



Darling River Water Savings Project Part A Report

April 2007

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Part A Report

Prepared for

**NSW Department of Natural Resources
and National Water Commission**

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Executive Summary

Background

The NSW and Federal Governments are jointly funding a feasibility study to identify substantial water savings in the Darling River System, including the Menindee Lakes. The outcome of the study is to be a 20 year Strategic Plan for water savings based on an integrated approach of structural works, river and storage operating strategies and water market activities.

The study is organised in two parts:

- **Part A** is aimed at generating and broadly screening a large number of options and compiling from these a manageable number of competing, integrated water saving schemes.
- **Part B** is intended to develop the Darling River System Strategic Plan. This would follow a benefit/cost analysis of short-listed schemes and a preliminary environmental assessment.

Maunsell Australia Pty Ltd, in association with Webb McKeown & Associates Pty Ltd (WMA), and Hassall & Associates Pty Ltd, has undertaken Part A of the study.

Objectives

The purpose and fundamental objective of this study is to develop a Strategic Plan to secure further, substantial water savings in the Darling River system.

Within this overall purpose, the following sub-objectives are important:

- To improve the operational flexibility of river and water storage management to better meet the needs of water users and the environment.
- To protect the environment and riverine ecology.
- To protect water quality and water security for water users.
- To contribute to economic development in the Region.

Part A of the project involves the identification and broad assessment of a wide array of possible water saving options. The purpose is to consolidate the most promising initiatives into a manageable number of integrated, competing schemes, for detailed assessment in Part B.

Feasibility of Making Water Savings

Work completed to date has demonstrated that aggressive initiatives at Menindee Lakes can bring about worthwhile evaporative water savings and increase flows in the Lower Darling River and Lower Murray River. Strategic initiatives can also be taken to address water security for the City of Broken Hill and other High Security users.

These important benefits for the Darling Basin are accompanied by some drawbacks. These drawbacks have been identified in Part A, but will require additional investigation in Part B of the study and are listed below:

- Reliability of water supply for local irrigators may be impacted, but could be partly offset by Basin-wide initiatives and other water supply opportunities associated with some of the initiatives under consideration to secure water supplies for Broken Hill and other water users.

- Environmental impacts need to be carefully assessed. The ecological benefits anticipated for options which extend the drying cycle for some lakes will need to be tested. Changes to operating regimes, including recovery of water from residual pools, will also affect lake ecology.
- Potential impacts on Aboriginal cultural heritage arise with all of the initiatives under consideration. Initial consultation with representatives of local Aboriginal Elders has demonstrated the importance of continuing discussions and developing a clear understanding of their position. This has particular relevance to those initiatives that could potentially impact on archaeological sites.
- Broader social issues also demand special attention. Some initiatives under consideration would affect or compromise the amenity enjoyed by local residents and visitors.

Study Approach

The consultant team has been active in consulting with community groups and stakeholder representatives to identify their issues and receive diverse water saving ideas. A wide array of possible water saving options has been developed and broad screening assessment has been completed.

As the Menindee Lakes account for the largest single concentration of evaporative water loss in the Darling River system, it has been the starting point for identifying options that will result in significant water savings. Options were modelled by WMA to provide an estimated upper bound to the potential water savings (evaporation reduction) associated with each option. For example, modelling has indicated that average evaporative savings of up to 211 GL per annum are possible if both Lakes Menindee and Cawndilla were used less frequently for water storage, although this is considered an extreme change to current operation.

While the hydrologic studies indicated that there is potential to achieve significant water savings and increased flows to South Australia, the studies also identified impacts on irrigation diversions (referred to as irrigation penalties in the body of the report) and downstream river salinity effects.

Options to offset the impacts on local and third party stakeholders have been explored. However, implementation of some of these options would reduce the extent of evaporative savings achieved, or increase the cost of the integrated schemes.

Options for mitigating or reducing third party impacts include:

- secure water supply for Broken Hill and other High Security users via a pipeline to the Murray River or a dedicated local storage
- access residual pools in the lakes for drought security
- review rules for Hume and Dartmouth interaction with Menindee Operation
- review Additional Dilution Flow (ADF) and other salinity mitigation rules
- compensation including licence buy-back and enterprise purchase
- revised water sharing arrangements to secure upstream water saving investments

Offset measures were not specifically evaluated in the preliminary hydrologic modelling used in Part A, and will need to be tested in more detail in Part B of the project. Some of these options may also involve changes to the Murray Darling Basin Agreement.

The most promising Menindee Lakes options, offset measures and wider basin water saving initiatives were used to develop six integrated water saving schemes. The schemes were developed in a workshop with the project steering committee.

Each scheme features options which address the three critical issues identified in the project brief:

- Structural and operational initiatives at Menindee Lakes targeting the largest point-source of evaporation in the basin.
- Alternative supply and storage options for Broken Hill and other High Security users.
- Darling Basin-wide initiatives to focus on water savings at private holdings and consideration of alternative bulk water storage possibilities.

In developing the alternative schemes, structural and operational changes at Menindee Lakes were considered to be the core initiative. However, it was recognised that each scheme will also need to include offset mechanisms to counter adverse impacts, as well as follow up initiatives to improve the efficiency of on-farm water management practices to generate savings in the Upper Darling and its tributary systems.

The range of offset measures and upstream efficiency initiatives is generally common across all integrated schemes. However, the best combination will ultimately depend on the location and magnitude of impacts.

The mechanisms for maintaining supply reliability for local users and in the basin, such as the alternative storage or supply offset options for Broken Hill and local High Security users, are included in each of the integrated schemes. However, further technical work is required to optimise the options within each of the schemes.

A consistent framework has been used to assemble competing schemes that span both a modest to high level of indicative water savings, and commensurate range of social and environmental impacts.

Indicative Schemes and Water Savings

This section outlines the schemes proposed in terms of the core works proposed at Menindee Lakes. Indicative evaporation savings at Menindee lakes are included for each scheme.

It should be noted that each scheme would include initiatives to better secure water supplies for Broken Hill and other High Security users. However, the best mix of options to supply Broken Hill and other High Security users has not yet been assessed.

Each scheme would also include basin wide efficiency measures. Water savings resulting from basin wide measures can not be quantified at this stage, but may be significant.

The schemes also include works to offset the impacts of changes at Menindee Lakes on local and downstream users.

The core initiative proposed for each scheme is set out in **Table 1**; while **Table 4** contains a more detailed description of each scheme. A diagrammatic layout of works proposed at the Menindee Lakes is shown in Scheme Layouts 1 - 6.

Table 1 Overview of Schemes for Initial Consideration

Scheme	Description of Core Initiative	Estimated Evaporation Saving for the Core Initiative
1	Reduced use of Lake Menindee.	Up to 120 GL
2	Reduced use of Lake Cawndilla.	Up to 60 GL
3	Reduced the use of both Lake Menindee and Lake Cawndilla.	Up to 180 GL
4	Partition Lake Menindee and reduce the use of lower Lake Menindee cell and reduce the use of Lake Cawndilla.	Up to 130 GL
5	Partition Lake Menindee and reduce the use of the lower Lake Menindee cell.	Up to 70 GL
6	More Rapid drawdown of Menindee Lakes when in NSW Control.	Up to 60 GL

The estimated evaporative savings for the schemes listed in **Table 1** are less than the maximum savings indicated by the hydrologic modelling. This reflects the need to store water on some occasions to preserve water security when Murray storages are at relatively low operating levels. Partial fill events would also be linked to the ephemeral environmental requirements of the storages, particularly if flows have not been diverted into selected lakes over an extended period of time. These operational parameters reduce the potential water savings.

Indicative Costs and Impacts

Indicative costs have been estimated for the works proposed at Menindee Lakes, which are summarised in **Table 2** together with a range of costs for Broken Hill water security and High Security offset measures. However, further work is needed to define the extent of works required for High Security users, particularly Broken Hill.

Table 2 Indicative Cost Estimates

Scheme	Est. Capital Cost - Works at Menindee Lakes	Works for Broken Hill and other High Security Water Users	Upstream Measures
1	\$25 M	\$85 – \$400M	not quantified at this stage
2	\$18 M		
3	\$26 M		
4	\$97 M		
5	\$87 M		
6	\$26 M		

Table 3 sets out a preliminary assessment of the basis of major local impacts associated with the Menindee Lakes works for each of the schemes.

Table 3 Preliminary Assessment of Major Impacts

Scheme Core Initiative		Estimated Evaporation Savings	Basis of Major Local Impacts
1	Reduced use of Lake Menindee.	Up to 120 GL	<ul style="list-style-type: none"> Extended drying cycle in Lake Menindee Reduced availability of Lake Menindee for recreation Periodic loss of water frontage at Sunset Strip Disturbance to Kinchega National Park due to the construction of a new Cawndilla outlet and channel to the Darling River.
2	Reduced use of Lake Cawndilla.	Up to 60 GL	<ul style="list-style-type: none"> Extended drying cycle in Lake Cawndilla Archaeological impacts at Menindee Outlet Archaeological impacts at Morton Boolka.
3	Reduced use of both Lake Menindee and Lake Cawndilla.	Up to 180 GL	<ul style="list-style-type: none"> Extended drying cycle in Lake Menindee Extended drying cycle in Lake Cawndilla Extended periods with loss of water frontage at Sunset Strip.
4	Partition Lake Menindee and reduce the use of the lower Lake Menindee cell and Lake Cawndilla.	Up to 130 GL	<ul style="list-style-type: none"> Extended drying cycle in the lower Lake Menindee cell. Extended drying cycle in Lake Cawndilla Significant archaeological impact within Lake Menindee Potential disturbance to Kinchega National Park, depending on outlet works selected.
5	Partition Lake Menindee and reduce the use of the lower Lake Menindee cell.	Up to 70 GL	<ul style="list-style-type: none"> Extended drying cycle in the lower Lake Menindee cell Significant archaeological impact within Lake Menindee Significant archaeological impact within Lake Cawndilla Disturbance to Kinchega National Park due to the construction of a new Cawndilla outlet and channel to the Darling River.
6	More Rapid drawdown of Menindee Lakes when in NSW Control.	Up to 60 GL	<ul style="list-style-type: none"> Significant archaeological impact within Lake Cawndilla Disturbance to Kinchega National Park due to the construction of a new Cawndilla outlet and channel to the Darling River.

Next Steps

The next stage of this project will investigate benefits and costs for the six schemes, with the aim of identifying a preferred scheme to incorporate into a twenty year Water Saving Strategy.

Part B of the project will more accurately identify the magnitude and nature of impacts such that the range of offset measures required for each scheme can be better scoped.

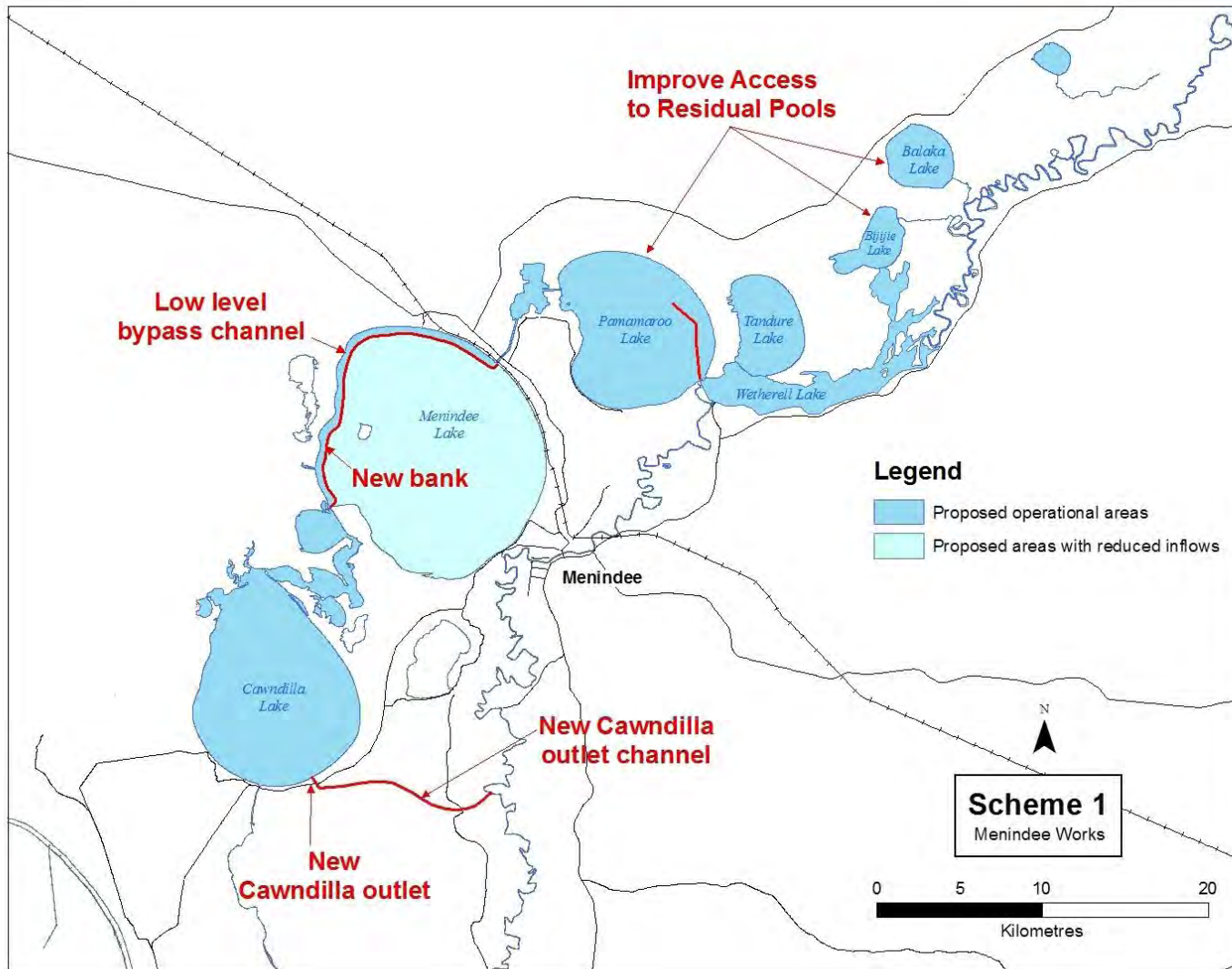
Scheme Summary

Table 4 presents a summary of the Menindee Lakes works, associated works and operational strategies, basin wide initiatives and offset measures for each of the six schemes, which are recommended for further assessment and refinement in the next stage of the project.

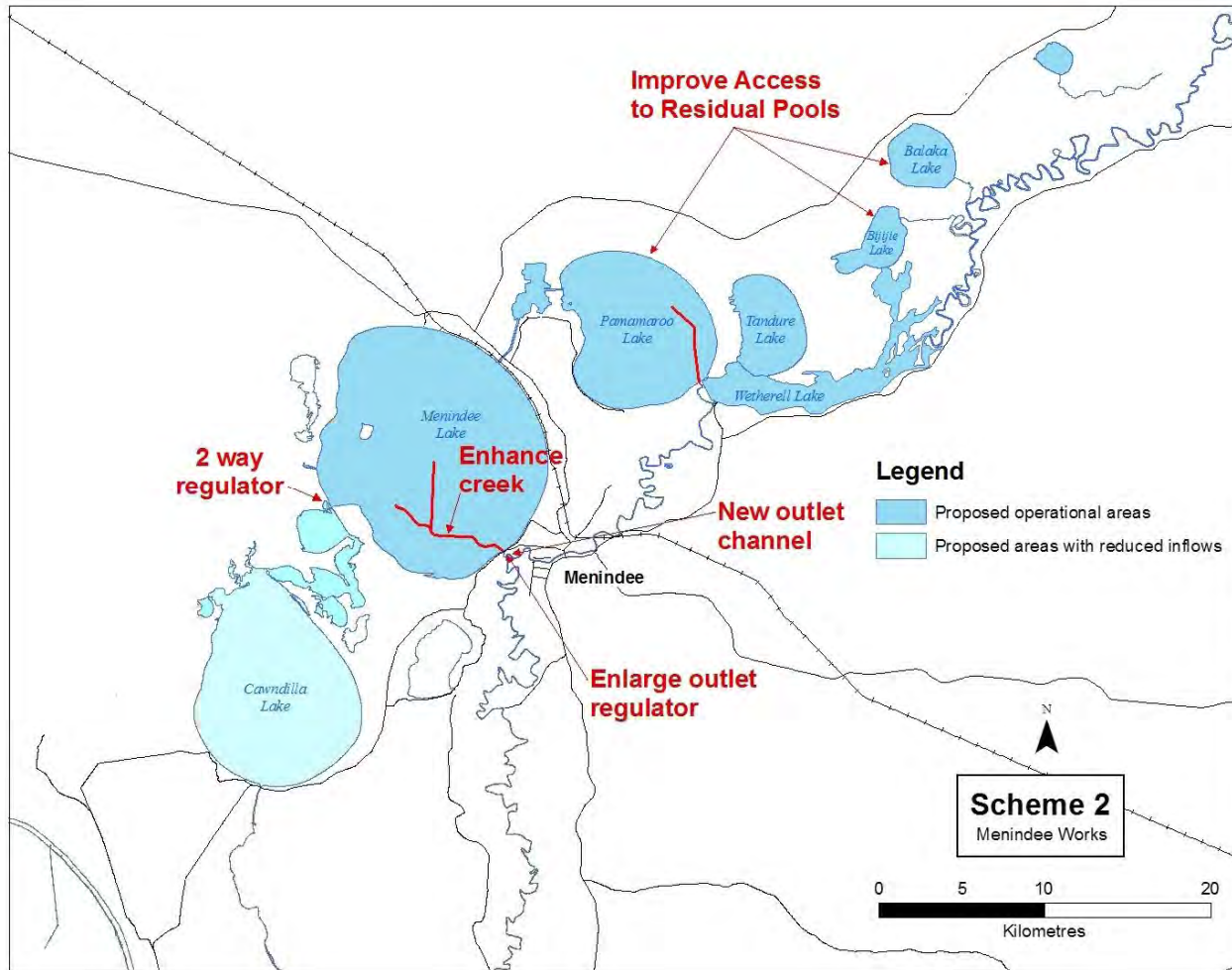
Table 4 Scheme Summary

Scheme	Menindee Works	Securing Broken Hill and High Security Water Supply	Wider Basin Initiatives
1	Reduced use of Lake Menindee		
	<ul style="list-style-type: none"> • Construct a bypass channel within Lake Menindee. • Construct a new regulator and outlet channel for Lake Cawndilla • Improve access to residual pools. 	<ul style="list-style-type: none"> • Demand management. • Additional domestic rainwater tanks & recycling. • Improvements to Stephens Creek Reservoir. 	<ul style="list-style-type: none"> • Encourage best practice construction and operation for on-farm storages. • Fund on-farm water use efficiency measures • Review runoff harvesting and water share components under Water Sharing Plans to secure savings from funded efficiency measures
2	Reduced use of Lake Cawndilla		
	<ul style="list-style-type: none"> • Construct a levee, incorporating a two way regulator upstream of Morton Boolka. • Increase Menindee outlet capacity via an additional outlet & channel from Lake Menindee to the Darling River. • Enhance Menindee Creek to access the Lake Menindee residual pool for drought security. • Improve access to residual pools. 	<ul style="list-style-type: none"> • Demand management. • Additional domestic rainwater tanks & recycling. • Improvements to Stephens Creek Reservoir 	<ul style="list-style-type: none"> • Encourage best practice construction and operation for on-farm storages. • Fund on-farm water use efficiency measures • Review runoff harvesting and water share components under Water Sharing Plans to secure savings from funded efficiency measures.
3	Reduced use of both Lakes Menindee and Cawndilla		
	<ul style="list-style-type: none"> • Enlarge Menindee outlet regulator and construct a new outlet channel from Lake Menindee to the Darling River, <u>or</u> construct a new Cawndilla outlet and channel to the Darling River. • Improve access to residual pools. 	<ul style="list-style-type: none"> • New dedicated storage at either North Copi Hollow or Lake Tandure or a pipeline from the Murray River. • Demand management. • Additional domestic rainwater tanks & recycling. • Improvements to Stephens Creek Reservoir. 	<ul style="list-style-type: none"> • Encourage best practice construction and operation for on-farm storages. • Fund on-farm water use efficiency measures • Review runoff harvesting and water share components under Water Sharing Plans to secure savings from funded efficiency measures.

