

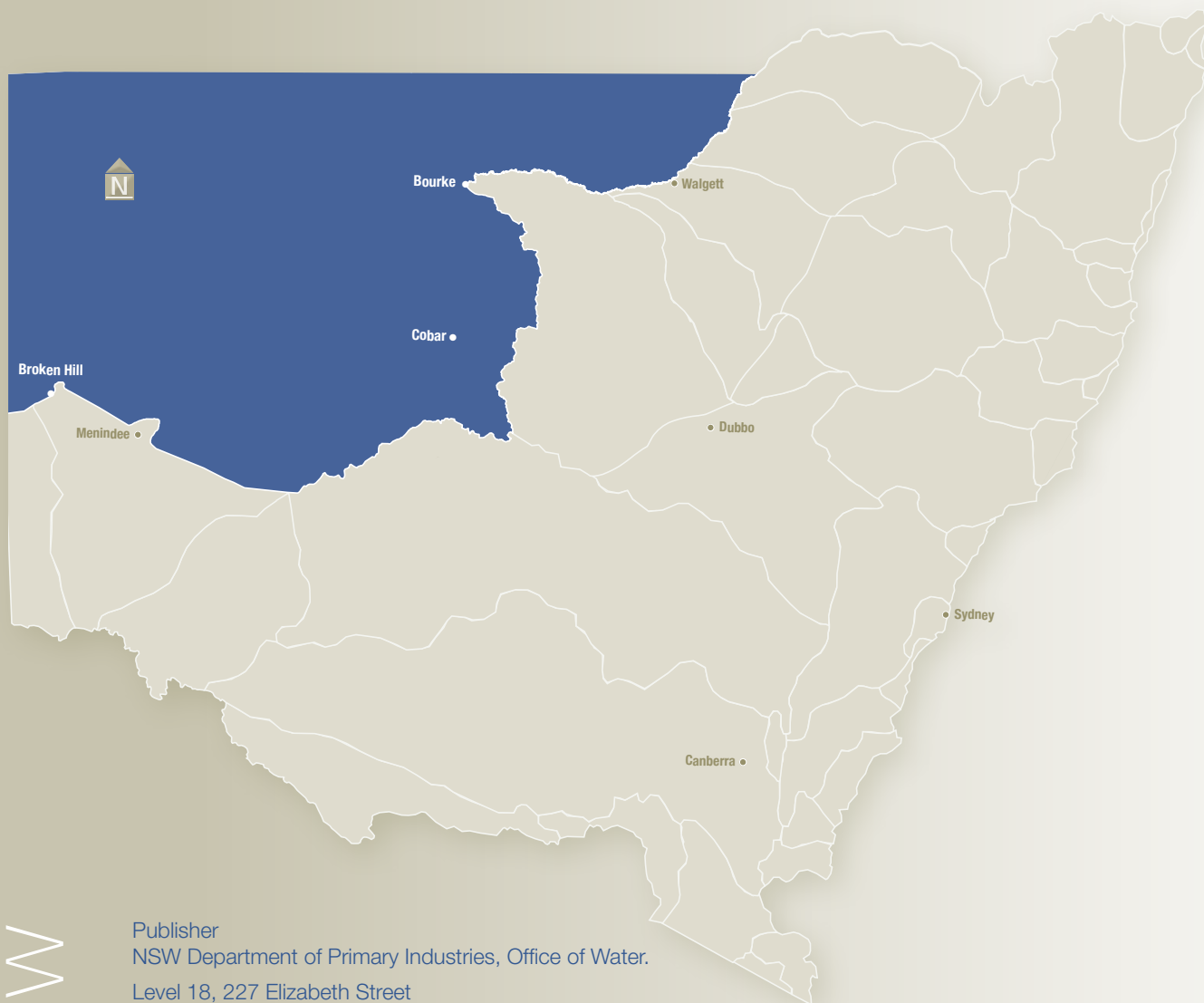


Department of  
Primary Industries  
Office of Water

# Environmental flow response and socio-economic monitoring

Far West NSW - progress report 2011





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The NSW Office of Water manages the policy and regulatory frameworks for the state's surface water and groundwater resources, to provide a secure and sustainable water supply for all users. It also supports water utilities in the provision of water and sewerage services throughout New South Wales.

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- progress report 2011***

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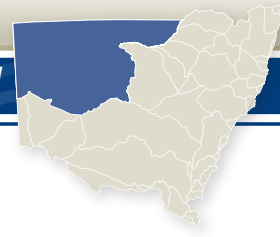
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# Introduction

## WHAT IS THE PURPOSE OF THIS REPORT?

This report provides an update on the monitoring and evaluation activities undertaken in 2010-11 to assess the ecological and socio-economic performance of water sharing plans adopted in the Far West region of NSW. It provides an interim assessment of outcomes of the investigations and identifies priority needs for future monitoring and evaluation activities.

## WHY DO WE NEED TO MONITOR PLANS?

Water sharing plans provide water to meet environmental and socio-economic needs, and spells out the rules governing access to water. The Far West region contains a number of important environmental assets, and in some valleys supports a valuable irrigation industry, although grazing predominates. Important environmental assets include the Barwon-Darling River system, which incorporates the rivers of the lower Balonne

catchment and those of the NSW-Queensland Intersecting Streams. The Far West region is larger than Victoria and Tasmania combined. It includes an exceptionally large number of important wetlands, three of which are Ramsar listed (namely, Narran Lake Nature Reserve, Paroo River Wetlands and Lake Pinaroo), and 49 others included on the Directory of Nationally Important Wetlands ([www.environment.gov.au](http://www.environment.gov.au)). The four catchment basins that drain from southern Queensland into NSW are represented within the region: the rivers of the lower Balonne (which includes the Narran, Culgoa, Bokhara and Birrie rivers), the Warrego, Cuttaburra Creek and the Paroo River. Further west, beyond Wanaaring, and only occasionally flowing, is the Bulloo River, with its vast 'overflow' terminal lakes, which sporadically provide major feeding and breeding habitat for waterbirds. Other terminal catchments, the Cobham Lakes, Lake Bancannia and tributaries of Lake Frome and Lake Eyre, lie further west. The

region also includes the Barwon-Darling River system which, although not formally regulated, has flows that are generally affected by storages and water extraction on its major tributaries in both NSW and Queensland.

It is important to know whether water sharing plans, where they have been implemented within the Far West, are meeting their environmental objectives so that their effectiveness can be reviewed at the end of their 10-year period of operation. The information collected will be used to make informed decisions on how the plans might be improved when they are renewed. To achieve this, the NSW Office of Water undertakes ecological and socio-economic monitoring and evaluation activities focused on specific clauses and performance indicators within the plans.

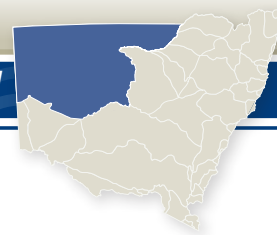
Figure 1 shows field work being undertaken to assess riparian vegetation response to environmental flows.





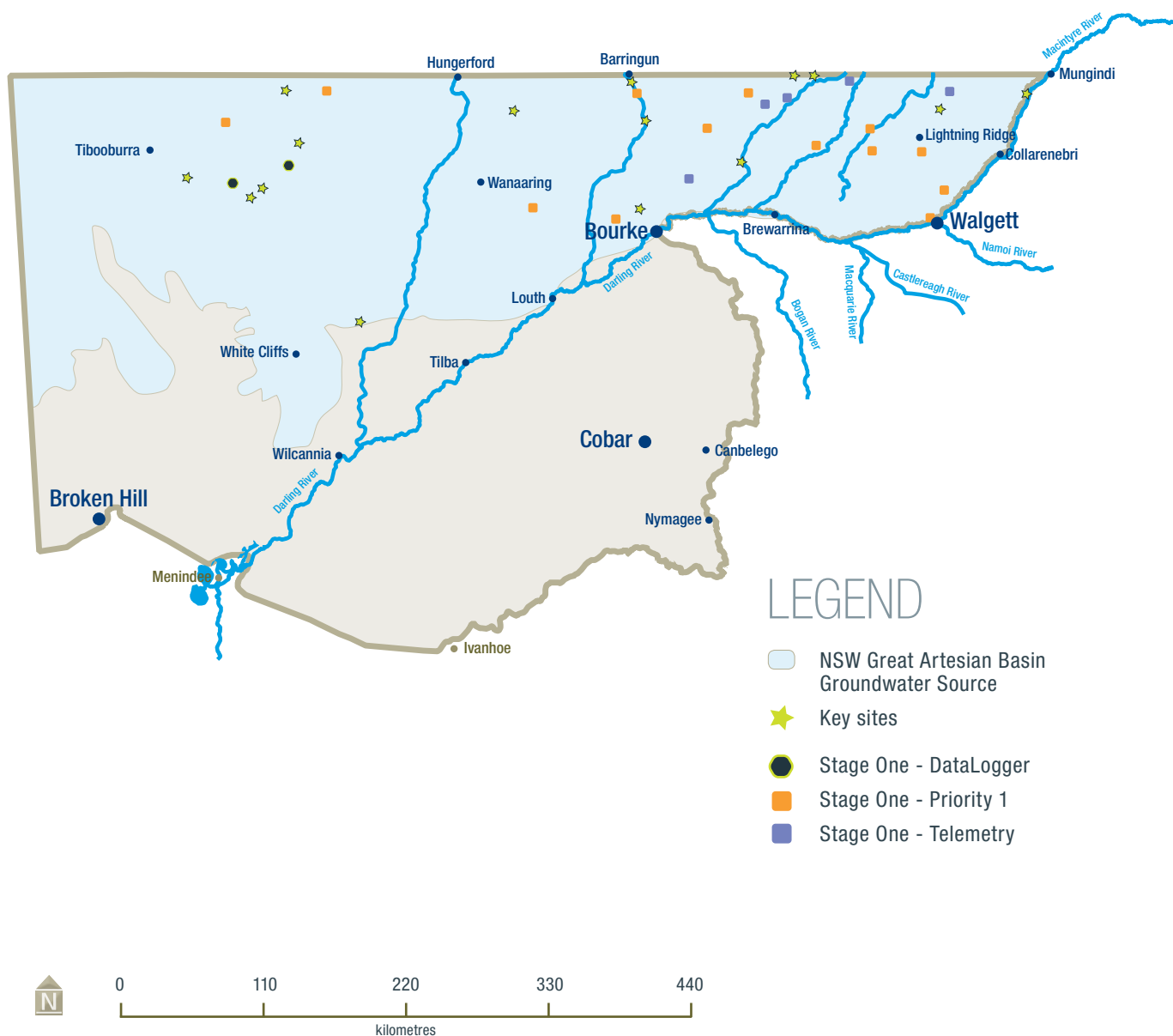
**FIGURE 1**

Monitoring vegetation response to flows on the Darling River.



**FIGURE 2**

Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources and location of monitoring sites in the Far West.





## WHAT WATER SHARING PLANS ARE CURRENTLY IN PLACE?

Two water sharing plans in the Far West are currently gazetted:

- Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources 2008 (Figure 2)
- Water Sharing Plan for the North Western Unregulated and Fractured Rock Water Sources 2011 (commenced on 1 October 2011; Figure 3).

More details on these plans can be found on the NSW Office of Water's website [www.water.nsw.gov.au](http://www.water.nsw.gov.au) go to Water Management > Water Sharing Plans.

