weirs, improve access through road culverts                    | I&I NSW, State Water, local government, BRG CMA | BRG CMA incentive funding to improve fish passage  
Local government works plans for new/replaced road crossings  
State Water Memorandum of Understanding (MoU) for fish passage and weir upgrades | Ongoing  |
|                                                                    | Minimise impacts of pumps on fish with screen technology                           | I&I NSW, Gwydir irrigation industry     | Research and implement screening technology to reduce pump impacts                             | Ongoing  |
|                                                                    | Address impacts of undershot weirs on downstream larval and juvenile fish mortality | I&I NSW                                 | State Water MoU for fish passage and weir upgrades  
MDBA Native Fish Strategy incentive programs                  | Ongoing  |
| Degradation of riparian zone and in-stream habitat                | Identify and protect important refuge areas for fish in dry times                 | I&I NSW Fisheries, University of New England (UNE), BRG CMA | Survey and assessment project                                                              | Ongoing  |
|                                                                    | Develop and implement guidelines for restoring fish habitat and fish passage in the Gwydir River and Gwydir Wetlands | I&I NSW, BRG CMA, DECCW, State Water   | BRG CMA incentive programs  
Local council incentive programs  
MDBA Native Fish Strategy incentive programs  
State Water MoU for fish passage and weir upgrades             | Ongoing  |
### Table 11 Land management.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Management action</th>
<th>Responsibility</th>
<th>Mechanism</th>
<th>Timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearing</td>
<td>Prevent clearing of core wetland vegetation communities</td>
<td>DECCW</td>
<td><em>Native Vegetation Act 2003</em></td>
<td>Ongoing</td>
</tr>
<tr>
<td></td>
<td>Review identification of semi-permanent and ephemeral wetland during dry cycles</td>
<td>DECCW</td>
<td><em>(‘Review of the non-woody vegetation in NSW’ project)</em></td>
<td>2011</td>
</tr>
<tr>
<td>Grazing</td>
<td>Improve understanding of the effects of grazing on wetland vegetation and determine grazing strategies required to protect and restore wetland vegetation</td>
<td>BRG CMA, I&amp;I NSW, DECCW</td>
<td>Implement grazing guidelines developed under Wetland Recovery Program (WRP)</td>
<td>Ongoing</td>
</tr>
<tr>
<td></td>
<td>Provide incentives to improve management of wetlands on private land</td>
<td>BRG CMA, DECCW, I&amp;I NSW</td>
<td>BRG CMA incentives programs</td>
<td>Ongoing 2008–2010, 2009–2010 (potential to extend)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>RERP sub program IV</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Fish Friendly Farms</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Habitat Action Program</td>
<td></td>
</tr>
<tr>
<td>Weed management</td>
<td>Minimise the effects of weeds on wetland values</td>
<td>Landholders, Moree Plains Shire Council, Livestock Health and Pest Authority (LHPA), I&amp;I NSW, BRG CMA</td>
<td>Ongoing management informed by lippia mapping, research and best management practice manual undertaken by WRP Water hyacinth control (funded by WRP and RERP SPIV)</td>
<td>Ongoing 2010</td>
</tr>
<tr>
<td>Feral animal control</td>
<td>Maintain feral control programs</td>
<td>LHPA, landholders</td>
<td>Core business activity</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Wetland restoration</td>
<td>Establish conservation reserve in the wetlands</td>
<td>DECCW</td>
<td>Purchase land</td>
<td>In accordance with reserve acquisition strategy</td>
</tr>
</tbody>
</table>
Table 11 (continued)  Land management.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Management action</th>
<th>Responsibility</th>
<th>Mechanism</th>
<th>Timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify Crown land that could enhance the conservation of the Gwydir Wetlands</td>
<td>Undertake a detailed review of Crown land in the Gwydir Wetlands</td>
<td>Land and Property Management Authority (LPMA)</td>
<td>Audit by Crown Lands Division of LPMA</td>
<td>2011</td>
</tr>
<tr>
<td>Identify land management opportunities on leasehold land</td>
<td>LPMA</td>
<td>Negotiate covenants with leaseholders</td>
<td>Consider lease exclusion options</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Create a network of Crown land managed to achieve AEMP objectives</td>
<td>LPMA, North West LHPA</td>
<td>Create regional Crown reserve or similar reserve structure</td>
<td>Develop a plan of management</td>
<td>2011</td>
</tr>
<tr>
<td>Issue</td>
<td>Management action</td>
<td>Responsibility</td>
<td>Mechanism</td>
<td>Timeline</td>
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<tr>
<td>Improve links between management, policy and science</td>
<td>Prepare waterbird breeding management manual</td>
<td>DECCW</td>
<td>WRP</td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>Map inundation frequency</td>
<td>DECCW</td>
<td>Rivers and Wetlands Unit (funded by WRP)</td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>Map vegetation area and condition</td>