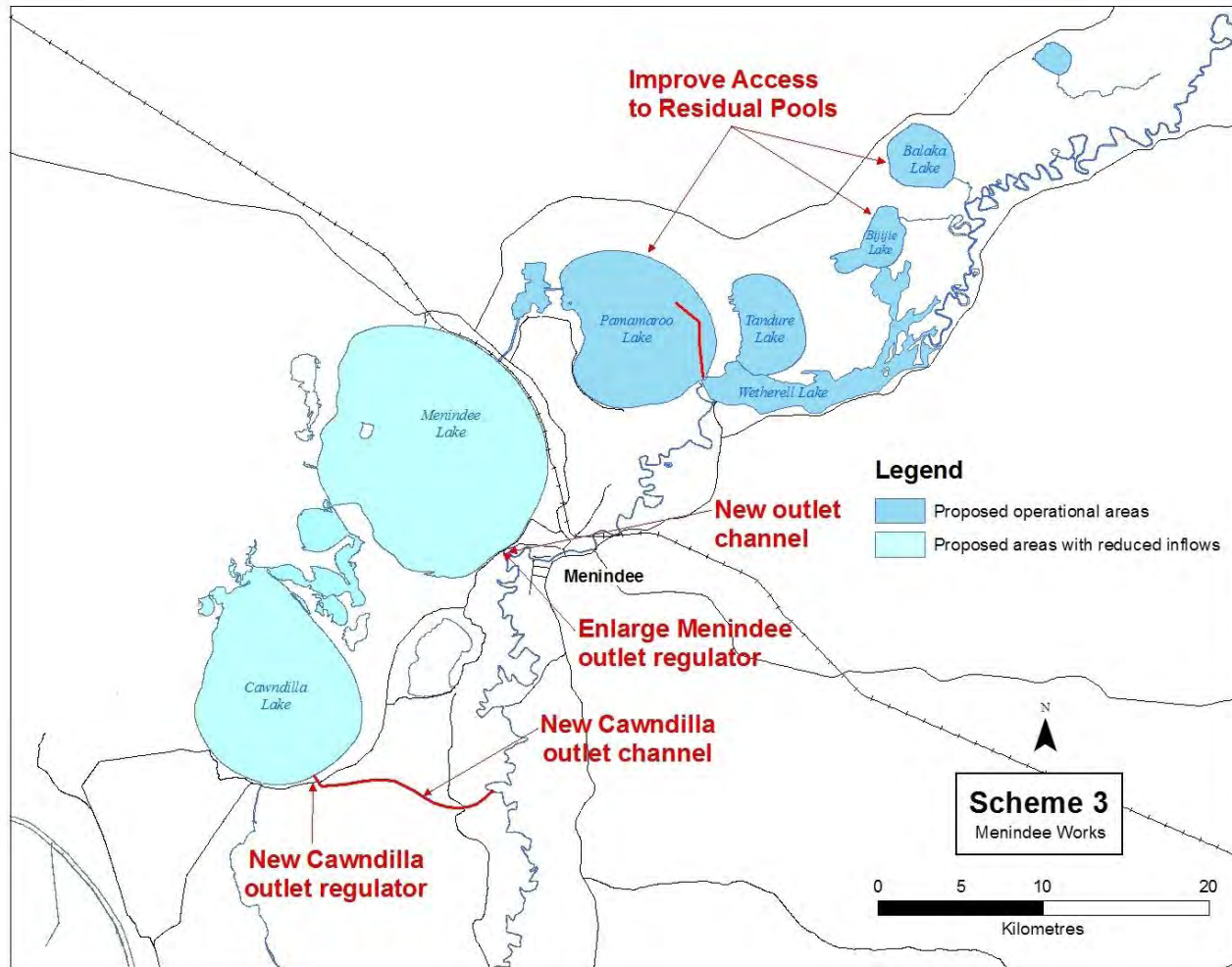
4	Partition Lake Menindee and reduce the use of the lower Lake Menindee cell and reduce the use of Lake Cawndilla		
	<ul style="list-style-type: none"> • Construct 16 km levee from west of Sunset Strip to south of the existing Menindee outlet regulator. • Construct new 8,000 ML/day regulator through the levee near Menindee outlet regulator • Improve access to residual pools. 	<ul style="list-style-type: none"> • New dedicated storage at either North Copi Hollow or Lake Tandure or a pipeline from the Murray River. • Demand management. • Additional domestic rainwater tanks • Improvements to Stephens Creek Reservoir. 	<ul style="list-style-type: none"> • Encourage best practice construction and operation for on-farm storages. • Fund on-farm water use efficiency measures • Review runoff harvesting and water share components under Water Sharing Plans to secure savings from funded efficiency measures.
5	Partition Lake Menindee and reduce the use of the lower Lake Menindee cell		
	<ul style="list-style-type: none"> • Construct 18 km levee from east of the Menindee inlet regulator to east of Morton Boolka • Construct a 4,000 ML/day regulator through the levee in line with Menindee Creek • Construct a new Cawndilla outlet regulator and channel to the Darling River • Improve access to residual pools. 	<ul style="list-style-type: none"> • New dedicated storage at either North Copi Hollow or Lake Tandure or a pipeline from the Murray River. • Demand management. • Additional domestic rainwater tanks & recycling. • Improvements to Stephens Creek Reservoir. 	<ul style="list-style-type: none"> • Encourage best practice construction and operation for on-farm storages. • Fund on-farm water use efficiency measures • Review runoff harvesting and water share components under Water Sharing Plans to secure savings from funded efficiency measures.
6	More Rapid drawdown of Menindee Lakes when in NSW Control		
	<ul style="list-style-type: none"> • Construct a new Cawndilla outlet regulator and channel to the Darling River • Improve access to residual pools. 	<ul style="list-style-type: none"> • New dedicated storage at either North Copi Hollow or Lake Tandure or a pipeline from the Murray River. • Demand management. • Additional domestic rainwater tanks & recycling. • Improvements to Stephens Creek Reservoir. 	<ul style="list-style-type: none"> • Encourage best practice construction and operation for on-farm storages. • Fund on-farm water use efficiency measures • Review runoff harvesting and water share components under Water Sharing Plans to secure savings from funded efficiency measures.



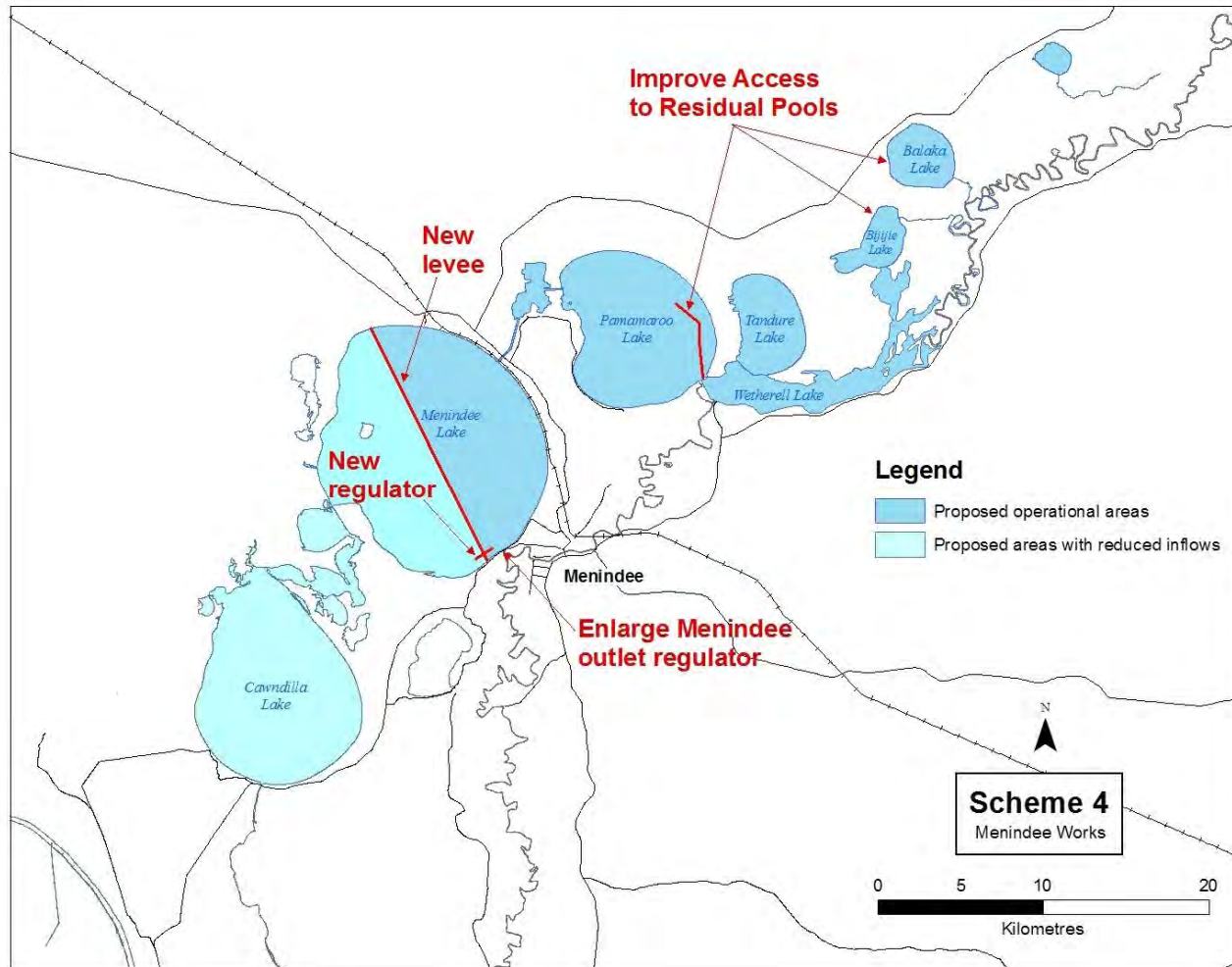
Menindee Layout 1



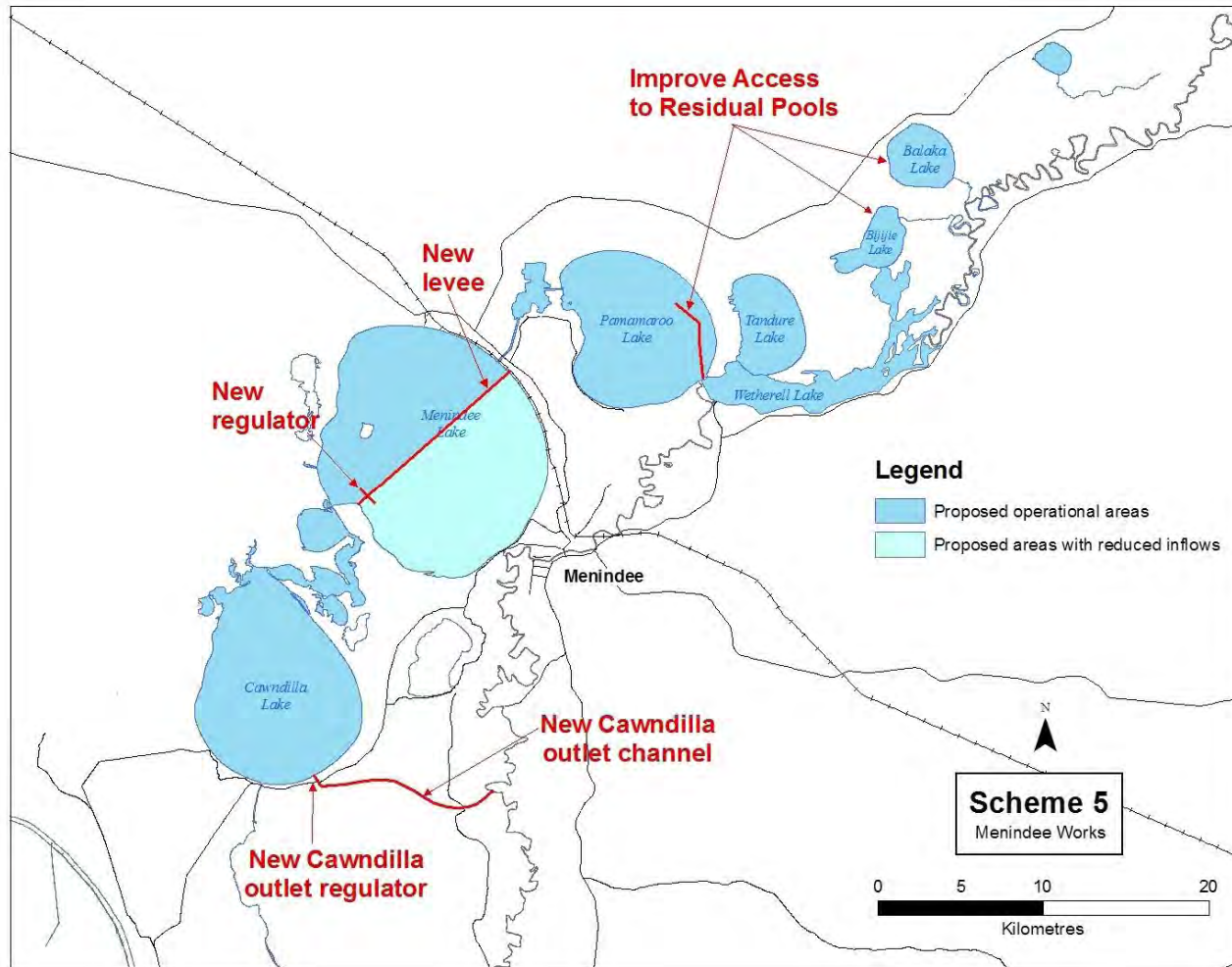
Menindee Layout 2



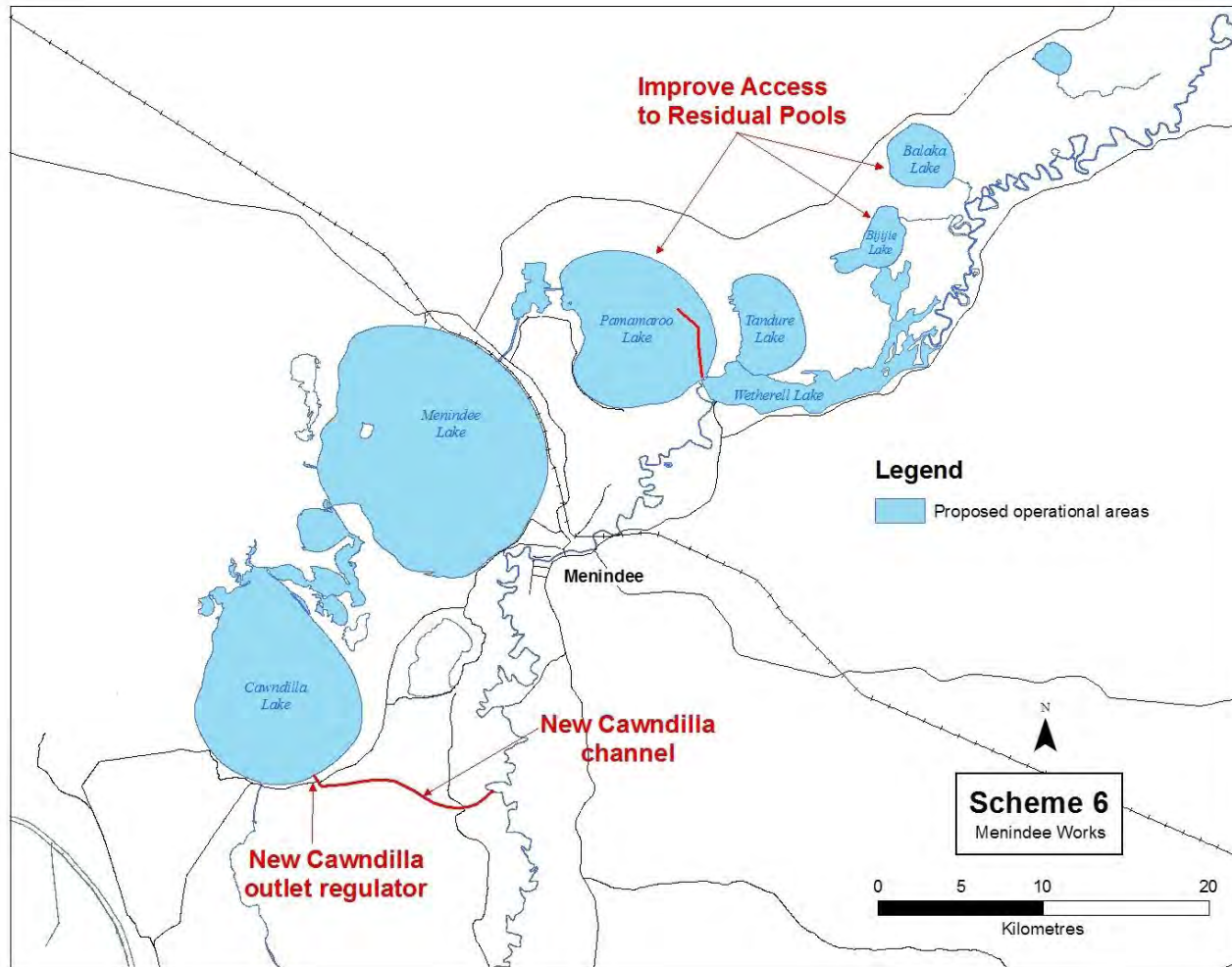
Menindee Layout 3



Menindee Layout 4



Menindee Layout 5



Menindee Layout 6

1.0 Introduction

1.1 Background

Maunsell Australia Pty Ltd (Maunsell) was engaged by the NSW Department of Natural Resources to undertake the Darling River Water Savings Project. The project, which was carried out in association with Webb McKeown & Associates and Hassall & Associates, was jointly funded by the Department of Natural Resources and the National Water Commission.

The project is being directed by a Steering Committee with representatives from:

- Department of Natural Resources
- State Water Corporation
- National Water Commission
- Murray Darling Basin Commission
- Lower Darling Community
- Lower Murray Darling Catchment Management Authority
- Country Energy

The overall aim of the project was to define how best to secure substantial water savings in the Darling River system and to develop a Strategic Plan for the staged implementation of water saving measures over a twenty year planning period.

This will include civil/structural works and operational changes that could be implemented at Menindee Lakes, as well as some of the more difficult to implement, but potentially feasible, basin wide initiatives associated with market mechanisms and programs to reduce on-farm evaporation losses and encourage greater on-farm efficiencies.

The Darling River Water Savings project forms part of the New South Wales and Commonwealth Governments' activities aimed at improved water management in the Murray-Darling Basin, which are being partly implemented through the Living Murray Initiative.

The project had a number of sub-objectives, which were to:

- improve the operational flexibility of river and water storage management
- protect the environment and riverine ecology
- protect water quality and water security for water users
- contribute to economic development in the region

This report presents the overall findings from the first stage of the project, which covered the identification, evaluation and short listing of feasible options and the development of a number of integrated schemes. A number of these schemes are thought to have the potential to result in substantial water savings in the Darling River system and therefore warrant further investigation in the next stage of the project.

It is important to note that in undertaking an evaluation of existing and potentially new water saving options over a twenty year planning horizon, that some options may become more favourable or cost effective over time. Likewise legislative and policy impediments to option implementation may also be resolved within the implementation timeframe.

1.2 Darling River System

Most of the options considered in this report have focussed on the Darling River, which commences near Bourke at the confluence of the Culgoa and Barwon Rivers and then flows through south-western NSW to the Menindee Lakes and then to its confluence with the Murray River at Wentworth.

However, it must be recognised that the Darling River forms part of the much larger Murray-Darling basin, which is shown on **Figure 1.1**.



Figure 1.1 Map of the Murray-Darling Basin

The climatic conditions in south-eastern Australia and the resulting rainfall patterns throughout the Murray-Darling Basin are amongst the lowest and most variable in the world, resulting in significant flow variability. Under natural flow conditions, prior to regulation, reaches of the Darling River periodically dried out. The longest period of zero flow ever recorded was 362 days in 1902/03.

Over the past 100 years, flows in the Murray-Darling Basin have been significantly modified by the construction of water storages to improve the security of water supply for rural and urban communities, large scale irrigation and stock and domestic purposes. However, it is recognised that

these economic and social benefits have also been offset by a number of impacts on the natural flow regime.

Approximately one third of the stored water in the basin is managed by the Murray Darling Basin Commission, with the major storages being Dartmouth, Hume, Lake Victoria and the Menindee Lakes. The water in these major storages is shared between Victoria, New South Wales and South Australia in line with the 1998 Murray-Darling Basin Agreement. These sharing arrangements are described further in the following section.

1.3 Murray Darling Basin Agreement

Despite the construction of dams and weirs, the natural variability of rainfall in the Murray-Darling catchments means that there will always be floods in some years and periods of reduced water availability in others. Therefore, it is important that the available water is shared fairly to support the communities and industries in each State and to ensure that the environmental health and productivity of the rivers are sustained.

In the River Murray system the rules for sharing water between the States have been agreed between the Commonwealth, New South Wales, Victorian and South Australian governments and are set out in the Murray-Darling Basin Agreement (MDBA). The actual water sharing rules and the procedures for accounting each State's share of the total volume available at any given time are extremely complex and will not be addressed here. However, a brief summary of issues relevant to the current project is given below.

The way in which the available water is shared between the environment and consumptive users within each State is a matter for the government of that State, which determines the State's allocation policy. However, since 1995 the States (NSW, Victoria and South Australia) must limit the volume of water extracted from the rivers and streams for consumptive use as agreed under the Murray-Darling Cap on diversions (Schedule F to the MDBA).

Under the Agreement, all of the water flowing into Lake Hume, Dartmouth reservoir, Menindee Lakes and into the Murray River from the Kiewa River is shared equally between NSW and Victoria. From these resources NSW and Victoria generally provide, in equal portions, South Australia's entitlement flow (including statutory reserves) and additional dilution flow. After meeting these requirements, NSW and Victoria may use the remaining water resources as they require.

Therefore, changes in the Darling River, particularly any reduction in the volume of water stored in Menindee Lakes and associated ability to provide for downstream demands, may have significant impacts elsewhere in the Murray-Darling Basin. This is particularly important with regard to the operation of the storages in the remainder of the system. For example if less water is stored in Menindee and/or it is released faster (in order to say reduce evaporation losses) this may put additional demands on Hume and Dartmouth.

