South Australian Murray-Darling Basin Natural Resources Management Board

WATER ALLOCATION PLAN FOR THE RIVER MURRAY PRESCRIBED WATERCOURSE

(As amended January 2011)

Government of South Australia

South Australian Murray-Darling Basin Natural Resources Management Board

Natural Resources Management Act 2004

Water Allocation Plan
for the
River Murray Prescribed Watercourse

I, Karlene Maywald, Minister for the River Murray, hereby adopt this Water Allocation Plan to be effective from 1 July 2009, pursuant to section 89(2)(f) of the Natural Resources Management Act 2004

Hon Karlene Maywald MP
Minister for the River Murray

Date: 15 July 2009

Contents

1. The River Murray Prescribed Watercourse

By notice in the South Australian Government Gazette dated 10 August 1978, the Governor, pursuant to section 25 of the now repealed *Water Resources Act 1976*, declared the River Murray and associated watercourses to be a Proclaimed watercourse for the purposes of that Act. The proclamation provides:

"The watercourse being the River Murray, Lakes Alexandrina and Albert, portions of Currency Creek and the Rivers Finniss, Angas and Bremer, and which is delineated on plans numbered 77-406, 77-407, 77-408, 77-409, 77-410, 77-411, 77-412, 77-413, 77-414, 77-415, 77-416, 77-417, and 77-418 which plans are deposited in the general registry office as G.R.O. number 926/78 sheets 1 to 13, to be a proclaimed watercourse for the purposes of the said Act.

The land shown on the said plans as being portion of the said watercourse which is beyond the bed and banks of the said watercourse to form part of the said watercourse.

That the said watercourse shall be known as the "River Murray Proclaimed Watercourse".

Pursuant to the now repealed *Water Resources Act 1990*, the River Murray Proclaimed Watercourse continued in existence as if it had been proclaimed under that Act.

Under the *Natural Resources Management Act 2004*, the proclamation continues in force as though it were a regulation declaring a prescribed watercourse under the current Act.

Figures 1(i) to 1(iii) show the boundary for the River Murray Prescribed Watercourse.

2. Assessment of needs of dependent ecosystems

This assessment has been based on the best scientific information available at the time of preparation of this plan. For the purpose of this assessment, it has been assumed that the management regime is to maintain, and where possible improve, the distribution of the respective ecosystems and the condition in which they are found today.

The major ecosystems that depend on water from the River Murray Prescribed Watercourse include the Lower Lakes, Coorong, the channel of the River Murray, wetlands and the floodplains.

The Lower Lakes (Lake Albert and Lake Alexandrina)

The Lakes are the largest freshwater reservoir in South Australia. Both lakes are relatively shallow; their waters are well mixed by the prevailing winds. Lake Albert is more saline but less turbid than Lake Alexandrina. The fresh water impounded in Lakes Albert and Alexandrina by the barrages maintains a variety of permanent and temporary wetlands. These are wetlands of international significance and are listed on the Ramsar register as important habitats for migratory birds that fly between Australia and Asia.

Coorong

The Coorong is an elongate coastal lagoon that extends from the mouth of the River Murray 100 kilometres south-east along the coast. The water-body is confined by the coastal dune barrier of Young husband and Sir Richard Peninsulas. The Coorong has three distinct habitats ranging from the seasonal fresh water near the barrages, to the brackish Murray Mouth and northern lagoon area, to the hypersaline southern lagoon. It is a significant region for migratory birds, fish, and unique vegetation communities. The Coorong, in conjunction with the Lower Lakes, is listed in the Ramsar register.

The channel of the River Murray

The channel of the River Murray includes the river-bed and banks. River regulation through the operation of the weirs, locks, storage reservoirs, and dams has kept river levels relatively constant. More than two-thirds of the water that would have flowed out of the River Murray mouth is now diverted for human use. The ecosystem is now predominantly lacustrine (that is, lake-like), the river-banks are lined with sedges and grasses with an overstorey of river red gums and willows.

Wetlands

There are more than 1,100 wetlands in 250 complexes along the River Murray valley. These wetlands display wide variation in their geomorphic and hydrological characteristics and, as such, support diverse and varied fauna. More than half the wetland complexes along the River Murray are considered to be of high conservation value. The Chowilla wetland complex is listed on the Ramsar register as a wetland of international significance.

The floodplain (terrestrial vegetation communities)

The vegetation of the River Murray flood plain can be divided into two major zones. These zones contain a variety of distinct vegetation associations and are generally dominated by one of two tree species. The river red gum *(Eucalyptus camaldulensis)* dominates areas close to the River and low-lying areas that are frequently inundated. Vegetation underneath the red gum forests is largely herbaceous with grasses *(Poaceae)*, sedges *(Cyperaceae)*, and daisies *(Asteraceae)* well represented. The black box *(Eucalyptus largiflorens)* is dominant on the higher, less frequently inundated areas of the floodplain.

The health and distribution of *E. camaldulensis* and *E. largiflorens* are considered to be key indicators of floodplain health. Water availability is a key factor in determining the distribution of these two dominant species *(and other plant species)* on the floodplains.

Water availability varies laterally across the floodplain and is dependent on the quantity of water in the river system. Within the river red gum community, there is a major division between what is known as the 'Riverine Plain' and 'Mallee' zone communities. Likewise, the major division within the black box community is between the higher, outer lying floodplain communities and the lower, inner lying floodplain communities. Lignum *(Muehlenbeckia florulenta)* is an important species on the floodplain during both inundation and drought. Lignum provides habitat for terrestrial species and regenerating seedlings.

2. *Assessment of needs of dependent ecosystems (cont.)*

2.1 | Water quality needed by ecosystems

The water quality needed by ecosystems that depend on the water resources of the River Murray is presented in Table 1. For the Coorong it is necessary to avoid sudden fluctuations in salinity in the Coorong estuary.

Table 1 Water quality needed by ecosystems

Major ecosystem	Dissolved oxygen (median)	Total phosperorus (median)	Total nitrogen (median)	Turbidity (median)	Salinity (median)
Lower Lakes	>6mg/L	<200µg/L	<1200µg/L	<100 NTU	<1,000 mg/L
Coorong	>6mg/L	<200µg/L	<1200µg/L	<100 NTU	35,000 - 100,000 mg/L in southern lagoon
River Channel	>6mg/L	<200µg/L	<1200µg/L	<100 NTU	<1,000 mg/L
Wetlands	>6mg/L	<200µg/L	<1200µg/L	<100 NTU	<1,000 mg/L
Food Plain	NA	NA	NA	NA	<1,000 mg/L

2.2 | Quantity and timing or period of water needed by ecosystems

The natural flow regime of the River Murray was, before regulation, highly variable but showed a pronounced seasonal variation. Peak flows in South Australia were usually in spring and early summer, reflecting the travel time for winter-spring run-off and snow-melt in the headwaters of the catchment. The impact of river control has altered the natural flow regime by changing the frequency, timing and magnitude of flooding, resulting in the seasonal redistribution of peak flows in the River. It has been estimated that the larger floods, those with a return interval of more than seven years, have not been significantly affected by regulation. However, the magnitude and frequency of smaller flood events have been significantly reduced, thereby reducing the area of inundation of the floodplain.

As a general principle, the quantity and timing or period of water delivered to water-dependent ecosystems along the River Murray should, within the constraints of a highly regulated river system, mimic the natural flow regimes that occurred before river regulation and high-flow events should continue to occur in late spring.

The current median flows to South Australia must be increased. The River is in ecological decline, with the current median flow of 4,714 gigalitres per annum (38% of natural median). A return to the flows of 1970 (63% of natural median) would achieve significant ecological improvement in the River. However, an increase to 7,025 gigalitres (55% of natural median) would deliver the above flow regime and halt the decline in river health. This is an increase of approximately 2,200 gigalitres in the annual median.

Lower Lakes

Sufficient flows are needed to ensure that fish passage is not hindered, sediment is transported out of the Murray Mouth, and fresh water enters the estuary. Since the construction of the barrages, the Lower Lakes are now managed as freshwater ecosystems. In order to maintain the lakes as freshwater systems, entitlement flows of 1,850 gigalitres per annum and median flows of 4,850 gigalitres per annum should, as an absolute minimum, be maintained. The median flow target is 7,025 gigalitres.

Lake levels should be managed to expose more mud-flat habitat for waders, to protect existing shore vegetation from flooding, and to reduce erosion and lake water turbidity. The mean water-level should target the range 0.7 to 0.75 metres AHD to increase the range and diversity of habitats. The lakes should also be allowed to fall to 0.6 metre AHD for very short periods before flushing flows and, when possible, a surcharge level of 0.85 metre AHD should be maintained for no more than three weeks. The rate of fall of water-levels should not exceed about 2 centimetres per day for 30 days. It is important to maintain an open passage between the lakes and the sea during the period of high fish migration during October to December.

Coorong

The Coorong continues to decline under the current allocation regime. The Coorong ecosystem requires as a minimum the median flow of 7,025 gigalitres coming into South Australia. Low-turbidity water in late summer or early autumn, in at least six years out of every ten, is also desirable for the Coorong ecosystem.

The range and magnitude of flood flows through the Coorong ecosystem should be of sufficient volume to flush sand and keep open the mouth of the River Murray, and to improve ecological health. As a minimum 600 gigalitres a year delivered over a consecutive 30-day period at 20,000 megalitres per day is required. This allocation should occur in late spring-early summer and should apply six years out of ten. It is also important to maintain the salinity gradient of estuarine to hypersaline along the Coorong. It is also essential to ensure that elevated sediment levels (and associated nutrients and heavy metals) are not transported into the Coorong Lagoon. The transfer of fresh water from the lakes to the Coorong should be maximised during periods of seasonal high flow from September to December, but sudden fluctuations in salinity and water levels should be avoided in the estuary. The tidal prism should be increased to maintain the mouth channel, fish passage, and extended estuarine habitat.

The Channel of the River Murray

The key environmental flow requirements for the main channel are 40,000 megalitres per day for up to eight consecutive weeks on average every second year. High flow events should continue to occur in late spring.

Draw-down of weir levels to the lowest possible levels (without accelerating the rate of groundwater incursion) should occur for two months in late winter-early spring. This will allow the banks of the main river channel to dry. Minor variations (for example, 200 millimetres over two to four weeks) in weir pool levels are needed to maintain and enhance the diversity of littoral zone vegetation and the biodiversity of food-chains.

Before late spring flood peaks, weir pools should be drawn down to the lowest possible level for two months to provide the opportunity for adjacent flood-plain wetlands and high level benches of the main channel to dry.

Low-flow conditions in the weir pools can contribute to the abundance of the potentially toxic cyanobacteria. To prevent cyanobacterium problems, river flows need to be maintained at a suitable regime. This should include the introduction of pulse flows in spring-early summer, increasing by 10,000 megalitres per day for two to three weeks. In addition, pool levels should be fluctuated to obtain more varied plant life and a greater variety in bacteria-algae communities.

Wetlands

Wetlands that are at present artificially permanently inundated or artificially permanently dry may benefit from having wetting and drying cycles introduced that mimic the natural regime as follows. Wetlands should experience a natural drying cycle that reflects and mimics a regime appropriate for each specific wetland. As a generalisation, temporary wetlands should dry out for a minimum of two months and a maximum of six months every two years in late summer-early winter. Wetlands should be inundated for two to six weeks to greater than 0.5 metres depth to stimulate flowering or growth of wetland vegetation and for a minimum of three and a maximum of four months to increase waterbird and fish breeding. This inundation should occur during late spring-early summer; however, the exact nature of the drying cycle will depend on the ecological characteristics of each wetland.

2. *Assessment of needs of dependent ecosystems (cont.)*

The floodplain

The restoration of floodplain health will require the reinstatement of a higher proportion of natural flow conditions, and a reconnection of the main stream with its floodplains, especially the internationally recognised Riverland Ramsar site (Chowilla). In particular the flow requirements are:

- 80 000 megalitres per day to cross the South Australian border once every three years for up to eight consecutive weeks on average, preferably in spring. This flood would inundate 47% of the total floodplain. It would maintain eucalypt stands, Murray cod stocks and waterfowl populations, water 80% of the threatened floodplain of Chowilla, flush salt from the floodplain, and maintain the aesthetic value of the floodplain.

80, 000	ML/day	Years in 100	Percentage of natural
	Natural	45	100
	SA requirement	33	82
	Current	12	27

- 110, 000 megalitres per day to cross the South Australian border once every five years for up to eight consecutive weeks on average, preferably in Spring. This flood would inundate 55% of the total floodplain, including all of Chowilla. It would increase Murray cod stocks, regenerate eucalypts and other floodplain vegetation, increase the aesthetic value of the floodplain, and provide additional water quality benefits.

110,000	ML/day	Years in 100	Percentage of natural
	Natural	27	100
	SA requirement	20	74
	Current	5	18

- 150 000 megalitres per day to cross the Border once every ten years for up to eight consecutive weeks on average, preferably in Spring. This flood would inundate 100% of the total floodplain and rejuvenate all animal and plant populations and their habitats.

150, 000	ML/day	Years in 100	Percentage of natural
	Natural	12	100
	SA requirement	10	83
	Current	4	33

3. Assessment of effect on other water resources

Section 76(4)(b) of the *Natural Resources Management Act 2004* requires this water allocation plan to include an assessment as to whether the taking or use of water from the River Murray prescribed watercourse will have a detrimental effect on the quality or quantity of water that is available from any other water resource.

This section of the plan provides an assessment of the effect of using River Murray water on the quality and quantity of water that is available from the water resources within the Barossa Prescribed Water Resources Area (Figure 2) and the Angas Bremer Prescribed Wells Area (Figure 3).

3.1 | Barossa Prescribed Water Resources Area

The surface and watercourse water resources of the Barossa Prescribed Water Resources Area are characterised by high annual variability of flow. The North Para River is the major watercourse in the Barossa Prescribed Water Resources Area serving as a significant water supply for existing users and supporting a range of ecosystems. A significant number of farm dams have been constructed in the region to capture surface water runoff and store watercourse water for vineyard irrigation, and stock and domestic use.

Since 1970, the development of vineyards in the region has resulted in a tenfold increase in the number of farm dams used for irrigation. This increase was effectively halted in 1992 with the prescription of watercourses. More recently, large-scale importation of River Murray water has occurred to meet increased water demand in the Barossa Valley.

SA Water currently transports approximately 1.2 GL of water into the Barossa Prescribed Resources Area for irrigation purposes.

There are currently proposals to import a further 5,000 to 7,000 ML of River Murray water into the Barossa Prescribed Resource Area. These proposals have been subject to environmental assessment.

Assessment of Effects of using River Murray Prescribed Watercourse water in the Barossa Prescribed Water Resources Area:

Hydrological modelling has been undertaken to assess whether the use of licensed River Murray water allocations in the Barossa Prescribed Water Resources Area has a detrimental effect on the quantity and quality of the prescribed water resources.

In summary, the use of River Murray water in existing irrigation districts is unlikely to have a detrimental effect on the prescribed water resources, provided land is irrigated efficiently. Where River Murray water is used in new irrigation districts, resulting in the introduction of new salt with the irrigation water, a detrimental effect over the long term may be expected. Section 5.7 of this Plan includes provisions designed to prevent inefficient use of River Murray water on land within the Barossa Prescribed Water Resources Area.

Water Budget and Effects on Regional Watertables:

The hydrological modelling demonstrates that if River Murray water is over-applied to land in the Barossa Prescribed Water Resources Area, it could seep past the root zone, and depending on soil type, this could lead to increased accession to the regional water table resulting in rising water table levels.

If the rate at which water is applied to the land is limited to 70-100mm per annum, however, it is unlikely River Murray water will escape past the root zone.

3. Assessment of effect on other water resources (cont.)

• Effects on the Salt Budget:

River Murray water used in the Barossa Prescribed Water Resources Area has a Total Dissolved Salts (TDS) average between 304mg/L and 568mg/L. This average is approximately one third of the average salinity of the prescribed groundwater resource. Hence, the use of River Murray water in the Barossa Water Resource area will not increase the salinity of the water resource.

It is likely, however, that any salt in irrigation water (including irrigation water sourced from the Barossa Prescribed Water Resources) will eventually reach the regional water table as a result of natural processes, and that this recharge will eventually discharge as base flows into catchment streams.

The effects of using River Murray water on the water quality of the Barossa Prescribed Water Resources, will vary across the area depending on various factors, including whether River Murray water is being used for new irrigation, and the extent to which it will replace the current use of the prescribed groundwater resource.

It has been estimated from the results of the hydrological modelling that if approximately fifty percent of total groundwater currently used on the floor of the Barossa Valley and Lyndoch Valley is replaced by River Murray water, there will be a reduction in salt accession. The use of River Murray water in the Greenock Creek region for new irrigation development is likely to increase the salinity of the underground water of the Barossa water resources.

• Effect on Ecosystems:

It is unlikely that using River Murray water in the Barossa Prescribed Water Resources area will detrimentally affect remnant native vegetation, because if perched watertables develop they are likely to occur underneath areas of land subject to irrigation, rather than underneath areas of land upon which remnant vegetation is growing. In addition, the remnant vegetation species are generally tolerant of salinity.

There will be no detrimental effects from using River Murray water on aquatic fauna in the watercourses within the Barossa Prescribed Water Resources Area. These watercourses experience seasonally high salinities as a result of natural saline groundwater discharge. As the use of River Murray water in the Barossa Valley floor and Lyndoch Valley areas is likely to reduce salinity levels in the water resources of the Barossa Prescribed Water Resource Area, there will be limited effect on aquatic fauna.

In the Greenock Creek area, however there may, in the very long term, be an increase in salinity in the small ephemeral watercourses as a result of using River Murray water on the land. The reason for the slight increase in salinity is that River Murray water will be used for new irrigation developments, resulting in the introduction of new salt from the irrigation water to the water resource in the Greenock Creek area. Section 5.7 of this plan include provisions designed to reduce the detrimental effects from salinity in that area resulting from use of River Murray water.

Analysis of the needs of persons using water from the Barossa Prescribed Water Resource.

Approximately 5,000ML per year of underground water from the Barossa Prescribed Water Resource is currently allocated for use in the Barossa. However, the level of use over the last few years has averaged only 4,400ML per year.

Approximately 2,800 ML per year of watercourse and surface water from the Barossa Prescribed Water Resource is currently allocated for use within the Barossa. Water allocated from the Barossa Prescribed Water Resources is primarily used for irrigation. It is also used, however, for commercial, industrial, stock and domestic purposes.

Analysis of the needs of ecosystems using water from the Barossa Prescribed Water Resource.

The use of River Murray water in the Barossa area will not have, or be likely to have, a detrimental affect on the Barossa Valley Floor or the Lyndoch Valley area of the Barossa Prescribed Water Resource. However there is likely to be a slight increase in the salinity of the water resource in the Greenock Creek Area as a result of using River Murray water in that area. Therefore an analysis of the needs of those ecosystems has been undertaken and is outlined in Tables 2, 3 and 4.

Table 2. Ecological Flow Requirements for the Pool in Flaxman Valley

Description	Peak flow (m3/s)	Daily flow (ML)	Average Frequency	Importance
Baseflow	<1	<0.22	>Yearly	Maintaining water level and quality in permanent pools. Riparian zone vegetation condition.
Freshets	<1	0.22	>Yearly	Maintain water quality and levels in pools.
Pool Connection	<1	0.46	Yearly	Maintaining connection and water quality. Fish breeding and migration.
Mid Flow Maintenance	n/a	n/a	Yearly (desirable)	Pool scouring.
Bank Full	4.5	265	Every 3 years	Habitat reset, sediment sorting and habitat modification and long-term maintenance.
Overbank	16	890	Every 10 years (minimum)	Mass recruitment and breeding of fish.

3. Assessment of effect on other water resources (cont.)

Table 3. Ecological Flow Requirements for the Transition Reach

Description	Peak flow (m3/s)	Daily flow (ML)	Average Frequency	Importance
Baseflow	Unknown	Unknown	All Year	Maintain and protect recharge zone and hyporheic habitat.
Freshets	<1	6	Weekly	Maintain and protect recharge zone and Quality of pool water.
Pool Connection	<1	14	Yearly	Maintain and protect recharge zone. Maintain riffle fauna. Fish migration and recruitment. Water supply downstream.
Mid Flow Maintenance	n/a	n/a	Yearly (desirable)	Maintain and protect recharge zone. Pool scouring and maintain habitat complexity. Water Supply downstream.
Bank Full	4.5	265	Every 3 years	Maintain and protect recharge zone. Provide organic inputs to pool environment.
Overbank	16	890	Every 10 years	Floodplain maintenance and organic inputs to channel.

Table 4. Ecological Flow Requirements for the Incised Reach

Description	Peak flow (m3/s)	Daily flow (ML)	Average Frequency	Importance
Baseflow	<1	<0.5	All Year	Maintain water quality in permanent pools.
Freshets	<1	1.4	Weekly	Maintain water quality in permanent pools.
Pool Connection	5	330	Yearly	Maintain water flowing over riffles between pools. Fish migration and recruitment. Water supply to downstream.
Mid Flow Maintenance	24	1,520	Yearly	Major connections between pools and provides fast flowing water across riffles. Flushes pools. Moves organic matter into pool environments. Reset flows. Water supply to downstream.
Bank Full	75	4,650	<Yearly	Major habitat reset, flows responsible for vegetation removal, sediment sorting and habitat modification.
Overbank	>75	>4,650	<Yearly	Floodplain maintenance and organic input to channel.

3.2 | Angas Bremer Prescribed Wells Area

The wells in the Angas Bremer Prescribed Wells Area ("the PWA") principally access two aquifers: (1) a shallow, unconfined aquifer, and (2) a deeper, confined aquifer used in parts to provide irrigation water.

The underground water resource is of variable quality, however, water in the unconfined aquifer is generally more saline than water in the confined aquifer.

The salinity of water in the unconfined aquifer ranges from 1,600 to 130,000 EC (1,000 to 80,000 mg/L total dissolved solids (TDS)) and is generally unsuitable for irrigation. However, good quality water is found in the unconfined aquifer in the vicinity of the two major rivers.

The salinity of the confined aquifer ranges from 2,800 to 3,300 EC (1,700 to 2,000 mg/L TDS), and the surrounding saline underground water averages around 5,000 EC (3,000 mg/L). The salinity of the confined aquifer is mostly rising, at an average rate of 65 EC per annum.

6,419 ML/per annum of water was authorised by water licences granted under the *Water Resources Act 1997* to be taken from the wells in the PWA in 2002. The actual volume of licensed water taken, however, is well below current water allocations. The reason for the low level of water usage is that the underground water in the PWA is generally unsuitable for irrigation due to high salinity levels.

An increasing volume of water taken from the River Murray watercourse is being used for irrigation in the PWA. In 1998-99, approximately 16,500 ML of licensed River Murray water allocations were being used for irrigation on land in the PWA.

Assessment of effects of using River Murray Prescribed Watercourse water in the Angas Bremer Prescribed Wells Area:

In summary, the use of River Murray water is likely to contribute to increases in groundwater salinity and waterlogging. These detrimental effects on the underground water resource can, however, be reduced by extracting groundwater from the resource. Section 5.5 of this Plan includes provisions designed to reduce the detrimental effects of salinity and waterlogging on the underground water resource.

- **Quantity of water within the Confined and Unconfined Aquifers:**

The use of River Murray water in the Angas Bremer Prescribed Wells Area has contributed to rising water tables, particularly south of Langhorne Creek. In the long term, it is likely that increased use of River Murray water on land in the northern part of the Prescribed Wells Area will also result in rising water tables.