<td>DECCW, University of NSW</td>
<td>Rivers and Wetlands Unit (completed 2005 and 2008 under WRP); Statewide Land and Tree Survey program</td>
<td>Completed; Ongoing</td>
</tr>
<tr>
<td></td>
<td>Monitor, evaluate and report on wetland condition</td>
<td>DECCW, NOW, I&amp;I NSW, Fisheries</td>
<td>Wetlands Monitoring, Evaluation and Reporting Program; Integrated Monitoring of Environmental Flows program</td>
<td>2008 and ongoing</td>
</tr>
<tr>
<td></td>
<td>Measure environmental water delivery and distribution</td>
<td>NOW, DECCW</td>
<td>Inundation mapping, field inspections, review gauging stations</td>
<td>Ongoing</td>
</tr>
<tr>
<td></td>
<td>Develop hydrodynamic model of the wetlands</td>
<td>DECCW</td>
<td>RERP sub program II</td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>Improve technical and scientific support for managers and decision-makers</td>
<td>DECCW</td>
<td>DECCW Rivers and Wetlands Unit (funded by DECCW, WRP, RERP sub program II); University of New England</td>
<td>Ongoing</td>
</tr>
</tbody>
</table>
Table 13 Aboriginal cultural values.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Management action</th>
<th>Responsibility</th>
<th>Mechanism</th>
<th>Timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aboriginal cultural values and environmental water</td>
<td>Negotiate Aboriginal cultural values as criteria for the management of environmental water</td>
<td>DECCW</td>
<td>ECAOAC</td>
<td>Short term</td>
</tr>
<tr>
<td>Aboriginal cultural values and environmental water</td>
<td>Define Aboriginal cultural flow</td>
<td>DECCW</td>
<td>Policy development</td>
<td>Medium term</td>
</tr>
<tr>
<td>Aboriginal cultural heritage sites</td>
<td>Identify Aboriginal cultural heritage sites and take appropriate conservation action</td>
<td>DECCW, BRG CMA landholders</td>
<td>Statutory responsibility, BRG CMA incentive programs</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Plants and animals with Aboriginal cultural values</td>
<td>Identify and protect plants and animals with cultural values</td>
<td>DECCW, BRG CMA, landholders</td>
<td>Aboriginal representation on ECAOAC</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Plants and animals with Aboriginal cultural values</td>
<td>Protect culturally significant areas, plants or animals within conservation reserve</td>
<td>DECCW, BRG CMA</td>
<td>Purchase land for conservation</td>
<td>Short and medium term</td>
</tr>
<tr>
<td>Access to Country</td>
<td>Increase negotiated access to private land in the Gwydir Wetlands to undertake cultural activities</td>
<td>BRG CMA, DECCW, private land holders</td>
<td>BRG CMA incentive programs, RERP sub-program IV</td>
<td>Medium term</td>
</tr>
<tr>
<td>Working on Country</td>
<td>Increase employment, training and economic opportunities on the wetlands</td>
<td>BRG CMA incentives programs, Involvement in DECCW programs, purchase of reserves and employment and training of Aboriginal staff</td>
<td>Short and medium term</td>
<td></td>
</tr>
<tr>
<td>Increased participation in management of the wetlands</td>
<td>Aboriginal representative(s) on ECAOAC should have access to appropriate training</td>
<td>DECCW</td>
<td>ECAOAC</td>
<td>2010 and ongoing</td>
</tr>
<tr>
<td>Increased participation in management of the wetlands</td>
<td>Aboriginal cultural awareness training for other members of ECAOAC</td>
<td>DECCW</td>
<td>ECAOAC</td>
<td>2010 and ongoing</td>
</tr>
<tr>
<td>Increased participation in management of the wetlands</td>
<td>Support formation of a Gwydir Aboriginal cultural heritage and land management reference group</td>
<td>DECCW, BRG CMA</td>
<td>CMA programs</td>
<td>Medium term</td>
</tr>
<tr>
<td>Acknowledging Aboriginal connection to Country and custodianship</td>
<td>Welcome to Country, acknowledgement of Country before major events in the Gwydir Wetlands</td>
<td>DECCW</td>
<td>Event organisers to be advised of acknowledgement request</td>
<td>In place</td>
</tr>
</tbody>
</table>

Short term: 2–3 years  Medium term: 3–5 years
Table 14  Adaptive management – participatory processes and consultation.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Management action</th>
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<th>Mechanism</th>
<th>Timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ensure stakeholder involvement in river and wetland management</td>
<td>Support community role in environmental flow management</td>
<td>DECCW, BRG CMA</td>
<td>ECAOAC</td>
<td>Established, ongoing</td>
</tr>
<tr>
<td>Ensure stakeholder participation in coordination and review of AEMP</td>
<td>DECCW</td>
<td></td>
<td>Carry out annual review of implementation of AEMP and identify priorities for watering assets in the wetlands. Include DECCW, BRG CMA, State Water, I&amp;I NSW, DSEWPC, ECAOAC and affected land holders.</td>
<td>Ongoing</td>
</tr>
<tr>
<td>Develop strategic adaptive management research program</td>
<td>DECCW, UNE, BRG CMA</td>
<td>Review information needs for strategic adaptive management</td>
<td>Ongoing</td>
<td></td>
</tr>
<tr>
<td>Develop communication strategy</td>
<td>DECCW</td>
<td>Various</td>
<td>Ongoing</td>
<td></td>
</tr>
</tbody>
</table>
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