The Murray Darling Basin Agreement is very prescriptive in terms of water sharing and operational arrangements. Therefore, there may be a need to review the Agreement at a fundamental level, such that it is not an impediment to significant changes, which may be appropriate at Menindee Lakes to achieve substantial water savings.

Any significant changes to the storage volume and/or operational characteristics of the Menindee Lakes may therefore require amendments to the Murray-Darling Basin Agreement, including interaction with Hume and Dartmouth, and the Menindee trigger points associated with the additional dilution flow for South Australia.

1.4 Terminology

The terminology used to describe WORKS, OPTIONS, SCHEMES and STRATEGIES in this report is summarised below:

- a number of WORKS, both structural and operational, produces an OPTION
- one or more options combined with offset measures or works results in a SCHEME
- the 20 YEAR STRATEGY will involve the implementation of the preferred scheme.

1.5 Objectives of Stages 1 and 2

The objectives of the current phase of the project were as follows:

- identification and broad assessment of a wide range of possible water saving options and consolidation into a manageable number of integrated schemes; and
- review by the Steering Committee and Project Team to workshop and then agree to a short list of Integrated Schemes that warrant further assessment.

1.6 Overview of Project Activities to Date

The tasks carried out in this phase of the project, which are discussed in more detail in the following report, are briefly summarised below:

- compilation of a “long list” of potential water saving works and options
- preliminary high level assessment to discard non-viable options
- hydrological assessment of Menindee Lakes options to identify potential water savings
- economic assessment of Menindee Lakes options that show ‘reasonable’ water savings
- multi-criteria assessment of Menindee Lakes options to identify viable schemes and offsets
- workshop with Steering Committee to develop Integrated Schemes

2.0 Water Savings

2.1 Water Savings v Water Recovery

The current project is aimed at securing substantial Water Savings as distinct from Water Recovery. Water Savings can be achieved by reducing current losses from the system, such as evaporation and transmission losses; whereas, Water Recovery requires existing users to reduce their demand, which could be achieved via demand management incentives or by the direct purchase of licence entitlements.

For flows along the Darling River, the reduction of transmission losses will be difficult to achieve and may have adverse environmental impacts. Equally, any increases in transmission losses may produce environmental benefits. Therefore in terms of losses from the system, that could potentially be “saved”, the reduction in evaporation losses became the primary target of the current project.

The initial focus of the study is aimed at achieving water savings through the reduction in evaporation losses. However, secondary initiatives such as market mechanisms and improved on-farm practices are also likely to generate significant water savings over time, and will therefore form an essential component of any twenty year strategic plan.

2.2 Evaporation Losses

The average annual net evaporation losses from the various storage types in the Darling River Basin were estimated in the State of the Darling Interim Hydrology Report (Webb McKeown, 2007) as follows:

- Major Dams – excluding Menindee 225 GL/yr
- Menindee Lakes System 393 GL/yr
- Hillside Dams – upper Darling Basin 727 GL/yr
- Ring Tanks – upper Darling Basin 630 GL/yr
- Ring tanks – lower Darling Basin 20 GL/yr

The above evaporation losses were derived from a number of sources, including IQQM modelling and other analyses. It should be noted that these are net evaporation losses (i.e. evaporation minus rainfall).

The methodology adopted by Webb McKeown to estimate net evaporation losses from ring tanks and Menindee lakes are essentially the same, in that both use appropriate pan to open water surface coefficients and calculate losses based on storage volumes, which can vary from full to empty. As noted in Webb McKeown, (2007), the reliability of evaporation data for hillside dams, which was obtained from the Hillside Farm Dams Investigation Report (Agrecon 2005), is questionable. It is also not clear whether these are net or gross evaporation figures.

The total average evaporation loss from storages in the Darling River basin is estimated at 1995 GL/yr, which represents about 17 % of the total storage volume. However, the total average evaporation loss, as a percentage of the total stored volume, is more pronounced from the hillside dams, followed by ring tanks and Menindee Lakes.

The major State owned dams (excluding Menindee), such as Keepit, Chaffey and Pindari are the most efficient in terms of evaporation loss, with an average of only 4% of total storage volume lost to evaporation each year. These storages are more efficient because of their greater depth and their location in the upper catchments, where evaporation rates are lower.

It is important to note that the average annual evaporation loss from the Menindee Lakes system, when based on more than 100 years of modelled inflow data, is estimated to be 426GL/yr. However, this can increase to approximately 700 GL/yr when the Lakes are full.

2.3 Focus of Current Project

Although there are significant evaporation losses from both hillside dams and ring tanks, the ability to readily turn these losses into savings that could be returned to the river will need additional work. Important issues to be addressed include:

- spatial distribution of storages and therefore the losses and potential savings
- the storages are in private ownership, which will require appropriate targeting of policies and regulations and potential fiscal incentives
- arrangements that will enable any water savings to be returned to the river and properly accounted for
- improved data and accounting regarding storage characteristics to quantify losses and savings
- equity issues as to who gets the savings, which may depend on the policies and financial incentives available

Therefore, although there is potential for significant evaporation reduction from on-farm storages (hillside dams and ring tanks) this needs to be countered by the potential difficulties in realising the savings. However, it will likely form a component of the twenty year strategic plan.

If the Darling River Water Savings Project is to achieve significant water savings in the short term it will be necessary to look at the single largest point loss in the system, which is evaporation from the largely shallow Menindee Lakes. The advantage of focussing on Menindee Lakes, at least as the primary initiative, is as follows:

- the evaporation loss is in one single location, although it comes from a number of individual but integrated lakes
- the lakes are under the ownership/control of the NSW Government/MDBC
- Cawndilla and Menindee lakes are currently dry - therefore it would be possible to start works almost immediately (following an approval process)

Therefore, the overall Strategy will include initial works at Menindee Lakes as well as long term initiatives to improve the efficiency of on-farm practices such as irrigation methods and measures to reduce losses from on-farm storages. Options to physically cover on-farm storages were addressed as part of this project. However, it became obvious that additional research and development work will be required before these options become economically viable. Increases in the price of water may also make covering storages more cost effective, within the twenty year implementation timeframe.

2.4 Menindee Lakes

The main water storage on the Darling River is provided by Menindee Lakes, which are a group of shallow lakes located on the lower section of the Darling River in far western New South Wales, adjacent to the township of Menindee and some 110km east of Broken Hill. The lakes are an important ecosystem as well as a critical water storage supplying part of New South Wales, South Australia, and a small part of Victoria. Water is extracted from the lakes for town water supply, irrigated agriculture, stock and domestic users, and to provide for environmental flow purposes.

Menindee Lakes, which are shown on **Figure 2.1**, were originally a series of ephemeral lakes, which under natural flow conditions would have filled during high river flows and subsequently drained back into the river. The water remaining in the lakes would slowly evaporate depending on subsequent flows. Under the natural flow regime many of the lakes would have been in a state of drying to very low or no water volume for significant periods of time. The intermittent nature of inflows to the area resulted in the lakes predominantly acting as isolated systems, with the exception of Lake Cawndilla, which filled through a connection with Lake Menindee. Hence reference in this report to “more natural system” or “more natural wetting and drying” reflects the rate of rise and fall in lake filling and emptying that occurred in all flooding prior to construction of the Menindee Lakes Storages.

The principal lakes in the Menindee Lakes system are: Cawndilla, Menindee, Pamamaroo and Wetherell, which is comprised of the main river channel, floodplain and a number of smaller lakes.

The current lake system covers an area of 463km² and has a total combined storage capacity of approximately 1750GL, which can be surcharged to 2050GL under certain flow conditions.

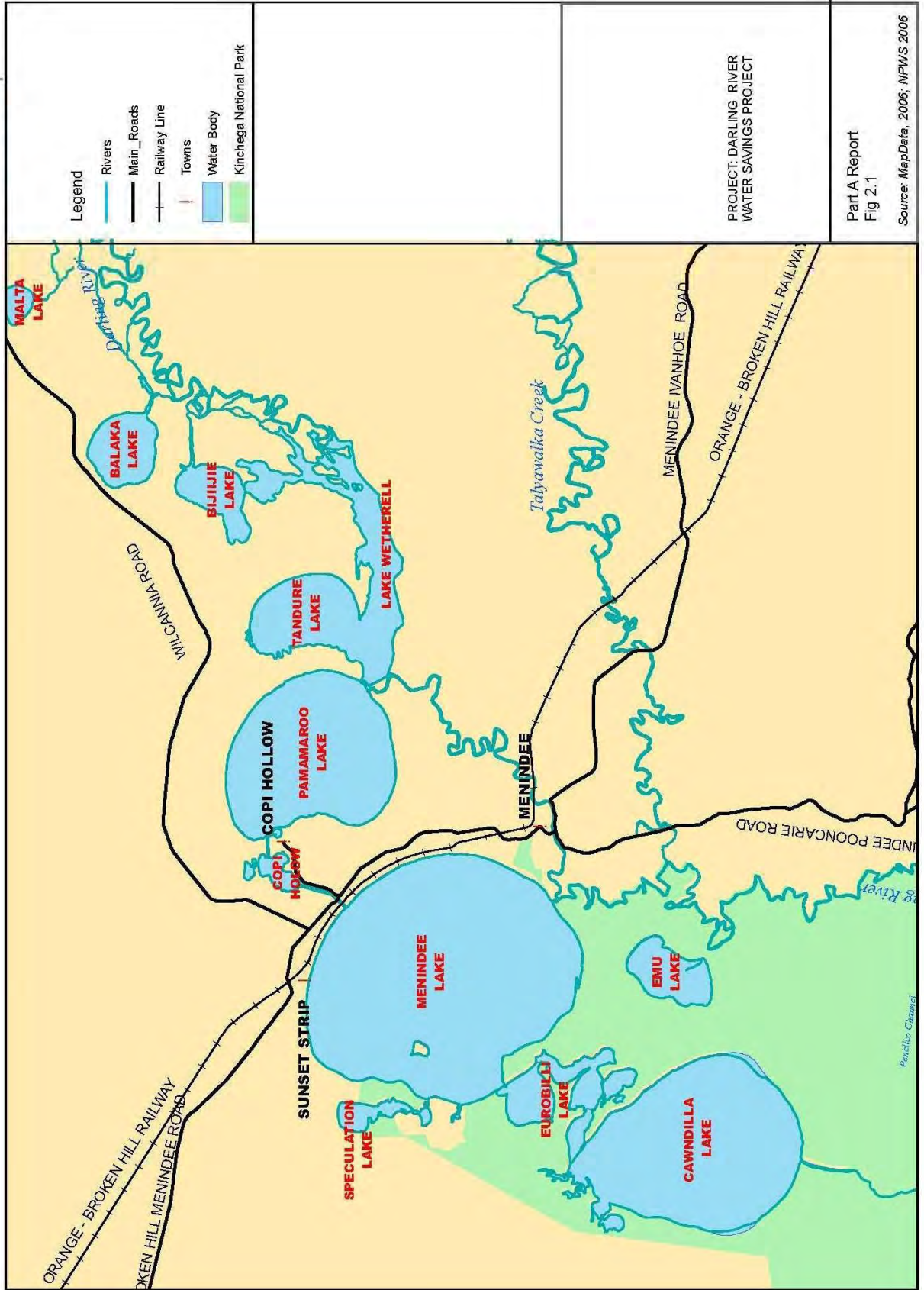
The lakes are owned by the NSW Government and jointly managed by the Department of Natural Resources, the Murray-Darling Basin Commission and State Water Corporation. Sharing of water between the States is managed by the MDBC and it controls the water release until the total lakes' water storage volume drops below 480GL. At this point water rights to the stored water and control of water release is passed to the NSW Government and stays in their jurisdiction until the total lake storage increases to greater than 640GL (this is referred to as the 480/640 Rule).

The natural environment of the lakes is unique, although it has been significantly changed by the construction of the water storage scheme. The lakes are amongst the most important breeding areas for native fish in the entire Darling River system as well as bird life, which includes a number of rare and endangered species as well as migratory species.

The lakes and surrounding areas are also significant in terms of Aboriginal heritage and cultural issues. Many Aboriginal burial sites are located in the sand dunes and banks of the lakes, while numerous scarred trees occur within and around the lakes.

In addition to the ecological and cultural heritage values, the Menindee Lakes also provide a focus for recreation and regional tourism as well as significant irrigation development, and are seen by many as vital to the local and regional economies.

Figure 2.1 Menindee lakes



Legend

- Rivers
- Main_Roads
- Railway Line
- Towns
- Water Body
- Kinchega National Park

PROJECT: DARLING RIVER
WATER SAVINGS PROJECT

Part A Report
Fig 2.1

Source: MapData, 2006; NPWS 2006



2.5 Need for Alternative High Security Supply

To ensure that High Security water, which is sourced from Menindee Lakes, is available when required, significantly more water than the actual entitlement is stored in the Lakes at the onset of dry conditions to allow for evaporation and transmission losses. **Figure 2.2** below shows the expected distribution of resources assuming low inflows and starting in October 2006.

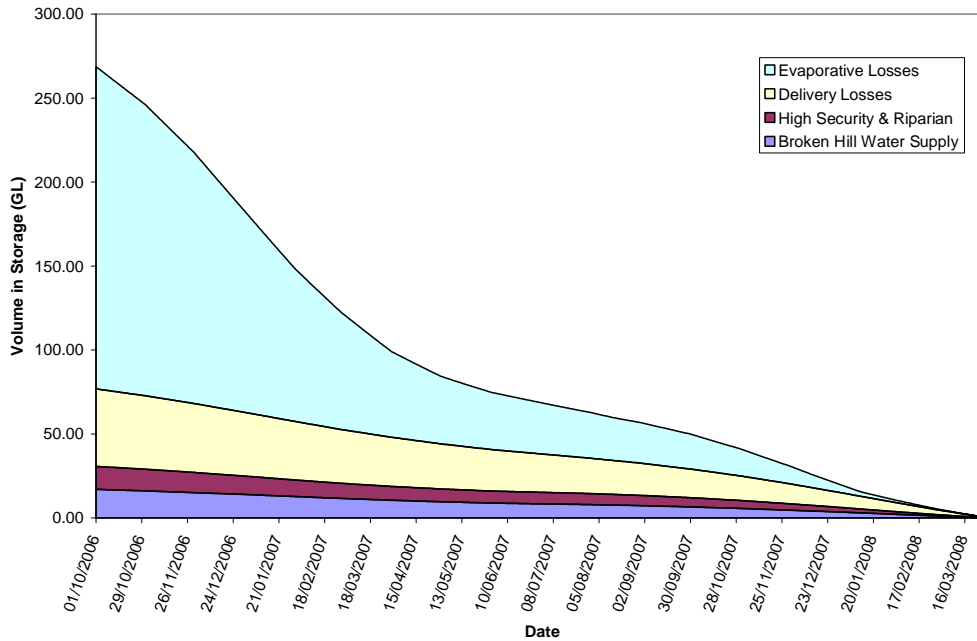


Figure 2.2 Possible Distribution of Resources under Dry Conditions – Essential Requirements Only Assumed Starting Date October 2006

Figure 2.2 shows that in order to provide eighteen months supply to the High Security Entitlement holders, including Broken Hill and the Lower Darling irrigators (i.e. a total entitlement of 18 GL/a), a total volume of about 270 GL must be kept in storage to allow for the evaporation and transmission losses, as well as the actual entitlements. To ensure eighteen months supply for Broken Hill alone, a storage volume of approximately 65 GL is required.

In addition to reducing evaporation losses, improved security for unregulated irrigation on the Barwon Darling or the NSW tributaries would also be possible if there was a reduced need to “quarantine” flow events for Menindee, Broken Hill, and other High Security users for drought security. At certain times under the current operational arrangements, upstream irrigators have their supplementary access suspended in order to protect Broken Hill’s water supply, which has an economic impact.

The way the Menindee Lakes storage is currently operated leads to large evaporation losses, as well as potential economic impacts to upstream irrigators and regional communities. Therefore, opportunities were explored to supply Broken Hill, Menindee and the Lower Darling High Security users from alternative sources and/or to store the water in a way that reduced the evaporation loss.

Although some of the options that were considered included provision for the Lower Darling High Security irrigators, the focus was primarily on the identification and assessment of supply and/or storage alternatives for Broken Hill.

2.6 Previous Studies

A number of studies have been conducted in recent years with a view to improving the operational efficiency of the Menindee Lakes system. This commenced with the identification of lake management issues by the Department of Land and Water Conservation (DLWC) and the Murray Darling Basin Commission (MDBC) during the 1990's. In 1998, the Menindee Lakes Advisory Committee in conjunction with the DLWC addressed these in The Menindee Lakes Storage Draft Management Plan, which identified objectives and strategies for the key management issues. This study proposed ten structural options to improve the operational efficiency of the water system.

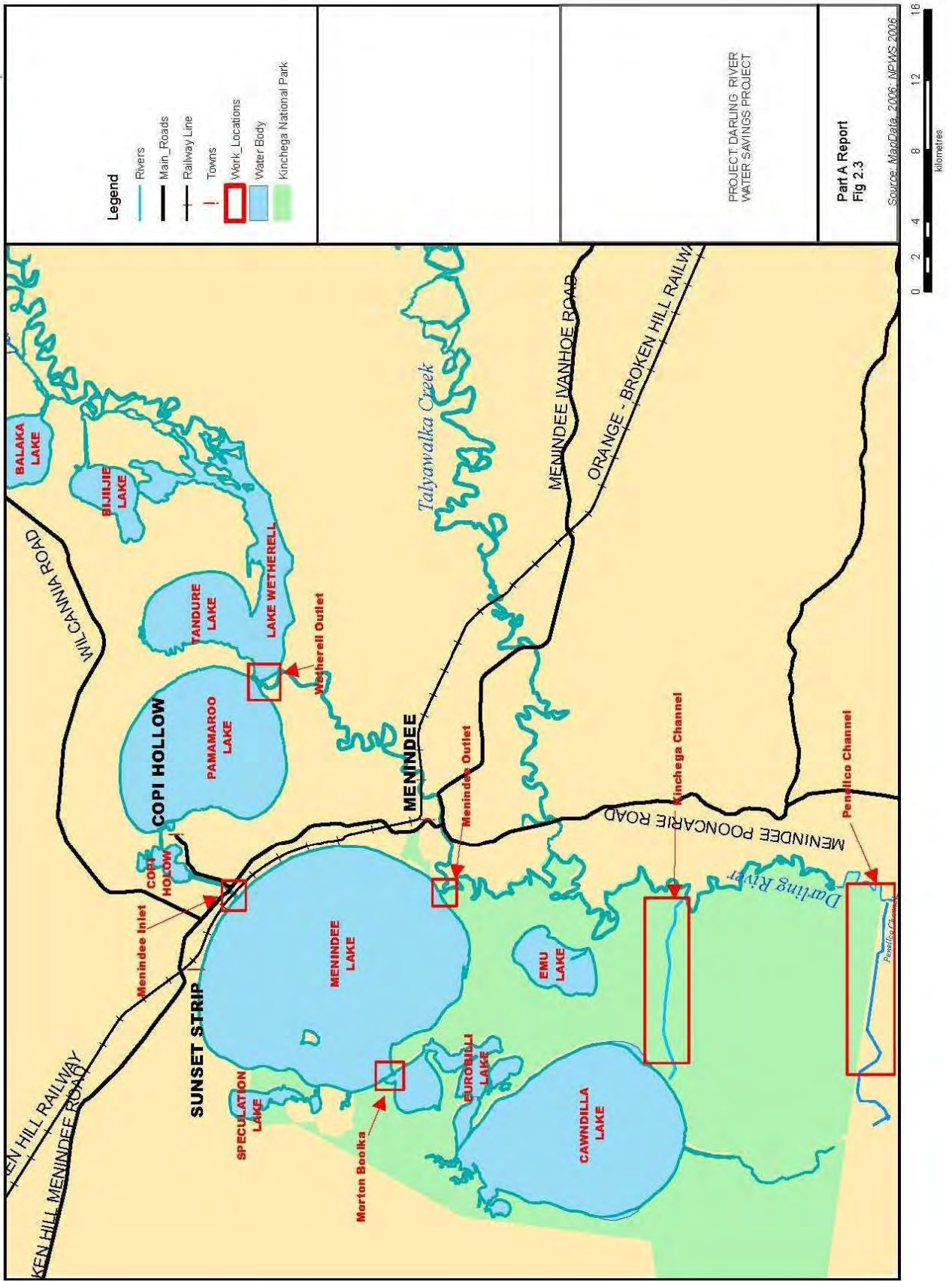
This work was followed by the Menindee Lakes Ecologically Sustainable Development (ESD) Project, which was prepared in 2002. The project collected detailed information on the natural resource interactions, cultural and socio-economic values of the Menindee Lakes system. The project assessed a number of structural options for modification of the operation of the lakes in an attempt to improve water quality, reduce water losses and improve the ecology and drought security performance of the lakes, and narrowed these down to three potential options. The short listed options included an enlarged Menindee outlet regulator, a channel to the Darling River from Cawndilla Lake and a regulator or weir at Morton Boolka. These and other work locations are shown on **Figure 2.3**.