- **Effect on Ecosystems:**

The use of River Murray water on land within the PWA is increasing the risk of waterlogging which has detrimental effects on ecosystems in the PWA

In particular, Red gum swamps are at risk from waterlogging because they generally occur in local depressions. Although, Red gums will tolerate some waterlogging, and can survive for three years or more under flooded conditions, waterlogging on a permanent basis could threaten the survival of Redgums.

- **Quality of Confined and Unconfined Aquifers:**

The drainage fraction of water applied for irrigation recharges the unconfined aquifer. The increasing use of River Murray water for irrigation rather than the underground water resource on land within the PWA has reduced the quantity of salt entering the unconfined aquifer. This is because the salinity of River Murray water is generally lower than underground water (ie groundwater salinity is up to 3000mg/L, whereas the salinity of River Murray water from Lake Alexandrina has an average of 600mg/L).

3. Assessment of effect on other water resources (cont.)

However, hydrological modelling demonstrates that groundwater quality in the confined aquifer is likely to deteriorate in the long term, even if a flow through the system is maintained. This is because downward leakage of saline water from the unconfined aquifer to the confined aquifer can be expected in the future from the continued application of River Murray water to land within the PWA and the presence of the aquitard maintaining a positive vertical gradient beneath irrigation areas. It is estimated that the increase in groundwater salinity will be in the order of 40 mg/L each year.

Analysis of the needs of Ecosystems in the Angas Bremer Prescribed Wells Area

Ecosystems currently observed in the Angas Bremer Prescribed Wells Area that depend on underground water include a small, permanent wetland on Mosquito Creek, the remnant red gum swamps scattered across the Angas Bremer floodplain, and Tolderol Game Reserve and other temporary wetlands fringing Lake Alexandrina.

There is no documented evidence of hypogean or hyporheic species (that is, those that live in underground water ecosystems) in the Angas Bremer Prescribed Wells Area. However it is likely that, given the salinity of the shallow unconfined and deeper confined aquifers and composition of sediments, quite a diverse assemblage of species could live in some of the underground water of the Prescribed Wells Area.

Quality of underground water needed by ecosystems

Mosquito Creek Wetland

Chara sp. can tolerate a wide range of salinity up to twice that of sea water, or 120 000 EC. *Triglochin striatum* can also tolerate a wide range of salinities and can be found in a range of aquatic habitats from freshwater to tidal systems or near saline groundwater seeps. It appears that *Triglochin striatum* is living at the fresher end of its wide salinity tolerance and thus seasonal peak salinities should be moderate. The quality of groundwater entering the pool should not exceed 60,000 EC.

Red gum Swamps

The salinity of floodwaters on which the swamp red gums predominantly rely can rise up to 4,000 EC. Red gums can tolerate groundwater with salinity levels up to 40 000 EC, provided the soil profile is refreshed by lower salinity floodwaters (on average, once every two years).

Quantity and Time or Period of Groundwater Needed by Ecosystems

Mosquito Creek Wetland

The presence of dense *Chara* stands in the centre of the wetland suggests that the wetland pool is permanent and does not dry out in summer. No similar pools occur elsewhere in the PWA, therefore it is unlikely that rainfall would sustain a permanent pool in this location. Changes to the current head regime should be minimised to ensure that groundwater inputs essential to maintaining the pool in summer and the on-going health of the ecosystem are sustained.

Red gum Swamps

The swamp red gums are predominantly dependent on seasonal flooding and are therefore likely to obtain most of their water from the saturated soil profile that is replenished during natural and artificial winter flooding. The swamp red gums may derive up to 50% of their water from the shallow unconfined aquifer during the drier summer months and/or extended periods of low rainfall.

Because they generally occupy local depressions, the red gums will feel the first impacts of rising watertables. Red gums are relatively tolerant of waterlogging, however if the period of inundation is longer than the winter and spring months, then poor tree health and eventually death will result. The creation of permanent groundwater fed pools in the low-lying red gum swamp areas will result in tree death in those areas permanently inundated. Experience in other red gum swamps suggests that red gums will survive following 3 years of permanent inundation. Maintaining groundwater levels in the red gum swamp areas at more than 3 metres below ground level will minimise the potential for waterlogging and tree health decline.

Analysis of the needs of persons using water from the Angas Bremer PWA

Variations in recorded underground water use reflect an overall decline in the demand for underground water in the Angas Bremer PWA since the onset of development in the 1950s. Demand for underground water has declined largely as a result of increased access to lower salinity River Murray water taken from Lake Alexandrina.

Current levels of demand for underground water for various purposes are estimated as follows:

- 2,120ML/annum for irrigation;
- 30 ML/annum for town water supply (Langhorne Creek);
- 20ML/annum for stock and domestic use;
- 15ML/annum for recreation (irrigation of sporting grounds); and
- 15ML/annum for industry.

4. Assessment of capacity of resource to meet demands

4.1 | Demands

4.1.1 Ecosystems:

See discussion under heading "Assessment of the Needs of Dependent Ecosystems" in Section 2.

4.1.2 Demands of Existing Users:

In October 2001, 794.1 GL of water was authorised to be taken from the River Murray Prescribed Watercourse by licensees for various purposes. These purposes include irrigation, industrial, commercial, recreational, stock and domestic, and Metropolitan Adelaide and country town water supplies.

At the time of adoption of this plan on 1 July 2002, allocations endorsed on water licenses granted under the *Water Resources Act 1997* were in excess of actual demand for water. The following table summarises allocations and actual average demands for River Murray Prescribed Watercourse water between 1996/97 and 2000/01.

Allocations and Actual Average Demands for River Murray Prescribed Watercourse Water 1996/97 to 2001/02

Water Use Purpose	Allocations of Water endorsed on Licences granted under *Water Resources Act 1997* as at October 2001 (expressed as gigalitres that may be taken and used in a water-use year)	Actual Average Demand 1996/97 to 2000/01 (expressed as gigalitres taken and used in a water-use year)
Irrigation	503.8	383.5
Lower Murray Reclaimed Areas Irrigation	99.6[1]	99.6[2]
Industrial	3.4	2.4
Stock and Domestic	1.7	2.1
Recreational & Environmental	5.6	3.8
Metropolitan Water Supplies	650 (over a rolling five year period)	123
Country Town Water Supplies	50	36

1 Figure denotes Lower Murray Reclaimed Irrigation Areas revised allocation adjusted for trade as at 2000/01.

2 Usage is equal to allocation as Lower Murray Reclaimed Irrigation Area diversions were un-metered for this period.

Since 1 July 2002 allocations and average demands have changed. On 1 July 2008, 805 GL of water was authorised to be taken, as allocations, from the River Murray Prescribed Watercourse. The increase since October 2001 is associated mainly with increases in allocations to irrigation water arising from interstate trade and allocation for wetland management as provided for in Section 5 of this Plan.

Allocations and Actual Average Demands for River Murray Prescribed Watercourse Water 2003/04 to 2007/08

Water Use Purpose	Allocations of Water endorsed on Licences as at July 2008 (expressed as gigalitres that may be taken and used in a water-use year)	Actual Average Demand 2003/04 to 2007/08 (expressed as gigalitres taken and used in a water-use year)[1]
Irrigation	554.0	381.8
Industrial	4.2	2.8
Stock and Domestic	6.8	5.1
Recreational & Environmental	22.9	16.8
Metropolitan Water Supplies	650 (over a rolling five year period)	97.0
Country Town Water Supplies	50.0	31.3
Wetlands	15.8	13.3
Environmental Land Management	21.3	25.7

1. To remove the distortion associated with restrictions on the use of irrigation allocations since 2003/04, figures have been derived by assigning a percentage share of use in 2005/06 (the last year in which 100 % allocations were issued) to the average demand over the 5 year period.

4.1.3 Future Demands for Water

The principal factors that are likely to affect future demand for River Murray water are:

(1) trends in the type and area of irrigated crops;

(2) improvements in water use efficiency; and

(3) increasing responsibility to account for environmental demands for water.

1. Trends in irrigated crop type and area.

It is likely that irrigated areas using River Murray water will expand over the next 10 to 20 years with major crop types including vines, citrus, tree crops and vegetables. However as no more water will be granted for consumptive purposes from the River Murray Prescribed Watercourse, any expansion in irrigation area should be accommodated through improved water use-efficiency or water transfers.

4. Assessment of capacity of resource to meet demands (cont.)

2. Improvements in Water use efficiency

Sections 5 and 6 of this water allocation plan include criteria that require water used for irrigation to be applied to the land efficiently. It is anticipated that these policies will lead to changes in current irrigation practices resulting in more efficient use of water in the future.

3. Environmental purposes

It is likely that environmental water demands will increase over the next 10 to 20 years. Meeting these demands will be essential to ensuring that the quality of River Murray water is maintained and the land upon which River Murray water is used remains productive. Sections 5 and 6 of this water allocation plan provide for the taking and use of water for environmental purposes (eg wetland and floodplain rehabilitation). In future, there may also be increasing regulatory obligations to apply River Murray water for environmental purposes to maintain river and floodplain health.

4.2 | The Capacity of the Prescribed Watercourse to meet the Demands for Water

The River Murray and its tributaries originate in Queensland, New South Wales and Victoria. The River Murray provides 29 per cent of South Australia's harvestable water resources and is the most important water resource within South Australia.

South Australia consumptive use of water from the River Murray for urban, agricultural and industrial purposes represents only 5.6 per cent of the total volume of water diverted from rivers of the entire Murray-Darling Basin system.

The flow of the River Murray is regulated by the Murray-Darling Basin Agreement 1992 (the Agreement). From December 2008 the Agreement appears as Schedule 1 of the *Water Act 2007 (Cth).* The Agreement is between the Commonwealth Government, the Australian Capital Territory and the South Australian, Victorian, New South Wales, and Queensland State Governments. Its purpose is to promote and co-ordinate effective planning and management for the equitable, efficient and sustainable use of the water, land and other environmental resources of the Murray-Darling Basin.

Flows of water in the River Murray to South Australia are regulated by releases of water from Lake Victoria, Menindee Lakes, Hume Weir, and Dartmouth Dam. The annual average and annual median flows of River Murray water to South Australia are 6,750 GL per annum and 4,600GL per annum respectively.

The assessment of the capacity of the River Murray Prescribed Watercourse to meet existing and foreseeable future demands for water must, however, take into account South Australia's Entitlement flow of River Murray water (under Part X of the Agreement), and is also constrained by the Cap which restricts the quantity of water South Australia can divert from the River Murray for consumptive purposes (Schedule E of the Agreement).

South Australia's Entitlement flow is 1,850GL, which is significantly below its annual average and annual median flows. In relation to the capacity of the resource to meet consumptive demands (including irrigation, industrial, commercial etc), the assessment of the capacity of the resource must take into account the impact of diversions under these low flow conditions.

Under average or median flow conditions, the capacity of the resource to provide for increased diversions without significant impact on the ecological health of the main stem of the river is greater than the current level of consumptive diversions. However, the South Australian Government made a decision in 1969 to limit further consumptive diversions on the basis of the ecological and water quality needs to the river under low flow conditions. This decision has been upheld since that time and is now reflected in the Cap on Water Diversions under the *Murray-Darling Basin Agreement 1992.*

This water allocation plan provides for a portion of South Australia's Entitlement flow to be taken from the Prescribed Watercourse for the purpose of meeting the needs of ecosystems as set out in Section 2.

At the date of amendment to this water allocation plan, clause 7 in Schedule E of the Agreement limits the quantity of water South Australia is entitled to take for consumptive purposes to the relevant volumes set out in the Table below.

South Australia's Right to Divert Water from the River Murray for Consumptive Purposes under the Murray Darling Basin Agreement as it appears in Schedule 1 of the *Water Act 2007 (Cth)*

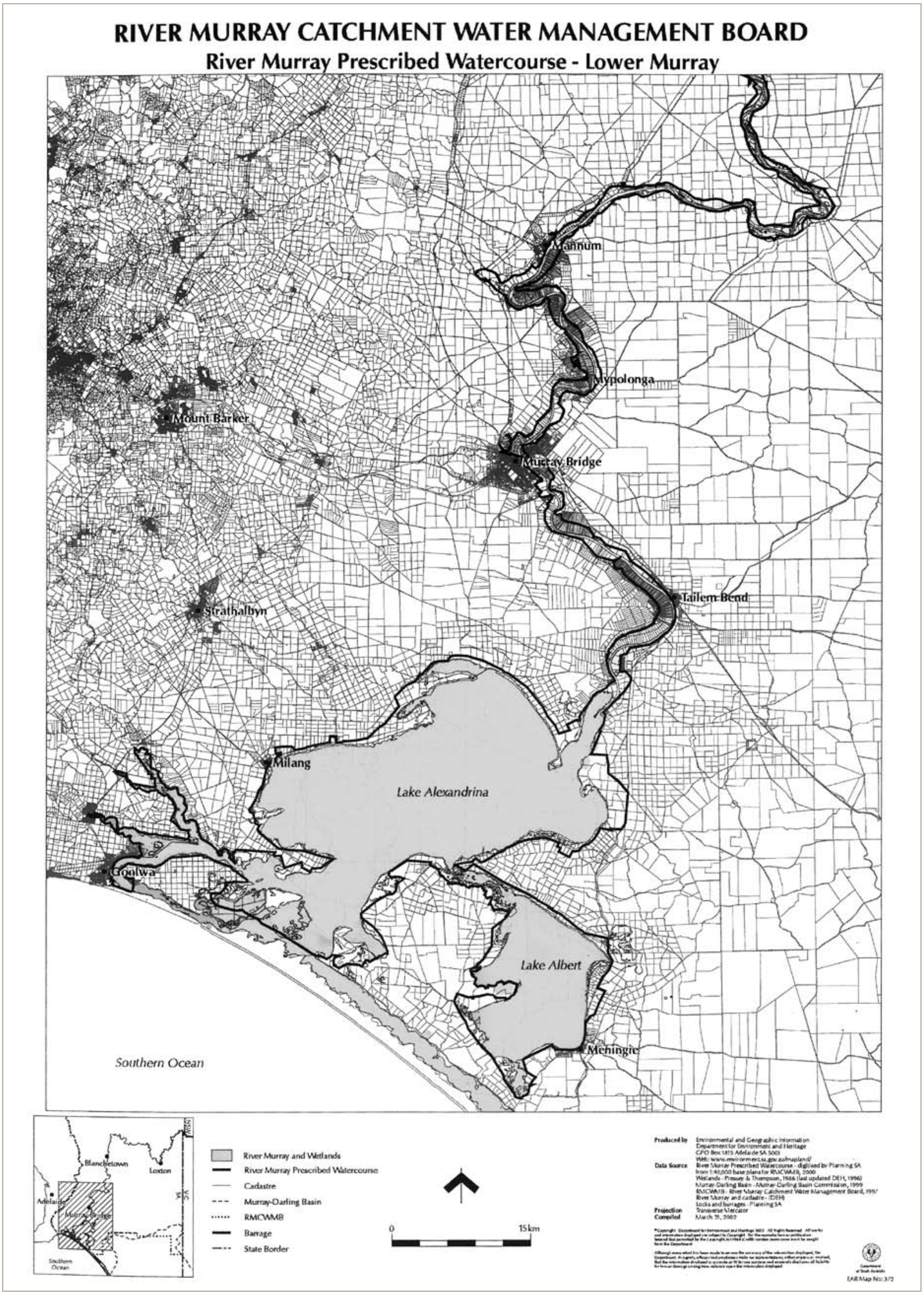
Consumptive Purpose	Maximum Volume of Water (Gigalitres)
Water supply purposes delivered to Metropolitan Adelaide and associated country areas through the Swan Reach-Stockwell, Mannum-Adelaide and Murray Bridge-Onkaparinga pipeline systems.	650 GL (over any five year period)
Lower Murray Swamp Irrigation	94.2 GL per year consisting of: 72.0 GL for irrigation, stock & domestic 22.2GL for environmental land management
Country Town Water Supply Purposes	50 GL per year
Other Purposes	449.9 GL (long term average annual diversion)

At the current time, the actual demands of existing users as outlined in Section 4.1.2 are well within the restrictions of the Cap under the Agreement.

Having regard to the requirements of the Cap, it is likely that any future demands for water for consumptive purposes will need to be met by intra-state or inter-state transfers.

The Murray-Darling Basin Agreement provides for the inter-state transfer of water between South Australia, New South Wales, and Victoria in certain circumstances. In future, it is likely that inter-state transfers will provide opportunities for new irrigation development in South Australia. From 2001-02 to 2007-08, 27.3 GL (net) of water has been permanently transferred into South Australia from New South Wales and Victoria. The effect of such transfers into South Australia is to increase South Australia's Entitlement flow under the Agreement, and to increase South Australia's right to divert water for consumptive uses under the Cap on Diversions.

Figure 1 (i)



RIVER MURRAY CATCHMENT WATER MANAGEMENT BOARD
River Murray Prescribed Watercourse - Lower Murray
Mannum
Mypolonga
Mount Barker
Murray Bridge
Tailem Bend
Strathalbyn
Milang
Lake Alexandrina
Goolwa
Lake Albert
Meningie
Southern Ocean
Blanchetown
Loxton
Adelaide
Murray Bridge
Southern Ocean
NSW
SA
VIC
River Murray and Wetlands
River Murray Prescribed Watercourse
Cadastre
Murray-Darling Basin
RMCWMB
Barrage
State Border
0
15km
Produced by
Environmental and Geographic Information
Department for Environment and Heritage
GPO Box 1815 Adelaide SA 5001
Web: www.environment.sa.gov.au/mapland/
Data Source
River Murray Prescribed Watercourse - digitised by Planning SA from 1:40,000 base plans for RMCWMB, 2000
Wetlands - Pressey & Thompson, 1986 (last updated DEH, 1996)
Murray-Darling Basin - Murray-Darling Basin Commission, 1999
RMCWMB - River Murray Catchment Water Management Board, 1997
River Murray and cadastre - (DEH)
Locks and barrages - Planning SA
Projection
Transverse Mercator
Compiled
March 21, 2002
EAR Map No: 372

Figure 1 (ii)

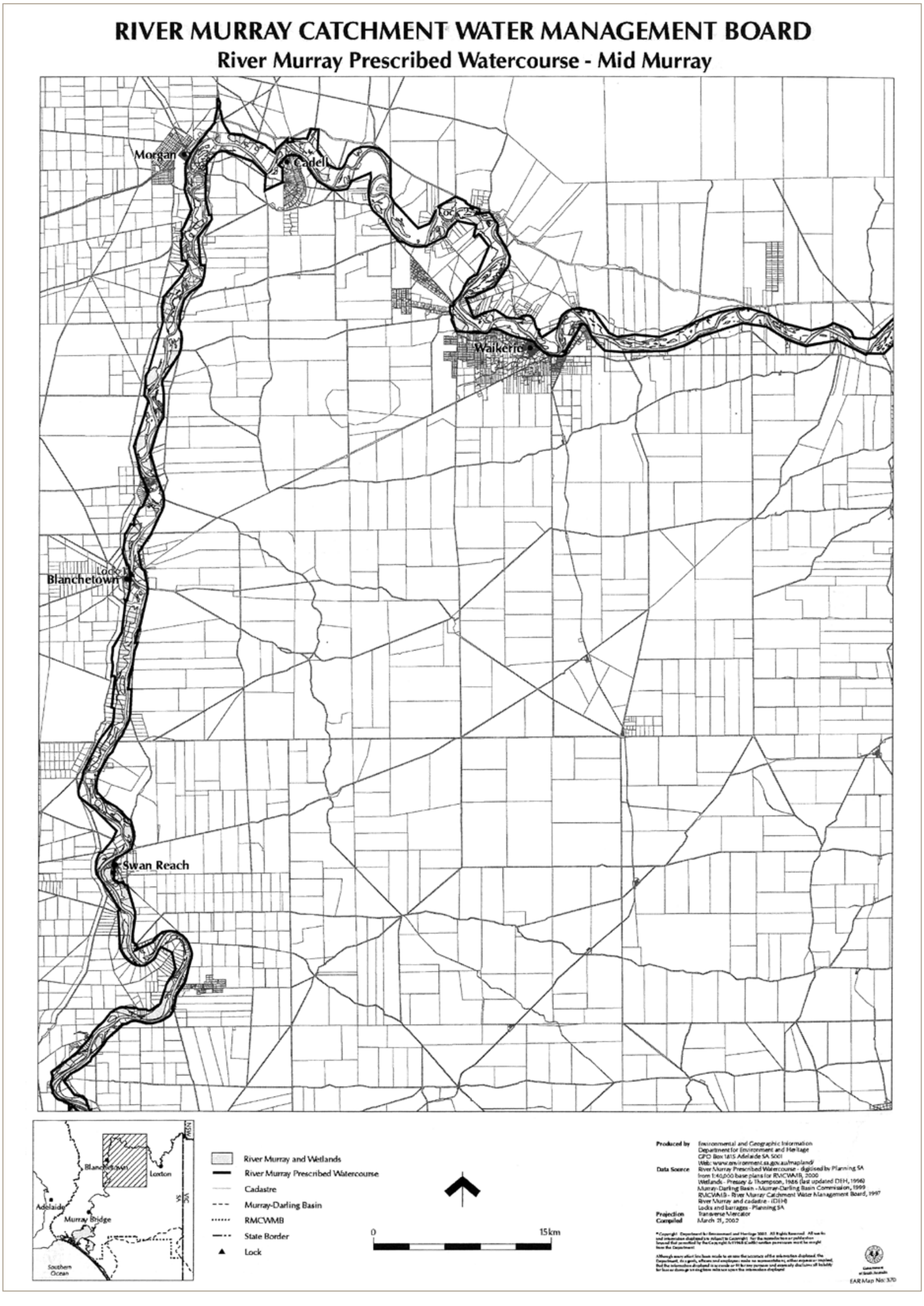
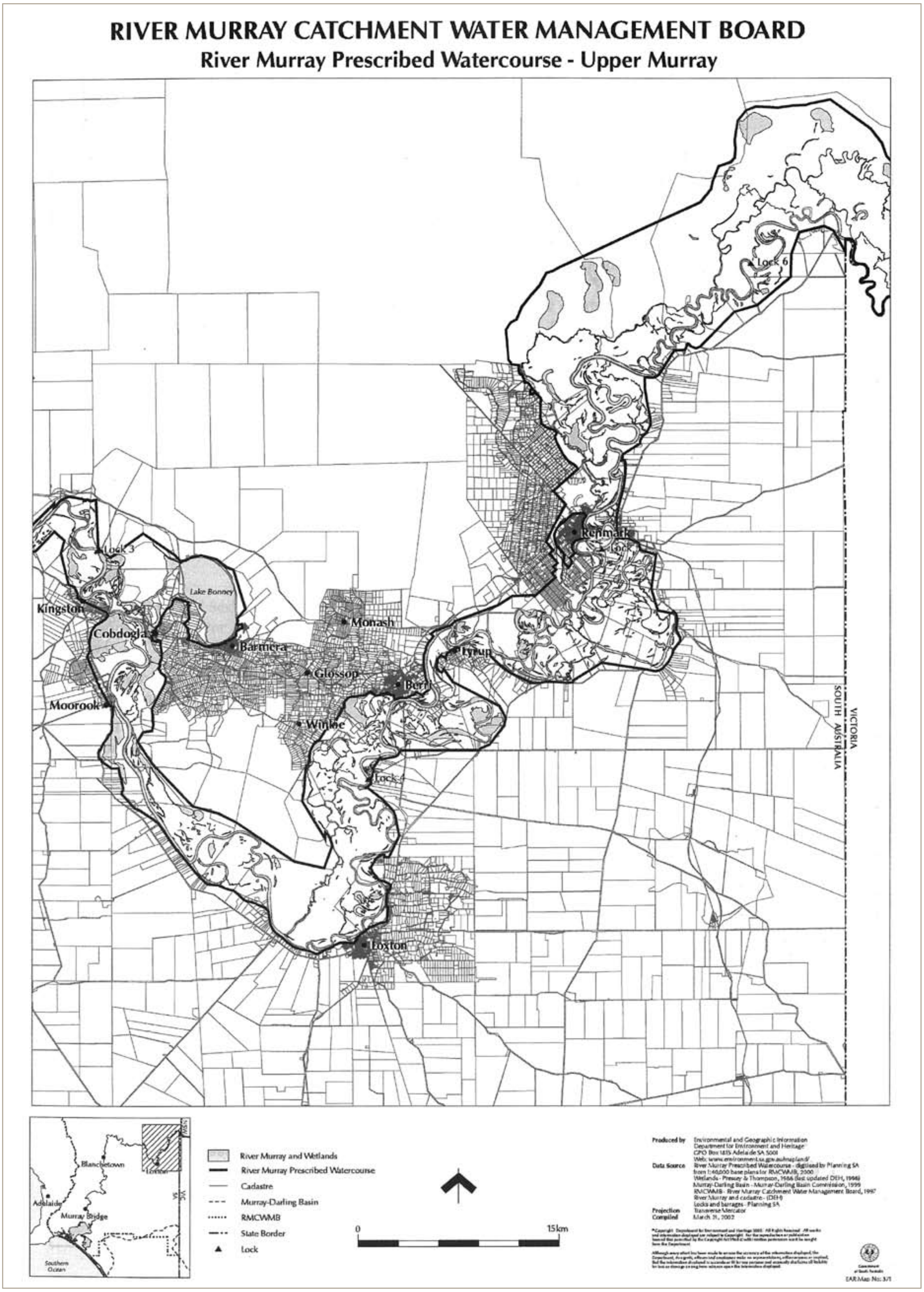
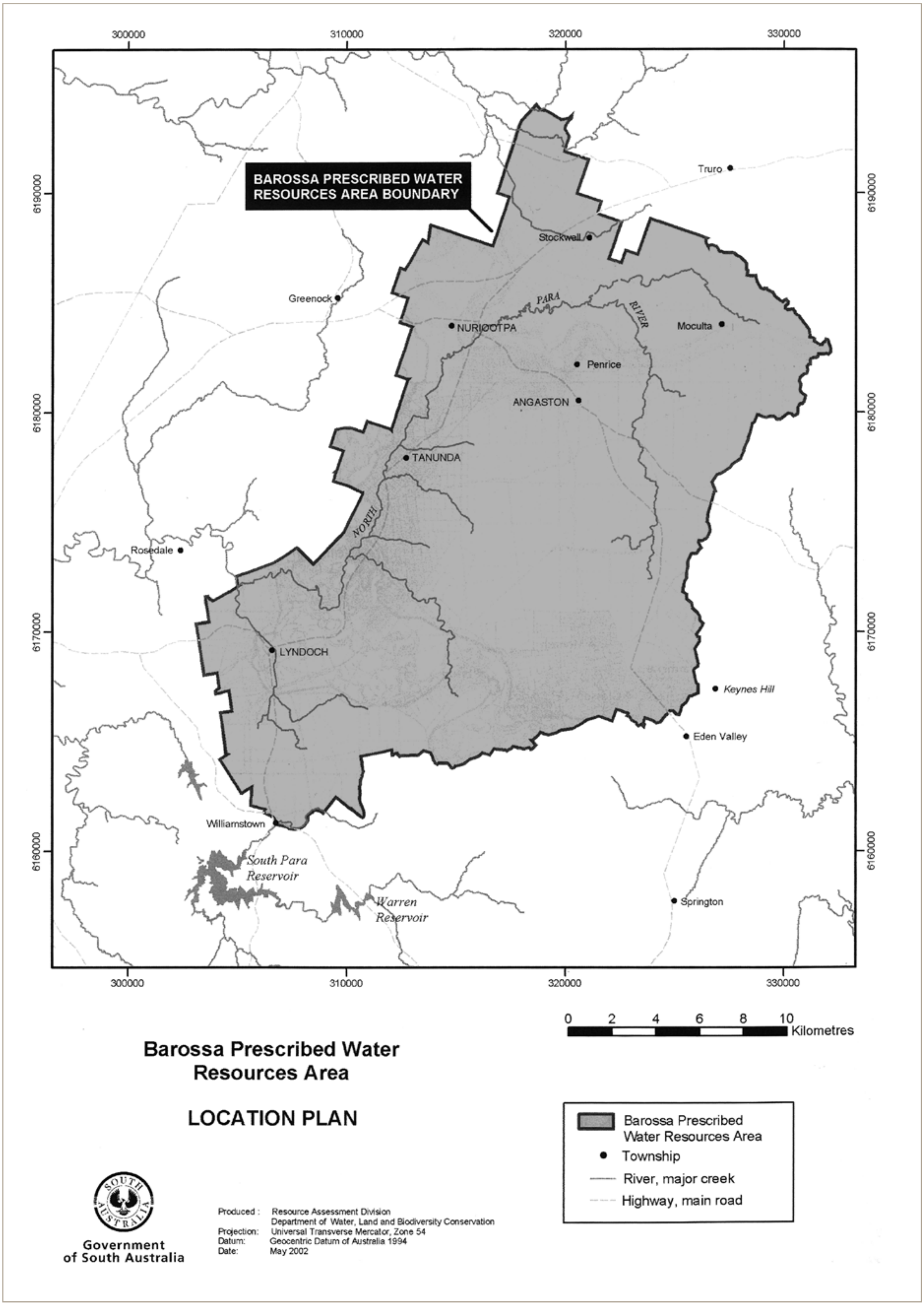