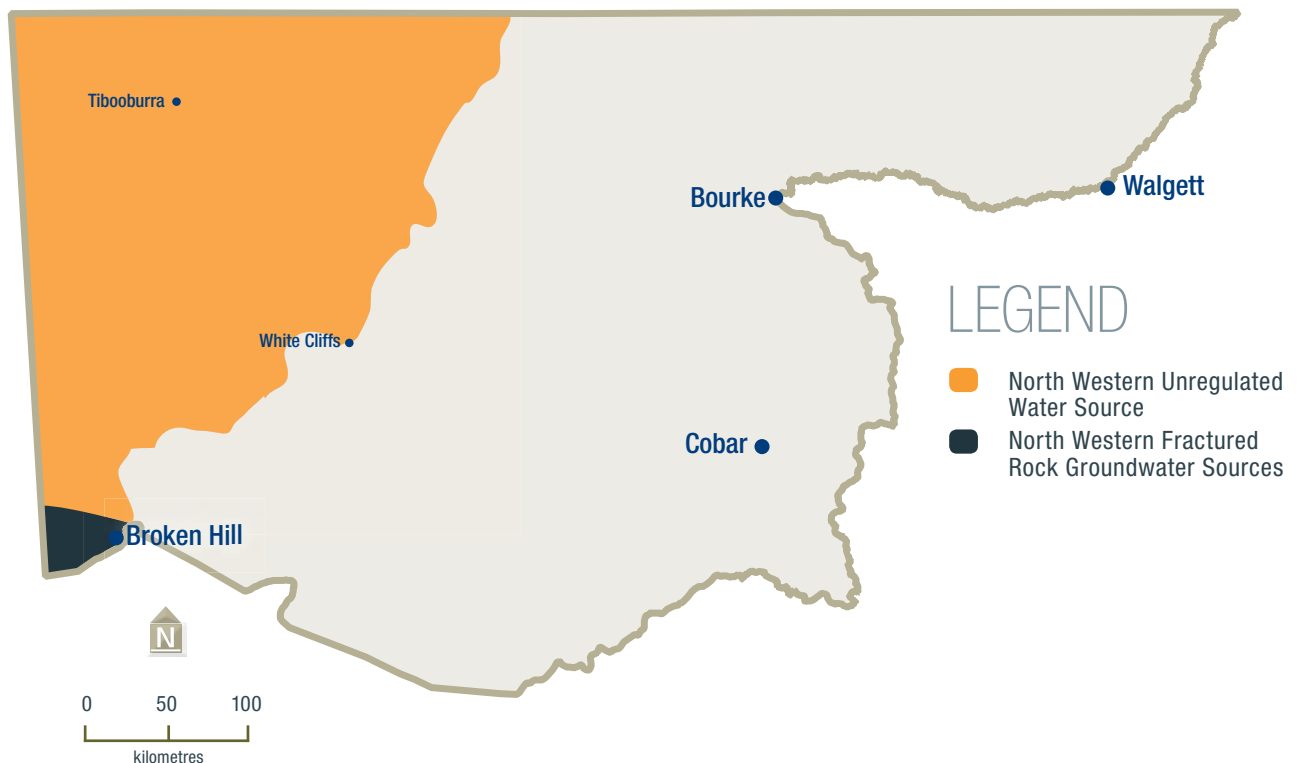
## WHAT OTHER WATER SHARING ARRANGEMENTS HAVE BEEN DEVELOPED IN THE FAR WEST?

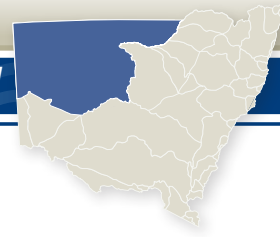
### Paroo River agreement

The Paroo River is an unregulated ephemeral river system located in the semi-arid region of far north-west NSW and south-west Queensland. The Paroo flows in a predominantly north-south direction, crossing the border near the town of Hungerford. Other key settlements along the Paroo include Eulo in Queensland and Wanaaring in NSW.

**FIGURE 3**

Water Sharing Plan for the North Western Unregulated and Fractured Rock Water Sources.





Flows in the Paroo are episodic, and 'permanent' waterholes provide important refugia for fish and other aquatic species during periods of low flow. Water from the Paroo River reaches the Darling River upstream of Wilcannia only during infrequent major floods such as those of 1990 and 2010. More often, flows terminate in the floodplains and wetlands south of Wanaaring. High flows in the Warrego River also contribute to the Paroo through Cuttaburra Creek, which connects the two systems.

The Paroo catchment contains ecological and environmental assets of national and international importance. It also contains areas of high economic, social, heritage and cultural values. A cooperative partnership between NSW and Queensland is required to ensure the sustainable management of these important areas and the overall health of the Paroo River system.

On 18 July 2003, the *Intergovernmental Agreement for the Paroo River between New South Wales and Queensland* was signed by the premiers of both states. The Agreement established a joint recognition by community, government and other stakeholders of the significance of the water resources in maintaining the unique character of the Paroo River catchment.

The Agreement highlights the ecological diversity, economic importance and spiritual values of the system. It recognises the unique character of the Paroo River and ensures that it will continue to provide spiritual connection, ecological diversity and integrity, and economic sustenance for future generations. More specifically, its purpose is to guide the development and implementation of water-related natural resource policies and strategies that may affect the quantity or quality of water in the Paroo River. In doing so, the Agreement aims to avoid adverse cross-border impacts on flow patterns and other water management issues.

The objectives of the Agreement are to:

- (a) provide a means for the parties to come together in good faith
- (b) define a process and context for raising and addressing water and related natural resource management issues
- (c) provide an emphasis for the Paroo River catchment under the Border Catchments Memorandum of Understanding and the Murray-Darling Basin Agreement
- (d) provide for a cooperative approach between community, industry, other stakeholders and all levels of government in the sustainable management of the Agreement area
- (g) encourage, promote and support management that reflects the Agreement's vision
- (h) encourage and promote research and monitoring to support informed decision making in the Paroo River catchment
- (i) provide for the review and, as necessary, revision of the Agreement
- (j) raise general public awareness of the special biodiversity and heritage values of the Paroo River catchment.

The Agreement will be superseded by the Murray-Darling Basin Plan when it is approved.

### Interim North West Unregulated Flow Plan

In February 1992, a draft interim plan for the management of unregulated flows in the north west of NSW was released for public comment. Its primary objective was to better manage unregulated flows in an effort to achieve a better health of the Barwon-Darling River without



severely impacting on water users. It establishes:

- target flows at key locations along the Barwon-Darling River and sets priorities for river health and riparian flows
- a framework for sharing unregulated flows between irrigators and for better management of extractions
- improved monitoring and research programs.

Environmental flow operational targets

Off-allocation pumping and B and C Class licence operation will not be permitted unless riparian flow targets are met. The targets at each location vary depending on inflows from contributing tributaries downstream of Mungindi. If no inflows from tributaries downstream of Mungindi exist the environmental flow operational targets will be:

LOCATION TARGETS	MEGALITRES PER DAY
Mungindi	850
Collarenebri	760
Walgett	700
Brewarrina	550
Bourke	390
Louth	280
Wilcannia	150

The water sharing plans for the Namoi, Gwydir and Border Rivers regulated rivers all contain provisions that enable the Interim North West Unregulated Flow Plan to be amended, although any such amendment must 'in the Minister's opinion, not substantially alter the long-term average volume of water that can be taken under supplementary water access licences in the Gwydir/Namoi/Border rivers Regulated River Water Sources.'

To enhance management of flow events in the Barwon-Darling Rivers, improved modelling capabilities are required that can better predict flood peak discharge from estimated tributary flows at key locations within the system. Integrated Quality and Quantity Model (IQQM) modelling is required to evaluate the potential for tributary end of system flows, as specified in the gazetted water sharing plans within each of the contributing valleys, to provide more frequent low flows which may maintain instream pool refugia and increase security of access to riparian flows within the Barwon-Darling.

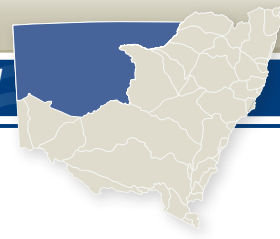
Algal suppression  
Blooms of blue-green algae (*cyanobacteria*) can cause major

problems in terms of water quality for domestic and stock water users along the length of the Barwon-Darling and can also affect town water supplies for centres such as Walgett, Bourke and Wilcannia.

Algal blooms can most often occur where instream flow is reduced, particularly during the summer months, to a point where thermal stratification results, thus producing conditions suitable for the rapid growth of *cyanobacteria*. Where possible, it is critical that stream flow is maintained such that the risk of *cyanobacterial* blooms is reduced.

Access to unregulated flows will be managed to achieve a flow of at least 2,000 megalitres per day for 5 days at Wilcannia between October and April inclusive unless a flow of at least this size has occurred within three preceding months within the October to April period.

B and C Class licences may have restriction to off-allocation flows if it is assessed that normal pumping will reduce flows below the targets, and restriction of pumping in the tributaries before three months of algal suppression



Fish traps constructed by traditional owner at Brewarrina - thought to be in use for hundreds of generations.

flows at Wilcannia may be necessary to allow for travel time to the target locations.

Fish migration flows  
Unregulated flows will be managed to achieve a target flow of at least 14,000 megalitres per day at Brewarrina or 10,000 megalitres per day at Bourke, or both, for 5 days between September and February inclusive, unless two such flows have occurred within this period. Restriction of access to supplementary flows and suspension of access to B and C Class licences on the Barwon-Darling may be necessary to achieve these

targets. These rules will apply until appropriate fishways are installed at Bourke and Brewarrina weirs.

These arrangements will be subsumed by the Murray-Darling Basin Plan when it is approved and implemented.

#### **Water shepherding for Commonwealth environmental water holder entitlements**

'Water shepherding' is the delivery of a volume of water from a nominated licence location to a downstream delivery location for use by the environment. Evaporation and transmission losses between the two points are taken into

account. The need for this concept has come about mainly owing to the Commonwealth's purchase of water entitlements in the Barwon-Darling and Warrego rivers through the 'Restoring the Balance in the Murray-Darling Basin' water purchasing program.

The water shepherding project involves the development of an implementation plan for introducing water shepherding in NSW, specifically in the Barwon-Darling River, Menindee Lakes and downstream of Menindee.

NSW agreed to trial shepherding of the water purchased by the Commonwealth from Toorale Station

(on the junction of the Warrego and Darling rivers), on the basis that the trial would not set any precedents for water shepherding in the future. NSW conducted three trials to shepherd water from the Barwon-Darling through Menindee Lakes to the Lower Darling and Murray rivers. These trials considered transmission and evaporation losses when calculating volumes that could be made available for environmental purposes at the downstream locations. The trials were conducted when flow events in the Barwon-Darling triggered the access conditions of the Toorale licence:

- In March 2009, 11,400 megalitres was shepherded from Toorale

Station, providing 5,976 megalitres for environmental use in the River Murray

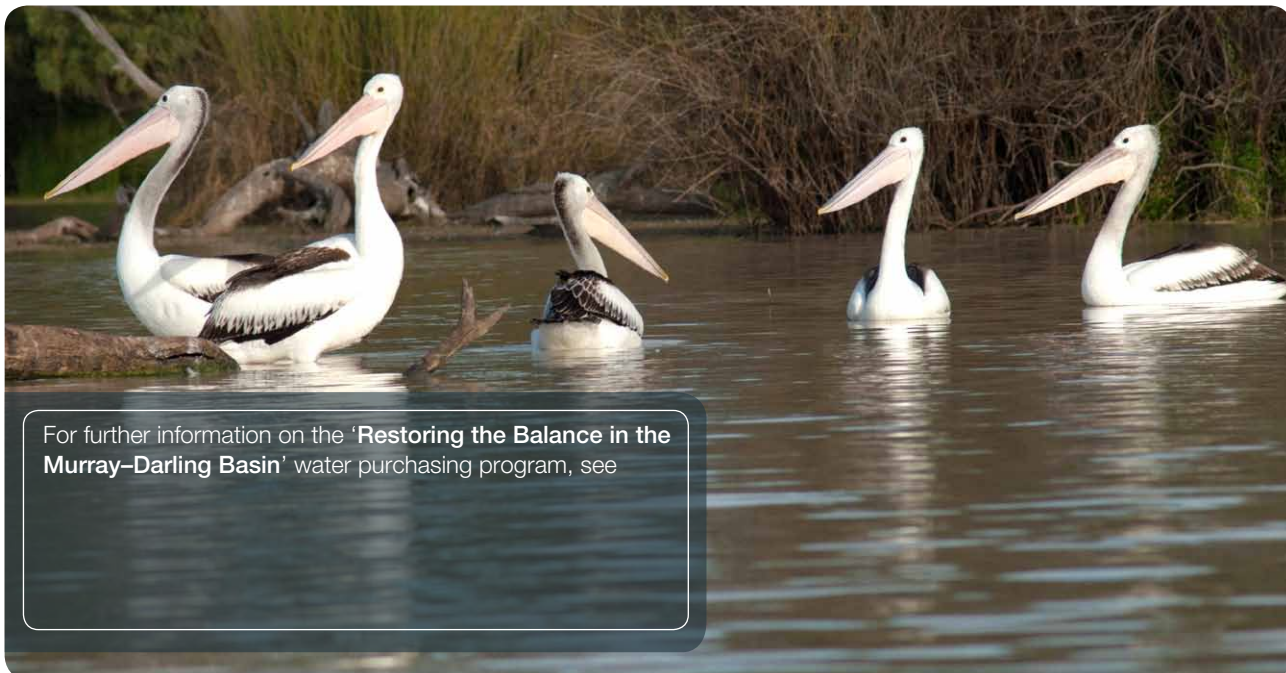
- In the summer of 2009-10, 38,000 megalitres was shepherded from Toorale Station, delivering 30,400 megalitres to the Menindee Lakes
- In September 2010, 6,580 megalitres was shepherded from Toorale Station, releasing 6,580 megalitres into the Great Darling Anabranch.