Following the ESD project, an EIS assessing six options for structural works on Lakes Menindee and Cawndilla to improve operational efficiency and environmental conditions was completed in 2005. The additional three options assessed in the EIS resulted from a better understanding of the siltation issues associated with Lake Menindee and the environmental and heritage impacts associated with the proposed works. The options investigated in the EIS were:

- New enlarged Menindee outlet regulator and new secondary outlet channel
- Lake Menindee residual pool pumping station and channel
- Morton Boolka low level regulator
- Penellco channel emergency pumping station and outlet works
- Wetherell outlet regulator offset fishway
- Kinchega Channel

The objectives of the works assessed in the EIS were to improve operational efficiency of the lake system, improve the security of the water supply for the local users, increase opportunities to improve the ecology of the lake system, generate evaporative water savings and improve fish migration. The report proposed five structural changes that would save an average of 10GL of water per annum. The schemes achieved improvements to the internal distribution of water in the Lakes, which would improve security of supply for local water users, including Broken Hill. However, the water savings proposed were not considered sufficient to warrant the civil works required to achieve them. The works were also considered expensive, compared with the volume of water saved. Furthermore, the recommendations from the EIS did not receive broad community support. Therefore, after the completion of the EIS, it was considered that further work was required on the options proposed to save water. This project was therefore to involve a higher level of community consultation and a more robust assessment of the positive and negative effects of all the options.

Figure 2.3 Locality Plan Showing Location of Works Previously Assessed



To date, many of the options that have been assessed in detail can be described as “soft” operational options, designed to empty and fill the lakes in a pattern and at flow rates that could reduce evaporation losses. However, they were constrained by the requirement to maintain the existing storage volumes. As these options do not substantially change the existing storage volume and area of the lakes, or alter the current demand patterns or inflows, water savings have been found to be small. Furthermore, many options previously proposed would have resulted in an increase in the salinity of the Lower Darling River.

3.0 Stakeholder and Community Engagement

3.1 Overview

The Darling River Water Savings project is of interest to a diverse range of stakeholders across a wide geographical area. Therefore a consultation strategy was developed to capture a set of views that were considered representative across the spectrum of stakeholders through targeted engagement with key stakeholder organisations, while encouraging the broader community to have their say through website feedback and by telephone.

With a long term view of delivering a water saving strategy, which is endorsed by the community, the objectives of the Stage 1 community engagement activities were to:

- inform the community about the project and how they could be involved in developing the solution
- actively engage key stakeholder organisations and the broader community throughout the project
- identify a number of integrated schemes that are generally endorsed by the community

To enable an open exchange of information and to facilitate community feedback, a project website was established as well as a 1-800 number. Advertisements were also placed in local newspapers providing contact details for the project team. A number of written submissions were also received.

3.2 Key Stakeholder Groups

Stakeholders identified in consultation with the Steering Committee were categorised into three main groups as follows:

- Targeted Group, which included those in the local area with a direct interest, or who are directly affected, and with whom Maunsell are engaging on a one-on-one basis. The project team met stakeholders in Broken Hill and Menindee in October and December 2006. These meetings were arranged to identify and discuss the likely options that were to be assessed during the project and to identify community and stakeholder issues and concerns that would need to be taken into consideration.
- Personalised Group, which included those in the vicinity with a direct interest, or who are directly affected, and with whom, due to the short time frame, Maunsell are engaging via telephone or email contact with identified contact individuals within each organisation. All organisations identified in the Personalised category were contacted by telephone to establish an ongoing communication channel and added to the mailing list to receive project updates.
- General Community Group, which included those who are indirectly affected or have an interest in the project. Generally this group includes the wider community, who were invited to provide feedback and join the personalised group, receiving email/postal updates on the project but were not contacted directly by Maunsell. Press releases and advertisements were placed in local and regional publications to disseminate the project website address and contact details at the project outset.

3.3 Summary of Stakeholder and Community Issues

A broad summary of stakeholder and community issues that have been raised to date is given in **Table 3.1**.

Table 3.1 Summary of Issues Raised by Key Stakeholder Organisations and Community

Urban Water Supply
Improve quality of Broken Hill's supply
Resistance to forgoing access to Lakes supply
Towns along the river need water – there are also social implications
Greywater reuse and improvements in efficiency should also be considered – in line with efficiency improvements in rest of system
Operation of River and Lakes
Upstream storages and upstream users that take water do not allow flows down the system
Evaporation occurs from dams upstream as well. Evaporation rates quoted for Menindee appear to be higher than water level changes observed. The root of the problem is upstream – storages, excessive use and illegal extractions
The river is over allocated
Bad quality water is released ahead of fresh water
Water Quality is very poor
Upstream dams are more efficient
Floodplains need replenishing. Need to consider economic and ecological costs of not having overbank flows
Lakes provide a flood management function for South Australia
Store water in a deep, efficient storage – maybe the river in weir pools
Use Lake Speculation for Broken Hill Supply
Use Copi Hollow for Broken Hill supply
Anabranch pipeline would be very costly to build and operate
Need to flush water through system (for quality) – need a channel from Cawndilla
Putting a channel to drain Cawndilla through the National Park would be an issue
Support schemes that reduce evaporative loss
Want water in lakes (particularly Menindee and Copi Hollow)
Install a weir at Wetherell to increase storage in the channel
Protect most natural/significant areas – includes upper small lakes, Tandure, Wetherell, Speculation, Morton Boolka, Kinchegea National Park
Deepen upper lakes
Use upper lakes in preference to lower lakes
Do not decommission Cawndilla
Do not decommission Lake Menindee
Empty residual pools quickly – provides additional drought security in crunch times
Concerns about ecological impacts of rapid draining of pools
Do not use residual pools when water quality deteriorates significantly
Desilting outlet channels needs to be included in the strategy

Lakes Environment
Preference towards soft options preferred which mimic the natural system
Great significance of River and Lakes for Aboriginal people testified by abundance of aboriginal sites and burial grounds
Protection of dune system and indigenous heritage, pre and post construction and operational phases
Lakes are a key breeding area for fish and birds (including rare and migratory species)
Lakes have always been there
Darling River Environment
Want a healthy sustainable ecosystem – improved water quality and flows in river. Flow on effects to towns, business and economy
Fish passage and recruitment
Clean up river system
Less water in river since 1980s when river seemed to cope with amount of upstream extraction, trend should be reversed
Installation of rock bars to provide fish breeding areas and slow river flow, would be beneficial
Talyawalka Creek needs flood flows for fish and graziers
Need to restore healthy flows in Murray as well as the Darling
Socio-Economic Issues
Cotton growers – inappropriate crop, and excessive water use – should be restricted
Cotton growers – important for employment and economy. Further investment in irrigation systems and increased productivity is constrained by water supply
Irrigators need to install efficient watering systems
Infrastructure is also needed to link area to other centres
Who gets the savings? All savings should go to the river, irrigators or the environment? Concern that water will go to irrigators. Irrigators concerned about which irrigators may get the savings?
Who will pay for works – costs passed onto users or those who benefit from savings?
Menindee Lakes are a major recreational asset and a tourism drawcard. Highly important for economy in the area – flow on effects across local businesses of no water in lakes very significant. Strategy needs to maintain key areas of significance for tourism and strategy should include development of options into tourism features.
Ecotourism - Schemes need to protect key areas. Schemes may provide an opportunity to attract visitors within a wider tourism strategy for the area
Policy/Legislation
Water Sharing Plan needed that includes representation from Lower and Upper Darling River. Too many States involved in running the system.
Current operational rules significantly impact on irrigators in Northern Valleys
Should review licensing rules – carry over, trigger levels for pumping along river etc, re-assess water trading strategy. Reducing allocations affects smaller user much more than larger user
Fines for illegal extraction need to be at a level such that they are not considered as just a business expense and the water is not taken at all
Flow events need to be policed so that water reaches the downstream end of the river
Water pricing and metering for floodplain harvesting is inadequate
Wider community creates the demand for irrigation development.
Other
Concerns about whether the project involves the public enough – need for public meetings

A summary of the conclusions from the consultation program is given below:

- There are numerous viewpoints (often conflicting) from a wide range of stakeholders
- These issues have helped guide the development of integrated schemes, and in particular the offset options
- During subsequent stages of the project and as the preferred schemes are refined (particularly after the completion of the necessary drawings, cost estimates, detailed hydrologic and economic modelling), further comment should be sought from the stakeholders
- Additional face-to-face consultation will be required, especially with the local Aboriginal communities
- The preferred scheme needs to share gain and pain across all stakeholder groups, including upstream and downstream, irrigators and other water users (including the environment)
- Broad community acceptance is unlikely unless stakeholders and the community are given clarity on where the savings will go, and who will bear the capital and ongoing operating costs associated with the scheme
- Stakeholders and the community are requesting public meetings be held during the next stage of the project. This will need to be considered.

4.0 Available Options and Assessment Methodology

4.1 Identification of “Long List” of Individual Works/Options

In recent years, a wide range of works and options have been proposed, which it is claimed could potentially be implemented to enable water savings within the Darling River system. However, the technical feasibility of many of these suggestions has generally not been assessed in detail and/or the findings have not been compiled into a single document.

These options include radical proposals such as diverting coastal rivers inland as well as more wide ranging proposals, such as the application of market mechanisms to encourage the more efficient use and allocation of the available water resources. A wide range of structural and operational changes specifically aimed at reducing evaporation losses from the Menindee Lakes, have also been canvassed.

A “long list” of works/options was therefore compiled, based on a review of previous studies, information provided to the project team and ideas generated during the more recent community consultation.

This list was considered as the starting point for further assessment and fine tuning, which was necessary to derive a manageable list of potential water saving options and offset mechanisms (i.e. measures required to reduce adverse impacts associated with the water saving options), that could then be assessed in greater detail.

4.2 Preliminary High Level Assessment

A preliminary high level assessment of the “long list” of options was initially carried out as a “desktop”, analysis based on the findings from previous studies and other readily available information. This very “broad brush” initial assessment resulted in the following options being dismissed from further assessment because of poor technical feasibility, environmental impact and/or cost efficiency:

- diversion of coastal rivers inland and inter-basin transfer options
- towing icebergs from Antarctica to Australia
- transportation of fresh water from Tasmania in floating sacks
- cloud seeding to increase rainfall over the upstream catchment areas
- creating an inland sea to increase humidity and therefore increase rainfall
- storage of water in disused mining voids around Broken Hill

4.3 Options Assessed in Greater Detail

The remaining options, which were still considered feasible after this high level assessment and subsequent sieving process, were divided into the following three categories:

- structural and operational changes at Menindee Lakes
- alternative supply and storage options for Broken Hill (and other High Security users)
- basin wide initiatives and potential offsets to reduce/compensate for adverse impacts

A summary of the options under each of these categories, which were carried forward for more detailed assessment, is given below.

Structural and Operational Changes at Menindee Lakes (options include a range of works)

- allow for more rapid drawdown of lakes by releasing water at maximum rates, up to channel capacity, either from NSW control (<480 GL) or at higher starting levels (4 options considered)
- access residual pools for local High Security Users
- reduce use of Lakes Menindee and Cawndilla as storages, except for larger floods
- reduce use of Lake Cawndilla as a storage, with existing outlet at Menindee
- reduce use of Lake Cawndilla as a storage, with enlarged outlet at Menindee
- reduce use of Lake Menindee as a storage, with existing outlet at Cawndilla
- reduce use of Lake Menindee as a storage, with enlarged outlet and associated channel
- division of Lake Menindee into two cells – two different options (levee alignments) considered
- increase capacity of certain lakes by surcharging
- increased use of the more efficient (deeper) lakes in the Menindee Lakes system
- utilisation of existing or new storages/weirs upstream of Menindee (including northern valleys)
- utilisation of existing or new storages downstream of Menindee

Alternative Supply and Storage Options for Broken Hill (and possibly other High Security users)

- develop an integrated water supply strategy including feasibility of local rainwater, greywater and effluent reuse to reduce demand on river extractions and lakes storage
- aquifer storage and recovery (ASR) at Stevens Creek and/or Menindee (Weir 32)
- groundwater piped from the Great Artesian Basin to Broken Hill
- pipeline from the River Murray to Broken Hill and/or Menindee
- use of terminal storage at Broken Hill and/or Menindee to reduce size of Murray pipeline
- desalination (Reverse Osmosis) facility (as an emergency measure only)
- construct deep or multi-cell storage at Menindee or North Copi Hollow (including new ring tank)
- use of alternative storages for High Security water, such as Lake Speculation and Tandure
- improve efficiency of Stevens Creek storage by desilting and reducing evaporation losses
- possibly cover the storage at Stevens Creek and/or North Copi Hollow

Basin Wide Initiatives and Potential Offsets to Reduce/Compensate for Adverse Impacts

- covering of on-farm storages to reduce evaporation losses
- improved on-farm practices, including storage and irrigation methods
- review appropriate cropping, including type of crops grown and location
- assess alternative market mechanisms and trading rules
- compensation, including purchase of current entitlements and/or entire enterprise

4.4 Offset Measures

The range of offset measures available is generally common across all integrated schemes. However, the exact combination that will be applied to the final strategy will ultimately depend on the location and magnitude of the impacts, and will be tailored to the affected stakeholder group. Possible combinations of offset measures are suggested for the six proposed integrated schemes, which are outlined in Section 7.

Possible mechanisms for reinstating supply reliability such as the alternative storage or supply offset options for Broken Hill and local High Security users, are included in each of the integrated schemes. At this stage more technical work is required to identify the best solutions, therefore the full range of options is common to each of the integrated schemes. However, the extent to which say Broken Hill storage and/or supply is met by means other than the Menindee Lakes will depend to some extent on the Menindee Lakes option that is adopted in the final integrated schemes.

5.0 Potential Strategies - Menindee Lakes Options

5.1 Overview of options

The preliminary list of feasible structural and operational options at Menindee Lakes, as listed in **Section 4.3**, are briefly described in the following sections.

5.1.1 Potential to Allow for More Rapid Drawdown of the Lakes

A number of options to release water from the Lakes at high rates (up to channel capacity) over defined storage ranges were investigated using the hydrological model.

The objective of this exercise was to investigate the effect of minimising the surface area of the lakes in order to estimate the magnitude of water savings that could be achieved by altering the operational rules.

The modelling assumed existing lake configuration and that drawdown is limited to the existing regulator capacities. However, this option may be combined with structural changes to the lakes and outlets as part of an integrated scheme.

5.1.2 Potential to Access Residual Pools for Local High Security Users

A number of stakeholders, principally local irrigators, stressed the importance to their operations of being able to quickly use the residual pools for irrigation supply, before the salinity elevated to a level that is detrimental to the plants. The option would require various arrangements of pumps, pipes and channels from the residual pools to the existing outlets.

This is a short term drought management option, which does not produce significant water savings over the long term. However, it is extremely valuable to irrigators in the short term in order to avoid complete crop failure. It is not strictly a water saving option in its own right, but is likely to be included as an additional option in all of the integrated schemes to provide emergency drought security.

5.1.3 Potential to Reduce Use of One or More of the Lakes as a Storage

An obvious way of achieving evaporative savings from Menindee Lakes is to restrict flows into one or more of the lakes, so that water is not held there and therefore the evaporative loss does not occur.

If water was not captured in Menindee Lakes it could:

- provide environmental flows
- flow downstream for storage in Lake Victoria and to increase flows (particularly environmental flows) in the Lower Murray

However, it should be noted that evaporation and transmission losses would still occur under each of these scenarios.

The maximum possible saving using minimum works and maximum operational changes would be achieved by restoring all of the lakes to a more natural system. However, this is not considered acceptable, or realistic. Therefore the option was limited to reducing the use of one or two of the lakes as operational storages.

This option has previously been referred to as decommissioning, but this term is misleading, as it implies that the lakes will be kept dry. In fact the lake in question would revert to a more natural wetting and drying cycle.

Although over the long term the lake(s) would be used less as an operational storage, it will still be allowed to flood periodically. The ultimate water saving will be a function of the rate at which the flooded lake is then emptied. Therefore, it may also be necessary to enable increased outflow from these lakes after they are flooded.

It should be noted that removing some of the storage volume at Menindee will place a greater demand on the Hume and Dartmouth storages. This has obvious implications for River Murray users. Therefore, when incorporated into integrated schemes consideration needs to be given to rules for interaction of Menindee Lakes with Hume and Dartmouth storages, which are discussed further in **Section 6**.

Potential to Reduce Use of Lakes Cawndilla and Menindee as Storages

Restricting storage of water in Lakes Cawndilla and Menindee estimates the potential water savings that could be achieved by significant modification to the storage and operational management of the Menindee system.

Realistically, the Lake system needs to retain some storage and release function, which can best be achieved by retaining water in the upper lakes where the Darling enters the Menindee system, while restricting flows into the lower end of the system. This option would also place the greatest emphasis on a need for an offset to reinstate the security of supply for Broken Hill and local High Security users.

Although this option reduces the use of the lakes as formal storages, they will still fill in times of flood. Therefore, in order to achieve the greatest evaporative savings, it will still be necessary to ensure that these lakes can be emptied as quickly as possible in order to minimise the total surface area. Ideally, this will require either an enlarged outlet from Cawndilla with an associated channel to the Darling River and/or an enlarged outlet from Menindee. Enlarging the Cawndilla outlet would also improve drought security for Lower Darling users because it avoids the isolation of a large (100 GL) residual pool in Cawndilla.

Potential to Reduce Use of Lake Menindee as a Storage

Of all the lakes, Menindee is the most inefficient in terms of its volume to surface area ratio. Therefore, it has the greatest evaporation loss. This option aims to focus more operation in Cawndilla by restricting flow into Lake Menindee except under flood conditions.

Restricting flows into Lake Menindee is best achieved by constructing a wide bypass channel around the northern edge of the lake using an engineered bank. This would mean that the Menindee outlet is only used when the water level in Cawndilla rises to the point where the bank is overtopped, flooding the remaining area of Lake Menindee. If taken through to later stages of the project, the trade off between bank height and stability when wetted, versus frequency of overtopping into the remainder of Lake Menindee (hence savings achieved) will need to be assessed.

Two options were assessed to maintain the outlet capacity to pass 9GL/day for South Australian needs. These are:

- Retain the existing Cawndilla outlet, but increasing other regulator capacities in the system. However, this results in a large volume being retained in Cawndilla, which is not considered to be operationally efficient
- Provision of an enlarged Cawndilla outlet, which also requires a channel from Cawndilla to the Darling River

Potential to Reduce Use of Lake Cawndilla as a Storage

This is a sister option to the one above, except focussing on selectively isolating Lake Cawndilla and optimising Lake Menindee operation. Restricting flows into Lake Cawndilla could be achieved by constructing a block bank with a regulator between the two lakes, at a point just upstream of Morton Boolka. Constructing the embankment within Lake Menindee, rather than at Morton Boolka would reduce the impacts at Morton Boolka, which is an area with a high environmental status (RAMSAR equivalent) and cultural heritage significance. However, there would still be some localised impact at either end of the embankment.

The existing Menindee regulator capacity could be maintained for this option. However, operational flexibility of the lakes would be improved by enlarging the outlet capacity to prioritise the emptying of Lake Menindee thus promoting long term storage in the more efficient upper lakes. Both outlet options (i.e. existing and enlarged outlet from Menindee) were assessed.

This option has impacts on the provision of regulated Darling Anabranch environmental flows since water would be stored less frequently in Lake Cawndilla.

Potential to Divide Lake Menindee into Two Cells

Local residents have proposed an option where an engineered embankment is constructed across Lake Menindee. In this scenario, half of the lake would remain dry except under flood conditions. This would reduce the surface area open to evaporation, whilst maintaining water in front of Sunset Strip, a village that overlooks Lake Menindee. State Water advises that the bank would need to be up to 10m high.

There are a number of configurations that could be adopted to achieve the division of Lake Menindee. This study has assessed two possible options.

The first option would result in reduced use of half of Lake Menindee and all of Lake Cawndilla. This would require an engineered bank, 16km in length, to be constructed from west of Sunset Strip to just south of the existing Menindee outlet (i.e. the Menindee outlet would be located within the active half of the lake). To enable flood flows to be passed into the lower part of the system a regulator would be required in the bank.

The second option would result in reduced use of half of Lake Menindee only, with flow allowed into Lake Cawndilla. This would require a bank, 18km in length, to be constructed from the north-east shore of Lake Menindee, near the existing inlet; to south-west of Morton Boolka (i.e. both the inlet and Morton Boolka would be located within the active half of the lake). To enable flood flows to enter the southern half of Lake Menindee, a regulator would need to be installed in the bank. If the current Menindee outlet capacity is to be replicated, the regulator would have a capacity of 4 GL/d. In order to promote efficient flow through the southern half of Menindee during smaller events, the regulator should be located where the bank crosses Menindee Creek.

Potential to Reduce Use of Lake Tandure as a Storage

Since Lake Wetherell and Pamamaroo are required to move water in and out of the other lakes, restricting flows into Tandure is the only other lake that was considered with regard to reducing the storage function. To do this would require installation of a bank between Lake Wetherell and Lake Tandure. The bank would require a rock weir to allow the flood flows to enter.

5.1.4 Potential to Increase Capacity of Certain Lakes by Surcharging

Increasing the capacity of one or more of the lakes to improve the overall storage-surface area relationship may be another way to achieve water savings. This could be achieved by deepening a lake or constructing a levee around the lake. Depending on which lake is increased, additional regulators may also be required.

Although the lakes could theoretically be deepened by excavation, provided the geological conditions are favourable, it is likely that this option would not be cost effective. A cheaper alternative would be to increase the depth of storage using a combination of excavation and banks via a cut and fill exercise.