RIVER MURRAY CATCHMENT WATER MANAGEMENT BOARD
River Murray Prescribed Watercourse - Mid Murray
Morgan
Cadell
Waikerie
Blanchetown
Swan Reach
Blanchetown
Loxton
Adelaide
Murray Bridge
Southern Ocean
NSW
SA
VIC
River Murray and Wetlands
River Murray Prescribed Watercourse
Cadastre
Murray-Darling Basin
RMCWMB
State Border
Lock
0
15km
Produced by
Environmental and Geographic Information
Department for Environment and Heritage
GPO Box 1815 Adelaide SA 5001
Web: www.environment.sa.gov.au/mapland/
Data Source
River Murray Prescribed Watercourse - digitised by Planning SA
from 1:40,000 base plans for RMCWMB, 2000
Wetlands - Pressey & Thompson, 1986 (last updated DEH, 1998)
Murray-Darling Basin - Murray-Darling Basin Commission, 1999
RMCWMB - River Murray Catchment Water Management Board, 1997
River Murray and cadastre - (DEH)
Locks and barrages - Planning SA
Projection
Transverse Mercator
Compiled
March 21, 2002
EAR Map No: 370

Figure 1 (iii)



RIVER MURRAY CATCHMENT WATER MANAGEMENT BOARD
River Murray Prescribed Watercourse - Upper Murray
Lock 6
Renmark
Lock 3
Lake Bonney
Kingston
Cobdogla
Barmera
Monash
Glossop
Berri
Lyrup
Moorook
Winkie
Lock 4
Loxton
SOUTH AUSTRALIA
VICTORIA
Blanchetown
Loxton
Adelaide
Murray Bridge
Southern Ocean
VIC
River Murray and Wetlands
River Murray Prescribed Watercourse
Cadastre
Murray-Darling Basin
RMCWMB
State Border
Lock
0
15km
Produced by Environmental and Geographic Information
Department for Environment and Heritage
GPO Box 1435 Adelaide SA 5001
Web: www.environment.sa.gov.au/mapland/
Data Source River Murray Prescribed Watercourse - digitised by Planning SA from 1:40,000 base plans for RMCWMB, 2000
Wetlands - Pressey & Thompson, 1986 (last updated DEH, 1996)
Murray-Darling Basin - Murray-Darling Basin Commission, 1999
RMCWMB - River Murray Catchment Water Management Board, 1997
River Murray and cadastre - (DEH)
Locks and barrages - Planning SA
Projection Transverse Mercator
Compiled March 21, 2002
EAR Map No: 3/1

Figure 2 (ii)


300000
310000
320000
330000
6190000
6180000
6170000
6160000
BAROSSA PRESCRIBED WATER RESOURCES AREA BOUNDARY
Truro
Stockwell
Greenock
PARA
RIVER
NURIOOTPA
Moculta
Penrice
ANGASTON
TANUNDA
NORTH
Rosedale
LYNDOCH
Keynes Hill
Eden Valley
Williamstown
South Para Reservoir
Warren Reservoir
Springton
0 2 4 6 8 10 Kilometres
Barossa Prescribed Water Resources Area
LOCATION PLAN
Barossa Prescribed Water Resources Area
Township
River, major creek
Highway, main road
Government of South Australia
Produced : Resource Assessment Division
Department of Water, Land and Biodiversity Conservation
Projection: Universal Transverse Mercator, Zone 54
Datum: Geocentric Datum of Australia 1994
Date: May 2002

5. Criteria for water management

The present needs for water of the occupiers of land who use water taken from the River Murray Prescribed Watercourse area have been outlined in Section 4. Future needs for water from the prescribed water resource of these occupiers of land may increase in future depending upon structural changes in the irrigation sector, changes in irrigation practice, and the future productive capacity of the land.

In future, there is likely to be ongoing structural changes within the irrigation sector toward high value horticultural crops. At the same time, there are likely to be improvements in irrigation efficiency. Hence, although the nature of the crops irrigated on land upon which the prescribed water resource is used may change over time, the policies set out in Section 5 and 6 of the plan are not expected to limit the future capacity of the land for uses that may differ from current uses. In general, it is anticipated that future water needs will be satisfied from existing water access entitlements and that land will be irrigated efficiently. If there is demand for additional water, however, this demand will have to be met through water trade.

Generally, the effects of the policies in this plan on land values are thought to be minimal. Land that is most suitable for irrigation generally has a higher value than other land in the South Australian Murray Darling Basin Natural Resources Management Region. Such land is generally located in areas where salinity and waterlogging are minimal and there is good access to water.

In setting the policies and criteria in this water allocation plan for the allocation of water the South Australian Murray Darling Basin Natural Resources Management Board has taken into account present and anticipated future needs of occupiers of land for water, the anticipated future capacity of land and associated water needs, and the likely effect of policies on the value of land.

Definitions

For the purposes of Sections 5, 6 and 7 of this water allocation plan, notwithstanding the provisions of the *Natural Resources Management Act 2004*, the following words and phrases are defined as follows:

"anabranch" means a branch of the prescribed watercourse which leaves the watercourse and either enters it again or dries up.

"annual long-term average effective rainfall" means the sum of monthly rainfall during a growing season determined for each month by multiplying the rainfall (for the months in which the relevant crop factor set out in Tables 3 and 4 of Appendix C is greater than zero) by 0.60 if monthly rainfall is below 75mm/month or 0.8 if monthly rainfall is above 75mm/month (refer Table 2 of Appendix C).

"authorised area" means the area specified on a licence in existence as at 1 July 1994 that authorises the use of water for irrigation of that area where the land endorsed on that licence is situated in the Lower Murray Reclaimed Areas Irrigation Management Zone (as delineated in Figure 4(i) to 4(iii) of this water allocation plan).

"available water" means the volume of water that is available for allocation from a consumptive pool in a given period.

"backwater" means a temporary or permanent body of water that fills from the main river channel but excludes the Coorong, Lake Alexandrina and Lake Albert.

"CEWH" means the Commonwealth Environmental Water Holder as defined in the *Water Act 2007* (Commonwealth).

"Country towns" means Renmark, Cooltong, Berri, Glossop, Monash, Barmera, Moorook, Kingston, Loxton, Waikerie, Woolpunda (Moorook Country Lands), Cadell, Blanchetown, Cowirra, Jervois, Milang, Morgan No.1 Pump Station, Mypolonga, Pompoota, Swan Reach Water District, Tailem Bend No.1 Pump Station and Wall.

"domestic purpose" in relation to the taking of water does not include –

a) taking water for the purpose of watering or irrigating more than 0.4 of a hectare of land; or

b) taking water to be used in carrying on a business (except for the personal use of persons employed in the business).

"environmental water use" means water for non-profit environmental purposes including, but not limited to, the maintenance or rehabilitation of aquatic or riparian ecosystems.

"industrial water use" means water for an industrial purpose or industrial purposes including, but not limited to, processing, manufacturing, construction, fabrication, mining, quarrying, smelting, bulk handling, slaughtering, commercial, business, aquaculture, or intensive farming.

"irrigation water use" means water for primary production and/or for watering a crop or crops.

"point of extraction" means the physical point from which water is taken from the River Murray Prescribed Watercourse.

"recreational water use" means water taken and/or used for recreational purposes including, but not limited to, the watering of land commonly used for playing sports or games, or the use of a body of water for recreational purposes including swimming, boating and recreational fishing.

"stock purposes" means water that is taken for drinking water for stock not subject to intensive farming (as defined by the Act).

"Site Use approval" – an authorisation to use water at a particular site

"South Australian Murray Darling Basin Natural Resources Management Region" means the region established by proclamation on 2 September 2004 as varied by proclamation on 9 October 2008, which is defined in General Registry Office Plan No. GP27/2008.

"Tagged Trade" means an arrangement under which every allocation made under an entitlement in a State of origin is made available for use in a State of destination, either permanently or for a fixed term.

"waterlogging" means the permanent or temporary saturation of the soil profile so as to impede plant growth.

"Water access entitlement" – means in respect of a water licence, an entitlement to gain access to a share of the consumptive pool to which a licence relates.

"Water allocation" – the volume of water granted to the holder of a water access entitlement for a period not exceeding 12 months. This is based on the total volume determined as being available for allocation to water access entitlement holders from the consumptive pool in that period.

"Water Resource Works Approval" – means an authorisation to construct, maintain or operate any works for the purpose of taking water.

"water-use year" means the period between 1 July in any calendar year and 30 June in the following calendar year.

"wetland" or **"wetlands"** means any area within the River Murray Prescribed Watercourse, which at the date of adoption of this plan, was inundated permanently or seasonally with water, either by artificial means or naturally; but does not include the principal channel of the River Murray, any marina, or any land inundated for the purpose of primary production (whether such inundation occurs directly or indirectly, and whether or not such inundation is incidental or ancillary to the purpose of primary production).

5. Criteria for water management (cont.)

"wetland management" means the management of a wetland or wetlands, including:

(a) promoting the recruitment and survival of native flora and fauna;

(b) improving the quality of water in the wetland or wetlands;

(c) rehabilitating and/or creating habitat for native fauna;

(d) minimising or preventing any threatening processes;

(e) promoting the connectivity between the river and the floodplain;

(f) promoting nutrient exchange; or

(g) improving the duration and/or frequency of wetland inundation;

but not including the taking and use of water for the purpose or purposes relating to (or ancillary or incidental to):

(h) irrigating a crop or crops;

(i) primary production purposes;

(j) improving the quality or reliability of supply of water for irrigating a crop or crops;

(k) active recreational activities; or

(l) stock or domestic purposes.

"wetlands of conservation significance" means the Coorong, Lake Alexandrina and Lake Albert and the wetlands and wetland complexes identified in the Wetlands Atlas of SA (1996) as listed in Appendix A.

5.1 | Objectives

The following objectives apply to the River Murray Prescribed Watercourse:

1. Maintain and improve the quality of water resources.
2. Provide for the water needs of water-dependant ecosystems.
3. Provide for the sustainable use of water.
4. Implement South Australia's obligations under the *Murray-Darling Basin Agreement*.
5. Provide water for environmental land management purposes in the Lower Murray Reclaimed Areas Irrigation Management Zone particularly the minimisation of rising saline underground water.
6. Prevent:
   a) increases in salinity;

   b) increases in waterlogging;

   c) adverse impacts on the water quality of the River Murray Prescribed Watercourse, including increases in salinity, nutrients, turbidity, and chemical or biological contaminants;

   d) adverse impacts on the quantity and quality of other water resources;

   e) adverse impacts on the health, biodiversity status or habitat value of floodplains, or wetlands of conservation significance; and
7. Provide for the efficient use of water taken from the prescribed watercourse.

5.2 | General Principles

1. The River Murray consumptive pool is the water available to be taken from the River Murray Prescribed Watercourse (as shown in Figures 1(i) to 1(iii)).
2. The water available to be taken for the purposes of Principle 1 comprises:
   a. Water that may be taken as authorisations of the Minister issued pursuant to Section 128 of the Act;

   b. The volume specified by the Minister as available for allocation in a relevant period by gazette notice; and

   c. Water that may be taken without an authorisation or allocation (pursuant to section 124 (4)(6) or (6a) of the Act).

3. For the purpose of issuing water allocations, water access entitlement classes are established and limited to the following number of unit shares[1]:

(class 1)	8 704 910	unit shares[2]
(class 2)	50 000 000	unit shares
(class 3a)	544 018 767	unit shares
(class 3b)	21 038 369	unit shares
(class 4)	4 423 526	unit shares
(class 5)	5 519 841	unit shares
(class 6)	130 000 000	unit shares
(class 7)	38 366 550	unit shares
(class 8)	22 200 000	unit shares
(class 9)	200 000 000	unit shares[3]

4. The Minister may grant class 1 water access entitlements to existing non-licensed stock and or domestic water users where it can be demonstrated, at the date of application, that the water use was also in existence at 1 July 2002.
5. The Minister may grant class 9 water access entitlements for wetlands where the wetland can be managed at or below South Australia's Entitlement flow, pursuant to the Murray Darling Basin Agreement as it appears in Schedule 1 of the *Water Act 2007*.
6. An entitlement cannot be converted (on application of the holder) to become an entitlement of any other class with the exception of conversion between class 3a and 3b.

Basis for water allocation

Water allocations will be issued on account of a water access entitlement granted under Principle 3 in accordance with the provisions set out in the *Natural Resources Management Act 2004* and the following principles:

7. The Minister will determine the volume of water available for allocation under each entitlement class pursuant to Section 146(4) of the *Natural Resources Management Act 2004*.
8. Water allocations will be issued for the relevant period of no more than twelve months, and assigned to the respective water access entitlement shares as the volume of water that has been determined to be available.

1. Classes have been established to reflect the reliability and transferability of the water in the South Australian section of the Murray Darling Basin. Whilst the classes do not reflect purpose of use, they align to individual or groupings of the former purpose-based allocations as follows:
Class 1 – Stock, domestic and stock and domestic purposes
Class 2 – Urban water use – country towns
Class 3 a – Irrigation + holding other than in the Qualco Sunlands Groundwater Control area
Class 3 b –Irrigation and holding in the Qualco Sunlands Groundwater Control Trust area
Class 4 –Recreation
Class 5 – Industrial and industrial dairy
Class 6 – Urban water use – metropolitan Adelaide through the Swan Reach – Stockwell Mannum Adelaide and Murray Bridge-Onkaparinga pipelines = rolling 5 year allocation
Class 7 – Environment
Class 8 – Environmental land management
Class 9 – Wetlands

2. Includes a contingency of 1 000 000 unit shares to provide for entitlements granted through Principle 4.

3. Includes a contingency to provide for entitlements granted through Principle 5.

5. Criteria for water management (cont.)

9. Except for class 6 and class 9 entitlements, the maximum volume of water that can be made available for allocation is 1 kilolitre per unit share[4].

10. Water allocations are issued to holders of an Interstate Water Entitlements Transfer Scheme (IWETS) entitlement in accordance with the terms and conditions relevant to the State of origin.

5.3 | Wetlands

The following principles are in addition to those set out in Section 5.2 of this water allocation plan and apply to water authorised to be taken and used for wetland management purposes.

11.1 Water allocations issued pursuant to a class 9 entitlement shall only be used in wetlands, including those listed in Appendix A, for which a management plan has been accredited.

11.2 Despite any other principle or criteria in this water allocation plan, water allocations issued pursuant to water access entitlements of any class except class 8 that are held by the CEWH are not subject to any restriction or condition on transfer or use.

12. Water shall only be used for wetland management if it will have, or will be likely to have, environmental benefits including:

   a) the reintroduction of a wetting and drying regime;

   b) an increase in the recruitment and survival of native flora and fauna in the wetland or wetlands;

   c) an improvement in the quality of water in the wetland or wetlands, and/or the River Murray;

   d) an increase or improvement in habitat for native fauna;

   e) the mitigation of any threatening processes;

   f) an improvement in the connectivity between the river and the floodplain;

   g) the promotion of nutrient exchange;

   h) extending the duration or increasing the frequency of wetland inundation.

13. Water shall only be used for wetland management where it will not cause, or be likely to cause, an increase in salinity of the River Murray except where the increase can be offset by an agreement, undertaking, or obligation for works, actions or practices to prevent increases in salinity.

14. Water shall only be used for wetland management where the wetland or wetlands will be managed with a hydrological regime that will have environmental benefits which may include those listed in Principle 12.

4. The water allocations obtained on account of class 6 water access entitlements may exceed 1 kilolitre per share consistent with the pre 1 July 2009 arrangements whereby the SA Water allocation for metropolitan Adelaide offtakes is managed as a rolling total of no more than 650 gigalitres over 5 years. The water allocations obtained on account of class 9 water access entitlements may exceed 1 kilolitre per share to enable the existing policy of an additional (up to) 200 gigalitres of water being available in years of above entitlement flow, for wetland management purposes

5.4 | The River Murray Irrigation Management Zone

The following principles are in addition to those set out in Section 5.2 of this water allocation plan and apply to water used within the South Australian Murray Darling Basin Natural Resources Management Region excluding the Angas Bremer Irrigation Management Zone and the Lower Murray Reclaimed Areas Irrigation Management Zone ("the River Murray Irrigation Management Zone").

15. Water shall only be used for irrigation where it achieves a water-use efficiency of no less than 85% (refer Appendix C).
16. Water shall only be used for irrigation on land overlying a Blanchetown Clay layer within the River Murray Irrigation Management Zone where there is a monitoring well on that land drilled and sealed in accordance with guidelines in Appendix F of this water allocation plan.
17. Where a use approval provides for a water use limit of 500ML or greater, water shall only be used for irrigation on land overlying a Blanchetown Clay layer within the River Murray Irrigation Management Zone where there is a minimum of two monitoring wells. The monitoring wells must be located on the land to which the site use approval relates.
18. For the purpose of Principles 16 and 17, a Blanchetown Clay layer is present in the shaded area delineated on the maps in Appendix B.
19. Water may only be used for irrigation where the use will not detrimentally affect, either directly or indirectly:
    i) the quality of water in the River Murray Prescribed Watercourse, including increases in salinity, nutrients, turbidity, and chemical or biological contaminants;
    ii) the biodiversity status or habitat value of floodplains, or wetlands of conservation significance.
20. Despite Principle 19, water may be used for irrigation notwithstanding that such use may detrimentally affect, by increasing salinity
    i) the quality of water in the River Murray Prescribed Watercourse; or
    ii) the biodiversity status or habitat value of floodplains or wetlands of conservation significance;

    if the increase in salinity is offset by an agreement, undertaking or obligation for works, actions or practices to prevent increases in salinity (including drainage management infrastructure, salinity mitigation infrastructure or revegetation to control irrigation recharge).
21. Water shall not be extracted from a point that lies on a backwater or anabranch of the prescribed watercourse where water was not being extracted from that point on or before 1 July 2002.

5.5 | The Angas Bremer Irrigation Management Zone

The following principles are in addition to those set out in Section 5.2 of this water allocation plan and apply to the Angas Bremer Irrigation Management Zone delineated in Figure 3 of this water allocation plan ("the Angas Bremer Irrigation Management Zone").