The Water Shepherding Taskforce agreed to investigate an end-of-system accounting method that is structured around a licensing and dealing framework. The method establishes a mechanism to

shepherd water to the end of the Barwon-Darling system and for the volume reaching the end of system to be accounted for and potentially recognised downstream.

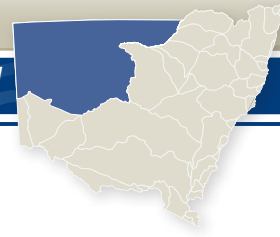
The NSW Water Shepherding Taskforce is now further developing the end-of-system method to take into account legal and licensing issues, accounting, water delivery, modelling and monitoring, trading, interstate water sharing arrangements, cap management and the treatment of overbank flows. It is also considering how water shepherded from Queensland and tributaries flowing into the Barwon-Darling Rivers could be accommodated.

Image courtesy of Neal Foster



For further information on the 'Restoring the Balance in the Murray-Darling Basin' water purchasing program, see





# available water determinations

## WHAT HAS INFLUENCED THE WATER SHARING PLANS' OPERATIONS IN 2010-11

### Groundwater - water availability

NSW Great Artesian Basin  
Groundwater Sources

Only three out of five NSW Great Artesian Basin Groundwater Sources underlie the Far West catchment. The entire Warrego and Central Groundwater Sources and the western part of the Surat Groundwater Source fall into the Far West catchment. The extraction of groundwater in the NSW Great Artesian Basin Groundwater Sources is managed sustainably and equitably through the announcement of available water determinations for each category of licences at the beginning of the water year. In the two water years since the announcement of the plan in July 2008, the available water determination remained the same for all NSW Great Artesian Basin

Groundwater Sources. The level of extraction from the aquifer access licences from all three Great Artesian Basin groundwater sources under the Far West catchment was well below the long-term average annual extraction limit. As provided under the *Water Management Act 2000*, thirty percent of water savings (1,200 megalitres) made under the Cap and Pipe the Bores Program (Great Artesian Basin Sustainable Initiative) since 1999 in the Surat, Warrego and Central groundwater sources was released to the public through controlled allocation in 2009-10.

In the Surat, Warrego and Central groundwater sources, local water utility, domestic and stock users have been allowed to access 100 per cent of their share component. For the share components of aquifer access licences authorized to extract from these groundwater sources, available water determination is set at 1 megalitre per share unit.

## WHAT ENVIRONMENTAL ISSUES ARE ADDRESSED BY THE WATER SHARING PLANS?

### Unregulated rivers water sharing plans

The Water Sharing Plan for the North Western Unregulated and Fractured Rock applies to all of the unregulated streams within the North Western Water Source, which include:

- Bulloo River Overflow
- Coopers Creek and Lake Eyre
- Lake Bancannia
- Lake Frome.

These systems are characterised as being highly ephemeral due to the low rainfall received within their catchments. This means that it is important to protect the instream pools, lagoons and other water bodies that may be critical for the survival of both aquatic and



**FIGURE 4**

The Ramsar-listed Lake Pinaroo, in the far north west of the plan area, is important for waterbirds.

terrestrial organisms. Many of these features provide key feeding and nesting habitat for colonially nesting waterbirds and migratory bird species. Figure 4 illustrates a key migratory bird habitat which is also listed under the Ramsar Convention. Provisions within the plan are also included to protect culturally significant areas.

### Groundwater water sharing plans

NSW Great Artesian Basin  
Groundwater Water Sources

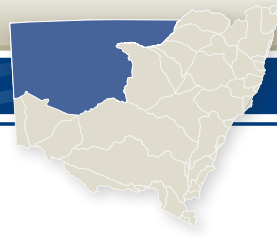
The Water Sharing Plan for the Great Artesian Basin Groundwater Sources requires that water be allocated for the fundamental health of a water source and its dependent ecosystems as a

first priority. Of 37 geothermal springs identified as high-priority groundwater-dependent ecosystems which need a high level of protection in the plan, 35 lie in the Far West catchment. The plan also recognises (though not mentioned explicitly) that the upward leakage and refused recharge from the Great Artesian Basin Groundwater Sources contribute base flows to water courses. To protect the geothermal springs and water courses, the plan sets distance rules for granting work approvals. Figure 5 illustrates artesian mound springs occurring at Peery Lake on the lower Paroo River. In the Surat, Warrego and Central groundwater sources, the plan reserves the volume of water

required to maintain 1990 pressure levels, minus increased extraction from 1990 until the end of June 2008, plus water savings made under the Cap and Pipe the Bores Program between 1990 and 1999, plus 70 per cent of water savings made under that program since 1999 for the environment (that is, to maintain the health of the groundwater sources).

North Western Fractured Rock  
Water Source

The Water Sharing Plan for the North Western Fractured Rock Water Source provides for the protection of groundwater-dependent ecosystems (GDEs), particularly through access to shallow alluvial groundwater systems and water



stored in rock fractures. Surface expressions of groundwater from fractured rock systems in this arid region are key refugia for aquatic organisms and critical water sources for terrestrial animals. In the past, these sources of water were often critical for the survival of the indigenous inhabitants of the area.

The plan provides protection for the Tarrawingee and Corona Springs, in the Adelaide Fold Belt, and the Mutawintji and Torrowangee Karst systems through the application of long-term average annual extraction limits and limiting activities that may cause aquifer interference. Other provisions are designed to minimise

interference between neighbouring works, to protect culturally significant works, and to ensure that any further works are located away from contaminated areas.

For more details on the water sharing plans, visit [www.water.nsw.gov.au](http://www.water.nsw.gov.au) go to Water Management > Water Sharing Plans > Plans commenced

Image courtesy of Neal Foster



**FIGURE 5**

Great Artesian Basin mound springs at Peery Lake.

# ecological monitoring

## WHAT ECOLOGICAL MONITORING IS OCCURRING?

### Unregulated rivers water sharing plans

Water Sharing Plan for the North Western Unregulated Water Sources

A study investigating the physical condition and hydrological status of key pool refugia in the NSW-Queensland intersecting streams will provide information necessary for adequate monitoring and evaluation of the performance of the water sharing plan for these river systems. The study involves aerial assessment and interrogation of satellite imagery with follow up ground-truthing and assessment of environmental attributes. Key pool refugia are being assessed for geomorphology and for ecological/habitat condition.

Stage 1, which involves aerial surveying and mapping of remnant pool refugia, was completed in December 2009, before the floods. Analysis of video and photographic records is in progress.

Key pools within each river are being assessed, and instrumentation to measure water levels and temperature profiles in pools is

being installed. Water quality data are being collected to supplement the Intersecting Streams Water Quality Program, funded through the Border Rivers Commission.

The study will improve our understanding of the physical condition of the pool refugia within the Paroo, Warrego, Moonie, Culgoa, Narran, Bokhara and Birrie Rivers and inform the development of water sharing principles for the water sharing plan. It will also provide a better understanding of:

- the broad ecological values of these rivers and wetlands
- key environmental assets within the river systems
- the specific flow regime requirements to maintain connectivity or refuge value within these systems
- the location of and potential impact of anthropogenic changes to the character of the river channel (such as weirs and artificial barriers).

Water Sharing Plan for the Barwon-Darling Water Source (in preparation)

### Wetlands and instream values

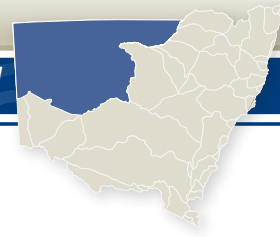
The flooding of many floodplain

wetland features such as flood-runners, warrumbools and ox-bows has been identified as being necessary for the stimulation and growth of many aquatic and terrestrial plants and animals.

Particularly important for the riverine ecology are the in-channel structures such as terraces or benches, on which debris or detritus is deposited during low flow periods. This material may include leaf litter and the remains of insects. When floods occur and these areas are inundated, the organic material, in addition to being an in situ food source for many aquatic organisms, may also be transported from the bench to be recycled within the river-floodplain system (Figure 6). These benches are more frequently inundated than similar higher level instream features owing to their location lower down the cross-sectional profile of the river channel, and therefore provide an important role in the cycling of carbon and nutrients.

Ox-bows, warrumbools and billabongs are also important in the provision of habitat, breeding areas and food. These features tend to be located higher up the stream





cross-sectional profile, and as many contain standing water on a semi-permanent basis, they provide a critical refuge for aquatic organisms during low flow periods. Aquatic and terrestrial biota associated with these wetland types are adapted to this semi-permanent to permanent state (Foster 1999). Populations of organisms at all levels of the food chain occur in these wetlands and

may be an important colonisation source during large floods.