5.2 Evaluation of Menindee Lakes Options

Due to the short time frame of the initial stages of the project, a broad screening tool was developed to assess the above Menindee Lakes options. The options were assessed against a range of criteria with the objective of discounting those that were not considered feasible on technical, environmental or socio-economic grounds. The assessment included criteria such as water savings, impact on river flows, impact on diversions and impacts on river salinity.

In order to quantify the potential water savings, which was the primary objective of the study, Webb McKeown & Associates (WMA) were engaged to carry out an initial assessment of a range of options, using a hydrological model provided by DNR. This provided sufficient detail to enable a broad assessment of the Menindee Lakes options in terms of average annual evaporation reductions, which was used as an indicator of water savings, and potential third party impacts.

A preliminary economic analysis was also completed. Economic indicators considered in the assessment included the agricultural value of the saved water, salinity impacts and flow on effects to the community such as impact on property values, tourism, recreational values and regional development.

A base case was used as a benchmark against which all other options were assessed. The base case represents current management and operational practices, as well as storage volumes and resource demands that were included in the DNR model. This was considered suitable for the current broad assessment and short-listing exercise, since the purpose of this assessment was to compare Menindee Lakes options to identify any potential "show stoppers". However, it should be noted that a more detailed assessment will be carried out for the integrated schemes, which are taken through to the next stage of the project.

Each of the Menindee Lakes options was broadly assessed against the following criteria in terms of the level of change/impact. These aim to address the primary objectives and sub objectives of the project as defined in the Brief.

Achieve substantial water savings in the Darling River system

This is the primary objective that each Menindee Lakes option must satisfy in order to be included in subsequent stages of the assessment. An upper bound value of the average annual evaporation reduction at Menindee is used as the indicator for this criterion.

Where the result above is favourable, the following sub objectives are assessed:

Contribute to economic development in the region

Economic indicators generated in the preliminary economic analysis were included in the assessment. The preliminary economic analysis included an assessment of flow on impacts to the community. Additional comments were made on the likely impact of each option on the local and regional community, based on Maunsell's stakeholder and community engagement activities.

Protect security for water users

Hydrological model outputs include the change in diversions in Victoria, South Australia and New South Wales (Murray upstream of the Darling Junction), and the Lower Darling as a separate reach. These were used as indicators of the change in security of supply for water users.

Protect the environment and riverine ecology

A number of indicators were used to assess the potential change in the environment and riverine ecology. In terms of riverine ecology, the following were determined from the hydrological model output:

- impact on frequency of low flow
- impact on frequency of high flow
- average annual flows in the Lower Darling
- variation in lake levels

In terms of changes to the environment, for this broad, screening level assessment the following indicators were qualitatively included in the assessment:

- likelihood of impact on threatened species, based on the footprint of the works
- likely impact on indigenous heritage, based on the footprint of the works and interaction with dune systems (eg where increased lake levels are proposed)
- likely impact on birds, based on location of works in relation to mapped bird breeding sites
- likely impact on fish, based on possible impact on fish passage
- energy requirements (eg pumping requirement)

5.3 Quantification of Water Savings – Hydrological Modelling

As noted above, a number of structural and operational changes at Menindee Lakes, which could potentially be implemented in the short term, were assessed in the study. These were focussed on reducing the surface area, or improving the surface area to volume relationship to reduce evaporation losses.

A subset of the possible options was selected for modelling by Webb McKeown & Associates (WMA) to provide an upper bound to the potential water savings (evaporation reduction) associated with the different options. A summary of the overall evaporation reductions and associated diversion changes for the modelled options is given in **Tables 5.1 and 5.2**.

All but one of the modelled options produces evaporative water savings. The exception is the option for increasing the capacity of Lake Pamamaroo. For this option the savings created by increased storage in Lake Pamamaroo is exceeded by the additional evaporative losses incurred in Lake Wetherell.

All but one option produced reductions in Lower Darling diversions. The smallest reduction was 0GL/yr and the largest reduction, 97GL/yr. However, for most options, diversion changes for New South Wales (Murray), Victoria and South Australian users are relatively small. For NSW the range was +3 to – 44GL/yr, Victoria, 0 to -39GL/yr and SA, 0 to +6GL/yr.

Although the average diversion reductions are often small, this does not yet take into account the timing of the changes to diversions. Although some details have been provided in the current hydrological model results, this will need to be addressed in more detail in the next stage of the project.

The largest evaporation reductions are achieved by removing the storage function from one or more of the lakes. For example, if both Menindee and Cawndilla Lakes were removed from the system, an average annual evaporation saving of 211 GL could potentially be achieved. However, this option also has the largest reduction in downstream irrigation diversions, 97GL/yr in the Lower Darling and 81GL/yr in the Murray. These reductions effectively add to flows in the Darling and the Murray.

In summary, the best structural and operational options to reduce evaporation losses from Menindee Lakes are listed below, in decreasing order of average annual evaporation savings:

- reduce use of Menindee and Cawndilla as storages (average annual evaporation reduced by a maximum of 211 GL/a)
- reduce use of Menindee, with existing Cawndilla outlet (average annual evaporation reduced by a maximum of 136 GL/a)
- reduce use of Menindee, with enlarged Cawndilla outlet (average annual evaporation reduced by a maximum of 134 GL/a)
- allowing for more rapid drawdown from 680 to 100 GL (average annual evaporation reduced by a maximum of 91 GL/a)

It is important to note that the evaporative savings listed above are largely based on the existing demand profile.

Table 5.3 shows the water savings and potential changes to diversions for a number of key users.

Table 5.1 – Key Modelled Options – Maximum Net Evaporative Loss (GL/Yr)

Option	Wetherell	Pamamaroo	Menindee	Cawndilla	Total	Change from Base Case
Base case	50	82	168	126	426	0
Rapid release rule 480/200	62	77	128	105	372	-54
Rapid release rule 480/300	64	81	133	108	387	-39
Rapid release rule 680/100	55	69	117	95	335	-91
Rapid release rule 300/100	69	81	143	113	406	-20
Reduce use of Menindee and Cawndilla as storages	117	94	5	0	215	-211
Reduce use of Cawndilla as a storage, existing Menindee outlet	80	91	183	0	353	-73
Reduce use of Cawndilla as a storage, enlarged Menindee outlet	82	92	176	0	351	-76
Reduce use of Menindee as a storage, existing Cawndilla outlet	75	83	0	134	291	-136
Reduce use of Menindee as a storage, enlarged Cawndilla outlet and associated channel	83	92	0	118	292	-134
Increase capacity of Pamamaroo by surcharging	65	86	162	123	435	+9
Division of Menindee into two cells (both filled)	50	82	130	123	388	-38
Division of Menindee into two cells (one filled)	56	84	87	130	357	-70

Table 5.2 – Long Term Average Diversion Change (GL/Yr)

	NSW Lower Darling	Change from Base Case	NSW Murray	Change from Base Case	Victoria	Change from Base Case	South Australia	Change from Base Case
Base case	129		1966	0	1675		1139	
Rapid release rule 480/200	119	-10	1979	13	1671	-4	1143	4
Rapid release rule 480/300	121	-8	1986	20	1674	-1	1143	4
Rapid release rule 680/100	112	-17	1969	3	1665	-10	1145	6
Rapid release rule 300/100	124	-5	1979	13	1673	-2	1144	5
Reduce use of Menindee and Cawndilla as storages	32	-97	1922	-44	1636	-39	1141	2
Reduce use of Cawndilla as a storage, existing Menindee outlet	55	-74	1968	3	1670	-5	1142	3
Reduce use of Cawndilla as a storage, enlarged Menindee outlet	55	-74	1969	3	1671	-4	1142	3
Reduce use of Menindee as a storage, existing Cawndilla outlet	116	-13	1963	-2	1673	-2	1142	3
Reduce use of Menindee as a storage, enlarged Cawndilla outlet and associated channel	112	-17	1964	-2	1672	-3	1143	4
Increase capacity of Pamamaroo by surcharging	122	-7	1966	0	1675	0	1140	1
Division of Menindee into two cells (both filled)	129	0	1966	0	1675	0	1139	0
Division of Menindee into two cells (one filled)	116	-13	1968	2	1675	0	1142	3

Table 5.3 Water Savings and Potential Changes to Current Irrigation Diversions (GL/a)

Option	Max Water Savings (Reduced Evaporation)	Changes to Current Irrigation Diversions				
		NSW Lower Darling	NSW Murray	Victoria	South Australia	Total All States
Base case	0					
Rapid release rule 480/200	54	-10	13	-4	4	3
Rapid release rule 480/300	39	-8	20	-1	4	15
Rapid release rule 680/100	91	-17	3	-10	6	-18
Rapid release rule 300/100	20	-5	13	-2	5	11
Reduce use of Menindee and Cawndilla as storages	211	-97	-44	-39	2	-178
Reduce use of Cawndilla as a storage, existing Menindee outlet	73	-74	3	-5	3	-73
Reduce use of Cawndilla as a storage, enlarged Menindee outlet	76	-74	3	-4	3	-72
Reduce use of Menindee as a storage, existing Cawndilla outlet	136	-13	-2	-2	3	-14
Reduce use of Menindee as a storage, enlarged Cawndilla outlet and associated channel	134	-17	-2	-3	4	-18
Increase capacity of Pamamaroo by surcharging	-9	-7	0	0	1	-6
Division of Menindee into two cells (both filled)	38	0	0	0	0	0
Division of Menindee into two cells (one filled)	70	-13	2	0	3	-8

The extraction of water from residual pools is thought to have significant potential as a drought security measure. This aspect (which as not specifically tested in the hydrologic model runs to date) should be investigated in the next stage of the study.

With regards to some of the other options, the use of upstream storages in north east NSW (such as Keepit) to store water in preference to storing it at Menindee was discounted because of the excessive transmission losses associated with getting the water to Menindee. The transmission losses were found to be a similar order of magnitude to the evaporation savings.

Additionally, although existing weirs are an effective way of storing water, hydrological assessment showed that only small (i.e. less than 10GL/a) savings could be achieved using these storages.

In conclusion, while substantial water savings may be achieved, all of the options were found to have adverse impacts on at least some stakeholders. These impacts typically included the reduction of downstream diversions, increases in salinity, and social impacts associated with the removal of amenity.

The security of supply for Broken Hill and the other High Security users was not specifically assessed in detail in the hydrologic studies. This will be significant for some options, therefore integrated schemes should include suitable offset mechanisms to address these impacts. This aspect is taken up in detail in Section 6.

5.4 Economic Modelling and Preliminary Results

The above section described the initial hydrologic modelling used to estimate the likely water savings for the preliminary list of Menindee Lakes options. Following the hydrologic modelling, cost estimates (with large contingency allowances) were prepared for the Menindee Lakes works as individual options to facilitate preliminary economic modelling. It should be noted that these preliminary cost estimates for Menindee Lakes works when considered as individual options differ from the cost estimates provided later in this report, when Menindee Lakes works are included in integrated schemes (since scheme costs include additional works to improve overall operational flexibility).

These results together with the cost estimates for the various options provided the necessary data for a preliminary benefit cost assessment (PBCA) and a preliminary regional economic development analysis (PREDA). This work was undertaken by Hassall & Associates and has provided the project with a good understanding of the likely distribution of benefits and costs associated with selected works and options. The following options were selected from the best performers in the initial hydrologic list:

- Rapid release, 680 to 100GL
- Options which reduce the use of certain lakes:
 - Menindee and Cawndilla
 - Cawndilla only
 - Cawndilla plus an enhanced Menindee outlet
 - Menindee only
 - Menindee plus and enhanced Cawndilla outlet
- Deepening Lake Pamamaroo
- Menindee cells

The preliminary cost estimates for this option list are shown in **Table 5.4**. The capital cost of the options ranged from zero for Rapid Release to \$70M for the construction of cells in Lake Menindee. Operational and maintenance (O & M) costs ranged from zero for Rapid Release to \$0.6M/year for Menindee cells. The present value of costs (over 30 years at a discount rate of 7%) is also shown in the table.

Table 5.4: Implementation Works for Hydrology Options

Preliminary Hydrology Option	Capital (\$ million)	O & M (\$ million)	Present Value (\$ million)
Rapid Release (680 - 100 GL)	-	-	-
Options which reduce use of:			
Menindee and Cawndilla	4.0	0.05	4.5
Cawndilla only	5.0	0.10	6.1
Cawndilla (+Menindee Outlet)	15.0	0.23	17.6
Menindee only	22.0	0.26	24.9
Menindee (+Cawndilla Outlet)	43.0	0.47	48.3
Deepening Lake Pamamaroo	15.0	0.45	20.1
Divide Menindee into Cells (fill one)	70.0	0.60	76.8

As will be shown in Section 6, eight local supply security offsets were developed and costed. The range of offset options and their estimated costs are shown in **Table 5.5**.

For this preliminary economic review, the covering of Stevens Creek reservoir and providing improved access to residual pools were included. These projects have a combined capital cost of \$68.5M and annual operation and maintenance costs of \$2.5M/year.

Table 5.5: Local Supply Security Offsets

Local Security Offset Option	Capital (\$ million)	O & M (\$ million)	Present Value (\$ million)
ASR bore field	52	1.00	64.3
GAB bore field	138	4.00	187.1
Pipeline from Murray River (Broken Hill)	263	3.00	299.8
Pipeline from Murray River (Weir 32)	320	3.50	363.0
Cover Stephens Creek Reservoir	63	1.50	81.4
Upstream Storages & Other Supplies	Un-costed		
Draw on Lake Speculation	Un-costed		
Improved Access to Residual Pools	5.5	0.95	17.2

The PBCA was a comprehensive analysis and included preliminary consideration of:

- cost of a typical offset program
- implementation works cost
- salinity penalties (and benefits)
- Lower Darling/Menindee irrigation penalties
- other NSW irrigation penalties
- effect on Sunset Strip property values

- value added to Menindee tourism
- value added to Hume recreational benefits
- hydroelectricity penalties (or benefits)
- salinity effects in urban areas
- water savings as measures by Lock 7 flow changes

Table 5.6 shows the main factors contributing to the PBCA results.

Table 5.6: Contributing Factors to PBCA Results

Scenario	NPV (7%)	Comprising (\$ million)				
	(\$ mill)	Savings	Works	Salinity	Irrigation	Other
Rapid Release (680-100GL)	(\$69)	\$26	(\$99)	\$29	(\$23)	(\$3)
Options which reduce use of						
Both Menindee and Cawndilla	(\$199)	\$55	(\$103)	\$20	(\$158)	(\$12)
Cawndilla	(\$170)	\$17	(\$105)	(\$62)	(\$21)	\$1
Cawndilla (+Menindee Outlet)	(\$181)	\$17	(\$116)	(\$62)	(\$21)	\$1
Menindee	(\$152)	\$18	(\$124)	(\$44)	(\$3)	\$0
Menindee (+Cawndilla Outlet)	(\$199)	\$19	(\$147)	(\$66)	(\$6)	\$0
Deepening Lake Pamamaroo	(\$157)	(\$3)	(\$119)	(\$35)	(\$1)	(\$0)
Divide Menindee into Cells	(\$207)	\$10	(\$175)	(\$47)	\$3	\$1

In summary, the preliminary results show:

- All options have very large negative net present values (NPV) ranging from - \$69M (Rapid Release) to -\$207M (division of Menindee into cells).
- Water savings provide the largest positive NPV. These values ranged from \$55M for reducing the use of both Menindee and Cawndilla to -\$3M for Deepening Lake Pamamaroo.
- While the rapid release option could break even with a near fourfold increase in the value of the saved water, most of the other options would require increases of ten or more.
- The cost of the works (\$99 to \$175M), salinity impacts (+\$29M to -\$66M) and irrigation penalties (+\$3M to -\$158M) are largely negative.
- When ranked in terms of NPV, the best three options are:
 - Rapid release, 680 to 100GL (-\$69M)
 - Reducing the use of Menindee only (-\$152M)
 - Deepening Lake Pamamaroo (-\$157M)
- As Deepening Lake Pamamaroo does not produce any evaporation savings, it was not considered further.

The key findings of the benefit cost and regional economic assessment are therefore as follows:

- substantial additional benefits and/or cost reductions are required to generate positive economic outcomes
- government intervention will therefore be required to implement the strategies
- opportunities to manage impacts using market mechanisms may be limited by the scale of the interventions required

- managing impacts outside the Lower Darling/Menindee region will involve complex compensatory mechanisms probably including changes to the current Hume/Dartmouth operating rules and the existing Murray-Darling Basin Agreement

For a set of preliminary analyses, the approach can certainly be regarded as comprehensive. However, in the hydrologic model, all the saved water and the irrigation penalties appears as extra flow to South Australia. As it is very rare for South Australian water users to be restricted, subsequent stages of the project's economic analysis may need to consider use of the "saved water" as a component in an environmental flow regime. This will require consideration of the constraints associated with:

- seasonal releases to be limited to winter months
- "saved water" being added to the recession limb of Murray floods in winter and spring months
- selling or trading the "saved water" on an opportunistic basis through a market mechanism to help fund environmental works

In the next stages of the project, the best schemes shall be tested using more sophisticated modelling. When water savings have been better defined, a further round of economic analyses will be undertaken using more complete cost estimates.

5.5 Outcomes from Multi-Criteria Assessment

A Multi Criteria Analysis (MCA) was carried out to incorporate not only the already quoted results of the hydrologic and economic modelling but also consideration of the likely impacts of each of the options on socioeconomics, indigenous heritage, indirect effects on water users, environmental impacts including impacts on fish, birds and particularly on threatened species and likely benefits from greater operational flexibility.

Table 5.7 provides a brief summary of the outcomes from the Multi Criteria Analysis. It also identifies offsets for the main impacts.

Of the modelled options, the best performers were the rapid drawdown (680 to 100 GL) option and the reduced use of Cawndilla with the existing Menindee outlet. The next best option was the reduced use of Menindee with the existing Cawndilla outlet.

These preliminary conclusions generally match those produced by the hydrologic and economic analyses.

Table 5.7 - Menindee Lakes Options – Results from the Multi Criteria Analysis

Option	Main impacts	Potential offsets
Allow for more rapid drawdown of lakes within defined storage ranges	Impact on diversions to Victoria and Lower Darling is up to around 10%, depending on triggers adopted.	Impacts on irrigation diversions may be offset by a combination of buy-back, compensation, residual pool access, pumping from the Darling River to Anabranch users NB Impact on diversions can be moderated through adoption of appropriate triggers.
	Impact on drought security for Broken Hill and local High Security entitlement holders.	Alternative supply for Broken Hill and other High Security Users. Refer Section 6.1.
	Low flows are more frequent compared to regulated conditions.	This is a return to more natural flow conditions, since regulation provided by the storages is removed. This should benefit the biodiversity of the Darling River.
	Possible ecological impacts.	Further work is required to fully understand the ecological changes that would occur as a result of more rapid drawdown, although it should be noted that some of the current residual pools are artificial and are growing in size due to siltation within the lakes.
	Social Impacts.	More rapid drawdown of lakes would generally decrease amenity value. Offsets include maintaining water levels at key recreational areas, plus improved facilities to compensate for overall reduced amenity. Sunset Strip and the caravan park require careful assessment
	Flow-on effects to tourism and local economy.	Any of the offset strategies also require careful consideration of the broader community and flow on effects to tourism, businesses and employment. These can only really be defined for the preferred strategy on a case by case basis.
Reduce use of Menindee and Cawndilla as storages, except for larger floods	Has the greatest impact on downstream security of supply. Most significant for Lower Darling users, but also would be impact Murray users in New South Wales and Victoria.	Impacts on irrigation diversions may be offset by a combination of buy-back, compensation, residual pool access, pumping from the Darling River to Anabranch users. May also need to consider purchase of farm enterprises. Impact on Murray users due to reduced storage at Menindee could be offset by adjusting Hume and Dartmouth lake operations
	Impact on drought security for Broken Hill and local High Security.	Alternative supply for Broken Hill and other High Security Users. Refer Section 6.1.
	Social Impacts.	Reduced use of both Menindee and Cawndilla would have significant social issues, since both lakes represent a significant water and lakeside recreational area, which is highly valued by visitors and the community. We would need to more accurately define how frequently the lakes will be dry, before the actual impact, and therefore offset be defined.
	Flow-on effects to tourism and local economy.	Any of the offset strategies also require careful consideration of the broader community and flow on effects to tourism, businesses and employment. These can only really be defined for the preferred strategy on a case by case basis.
	Extent of works in sensitive areas if an enlarged outlet from Cawndilla is included in this strategy.	Environmental assessments and management plans. Ecological impacts associated with works in Kinchega National Park could be offset to some extent by a proposed extension to the park.