22. Water shall only be used for irrigation where there is a monitoring well on the land upon which the water is to be used that is drilled and sealed in accordance with Section 7.1.2 of this water allocation plan.
23. Where a site use approval provides for a water use limit of 500ML or greater, there is to be a minimum of two monitoring wells. The monitoring wells must be located on the land upon which the site use approval relates.
24. Water shall only be used for irrigation where it achieves a field application efficiency of no less than 85%.

5. Criteria for water management (cont.)

25. For the purposes of Principle 24, the term "field application efficiency" means the proportion (expressed as a %) of the water applied to a particular location that is not lost under the roots of the crop quantified by:

$$\frac{\text{Irrigation water available to the crop}}{\text{Water received at the field inlets}}$$

26. For the purposes of Principle 25:

    a) The particular location shall be sited below the roots of the major crop types in such a manner that it accurately represents the water tight integrity and the distribution uniformity of the irrigation system;

    b) The numerator shall be defined by: the sum of [Irrigation water applied (mm) less water lost to drainage (mm)] for each irrigation event; and

    c) The denominator shall be defined by: the sum of Irrigation water applied (mm) for each irrigation event.

27. Water may only be used for irrigation if the irrigation system used is:

    a) maintained in a sound and water tight condition (except at the delivery points in actual use in the particular irrigation event); and

    b) designed, managed and used in such a way that it distributes water uniformly to the area of crop irrigated in the particular irrigation event.

28. Where water is used for irrigation purposes in the Angas Bremer Irrigation Management Zone, non-irrigated vegetation must have been planted and nurtured at a rate of two (2) hectares for every 100ML. Non irrigated vegetation must be planted on relevant land in accordance with the Angas Bremer Irrigation Region Revegetation Booklet (set out in Appendix E to this Water Allocation Plan) and at sufficient density to minimise the potential for water-logging on the land to be irrigated or on any other land in the Angas Bremer Irrigation Management Zone.

29. For the purposes of Principle 28, "relevant land" means land within the Angas Bremer Irrigation Management Zone:

    a) that is owned by the holder of a site use approval; or

    b) in which the holder of a site use approval has a legal interest; or

    c) that is under the care, control and management of the relevant Council under the Local Government Act 1999, the South Australian Murray Darling Basin Natural Resources Management Board, or a Minister, instrumentality or agency of the Crown with the written consent of that Council, Board, Minister, instrumentality or agency.

30. For the purposes of Principle 28, the term "planted and nurtured" means:

    a) vegetation that has been planted since 2 January 2001, or will be planted (in the case of land not owned by the approval holder, pursuant to some legally binding agreement or obligation) and will be maintained (in the case of land not owned by the approval holder, pursuant to some legally binding agreement or obligation), and

    b) vegetation that has not been planted by humans but has been (and will continue to be) maintained or allowed to exist in good condition (in the case of land not owned by the approval holder, pursuant to some legally binding agreement or obligation).

31. Water shall only be used for irrigation where the proportion of water applied, or to be applied, that drains past the root zone of the crop or crops does not enter the underground water or the River Murray, except where the proportion of water which enters the underground water is subsequently removed via saline underground water mitigation scheme(s).

5.6 | Lower Murray Reclaimed Areas Irrigation Management Zone

The following principles are in addition to those set out in Section 5.2 of this water allocation plan and apply to water used in the Lower Murray Reclaimed Areas Irrigation Management Zone delineated by shading in Figures 4(i) to 4(iii) of this water allocation plan ("the Lower Murray Reclaimed Areas Irrigation Management Zone").

32. Water shall not be applied at a rate greater than 13.92ML per hectare per water-use year over the authorised area.

33. Water allocations obtained on account of class 8 entitlements for environmental land management purposes shall only be applied to land within an Irrigation Area listed in Table 1 of Appendix D.

34. Water allocations obtained on account of class 8 entitlements used on land upon which pasture is irrigated shall not be used at a rate greater than the relevant rate applicable to the Irrigation Area (as set out in Table 1 of Appendix D).

35. Where pasture is not irrigated on the land upon which water allocations obtained on account of class 8 entitlements are to be used, the rate of application shall reflect a rate that is appropriate for managing the effects of rising saline groundwater on the particular land.

36. Water shall only be used for irrigation where it achieves a water-use efficiency of no less than 65% (refer Appendix C).

5.7 | Outside of the South Australian Murray-Darling Basin Natural Resources Management Board Region

Unless otherwise provided for in a Natural Resources Management Plan, the following principles apply to River Murray Watercourse water used on land outside of the boundary of the South Australian Murray Darling Basin Natural Resources Management Region except on land within the Torrens and Onkaparinga Aqueducts as defined in Figures 5(i) to 5(iv).

37. Water shall not be used where it will cause, or is likely to cause, a rise in the underground water level resulting in detrimental effects to ecosystems.

38. Water shall not be used where it results, or is likely to result in, adverse effects on the natural flow or quality of another water resource (excluding effluent).

39. Water shall not be used where it may adversely affect the productive capacity of the land including salinity, waterlogging or perched water tables.

40. Water shall not be used where it may adversely effect water dependant ecosystems

6. Transfer Criteria

6.1 | Water access entitlement transfers

41. Water access entitlements from the River Murray consumptive pool may be transferred to another person where it remains of the same class for which it was issued.

42. Principle 41 does not apply to the transfer of entitlements between class 3a and 3b, which may be converted to the other upon a transfer.

43. Class 6 water access entitlements may not be transferred.

6.2 | Water allocation transfers

44. Except for water allocations obtained on account of a class 6 water access entitlement, water allocations may be transferred to another person.

45. Water allocations obtained on account of a class 8 entitlement may be transferred but remain subject to the conditions set out in principles 33, 34 and 35.

46. Water allocations obtained on account of a class 9 entitlement may be transferred but remain subject to the conditions set out in Section 5.3.

7. Permits

7.1 | Drilling of Monitoring Wells

The following objectives and principles apply to permits for the activity of drilling or sealing a monitoring well under section 9(3)(a) of the *Water Resources Act 1997*.

7.1.1 Objectives

1. To monitor the effects of using water from the River Murray Prescribed Watercourse on other water resources.

7.1.2 Principles

1. A permit shall only be granted for the purpose of drilling or sealing a watertable monitoring well where:
   - 1.1 The proposed well is completed to 2 metres below the current standing watertable to a maximum depth of six metres;
   - 1.2 The proposed well is cased with 75mm ID (internal diameter) Class 12 UPVC with three metres of slots directly above the bottom of the well, and a PVC bottom cap;
   - 1.3 The casing of the proposed well extends one metre above the natural surface of the land;
   - 1.4 The slotted section of the proposed well is covered with a geotextile fabric commonly referred to as terra firma fibre cloth;
   - 1.5 The bottom four (4) metres of the annulus (area outside the casing) of proposed well is backfilled with 1.5mm of graded gravel;
   - 1.6 The annulus (area outside the casing) of the proposed well is backfilled with cement from the top of the graded gravel (see above) to the surface;
   - 1.7 The casing of the proposed well that extends above the natural surface of the land is protected by an outer sleeve of galvanised pipe 1.5m in length, with a wall thickness of 4mm, a screw-on top cap, and set into cement at the ground surface.
2. A permit shall only be granted for the purpose of drilling or sealing a watertable monitoring well where the proposed location of the monitoring well is the lowest practicable point of the land.

8. Monitoring

Section 76(4)(d) of the *Natural Resources Management Act 2004* requires this WAP to assess the capacity of the resource to meet the demands for water on a continuing basis and provide for regular monitoring of the River's capacity to meet those demands.

To meet this requirement, River Murray flows will continue to be recorded at the South Australian border (Station 426200 – River Murray below Rufus River) by an appointed representative of the Minister. An annual review of this data (and other data collected for the catchment water management plan) will be undertaken to assess the capacity of the resource to meet existing and future demands in a sustainable way.

Regular monitoring of the resource will be provided by monitoring variables currently collected by State agencies and other parties. The key variables are flow, salinity as electrical conductivity (EC where 1 EC = 1 mS/cm = .640mg/L), acidity as pH, turbidity, faecal coliforms, total coliforms, cryptospridium, oxidised nitrogen, total nitrogen, filterable reactive phosphorous, total phosphorous, reactive silica, chlorophyll, algal counts for specific algae, heavy metals, insecticides and herbicides.

8.1 | River Murray Irrigation Management Zone Reporting

An Irrigation Annual Report is to be prepared at the end of each water-use year, and provided to the Minister by 31 August, by each site use approval holder where the water is used for irrigation in the River Murray Irrigation Management Zone. The Irrigation Annual Report will include (but not necessarily limited to) the following data:

a) The volume of water allocated during the year;

b) The volume of water actually used during the water-use year as calculated by the definition of "Water Applied" in Appendix C;

c) The location, area and age of each crop type irrigated;

d) The volume of water used by each crop type as calculated by the definition of "Crop Water Use" in Appendix C;

e) The water-use efficiency for each licence, calculated using the equation outlined in Appendix C;

f) The nature of any soil moisture monitoring devices used by the holder;

g) The level and salinity of underground water as measured in December and June of every water-use year; and

h) The progress of implementing actions to comply with Principles 19 and 20 as outlined on the approval.

8.2 | Angas Bremer Irrigation Management Zone Reporting

An Irrigation Annual Report is to be prepared at the end of each water-use year by each approval holder using water for irrigation in the Angas Bremer Irrigation Management Zone, and is to be fully completed and submitted to the Minister through the Angas Bremer Water Management Committee Inc. by 31 July (or directly to the Minister if the Committee expires by the 31 August). The Irrigation Annual Report will include (but not necessarily limited to) the following data:

a) The volume of water allocated during the year;

b) The volume of water actually used and recorded on each meter during the water-use year;

c) The volume of water actually used and recorded on each meter during the water-use year for the purpose of shallow saline water table management;

d) The total amount of water recharged for each meter in the twelve months prior to the 31 October of the water-use year;

e) Salinity of equipped production bores measured in December and June;

f) The location and area of each crop type irrigated;

g) Percentage of the total volume of water actually used on each crop type;

h) Drainage past the root zone (including the volume of water, the salinity and the concentration of nutrients);

i) The level of the watertable below the natural surface level of the land upon which the water endorsed on the approval is used measured in September, December, March and June of every water-use year;

j) Area and duration of any flooding (whether natural or artificial);

k) The nature of any soil moisture monitoring devices used on the relevant land; and

l) Area of non-irrigated vegetation on relevant land.

Each water-use year the Angas Bremer Water Management Committee Inc. will prepare an aggregate district annual report and forward it to the South Australian Murray Darling Basin Natural Resources Management Board.

8.3 | Lower Murray Reclaimed Areas Irrigation Management Zone

Reporting

An Irrigation Annual Report is to be prepared at the end of each water-use year, and provided to the Minister by 31 August, by each holder of an approval using water for irrigation in the Lower Murray Reclaimed Areas Irrigation Management Zone. The Irrigation Annual Report will include (but not necessarily limited to) the following data:

a) The volume of water allocated during the year;

b) The volume of water actually used during the water-use year as calculated by the definition of “Water Applied” in Appendix C;

c) The area of each crop type irrigated;

d) The volume of water used by each crop type as calculated by the definition of “Crop Water Use” in Appendix C;

e) The water-use efficiency for each approval, calculated using the equation outlined in Appendix C; and

f) The nature of any soil moisture monitoring devices used on the land to which the approval relates.

9. Miscellaneous

In preparing the 2002 Plan the Board had regard to the following:

- the matters referred to in Section 6(2) of the *Water Resources Act 1997*; and
- the benefits of consistency with:

a) relevant Development Plans under the *Development Act 1993*;

b) relevant environment protection policies under the *Environment Protection Act 1993* (ie Environment Protection *(Marine)* Policy 1994, Environment Protection *(Milking Shed Effluent Management)* Policy 1997 and Environment Protection *(Vessels on Inland Waters)* Policy 1998);

c) relevant district plans under the *Soil Conservation and Land Care Act 1989* (ie Murray Plains Soil Conservation Board District Plan, Coorong and Districts Soil Conservation District – District Plan and Murray Mallee Soil Conservation District – District Plan and Three Year Programme);

d) guidelines relating to the management of native vegetation adopted by the Native Vegetation Council under the *Native Vegetation Act 1991*;

e) the relevant policies under the *Groundwater (Qualco-Sunlands) Control Act 2000*;

f) the relevant policies under the *Murray-Darling Basin Agreement 1992*;

g) the relevant policies under the *Murray-Darling Basin Act 1993*;

h) the relevant policies under the *Irrigation Act 1994*;

i) the relevant policies under the *Environment Protection and Biodiversity Conservation Act 1999*;

j) the relevant policies in the Coorong and Lakes Alexandrina and Albert Rasmar Management Plan.

Figure 3

Figure 3 Angas Bremer Irrigation Management Zone and Prescribed Wells Area

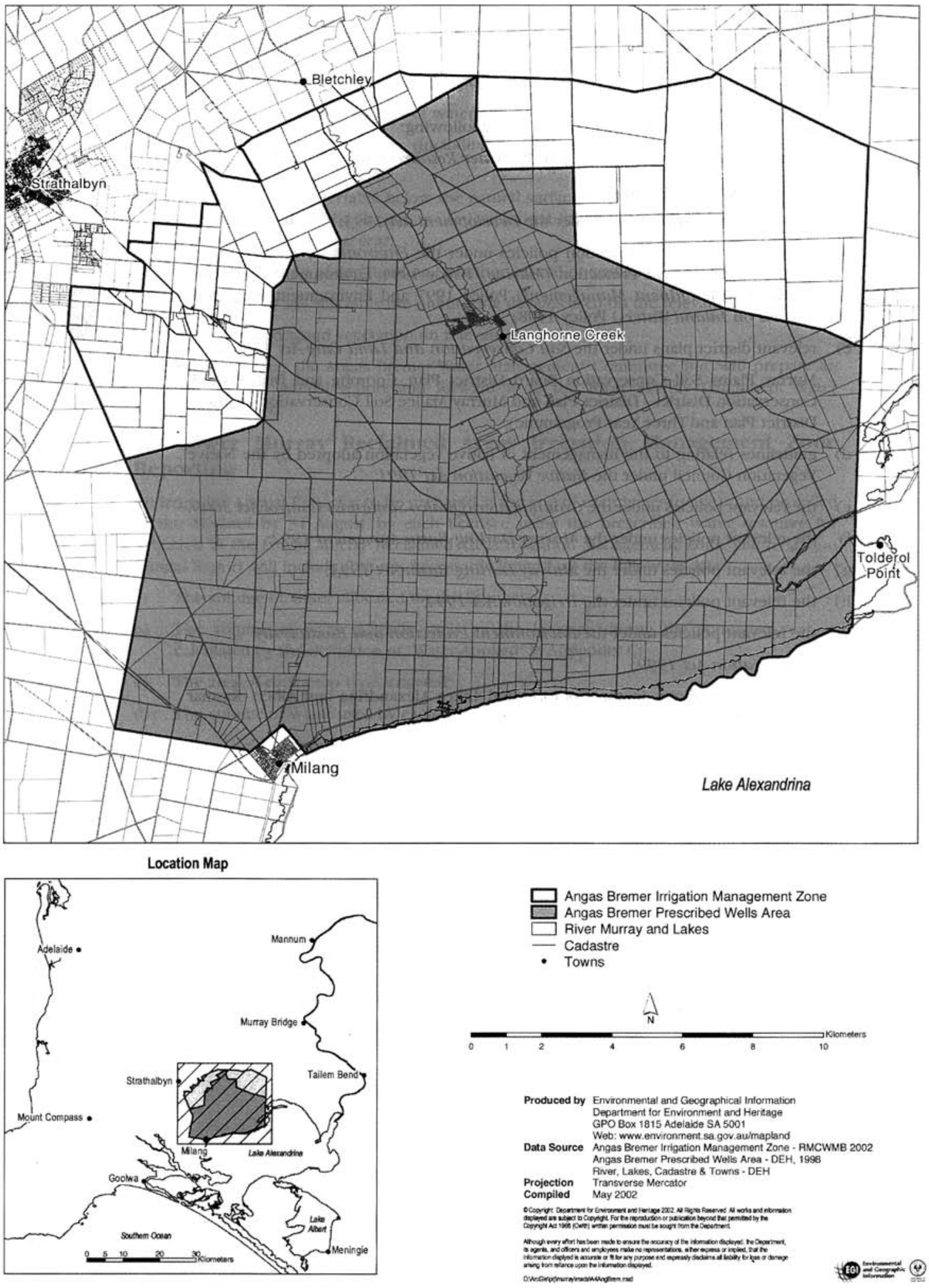


Figure 4 (i)

Figure 4 (i) Lower Murray Zone

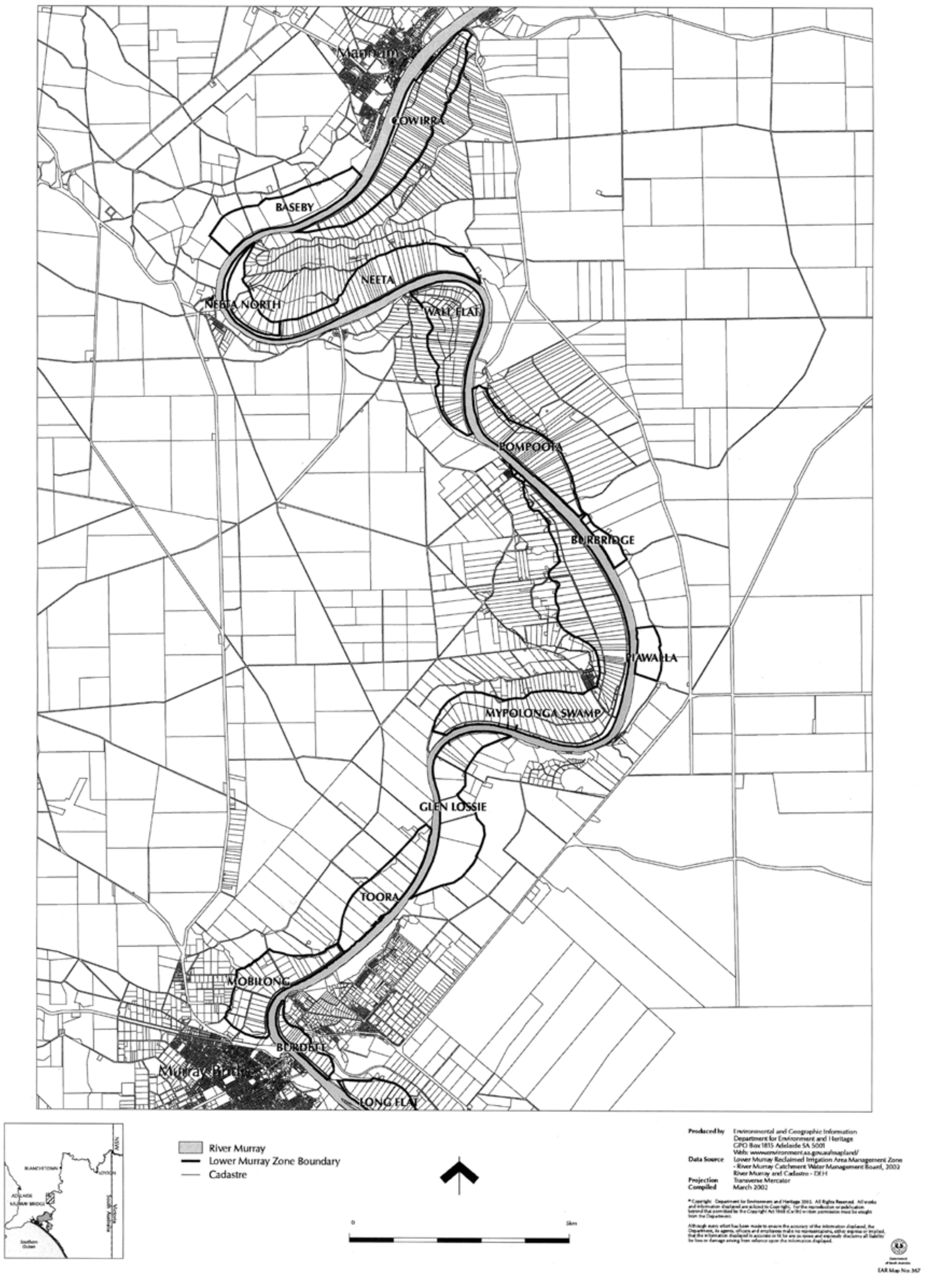


Figure 4 (ii)

Figure 4 (ii) Lower Murray Zone

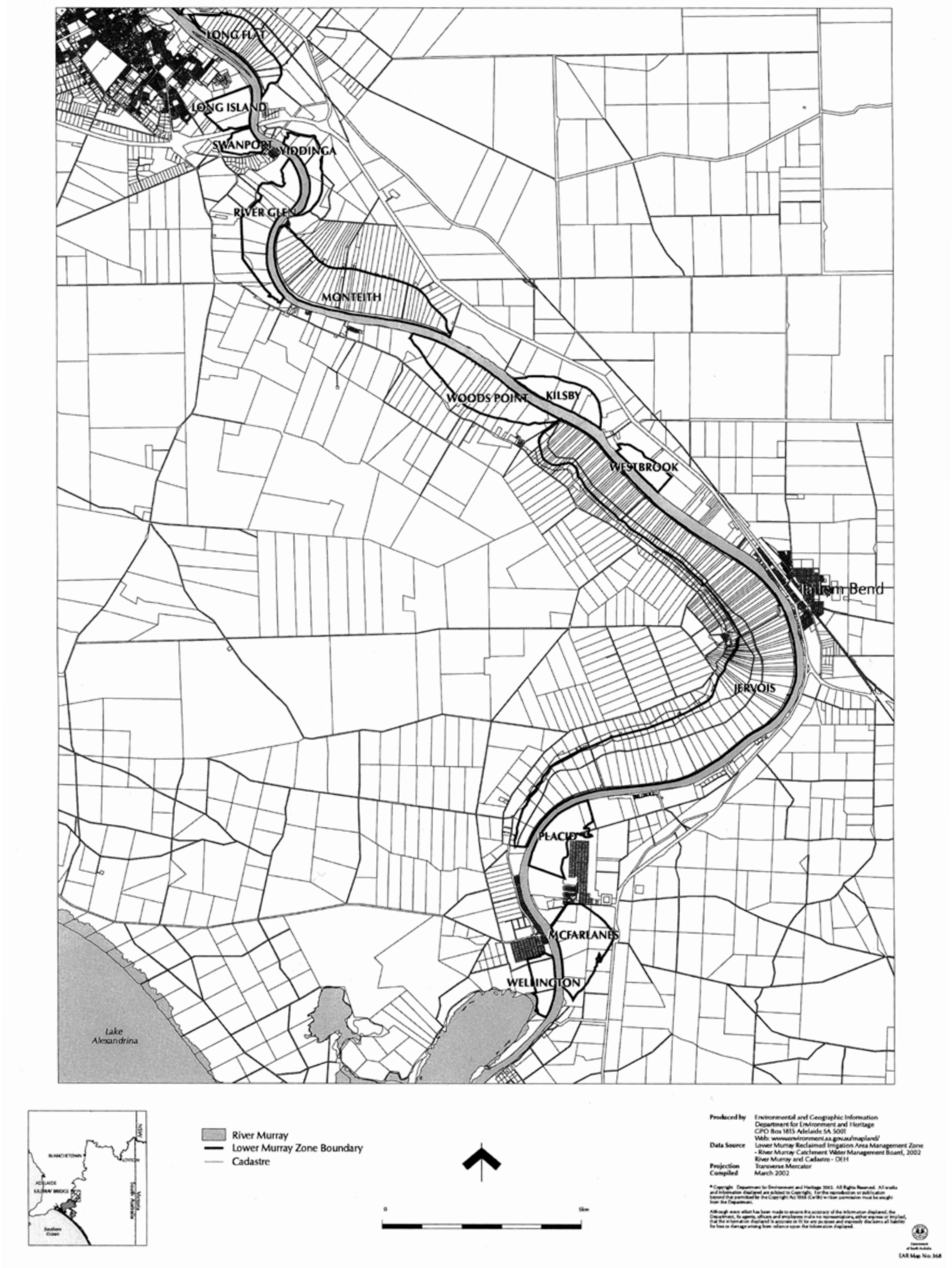


Figure 4 (iii)