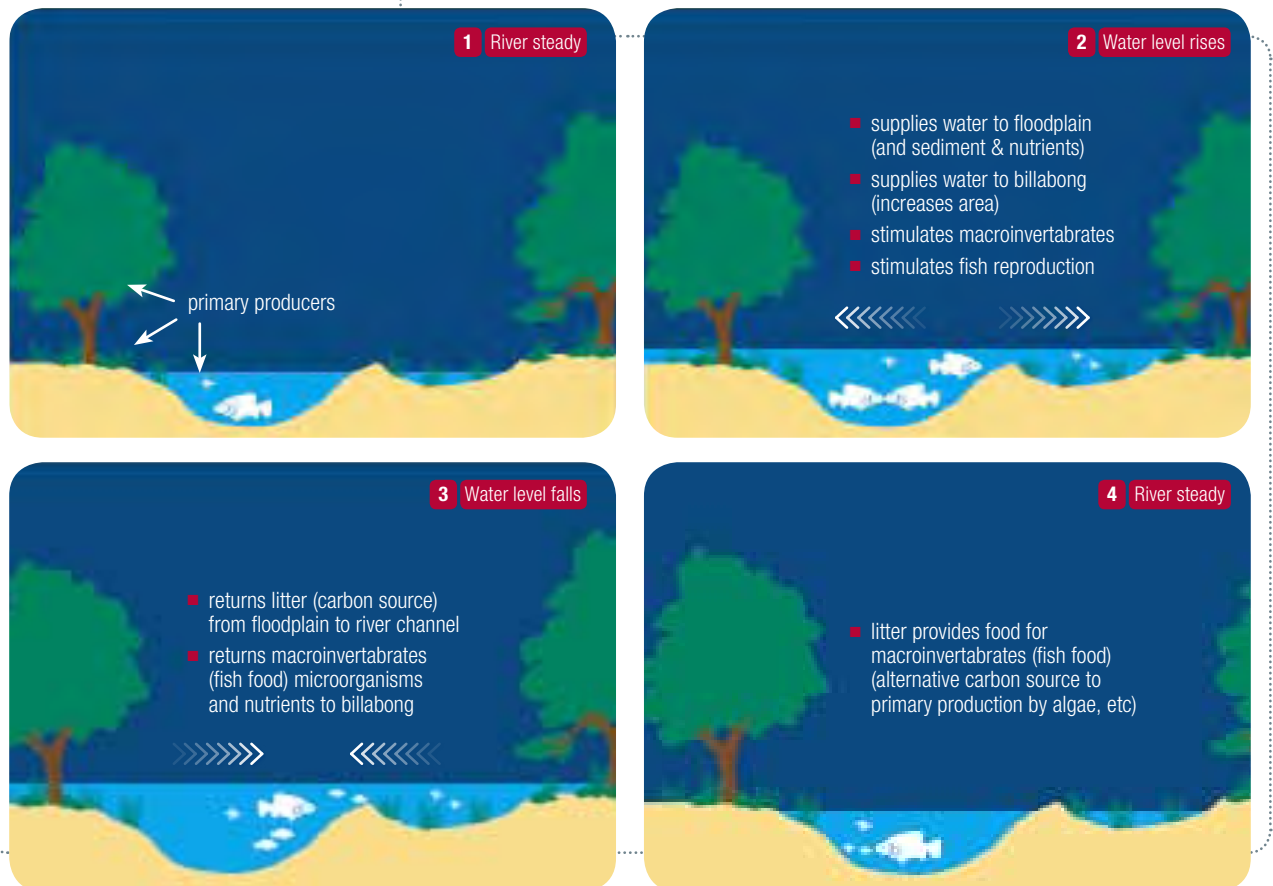
Low to medium level pulses in the system also play a major role in instream ecological processes, resulting in flushing of small particulate sediments, dispersal of algal blooms and thermal stratification, increased benthic algal and biofilm diversity, and increased invertebrate and fish population richness and abundance.

Water resource development has had a major impact on the hydrology of

the Barwon-Darling River. Flows are highly modified through the presence of 9 headwater dams, 15 main channel weirs and 267 licensed water extractors. Median annual runoff has been reduced by 42 per cent over 60 years. Small flood events (for example, an average recurrence interval of less than 2 years) have suffered the greatest impact, with reductions in magnitude of between 35 and 70 per cent. At a number of stations, the seasonality of flows has also been affected with a distinct

**FIGURE 6**

Flood pulse concept (Mussared 1997)





shift in seasonal flow peaks relating to irrigation diversions. Overall, flows show a marked increase in predictability and consistency.

As a result of these changes, wetted channel habitat for native fish has been reduced (Boys et al., 2005), the frequency and duration of inundation of instream benches and terraces has changed (Brennan et al., 2002), and hydrological connectivity with floodplain wetlands has been significantly altered, potentially affecting the ecological functions in these features.

The IQQM (Integrated Quality and Quantity Model) has analysed the period of rainfall records from 1897 to the present to enable the assessment of the impact of changes to river hydrology as a result of irrigation development or access conditions.

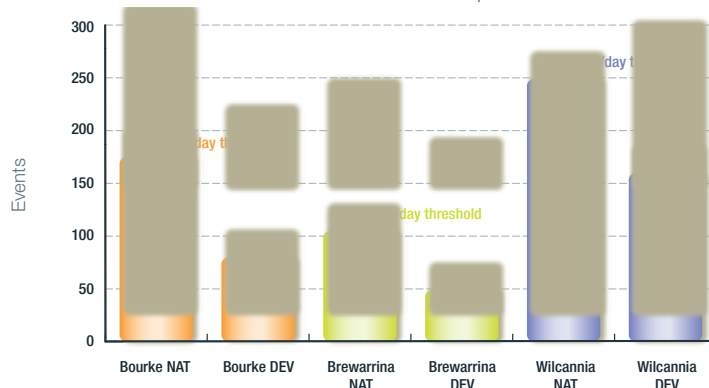
Figures 7a, 7b and 7c compares the hydrological character modelled for the Barwon-Darling at Bourke, Brewarrina and Wilcannia and demonstrate the impact of irrigation development in the Barwon-Darling and its tributaries (Namoi, Gwydir and Border Rivers, etc) on the frequency of achieving key flow thresholds identified for those sites within the Barwon-Darling.

#### NOTE

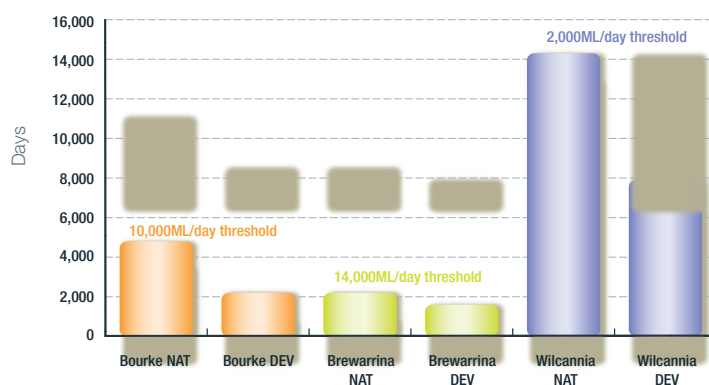
**NAT** No development in tributaries and no development in Barwon-Darling.

**DEV** Tributary Inflows and Barwon-Darling irrigation at 1993-94 CAP Development and Access Conditions.

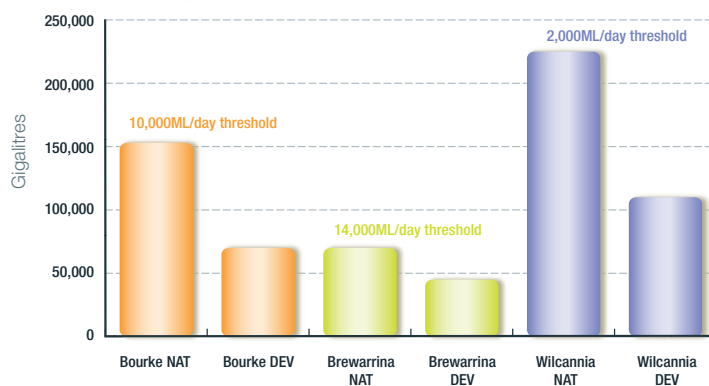
**FIGURE 7a** Number of events exceeding nominated flow thresholds at Bourke, Brewarrina and Wilcannia over the period from 1897 to 2008.

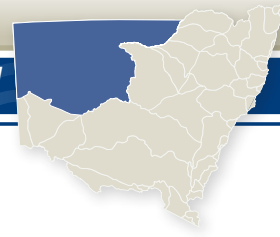


**FIGURE 7b** Total duration (days) of events exceeding nominated flow thresholds at Bourke, Brewarrina and Wilcannia over the period from 1897 to 2008.



**FIGURE 7c** Total volume (in Gegalitres) of events exceeding nominated flow thresholds at Bourke, Brewarrina and Wilcannia over the period from 1897 to 2008.





Critical discharge required for thermal destratification of weir pools

Weir pools and natural waterholes (Figure 8) within the Barwon-Darling River are frequently affected by planktonic blooms of the toxic filamentous cyanobacterium *Anabaena circinalis* (Mitrovic and Gordon, 1998). Blooms of this and other species of blue-green algae can significantly impact on town water supplies and stock water quality through the release of toxins and of taste and odour compounds, potentially affecting more than 250 licensed urban and rural extractors within the Barwon-Darling system (Figure 9).

In an attempt to better understand the relationship between stream discharge, stream velocity and the incidence of cyanobacterial blooms (greater than 15,000 cells per millilitre), Mitrovic and Gordon (1998) used a hydrological model, IQQM, to assess the effectiveness of the environmental water provisions in suppressing bloom development.

#### River Styles® project

The NSW Office of Water, in conjunction with the Western Catchment Management Authority (WCMA), engaged consultants to undertake a River Styles® assessment of all named streamlines in the WCMA area. The aim of this project was to assess and map the geomorphic character of streams



**FIGURE 8**  
The Darling River near Tilpa.

Image courtesy of Neal Foster



**FIGURE 9**  
Blue-green algal bloom on the Darling River.

Image courtesy of Neal Foster

utilising the River Styles® method, that occur across the WCMA area and the geomorphic condition, fragility, recovery potential and refugia potential of waterways. The data will improve our understanding of the physical processes that determine the structure and character of waterways and will guide the selection of monitoring sites to allow the comparison and identification of particular stream types that are essential for maintaining ecological function across the flow regime. See Figure 10 for examples of River Styles® mapping.

### Groundwater water sharing plans

#### NSW Great Artesian Basin Groundwater Sources

Over 500 flowing bores in the NSW Great Artesian Basin Groundwater Sources have been monitored for pressure, flow, temperature and groundwater quality over the last 100 years. Monitoring was discontinued in many bores as they were plugged, became sub-artesian or became unsuitable owing to the poor condition of the bore head. At present, 60 bores are being monitored at least once every 2 years. As part of the federally funded basin-wide monitoring of the health of Great Artesian Basin aquifers, 29 of these bores are being monitored for pressure, flow, temperature and water quality once a year. Twelve

of these bores are being fitted with telemetered data loggers to monitor pressure, flow, temperature and water quality in real time.

#### North Western Fractured Rock Water Source

This water source is not currently being monitored.

#### Mapping of groundwater-dependent ecosystems

Two major projects are associated with identification of groundwater-dependent ecosystems (GDEs) in the Far West of NSW:

1. Stage 1 mapping of high-priority GDEs for the Macro and other water sharing plan processes using a preliminary desktop study of geological maps, vegetation and land use maps, and information from any prior studies. So far only the mound springs within the region have been identified (Figure 11).
2. Mapping of terrestrial vegetation communities across NSW using satellite imagery and MODIS (Moderate Resolution Imaging Spectroradiometer) data to identify vegetation that uses groundwater. This project is expected to be completed by mid 2012. Follow-up field survey work is needed to establish the extent of natural values, the condition of these sites and their level of groundwater dependency.