Option	Main impacts	Potential offsets
Reduce use of Menindee as a storage <ul style="list-style-type: none"> Existing Cawndilla outlet Enlarged Cawndilla outlet 	Moderate impact on Lower Darling security of supply	Impacts on irrigation diversions may be offset by a combination of buy-back, compensation, residual pool access, pumping from the Darling River to Anabranh users. Impact on Murray users due to reduced storage at Menindee could be offset by adjusting Hume and Dartmouth lake operations.
	Impact on drought security for Broken Hill and local High Security.	Alternative supply for Broken Hill and other High Security Users. Refer Section 6.1.
	Social Impacts.	Menindee is one of the most publicly accessible lakes. As the icon lake it is highly valued by visitors and the community. Although some amenity value for Sunset Strip residents is retained, offset measures will need to be developed with the community if this is the preferred strategy.
	Flow-on effects to tourism and local economy.	Any of the offset strategies also require careful consideration of the broader community and flow on effects to tourism, businesses and employment. These can only really be defined for the preferred strategy on a case by case basis.
	Menindee is a fish breeding site	Potential offsets to be developed in next stage with DPI NSW Fisheries
	Extent of works in sensitive areas, particularly for enlarged outlet	Environmental assessments and management plans. Ecological impacts associated with works in Kinchega National Park could be offset to some extent by a proposed extension to the park
Reduce use of Cawndilla as a storage <ul style="list-style-type: none"> Existing Menindee outlet Enlarged Menindee outlet 	Significantly impacts Lower Darling security of supply – particularly Anabranh users.	Impacts on irrigation diversions may be offset by a combination of buy-back, compensation and residual pool access. May also need to consider purchase of farm enterprises. Impact on Murray users due to reduced storage at Menindee could be offset by adjusting Hume and Dartmouth lake operations.
	Impact on drought security for Broken Hill and local High Security.	Alternative supply for Broken Hill and other High Security Users. Refer Section 6.1.
	Social Impacts.	Cawndilla is not as readily accessible as Menindee. However it is located within the Kinchega National Park and is valued as a tranquil and remote waterside recreational area in the National Park.
	Flow-on effects to tourism and local economy.	Any of the offset strategies also require careful consideration of the broader community and flow on effects to tourism, businesses and employment. These can only really be defined for the preferred strategy on a case by case basis.
	Reduced ability to provide environmental flow to the Darling Anabranh.	Implications of this will need to be part of the next stage of assessment based on a better understanding of the frequency of which Cawndilla will be flooded, and environmental needs.
	Impact on bird breeding sites at Cawndilla	Impacts uncertain at this stage. A more natural wetting cycle could be a benefit, but reduced frequency of flooding could impact certain species. However, could be offset by improvements in upper lakes
	Extent of works in sensitive areas	Environmental assessments and management plans
Division of Menindee into two cells	May have some impact on Lower Darling Security of Supply depending on operation of system	Impacts on irrigation diversions may be offset by a combination of buy-back, residual pool access, pumping from the Darling River to Anabranh users.

Option	Main impacts	Potential offsets
	Impact on drought security for Broken Hill and local High Security.	Alternative supply for Broken Hill and other High Security Users. Refer Section 6.1.
	Social Impacts.	Majority of Sunset Strip residents support this solution
	Flow-on effects to tourism and local economy.	This option would have the least impact on tourism, since there would still be water in Menindee at the most accessible locations, except for during prolonged dry periods. Any of the offset strategies also require careful consideration of the broader community and flow on effects to tourism, businesses and employment. These can only really be defined for the preferred strategy on a case by case basis.
	Extent of works in sensitive areas, particularly for enlarged outlet	Environmental assessments and management plans. Ecological impacts associated with works in Kinchega National Park could be offset to some extent by a proposed extension to the park.
Increase capacity of upper lakes	Potential erosion of indigenous heritage sites	Liaison with local community to develop management plans and appropriate foreshore protection measures
	Extent of works – depending on new FSL and MSL, extensive cut and fill operations around lake perimeter may be required	Environmental assessments and management plans
	Depending on whether new embankments and regulators are required, fish passage may require consideration	Environmental assessments and management plans
	Depending on new FSL and MSL additional pumping may be required to surcharge lakes	Consideration of greenhouse gases

6.0 Potential Offset Solutions

The project also sought to generate a list of all possible offset measures to partially or fully reduce the social and economic impact of some of the water saving measures. The potential offset measures are listed in the following section.

6.1 Alternative Supply for Broken Hill and other High Security Users

6.1.1 Current Broken Hill Supply

Security of Supply

On average, the local reservoirs at Broken Hill are seldom full and town water supply is solely dependent on water sourced from the Darling River for eight years in every ten. In terms of water quantity, the security of supply for Broken Hill from the Lakes is historically close to 100%. However, water quality becomes the limiting factor during prolonged dry periods, when water is concentrated in residual pools within the lakes.

Existing Pipeline from Menindee to Broken Hill

Country Water advises that the pipeline from Menindee to Broken Hill will need to be upgraded in the near future. If the whole 120km of pipeline was to be replaced it would cost approximately \$100 million. Country Water has identified that if demand can be reduced, then this would also reduce the required pipe capacity. In this case it may be possible to line the pipeline, which would be significantly cheaper than replacement of the 600mm pipeline.

Incremental Gains of Increasing Capacity of Local Storages

Umberumberka and Stephens Creek reservoirs both contain significant deposits of silt, which reduce their capacity. There is a perception that desilting the reservoirs alone would improve the security of supply for Broken Hill. However, based on current cost estimates to desilt the reservoir and noting how infrequently the storages currently fill, this is not considered to be cost effective.

6.1.2 Potential Options to reduce Broken Hill's Reliance on the Lakes

Broken Hill and local users' reliance on the Lakes could possibly be reduced by covering some existing storages, by developing (and perhaps covering) new storages, by dedicating storage cells within lakes, by constructing a pipeline from the Murray or by using aquifer storage and recovery, or a combination of some of these measures. Each of these options is discussed below.

6.1.3 Storage Options

Use additional/existing storage and cover

For any alternative supply option, an efficient terminal storage is required that reduces the evaporative loss per unit volume that currently occurs from the lakes. Evaporation rates are extremely high in the Broken Hill – Menindee area, and since the feasible depth of excavation will be limited by costs and geotechnical constraints, an 18GL storage (i.e. the volume required to supply Broken Hill and High Security entitlement for 18 months) will still have a large surface area and experience high evaporative losses. Therefore it is recommended that options to cover any new terminal storage should be assessed as part of the long term strategy.

Any dedicated storage should be the most efficient possible. This includes proximity to existing infrastructure, possibly lining to protect water quality and reduce seepage losses, splitting into cells and covering. A number of alternative storages have been assessed, and these are described in the following sections.

Stephens Creek Reservoir

Stephens Creek reservoir holds approximately 18 GL. If Stephens Creek is to be used as a terminal storage for Broken Hill, it would need to be covered in order to reduce the evaporative loss. Based on available literature, it appears that 4ha is the largest area that can be effectively covered. Therefore fifty individual 4ha covers would be required to cover a 10GL storage at Stephens Creek, assuming existing bathymetry. It would be necessary to construct a framework to keep each individual floating cover in place, while allowing it to move up and down with the water level. It should be noted that if the supply is at the lakes and the storage is at Stephens Creek, a larger pipeline may also be required to fill the storage plus provide the ongoing supply.

The likely cost to cover Stephens Creek reservoir is estimated to be approximately \$60 million. However, this figure would be subject to detailed design and confirmation regarding feasibility.

Lake Speculation

Country Water analysed water quality samples taken from Lake Speculation during 2003 and 2004 as it retreated into a residual pool. The quality of the water was of concern.

With this in mind, plus the additional infrastructure required to facilitate pumping from Lake Speculation into the existing pipeline and the fact that Lake Speculation is an important ecological habitat, there is no benefit in developing Lake Speculation as a storage for Broken Hill supply over alternatives in areas which are already developed such as Copi Hollow or Stephens Creek reservoir.

Copi Hollow

High levels of contaminants are known to have occurred at Copi Hollow. Pumping from residual pools once water quality in the pools has deteriorated is not recommended for Broken Hill water supply because of the documented quality issues that occur in residual pools.

The objective of proposed schemes is to achieve significant savings, and a new dedicated storage should, if possible, be covered in order to reduce evaporative losses. The social implications of covering Copi Hollow would be unacceptable, and therefore this option is not considered further.

Dedicated Storage in Lakes

This option involves constructing and possibly covering a deep storage (possibly multi-cell) in the vicinity of the lakes.

An 18 GL storage, which is say 9 metres deep would have a surface area of 200ha. Assuming a maximum area of 4ha can be covered, this would require fifty 4ha covers, which would cost approximately \$60 million (refer to cost estimate to cover Stephens Creek reservoir).

Essentially this option would be implemented in conjunction with the option to reduce use of certain lakes, or to draw levels down more quickly. Another advantage of locating the storage at the lakes is that the capacity of the pipeline to Broken Hill only needs to be sufficient to provide Broken Hill's demand. It should be noted that pumping from residual pools once water quality deteriorates is not considered to be acceptable for Broken Hill water supply.

Two potential locations have been identified at the lakes.

North Copi Hollow

The first is a depression located to the north of, and isolated from the existing Copi Hollow storage. This site is referred to as North Copi Hollow. It has an area of 155 ha at a level of 62 m AHD, and therefore the capacity would need to be increased by excavation and levee building to create about 10m depth, providing 15GL, which could supply Broken Hill alone for 18 months. Lining may also be required.

It is envisaged that this storage would be filled by pumping water from Weir 32. North Copi Hollow is located close to the existing supply pipeline, which has obvious advantages.

Developing and covering a storage at this location would not affect the recreational values of Copi Hollow. Furthermore, water quality can be more readily managed through flexibility in choice of the water source.

Adjacent to other upper Lakes

The second option is to construct a multi cell ring tank adjacent to one of the other lakes.

Alternative storage options will be further assessed during the next stage of the project.

6.1.4 Pipeline from the Murray

Some members of the community have looked to the River Murray as a secure source of water for Broken Hill. The water quality is good, and therefore it would improve the current situation at Broken Hill during prolonged dry periods when poor water quality becomes an issue.

However, some Broken Hill residents are against the pipeline proposal due to the high cost and ongoing pumping requirements, which will be significantly higher than the current situation. There is also a concern that the pipeline would serve present demand but not potential growth, and that water currently stored in Menindee for Broken Hill supply would be given to irrigators upstream.

A range of pipeline options were considered, including:

- supply direct to Broken Hill (with and without terminal storage)
- supply to Broken Hill and High Security Irrigation at Menindee (with and without terminal storage)

The cost of these options ranged from approximately \$200 million to \$500 million depending on the demand supplied and the availability of a suitable terminal storage (which is not included in the above cost).

Although there is currently limited community support for a pipeline from the Murray, no other potential fatal flaws have been identified to date and therefore we recommend that this option is considered further in the next stage of the project. Alternative sources such as ASR (described in the following Section) would be more cost effective, but ASR is much more uncertain in terms of its technical feasibility, compared to a pipeline from the Murray.

6.1.5 Aquifer Storage and Recovery

Aquifer Storage and Recovery (ASR) is the injection and storage of water in an aquifer during times when water of good quality is available, and the recovery of water from the same borehole during times when it is needed. ASR has evolved rapidly during the past 25 years and is now being applied throughout the world, with some well-documented work in South Australia. It is an alternative way to store water to reduce the loss from evaporation.

Previous studies have identified two areas where aquifer storage and recovery might be hydrogeologically feasible and operationally advantageous. These areas are:

- downstream of the Stephens Creek dam and the Barrier Highway
- alluvium and shallow aquifers at Menindee, near Weir 32

Both are located close to existing infrastructure, but would require the development of new bore fields. Initial investigations of both sites by others have indicated that ASR schemes *could* be feasible, but it is emphasised that further work is required to prove this. Furthermore, ASR schemes are not 100% efficient (i.e. it is not possible to pump out all the water that is injected into storage). This loss would need to be compared to existing evaporative losses.

This option will require further technical investigations before it can be considered part of a strategy.

The ASR schemes could cost between \$50 and \$90 million. These estimates include significant investigative costs, and as indicated above, their feasibility is uncertain.

6.1.6 Reducing the Reliance on the River through Rainwater, Reuse and Efficiency Measures

Broken Hill's demand on the Darling River may be reduced by using alternative sources of water such as treated effluent, greywater and rainwater. Reducing demand in combination with a new supply and/or storage for Broken Hill could also defer infrastructure costs, particularly if the pipeline from Menindee to Broken Hill is still required to pump water from a dedicated storage located in the Menindee area.

- **Effluent Reuse** – more recycled effluent could be used on parks and ovals in Broken Hill. There is potential to save 1GL/a. A further possibility may be to develop indirect potable reuse to further reduce demand on the existing system.
- **Greywater reuse** - greywater is household wastewater that has not come into contact with toilet waste, (i.e. waste water from the bath, shower, bathroom wash basins, washing machines, and laundry). Greywater could be diverted and used for residential garden watering. Increased greywater reuse may reduce the potential saving from effluent reuse.
- **Rainwater tanks** – The amount of water that can potentially be saved through installation and use of rainwater tanks depends on the amount of rainfall, size of roofs, and ability to capture rainwater from downpipes. To gain the full benefits of rainwater tanks they must be connected to at least the toilets and preferably toilets and washing machines and also used for lawns and gardens.

Country Water's H2Overhaul program does not provide an alternative source. However, it reduces demand on the potable supply by implementing water efficiency measures in the households.

6.2 Basin Wide Strategies

6.2.1 Overview of Basin Wide Evaporative Losses

So far, this report has focussed on reducing evaporative losses at Menindee Lakes. However, the twenty year strategy will aim to reduce evaporation from storages throughout the basin, and this will be implemented for whichever changes are made at Menindee. The storages in the Darling River Basin can be divided into three broad categories:

- a) Major Storages – very large storages, either man-made dams or modified lakes, which are usually State owned.
- b) Ring Tanks – large on-farm storages, which are usually situated on the flood-plain and filled by pumping from the river. They can also include natural areas modified to trap overbank flows. Additional work is required to establish a register of on-farm storage capacities and local evaporation rates to better understand the losses from these storages.
- c) Hillside Dams – small on-farm storages that are usually built in valleys and collect hillside run-off. There are an estimated 170,000 hillside dams within the Darling River Basin. Again, the data for on-farm hillside dams is unreliable and in many cases can only be estimated. As with ring tanks, a register of dams and their characteristics should be established to better understand the extent of evaporative losses from these storages.

There is a range of mechanisms which could be considered to encourage landholders to improve on-farm storage efficiency. Following the philosophy of “he who pays, gets the savings”, the government could wholly fund improvements and return the savings to the environment. However, a more appropriate and realistic approach would be for the government to pay for part of the measures, such that the savings could be shared between the environment and the landholder. It should be noted that this is not necessarily the cheapest option available to landholders to secure additional water.

6.2.2 Methods to Reduce Evaporation

A number of methods to reduce evaporative losses have been developed and are outlined below.

- Monolayers - consists of an invisible one molecule thick layer across the surface of the water that retards evaporation
- Shade cloth has been modified to reduce evaporative loss from water storages, by suspending it over the water surface thereby reducing both solar radiation and wind speed across the surface of the water
- Floating covers usually consist of a multi-layered membrane with air pockets to allow it to float on the water surface and holes to allow rainwater to pass through the membrane
- Sealed Surface Covers are similar to the floating cover, but cover the storage completely and form an air-tight seal
- Modular Floating Covers consist of modules either free-floating or attached together, which work by restricting the air movement at the water surface and reducing the area of water exposed
- Windbreaks formed by trees planted around a dam should reduce wind speed across the water surface and provide shading from solar radiation reducing water temperature and therefore evaporation

For evaporation reduction methods to be successful in reducing on-farm evaporation losses, more work is required to collect further data and carry out further studies to improve reliability of estimates of the amount of water that could be saved. Further studies are required on assessing the evaporation reduction technology and its affect on the environment and other water users.

6.2.3 Storage Design and Management

The usual method to optimise design of storages to minimise evaporation is to decrease the surface area to volume ratio of the storage by making the storage deeper. This can be done by either increasing the embankment height, or splitting the storage into cells enabling greater depths of water to be maintained with the varying volumes of water stored. Increasing embankment height or siting the storage in a sheltered area may also reduce wind speed across the surface thereby decreasing evaporation. A number of technical considerations are required prior to modifying existing storages. Careful operation of the water storage system will also reduce evaporative losses.

A key component of integrated schemes is to develop Best Practice Guidelines for construction and operation of on-farm storages. This should include a comprehensive education and publicity campaign.

6.2.4 Application of Market Mechanisms within Darling River Basin

The application of market mechanisms is an option that could be used to encourage water conservation and efficiency through market signals rather than through explicit directives. To date, trading has mainly applied to water for consumptive use. That is, while allocation decisions may have given consideration to environmental requirements, it has not been considered a trader on the water market. This is changing as a number of organisations are considering trading water on the environment's behalf. Market mechanisms could therefore be utilised to claw back the apparent over allocation, which could then be allocated to the environment.

Markets are already making a significant contribution to increasing rural water use efficiency. However, as the entitlements held do not always match water supply characteristics required by the environment, progress could be made to allow for more flexible market mechanisms to meet the variable nature of environmental requirements. The "trading rules" controlling the storage and release of the Barmah-Millewa Environmental Water Allocation (EWA) is a case in point. Some mechanisms currently in use could be used to improve the flexibility of the water trading market.

Different market schemes will have different strengths and weaknesses. Some provide more security of water availability while others provide flexibility to meet variable environmental demands. Therefore, the market mechanisms used need to be tailored for a given location.

Consideration of market measures should focus on how the water recovered for environmental use will meet the ecosystems requirements. Due to the complexity of the river system, much more work will be required to estimate the water requirement profile for the environment and to ensure the water reaches the environmental sites where it is needed and does not flood irrigation land. Uncertainty is likely to remain, and revisions to the estimates will be required over-time.

Water trading is limited by the physical boundaries within which water can be transported by the environment. It may not be possible to trade water from one physical area to another due to the impossibility of transporting the water into a different catchment for example. Robust trading rules need to be defined for a given trading zone before market mechanisms can be introduced. At present, these rules have not been established for the whole catchment. A more detailed hydrologic model will also be required in order to simulate system behaviour and transmission losses. The model may also need to include forecasting capability to ensure flows are delivered when required.

The value of water to irrigators will be the highest during dry periods. However, high environmental demands are likely to occur during flooding events, that is, when the value of water is low to irrigators. Therefore, during dry periods, when environmental demand is low, water could be sold on the market and then using the funds generated from these sales, water could be brought back during wet periods, when a large volume is required by the environment and the price is low. Again, the Barmah-Millewa EWA rules operate in this way.

The cost-competitiveness with alternative water savings measures, such as infrastructure works and on-farm savings also needs to be considered.

In conclusion, market mechanisms can provide a flexible approach that will more effectively meet the highly variable watering needs of both irrigation and the environment. However, before market mechanisms can be effectively implemented more work needs to be done in the following areas:

- a) A clearer definition of the variable needs of the environment in the Lower Darling and in South Australia is required to enable the optimum market options to be set-up and used to meet these demands.
- b) Analysis of seasonal trends to predict under a given market plan whether future water availability will be sufficient to supply the environmental needs.
- c) A water audit to establish more robust figures of where water is currently extracted or lost in transmission losses.
- d) Analysis of market data to develop the most cost-effective portfolio of market mechanisms to provide environmental water requirements.
- e) Initial funds required to set-up the market mechanisms and begin trading need to be established.
- f) Potential price impacts on the market need to be considered in more detail.
- g) The issue of how differences in carry-over provisions in different States are treated would need to be resolved.
- h) Links to other impacts, such as salinity, ground water etc should be established and incorporated into the scheme used.
- i) Suitability of each mechanism need to be assessed against:
 - Environmental water requirements
 - Opportunity cost of water to users
 - Transaction costs
 - Third party impacts

6.3 Associated Works and Offsets

6.3.1 Associated Works and Offsets in the Vicinity of the Lakes

Raising Full Storage Level in Certain Lakes

State Water currently operates Lakes Menindee, Cawndilla and Pamamaroo using the Maximum Surcharge Level (MSL) as the effective Full Storage Level (FSL). Both were previously lowered due to concerns regarding erosion of aboriginal cultural heritage sites. However, State Water report that the revised practice of using the MSL as the FSL has been quite satisfactory. In fact a higher FSL may be achievable at Pamamaroo. Lesser increases are possible for Menindee and Cawndilla.

An associated operational option that may enhance water savings may be to raise the FSL by 0.5m to 1m in certain lakes. This may increase the surface area, hence evaporation loss. However, the proportion of water lost compared to the total volume stored should decrease. The preliminary hydrologic modelling undertaken has effectively reflected the operational practice of drawdown from MSL, taking into account seasonal variations in storage targets to allow for flooding patterns.

Hume and Dartmouth Interaction Rules

This additional operational component is a refinement to the strategy for reducing the use of the storage function of Lakes Menindee and/or Cawndilla. The decision to selectively exclude inflows to lakes would be made with a knowledge of available water in storage in the River Murray system (and particularly in Hume and Dartmouth but also Menindee and Lake Victoria) and assessing whether there is a need to store additional water in the Darling system, or whether flows can be allowed to pass downstream.

Co-ordinating the changed operation of Menindee with Hume and Dartmouth in this way provides some intelligence to limit the impact on overall water security outcomes, while providing some additional lower river flooding and significant saved evaporation. It can offset some of the diversion changes in the NSW and Victorian Murray system that may occur as a result of the works at Menindee Lakes.

After drawing on Lake Victoria, the current harmony operation seeks to draw next on Menindee, in preference to the Murray storages, to supply downstream demands. This recognises the large volumes associated with Darling floods as well as the evaporative inefficiency of the Lakes. The proposed modification is an extension of the same philosophy.

Although there would be some discounting of the saved evaporation due to water being occasionally allowed into the lower lakes, overall impacts on system security must be appropriately addressed.

If Murray storages are drawn on more often, due to reduced Menindee Lakes storage, the existing constraint at Barmah Choke could become an issue on a more frequent basis.