Figure 4 (iii) Lower Murray Zone

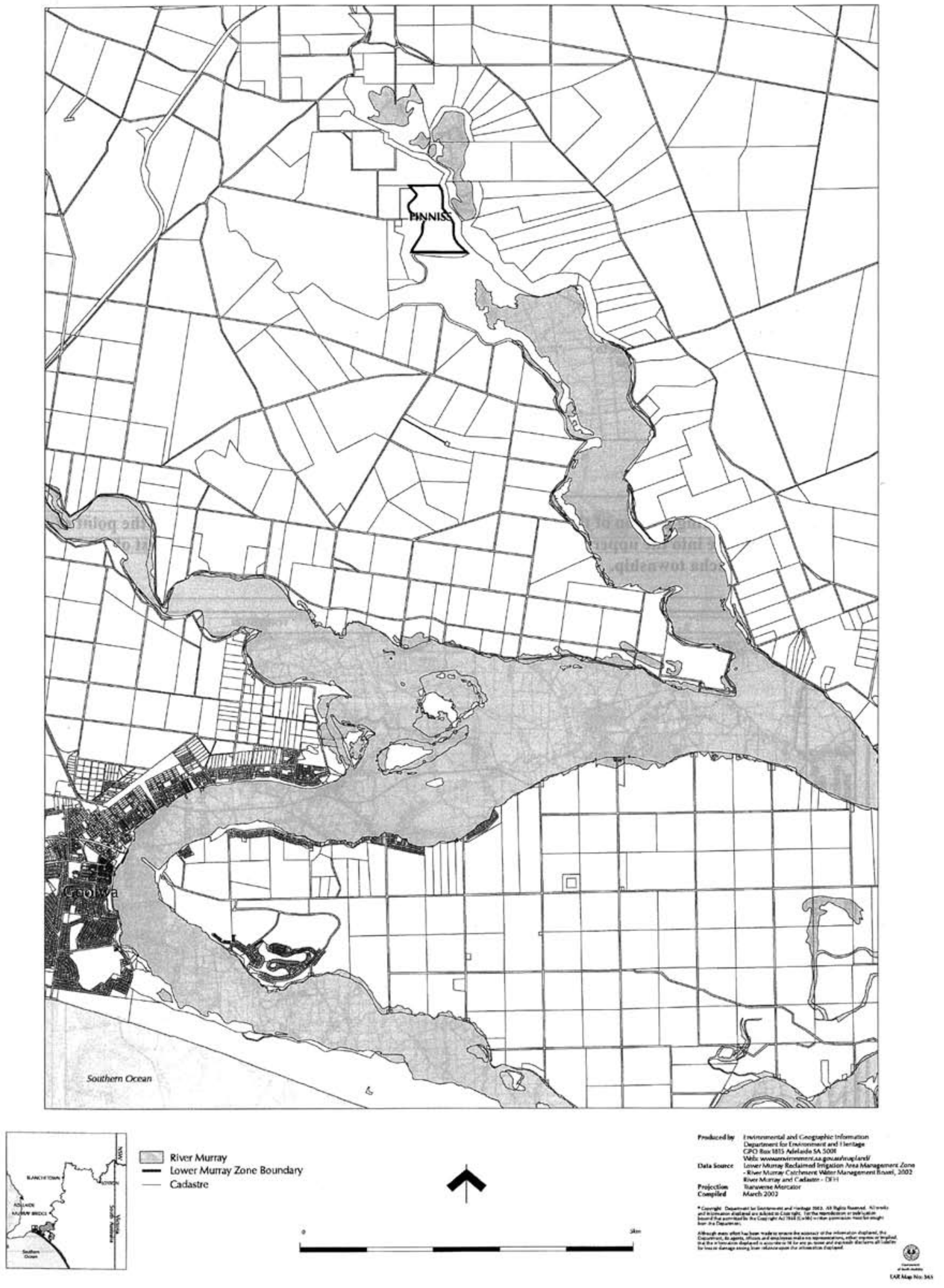
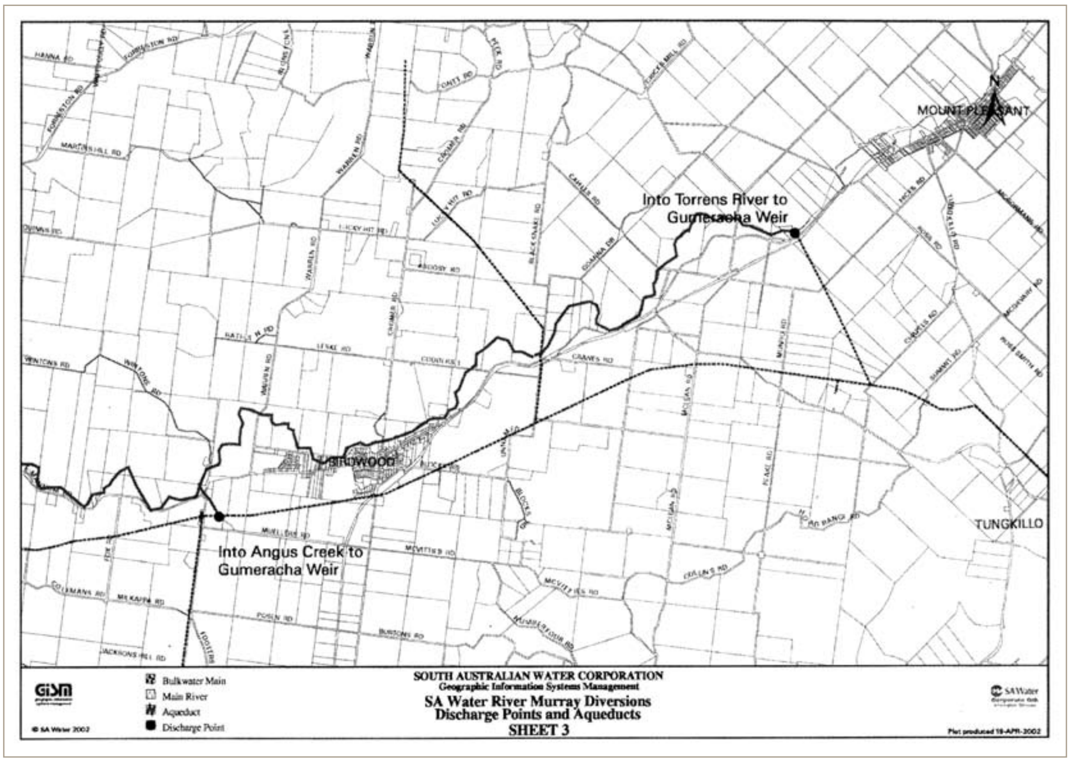
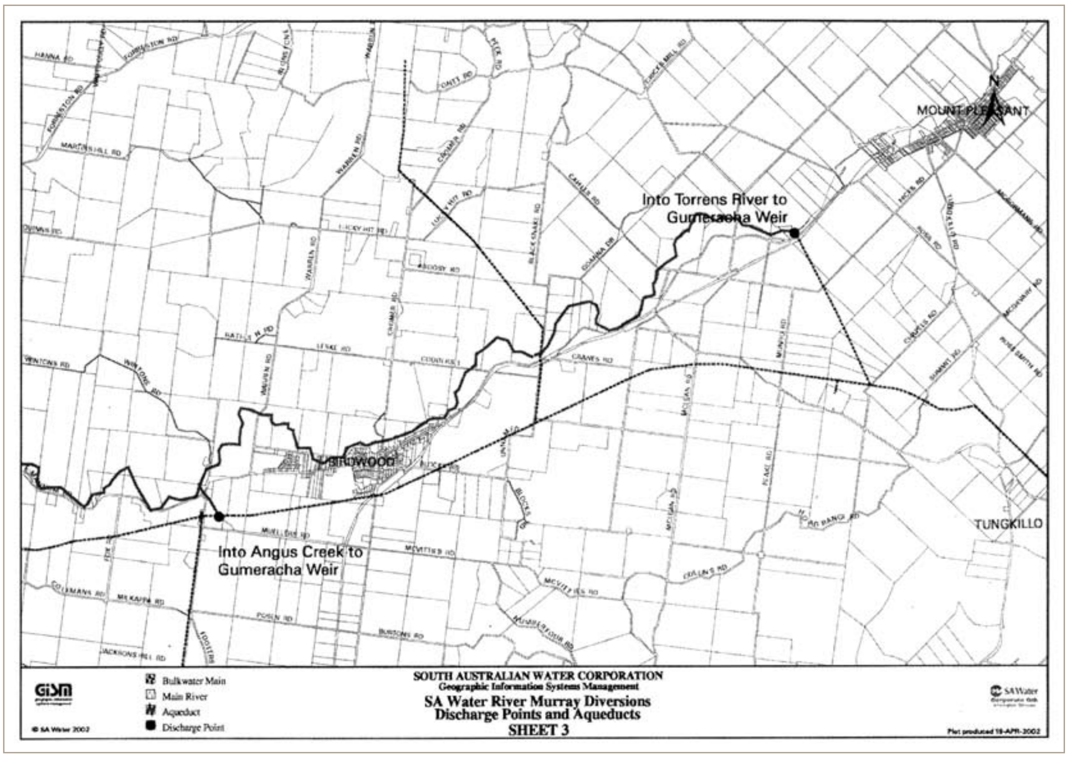


Figure 5 (i) (ii)

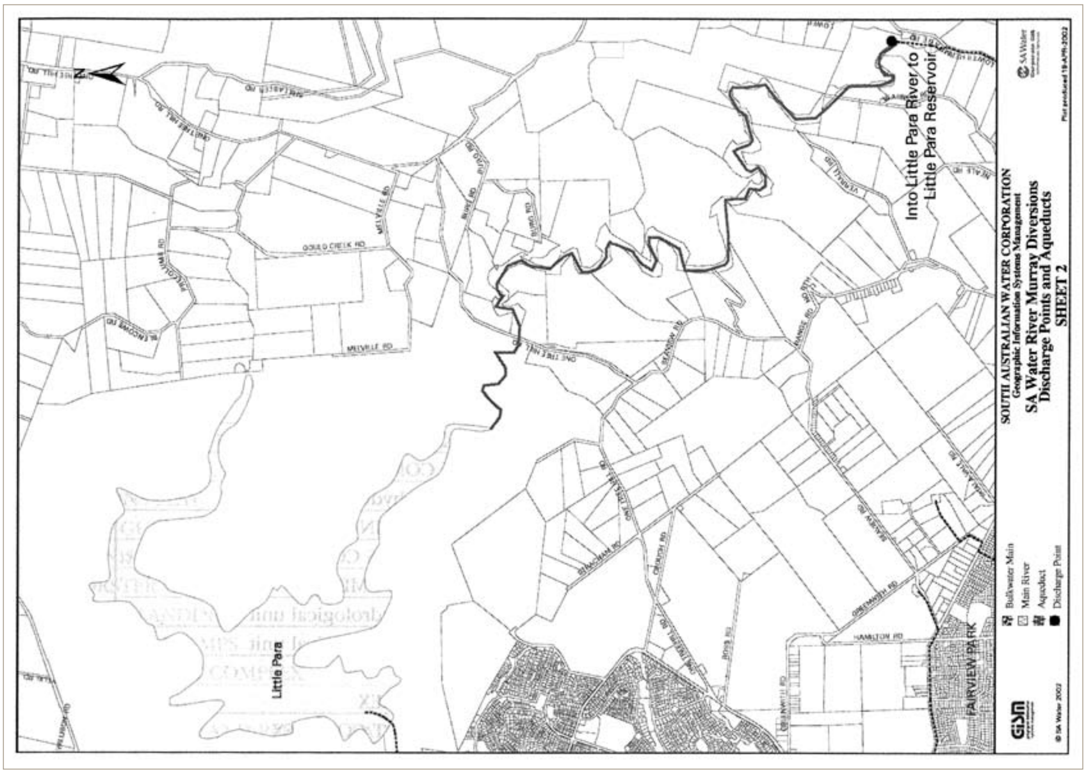


Map showing portion of the aqueduct zone for the Torrens River system between the point of discharge into the upper Torrens River, south-west of Mt Pleasant to a point east of Gumeracha township.

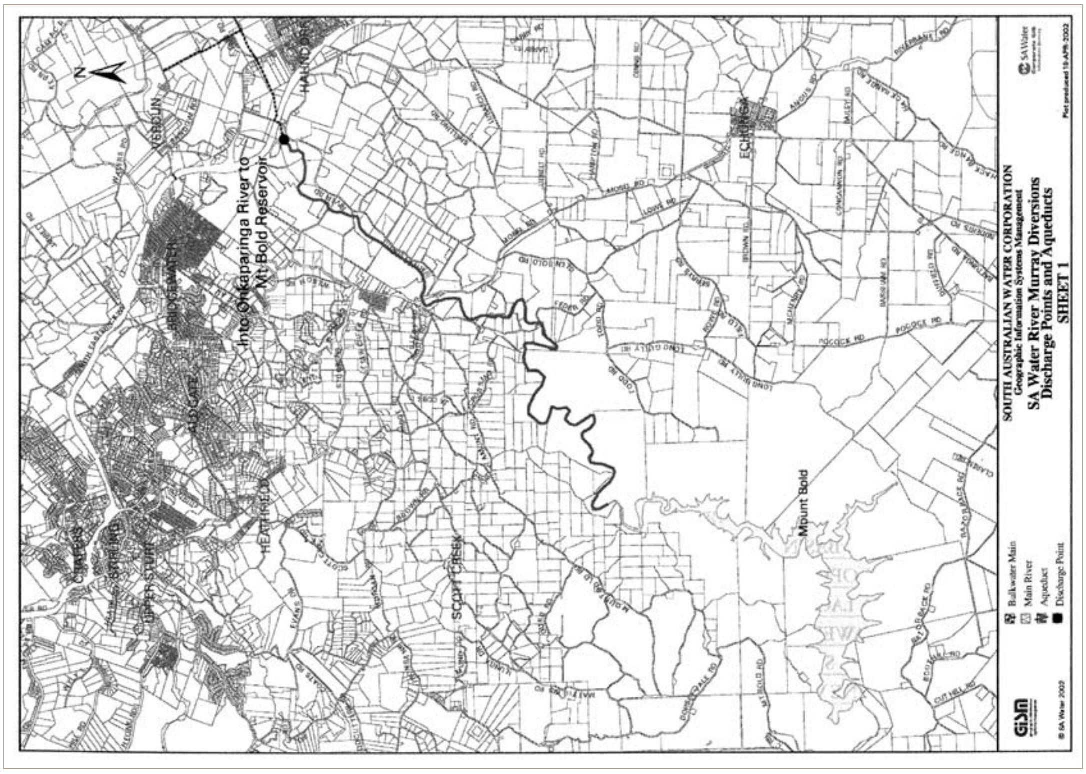


Map showing remaining portion of the aqueduct zone for the Torrens River system between Gumeracha township and the Gumeracha Weir.

Figure 5 (iii) (iv)



Map showing aquaduct zone for the Torrens River system between the point of discharge into the Little Para River to the Little Para reservoir.



Map showing aquaduct zone for the Onkaparinga River system between the point of discharge west of Hahndorf to the Mount Bold reservoir.

Appendix A: Wetlands from the Wetlands Atlas of South Australia (1996)

Wetlands Name	Complex Name
AJAX ACHILLES LAKE	Self-contained hydrological unit
ARLUNGA	Self-contained hydrological unit
BANROCK CREEK	BANROCK COMPLEX
BANROCK INLETS	BANROCK COMPLEX
BANROCK SWAMP	BANROCK COMPLEX
BASEBY LEVEE	Self-contained hydrological unit
BELCANOE	LAKE ALBERT FRINGING WETLAND
BELDORA WETLANDS	SPECTACLE LAKES COMPLEX
BERRI CAUSEWAY	GURRA LAKES COMPLEX
BERRI DISPOSAL BASIN COMPLEX	Self-contained hydrological unit
BIG BEND	Self-contained hydrological unit
BIG HUNCHEE LITTLE HUNCHEE AND AMAZON CREEKS	RAL RAL COMPLEX
BIG TOOLUNKA FLAT	TOOLUNKA FLAT COMPLEX
BLACKFELLOWS CREEK	LOVEDAY COMPLEX
BLACKIES OVEN	LOVEDAY COMPLEX
BLANCHETOWN CARAVAN PARK	EDSONS FLAT COMPLEX
BLANCHETOWN FLAT	PORTEE COMPLEX
BOAT CREEK	CHOWILLA COMPLEX
BOGGY FLAT	Self-contained hydrological unit
BOGGY LAKE	LAKE ALEXANDRINA FRINGING WETLAND
BOOKMARK CREEK	Self-contained hydrological unit
BOW HILL	Self-contained hydrological unit
BRANDY BOTTLE WATERHOLE	CHOWILLA COMPLEX
BRENDA PARK	BRENDA PARK AND MORPHETT FLAT
BULYONG ISLAND BASIN	RAL RAL COMPLEX
BURRA CREEK	NORTH WEST BEND COMPLEX
CADELL BASIN	CADELL COMPLEX
CADELL CREEK	CADELL COMPLEX
CADELL TRAINING CENTRE	CADELL COMPLEX
CAURNAMONT	Self-contained hydrological unit
CHAMBERS CREEK	LAKE BONNEY COMPLEX
CHOWILLA CREEK	CHOWILLA COMPLEX
CHOWILLA OXBOW	CHOWILLA COMPLEX
CLOVER LAKE	RAL RAL COMPLEX
COBDOGLA BASIN	Isolated by banks and control structures from Chambers Creek
COMPLEX OPPOSITE YARRA GLEN	Self-contained hydrological unit
COOLCHA LAGOON	Self-contained hydrological unit
COOLINDAWERH LAGOON	SALT LAGOON COMPLEX
COOMBOOL SWAMP	CHOWILLA COMPLEX
COPPERMINE WATERHOLE	CHOWILLA COMPLEX
COWIRRA LANDING	
CRAIGNOOK	Self-contained hydrological unit

Appendix A: Wetlands from the Wetlands Atlas of South Australia (1996) cont.

Wetlands Name	Complex Name
CURRENCY CREEK	LAKE ALEXANDRINA FRINGING WETLAND
DEVLINS POUND	Self-contained hydrological unit
DEVON DOWNS NORTH	BIG BEND
DEVON DOWNS SOUTH	BIG BEND
DEVON DOWNS SWAMP	Self-contained hydrological unit
DISHER CREEK	Self-contained hydrological unit
DONALD FLAT LAGOON	Self-contained hydrological unit
DOUBLE THOOKLE THOOKLE LAGOONS	RAL RAL COMPLEX
EAST HINDMARSH, MUNDOO AND EWE ISLANDS	LAKE ALEXANDRINA FRINGING WETLAND
EAST WELLINGTON	WELLINGTON COMPLEX
ECKERT CREEK AND THE SPLASH	KATARAPKO GAME RESERVE COMPLEX
EDSONS FLAT	EDSONS FLAT COMPLEX
EMU GULLY	NIKALAPKO COMPLEX
FINNISS RIVER	LAKE ALEXANDRINA FRINGING WETLAND
FORSTER LAGOON	Self-contained hydrological unit
FREDS LANDING	Self contained swamp
GERARD SWAMPS	Self-contained hydrological unit
GLEN DEVLIN COMPLEX	Self-contained hydrological unit
GLEN-LEE	Self contained hydrological unit
GOAT ISLAND AND PARINGA PADDOCK	Self-contained hydrological unit
GOOLWA CHANNEL ISLANDS	LAKE ALEXANDRINA FRINGING WETLAND
GREENWAYS LANDING	Self-contained hydrological unit
HANCOCK CREEK	CHOWILLA COMPLEX
HART LAGOON	Self-contained hydrological unit
HENLEY PARK	BIG BEND
HOGWASH BEND	Self-contained hydrological unit
HOLDER BEND	ROSS AND JAESCHKE LAGOONS COMPLEX
HORSESHOE SWAMP	RAL RAL COMPLEX
HYPURNA CREEK	CHOWILLA COMPLEX
IRWIN FLAT	Self-contained hydrological unit
ISLAND REACH	Self-contained hydrological unit
JAESCHKE LAGOON	ROSS AND JAESCHKE LAGOONS COMPLEX
JAESCHKE LAGOON SOUTH	ROSS AND JAESCHKE LAGOONS COMPLEX
JURY SWAMP (JAENSCHS BEACH)	Downstream end of Mypolonga Swamp
KATARAPKO BASIN	KATARAPKO GAME RESERVE COMPLEX
KATARAPKO CREEK AND KATARAPKO ISLAND	KATARAPKO GAME RESERVE COMPLEX
KIA WETLAND	TAWORRI COMPLEX
KINDARVAR CORNER	LAKE ALEXANDRINA FRINGING WETLAND
KINGSTON COMMON	Self-contained hydrological unit
KROEHNS LANDING	Self-contained hydrological unit
LAKE ALEXANDRINA STATION	LAKE ALEXANDRINA FRINGING WETLAND
LAKE BONNEY	LAKE BONNEY COMPLEX
LAKE BYWATERS	WALKER FLAT LAKES COMPLEX

Wetlands Name	Complex Name
LAKE CARLET	Self-contained hydrological unit
LAKE LIMBRA	CHOWILLA COMPLEX
LAKE LITTRA	CHOWILLA COMPLEX
LAKE MERRETI	RAL RAL COMPLEX
LAKE WOOLPOLOOL	RAL RAL COMPLEX
LARA INLET	Self-contained hydrological unit
LITTLE TOOLUNKA FLAT	TOOLUNKA FLAT COMPLEX
LOCH LUNA and NOCKBURRA CREEK	LOCH LUNA
LOVEDAY SWAMPS	LOVEDAY COMPLEX
LOWER PIKE RIVER	PIKE/MUNDIC COMPLEX
LOXTON FLOODPLAIN	Self-contained hydrological unit
LYRUP CAUSEWAY EAST	LYRUP CAUSEWAY COMPLEX
LYRUP CAUSEWAY WEST	LYRUP CAUSEWAY COMPLEX
LYRUP EAST	Self-contained hydrological unit
LYRUP FOREST	GURRA LAKES COMPLEX
MAIDMENT LAGOON	Self-contained hydrological unit
MAIZE ISLAND COMPLEX	Self-contained hydrological unit
MANNUM SWAMPS	Self-contained hydrological unit
MARKARANKA	MARKARANKA COMPLEX
MARKARANKA DEPRESSION	MARKARANKA COMPLEX
MARKARANKA EAST	MARKARANKA COMPLEX
MARKARANKA SOUTH	MARKARANKA COMPLEX
MARKS LANDING	Self-contained hydrological unit
MARNE RIVER MOUTH	Fed by Marne River catchment
MARNOO COMPLEX	LAKE ALBERT FRINGING WETLAND
MARTIN BEND COMPLEX	Self-contained hydrological unit
MASON ROCK	Self contained hydrological unit
McBEAN POUND NORTH	MCBEAN POUND COMPLEX
McBEAN POUND SOUTH	MCBEAN POUND COMPLEX
MCCAULEY SWAMP	Self-contained hydrological unit
McINTOSH CANAL	LAKE BONNEY COMPLEX
MILANG SHORES	LAKE ALEXANDRINA FRINGING WETLAND
MOBILONG SWAMP	Self-contained hydrological complex
MOLO FLAT	Self-contained hydrological unit
MONOMAN CREEK	CHOWILLA COMPLEX
MOORUNDIE	PORTEE COMPLEX
MOORUNDIE CREEK	PORTEE COMPLEX
MORGAN CONSERVATION PARK	MORGAN COMPLEX
MORGAN EAST	MORGAN COMPLEX
MORPHETT FLAT	BRENDA PARK AND MORPHETT FLAT
MUD ISLANDS	LAKE ALEXANDRINA FRINGING WETLAND
MUNDIC CREEK	PIKE/MUNDIC COMPLEX
MURBKO FLAT COMPLEX	Self-contained hydrological unit

Appendix A: Wetlands from the Wetlands Atlas of South Australia (1996) cont.