The NSW Office of Water and the Office of Environment and Heritage have developed draft risk assessment guidelines for groundwater-dependent ecosystems for identifying and valuing GDEs and their associated aquifers. The guidelines allow potential and actual impacts of proposed activities on GDEs to be assessed, and provide a method for developing management strategies for aquifers and identified GDEs. The process for identifying and valuing GDEs involves two stages:

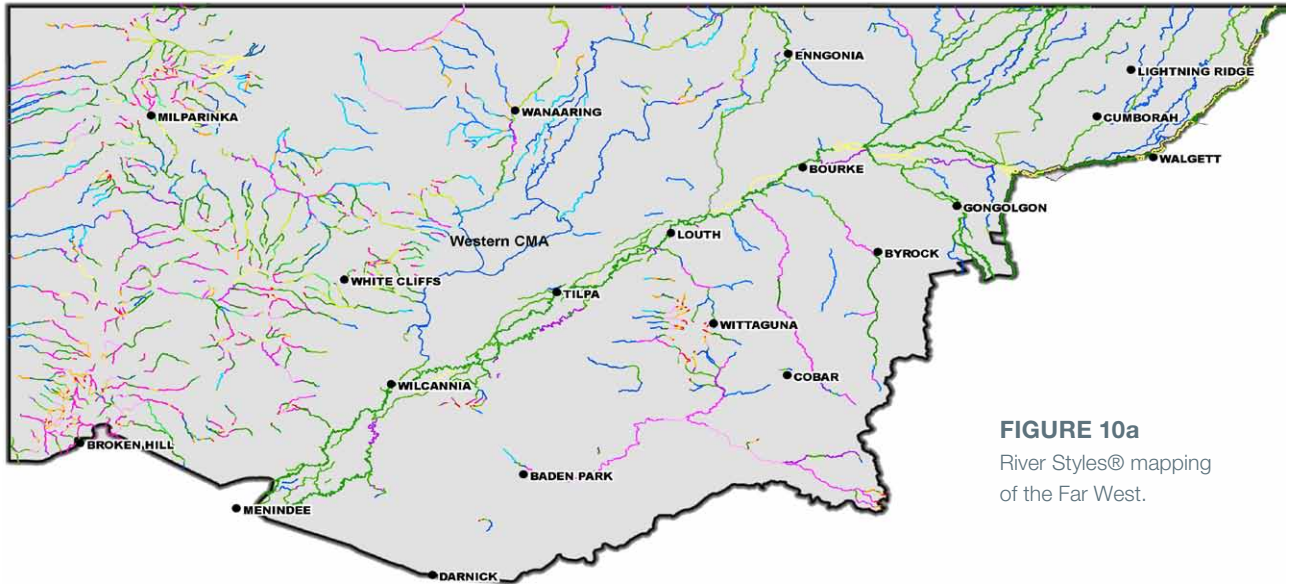
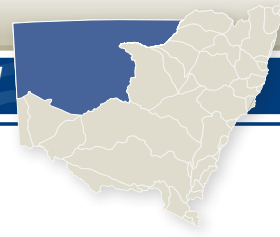
**Stage 1** Identification of high-ecological-value assets and high-priority GDEs within the aquifer or groundwater source. This is a desktop approach that lists:

- areas of known or potential GDEs that have been identified as having high conservation value under legislative or other assessment programs
- obligate or entirely dependent ecosystems and species.

**Stage 2** Valuation of GDE and aquifer or groundwater source ecology. This involves a detailed ecological assessment based on criteria adapted from Dunn (2000), and covers:

- GDE environment (surface and subsurface)
- rarity of the dependent biota or physical features
- diversity
- special features.




**FIGURE 10a**

River Styles® mapping  
of the Far West.

## LEGEND

- |  |   |  |  |
|--|---|--|--|
|  | <b>CVS</b> Floodplain pockets, gravel     |  | <b>PCVS</b> Bedrock controlled, gravel                     |
|  | <b>CVS</b> Floodplain pockets, sand       |  | <b>PCVS</b> Bedrock controlled, sand                       |
|  | <b>CVS</b> Gorge                          |  | <b>PCVS</b> Dune controlled, anabranching                  |
|  | <b>CVS</b> Headwater                      |  | <b>PCVS</b> Planform controlled, anabranching              |
|  | <b>LUV CC</b> Anabranching                |  | <b>PCVS</b> Planform controlled, low sinuosity, fine grain |
|  | <b>LUV CC</b> Anabranching, gravel        |  | <b>PCVS</b> Planform controlled, low sinuos                |
|  | <b>LUV CC</b> Anastomosing                |  | <b>PCVS</b> Planform controlled, wandering                 |
|  | <b>LUV CC</b> Channelised fill            |  | <b>SMG</b> Dune controlled, chain of ponds                 |
|  | <b>LUV CC</b> Low sinuosity, fine grained |  | <b>SMG</b> Dune controlled, floodout                       |
|  | <b>LUV CC</b> Low sinuosity, sand         |  | <b>SMG</b> floodout  |
|  | <b>LUV CC</b> Meandering, fine grained    |  | <b>SMG</b> Valley fill, fine grained                       |
|  | <b>LUV CC</b> Wandering, gravel           |  | <b>SMG</b> Valley fill, sand                               |
|  | <b>LUV CC</b> Wandering, sand             |  | <b>Water storage dam or weir pool</b>                      |
|  | <b>LUV DC</b> Variable lake delta         |  |  |



0 25 50 100  
kilometres

This map is to be used as a general guide for regional and local scale natural resource planning and management only, not for the assessment of specific sites which can only be assessed by investigation specific to those sites. The field information contained on this map may not be verified or complete.

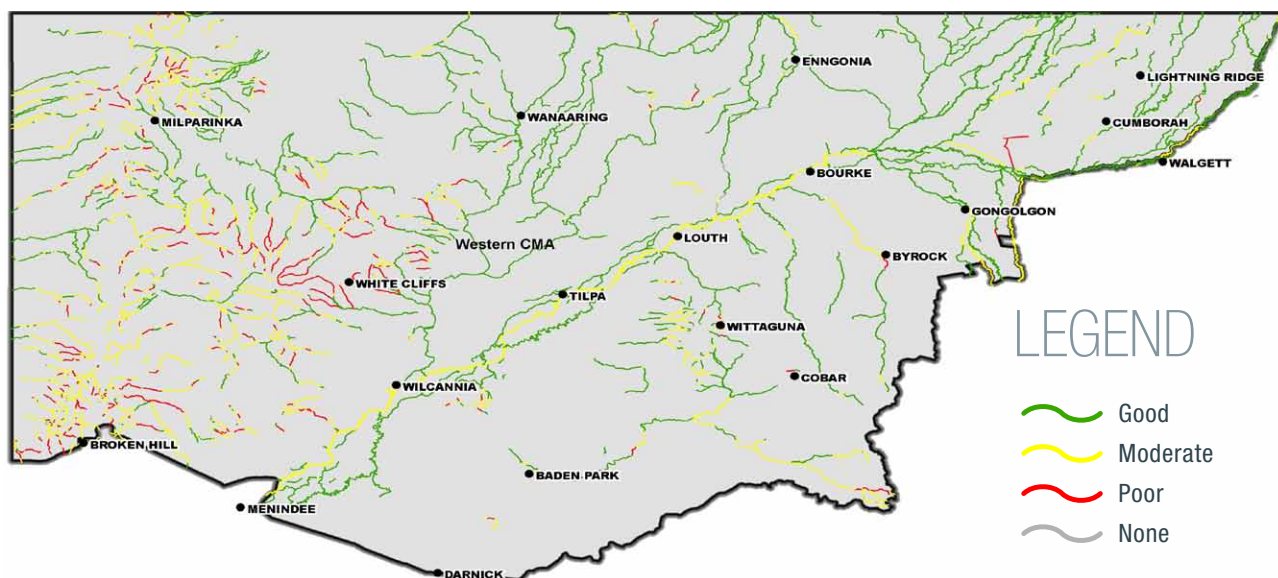
This map is published by the NSW Office of Water. While every reasonable effort has been made to ensure the accuracy of the information contained in the map, you should satisfy yourself as to the accuracy of the information before relying on it.

The State of New South Wales, its agents and employees, disclaim any and all liability to any person in respect of anything or the consequences of anything done or omitted to be done in reliance upon the whole or any part of this map.

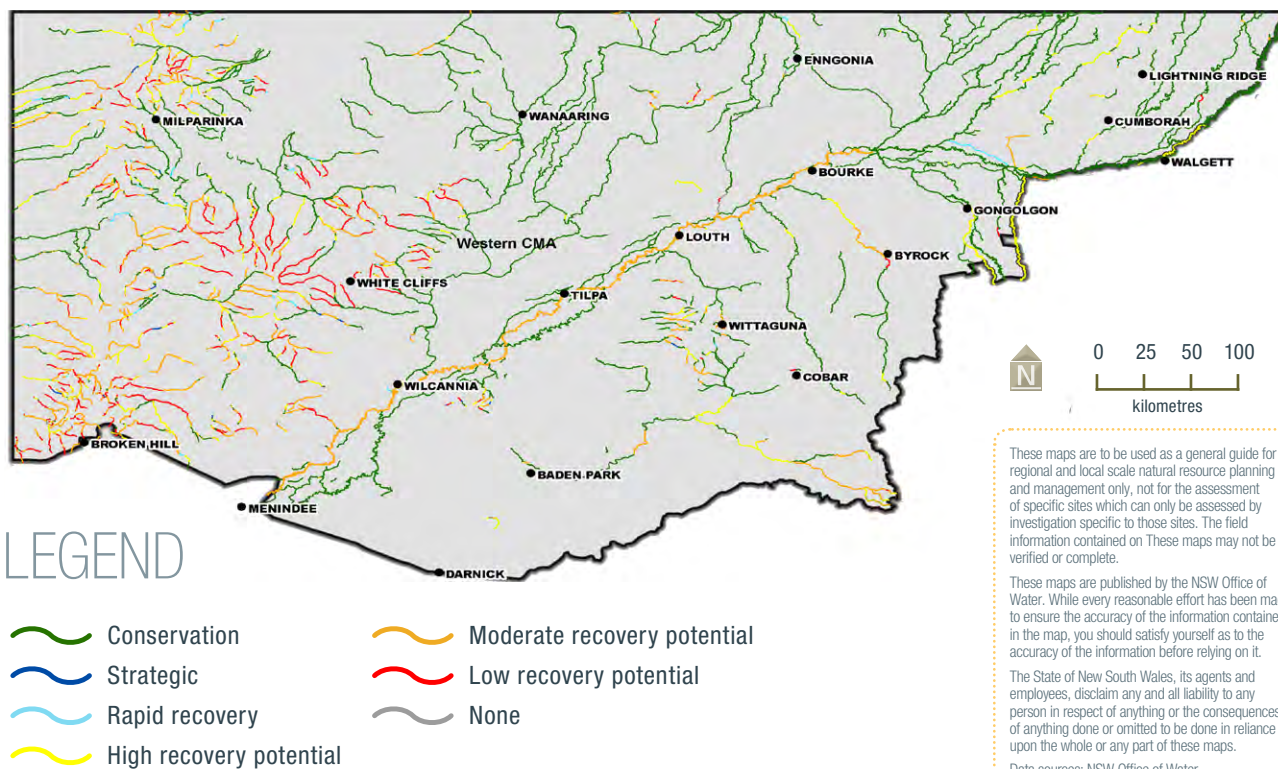
Data sources: NSW Office of Water

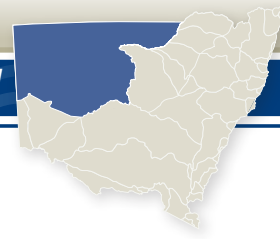


**FIGURE 10b** River Styles® Geomorphic Condition of the Far West.



**FIGURE 10c** River Styles® Recovery Potential of the Far West.





### Stage 2 has two steps:

Step 1: Identification of the ecological value of individual GDEs within a groundwater source. This step involves a rapid identification of high-ecological-value assets and is a broad-scale assessment that aims to identify