Review Additional Dilution Flow Rules/Develop Salinity Mitigation Rules

The Additional Dilution Flow (ADF) rules were created to provide a fixed pattern of additional releases from the Lakes when the total Menindee storage volume is above 1300 GL and total storage in the system is above 2-3000 GL, and are made at 3 GL/day. The effect of reducing the use of certain lakes may have the effect of “turning off” the ADF rules because the Lakes do not reach the ADF storage trigger volumes. Hence such options can exhibit significant salinity impacts and therefore similar salinity costs.

Where schemes create potential salinity impacts with significant economic costs, it may be appropriate to:

- investigate the adequacy of the modelling framework to reflect salinity management objectives (eg Additional Dilution Flow rules)
- develop salinity management rules which could mitigate salinity impacts without drastically altering the water saving outcomes.

An example of a salinity mitigation rule could be to restrict Lake Cawndilla releases (this assumes an enlarged Cawndilla outlet is implemented) when lake salinity is above a certain value. It may have the effect of reducing opportunities to draw on Cawndilla, but it would reduce the downstream salinity costs.

Residual Pools Access

Previous studies have scoped and costed works to access residual pools. These were briefly discussed in Section 5.1 as a short term drought management option, which is extremely valuable to some irrigators to avoid complete crop failure during “crunch times”.

Both Cawndilla and Menindee residual pools have been accessed in the past. If the Cawndilla outlet remains as it is, future access of the residual pool may be enhanced by utilising the Penellco Channel to pump the water into the Darling for downstream use. However, this requires pumping the water firstly into Tandou Creek, and then pumping again into the Darling.

Future access of Menindee residual pool to optimise water supply operations may be commensurate with options that focus on utilising Lake Menindee as a storage. Access could be improved by enhancing the efficiency of Menindee Creek, which drains to the outlet regulator. This would essentially alter the meandering channel to a more direct route, increasing the velocity and therefore reducing siltation. The route would need to be carefully selected to avoid trees and heritage sites.

Likewise, should Pamamaroo residual pool need to be accessed for any of the options, a similar exercise could be carried out, forming a straightened, more efficient channel from the residual pool in the northern part of the lake, to the outlet regulator in the south east corner. This would improve drought security for Lower Darling users.

Further up the lakes system, consideration could be given to accessing Bijije and Balaka residual pools. State Water notes that the Balaka weir, which is a relatively small structure a few tens of metres long and a couple of metres high, currently holds back a large residual pool. State Water advises that its removal would result in some water savings in terms of reducing the area of the residual pool that remains when Wetherell is drawn down.

Increased Pumping across Penellco Channel

Currently, when water cannot be released by gravity from Lake Cawndilla to supply the Tandou enterprise, the company pumps water from the Darling across the Penellco channel. For those Menindee Lakes options which include a reduced use of Lake Cawndilla, a possible offset would be compensation for the increased private pumping required to maintain the status quo.

6.3.2 Associated Works and Offsets in the Wider Basin

Renegotiate Water Shares

Water Sharing Plans were introduced in NSW in 2004 and now apply to most NSW river valleys. Each of these plans includes Bulk Access Regimes (BAR), which specify provision for environmental flows and identify the proportion of water available for extractive use by licensed water users. NSW has developed a Water Sharing Plan in the Murray Valley (*Water Sharing Plan for the Murray and Lower Darling Regulated Rivers Water Source*).

Each plan applies for a period of 10 years. During the life of the plan, any changes to water management arrangements that reduces the security of supply for consumptive users from that specified in the BAR may incur compensation. However, this specifically excludes compensation for any reduction in access to supplementary water.

Therefore impacts on license diversions associated with water saving options may require compensation, if done within the life of the Plan. Also, if water savings are generated on-farm from Government investment in water savings it may be necessary to revise the Plan to ensure that 'saved' water is returned to the river.

Review Runoff Harvesting under Water Sharing Plan

Water Sharing plans for the Darling tributaries contain provisions for sharing access to unregulated flow events. In addition, flood plain harvesting is recognised within the hydrologic modelling for the water sharing plans.

Renegotiation of rules for unregulated harvesting under a water sharing plan may include adjustment to the rules of access to unregulated flow events, including those which are currently accessed from flood plain diversions.

Fund On-Farm Water Use Efficiency Measures

Options should be explored to fund on-farm water efficiency measures, which may help to accelerate the take-up of new initiatives. Often the capital cost of water saving initiatives, such as covering storages, more efficient water distribution and implementation of more efficient irrigation devices can be delayed and/or prevented by cash-flow constraints.

However, this should also include mechanisms to ensure that the 'saved' water is returned to the river. This would include possible sharing arrangements.

Compensation or Buy-Back

In some circumstances it may not be feasible to offset impacts on diversions. In these situations it will be necessary to either compensate and/or buy back licences. In some situations it may even be necessary to purchase an entire enterprise if its overall viability is affected by loss of the water allocation. However, these will need to be treated on a case-by-case basis.

6.4 Other Offsets

Ecology

All works will ultimately require environmental impact assessment and approvals prior to construction. They will also require construction and operational management plans to manage environmental impacts.

Significant changes to the operational regime of a lake are likely to affect the local ecology, since the communities are currently tuned to a more regulated regime. The rate of draw down of lake levels is an important factor on the extent of impact, so some of the options considered would alter the ecology. However, one might accept this change at the affected lake and offset this by returning other lakes to a more natural wetting and drying cycle.

It should be noted, that returning water savings to the river would aim to achieve a net benefit in the overall system. Buy back of licence entitlements could also realise ecological benefits. However, the returned flows need to be released in an appropriate pattern.

It is understood that there may be an opportunity to extend Kinchega National Park as a possible offset measure for works that may impact the area.

Indigenous Heritage

The project team sought feedback on cultural heritage issues with a range of indigenous stakeholders from Menindee to Broken Hill. The outcomes of these face-to-face meetings revealed the strong traditional ownership and spiritual significance of Menindee Lakes to Aboriginal communities

throughout the Darling River catchment and beyond. Of paramount concern by all involved in the preliminary round of consultation were the conservation, protection and management of significant sites and places in the area.

Discussion on the impact of the various options was sometimes difficult due to strong traditional relationship and ownership over Menindee Lakes combined with the potential massive effects of some of the structural options. It remains challenging to explain the complex nature of the options up to this stage particularly as there was a very long list of options presented. Therefore it is strongly recommended that additional consultation be carried out as soon as short-listed schemes are revealed since this short-listing permits better focus. Discussion up to this point remained somewhat general, although a range of opinions was revealed on the acceptability of certain components.

Previous investigations have highlighted the existence of numerous sites of Aboriginal cultural heritage significance and the ongoing close Aboriginal ties to the area. The Menindee Lakes ESD Project collated this material and conducted further investigations to address some of the known shortfalls. However the investigation process has raised some new concepts and variations of existing concepts and therefore additional on-ground work is recommended as well as further scoping of several offset measures raised by the Aboriginal community.

Social Impacts

The potential area of influence of this project covers a wide geographic area that encompasses a diverse range of stakeholder groups whose social and economic well being is linked to the Darling River and Menindee Lakes.

Also, as a result of the MDBC operating rules, the area of influence of proposed strategies extends beyond the physical project boundaries into the River Murray upstream and downstream of Wentworth.

There are a number of potential direct impacts to water users, the local community and the environment associated with a changed flow regime in the Darling River and reduced use of the Menindee Lakes as water storages. These include:

- loss of income and revenue due to reduced irrigation supplies
- lost opportunity for further development of irrigation infrastructure due to restricted access (both at Menindee and upstream/downstream)
- impact on businesses which rely on water in the River and Lakes – for example Speed Boat Club, Sailing Club, tour companies, and caravan park
- social well being of those living near the River and Lakes
- economic value of properties near the River and Lakes
- lack of employment as a result of the above, across all sectors of the community
- loss of recreation opportunities (camping, boating, skiing, jet skiing, swimming, relaxing and enjoying community and family functions at key social centres such as the Speed Boat Club).

Appropriate offset measures to reduce impacts associated with the above will therefore need to be considered during the next stage of the project, when impacts can be more accurately defined. Such measures shall be developed through ongoing dialogue with any affected communities. The project team and Steering Committee strongly recognises the value the local community places on their quality of life and the central role that the Darling River and Menindee Lakes play in their feelings of overall well-being. This is an aspect of the project which is intangible, yet must be recognised and addressed.

There may be a loss of amenity to the local community as a result of reduced use of certain parts of lakes. There are many camping areas around the lakes and alternative and improved sites should be located, if this is what the community would like to see.

The mix between accessible areas, and isolated tranquil areas should be retained. Initiatives such as boardwalks with birdwatching areas and viewing platforms may be a recreational opportunity that could be developed as part of an integrated scheme.

Tourism is crucial to the regional economy, and development of an innovative integrated strategy should be linked with a wider strategy to build on the tourism potential of the area. There is potential to create new diversified employment through the development of a mass tourism business at magnet icons like Broken Hill and Menindee Lakes (similar to Alice Springs and Broome).

It has been demonstrated that people can be attracted to the outback experience and can provide revenue, and a workforce. Such ideas should be developed by the community. What would represent a good tourism draw card to attract visitors to the area, and what is required to make it happen? An ecotourism strategy focussing on the serenity and wildlife of upper lakes could be an interesting contrast to Silverton and Broken Hill environs. Improved infrastructure is likely to be a necessary component.

If there are significant impacts on irrigation diversions that result in loss of local employment, offset measures will need to be developed that provide some alternative employment. The flow on effects to the wider community and economy will also need to be considered.

7.0 Integrated Schemes

7.1 Introduction

Following identification and assessment of Menindee Lakes options, associated works, operational strategies, basin wide initiatives and offset measures, these components were drawn together into six integrated schemes for further assessment in the next stage of the project.

This section summarises the findings from the initial part of the study, and then describes scheme development and provides a discussion of the assumptions inherent in the integrated schemes. Scheme components are then detailed, and the actual schemes presented in **Table 7.3**.

A “desk top” adjustment to actual modelled water savings has been carried out for the integrated schemes. The adjustment has been applied to the maximum water saving to account for evaporation that might be expected to occur with periodic flooding and occasional storage in certain lakes. The revised water savings are summarised in **Table 7.2**. Cost estimates of capital works at Menindee Lakes are provided at the end of this section.

7.2 Findings from Initial Part of the Study

The findings from the initial part of the study are as follows:

- a long list of “fringe options” were analysed, and largely rejected
- the report then concentrated on a preliminary short-list of Menindee Lakes options and offsets required for Broken Hill and other High Security users
- hydrologic studies showed significant water savings and increased flows to South Australia but identified irrigation penalties and downstream salinity effects
- economic studies (incorporating both works and selected offset costs) showed that serious (government) interventions will be needed to implement the best options and identified dollar relationships between water savings, cost of the works, salinity effects and irrigation penalties
- a Multi Criteria Analysis (MCA) was carried out to assess each option against a number of criteria to address the project objectives

7.3 Scheme Development

A two day workshop debated the above conclusions and then agreed to:

- develop integrated schemes based on the conclusions of the Background Report.
- concentrate on the available evaporation savings and operational flexibility
- seek positive interactions between selected works and operations
- develop a comprehensive and integrated set of offsets for affected parties
- prepare detailed descriptions of six schemes covering key elements, local operations, construction works, potential impacts, upstream efficiency measures and Broken Hill security measures

7.4 Assumptions

The next stage of this project will investigate benefits and costs of the six schemes to develop a 20 year water saving strategy. Investigations will test the following assumptions that are inherent in many of the six schemes presented in this section.

- Irrigation penalties can be reduced by reviewing the Hume/Dartmouth/Lake Victoria/Menindee harmony operation rules.
- Salinity impacts can be reduced by reviewing dilution flow triggers and other salinity mitigation rules.
- Operational flexibility (particularly access to residual water), rapid draw-downs and the use of enhanced outlets re-visited with revised storage operation rules at Menindee.
- Engineering feasibility (and cost) of any new banks within Lake Menindee.
- High Security Users drought security maintained.

7.5 Scheme Components

The Schemes, which are presented in **Table 7.3**, are based on the most favourable Menindee Lakes options in terms of water savings, coupled with offsets to address potential impacts that were identified in **Section 5** and **Section 6**, plus associated local works and basin wide initiatives.

The six Menindee Lakes options, which form the basis of the Schemes, are as follows:

- 1) reduced use of Lake Menindee as a storage, except for larger floods
- 2) reduce use of Lake Cawndilla as a storage, except for larger floods
- 3) reduce use of Lakes Menindee and Cawndilla as storages, except for larger floods
- 4) divide Lake Menindee into two cells – reduce use of half Menindee and all Cawndilla
- 5) divide Lake Menindee into two cells - reduce use of half Menindee only
- 6) allow more rapid drawdown of lakes – which can also be combined with any of the above

Offsets identified for possible inclusion in the Schemes are:

- secure water supply for Broken Hill and other High Security users
- compensation including licence buy-back and enterprise purchase
- access residual pools for drought security
- review Hume and Dartmouth interaction rules
- review Additional Dilution Flow and develop salinity mitigation rules
- renegotiate and revise Water Sharing Plans
- changes to the Murray Darling Basin Agreement
- measures to promote effective management and promotion of indigenous cultural heritage
- research devoted to the Aquifer Storage and Recovery (ASR) options
- social and ecological offsets, which will be developed for the preferred strategy
- extension of Kinchega National Park

Likewise, basin wide initiatives linked to most Schemes include:

- reduction of on-farm evaporation
- improved on-farm water use efficiency, including funding
- best practice construction and operational guidelines for on-farm storages
- review runoff harvesting under Water Sharing Plans
- market mechanisms

Additional local works and operational changes include:

- possibly raising FSL of certain lakes by 0.5 – 1m
- selective flood fill and rapid release
- remove Balaka weir

The offsets, which are included in the Schemes presented in **Table 7.3**, have been chosen to illustrate the type of works and measures that may be required. However, the final mix of offsets can only really be defined for the preferred scheme/strategy following better definition of the impacts and more comprehensive consultation with the affected stakeholders. Some of the offsets, such as possible compensation, will need to be developed on a case-by-case basis.

It is believed that the six Schemes warrant further investigation in the next stage of the project.

7.6 Evaporative Savings

7.6.1 Assumed Filling and Emptying Rates

Following the initial identification of the integrated schemes, WMA carried out a desk top analysis to better define the range of evaporative savings for a number of the Menindee Lakes options. This was based on assumed filling/emptying rates and frequencies for each of the Menindee Lakes, as presented in **Table 7.1**. The lakes have been assumed to be emptied based on an average outlet capacity, with emptying taking place as soon as practicable. An average outlet capacity has been used in recognition that the outlet capacity will reduce for lower lake volumes. Any operational or resource management requirements that dictate increases in the assumed emptying durations or filling frequencies presented in this document will result in substantial reductions to the revised volumes of water savings presented.

7.6.2 Filling of Lakes for Flooding and Murray Resource Security Purposes

The times that the lower lakes might be filled for both flood mitigation purposes, and when resources in the Murray system are low have also been assessed. In all instances, filling of the lakes occurs over a substantially shorter timeframe than emptying.

The decision to store floodwaters was based on an inflow threshold of 2,000GL/Month. This roughly equates to an overbank flood event with a daily flow of 66,000ML/D and a percent exceedence of probability of about 1%. These events can be seen in **Figure 7.1**.

The joint analysis trigger for the Murray low resources scenario was based on the times when the combined Hume and Dartmouth storage volume fell below 20%, and there was greater than 20th %tile flows in the Darling (250GL/Month). In most instances low Darling flows coincide with Low Murray Resources, consequently, opportunities to supplement Murray resources through use of the lower lakes occurs on only five occasions. These are not concurrent with the times at which the lakes are used for flood mitigation purposes, meaning that the lower lakes are likely to be refilled on a total of eleven occasions during the period of analysis.

Instances of filling for flood mitigation purposes and Murray resource security are shown as negative values in **Figure 7.2**.

Rules for storage of water in the lower lakes, co-incident with low Murray storage conditions will be modelled explicitly over a range of thresholds during the next phase of studies.

Table 7.1 Adopted Lake Filling and Emptying Rates

Reduced use of Lakes Menindee and Cawndilla as storages	
<u>Filling Rate (GL/Month)</u>	<u>Emptying Rate (GL/Month)</u>
450	135
<u>Time to fill (months)</u>	<u>Time to empty (months)</u>
3	10.5
Reduce use of Lake Menindee as a storage	
<u>Filling Rate (GL/Month)</u>	<u>Emptying Rate (GL/Month)</u>
750	90
<u>Time to fill (months)</u>	<u>Time to empty (months)</u>
1	8.0
Division of Lake Menindee into cells (Reduced use of half of Lake Menindee Only)	
<u>Filling Rate (GL/Month)</u>	<u>Emptying Rate (GL/Month)</u>
750	90
<u>Time to fill (months)</u>	<u>Time to empty (months)</u>
0.4	4.0
Reduce use of Lake Cawndilla as a storage	
<u>Filling Rate (GL/Month)</u>	<u>Emptying Rate (GL/Month)</u>
300	45
<u>Time to fill (months)</u>	<u>Time to empty (months)</u>
2	15.7

7.6.3 Adjustments to Previously Presented Water Savings

The water saving volumes for each scheme differs from those initially presented in the Webb McKeown hydrology report that focused on component options. In general the volumes identified under the option analysis will have to be discounted for times when the lower lakes are refilled, and increased in recognition of any drought security measures that result in the volumes of water that has to be set aside for Broken Hill and High Security requirements decreasing. Further optimisation of storage operation may also result in increased saving volumes. However, such optimisation analysis is beyond the scope of this current stage of the project.

New “desktop” estimates of water savings volumes, based on the revised filling frequencies and potential savings that can be realised under revised drought security arrangements are presented in **Table 7.2**. Savings are reduced by the order of ten percent for many of the schemes involving decreased storage use. However, schemes that do not require lake refilling (i.e. rapid drawdown) or only require small fill volumes (half Menindee) may experience increased savings as a result of drought security measures.

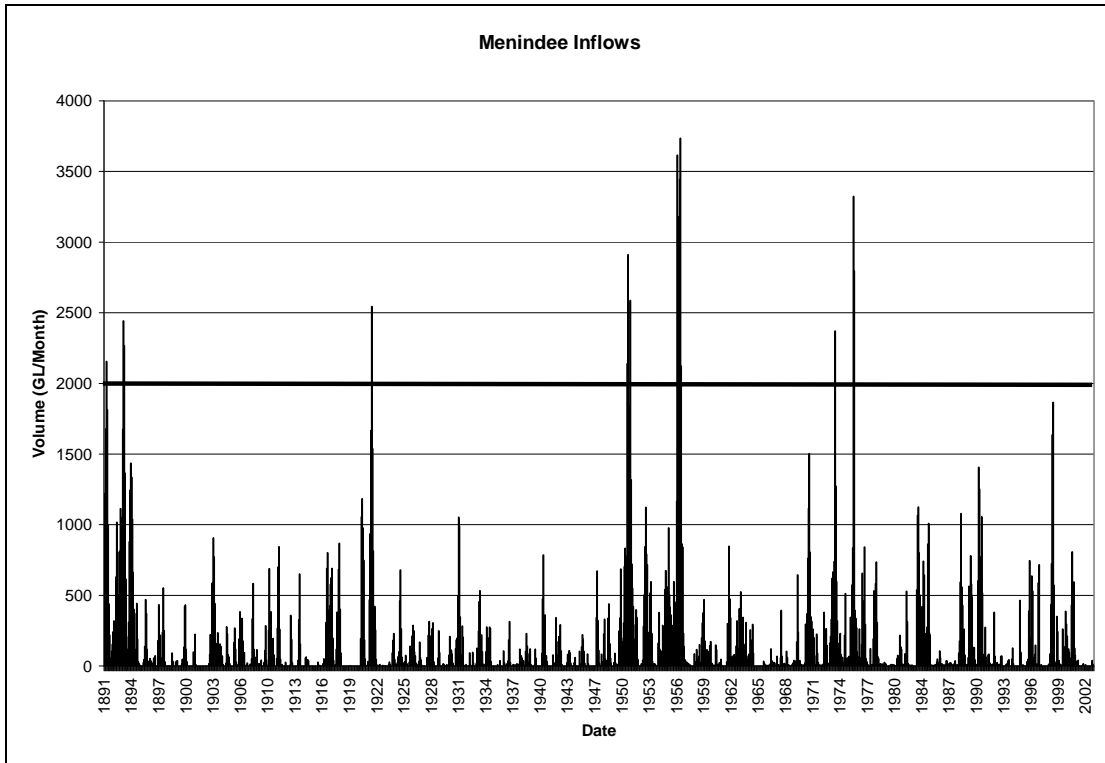


Figure 7.1 Menindee Inflows GL/Month

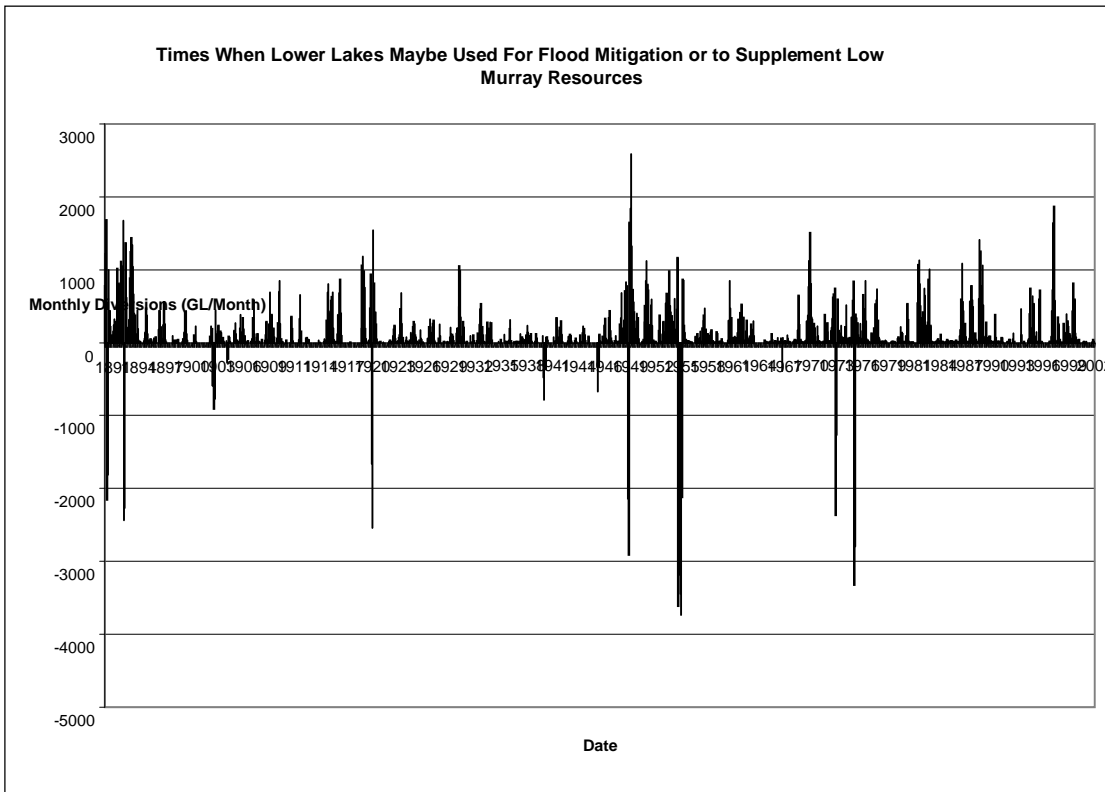


Figure 7.2 Menindee Filling Events (GL/Month)