Wetlands Name	Complex Name
MURBKO SOUTH	Self-contained hydrological unit
MURBPOOK LAGOON COMPLEX	Self-contained hydrological unit
MURTHO PARK COMPLEX	Self-contained hydrological unit
MUSSEL LAGOONS	LOVEDAY COMPLEX
MYPOLONGA LEVEE	Isolated by levee bank self-contained hydrological unit
MYPOLONGA NORTH	Contained within levee banks and roadway
NANDA WETLAND	LAKE ALEXANDRINA FRINGING WETLAND
NARRUNG	LAKE ALBERT FRINGING WETLAND
NARRUNG NARROWS	LAKE ALBERT FRINGING WETLAND
NEETA FLAT DEPRESSIONS	Self-contained hydrological unit
NELWART SWAMP	Self-contained hydrological unit
NIGRA CREEK	NIGRA CREEK COMPLEX
NIGRA LAGOON	NIGRA CREEK COMPLEX
NIKALAPKO	NIKALAPKO COMPLEX
NIKALAPKO WEST	NIKALAPKO COMPLEX
NIL NIL	Self-contained hydrological unit
NORTH CAURNAMONT	Self-contained hydrological unit
NORTH PURNONG	Self-contained hydrological unit
NORTH WEST BEND	NORTH WEST BEND COMPLEX
OVERLAND CORNER COMPLEX	Self-contained hydrological unit comprising M152 M153 and M154
PAIWALLA GULLY	Contained within levee banks
PARCOOLA WEST	Self-contained hydrological unit
PARINGA ISLAND	Self-contained hydrological unit
PASCHKES FLAT	Self-contained hydrological unit
PELLARING FLAT	Upstream end of hydrological unit
PENFOLDS LAGOON	BRENDA PARK AND MORPHETT FLAT
PENNS INLET	Self-contained hydrological unit
PERRES FLOODPLAIN	Self-contained hydrological unit
PILBY CREEK	CHOWILLA COMPLEX
PIPECLAY CREEK	CHOWILLA COMPLEX
POINT STURT	LAKE ALEXANDRINA FRINGING WETLAND
POINT STURT SOUTH	LAKE ALEXANDRINA FRINGING WETLAND
POLTALLOCH	LAKE ALEXANDRINA FRINGING WETLAND
POMPOOTA	Isolated by levee banks
PORTEE	PORTEE COMPLEX
PORTEE CREEK	PORTEE COMPLEX
PRIESS LANDING	BIG BEND
PUNKAH CREEK	CHOWILLA COMPLEX
PUNKAH HORSESHOE LAGOONS	CHOWILLA COMPLEX
PUNYELROO	Self-contained hydrological unit
PYAP HORSESHOE	PYAP COMPLEX
PYAP LAGOON	PYAP COMPLEX
PYAP SWAMPS	PYAP COMPLEX

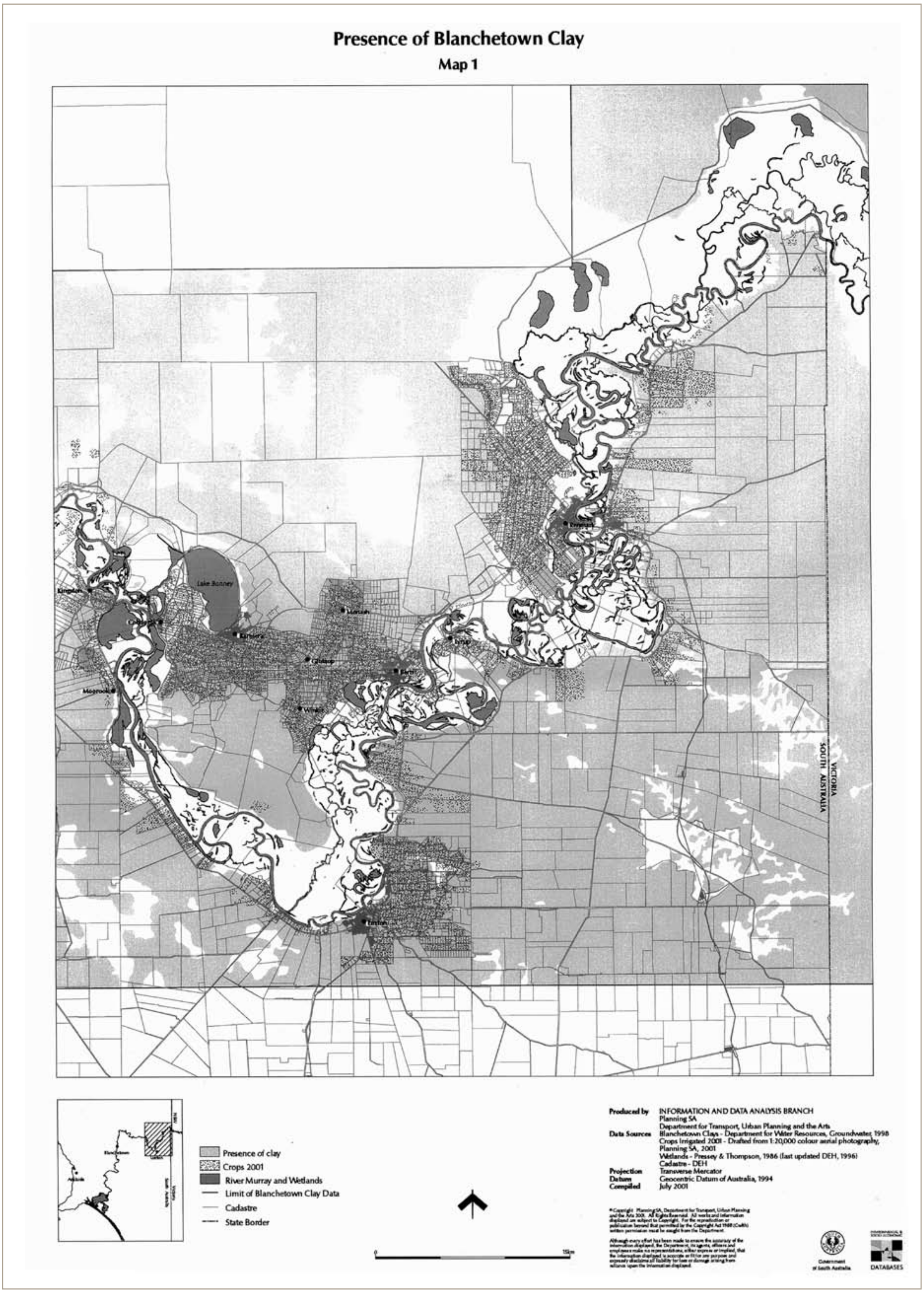
Wetlands Name	Complex Name
QUALCO NORTH	QUALCO COMPLEX
QUALCO SWAMP	QUALCO COMPLEX
RAL RAL CREEK AND RAL RAL WIDEWATERS	RAL RAL COMPLEX
RAMCO LAGOON	RAMCO LAGOON COMPLEX
RAMCO OUTLET	RAMCO LAGOON COMPLEX
REEDY CREEK	Self-contained hydrological unit
REEDY ISLAND FLAT	Self-contained hydrological unit
REEDY POINT	LAKE ALEXANDRINA FRINGING WETLAND
REID FLAT	Self-contained hydrological unit
RILLI LAGOONS	Self-contained hydrological unit
RILLI REACH	Self-contained hydrological unit
RIVERGLADES	Self-contained hydrological unit
ROONKA	Self-contained hydrological unit
ROSS LAGOON	ROSS AND JAESCHKE LAGOONS COMPLEX
RUMPAGUNYAH CREEK	PIKE/MUNDIC COMPLEX
SALT CREEK AND GURRA GURRA LAKES	GURRA LAKES COMPLEX
SALT LAGOON	SALT LAGOON COMPLEX
SALTBUSH FLAT	Self-contained hydrological unit
SCHILLERS LAGOON	NIGRA CREEK COMPLEX
SCOTT CREEK	BRENDA PARK AND MORPHETT FLAT
SCOTT CREEK LAGOONS	BRENDA PARK AND MORPHETT FLAT
SCRUBBY FLAT	SCRUBBY FLAT COMPLEX
SCRUBBY FLAT CREEK	SCRUBBY FLAT COMPLEX
SECTION 57	LAKE ALEXANDRINA FRINGING WETLAND
SINCLAIR FLAT	Self-contained hydrological unit
SLANEY CREEK	CHOWILLA COMPLEX
SLANEY OXBOW	CHOWILLA COMPLEX
SMITHS SWAMP	Self-contained hydrological unit
SOUTH PORTEE	PORTEE COMPLEX
SPECTACLE LAKES	SPECTACLE LAKES COMPLEX
SPECTACLE LAKES SOUTH	SPECTACLE LAKES COMPLEX
SUNNYSIDE CONSERVATION PARK AND	Two self-contained hydrological units
PAIWALLA SWAMP	isolated by levee banks
SWAN REACH COMPLEX	Self-contained hydrological unit
SWAN REACH FERRY	Self-contained hydrological unit
SWANPORT WETLAND	Upstream end of Irrigation Area
TAILEM BEND	Isolated downstream end of hydrological unit
TANYACA CREEK	PIKE/MUNDIC COMPLEX
TAWORRI WETLAND	TAWORRI COMPLEX
TEAL FLAT	TEAL FLAT COMPLEX
TEAL FLAT HUT	TEAL FLAT COMPLEX
TERINGIE COMPLEX	LAKE ALEXANDRINA FRINGING WETLAND
THIELE FLAT	Self-contained hydrological unit

Appendix A: Wetlands from the Wetlands Atlas of South Australia (1996) cont.

Wetlands Name	Complex Name
TOBALONG	Isolated upstream end of hydrological unit
TOLDEROL	LAKE ALEXANDRINA FRINGING WETLAND
TOOKAYERTA CREEK and BLACK SWAMP	LAKE ALEXANDRINA FRINGING WETLAND
TOORA LEVEE	Self-contained hydrological unit
UPPER PIKE RIVER AND SNAKE CREEK	PIKE/MUNDIC COMPLEX
WACHTELS LAGOON	Self-contained hydrological unit
WALKER FLAT SOUTH LAGOON	WALKER FLAT LAKES COMPLEX
WALL LEVEE	Self-contained hydrological unit
WALL SWAMP	Self-contained hydrological unit
WALTOWA SWAMP	LAKE ALBERT FRINGING WETLAND
WEILA COMPLEX	Self-contained hydrological complex
WELLINGTON	Self contained hydrological unit
WELLINGTON MARINA	WELLINGTON COMPLEX
WELLINGTON NORTH	Southern end of Jervois reclaimed swamp.
WELLINGTON SOUTH	WELLINGTON COMPLEX
WELLINGTON SPIT	LAKE ALEXANDRINA FRINGING WETLAND
WERTA WERT	CHOWILLA COMPLEX
WEST KILBRIDE	LAKE ALBERT FRINGING WETLAND
WESTON FLAT LAGOON	Self-contained hydrological unit
WHIRLPOOL CORNER	Self-contained hydrological unit
WIGLEY FLAT	WIGLEY FLAT COMPLEX
WIGLEY FLAT EAST	WIGLEY FLAT COMPLEX
WIGLEY REACH	Self-contained hydrological unit
WOMBAT REST BACKWATER	BRENDA PARK AND MORPHETT FLAT
WOMBAT REST SWAMP	BRENDA PARK AND MORPHETT FLAT
WONGULLA LAGOON	Self-contained hydrological unit
WOOD LANE	Contained by hill slopes and roadway
WOOLENOOK BEND COMPLEX	Self-contained hydrological unit
WOOLPUNDA	Self-contained hydrological unit
YALKURI MARSH	LAKE ALEXANDRINA FRINGING WETLAND
YARRA COMPLEX	Self-contained hydrological unit
YARRAMUNDI	PORTEE COMPLEX
YARRAMUNDI NORTH	PORTEE COMPLEX
YATCO LAGOON	Self-contained hydrological unit
YOUNGHUSBAND	YOUNGHUSBAND COMPLEX
YOUNGHUSBAND POINT	YOUNGHUSBAND COMPLEX
YOUNGHUSBAND WEST	Self-contained hydrological unit

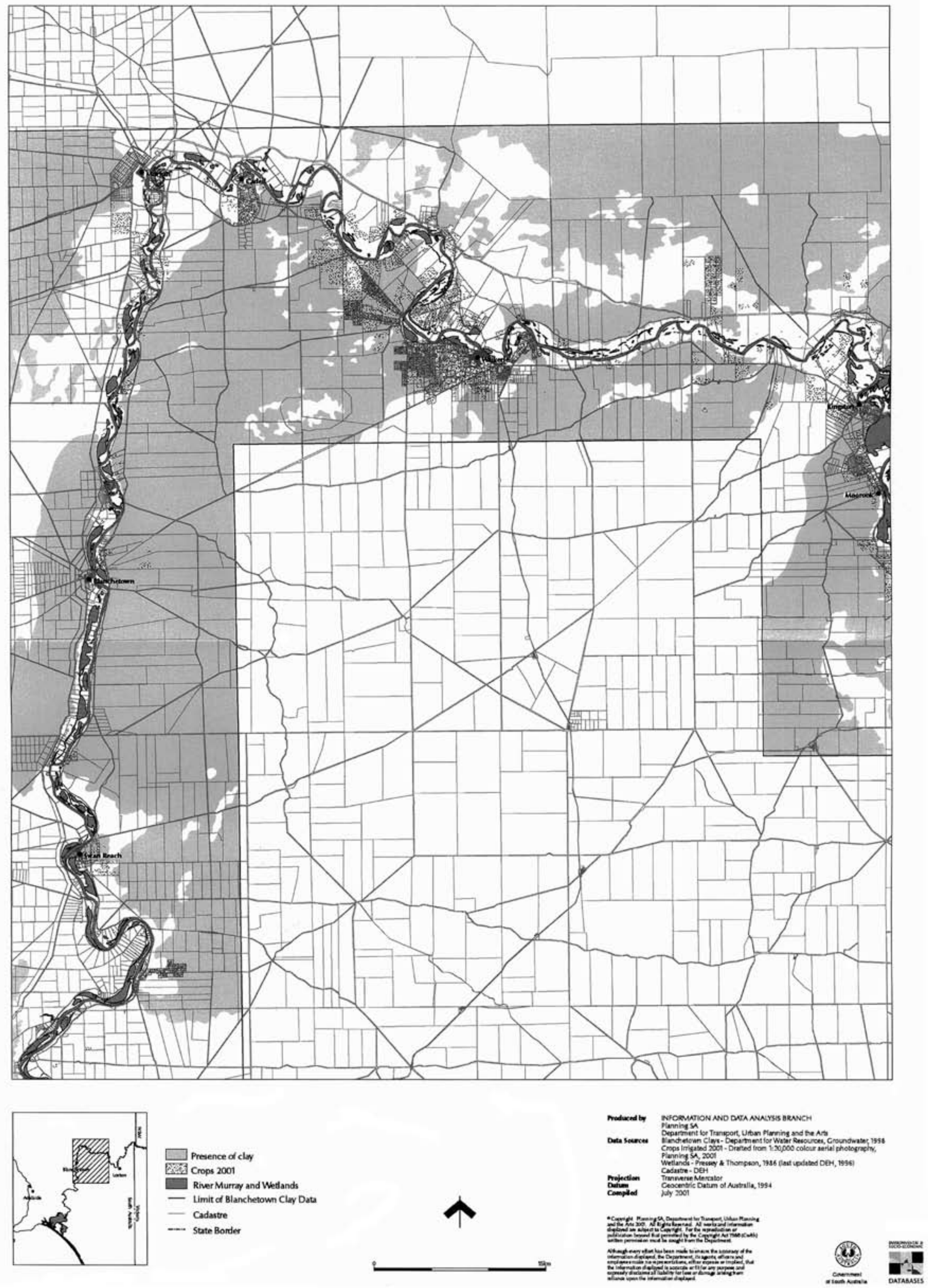
Appendix B: Blanchetown Clay Layer Maps

Appendix B: Blanchetown Clay Layer Maps (cont.)

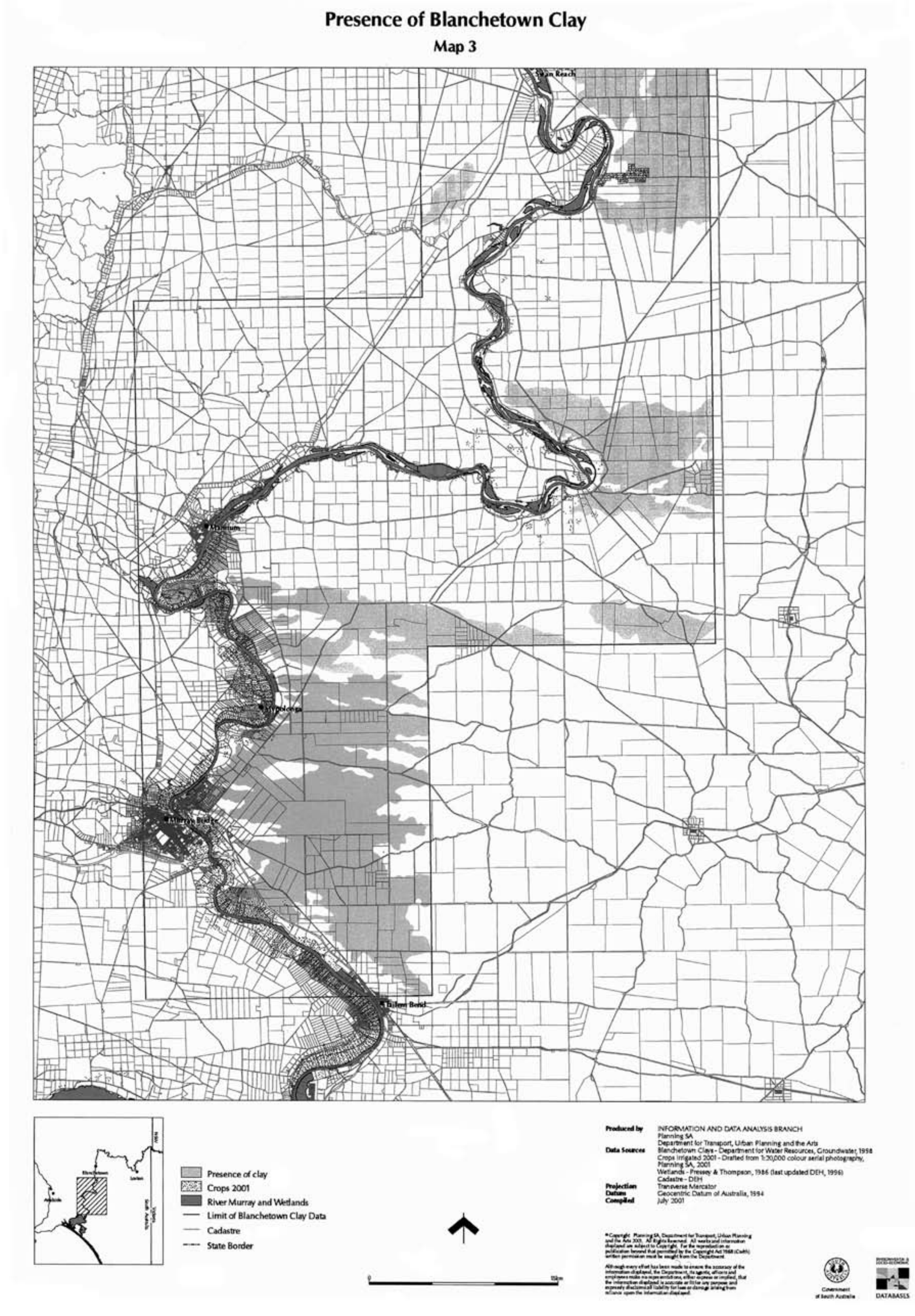


Presence of Blanchetown Clay

Map 2



Appendix B: Blanchetown Clay Layer Maps (cont.)



Appendix C:

For the purposes of Principles 15, and 36 "water-use efficiency" (expressed as a percentage) is the amount of water required by the particular crop or crops ("Crop Water Use") multiplied by 100 and divided by the amount of water applied to the particular crop or crops ("Water Applied") in a water-use year.

$$WUE\% = \frac{\text{Crop Water Use (mm)}}{\text{Water Applied (mm)}} = \frac{\text{Evaporation (mm)} \times \text{Crop Factor}}{\text{Irrigation (mm)} + \text{Effective Rainfall (mm)}} \times 100$$

where **"Crop Water Use"** is the total of multiplying each monthly crop factor for the particular crop or crops (set out in Table 3 of Appendix C) by each monthly long-term average evaporation rate of the station nearest to the land upon which the water is to be used (set out in Table 1 of Appendix C) for the water-use year.

Note: The monthly crop factor is the crop factor as set out in Table 3 of Appendix C for the particular crop or crops multiplied by the age factor of the particular crop or crops as set out in Table 4 of Appendix C.

where **"Water Applied"** to a particular crop or crops means:

i) the sum of the total volume of water taken through a meter in the previous water use year for the purpose of irrigating the particular crop or crops and the annual long-term average effective rainfall as set out in Table 2 of Appendix C; or

ii) where water has not been taken through a meter, or there is no existing water allocation for the purpose of irrigating the particular crop or crops, the estimated volume of water required to irrigate the particular crop or crops as set out in the relevant Irrigation and Drainage Management Plan, or determined by having regard to the area of the particular crop or crops to be irrigated and, the irrigation system to be used.

Note: Water meter readings will need to be converted from kilolitres to millimetres. This conversion is explained in the example provided below:

Example: A 50 hectare property with an annual metered use of 450,000 kilolitres.

Step 1: The first step is to convert the metered use into kilolitres per hectare. To do this all you need to do is divide 450, 000 kilolitres divided by 50 hectares.

$$\frac{450{,}000}{50} = 9{,}000 \text{ kilolitres per hectare}$$

Step 2: Now convert kilolitres per hectare to millimetres (mm).A simple conversion factor is used for this calculation:

1 kilolitre per hectare = 0.1mm;

so to now convert kilolitres per hectare to millimetres multiply 9,000 kilolitres per hectare x 0.1mm = 900mm

900 mm is the irrigation water applied to the irrigated property. To complete the calculation of total water applied to the property (crop/s) you now need to add the sum of effective rainfall for the months where the crop factor in Table 3 of Appendix C is greater than zero.

Appendix C: (cont.)