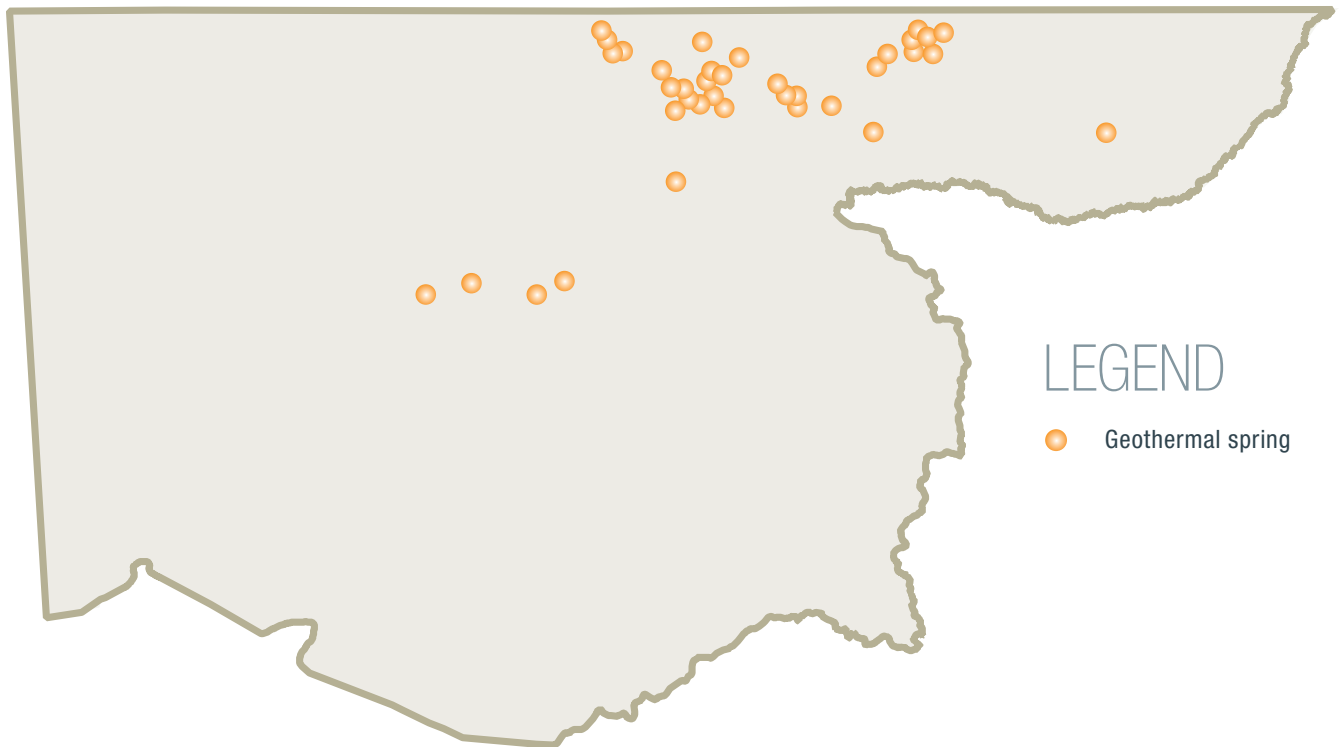
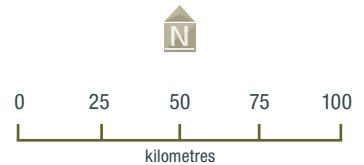
whether an aquifer has any environmental assets that have been identified through other legislated conservation processes or programs as having important conservation significance; that is, they have high ecological value and should be classed as high-priority GDEs. This

allows for the protection of GDEs of known high conservation value via the protection of the water source.

Step 2: Identification of the ecological value of the aquifer or groundwater source. This step involves a desktop exercise assembling all known

**FIGURE 11**

Map of identified groundwater-dependant ecosystems in Far West region of NSW



records of communities, species and areas of high ecological value within an aquifer or groundwater source. It includes interrogating known databases, GIS records and other studies, followed by the identification of the high-priority GDEs.

#### Identification of high-priority GDEs within the aquifer or groundwater source

A high-priority GDE has high ecological value. This means natural or near-natural condition, health and integrity, or that fulfils any of the criteria in stage 1 and/or is assessed as such. High-priority GDEs include any of the following:

- (a) Groundwater-dependent communities in which a slight to moderate change in groundwater discharge or water tables would result in a substantial change in their distribution, species composition or health. This includes all ecosystems that are identified and acknowledged as being entirely (or obligately) dependent on groundwater for their survival. These ecosystems include all karst, springs, mound spring and subterranean aquifer ecosystems and some wetlands, including hanging swamps
- (b) Those ecosystems that have already been identified as

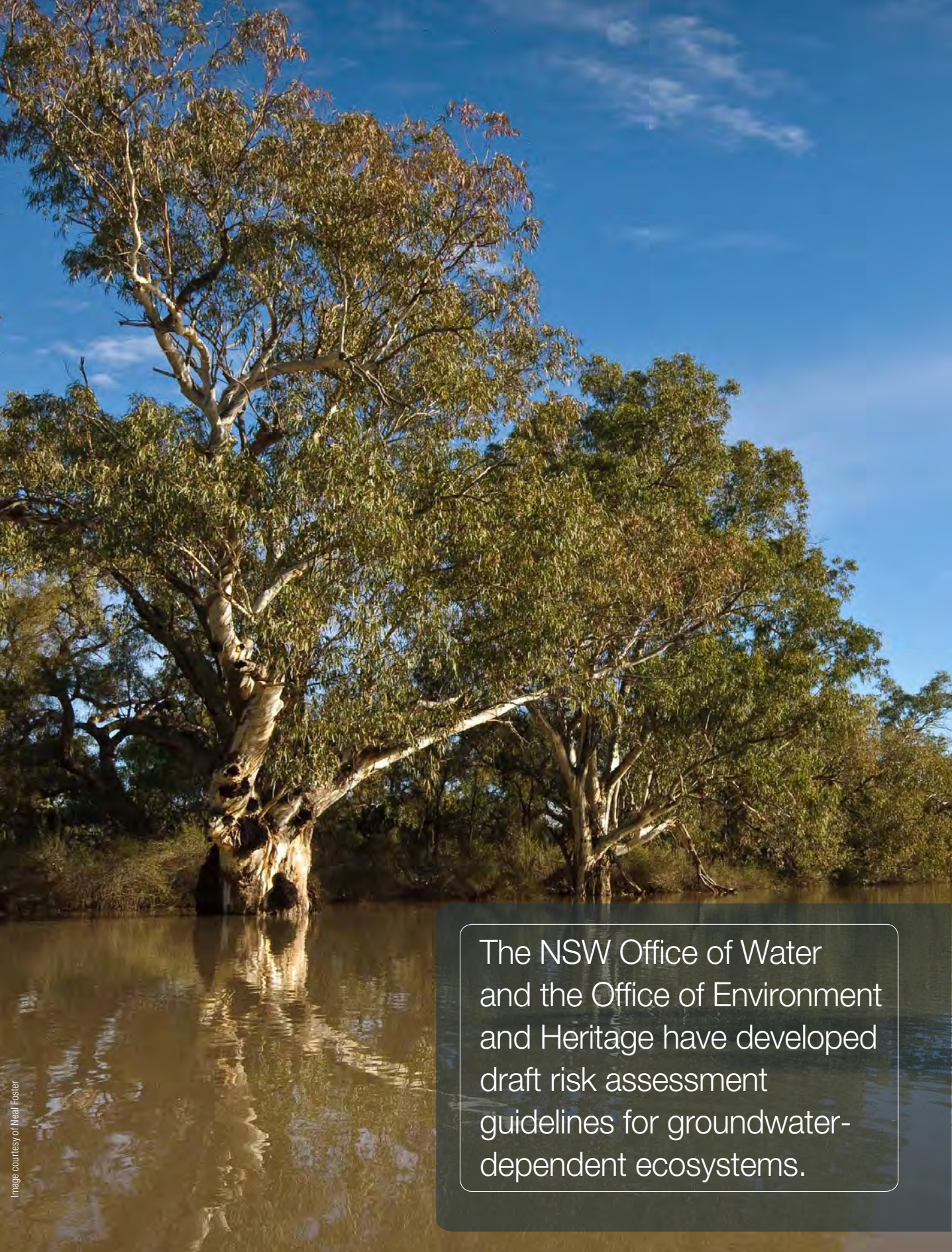
important by other environmental agencies or within existing legislation or international agreements: that is, those GDEs that are partly or wholly located within a state or federal reserve system (for example, a national park) or a recognised high conservation area, such as a subcatchment identified as having high conservation value (for example, stressed rivers, high-value vegetation, State Environmental Planning Policy 14 - Coastal Wetlands, or those listed on the Directory of Important Wetlands in Australia (DIWA))

- (c) Any natural groundwater-dependent system that is habitat for any endemic, relictual, rare or endangered fauna or flora populations or communities as listed under the *NSW Threatened Species Act 1995*, the *NSW Fisheries Management Act 1994* or the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*, or identified by an acknowledged expert taxonomist or ecologist.

Acknowledging the presence of these ecological assets is the first step in assigning an ecological

value to a groundwater source and individual GDEs and in developing an appropriate strategy to manage the risk from both land use and water management impacts. Bioregional and catchment-scale issues, such as reservation status or whether there are recognised and listed rare or threatened species or communities, are also important. The area and number of GDE subtypes and the relative condition of those GDEs in the landscape and bioregion place the threat to the biota in a regional context. Consideration of these issues can assist in determining the role that the aquifer plays in relation to the maintenance and protection of biodiversity within any legislated assets and within the region as a whole. In addition, there may be particular species or features present that are considered to make an additional contribution to an aquifer's biodiversity value. This is of particular relevance to many of the small, isolated relict GDE communities characteristic of the arid environment of the Far West region. Although the risk assessment guidelines for groundwater-dependent ecosystems will continue to be developed and applied, at this stage no on-ground monitoring of the ecological attributes is planned for 2011-12.





The NSW Office of Water and the Office of Environment and Heritage have developed draft risk assessment guidelines for groundwater-dependent ecosystems.



# plan provisions being monitored

## WHICH PLAN PROVISIONS ARE WE MONITORING?

### Unregulated rivers water sharing plans

Water Sharing Plan for the North Western Unregulated and Fractured Rock Water Sources

#### Clause 8: Objectives

The objectives of the plan are to:

- (a) protect, preserve, maintain and enhance the important river-flow-dependent and high-priority groundwater-dependent ecosystems of these water sources
- (b) protect, preserve, maintain and enhance the Aboriginal, cultural and heritage values of these water sources
- (c) contribute to the maintenance of water quality
- (d) provide recognition of the connectivity between surface water and groundwater
- (e) adaptively manage these water sources
- (f) contribute to the environmental and other public benefit outcomes identified under the

*Water Access Entitlements and Planning Framework in the Intergovernmental Agreement on a National Water Initiative (2004) (the NWI).*

Under the NWI, water that is provided by NSW to meet agreed environmental and other public benefit outcomes is to:

- (i) be given statutory recognition and have at least the same degree of security as water access entitlements for consumptive use and be fully accounted for
- (ii) be defined as the water management arrangements required to meet the outcomes sought, including water provided on a rules basis or held as a water access entitlement
- (iii) if held as a water access entitlement, may be made available to be traded (where physically possible) on the temporary market, when not required to meet the environmental and other public benefit outcomes sought, and provided such trading is not in conflict with these outcomes.

#### Clause 10: Performance indicators

The performance of the plan is assessed against changes in:

- (a) low flows
- (b) moderate to high flows
- (c) or maintenance of, the ecological value of key water sources and their dependent ecosystems
- (d) the economic benefits derived from water extraction and use.

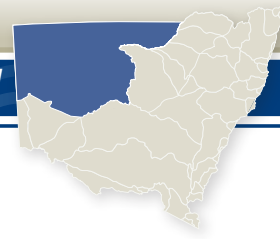
### Groundwater water sharing plans

Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources

#### Clause 9: Objectives

The objectives of the plan are to:

- (a) improve pressures and flows in the artesian portion of the groundwater sources through efficient water use, and to achieve sustainable extraction in their recharge areas
- (b) protect, maintain and, where possible, restore priority environmental assets
- (c) maintain and enhance cultural and heritage values affected by the use of water from the groundwater sources



- (d) enhance groundwater use for community benefit
- (e) adaptively manage these groundwater sources
- (f) protect groundwater quality.

#### Clause 11: Performance indicators

The performance of the plan is assessed against:

- (a) change in groundwater extraction volume relative to the long-term total average annual extraction limit
- (b) change in groundwater levels and pressures
- (c) change in groundwater levels and pressures adjacent to identified groundwater-dependent ecosystems
- (d) change in groundwater quality
- (e) change in economic benefits derived from groundwater extraction and use
- (f) the total length of bore drains replaced by efficient water distribution methods.