Table 7.2 Revised Water Saving Volumes

Scheme		Original Saving (GL/Yr)	Saving Discount for Flood Mitigation and Murray Resource Security (GL/Yr)	Saving Increase as a result of improved drought security arrangements. (Based on using Lake Tandure) (GL/Yr)	New Saving (GL/Yr)	% Change
1	Reduce use of Lake Menindee as a storage	134	15	9	128	-4%
2	Reduce use of Lake Cawndilla as a storage	76	19	9	66	-13%
3	Reduce use of Lakes Menindee and Cawndilla as storages	211	33	9	187	-11%
4	Partition Lake Menindee into cells (Reduced use of half of Lake Menindee and all Lake Cawndilla)	146	23	9	132	-10%
5	Partition Lake Menindee into cells (Reduced use of half of Lake Menindee Only)	70	4	9	75	7%
6	Allow more rapid drawdown when in NSW Control (480GL to 200GL)	54	no change	9	63	17%

7.7 Scheme Summary

Table 7.3 presents a summary of the Menindee Lakes works, associated works and operational strategies, basin wide initiatives and offset measures for each of the six schemes, which are recommended for further assessment and refinement in the next stage of the project.

Table 7.3 Scheme Summary

Scheme	Menindee Works	Securing Broken Hill and High Security Water Supply	Wider Basin Initiatives
1	Reduced use of Lake Menindee		
	<ul style="list-style-type: none"> • Construct a bypass channel within Lake Menindee. • Construct a new regulator and outlet channel for Lake Cawndilla • Improve access to residual pools. 	<ul style="list-style-type: none"> • Demand management. • Additional domestic rainwater tanks & recycling. • Improvements to Stephens Creek Reservoir. 	<ul style="list-style-type: none"> • Encourage best practice construction and operation for on-farm storages. • Fund on-farm water use efficiency measures • Review runoff harvesting and water share components under Water Sharing Plans to secure savings from funded efficiency measures
2	Reduced use of Lake Cawndilla		
	<ul style="list-style-type: none"> • Construct a levee, incorporating a two way regulator upstream of Morton Boolka. • Increase Menindee outlet capacity via an additional outlet & channel from Lake Menindee to the Darling River. • Enhance Menindee Creek to access the Lake Menindee residual pool for drought security. • Improve access to residual pools. 	<ul style="list-style-type: none"> • Demand management. • Additional domestic rainwater tanks & recycling. • Improvements to Stephens Creek Reservoir 	<ul style="list-style-type: none"> • Encourage best practice construction and operation for on-farm storages. • Fund on-farm water use efficiency measures • Review runoff harvesting and water share components under Water Sharing Plans to secure savings from funded efficiency measures.
3	Reduced use of both Lakes Menindee and Cawndilla		
	<ul style="list-style-type: none"> • Enlarge Menindee outlet regulator and construct a new outlet channel from Lake Menindee to the Darling River, <u>or</u> construct a new Cawndilla outlet and channel to the Darling River. • Improve access to residual pools. 	<ul style="list-style-type: none"> • New dedicated storage at either North Copi Hollow or Lake Tandure or a pipeline from the Murray River. • Demand management. • Additional domestic rainwater tanks & recycling. • Improvements to Stephens Creek Reservoir. 	<ul style="list-style-type: none"> • Encourage best practice construction and operation for on-farm storages. • Fund on-farm water use efficiency measures • Review runoff harvesting and water share components under Water Sharing Plans to secure savings from funded efficiency measures.

4	Partition Lake Menindee and reduce the use of the lower Lake Menindee cell and reduce the use of Lake Cawndilla		
	<ul style="list-style-type: none"> • Construct 16 km levee from west of Sunset Strip to south of the existing Menindee outlet regulator. • Construct new 8,000 ML/day regulator through the levee near Menindee outlet regulator • Improve access to residual pools. 	<ul style="list-style-type: none"> • New dedicated storage at either North Copi Hollow or Lake Tandure or a pipeline from the Murray River. • Demand management. • Additional domestic rainwater tanks • Improvements to Stephens Creek Reservoir. 	<ul style="list-style-type: none"> • Encourage best practice construction and operation for on-farm storages. • Fund on-farm water use efficiency measures • Review runoff harvesting and water share components under Water Sharing Plans to secure savings from funded efficiency measures.
5	Partition Lake Menindee and reduce the use of the lower Lake Menindee cell		
	<ul style="list-style-type: none"> • Construct 18 km levee from east of the Menindee inlet regulator to east of Morton Boolka • Construct a 4,000 ML/day regulator through the levee in line with Menindee Creek • Construct a new Cawndilla outlet regulator and channel to the Darling River • Improve access to residual pools. 	<ul style="list-style-type: none"> • New dedicated storage at either North Copi Hollow or Lake Tandure or a pipeline from the Murray River. • Demand management. • Additional domestic rainwater tanks & recycling. • Improvements to Stephens Creek Reservoir. 	<ul style="list-style-type: none"> • Encourage best practice construction and operation for on-farm storages. • Fund on-farm water use efficiency measures • Review runoff harvesting and water share components under Water Sharing Plans to secure savings from funded efficiency measures.
6	More Rapid drawdown of Menindee Lakes when in NSW Control		
	<ul style="list-style-type: none"> • Construct a new Cawndilla outlet regulator and channel to the Darling River • Improve access to residual pools. 	<ul style="list-style-type: none"> • New dedicated storage at either North Copi Hollow or Lake Tandure or a pipeline from the Murray River. • Demand management. • Additional domestic rainwater tanks & recycling. • Improvements to Stephens Creek Reservoir. 	<ul style="list-style-type: none"> • Encourage best practice construction and operation for on-farm storages. • Fund on-farm water use efficiency measures • Review runoff harvesting and water share components under Water Sharing Plans to secure savings from funded efficiency measures.

7.8 Indicative Cost Estimates for Schemes

Preliminary cost estimates for each of the six schemes are shown in **Table 7.4**

Table 7.4 Indicative Capital Cost Estimate

Scheme	Est. Capital Cost - Works at Menindee Lakes	Works for Broken Hill and other High Security Water Users	Upstream Measures
1	\$25 M	\$85 – \$400M	not quantified at this stage
2	\$18 M		
3	\$26 M		
4	\$97 M		
5	\$87 M		
6	\$26 M		

8.0 Summary and Conclusions from the Part A Study

The following conclusions can be drawn from the Part A study:

Overview

- A number of recent studies on the Darling River and Menindee Lakes have provided significant input into the option generation and preliminary assessment tasks required by this present study.
- These options include works and operations designed for:
 - Basin wide application such as on-farm storage improvements and market mechanisms
 - Primary works at Menindee Lakes including more rapid drawdown operations and reduced use of certain lakes as storages
 - Other works to help offset and thus reduce the impact of the primary works.

Stakeholder Issues

- As well as past studies, three groups of stakeholders have helped compile a comprehensive list of issues.
- The issues came from one-on-one meetings with a “Targeted Group”, telephone and email discussions with a “Personalised Group” and responses from the wider community following local news releases.
- While all viewpoints have been recorded, it is not surprising that, given the complexity of the issues, a number were sometimes in conflict.
- Where-ever possible, these identified issues have helped guide the development of integrated strategies, and in particular, the offset options.
- The Part A Final Report should be made available to all stakeholders.
- During the next stages and as the assumptions behind the integrated schemes are checked and as the preferred 20 year strategy is refined (particularly after the completion of the necessary drawings, cost estimates, detailed hydrologic and economic modelling), further comment should be sought from the stakeholders at (the requested) public meetings.
- In particular, comments should be sought from groups representing High Security water users, tourist operators and the Aboriginal community.

Long List of Works and Options

- “Desk top” analyses, based largely on earlier documented findings, were used to dismiss some options on the grounds of poor technical feasibility, high costs or environmental impact.
- This process left for further assessment the following broad options:
 - Structural changes at Menindee Lakes
 - Operational changes at Menindee lakes
 - Alternative supplies for High Security users and for Broken Hill
 - Basin wide options to be applied to farm storages
 - Market mechanisms
- This study’s Part A then concentrated on the first three groups.

Structural and Operational Changes at Menindee Lakes

- Works and operations considered from this group included:
 - More rapid drawdown of storages particularly at low storage levels. by releasing at channel capacity.
 - Reduced use of Lakes Menindee and Cawndilla except for trapping large floods.
 - Increased use of the deeper lakes.
 - Dividing Lake Menindee into two cells.
 - Surcharging selected lakes.

Alternative Supplies for Broken Hill

- Options considered under this heading included:
 - Demand management and integrated supply strategies.
 - Aquifer Storage and Recovery at Stevens Creek and Menindee Weir 32.
 - Pipeline from the River Murray.
 - Multi-cell storages at Menindee or North Copi Hollow.

Basin Wide Initiatives

- Preliminary examinations identified the following works for later assessment:
 - Covering off-river storages.
 - Improved on-farm management including crop type and irrigation methods.
 - Market mechanisms and trading rules.

Primary Options

- Works and operations at Menindee were then adopted as the primary options. Securing supplies for Broken Hill and other High Security users were identified as necessary offset works. The Basin wide initiatives were to be examined in later stages of the study.

Assessment of Menindee Lake Options

- Water savings arising from reduced evaporation at storages are technically feasible throughout the Darling River Basin.
- Of the three storage types (major storages at Menindee and elsewhere, hillside dams and ring tanks) the government owned major storages offer the best short-term opportunity.
- The Menindee Lakes represent the largest point source of evaporation, they are also the least efficient storages and thus the best target for the first round of option and scheme assessment.
- At Menindee, the best options are associated with:
 - Allowing more rapid drawdown of storage contents particularly when the system is approaching NSW control, say from 680 down to 100 GL.
 - Establishing a more natural filling operation by preferably excluding Menindee Lake from the system.
- The effectiveness of works to implement these changes were then investigated through a carefully structured set of hydrologic model runs utilising existing and well tested models.

Preliminary Hydrologic Modelling

- Preliminary testing of operational options has identified for example, that a rapid drawdown from 680 GL to 100 GL can produce a long term average water saving of up to 91GLper year.
- The four tested rapid drawdown operations produced an average saving of 51 GL/year with a penalty to other water users of only 3 GL/year.
- The reduced use of selected storages produced “natural filling and emptying” options. This group produced more savings than the rapid drawdown group. The five options averaged 126 GL/year but with major impacts on other users, which averaged 71 GL/year.
- The most ambitious of the more natural filling and emptying operations involved both Menindee and Cawndilla. This change could produce up to 211 GL/year average saving.
- The penalties for existing water users are most severe on the Lower Darling. In addition River Murray users in Victoria and New South Wales are also affected.
- More natural filling of Lake Menindee (an average saving of 136 GL/a) was more effective than more natural filling of Lake Cawndilla (an average saving of 74 GL/year).
- Enhancing the Cawndilla outlet to help “unplug the bath at the bottom of the system” actually reduced the potential savings by 2 GL/year on average. However, it should still be considered in the next stage, as it allows improved operational flexibility.
- The hydrologic model identified flow increases upstream of Wentworth in both the Murray and Darling as well as to South Australia. In summary, the water savings from reduced evaporation together with the reduced State diversions produced “new water” for the lower river. In turn, the new water increased not only the flow to South Australia but also transmissions losses (higher overbank ‘losses’ may also reflect ecological benefits) and may have slightly increased evaporation losses in Lake Victoria as well.
- Effectively utilising this “new water” in the lower Murray for either irrigation, town supplies or even for watering selected “icon” sites, remains a serious task for the next stages of investigation.
- More sophisticated modelling will be necessary during subsequent study stages to refine these estimates.
- Adjusting the Hume Dartmouth harmony operation may reduce some of the River Murray user penalties.
- Options which empty the lakes more rapidly decrease salinities in both the Lower Darling and the Murray although they increase lake average salinities.
- Restoration of Lakes Menindee and Cawndilla to more natural filling increases the long term salinity in the remaining lakes. Restoration of Menindee alone improves the average salinity in Cawndilla.
- Adjusting the dilution flow triggers at Menindee Lakes may reduce these salinity penalties.
- None of the hydrologic modelling specifically analysed the direct impact on High Security Water Users including Broken Hill.
- The study accordingly identified and then assessed a number of offsets required to limit the impacts on this group. Most of the offset work concentrated on Broken Hill water supply options.

Broken Hill Offset Options

- Broken Hill is the largest urban settlement in the study area and is experiencing a major mining boom with a new mine opening and significant expansion of the existing mine. It is also an important and popular tourist destination. Accordingly, a range of projects to help offset possible impacts from any changed Menindee arrangements were assessed.
- The hydrologic modelling did not evaluate supply to Broken Hill in detail so this must be a subject for the next study stage.
- The study examined and costed four main options; (1) Covering existing storages (using chemical, physical or structural means); (2) Aquifer Storage and Recovery (ASR) at Stevens Creek near Broken Hill and at Weir 32; (3) A pipeline from Lock 9 on the Murray and (4) Demand management and the reuse of grey water in Broken Hill.
- The best of the options were costed. For the economic analysis, it was agreed to include the covering of Stevens Creek Reservoir (\$63M) and improved access to residual pools (\$5.5M). The present value of these two projects is \$99M, a significant sum and a reflection of the importance of this water use.
- The next stage of the study will review and cost further offset options including: a dedicated efficient storage at North Copi Hollow, installing rainwater tanks in Broken Hill and effluent/greywater reuse.

Preliminary Cost Estimates

- Following the hydrologic model testing, cost estimates (with large contingency allowances) were prepared for the Menindee Lakes works as individual options to facilitate preliminary economic modelling. It should be noted that the preliminary cost estimates for individual options differ from the cost estimates for the Menindee Lakes works when included in integrated schemes, since scheme costs include additional works to improve overall operational flexibility.
- The estimates included the capital cost of the works and annual costs covering operations and maintenance. The highest works costs were about \$70M for division of Menindee into cells, followed by \$43M for the option of reducing the use of Menindee as a storage and enhancing the Cawndilla outlet with provision of a new channel to the Darling River. By contrast, reducing the use of Menindee and Cawndilla as storages using the existing regulators carries a lower capital cost of \$4M.
- After capitalising the O and M costs, “cost effectiveness” measures for the tested options were calculated by dividing the present value of the option cost by the potential water savings. The best three performing options were:
 - Rapid emptying of the Menindee lakes system, 680 to 100 GL at \$0M/GL/year
 - More natural filling of Menindee and Cawndilla at \$0.02M/GL/year
 - More natural filling of Cawndilla at \$0.18M/GL/year
- As indicated above, the above “cost effectiveness” measures do not include any offset allowances. As a minimum offset allowance, the study adopted two works. They were the covering of Stephens Creek storage and providing improved access to the residual pools in the Lakes. These offsets were incorporated into the following Economic Analyses. A preliminary estimate of these two works is capital \$69M and operating costs of \$2.5M/year, which in most cases more than doubles the cost of the Menindee Lake works.

Preliminary Economic Modelling

- The best of the above hydrologic model results were tested in a comprehensive economic model.
- The model included allowances for:
 - Cost of the offset program
 - Cost of the works required to implement the scheme
 - The impact of salinity changes on agriculture and urban uses
 - Irrigation penalties in Victoria, NSW and the Lower Darling
 - Changes in Menindee Lake's Sunset Strip property values
 - Menindee Lake tourism effects
 - Hume recreation values
 - Hydroelectricity impacts
 - Water savings in South Australia.
- The economic analyses presented dollar values (discounted over 30 years at 7%) of project costs, offset costs, the value of water savings, salinity impacts, irrigation penalties and totalled these items as net present values.
- None of the options produced a positive net present value. Those that came closest were:
 - Rapid drawdown from 680 to 100 GL at -\$69M
 - More natural filling of Lake Menindee at -\$152M
 - Deepening Lake Pamamaroo at -\$157M
- Of these best options, even "rapid drawdown" would require a near four-fold increase in the value of the saved water to break even. The other two best options would require the water value to increase by more than ten times. Thus government intervention in some form will likely be required.
- In terms of net present value, adding an enhanced outlet to Cawndilla increased the shortfall by \$M47 through not only an increased cost of the works but also as a result of increased salinity penalties.
- Despite being ranked third in NPV, the deepening of Lake Pamamaroo was rejected for further analysis as it produced no water savings at all.

Multi Criteria Analysis

- A Multi Criteria Analysis (MCA) was carried out to incorporate not only the already quoted results of the hydrologic and economic modelling, but also consideration of the likely impacts of each of the options on socioeconomics, indigenous heritage, indirect effects on water users, environmental impacts including impacts on fish, birds and particularly on threatened species and likely benefits from greater operational flexibility.
- The MCA showed no "fatal flaws" in any of the options. The issue then remains to develop rankings between the various options and works.

Integrated Schemes

- At a two day workshop the Steering Committee and the Study Team debated the above conclusions and then agreed to:
 - Develop integrated schemes based on the conclusions of the Background Report.
 - Concentrate on the available evaporation savings and operational flexibility.
 - Seek positive interactions between selected works and operations.
 - Develop a comprehensive and integrated set of offsets for affected parties.
 - Prepare detailed descriptions of six schemes covering key elements, local operations, construction works, potential impacts, upstream efficiency measures and Broken Hill security measures.
- The six Menindee Lakes options, which form the basis of the Schemes, are as follows:
 - reduce use of Lake Menindee as a storage, except for larger floods
 - reduce use of Lake Cawndilla as a storage, except for larger floods
 - reduce use of Lakes Menindee and Cawndilla as storages, except for larger floods
 - divide Lake Menindee into two cells – reduce use of half Menindee and all Cawndilla
 - divide Lake Menindee into two cells - reduce use of half Menindee only
 - allow more rapid drawdown of lakes – can be combined with any of the above
- The key elements of the offset packages will likely include:
 - Secure water supply for Broken Hill and other High Security users
 - Changes to the Murray Darling Basin Agreement
 - Research devoted to the Aquifer Storage and Recovery (ASR) options
 - Revision to Water Sharing Plan
 - Social, ecological and cultural heritage considerations
- Extra hydrologic work covering expected filling and emptying rates allowed improved estimates of the evaporation savings to be incorporated into the six Schemes.

Task Required in the Next Stage

During the next stages, the following more detailed analyses will be required to help with the finalisation of a twenty year strategy:

- Developing effective environmental ‘demands’ in the Lower River particularly at the so-called “icon sites”.
- Use the contemporary MDBC “MSM Big Mod” modelling suite to assess integrated schemes in greater detail.
- Followed by modifications to the model coding and parameter settings to:
 - Optimise Menindee storage rules to minimise evaporation for the best structural options.
 - Further optimise the Hume/Dartmouth/Lake Victoria /Menindee harmony operations to minimise the impact (of reduced storage at Menindee) on existing diverters particularly in the Lower Darling and in the NSW and Victorian Murray.
 - Identify appropriate operational ranges for new or enhanced outlet capacity.
 - Review the salinity dilution flow triggers and other operation rules to balance downstream salinity costs with water saving benefits.
- Finalise Broken Hill demand and supply studies and develop a cost effective offset program.
- Test the economic impact of selected works, offsets and operations.
- Discuss findings with the key stakeholder groups