Table 1: Monthly Evaporation (Epan) in milimetres (mm)

Name	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Barmera	52	95	134	184	271	329	324	288	260	143	97	56	2233
Berri	53	95	133	183	269	328	326	286	257	143	96	55	2224
Blanchetown	50	91	127	170	275	311	303	275	261	137	98	59	2157
Bow Hill	50	84	114	151	248	281	271	243	226	129	86	56	1939
Cadell	50	95	136	186	281	326	315	289	275	142	103	59	2257
Chowilla	56	100	140	194	270	340	338	297	264	148	99	56	2302
Claypans	50	85	115	154	254	286	277	249	230	130	88	56	1974
Cooltong	54	97	137	189	270	334	331	292	261	145	98	56	2264
Eden Valley	49	85	113	150	254	283	260	247	237	129	88	57	1952
Goolwa	49	73	95	129	206	240	206	199	187	116	73	52	1625
Kingstonom	51	95	134	184	273	328	322	288	262	143	98	57	2235
Langhorne Creek	50	76	101	139	212	251	225	206	200	122	76	52	1710
Loxtondoa	52	93	130	177	266	320	321	280	251	140	94	55	2179
Mannum	50	83	111	147	241	276	257	235	221	127	84	55	1887
Meningie	50	72	96	131	196	238	224	201	191	115	73	52	1639
Milangews	50	74	99	135	209	246	218	202	195	119	75	52	1674
Morgan	50	94	135	184	281	324	312	287	276	142	103	59	2247
Murray Bridge	50	79	106	144	223	262	246	218	210	125	80	53	1796
Mypolonga	50	81	109	146	232	269	254	227	215	126	82	54	1845
Nildottie	50	87	119	158	263	296	285	260	240	132	91	57	2038
Qualco	50	95	136	185	279	327	317	289	272	143	102	59	2254
Renmark	55	97	136	188	269	334	332	291	259	145	97	55	2258
Swan Reach	50	89	122	161	269	302	289	266	248	134	94	58	2082
Tailem Bend	50	77	104	144	214	256	247	214	206	123	78	52	1762
Wailkerie	50	95	134	183	277	325	317	288	267	142	100	58	2236
Wellington	50	76	103	140	211	254	243	212	204	123	78	52	1746

Table 2: Monthly Evaporation (Epan) in milimetres (mm)

Name	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Barmera	15	13	14	16	13	10	11	10	7	10	14	13	146
Berri	17	16	17	19	14	10	13	10	7	11	14	14	162
Blanchetown	14	16	14	16	11	11	10	11	8	13	16	15	154
Bow Hill	27	29	22	19	18	7	10	5	11	20	24	26	217
Cadell	13	12	13	15	10	11	10	13	7	10	13	11	137
Chowilla	11	13	14	13	11	9	9	11	7	8	13	14	133
Claypans	20	19	18	19	14	13	11	11	10	14	19	18	185
Cooltong	17	16	16	20	11	7	14	11	8	12	13	14	160
Eden Valley	75	73	42	32	16	17	11	14	11	36	68	46	443
Goolwa	38	34	29	25	17	14	12	12	13	23	31	37	286
Kingstonom	13	14	15	15	12	10	10	11	8	8	14	14	144
Langhorne Creek	26	26	24	22	16	15	11	11	13	20	25	26	235
Loxtondoa	20	19	16	18	13	12	10	7	6	8	16	19	164
Mannum	17	19	18	16	13	12	10	10	10	15	18	19	177
Meningie	37	34	28	24	17	15	12	10	14	24	32	37	284
Milangews	30	28	22	19	13	12	11	12	12	20	22	28	227
Morgan	13	14	14	14	11	11	8	11	8	10	15	14	143
Murray Bridge	21	22	22	20	15	14	10	10	12	17	21	22	207
Mypolonga	18	20	19	19	16	14	9	11	11	14	21	18	190
Nildottie	17	15	17	16	11	10	10	7	8	10	17	16	154
Qualco	12	13	14	17	12	11	8	13	8	8	11	14	142
Renmark	14	15	16	17	13	11	10	11	8	11	14	14	154
Swan Reach	16	16	17	16	11	11	10	11	10	11	17	17	164
Tailem Bend	24	24	23	22	17	16	10	12	13	17	24	24	226
Wailkerie	14	14	14	16	11	11	10	13	7	10	15	16	152
Wellington	26	29	26	29	20	14	13	10	16	24	22	28	257

Note : PE values in the above table have been determined by multiplying average monthly precipitation by 0.6 where monthly precipitation <75mm OR 08 where precipitation >75mm:

Appendix C: (cont.)

Table 3 Monthly Crop Factor

Crop	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Treecrops												
Almond		0.33	0.63	0.97	0.82	0.78	0.75	0.76	0.65	0.61	0.29	
Avocado	0.41	0.49	0.53	0.53	0.57	0.61	0.60	0.60	0.56	0.52	0.51	0.47
Citrus	0.48	0.49	0.46	0.46	0.46	0.46	0.46	0.46	0.45	0.48	0.47	0.47
Lucerne	0.61	0.63	0.63	0.64	0.67	0.68	0.67	0.67	0.66	0.65	0.61	0.61
Olive	0.34	0.35	0.46	0.50	0.50	0.50	0.50	0.50	0.49	0.48	0.47	0.34
Pistachio			0.28	0.43	0.57	0.79	0.78	0.78	0.56	0.31		
Pomefruit*			0.42	0.50	0.60	0.68	0.67	0.67	0.66	0.59	0.51	
Stonefruit**			0.39	0.50	0.57	0.64	0.64	0.64	0.63	0.55	0.44	
Vine			0.21	0.21	0.35	0.50	0.50	0.50	0.49	0.31		
Walnut			0.39	0.57	0.78	0.79	0.78	0.78	0.77	0.76	0.44	
Vegetables* **												
Carrot	0.20	0.20	0.20	0.50	0.64	0.75	0.71	0.20	0.20	0.20	0.20	0.20
Onion	0.20	0.20	0.49	0.64	0.74	0.75	0.74	0.53	0.20	0.20	0.20	0.20
Potato	0.20	0.20	0.35	0.60	0.81	0.81	0.68	0.53	0.20	0.20	0.20	0.20
Pumpkin	0.20	0.20	0.20	0.35	0.53	0.72	0.71	0.57	0.20	0.20	0.20	0.20

* *Pomefruit includes Apple, Cherry and Pear (FAO 56)*

** *Stonefruit includes Apricots, Peach, Pecan and Plum (FAO 56)*

*** *Vegetable crop factors are shown in a typical season, but planting time and harvest are variable. The 0.2 crop factor outside of the growing season for vegetable crops allows for water requirement of groundcover for (sandy) soil stabilisation.*

Table 4 Proportional adjustment of crop factors

Crop	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10+
Almond	0.40	0.49	0.57	0.66	0.74	0.83	0.91	1.00	1.00	1.00	1.00
Avocado	0.40	0.48	0.55	0.63	0.70	0.78	0.85	0.93	1.00	1.00	1.00
Citrus	0.40	0.47	0.53	0.60	0.67	0.73	0.80	0.87	0.93	1.00	1.00
Lucerne	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Olive	0.40	0.46	0.52	0.58	0.64	0.70	0.76	0.82	0.88	0.94	1.00
Pistachio	0.40	0.49	0.57	0.66	0.74	0.83	0.91	1.00	1.00	1.00	1.00
Pomefruit	0.40	0.48	0.55	0.63	0.70	0.78	0.85	0.93	1.00	1.00	1.00
Stonefruit	0.40	0.48	0.55	0.63	0.70	0.78	0.85	0.93	1.00	1.00	1.00
Walnut	0.40	0.49	0.57	0.66	0.74	0.83	0.91	1.00	1.00	1.00	1.00
Vine	0.40	0.52	0.64	0.76	0.88	1.00	1.00	1.00	1.00	1.00	1.00
Vegetables	1.00										

Note: Year 0 represents the year of planning.

Appendix D: Lower Murray Reclaimed Irrigation Area Management Zone

Table 1. Rates of the water referred to in Principle 4(b) (ELMA)
As per the 2004 amendments to the River Murray WAP to the 2002 plan

Irrigation Area	Rate (ML/Ha)
Cowirra	6.49
Baseby	6.44
Neeta	6.23
Neeta North	6.14
Wall Flat	6.06
Pompoota	5.86
Mypolonga	5.50
Burbridge	5.37
Paiwalla	5.15
Glen Lossie	5.10
Toora	4.87
Mobilong	4.68
Burdett	4.56
Long Flat	4.46
Long Island	4.22
Swanport	4.15
Yiddinga	4.13
River Glen	3.98
Monteith	3.87
Kilsby	3.61
Woods Point	3.58
Westbrook	3.46
Jervois	2.96
Seymour	2.33
Finniss	1.38

Appendix E: Angas – Bremer Revegetation Booklet

Angas - Bremer Irrigation Region

Revegetation Booklet

Commissioned by
The Angas-Bremer Water Management Committee
August 2000

Produced by Environmental Regeneration Australia

Natural Heritage Trust
Helping Communities Helping Australia

Angas-Bremer
Water Management Committee

River Murray Catchment
Water Management Board

Appendix E: Angas – Bremer Revegetation Booklet (cont.)

Table 1. Rates of the water referred to in Principle 4(b) (ELMA) As per the 2004 amendments to the River Murray WAP to the 2002 plan

Irrigation Area	Rate (ML/Ha)	Irrigation Area	Area (Ha)
Cowirra	6.49	*Long Flat*	4.46
Baseby	6.44	*Long Island*	4.22
Neeta	6.23	*Swanport*	4.15
Neeta North	6.14	*Yiddinga*	4.13
Wall Flat	6.06	*River Glen*	3.98
Pompoota	5.86	*Monteith*	3.87
Mypolonga	5.50	*Kilsby*	3.61
Burbridge	5.37	*Woods Point*	3.58
Paiwalla	5.15	*Westbrook*	3.46
Glen Lossie	5.10	*Jervois*	2.96
Toora	4.87	*Seymour*	2.33
Mobilong	4.68	*Finniss*	1.38
Burdett	4.56		

How To Use This Guide

Re-establishing vegetation requires a reasonable understanding of what the land is capable of supporting. In order to assess this and to give an indication of what may formerly have been present on the land throughout the Angas-Bremer Irrigation region, this guide has been put together.

Because of the range of vegetation associations and soil types it has been necessary to tackle this in a number of stages.

This revegetation guide has divided the Angas-Bremer Irrigation area into five common soil types. A brief description of each of these is given in the main body of the text.

In each of the soil types a description of the site is given, a list of weeds and plants likely to be around on such a site and photos to help identify the site type.

If the site description matches the sort of revegetation project you wish to undertake, it is worthwhile checking the former vegetation list and even visiting some remnant vegetation areas or revegetation sites to provide a realistic insight into what you are trying to achieve.

Appendix E: Angas – Bremer Revegetation Booklet (cont.)

The former vegetation lists are by no means exhaustive and merely try to pick out some indicator species that help show the differences between sites and include species likely to be useful in revegetation projects.

General revegetation information is gathered together at the front of the booklet because most of this information is common to any revegetation project in this area. This is probably the most important information because it really is dealing with the basic requirements of good revegetation planning.

Obviously, all sites are different and historical management practices have had impacts on all sites. A couple of the significant factors likely to make it difficult to re-establish vegetation are also dealt with in the front section of the booklet.

Good luck with your planting!

Easy Steps To Revegetation

Woody Weed Control

Woody weed control needs to be done as far in advance of revegetation as possible. For example, 2-5 years of follow up control may be required on species such as Bridal Creeper and Boxthorn, however this will become more difficult in among newly planted trees. Swamp areas will have significant ongoing weed control issues with a broad range of woody weeds including Olives, Caster Oil Plant etc.

Fencing

Fencing should be carried out well in advance of planting time. Under no circumstances should planting go ahead without fencing in place. All likely grazing animals need to be excluded from the revegetation area. If machine planting and weed control is likely, fencing will need to allow for access. For example,

- Wide end of rows to allow for machinery to turn around.
- Fencing far enough back from steep banks to allow for machinery access.
- Openable panels or drop fences if fences are too close to allow for turning.

Other Grazing Control

Grazing by pest and other species may need to be considered:

- RABBITS need to be controlled prior to planting – contact Animal and Plant Control Board
- Ideally, HARE numbers need to be low for successful revegetation.
- RED LEGGED EARTH MITE can be a significant problem but are usually only a nuisance. If huge numbers are present and spraying is an acceptable option this is possible but will need to extend into adjacent paddocks and be repeated regularly.
- KANGAROOS grazing can be a problem. Exclusion fencing or individual tree guards may be possible in some cases. Otherwise plant species selection and planting methods and layout may be adjusted to accommodate the extra grazing pressure. These measures will only be necessary if kangaroos occur in large numbers.

Weed Control

Woody and perennial weeds will need to be dealt with in the year prior to planting as a minimum. Some weeds, eg Couch, Kikuyu, Horehound etc. need to be controlled during active growth in the spring and early summer in the season prior to planting.

Annual weeds can be controlled with a 2-litre/ha glyphosate spray before planting. In wetter seasons with an early season break and in later sowing areas 2 weed control sprays will be necessary – one soon after initial germination and one in the fortnight before planting. (This strategy will need to be adjusted for individual sites, eg if erosion is a concern 2 sprays may be inadvisable).

It is very important to only use Glyphosate for weed control if direct seeding, unless your contractor advises otherwise. Particularly avoid residuals as these can affect germination in direct seeding.

Timing

This will be dealt with under the individual soil types. As all the Angas Bremer Water Management Committee area is under 500mm rainfall, unirrigated planting will generally take place between May and August.

If possible, get advice from someone who has seen your site and has experience with tree planting in your area. Irrigated planting needs more planning but planting can be carried out into spring and summer.

Species Selection

Species to be planted need to be determined well in advance of planting. The species mix under each soil type will assist in compiling a list. Sourcing seed from local areas is important. There will be sites that have been seriously altered eg increased salinity or waterlogging. These site changes will mean that the planting lists will also need to be changed. Again seek advice on any tricky sites.

Seed And Seedlings

Species to be planted need to be determined well in advance of planting. The species mix under each soil type will assist in compiling a list. Sourcing seed from local areas is important.

There will be sites that have been seriously altered eg increased salinity or waterlogging. These site changes will mean that the planting lists will also need to be changed. Again seek advice on any tricky sites.

Planting

This is the simplest part of the job if all preparation has been done effectively. Organise plants to be on site well in advance of planting. Organise a demonstration of appropriate planting technique on site if possible.

If direct seeding, the direct seeding contractor should be contacted regularly to ensure they understand the status of the job and preparations. Ensure all preparations are complete and if possible be on site on the day of sowing.

Post Planting

Watch out for unexpected grazing and deal with it. Watch out for serious weed competition and discuss with the contractor if concerned. Relax about germination if it is direct seeded. It may take 6 – 10 weeks before you see anything and you will need to put your nose in the trench to see anything at all.

Tubestock will need similar vigilance. Weed competition is the greatest threat to survival so wet spring or summer conditions will probably mean follow up weed control around each plant will be necessary.

Appendix E: Angas – Bremer Revegetation Booklet (cont.)

Plants For Modified Site Conditions

Some sites will have experienced changes since clearing that will make it impossible to replace the former vegetation. The two commonest problems in this regard are salinity and waterlogging. These problems are often linked and due to the wide range of ways they affect a site it is impossible to give specific treatments for all cases. Below are some general statements on the way these problems impact on plants. Before investing time and effort in planting such sites get advice from experienced people who have seen your situation.

Salinity

High salinity levels significantly impact on plants. Re-establishing deep-rooted perennial vegetation may be very difficult on seriously saline sites.

Also, salinity may not be the only issue on some sites that are very salt affected. In order to establish what may be possible; identify what is currently surviving on site.

1) Bare soil, salt crusting on surface, no vegetation cover. Action: Fence well beyond bared area. Trees will not grow in these conditions. Mounding of bared site and allowing two winters prior to planting may establish some highly tolerant species. Focus efforts on areas that have grass cover around the perimeter of the bared areas. Also, revegetation anywhere in the catchment zone for these areas will be beneficial.
2) Samphire, occasional mounds with taller vegetation or grasses. Samphire is you best bet on these sites. Exclude stock and plant perimeter areas with highly tolerant species.
3) Saltwater Barley Grass, Saltwater Couch etc. Exclude stock, mound if possible, plant with salt tolerant species.

It is important to note that most of the species native to this area have reasonable salt tolerance due to their exposure to saline soils and the historical coastal influence. However, changes in water tables and other changes mean some areas are too salty even for these species. Incredibly salt hardy plants such as the samphires, melaleuca halmaturorum and melaleuca brevifolia mean most areas can support some sort of plant life.

Areas that are currently supporting salt tolerant grasses will grow trees and as the range of plants increases so will the possible revegetation species. It is important to realise that part of the cost of salt tolerance is growth rate. Melaleuca halmaturorum is one of the most salt tolerant trees around but it will not grow fast and it will not grow large. In seriously salty situations it will grow even slower!

Water Use

Ironically in low rainfall areas such as the Angas Bremer irrigation area there are occasions where high water use plants are desirable. Such plants are used to reduce recharge, planting in wet areas or to utilise wastewater.

1. Reducing recharge

Local vegetation is probably the most effective plant association at surviving on local rainfall and yet being able to reduce recharge flow through the root zone. It manages this by relying on a wide species range all competing for water and each responding to different situations.

For instance, native grasses will grow when there is plenty of water and the big mallees have deep roots that grab any moisture that gets past all the other plants' root zones.

2. Wet Areas

If planting into a recognised wet spot or an area with a water table that the plants can access it may be necessary to incorporate some higher water using species. If local species are appropriate for this use the former swamp vegetation list found in the 'Black Cracking Soils' section. However, if some sort of woodlot plantation is considered, seek advice. Information that will assist in these decisions should still be gathered. Soil type, existing vegetation, water table depths (summer and winter) salinity level, irrigation potential during establishment will all be helpful.

3. Waste Water Use

Again this is a specialised area and needs to tailor made to your project. It is however safe to generalise by saying that usually bigger plants use more water than smaller plants and faster growers use more water than slower growers do! Water quality and volume available as well as the specific pollutant information will also be necessary for planning. Do not overlook local species as we do have some species that do very well in irrigated situations.

Revegetating Heavy Red Soils

1. Site Type

Heavy Red Soils

2. Site Description {including indicator species likely to be on site}

These sites are characteristically flat to gently sloping areas with deep clay to sandy clay soil overlying calcareous subsoil. Currently they are rapidly being planted to vines. They are obviously very fertile sites capable of supporting large Peppermint Box trees and associated vegetation. Few areas of this vegetation are left in the district because of the ability of these sites to produce good cereal crops, etc and a long history of clearing.

Characteristic weed species on these sites are:

Soursob

Salvation jane

Native species that persist on these sites:

Eucalyptus odorata	Peppermint Box
Acacia microcarpa	Manna Wattle
Acacia brachybotra	Grey Wattle

Appendix E: Angas – Bremer Revegetation Booklet (cont.)

Plate 1: Langhorne Ck Cemetery, showing former heavy red soil vegetation type

Plate 2: Successful revegetation site on land adjoining the Langhorne Creek Cemetery, planted in 1991

3. Former Vegetation Type On These Sites

Acacia acainacea	Round Leaved Wattle
Acacia brachybotra	Grey Mulga
Acacia microcarpa	Manna Wattle
Acacia paradoxa	Kangaroo Thorn
Acacia pycnantha	Golden Wattle
Carpobrotus sp	Pigface
Callitris preissii	Native Pine
Danthonia sp	Wallaby Grasses
Dianella revoluta	Flax Lillee
Dodonaea viscosa	Hop Bush
Einadia nutans	Creeping Salt Bush
Enchylaena tomeentosa	Ruby Salt Bush
Eucalyptus odorata	Peppermint Box
Eutaxia microphylla	Mallee Bush Pea
Maireana sp	Bluebush
Melaleuca lanceolata	Dryland Tea Tree
Myoporum platycarpum	Sugarwood
Pittosporum phylliraeoides	Native Apricot
Vittadinia sp	

4. Considerations For Revegetation

These red soils have been the prime agricultural production areas in the region. Consequently they have nearly always been cultivated extensively causing significant changes in fertility and soil structure. Where cropping has been carried out in recent seasons there is also the complication of herbicide effects. As much information on the chemical history as possible should be gathered to help in planning. If regular pre-emergent herbicide applications have been made it is probably going to impact on direct seeding results.

Excellent results have been achieved on these sites, particularly in wetter years, but weed competition is always a major issue. A strategy for controlling weeds along seeding rows and immediately around seedlings to ease the competition if necessary should be considered in the planning stages.

Seeding rates

A typical direct seeding mix would consist of:

Species	Percentage of mix
Peppermint box and other mallees	25
Melaleuca species	15
Wattles (acacias), & others	40
Native pine	10
Dodonea, Enchylaena, etc	5
Grasses or other	5

Seeding rates overall need to be fairly high due to the potential difficulty of seasonal conditions. Recommended rate would be at least 500g per km for single row planting machines or approximately 2.5kg per ha at the minimum for other machines.

Timing

Direct seeding can be carried out as late as mid August. Earlier sowing is often desirable but if a wet spring is experienced extra weed control will be required.

Tubestock will need to be planted by August unless watering is intended.

Site preparation

Ideally couch can be controlled in the seasons prior to revegetation. Again, stock exclusion for a season or more is desirable to allow things to stabilise after a long history of cultivation.

Glyphosate at 2 litres a hectare is suggested as a knockdown spray to control annual weeds – once as soon as possible after the season breaks.

Sowing techniques

Direct seeding is generally effective on these sites.

Tubestock enable a broader range of species to be established but will be more expensive. Seedling plantings are often used in narrow strip plantings or small areas or where irrigation is being used. Often tubestock are used to broaden out species range and fill in gaps in the seasons following a large direct seeding job.

Appendix E: Angas – Bremer Revegetation Booklet (cont.)

Planting of tubestock can be carried out during the winter months as long as effective weed control has been done. Early winter plantings will probably require follow up weed control as will irrigated plantings.

Barerooted plants and seedlings are options for fodder plantings.

Post sowing management

Red-legged earthmite may need controlling in the weeks after sowing if direct seeding.

Weed competition will be an issue. If spraying is necessary in the first spring shielded spraying will be the only option. After the seedlings have survived a summer overspray options are available but specific advice on chemical, rate, timing and species to be oversprayed should be sought.

Long term site management strategies

Subsequent plantings and spot spraying of problem weeds should be carried out as seasonal conditions dictate.

6. Other Management Options

Agroforestry

There are really no options for commercial forestry on these sites on natural rainfall. Irrigated woodlots may be a good option where wastewater etc is available. Also high water tables may offer adequate water supply within the reach of plant roots in a few locations. In both these cases high water use, rapid growth species are required.

Private use woodlots are obviously a potential use of such sites. In other states (and Kangaroo Island) mallee areas are used to grow Eucalyptus oil successfully.

Fodder shrub

These heavier soils will suit saltbush growing very well. However, current returns from other crops probably make this potential unattractive unless salinity is an issue.

Revegetating Red Sandy Soils

1. Site Type

Red Sandy Soils

2. Site Description {including indicator species likely to be on site}

These sites are closely associated with the heavier red soil sites. There are many species that grow on both sites and the main differences are the needs of the plants growing on these sites to be able to cope with drier conditions. Often lighter sandy ridges cross a plain of heavier soil meaning that revegetation sites often cover both of these soil types.