Water Sharing Plan for the North Western Unregulated and Fractured Rock Water Sources

#### Clause 8: Objectives

The objectives of the plan are to:

- (a) protect, preserve, maintain and enhance the important

river-flow-dependent and high-priority groundwater-dependent ecosystems of these water sources

- (b) protect, preserve, maintain and enhance the Aboriginal, cultural and heritage values of these water sources
- (c) contribute to the maintenance of water quality
- (d) provide recognition of the connectivity between surface water and groundwater
- (e) adaptively manage these water sources
- (f) contribute to the environmental and other public benefit outcomes identified under the Water Access Entitlements and Planning Framework in the *Intergovernmental Agreement on a National Water Initiative (2004)*.

#### Clause 10: Performance indicators

The performance of the plan is assessed against changes in:

- (a) surface water and groundwater extraction relative to the long-term average annual extraction limit
- (b) or maintenance of, the ecological value of key water sources and their dependent ecosystems
- (c) economic benefits derived from water extraction and use.

#### Clause 15: Establishment and maintenance of planned environmental water

- (1) Planned environmental water in these water sources is established as follows:
  - (a) The physical presence of water:
    - (i) in the North Western Water Source that results from the access rules specified in Division 2 of Part 8 of the plan that set flow rates or flow levels below which the taking of water is not permitted
    - (ii) in the Kanmantoo Fold Belt North Western Groundwater Source equal to 40 per cent of the long-term average annual rainfall recharge in areas that are not high environmental value areas (estimated to be 46,550 megalitres per year) and 100 per cent of the long-term average annual rainfall recharge in high environmental value areas (estimated to be 5,145 megalitres per year) at the start of this plan
    - (iii) equal to 40 per cent of the long-term average annual rainfall recharge to the Adelaide Fold Belt North Western Groundwater Source (estimated to be 50,635 megalitres per year)

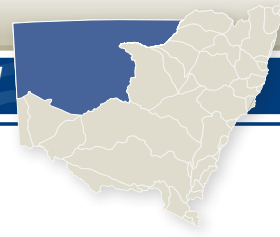
- (iv) equal to 100 per cent of the annual recharge to the Lachlan Fold Belt North Western Groundwater Source
  - (v) within the groundwater storage of these fractured rock groundwater sources over the long term.
- (b) The long-term average annual commitment of water in:
- (i) the North Western Water Source that results from the application of the available water determination rules as specified in Division 2 of Part 6, the water allocation management rules as specified in Division 1 of Part 8, and the resulting long-term average annual extraction limit as specified in Division 1 of Part 6
  - (ii) the Kanmantoo Fold Belt North Western Groundwater Source equal to 40 per cent of the long-term average annual rainfall recharge
  - (iii) the Adelaide Fold Belt North Western Groundwater Source equal to 40 per cent of the long-term average annual rainfall recharge
  - (iv) the Lachlan Fold Belt North Western Groundwater Source equal to 100 per cent of the annual recharge



Image courtesy of Neal Foster

- (v) these fractured rock groundwater sources equal to the volume of water within the groundwater storage over the long term.
  - (c) The water remaining after water has been taken pursuant to basic landholder rights and access licences in these water sources, in accordance with the rules specified in Part 6 and Part 8 of the plan.
- (2) The planned environmental water established under 15(1)(a) above is maintained in:
- (a) the North Western Water Source by the rules specified in Division 2 of Part 8 of the plan
  - (b) these fractured rock groundwater sources by the rules specified in Part 6 and Part 8 of the plan.
- (3) The planned environmental water established under 15(1)(b) is maintained in:
- (a) the North Western Water Source by the available water determination rules as specified in Division 2 of Part 6, the water allocation account management rules as specified in Division 1 of Part 8, and the resulting long-term average annual extraction limit as specified in Division 1 of Part 6
  - (b) these fractured rock groundwater sources by the rules in Part 6 which limit the water available for extraction under access licences.
- (4) The planned environmental water established under 15(1)(c) is maintained in these water sources by the rules specified in Part 6 and Part 8 of the plan to ensure that water will remain in these water sources over the long term by maintaining compliance with the long-term average annual extraction limit. The rules in Part 6 provide for a reduction in available water determinations when the long-term average annual extraction limit is assessed to have been exceeded.





## WHAT HAS THE ECOLOGICAL MONITORING TOLD US SO FAR?

### Unregulated rivers water sharing plan

Water Sharing Plan for the Barwon-Darling Water Sources (yet to be gazetted)

### Protection of flows to reduce the incidence of blue-green algal blooms in weir pools

Research by Mitrovic and Gordon (1998) in a number of weir pools in the Barwon-Darling identified the minimum discharges at which persistent thermal stratification and blooms do not occur. The 'critical' discharges at Bourke and Wilcannia were estimated from previous studies (Oliver et al. 2000; Mitrovic et al. 2003) and from *Anabaena* cell counts and discharge data over 1992–2003 (Department of Infrastructure, Planning and Natural Resources, unpublished data). Insufficient data were available for Brewarrina; the few blooms recorded there coincided with very low discharges (less than 50 megalitres per day) that probably were well below the critical discharge.

Model runs using the IQQM were performed:

- with environmental water provisions
- with extraction but with no environmental water provisions

**TABLE 1** Critical discharges and corresponding velocities to suppress persistent stratification and *Anabaena circinalis* growth, and wetted cross-sectional areas at the critical discharges, at three sites in the Barwon–Darling River (Mitrovic et al. 1998).

SITE	Critical discharge (ML d <sup>-1</sup> )	Critical velocity (mean ± SD) (ms <sup>-1</sup> )	Cross-sectional area <sup>†</sup> (mean ± SD) (m <sup>2</sup> )
Barwon River at Brewarrina	510*	0.030 ± 0.003 <sup>†</sup>	196 ± 23
Darling River at Bourke	450	0.030 ± 0.004	175 ± 21
Darling River at Wilcannia	350	0.031 ± 0.004	132 ± 20

\* Estimated from cross-sectional area and critical velocity

† Estimated from critical velocity at other sites

<sup>†</sup>n = 15

ML d<sup>-1</sup> = megalitres per day  
ms<sup>-1</sup> = metres per second  
m<sup>2</sup> = square metres

- without extraction (that is, 'natural' discharge).

Study sites were selected to represent the upper (Brewarrina), mid (Bourke) and lower (Wilcannia) sections of the Barwon-Darling River. At each site, cross-sectional profiles were derived, and wetted area was calculated for river heights equivalent to the critical discharges at Bourke and Wilcannia.

Table 1 shows the critical discharges and corresponding flow velocities required to suppress persistent thermal stratification and *Anabaena circinalis* growth.

Mitrovic et al's modelling implies that the environmental water provisions in place since mid 2000 are not yet likely to have had much effect on the frequency of blooms of *A. circinalis*. However, modelling of their potential impact, had they been in place from 1990 to 2000, indicates that they

could have reduced the frequency by up to a third at some sites. It thus appears that the environmental water provisions could decrease bloom frequency appreciably over the longer term. Mitrovic et al. (1998) suggest maintenance of flow velocities above 0.04 metres per second from 15 October to 15 March of each year to minimise the frequency and intensity of blooms.

### Groundwater water sharing plans

NSW Great Artesian Basin Groundwater Sources

All except two high-priority geothermal springs identified for protection in the Great Artesian Basin Groundwater Sources are located in the Far West catchment. The analysis of flows shows that 95 free-flowing (uncontrolled) bores in this catchment have significant impact on the protected geothermal springs. The number of impacting

bores is estimated as 9 in the Central, 58 in the Warrego and 28 in the Surat groundwater sources in this catchment.

The monitoring also shows that the pressure head in the Great Artesian Basin Groundwater Sources in the Far West catchment rose by between 1 and 6 metres in the last 10 years. Noticeable rise in pressure in the artesian aquifer in the Warrego and Surat groundwater sources near areas where many free-flowing bores were plugged under the Cap and Pipe the Bores Program. However, no significant increase in pressure was observed in the Central Groundwater Source. The reasons for this observation may be a lack of long-term monitoring information, discontinuity of monitoring of bores owing to gas in the water, and a low number of bores plugged, capped and piped in this groundwater source.

#### Links to other projects

The statewide groundwater monitoring network in the NSW Great Artesian Basin Groundwater Sources is linked to the federally funded Great Artesian Basin Monitoring Network. Twenty-nine bores of the statewide monitoring network are being used for monitoring of the Great Artesian Basin. Data obtained from this

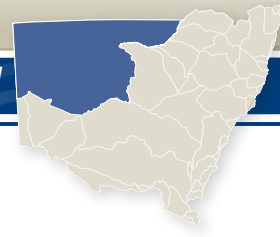
monitoring will be used to evaluate the effectiveness of the water sharing plans through changes in pressure within the aquifer.

The NSW Macro Plan process is expected to have plans in place for all groundwater sources in the Far West by mid 2012. The plans

for each groundwater source will contain long-term average annual extraction limits and rules that will allow only acceptable impacts on users and the environment. Groundwater sources that are highly connected to the rivers will include cease-to-pump criteria.



Image courtesy of Neal Foster



# Socio-economic monitoring

In 2005, the NSW Office of Water began a statewide project to monitor changes in the NSW irrigation industry following the introduction of water sharing plans. The project is designed to:

- monitor key social and economic changes at the farm and regional levels arising from water sharing plans
- provide data for the NSW Office of Water's review and evaluation of water sharing plans
- provide data for the Natural Resources Commission's review of water sharing plans
- provide a benchmark for other economic and social monitoring exercises in natural resource management.

The project was developed after extensive consultation with stakeholders, including the NSW Irrigators' Council and the Primary Industries and Economic Development Standing Committee of the NSW Natural Resources Advisory Council.

The project reports on changes in a number of identified social and

economic indicators. The data are collected primarily in a 20-minute telephone survey of irrigators who responded to an invitation to participate. A sample size of approximately 10 per cent of the eligible irrigators is targeted for each survey. Additional customised data from the Australian Bureau of Statistics' agricultural census are also used.

The first of the surveys, in 2006, targeted irrigators in areas where the first 31 water sharing plans were implemented in July 2004. These plans covered all major regulated rivers in NSW, and represented approximately 80 per cent of the extractive water use in NSW. The 2006 survey collected baseline data reflecting the socio-economic conditions of farms in these areas.

For reporting purposes, the results of the irrigator surveys are tabulated by catchment management authority (CMA) area. The Far West data are reported for the Western CMA area.

No water sharing plans were gazetted in the Far West in 2004, so no data were collected in this area in the 2006 survey.

In 2009, the companion baseline survey targeted irrigators in areas where water sharing plans were implemented after 2004 or are about to be implemented. This survey covered irrigators whose water sources are predominantly unregulated rivers or major inland groundwater systems.

The combined 2006 and 2009 survey data provide a complete statewide baseline data set for use in the socio-economic indicator reporting of plan performance.

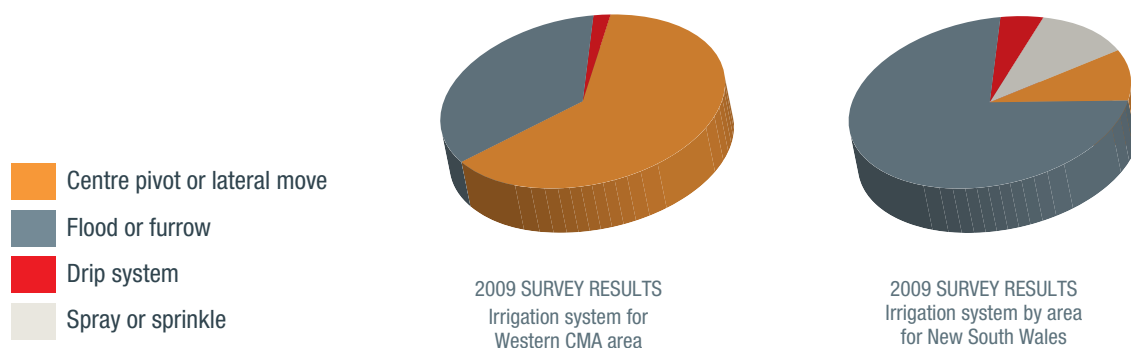
The 2009 survey included six water sharing plan areas in the Far West:

- NSW Great Artesian Basin Groundwater Sources (plan gazetted 2008)
- North Western Unregulated and Fractured Rock Water Sources
- Barwon-Darling Unregulated and Alluvial Water Sources
- Intersecting Streams Unregulated and Alluvial Water Sources
- Murray-Darling Basin Fractured Rock Groundwater Sources
- Murray-Darling Basin Porous Rock Groundwater Sources.