Characteristic weed species on these sites are:

Veldt Grass is the main weed species present on nearly all of these sites

Native species that persist on these sites:

Callitris preissii	Native Pine
Allocasuarina verticillata	Drooping sheoak
Mallee Eucalypts	

3. Former Vegetation Type On These Sites

Acacia calamifolia	Sandhill Wattle
Acacia pycnantha	Golden Wattle
Acacia paradoxa	Kangaroo Thorn
Acacia brachybotra	Grey Mulga
Acacia acinacea	Round Leaf Wattle
Allocasuarina verticillata	Drooping Sheoak
Bursaria spinosa	Christmas Bush
Callitris preissii	Native Pine
Dianella revoluta	Flax Lillee
Eucalyptus fasciculosa	Pink Gum
Eucalyptus spp.	Mallee species
Lomandra spp	Iron Grass,Tussocks
Melaleuca uncinata	Broom Bush

Plate 3: Native vegetation on red sandy soils along Sheoak Road

Plate 4: Successful revegetation on roadside

4. Considerations For Revegetation

These sandy sites are generally located adjacent to heavier soil types, and in planning revegetation it is necessary to allow for these variations.

Throughout the district there is evidence of historical movement of this sand in the deposits that have been left along roadsides and in other less disturbed areas. Roadsides and fencelines are often targeted for revegetation areas, so it is likely many trees will be planted into these windblown deposits. It is worth remembering that if they blew around once they could easily be eroded again.

All sandy sites need to be treated with care during any change of land use. Potential for erosion needs to be assessed before on site work commences, and steps to reduce the risk taken.

These would include using cover crops, delaying planting to allow site consolidation, spraying narrow bands rather than blanket areas, mulching or spot spraying and planting tubestock.

Appendix E: Angas – Bremer Revegetation Booklet (cont.)

These sites vary greatly in what grows on them so locate the nearest remnant to your planting area to give some clues. Also seek advice from locals who may remember some of the former Sheoak or Native Pine patches that are common on these sandy sites.

5. Re-Establishing Native Vegetation On These Sites

Species selection

On sandy areas it is important to get plants established rapidly to reduce the risk of erosion. The initial planting needs to focus on pioneering species with the capability of establishing strongly. If seed is available other plants can be utilised but generally it is better to look at broadening the species range in later seasons once the site is more stable.

Seeding rates

A typical direct seeding mix would consist of:

Species	Percentage of mix
Eucalypts	15
Melaleuca species	10
Wattles (acacias), & others	35
Native pine	15
Allocasuarina (sheoak)	15
Grasses or other (eg. enchylaena)	10

Seeding rates overall need to be fairly high due to the potential difficulty of seasonal conditions. Recommended rate would be at least 500g per km for single row planting machines or approximately 2.5kg per ha at the minimum for other machines.

Seedling planting

Seedling planting is very easy on these soils. Species mixes can closely resemble those recommended for direct seeding although seedlings allow for trickier to grow plants to be included. Propagating cuttings can also be used to grow plants not germinated by seed.

Weed competition needs to be controlled for about 1 metre from each plant.

Planting can commence at the same time as seeding or even up to a couple of months earlier if follow up weed control can be carried out if necessary.

Timing

Seeding times on these sites is determined more by site preparation than some other low rainfall sites. Late July to early August is reasonable because they allow for later weed control in the season of sowing. Cover crop establishment is also necessary on some sites and this also may require an early August sowing time.

Site preparation

Veldt grass is usually the major weed problem on these sites. Weed control should commence as soon as practical after there is enough cover on the site to hold it together. It is also a good idea to prevent any soil disturbance, including grazing, for at least the twelve months prior to sowing. Other annual weeds should be controlled in the same operation. Perennial weeds such as Bridal Creeper will need to be controlled in the year prior to planting and followed up as required.

It is occasionally necessary to secure a site with a cover crop to prevent blowing and this is another operation that will impact on both timing and planting layout so needs to be considered in the early planning stages.

Sowing techniques

Direct seeding is quite effective on red sandy sites but is variable depending on seasonal conditions.

Tubestock enable a broader range of species to be established but will be more expensive. Often tubestock are used to broaden out species range and fill in gaps in the seasons following a large direct seeding job.

Barerooted and seedlings are options for fodder plantings.

Post sowing management

Red-legged earthmite may need controlling in the week's post sowing if direct seeding.

Weed competition will be an issue. If spraying is necessary in the first spring shielded spraying will be the only option. After the seedlings have survived a summer overspray options are available but specific advice on chemical, rate, timing and species to be oversprayed should be sought.

Long term site management strategies

Subsequent plantings and spot spraying of problem weeds should be carried out as seasonal conditions dictate.

6. Other Management Options

Agroforestry

There are really no options for Forestry on these sites on natural rainfall.

Fodder shrub

Other

With irrigation a broad range of species can be grown on these sites. Horticultural possibilities with native flowers may be an option in these areas.

Appendix E: Angas – Bremer Revegetation Booklet (cont.)

Revegetating Black Cracking Soils

1. Site Type

Black Cracking Soils

2. Site Description {including indicator species likely to be on site}

These are the former swamp sites along the watercourses and lakefront. There is a number of standing swamps still to be found in the area, particularly south of Langhorne Creek, along the lower stretch of the Angas and the flood out areas adjacent to these areas. The swamps are very different to any other landscape in the district and immediately identified by the huge redgum overstorey. Former locations of these sites can also be readily identified by the blackish coloured; deeply cracking soils that that become sloppy grey mud when wet. The original swamps also experienced regular inundation that may no longer occur due to changed drainage patterns.

Lakefront revegetation has had mixed results. Revegetation efforts are complicated by the serious changes these areas have suffered over the last 60-70 years. Total clearing, long term grazing, rising lake levels after the building of the barrages (and resulting groundwater changes) and increased salinity mean these are highly altered sites with a reduced range of appropriate species for revegetation. The highly exposed lakefront means only highly salt tolerant, coastal type species are likely to withstand the elements and weed competition is aggressive. Good results have been achieved only slightly inland from the lake's edge where weed competition is still a major issue.

Characteristic weed species on these sites are:

Boxthorn

Salvation jane

Olives

Castor oil plant

Fennell

Dock

Marshmallow

Briar rose

Nightshade

Myrsiphyllum

Native species that persist on these sites:

Eucalyptus camaldulensis	Red Gum
Muehlenbeckia cunninghamii	Lignum

3. Former Vegetation Types On These Sites

Former Swamp Areas

Acacia retinodes	Swamp Wattle
Acacia melanoxylon	Blackwood
Muehlenbaekia cunninghamii Lignum	
Eucalyptus camaldulensis	Redgum
Eucalyptus largiflorens	River box
Phragmites australis	Common reed
Cyperus spp	Sedges
Isolepis spp	Sedges
Juncus spp	Sedges

Lake Front Areas

Acacia brachybotra	Grey Mulga
Acacia cupularis	Coastal Umbrella Bush
Acacia microcarpa	Manna Wattle
Acacia pycnantha	Golden Wattle
Allocasuarina verticillata	Drooping Sheoak
Disphyma sp	Small Pigface
Enchhylaena tomentosa	Ruby salt bush

Plate 5: Native vegetation on red sandy soils along Sheoak Road

Plate 6: Successful revegetation on roadside

Plate 7: Successful revegetation on roadside

Appendix E: Angas – Bremer Revegetation Booklet (cont.)

Eucalyptus fasciculosa	Pink Gum
Eucalyptus leucoxylon	SA Blue Gume
Melaleuca halmaturorum	Salt Water Paper Bark
Nitraria billardierei	Nitre Bush
Acacia retinodes	Swamp Wattle
Muehlenbaekia cunninghamii	Lignum
Eucalyptus camaldulensis	Redgum
Eucalyptus largiflorens	River box
Phragmites australis	Common reed
Cyperus spp	Sedges
Isolepis spp	Sedges
Juncus spp	Sedges

4. Considerations For Revegetation

Black cracking soils are very difficult revegetation targets. Access difficulties, occasional flooding, weed competition, soil cracking and exposed sites all contribute to make plant establishment difficult. If high salinity levels are present it becomes even more complex.

5. Re-Establishing Native Vegetation On These Sites

Species selection

There is only a narrow range of plants suited to revegetation on these sites. Lignum for instance is not usually grown from seed so is only available in smaller numbers from cuttings.

The revegetation of these areas is really hard due to weed competition and so tubestock are often a good option making both species range broader and weed control easier.

If direct seeding is being used Redgum and Wattles will dominate the mix.

Seeding rates

A typical direct seeding mix would consist of:

Species	Percentage of mix
Eucalypts	30
Acacia (wattles)	60
Melaleuca (if appropriate)	
Sedges	5 (seedlings ?)
Lignum	5 (seedlings)

Seeding rates overall need to be fairly high due to the potential difficulty of seasonal conditions. Recommended rate would be at least 500g per km for single row planting machines or approximately 2.5kg per ha at the minimum for other machines.

Timing

Seeding times on these sites is determined by access as much as anything is. Given that they often go underwater in winter and spring it is a bit of guesswork to try to time planting before the sites dry out. Late July in drier seasons to early spring are the likely planting times.

If it is a site not likely to get inundated access can still be difficult. This is less of an issue for tubestock planting but even this can be difficult in sticky wet conditions. Planting times on these sites should be much earlier, eg June to August.

Site preparation

Woody weeds are a significant problem on the swamp sites. They need to be controlled well in advance of planting.

Weed control can start in the season prior to sowing to reduce seed set on annual weeds as well. Two sprays prior to sowing are a good idea if possible. Exclude stock.

Sowing techniques

In larger plantings direct seeding is still worth using but may require extra follow up. Progress is often slow for the first few seasons after planting.

Tubestock enable a broader range of species to be established but will be more expensive.

Often tubestock are used to broaden out species range and fill in gaps in the seasons following a large direct seeding job.

Barerooted and seedlings are options for fodder plantings.

Post sowing management

Red-legged earthmite may need controlling in the week's post sowing if direct seeding.

Weed competition will be an issue. If spraying is necessary in the first spring shielded spraying will be the only option. After the seedlings have survived a summer overspray options are available but specific advice on chemical, rate, timing and species to be oversprayed should be sought.

Long term site management strategies

Subsequent plantings and spot spraying of problem weeds should be carried out as seasonal conditions dictate.

6. Other Management Options

Agroforestry

These are the best big tree growing areas around. If ground water is good quality good growth can be expected.

Redgums are ideal as can be seen in any of the surviving swamps. Other forest species could be used in specific situations. Seek advice.

Fodder shrub

Salt bush would do very well on these sites.

Appendix E: Angas – Bremer Revegetation Booklet (cont.)

REVEGETATING WHITE SANDY SITES

1. Site Type

Sandy Sites – White non-wetting sand dune systems

2. Site Description {including indicator species likely to be on site}

These sites are common on the western edge of the Angas floodplain area as well as other isolated pockets scattered through the irrigation area. Historically they have posed serious management problems as they are prone to rabbit infestation and wind erosion. Consequently they have often been neglected and may have been left with some remnant mallee for shelter or just allowed to become barren stock campsites.

Characteristically non-wetting dunes bared off over summer. Plants that are likely to occur on these sites are:

Couch Grass

Silver Grass

Evening Primrose

Nut Grass

Veldt Grass

Native species that often persist on these sites:

Danthonia species	Wallaby Grass
Stipa species	Spear Grass
Eucalyptus incrassata	Ridge Fruited Mallee
Melaleuca uncinata	Brownbush

3. Former Vegetation Type On These Sites

Acacia calamifolia	Sandhill Wattle
Acacia pycnantha	Golden Wattle
Acacia spinescens	Spiney Wattle
Baekea behrii	Silver Baekea
Banksia marginata	Silver Banksia
Banksia ornata	Desert Banksia
Billardia cymosa	Sweet Appleberry
Callitris preissii	Southern Cypress Pine
Callitris verrucosa	Mallee Cypress Pine
Calytrix tetragona	Fringe Myrtle
Clematis microphylla	Old Mans Beard
Danthonia species	Wallaby Grass
Dianella revoluta	Flax Lily
Dodonea viscosa	Sticky Hop Bush
Enchylaena tomentosa	Ruby Salt Bush
Eucalyptus fasciculosa	Pink Gum
Eucalyptus incrassata	Ridge Fruited Mallee
Eutaxia microphylla	Mallee Bush Pea
Grevillea ilicifolia	Holly Leaved Grevillea
Hakea muelleriana	Desert Hakea
Kennedia prostrata	Running Postman
Kunzea pomifera	Muntries
Lasiopetalum behrii	Pink Velvet Bush
Leptospermum coriacium	Mallee Tea Tree
Lomandra species	Iron Grass
Maireana species	Blue Bush
Melaleuca acuminata	Mallee Honey Myrtle
Melaleuca uncinata	Broombush
Pultenea tenuifolia	Sand Dune Bush Pea
Rhagodia candolleana	Seaberry Saltbush
Stipa species	Spear Grass

4. Considerations For Revegetation

All sandy sites pose definite difficulties for management. This is highlighted in areas of rainfall below about 450mm. This is because of the instability of these sites and the difficulty of controlling this during a major land use change. Revegetation relies on removing competition to allow desirable vegetation cover to establish.

These white sands also suffer the effects of historical management practices which have broken down any soil structure that existed

Plate 8: Typical presentation of the white non-wetting sand dunes in the Angas Bremer region.

makes farm planning around them quite difficult and a range of options will be used to deal with them. Revegetation with native and fodder species

Seeding rates

A typical direct seeding mix would consist of:

Species	Percentage of mix
Mallee eucalypts	25
Melaleuca species	15
Wattles (acacias), & others	40
Native pine	10
Allocasuarina (sheoak)	5
Grasses or other	5

Seeding rates overall need to be fairly high due

Site preparation

Ideally couch can be controlled in the seasons

Plate 9: Good growth rates can be achieved with the right vegetation mix on these formerly infertile sites.

Tubestock enable a broader range of species to be established but will be more expensive.

Often tubestock are used to broaden out species range and fill in gaps in the seasons following a large direct seeding job.

Barerooted and seedlings are options for fodder plantings.

Post sowing management

Red-legged earthmite may need controlling in the week's post sowing if direct seeding.

Weed competition will be an issue. If spraying is necessary in the first spring shielded spraying will be the only option. After the seedlings have survived a summer overspray options are available but specific advice on chemical, rate, timing and species to be oversprayed should be sought.

Long term site management strategies

Subsequent plantings and spot spraying of problem weeds should be carried out as seasonal conditions dictate.

6. Other Management Options

Agroforestry

There are really no options for Forestry on these sites on natural rainfall.

Fodder shrub

The most common fodder shrub used on these sites is Tagasaste (Tree Lucerne). It does extremely well on these acid sands. It can provide good fodder reserves in autumn and good shelter paddocks. Tagasaste requires tight management to get the best results. Grazing control is critical. Establishment is by direct seeding or seedlings with a number of growers or contractors available. Advice on layout and management should be sought from both suppliers and other farmers with experience.

Plate 10: Roadside showing typical low mallee found on these soils

Management for this plant includes not permitting any seed escape, as it is a potentially serious weed in scrub areas.

Pasture

In some areas of SA acid sands such as this are extensively modified by clay spreading enabling a wider range of cropping and pasture options. This would possibly also extend the options for fodder shrubs and revegetation. Specific advice should be sought.

Other

With irrigation, a broad range of acid loving species is able to be grown on these sites. Horticultural possibilities with native flowers may be an option in these areas.

Appendix E: Angas – Bremer Revegetation Booklet (cont.)

Revegetating Gradational Soils

1. Site Type

Gradational soils

2. Site Description {including indicator species likely to be on site}

These are the typical hard mallee soils. Usually grey to brown in colour with textures ranging from loamy clay to sandy. These sites often overly limestone and may have significant limestone scattered on the surface. The plants associated with them are also varied but can be described as typical mallee. On some of the drier parts of the Angas-Bremer area, to the north and east, where these soils are common, the mallee is relatively short and stunted. One of the typical features of these associations is the very large range of mallee eucalypts present (usually 3 or 4). If grazing has been allowed in these associations only larger shrubs will be left in the understorey. This often leaves these patches looking dry and uninviting. Mallee with an intact understorey is less common but worth a visit during the wetter months.

Characteristic weed species on these sites are:

- Horehound
- Scabious
- Wild Turnip
- Wild Radish
- Capeweed
- Wire Weed
- Ryegrass
- Barley grass

Native species that persist on these sites:

- A range of Mallee Eucalypts
- Melaleuca lanceolata

3. Former Vegetation Type On These Sites

Acacia pycnantha	Golden Wattle
Acacia brachybotra	Grey Mulga
Allocasuarina verticillata	Drooping Sheoak
Dianella revoluta	Flax Lillee
Enchylaena tomentosa	Ruby Salt Bush
Eucalyptus calycagona	Square Fruited Mallee
Eucalyptus gracilis	Yorrell
Eucalyptus incrassata	Ridge Fruited Mallee
Eucalyptus leptophylla	Slender Leaved Red Mallee
Eucalyptus socialis	Red Mallee
Eucalyptus spp	Other Mallees
Hakea muelleriana	Desert Hakea
Lomandra spp	Tussocks, Irongrass
Melaleuca acuminata	
Melaleuca lanceolata	Dryland Tea Tree
Melaleuca uncinata	Broom Bush
Pittosporum phyllyraeoides	Native Apricot
Santalum acuminatum	Quandong

4. Considerations For Revegetation

A lot of the sites that are being considered for revegetation on this soil type will be quite degraded. If there has been significant wind erosion, a long history of cultivation, significant weed infestation or serious limestone, growth rates may be slow. This is even more likely on sites that originally only supported low vegetation anyway.

Well prepared sites can get excellent results in good seasons because these sites are less hospitable to weeds, and once the site is clean most resources are available for the newly established plants.

Extra site preparation in the form of ripping and rolling may be required in rocky areas. There are good examples of these mallee areas persisting along roadsides.

Appendix F: Guidelines for Installing Monitoring Test Wells

5. Re-Establishing Native Vegetation On These Sites

Species selection

Use a good range of species from the list. Look at local stands to identify more accurately the species you want for your project. Collect seed from as local as possible.

Seeding rates

A typical direct seeding mix would consist of:

Species	Percentage of mix
Mallee eucalypts	25
Melaleuca species	15
Wattles (acacias), & others	40
Native pine	10
Allocasuarina (sheoak)	5
Grasses or other	5

Seeding rates overall need to be fairly high due to the potential difficulty of seasonal conditions. Recommended rate would be at least 500g per km for single row planting machines or approximately 2.5kg per ha at the minimum for other machines.

Timing

Direct seeding and tubes need to be planted as early as practical in most of these sites. Weed control needs to be carried out early and sowing carried out by July.

Site preparation

Ideally couch can be controlled in the seasons prior to revegetation. Otherwise weed control should commence as soon as practical. It is also a good idea to prevent any soil disturbance, including grazing, for at least the twelve months prior to sowing.

If ripping is required it should be done by May.

Sowing techniques

Direct seeding is quite effective on these sites. Seasonal variation can be an issue but given the fact some of these sites are large and results are often as good or better than tubestock planting direct seeding is an obvious choice.

Often tubestock are used to broaden out species range and fill in gaps in the seasons following a large direct seeding job or they lend themselves to smaller jobs on these sites.

Barerooted and seedlings are options for fodder plantings.

Post sowing management

Red-legged earthmite may need controlling in the week’s post sowing if direct seeding.

Weed competition can be an issue. If spraying is necessary in the first spring shielded spraying will be the only option. After the seedlings have survived a summer overspray options are available but specific advice on chemical, rate, timing and species to be oversprayed should be sought.

Long term site management strategies

Subsequent plantings and spot spraying of problem weeds should be carried out as seasonal conditions dictate.

6. Other Management Options

Agroforestry

There are really no options for Forestry on these sites on natural rainfall.

Appendix G: Glossary

Monitoring Test wells should be installed to demonstrate how irrigation activity could influence perched water tables. Irrigators can then better understand what is happening under the ground water they irrigate.

Monitoring Wells should be installed in accordance with the following principles:

1. The proposed well should be completed to the current water table or Blanchetown clay layer, or to a depth of no greater than three metres.
2. The Test well casing is constructed with 75mm PVC storm water pipe, with one metre of slots from the bottom up and a 75mm stormwater cap glued to the bottom with two small holes drilled in it.
3. The casing of the proposed well should extend 300 millimetres above the natural surface of the land.
4. The bottom 1.5m of the outside area of the casing is backfilled with course washed river sand or fine gravel (1.5mm).The rest is backfilled to ground level with the natural topsoil extracted when the hole was bored.
6. A 75mm stormwater cap is pushed on top of the casing pipe. This will need to have a 32mm hole drilled in it if the Test well is to have a floating flag installed in it.
7. A floating flag is constructed from UPVC pipe as follows:

Float:	500mm x 40mm c16 UPVC 1 x 40mm elnd cap 1 x 40mm x 20,, reducer coupling
Float pole:	20mm cl12 UPVC, manufactured to a length that when at the bottom of the Test well it is 300mm above the top of the casing pipe (this must take into account the 500mm float at the bottom). 1 x 20mm end cap 1 x Plastic Marker Flag

The proposed Test well should be installed in the lowest practicable point of the land or naturally wet area on the property.

Appendix G: Glossary (cont.)

AHD Australian Height Datum

Aquitard a layer in the geological profile which retards groundwater flow.

Biota living organisms such as plants, animals and micro-organisms.

Biodiversity The variety of life forms: the different plants, animals and micro-organisms, the genes they contain, and the ecosystems they form. Biodiversity is usually considered at three levels – genetic, species and ecosystem diversity.

EC Electrical Conductivity is the ability of a soil or water to conduct electricity. The electrical conductivity of the solution increases in proportion to the concentration of ions and hence measuring conductivity is a convenient way of estimating salinity. Along the River Murray, water salinity is referred to as EC units although the actual units are microSiemens per centimetre abbreviated as mS/cm.

Ecosystem A community of organisms that may include humans, interacting with one another. Incorporating the physical, chemical and biological processes inherent in their interaction and the environment in which they live.

GL A Gigalitre, equal to one thousand million litres (1,000,000,000).

Kl A kilolitre, equal to one thousand litres (1,000)

Littoral Zone The ecological zone between the high and low water mark of the River, and can also be considered the bank or shore.

MDBC The Murray-Darling Basin Commission established by the *Murray-Darling Basin Act 1993*.

Minister The Minister who is responsible for administering the *Natural Resources Management Act 2004*.

ML A Megalitre, equal to one million litres (1,000,000)

Murray-Darling Basin Agreement 1992
The Agreement between the States as set out in Schedule 1 of the *Water Act 2007.*

Ramsar register A list of Ramsar sites designated as a Wetland of International Importance against the criteria established by the Ramsar Convention on Wetlands.

Ramsar site A site designated as a Wetland of International Importance against the criteria established by the Ramsar Convention on Wetlands.

Salinisation the build up of salts in the soil as a result of the capillary flow of saline water toward the surface.

SA Water The South Australian Water Corporation established under Part 2 of the South Australian *Water Corporation Act 1994*.

Tidal Prism The total volume of water moving past a fixed cross section of the estuary during each flood or ebb tide. The larger the tidal range within the estuary and the greater the dimensions of the estuary, the larger the tidal prism.

To take water To pump or siphon the water; to stop or impede the flow of water over land for the purpose of collecting the water; to divert the flow of water in a watercourse away from the watercourse; to release water from a lake; to permit water to flow under natural pressure from a well; or to permit stock to drink from a watercourse, a natural or artificial lake, a dam or reservoir.

TDS Total Dissolved Salts is a term that expresses the quantity of dissolved material in a sample of water, typically measured in milligrams per litre (mg/L).

Transfer The transfer of a licence, water access entitlement or water allocation (in whole or part) to another person. In the case of a licence or water access entitlement, the transfer may be for a limited period.

Underground water Water that naturally occurs below ground level, or water that is pumped, diverted or released into a well for storage underground.

Water Allocation Plan (WAP) A plan prepared and adopted by the Minister under Part 7 Division 3 of the *Natural Resources Management Act 2004*.

Water licence A water management authorisation that sets out the water access entitlement(s) against which water allocations are obtained.