In the Western CMA area there were



**FIGURE 12** 2009 survey results showing proportion of irrigation systems used by respondents in the 2009 survey in the Western CMA area and statewide



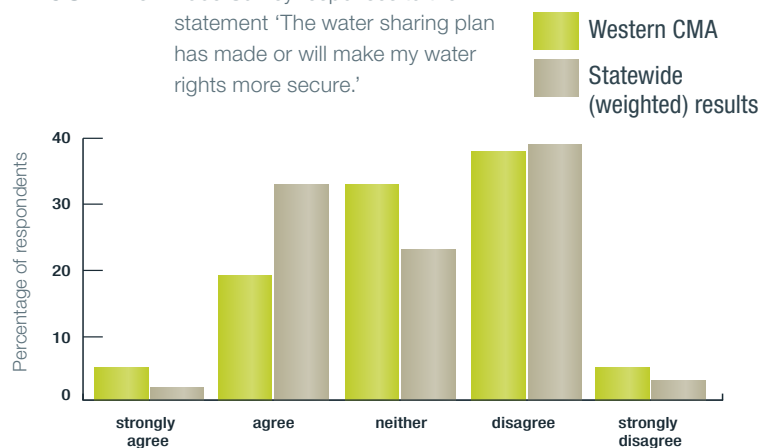
Source: 2009 Irrigators survey.

278 irrigators with an entitlement of 215,600 megalitres. The 2009 survey obtained responses from 26 irrigators with entitlements of 38,366 megalitres.

The 2009 survey results showed:

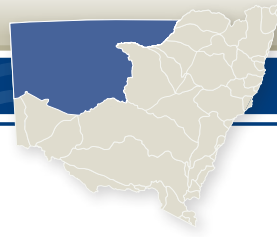
- The median irrigation farm size in the Western CMA area was 4,215 hectares, with a 25th to 75th percentile range of 487 to 10,422 hectares. The statewide median was 90 hectares (percentile range 30 to 409 hectares)
- Centre pivot and lateral-move irrigation systems were used on 63 percent of irrigated land in the Western CMA area and compares this to statewide results (Figure 12)
- Figure 13 shows the irrigators' responses to the statement 'The water sharing plan has made or will make my water rights more secure'

**FIGURE 13** 2009 Survey responses to the statement 'The water sharing plan has made or will make my water rights more secure.'

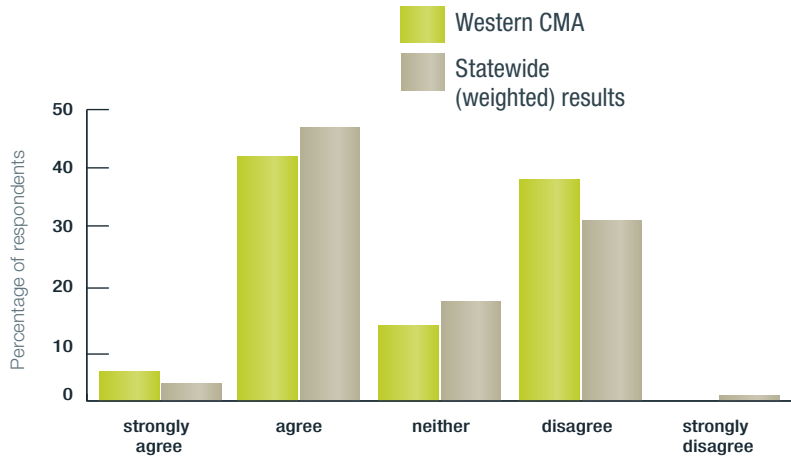


Source: 2009 Irrigators survey.

- Irrigators derived 12 per cent of total farm income from irrigated crops and pastures. The statewide average was 30 per cent
- 27 per cent of irrigators had used their water entitlement as security for a loan. The statewide average was 17 per cent
- 69 per cent of irrigators employed non-family members on farm. The statewide average was 45 per cent
- Full-time employment of family and non-family members per irrigation farm was 3.5 equivalent full-time (EFT) positions. The statewide average was 2.1 EFT positions



**FIGURE 14** 2009 Survey responses to the statement 'The water sharing plan has made or will make a lot of difference to water use in this catchment.'



Source: 2009 Irrigators survey.

- The ratio of water entitlement to EFT employee was 409 megalitres per EFT employee. The statewide ratio was 136 megalitres per EFT employee
- Figure 14 shows the water users' responses to the statement 'The water sharing plan has made or will make a lot of difference to water use in this catchment.'

Detailed reports of the 2006 and 2009 surveys are available at the NSW Office of Water web site

[www.water.nsw.gov.au](http://www.water.nsw.gov.au)



Image courtesy of Neal Foster

For more details visit the  
NSW Office of Water's website  
[www.water.nsw.gov.au](http://www.water.nsw.gov.au)

# monitoring plans for 2011-12

## WHAT ECOLOGICAL MONITORING IS PLANNED FOR 2011-12?

### Unregulated rivers water sharing plans

The NSW Office of Water continues to monitor a range of water quality parameters within streams of the Far West including the Barwon-Darling, Narran, Bokhara, Birrie, Warrego and Paroo rivers under the statewide and Intersecting Streams water quality programs. Ongoing monitoring of instream pool hydrology and ecology will provide valuable information to better explain the environmental water need of these systems and so inform the development and review of water sharing plans.

### Groundwater water sharing plans

The NSW Office of Water continues to monitor water usage, wastage, savings, pressure, flow, temperature and quality in the Great Artesian Basin Groundwater Sources.

## WHAT SOCIO-ECONOMIC MONITORING IS PLANNED FOR 2011-12?

The third of the planned series of irrigator surveys was undertaken in 2010, targeting the water users surveyed in 2006. The results will be compared against the benchmark surveys, and will be used to report against the water sharing plans' performance reporting requirements. The report on the 2010 survey will be released in 2011.

To assist in the socio-economic assessment of changes at the water sharing plan level, the NSW Office of Water will be purchasing from Australian Bureau of Statistics customised agricultural census data, reported by water sharing plan water source areas.

## WHAT'S PLANNED FOR FUTURE WATER SHARING PLANS?

Four additional water sharing plans covering the Far West are currently being developed for the:

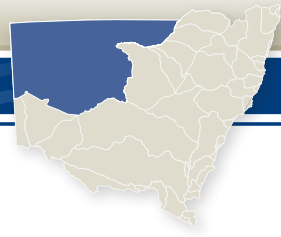
- Intersecting Streams Unregulated and Alluvial Water Sources
- Murray-Darling Basin Fractured Rock Groundwater Sources
- Murray-Darling Basin Porous Rock Groundwater Sources.

## FUTURE PRIORITY NEEDS FOR ECOLOGICAL MONITORING AND EVALUATION ACTIVITIES IN THE FAR WEST

In accordance with the Macro Water Sharing Plans - the approach for unregulated rivers. Report to assist community consultation, 2nd Edition (DWE 2009; available at [www.water.nsw.gov.au](http://www.water.nsw.gov.au)), high-priority water sources are identified as being at high risk to instream environmental value by water extraction.

During the development of the Water Sharing Plan for the Intersecting Streams Unregulated and Alluvial Water, no water sources were identified as potentially high-priority water sources. However, this may change as a result of further consideration by the Regional Panel covering this plan area.





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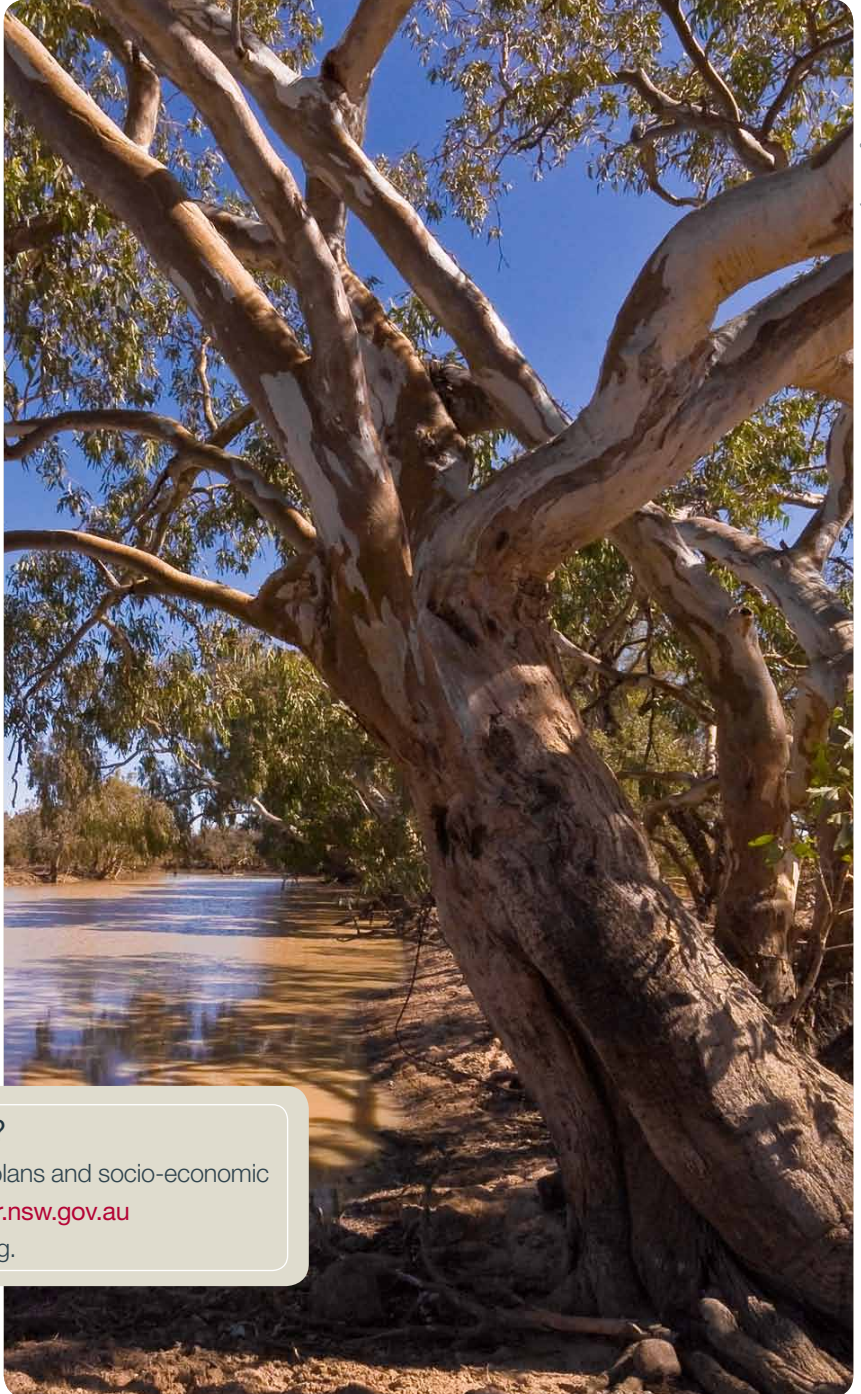


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### WANT MORE INFORMATION?

Further information on water sharing plans and socio-economic assessment is available at [www.water.nsw.gov.au](http://www.water.nsw.gov.au)  
go to Water Management > Monitoring.